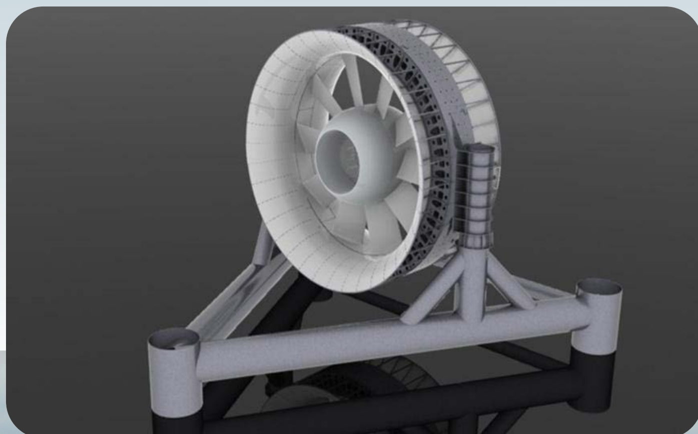
ADMIRALTY INLET PILOT TIDAL PROJECT

FERC PROJECT NO. 12690

APPLICATION for a NEW PILOT PROJECT LICENSE
(MINOR WATER POWER PROJECT)



VOLUME II

EXHIBIT E

Public Utility District No. 1
of Snohomish County

February 29, 2012

U.S. Department of Energy
University of Washington
HDR | DTA
Sound & Sea Technology
OpenHydro Group Limited
Pacific Northwest National Laboratory

Prepared with additional assistance from:

SMRU Limited
Northwest National Marine Renewable Energy Center
National Renewable Energy Laboratory
BioSonics, Inc.
Sandia National Laboratory
Van Ness Feldman GordenDerr
Electric Power Research Institute
Evans-Hamilton, Inc.
Fugro Survey Limited
Global Diving & Salvage
Beam Reach Marine Science and Sustainability School
The Whale Museum
The Orca Network
Golder Associates

APPLICATION CONTENTS

ADMIRALTY INLET PILOT TIDAL PROJECT
(PROJECT NO. 12690)

ENVIRONMENTAL REPORT

PUBLIC UTILITY NO. 1 OF SNOHOMISH COUNTY
Everett, Washington

February 29, 2012

ADMIRALTY INLET PILOT TIDAL PROJECT
ENVIRONMENTAL REPORT

TABLE OF CONTENTS

Section **Title** **Page No.**

TABLE OF CONTENTS
(Continued)

Section **Title** **Page No.**

TABLE OF CONTENTS
(Continued)

APPENDICES CITED

TABLE OF CONTENTS
(Continued)

Section **Title** **Page No.**

ADMIRALTY INLET PILOT TIDAL PROJECT

ENVIRONMENTAL REPORT

LIST OF FIGURES

Figure **Title** **Page No.**

LIST OF FIGURES
(Continued)

Figure **Title** **Page No.**

LIST OF FIGURES
(Continued)

Figure	Title	Page No.

LIST OF FIGURES
(Continued)

Figure	Title	Page No.

LIST OF FIGURES
(Continued)

Figure	Title	Page No.

ADMIRALTY INLET PILOT TIDAL PROJECT

ENVIRONMENTAL REPORT

LIST OF TABLES

Table **Title** **Page No.**

LIST OF TABLES
(Continued)

Table **Title** **Page No.**

LIST OF TABLES
(Continued)

Table **Title** **Page No.**

Acronyms and Abbreviations

ACRE - Alderney Commission for Renewable Energy

ADCP - Acoustic Doppler Current Profiler

aMW - average megawatt

APL - Applied Physics Laboratory

BA - Biological Assessment

BOD - Biochemical Oxygen Demand

cm - centimeter

cm^2 - square centimeters

cm^3 - cubic centimeters

Commission or FERC - Federal Energy Regulatory Commission

CPA - Coast Protection Act

CPDF - Cumulative Probability Density Function

CTD - Conductivity-Temperature-Depth

CZMA - Coastal Zone Management Act

DAHP - Department of Archaeology and Historic Preservation

District - Public Utility District No. 1 of Snohomish County, Washington

DO - Dissolved Oxygen

DOE Canada - Department of Energy Canada

DON - Department of the Navy

DPM - Detection Positive Minutes

DPS - Distinct Population Segment

EA - Environmental Assessment

EFH - Essential Fish Habitat

EIA - Environmental Impacts Assessment

EMEC - European Marine Energy Center

EPA - Environmental Protection Agency

ESA - Endangered Species Act

ESU - Evolutionary Significant Unit

FEPA - Food and Environment Protection Act

FERC or Commission - Federal Energy Regulatory Commission

FMO - Foraging, Migration, and Overwintering

FPA - Federal Power Act

Fugro - Fugro Seafloor Surveys, Inc.

GRP - Glass Reinforced Plastic

HAPC - Habitat Areas of Particular Concern

HDD - Horizontal Directional Drilling

HVAC - Heating Ventilating and Air Conditioning

IAC - Interagency Committee for Outdoor Recreation

ITA - Indian Trust Assets

JARPA - Joint Aquatic Resources Permit Application

km - kilometer

km^2 - square kilometers

km^3 - cubic kilometers

kV - kilovolt

kW - kilowatt

kWh - kilowatt-hour

m - meter

m^2 - square meters

m^3 - cubic meters

mL - milliliter

mg/L - milligrams per liter

MARC – Marine Aquatic Resource Committee

MLLW - Mean Lower Low Water

mm - millimeter

MMPA - Marine Mammal Protection Act

m/s - meter per second

MW - megawatt

MWh - megawatt hour

NAICS - North American Industry Classification System

National Register - National Register of Historic Places

NAWQA - National Water-Quality Assessment

NEPA - National Environmental Policy Act

NHPA - National Historic Preservation Act

NMFS - National Marine Fisheries Service

NNMREC - Northwest National Marine Renewable Energy Center

NOAA - National Oceanic and Atmospheric Administration

NPDES - National Pollutant Discharge Elimination System

OHWM - Ordinary High Water Mark

PAD - Pre-Application Document

PAH - polycyclic aromatic hydrocarbons

PBDE - polybrominated diphenyl ethers

PCB - polycholorinated biphenyl

PFMC - Pacific Fishery Management Council

PHS - Priority Habitats and Species

POST - Pacific Ocean Shelf Tracking Project

PNNL - Pacific Northwest National Laboratory

Project - Admiralty Inlet Pilot Tidal Project (FERC Project No. 12690)

PSAMP - Puget Sound Assessment and Monitoring Program

PSAT - Puget Sound Action Team

PSE - Puget Sound Energy

PSWQA - Puget Sound Water Quality Authority

RCO - Recreation and Conservation Office

ROV - Remotely Operated Vehicle

rpm - revolution per minute

RPS - Renewable Portfolio Standard

RV - Recreational Vehicle

SCORP - State Comprehensive Outdoor Recreation Plan

SMA - Shoreline Management Act

SMP - Shoreline Master Program

SPL - Sound Pressure Level

SSPS - Shared Strategy for Puget Sound

SRKW - Southern Resident killer whale

TISEC - Tidal In-Stream Energy Conversion

TSS - Total Suspended Solids

U&A - Usual and Accustomed

USACE - U.S. Army Corps of Engineers

USCG - U.S. Coast Guard

USFWS - U.S. Fish and Wildlife Service

USGS - U.S. Geological Survey

WDF - Washington Department of Fisheries

WDFW - Washington Department of Fish and Wildlife

WDNR - Washington Department of Natural Resources

WDOE - Washington Department of Ecology

WHR - Washington Historic Register

WQC - Water Quality Certification

Executive Summary

Public Utility District No. 1 of Snohomish County (the District) is filing this Environmental Report as part of an Application for an Original Hydrokinetic Pilot License with the Federal Energy Regulatory Commission (FERC or Commission) for the construction and operation of the proposed Admiralty Inlet Pilot Tidal Project (FERC Project No. 12690) (Project). This environmental report assesses the effects associated with construction, installation, and operation of the proposed Project and Project alternatives, and recommends to the Commission that a license be issued.

The primary goal of the Project is to conduct research and gather data, with energy production playing a secondary role. The information Snohomish expects to gather is critical to informing questions of regional and national interest relative to the technical, economic, and environmental viability of tidal energy generation, and will inform Snohomish's potential further development of the Admiralty Inlet site, and potential development of other sites in and around Puget Sound. The District believes there is potential to generate renewable, emission free, environmentally responsible, and cost effective energy from tidal flows in the Admiralty Inlet region of Puget Sound, and that successful tidal energy demonstration in the Sound may result in important benefits for both the northwest region and the country.

The District has designed this Project by implementing an extensive stakeholder outreach effort resulting in numerous meetings with the public and/or jurisdictional authorities. This approach is consistent with the District's vision for responding to the electric generation needs of the community by responsibly providing a new and clean source of renewable power and allowing for public and stakeholder input as well as being sensitive to the environmental resources present in Puget Sound. The District also recognizes the value of the many resources within Puget Sound, and has utilized local experts as partners in the effort to describe and assess the potential effects to these resources from the Project. These partners include the University of Washington, the Northwest National Marine Renewable Energy Center (NNMREC), the Pacific Northwest National Laboratory (PNNL), and SMRU Ltd. The District has also utilized the expertise from the Orca Network, Beam Reach Marine Science and Sustainability School, and the Whale Museum to support the District's assessment of potential effects to killer whales.

The District has performed and/or proposes the following activities which will significantly diminish the potential for environmental effects from the Project:

A. Implemented a staged approach at selecting the best location - Admiralty Inlet. The District initially received preliminary permits from FERC to study seven locations in Puget Sound. After review of physical, environmental and social aspects with each location the District chose Admiralty Inlet as the best location for the Project. After choosing Admiralty Inlet, the District reviewed in greater detail the same pertinent aspects within the area of the preliminary permit to identify the best location in Admiralty Inlet to site the Project.

B. The District performed an extensive review of the tidal generation technologies available. This review focused not only on the generation technology but also the technology developer's experience with regard to device deployment, retrieval, and understanding of environmental effects. The design includes two OpenHydro tidal turbines. The turbine design incorporates several important features to avoid or minimize environmental risk:

- No requirement for oil/grease lubrication.
- The rotor blade tips are retained within the outer housing and therefore are not exposed.
- The rotor has a low rotational speed. The turbines will rarely operate at the 29 revolutions per minute (rpm) maximum, less than 0.1 percent of the time; typical rotational speeds will range from 6 to 20 rpm.
- Turbine contains an electrical brake to control the rotor speed during extreme events, fault conditions, or on demand. At maximum tidal current flow, the turbine can be slowed to 5 rpm, which would equate to a tip speed of approximately 1.2 m/s.
- Cavitation is prevented by design at this deployment depth and tip speed ratio (i.e., the ratio of the blade tip velocity to water current velocity).
- The deployment method and foundation design eliminate the need for any drilling or piling operations, as well as facilitate potential relocation and complete removal of both the foundation and the turbine. In fact, both the turbines and their foundations are specifically designed to be completely removable for scheduled maintenance or other needs.

C. Designed a Project of limited scale, representing less than 0.05 percent of the Inlet's cross-sectional area.

D. Collected physical and environmental data from Admiralty Inlet to supplement the existing relevant information. The District recognizes the value of the resources present in Puget Sound and has performed the following pre-installation efforts to further characterize the environmental resources in the Project area:

- Deployed stationary instrumentation tripods (Sea Spiders) in partnership with NNMREC on the seabed in the project area beginning in April 2009 and continuing through present to collect the following information:
    - Noise - ambient underwater noise using stationary hydrophones;
    - Cetacean echolocations - passive acoustic monitoring using specialized hydrophones (Chelonia T-POD and C-POD);
    - Water velocity - using stationary acoustic Doppler current profilers (ADCP);
    - Tagged fish monitoring - monitoring of passing marine fish, such as green sturgeon and salmon, that have had acoustic tag receivers implanted by NMFS and others; and

  - o Water quality - temperature, salinity, and dissolved oxygen (in partnership with the Washington Department of Ecology).

- Conducted four hydroacoustic surveys (in April, August, and November 2009, and February 2010) to characterize fish density and spatial distribution in the Project area.

- Recorded cetacean vocalizations using a cabled hydrophone at Port Townsend.

- Conducted water quality vertical profiles on shipboard surveys for temperature, salinity, dissolved oxygen, and pH. The mobile water quality surveys occurred in April, May, August, and November 2009 and February and May 2010.

- Conducted mobile underwater noise surveys to provide spatial information on underwater noise in the Project vicinity in April, May, August, and November 2009, and February and May 2010.

- Conducted boat and land-based observations of marine mammals from October 1, 2009 to April 31, 2010, which included the months during which SRKW are most likely to be transiting Admiralty Inlet.

- Conducted mobile shipboard ADCP surveys to provide spatial information on the tidal stream current resource in April, May, August, and November 2009, and February and May 2010, and June and August 2011.

- Performed bathymetric, geophysical, and geological hazard site surveys in the Project area. The study, conducted between June 25 and 30, 2009, included high-resolution multi-beam bathymetric, sub-bottom profiling, side-scan sonar, bottom grab, and magnetometer surveys.

- Collaborated with POST to detect acoustically tagged species. A string of 13 acoustic tag receivers are located across Admiralty Inlet, approximately 9.7 kilometers south of the Project.

- Conducted ROV video investigations to characterize the Project area seafloor in April and August 2009 and August, September, and October 2010.

- Conducted a historical review of the Whale Museum-maintained database of SRKW sightings. The database, termed the Orca Master, is considered the most comprehensive long-term dataset of broad-scale whale distribution in Washington State inland waters. The purpose of the database review was to describe SRKW habitat use within the Project vicinity and aid in providing data to assess encounter risk with the Project turbines.

- Collaborated with NNMREC and NOAA to characterize the pre-installation ambient noise in Admiralty Inlet associated with shipping using fixed hydrophones and Automatic Identification System transmissions.

- Collaborated with NNMREC to assess the feasibility of infrared cameras to increase effectiveness of shoreline observers.
- Collaborated with PNNL to assess the physiological effect of exposure to turbine noise on juvenile salmon.
- Collaborated with PNNL and Sandia National Laboratories to model the effects of blade strike on SRKW during worst-case operating conditions.
- Collaborated with NNMREC to develop stereo-cameras to observe close range interactions between marine animals and the turbine, as well as identify the species involved.

E. Implementation of environmental monitoring during project construction (primarily through the Water Quality Monitoring Plan) and environmental monitoring during project operation, including:

- Benthic Habitat Monitoring Plan
- Derelict Gear Monitoring Plan
- Acoustic Monitoring Plan
- Near-Turbine Monitoring Plan
- Marine Mammal Monitoring Plan

F. Implementation of Project Safeguard Plans as needed, which includes:

- Public Safety Plan
- Navigation Safety Plan
- Emergency Shutdown Plan
- Project Removal Plan

G. Implementation of an adaptive management approach for monitoring and operating the Project.

The proposed Project represents an environmentally responsible approach for the development of a pilot tidal energy project in Puget Sound. It is has been developed consistent with state and federal policies as agreed between the State of Washington and FERC to study, monitor and evaluate the environmental effects of hydrokinetic energy within Washington State waters and has the potential to provide numerous benefits to the environment and economy of the Puget Sound area and beyond.

Section 1
Introduction

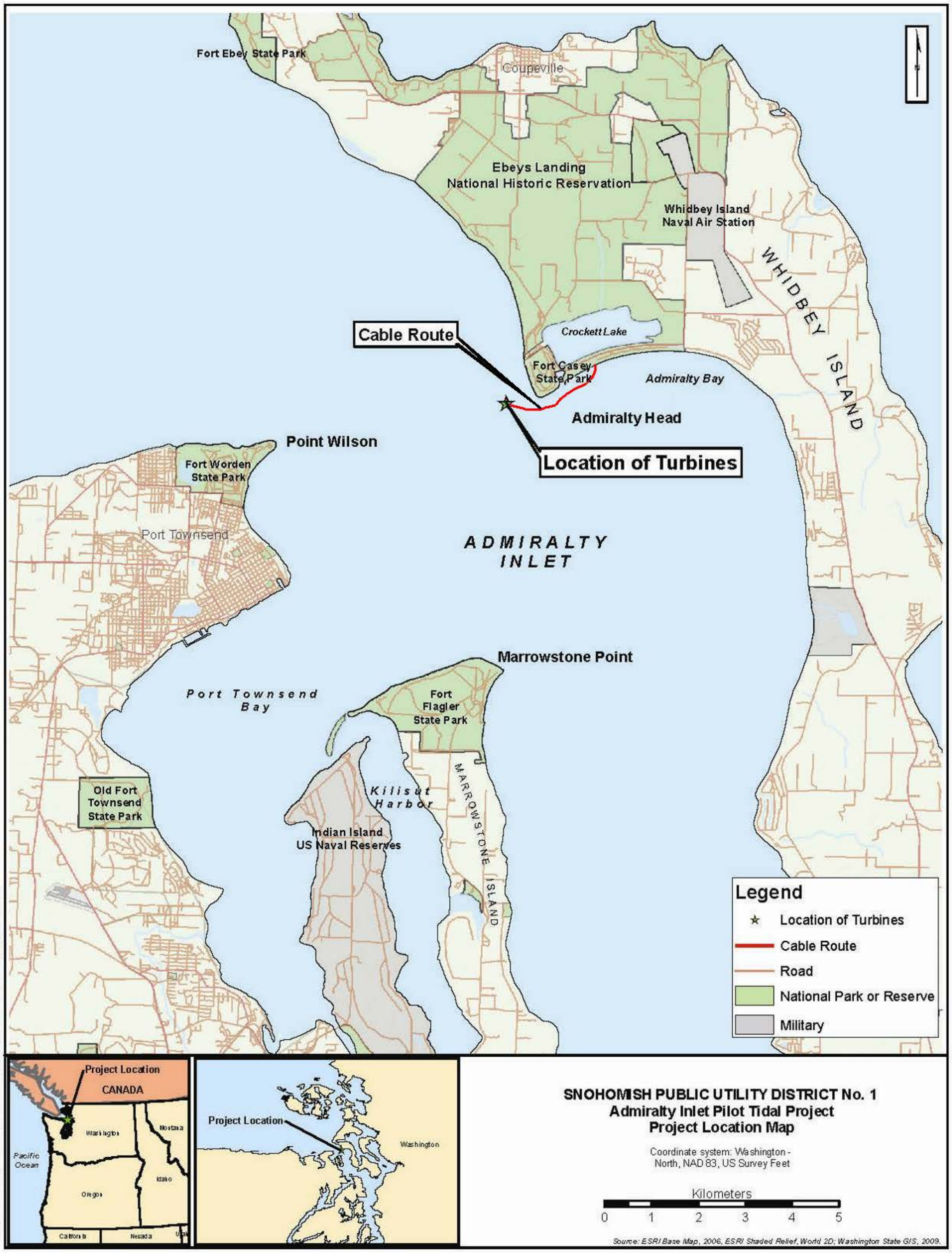
1.1 Application

The District is filing an Application for a Hydrokinetic Pilot Project License (Minor Water Power Project) with the Commission for the construction and operation of the proposed Admiralty Inlet Pilot Tidal Project (FERC Project No. 12690) (Project). The proposed Project is located on the east side of Admiralty Inlet in Puget Sound, Washington, about 1 kilometer west of Admiralty Head, which is part of Whidbey Island (Figure 1-1). The Project will not occupy any federal lands. FERC issued a Preliminary Permit to the District for the proposed Project on March 9, 2007, and the District filed a Draft License Application (DLA) with FERC on December 28, 2009.

This Admiralty Inlet Pilot Tidal Project would temporarily place two 6-meter OpenHydro turbines in a high-current area approximately 58 meters deep and 1 kilometer offshore of Admiralty Head, Washington. The Project is expected to generate approximately 680 kilowatts (kW) of electrical energy at peak tidal currents, and an average annual generation of approximately 27.5 kW, or 216,000 kilowatt-hours.[1] Power would be transferred to the grid via a subsea trunk cable (transmission cable) to Whidbey Island. The cable deployment will utilize Horizontal Directional Drilling (HDD) so as to avoid disturbing the nearshore and seabed habitats. The turbines fit on a gravity-based foundation and no anchor placements, pilings, or surface-piercing structures would be involved with the turbine installations or cable, however two semi-permanent anchors are proposed for the duration of the project to aid maintenance and monitoring vessels. Both the turbines and their foundations are specifically designed to be completely removable for scheduled maintenance or other needs.

[1] Expected peak and average annual generation figures are based on the most recent data available to the District and are the output of a model intended to predict turbine performance within Admiralty Inlet. However, electrical generation from tidal energy conversion devices is highly site-specific and may be influenced by even small changes in the final location of the turbines. Further, performance will be influenced by other factors as well, including actual efficiency of the devices, specific currents encountered, and the effect of turbulence. Therefore, the figures herein are estimates only and may change based on updated data, precise turbine location following deployment, actual performance, and other factors.

FIGURE 1-1
ADMIRALTY INLET PILOT TIDAL PROJECT
PROJECT LOCATION MAP



While the Project will produce a modest amount of energy, the driving purpose for the Project is to explore the feasibility of tidal energy generation. This information is critical to informing questions of national interest relative to the technical, economic, and environmental viability of tidal energy generation, and will inform the District's potential further development of the Admiralty Inlet site, and potential development of other sites in and around Puget Sound. The District believes there is potential to generate renewable, emission free, environmentally responsible, and cost effective energy from tidal flows in the Admiralty Inlet region of Puget Sound, and that successful tidal energy demonstration in the Sound may result in important benefits for both the northwest region and the country.

1.2 Purpose of Action and Need for Power

1.2.1 Purpose of Action

The issuance of a pilot license for the proposed Project is the proposed action. The purpose of this action is to authorize the District to construct, operate, and maintain the Project for a 10-year pilot license which will allow the District to operate the turbines for up to five years prior to deciding whether to develop a commercial-scale project (which would require conducting an additional FERC licensing process to obtain an original FERC license). Issuing a license for the Project would allow the District to generate electricity at the Project for the term of the license, making electric power from a renewable resource available to their customers.

This Environmental Report assesses the effects associated with construction, installation, and operation of the proposed Project and Project alternatives, and recommends to the Commission that a license be issued. In deciding whether to issue a license for a hydroelectric project, the Commission must determine that the Project will be best adapted to a comprehensive plan for improving or developing the waterway. In addition to the power and developmental purposes for which licenses are issued, the Commission must give equal consideration to the purposes of energy conservation, the protection, mitigation of damage to, and enhancement of fish and wildlife (including related spawning grounds and habitat), the protection of recreational opportunities, and the preservation of other aspects of environmental quality.

1.2.2 Need for Power

The District is the second-largest publicly owned utility in the Pacific Northwest and the twelfth-largest in the nation in terms of customers served. The District is a municipal corporation of the State of Washington, formed by a majority vote of the people in 1936 for the purpose of providing electric and/or water utility service. The District began providing electric service in 1949 and currently serves an area of 5,700 square kilometers, encompassing all of the District County and Camano Island. Despite the economic downturn, Snohomish County continues to exhibit population growth. In 2010 the District received 3,100 requests for new electric service connections, and the growth is expected to continue.

In November 2006, Washington State enacted a Renewable Portfolio Standard (RPS) requiring large utilities, including the District, to obtain 15 percent of their electricity from new renewable resources by 2020, as well as to undertake all cost-effective energy conservation. The District currently receives more than 80 percent of its energy from traditional hydropower resources, which will not count towards that 15 percent requirement.

The policy statement associated with the Washington State RPS maintains that: "Making the most of our plentiful local resources will stabilize electricity prices for Washington residents, provide economic benefits for Washington counties and farmers, and create high-quality jobs in Washington." The District believes that delivering on this vision will require the intensive evaluation of *all* potentially viable renewable energy resources available to our region. This approach is consistent with the District's Climate Change Policy, which states:

> *Snohomish County PUD will provide electric, water and associated services to its customers in an environmentally responsible way while increasing economic value, financial stability and operational safety and security for our ratepayers. Snohomish County PUD faces significant challenges and some uncertainty in serving community growth while at the same time addressing the issue of global climate change.*
>
> *Climate change is a serious global problem, and we believe that it should be addressed through the development of thoughtful and forward-looking legislation that actually results in the reduction of greenhouse gas emissions in a workable and cost-effective manner. It is also important that any legislative solutions promote and provide incentives for the development and application of innovative technologies as part of a climate change strategy.*
>
> *The Northwest's investments in energy efficiency and renewable hydroelectricity have yielded substantial environmental benefits. We will continue this legacy by meeting customer growth through conservation and a diverse mix of renewable technologies including, but not limited to, wind, tidal, solar, biomass, and geothermal.*
>
> *Using our natural resources more efficiently and wisely makes good environmental and economic sense. Therefore, legislation to reduce greenhouse gas emissions, if done correctly, should not negatively impact the nation's economy or competitiveness.*

The District estimates that even with a robust conservation program it will still need to acquire approximately 140 aMW from renewable energy resources by 2020 to meet both its load growth and RPS requirements. While wind energy will contribute substantially to achieving this objective, wind energy faces a number of constraints (intermittency, integration, competition for resources, siting challenges, etc.), which will likely limit its contribution. The District believes that meeting this energy challenge will require a richly diversified portfolio of conservation initiatives and renewable energy resources, of which tidal energy has the potential to contribute significantly. The predictability of tidal energy, coupled with its proximity to load in the Puget Sound area, are of particular importance to meeting energy challenges in our region.

The District's tidal energy efforts are consistent with national energy policy priorities, represent one of the primary tidal energy research efforts in the United States, and continue to have the strong support of the U.S. Department of Energy's Advanced Water Power Projects program.

With a capacity of approximately 700 kW, the Project would provide approximately 216,000 kWh annually of clean renewable ocean energy. The successful development of the Admiralty

Inlet Pilot Tidal Project would demonstrate the potential of an emergent renewable energy industry segment with the goal of bringing clean, competitively priced electricity to commercial and residential consumers in Washington State and other coastal states. The future use of the Project's power, its displacement of non-renewable fossil-fueled generation, and its contribution of a predictable renewable energy resource to a diversified generation mix demonstrate that the Project would help meet a need for power in the region and the the District service territory during the pilot license term.

1.3 Statutory and Regulatory Requirements

A license for the Admiralty Inlet Project is subject to numerous requirements under the Federal Power Act (FPA) and other applicable statutes. The District's compliance with or consultation under these statutes is discussed below.

1.3.1 Clean Water Act

1.3.1.1 Water Quality Certification

Under Section 401 of the Clean Water Act, a license applicant must obtain certification from the appropriate state pollution control agency verifying compliance with the Clean Water Act. The Project is located in Admiralty Inlet within the territorial limits of the State of Washington. The District will apply to the Washington State Department of Ecology (WDOE) for Section 401 Water Quality Certification (WQC), as required by the Clean Water Act (33 U.S.C. § 1341). The District will request a WQC through a Joint Aquatic Resources Permit Application (JARPA) filing concurrent with its Final License Application (FLA) filing. By agreement between WDOE, U.S. Army Corps of Engineers (USACE), and other agencies, a JARPA can be used to file for a 401 WQC as well as other state and federal permits. The District filed its JARPA with the appropriate agencies on February 7, 2012.

1.3.1.2 Section 404 Permit

Under Section 404 of the Clean Water Act (33 U.S.C. § 1344), the District will be required to apply for a Section 404 permit from the USACE for the deposit or discharge of dredged or fill material, including structures, into waters of the United States. The District filed an application for a Section 404 permit for the construction of this Pilot Project as part of its February 7, 2012, JARPA filing.

1.3.2 Endangered Species Act

Section 7 of the Endangered Species Act (ESA) requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or destroy or adversely modify the critical habitat of such species. The District requested species lists from U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) in a letter dated December 3, 2007. The USFWS directed the District to their online listing of Washington species and, most recently, NMFS provided a list of species in a letter to the District and FERC, dated August 11, 2010. The District developed a draft Biological Assessment (BA) in consultation with NMFS and USFWS. The District provided drafts of the

BA for agency review on May 18, 2010 (Sections 1-4), December 3, 2010, and February 21, 2011. Fourteen ESA-listed species (nine fish, three mammals, one bird, and one plant) are considered to have the potential to occur in the Project area (Table 1-1).

TABLE 1-1
ESA-LISTED SPECIES POTENTIALLY OCCURRING IN THE ADMIRALTY INLET PROJECT AREA

Common Name	Scientific Name	Federal Status	Relevant Recovery Plans and Status Reports
Fish			
Chinook salmon (Puget Sound)	*Oncorhynchus tshawytscha*	CH T	Good et al. 2005; SSPS 2007
Chum salmon (Hood Canal Summer-run)	*Oncorhynchus keta*	CH T	Good et al. 2005; Brewer et al. 2005; SSPS 2007
Steelhead (Puget Sound)	*Oncorhynchus mykiss*	T	Good et al. 2005; NOAA 2005*b*
Bull trout (Coastal/Puget Sound)	*Salvelinus confluentus*	CH T	USFWS 2004; SSPS 2007
Green sturgeon (Southern DPS)	*Acipenser medirostris*	CH T	NMFS 2005*b*
Bocaccio (Puget Sound/Georgia Basin)	*Sebastes paucispinis*	E	Drake et al. 2010*a*
Canary rockfish (Puget Sound/Georgia Basin)	*Sebastes pinniger*	T	Drake et al. 2010*a*
Yelloweye rockfish (Puget Sound/Georgia Basin)	*Sebastes ruberrimus*	T	Drake et al. 2010*a*
Eulachon (Southern Pacific)	*Thaleichthys pacificus*	T	Drake et al. 2010*b*
Marine Mammals			
Humpback whale (North Pacific)	*Megaptera novaeangliae*	E	NMFS 2005*a*; 1991
Killer whale (Southern Resident)	*Orcinus orca*	CH E	NMFS 2008*a*, Krahn et al. 2004
Steller sea lion (Eastern)	*Eumetopias jubatus*	CH T	NMFS 2008*b*; Angliss and Outlaw 2006
Birds			
Marbled murrelet	*Brachyramphus marmoratus*	CH T	USFWS 2003, 1997
Plants			
Golden paintbrush	*Castilleja levisecta*	T	USFWS 2007,2000

Status definitions: CH - critical habitat has been designated; E - endangered; T - threatened
Source: Letter from NMFS dated December 8, 2008 and July 6, 2009; email from NMFS (Alicia Bishop dated August 11, 2010).

On November 7, 2008 the District was designated by FERC as the non-federal representative for the purpose of conducting informal consultation with NMFS and USFWS pursuant to Section 7 of the ESA and the Magnuson-Stevens Fishery Conservation and Management Act for the Project. Discussion of ESA listed species that could occur in the Project area along with analysis of potential Project impacts on threatened and endangered species are presented in the draft BA (Appendix G).

1.3.3 Coastal Zone Management Act

Section 307(c)(3) of the Coastal Zone Management Act (CZMA) requires that all Federally licensed activities within or affecting a state's coastal zone be consistent with approved state Coastal Zone Management Programs. WDOE has the responsibility to certify that the Project is in compliance with the CZMA. The District is working with the WDOE to comply with the requirements of the CZMA and is filing its request for consistency certification concurrently with this Final License Application. Following an applicant's request for coastal zone determination from WDOE, the agency would have six months to act upon the request.

1.3.4 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) (16 U.S.C. § 470 et seq. [as amended]) requires that every federal agency "take into account" how each of its undertakings could affect historic properties. Historic properties are districts, sites, buildings, structures, traditional cultural properties, and objects significant in American history, architecture, engineering, and culture that are eligible for inclusion in the National Register of Historic Places (National Register).

If an agency official determines that the undertaking may have adverse effects on properties listed in or eligible for listing in the National Register, the agency official must document their findings and afford a reasonable opportunity for the Advisory Council on Historic Preservation to comment.

On November 7, 2008, the Commission granted the District's request to initiate Section 106 consultation of the Commission's behalf, and therefore authorized the District to initiate consultation with the Washington State Historic Preservation Officer and other consulting parties. The District submitted a proposed Area of Potential Effect (APE) concurrence request with the State on August 3, 2011 (see Section 3.3.6). In a letter to the District dated August 8, 2011, the Washington Department of Archaeology & Historic Preservation (DAHP) concurred with the proposed determination of the APE. On February 23, 2012, the District submitted a request to DAHP for concurrence with the determination of "No Adverse Effects to Historic Properties." On February 28, 2012, DAHP responded, agreeing that the Project as proposed will have "NO ADVERSE EFFECT" on National Register eligible or listed historic and cultural resources. Documentation of the District's consultation with DAHP and with tribal historic preservation offices is contained in Appendix M.

1.3.5 Magnuson-Stevens Fishery Conservation and Management Act

Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act requires federal agencies to consult with the Secretary of Commerce regarding all actions or proposed actions that are authorized, funded, or undertaken by the agency that may adversely affect essential fish habitat (EFH).

EFH is defined as:

> *…those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (Magnuson-Stevens Act, 16 U.S.C. § 1801 et seq.). For the purpose of interpreting the definition of essential fish habitat: Waters include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; substrate includes sediment, hard bottom, structures underlying the waters, and associated biological communities; necessary means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and spawning, breeding, feeding, or growth to maturity covers a species' full life cycle (EFH Interim Final Rule, 62 Fed. Reg. 66531).*

EFH is determined by identifying spatial habitat and habitat characteristics that are required for each federally managed fish species through a cooperative effort by the National Oceanic and Atmospheric Administration (NOAA), regional fishery management councils, and federal and state agencies.

As indicated in NMFS' letters to the District dated December 8, 2008 and February 26, 2008, NMFS designated Puget Sound as EFH for Pacific salmon including Chinook, coho, and Puget Sound pink salmon (Pacific Fishery Management Council [PFMC] 2000), and Pacific groundfish including rockfish, lingcod, and Pacific cod (PFMC 2005), and coastal pelagic species including northern anchovy, Pacific sardine, Pacific mackerel, jack mackerel, and market squid species. All the marine water out to the Exclusive Economic Zone with water temperatures between 10°C and 26°C are considered EFH for coastal pelagic species. Admiralty Inlet is EFH when temperatures are between 10°C to 26°C (PFMC 1999).

The proposed Project is therefore within EFH for fishery resources which are managed with the following fishery management plans (FMPs) (letter from NMFS to the District dated July 6, 2009):

- Pacific Groundfish FMP (as amended through Amendment 19) (PFMC 2008) - including many species of rockfish, flatfish, shark, and lingcod;
- Pacific Coast Salmon FMP (PFMC 2000) - Chinook salmon, coho salmon, and Puget Sound pink salmon; and
- Coastal Pelagics FMP (PFMC 1998) - including northern anchovy, Pacific sardine, and Pacific mackerel.

An EFH assessment is included as part of the draft Biological Assessment (Appendix G).

1.3.6 Marine Mammal Protection Act

The 1972 Marine Mammal Protection Act (MMPA) prohibits, with certain exceptions, the "take" of marine mammals in United States waters and the high seas, and the importation of marine mammals and marine mammal products into the United States. The MMPA defines take as to "harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal."

Under the MMPA, depending upon the species involved, either NMFS or USFWS can authorize the incidental take of a marine mammal coincident with conducting otherwise lawful activities.

Under section 101(a)(5) of the MMPA, NMFS, or USFWS may authorize the incidental taking of a small number of marine mammals. The MMPA provides for two types of authorizations depending upon the severity and duration of the impact: (1) Incidental Take Authorizations, also known as Letters of Authorization (LOA); and (2) Incidental Harassment Authorizations (IHAs). For a LOA, an applicant must first request the promulgation of incidental take regulations and then, following their completion and publication in the Federal Register, request the LOA to conduct activities pursuant to the regulatory provisions. LOAs will only be authorized if NMFS or USFWS finds that the take will have no more than a “negligible impact” on the species or stocks. IHAs provide an expedited process for U.S. citizens to obtain authorization to incidentally take small numbers of marine animals by non-lethal “harassment,” i.e., an act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild, or has the potential to disturb a marine mammal or marine mammal stock in the wild by disrupting behavioral patterns.

Analysis of potential Project effects on marine mammals is presented in Sections 3.3.2, Marine Resources, and the Biological Assessment (Appendix G). The District will continue to work with NMFS to ensure compliance with the MMPA.

1.3.7 Ports and Waterways Safety Act

The U.S. Coast Guard (USCG) is responsible for providing FERC, the lead National Environmental Policy Act (NEPA) agency for the proposed Project, with an evaluation of the potential impacts of the proposed Project on the safety of navigation and the traditional uses of the waterway. The USCG must also offer recommendations to provide for navigational safety and to minimize potential adverse impacts. The USCG’s authority comes from the Ports and Waterways Safety Act (33 U.S.C. § 1221 et seq.), which requires the USCG to take into account all possible uses of a waterway to reconcile the need for safe access routes with the needs of all other waterway uses (USCG 2007). The USCG is also authorized to approve private aids to navigation. The analysis of this Project on navigation issues is further discussed in Section 3.3.5, Recreation, Ocean, and Land Use. The District has developed a Navigation Safety Plan and Marine Safety Risk Assessment in consultation with the USCG. The plan and risk assessment are included in Appendix E.

1.4 Public Review and Comment

The Commission's regulations at 18 CFR Part 5 require that applicants consult with appropriate resource agencies, tribes, and other entities before filing an application for a license. Since applying for a preliminary permit for the Project site, the District has engaged in an extensive consultation process with private, governmental, and tribal representatives. This consultation process has included numerous meetings, phone communications, and written exchanges. Below we summarize the consultation process in two parts: (1) consultation prior to filing the draft license application on December 28, 2009 and (2) subsequent consultation.

1.4.1 Consultation Prior to Filing the Draft License Application

The District and stakeholders had formal meetings with agency and tribal stakeholders on the following dates:

- December 5, 2007
- September 30, 2008
- November 3, 2008
- January 22, 2009 (scheduled meeting replaced by conference call)
- February 13, 2009
- March 18, 2009 (with Suquamish Tribe and Skagit River System cooperative)
- March 25, 2009 (joint Navy/District meeting)
- March 31, 2009 (conference call)
- April 9, 2009 (scheduled meeting with NMFS replaced by conference call)
- April 13, 2009 (conference call with NMFS)
- May 8, 2009 (conference call)
- June 18, 2009
- June 29, 2009
- July 15, 2009 (Suquamish Tribe and Skagit River System cooperative)
- August 25, 2009
- September 17, 2009
- October 27, 2009
- November 6, 2009

In addition to these meetings, the District has extensively communicated and/or met with numerous other stakeholders and interested parties, including the Washington Department of Ferries, Fort Casey State Park, Puget Sound Anglers, the Washington Scuba Alliance, the Orca Network, the Whale Museum, Whidbey Island Economic Development Council, Island County Marine Resource Committee, and the Washington Department of Archaeology and Historic Preservation.

To facilitate development of the draft license application, the District prepared and distributed a detailed Pre-Application Document (PAD) on January 31, 2008, engaged in subsequent peer review on the document, conducted additional information collection (as described in stakeholder meetings on September 30 and November 3, 2008), and developed a number of pre-installation resource studies which are now being implemented (pre-installation study reports are contained in Appendix L).

On November 3, 2008, the District issued initial drafts of its Underwater Noise Study Plan and Water Quality Study Plan to Project stakeholders. The District received the following letters commenting on the PAD and/or these pre-installation study plans.

- November 6, 2008 - Washington Department of Fish and Wildlife (WDFW)
- November 25, 2008 - WDFW
- December 8, 2008 - NMFS
- January 27, 2009 - Skagit River System Cooperative

On February 6, 2009, revised versions of these plans were distributed along with initial drafts of an Aquatic Species study plan and a Geophysical and Bathymetric Study Plan. The District received the following letters commenting on the revised pre-installation study plans:

- March 1, 2009 - Tulalip Tribes
- March 6, 2009 - Washington Department of Natural Resources (WDNR)
- March 8, 2009 - Suquamish Tribe
- March 9, 2009 - NMFS
- March 9, 2009 - WDOE
- March 10, 2009 - USFWS (email)
- April 16, 2009 - NMFS

The District substantially modified and added to the pre-installation study plans in an effort to be responsive to the comments and distributed revised study plans on May 1, 2009. The District received the following letters commenting on the revised pre-installation study plans:

- June 16, 2009 - WDFW
- July 6, 2009 - NMFS
- July 23, 2009 - NMFS

The District responded to these comments in letters dated August 19 and October 16, 2009.

The District's revised pre-installation study plans dated May 1, 2009 indicated a commitment to develop and implement an additional pre-installation effort in regards to the Southern Resident killer whale and other marine mammals. This effort was meant to supplement existing datasets (e.g., NMFS stock assessments and WDFW vessel surveys) and passive acoustic monitoring efforts included in the existing pre-installation studies. The Marine Mammal Pre-installation Study Plan was distributed to stakeholders on September 11, 2009. On October 7, 2009, the District received from NMFS a comment letter on the Marine Mammal Pre-installation Study Plan.

The District discussed these comments during a stakeholder meeting on November 6, 2009, and again during a technical conference call with NMFS on November 16, 2009. The District issued a revised Marine Mammal Pre-installation Study Plan via email on November 16, 2009. Further comments were provided by NMFS on November 20, 2009. The District again revised the Marine Mammal Pre-installation Study Plan in response to these comments (the study results are included in Appendix A).

The District also solicited stakeholder input in the development of its draft monitoring plans. FERC monitoring plan requirements were first described during a stakeholder meeting on November 3, 2008. These requirements were revisited and the broad outlines and key considerations of the District's monitoring plan were presented during a September 17, 2009 stakeholder meeting. On October 30, 2009, the District distributed a detailed monitoring discussion document presenting its view of monitoring technologies, methods, and rationale; this document was again presented to stakeholders during the November 6, 2009 meeting, and written comments were requested from all participants. The District did not receive any comments on the draft monitoring plans prior to filing the draft license application on December 31, 2009.

In addition to the meetings with agencies and tribes listed above, the District conducted numerous presentations and discussions regarding the Project. Attendees at these meetings included non-governmental organizations, community leaders, community groups, recreational groups, local resource committees, and interested citizens. The list below does not include informal phone and email communications regarding the Project.

2007

- Presentation at an open public meeting of the San Juan County Council on September 11, 2007;
- Meeting with representatives from Washington State Department of Community, Trade & Economic Development ("CTED") and the Governor's Office of Regulatory Assistance ("ORA") on February 2, 2007;
- Meeting with representatives from numerous state and federal agencies on February 23, 2007;
- Presentation at the Georgia Basin/Puget Sound Action Team Research Conference on March 26, 2007;
- Presentation at a meeting with residents of Camano Island on April 2, 2007;
- Meeting with representative from ORA on April 5, 2007 to discuss progress resulting from the February 23, 2007 meeting;
- Participated, and provided a project update, at a Washington State ocean energy Legislative Forum on August 30, 2007;
- Met with the staff and leadership of the Environment and Heritage Service in Belfast, Northern Ireland to discuss permitting approach/processes utilized for the licensing of the 1.2 MW Marine Current Turbines "SeaGen" installation planned for Strangford Narrows, Northern Ireland in 2008;
- Met with the staff and leadership of the European Marine Energy Center ("EMEC") in Orkney, Scotland to discuss environmental monitoring activities being conducted and planned for EMEC tidal energy device installations;
- Participated on a panel at the FERC Pilot Project Licensing Conference on October 2, 2007 in Portland;
- Conducted a teleconference with FERC representatives on October 16, 2007, to discuss Project requirements with respect to Strict Scrutiny and PAD/NOI submission in light of the new Pilot Plant Licensing Process;
- Delivered a project overview presentation at the Electric League Expo on October 17, 2007 in Seattle;
- Conducted a tidal energy project public meeting with residents of Fidalgo Island on October 18, 2007;
- Provided a tidal energy project update/briefing at Naval Station Everett on October 25, 2007;
- Provided a tidal energy overview and project update at the Northwest Straits Marine Resources Committee Conference on Orcas Island on November 3, 2007;
- Provided a tidal energy project overview and study update to the Jefferson County and Port Townsend City councils, Jefferson Country Marine Resource Committee, and interested community members on November 6, 2007 in Port Townsend, Washington; and

- Conducted a tidal project open house/town hall meeting in Everett on November 13, 2007.

2008

- Provided a tidal energy project overview and update at the Puget Sound Anglers annual board meeting on January 5, 2008 in Edmonds, Washington;
- Participated, and provided a project update, at the Sound Waters 2008 environmental conference in Coupeville, Washington on February 2, 2008;
- Conducted a Tidal Energy overview and project update to Washington State legislators in Olympia, Washington on February 14, 2008;
- Provided a tidal energy project overview and study update at the Washington State University/Skagit County lecture series in Anacortes, Washington on February 15, 2008;
- Provided a tidal energy project overview and study update at the Pacific Seabird Conference in Blaine, Washington on February 29, 2008;
- Provided a tidal energy project overview and study update at the American Fisheries Society annual conference in Bellingham, Washington on March 5, 2008;
- Provided a tidal energy project overview and study update at the Bonneville Power Administration/National Renewable Energy Lab conference in Seattle, Washington on April 2-3, 2008;
- Provided a tidal energy project overview and study update at the National Hydropower Association conference in Washington DC on April 14, 2008;
- Provided a tidal energy project overview and study update for the Anacortes City Council in Anacortes, Washington on April 28, 2008;
- Provided a tidal energy project overview and study update for the Whidbey Island/Washington State University Beach Watchers training session in Coupeville, Washington on April 28, 2008;
- Provided a tidal energy project overview for former Vice-President A1 Gore at Vice-President Gore's climate change *Solutions Summit* in New York, New York on May 1, 2008;
- Moderated a new hydro technologies panel session at Hydrovision in Sacramento on July 18, 2008;
- Provided a tidal energy project overview at the Pacific Northwest Economic Region Forum in Vancouver, B.C. on July 22, 2008;
- Participated, and provided a project update, at the Ocean Research and Resources Advisory Panel meeting in Redmond, Washington on August 4, 2008;
- Participated, and provided a project update, at the UK trade delegation meeting in Seattle, Washington on August 22, 2008;
- Provided a project overview and update to a Camano Island environmental stakeholder group on September 17, 2008 on Camano Island, Washington;
- Met with members of the U.S. Navy/Verdant Power team also working to develop a tidal energy demonstration project in Puget Sound on October 10, 2008 in Lynnwood, Washington;
- Provided a project overview and update, along with the University of Washington, to the Director of the Puget Sound Partnership on October 17, 2008 in Seattle, Washington;
- Provided a project overview and update to the Tulalip Tribes Board of Directors on November 10, 2008 in Tulalip, Washington;
- Met with the U.S. Navy tidal energy team on November 13, 2008 in Lynnwood, Washington to discuss project collaboration needs and opportunities;

- Provided a project overview and update at the Electric Power Research Institute Marine Energy Interest ("EPRI") Group meeting on November 21, 2008 in Whistler, British Columbia; and
- Provided a project overview and update to a Camano Island community environmental stakeholder group on December 6, 2008.

2009

- Met with the U.S. Navy tidal energy team on January 6, 2009 in Lynnwood, Washington to discuss environmental study plan development and collaboration;
- Provided a project presentation and update at the Whidbey Island Marine Resources Committee meeting on January 6, 2009 in Coupeville, Washington;
- Conducted phone and/or email dialogue with the Washington State Dept. of Ferries, Fort Casey State Park management, the Puget Sound Anglers, the Washington Scuba Alliance, Seattle Pacific University-Camp Casey management, the Orca Network, Whidbey Island Economic Development Council, Island County Marine Resource Committee, and the Washington State Department of Archaeology and Historic Preservation;
- Participated, and provided a project update, at the Puget Sound Georgia Basin Ecosystem Conference in Seattle, Washington on February 9, 2009;
- Provided a project overview and update to a group of Washington State legislators in Olympia, Washington on February 12, 2009;
- Provided a project presentation/overview and update at the Northwest Straits Marine Conservation Initiative Commission Meeting on February 27, 2009 in Everett, Washington;
- Met with the Navy tidal energy team on March 4, 2009 in Lynnwood, Washington to discuss environmental study plan development and collaboration;
- Provided a project overview and update to members of the Whidbey Island community on March 27, 2009 in Coupeville and Oak Harbor, Washington;
- Met with the Puget Sound Harbor Safety Committee on April 1, 2009 in Seattle, Washington to review the project and discuss maritime industry comments;
- Provided a project overview and update to members of the Edmonds community on April 2, 2009 in Edmonds, Washington;
- Conducted meeting with the Fort Casey State Park Manager, Washington State DOT Ferries Environmental Coordinator, and WDNR Aquatic District Manager at Keystone Harbor, Washington on April 9, 2009 to discuss project studies and discuss/visit potential subsea cable landing locations;
- Met with OpenHydro, the University of Washington, Devine Tarbell and Assoc., and Sound and Sea Technology on June 24-26, 2009 in Everett, Washington to discuss project planning and plant design;
- Met with Camp Casey Site Manager on June 25, 2009, at Whidbey Island, Washington to discuss subsea cable shore landing facilities and collaboration opportunities;
- Met with Seattle Pacific University ("SPU") Vice-President and SPU's Camp Casey Site manager in Seattle, Washington on July 2, 2009 to discuss subsea cable shore landing facilities and collaboration opportunities;
- Conducted an on-the-water site visit and project overview/discussion with a number of local community/NGO stakeholders, legislative representatives, and media on August 4, 2009 at the project site in Admiralty Inlet. This included observation and discussion of study efforts in progress at the time by the University of Washington's Applied Physic Lab;

- Provided a project overview and update to community and NGO stakeholders at a public town hall meeting in Coupeville, Washington on August 26, 2009;
- Conducted a consultation meeting with the Puget Sound Harbor Safety Committee in Seattle, Washington on August 28, 2009;
- Provided a project overview and update to community and NGO stakeholders at a public meeting on Camano Island, Washington on September 8, 2009;
- Provided a project overview and update to a community stakeholder group in Oak Harbor, Washington on September 8, 2009;
- Participated in the NOAA Marine and Coastal Renewable Energy Adaptive Management Workshop on September 29-30, 2009 in Washington D.C.;
- Met with the White House Council on Environmental Quality to discuss the project and Marine Spatial Planning efforts on September 30, 2009 in Washington D.C.;
- Met with OpenHydro and Nova Scotia Power (NSP) on October 5, 2009 in Halifax, Nova Scotia to discuss the imminent NSP deployment of an OpenHydro turbine in the Bay of Fundy;
- Met with Seattle Pacific University (SPU) Vice-President and SPU's Camp Casey Site manager in Everett, Washington on October 9, 2009 to continue discussion of subsea cable shore landing/facilities and collaboration opportunities; and
- Conversation with Ebey's Landing National Historic Reserve Trust Board Manager to provide project overview and address questions on October 26, 2009.

On December 31, 2009, the District filed a Notice of Intent, a request for waivers of certain regulations of FERC’s Integrated Licensing Process to expedite processing of a license application for the Admiralty Inlet Pilot Tidal Project, and a DLA.

1.4.2 Consultation Following Submittal of the DLA

The vast majority of stakeholder comments following submittal of the DLA and the various monitoring plans were presented to the District during in-person meetings, including the facilitated meetings that took place throughout 2010, and through phone calls or other informal communications. The primary written comments received by the District are contained in the District’s June 24, 2011, response to the Commission’s August 2010 request for additional information.

Stakeholder Consultation During 2010

The District has also received written stakeholder comments in response to the Draft License Application. The District received the following letters commenting on the Draft License Application, all of which were filed in the official FERC docket:

- Sauk-Suiattle Indian Tribe, February 24, 2010
- Swinomish Indian Tribal Community, February 24, 2010
- USFWS, February 25, 2010
- NMFS, February 26, 2010
- National Park Service, February 24, 2010
- Suquamish Tribe, February 26, 2010
- Tulalip Tribes, March 1, 2010

The comments on the Draft License Application questioned (1) whether the Project was appropriate for the Commission's pilot license process, and (2) whether the pre-installation and proposed monitoring plans were adequate to support environmental analysis.

These comments prompted Commission staff to hold a technical meeting on April 12, 2010, to scope issues and to discuss information and monitoring needs for the license application. At the technical meeting, Commission staff focused discussion on the information gaps that needed to be addressed to ensure that sufficient information exists for the Commission to make a determination on whether the proposed Project meets the criteria for a pilot project and for processing a license application for a pilot project once it is filed with the Commission.

Following the April 12, 2010, technical conference, the District and several agencies and tribes engaged a professional facilitator to oversee regular meetings and/or conference calls, including meetings throughout 2010. The meeting dates and general topics covered are listed below:

- April 21 and 22 – Introduction to the process, general objectives, discussion of DLA
- May 6 and 7 – Adaptive management framework, baseline information needs
- May 18 – HDD Plan, adaptive management, FERC additional information request, development of draft Biological Assessment
- May 26 and 27 – Baseline information needs, potential acoustic impacts, Southern Resident killer whale concerns, adaptive management triggers, potential marine mammal impacts
- June 3 – Adaptive management triggers, potential marine mammal impacts, FERC additional information request
- June 15 – FERC additional information request
- June 22 – Full stakeholder meeting, review progress made during facilitated discussions during April, May, and early June (not facilitated)
- June 25 – FERC additional information request, finalize June 30 letter to send to FERC
- July 19 – Derelict Gear Monitoring Plan, Benthic Habitat Monitoring Plan, Acoustic Monitoring Plan
- July 21 – Benthic Habitat Monitoring Plan (conference call)
- July 30 – Acoustic Monitoring Plan, Near-Turbine Monitoring Plan, Southern Resident killer whale monitoring/mitigation plan
- August 5 – Acoustic Monitoring Plan, draft Biological Assessment
- August 25 – Derelict Gear Monitoring Plan, Benthic Habitat Monitoring Plan, Adaptive Management Framework, HDD Plan, update from PNNL work on SRKW detection, Near-Turbine Monitoring Plan, EMF
- September 9 – Benthic Habitat Monitoring Plan, Adaptive Management Framework, Derelict Gear Monitoring Plan, Acoustic Monitoring, review outstanding issues
- October 20 – Acoustic Monitoring Plan, ROV Survey, Benthic Habitat Plan, Near-Turbine Plan (conference call)
- November 12 – Update on status of outstanding issues (conference call)
- November 17 – Update on PNNL work on SRKW detection, Acoustic Monitoring Plan, ROV Survey Report, updates on Near-Turbine Monitoring Plan, Cable Laying Plan, and draft Biological Assessment
- December 20 – Update on status of outstanding issues (conference call)

A second technical conference was held with Commission staff on November 15, 2010, to clarify the Commission's request for additional information. The District utilized many of the facilitated meetings described above to discuss with stakeholders how to respond to the Commission's requests.

Stakeholder Consultation During 2011

Meetings continued during 2011, but the pace slowed down as the District began preparing documents in response to the Commission's August 2010 request for additional information. During the early months of 2011, the District finalized draft responses, including revised monitoring plans, and shares those with stakeholders. The District received written comments on many aspects of its response to the Commissions additional information request. Those comments, and the District's written responses to them, are attached to the District's June 24, 2011, response filed with the Commission.

Most of the consultation during 2011 was either ad-hoc and informal, or part of the 30-day written comment period required by the Commission as part of its additional information request. However, some stakeholder meetings were held, though this list does not cover every meeting or discussion between the District and stakeholders, nor does it cover discussions with members of the public and other interested non-agency parties, as most of those discussions were ad-hoc and informal.

Although some meetings were held, as summarized below, the monitoring plans were primarily revised by consultants for the District working closely with agency technical staff, exchanging and developing language for the plans informally. As a result, no written comments and responses were exchanged. This collaborative effort continues as the District works with NOAA Fisheries and other agencies to complete the Near-Turbine Monitoring Plan, the Acoustic Monitoring Plan, and the Marine Mammal Monitoring Plan (further described in Appendix A to the Final License Application).

- January 26 – Acoustic levels, status of District's response to FERC additional information request, review ROV habitat characterization report (conference call)
- February 25 – Partial response to the Commission's additional information request sent to stakeholders for review, with comments due March 28
- April 6 – Second partial response to the Commission's additional information request sent to stakeholders for review, with comments due May 9
- April 14 – Southern Resident killer whale monitoring/mitigation plan
- August 16 – Southern Resident killer whale monitoring/mitigation plan
- September 14 – Meeting with NOAA Fisheries to discuss Southern Resident killer whale monitoring/mitigation plan
- November 22 – Meeting with NOAA Fisheries, U.S. Department of Energy, Pacific Northwest National Laboratory, and Sandia National Laboratories to discuss Project impacts to Southern Resident killer whales
- December 12 – Status of strike analysis being conducted by Pacific Northwest National Laboratory and Sandia National Laboratories

Stakeholder Consultation During 2012

On February 24, 2012, a conference call and web link was held to discuss a draft report describing the preliminary findings of the strike analysis developed by Pacific Northwest National Laboratory and Sandia National Laboratories. The final report was released on February 28, 2012, though NOAA Fisheries has indicated that they are still reviewing the report and may provide additional comments once that review is complete.

Consultation with PC Landing Corp.

In addition to the exchange of information related to the Draft License Application and the included monitoring plans, and the written comments received in connection with the Commission's August 2010 request for additional information (the District's written responses to those comments can be found with the District's June 24, 2011, filing in response to the information request), the District has received comment letters from PC Landing Corp. PC Landing Corp. has raised concerns regarding the proximity of the turbines to their fiber optic cables on the Admiralty Inlet seafloor. The District's written responses to the two most recent letters are included as Attachment 1 to Appendix N.

General Stakeholder Distribution List

A list of the stakeholders receiving communications about the Project is included as Attachment 2 to Appendix N.

Section 2
Proposed Action and Alternatives

2.1 No-action Alternative

Under the no-action alternative, the proposed Project would not be constructed. There would be no changes to the environmental resources of the area and electrical generation from the hydrokinetic resources of Puget Sound would not occur. The power that would have been generated from this renewable technology would instead continue to be provided to residents and businesses in western Washington from the existing generating resource mix and may accelerate the need to develop additional, non-renewable generation resources. The Project would not be available to help the state of Washington meet its renewable energy generation goal of 15 percent new renewables by 2020, nor would this Project provide information that might help facilitate the development of other hydrokinetic generating technologies in Washington and elsewhere. Section 4.2 contains additional discussion of alternatives.

2.2 Proposed Action

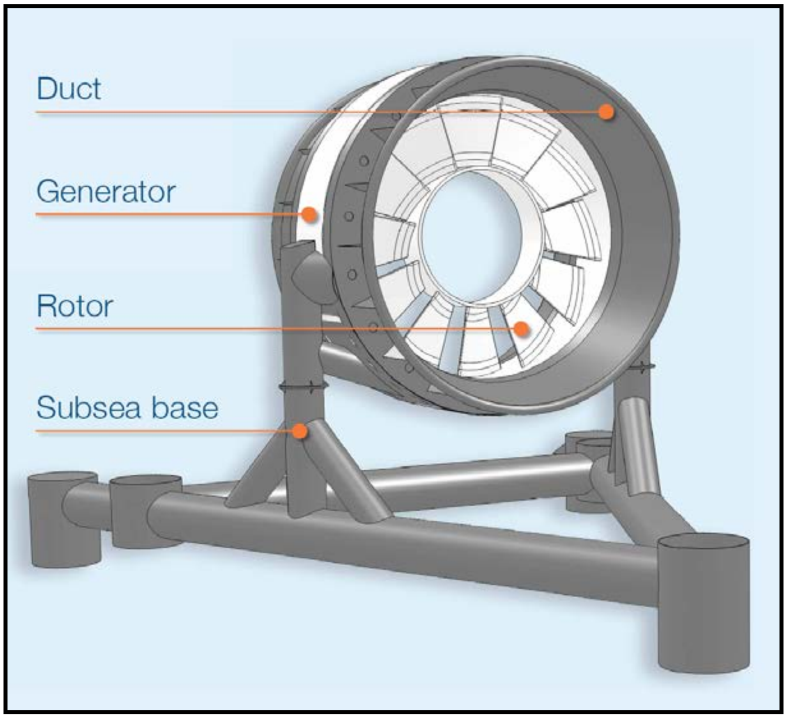
2.2.1 Proposed Project Facilities

2.2.1.1 Tidal Energy Device

The OpenHydro turbine features a horizontal axis rotor with power off take through a direct drive, permanent magnet generator (Figure 2-1). It is principally comprised of three components:

- Turbine rotor which is an assembly of glass reinforced plastic (GRP) components including blades, inner and outer rings;
- Stator (generator) which is constructed from structural steel and GRP; and
- The external venturi (duct) which attaches to the stator and is assembled from GRP or steel.

FIGURE 2-1
OPENHYDRO TURBINE[2]



The design has no need for a gearbox or other complicated components requiring regular intervention. The design is based on a philosophy of zero maintenance between overhauls. From an environmental perspective a number of key design features minimize the risk to marine life:

- No requirement for oils or lubricants, thereby removing pollution risk;
- Rotor blades retained within the outer housing; and
- Open center which provides a passage for marine life, other than whales.

The turbines will have a diameter of 6 meters (actual rotor diameter will be 4.7 meters) and will have 10 rotor blades, the edges of which will be enclosed, and the following approximate dimensions:

- Height of turbine - 13 meters above the seabed,
- Centerline of turbine - 10 meters above the seabed,
- Venturi/duct diameter - 5.9 meters,
- Turbine stator diameter - 5.9 meters,
- Turbine rotor diameter - 4.7 meters, and
- Turbine inner ring diameter - 2.2 meters.

---

[2] 10 m diameter model shown. The 6 m diameter turbines proposed for the Project will have an identical subsea base, but a smaller shroud and blade assembly.

2.2.1.2 Foundation

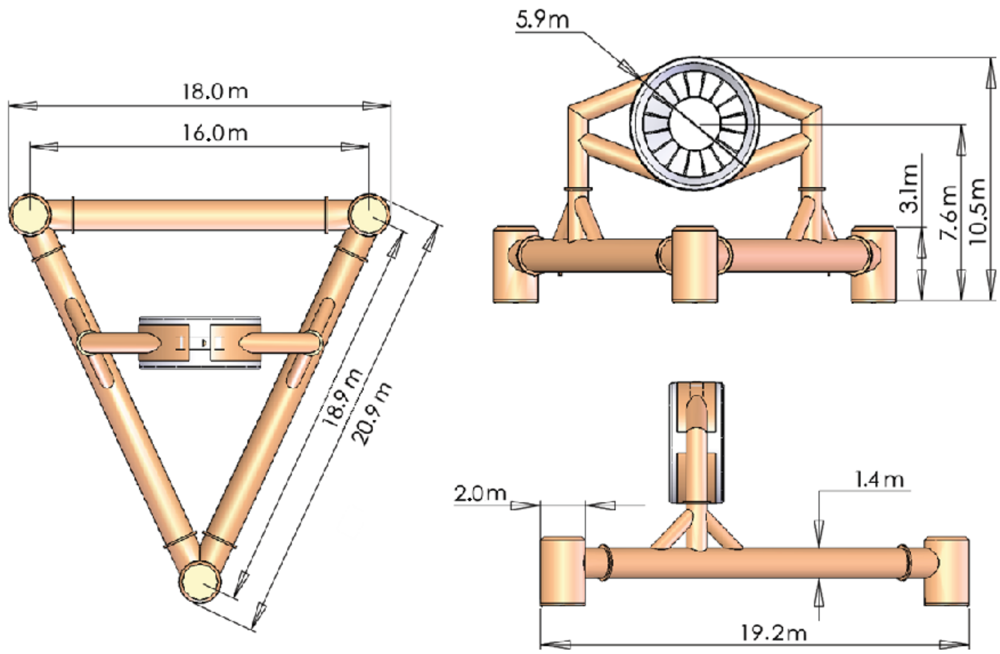
The turbines will be installed directly on the seabed, with no part of the structure visible above the surface of the water. The subsea base consists of a steel tubular frame filled with concrete and stone ballast. The base requires no pinning, piling, or drilling to secure the unit to the seabed. Overturning and lateral forces acting upon the structure are resisted as a function of the weight of the structure.

The foundation will be approximately 19.2 meters in total length and approximately 18.0 meters in total width. The total seabed interface area (contact footprint) for each turbine will be approximately 10 square meters. Figure 2-2 shows the plan, front, and side elevation views of the 6-meter turbine and subsea base. Figure 2-3 shows a constructed unit of a 10-meter turbine that was deployed in Nova Scotia.

The mass of the subsea base will be dependent on the site conditions and will be subject to detailed design. It is anticipated that the combined turbine and subsea base will have a total submerged weight of 253 metric tons, or a total dry weight of 386 metric tons.

No seabed preparation, multiple operations or time-consuming drilling, piling or pinning work is required. The subsea base foundation is designed to penetrate the cobbled top layer of seabed. The footprint of the structure will be three legs, covering a maximum area of approximately 10 square meters. It is expected that the feet will not penetrate the seabed to a depth greater than 0.5 meters. The impact of the devices on seabed morphology have been assessed to be minor if located in areas that are not designated as being of geological or ecological conservation interest. Given the shallow penetration of gravity base legs and the restricted spatial coverage of the devices, it is anticipated that there will be a minimal impact on the rock faces where penetration occurs.

FIGURE 2-2
OPENHYDRO TURBINE (PLAN, FRONT, AND SIDE VIEWS)



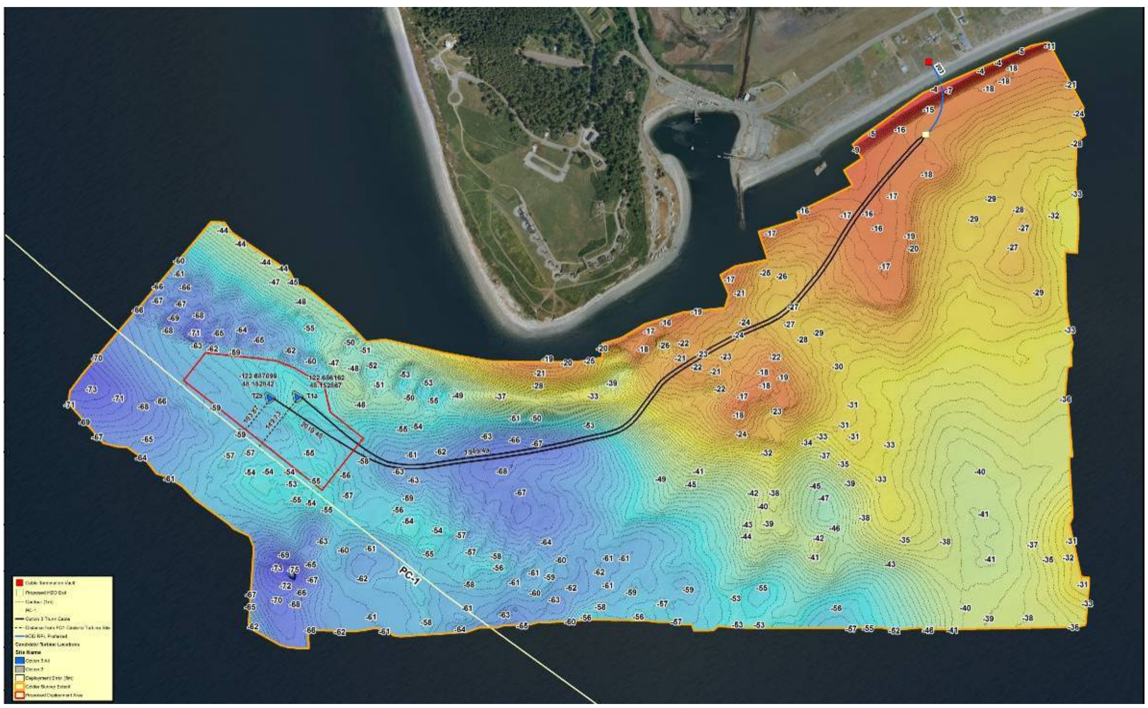
Note: Dimensions in meters

FIGURE 2-3
TRIAL ASSEMBLY OF 10 METER OPENHYDRO TURBINE & SUBSEA BASE
(DARTMOUTH, NOVA SCOTIA, CANADA)

2.2.1.3 Subsea Trunk Cables

The Project will transmit electrical power generated from the OpenHydro turbines to the onshore electrical grid via two parallel subsea trunk cables. The cables connect to a control room, and from the control room the cables connect to the Puget Sound Energy (PSE) grid. The shore landing, control room, and connection to the PSE grid is all located on private land east of Admiralty Head. The general configuration of the cables and shore landing is shown in Figure 2-4. The two trunk cables will be routed through a single HDD bore which runs from onshore to a minimum depth of 18 meters. From the HDD exit underwater, the cables will continue on the seabed to the turbines.

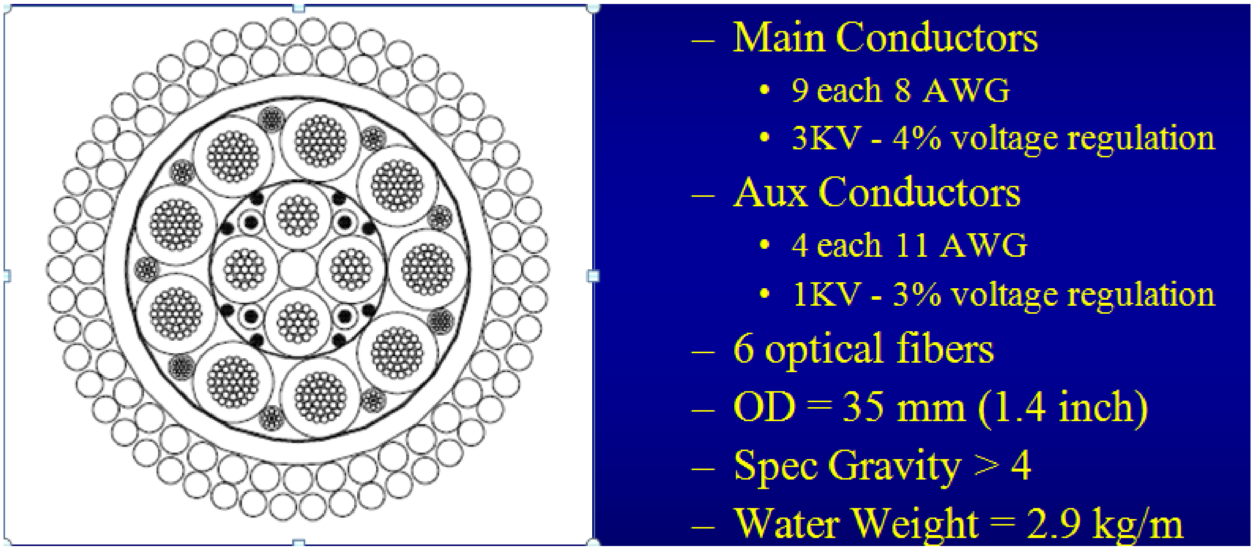
FIGURE 2-4
PROJECT TRANSMISSION ROUTE



Note: Soundings and distances in meters

The trunk cables transmit power at 6 kV (or less), 3 phase Alternating Current (AC) on three dedicated cores in the trunk cables. Turbine control and monitoring signals and environmental data are on dedicated single mode fiber optic elements within the trunk cables. Low voltage power for turbine control and the environmental monitoring system are provided by 2 kV or less dedicated low power elements in the trunk cables. A typical cable arrangement is shown in Figure 2-5.

FIGURE 2-5
TYPICAL TRUNK CABLE



The trunk cables are installed from the turbines to the HDD exit point immediately following the turbine installation. The trunk cables are installed parallel to each other along the seabed surface for approximately 2 km. The cables are installed separately, approximately two weeks apart due to the turbine installation sequence. Approximately 180 meters from the turbines each cable will have a cable connector that will allow for turbine disconnection and removal.

The cables are designed with a high Specific Gravity to assure they do not move on the sea floor due to the high currents along the route. For reference, the cable used with the OpenHydro turbine deployed at EMEC had a submerged weight of 18.4 kilograms per meter, and is likely to be of the same dimensions as the cables proposed for Admiralty Inlet. If there are areas where the cables are suspended across depressions in the seabed or where there are gravel or sand waves, the cables may have to be pinned to the bottom. This is done with weighted sacks or other cable stabilization techniques used in the industry (N. Murphy, Open Hydro and L. Armbruster, Sound & Sea Technology, FERC Technical Conference, Admiralty Inlet Conference, April 12, 2010).

2.2.1.4 Anchor Mooring System

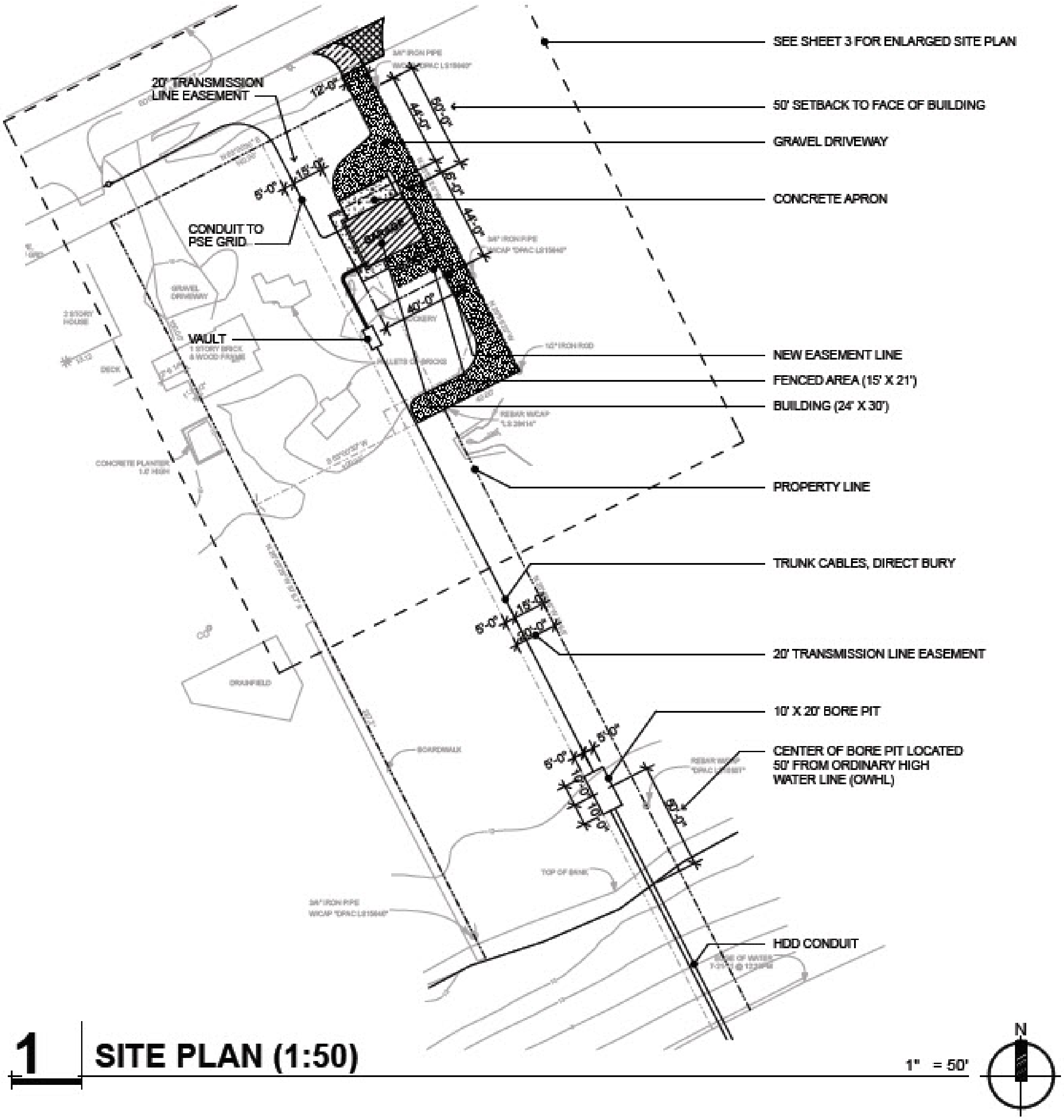
A two anchor mooring system is planned to be installed for installation and operations support. The anchors are installed to the east of the turbine locations so that they are positioned far away from the existing PC-1 telecommunications cable. The anchors are embedment type with gravity suppressor weights in line to reduce the vertical loading on the anchor. Each anchor is estimated to be about 50 tons. The anchor to suppressor weight link is chain and the remaining mooring line is chain for a distance and then either wire rope or synthetic line. The mooring line is stored on the bottom and retrieved during installation or inspection evolution in the operations time frame. The use of the mooring is to provide safety against any emergency situation during installation and inspection to avoid vessels needing to drop anchors in a power loss or equipment failure scenario. The District intends to remove the anchors prior to expiration of the license, following consultation with appropriate agencies and interested stakeholders.

2.2.1.5 Terrestrial Transmission Line and Grid Interconnection

Terrestrial components of the Project will be located on private land and will consist of the following:

- Shore landing cables leading to the cable termination vault,
- Cable termination vault,
- Cables from the vault to the control room,
- Control room, and
- Cable from the control room to the PSE grid (Figure 2-6).

FIGURE 2-6
TERRESTRIAL TRANSMISSION LINE AND GRID INTERCONNECTION



Shore Landing Cables

The cable landing site was selected for: (1) proximity to the subsea turbine site, (2) a suitable location for a shore facility building, and (3) proximity to the existing transmission infrastructure, the PSE grid. The trunk cables will come on shore through an HDD conduit pulled into the HDD bore, to the shore cable vault.

Cable Termination Vault

At the cable vault, the trunk cables terminate and are connected to the terrestrial buried cables (connection breakout point). This termination vault provides an accessible connect and disconnect working area for installation and in the event that the trunk cables need to be removed or disconnected for any reason. An example of the standard utility vault expected to be used measures approximately 1.2 by 1.8 by 0.9 meters and sits flush with the surrounding surface grade.

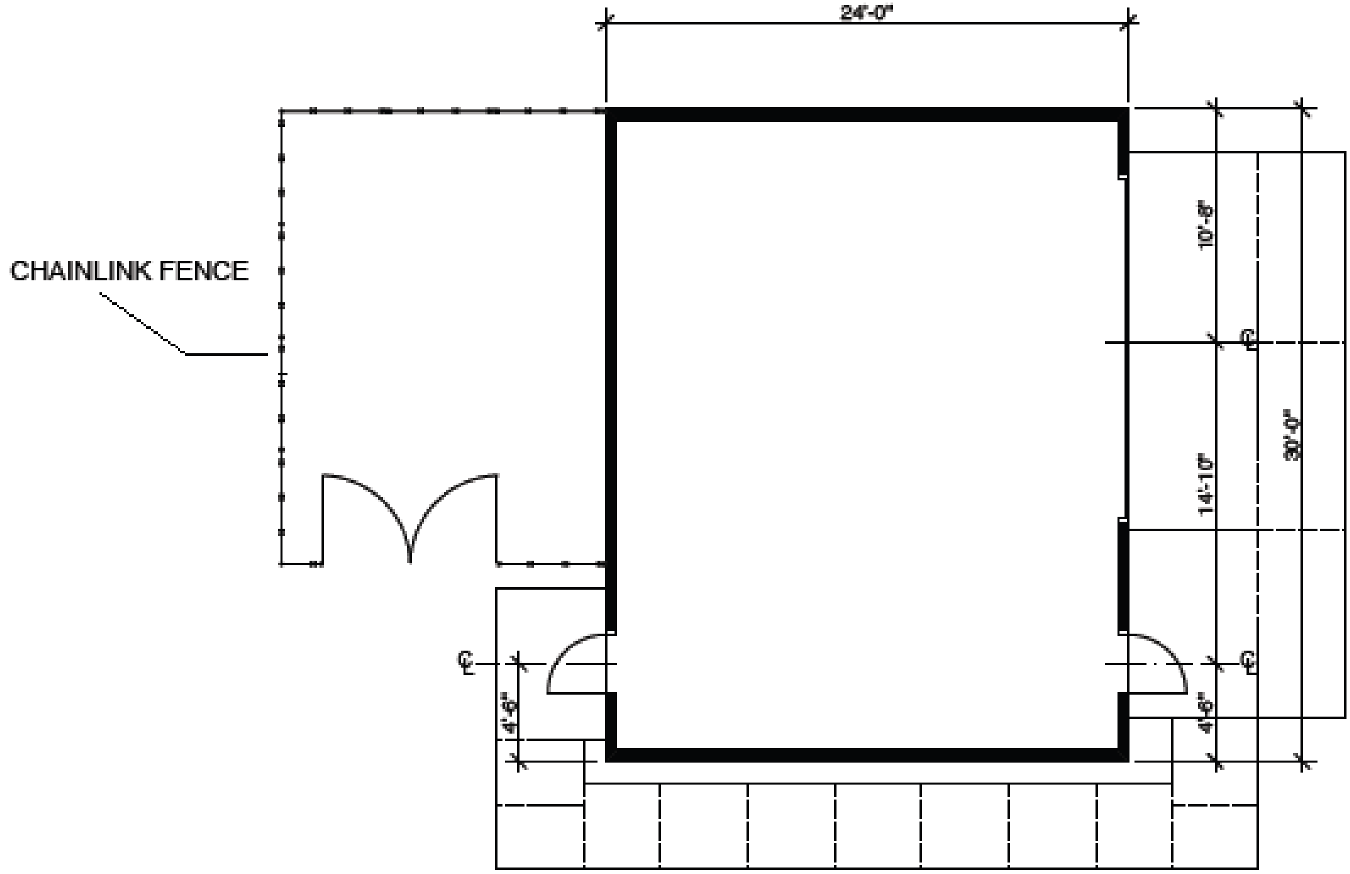
Back Haul Cable to the Control Room

From the cable vault the individual cable cores will be broken out and pulled through separate conduits. The terrestrial cables will run from the termination vault through a buried conduit to the control room. One conduit will contain the AC power transmission lines from Turbine One and a second conduit will contain the AC power transmission cores from Turbine Two. The fiber optic cable, low voltage power elements and the data and telemetry wire bundles will be in additional conduits. Both turbine power cables will be terminated at the first converter buss bar and the sensor cables will terminate at their respective controllers.

The control room will be architecturally designed to be appropriate for the existing buildings at and near the site. The control room will house the power conditioning and monitoring equipment; the major equipment will include transformers, power inverters and conditioners, cabling, and Heating Ventilating and Air Conditioning (HVAC) systems. The control room layout is shown in Figures 2-8 and 2-9. The cables will penetrate the building below ground and enter a diamond plate covered cableway in the floor.

FIGURE 2-7
REPRESENTATION OF CONTROL ROOM SITE

FIGURE 2-8
CONTROL ROOM PLAN



Back haul cable to the PSE grid

From the below ground cable penetration at the control room, the AC power cables will be run underground 70 meters to the 12-kV PSE grid at a utility pole located at approximately 48.159881° N and -122.672955° W.

2.2.2 Project Installation

The installation process begins with the control room facilities construction and HDD operation. It then proceeds offshore where the deployment of the subsea trunk cables and turbines is performed. A sample installation schedule (Table 2-1) shows the expected time before completion required for each major step in the installation.

TABLE 2-1
SAMPLE INSTALLATION SCHEDULE

Task	Description	Start Day	Complete Day	Duration
Shore	Control Room Facility Build	-360	-178	182
	Control Room Equipment Install/Precommission	-180	-54	126
	HDD Install	-180	-135	45
At Sea Installation	Turbine 1, Trunk Cable 1	-75	-72	3
	Turbine 2, Trunk Cable 2	-58	-55	3
Test and Verification	System Commissioning	-56	-1	56
System Start Up	Operations	0	0	

2.2.2.1 Terrestrial Facilities

Control Room

Terrestrial components of the Project are shown in Figure 2-6. Construction and outfitting of the control room will begin before the marine installation process. The major equipment in the control room includes SCADA, environmental monitoring terminals, transformers, power inverters and conditioners, cabling and HVAC systems. They will be installed, checked, and operationally verified before proceeding to marine installation operations.

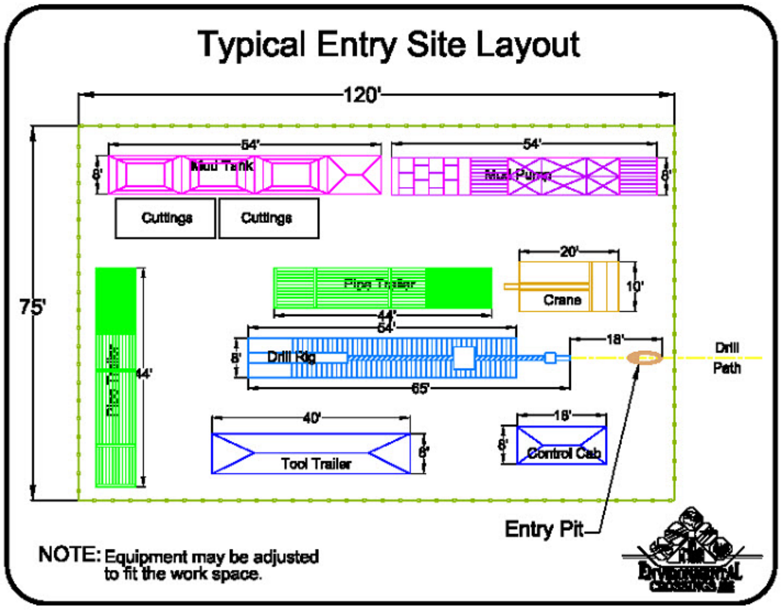
Shore Landing - HDD Operations

Overview

The shore landing of the subsea cables is accomplished through the pre-installed conduit in the HDD bore hole. The HDD design will be finalized based on the geology, bathymetry, and final bore diameter parameters. Installation of the HDD includes: site preparation, drill equipment set up, drilling operations, drill exit evolution with divers, conduit installation, cable installation, cable vault installation, demobilization, and site restoration. The HDD plan is provided in Appendix F, and a summary of the HDD operations is included below.

The HDD equipment will arrive on site aboard multiple trucks. Dependent on final equipment selection this can be as many as six eighteen-wheel trucks along with support equipment such as cranes, back hoes or excavators, and generators. A typical site set up is shown in Figure 2-10; however, the contractor will have flexibility in site layout, as site conditions may dictate.

FIGURE 2-9
TYPICAL HDD FOOTPRINT



HDD equipment includes the following components and is shown in Figure 2-11:

- Drill rig,
- Mud tanks and pumps (solids control unit),
- Pipe trailer and lifting crane,
- Tool trailer,
- Control room, and
- Mud trailer.

Additionally, a small sump pit will be excavated at the bore entry and is expected to be less than 1.8 meters (6 feet) deep, no more than 6 meters (20 feet), and with a width of approximately 2.4 meters (8 feet). The final engineering design of the site will dictate the actual dimensions. This sump pit allows for the recovery of the drilling fluid coming from the borehole back to the surface. The fluid is picked up by a sump pump and transferred to the solids control unit where the solids contained in the drilling fluid are mechanically separated allowing the mud to be re-circulated down hole and used again. The solids are discarded into dumpsters (hoppers) and transported to a local prearranged non-toxic dump site.

FIGURE 2-10
HDD COMPONENTS

	Typical HDD set-up. In this operation, the control cabin where driller and surveyor (steering hand) sit is to the right of the drill rig. An excavator is used to load pipe onto the drilling rig. The hose in the right forefront is pumping drill mud returns from return pit to mud separator units (not shown in this photo).
	Side view of an HDD rig.
	Mud separator units and the plastic lined dumpsters or hoppers that the non toxic solids and drill tailings are disposed into. The hoppers are then trucked offsite to an approved dump site/landfill.

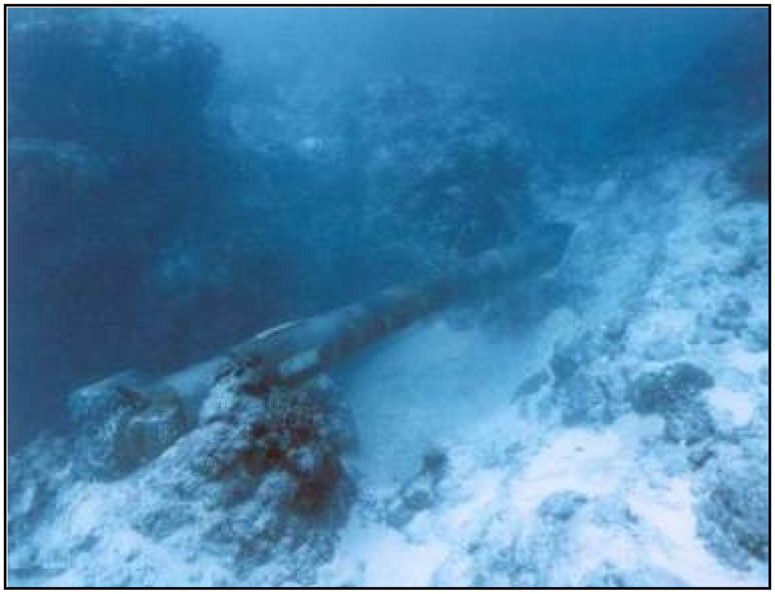
The total time to deploy, drill, demobilize, and restore the grounds typically takes approximately 45 days.

Prior to drilling, a profile of the ocean floor will be obtained. This basic survey will verify the depths provided in the bidding documents are correct so as to establish a true running line and elevation for the drill path. Divers will be used to assist the steering surveyor with obtaining a true shot at the exit point verifying the distance is correct. Should any conflict with a sea floor obstruction be encountered the drill path might need to be adjusted. Where possible a locating grid will be surveyed in along the entry portion of the drill path and a thin 8-gauge wire laid out on the perimeter. While drilling, a small DC current will be induced into the wire to create a magnetic field with known corner points that can be picked up by the sensors in the steering tool. The steering tool, located behind the drill bit, keeps track of the azimuth and the inclination of the drill head, giving the surveyor an accurate location of the bit at all times.

The drill string is advanced along the pre-determined drill path while drilling fluid is pumped down the inside of the bore pipe and exits through the drill head. The fluid then returns to the entry pit through the annulus between the outside of the drill pipe and the formation being bored. The drilling fluid is composed of naturally occurring bentonite clay and water. The clay is insoluble and made up of small particles that function as a lubricant for the drill head and pipe, a transport for the cuttings being removed from the hole, and as a sealant that fills the annulus space surrounding the drill hole. The drilling mud pressure and volume are monitored during drilling operations to assure there are no leakages due to fractures in the structure of the material being drilled through. If a fracture is present, drilling mud could escape onto the surface or into the water (a frac-out). While no fractures are expected in this glacially deposited substructure, the driller will monitor for a frac-out. By monitoring the pressure and volume, such fractures can be identified as they occur and steps can be taken to eliminate the problem. The driller can stop or slow down the operations to give the mud a chance to seal the frac-out. If that is impractical or does not work an alternative route can be taken.

As the drill stem approaches the exit point on the ocean floor, the drilling conditions are carefully monitored. These conditions determine the time or distance from the exit when a shift from the bentonite drilling fluid to fresh water drilling is achieved. By flushing the drill string with fresh water, the drilling mud is circulated out of the system and a mud free exit is achieved. It must be reiterated that drilling conditions, not a pre-determined distance will be the factor as to what point the change to water will occur. As a rule of thumb, 100 feet is the average distance at which a change to fresh water happens. The driller and surveyor will know when the bottom hole assembly exits the sea floor, not by a loss in pressure, but by watching the console inside the drill cab. When the bottom hole assembly is no longer supported by the soil, the angle of inclination will fall off dramatically thus signaling the bore exit. The marine support crew will be dispatched to dive on the exit and verify the exit point. Figure 2-12 shows a typical seaward entrance for the trunk cables.

FIGURE 2-11
HDD DRILLING HEAD EXITING SEAFLOOR



Once the drilling is complete, the contractor will blow a drilling pig (a cylindrical device used for cleaning or inspection) through the pipe from entry to exit to proof the conduit. While blowing the pig, a messenger line made of 5/16-inch stainless steel cable with a 3,000 pound safe working load is attached to the shore side of the pig and pulled into the bore behind the pig during the proofing process. The divers will remove the 5/16-inch wire from the pig, install a one-way valve, and secure the end of the wire around the end of the bore. The messenger line will be used to pull another pulling line through prior to pulling the trunk cables through the HDD bore.

Demobilization of the HDD operations consists not only of disassembling and removal from the site of all HDD equipment and materials but also site restoration including the following:

- Restoration of site to original grade;
- Replanting and/or new planting of grass, bushes and/or trees as needed;
- Repair of any site structures such as roads, fences, curbs, retaining walls, etc. to equal or better condition if damaged during the installation;
- Removal of any Project generated garbage; and
- Removal of any signs of the Project such as ruts in the road, excessive dirt, etc.

Back Haul Operations

As part of the HDD operation a back haul trench for cable conduit approximately 1.0 meter wide by 1.5 meters deep will be dug:

- A distance of 9 meters from the vault to the control room (trench will hold the power as well as the data and telemetry cores); and
- A distance of 70 meters from the below ground cable penetration at the control room to the PSE utility pole (trench will hold the AC power conduit from the control room to the 12 kilovolt PSE grid connections).

Both of these trenches will be filled in, graded, and restored to their original condition at the completion of the HDD operation.

2.2.2.2 Marine Facilities

Each turbine and its associated subsea cable will be first preassembled and coupled together at a mobilization site and then transported to the Project site. At the turbine deployment area the turbines will be lowered to the seafloor and then the turbine's subsea cable will be deployed along the cable route to the HDD bore hole. Finally the subsea cables will be installed into the HDD conduit. Turbine 1 (the eastern turbine) and its subsea cable will be deployed first and then approximately two weeks after the installation of Turbine 1, Turbine 2 and its cable will be preassembled and installed in the same manner as Turbine 1. All U.S. Coast Guard and maritime navigation rules will be enforced, and where required, they will become integral with installation procedures and practices. Marine installation work will also be conducted in WDFW-approved work windows[3].

Turbine and Trunk Cable Installation

The two turbines will be manufactured and tested with the power converters and controllers as a complete system by the OpenHydro group prior to disassembly and shipping. Once the equipment arrives in the Puget Sound area the components will be inspected, reassembled, and retested to verify satisfactory operation. The principles behind the deployment methodology described below allow for all commissioning works to be performed in the safe and controlled working environment of a harbor.

The following vessels will be required to deploy the OpenHydro turbines and subsea cables:

- Turbine installation barge
- Cable laying barge
- Three tugs
- ROV
- Small support vessels

The turbines will be installed using a specialized heavy lift turbine installation barge. Initial testing of the deployment methodology occurred with the successful deployment of a test unit at

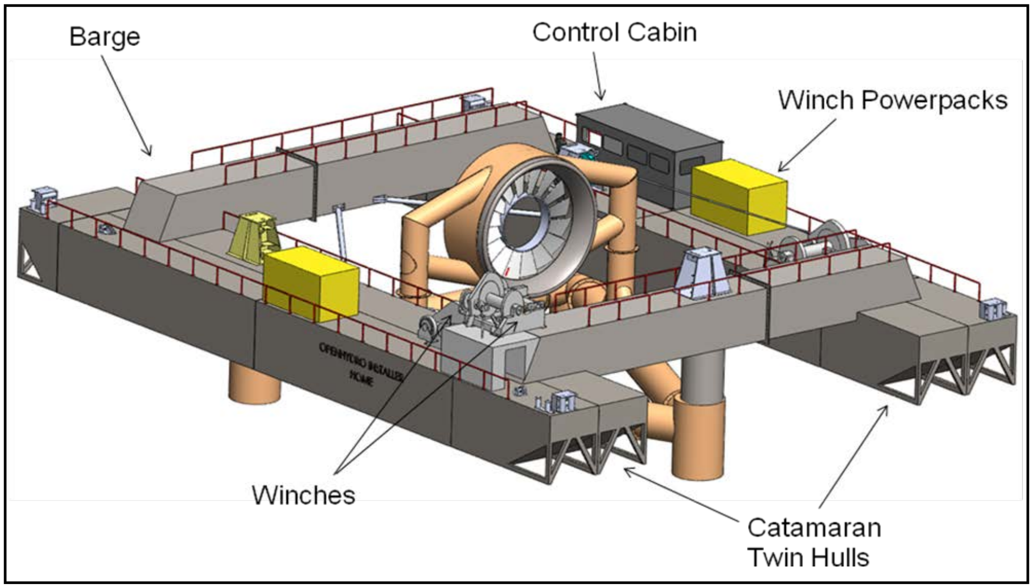
[3] The Project is located in the Tidal Reference Area 10 (Port Townsend). The species work windows for this reference area include: salmon, bull trout, Pacific herring, and Pacific sand lance. The work windows are from July 16 to March 1 for salmon, July 16 to February 15 for bull trout, May 1 to January 14 for Pacific herring, and March 2 to October 14 for Pacific sand lance.

the EMEC facility in 2008 and a subsequent deployment of an operational unit occurred in Nova Scotia in November 2009.

OpenHydro recognized that the market could not provide the marine equipment required to install tidal turbines in a safe and economic manner. In 2007 the company decided to design and manage the construction of a specialized heavy lift barge. This turbine installation barge (Figures 2-13 and 2-14), was completed in July 2008. The barge is a modular construction barge and can be disassembled and shipped to suitable dockside location for reassembly on site. This barge will be used to deploy the turbines in Admiralty Inlet using an OpenHydro Installation Superintendent and United States-supplied deck hands and support personnel. Support vessels will be United States flag vessels.

FIGURE 2-12
HEAVY LIFT OPENHYDRO TURBINE INSTALLATION BARGE

FIGURE 2-13
TURBINE INSTALLATION BARGE CARRYING A 6-METER OPENHYDRO TURBINE



Stage 1 - At the port mobilization area the first turbine (Turbine 1) will be lifted on to the installation barge and coupled to the cable laying barge. The subsea cable will be electrically connected to the turbine at this time. All components will be physically secured for transport to the deployment site. The turbine will be placed in a safe transport configuration. Essential equipment and spares for test and maintenance will be loaded.

Stage 2 - Once mobilization is complete the turbine installation barge and the cable laying barge are transported to the deployment site by two tugs during an ebb tide. The first turbine to be installed will be the eastern turbine (Turbine 1). The tugs will move the turbine installer barge and cable laying barge to the first turbine location in Admiralty Inlet and the third tug repositions the barges for directional control. Before lowering the turbine and cable, a final safe deployment readiness test and inspection will be completed, and the turbine and cable will be lowered to the sea floor where it will be integrity tested and checked for position, levels, and orientation. As the turbine is lowered the cable laying barge remains coupled to the turbine installation barge and pays out the cable while keeping tension on the cable. Once the turbine is positioned on the seabed, the cable laying vessel will be disconnected from the turbine installation vessel. One tug will pull the turbine installation barge away while the other two tugs begin the cable laying process.

Stage 3 - The cable laying process will occur during the flood tide. Two tugs will traverse the cable laying barge over the cable route while the third tug operates the ROV to inspect the cable installation of the seafloor. At the HDD location the cable laying barge will be anchored via a pre-installed mooring and one tug remains to provide directional control of the barge.

Stage 4 - To prepare the cable to be pulled into the HDD conduit, small assist vessels will pay out the HDD cable end from the cable laying barge. The HDD cable end being paid out from the cable laying barge will have floats attached to keep the cable at the water surface. Once the cable is completely paid out off the cable laying barge and oriented toward the HDD borehole, a pull line from inside the HDD borehole will be pulled to the water surface and attached to the cable end.

Stage 5 - The pull line from inside the HDD borehole will pull the cable through the HDD conduit. As the cable is pulled through the HDD conduit, the cable floats will be removed. Divers will monitor the cable installation into the HDD conduit. The remaining floats on the subsea cable will be removed and the cable will rest of the seafloor.

The second turbine and subsea cable will be assembled at the port mobilization area and deployed in the same manner as the first turbine and cable.

The barge and tugs will remain near or on station until all tests are performed to verify the integrity of the connections and full subsea turbine and environmental operational status, monitoring, and control from the control room.

2.2.2.3 Test and Verification

OpenHydro will conduct verification and validation tests to ensure that the turbines are fully functional and operating in a safe electrical and mechanical mode. Automatic controls will be put in place to synchronize to the grid and maintain one way power delivery. The system will comply with IEEE 519 Harmonic Specifications and relevant PSE requirements. Final testing will be performed to demonstrate and validate grid performance under various emergency turbine shutdown scenarios.

2.2.3 Proposed Project Operation and Maintenance

2.2.3.1 Project Operation

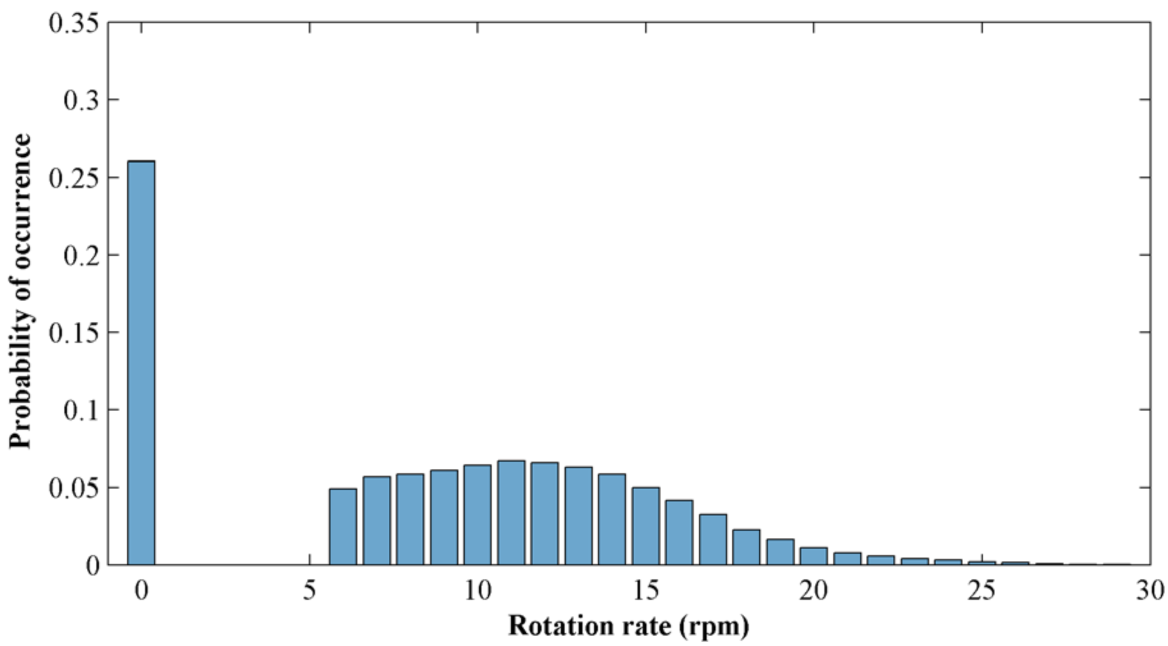
The two turbines will be deployed for five to seven years, depending on the length of the license and the operational capability and reliability of the turbines. During that time, the turbines are expected to rotate 70 percent of the time (when sufficiently high water velocities to rotate the turbines will occur).

The turbine operation will be monitored and controlled using a Supervisory Control and Data Acquisition (SCADA) system. This system will be monitored remotely 24/7 by the District personnel via an internet connection. The system is capable of monitoring a number of sensors including electrical output, critical component temperatures, tidal flow, turbine rpm and electrical contact or status signals. The turbine can be controlled automatically or remotely. Control operations include slowing down of the turbine (to prevent over-speed), speeding up of the turbine (to prevent over-current) and application of the electrical brake.

In normal operation the turbine load is controlled automatically to ensure optimum output. Should an abnormal condition occur, two levels of alarm exist; a warning level at which an alarm message is generated, and a trip level at which the control algorithm is engaged. The system is flexible and allows alarm and trip levels to be adjusted.

Under normal operating conditions, no braking will be applied to slow the turbine as the water velocity is completely predictable and the turbine design will allow for all conditions that could occur. Under the measured tidal conditions at the Project site, the rotor is calculated to spin at a maximum of 29 rpm, and under typical operating conditions, the rotor will spin between 6 and 16 rpm (Figure 2-14).

FIGURE 2-14
PROBABILITY DISTRIBUTION OF ROTATIONAL RATE FOR 6-METER-DIAMETER OPENHYDRO TURBINES IN ADMIRALTY INLET



Source: Personal communication, Brian Polagye, NNMREC, February, 2012 based on most recently available current meter data from Project site.

OpenHydro has developed an electrical braking system for its turbines which has been tested at EMEC. The electrical brake has several purposes. For safety reasons during marine operations, such as installation, cable connection, and removal, it is preferable to have the turbine braked so that the turbine does not generate. The brake can also be used to control rotor speed during extreme events, fault conditions, or on demand. At maximum tidal current flow the braked speed of 5 rpm would equate to a tip speed of approximately 1.2 m/s.

Real-time monitoring information of turbine operations will be transmitted to the control room by the fiber optics or copper wire bundles in the trunk cable. An integrated electronic turbine health and data management capability is an important aspect of the long-term viability and structural integrity of the turbines. An integrated sensor approach to turbine management will quickly identify and respond to unusual turbine behavior.

- Electrical - Real-time operational status of the turbine will be monitored by measuring and recording electrical parameters. Automatic alarm thresholds will be set locally with processor control or remotely by maintenance personnel. An integrated tilt sensor will be mounted to the gravity mount frame to assist in establishing levels
- Mechanical - A three-axis orthogonal accelerometer will be mounted on the turbine to measure real-time vibration levels in x, y, and z axes. Alarm levels and automatic controls will be set to shut down the turbine at preset acceleration levels to prevent potential turbine damage due to fan blade damage or internal mechanical or electrical imbalances. The tilt sensors will monitor the turbine for long term settling.
- ROV - An ROV may be used to inspect the turbines and the area in the vicinity of the turbines quarterly or as needed.

Manual control in the control room and remote web-based monitoring and control will be provided for turbine and grid connection functions. Turbine control functions will include grid connection and disconnection and turbine braking for maintenance. A computer will manage and display sensor information as it arrives. The program that manages the sensor data collection will also keep historical records, track sensor level thresholds, and perform calculations. The computer will have internet access for remote data displays and commands.

2.2.3.2 Project Maintenance

Simplicity of design is at the core of the OpenHydro Turbine, which is manufactured by OpenHydro Group, Ltd. It is OpenHydro's belief that to survive in the marine environment and to minimize operational cost it is essential that the units be robust and require minimal maintenance.

A system level maintenance schedule will be put in place. Maintenance records will be kept and monitored for system degradation. A dedicated computer and data collection program will maintain records of maintenance and will include a real-time operational display and historical charts. The data will be available at remote locations over the internet. A schedule will be developed for periodic database archival.

The maintenance requirements for the OpenHydro turbine take into consideration the following:

- Design,
- Experience from in-house testing,
- Experience from testing at EMEC, and
- Experience from OpenHydro’s 10-meter Turbine deployed in the Bay of Fundy in 2009.

While it is important to note that experience of long term turbine operation will influence the maintenance planning, the District expects to implement the following maintenance and monitoring measures.

Stage 1 Monitoring

Engineers will analyze all data and results from the control and monitoring equipment on each turbine. This data analysis will attempt to highlight any anomalies in the equipment.

Stage 2 Inspection

The District anticipates performing an ROV survey of each turbine and subsea-base consistent with the schedule outlined below to assess features including:

- Overall structural integrity,
- Growth on the structure,
- Condition of the blades,
- Condition of the anodes,
- Position on the seabed, and
- Position and condition of the cables.

OpenHydro propose performing ROV inspections on the following schedule:

- Inspection 1 - Immediately following installation of the tidal array.
- Inspection 2 - Routine inspection following 1 month of operation.
- Inspection 3 - Routine inspection following 3 months of operation.
- Inspection 4 - Routine inspection following 6 months of operation.
- Inspection 5 - Routine inspection following 9 months of operation.
- Inspection 6 - Routine inspection following 12 months of operation.
- Inspection 7 - Routine inspection following 18 months of operation.
- Inspection 8 - Routine inspection following 24 months of operation.

Stage 3 Maintenance

Planned maintenance requiring removing the turbine would not be needed for five years after deployment, which is the term of the deployment. However, pending the results from the above inspections it may be necessary to recover the turbine and return it to port for maintenance, and if so, the maintenance measures outlined below would be implemented. The results from the inspection stage will enable any parts required to be ordered and prepared for fitting.

Turbine Maintenance

Upon recovery OpenHydro will perform the following detailed inspection of the extracted turbine:

- Clean each turbine and prepare for maintenance inspections and work,
- Inspection of the venturi and associated connection points,
- Detailed examination of the blades for damage or wear,
- Inspection of the inner and outer ring,
- Inspection of the bearings and journals for general wear or damage,
- Examination of the anodes,
- Check all fasteners and replace as necessary, and
- Inspect key stress points.

If required:

1. Perform GRP repairs to blade leading edges (erosion or debris impacts),
2. Replace bearing pads if wear is identified,
3. Replace anodes as required,

4. Reapply turbine surface treatments (antifouling paint), and
5. Service turbine instrumentation and monitoring equipment.

Turbine Electrical

- Fully inspect all wiring and electrical enclosures,
- Inspect the coil cables and check the coils and magnets to ensure there are no signs of damage,
- Complete a detailed check on all sensors and ancillary equipment, and
- Fully test electrical and monitoring systems.

If required:

1. Replace any faulty sensors,
2. Replace any faulty generator components,
3. Replace connectors showing signs of water ingress, and
4. Repair any damage to the turbine umbilical cabling and connection.

In the event of power outages, an uninterruptible power supply and power conditioner will provide continuous power to the computer during power outages for up to 24 hours. This power conditioner will also maintain turbine braking control and sensor monitors during a complete power outage.

Subsea Base

The following maintenance requirements are predicted for the subsea base:

- Inspect base (diver/ROV), and
- Clean high stress areas and perform NDT weld tests.

If required:

1. Replace anodes as required, and
2. Repairs to subsea base/umbilical connection.

Potential non-scheduled maintenance events may occur. The maintenance and data logging computer will immediately place an alert over the internet when threshold alarms are reached or non-scheduled automatic shutdowns occur. The notification will go out to key personnel and will identify and describe the source of the fault and the urgency of the notice. A fault tree will be available online as well as a roster list of contact phone numbers.

Removal of the turbines for maintenance will require raising the turbines and mounting assemblies. This may also be required for unscheduled large-scale maintenance. For periodic routine maintenance, the following vessels will be required to recover the OpenHydro turbines:

- Turbine installation barge
- Cable laying barge
- Three tugs
- ROV
- Small support vessels

It is planned for the installation barge to remain in the Seattle area during the demonstration period. The turbine system is designed such that each turbine can be raised without disturbing the other turbine. Slack service and trunk cabling provides removal of either turbine to the surface.

The installation barge will recover the turbine and subsea base using a reversal of the deployment methodology (see Section 2.2.2). Lifting cables from the barge will be attached to the subsea base *in-situ* using a specialized turbine recovery tool which has been designed, built, and tested by OpenHydro in Minas Passage, Canada, allowing the base and turbine to be recovered to the surface. Here, the turbines will be electrically disconnected and disabled on-site. Once secured to the barge, the entire spread will be towed to a suitable dockside location where the turbine will be removed from the subsea base for maintenance. A dockside location has not yet been selected for unloading the turbines for refurbishment, though a number of suitable facilities occur in Puget Sound. It is anticipated that the majority of the work will be carried out at an operations base situated locally to the site and using locally employed labor.

2.2.4 Proposed Environmental Measures

The District's tidal energy efforts are consistent with national and state energy policy priorities, represent one of the primary tidal energy research efforts in the United States, and continue to have the strong support of the U.S. Department of Energy's Advanced Water Power Projects program. With a capacity of approximately 700 kW, the Admiralty Inlet Project would provide approximately 216,000 kWh annually of clean renewable ocean energy. The chosen deployment site is in an area highly used by various industrial and commercial interests. The successful development of the Admiralty Inlet Project would demonstrate the potential of an emergent renewable energy industry segment with the goal of bringing clean, competitively priced electricity to commercial and residential consumers in Washington State and other coastal U.S. states. From the future use of the Project's power, its displacement of non-renewable fossil-fueled generation, and its contribution to a diversified generation mix, the Project will help meet a need for renewable, emission free, and environmentally responsible energy in the Puget Sound region.

Following a rigorous and detailed selection and evaluation process, the District has selected the OpenHydro turbine. OpenHydro has worked closely with several key partners in delivering projects using OpenHydro tidal turbines through various permitting processes and to date, has achieved permits for projects in the United Kingdom, the Channel Islands, and in Canada. These permitted projects have included the assessment of the possible environmental effects of the OpenHydro turbine and have led to a number of environmental studies including pre-construction baseline assessments, Environmental Impacts Assessments (EIAs), real time monitoring of the test facility at EMEC, and post construction surveys currently being undertaken. From environmental monitoring of the OpenHydro turbine at EMEC, no recorded post-construction environmental incidents have occurred, and the levels of underwater noise, seabed recovery, and marine animal interaction with the piled test structure have been shown to be well within acceptable environmental limits. The subsea unit, also deployed at EMEC, has caused no effect to the navigational traffic and the level of seabed impact has been shown to be negligible.

The OpenHydro turbine is designed to be as environmentally acceptable as possible, having only one moving part, requiring no oils, grease, or lubricants, and causing no visual impact. Deployment is targeted at locations where water depths are such that the devices will cause no interference to marine navigation.

The District proposes to construct and operate the Project as previously described in Section 2.2 above and to implement the following environmental measures:

- Use HDD to deploy subsea trunk cable from on land to a depth of 19 meters to avoid impacts to eelgrass or near-shore sensitive areas, and deploy terrestrial transmission underground to grid connection;
- Minimize potential terrestrial and cultural effects by siting the terrestrial component of the Project so as to connect to the grid at a location that is close to shore and has been previously developed;
- Minimize effects to shipping by siting the Project outside of the shipping channel and at sufficient depths to allow for acceptable navigational clearances even for deep draft shipping vessels;
- Minimize use of antifouling paint - only the turbine blades and rotor outer ring will be coated with antifouling paint (non-flaking paint to be used);
- Conduct installation work during WDFW-approved work windows;
- Implement near-turbine monitoring and identification of aquatic species (see Appendix A);
- Implement acoustic monitoring of turbine operational noise (see Appendix A);
- Implement marine mammal monitoring during Project construction, operation, and removal (see Appendix A);
- Utilize Doppler profilers and Doppler velocimeters to monitor tidal currents at the project site. Doppler frequencies will be at least 450 kHz;
- Conduct benthic habitat monitoring (see Appendix B);
- Monitor for derelict gear and remove as necessary (see Appendix C);
- Conduct water quality monitoring as necessary (see Appendix D);
- Implement a Project Safety Plan (part of the Project Safeguard Plans, see Appendix E);
- Implement a Navigation Safety Plan (part of the Project Safeguard Plans, see Appendix E);
- Implement an Emergency Shutdown Plan, if needed (part of the Project Safeguard Plans, see Appendix E);

- Implement a Project Removal Plan, if needed (part of the Project Safeguard Plans, see Appendix E); and

- Implement an adaptive management process to modify project and project operations, as necessary, based on monitoring results.

The Marine Mammal Monitoring Plan mentioned above will include monitoring Southern Resident killer whales (SRKW) to assess the potential for the Project to cause attraction, avoidance, or change of behavioral state. The approach will utilize passive acoustic monitoring (PAM) technology, backed up by visual observation by a locally enhanced observer sightings network (coordinated by Orca Network). The effects of the Project on SRKWs and other ESA-listed species are discussed in the draft BA (Appendix G).

It is important to note that the purpose of the Admiralty Inlet Pilot Tidal Project is to explore the feasibility of tidal energy generation; the District is striving to offset the impacts of the intense developmental pressure in the Puget Sound region, specifically by providing a renewable source of energy to meet the growing energy demand. The accelerated development of renewable energy projects in Washington and the United States will likely result in decreased emissions of greenhouse gases and, consequently, in cumulative environmental benefits to marine resources in Puget Sound. In addition, economic stimulus will result from Project construction and post-deployment operations, maintenance, and monitoring efforts during the proposed 10-year pilot license term.

To enhance these environmental measures, the proposed action includes an adaptive management process that the parties will use to oversee and evaluate results of pre-installation and monitoring studies. These results will be used in combination with an understanding of the ecosystem and information from other relevant sources to make adjustments to study methods as appropriate and to manage or change aspects of the Project operation, as necessary, to avoid or minimize unexpected or undesirable impacts on resources. The adaptive management process allows for immediate action where necessary to address a critical adverse effect of the Project, should that occur.

2.2.5 Other Licensed Projects for OpenHydro Turbine Deployment

While not part of the Proposed Action, it is informative to note that deployment and operation of OpenHydro turbines have been permitted for the following projects located in the United Kingdom, the Channel Islands, and in Canada:

- Permits (FEPA & CPA) for the installation and operation of the piled test structure, subsea unit, and subsea cable (EMEC);
- Permit (ACRE) to deploy four 10 meter OpenHydro Turbine array, Alderney; and
- Permission (DOE Canada) to deploy one 10 meter OpenHydro Turbine, Bay of Fundy, Canada for Nova Scotia Power.

In addition, an application has been submitted to the French Government by the French Utility, Electricité de France (EDF), to deploy a grid-connected array of four 16 meter OpenHydro Turbines in two phases.

- Phase 1: Single 16 meter turbine on remote, not grid-connected, operation for a period of 3 months (installed Q3 2011).
- Phase 2: Three additional 16 meter turbines and the balance of plant (installation scheduled Q2 2012).

This success is based largely on the level of proven environmental performance of the existing turbines at EMEC as has been shown by the environmental studies and assessments which have been carried out there. The following EIAs (Table 2-2) have been submitted for deployment of OpenHydro turbines.

TABLE 2-2
OPENHYDRO SUBMITTED EIAS

Document	Project	Status
Alderney Race Environmental Statement 20080520	Alderney 4 turbine array	Permit Granted - 2008
Alderney Race 285 MW Environmental Statement 20080302	285MW Tidal Development	In Principle
OpenHydro Environmental Assessment v1.2	OpenHydro Research Structure, EMEC	Permit Granted - 2006
OpenHydro EMEC Supplementary Environmental Information (v2)	OpenHydro Subsea Base, EMEC	Permit Granted - 2008
Minas Basin Tidal Energy Project http://www.gov.ns.ca/nse/ea/minas.passage.tidal.demonstration.asp	1 x 10 meter turbine at Bay of Fundy Tidal research facility	DOE permit granted - 2009
EDF - Multiple Documents	Paimpol Bréhat Tidal Array (4 x 16 meter Turbines)	Permit Granted - 2011

These permitted projects have included the assessment of the possible environmental effects of the OpenHydro Turbine on the receiving environment. The projects and deployments have led to a number of environmental studies including pre-construction baseline assessments, EIAs, real time monitoring of the EMEC test facility, and post construction surveys being undertaken.

As part of the permitting requirements, and also to inform OpenHydro of the effects of the turbine in the marine environment, several studies have been undertaken at the EMEC test structure and subsea unit. To date there have been no recorded post-construction environmental incidents. The levels of underwater noise, seabed recovery, and marine animal interaction with the piled test structure have been shown to be well within acceptable environmental limits. Also the subsea unit has caused no effect to the navigational traffic and the level of seabed impact has been shown to be negligible. A variety of monitoring has occurred at the EMEC facility, and resulting findings are included in the relevant resource sections of Section 3.

2.3 Alternatives Considered but Eliminated from Detailed Study

The District engaged in exploration of tidal energy locations in and around Puget Sound. In February and March 2007, the District was awarded preliminary permits to study seven sites for their potential ability to generate electricity from tidal currents. The projects were[4]:

- Deception Pass (FERC Project No. 12687),
- Rich Passage (FERC Project No. 12688),
- Spieden Channel (FERC Project No. 12689),
- Admiralty Inlet (FERC Project No. 12690),
- Agate Passage (FERC Project No. 12691),
- San Juan Channel (FERC Project No. 12692), and
- Guemes Channel (FERC Project No. 12698).

ADCP measurements studies were made at candidate sites. In addition, water quality and other measurements and observations were evaluated by the Applied Physics Laboratory (APL) at the University of Washington. The District evaluated each site's potential for tidal energy generation and identified the potential environmental, economic, and social impacts of a tidal energy development in Puget Sound.[5] Following three years of evaluating numerous sites within Puget Sound, the District and its partners determined that Admiralty Inlet is the most appropriate location to begin in-water evaluation of tidal energy.

The District has surrendered the preliminary permits at Rich Passage (October 7, 2009), Agate Passage (October 7, 2009), and San Juan Channel (December 2, 2009).

The preliminary permit area for the Admiralty Inlet Project included all of Admiralty Inlet. The most feasible areas for turbine installation were:

- Northern Admiralty Inlet: Roughly enclosed by the triangular area with Point Wilson, Admiralty Head, and Marrowstone Point at the vertices.
- Bush Point: A wide transect connecting Bush Point to Nodule Point in the southern part of the inlet (Previsic et al. 2007).

A number of large-scale eddies form on ebb and flood tide in the inlet. On flood tide, an eddy forms to the southeast of Point Wilson and in the entirety of Admiralty Bay to the southeast of Admiralty Head. On ebb tide, there are eddies to both sides of Point Wilson and to the northeast of Admiralty Head. The presence of turbulent eddies restricts turbine build-out to the central channel where the currents are, conveniently, also the strongest (Previsic et al. 2007).

The District carried out a bathymetric and geophysical survey of the proposed deployment zone near Admiralty Head (Whidbey Island). Sidescan sonar and multi-beam bathymetry were used to

---

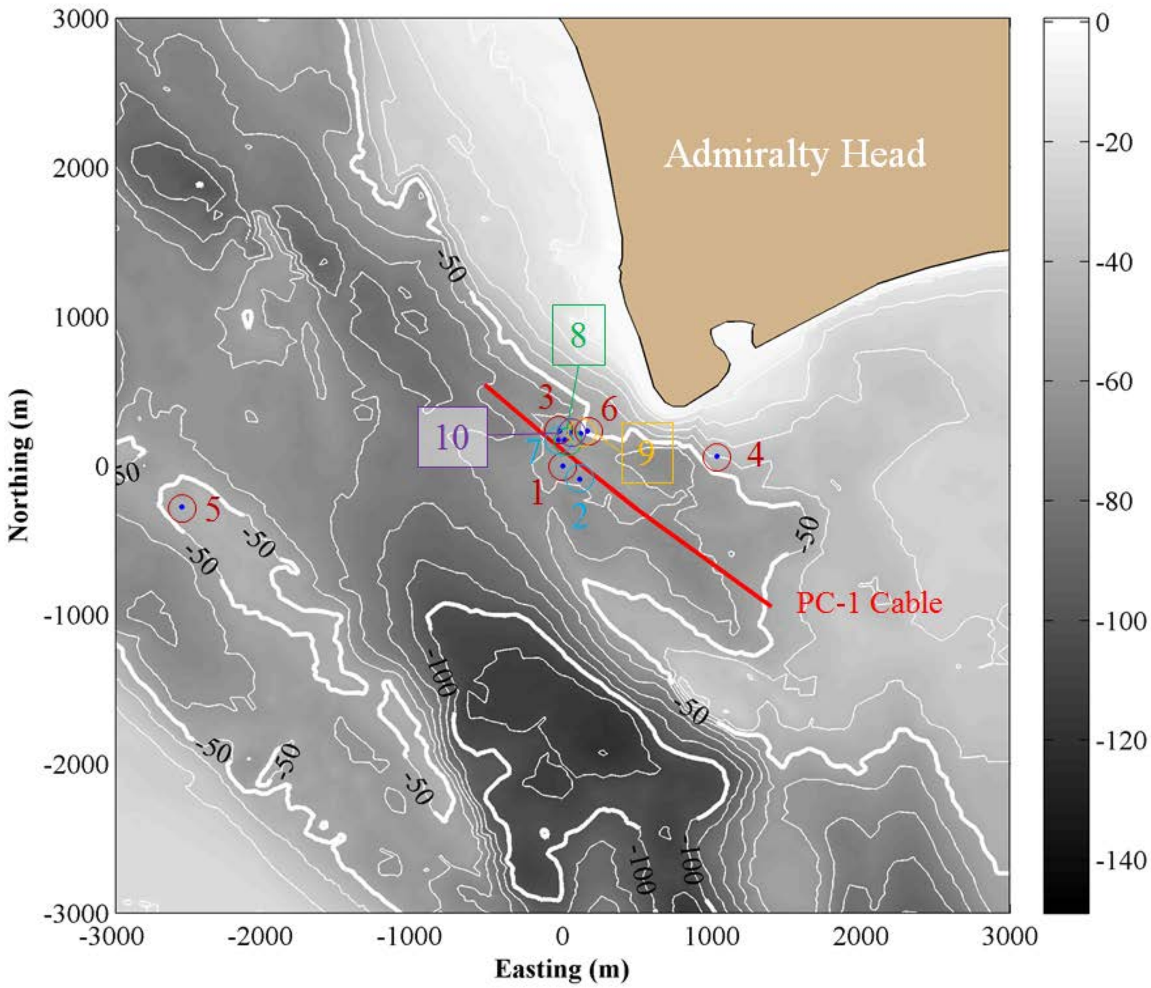
4 On February 22, 2007, Snohomish was issued preliminary permits for five of the tidal projects: Rich Passage, Spieden Channel, Agate Passage, San Juan Channel, and Guemes Channel. On March 1, 2007 and March 9, 2007, Snohomish was issued preliminary permits for Deception Pass and Admiralty Inlet, respectively.

5 Additional detail about these activities is contained in the semi-annual progress reports filed in the Dockets (FERC Project No.) listed above.

identify potential deployment sites within the zone. In addition, a sub-bottom profiler and drop camera were used to identify the seafloor and subsurface conditions.

Since 2009, the District, in partnership with NNMREC, has deployed Doppler profilers at multiple locations in Admiralty Inlet, as shown in Figure 2-15. Details of each deployment are provided in Table 2-3. Power generation estimates are based measured currents during each deployment. Based on analysis presented in Polagye and Thomson (2012), Doppler profiler deployments of at least 30 days or longer than 70 days can provide average power generation estimates with at least 5% accuracy relative to long-term values over the tidal epoch (18.6 years). Power generation estimates assume a turbine hub height of 10 m, turbine diameter (rotor + shroud) of 6 m, water-to-wire efficiency[6] of 30%, and cut-in speed of 0.7 m/s.

FIGURE 2-15
DOPPLER PROFILER DEPLOYMENTS IN ADMIRALTY INLET (2009 – 2011)



[6] Power generation efficiency including extraction and drive train losses.

TABLE 2-3
DOPPLER PROFILER DEPLOYMENT DETAILS

Survey #	Lat	Lon	Start Date	End Date	Duration (days)	Depth (m)	Power Generation (kW)
1	48.1509	-122.6877	5/20/2009	8/3/2009	75	56	14
2	48.1501	-122.6862	2/11/2010	5/4/2010	82	56	11
3	48.1530	-122.6880	8/18/2010	8/9/2011	356	59	10[a]
4	48.1515	-122.6738	11/10/2010	2/10/2011	92	48	4
5	48.1486	-122.7221	2/13/2011	5/9/2011	85	49	7
6	48.1530	-122.6855	5/9/2011	6/8/2011	30	56	14
7	48.1525	-122.6881	5/11/2011	8/9/2011	90	61	13
8	48.1525	-122.6876	7/5/2011	8/4/2011	30	61	13
9	48.1529	-122.6861	8/10/2011	11/14/2011	96	54	14
10	48.1529	-122.6871	8/10/2011	11/14/2011	96	58	13

[a] Instrument configuration under-estimates velocity at 10 m elevation due to reflection of acoustic energy in the along-beam direction from the surface. True power generation potential is likely 13-14 kW.

The general interest in the area off Admiralty Head is motivated by high power generation potential in comparison to other locations in the inlet (e.g., sites 6-10 are significant more energetic than sites 4-5 in Table 2-3), separation from both the vessel traffic lanes to the west of the Project site and ferry lanes to the southeast, and suitable seabed conditions for both deployment of the turbines and routing of power cables. Additionally, locations closer to Admiralty Head increase the effectiveness of shoreline observers to monitor the effects of the project on marine mammals. Initial surveys in early 2009 and 2010 considered sites somewhat to the southwest of the proposed deployment location. A shift to the east was made in late 2010 to avoid a cable run across the PC-1 cable. Further micro-siting deployments in this area were undertaken on the basis geotechnical considerations and increasing separation between the Project and PC-1 cable. During this time, the District also evaluated a location in the center of Admiralty Inlet, between the northbound and southbound vessel traffic lanes and determined that this site would not be suitable for demonstrating technology feasibility (power generation potential 50% lower than selected sites). Similar considerations also apply to sites to the southeast of Admiralty Head, where the eddy that forms on flood tides greatly diminishes the power production potential. Survey sites 9 and 10 in Table 2-3 correspond to the sites proposed for turbine deployment.

In addition to the power generation potential of different locations, survey data have been used to characterize tidal currents in terms of vertical shear and ebb/flood asymmetry (Polagye and Thomson, 2012), as well as turbulence intensity (Thomson et al., 2012). Data from Doppler profiler deployments can also be used to extract harmonic constituents for long-term current predictions. The predictability of tidal currents relative to other renewable resources is a key driver around interest in developing this technology.

Section 3
Environmental Assessment

3.1 General Description of the Project Area

The District is engaged in the FERC licensing of the Admiralty Inlet Pilot Tidal Project (FERC Project No. 12690) in Puget Sound, Washington. The Project involves installation of two tidal in-stream energy conversion (TISEC) devices in Admiralty Inlet, as well as placement of a subsea trunk cable to shore (Figure 1-1), deployment of anchors to facilitate installation and maintenance, and construction of a control room.

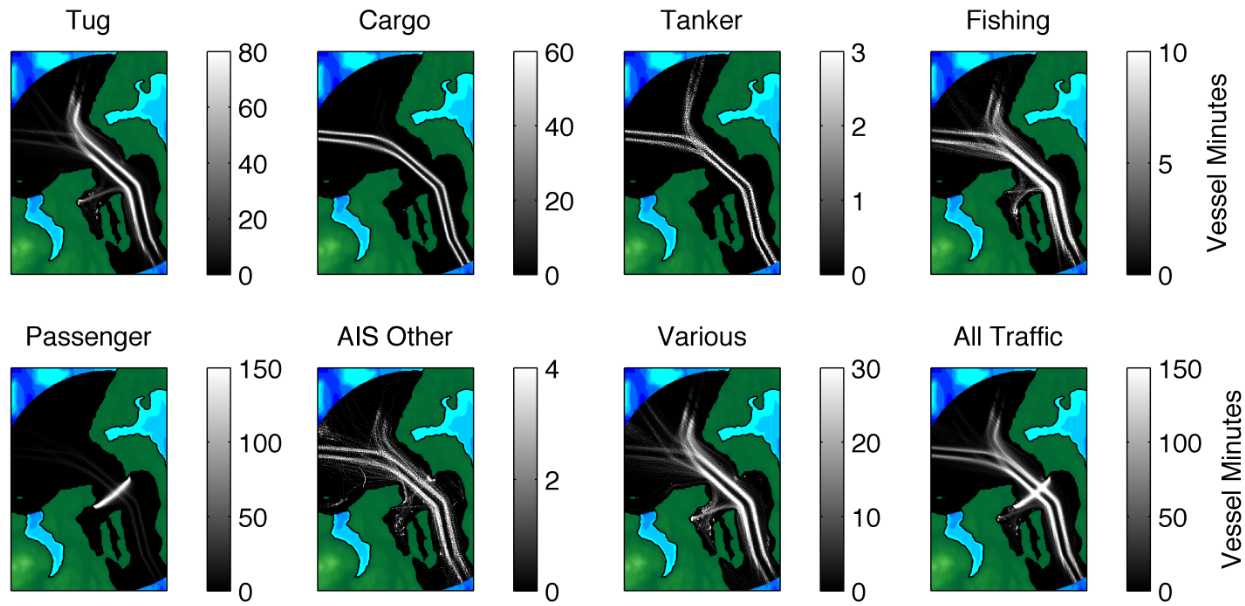
Puget Sound is a semi-enclosed body of water in which salt water from the Pacific Ocean passes through the Strait of Juan de Fuca and mixes with fresh water runoff from the surrounding watershed. The second largest estuary in the United States, Puget Sound has 3,790 kilometers of shoreline. Admiralty Inlet is located in the northwestern portion of Puget Sound, between the Olympic Peninsula on the mainland of the State of Washington (Jefferson County and Kitsap County) and Whidbey Island (Island County), where the northwestern end of Puget Sound connects to the Strait of Juan de Fuca. The turbines will be located approximately 1 kilometer west-southwest of Admiralty Head, in a water depth of approximately 58 meters. Turbine 1 will be deployed at latitude 48.152867° N, longitude -122.686162° W, and turbine 2 will be deployed at 48.152842° N, longitude -122.687099° W. This location was based on the results of feasibility studies, ADCP velocity measurements, bathymetrical data, geotechnical data, grid interconnection, navigational traffic, and feedback from numerous stakeholders. While Admiralty Inlet is a constriction in comparison to the Strait of Juan de Fuca to the west and the main basin to the south, it is quite large in absolute terms, nearly 5 kilometers across with an average depth of 65 meters.

The Project will consist of two OpenHydro tidal energy turbines deployed on a fairly flat area of the seabed and two subsea cables, which will connect to the grid on private land near Admiralty Head.

Fort Casey State Park occupies the land on Admiralty Head to the west of the terrestrial component of the Project. This part of the coastline is dominated by high, sandy bluffs. The beaches along Admiralty Head tend to be sand and cobbles.

Admiralty Inlet serves as a main route for all shipping traffic for the ports of Everett, Seattle, Tacoma, and Olympia (McCurdy 2007). Admiralty Inlet is also traversed by a ferry route: the Port Townsend-Coupeville ferry runs between Port Townsend and Admiralty Head on Whidbey Island. Admiralty Inlet also supports substantial Naval traffic, including that associated with the Naval Station Everett, Puget Sound Naval Shipyard, and the Bangor Submarine Base. Vessel traffic density by vessel class is shown in Figure 3-1 (Bassett et al., 2012*a*).

FIGURE 3-1
VESSEL TRAFFIC DENSITY IN ADMIRALTY INLET



Source: Bassett et al., (2012*a*)
Note: "Vessels Minutes" refers to the number of minutes in a year that a vessel of a particular class is present in a 100 m x 100 m horizontal cell.

In support of siting the Project and developing this document, and to better understand the environmental resources in the Project area, the District has performed the following pre-installation studies (results of which are summarized in the following sections):

- Deployed Sea Spiders on the seabed in the project area beginning in April 2009 to collect the following information (continuing through December, 2013):
  - Noise - ambient underwater noise using stationary hydrophones;
  - Cetacean echolocations - passive acoustic monitoring using specialized hydrophones (Chelonia T-POD and C-POD);
  - Water velocity - using stationary ADCP;
  - Tagged fish monitoring - monitoring of passing marine fish, such as green sturgeon and salmon, that have had acoustic tag receivers implanted by NMFS and others; and
  - Water quality - temperature, salinity, and dissolved oxygen.
- Conducted four hydroacoustic surveys (in April, August, and November 2009, and February 2010) to characterize fish density and spatial distribution in the Project area.
- Recorded cetacean vocalizations using a cabled hydrophone at Port Townsend.
- Conducted water quality vertical profiles on shipboard surveys for temperature, salinity, dissolved oxygen, and pH. The mobile water quality surveys occurred in April, May, August, and November 2009 and February and May 2010.
- Conducted mobile underwater noise surveys to provide spatial information on underwater noise in the Project vicinity in April, May, August, and November 2009, and February and May 2010.

- Conducted boat and land-based observations of marine mammals from October 1, 2009 to April 31, 2010, which included the months during which SRKW are most likely to be transiting Admiralty Inlet.
- Conducted mobile shipboard ADCP surveys to provide spatial information on the tidal stream current resource in April, May, August, and November 2009, and February and May 2010.
- Performed bathymetric, geophysical, and geological hazard site surveys in the Project area. The study, conducted between June 25 and 30, 2009, included high-resolution multi-beam bathymetric, sub-bottom profiling, side-scan sonar, bottom grab, and magnetometer surveys.
- Collaborated with POST to detect acoustically tagged species. A string of 13 acoustic tag receivers are located across Admiralty Inlet, approximately 9.7 kilometers south of the Project.
- Conducted ROV video investigations to characterize the Project area seafloor in April and August 2009 and August, September, and October 2010.
- Compiled a habitat characterization map and report discussing benthic habitat and geologic setting of the project area in Admiralty Inlet, based on information gathered during the October, 2010 ROV survey.
- Conducted a historical review of the Whale Museum-maintained database of SRKW sightings. The database, termed the Orca Master, is considered the most comprehensive long-term dataset of broad-scale whale distribution in Washington State inland waters. The purpose of the database review was to describe SRKW habitat use within the Project vicinity and aid in providing data to assess encounter risk with the Project turbines.
- Conducted a Cultural Resources Assessment to determine if archaeologically or historically significant sites exist in the project area.
- Collaborated with NNMREC and NOAA to characterize the pre-installation ambient noise in Admiralty Inlet associated with shipping using fixed hydrophones and Automatic Identification System transmissions.
- Collaborated with NNMREC to assess the feasibility of infrared cameras to increase effectiveness of shoreline observers.
- Collaborated with PNNL to assess the physiological effect of exposure to turbine noise on juvenile salmon.
- Collaborated with PNNL and Sandia National Laboratories to model the effects of blade strike on SRKW during worst-case operating conditions.
- Collaborated with NNMREC to develop stereo-cameras to observe close range interactions between marine animals and the turbine, as well as identify the species involved.

3.2 Scope of Cumulative Effects Analysis

According to the Council on Environmental Quality's regulations for implementing NEPA (50 CFR § 1508.7), an action may cause cumulative impacts on the environment if its impacts overlap in space and/or time with the impacts of other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time, including hydropower and other land and water development activities.

Based on information in this license application, agency comments, other filings related to the proposed Project, and our independent analysis, we have identified marine resources and commercial fishing and navigation as resources/uses having the potential to be cumulatively affected by the proposed Project in concert with other activities in the proposed Project area. These potential cumulative effects are discussed at the end Section 3.3.2, Marine Resources, and Section 3.3.5, Recreation, Ocean, and Land Use.

3.2.1 Geographic Scope

The geographic scope of analysis defines the physical limits or boundaries of the proposed action's effects on the resources. Because the proposed action would affect the resources differently, the geographic scope for each resource may vary.

Based on the small scale and location of the proposed Project, the geographic scope for the cumulatively affected resources (marine resources and commercial fishing and navigation) encompasses all of Puget Sound. The pilot Project, in combination with other recent, on-going, or proposed activities in Puget Sound that have the potential to cumulatively affect marine resources over the next ten years (the proposed license term for the pilot Project) include the following:

- Commercial fishing,
- Vessel traffic,
- Other proposed tidal energy projects,
- Subsea cables,
- Other industrial/urban development in Puget Sound, and
- Proposed Navy small-scale demonstration tidal energy project off Marrowstone Island (development of which is currently on hold).

3.2.2 Temporal Scope

The temporal scope of analysis in the Environmental Report includes a discussion of the past, present, and future actions and their possible cumulative effects on marine and recreation resources. Based on the term of the proposed license, we look ten years into the future, concentrating on the effect on the resources from reasonably foreseeable future actions. The historical discussion is limited, by necessity, to the amount of available information for each resource.

3.3 Proposed Action

In this section, we discuss the effects of the proposed action on environmental resources. For each resource, we first describe the affected environment, which is the existing condition and baseline against which we measure effects. We then discuss and analyze the specific environmental issues.

3.3.1 Geologic and Soil Resources

3.3.1.1 Affected Environment

Regional Geology

The geology of the Puget Sound area is essentially the result of two processes. The first is the subduction of the Juan de Fuca plate beneath the western margin of the North American Plate. This process has been underway for over 150 million years and is responsible for the volcanic Cascade Mountains, the uplift of the Olympic Mountains, the mountains along western Vancouver Island, and the depression of Georgia Basin and Puget Sound Lowlands. The second process shaping the regional geology was the advance and retreat of glaciers (Fugro 2009).

The Puget Sound Basin lies between the Cascade Volcanic Arc and the Cascadia Subduction Zone. Within this region the Juan de Fuca Plate, a small remnant of the larger subducted Farallon Plate, is being subducted beneath the North American Plate, forming the Puget Lowland to the west, and the Cascade Mountain Range to the East (Finlayson 2006). The faulting of the Cascadia subduction zone causes the region to be prone to both volcanic and seismic activity (Bourgeois and Johnson 2001).

At depths of approximately 120 kilometers beneath the North American Continental Plate, fracture zones in the crust have allowed magma to surface following escaping gases, forming the Cascade volcanic chain (Sound and Sea Technology 2009). Mount Rainier is the dominant site of volcanic activity in the region's recent geologic history (Swanson et al. 1989). Stratigraphic investigations show Quaternary volcanic andesite deposits, tephras, lava flows, and lahars, originating from the now 4,300-meter-high mountain within the past approximately 0.85 million years (Swanson et al. 1989). A number of more-recent volcanic events have occurred during the Holocene era, within the past 10,000 years, since the retreat of the Cordilleran ice sheet from the Fraser Glaciation (Fugro 2009).

The region is characterized by moderate to high seismicity and activity occurs in the region in three different depth zones: (1) subduction zone, where the North American plate and the Juan de Fuca plate make contact; (2) Benioff (deep) zone, where the subducted portions of oceanic plate slip into the upper mantle; and (3) and shallow zone, which occur on faults within the North American continental area (U.S. Geological Survey [USGS] 2006*a*). The Seattle fault is the only crustal fault in the area that has been verified to be recently active, and has been responsible for a number of crustal earthquakes within the past 14,000 years (Johnson et al. 1999). It has not, however, been the source of the 20th-century earthquakes in the Seattle area; the 1949 and 1965 earthquakes originated in the Benioff zone (USGS 2006*b*). The North Whidbey Island and South Whidbey Island faults are currently being studied, but no recent activity has proven them to be currently or recently active. Geologic investigations indicate that seismic events associated with the Seattle fault have caused liquefaction and ground subsidence in the past and that the potential for liquefaction still exists (Johnson et al. 1996).

The Project site is located between two mapped splays of the South Whidbey Island fault zone. Another short fault splay is located southeast of the site and Project toward the steep slope in the northern part of the survey area. This splay is shown on State maps as being older than

15,000 years in age. Consequently, the hazard posed by surface fault rupture within the survey area is considered low (Sound and Sea Technology 2009).

During the Pleistocene Epoch, glaciers frequently covered Puget Sound. The last glacial advance, the Fraser Glaciation, spanned a period of about 10,000 years (USGS 2002). The Fraser Glaciation started about 26,000 years ago, arrived in the region 19,000 years ago, covered the region for several thousand years, and then retreated from the region 16,000 years ago. At its maximum extent the Cordilleran Ice Sheet blanketed Puget Sound and Vancouver Island with over 1.5 kilometers of ice in some areas, covering everything between the Olympic and Cascade Mountains, and extending 300 kilometers south of the Canadian border (James et al. 2006; Fugro 2009).

The advance and retreat of glaciers formed the characteristic glacial landforms of Puget Sound's shoreline and seabed and carved the fjords of the areas rimming the basin, many of which are now above water. During glaciation, the weight of the Cordilleran Ice Sheet depressed the earth's crust; upon retreat of the glacier, the decrease in lithostatic pressure allowed isostatic rebound of the crust and land surfaces rise during the process known as post-glacial rebound. Recent measurements show that the post-glacial rebound has essentially ended, and the Puget Sound area is rising at a rate of less than 1 millimeter per year (James et al. 2006).

Analysis of high-resolution digital elevation models reveals five distinct morphological units that help explain the geologic history of the Puget Lowland and its 1,600-year post-glaciation recovery (Finlayson 2006):

1. The oldest of the morphologic units includes the cores of the Olympic and Cascade Mountains and the Olympic Range's basaltic, Eocene Crescent formation. The peaks of the ranges remained well above the ice sheet and do not include glaciation features shown in the topography of the lower elevations.

2. The second major morphological unit is the surface layers of the lowland fill. Streamlined hills left by the glacier show the distinct east-to-southwest limitations in the topography.

3. The third major morphological unit is associated with the channels of Puget Sound itself. Massive sub-glacial water flows carved the channels of the Sound, resulting in over-deepened basins with shallow sills.

4. The fourth geomorphic unit is associated with modern erosion processes that have reworked the topography since ice retreat. These small-stream delta deposits have accumulated in lobes at the base of steep trough walls from sediment eroded from the coastal bluffs.

5. The fifth geomorphic unit is the Holocene terrace on which the beaches in Puget Sound are formed. This narrow, wave-cut shelf typifies the morphology of Puget Sound beaches, which occupy Holocene benches cut into the sheer walls of the glacially formed marine basins (Finlayson 2006).

During the glacial retreat, the formation and bursting of a massive proglacial lake also contributed to the landscape of Puget Sound. The lake, formed by glacial melt-waters, swelled to 37 meters above the current Sound (James et al. 2006). When the lake drained, it carved a large valley and distributed giant slabs of ice carrying mud, sand, and gravel over most of Puget Sound (James et al. 2006). These deposits, known as a glaciomarine drift, still form an important part of the surficial geology of the Sound, as do the lacustrine sediment deposits from the proglacial lakes themselves (Easterbrook 1999).

The final retreat of the glaciers left behind deeply gouged channels, river valleys, fjords, north-south oriented passages, and bays. Over the past 10,000 years, weathering, fluvial and eolian processes and wave erosion have reworked glacial sediment to form beaches, bluffs, rocky intertidal zones, marshes and tidal flats in Puget Sound (WDOE 2007*a*).

Snowmelt and glacial-melt waters still feed a number of the rivers flowing into the Sound. Fourteen major rivers flow into Puget Sound (Puget Sound Partnership undated). These rivers continue to deposit sediments into the Sound, some of which are remnant glacial tills or drifts from the interior of Washington and British Columbia. The strong daily currents within the Sound distribute these fluvial sediments over large areas of the basin and carry them far beyond the extent of the river deltas (Puget Sound Partnership undated). There are no major rivers on Whidbey Island, and the island serves as a barrier against inflow of two of the primary rivers, Skagit and Snohomish) in the central part of Puget Sound (Sound and Sea Technology 2009). There are no perennial stream outfalls near the Project.

There is high seismic activity along the Pacific and North American Plate boundaries and a history of Pacific-wide tsunamis occurring every 10 to 20 years. In particular, the Washington coast has been largely affected by several Pacific-wide events. The largest known Holocene tsunami event occurred about 1,100 years ago, when the Puget Sound area experienced a large seismic event accompanied by a northward-moving tsunami (Bourgeois and Johnson 2001). Recent research in the Puget Sound region indicated substantial tidal-marsh subsidence followed the seismic event and tsunami. Areas that had been freshwater marsh, and even coastal uplands outside the tidal zone, subsequently sank to become saltwater marsh, or were submerged entirely (USGS 2007). The most recent major tsunami event occurred around the year 1700, and there is still the potential for large seismic events and associated tsunamis to occur today (Bourgeois and Johnson 2001).

Although the west shore of Whidbey Island faces almost directly toward the entrance to the Strait of Juan de Fuca, modeling of tsunami waves entering Puget Sound from the Northeast Pacific Ocean shows that attenuation along the shoreline of the Strait is significant. The greatest risk of a tsunami comes not from a remote earthquake, but from fault movement or mass movement within the Sound (Sound and Sea Technology 2009).

Geologic history indicates that Puget Sound is prone to submarine landslides. Marine slope failures occur when shear stresses acting down-slope exceed the sediment shear strength. Submarine mass-wasting can be triggered by earthquakes, storm waves, extreme tidal excursions, artesian pressures, construction, and vibrations, or may occur somewhat spontaneously under the normal forces of gravity (Finlayson 2006). On the east side of the deepest part of Admiralty Inlet channel, steep areas are present (see Appendix A for bathymetry mosaic). Geologic investigations indicate that seismic events associated with the Seattle fault have caused liquefaction and ground subsidence in the past and that the potential for liquefaction still exists (Johnson et al. 1996). Regionally, some of the deeper unconsolidated deposits pose a liquefaction risk when subjected to significant seismic activity (Crawford et al. 2001). There are known to be small pockets of unconsolidated deposits on Whidbey Island near the Project site (USGS 2006*a*).

Site Specific Geology

Admiralty Inlet represents a separate basin in Puget Sound, consisting of a shallow sill that substantially mixes the water exiting or entering the main basin. The sills at Admiralty Inlet cause a considerable turbulence as water flows to and from the main basin. This turbulence results in extreme mixing at the sill and the surface water leaving the Sound is mixed with the more saline water entering the Sound from the depths. The combination of refluxing and the sill at Admiralty Inlet results in a strong oceanographic division between the basins to the north and south of Admiralty Inlet (Palsson et al. 2009).

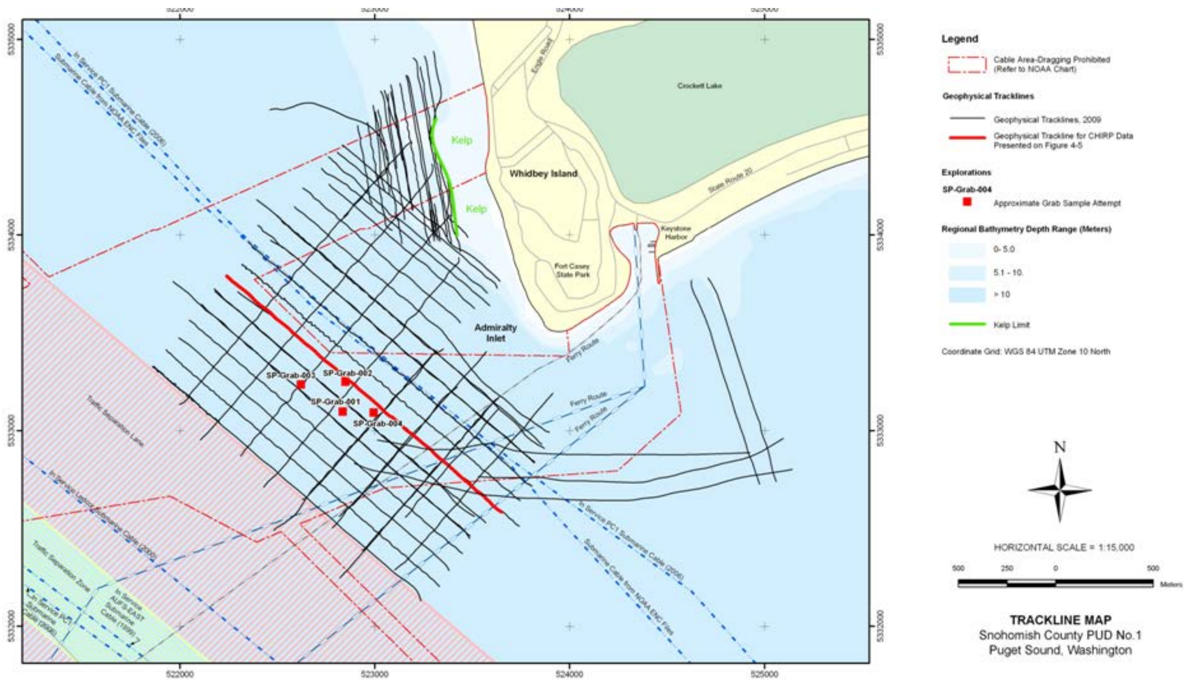
The geology around the Project site is dominated by Fraser-era glacial till, with smaller areas of Fraser-era glacial drift and outwash on Whidbey Island. When the Fraser Glacier receded, Whidbey Island was left with areas of very uneven topography as well as several large, shallow lakes. When the lakes dried up, they left behind boggy areas of very fertile soil. While forests grew over most of the rest of the island, the prairies remained open, supporting grassland communities. The terrestrial area of the Project occurs at a conference center complex belonging to Seattle Pacific University, which is within the Ebey’s Landing National Historic Reservation, just north of Admiralty Head. This area is also called Ebey’s Prairie, which is one of three such prairies located in former lake beds. Its area is a little more than 2 square miles and has an elevation of less than 100 feet (Sound and Sea Technology 2009).

Soils around the Admiralty Inlet site are closely related to the geologic depositions, and consist mostly of loamy-skeletal, fine-mixed, sandy-mixed, and mixed-mesic soils from the glacial till material (WDNR 2000 and 2005). The Ebey’s Prairie topography is reasonably flat and soils in this area of the following (U.S. Department of Agriculture 2009*a* and *b*):

- Coupeville-Ebeys complex - Comprising sand and silt, and to a lesser degree, clay. Resulting from glacial drift over glaciomarine deposits, and Eolian sands over sandy glaciomarine deposits, respectively;
- Sucia loamy sand - Comprising sand, and to a lesser extent, silt and clay. Resulting from glacial drift over dense glaciomarine deposits; and
- Xerorthents-Endoaquents - Comprising very gravelly sand. Resulting from beach sand and colluvium from glacial outwash.

To obtain site-specific data for the marine portion of the Project area, the District performed bathymetric, geophysical, and geological hazard site surveys (reports located in Appendix A). One study was conducted between June 25 and 30, 2009, included high-resolution multi-beam bathymetric, sub-bottom profiling, side-scan sonar, bottom grab, and magnetometer surveys. The surveys were conducted in a grid pattern, and the tracklines from the survey are shown in Figure 3-2. A second seismic reflection survey of the turbine site was conducted and summarized by the District (in a 2011 memorandum *Preliminary Geophysical Interpretation at the Turbine Site* also included in Appendix A).

FIGURE 3-2
GEOPHYSICAL STUDY TRACKLINE MAP



Source: Fugro 2009

The sub-bottom profile data showed little or no subsea penetration. This is because the seafloor is covered in granular materials that diffract the high-frequency energy from the system. Strong currents have apparently removed fine grain sands, silts, and clays from the seafloor, leaving coarse sands, gravels, and boulders (Fugro 2009).

Using a Van Veen grab sampler, four sediment sample locations were attempted near the proposed turbine deployment area (Table 3-1). However, after multiple unsuccessful attempts at three of the sites, the fourth site was abandoned. Because no samples from the seabed were recovered, the side-scan imagery could not be directly ground-truthed in the survey (Fugro 2009), however multiple ROV investigations in the Project area, as described below, support the side-scan imagery data seafloor composition of large rocks, boulders, and cobble.

The seafloor sediments, cobbles, and boulders are believed to be of glacial origin. Glacial moraines and outwash sediments are common in the Puget Sound Area, a product of the recent geologic past. Glacial moraine and outwash deposits commonly include poorly sorted silt, sand, gravel, cobbles, and boulders. As mentioned above, the strong currents in Admiralty Inlet appear to have removed the silt and fine sand, leaving behind coarse sand, gravel, cobbles, and boulders (Fugro 2009).

TABLE 3-1
GRAB SAMPLE LOCATIONS AT THE PROPOSED TURBINE DEPLOYMENT SITE

Sample	Latitude	Longitude	Water Depth (m)	Comment
SnoPUD-Grab-001	48° 09.04’ N	122° 41.58’ W	64	No Recovery (3 attempts)
SnoPUD-Grab-002	48° 09.13’ N	122° 41.57’ W	68	Not Attempted
SnoPUD-Grab-003	48° 09.12’ N	122° 41.75’ W	68	No Recovery (3 attempts)
SnoPUD-Grab-004	48° 09.04’ N	122° 41.45’ W	62	No Recovery (1 attempt)

Source: Fugro 2009

The magnetometer survey conducted along the proposed cable route did not detect any magnetic anomalies along the proposed cable route, indicating that no ship wrecks or other man-made structures are present on the seabed in this area. There are two telecom cables (PC-1 North and PC-1 East) that cross west of the Admiralty Inlet Project deployment area running from northwest to southeast. The Project components, including the subsea cables, will not interfere with or cross the telecom cables en route to shore. The District began an exchange of letters with the owner of the cables, PC Landing Corp., in mid-2011. Those letters, which include comments and information requests from PC Landing Corp. and the District’s responses to those comments and information requests, are included as Attachment 1 to Appendix N. As a result of these discussions, the District undertook several steps to increase the distance between the proposed Project and the PC-1 North and PC-1 East cables, ultimately moving from 26 m to 100 m from the PC-1 North cable.

As part of the pre-installation studies to characterize the Project area, NNMREC conducted ROV investigations and grab samples in the Project area during April and August of 2009. Sampling locations were approximately N 48.152066° W 122.695350° (April 2009) and N 48.149065° W 122.691319° (August 2009) in depths of 55 to 65 meters. Grab samples were conducted using a Shipeck spring-loaded grab sampler. The sampler is capable of collecting up to 20 cm^3 of material, depending on the bottom composition. Out of several grab attempts during slack tide, only one grab returned any samples (Figure 3-3).

FIGURE 3-3
NNMREC GRAB SAMPLES IN THE TURBINE DEPLOYMENT AREA

Source: NNMREC 2009*a*

The video footage from the ROV found no sediment deposition in the turbine deployment areas: the substrate was mostly cobble 6-18 cm in diameter. Examples of still frames from the ROV surveys are shown in Figure 3-4.

FIGURE 3-4
ROV VIDEO IMAGE IN THE TURBINE DEPLOYMENT AREA
APRIL 6, 2009 SURVEY

Source: NNMREC 2009*a*

To further characterize the site-specific benthic habitat and community, ROV surveys in the Project area were conducted in August and late September and early October 2010. As observed in the NNMREC ROV study and the geophysical study described above, the Project area was dominated by coarse grain substrate (Greene 2011). A mixture of cobble-pebble-small boulder substrate type is the most representative substrate of the turbine site, as it represents the largest percentage of grain size combinations (45 percent). The second most representative substrate is cobble-pebble (22 percent). Therefore, these substrates represent over two-thirds of the area investigated by ROV transects (Greene 2011).

Since the filing of the draft license application, the District has moved the shore landing site to east of Admiralty Head. An ROV video survey of the new cable route will be conducted after the FLA is submitted and the results will be shared with stakeholders as soon as possible. Sonar imaging of the region has already been conducted, and is indicative of the same type of seabed conditions that have been previously encountered during surveys of the initial project area.

3.3.1.2 Environmental Effects

The turbines and the majority of the subsea trunk cables will lie on the bottom and will affect the subsea geology and seabed, while the terrestrial components of the Project will affect terrestrial soils. Resource agencies have expressed concern over suspension of contaminated sediments at the turbine deployment site and along the cable route (e.g., letters to the District from NMFS dated July 6, 2009 and December 8, 2008; WDOE dated March 9, 2009; Washington Department of Natural Resources dated March 6, 2009; and Tulalip Tribes dated March 1, 2009). In its letter to the District dated March 6, 2009, the WDNR also expressed concern with how seabed slumping resulting from seismic activity may affect the Project.

As mentioned above, to characterize the seabed in the turbine deployment area and along the cable route, the District performed bathymetric, geophysical, and geological hazard site surveys (Appendix N) and also conducted a desktop study to assist in siting the subsea cable route. The

District used the results of these studies to site the turbines on a fairly flat and featureless area of the seabed and to site the cable route so as to minimize risks of mass movement and traversing the rocky bottom and areas of steep slopes and topographically irregular seafloor that occur in areas between the deployment site and shore.

Stakeholders also raised the potential for hydrodynamic effects from the project as a concern, and requested that the District evaluate the effects. This is discussed in Section 3.3.2, Marine Effects.

Our Analysis

Benthic Effects

The turbine deployment methodology, developed by OpenHydro and discussed above in Section 2.2.2, requires no invasive seabed preparation, multiple operations or drilling, piling or pinning works. Using a specialized deployment barge, the turbine and supporting subsea base can be transported to the site and the entire structure lowered, as one, to the seabed within a single tidal cycle (less than 6 hours). The turbine foundation, placed on top of the seabed, is designed to penetrate the top layer of substrate to aid with stability and prevent any lateral movements of the turbine structures. It is estimated that the foundation legs will penetrate the seabed to a depth no greater than 0.5 meters. Each foundation structure will consist of three legs, with a footprint covering a maximum area of approximately 10 square meters. The impact of the devices on seabed morphology have been assessed to be minor if located in areas that are not designated as being of geological or ecological conservation interest. Given the shallow penetration of gravity base legs and the restricted spatial coverage of the devices, it is anticipated that there will be minimal impact on the rock faces where penetration occurs.

Removal of turbines for maintenance or decommissioning will simply involve use of the deployment barge to lift the entire turbine structure from the water. The District anticipates that this procedure will disturb some localized coarse sediments; however, these would be quickly dispersed from the strong tidal currents in Admiralty Inlet.

The subsea trunk cables will connect the OpenHydro turbines to the electrical grid onshore. The cables will be laid in parallel on the seabed, and starting from a minimum depth of 18 meters to onshore, they will be installed beneath the seabed via a single HDD bore to avoid adverse impacts to sensitive shoreline areas, including eelgrass. The cables sit on the seabed and allow for either of the turbines to be retrieved without disturbing the other in the event of needed maintenance or inspection. The District does not anticipate that the cable laying process will have any significant effects on the seabed.

The HDD process will enable the avoidance of sensitive nearshore areas. It is anticipated that some minimal seabed disturbance will occur, localized to the drill exit area. Any fine sediments surfaced from the drilling process are not expected to increase turbidity, but will quickly disperse with the strong tidal currents in Admiralty Inlet.

As previously described, strong currents cause seafloor erosion, transport, and removal of fine grain sediments, leaving only granular sediments, cobbles, and boulders in the turbine deployment area (Fugro 2009). Figure 3-4 above shows photographs of substrate at the deployment site, showing mostly cobble 6 to 18 centimeters across. Because of the high currents in the area and lack of fine sediment, it is unlikely that there is any risk of contaminated sediments occurring at the project site. In addition, because the turbines and the trunk cables will sit on the seabed (thus, no trenching is required), disruption of the seabed will be minimal.

Bentonite slurry/dredging spoils resulting from HDD will be removed to a holding tank located on shore and removed by vactor truck as needed. Thus, the project deployment poses no risk to disruption of contaminated sediments. This conclusion was reinforced by the WDOE, which stated that “Ecology does not require sediment sampling conducted at where (the) turbines will be deployed at the Admiralty Inlet project area. This determination is based on presence of the sediment and status of the depositional environment at the proposed working areas.” (email dated September 18, 2009 from G. Yang, WDOE, to D. Malkin, HDR).

Although the Project will not increase the potential for geological hazards, there is some evidence of past mass movement in the Project survey area at depths of 30 to 60 meters. Mass movement processes are common both on land and beneath the sea, and include rockfalls, slides, slumps, debris flows, and other forms of transport such as turbidity currents and debris flows. Mass movement is most common on slopes where soft unconsolidated sediments exist, but can also occur in bedrock and stiff soils. Tectonic and glacial oversteepening of slopes, rapid sedimentation, unfavorable bedding relationships, erosion, seismicity, and other factors can facilitate mass movement. Within the geophysical survey area the most susceptible areas to mass movement are considered (1) the steep slopes between 30 and 60 meters water depths, (2) shore bluffs, (3) hyperpycnal or turbidity currents down the axis of the northwest-trending channel, and (4) the nearshore areas subject to intensification of infragravity wave action at low tide (Sound and Sea Technology 2009).

The proposed turbine location is situated on fairly flat and featureless seabed on the shoulder of the west trending ridge near the center of the survey area, at about 58 meters water depth. The essentially flat seabed extends over an area about 100 meters in diameter, and the seabed in the vicinity of the proposed turbine site is fairly uniform. It is therefore expected that the turbine deployment area is not subject to mass movement processes.

Strong currents in Admiralty Inlet have removed fine grained sediments that might also be prone to slope failure. Larger sediments, particularly cobbles and boulders, tend to “lock” together, effectively resisting slope failure. Storm events that might result in rapid runoff of finer sediments from land in streams and rivers are not likely to affect the Project site because there are no watercourses near enough to contribute local sediments (Sound and Sea Technology 2009).

Terrestrial Effects

Terrestrial Project components consist of an approximately 55-meter shore landing cable, a termination vault, an approximately 9-meter back haul cable to the control room, a control room, and an approximately 70-meter back haul cable to the PSE grid. The shore landing, control room, and connection to the PSE grid is all located on private land east of Admiralty Head.

As discussed in Section 2.2.2.1 above, a typical HDD entry site layout measures 37 m by 23 m (120 feet by 75 feet) and a sump pit expected to be less than 1.8 meters (6 feet) deep, no more than 6 meters (20 feet), and with a width of approximately 2.4 meters (8 feet), will be excavated near the entry point. The sump pit allows the recovery of the drilling mud coming from the borehole. The fluid is picked up by a sump pump and transferred to the solids control unit where the solids contained in the drilling fluid are mechanically separated allowing the mud to be re-circulated down hole and used again. The solids are discarded into dumpsters (hoppers) and transported to a local prearranged non-toxic dump site.

Once the trunk cable conduit is placed, the HDD equipment will be removed and only the cable pull and trenching equipment will remain to complete the HDD operations. Demobilization of the HDD operations consists not only of disassembling and removal from the site of all HDD equipment and materials but also site restoration including the following:

- Restoration of site to original grade;
- Replanting and/or new planting of grass, bushes and/or trees as needed;
- Repair of any site structures such as roads, fences, curbs, retaining walls, etc. to equal or better condition if damaged during the installation;
- Removal of any project generated garbage; and
- Removal of any signs of the project such as ruts in the road, excessive dirt, etc.

The total time to deploy, drill, decommission, and restore the grounds is estimated to take 45 days.

the District does not anticipate any significant effects to the terrestrial soils. The Project will introduce only minor and temporary disturbances to soils from installation of the termination vault and control room, trenching the two back haul segments of cable, and HDD process. The District will restore the site to pre-installation conditions, ensuring no long term effects.

3.3.2 Marine Resources

3.3.2.1 Affected Environment

Puget Sound is the second largest estuary in the United States, where salt water from the Pacific Ocean is mixed with fresh water draining from the surrounding watersheds. More than 10,000 rivers and streams drain into Puget Sound (PSAT 2005). The entire drainage basin has been estimated to have more than 33,000 km^2 of land and 8,000 km^2 of marine waters (Gelfenbaum et al. 2006). The average water depth in Puget Sound is 140 meters, with a maximum depth of 285 meters (just north of Seattle) (Fugro 2009). Puget Sound supports a wide range of habitats that are home to thousands of plant and invertebrate species, as well as more than 200 species of fish, 100 species of marine birds, and nine species of marine mammal (Gustafson et al. 2000; Palsson et al. 1997). This section summarizes the existing water resources and marine life (not including ESA-listed species - a detailed discussion of ESA species is located in the draft BA, Appendix G) that inhabit the project area, as follows:

- Wind, Tide and Current Characteristics
- Water Quality

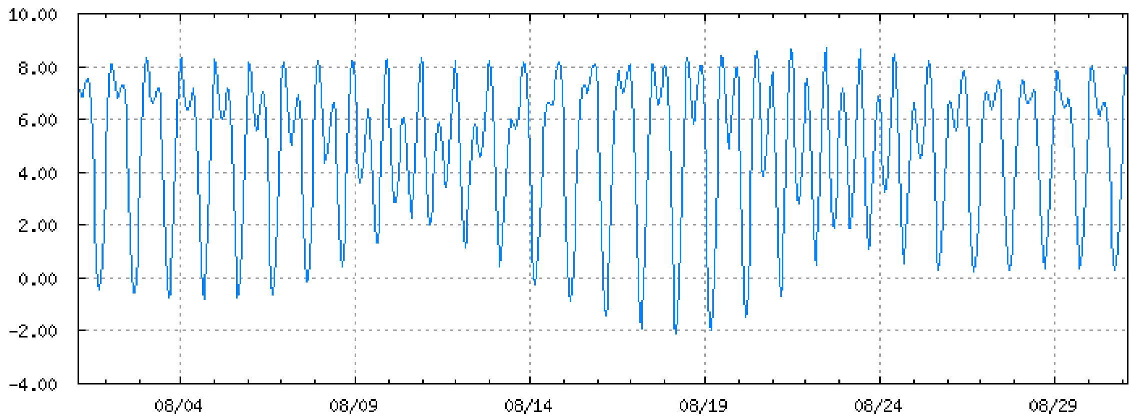
    - Water Quality Standards
    - Water Quality Data
    - Water Discharge Permits
- Marine Vegetation/Algae
- Invertebrates
- Fish
    - Fish Community Overview
        - Anadromous fish
        - Demersal fish
        - Pelagic schooling fish
        - Elasmobranchs (sharks, skates and rays)
    - Site specific sampling results
- Marine Mammals
- Seabirds
- State Special-Status Aquatic Life

Wind, Tide and Current Characteristics

Puget Sound is bordered to the west and east by the Olympic and Cascade mountain ranges, respectively. This topography generally channels winds in a north/south direction, although wind conditions across the Sound can vary depending on local effects. Winds are strongest in the winter and early spring, when sustained winds of 10 to 17 meters per second (20 to 33 knots) from the south are common and gale winds (17.5 to 21 meters per second; 34 to 47 knots) occur. From late spring through early fall, winds are lighter, with speeds of 4 to 7.7 meters per second (8 to 15 knots) in the afternoons (NOAA 2007*a*).

The volume of water between mean high water and mean low water in Puget Sound is equal to 8.1 km^3, about 4.8 percent of the total volume of 168.7 km^3 (Mofjeld and Larsen 1984). Tides in Puget Sound generally follow a semi-diurnal cycle over a 25-hour period, with two high and two low tides that tend to be different in range and timing. The average daily tidal variation is 2.4 meters in northern areas of the Sound and 4.3 meters in southern areas of the Sound; however, geographic variation in the shape and depth of the Sound influences local tidal patterns. In Admiralty Inlet the tidal range is recorded by the NOAA observational station 9444900 located at Port Townsend (48°6.7’N 122°45.4’W) and reaches 3.4 meters (Figure 3-5).

FIGURE 3-5
TIDE HEIGHT AT PORT TOWNSEND NOAA STATION 9444900 (AUGUST 2009)



Source: NOAA 2009*a*. Note: Height in feet, relative to MLLW.

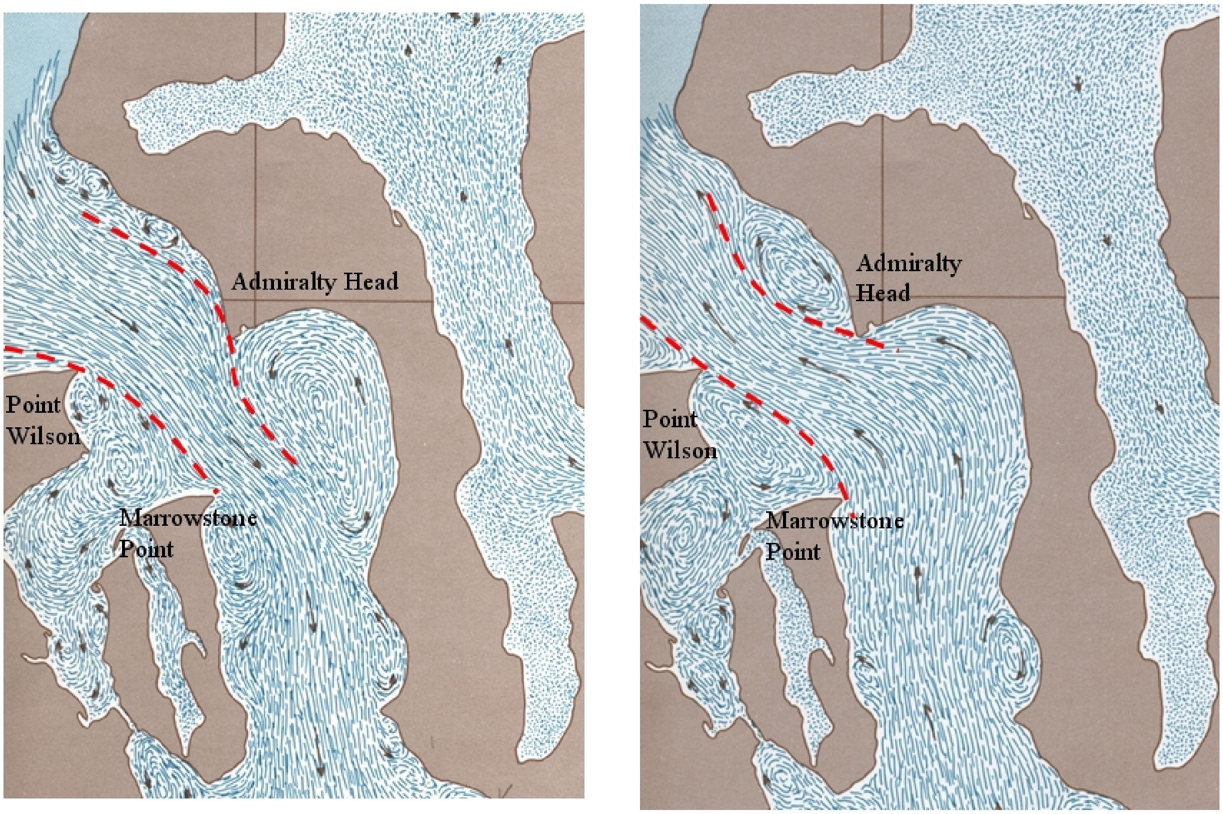
Currents within the Sound are primarily driven by tides and the inputs from surface water sources, although the speed and direction of winds can also be influential. Generally, current velocities in the Sound range from 0.3 to 1.0 meters per second (0.5-2.0 knots), although 1.5 meters per second (3.0 knots) is normal in some regions (Gilmore et al. 1996). Narrow channels tend to have stronger currents due to the restricted flow area.

Admiralty Inlet is the major connection between Puget Sound and the Strait of Juan de Fuca. Some hydrodynamic characteristics of Admiralty Inlet are provided in Table 3-2. Strong currents occur within the site because the relatively narrow and shallow channel reduces the cross-sectional area (213,000 to 317,000 m^2) and regulates flow. Currents in the main portion of the inlet are effectively bi-directional, and velocities of 2.6 meters per second (Polagye et al. 2007) and 2.2 meters per second (NOAA 2007*a*) have been recorded in the Project area. Outside of the deep channel, current velocities decrease because of shallower depths and eddies. Numerous turbulent eddies form on ebb and flood tides (McGary and Lincoln 1977). On flood tide, an eddy forms in the entirety of Admiralty Bay southeast of Admiralty Head, and on ebb tide, eddies form to the northeast of Admiralty Head (McGary and Lincoln 1977) (Figure 3-6).

TABLE 3-2
ADMIRALTY INLET SITE PARAMETERS (POLAGYE ET AL. 2007)

Site	Measurement
Channel Width (m)	3,240
Average Depth (m, MLLW reference)	64
Deepest Point (m)	81
Average Cross-sectional Area (m^2)	213,000
Maximum Surface Current (m/s)	2.6

FIGURE 3-6
FLOOD AND EBB EDDIES IN NORTHERN ADMIRALTY INLET*



Flood Tide   Ebb Tide

*The low eddy region on ebb and flood are bounded by dashed red lines.
Source: McGary and Lincoln 1977

To characterize the tidal resource at the Project site, NNMREC conducted stationary and mobile ADCP surveys in the Project area. NNMREC deployed stationary ADCPs on several Sea Spiders at the site beginning on April 9, 2009 and has recovered data on many occasions since. The stationary ADCPs have been deployed on the seabed at the most probable location for turbine deployment. The Sea Spiders also included additional equipment collecting data on water quality, underwater noise, marine mammal vocalizations, and acoustic tagged fish. The metrics to characterize the tidal resource in Admiralty Inlet included: maximum and mean water velocity, eddy intensity, rate of turbulent kinetic energy dissipation, vertical shear, directionality, ebb and flood asymmetry, and vertical profile.

The mean, depth-averaged, water velocity is plotted in Figure 3-7 for a fortnightly period, which is the dominant periodicity for tidal currents. The mean, depth-averaged velocity at the turbine deployment sites is 1.2 m/s. The maximum sustained (at least 5 minutes) water velocity was 3.4 m/s at a depth of 10 meters (turbine hub height) (Personal communication, Brian Polagye, NNMREC, February, 2012). Based on analysis presented in Polagye and Thomson (2012), this is likely within 15% of the maximum harmonic velocity at this location. Figure 3-8 shows the velocity and power density histograms based on 90 day ADCP deployments at the two turbine locations.

FIGURE 3-7
REPRESENTATIVE DEPTH-AVERAGED VELOCITY PLOT FROM STATIONARY ADCP MEASUREMENTS IN THE PROJECT AREA

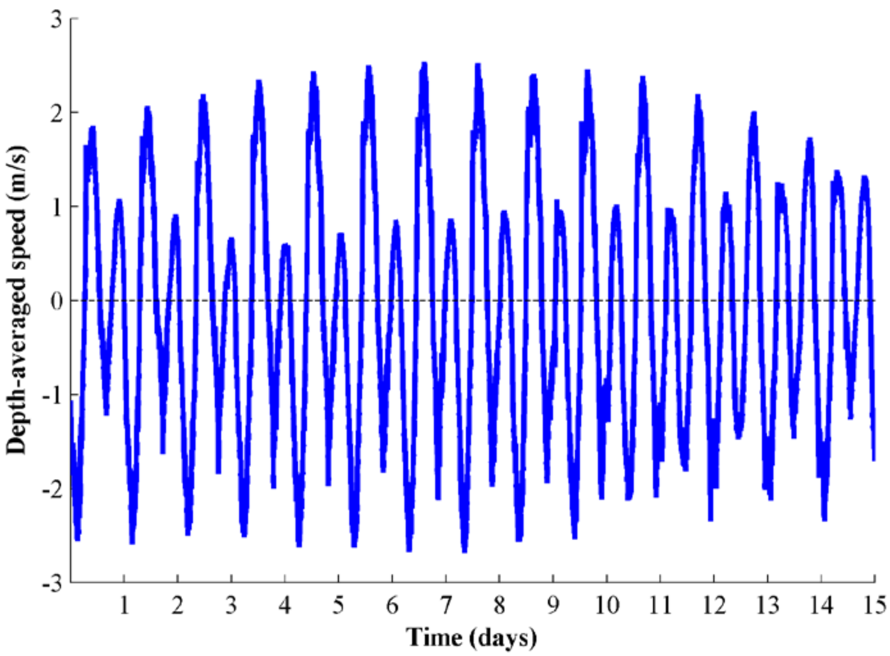
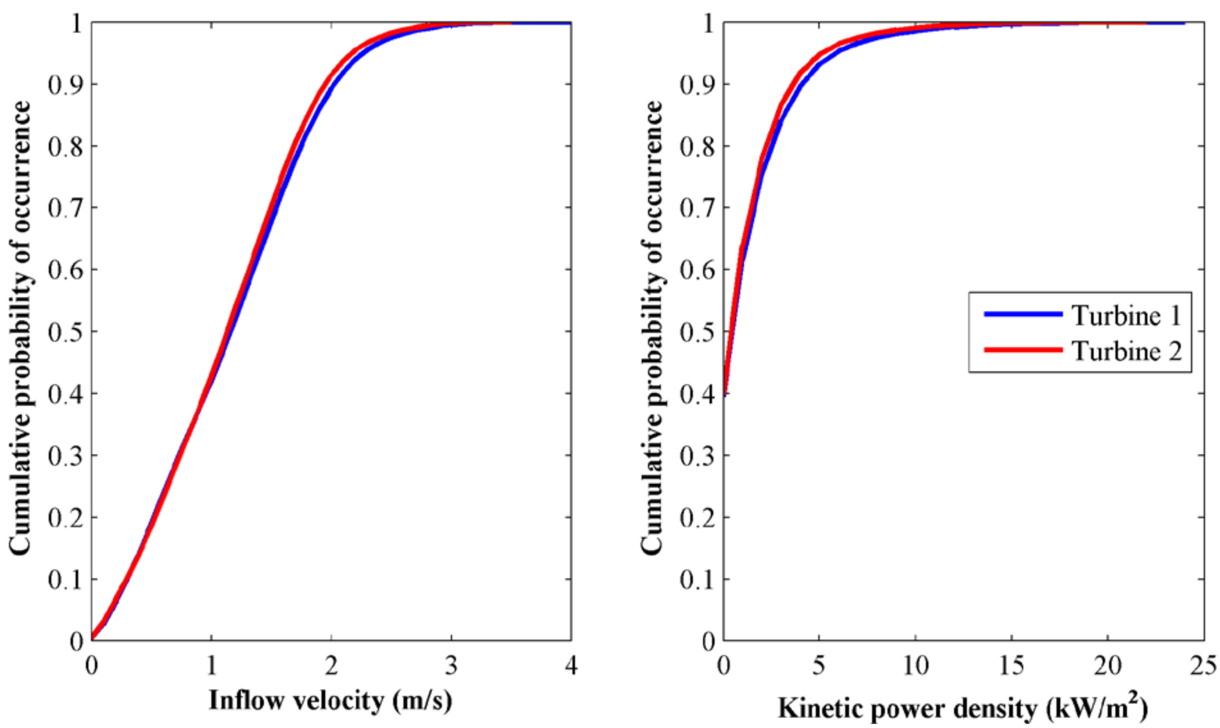


FIGURE 3-8
TIDAL VELOCITY AND POWER DENSITY CUMULATIVE PROBABILITY DISTRIBUTIONS FROM STATIONARY ADCP SURVEYS AT TURBINE DEPLOYMENT SITES



Source: Personal communication, Brian Polagye, NNMREC, February, 2012.
Note: Distributions based on Doppler profiler deployments from August – November 2011.

A histogram of the expected water velocity, turbine power generation, and turbine seasonal operation is presented in Figure 4-1 and Figure 4-2.

Water Quality

The U.S. Environmental Protection Agency (EPA) designated Puget Sound as an Estuary of National Significance in 1988. There are indications that the increase in human disturbance in the Puget Sound area threatens the health of the Sound. These indicators include the loss or impairment of habitat, historic and current toxic contamination of sediment and organisms, and diminished populations of certain species. In response to these concerns, a number of governmental programs have been established related to restoring the water quality of Puget Sound. The EPA’s Region 10 cooperates with the Canadian government on the Puget Sound Georgia Basin Ecosystem Project, which monitors certain key indicators, including transboundary air quality, and organizes an annual conference to share information on progress and emerging challenges. The USGS maintains a Puget Sound Basin study unit under the National Water-Quality Assessment (NAWQA) Program, which collects and analyzes surface-and ground-water quality data. In 2007, the state of Washington established the Puget Sound Partnership to direct long-term efforts to protect and restore the Sound (PSAT 2007*b*).

Water Quality Standards

WDOE is responsible for developing water quality standards for the State of Washington. In 2003 the WDOE completed a significant revision of these standards, although aspects related to temperature criteria were not approved by the EPA at that time. Revised rules were implemented in December 2006 that addressed the issues identified by the EPA.

The Washington water quality standards establish an existing or designated use for every body of water in the state. Each use has its own set of associated criteria that are designed to ensure that all waterbodies are used as intended. Table 3-3 presents the designated uses for waters within the Project area. “Aquatic Life Uses” refers to the character and integrity of fish migration, rearing, and spawning; clam, oyster, mussel, and other shellfish rearing and spawning; and crustacean rearing and spawning. “Shellfish Harvest” is related to whether harvesting for shellfish is expected. The Project site is designated as an area of primary contact recreation, where activities potentially involve total body immersion and/or incidental water exposure. Such activities include but are not limited to swimming, canoeing, kayaking, and SCUBA diving. Other uses include fishing (both for salmonids and other species), shellfish harvesting, commerce and navigation, boating, the viewing of aesthetic features such as landscapes, and the provision of wildlife habitat (additional information is located in Section 3.3.5, Recreation, Ocean Use, and Land Use).

TABLE 3-3
USE DESIGNATIONS FOR ADMIRALTY INLET

Use	Designation
Aquatic Life Uses	Extraordinary
Shellfish Harvest	✓
Recreational Uses	
• Primary Contact	✓
• Secondary Contact	
Other Uses	
• Wildlife Habitat	✓
• Harvesting	✓
• Commercial/Navigation	✓
• Boating	✓
• Aesthetics	✓

Source: Chapter 173-201A-612 WAC

The State of Washington has established water quality criteria for each of the designated uses. Table 3-4 outlines the requirements for the two “aquatic life” categories found within the Project area. To protect shellfish harvesting and primary contact recreational activities, fecal coliform organism levels must not exceed a geometric mean value of 14 colonies per 100 milliliters (mL), and not have more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 43 colonies per 100 meters (WAC 173-201A-210). Aesthetic qualities must not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste. In addition, established limits have been set on the discharge of toxic, radioactive, and other contamination in order to protect water uses, biota, and the public health.

TABLE 3-4
CRITERIA FOR AQUATIC LIFE USES

Description	Extraordinary Quality	Excellent Quality
Aquatic Life Temperature: 1-day maximum temperature due to human activities	13°C (55.4°F)	16°C (60.8°F)
Aquatic Life Dissolved Oxygen Criteria: lowest 1-day minimum	7.0 mg/L	6.0 mg/L
Aquatic Life Turbidity Criteria	Turbidity must not exceed: • 5 NTU over background when the background is 50 NTU or less; or • A 10 percent increase in turbidity when the background turbidity is more than 50 NTU.	Turbidity must not exceed: • 5 NTU over background when the background is 50 NTU or less; or • A 10 percent increase in turbidity when the background turbidity is more than 50 NTU
Aquatic Life pH Criteria	pH must be within the range of 7.0 to 8.5 with a human-caused variation within the above range of less than 0.2 units.	pH must be within the range of 7.0 to 8.5 with a human-caused variation within the above range of less than 0.5 units.

Source: WAC 173-201A-210

Water Quality Data

Within Puget Sound and the Strait of Juan de Fuca, a large-scale and long-term water quality monitoring program is administered by WDOE. Employing more than 40 fixed-station and rotational sites, sampled monthly, and several permanent moorings, the WDOE's program is part of a larger, inter-agency environmental protection campaign - PSAMP (Puget Sound Ambient Monitoring Program) - designed to measure background conditions within Puget Sound and to assess the extent of environmental perturbation that may result from human activity (WDOE 1992). PSAMP has provided essential science for conservation, recovery, and management of the Puget Sound Ecosystem since 1989. PSAMP is one of the nation's longest-running marine monitoring programs.

Approximately every two years, the PSAMP releases a report entitled the Puget Sound Update, which summarizes the findings of research and monitoring efforts. The latest Update (PSAT 2007*a*) included the following key findings related to water quality in Puget Sound:

- Overall dissolved oxygen concentrations in Puget Sound appear to be continuing a downward trend.
- Analysis of sediment samples collected from 1997 to 2003 indicate that approximately 1 percent of Puget Sound sediments are highly degraded, 31 percent are of intermediate

quality, and 68 percent are of high quality. The 1 percent of highly degraded sediments is located primarily in urban bays.

- Chinook salmon sampled from Puget Sound in 2005 had three to five times the polycholorinated biphenyl (PCB) levels of Chinook from Alaska, British Columbia, and Oregon.
- Flame retardants or polybrominated diphenyl ethers (PBDE) occurred in 16 percent of the samples from 10 Puget Sound sampling sites in 2005. Scientists estimate that PBDE levels are doubling every four years in marine mammals, including harbor seals and killer whales, and will surpass PCB levels in these species by 2020.
- Pre-spawn mortality occurred in 25 to 90 percent of female coho salmon returning to urban streams between 2002 and 2005, suggesting that contaminants from stormwater were posing a threat.
- The most recent water quality assessment lists 76 water bodies in Puget Sound with fecal coliform problems, although data suggests that there has been an overall decline in this contaminant from 2001 to 2005.
- Twenty percent of the 428 recreational beaches in 12 Puget Sound counties are threatened by fecal pollution, while 5 percent of these beaches are closed because of biotoxins.
- In 2003, a short-lived pseudo-nitzschia bloom occurred near Port Townsend and in 2005 blooms occurred in four northern Puget Sound locations (Sequim Bay, Port Townsend, Holmes Harbor, and Penn Cove). All four areas were closed to shellfish harvest.

Concurrent with the release of the update document, the Puget Sound Action Team produces a State of the Sound report. This study traces more than two dozen environmental indicators, providing a rating on both their current condition on a scale from one to five, with one being the worst, and their overall trend (positive or negative). The findings related to water quality, including the condition rating, in the most recent report (PSAT 2007*b*) are as follows:

- Marine water quality (rating = 2, negative trend): Out of 39 monitoring sites, eight were rated as highest concern and ten were rated as high concern.
- Marine and fresh water health (rating = 2, negative trend): In 2004, approximately 1,474 fresh and marine water bodies in the Puget Sound Basin were deemed to be "impaired." Fifty-nine percent were found to be impaired as a result of toxic contamination, pathogens, low dissolved oxygen, or high temperatures.
- Toxics in sediments (rating = 2, no trend): In a study of 2,360 km^2 of submerged lands, about 1 percent were found to have high levels of toxic contaminants while another 31 percent were moderately contaminated.
- Toxics in Chinook and coho salmon (rating = 2, negative trend): PCB levels in salmon are remaining stable but rising PBDE levels in seals suggest that PBDE levels in salmon are also increasing.
- Toxics in mussels (rating = 2, positive trend): Mussel Watch data collected from 1984 shows that Puget Sound mussels exceed national averages for PAHs, i.e., polyaromatic hydrocarbons (100 - 1,000 percent), PCBs (60 percent) and mercury (20 percent). There have been declines in the levels of PCB and PAH concentrations reported.
- Toxics in harbor seals (rating = 2, negative trend): Harbor seal pups in south Puget Sound are seven times more contaminated with PCBs than those in Georgia Basin. Over the last twenty years PBDE levels have risen from less than 50 parts per billion in fatty tissue to more than 1,000 parts per billion in harbor seals within south Puget Sound.

- Liver disease in English sole (rating = 2, no trend): While there is an increased risk of developing liver disease in parts of the Sound, overall there has been a general decrease.
- Safe swimming beaches (rating = 4, no trend): During the summer of 2005, 24 of 65 Puget Sound beaches violated water quality standards for bacteria, a 12 percent decrease from 2004.
- Safe, edible shellfish (rating = 3, no trend): Between 1995 and 2005, improved water quality reduced harvest restrictions on 51.1 km^2, while 21.1 km^2 were downgraded due to pollution and a high number of areas were classified as “threatened.”

The report concluded that, while there were positive signs, the overall trend was one of decline. The primary threat was determined to be the pace of growth, which resulted in more impervious surfaces with increased urban runoff, loss of habitat, and the introduction of contaminants in the air and water (PSAT 2007*b*).

Of particular relevance to the Project are three sampling sites and one permanent mooring located in the vicinity of Admiralty Inlet: the Admiralty Inlet inner site - ADM001 (water body ID#: 48122A6D1), Admiralty Inlet outer site - ADM002 (water body ID#: 48122B8I4), and Port Townsend site - PTH005 (water body ID#: 48122A7I6), and NOAA’s Port Townsend nearshore mooring - PTOWN (mooring ID#: 9444900). Parameters monitored include profiles of temperature, salinity, density, dissolved oxygen, light transmission, pH, as well as discrete samples at various depths for fecal coliform bacteria, chlorophyll *a*, phaeopigment, nitrate, nitrite, ammonium, orthophosphate, silicate, and Secchi disk depth. Generally samples were taken at depths of 0, 10, and 30 meters. The WDOE provides public access to data collected from 1990 to the present on their website.

Admiralty Inlet inner site (ADM001) is located to the west of Bush Point, in the southcentral portion of the channel. The observed pattern of stratification or layering of waters due to density was classified as moderate-infrequent. DO levels are generally higher than those reported at the outside of Admiralty Inlet (ADM002), which is due to the mixing and aeration that occurs as water flows over the sill at the entrance to the Inlet (WDOE 2007*b*).

At the Port Townsend station (PTH005), the observed pattern of stratification or layering of waters due to density was classified as moderate-infrequent. Low levels of dissolved oxygen (< 5 mg/L) have been reported at this site, generally at depths of 6.0 meters or deeper. This area commonly upwells deep anaerobic waters to the surface lowering dissolved oxygen levels. Shallow euphotic zones, most likely due to algal blooms, have been reported at this site from late spring through early fall (City of Port Townsend 2007).

The University of Washington PRISM[7] program has maintained conductivity-temperature-depth (CTD) profiling stations throughout Puget Sound. Station P20 is located near Admiralty Head, at 48°05.5188’N 122°41.0904’W. Processed CTD profile data are available for June and December 1998, June, August, and December 1999, June and December 2000, June and November 2001, June 2002, and June and December 2003 (Pers. comm. J. Thomson, University of Washington NNMREC July 17, 2009). A summary of these data are provided in Table 3-5.

---

[7] PRISM is an acronym for the Puget Sound Regional Synthesis Model.

TABLE 3-5
WATER QUALITY DATA FROM PRISM P20 STATION

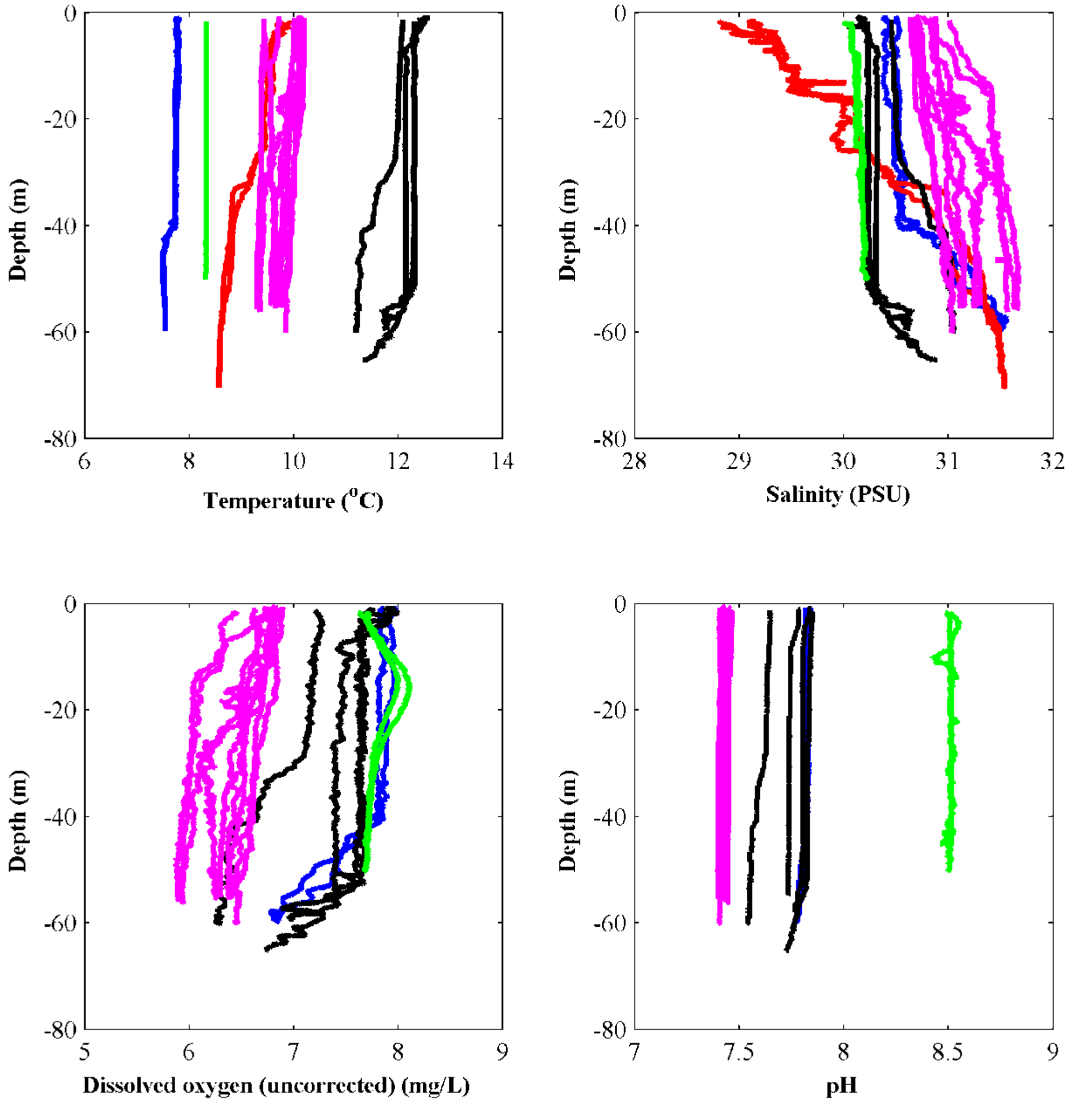
	June	July	August	November	December
Depth Range (m)	41.1 - 88.7	48.1	43.1 - 47.1	41.1	28.3 - 65.4
Temperature (°C.)	n=8	n=1	n=2	n=1	n=6
Surface Range	9.80 - 11.32	12.53	10.94 - 11.62	9.44	8.73 - 9.31
Bottom Range	8.85 - 10.89	10.78	10.48 - 10.76	9.36	8.50 - 9.32
Salinity (PSU)	n=8	n=1	n=2	n=1	n=6
Surface Range	29.71 - 31.07	30.05	29.71 - 30.71	31.33	29.09 - 30.70
Bottom Range	30.35 - 31.43	31.1	30.35 - 31.08	31.41	29.76 - 31.67
Dissolved Oxygen (mg/L)	n=8	n=1	n=1	n=1	n=5
Surface Range	6.79 - 8.11	7.43	6.76	4.32	6.51 - 8.40
Bottom Range	5.56 - 7.32	6.24	5.89	6.45	6.13 - 8.12
Fluorescence (mg/m^3)	n=8	n=1	n=2	n=1	n=6
Surface Range	0.15 - 5.78	0.84	5.11 - 7.84	0.59	0.12 - 1.35
Bottom Range	0.09 - 5.01	1.39	4.17 - 8.37	0.6	0.07 - 1.40
Backscatter (NTU)	n=1	n=0	n=0	n=1	n=0
Surface Range	6.04	NaN	NaN	10.5	NaN
Bottom Range	7.12	NaN	NaN	10.51	NaN

Source: Pers. comm. J. Thomson, University of Washington NNMREC July 17, 2009. Data collected in June and December 1998, June, August, and December 1999, June and December 2000, June and November 2001, June 2002, and June and December 2003.

A low level of dissolved oxygen (< 5 mg/L) was measured in November 2001 at the surface (Table 3-5). As discussed above, Admiralty Inlet represents an area of upwelling and mixing that brings deep anaerobic water to the surface lowering dissolved oxygen levels (City of Port Townsend 2007).

During 2009 and 2010, NNMREC researchers assessed water quality in the Project area through shipboard surveys (April, May, August, and November 2009 and February 2010). Seabed instrumentation packages were deployed at particular locations on the seabed from April-May, May-August, and August-November 2009 and November-February 2010 (Polagye and Thomson 2010). Figure 3-9 shows the vertical profiles for temperature, salinity, dissolved oxygen, and pH collected during the shipboard surveys. Profiles indicate both cast-to-cast and seasonal variability. As expected, the degree of stratification depends on the season, with casts from April and May considerably more stratified than casts from November and February. Seasonal patterns in temperature and salinity are representative of typical estuarine circulation and show the effects of varying levels of freshwater input to the system and solar radiation; water is less salty and warmer in the summer than in the late spring and fall (Polagye and Thomson 2010).

FIGURE 3-9
NNMREC WATER QUALITY CAST DATA



Blue: April 2009; red: May 2009; black: August 2009; magenta: November 2009; green: February 2010.
Source: Polagye and Thomson 2010

Analysis of water quality samples obtained at specific depths during cruises in April, August, November, and February are presented in Table 3-6. Each survey consists of a pair of casts made in rapid succession. Results indicate very low turbidity during all measurements. Biological productivity is higher in the summer than in the spring, with higher chlorophyll levels and depleted nutrients in August (Polagye and Thomson 2010). This information has been collected in continued partnership with the Washington Department of Ecology.

TABLE 3-6
WATER QUALITY SAMPLE RESULTS (MEAN VALUES)

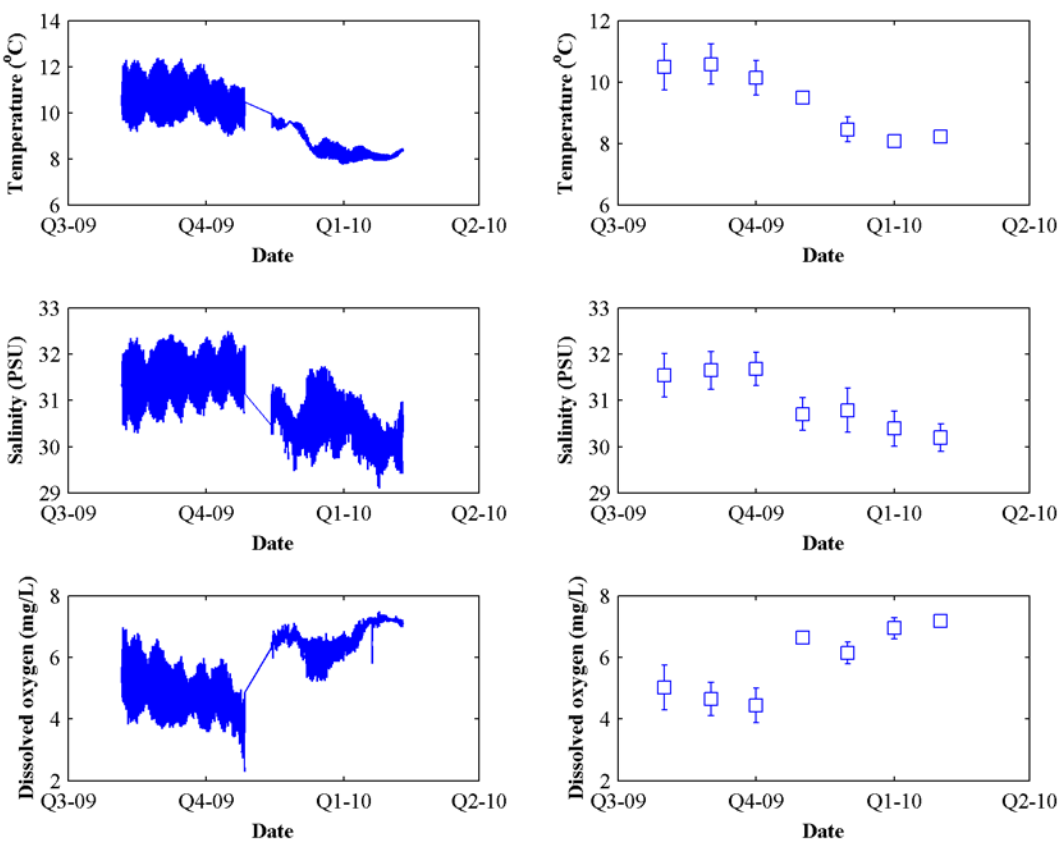
Survey		April	August	November	February
Date		4/7/09	8/3/09	11/11/09	2/9/10
Casts		2	2	2	2
Salinity (PSU)	Seabed	31.5	30.7	31.0	30.2
	-30m	30.7	30.2	30.9	30.2
	-10m	30.5	30.2	30.7	30.1
	Surface	30.4	30.2	30.7	30.1
Dissolved Oxygen (mg/L)	Seabed	5.2	7.0	6.9	10.9
	-30m	6.0	7.9	6.8	9.7
	-10m	5.9	7.9	6.7	8.5
	Surface	6.1	8.1	6.7	8.3
Chlorophyll (μg/L)	Seabed	0.4	4.3	0.4	0.2
	-30m	0.6	1.5	0.4	0.2
	-10m	0.6	1.7	0.4	0.2
	Surface	0.6	1.8	0.4	0.2
Turbidity (NTU)	Seabed	0.9	0.3	0.5	0.8
	-30m	0.7	0.3	0.5	1.7
	-10m	0.5	0.2	0.5	1.0
	Surface	0.6	0.3	0.5	1.1
Total Nitrogen (μM)	Seabed	46.7	28.9	39.2	36.7
	-30m	48.5	31.4	40.1	36.5
	-10m	46.7	26.3	38.1	35.2
	Surface	46.9	26.6	37.7	36.9
Total Phosphorous (μM)	Seabed	2.7	2.3	2.8	2.5
	-30m	2.7	2.4	2.8	2.4
	-10m	2.8	2.2	2.8	2.4
	Surface	2.7	2.2	2.8	2.4
[PO_4] (μM)	Seabed	2.3	2.0	2.6	2.2
	-30m	2.3	1.9	2.6	2.2
	-10m	2.3	1.8	2.6	2.2
	Surface	2.3	1.8	2.6	2.2
[$Si(OH)_4$] (μM)	Seabed	48.2	33.9	52.9	45.6
	-30m	50.4	26.6	53.2	45.8
	-10m	51.7	26.7	53.6	57.9
	Surface	52.2	25.7	53.7	58.0
[NO_3] (μM)	Seabed	26.9	18.2	27.6	26.1
	-30m	26.1	14.8	27.5	25.8
	-10m	26.2	14.8	27.3	26.1
	Surface	26.2	14.1	27.3	26.2
[NO_2] (μM)	Seabed	0.3	0.4	0.4	0.1

Survey		April	August	November	February
	-30m	0.4	0.4	0.4	0.1
	-10m	0.4	0.4	0.4	0.1
	Surface	0.4	0.4	0.4	0.1
$[NH_4]$ (μM)	Seabed	0.5	1.2	0.3	0.1
	-30m	0.6	1.2	0.2	0.6
	-10m	0.6	1.2	0.1	0.3
	Surface	0.5	1.1	0.1	0.4

Source: Polagye and Thomson 2010

Stationary water quality measurements were taken near the seabed by NNMREC (April 2009 - February 2010) and Department of Ecology (August 2009 - February 2010). NNMREC monitoring showed that from April to November, the mean temperature at instrument depth varied from 8-10º C, with inter-tidal variability reaching a maximum from mid-July through early September and a minimum during December. The Department of Ecology results (Figure 3-10) demonstrate that temperature, salinity, and dissolved oxygen all vary considerably with stage of the tide and season (Polagye and Thomson 2010).

FIGURE 3-10
BOTTOM MOUNTED WATER QUALITY MEASUREMENTS



Left: 15 minute intervals. Right: monthly averages with one standard deviation. Dissolved oxygen values are uncorrected and should be considered preliminary.
Source: Polagye and Thomson 2010

Water Discharge Permits

The WDOE is delegated by the EPA as the state water pollution control agency, responsible for implementing all federal and state water pollution control laws and regulations. Wastewater discharge is regulated primarily by National Pollutant Discharge Elimination System (NPDES) permits, which stipulate specific limits and conditions of allowable discharge. A wastewater discharge permit is required for disposal of waste material into “waters of the state,” which include rivers, lakes, streams, and all underground waters and aquifers. A wastewater discharge permit is also required for certain industrial users that discharge industrial waste into sanitary sewer systems (WDOE 2004).

The following is a listing and description of facilities within the northern half of Admiralty Inlet that are regulated by the WDOE[8]:

- Fleet Marine Inc., Port Townsend (NPDES Permit WAG031003): This facility provides marine services including boat repair, long-term boat storage, working-boat storage, and boat haul-out. Readily available state and EPA records do not provide any information about the permit limitations for this facility, although the EPA database suggests it is related to excavation work.

- Port Townsend Port Washington (State Permit WAG031006): This facility provides boat repair and maintenance services. The general permit allows for wastewater discharges from an industrial facility, although readily available state records do not provide any information about the permit limitations for this facility.

- Port Townsend Shipwrights (State Permit WAG031004): This facility provides boat repair and maintenance services. The general permit allows for wastewater discharges from an industrial facility, although readily available state records do not provide any information about the permit limitations for this facility.

- Port Townsend Foundry (State Permit WAG031002): This facility provides boat repair and maintenance services. The general permit allows for wastewater discharges from an industrial facility, although readily available state records do not provide any information about the permit limitations for this facility.

- Grant Seran, Port Townsend (State Permit WAG031041): This facility provides boat repair and maintenance services. The general permit allows for wastewater discharges from an industrial facility, although readily available state records do not provide any information about the permit limitations for this facility.

- New Day Fisheries Inc., Port Townsend (NPDES Permit WA0042048): The facility is a processor of seafood (primarily shrimp, crab, and salmon) located on a site leased from Port

[8] The location of the facilities was determined using databases made publicly available on the WDOE’s Geographic Information System website (www.ecy.wa.gov/services/gis) and EPA’s EnvironMapper application for the Envirofacts database (www.epa.gov/enviro/emef).

Townsend. While historically this facility discharged its waste to the local sewage treatment plant, it now discharges its effluent at least 0.8 km offshore using a vessel. The current permit for the facility includes limitations on biochemical oxygen demand (BOD), total suspended solids (TSS), pH, fecal coliform bacteria, and total residual chlorine.

- Fort Flagler State Park STP, Marrowstone Island (State Permit WA0037282): This facility has a water discharge permit to discharge to a minor municipal facility. Readily available state records do not provide any information about the permit limitations for this facility.

- WPNSTA Seal Beach Detachment Port Hadlock, Indian Island (NPDES Permit WA0021997): This facility is licensed as a sewage-treatment facility. The current permit for the facility includes limitations on five-day biochemical oxygen demand (BOD5), TSS, pH, and fecal coliform bacteria.

- Island County PW Lagoon Point Pit, Whidbey Island (State Permit WAG503011): This facility has a general water discharge permit. Readily available state records do not provide any information about the permit limitations for this facility, although the WDOE database suggests it is related to discharges from a sand and gravel operation.

- Rempel Bros Concrete Greenbank Inc., Whidbey Island (State Permit WAG503224): This facility has a general water discharge permit. Readily available state records do not provide any information about the permit limitations for this facility, although the WDOE database suggests it is related to discharges from a gravel operation.

- Marrowstone Field Station (NPDES Permit WA0025879): This facility is a field station for the Western Fisheries Research Center, which conducts research and provides technical assistance related to fish health, fish, ecology, and aquatic systems. Readily available state and EPA records do not provide any information about the permit limitations for this facility, although the EPA database suggests it is related to discharges from fish hatchery and preserve activities.

- Port Townsend Paper (NPDES Permit WA0000922): This facility produces pulp and paper for mills, converters, and retailers. The current permit for the facility includes limitations on temperature, five-day biochemical oxygen demand (BOD5), pH, TSS, fecal coliform bacteria, and total residual chlorine.

Marine Vegetation/Algae

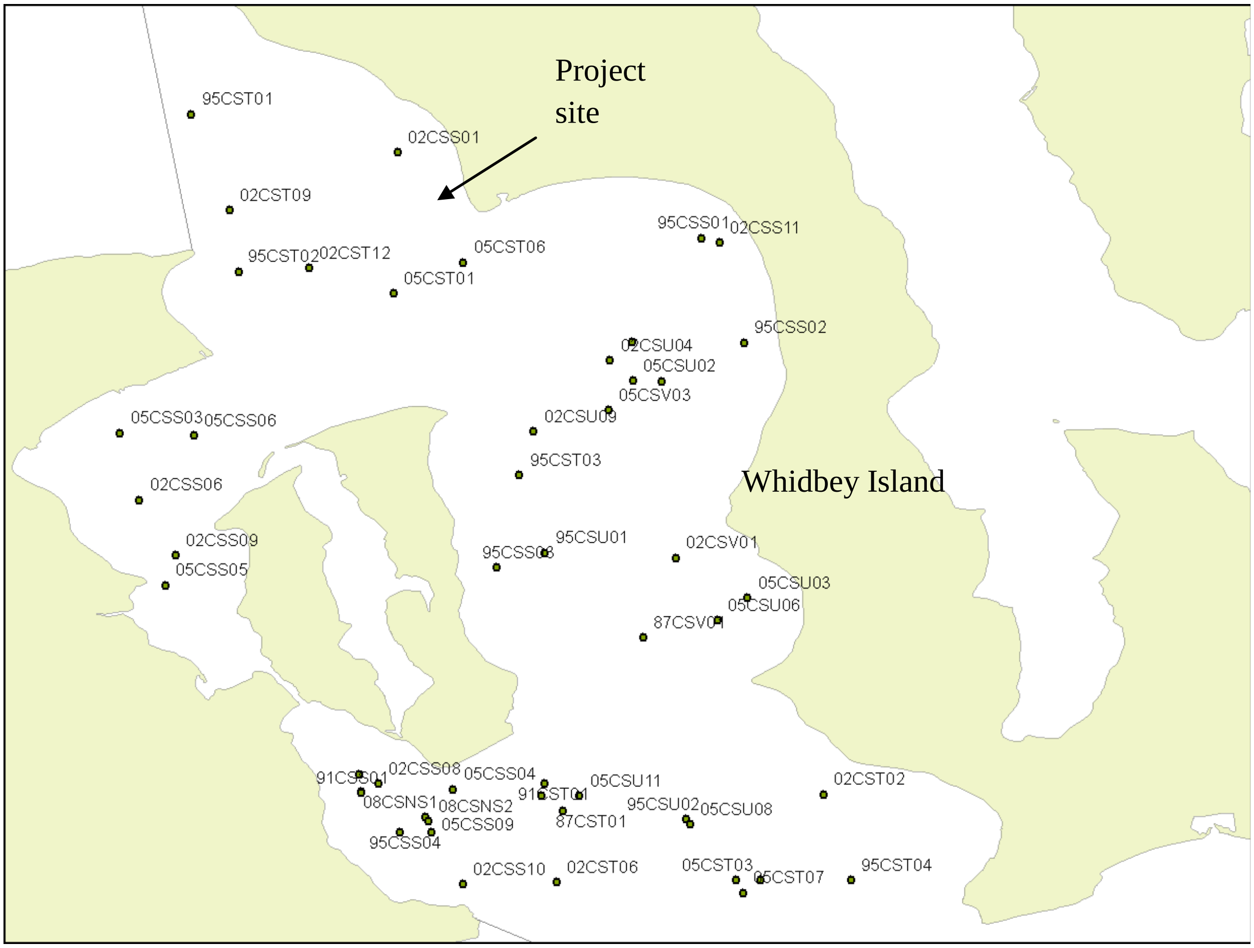
Marine macroalgae occur throughout Puget Sound, from above the high water mark where they are only occasionally wetted by the splash of waves, in tide pools, throughout the shallow sub-tidal zone, and when the clarity of the water column permits, to depths of more than 60 meters (Guiry 2007; Kozloff 1993). Although some species, such as *Sargassum* spp., can survive unattached to the seafloor as fully planktonic organisms, seaweeds are generally sessile and typically associated with rocks, hard-bottom and larger-grained unconsolidated substrates as well as man-made structures (DON 2006; Guiry 2007; Williams et al. 2003). Within Puget Sound, marine macroalgae of the supra-littoral fringe (greater than approximately 2 meters above MLLW) are dominated by the green algae genus *Prasiola* (Kozloff 1993). However, below this level, within the inter-tidal and sub-tidal zones, a diverse range of seaweeds are present in abundance. Kelp forests typically posses a canopy composed of two species, bull kelp (*Nereocystis luetkeana*), which is dominant in exposed regions, and giant kelp (*Macrocystsis pyrifera*) which is more prevalent in sheltered lower energy environments; an understory formed by several species, including walking kelp (*Pterygophora californica*), winged kelp (*Alaria marginata*), laminariales (*Laminaria saccharina* and *L. setchellii*), and feather boa kelp (*Egregia menziesii*); a turf layer consisting of filamentous and thallose red algae; and a crustose layer made up of encrusting (*Lithophyllum* spp.) and articulated corallines (e.g., *Calliarthron* spp. and *Bossiella* spp.) algae (Airamé et al., 2003; DON 2006; Kozloff 1993; Proctor et al. 1980; Williams et al. 2003).

Both kelp and eelgrass organisms need fairly high light levels to grow and reproduce. They are typically found only in shallow waters, mostly less than 20 meters for kelp, and 10 meters for eelgrass (Mumford 2007). Canopy-forming kelp are found in Admiralty Inlet, along both shores of the northwest entrance, and patches of stand-alone understory kelp are spread throughout the remainder of the Admiralty Inlet along both shores as well as around Indian Island (DON 2006; WDNR 2007; City of Port Townsend 2007). The dominant species of eelgrass is *Zostera marina*. Eelgrass beds are found in narrow strips along the northeast shore of Admiralty Inlet (DON 2006), but not at the Project site.

Invertebrates

WDFW conducts bottom trawl surveys in Puget Sound, including Admiralty Inlet, in support of population assessments. Figure 3-11 shows the location of 50 trawl locations that have occurred from 1987 to 2008 within and around Admiralty Inlet. The trawl is capable of targeting mid and deeper water species and the majority of the species captured were demersal. Table 3-7 lists invertebrate species sampled at two locations, 05CST01 and 05CST06, that are within the mid-channel and near the Project site, respectively.

FIGURE 3-11
WDFW RESEARCH TRAWL LOCATIONS IN ADMIRALTY INLET



Source: Pers. comm. W. Palsson, WDFW
Note: The first two digits of each station identify the year.

TABLE 3-7
NUMBERS OF INVERTEBRATES PER HECTARE SAMPLED DURING WDFW TRAWL SURVEYS AT STATION 05CST06 AND STATION 05CST01

Type	Species	05CST01 Located Mid-Channel (no. per hectare)	05CST06 Located near Project Site (no. per hectare)
Bivalve	Northern horse mussel		23.7
	Pink scallop (deep ribs)		11.8
	Pink scallop (smooth)		3.0
Snail	Leafy hornmouth		3.0
	Oregon hairy triton		3.0
Crustacean	Dock shrimp		5.9
	Giant barnacle	66.6	44.4
	Pygmy rock crab	4.4	3.0

Type	Species	05CST01 Located Mid-Channel (no. per hectare)	05CST06 Located near Project Site (no. per hectare)
	Sharpnose crab	4.4	
Other	Fat blood star		3.0
	Fried egg jellyfish		8.9
	Gigantic anemone		3.0
	Glassy sea squirt		3.0
	Green sea urchin		5.9
	Lampshell brachiopod	4.4	
	Long armed spiny seastar		3.0
	Sponge unidentified	4.4	3.0

Source: personal communication, W. Palsson, WDFW
Note: Average trawl depths were 49 meters. Both stations were sampled on June 1, 2005.

Table 3-8 shows the invertebrate species collected during all 50 Admiralty Inlet trawls from 1987 to 2008 (Figure 3-11) at trawl depths of 102 to 198 feet, a depth range within which the turbines will be deployed. The primary crustaceans collected were dock shrimp, Alaskan pink shrimp, giant barnacle, Dungeness crab, and red rock crab. The primary echinoderms collected were green sea urchin, sunflower star, red sea cucumber, and red sea urchin. The most abundant mollusks collected were pink scallop, California market squid, and northern horse mussel. Other invertebrates collected include gigantic anemone and warty sea squirt (Table 3-8).

TABLE 3-8
DENSITY OF INVERTEBRATES PER HECTARE SAMPLED AT 102-198 FEET CATEGORY IN ADMIRALTY INLET DURING WDFW TRAWL SURVEYS (50 TOWS TOTAL FROM 1987-2008)

Name	No. per hectare	Name	No. per hectare
Crustacean		**Echinoderm (cont.)**	
Dock shrimp	54.7	Long armed spiny seastar	0.3
Alaskan pink shrimp	17.2	Pallid sea urchin	0.2
Giant barnacle	10.9	Sea star unidentified	0.2
Dungeness crab (female)	4.2	Slime star	0.2
Red rock crab (male)	2.7	*Eupentacta pseudoquinquesemita* (sea cucumber)	0.1
Shrimp unidentified	1.4	Leather star	0.1
Coonstriped shrimp	1.2	Pink short spined seastar	0.1
Crangonid shrimp unidentified	1.2	Solaster unidentified.	0.1
Graceful crab (male)	0.9	Vermilion star	0.1
Shortscale eualid	0.9	**Mollusk**	
Spotted prawn	0.9	Pink scallop (deep ribs)	209.7
Pygmy rock crab	0.8	California market squid	14.5
Idotea resecata (isopod)	0.7	Northern horse mussel	9.8
Dungeness crab (male)	0.5	Pink scallop unidentified	1.3

Name	No. per hectare	Name	No. per hectare
Sharpnose crab	0.4	Oregon hairy triton	1.2
Bering hermit crab	0.3	Rosy tritonia	1
Graceful crab (female)	0.3	Pink scallop (smooth)	0.9
Hermit crabs unidentified	0.3	Leafy hornmouth	0.6
North Pacific toad crab	0.3	Little red octopus	0.2
Spiny lebbeid	0.3	Stubby squid	0.2
Cryptic kelp crab	0.2	**Other**	
Dungeness crab (mixed)	0.1	Gigantic anemone	21.6
Flattop crab	0.1	Warty sea squirt	7.2
Red rock crab (female)	0.1	Fried egg jellyfish	0.8
Widehand hermit crab	0.1	Sponge unidentified	0.7
Echinoderm		Glassy sea squirt	0.6
Green sea urchin	18.4	California arminid	0.5
Sunflower star	11.3	Orange sea pen	0.4
Red sea cucumber	7.7	Lampshell brachiopod	0.4
Red sea urchin	1.1	Chaetopterid unidentified	0.3
Sea cucumber unidentified	0.4	Cloud sponge	0.3
Fat blood star	0.3	Lion's mane jelly	0.1
Long armed spiny seastar	0.3		

Source: Pers. comm. W. Palsson, WDFW

WDFW conducted sampling in Admiralty Inlet using video assessment technique in 1995 at 52 stations ranging in depth of 16 to 117 feet and in 2001 at 28 stations ranging in depth of 25 to 112 feet. Red sea urchin and green sea urchin were the only invertebrate species identified from the video assessment (Pers. comm. Sharon Kramer, H.T. Harvey & Associates, with Robert Pacunski, WDFW, August 2009).

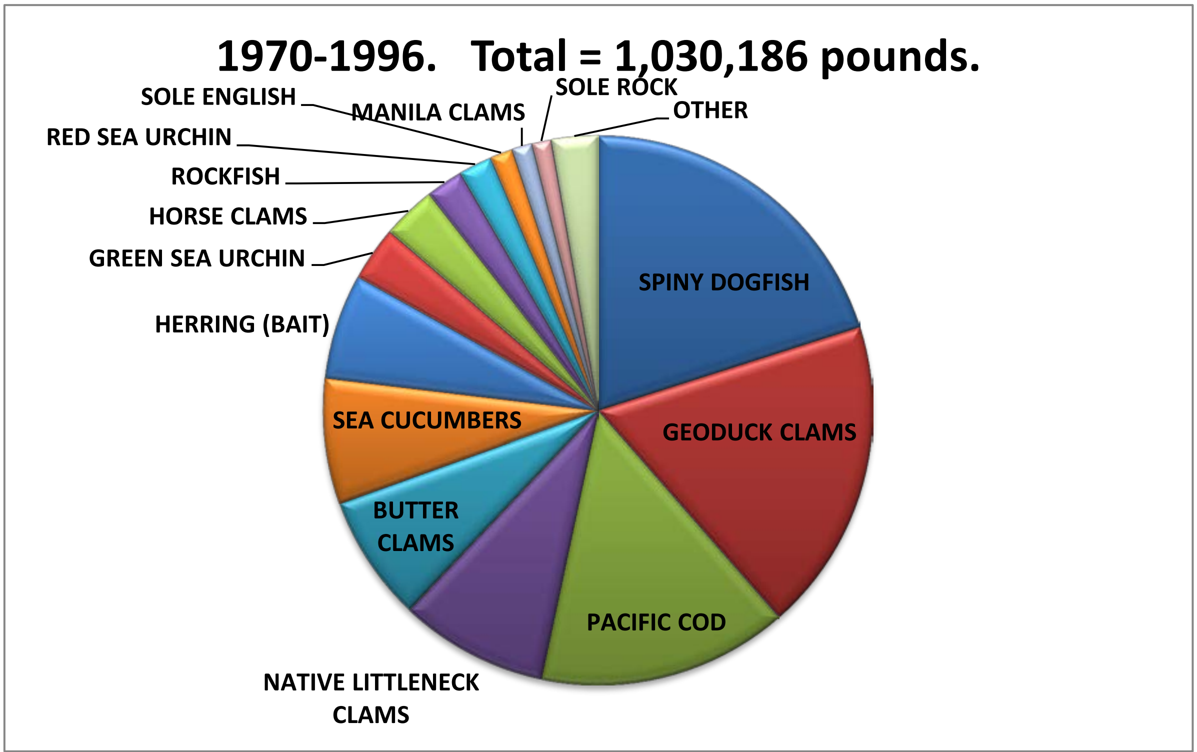
Invertebrate species harvested commercially in Admiralty Inlet are listed in Table 3-9, and the catch of invertebrate and fish species is graphically represented in Figure 3-12. The primary invertebrate species harvested in Admiralty Inlet are geoduck clams, Dungeness crabs, and green sea urchins (Table 3-9, Figure 3-12). Total shellfish and fish harvest has decreased substantially in Admiralty Inlet (Figure 3-13), though commercially targeted crab and shrimp species catch have increased since the 1980s. Excluding clam harvest in nearshore marine areas, harvest of other species has decreased (Figure 3-13).

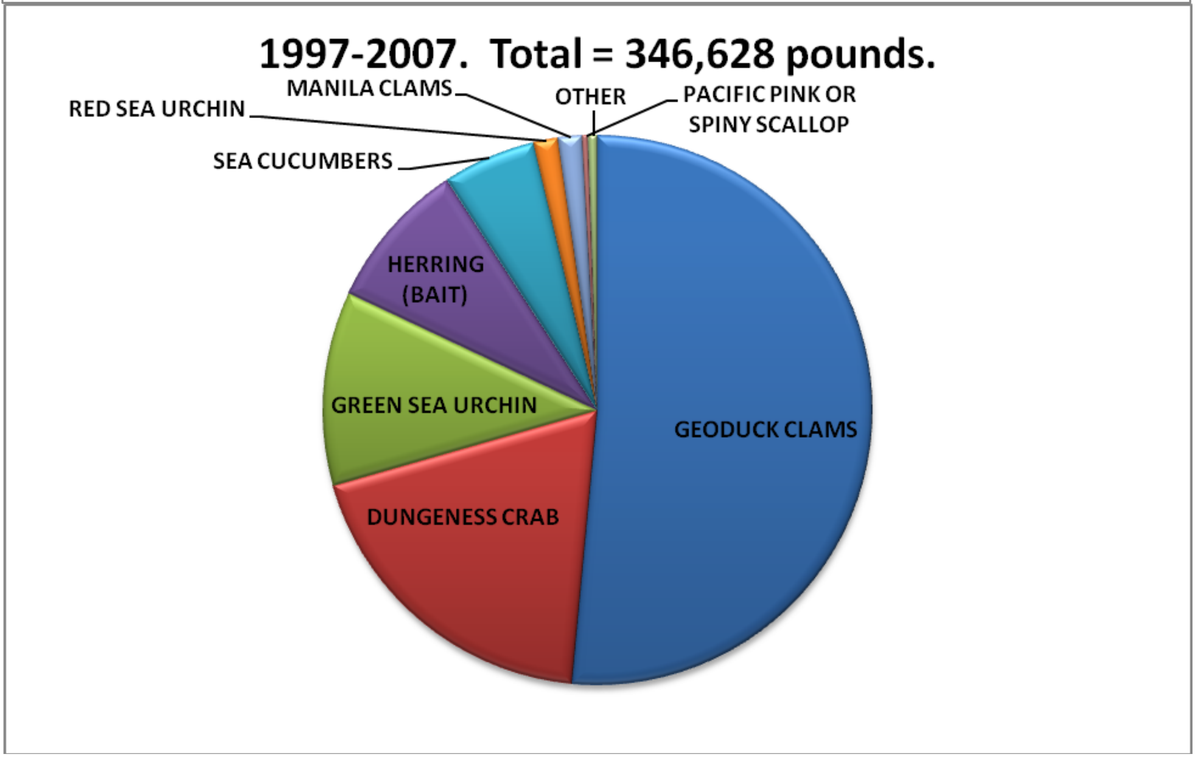
TABLE 3-9
ADMIRALTY INLET ANNUAL COMMERCIAL HARVEST (TRIBAL AND NON-TRIBAL) OF MARINE SHELLFISH IN ADMIRALTY INLET DURING 1997-2007

Species	Harvest (pounds)
Bivalve	
Geoduck clams	178,463
Manila clams	4,908
Pacific pink or spiny scallop	1,171
Native littleneck clams	93
Horse clams	23
Crustacean	
Dungeness crab	66,212
Spots shrimp	337
Rock crab	139
Coonstriped shrimp	115
Echinoderm	
Green sea urchin	39,578
Sea cucumbers	19,070
Red sea urchin	5,039

Source: Pers. comm. L. Hoines, WDFW, with G. Ruggerone, NRC, Inc.

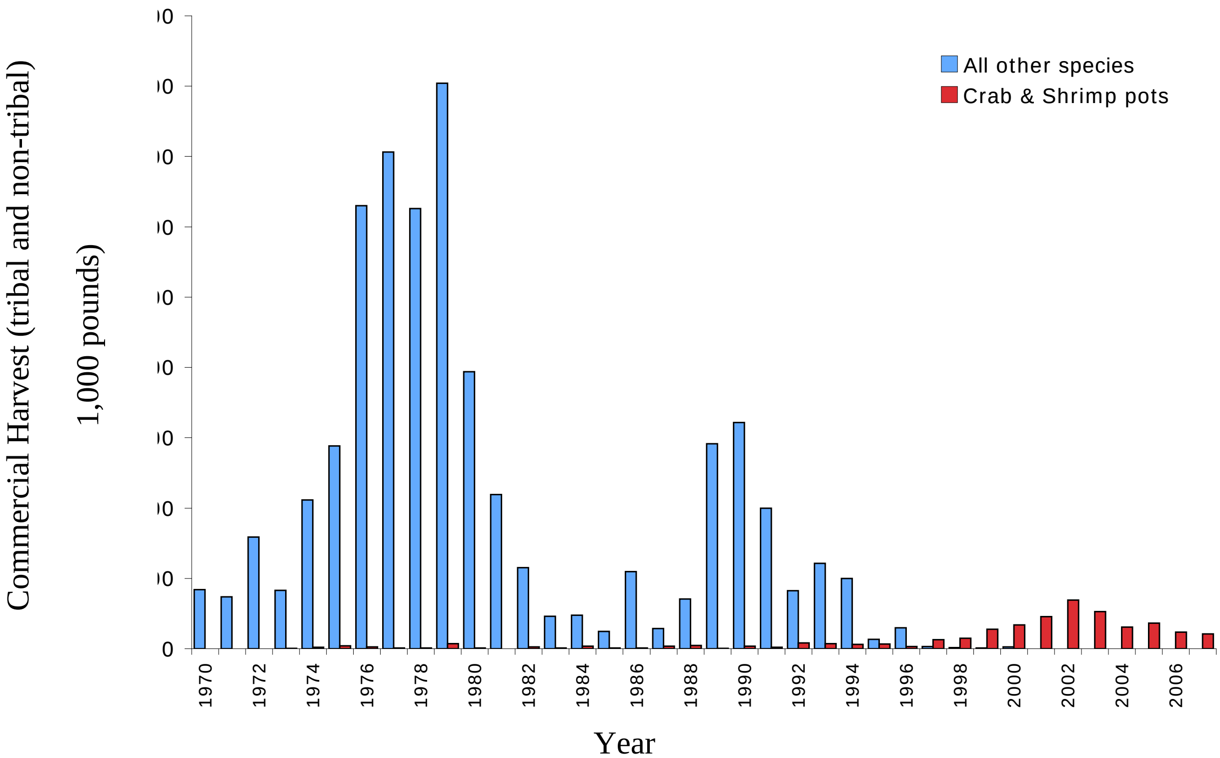
FIGURE 3-12
ANNUAL COMMERCIAL HARVEST (TRIBAL AND NON-TRIBAL) OF MARINE FISH AND SHELLFISH DURING 1970-1996 AND 1997-2007





Source: Pers. comm. L. Hoines, WDFW, with G. Ruggerone, NRC, Inc.

FIGURE 3-13
ANNUAL COMMERCIAL HARVEST (TRIBAL AND NON-TRIBAL) OF CRAB AND SHRIMP AND ALL OTHER SPECIES IN ADMIRALTY INLET 1970-2007



Source: Pers. comm. L. Hoines, WDFW, with G. Ruggerone, NRC, Inc.
Note: Statistical area 25b, excluding clams in nearshore marine areas.

To characterize the site-specific benthic habitat and community, the District conducted ROV surveys in August, late September, and early October 2010 (Greene 2010). The benthic community in the turbine site, especially the boulder and cobble substrate, was dominated with encrusting organisms such as sponges, bryozoans, and tubeworms. The finer grain substrate, pebbles, and gravel are relatively easily moved by the tidal currents, and are therefore not encrusted with organisms. In addition a variety of attached organisms (anemones) were observed. The anemones varied in size from 4 to 12 cm in diameter when closed and three basic types were distinguished by color and pattern. A total of 1,375 anemones were counted. Sessile organisms observed included chitons, limpids, tunicates, clams, and stemmed and basket sponges. Epifauna observed included shrimp, hermit crab, crab, sea stars, urchins, and turban snails. The most dominant epifauna species observed were urchin and common five-legged orange starfish, which comprised 90 percent of the species observed (Greene 2010).

An ROV video survey of the revised cable route will be conducted after the FLA is submitted and the results will be shared with interested stakeholders as soon as possible. Sonar imaging of the region has already been conducted, and is indicative of the same type of seabed conditions that have been previously encountered during surveys of the initial project area. In the event that any unanticipated or notable seabed habitat is observed, the results will be communicated with stakeholders and the FLA's environmental analysis will be updated.

Fish

A discussion of Project area fish is presented below as follows:

- Fish Community Overview
    - anadromous fish
    - demersal fish
    - pelagic schooling fish
    - elasmobranchs (sharks, skates and rays)
- Site specific sampling results

Fish Community Overview

Anadromous Fish - There are a total of eight salmonid species that reside within Puget Sound: Chinook salmon, chum salmon, coho salmon, pink salmon, sockeye salmon, steelhead, cutthroat trout, and bull trout. Bull trout, Puget Sound Chinook salmon, steelhead and chum salmon are ESA-listed species that are federally protected (DON 2006). Species listed under the ESA are addressed in the draft BA (Appendix G). The remaining species that are not federally protected are addressed below and include: coho salmon, pink salmon, sockeye salmon, and anadromous cutthroat trout.

All species of anadromous salmonids originating from the Skagit River, Stillaguamish River, Snohomish River, Lake Washington Basin, Duwamish/Green River, Puyallup River, Nisqually River Deschutes River, Skokomish River, Hamma Hamma River, Dosewallops River, Duckabush River, and Quilcene River, both out-migrating juveniles and returning adults, pass through Admiralty Inlet. These rivers collectively produce in excess of a million adult fish, of hatchery and wild origin, each year (Letter from NMFS to the District dated July 23, 2009).

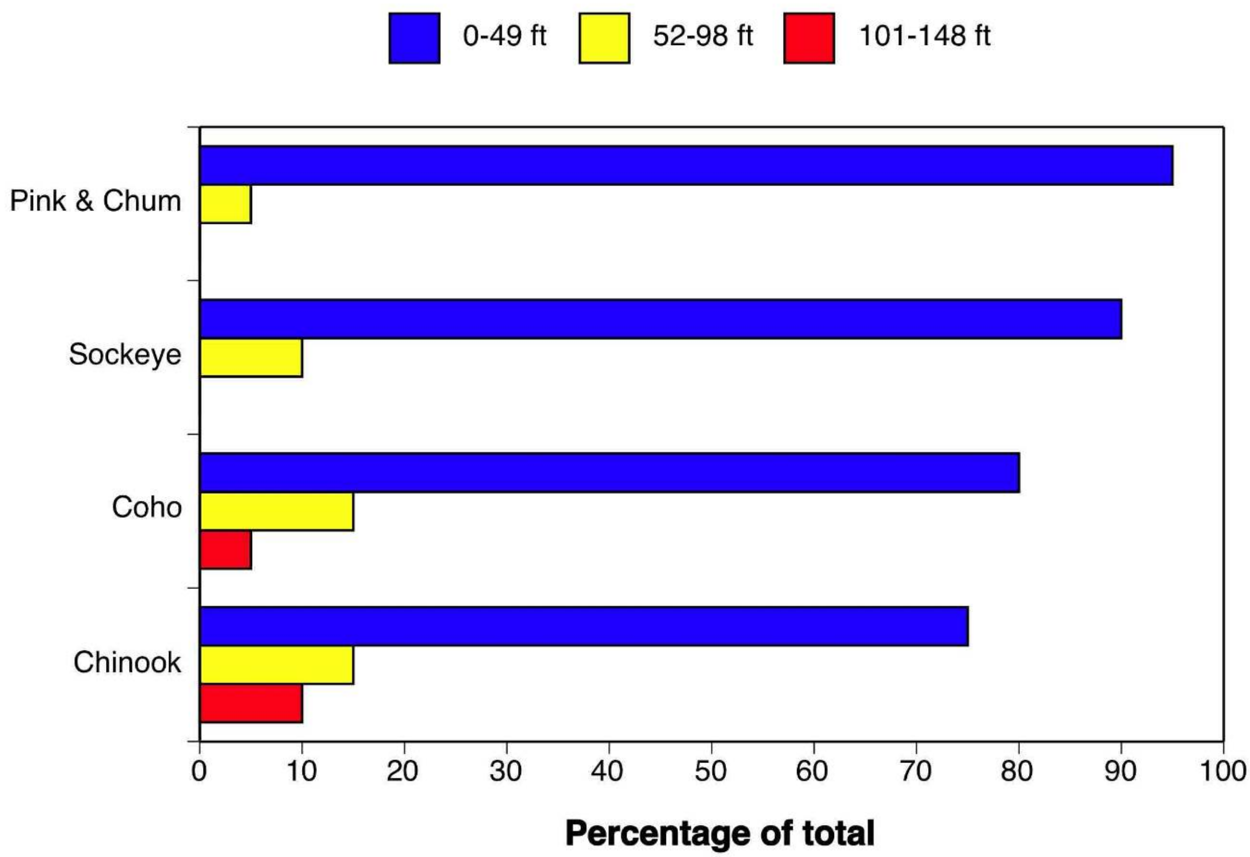
Salmon return to their natal stream to spawn, but use of specific marine locations is less predictable. Coho salmon (*Oncorhynchus kisutch*) have a large oceanic range and can be found throughout Puget Sound (PFMC 2000). Adults begin the freshwater migration in late summer and fall, spawn in natal rivers and streams by mid-winter and then die (NOAA 1995*a*). Juvenile coho salmon migrate to the ocean to feed and grow. Adults typically remain for two years in the ocean before returning to their natal streams as three-year-olds (NOAA 1995*a*).

The Department of Fisheries and Ocean Canada (CDFO) examined the depth distribution of juvenile salmon in Puget Sound and the Strait of Georgia: CDFO has conducted over 158 tows since the late 1990s using the following methods:

- Survey tows generally consisted of durations up to 15 minutes and occurred on either side the shipping lanes in water depths greater than approximately 120 feet.
- Each tow sampled approximately 1 million cubic meters of water each (personal communication, R. Sweeting, CDFO with G. Ruggerone, NRC, Inc.).

From review of these data, about 95 percent of juvenile coho salmon occur from the surface to 30 meters (100 feet) and 80 percent occur in the top 15 meters (50 feet) of the water column (Figure 3-14) (Pers. comm. G. Ruggerone, NRC, Inc. with R. Sweeting, CDFO).

FIGURE 3-14
DEPTH DISTRIBUTION OF JUVENILE SALMON IN MID-CHANNEL AREAS OF THE STRAIT OF GEORGIA AND PUGET SOUND



Source: Pers. comm. G. Ruggerone, NRC, Inc. with R. Sweeting, CDFO

While the coho salmon is not listed as threatened or endangered, it was categorized as a species of concern in July 1995 (NOAA 1995*a*). Puget Sound coho salmon are heavily supported through artificial propagation. Production and release of smolts tallies several million annually (NOAA 1995*a*). A large population of coho salmon resides in Hood Canal and surrounding freshwater streams (NOAA 1995*a*). The proximity of Admiralty Inlet to Hood Canal and the surrounding freshwater streams suggests that coho salmon are likely found in and around the inlet. In addition, Chimacum Creek supports coho salmon and flows directly into Admiralty Inlet. During the fall, anglers fish for coho salmon in Useless Bay and at Indian Point, which is along the southern end of Admiralty Inlet (Keizer and Nelson 2007).

Pink salmon (*O. gorbushcha*) range on the West Coast from southern Puget Sound to Alaska. Sizeable populations of pink salmon spawn in both large and small river systems during late summer and fall. Most Puget Sound pink salmon are wild fish, and approximately 70 percent of spawning escapement occurs in northern Puget Sound (WDF et al. 1993). Juvenile pink salmon migrate rapidly downstream in schools, residing in estuaries from several weeks to a few months and then enter the ocean environment. Ocean residence is from twelve to sixteen months (Heard 1991). Only a single population of even-year[9] pink salmon occurs in the United States south of Alaska (NOAA 1995*b*). The Snohomish River serves as the natal stream. While the size of the population is relatively small, it is stable and gradually increasing. Odd-year pink salmon are common throughout the Sound and are likely to be found within the Admiralty Inlet Project area. From review of mid-channel sampling in the Strait of Georgia and Puget Sound, all juvenile pink salmon occur from the surface to 30 meters (100 feet) and 95 percent occur in the top 15 meters (50 feet) of the water column (Figure 3-14) (Pers. comm. G. Ruggerone, NRC, Inc. with R. Sweeting, CDFO). WDFW estimated the 2007 run of pink salmon would be an estimated 3.34 million, an increase of 1.23 million from 2005 (PFMC 2007).

Sockeye salmon (*O. nerka*) migration generally begins in late April and extends through early July, with southern stocks migrating earliest (Emmett et al. 1991). Northward migration of juveniles to the Gulf of Alaska occurs along the coast, and offshore movement of juveniles occurs in late autumn or winter. Sockeye prefer cooler ocean conditions than other Pacific salmon species (Burgner 1991). Freshwater habitat for sockeye salmon is along the western portion of the Sound within Lake Washington, Snohomish River, and Stillaguamish River (DON 2006). Admiralty Inlet likely provides a migratory corridor leading towards Rosario Strait, as juvenile sockeye move along the shoreline north. From review of mid-channel sampling in the Strait of Georgia and Puget Sound, all juvenile sockeye salmon occur from the surface to 30 meters (100 feet) and 90 percent occur in the top 15 meters (50 feet) of the water column (Figure 3-14) (Pers. comm. G. Ruggerone, NRC, Inc. with R. Sweeting, CDFO).

Anadromous coastal cutthroat trout (*O. clarki clarki*) occur within Puget Sound. Anadromous cutthroat trout generally spawn from January through April in freshwater streams throughout the Puget Sound basin (WDFW 2000; Giger 1972). The marine distribution of cutthroat trout is generally in estuaries and nearshore areas. There have been reports of cutthroat being found kilometers offshore, but this is generally uncommon (WDFW 2000; Pearcy 1997). After feeding for several months in marine waters, most cutthroat return to their natal stream to overwinter and spawn (WDFW 2000). Notably in Puget Sound, two entry times—early and late—are seen. Larger river systems see fish returning from August through October (i.e., early), and smaller streams see returns from December through February (i.e., late) (WDFW 2000). Anecdotal reports identified a relatively high abundance of coastal cutthroat trout in northern Puget Sound but only a low abundance of trout in the streams of the basin's southwestern region (NOAA 1999). The coastal cutthroat population of Puget Sound is not presently, nor within the near future, in danger of becoming extinct (Good et al. 2005). Coastal cutthroat trout are well distributed in the Strait of Juan de Fuca and Hood Canal. Both of these areas are proximal to the Project area; however, cutthroat trout tend to remain near their natal streams, residing mostly in estuarine waters. There is a strong potential for cutthroat to forage or reside intermittently in

[9] Maturing at two years of age, pink salmon display a unique and rigid age structure (Turner and Bilton 1968). This structure results in two broodlines that include both even and odd-year populations.

Admiralty Inlet. The predominant use of nearshore estuarine areas suggests that the inlet is not a commonly used foraging area.

Other anadromous species within Puget Sound include white sturgeon (*Acipenser transmontanus*), river lamprey (*Lampetra ayresii*), and Pacific lamprey (*Lampetra tridentata*). Green sturgeon (*Acipenser medirostris*), an endangered species, is discussed in the draft BA (Appendix G). Both species of lamprey are listed in Washington State as species of concern. While not common, white sturgeon are noted to occur in the Puget Sound and Hood Canal (PSMFC 1996).

<u>Demersal Fish</u> - Groundfish are important species for both commercial and recreational harvest in the Pacific Northwest, and are managed by the Pacific Fisheries Management Council (PFMC). It is estimated that 75 of the 82 groundfish species managed by PFMC occupy the Puget Sound area at least once during their life cycle (DON 2006). Moreover, WDFW estimates that over 80 species of groundfish occur within the basin altogether, of which 21 are additionally managed by WDFW including: spiny dogfish, skates, spotted ratfish, Pacific cod, walleye pollock, Pacific whiting (hake), rockfish, sablefish, greenlings, lingcod, sculpins, wolf-eel, surfperches, Pacific halibut, Dover sole, English sole, starry flounder, rock sole, sand sole, other bottomfishes, and unclassified marine fishes (Palsson et al. 1998). These species were selected based upon commercial, recreational, and ecological importance.

The diverse species incorporated within the general grouping of ‘groundfish’ exhibit a wide range of life histories, and habitat use within the group is, as a result, also quite variable. Rockfish are the most diverse group regarding habitat use and can be found in nearshore areas as well as deeper shelf waters. Habitat use also changes by life-cycle stage with dispersed eggs and larvae frequently occupying large areas, and adults often being tightly associated with sand, gravel, or exposed rocky areas (PFMC 2003). Currents also determine species location; the California Current and counter current (Davidson current) play a major role in determining habitat use (PFMC 2003).

<u>Pelagic Schooling Fish</u> - Pelagic fish are an important base component of marine food chains and serve as prey for numerous predatory species. Pelagic fish are found throughout the water column and feed on small invertebrate species. Most pelagic fish are found in the warmer waters of California, but several important species are found within Puget Sound including northern anchovy, Pacific sardine, and Pacific mackerel. The abundance of each species can fluctuate greatly, varying considerably from year to year.

<u>Elasmobranchs</u> - Comprising sharks, skates, and rays, elasmobranchs are fish with a cartilaginous rather than bony skeleton. Puget Sound provides habitat for a number of such species including ten sharks, one ray, and five skates (see Table 3-10).

TABLE 3-10
SHARKS, SKATES AND RAYS FOUND WITHIN PUGET SOUND AND ASSOCIATED HABITAT

Common Name	Scientific Name	Occurrence In Puget Sound	Orientation or Habitat Usage Type
Brown cat shark	*Apristurus brunneus*	Common	Demersal, deep water
Blue shark	*Prionace glauca*	Rare	Epipelagic
Common thresher	*Alopias vulpinus*	Rare	Pelagic
Basking shark	*Cetorhinus maximus*	Rare	Pelagic
Salmon shark	*Lamna ditropis*	Infrequent	Pelagic
Sixgill shark	*Hexanchus griseus*	Infrequent	Deepwater
Sevengill shark	*Notorynchus cepedianus*	Infrequent	Deepwater
Spiny dogfish	*Squalus acanthias*	Common	Widespread
Sleeper shark	*Somniosus pacificus*	Rare	Deepwater
Pacific angel shark	*Squatina californica*	Rare	Demersal, shallow water
Pacific electric ray	*Torpedo californica*	Infrequent	Demersal
Sandpaper skate	*Bathyraja kincaidi*	Common	Demersal
Big skate	*Raja binoculata*	Common	Demersal
California skate	*Raja inornata*	Common	Demersal
Longnose skate	*Raja rhina*	Common	Demersal
Starry skate	*Raja stellulata*	Common	Demersal

Source: DON 2006

Site Specific Sampling Results

The density of fish (number fish/hectare) sampled during WDFW surveys at the two locations nearest the project site is shown in Table 3-11 (Pers. comm. G. Ruggerone, NRC, Inc. with W. Palsson). The most numerous fish sampled were spotted ratfish, ribbed sculpin, buffalo sculpin, grunt sculpin, kelp greenling, and lingcod. No salmon were captured in trawls at either of these locations.

TABLE 3-11
NUMBERS OF FISH PER HECTARE SAMPLED DURING WDFW TRAWL SURVEYS AT STATION 05CST06 AND STATION 05CST01

Species	05CST01 Located mid-channel (Fish per hectare)	05CST06 Located near project site (Fish per hectare)
Buffalo sculpin	26.6	
Decorated warbonnet		3.0
Grunt sculpin		11.8
Kelp-greenling	8.9	8.9
Lingcod	8.9	
Mosshead sculpin		3.0

Species	05CST01 Located mid-channel (Fish per hectare)	05CST06 Located near project site (Fish per hectare)
Rex sole	4.4	
Ribbed sculpin	31.1	
Spiny dogfish	4.4	5.9
Spotted ratfish		79.9

Source: W. Palsson, WDFW, Pers. comm.
Note: Average trawl depths were 49 meters. Both stations were sampled on June 1, 2005.

Table 3-12 shows the fish species collected during all 50 Admiralty Inlet trawls from 1987 to 2008 (Figure 3-11) at trawl depths of 102 to 198 feet, a depth range within which the turbines will be deployed (Pers. comm. G. Ruggerone, NRC, Inc. with W. Palsson). By and far, the most numerous species collected in Admiralty Inlet at this depth was spotted ratfish (65 percent of the catch). The next most abundant species were Pacific sanddab (5 percent), English sole (4 percent), southern rock sole (4 percent), great sculpin (3 percent), buffalo sculpin, Pacific tomcod, spiny dogfish, and Puget Sound rockfish (all 2 percent). All species of rockfish caught (Puget Sound, copper, greenstripe, quillback, redstripe, and unidentified rockfish) comprised 5 percent of the total catch (personal communication, G. Ruggerone, NRC, Inc. with W. Palsson, WDFW).

TABLE 3-12
DENSITY OF FISH PER HECTARE SAMPLED AT 102-198 FEET CATEGORY IN ADMIRALTY INLET DURING WDFW TRAWL SURVEYS
(50 TOWS TOTAL FROM 1987-2008)

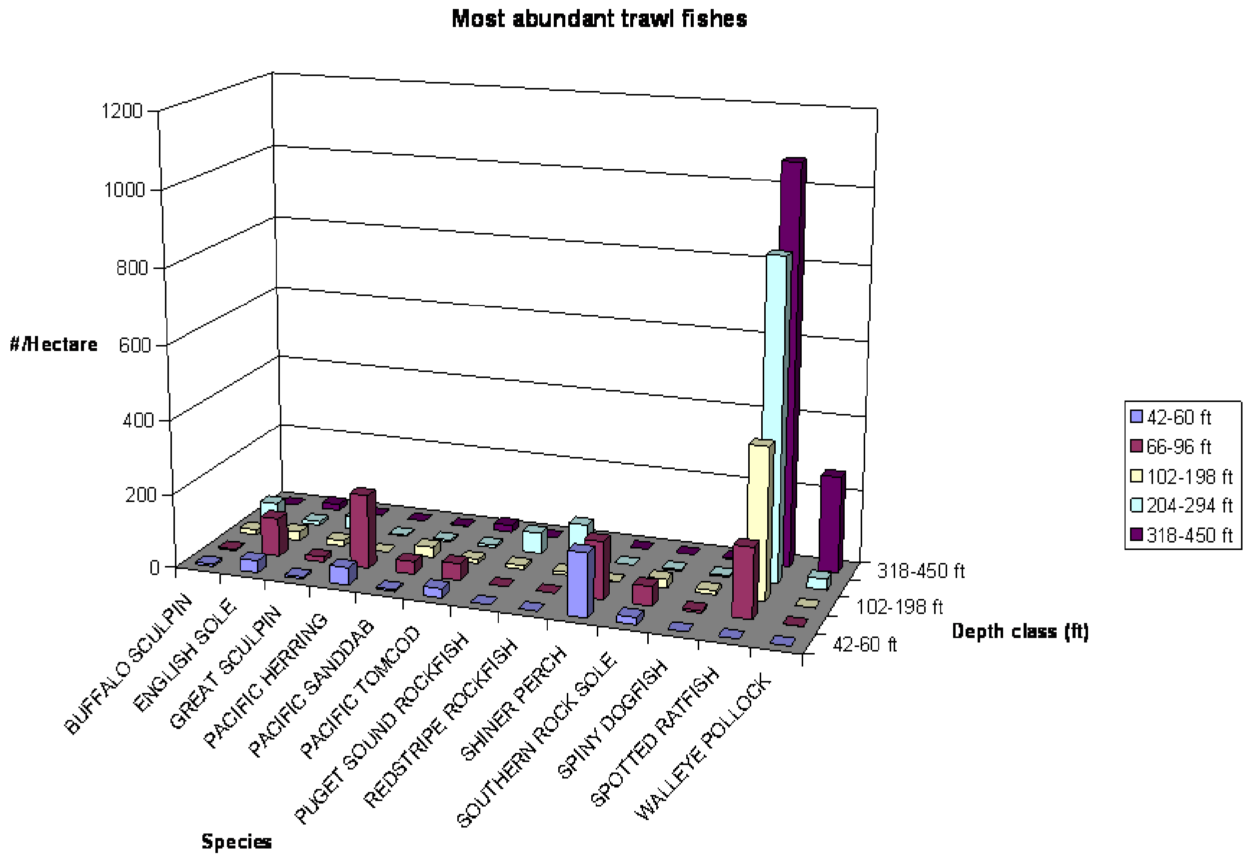
Name	No. per hectare	Name	No. per hectare
Spotted ratfish	406.1	Dover sole	0.8
Pacific sanddab	29.5	Shiner perch	0.8
English sole	24.3	Rex sole	0.6
Southern rock sole	23.9	Longnose skate	0.5
Great sculpin	15.7	Padded sculpin	0.5
Buffalo sculpin	14.1	Spotted ratfish egg case	0.5
Pacific tomcod	11.8	Decorated warbonnet	0.4
Spiny dogfish	11.1	Sturgeon poacher	0.4
Puget Sound rockfish	10.9	Blackbelly eelpout	0.3
Rock sole unidentified	9.6	C-o sole	0.3
Rockfish unidentified	9	Mosshead sculpin	0.3
Ribbed sculpin	8.7	Pacific staghorn sculpin	0.3
Redstripe rockfish	8.4	Pile perch	0.3
Roughback sculpin	5.3	Quillback rockfish	0.3
Copper rockfish	3	Red Irish lord	0.3
Northern ronquil	3	Slim sculpin	0.3
Speckled sanddab	3	Northern sculpin	0.2
Cabezon	2.7	Poacher unidentified	0.2

Name	No. per hectare	Name	No. per hectare
Northern spearnose poacher	2.4	Big skate	0.1
Grunt sculpin	1.7	Greenstriped rockfish	0.1
Kelp greenling	1.6	Pacific herring	0.1
Flathead sole	1.5	Pacific pompano	0.1
Whitespotted greenling	1.4	Sculpin unidentified	0.1
Pacific cod	1.3	Spinyhead sculpin	0.1
Lingcod	1.1	Starry flounder	0.1
Sailfin sculpin	1		

Source: Pers. comm. W. Palsson, WDFW.

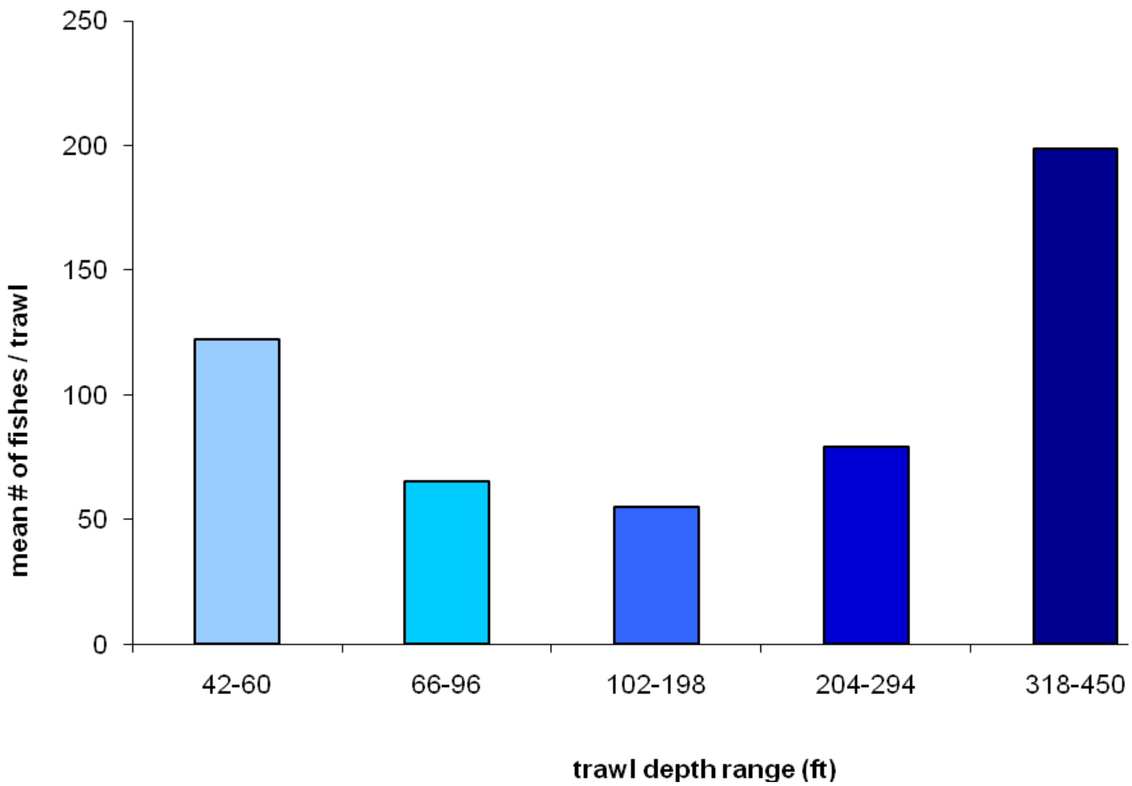
The trawl data collected at all five depth ranges, evaluated for the top five most abundant fish species for each depth category, is presented in Figure 3-15. As would be expected, certain species are found at different depths. For example, English sole, Pacific herring, Pacific sanddab, Pacific tomcod, southern rock sole were most abundant at trawling depths of 66 to 96 feet. Shiner perch were most abundant in trawling depths of 42 to 96 feet. Ratfish and walleye pollock had greatest abundance was greatest at depths of 318 to 450 feet, though this species was also abundant at depths greater than 66 feet. Buffalo sculpin, Puget Sound rockfish and redstripe rockfish were most abundant in trawling depths of 204 to 294 feet (Figure 3-15). Of the five depth categories, the depth range at which the turbines will be deployed represent the least number of fish collected (Figure 3-16).

FIGURE 3-15
DEPTH DISTRIBUTION AND SPECIES COMPOSITION OF TRAWLED FISHES DURING WDFW TRAWL SURVEYS (50 TOWS TOTAL FROM 1987-2008)



Source: Pers. comm. W. Palsson, WDFW.

FIGURE 3-16
DEPTH DISTRIBUTION OF DOMINANT TRAWLED FISHES DURING WDFW TRAWL SURVEYS (50 TOWS TOTAL FROM 1987-2008)



Source: Pers. comm. G. Ruggerone, NRC, Inc. with W. Palsson

WDFW conducted sampling in Admiralty Inlet using video assessment technique in 1995 at 52 stations ranging in depth from 16 to 117 feet and in 2001 at 28 stations ranging in depth from 25 to 112 feet (Pers. comm. Sharon Kramer, H.T. Harvey, with Robert Pacunski, WDFW, August 2009). Fish species identified from the video assessment include copper rockfish, quillback rockfish, lingcod, kelp greenling, white spotted greenling, painted greenling, flatfish, red sea urchin, and green sea urchin.

Commercial fishing for salmon ended in Admiralty Inlet in the early 1990s because this area is non-terminal (mixed stocks passing through). Four species of fish have been commercially harvested in Admiralty Inlet from 1997 to 2007: herring, spiny dogfish, sole rock, and starry flounder; herring represents 97 percent of the catch (Table 3-13). Captures of commercially sought fish species have been decreasing in Admiralty Inlet over the last 35 years, and the annual commercial harvest of all species (fish and invertebrates) has decreased from 1,030,186 pounds from 1970-1996 to 346,628 pounds from 1997 to 2007 (Figures 3-12 and 3-13 above) - a reduction of two-thirds (Pers. comm., L. Hoines, WDFW, with G. Ruggerone, NRC, Inc.).

TABLE 3-13
ANNUAL COMMERCIAL HARVEST (TRIBAL AND NON-TRIBAL) OF MARINE FISH IN ADMIRALTY INLET DURING 1997-2007

Species	Harvest (pounds)
Herring (bait)	30,418
Spiny dogfish	573
Sole rock	346
Starry flounder	146

Source: Pers. comm., L. Hoines, WDFW, with G. Ruggerone, NRC, Inc.

As part of the pre-installation studies for this Project, Vemco VR2W acoustic tag receivers were placed on Sea Spider instrumentation packages from late 2009 through the present in the Project area. While the receivers have not detected as many tagged fish as expected, from May 21 to August 3, 2009, there were 23 tag detections, of which 78 percent (18) were detected on an ebb tide, and the majority of detections occurred in May and June. From August 5, 2009 to November 8, 2010 only 13 tagged fish were detected. Currently there is one Sea Spider deployed in the Project area and equipped with a Vemco VR2W receiver that will collect data through December, 2013. The District has been unable to locate detected tag IDs in the POST database, but considering from May 21 to August 3, 2009, that the detections were in spring and on the ebb tide, it is expected that the fish were out-migrating juvenile salmon.

Sport fishermen frequently troll for Chinook salmon, including resident Chinook salmon, during winter in Admiralty Inlet, including at the Project site (www.salmonuniversity.com). Chinook salmon are often hooked while fishing with downriggers near the bottom, often in water approximately 50-140 feet deep. The average sport catch of salmon in Admiralty Inlet (Area 9) during 2000 to 2006 is shown in Table 3-14 (pink salmon are only captured in odd-numbered years) (Pers. comm. S. Thiesfeld, WDFW, with G. Ruggerone, NRC, Inc.).

TABLE 3-14
AVERAGE SPORT CATCH OF SALMON IN ADMIRALTY INLET (AREA 9) DURING 2000 TO 2006

Species	Harvest (pounds)
Chinook	2,480
Coho	16,641
Chum	233
Pink (odd years)	16,168
Sockeye	11

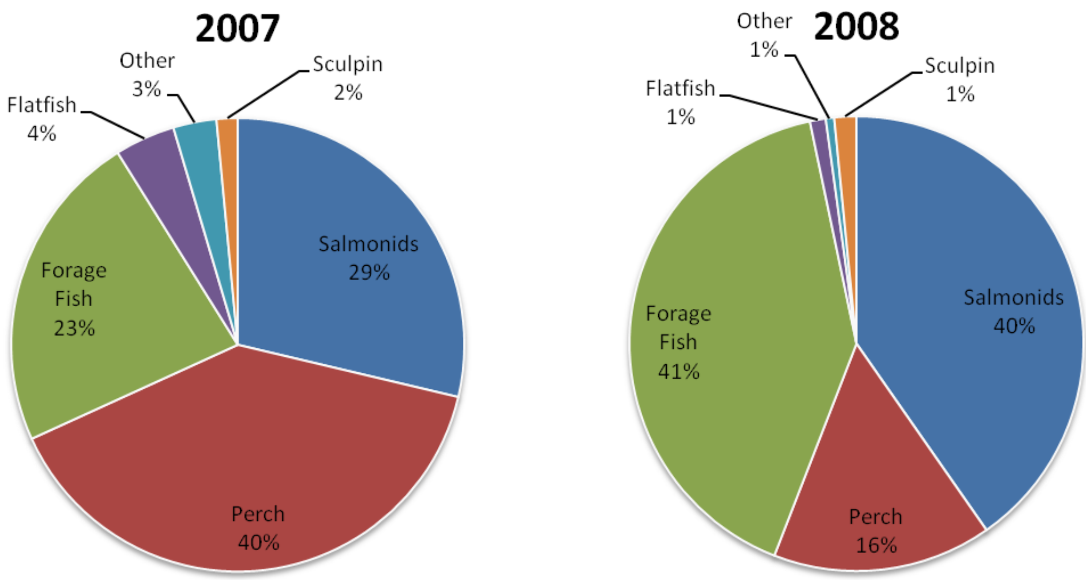
Source: Pers. comm. S. Thiesfeld, WDFW, with G. Ruggerone, NRC, Inc.

Nearshore sampling of the northeast side of Kitsap Peninsula was conducted by the Suquamish Tribe and WDFW in 2007 and 2008 (Figure 3-17). Researchers sampled fishes with a beach seine between February and November. A total of 111,208 fish representing 46 species were captured over the two year period. Catch was dominated by salmonids in the spring and forage fish and perch in the summer and early fall (Figures 3-18 and 3-19). Captured salmonids were primarily represented by chum salmon in 2007 and pink salmon in 2008. Chinook and coho salmon were caught in late spring and early summer, with peak catch occurring in June in both 2007 and 2008. The majority of captured Chinook had their adipose fin clipped (representing hatchery fish), while most of the coho were unclipped (Pers. comm., D. Small, WDFW, with G. Ruggerone, NRC, Inc., March 2009).

FIGURE 3-17
LOCATION OF NEARSHORE BEACH SEINE SAMPLING OCCURRING ON THE NORTHEAST SIDE OF THE KITSAP PENINSULA

Source: Pers. comm. D. Small, WDFW, with G. Ruggerone, NRC, Inc., March 2009.

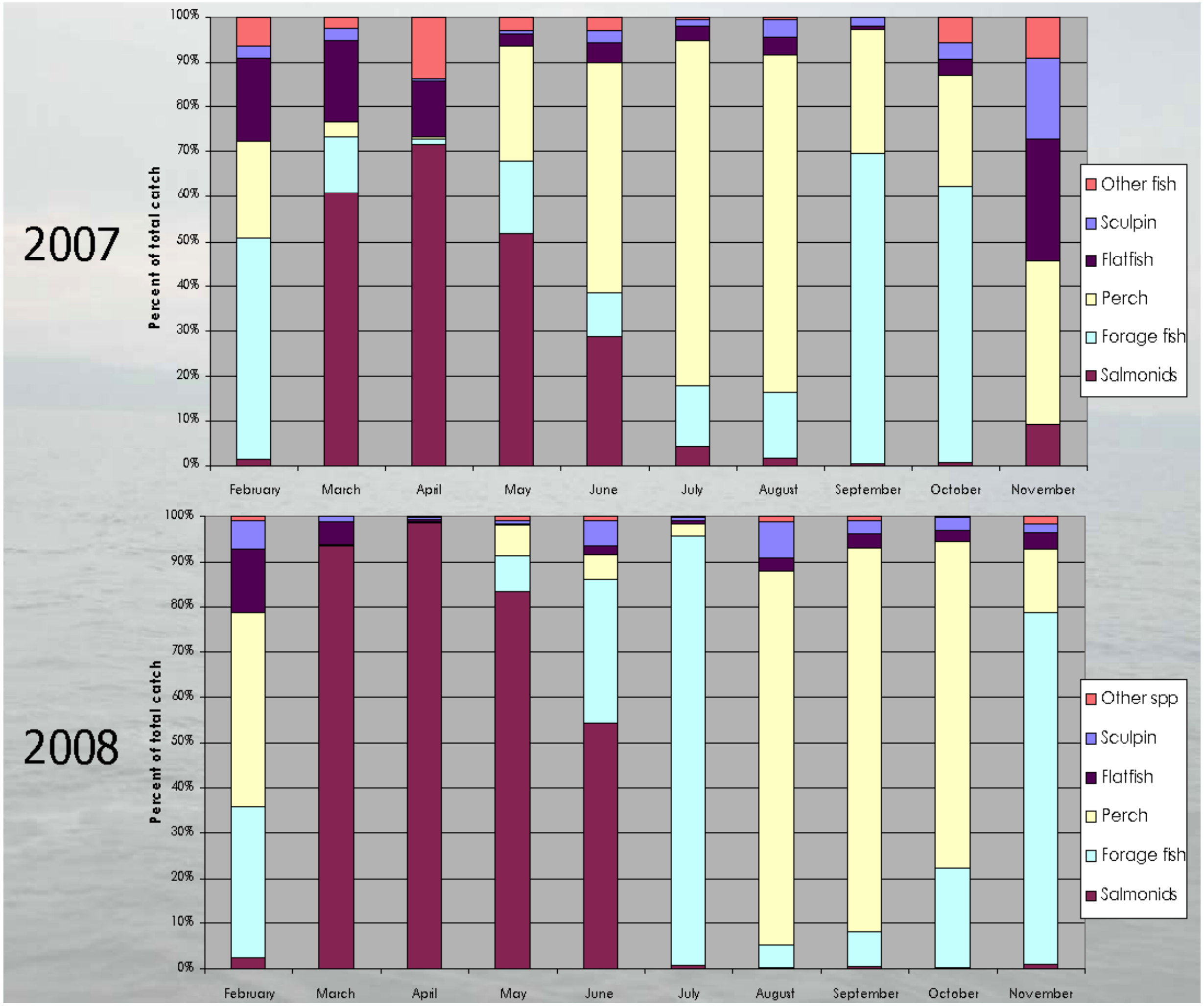
FIGURE 3-18
CATCH DURING NEARSHORE BEACH SEINE SAMPLING OCCURRING ON THE NORTHEAST SIDE OF THE KITSAP PENINSULA



	2007		2008
No. Fish	38,242	No. Fish	72,780
Species	45	Species	28
Sets	161	Sets	171

Source: Pers. comm., D. Small, WDFW, with G. Ruggerone, NRC, Inc., March 2009.

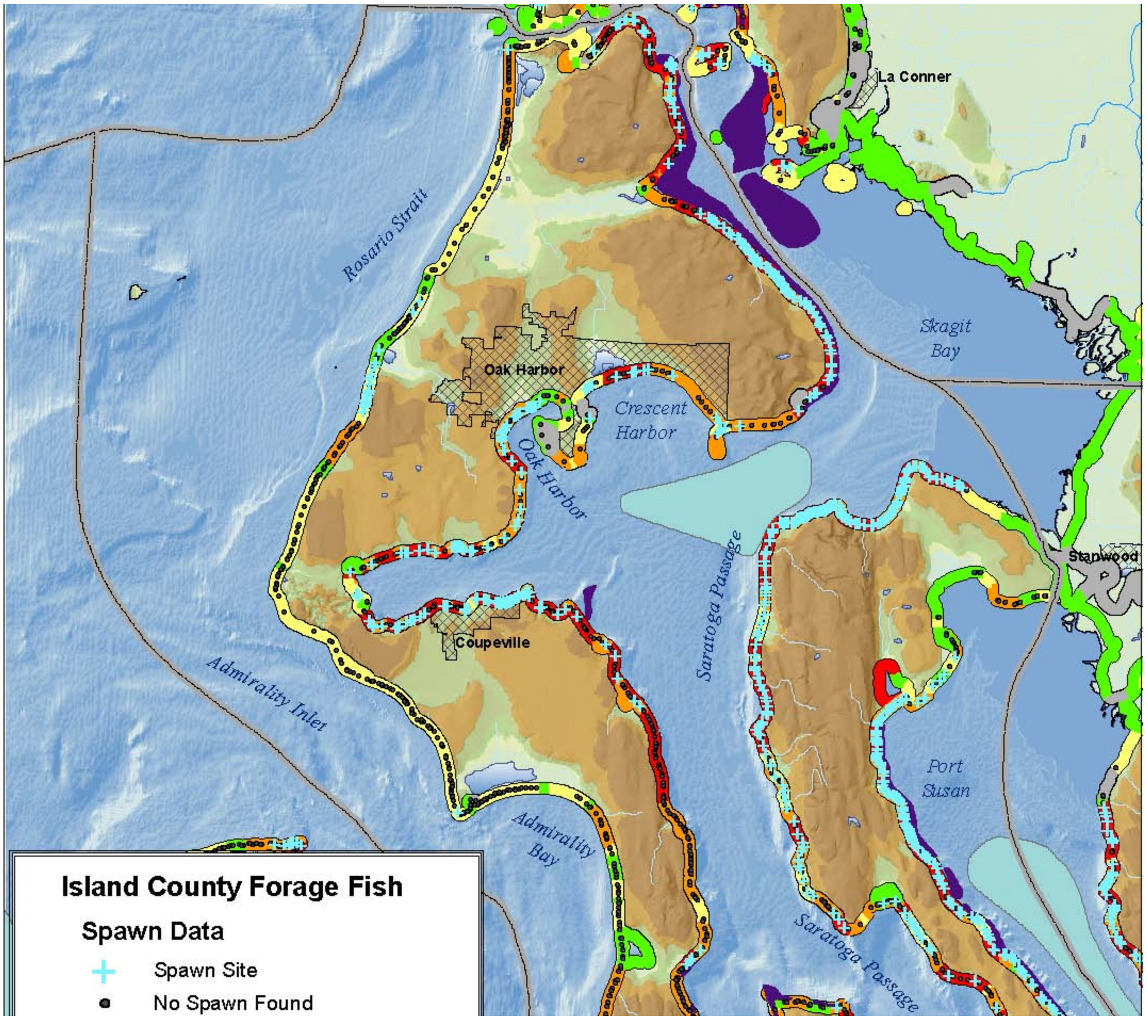
FIGURE 3-19
CATCH TIMING DURING NEARSHORE BEACH SEINE SAMPLING OCCURRING ON THE NORTHEAST SIDE OF THE KITSAP PENINSULA



Source: Pers. comm. D. Small, WDFW, with G. Ruggerone, NRC, Inc., March 2009.

The 2002 Northwest Straits Marine Conservation Initiative, Habitat Suitability Index estimated the suitability of the Puget Sound shoreline to support forage fish spawning. Figure 3-20 shows the HSI for forage fish for the Project Area. A shoreline having a score of greater than 30 is considered very likely to provide spawning habitat even though spawning may have been sampled but not observed at the location. The shoreline of the project area was classified as moderate (score of 11-30). No documented forage fish spawning has been identified near Admiralty Head (Penttila 2007), but forage fish could be present in areas where no spawning occurs.

FIGURE 3-20
HABITAT SUITABILITY INDICES FOR FORAGE FISH HABITAT FOR PROJECT AREA



Source: Northwest Straits 2008

The District conducted a series of mobile hydroacoustic surveys to provide additional baseline data on fish distribution in the Project area. The surveys were conducted during day and night and during times of slow and fast current.

Fish density values from the April 4-5 survey ranged between nominal density values of 0.5 to 2 fish per 100,000 m^3 of water throughout the survey area. There were no significant density differences observed as a function of day/night or current speed (Dawson and McClure 2009). Fish density values in the August survey were larger. The daytime mean fish density during fast current and slow current ranged between 3.3 and 7.8 fish and 2.7 and 7.2 fish per 10,000 m^3, respectively. At nighttime, mean fish density during fast current and slow current ranged between 2.7 and 14.4 fish and 2.0 and 4.9 fish per 100,000 m^3, respectively. These values are approximately 5 to 10 times higher than those observed in the April survey. Fish density appeared evenly distributed alongshore and offshore during daytime. At night, the fish were concentrated inshore when the current was fast and offshore when the current was slow (Dawson and McClure 2009).

As part of the ROV surveys conducted in August, late September, and early October 2010 to characterize the site-specific benthic habitat and community, a total of 192 fish were observed[10]. Ratfish was the most commonly observed species, representing 49 percent of the total count. The dominant presence of ratfish in the ROV surveys is consistent with the results from the 50 WDFW Admiralty Inlet trawls conducted from 1987 to 2008, where the most numerous species collected in Admiralty Inlet was ratfish (65 percent of the catch), as reported above. Sculpin was the most prominent benthic fish observed (38 percent of the fish observed), and other fish species observed included lingcod, kelp cod or kelp greenling, and Pacific sand lance (Greene 2010).

As part of a NOPP-funded project (National Ocean Partnership Program) to evaluate environmental effects of marine energy development, researchers from the University of Washington evaluated the effectiveness of hydroacoustic sonars to detect, classify, and identify marine animals. During May, 2011, three autonomous sonars (split beam, multi-beam, and acoustic camera) were deployed on the seabed in the Project area. A surface vessel deployed a mid-water trawl and multi-beam sonar to ground truth the duty-cycled measurements from bottom platforms. Data analysis is ongoing and may provide further information about patterns in site usage by aquatic species to structure post-installation monitoring (e.g., the Near-Turbine Monitoring plan discussed in Appendix A).

Marine Mammals

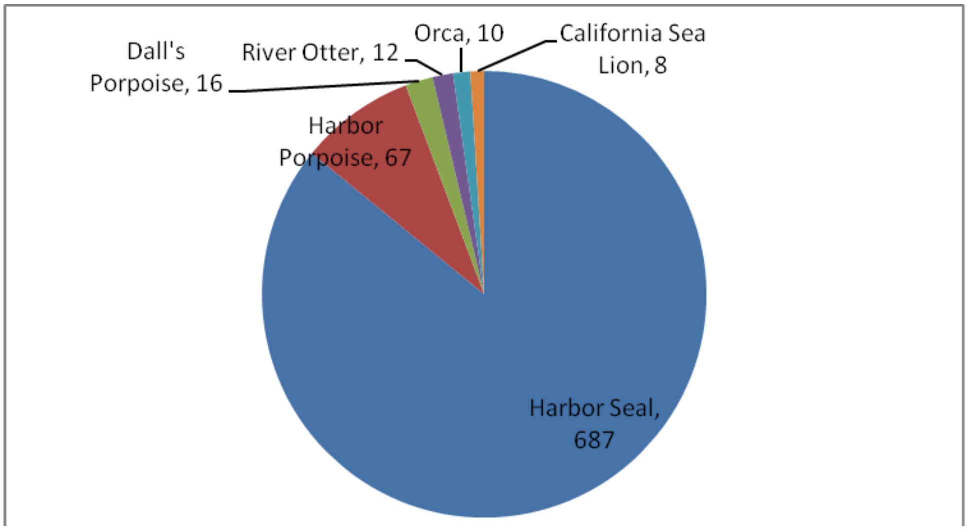
Marine mammals listed under the Endangered Species Act (ESA) are covered in the Biological Assessment (Appendix G). Non-ESA listed marine mammal species that are observed in central Puget Sound include harbor porpoise (*Phocoena phocoena*), Dall's porpoise (*Phocoenoides dalli*), Minke whale (*Balaenoptera acutorostrata*), gray whale (*Eschrichtius robustus*), California sea lion (*Zalophus californianus*), harbor seal (*Phoca vitulina*), and northern elephant seal (*Mirounga angustirostris*)[11]. Programs to document presence of marine mammals in Puget Sound include twelve years of vessel surveys conducted by the WDFW. These surveys were conducted basin-wide, and WDFW has compiled the results in a spatially rectified database. Harbor seals accounted for 687 sightings in Admiralty Inlet followed by harbor porpoise (67 sightings), Dall's porpoise (16 sightings), river otter (12 sightings), killer whale (10 sightings), and California sea lion (8 sightings) (WDFW 2006) (Figure 3-21).

---

[10] This count is a conservative estimate as many fish were seen several times. Fish were not counted when thought to be a repeat fish (Greene 2010).

[11] Northern fur seals typically occur offshore in Washington, though they occasionally visit the Juan de Fuca Strait, Puget Sound, and the Strait of Georgia, with one or two records per year (Calambokidis and Baird 1994).

FIGURE 3-21
MARINE MAMMAL SIGHTINGS WITHIN 0.4 KM (0.25 MILES) OF ADMIRALTY INLET FROM WDFW VESSEL SURVEYS (1992 TO 2004)



Source: WDFW 2006.

Harbor seal - Harbor seal is the most common, widely distributed pinniped found in Washington waters and represented 86 percent of the marine mammals observed by WDFW between 1992 and 2004 (Figure 3-21). Harbor seals use hundreds of sites along the coast to rest or haulout including intertidal sand bars and mudflats in estuaries, intertidal rocks and reefs, sandy, cobble, and rocky beaches, islands, logbooms, docks, and floats in all marine areas of the state. Jeffries et al. (2000) identified 13 harbor seal haulout locations in the Project area (Figure 3-22). In the Marrowstone Island vicinity, harbor seals have been sighted on haulouts on scattered intertidal rocks along the northeast and southeast side of the island. In the same vicinity, harbor seals have been noted along the beach and spit at the entrance into Kilisut Harbor. Northwest of the Project area, harbor seals utilize haulouts on Protection Island. These include on the beach and spit areas around Kanem Point and Violet Point. Both of these areas are also considered nursery areas for harbor seals and have peak counts during the pupping season (mid-June through August) and annual molt (late July through September). South of the Project area, harbor seals utilize intertidal shoals around Klas Rock and Colvos Rock as haulouts. North of the Project area, harbor seals utilize beaches and rocks on the north and south side along Smith Island as haulout areas as well as beaches along the north and south side of Minor Island (Jeffries et al. 2000).

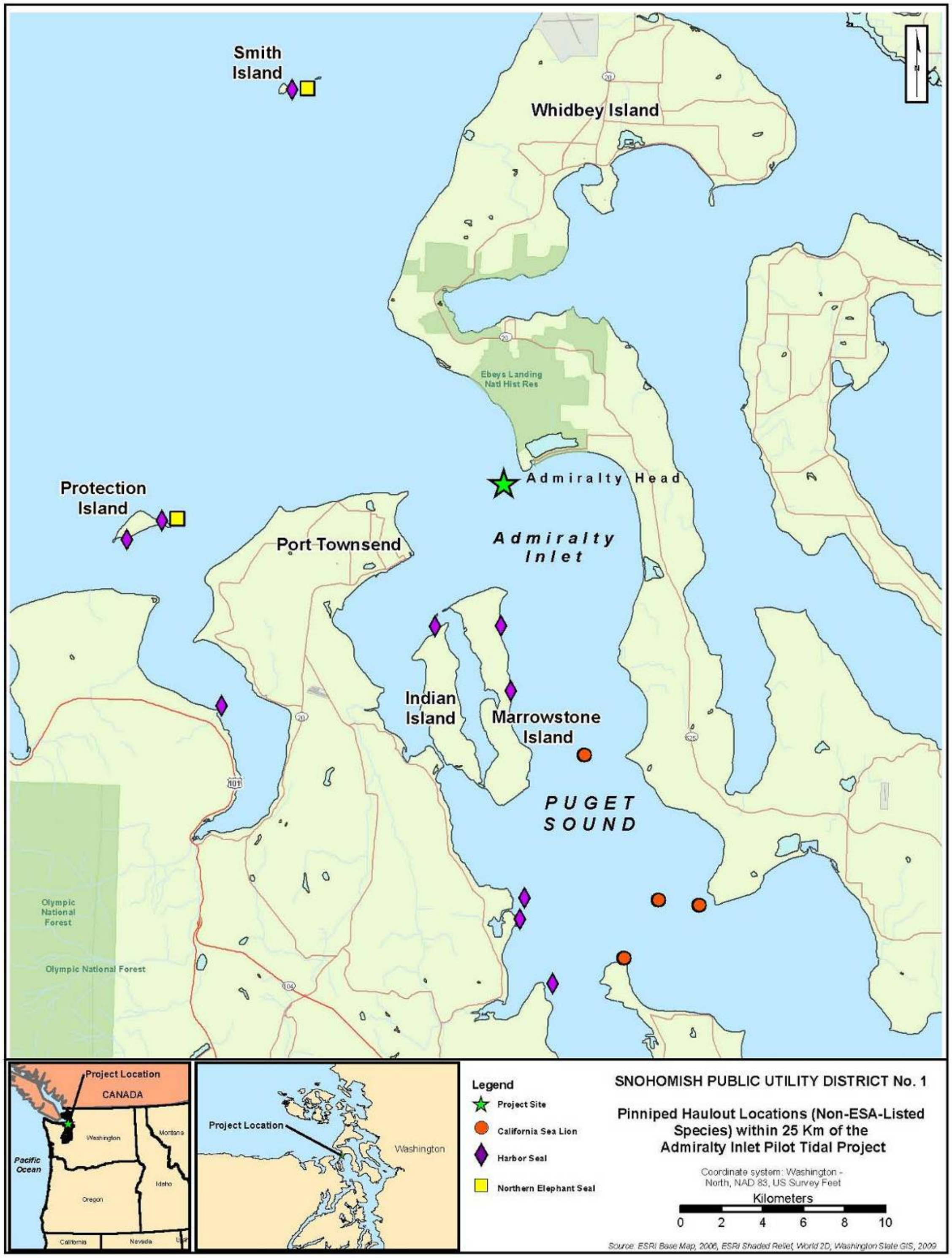
Between October 2009 and April 2010, marine mammal pre-installation field studies were conducted to collect information to characterize the existing marine mammal use within the Project vicinity. The field studies included land-based and boat-based observations of marine mammals in the study area (a five nautical mile radius around the proposed Project deployment site). Overall, 2,145 sighting locations were recorded of seven species. Harbor seals were observed most often, occurring on 95 percent of days and 49 percent of all sightings, with a total of 1,041 sightings recorded on 110 separate days. Median group size of harbor seal observations was one and the maximum group size was four. Sightings of harbor seals sometimes included observations of surface feeding behavior events (Tollit et al. 2010).

Harbor seals are generally non-migratory, and often move based on factors such as tides, weather, season, food availability, and reproduction. According to aerial surveys conducted during 1999 and radio-tagging studies from 1991-1992, the Washington inland water stock of harbor seals is estimated to be at a population of 14,612 (Jeffries et al. 2003). The population of the Washington inland water stock of harbor seals was estimated to be growing at an annual rate of 10 percent with a maximum net productivity rate of 12 percent; the harbor seal population is within its optimum sustainable population level (Carretta et al. 2006).

California sea lion - The California sea lion is found in Washington waters and utilizes haulout sites along the outer coast, Strait of Juan de Fuca, and in Puget Sound. In Admiralty Inlet, only eight California sea lions were observed during WDFW marine mammal surveys conducted between 1992 and 2004 (WDFW 2006) (Figure 3-21). During the marine mammal pre-installation field studies conducted between October 2009 and April 2010, 19 California sea lions were observed on 15 separate days. Medium group size observed was one and maximum group size was four (Tollit et al. 2010).

Similar to harbor seals, haulout sites are located on jetties, offshore rocks and islands, logbooms, marina docks, and navigation buoys. Four California sea lion haulout locations have been identified in Admiralty Inlet, all navigation buoys in the southern half of Admiralty Inlet (Figure 3-22) (Jeffries et al. 2000). California sea lions are frequently sighted resting in the water in groups within Puget Sound (Carretta et al. 2007). The California sea lion is a social species and can forms groups of several hundred individuals onshore at haulout locations. They typically use shallow coastal and estuarine waters (NOAA 2009*b*). The California sea lion population has been estimated at 238,000, which includes the range from southern Mexico to southwestern Canada (Carretta et al. 2007). Recent peak numbers of 3,000 to 5,000 California sea lions have been noted within northwest waters (Washington and British Columbia) during the fall until late spring when most return to breeding rookeries in California and Mexico. Peak counts of over 1,000 California sea lions have been recorded in Puget Sound in recent years (Jeffries et al. 2000).

FIGURE 3-22
PINNIPED HAULOUT LOCATIONS IN THE VICINITY OF THE ADMIRALTY INLET PILOT TIDAL PROJECT (NON-ESA LISTED SPECIES)



Source: Jefferies et al. 2000

Northern elephant seals - Northern elephant seals are the largest pinniped found in Washington waters. Breeding occurs at rookeries in California and Mexico. After the winter breeding season and annual molt cycles, they disperse to waters off Oregon and Washington and beyond. Males travel to the Gulf of Alaska to feed and females feed in deep offshore waters from southern California to northern Oregon (between 35° and 45° N) (Jeffries et al. 2000). Northern elephant seals spend much of the year in the ocean diving to depths of about 1,000 to 2,500 feet. However, while on land, northern elephant seals prefer haulouts on sandy beaches (NOAA 2009*c*). Two northern elephant seal haulouts, Protection Island and Minor Islands, have been identified in the Project area, where individuals have been seen hauled out at beaches (Figure 3-22). Pups have also been occasionally observed at these sites as well. Recent northern elephant seal counts have been recorded in excess of 100,000 animals in northwest waters (Jeffries et al. 2000).

Harbor porpoise - Harbor porpoise are found in coastal and inland waters extending from the Alaskan coast down to Point Conception, California. The species occurs year-round in the inland trans-boundary waters of Washington and British Columbia and along the Oregon and Washington coast. Harbor porpoises are relatively common and can be observed in the region year-round (Calambokidis and Baird 1994). Densities of 1-1.5 animals/km^2 are reported in the region, with selection of habitat with high current speeds noted and abundances higher in the summer months (Hall 2004). While seasonal changes in abundance along the west coast have been noted, movement patterns are not fully understood. From aerial surveys of inland waters of Washington conducted during August 2002 and 2003, the harbor porpoise population was estimated to be 10,682. In Admiralty Inlet, 67 harbor porpoise were observed during WDFW marine mammals surveys conducted between 1992 and 2004 (WDFW 2006) (Figure 3-21).

As part of the District's pre-installation studies, a multi-year study was conducted in the northeastern area of Admiralty Inlet to investigate the acoustic activity of porpoises logged by PODs - passive acoustic monitoring hydrophones used to collect high frequency cetacean echolocations. The study information was evaluated to characterize site use and investigate typical patterns of porpoises. However, it is important to note that PODs only record porpoises that are actively echolocating and range is likely to vary depending on direction of travel and to what directional extent clicks are produced off-axis[12]. T-PODs log continuously 24 hours a day and have a detection radius up to approximately 300 meters, with a detection function equivalent to 100 percent detection within approximately a 70-100 meter radius (Tougaard et al. 2006).

Between May 2009 and May 2010, four POD deployments were conducted using a T-POD. During the study, the PODs were attached laterally to a Sea Spider, which was then lowered to the sea floor. Data was logged over a period of 321 full days from a single T-POD moored at four locations in 51-62 meters water depth. The T-POD only detected porpoises; there were no detections on the 50 kHz scan channel set to detect dolphin echolocations (Tollit et al. 2010).

Porpoises were detected by the T-POD every day of the 321 day study period, with detections logged 16 individual hours of each day and averaging 130 detection positive minutes (DPM) per

---

[12] The PODs cannot discern between harbor and Dall's porpoise, and they do not provide a count of the number of porpoises.

day, which represents on average nine percent of a day. More than one third of all hours had no detectable porpoise click trains (e.g., DPM per hour = 0) and in 11.2 percent of hours recorded, DPM per hour exceeded 15. The median value was two minutes per hour, DPM per hour between night and day periods were found to be highly significant, with DPM median values during the night period five-fold than that of during the day period. Highs in DPM occurred around midnight, while lows occurred around midday. Further evaluation of the study indicates that echolocation use by porpoises in Admiralty Inlet is highest at night, especially during neap tides. Neap tides in Admiralty Inlet may also provide improved foraging conditions due to increased availability of prey aggregations or water clarity and/or potentially reduced energetic demands during foraging trips. The study also indicated monthly variation in click detections with clear lows (DPM) in April and August and a clear peak in June (Tollit et al. 2010).

Land-based studies that took place between October 2009 and April 2010, found that porpoises were present on average 63 percent of the 116 days, and 56 percent of every hour, monitored (n=231 hours) (Tollit et al. 2010). This appears to be consistent with data collected the POD that had DPM in 51 percent of all daylight hours recorded.

Porpoise ‘encounters’ per day ranged between 30 and 48. Encounters (and DPM rates) may represent either multiple individuals or the same individual repeatedly. Typical group sizes in daylight periods were between two and six in land-based observer studies in the area (Tollit et al. 2010). This study also clearly documented that between October 2009 and April 2010, all porpoise sightings in the vicinity of the Project site that were confidently confirmed to species were harbor porpoises (Tollit et al., 2010).

Since November, 2009, Sea Spider deployments have also included C-PODs. These are the successor to the T-POD and, whereas a T-POD uses analog electronics, the C-POD records click trains digitally for post-processing to classify click trains (sonar, sediment motion, echolocation). Because of their relatively recent development, C-PODs are not discussed to a great extent in the literature, but have provided further information about harbor porpoise trends at this site and the potential to use these tools for post-installation monitoring. Generalized Linear Model (GLM) analysis of long-term C-POD identifies, among other factors, time of day, ambient noise level, tidal current velocity, and season as significant in explaining echolocation activity. However, the residual deviance in the model (detections unexplained by the model) is still quite high suggesting that activity is somewhat stochastic or driven by other factors not measured by Sea Spider instrumentation (e.g., prey density) (Cavagnaro et al., 2012).

Notably, both C-POD and T-POD data indicate harbor porpoise activity at this location is significantly higher than at other locations were tidal energy devices have been deployed (personal communication, Dom Tollit, June 2011), suggesting that harbor porpoise may serve as an effective marker species for understanding the effects that turbine operation may have on marine mammals. This is tempered by a study by Polagye et al. (2012*b*) that monitored harbor porpoise responsiveness to passenger ferries using C-PODs and concluded that no significant changes in harbor porpoise echolocation activity could be correlated with elevated noise levels from ferry passage, despite an expected pronounced avoidance response when broadboand sound pressure levels exceed 140 dB re 1µPa (e.g., Southall et al., 2007). Turbine noise will only rarely reach the same intensity as ferry noise (further discussion later in this section). Results suggest that harbor porpoise in Admiralty Inlet may be habituated to relatively high levels of anthropogenic noise due to omnipresent shipping traffic (Bassett et al., 2012*a*).

Dall's porpoise - Dall's porpoise are common in shelf, slope, and offshore waters along California, Oregon, and Washington. The species prefers temperate waters that are more than 600 feet deep with temperatures between 36˚F and 63˚F (NOAA 2009*d*). North-south movement along the coast is based on changes in oceanographic conditions and seasonality. Dall's porpoise often travel in groups averaging between 2 and 20 individuals, but have also been seen in larger groups. The distribution of Dall's porpoise throughout the California, Oregon, and Washington region varies yearly due to oceanographic conditions. The most recent population estimate of Dall's porpoise for the west coast region is 48,376. An estimate of population for the inland waters of Washington State is not available (Carretta et al. 2008*a*). In Admiralty Inlet, 16 Dall's porpoise were observed during WDFW marine mammals surveys conducted between 1992 and 2004 (WDFW 2006) (Figure 3-21). During the marine mammal pre-installation studies conducted between October 2009 and April 2010, a probable Dall's porpoises was detected only once during the T-POD study (Tollit et al., 2010). C-POD auto-detection algorithms are, as yet, unable to discriminate between echolocation by Dall's porpoise and harbor porpoise.

Minke whale - The minke whale stock within the inland waters of Washington establishes home ranges and does not migrate like other stocks (Carretta et al. 2008*b*). Minke whales prefer temperate waters within coastal/inshore and oceanic/offshore areas and often feed in cooler waters (NOAA 2009*e*). There is no estimated population size for minke whales and there are no data or trends related to minke whale abundance in inland Washington waters (Carretta et al. 2008*b*). No minke whales were observed in Admiralty Inlet during WDFW marine mammals surveys conducted between 1992 and 2004 (WDFW 2006). However, two minke whale observations were documented in Admiralty Inlet from recreational land-based surveys conducted by the public during 2005 and 2006: one in March 2005 and one in September 2006 (OrcaNetwork 2007). During the marine mammal pre-installation studies conducted between October 2009 and April 2010, four minke whales were sighted on two separate days. During each observation of minke whale, only one (lone whale) was observed (Tollit et al. 2010).

Gray whale - Gray whales make one of the longest migrations of any mammal between their winter breeding grounds off Baja California, Mexico and their feeding grounds in the Bering and Chukchi Seas and are found mainly in shallow coastal waters. Migration of gray whales along the Pacific northwest coast occur in December and January (southbound) and in the spring (northbound). Gray whales have also been identified outside of the migratory time periods along California, Oregon, Washington, and British Columbia and are referred to as "seasonal residents" or the Pacific Coast Feeding Aggregation whales by NMFS. Gray whales are frequently observed traveling alone or in small groups; however, in feeding and breeding grounds are often found in larger groups. Gray whales are occasionally observed in Puget Sound; Table 3-15 presents sighting information of gray whales documented during a study of gray whales by eight collaborating organizations conducted between March and November 1998 (Calambokidis et al. 2002). The research shows that gray whales using Puget Sound are the same few individuals returning to the same locations and usually in the springtime (Pers. comm. Jason Wood, Whale Museum).

TABLE 3-15
IDENTIFICATION OF GRAY WHALES IN PUGET SOUND DURING 1998 STUDY (CALAMBOKIDIS ET AL. 2002)

Region	IDs	Unique IDs	Dates
East of Cape Flattery extending to Admiralty Inlet	35	15	August to November
Inside waters and embayments from Edmonds to the Canadian border	27	6	March to May
Central and southern Puget Sounds (south of Edmonds) and Hood Canal	6	4	March to November

Gray whales were also observed in Admiralty Inlet during the public recreational land-based surveys conducted during 2005 and 2006 (OrcaNetwork 2007):

- 2005
  - March - 4 sightings
  - April - 2 sightings
  - May - 2 sightings
- 2006
  - January - 1 sighting
  - March - 1 sighting
  - October - 1 sighting

Seabirds

Shorebird and seabird observational data from WDFW vessel surveys are available from 1992 through 2004 (Table 3-16). These data were processed in GIS to evaluate birds sighted within 0.4 kilometers (0.25 miles) of Admiralty Inlet. Sightings in Admiralty Inlet included 55,590 sightings birds representing 57 species. WDFW also maintains records for seabird colonies in the vicinity of Admiralty Inlet and has identified colonies of the following: alcids, cormorants, and “other” species.

TABLE 3-16
SHORE AND SEABIRD SIGHTINGS WITHIN 0.4 KM (0.25 MILES) OF ADMIRALTY INLET FROM WDFW VESSEL SURVEYS (1992 TO 2004)

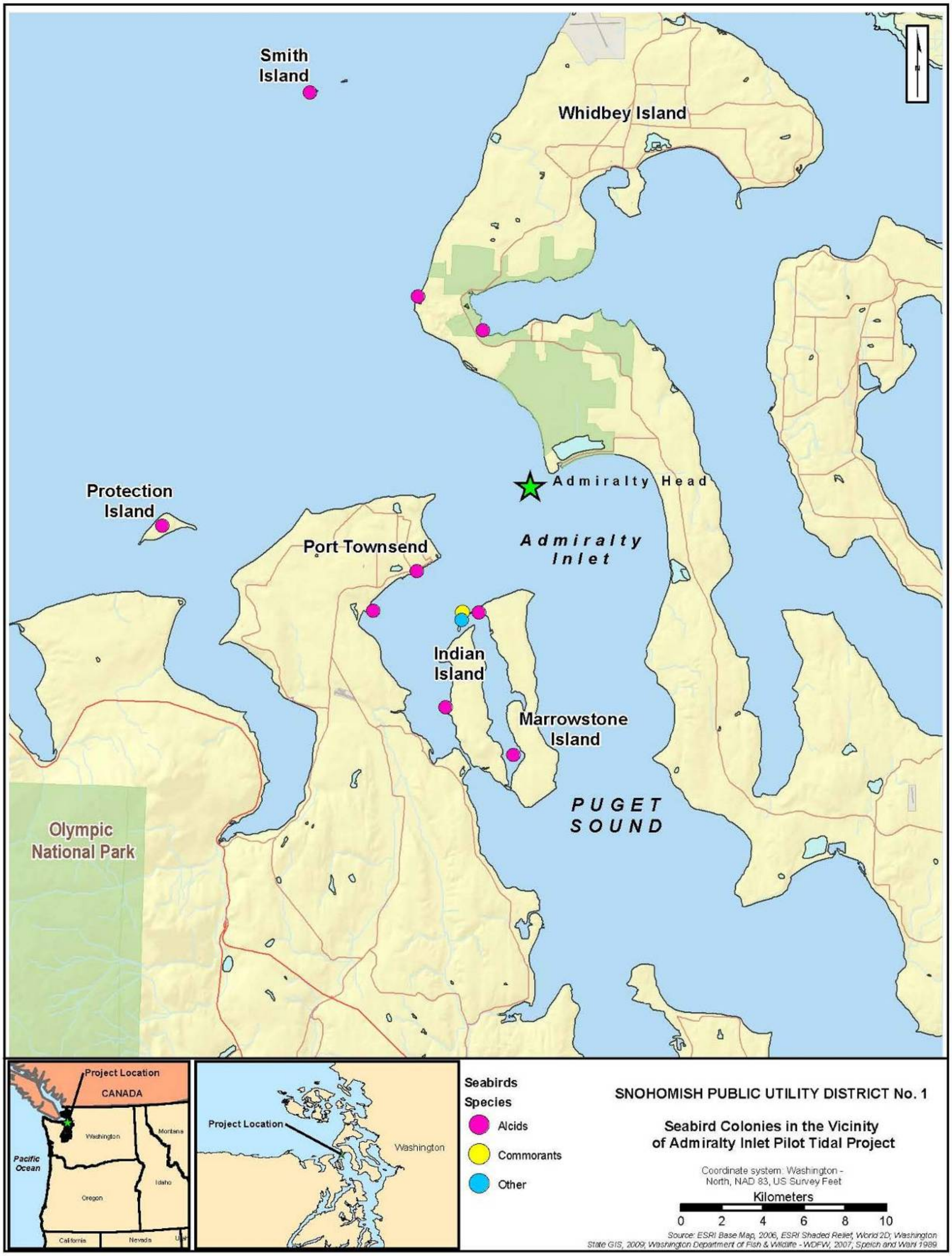
Species	Number	Species	Number
American wigeon	2,698	Heermann's gull	3,853
Ancient murrelet	152	Herring gull	386
Bald eagle	83	Hooded merganser	183
Barrows goldeneye	67	Horned grebe	408
Belted kingfisher	38	Killdeer	2
Black brant	1,635	Mallard	889
Black oystercatcher	8	Marbled murrelet	250
Black scoter	258	Mew gull	432
Black turnstone	8	Northern pintail	444

Species	Number	Species	Number
Black-bellied plover	20	Northwestern crow	930
Bonapartes gull	1,879	Oldsquaw	398
Brandts cormorant	10	Osprey	3
Bufflehead	9,455	Pacific loon	502
California gull	99	Pelagic cormorant	98
Canada goose	35	Pigeon guillemot	1,897
Canvasback	25	Red-breasted merganser	815
Caspian tern	74	Red-necked grebe	318
Common goldeneye	662	Red-tailed hawk	4
Common loon	240	Red-throated loon	143
Common merganser	124	Rhinoceros auklet	5,177
Common murre	6,062	Rock dove	1
Double-crested cormorant	789	Ruddy duck	166
Dunlin	200	Sanderling	5
Gadwall	77	Surf scoter	2,748
Glaucous-winged gull	4,713	Tufted puffin	1
Great blue heron	419	Western grebe	3,129
Greater scaup	121	Whimbrel	1
Green-winged teal	141	White-winged scoter	1,198
Harlequin duck	1,117		
Species Total			***57***
Observational Total			***55,590***

Source: Seamap 1992

Figure 3-23 shows the location of seabird colonies near the Project area. Of note, rhinoceros auklets (*Cerorhinca monocerata*) nest at only two sites in the inland marine waters of Washington: about 34,000 birds nest on Protection Island (Wilson 1977, Thompson et al. 1985), and about 2,600 birds nest on Smith Island (Speich and Wahl 1989), located approximately 18 km and 22 km north of the Project area, respectively. The colony of Rhinoceros Auklets on Protection Island is considered the third largest colony in North America (Pers. comm. C. Collar, District, with Sue Thomas, USFWS, August 27, 2009). From studies performed in the late 1970s it was found that Admiralty Inlet was a major foraging area for the auklets, with foraging occurring mostly in the western part of the Inlet near Port Townsend (Wahl and Speich 1994). Marbled murrelets are discussed in the draft BA (Appendix G).

FIGURE 3-23
LOCATION OF SEABIRD COLONIES NEAR THE PROJECT AREA



State Special-Status Aquatic Life

Based on WDFW Priority Habitats and Species (PHS) and Wildlife Heritage data, Washington GAP occurrence data, NOAA listings, and information on species habitat requirements, a number of special-status marine species (state-listed species) could potentially occur in the vicinity of Admiralty Inlet (Table 3-17). Species listed under the ESA (federally listed species) are further described in the draft BA (Appendix G).

TABLE 3-17
SPECIAL-STATUS MARINE LIFE KNOWN TO OCCUR OR POTENTIALLY OCCURRING IN THE ADMIRALTY INLET VICINITY

Common Name	Scientific Name	State Status	Federal Status	Habitat Requirements
River lamprey	*Lampetra ayresi*	SC	FCo	Early lifestages rear in freshwater. Parasitic adults feed in marine water
Pacific herring (Georgia Basin DPS)	*Clupea pallasi*	SC	None	Young found in shallow, vegetated areas in the intertidal and subtidal zones. Developed young and adults found in pelagic waters
Chinook salmon (Puget Sound)	*Oncorhynchus tshawytscha*	SC	FT	Spawning occurs in freshwater streams. Smolts, juveniles, and adults rear in nearshore habitat and pelagic marine water.
Steelhead (Puget Sound)	*Oncorhynchus mykiss*	none	FT	Spawning occurs in freshwater streams. Smolts, juveniles, and adults rear in nearshore and pelagic marine waters.
Bull trout (Coastal/Puget Sound)	*Salvelinus confluentus*	SC	FT	Spawning occurs in freshwater streams. Juveniles and adults rear primarily in nearshore habitat and some pelagic marine waters.
Eulachon (southern DPS)	*Thaleichthys pacificus*	SC	FT	Spawning occurs in freshwater streams. Young are quickly swept to estuary and pelagic water. Young and adults reside in pelagic marine waters
Pacific cod (Puget Sound)	*Gadus macrocephalus*	SC	FCo	Eggs are demersal and found sublittorally. Larvae and small juveniles are pelagic; large juveniles and adults are parademersal
Pacific hake (Puget Sound)	*Merluccius productus*	SC	FCo	Eggs and larvae of the coastal stock are pelagic in 40-140 m of water; adults are epi-mesopelagic
Walleye pollock (South Puget Sound)	*Theragra chalcogramma*	SC	FCo	Midwater to bottom-dwelling fish, living anywhere between shallow, nearshore waters to 1000 m. Most occur between 100-300 m depth.
Brown rockfish	*Sebastes auriculatus*	SC	FCo	Common in waters less than 53 m and the young are widely distributed in shallow water bays.
Copper rockfish	*Sebastes caurinus*	SC	FCo	Young are pelagic and associated with surface waters. Adults occur in nearshore waters from the surface to 183 m in depth.
Greenstriped rockfish	*Sebastes elongatus*	SC	None	Young found in 60-100 m depths. Adults generally reside in deepwater from 52-828 m, but can move inshore.
Widow rockfish	*Sebastes entomelas*	SC	none	Larvae are neritic and epipelagic, occurring from near surface to 20 m deep. Adults are sublittoral to bathyal from depths of 24-549 m.

Common Name	Scientific Name	State Status	Federal Status	Habitat Requirements
Yellowtail rockfish	*Sebastes flavidus*	SC	none	Yellowtail rockfish is a common species that is most abundant over the middle shelf. They are most common near the bottom, but not on the bottom. They are found generally 24+ km offshore
Quillback rockfish	*Sebastes maliger*	SC	FCo	Young quillback rockfish occur along the shores at depths less than 60 m and adults usually in deeper waters to 140 m.
Black rockfish	*Sebastes melanops*	SC	none	Black rockfish occur from the surface to 366 m, but are most common at depths shallower than 55 m. Off Oregon, they are most common in waters from 12 to 90 m.
China rockfish	*Sebastes nebulosus*	SC	none	China rockfish occur both inshore and along the open coast from 3 to 128 m. They are most commonly found in waters between 18 and 92 m. The juveniles are pelagic, but the adults are sedentary, associated with rocky reefs or cobble.
Tiger rockfish	*Sebastes nigrocinctus*	SC	none	Tiger rockfish are generally found in waters less than 30 m in Puget Sound. Juveniles are found near surface around floating plant matter. Adults are found near reefs and undersea caves.
Bocaccio (Georgia Basin DPS)	*Sebastes paucispinis*	SC	FE	Nearshore and offshore species commonly found from 50 to 250 m depths. Categorized as a middle shelf-mesobenthal species.
Canary rockfish (Georgia Basin DPS)	*Sebastes pinniger*	SC	FE	Middle shelf-mesobenthal species. Young start in shallow water and move to greater depths with age. Depth range is from shallow to 425 m of depth.
Redstripe rockfish	*Sebastes proriger*	SC	none	Inhabit the outer shelf and upper slope. Reported between 12 and 425 m in depth, but are most common (95%) between 150 and 275 m.
Yelloweye rockfish (Georgia Basin DPS)	*Sebastes ruberrimus*	SC	FE	Middle shelf-mesobenthal species. Occur in water 25-475 m deep; they most commonly occur at depths from 91 to 180 m.
Leatherback sea turtle	*Dermochelys coriacea*	SE	FE	Young born on southern beach habitat. Maturing young adults reside in pelagic marine waters.
Green sea turtle	*Chelonia mydas*	ST	FT	Young born on southern beach habitat. Maturing young adults reside in pelagic marine waters.
Loggerhead sea turtle	*Caretta caretta*	ST	FT	Young born on southern beach habitat. Maturing young adults reside in pelagic marine waters.
Common loon	*Gavia immer*	SS	none	Spend breeding season on large secluded lakes, deep inlets and bays, and near a good supply of small fish. In winter, they are usually found on salt water, but occasionally on fresh water. WDFW records for Deception Pass.
Western grebe	*Aechmophorus occidentalis*	SC	none	In winter they are found mostly on saltwater bays. During breeding season they are found on freshwater wetlands with a mix of open water and emergent vegetation.

Common Name	Scientific Name	State Status	Federal Status	Habitat Requirements
Brown pelican	*Pelecanus occidentalis*	SE	Delisted	Nest on islands off the coasts of southern California and Mexico. After the breeding season, they move north along the coast, frequenting shallow marine areas such as bays, offshore islands, spits, breakwaters, and open sandy beaches.
Brandt's cormorant	*Phalacrocorax penicillatus*	SC	none	Almost always found on salt or brackish water, they inhabit rocky shorelines and open ocean. Nesting colonies are typically on slopes and occasionally on steep cliffs.
Common murre	*Uria aalge*	SC	none	Most colonies in Washington are located on sea stacks and flat-topped islands. They are found closer to rocky shorelines during the breeding season, and farther offshore during the non-breeding season.
Marbled murrelet	*Brachyramphus marmoratus*	ST	FT	Marbled Murrelets inhabit calm, shallow, coastal waters and bays, but breed inland, up to 70 km from shore, in mature, wet forest.
Cassin's auklet	*Ptychoramphus aleuticus*	SC	FCo	When breeding, they come inland and nest on islands. In the non-breeding season, they are found in the open ocean, at the outer edge of the continental shelf.
Tufted puffin	*Fratercula cirrhata*	SC	FCo	They can be found in many coastal habitats adjacent to the northern Pacific coast, with the exception of estuaries. They breed in colonies on islands with steep, grassy slopes or on cliff tops. Winter habitat is well offshore, in mid-ocean.
Sea otter	*Enhydra lutris*	SE	FCo	Live in coastal waters usually within 2 km of shore, especially shallows with kelp beds and abundant shellfish.
Gray whale	*Eschrichtius robustus*	SS	none	Eastern north Pacific stock migrates from Alaska to Mexico. Uses marine near shore pelagic, and estuarine bay/sound, lagoon habitats. Lives mainly in coastal and shallow shelf waters. Young are born in lagoons and bays in southern range.
Sei whale	*Balaenoptera borealis*	SE	FE	Generally found in deep water, along edge of continental shelf and in open ocean. Migrates between lower-latitude wintering grounds and higher-latitude feeding grounds.
Fin whale	*Balaenoptera physalus*	SE	FE	Pelagic, usually found in largest numbers 40 km or more from shore. Migrates seasonally to colder high-latitude waters for summer feeding, to warmer lower-latitude waters for winter breeding. Young are born in the warmer waters of the lower latitudes.
Blue whale	*Balaenoptera musculus*	SE	FE	Mainly pelagic, generally prefers cold waters and open seas, but young are born in warmer waters of lower latitudes.
Humpback whale	*Megaptera novaeangliae*	SE	FE	Pelagic and coastal waters, sometimes frequenting inshore areas such as bays. Winters largely in tropical/subtropical waters near islands or coasts, summers in temperate and subpolar waters.

Common Name	Scientific Name	State Status	Federal Status	Habitat Requirements
Killer whale	*Orcinus orca*	SE	FE	Mainly in coastal waters, but may occur anywhere in all oceans and major seas at any time of year.
Harbor porpoise	*Phocoena phocoena*	SC	none	Coastal waters and adjacent offshore shallows, also inhabits inshore areas such as bays, channels, and rivers. Mothers and young tend to move into sheltered coves and similar sites soon after parturition.
Sperm whale	*Physeter macrocephalus*	SE	FE	Pelagic, prefers deep water, sometimes around islands or in shallow shelf waters. Seasonal north-south migration, from higher latitudes in summer to lower in winter.
Steller sea lion	*Eumetopias jubatus*	ST	FT	Marine habitats include coastal waters near shore and over the continental slope, sometimes rivers are ascended in pursuit of prey. Terrestrial habitats consist of a variety of shoreline types.

State Status: SC- State Candidate, SE- State Endangered.
Federal Status: FCo- Federal Species of Concern, FC- Federal Candidate, FT- Federal Threatened, FPT- Federally Proposed Threatened, FPE- Federally Proposed Endangered, FE- Federal Endangered.

WDFW datasets include its PHS and Wildlife Heritage databases, which include digital records of important wildlife habitats and sensitive and other wildlife occurrences in Admiralty Inlet. PHS and Wildlife Heritage database records in the vicinity of Admiralty Inlet include the following for marine resources:

- Harbor seal
- Pacific lamprey
- Seabird concentrations
- Shorebird concentrations
- Surf scoter

3.3.2.2 Environmental Effects

The District has consulted with state and federal agencies, tribes, and other stakeholders, in support of development of this license application. Through this process, the District has identified the following potential effects of deploying and operating the project on marine resources:

- Changes to hydrodynamics
- Effects to water quality
- Blade strike
- Habitat alteration (effects of placement of project components and creation of "new" habitat features [hard structure in water column and benthic habitats]) resulting in the following potential environmental effects
    - Construction impacts (from construction and placement of project components on the seabed)
    - Changes to marine community composition (use patterns, attraction, aversion)
- Marine debris entanglement
- Noise/vibration

- Electromagnetic fields

A discussion of each of these issues is presented below.

Changes to Hydrodynamics

The proposed Project will generate electricity from extracting power from the kinetic energy in the tidal currents and converting it to electrical power. The OpenHydro turbines will remove energy from the water as it flows past the rotor, resulting in a decrease in water velocity on the downstream side. Significant changes to the hydrodynamic properties in the Project area have the potential to affect water resources, including circulation, water quality, sediment transport, and erosion and accretion.

Stakeholders raised the potential for hydrodynamic effects from the project as a concern (e.g., NMFS letters to the District dated July 6, 2009 and December 8, 2008, and various stakeholder meetings), and requested that the District evaluate the effects. To address this concern, NNMREC conducted a modeling effort to evaluate the potential hydrodynamic effects of the Admiralty Inlet Project (Polagye et al., 2009).

Our Analysis

Admiralty Inlet is a constricted channel in Puget Sound, and therefore by its nature, experiences strong tidal currents and significant vertical mixing. Polagye et al., 2009 modeled the effects of energy removal by tidal turbines on Puget Sound for turbine arrays in Admiralty Inlet and Tacoma Narrows. From model results, it was concluded that "The far-field effects of extraction from an array this size [pilot-scale, 300 kW average power generation] would have an immeasurably small effect on the tidal regime of Puget Sound… Any detectable effects should be confined to near-field flow variations in the immediate vicinity of the devices" (Polagye et al., 2009). The expected minor flow variations only in the immediate vicinity of the turbines do not represent a significant effect to either the tidal flow in the project area (near or far field) or the marine environment.

Effects on Water Quality

Potential effects of the project on water quality include the following:

- Spills during construction and operation and maintenance,
- Fluid leakage from project components, and
- Leachate from antifouling paint.

During the construction and maintenance of the Project, a number of vessels, including tugs, a deployment barge, and other workboats will be employed. These vessels contain fuel, hydraulic fluid, and other potentially hazardous materials. Concerns have been raised that a spill of such materials could negatively affect the environment. Antifouling paint can have negative effects on non-target marine biota.

Resource agencies have identified these topics to be of concern (e.g., the following letters to the District: NMFS letters dated July 6 and 23, 2009 and December 8, 2008; WDFW letter dated

June 16, 2009, Washington Dept. of Ecology letter dated March 9, 2009, and the Suquamish Tribe letter dated March 8, 2009).

The District proposes to minimize project effects to water quality by incorporating the following actions:

- Spills - require that all contractors have spill response plans and their own insurance;
- Fluid leakage – The turbines contain no oils or lubricants that could potentially leak to the aquatic environment. Electrical components associated with the turbines will either be “potted” units containing no fluid, or will be located on land; and
- Antifouling paint - minimize use of antifouling paint - only the turbine blades and outer rotor ring only will require antifouling paint (non-flaking paint will be used).

Our Analysis

Spills - In addition to the tugs, the only fuels and oils used during deployment are those required in order to power the electrical systems and the winches on the installation barge, a special-use vessel designed to install OpenHydro turbines. These are marine grade hydraulic oil and diesel fuel. Each power unit currently has a 300 liter diesel tank and 350 liter hydraulic oil tank. These tanks have full secondary containment with a total capacity of 1,033 liters, giving an excess capacity of 383 liters. The degree of secondary containment is designed to minimize the risk of hydrocarbon spillage. Figure 3-24 illustrates the secondary containment for the winch power packs currently installed on the installation barge.

FIGURE 3-24
HPU SECONDARY CONTAINMENT BELOW WINCH ON THE INSTALLATION BARGE

The marine construction and maintenance contractors that the District contracts (e.g., tug operators) will be licensed and the District will require that they have spill response plans and their own insurance. OpenHydro is experienced in deploying its units, with recent deployments occurring at the EMEC site in Scotland and the Bay of Fundy site in Nova Scotia. As occurred at these sites, the District believes that the Project can be deployed with safeguards to minimize the effects of spills in the unlikely event that one occurs.

Vessel presence and the length of installation time will be minimized by the OpenHydro turbine design and deployment methodology. The deployment method developed by OpenHydro eliminates the need for drilling or piling operations, therefore significantly reducing the time required for installation. The gravity base design allows for rapid installation and facilitates the ease of potential relocation and removal/decommissioning of the turbines. It is expected that each turbine will be deployed within one tidal cycle (less than 6 hours). For a description of the installation practices refer to Section 2.2.1 Proposed Project Facilities. The short time required for deployment and the precautions taken to prevent and respond to any accidental spills in a high tidal velocity area minimizes potential effects to water quality.

<u>Fluid leakage</u> - The turbines have no oils or lubricants that could potentially contaminate the environment. Electrical components including transformers and surge protectors will either be “potted” dry units or will be located on land. No fluid-filled electrical components will be

located underwater. This will eliminate the risk of adverse effects to the aquatic environment due to leaking electrical components.

Antifouling paint - Biofouling is not considered to be an operational issue for the OpenHydro unit based on previous deployment experience. A double layer of antifouling paint will be applied to the turbine blades and the rotor outer ring only, representing a total surface area of approximately 95 m^2 per turbine.

Antifouling paint will be applied to the above components prior to shipping or deployment of the turbines, well in advance of the turbine entering the marine environment. All coatings and paints will be fully approved for use in the marine environment.

The painting process for the turbine includes the following steps:

- All GRP surfaces are abraded using a specific sequence of sanding pads;
- Etch primer is applied to all surfaces which allows for chemical impregnation of GRP and creating a suitable surface for the application of anti-fouling paint. This minimizes the quantity of anti-fouling paint required;
- A double coat of surfacing primer is applied to the turbine, which both levels the surface of the turbine and allows for the anti-fouling paint to be applied; and
- The final step is the application of two coats of anti-fouling paint.

The District will use an anti-fouling system provided by International Paint, Ltd. (International). Specification & Safety Data Sheets ("SDS") are provided in Appendix L,[13] namely:

- Primer option 1: Intershield 300 2-part primer
- Primer option 2: Primocon 1-part primer
- Topcoat: Trilux 33 topcoat

All of these paints are widely used in the marine industry for the protection of vessel hulls. International has advised that the biocides in Trilux 33 are copper thiocyanate and ZPT. Unfortunately, International is unable to provide release rates for these biocides. These anti-fouling systems should be considered as being indicative of the type of paint which will be employed on the Puget Sound turbines as final selection will be subject to detailed design and procurement limitations.

The components requiring antifouling paint represents a very small part of the turbine assembly; the gravity based foundation, the turbine frame, and the steel portions of the duct will not require antifouling paint.

Admiralty Inlet is used by essentially all maritime traffic transiting to and from the ports of Seattle, Tacoma, Olympia, and Everett, as well as Naval facilities including Naval Station Everett, Puget Sound Naval Shipyard, and the Bangor Submarine Base. In addition, the ferry passing between Whidbey Island and the city of Port Townsend makes 20 crossings daily.

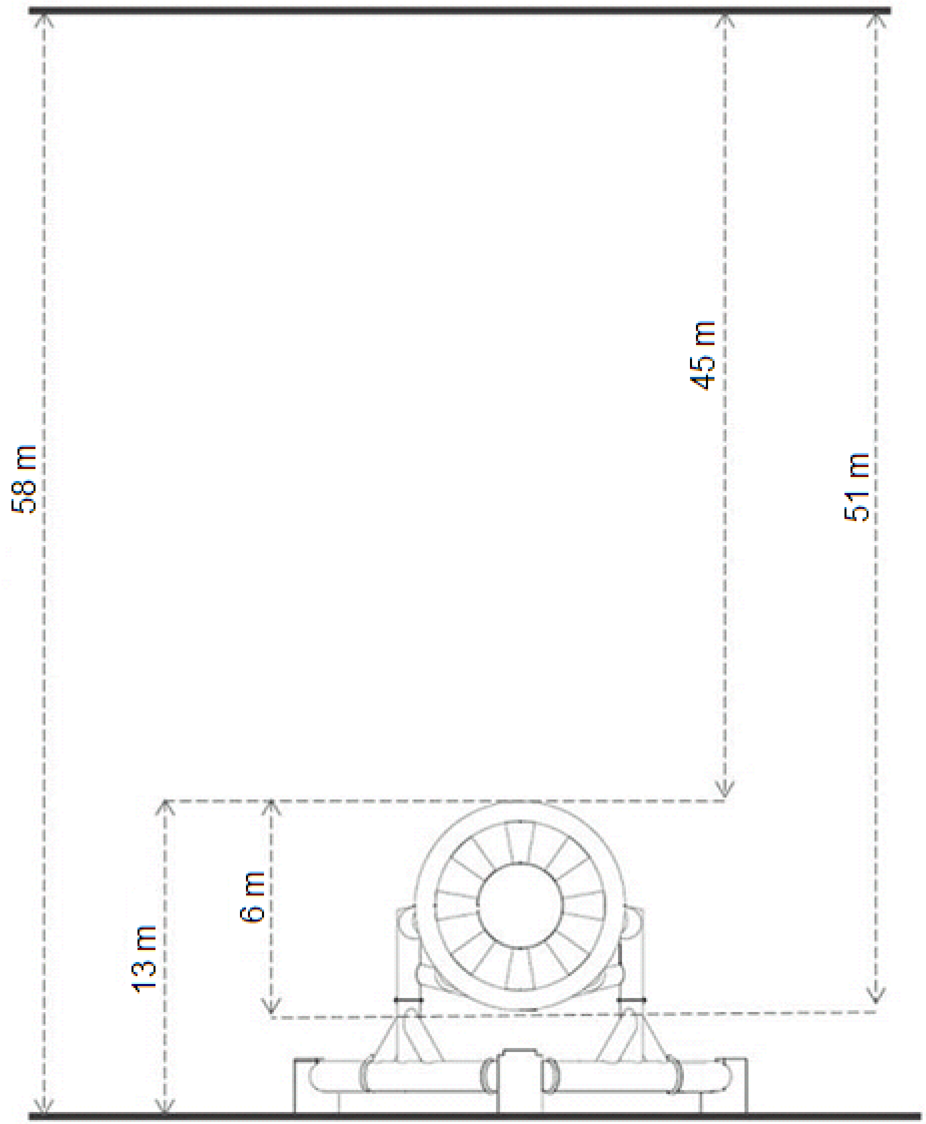
[13] The SDS were also provided in Appendix 9 of the June 24, 2011, response to FERC's Additional Information Request for all international products currently used by OpenHydro.

Antifouling paint is used on all of these ships. The small amount of antifouling paint used on the two OpenHydro turbines does not represent a significant effect to water quality and aquatic life, especially given the prevalence of antifouling paint associated with the shipping and marine traffic in Admiralty Inlet. Additionally, the OpenHydro turbines will be located in a high tidal velocity area with significant vertical mixing. The leachate from the antifouling paint will therefore disperse and will not accumulate in the vicinity of the turbines.

Blade Strike

Each OpenHydro turbine is 6 meters in diameter (actual rotor diameter is 4.7 meters), will be deployed in water approximately 58 meters deep, and will sit on a foundation that will extend the top of the turbine to 13 meters above the seabed. The turbine rotor will be located at depths of approximately 45 to 51 meters (Figure 3-25). The turbine is expected to reach a maximum rotational speed of approximately 29 rpm, though typically the turbine will operate at 6 to 20 rpm (Figure 2-16). Although the turbine rotors have open centers and the turbine rotor tips are covered (i.e., not exposed), there is a chance that animals could come into contact with the rotors when the rotors are spinning, which is 70 percent of the time. This creates a risk of injury or mortality.

FIGURE 3-25
DIMENSIONS OF TURBINES IN RELATION TO DEPTH AT DEPLOYMENT SITE



Note: Figure not to scale

A variety of marine life occurring in Admiralty Inlet, both resident and migratory species, has the potential to occur in the vicinity of the OpenHydro turbines. Resource agencies and stakeholders have expressed concern about marine life interacting with the units' rotors (e.g., NMFS letters to the District dated July 23, 2009, July 6, 2009, and December 8, 2008; WDFW letters to the District dated June 16, 2009 and November 25, 2008; and various stakeholder meetings), and have requested that the District evaluate Project operations to determine the potential effect.

Marine mammals and fish are highly sensitive of their surrounding environment and it is expected that they will be able to detect and avoid the hydrokinetic turbines. Further, a recent assessment of potential injury to killer whales from blade strike concluded that the consequences are, at most, minimal bruising.[14] However, there is uncertainty about how marine mammals and fish will interact with the turbines. Therefore, the District proposes to conduct a Near-Turbine Monitoring Plan to evaluate if marine species approach a turbine, and if so, how they behave (see Appendix A). The District has developed an Emergency Shutdown Plan (see Project Safeguard Plans, Appendix E) that will be implemented if results of the Near-Turbine Monitoring Plan indicate unacceptable effects.

Our Analysis

Our analysis consists of the following:

- Frequency of interaction with turbine;
- Turbine design, speed, operation frequency;
- Abilities of fish and marine mammals to detect large underwater features;
- Past blade strike analyses;
- Flow analysis;
- Comparison of OpenHydro tidal turbine to traditional hydropower and other turbines for potential injury of marine life;
- Project scale and context;
- The District's proposed near-turbine monitoring study;
- Proposed safeguards to protect marine life; and
- Conclusion.

<u>Frequency of interaction with turbines</u> - The likelihood of exposure to blade strike for marine life would be influenced by overlap in both the spatial and temporal distribution of species with the Project. Migratory species/life stages, such as inbound adult salmonids, are expected to be transiting through the Admiralty Inlet area and would be exposed to the turbines infrequently and for a very short period of their life. In contrast resident species, such as rockfish, could be exposed to the turbines more frequently.

Some species of fish are unlikely to interact with the turbines because they do not use habitat at the depths at which the turbines will be located. For example, from CDFO surveys of juvenile salmon in Puget Sound and the Strait of Georgia, consisting of over 158 tows conducted since the late 1990s, all juvenile salmon were captured at depths of 45 meters or less (Figure 3-14). Because the turbines will be deployed on the seabed and the turbines will be located at depths of 47.5 to 53.5 meters, juvenile salmon are unlikely to interact with the turbines, and therefore will not be at risk of blade strike.

<u>Turbine design, speed, operation frequency</u> - The design of the turbine, the speed at which the turbines rotates, and the frequency that the turbine operates will likely minimize the risk of a fish or marine mammals coming in contact with a moving blade.

---

[14] The full report, titled *Assessment of Strike of Adult Killer Whales by an OpenHydro Tidal Turbine Blade*, is summarized later in this section. The report can be found in Appendix K.

Regarding the turbine design, the size of the turbine is relatively small, given the depth and width of Admiralty Inlet, which limits the chance that a fish could potentially intersect the immediate turbine sweep area. As discussed in Section 2.2.1.1, the turbine rotor diameter is 4.7 meters (the venturi duct diameter is 6 meters) with a 2.2 meter diameter open center. Therefore, the turbine sweep area would be only 13.5 square meters for both turbines. Further, there are a number of design characteristics of the OpenHydro turbine that are expected to minimize the risk of blade strike on marine species:

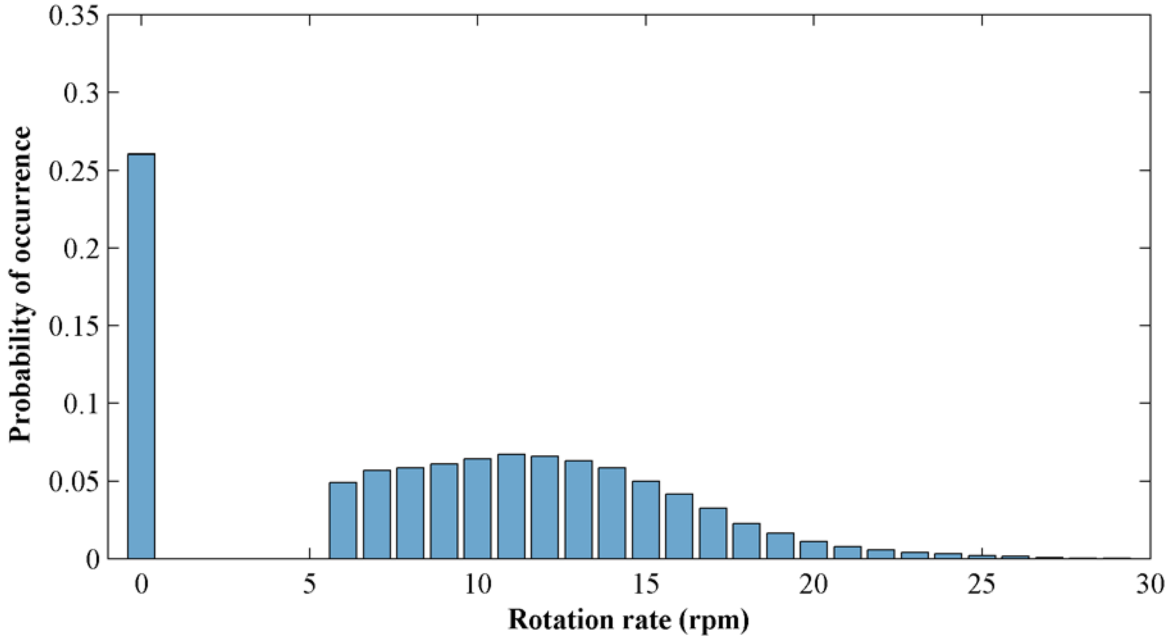
- Closed-shroud of the turbine structure (no exposed blade tips),
- Open-centered rotor, and
- Runs at low speed without cavitation.

The closed shroud prevents marine life from swimming into the turbine blades from the sides, and because the ends of the rotor blades are enclosed, the risk for blade strike is further reduced. As mentioned below, in the event that an animal attempts to pass through the turbine, the OpenHydro turbine is designed with an open center (2.2 meters in diameter). This allows adequate space for marine life, other than whales, to pass through the center of the turbine.

Regarding the turbine speed, the OpenHydro turbines will rotate at slow speeds. The typical rotational speeds will range from 6 to 20 rpm, with a maximum rotational speed of 29 rpm (Figure 3-26). OpenHydro turbine rotation speeds are significantly slower than traditional hydroelectric turbines rotational speeds (30 to 150 rpm).

Regarding operational frequency, the OpenHydro turbines will be deployed for a limited duration (maximum five years) and the frequency of operation is limited. Because the Admiralty Inlet current velocity at which the turbine will start rotating is 0.7 m/sec, the turbines will rotate only 70 percent of the time.

FIGURE 3-26
PROBABILITY DISTRIBUTION OF ROTATIONAL RATE FOR 6-METER-DIAMETER OPENHYDRO TURBINES IN ADMIRALTY INLET



Source: Personal communication, Brian Polagye, NNMREC, February 27, 2011 (based on unpublished Doppler profiler data).

Abilities of fish and marine mammals to detect large underwater features - In addition to the turbine design characteristics which will help fish and marine mammals avoid being struck by the turbine blades, there is little evidence that fish or marine mammals collide with large stationary objects in the ocean. Marine species have evolved to avoid colliding with natural features such as rocks, and other fixed obstructions, and most species are able to avoid moving vessels as well (AECOM 2009). Fish are known to be able to detect, avoid, or use structure from visual cues but perhaps more importantly, their lateral line system for detecting changes in pressure and velocity, including changes associated with detecting obstacles (Bouffanais et al. 2011, Liao 2007, Coutant and Whitney 2000), and their inner ear for detecting changes in acceleration (Coutant and Whitney 2000). The region of relatively elevated pressure extends approximately 10 meters upstream of the turbine during the modeled operating condition (personal communication, Nick Murphy, OpenHydro, memo December 2010). Unlike traditional hydropower, fish cannot be entrained into an intake where they have no other route for escape; laboratory studies indicate that if fish can move around a hydrokinetic turbine, they will (Amaral et al. 2010, Gorlov 2010).

Smaller pelagic organisms are likely to have the shortest detection distance and weakest swimming capabilities and therefore are less likely to detect and avoid the turbine; larval fish (e.g., larval rockfish) and small pelagic invertebrates would be most likely to "go with the flow." Hypothetically, these smaller organisms have the potential to be swept through the turbine and to survive without injury or mortality (Coutant and Whitney 2000). Larger fish have greater detection abilities and stronger swimming capabilities, and are more likely to be able to detect and avoid the turbine, or even to detect and use the turbine (Sue Barr, OpenHydro, memo November 2010).

Marine mammals are also highly sensitive of their surrounding environment, and there is little evidence that they collide with large stationary objects in the ocean. For example, many toothed whales have a well-developed ability to echolocate and avoid structures in the water (Akamatsu et al. 2005). Akamatsu et al. (2005) found that finless porpoises (*Neophocaena phocaenoides*) inspected the area ahead of them before swimming into it. The porpoises inspected ahead, a distance of up to 77 meters, while the distance they would swim without using sonar was less than 20 meters. The inspection distance was far enough to allow for a wide safety margin before meeting any risk (Akamatsu et al. 2005). Pinnipeds can detect changes in pressure or vibrations in the water through the use of their vibrissae (Dehnhardt et al. 2001, Mills and Renouf 1986).

It is expected that fish and marine mammals will detect and avoid the OpenHydro turbines (e.g., through detecton of turbine noise, as described in Polagye et al., 2012*a*). In addition, marine species in Admiralty Inlet, and throughout Puget Sound, are exposed to a variety of anthropogenic structures, including dock pilings, anchored and moving ships, and moored navigation aids. Species that are conditioned to avoiding predators and that regularly swim in areas of strong currents, such as Admiralty Inlet, are likely fast and agile and can successfully avoid fixed, relatively slowly rotating objects (AECOM 2009).

Given the demonstrated ability of fish and marine life to avoid in-water large structures and the fact that marine life can pass through 99.95 percent of cross section of Admiralty Inlet at the Project location without encountering the proposed turbines, it appears unlikely that the presence of the Project will pose a risk to resident or migratory species.

<u>Past blade strike analyses</u> - Actual *in-situ* data on turbine strike effects to fish are very limited. Much of the available information is based on theoretical “white papers” evaluating potential effects of ocean energy devices in general (Michel et al. 2007, Boehlert et al. 2008, Cada 2008, and Polagye et al., 2011)) while others are either addressing specific projects or are not publically available. Wilson et al. (2007) concluded that there is a high potential that marine life will avoid marine renewable energy devices, but the magnitude of the reactions would depend on the species and any sensory output detected by the species from the turbines. It is possible that avoidance reactions will exclude fish from a larger area than necessary to escape collisions (Wilson et al. 2007). The Fundy Tidal Energy Demonstration Project Environmental Assessment report concluded the risk of fish strike or collision with the hydrokinetic devices evaluated would be extremely low. This conclusion for the OpenHydro turbine was supported by the turbine design measures meant to minimize the potential for injury to fish and marine mammals, which include the slow rotor rotation rate and shrouded blades. Additionally, it was concluded that the biological adaptations for predation and predator avoidance and escapement would minimize the risk of blade strike (AECOM 2009).

Three *in-situ* studies have evaluated the potential for hydrokinetic turbine entrainment of fish. These are listed here and discussed below:

- Video monitoring of OpenHydro’s 6-meter diameter turbine at EMEC;
- EPRI entrainment and survival study in a flume tank; and

- Hydro Green Energy, LLC entrainment and survival study in the Mississippi River.

There has been extensive environmental monitoring conducted on the OpenHydro turbine deployment at EMEC to characterize fish abundance and behavioral responses of marine life to the turbine. Since 2006, continuous daytime video coverage of operation of this 6-meter diameter turbine has occurred from a camera mounted on a 2-meter pole to observe marine life approaching the turbine. The OpenHydro turbine at EMEC is deployed relatively near the surface, and sufficient ambient lighting allows for video coverage during daylight without artificial lighting (video coverage only occurs during the day). During the first two years of operation, there were no fish observed in the near-turbine vicinity at the EMEC site. However, beginning in 2009, some species of pelagic fish began to appear in the footage (Sue Barr, OpenHydro, memo November 2010).

To characterize the abundance and behavioral responses of marine life to the EMEC turbine, OpenHydro extracted photographic stills from continuous underwater video footage for 15 days in July 2009 and 16 days in May-June 2010. These data were then compared to ADCP recorded tidal flow rates. During the study periods, only a single species of fish, pollock (*Pollachius pollachius*), was observed near the turbine. Both years portrayed similar behavioral abundance patterns during daylight hours (when video coverage occurred) with no significant relationships observed between abundance counts with time of day or individual day periods. Fish abundance counts were highest at low water velocities and low turbine rotation rates (0 to 1.2 m/s in 2009 and 0.5 to 1.7 m/s in 2010). Study findings show that fish only appear to utilize the structure during periods when the turbine is not rotating or rotating at very low speed (Sue Barr, OpenHydro, memo November 2010). Figure 3-27 illustrates the observed pattern over daily tidal cycles at the pile-mounted turbine. As an example of how the fish behave during the tidal cycle, screen shots have been taken from the full tidal cycle during July 15, 2009. During periods of low velocity of the tidal cycle, fish utilize the OpenHydro turbine as a velocity refuge downstream of the turbine (Sue Barr, OpenHydro, memo November 2010), which is a common fish behavior to minimize energy use (Cook and Coughlin 2010, Liao 2007). As the tide increases and changes direction, the fish are observed to turn into the oncoming tide and gradually reduce in number. To date no occurrences have been recorded indicating any harm has been caused to marine life. It is believed that this is very predictable behavior and is indicative of the fishes' desire to move out of areas of high tidal flow in order to conserve energy (Sue Barr, OpenHydro, memo November 2010).

As the EMEC analysis indicates, fish leave the turbine area as the tidal velocity increases and the turbine starts turning. This would suggest minimal risk of blade strike since fish appear to be present only when the turbine is still or rotating at low speed. There has been no evidence that marine mammals approach the turbines and no evidence of injury or mortality of marine mammals from almost four years of monitoring. If fish are attracted to the structure, especially in numbers similar to that seen for the EMEC structure during slack tide, it can be expected that predators, such as marine mammals will consequently be attracted to the turbine structure to feed. As shown by the District's pre-installation passive acoustic monitoring, harbor porpoise are very common in the project area; T-POD monitoring detected an average range of 30-48 harbor porpoise "encounters" per day within 300 meters of the proposed turbine deployment site (Tollit et al. 2010). The EMEC analysis suggests, however, minimal risk of blade strike to fish, and consequently marine mammals attracted to a potential prey source, because fish appear to not be present when the turbine is rotating.

FIGURE 3-27
EMEC OPENHYDRO TURBINE SCREEN SHOTS, JULY 15, 2009

Left: Screenshot at 6:00 a.m.; tidal velocity = 1.8 m/s. The turbine is rotating; no pelagic species are present. *Right*: Screenshot at 10:30 a.m.; tidal velocity has reduced and is approaching 1.2 m/s. Fish are observed beginning to arrive from the downstream side of the turbine in small numbers. The numbers of fish observed slowly begins to increase throughout the following hour as the flow stops.

Left: 11:14 a.m.; tidal velocity has reduced to 0.5 m/s. Large numbers of pelagic fish (pollock) can be observed actively feeding downstream of the turbine. The fish appear to stay downstream while feeding on debris and particulate matter in the water flow. Fish are not observed upstream of the turbine. The turbine is currently stationary. *Right*: 7:03 p.m. - tide has turned and velocity is recorded at 1.5 m/s. Turbine is rotating and no fish are observed during this state of the tide.

Source: Sue Barr, OpenHydro, memo November 2010.

From April to June 2010 EPRI conducted flume tests to determine injury, survival rates, and behavioral effects for 250 Atlantic salmon smolts and 300 adult Atlantic shad passing through a 4-blade Encurrent 5-kW vertical axis turbine (Darrieus-type runner) (model Enc-005-F4; NewEnergy Corp.) at the U.S. Geological Survey's Conte Anadromous Fish Research

Laboratory in Massachusetts. Interim results were presented in a progress report (EPRI 2010) and are summarized here. Both species were held for 48 hours after the experiment to evaluate any delayed mortality effects. No mortality or visible injury occurred to Atlantic salmon smolts from either the treatment or control fish, and no evidence of strike injuries was detected among the American shad[15]. There was some mortality of shad in both the treatment and control fish, though the researchers noted that shad are sensitive to handling and holding, and that the observed mortality level represents a typical problem as warmer temperatures occur in June. Researchers indicated that shad sensitivity to handling might be the cause of the mortality and not the effects of the turbine. This study is ongoing, and additional flume studies are currently underway at the Alden Research Laboratory, also in Massachusetts, for Current2Current's ducted horizontal-axis turbine and Lucid Energy's spherical turbine (EPRI 2010).

A study to estimate the survival, injury, and predation of fish passing through a hydrokinetic turbine, and potential entrainment rates based on known population data, was conducted for an instream current project, consisting of a barge-mounted Hydro Green Energy hydrokinetic turbine deployed in the tailrace of the U.S. Army Corps of Engineers Lock and Dam No. 2 on the Mississippi River in Hastings, Minnesota (FERC No. 4306) (Normandeau 2009). The Hydro Green Energy turbines are ducted horizontal axis turbines that are similar to the OpenHydro turbine (Figure 3-28). Researchers deployed 502 balloon and radio tagged fish, representing five species and two size classes[16]. Of these, 402 fish swam through Hydro Green Energy's hydrokinetic turbine, which rotates at 21 rpm (the OpenHydro turbine will typically rotate at 6 to 20 rpm [Figure 3-26]), and 100 were allowed to swim freely in the river near the turbine. After recapture of nearly all the tagged fish, survival and injury rates of treatment and control groups were evaluated. Pre-installation computer modeling (desktop evaluation) performed by Hydro Green Energy, which relied on models created by the U.S. Army Corps of Engineers and the Department of Energy, estimated a 97 percent fish survival rating for the turbine (Hydro Green Energy 2010*a*). Results of the actual field study, however, indicated survival estimates for the two size categories - small fish (115-235 mm) and large fish (388-710 mm) - through the hydrokinetic turbine was 99 percent, and no turbine blade passage injuries were observed. Predation of tagged fish was not directly observed, and subsequent radio telemetric tracking of tagged fish did not indicate predation (i.e., rapid movements of tagged fish in and out of turbulent waters or sudden appearance of fully inflated tags). Researchers noted that many factors that may impair a fish's ability to avoid predators (e.g., stress, loss of equilibrium) are not an issue with the hydrokinetic turbine evaluated, because pressure changes, severe turbulence, shear stress, and cavitation do not occur. Researchers concluded that because survival was 99 percent, and there was no indication that fish were injured upon passing the through the hydrokinetic turbine, the units should have little if any effect on entrained fish (Normandeau 2009, Hydro Green Energy 2010*a*). FERC acknowledged these findings in a letter issued March 3, 2010 and stated that the report fulfilled the study requirements.

---

[15] Study results in relation to shad, or other fish species not found in the Admiralty Inlet Project area, are relevant regarding how similarly sized fish react to tidal turbines.

[16] Smaller species were yellow perch (*Perca flavescens*, 118-235 mm) and bluegill (*Lepomis macrochirus*, 115-208 mm); larger species were channel catfish (*Ictalurus punctatus*, 451-627 mm), bigmouth buffalo (*Ictiobus niger*, 388-482 mm), and smallmouth buffalo (*I. bubalus*, 415-710 mm) (Normandeau 2009).

FIGURE 3-28
HYDRO GREEN ENERGY HYDROKINETIC TURBINE DEPLOYED IN THE TAILRACE OF THE U.S. ARMY CORPS OF ENGINEERS LOCK AND DAM NO. 2 ON THE MISSISSIPPI RIVER IN HASTINGS, MINNESOTA (FERC NO. 4306)

Source: Hydro Green Energy 2010*b*.

Flow analysis - TISEC devices like the OpenHydro turbine remove energy from flowing water (Wilson et al. 2007). Wilson et al. (2007) further stated that "…by being turned by the moving flow, the motion of the rotors is that of a spiral with the blades traveling at angles shallower than 90° to objects passing through their area of sweep. This means that the rotor blades are as much pushing along the tube of water within which they are rotating (stream tube) as they are cutting through it." The installation of an OpenHydro turbine in the Bay of Fundy was evaluated in a comprehensive EA (AECOM 2009) to Canadian federal and provincial governments (the turbine was subsequently deployed November 12, 2009). In the EA, a discussion on particle flow expands on the discussion above from Wilson et al. (2007):

> *Tidal currents flow through (tidal) turbines in a helical path through the turbine such that any passive, neutrally buoyant object will follow a path aligned with the rotor blades rather than across them. This occurs because water slows down as it passed through the turbine due to the removal of energy. Furthermore, as water slows down it spreads to occupy a greater cross sectional area. The rotating turbine blades deflect the current tangentially into helical pathways, at velocities proportional to the distance from the rotational center of the turbine (CREST Energy Limited 2006). A marine animal approaching a turbine by swimming downstream will tend to follow the helical*

path (i.e., it will not swim directly through the plane of rotation, but rather will be swept tangentially with the helical movement of the currents). Subsequently, after passing the turbine, the animal would be swept along with the current as the helical flows gradually regain the natural flow (CREST Energy Limited 2006).

OpenHydro conducted computational fluid dynamic (CFD) analysis on the 6-meter subsea turbine at EMEC to estimate water velocity and pressure change, as the OpenHydro turbines proposed for Admiralty Inlet are also 6-meters, these data are directly applicable. The analysis provided quantification of the velocity and pressure change at three key locations within the turbine structure, as shown in Figure 3-29:

- At the center of the opening;
- At the perimeter of the blades on the interior of the hub; and
- Along the outside edge of the turbine, but inside portions of the support structure.

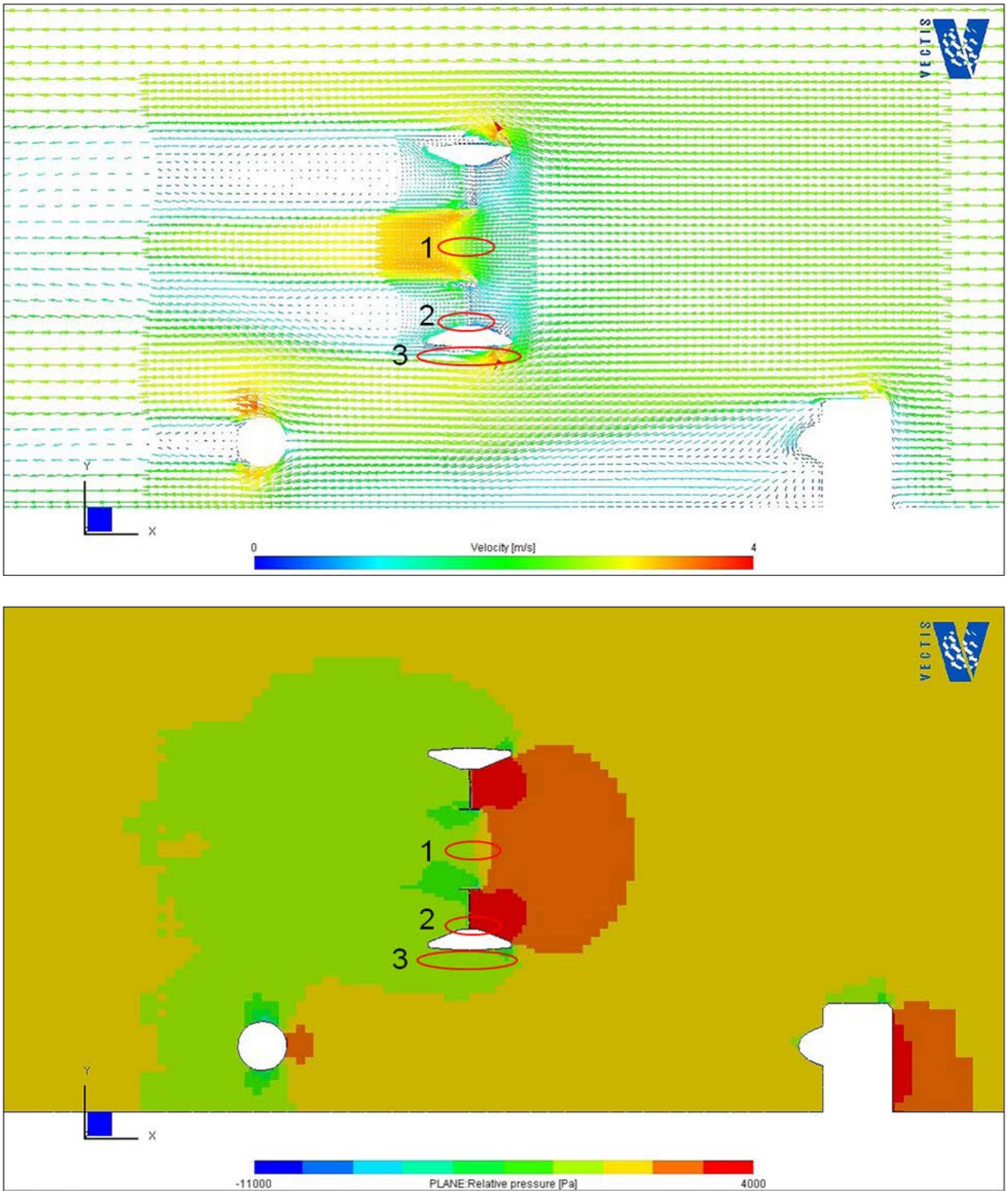
Kinetic power extraction increases pressure in the upstream direction and generally decreases pressure at the open center along the sides of the rotor shroud (Figure 3-29). CFD results are shown for 2.5 m/s free stream current velocity, which correspond to a relatively strong tidal exchange in northern Admiralty Inlet. The pressure change is greatest at the blade perimeter (-4.5 kPa), followed by the open center (-3.0 kPa) (Table 3-18). Along the outside edge of the turbine the pressure change increases slightly (1.5 kPa) (Table 3-18). The corresponding velocity changes indicate flows increases at the blade perimeter and open center (by approximately 1 m/s), and initially speed up at the outside edge of the device but rapidly slow down (change of -1.4 m/s) (Table 3-18). For context, hydrostatic pressure changes by 5 kPa over 0.5 m depth (i.e., a fish would experience a similar pressure change through small changes in depth during normal travel through areas with high natural turbulence).

TABLE 3-18
PRESSURE AND VELOCITY CHANGE IN A 2.5 M/S FLOW AT LOCATIONS AS INDICATED IN FIGURE 3-29

Location	Pressure Change [kPa]	Velocity Change [m/s]
1 - Centre Line	-3.0	0.9
2 - Blade Perimeter	-4.5	1.0
3 - Outside Edge	1.5	-1.4

Source: Nick Murphy, OpenHydro, memo December 2010.

FIGURE 3-29
CFD SIMULATION OF VELOCITY VECTORS AND PRESSURES THROUGH AND AROUND THE TURBINE IN 2.5 M/S FLOW



Note: This is an x-y cross-section through the centerline of the turbine with the water moving from right to left and the seabed is located at the bottom of the image. The three marked locations correspond to the entries in Table 3-18.
Source: Nick Murphy, OpenHydro, memo December 2010.

<u>Comparison of OpenHydro tidal turbine to traditional hydropower and other turbines for potential fish injury</u> - There are numerous studies identifying mechanisms of injury and mortality of fish associated with passage through turbines at traditional hydroelectric projects (Cada et al. 2007). Traditional hydropower projects entrain fish into an intake where they have no other route for escape. Once a fish has entered the intake, the physical barrier of the intake severely impairs, if not blocks altogether, its ability to voluntarily avoid an obstacle such as a fast-rotating turbine. Even so, juvenile salmonid injury and mortality rates are on the order of 0-15 percent for traditional hydropower projects, though they can be higher than this depending on the turbine design and type.

Comparison with traditional hydropower provides some insights about potential for injury or mortality associated with pressure change and shear forces; however, as described below, the OpenHydro turbine is not directly comparable to a traditional hydropower turbine in that there is no entrainment, and pressure changes and shear stresses are well below thresholds known to cause injury to juvenile fishes (salmonids are often evaluated for conventional hydropower projects) (Table 3-19).

A traditional hydropower project typically involves a pipe, tunnel, or some other mechanism to direct and concentrate water at a turbine. Once a fish enters the intake, there is little opportunity to detect and avoid the turbine. Because there is no route for the entrained fish to escape from a traditional hydropower turbine intake, many traditional hydropower projects have developed fish screens or deterrent systems to aid in keeping fish away from the turbine intakes. In contrast, the OpenHydro turbine does not contain any piping or other equipment that would prevent a fish from avoiding the device. In this manner, the OpenHydro turbine is more akin to a large structure or object on the seafloor. In addition, the Admiralty Inlet Project is proposed to be installed in an open body of water, whereas a conventional hydropower project often funnels most, if not all, of the river through the project turbines. As mentioned earlier, fish are known to be able to detect, avoid, or use structure from visual cues, but perhaps more importantly, their lateral line system for detecting changes in pressure and velocity, including changes associated with detecting obstacles (Bouffanais et al. 2011, Liao 2007, Coutant and Whitney 2000), and their inner ear for detecting changes in acceleration (Coutant and Whitney 2000). Laboratory studies indicate that if fish can move around a turbine, such as at the OpenHydro turbine at EMEC and the Hydro Green turbine at Hastings, they will (Amaral et al. 2010, Gorlov 2010).

TABLE 3-19
COMPARISON OF CHARACTERISTICS OF THE HASTINGS HGE HYDROKINETIC TURBINE, OPENHYDRO TURBINE, AND TRADITIONAL HYDRO PROJECT TURBINES AND EFFECTS ON FISH SURVIVAL

	Hastings turbine (hydrokinetic)	OpenHydro turbine (hydrokinetic)	Traditional hydropower
Maximum velocity (m/s)	2.9	3.3	>6
Rotor speed (rpm)	21	<24[1]	30-150
No. of blades	3	10	5+
Diameter (m)	3.6	6	2.7-7.9
Tip velocity (max, m/s)	<4.2	5.8[2]	>15

	Hastings turbine (hydrokinetic)	OpenHydro turbine (hydrokinetic)	Traditional hydropower
Survival estimate (%)	99%[3] (no turbine blade passage injuries were observed)	99%[4]	85-100[5]
Pressure head	No	No	>4.9 m
Maximum pressure change at turbine rotor (kPa)	Unknown	<4.5	>30-90
References	Normandeau 2009	Nick Murphy memo December 2010	Abernethy et al. 2003, Normandeau 2009, Skalski et al. 2002

1 The study was performed at 24 rpm. Although 29 rpm is the maximum rotor speed at this location, typical rotor speeds will be more between 6-20 rpm.
2 Tip speed of a 4.7-meter rotor at 24 rpm.
3 Fish species evaluated: yellow perch, bluegill, channel catfish, bigmouth buffalo, and smallmouth buffalo.
4 There has been no indication of mortality or injury to marine life from video monitoring at EMEC; however, the Hastings study shows a 99% survival estimate, so that figure is used here.
5 Fish species evaluated: salmonids.

Even if a fish was unable to avoid the hydrokinetic turbine, the possibility of surviving the encounter is much higher for hydrokinetic projects as compared to traditional hydropower projects (a mortality rate of 15% or higher, compared to only 1% found in the Hastings study). As discussed earlier, Normandeau (2009) evaluated potential for fish injury or mortality associated with an in-river hydrokinetic turbine at Hastings, Minnesota for both small (<235 mm TL) and large (388-710 mm TL) fish. Although fish were placed directly through the turbine with no possibility to avoid the device, injury and mortality were extremely low; survival estimates of 99 percent and no turbine blade passage injuries were observed; Table 3-19[17].

For traditional hydropower projects, rapid pressure changes are known to cause injury or mortality. Reported thresholds for injury for juvenile salmonids are above a pressure change of 30-90 kPa (Abernethy et al. 2003). Atlantic herring (11-16 cm in length) exhibited injury associated with rapid pressure changes as low as 100 kPa (Blaxter and Hoss 1979). Traditional hydropower projects often have pressures exceeding these levels at or near the turbines. In contrast, the largest potential change in pressure associated with the turbines is calculated by OpenHydro as -4.5 kPa at the perimeter of the blade on the interior of the hub (Nick Murphy, OpenHydro, memo December 2010). Pressure changes were much smaller at the open center (-3.0 kPa) and at the outer edge (+1.5 kPa). All of the calculated pressure changes for the OpenHydro device are significantly lower than thresholds for injury associated traditional hydropower systems and well below laboratory-derived thresholds.

Shear stress/strain rates are known to cause injury or mortality of juvenile salmonids based on laboratory studies and monitoring of traditional hydropower systems. Injury begins to occur at velocities above a threshold of 9.1 m/s (Cada et al. 2007). CFD analysis of the OpenHydro turbine indicates the maximum flow velocity in the vicinity of the rotor to be 4 m/s or less in free

17 Although the Hastings study placed fish in a manner that prevented them from avoiding the turbine, the real-world installation of the OpenHydro turbines in Admiralty Inlet will occupy less than 0.05% of the cross-sectional area of the Inlet. Admiralty Inlet is approximately 8,000 meters (5 miles) wide, while the OpenHydro turbines are each a 10 meters wide.

stream currents of 2.5 m/s. These are considerably lower than velocity thresholds associated with injury at traditional hydropower facilities. Strain rates of <500cm/s/cm (for $\Delta y = 1.8$ cm[18]) do not result in injury to juvenile salmonids, shad, or rainbow trout (Neitzel et al. 2000, 2004). The maximum, conservatively estimated strain rate associated with juvenile fish moving past the highest pressure gradient at the OpenHydro turbine (the outside edge) is <80 cm/s/cm (140 cm/s divided by 1.8 cm[19]), which is well below the minimum strain rate threshold for injury to occur for fish as small as juvenile salmonids (Nick Murphy, OpenHydro, memo December 2010). Injury to small fish, including larval rockfish, passing through the OpenHydro turbines is expected to be even more unlikely; the CFD model indicates a velocity change at the blade perimeter of 100 cm/s, for a maximum, conservative estimate of strain rate of 56 cm/s/cm. For larger fish, such as adult rockfishes and adult salmon, Δy increases and the maximum strain rate will be lower (Neitzel et al. 2000, 2004). In addition, blade tip speeds are much lower than speeds of traditional hydropower turbines (Table 3-19).

As stated above, the region of relatively elevated pressure upstream of the OpenHydro device extends approximately 10 meters upstream of the turbine during the modeled operating condition. As previously discussed, during low velocity periods of the tidal cycle, fish were observed using the OpenHydro turbine operating at EMEC as a velocity refuge downstream of the turbine (Sue Barr, OpenHydro, memo November 2010), which is a common fish behavior to minimize energy use (Cook and Coughlin 2010, Liao 2007). The ability for fish to detect and avoid the OpenHydro turbine is not known, but can be hypothesized. Smaller pelagic organisms are likely to have the shortest detection distance and weakest swimming capabilities and therefore are less likely to detect and avoid the turbine; larval fish (e.g., larval rockfish) and small pelagic invertebrates would be most likely to "go with the flow." Hypothetically, these smaller organisms have the potential to be swept through the turbine and to survive without injury or mortality (Coutant and Whitney 2000). Larger fish have greater detection abilities and stronger swimming capabilities, and are more likely to be able to detect and avoid the turbine, or even to detect and use the turbine (Sue Barr, OpenHydro, memo November 2010).

Based on a study by Fraenkel (2006), tidal turbines pose less potential effect to marine life than ship propellers (which in contrast, represent active propulsion) as tidal turbine rotors would absorb about 4 kW/m^2 of swept area from the current compared to the forceful release of over 100 kW/m^2 of swept area into the water column by a typical ship propeller. Additionally, the design of the OpenHydro turbine itself, with a closed shroud design, reduces the potential for blade strike as the ends of the rotor blades are not exposed.

<u>Project scale and context</u> - The chance of migratory or resident species interacting with one of the two turbines is very small. Figure 3-30 provides an important perspective on how the size of the turbines relates to the volume of Admiralty Inlet. While Admiralty Inlet represents a notable narrow in Puget Sound, at 3.5 miles wide at the narrowest constriction, it is still a vast corridor in

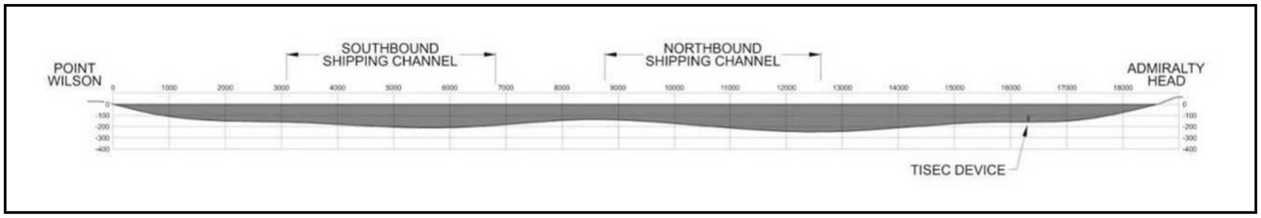
---

[18] The spatial resolution of 1.8 cm was selected to approximate the minimum width of juvenile salmonids tested in laboratory facilities (Neitzel et al. 2000).

[19] Velocity shear used for laboratory shear stress studies (Neitzel et al. 2000, 2004) were extremely high (0-21.3 m/s) with an extremely thin gradient, 1.8 cm was used because it represents the average fish width. Thin shear gradients were not observed in the CFD model, so using 1.8 cm is extremely conservative.

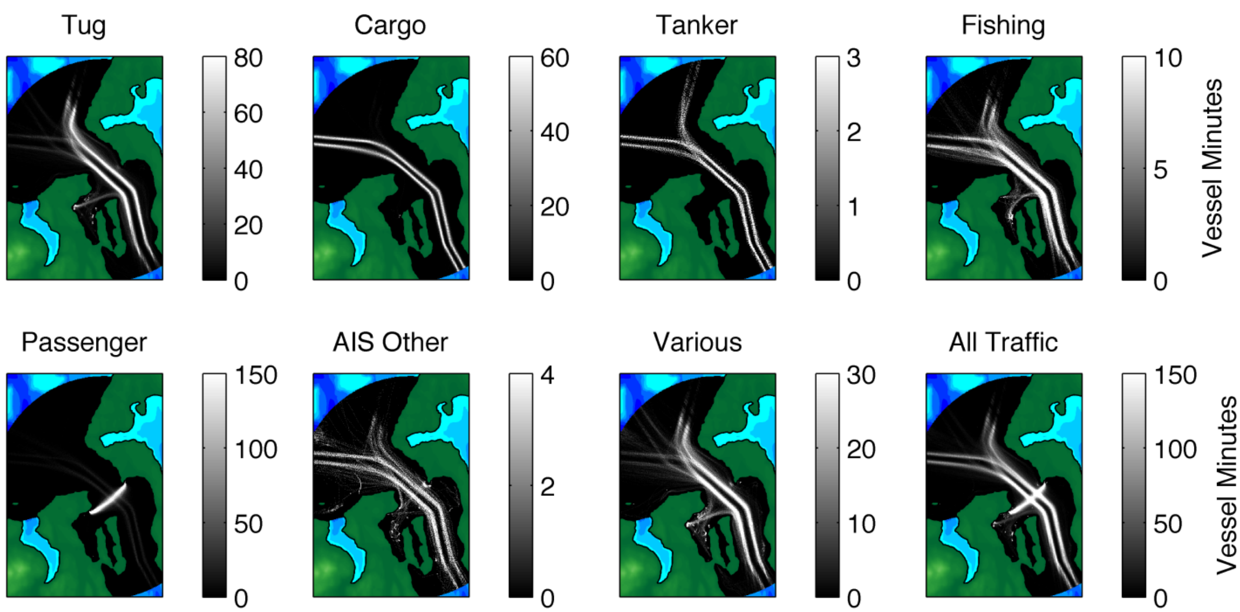
relation to the area represented by the two rotors, each of which is 4.7 meters wide. The proposed Project represents 0.05 percent of the cross sectional area of Admiralty Inlet.

FIGURE 3-30
SCALED CROSS-SECTION OF ADMIRALTY INLET AND OPENHYDRO TURBINE



Maritime travel on Puget Sound is heavy; all maritime traffic bound for, or departing from, the ports of Seattle, Everett, Tacoma and Olympia transits through the Inlet via a major shipping lane in the middle of Admiralty Inlet (NOAA 2007*a*) (Figures 3-30 and 3-31). The Port Townsend-Coupeville ferry runs about 1.5 km from the turbine deployment site, making 10 round trips across Admiralty Inlet. The U.S. Navy also has a strong presence in Admiralty Inlet. Across Admiralty Inlet from the Project is the Admiralty Bay Mining Range, a restricted area 7/R-6701; no anchors, fishing gear, grapnels, or dumping of non-buoyant objects are allowed in this area. In addition, many small commercial craft also operate throughout the Project area. This heavy shipping and other industrial uses of Admiralty Inlet have occurred for years and likely pose a substantially greater risk to marine resources, especially blade strike, than does the proposed Admiralty Inlet Project, which will occupy an exceedingly small footprint on the outskirts of the inlet.

FIGURE 3-31
VESSEL TRAFFIC DENSITY IN ADMIRALTY INLET



Source: Bassett et al., (2012*a*)

<u>Southern Resident killer whale</u> - Except for potential noise impacts on SRKW, it is unlikely that SRKW will directly interact with the OpenHydro turbines for the following reasons:

- The inherent ability of marine mammals to avoid colliding with larger stationary underwater features;
- The small Project size relative to the cross -sectional volume of Admiralty Inlet limits the potential for random encounter (i.e., collision);
- The risk of derelict fishing gear entangling on the turbines and jeopardizing SRKW is discountable and insignificant; and
- No evidence of attraction, injury, or mortality of marine mammals from almost four years of monitoring the EMEC OpenHydro turbine.

Furthermore, in the unlikely event that a SRKW does interact with the OpenHydro turbines (i.e., attraction to prey aggregation or noise), it is unlikely that a SRKW will be harmed by such interaction as demonstrated by the *Assessment of Strike of Adult Killer Whales by an OpenHydro Tidal Tirbine Blade* prepared by the Pacific Northwest National Laboratory and Sandia National Laboratories (collectively, the National Labs). After calculating the forces (stress and strain) that would be encountered, the National Labs concluded that in the highly unlikely situation where a Southern Resident killer whale encountered a turbine blade, the consequences are, at worst, minor bruising (Carlson et al., 2012). Additionally, blade speed varies with current velocity, meaning that the consequences of blade strike will be even less significant during the majority of operation, when rotational speeds will be below those used in the National Labs' analysis.

<u>Proposed near-turbine monitoring study</u> - While these and similar assessments do not by themselves document the safety of the Admiralty Inlet Project, they provide a basis for the District's expectation that marine life will be able to detect and avoid the turbines when operating. The District will conduct post-construction monitoring to evaluate the hypothesis that marine life is unlikely to be struck by the turbine blades. In particular, the near-turbine monitoring study will characterize the frequency and type of interactions between marine life and the moving turbine rotor (limited interaction is expected based on past projects).

One of the purposes of pursuing a FERC Pilot License is to collect the environmental information needed to more completely evaluate the potential effects of hydrokinetic technologies *in-situ* rather than rely on theoretical evaluations and models. The District and NNMREC have collaborated to develop, in consultation with resource agency staff, sampling methods to characterize the interactions between marine life and the OpenHydro turbines. The proposed methods include stereo imaging with strobe illumination. In summary, the District will mount a pair of custom-designed stereo vision systems on the Project turbine foundation at turbine hub height. One will be directed across the turbine rotor to laterally image fish (highest probability for taxonomic classification at the species level) and a second directed at the turbine rotor (highest probability for detecting interactions with the rotor). Initially, the District will conduct system testing in Admiralty Inlet. Lighted video observations will be conducted each hour on the following cycle: 1 minute lit, 15 dark, followed by 4 minutes lit, 15 minutes dark, and finally 10 minutes lit, 15 minutes dark. This sample cycling will be used to evaluate the behavioral effects of artificial light. Specifically, there may be distinct trends in species behavior correlated with the duration of lighting. This sampling frequency is consistent with other studies documenting fish and invertebrate behavior in response to artificial lighting (e.g., Raymond and Widder 2007, Kubodera et al. 2007, Widder et al. 2005, Williams et al. 2010). After one month of sampling, video footage will be evaluated to determine if fish behavior varies substantially with light timing. The lighting and video schedule may be adjusted, if necessary, to best capture fish behavior[20]. The data from the monitoring system will be transmitted to shore via the project's subsea cable and stored on land-based hard drives for subsequent analysis. Additional details are included in the monitoring plan summary in Appendix A.

- Proposed safeguards to protect marine life - Important safeguards have been developed to ensure that, in the event the pilot Project is causing unexpected adverse effects to marine life from blade strike, the turbines can be immediately shut down to cease turbine rotation. Specifically, in implementing the Near-Turbine Monitoring Plan, the District will consult with the MARC to evaluate the effectiveness of monitoring methods described above, the collected data, and whether adjustments to monitoring methods are necessary. The District has proposed certain adaptive management triggers and subsequent actions in the event negative effects are determined. Triggers include blade strike, turbine interaction, substantial changes in species assemblage, system performance, and behavioral changes from lighting. Each of these triggers will be discussed in the Near-Turbine Monitoring Plan.

The District will follow the procedures described in the Adaptive Management Framework (Appendix H) when consulting with the MARC on implementation of the Near-Turbine Monitoring Plan. By June 30 of each year, the District will develop and file an annual report to FERC fully describing its implementation of the plan during the previous calendar year and a list of the proposed activities during the current calendar year. The MARC will have at least 30 days to review and comment on a draft report prior to the District finalizing and filing the report with FERC. The annual report will provide the following:

- A summary of the monitoring results,
- A summary of any issues or concerns identified by members of the MARC during the year regarding implementation of the plan,
- A list of any changes to the plan proposed by consensus of the MARC during the year, and
- A list of activities planned for the current year.

In addition to these efforts, the District will implement a Marine Mammal Monitoring Plan intended to detect and observe marine mammals in the Project area, during turbine installation, operations, and removal, and to improve the understanding of how marine mammals interact

[20] Because artificial light sources can affect fish behavior, this effect will be evaluated by analyzing the potential differences in species abundance, composition, and behavior within sampling periods. For example, the accumulation of ratfish over five minutes would suggest that these species are responding positively to the artificial lights; the presence of Pacific herring only within the first 15 seconds of each period would suggest that this species avoids this light source. To best account for the influence of artificial light using the proposed lighted video technology, video information collected initially will be analyzed with the objective of refining the sampling protocol as appropriate (e.g., increase the frequency of sampling within a 24 hour cycle, but reducing the duration of each sampling period from 5 to 1.5 minutes).

with operating tidal turbines. The primary considerations are attraction or avoidance. The plan gives particular attention to Southern Resident killer whales (given their status under the Endangered Species Act) and harbor porpoise (given their near-ubiquitous presence in the project area and correspondingly greater power to detect changes). A variety of monitoring tools will be employed to analyze interaction, including shore observers overlooking the project area, click detectors on the turbine foundations, localizing hydrophones (either on the turbine foundation or a vertical array deployed from a surface vessel), the hydrophone at Port Townsend, and the stereo imaging system. This monitoring plan is further discussed in Appendix A (Monitoring Plan Summary) and Appendix G (draft Biological Assessment).

Conclusion

The response of fish and marine mammals to the presence of the turbines may be avoidance, attraction, or injury/mortality if the animal comes in contact with the rotating turbine. The likelihood of harm to individuals or populations is low because of the following:

- The small Project size relative to the cross sectional volume of Admiralty Inlet at the deployment site (0.05 percent). Additionally, The majority of water flows around, not through, the turbine blades (Wilson et al. 2007, CREST Energy Limited 2006);
- Within the context of the many human uses of Admiralty Inlet, the pilot Project represents a *de minimis* footprint on the margins of the inlet, will rotate only 70 percent of the time, and is not expected represent a risk to marine life currently passing through Admiralty Inlet;
- No evidence of injury or mortality of marine life from almost four years of monitoring the EMEC OpenHydro turbine;
- 100 percent survival and no injury of Atlantic salmon and no evidence of strike injuries of American shad[21] in the EPRI (2010) flume entrainment study;
- 99 percent survival of a variety of species and size fish in the Hydro Green Energy entrainment study (Normandeau 2009);
- Turbine design characteristics that minimize risk of blade strike:
    - low rpm/rotor speed
    - closed shroud (enclosed blade tips)
    - open rotor center
- The inherent ability of fish to avoid colliding with larger underwater features (AECOM 2009, Bouffanais et al. 2011, Liao 2007, Coutant and Whitney 2000);
- The turbines will be deployed at depths greater than those typically used by juvenile salmon; and
- The important safeguards have been developed to ensure that, in the event the near-turbine monitoring of the pilot Project show that unexpected adverse effects to marine life are occurring from blade strike, the turbines can be immediately shut down to cease turbine rotation.

[21] As indicated above, there was some mortality of shad in both the treatment and control fish, though the researchers noted indicated that the mortality of shad could be because shad are notoriously sensitive to handling and holding especially during warmer temperatures such as when the study occurred, and not because of any effects of the turbine.

The District therefore expects that the potential for fish or marine mammals being injured or killed by turbine strike is unlikely. However, there are very few tidal turbines deployed in the world and there is therefore uncertainty how marine organisms will interact with the turbines. This uncertainty defines the need for the monitoring studies described above. Furthermore, the Adaptive Management Plan provides a process outlining how the District will consult with the MARC to evaluate the effectiveness of the monitoring methods, the collected data, and whether adjustments to monitoring methods is necessary, as well as actions to take, including shutdown, if certain defined negative effects occur.

Habitat Alteration

Installation and presence of Project components in the water column and benthic habitats will alter habitat in the Project area and create new habitat features resulting in the following potential environmental effects:

- Construction impacts (from construction and placement of Project components on the seabed), and
- Changes to marine community composition (use patterns, attraction, and aversion).

Direct effects to the benthic community could result from placement of Project components on the seafloor and installation of the subsea trunk cables. The disturbance of the seabed could affect the local benthic community, specifically within the footprint of the gravity base foundations and the subsea trunk cables laid on the seafloor. Resource agencies and stakeholders indicated concern about effects to marine life resulting from deploying and operating the Project (e.g., letters from NMFS to the District dated July 23, 2009, July 6, 2009, and December 9, 2008).

The OpenHydro turbines may change local habitat by adding high-relief structure to an area of low relief. Areas of shelter, structure, or cover are typically sought by fish for protection from predators (Johnson and Stickney 1989). Increased colonization, or new colonization, by marine life that otherwise would not occur in a particular area may attract predators (Ogden 2005), may increase predation, and as NMFS noted in their letter dated July 23, 2009, specifically rockfish stocks, which have low productivity. The underwater Project infrastructure may provide new hard-structure habitat for marine life including biofouling organisms. The turbines will be deployed at a depth of 58 meters. Biofouling organisms have been observed to thrive from the surface to depths ranging from 660 to 6,600 feet (200 to 2,000 meters) (Hart 2005). Resource agencies and other stakeholders have raised concern about the potential effects of new habitat being introduced into the Project area and how it affects marine community composition (e.g., letters to the District from NMFS dated July 23, 2009, July 6, 2009, and December 9, 2008; WDFW dated June 1, 2009 and November 25, 2008, WDOE dated March 9, 2009). For example, resource agencies indicated interest in whether the Project influences behavioral changes such as repulsion, attraction, migration, schooling, rearing or foraging, and whether the Project will concentrate fish away from nearby reefs or provide new habitat for settlement of larval fish and enhance populations. Additionally, NMFS noted that artificial habitats may not serve as well as natural habitats because of the potential for overcrowded conditions and the need to search for food (Matthews 1990; Palsson et al. 2009).

To avoid adverse impacts to sensitive shoreline areas and near-shore habitat, the District will deploy the subsea trunk cables under the seabed using HDD. From land the cables will be HDD to a minimum depth of 18 meters. The cables will exit the single HDD bore hole and continue along the seabed surface for approximately 2 km and will connect to the turbines. Because of this preventative measure of deploying the cable under the shoreline and near-shore habitat, and as discussed below, because of the relatively small size of the Project, the District does not believe the actual placement of the Project components represents a significant impact on marine life. Any effects should be small and temporary.

Because the District is uncertain to what degree, if any, the Project will affect the marine community composition in, and use of, the area the District has proposed the (1) Near-Turbine Monitoring Plan, (2) Marine Mammal Monitoring Plan, and (3) Benthic Habitat Monitoring Plan to monitor for potential effects. (These three monitoring plans are described in Appendix A.)

Following Project deployment, the proposed Near-Turbine Monitoring Plan will allow evaluation of what species approach the turbine and how they behave in the near-turbine vicinity (summarized above in discussion on Blade Strike). The video cameras mounted on the turbines as part of the Near-Turbine Monitoring Plan will allow for monitoring of the turbine for biofouling and viewing of species that approach the turbine.

The goal of the Marine Mammal Monitoring Plan is to detect and observe marine mammals in the Project area, during turbine installation, operations, and removal, and to improve the understanding of how marine mammals interact with operating tidal turbines. Monitoring will include passive acoustic monitoring, land- and vessel-based observations during installation, operations, maintenance, and removal.

The Benthic Habitat Monitoring Plan will (1) monitor benthic habitat (including substrate type, water depth, relief, and habitat patchiness) in the vicinity of the two turbines, along the cable route, and at six selected sampling locations; (2) determine if cable placement moves over time, potentially requiring repair or anchoring; (3) provide observations of fish abundance and size; (4) provide habitat descriptions associated with observations of fish use in these areas; (5) review data relative to previous data sets; and (6) consult with the Admiralty Inlet MARC to consider modification to the Benthic Habitat Monitoring Plan in response to the results of benthic habitat monitoring efforts. This study will complement the District's pre-installation evaluation of benthic habitat in the Project area, as well as the post-installation ROV operations monitoring to (1) periodically inspect project components, (2) periodically survey the subsea cable route, and (3) monitor for derelict gear.

Our Analysis

Construction Impacts - The proposed turbine location is situated on hard-bottom habitat with a fairly flat and featureless seabed at about 58 meters water depth. The OpenHydro turbines will be lowered from the installation barge and placed on the seafloor. The turbine foundation is a triangular gravity-based structure approximately 19.2 meters long by 18 meters wide, and weighs approximately 386 metric tons (air weight). The maximum footprint area of the foundation that will be in direct contact with the seabed will be approximately 10 square meters per turbine (20 square meters total footprint for Project).

As requested by NMFS in the December 8, 2008 letter, the District performed studies to characterize the existing benthic environment, and to identify sensitive areas along the proposed subsea transmission cable route. The existing substrate in the turbine deployment area is composed of cobble as strong currents cause seafloor erosion, transport, and removal of fine grain sediments, leaving only granular sediments, cobbles, and boulders (Fugro 2009; further described in Section 3.3.1, Geology and Soil Resources,). Figure 3-32 shows photographs of substrate at the deployment site, showing mostly cobble 6-18 cm in diameter.

FIGURE 3-32
ROV VIDEO IMAGE OF SEABED AT PROJECT TURBINE DEPLOYMENT SITE, APRIL 6, 2009 NNMREC SURVEY

Benthic invertebrates including bivalves, snails, sea stars, and other species of immobile or slow-moving benthic organisms located directly beneath the gravity foundation could be crushed, injured, or disturbed during the Project installation. Pelagic fish, marine mammals, and birds are highly mobile, and therefore, the District anticipates that these species will not be affected by the deployment of the OpenHydro turbines and the installation of the subsea transmission cable. Bottom-dwelling fish and other mobile organisms, such as crabs, would likely move to nearby areas during deployment activities (FERC 2007).

The subsea trunk cables will connect the turbines to the land-based electrical grid. NMFS, in a letter to the District dated July 6, 2009, indicated concern about disturbance of rocky habitats in less than 18 meters of water, which are typically covered with macroalgae including canopy and understory kelps, bladed and filamentous red and brown algae, and surfgrasses (Mumford 2007). In this letter, NMFS stated that “the near-shore habitats are particularly important as nursery areas for juvenile fish, and provide connecting pathways for movement to adjacent habitat used by later life-stages (Palsson et al. 2008)”. To avoid adverse impacts to sensitive shoreline areas and to avoid impacts to the near-shore habitat and benthic species, the District will deploy the trunk cables inside an HDD bore from onshore to a minimum depth of 18 meters. While excavated material will be deposited on shore during the HDD process (see Section 3.3.3, Terrestrial Resources), some minor bottom disturbance will occur on the seabed where the trunk cables exit from the HDD bore. This disturbance will be localized to the drill exit area. This approach avoids any impacts to the kelp beds and eelgrass as the exit point for the HDD is located in water much deeper than where the kelp beds and eelgrass are located.

Due to the relatively small size of the Project, the District does not believe the deployment of the Project represents a significant impact on benthic organisms. Any effects to benthic marine life and habitat should be small and temporary. The presence of the gravity-based foundations may slightly reduce available bottom habitat and temporarily displace some species during installation.

<u>Changes to marine community composition</u> - The potential effects to the marine community resulting from changing an open-water marine habitat to one with an anthropogenic structure may result in a local change in the distribution and abundance of marine species relative to areas outside of the turbine vicinity. The likelihood of exposure of marine life to the Project and its associated habitat change is influenced by overlap in both the spatial and temporal distribution of species with the Project. Migratory species/life stages, such as inbound adult salmonids, outbound juvenile salmonids are expected to be transiting through the Admiralty Inlet area and would be exposed to the project infrequently and for a very short period of their life. In contrast resident species, such as ratfish and rockfish, could be exposed to the project more frequently.

Given the results from the observations of fish use of the EMEC platform-mounted turbine (see Figure 3-27 above and discussion about blade strike), it can be expected that some fish species may be attracted to the downstream side of a turbine during the limited periods of slack tide and low tidal velocity. The District anticipates that habitat alterations attributable to the OpenHydro turbines would be on a small spatial scale (the total footprint area is 0.05 percent of the cross section of Admiralty Inlet) and that an effect to populations of affected species is very unlikely.

Project components could provide habitat for marine life including biofouling organisms, including barnacles, mussels, bryozoans, corals, tube dwelling invertebrates, algae, sponges, tunicates, and hydroids. As discussed above, from OpenHydro's experience at EMEC in Scotland, biofouling is not considered to be an operational issue for the turbine, and antifouling paint will be applied to only the each turbine's blades and outer ring of the rotor. It is expected that biofouling will develop on the untreated parts of the turbine structure (e.g., the subsea base and turbine support frame). Biofouling may contribute to an artificial reef effect of the project, creating more complex structure. Structure oriented forage species may be attracted to the turbine structures and the biofouling community, and in turn their predators may also be attracted to the area.

It is unclear whether OpenHydro turbines may attract structure-oriented fish, such as rockfish, and given the results from EMEC, even benthopelagic fish. Artificial structures may benefit rockfish (Love et al. 2006) and may enhance local fisheries. However, as NMFS stated in its letter to the District dated July 23, 2009, other researchers conclude that artificial habitat may not serve as well as natural habitats because of overcrowded conditions and the need to search for food (Matthews 1990, Palsson 2008). Given these variables and that there is uncertainty to what degree the Project structures will serve in an artificial reef capacity, it is unknown how rockfish and other structure-oriented species will react to the presence of the turbines. A marine fish enhancement program started in 1974 to improve urban recreational fishing in Puget Sound has found that abundant and diverse algal growth on the artificial structures increases habitat complexity and heterogeneity, and may well be the most important element in the transition from introduced materials to replicates of productive natural reefs (Buckley 1982). If fish are attracted to the structure, especially in numbers similar to that seen for the EMEC structure during slack tide, it can be expected that predators, such as marine mammals will consequently be attracted to the area of the turbine structure to feed during periods of slack tide. Also, as indicated by the EMEC analysis, it appears that fish leave the turbine area as the tidal velocity increases and the turbine starts turning. These findings indicate little risk to fish or marine mammals because they are not present when the turbine is rotating.

While there is considerable existing information on use of Admiralty Inlet by marine species, as characterized by the Affected Environment of this section, how marine life will respond to the Project's localized alteration of habitat is not understood, defining the need to evaluate potential effects as follows:

- Near-Turbine Monitoring Plan - This monitoring study will provide information about whether species are attracted to Project structures. The video cameras mounted on the turbines will monitor part of the turbine face for biofouling and viewing of species that approach the turbine.
- Benthic Habitat Monitoring Plan - This monitoring study will monitor the benthic habitat in the vicinity of the two turbines and at six selected sampling locations. The study will provide observations of fish abundance and size, provide habitat descriptions associated with observations of fish use in these areas, and review data relative to previous data sets. This study will complement the District's pre-installation evaluation of benthic habitat in the Project area, as well as the post-installation ROV operations monitoring.
- Marine Mammal Monitoring Plan - This monitoring study will detect and observe marine mammals in the Project area. One of the primary objectives of the study is to improve the understanding of how marine mammals interact with operating tidal turbines, and will include periodic reporting to the MARC.

For all monitoring studies, the District will analyze and report the study results to the MARC. The District and the MARC will then evaluate the effectiveness of the monitoring methods, the collected data, and whether adjustments to monitoring methods are necessary. The District has proposed certain actions (safeguards) in the event negative effects are determined. These Adaptive Management Responses are detailed in each monitoring plan.

In conclusion, because of the small size of this pilot-scale Project relative to the surrounding waters (the proposed Project will occupy 0.05 percent of the cross sectional area of Admiralty Inlet [Figure 3-30]) and the temporary nature of the deployment, the Project will represent a very small amount of both (1) habitat that structure-oriented species might be attracted to and (2) changes to the marine community composition in, and use of, the area. That is, even though the placement of the two turbines on the seabed will change the local habitat from low relief to an area of high relief, because of the small size and short deployment term of the Project, the District anticipates that habitat alterations attributable to the OpenHydro turbines would be on a small spatial scale and with a potential for attraction of only a few individuals but no effect to populations. In fact, it might be beneficial if these fish prefer high relief structure as it is lacking in the area. Monitoring studies have been developed for the collection of data to detect unanticipated negative effects, and the adaptive management framework provides for addressing negative effects in the event that they do occur.

Marine Debris Entanglement

In dynamic tidal sites, there is the potential for any floating or benthic debris to be carried within the water column in the tidal flow. As a result, debris may contact or become entangled on the turbine or gravity based foundation. Derelict fishing gear has been identified as a specific concern. In the 1950's synthetic materials replaced natural fibers in fishing gear in most of the world's fisheries (USOAP 2004). The newer synthetic fishing gear is much less prone to degradation in water, and when discarded or lost in the marine environment, it can last for decades (Morton 2005). In a letter to the District dated December 8, 2008, NMFS expressed concern that derelict fishing gear may snag on turbine structures and pose an entanglement risk to marine mammals, fish, and potentially marine birds in the vicinity of the Project. NMFS recommended conducting underwater inspections every 90 days to monitor for entangled debris.

If debris should become entangled with the device, it is anticipated that the performance of the turbine would reduce noticeably and that this performance drop would be monitored and recognized on the control system. The District will monitor for derelict fishing gear as part of its Monitoring Plan (Appendix C). There will also be an ability to monitor much of the turbine face from the video cameras installed as part of the Near-Turbine Monitoring Plan.

During the first year following Project installation, the District will deploy an ROV at a minimum of once every three months. Following the first year, the MARC will review the results of the Derelict Gear Monitoring Plan to determine the degree to which derelict gear gets caught on the project, if at all, and determine whether changing the frequency of subsequent underwater inspections is appropriate.

If the District observes derelict fishing gear snagged on the Project works, the District will remove the gear as soon as possible. Successful removal of deep-water fishing gear using ROVs has been demonstrated in Puget Sound (NRC 2008). ROVs capable of detection and subsequent removal of derelict gear are available for deployment at the Project site within 48 hours. The gear removal deployment will generally involve vessel anchoring, ROV anchoring, ROV approach and assessment of the derelict gear and any aquatic species trapped, ROV securing of the derelict gear using a manipulator arm and/or cutting tool, and winching up of the ROV, derelict gear, and ROV anchor by the support vessel. Upon removal, the derelict gear will be examined by a marine biologist. Species, size, and number of trapped or entangled marine life observed by video and from observations of gear brought to surface will be recorded and reported to the MARC. Disposal typically consists of removal of lead from nets for recycling, and landfill disposal for all remaining material (Pers. comm., Greg Ruggerone, Natural Resource Consultants, Inc. August 2010).

Our Analysis

Commercial and recreational fishing activities have contributed to numerous instances of derelict fishing gear in the Puget Sound region. The Northwest Straits Commission independently estimated that as many as 4,000 derelict fishing nets/gear are present on the seafloor in Puget Sound and the Northwest Straits south of the U.S.-Canada border (NWSF 2007).

Good et al. (2009) reported that for the 902 derelict fishing nets recovered since 2002 from the United States portions of the Juan de Fuca Strait and Puget Sound, there were 876 gillnets, 23 purse seines, two trawl nets, and one aquaculture net. Most gillnets were recovered from depths less than 22 meters, with a maximum depth of 42.7 meters (Good et al. 2009)[22].

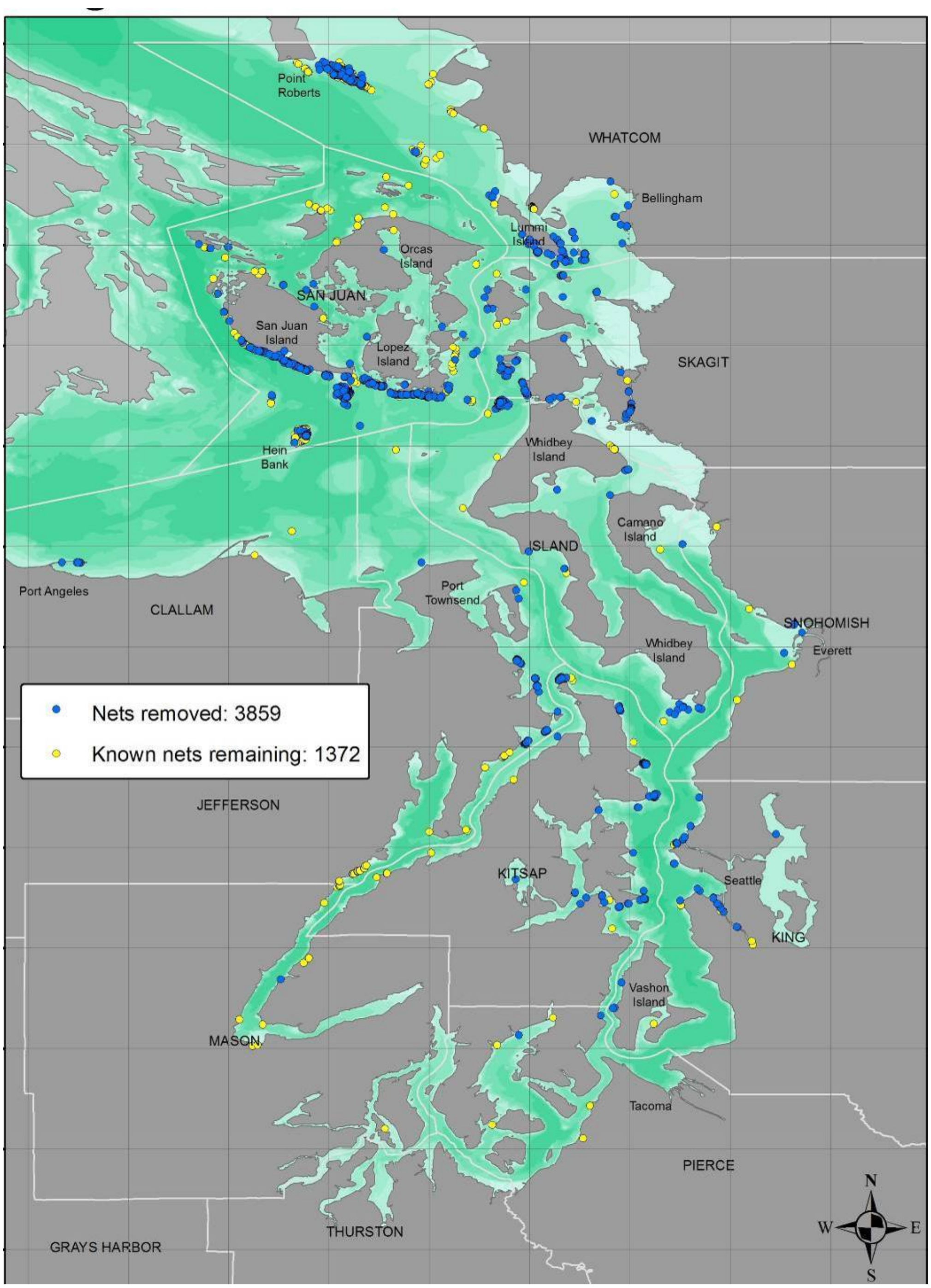
According to the gillnet recovery data, marine birds were entangled in 14 percent of the nets and were more likely to be present in gillnets that were in relatively good condition, recovered less than one year after being reported to the recovery program, located in the San Juan Islands and Strait of Juan de Fuca, large in size (1,000 to 14,000 m^2), and recovered from minimum depths of 20 to 40 meters (Good et al. 2009).

In 2010, the Northwest Straits Marine Conservation Initiative was awarded $4.6 million in economic stimulus from the American Recovery and Reinvestment Act (ARRA) to continue to recover derelict fishing gear from Puget Sound. The funds provided resources to locate and remove approximately 2,500 high priority derelict nets and move toward fulfilling the Derelict Fishing Gear Removal Program goal to clear 90 percent of the existing derelict fishing nets from high priority areas of Puget Sound by 2012 (Northwest Straits 2012). High priority areas in Puget Sound include the San Juan Islands, Central Puget Sound, and Admiralty Inlet (Northwest Straits 2009).

Utilizing divers and side scan sonar, the program, as of December 31, 2010, has removed 2,493 derelict nets. An additional 1,366 nets have been removed through other Northwest Straits Marine Conservation Initiative projects (NWSF 2012). Because of these efforts, it is expected that the risk of derelict fishing gear snagging on project works has decreased substantially, and will decrease even more in the future. Figure 3-33 shows the derelict nets removed and nets known to be remaining in Central and South Puget Sound and Hood Canal. There are two nets that remain in Admiralty Inlet.

[22] The report does not specify whether the derelict gear is more common in depths less than 22 meters or if gear in shallower water was targeted for recovery.

FIGURE 3-33
KNOWN AND REMOVED DERELICT FISHING GEAR IN PUGET SOUND AS OF JUNE 2010



Source: NWSF 2011

The Project's two turbines will be located at approximately 58 meters depth and will rise 10.5 meters above the seabed. Therefore, the top of the turbine will be at a depth of approximately 47.5 meters. The turbines do not have any mooring or anchoring lines that could snag derelict fishing gear. However, derelict fishing gear could potentially entangle on the gravity base foundation or the turbine structure itself. The District believes that the risk of debris entangling with the turbine is reduced due to the hydrodynamic movement of water around the turbine and through the open center. Since the tide changes direction every 6 hours it is considered unlikely that any debris would remain attached to the turbine for any period of time. Should debris become entangled with the device, it is anticipated that the performance of the turbine would reduce noticeably and that this performance drop would be monitored and recognized on the control system.

The District's proposed Derelict Gear Monitoring Plan allows for detection and removal of derelict fishing gear. This will minimize the chance that recreational fishing gear will snag on Project components. These mitigation measures reduce the likelihood of derelict fishing gear entangling on Project works and impacting marine species.

While injury or mortality from entanglement in derelict gear caught on Project turbines could occur to marine life that that may be attracted to the turbines or passing through the Project area, the District expects the risk to be discountable and insignificant because:

- There is no gillnet fishing occurring in Admiralty Inlet (gillnets represented 97 percent of the derelict gear retrieved as reported by Good et al. [2009]). The closest commercial gillnet fishing occurs in Hood Canal to the south and the San Juan Islands area to the north (WDFW 2010b).
- Much of the derelict gear has been removed (NSWF 2011), lessening the chance of derelict fishing gear snagging on Project turbines[23].
- A Regulated Navigation Area will be established in the area around the two turbines. This will minimize the chance that recreational fishing gear will snag on Project components.
- The risk of derelict gear entangling with the turbine is reduced due to the hydrodynamic movement of water around the turbine and through the open center, and because of the reversal of the tide direction every 6 hours.
- Should derelict gear become entangled with the turbine, it is anticipated that the performance of the turbine would reduce noticeably and that this performance drop would be monitored and recognized on the control system.
- The District's proposed Derelict Gear Monitoring Plan represents the best method to evaluate whether marine debris collects on the turbines, and if it does, to remove it.
- There will also be an ability to monitor much of the turbine face from the video cameras installed as part of the Near-Turbine Monitoring Plan and to monitor the gravity base during periodic inspections with the ROV during project maintenance.
- The District will consult with the MARC to evaluate the effectiveness of monitoring methods described above and determine whether adjustments to monitoring methods are necessary.

In contrast to the known risks to marine life of derelict gear that is "ghost fishing" at an unknown site, the Project does not pose a risk to marine life because the site will be regularly monitored and gear will be promptly removed if detected.

[23] Most gillnets were recovered by divers from depths less than 22 meters, with a maximum depth of 42.7 meters (Good et al. 2009). The report does not specify whether the derelict gear is more common in depths less than 22 meters or if gear in shallower water was targeted for recovery.

Noise / Vibration

The installation, maintenance, and removal of the Project would result in the temporary production of underwater noise from installation/removal and service vessels. This noise may cause fish, seabirds, and marine mammals to temporarily alter their behavior to avoid the immediate Project vicinity. During operation of the turbines, broadband noise will be generated by the rotation of the turbine. Noise generated by the flow of water around the support structure or in the turbine wake is not expected to significantly contribute to ambient noise levels because the source is weak (i.e., noise from shed, turbulent eddies is predominantly a local source) (Polagye et al. 2011).

Marine life such as fish and marine mammals have biological receptors that are sensitive to sound pressure levels (SPL) (expressed in dB re 1 μPa), particle velocity (expressed in m/s), and the frequency of sound (expressed in Hz). The potential effects of variable noise frequencies and pressure levels on marine life include changes in hearing sensitivity and behavioral patterns (NAS 2003).

The concern for potential effects of noise generated by ocean energy projects has been a primary environmental concern in the development of ocean energy projects (Cada et al. 2007, Scottish Executive 2007, MMS 2007, Michel et al. 2007), and has been raised by resource agencies involved with the Admiralty Inlet Pilot Tidal Project licensing process (e.g., NMFS letters to the District dated July 6 and 23, 2009 and December 8, 2008, and WDFW letter to the District dated June 16, 2009). NMFS is specifically concerned that sounds introduced into the sea by man-made devices would have a deleterious effect on marine mammals by causing stress, interfering with communication and predator/prey detection, and changing behavior (NMFS letter to the District dated July 6, 2009).

A federal Interagency Task Force on Anthropogenic Sound and the Marine Environment[24] have identified the importance (assigned as a moderate priority) of conducting sound source characterization and, where appropriate, monitoring of emerging tidal energy technologies (Southall et al. 2009). As defined by the Task Force's report (Southall et al. 2009), source characterizations should include full-azimuth measurements, careful reporting of all calibrations, and wide-frequency bandwidth measurements.

To determine the levels of underwater noise generated from the Project during operation, the District proposes to implement a post-deployment underwater noise study that will involve conducting *in-situ* measurements of the acoustic emissions of the operating OpenHydro turbines (see Appendix A). The results from the monitoring study will be compared to the results of the pre-installation underwater noise study and used to evaluate whether the noise generated by the Project is expected to negatively affect marine species. In addition, to minimize environmental

[24] The Interagency Committee on Ocean Science and Resource Management Integration (ICOSRMI) formed an "Interagency Task Force on Anthropogenic Sound and the Marine Environment" within the Joint Subcommittee on Ocean Science & Technology (JSOST). JSOST developed the referenced report "Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U.S. Federal Agencies" (Southall et al. 2009).

effects during project construction, the District will conduct marine installation work during WDFW-approved work windows.[25]

Our Analysis

Our analysis consists of the following:

- Noise exposure criteria,
- Noise and marine life,
- Ambient noise measurements,
- Project noise,
- Potential effects, and
- Conclusions.

Noise Exposure Criteria - Noise exposure criteria for injury to marine mammals are given for two types of sounds, impulsive (transient) and non-impulsive (continuous). Impulsive sounds are generally characterized by rapid rise of sound pressure followed by a sound pressure fall. Examples of impulsive sound include explosions, gunshots, and pile driving strikes. Non-impulsive sounds, intermittent and continuous, do not have the same rapid rise and fall characteristic as impulsive sounds. Examples of non-impulsive sounds include marine traffic, and drilling machinery. Noise from turbine operation is also a continuous, non-impulsive source.

Under the Marine Mammal Protection Act (MMPA), NOAA has established two levels of acoustic thresholds to evaluate potential effects to marine mammals, Level A and Level B Harassment. Level A Harassment has the potential to injure a marine mammal or marine mammal stock in the wild, while Level B Harassment has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (letter from NMFS to the District dated July 23, 2009). Sound intensities discussed below are rms (root mean square) values.

Project construction and operation will only generate non-impulsive sounds. For non-impulsive sounds, received SPL of 120 dB (re 1 μPa) is considered Level B harassment and has the potential for behavioral disturbance to cetaceans and pinnipeds (letter from NMFS to the District dated July 23, 2009).

NOAA has continued to use a "do not exceed" exposure criterion of 180 dB (re 1 μPa) for mysticetes and (recently) all odontocetes exposed to sequences of impulsive sounds, and a 190 dB (re 1 μPa) criterion for pinnipeds exposed to such sounds (Southall et al. 2007). Southall et al. (2007) reported that the available data on marine mammal behavioral responses to multiple pulse and non-impulsive sounds are too variable and context-specific to justify proposing single disturbance criteria for broad categories of taxa and of sounds. In general, the behavioral response depends not only on the received level of noise, but the frequency distribution of that

[25] The Project is located in the Tidal Reference Area 10 (Port Townsend). The species work windows for this reference area include: salmon, bull trout, Pacific herring, and Pacific sand lance. The work windows are from July 16 to March 1 for salmon, July 16 to February 15 for bull trout, May 1 to January 14 for Pacific herring, and March 2 to October 14 for Pacific sand lance.

noise, the hearing sensitivity of the individual marine mammal, its life history exposure to similar noise, and behavioral state at the time the noise is received.

Noise and Marine Life - Many marine mammals and fish species use sound in communication, navigation, predator/prey interactions, and hazard avoidance. As stated above, these organisms have biological receptors that are sensitive to SPL, particle velocity, and the frequency of sound. Resource agencies have indicated particular concern about how Project noise may affect marine mammals and fish. For example, NMFS, in a letter to the District dated July 23, 2009, expressed concern that, because Admiralty Inlet is attractive to marine mammals and fish for foraging due to its bottleneck properties, if turbine operation leads to avoidance of the area, the Project may result in lost foraging opportunities.

The Environmental Assessment developed by FERC for the Makah Bay Offshore Wave Energy Pilot Project (FERC Project No. 12751), proposed off the Olympic Peninsula, FERC (2007) reported that “Sound induced effects on marine mammals are expected when the sound overlaps in frequency and level with the hearing capability of the species under consideration. There is considerable variation among marine mammals in both absolute hearing range and sensitivity.” Marine mammals as a taxonomic group have functional hearing ranges of 10 Hz to 200 kHz; this includes ultrasonic, frequencies greater than 20 kHz, and infrasonic, frequencies less than 20 Hz. Odontocetes and pinnipeds are typically more sensitive to higher frequencies and mysticetes are more sensitive to lower frequencies (Richardson et al. 1995).

While direct hearing measurements are usually not available for cetacean species, there is consensus that a whale’s hearing range is similar to the range of sound it produces (LGL and JASCO Research 2005). Mysticetes typically vocalize in lower frequencies (peak spectra of 12 Hz to 3 kHz) and odontocetes vocalize in high frequencies (10 kHz to 200 kHz) (Ketten 2000). Toothed whales are most sensitive to sounds above approximately 10 kHz and their upper limits of sensitive hearing range from about 65 kHz to over 100 kHz in some individuals. The sensitivity of many toothed whales to high-frequency sounds is related to their use of high frequency echolocation and communication (Richardson et al. 1995).

A number of mysticetes that were exposed to different sound sources, both impulsive and low frequency sounds, have displayed avoidance behaviors for received levels of 140 to 160 dB (Malme et al. 1983, 1984, 1988, Ljungblad et al. 1988, Tyack and Clark 1998). Large commercial vessels and oil and gas developments have been shown to create noise that can make gray whales change path, increase swim speed, or alter breathing patterns (Moore and Clark 2002).

Baleen whales demonstrate strongest avoidance behavior when boats approach directly or when vessel noise abruptly changes (Watkins 1986; Beach and Weinrich 1989). Humpback whales have been documented responding to boats at a minimum distance of 0.5 to 1 km, while avoidance can occur even at distances of several kilometers (Jurasz and Jurasz 1979; Dean et al. 1985; Bauer 1986; Bauer and Herman 1986).

Conversely, noise associated with some boats has also been observed to attract gray whales (Moore and Clarke 2002) and other baleen whales, especially minke whales, will approach slow moving or stationary boats (LGL and JASCO Research 2005), while humpback whales have been shown exhibiting no reaction to boats (Watkins 1986). Some baleen whales demonstrate habituation to frequent boat traffic: off Massachusetts, minke whales initially engaged in frequent positive interactions then, with time showed no interest, while humpback whales reactions changed from frequently being negative to being positive fairly often, and finback whales reactions were initially primarily negative and then changed to being mostly uninterested (Watkins 1986).

Harbor porpoises emit narrowband high frequency clicks with a peak frequency of 128 kHz and a mean Source Level of 157dB (re 1μPa) at 1m when measured in captivity (Au et al. 1999). Although sighted far less frequently in the region, Dall's porpoise echolocation clicks are also narrow band (2-10 kHz) with most peak frequencies between 117 and 141 kHz (Bassett et al., 2009). Harbor porpoise have left areas where pile driving was occurring (Tougaard et al. 2003). These are impulsive noises that would not occur at the Admiralty Inlet Project. Harbor porpoises typically avoid boats (Barlow 1988), but pre-installation studies of harbor porpoise avoidance of ferry traffic suggest a degree of habituation at this specific location (Polagye, et al., 2012*b*).

Studies on behavioral responses of pinnipeds to non-impulsive sounds suggested that exposures between 90 and 140 dB (re 1 μPa) generally do not appear to induce strong behavioral responses in water. No data exist regarding exposures at higher levels (Southall et al. 2007).

Most species of fish can detect sounds between 75 and 150 dB (re 1μPa) and frequencies from below 50 Hz up to 500-1,500 Hz (Hastings and Popper 2005, Popper and Hastings 2009). Atlantic salmon, which share similar auditory systems with Pacific salmon, typically can detect sounds between 95 and 130 dB (re 1μPa), at frequencies between 30 and 400 Hz (Hastings and Popper 2005). It is expected that noise from the operating turbines will be detectable by fish in the Project area under some ambient noise conditions (Polagye et al, 2012*a*).

In the Environmental Assessment for the Makah Bay Offshore Wave Energy Pilot Project (FERC No. 12751), FERC concluded: “With regard to fish, given that the greatest sound intensities that would be produced by the proposed project during construction/installation, operation, and maintenance would likely be less than 130-160 dB (re 1 μPa) and that adverse effects on fish are typically not seen at levels below 160 dB, we do not expect fish in the project area to be adversely affected by underwater noise associated with the project” (FERC 2007).

Hastings and Popper (2005) reported that “... fishes would show a startle response to sounds as low as 160 dB, but this level sound did not appear to elicit decline in catch.” NOAA noted in an email to the District dated April 11, 2011, that this source of noise was for impulsive sound and that the study did not identify a threshold intensity at which fish showed a startle response. Mueller-Blenkle et al. (2010) found that sole and cod exhibit changes in swimming behavior such as swim speed and swim direction when exposed to impulsive sounds from pile driving (there will be no pile driving or impulsive sounds associated with the Project). Significant changes in swimming speed and changes in swimming direction in sole were observed when the fish were exposed to impulsive sound between 144 and 156 dB (re 1μPa), while cod reactions in average swimming speed and an initial freezing response were observed in a sound pressure range from 140 to 161 dB (re 1μPa) from impulsive sound (Mueller-Blenkle et al. 2010).

Popper and Hastings (2009) reviewed peer-reviewed and "grey" literature with the goal of determining what is known about effects of noise on fish. A majority of the studies of effects of noise on fish has focused on impulsive sounds, such as pile driving or air guns (Popper and Hastings 2009), which would not occur at the Admiralty Inlet Project. Popper and Hastings (2009) report that "pile driving is the only anthropogenic sound source other than explosives that has caused fish kills in the wild that have been documented in the literature." Popper and Hastings (2009) reviewed studies that evaluated fish response to continuous sources of noise. They reported that corticosteroid levels, a measure of stress, were evaluated for the following two species, and no stress effects were found:

- Goldfish (*Carassius auratus*) in response to continuous exposure to band-limited noise in the 0·1-10 kHz frequency band with an overall rms pressure level of 170 dB (re 1 μPa) (Smith et al. 2004a); and
- Rainbow trout (*Oncorhynchus mykiss*) exposed to continuous band-limited noise at 150 dB (re 1 μPa) for the first nine months of their lives (Wysocki et al. 2007).

Temporary hearing loss, or TTS may occur from exposure to low levels of sound over long periods of time or to higher levels of sound for short periods of time. In their review Popper and Hastings (2009) reported TTS for some fish species that have been evaluated[26] (Smith et al. 2004a, b, Scholik and Yan 2001, Popper et al. 2005, 2007), but not for others (Smith et al. 2004a, b, Scholik & Yan 2002, Wysocki et al. 2007, Hastings et al. 2008).

An unpublished study (Jørgensen et al. 2005) reported that larval and juvenile (≤ 6 cm standard length) pollock (*Pollachius virens*), Atlantic cod (*Gadus morhua*), Atlantic herring (*Clupea harengus*), and spotted wolfish (*Anarhichas minor*) were exposed to between 4 and 100 pulses of 1 second duration of pure tones at 1.5, 4 and 6.5 kHz. SPLs at the location of the fish ranged from 150 to 189 dB (re 1 μPa), and "there were no effects on fish behavior during or after exposure to sound (other than some startle or panic movements by the *C. harengus* for sounds at 1.5 kHz) and there were no effects on behavior, growth (length and weight), or survival of fish kept as long as 34 days post-exposure"[27]. Internal organs showed no damage resulting from the sound exposure (Jørgensen et al., 2005).

<u>Ambient Noise Conditions</u> - There are many natural sources of ocean noise, such as those resulting from wind, waves, precipitation, cracking ice, and vocalizations by a variety of aquatic species (NAS 2003). Anthropogenic sources of ocean noise include commercial shipping, military activities, geophysical surveys, oil drilling and production, dredging and construction, sonar systems, and oceanographic research. Sound pressure spectral densities can range from about 35 to 80 dB (re 1 $\mu Pa^2/Hz$) for usual marine traffic (10 to 1,000 Hz), and 20 to 80 dB (re 1 $\mu Pa^2/Hz$) for breaking waves and associated spray and bubbles (100 to 25,000 Hz) (Richardson et al. 1995).

---

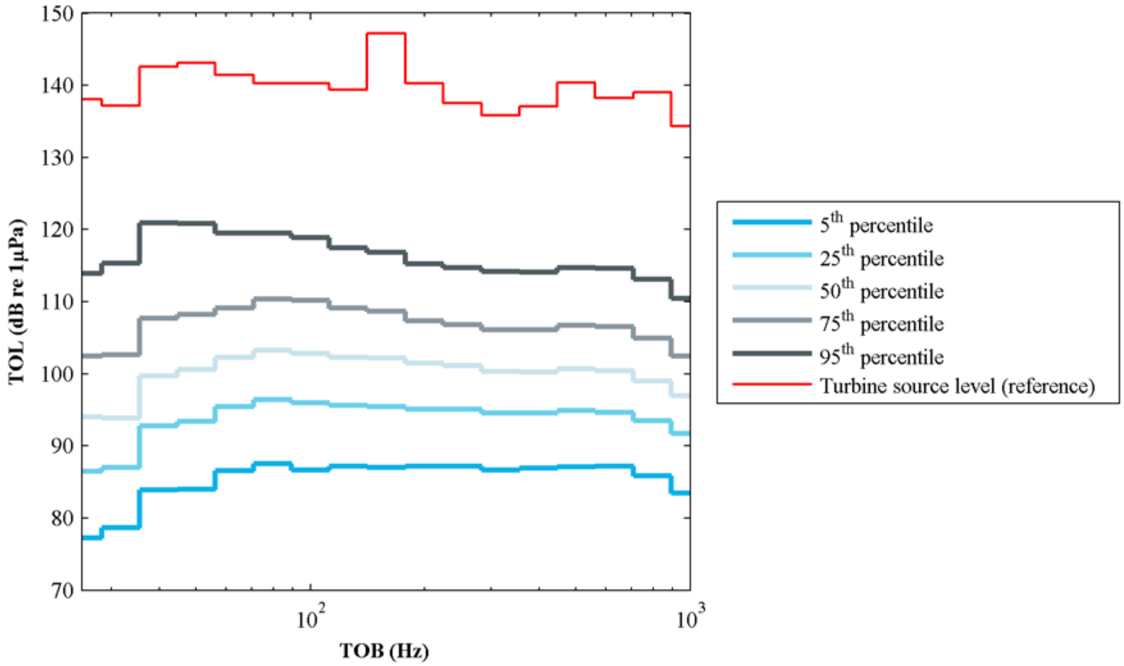
[26] Scholik and Yan (2001) found TSS occurred for fathead minnows (*Pimephales promelas*) exposed to a relatively low level of noise: 24 hours of exposure to white noise from 0.3 to 2.0 kHz with an overall SPL as low as 142 dB re 1 μPa.

[27] Exception was one test conducted on two groups of Atlantic herring at an SPL of 189 dB re 1 μPa, experienced post-exposure mortality of 20-30%.

As discussed in Bassett et al. (2012*b*), tidal currents affect ambient noise measurements in two ways. At frequencies below 1 kHz, as currents pass across the hydrophone element, turbulent eddies are shed and perceived as pressure fluctuations. This “pseudo-sound” is equivalent to the noise one hears while riding a bike downhill – it does not propagate and, therefore, should not be included in an ambient noise budget. Strong currents also mobilize gravel and shell hash mixed amongst the cobbles on the seabed. This movement gives rise to propagating ambient noise at frequencies greater than 1 kHz. The intensity of this “bedload transport” noise increases with current velocity and is significant when turbine hub-height currents exceed 1 m/s. In other words, at frequencies less than 1 kHz, ambient noise is uncorrelated with current velocity, but above 1 kHz ambient noise and current velocity are correlated.

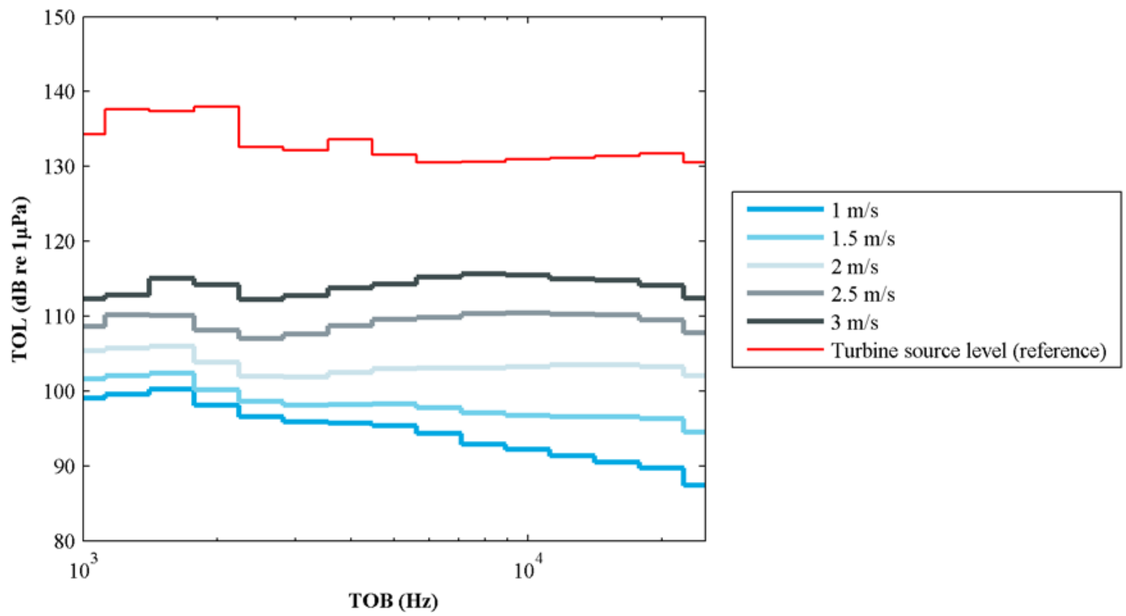
This understanding of ambient noise has been developed through three years of ambient noise monitoring in Admiralty Inlet by NNMREC. Measurements have included fixed hydrophones deployed on instrumentation packages, drifting hydrophones deployed from spar buoys or surface vessels, monitoring of vessel traffic using an Automatic Identification System (AIS) receiver, and monitoring currents with Doppler profilers and Doppler velicometers. Details of ambient noise monitoring are described in Bassett (2010), Bassett et al. (2010), Bassett et al. (2012*a*), and Bassett et al. (2012*b*). Low-frequency (25 Hz – 1 kHz) ambient noise probability distributions are presented in Figure 3-34 by one-third octave band. Figure 3-35 presents similar information for higher frequencies (1 kHz – 25 kHz), specifically, median one-third octave levels at different hub-height current velocities. The turbine source one-third octave levels derived from EMEC measurements is shown in both figures as a red line. These measurements were conducted at a current velocity of 1.8 m/s. Bassett et al. (2012*a*) demonstrates that low frequency ambient noise is dominated by shipping traffic. For higher frequencies, as the current velocity increases, bedload transport noise elevates ambient noise levels proportionally to the square of velocity (Bassett et al., 2012*b*). While rainfall and biological noise also elevate noise at these frequencies (e.g., 20 kHz), these do not affect ambient noise levels as significantly as bedload transport.

FIGURE 3-34
PERCENTILE ONE-THIRD OCTAVE LEVELS (TOLS) FOR AMBIENT NOISE (25 HZ – 1 KHZ)



Source: Polagye et al., (2012*a*) using data presented in Bassett et al., (2012*a*)

FIGURE 3-35
MEDIAN ONE-THIRD OCTAVE LEVELS (TOLS) FOR AMBIENT NOISE (1 KHZ – 25 KHZ) AS A FUNCTION OF CURRENT VELOCITY



Source: Polagye et al., (2012*a*) using data presented in Bassett et al., (2012*b*)

Project Noise - Installation, maintenance, and removal of the Project as well as operation of the turbines would generate underwater noise.

Installation, maintenance, and removal - Underwater noise will be generated from at sea actions including installation, maintenance, and removal of the Project. Noise during these operations, outlined in Section 2.2.2 above, would be primarily produced by project-associated vessels operating at the site (non-propulsion construction barges and supporting tugs). At sea installation activities are expected to require approximately 20 days and include the following actions: assist land-based HDD installation crew with exit of the HDD bore hole, deployment of turbines, laying trunk cables on seabed, and installation of the trunk cables through the HDD bore.

Removal of the turbines after five years will require raising the turbines and support frames. This may also be required for unscheduled large-scale maintenance. For device recovery, a non-propulsion turbine installation barge, ROV, supporting tugs, and personnel transfer/safety boats will be required. Removal is expected to be completed within one tidal cycle for each turbine.

Boats will be on site periodically for environmental monitoring and maintenance inspections (e.g., using an ROV). It is expected that these environmental monitoring and maintenance activities could occur during parts of several days each month during the early stages of operation and are expected to decrease in frequency over the five year deployment period.

The primary noise produced during Project installation, maintenance, and removal operations would be from boat engines (Minerals Management Service [MMS] 2007) and construction equipment on the non-propulsion barges. Sound sources, durations, and intensities expected during horizontal direction drilling, turbine installation, and cable laying are presented in Tables 3-20 through 3-22. All sound sources would be continuous and are presented as broadband rms source levels (dB re 1 µPa @ 1 m). When multiple sources of the same type are present, the presented source level is an incoherent addition representing the effective source level (e.g., the nominal source level for multiple tugs operating in close proximity).

TABLE 3-20
NOISE SOURCES DURING HORIZONTAL DIRECTIONAL DRILLING

Source	Description	Duration	Source Level (dB_{rms} re 1 µPa @ 1 m)
Horizontal directional drilling	Indirect paths from drill apparatus to water, subject to attenuation by sediments and interface loss at the boundary.	8 hours on breakout.	165 dB[28]
Two Scuba Divers	Noise from breathing and construction tasks.	One day, <8 hours	125 dB
1ea - barge w/o propulsion	Multiple hydraulic power units, winches and other apparatus.	On site < 5 days, operating intermittently.	174 dB
2ea - Tugs	V-S drive or Z drive propulsion.	On site < 5 days, operating intermittently with barge.	175 dB
1ea - Support vessel	4 stroke diesel plus twin screws, anchor winches.	Intermittently on site over 3 weeks for < 8 hours per day.	165 dB

Source: Garrood and Polagye 2011

TABLE 3-21
NOISE SOURCES DURING TURBINE INSTALLATION

Source	Description	Duration	Source Level (dB_{rms} re 1 µPa @ 1 m)
3ea - Tugs	V-S drive or Z drive propulsion.	On site <6 hours for each turbine.	175 dB
1ea - barge w/o propulsion	Multiple hydraulic power units, winches and other apparatus.	On site < 6 hours for each turbine.	174 dB
1ea - Support vessel	4 stroke diesel plus twin screws, anchor winches.	On site < 6 hours for each turbine.	165 dB

Source: Garrood and Polagye 2011

TABLE 3-22
NOISE SOURCES DURING CABLE LAYING

Source	Description	Duration	Source Level (dB_{rms} re 1 µPa @ 1 m)
3ea - Tugs	V-S drive or Z drive propulsion.	On site 3days for each turbine cable.	175 dB
1ea - barge w/o propulsion	Multiple hydraulic power units, winches, and cable handling apparatus.	On site 3days for each turbine cable.	174 dB

[28] This is an estimated value. Information on the noise propagation at the seabed/water interface for horizontal directional drilling is not available. Drilling regulations require divers to be present at drill breakout, suggesting the sound pressure levels in the marine environment associated with directional drilling are generally low. This is because there is no direct coupling between the drilling and the water column - noise generated by drilling activities is attenuated by both the seabed and the acoustical impedance mismatch at the seabed-water interface.

Source	Description	Duration	Source Level (dB$_{rms}$ re 1 µPa @ 1 m)
3ea - Support vessels	4 stroke diesel plus twin screws, anchor winches.	On site 3days for each turbine cable.	165 dB
1ea - ROV	Small electric thrusters and sonar.	On site 3days for each turbine cable.	146 dB
Two Scuba divers	Noise from breathing and construction tasks	One day, <8 hours.	125 dB

Source: Garrood and Polagye 2011

Vessels will also be on site periodically for environmental monitoring and maintenance (e.g., ROV inspections and turbine maintenance). Sound sources, durations, and intensities expected during these activities are described in Tables 3-23 and 3-24. Environmental monitoring and maintenance activities are likely to decrease in frequency over the five year deployment period as the turbine is better characterized. Initially, these activities would be expected to occur on several days each month. If turbine removal is required, the equipment and noise sources will be similar to installation.

TABLE 3-23
NOISE SOURCES DURING ROUTINE MAINTENANCE ACTIVITIES

Source	Description	Duration	Source Level (dB$_{rms}$ re 1 µPa @ 1 m)
2ea - Tugs	V-S drive or Z drive propulsion.	On site <6 hours for each turbine.	175 dB
1ea - barge w/o propulsion	Multiple hydraulic power units, winches, and cable handling apparatus.	On site <6 hours for each turbine.	174 dB
1ea - Support vessel for ROV	4 stroke diesel plus twin screws, anchor winches.	On site <6 hours for each turbine.	165 dB
1ea - ROV	Small electric thrusters and sonar.	On site <6 hours for each turbine.	146 dB

Source: Garrood and Polagye 2011

TABLE 3-24
NOISE SOURCES DURING ENVIRONMENTAL MONITORING SURVEYS

Source	Description	Duration	Source Level (dB$_{rms}$ re 1 µPa @ 1 m)
1 ea - Survey vessel	4 stroke diesel plus twin screws, anchor winches.	On site 2-5 days.	165 dB

Source: Garrood and Polagye 2011

The highest levels of underwater noise will occur when all of these sources are in operation simultaneously. The maximum rms source level (not peak-to-peak) for each type of activity is estimated as the incoherent sum of all sources as:

$$SL_{total} = 10\log_{10}\left(\left(\frac{P_1}{P_{ref}}\right)^2 + \left(\frac{P_2}{P_{ref}}\right)^2 + \ldots + \left(\frac{P_N}{P_{ref}}\right)^2\right)$$

where P_i is the broadband sound pressure associated with the i^{th} source and P_{ref} is the reference pressure (1 µPa for underwater acoustics). These are given in Table 3-25. In all cases, the noise from tugs and the construction barge dominates over other sources. Consequently, the frequency content will range from 20 Hz to 10 kHz (Richardson et al. 1995).

TABLE 3-25
MAXIMUM RMS SOURCE LEVELS FOR EACH TYPE OF CONSTRUCTION, MAINTENANCE, OR MONITORING ACTIVITY

Activity	Source Level (dB_{rms} re 1 µPa @ 1 m)
Horizontal directional drilling	178 dB
Turbine installation/removal	178 dB
Cable laying	178 dB
Routine maintenance	178 dB
Environmental monitoring	165 dB

Source: Garrood and Polagye 2011

Turbine operation - During project operations, broadband noise will be generated by the rotation of the turbine. Noise generated by the flow of water around the support structure or in the turbine wake is not expected to significantly contribute to ambient noise levels because the source is weak (i.e., noise from shed, turbulent eddies is predominantly a local source) (Polagye et al. 2011). The two turbines will be deployed for five years. During that time, the turbines are expected to create operational noise only when they are rotating, which, on the basis of pre-installation velocity surveys, is expected to occur 70 percent of the time (water velocity must exceed 0.7 m/s before the turbines will rotate). This noise will be a continuous, broadband source and, like construction noise, is presented as an rms value.

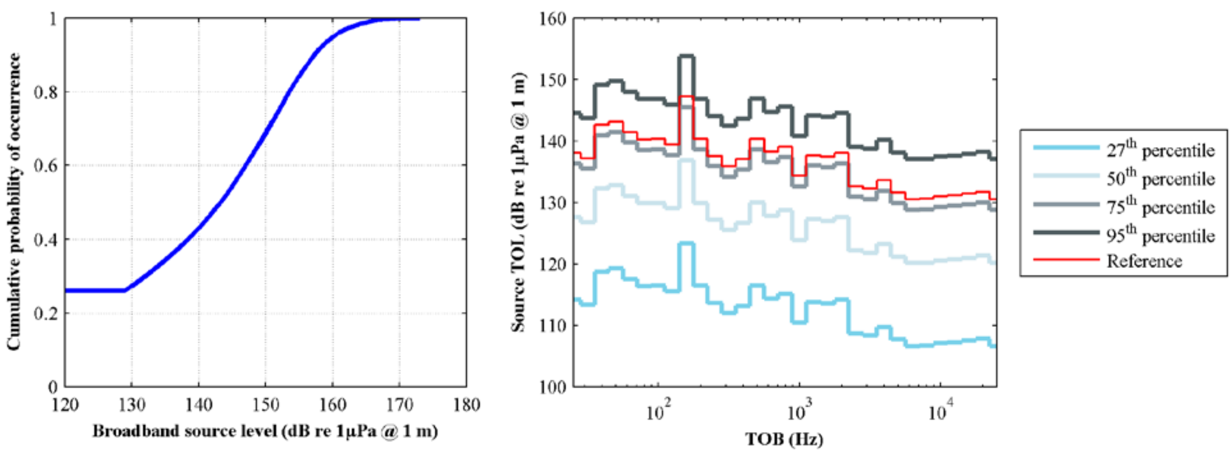
The spatial extent this anthropogenic noise depends on the propagation of underwater noise and intensity of the noise source (which will vary with turbine rotation rate), and the temporal extent is dependent on the water velocity. During non-operating periods, noise sources would be limited to flow over the support structure, which, as discussed above, is expected to be insignificant.

OpenHydro conducted an underwater noise assessment, using drifting hydrophone recordings, for a six-meter turbine at EMEC. OpenHydro obtained broadband source levels for the turbine by integrating over all frequencies of interest (i.e., from 10 Hz to 5 kHz). This resulted in an estimated broadband source level of 154 dB (re 1µPa at 1 meter).

Polagye et al. (2012*a*) conducted a re-analysis of these data to estimate receieved levels associated with operation of the turbines in Admiralty Inlet for a range of inflow velocities (e.g., measurements at EMEC were obtained at 1.8 m/s, wheres currents in Admiralty Inlet are expected to intermittently exceed 3 m/s). This draft analysis is attached as Appendix O. In order to estimate received levels for other operating states, Polagye et al. assumed that the noise emitted by rotor motion would vary with the power extracted (specifically, rms acoustic pressure is proportional to extracted power), as suggested by Hazelwood and Connelly (2005). No allowance is made for noise reduction through technology refinement (i.e., EMEC measurements are for "5th" generation turbines, wherehas the turbines deployed in Admiralty Inlet will be a newer generation) or for the different support structure design (foundation noise is expected to be negligible and, in any event, the surface area of the pile and gravity foundations are similar).

Figure 3-36 shows the expected distribution of broadband source levels (dB re 1µPa at 1m) for a 6 m diameter turbine and the frequency distribution of the source for different operating percentiles. The "reference" measurements from EMEC fall around the 75th percentile level for Admiralty Inlet (i.e., turbine noise would be no louder than this 75% of the time and louder 25% of the time). The maximum broadband source level is estimated to be 172 dB re 1µPa at 1 m, corresponding to an inflow velocity of 3.6 m/s. This source level is predicted to occur infrequently during turbine operation (i.e., < 0.01% of the time based on Doppler velocity measurements). Source levels are not predicted to exceed 180 dB re 1µPa under any operating condition.

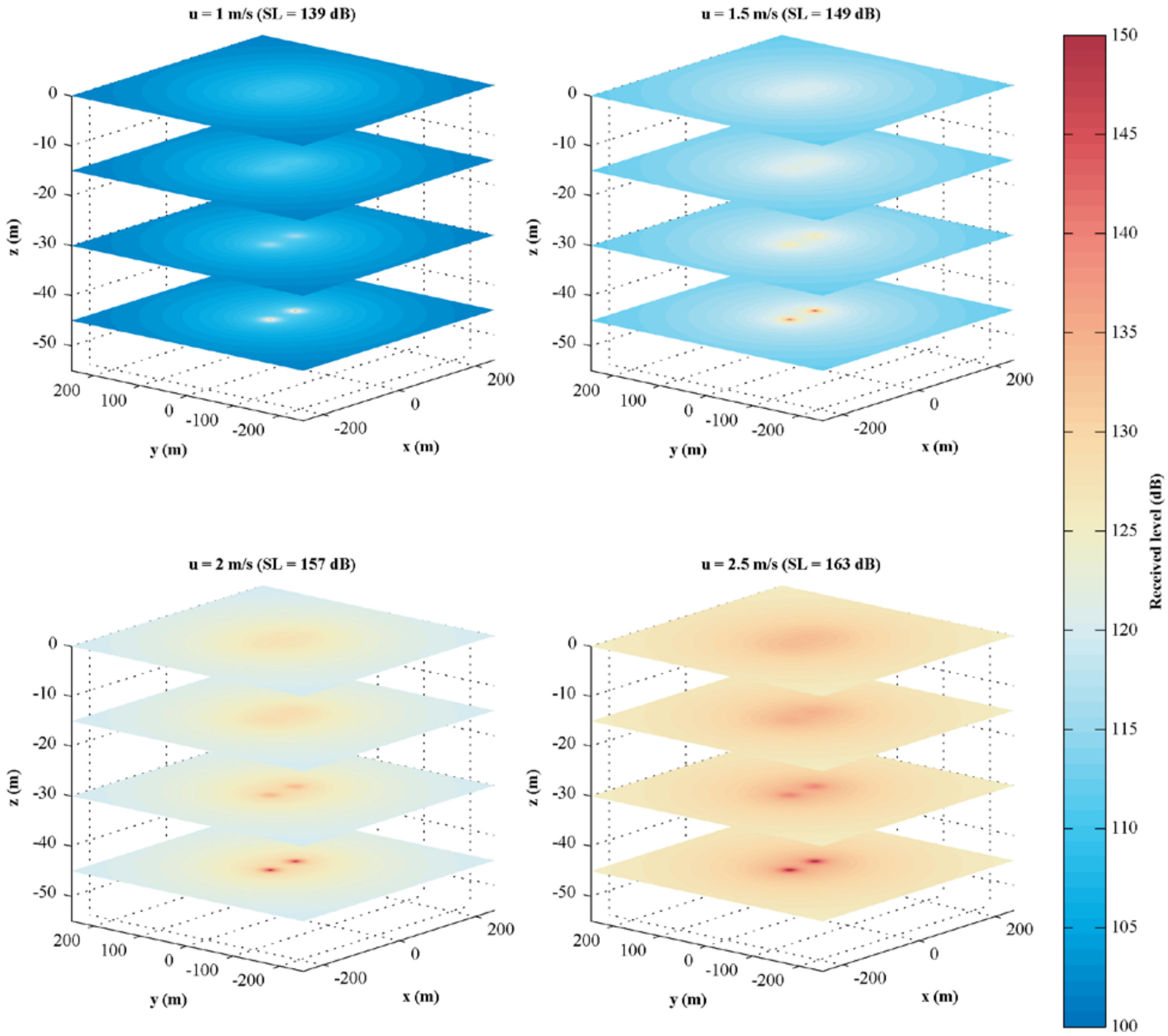
FIGURE 3-36
PROBABILITY DISTRIBUTION OF TURBINE SOURCE LEVELS. (LEFT) BROADBAND (25 HZ – 25 KHZ). (RIGHT) ONE-THIRD OCTAVE SOURCE LEVELS FOR SELECT OPERATING PERCENTILES.



Source: Polagye et al. (2012*a*)
Note: Turbine rotation begins at the 27th percentile current velocity.

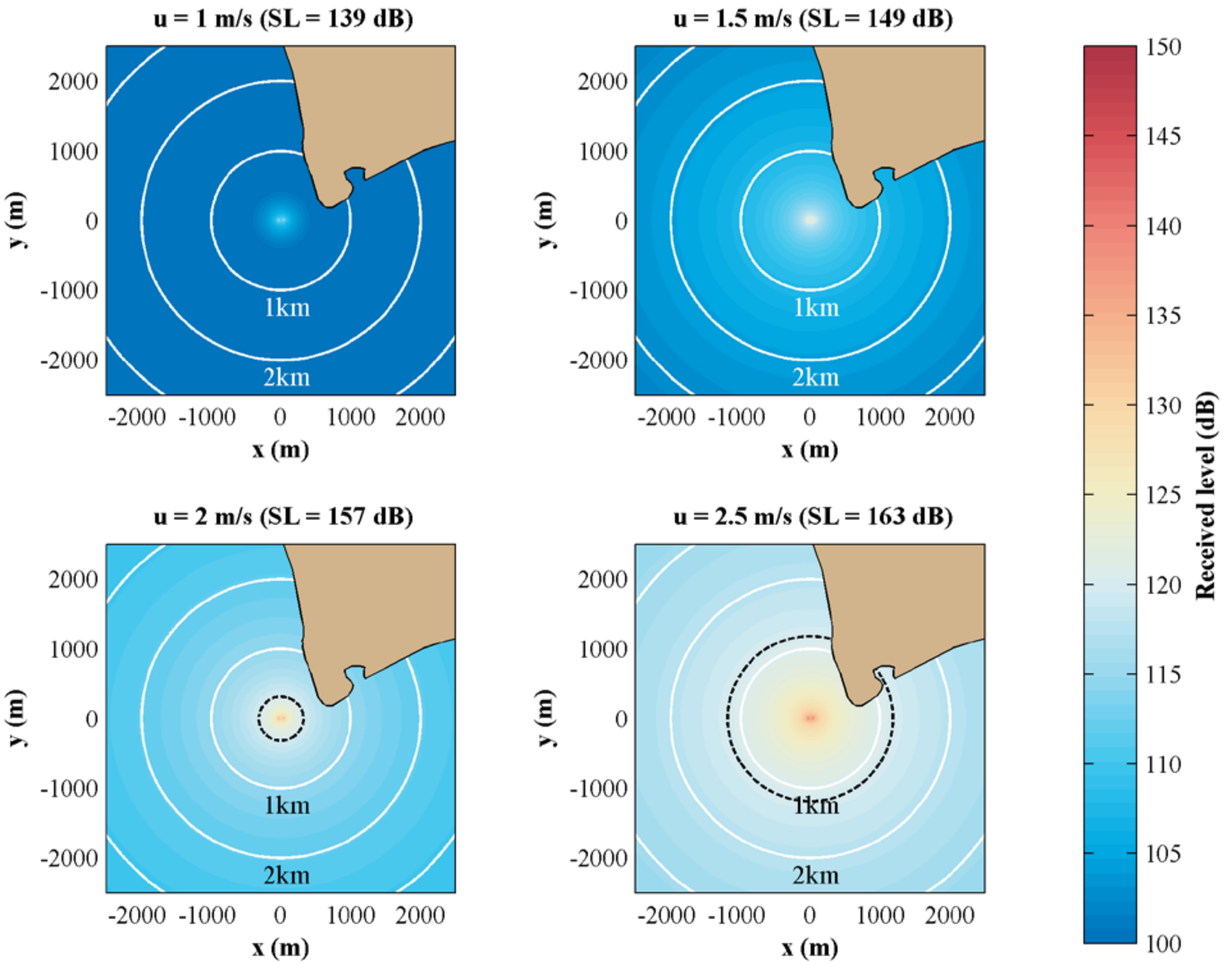
Received levels are calculated for one-third octave bands from 25 Hz to 25 kHz using a frequency-dependent transmission loss model that predicts spherical spreading to a slant distance of 30 m from the turbines and cylindrical spreading beyond. Acoustic pressure from the two turbines is expected to combine incoherently, resulting in increases throughout the project area of 1-2 dB for two turbines, versus a single device. Figure 3-37 shows broadband received levels (dB re 1 µPa) at four depths (surface, -15 m, -30 m, and -45 m) under four different inflow velocities at close range to the turbines. Figure 5-10 shows broadband received levels at -30 m over a larger area. For reference, an inflow velocity of 2 m/s corresponds to the 90th operating percentile (i.e., equal or lower velocities occur 90% of the time) and an inflow velocity 2.5 m/s corresponds to the 98th operating percentile.

FIGURE 3-37
RECEIVED BROADBAND SOUND PRESSURE LEVELS
AT CLOSE RANGE TO THE PROJECT AT VARIOUS DEPTHS



Source: Adapted from Polagye et al. (2012*a*)
Note: Turbine hub height is 45 m relative to the surface.

FIGURE 3-38
RECEIVED BROADBAND SOUND PRESSURE LEVELS IN THE VICINITY OF THE PROJECT



Source: Polagye et al. (2012*a*)
Note: 30 m depth relative to surface; dashed black lines denote the 120 dB re 1μPa isobel (Level B harassment threshold for marine mammals)

Potential Effects

Installation, maintenance, and removal - Noise associated with Project installation, maintenance, or removal may cause fish and marine mammal species to avoid the Project area, but because these activities would be short term and temporary, it is not expected to cause adverse effects to fish or marine mammal species.

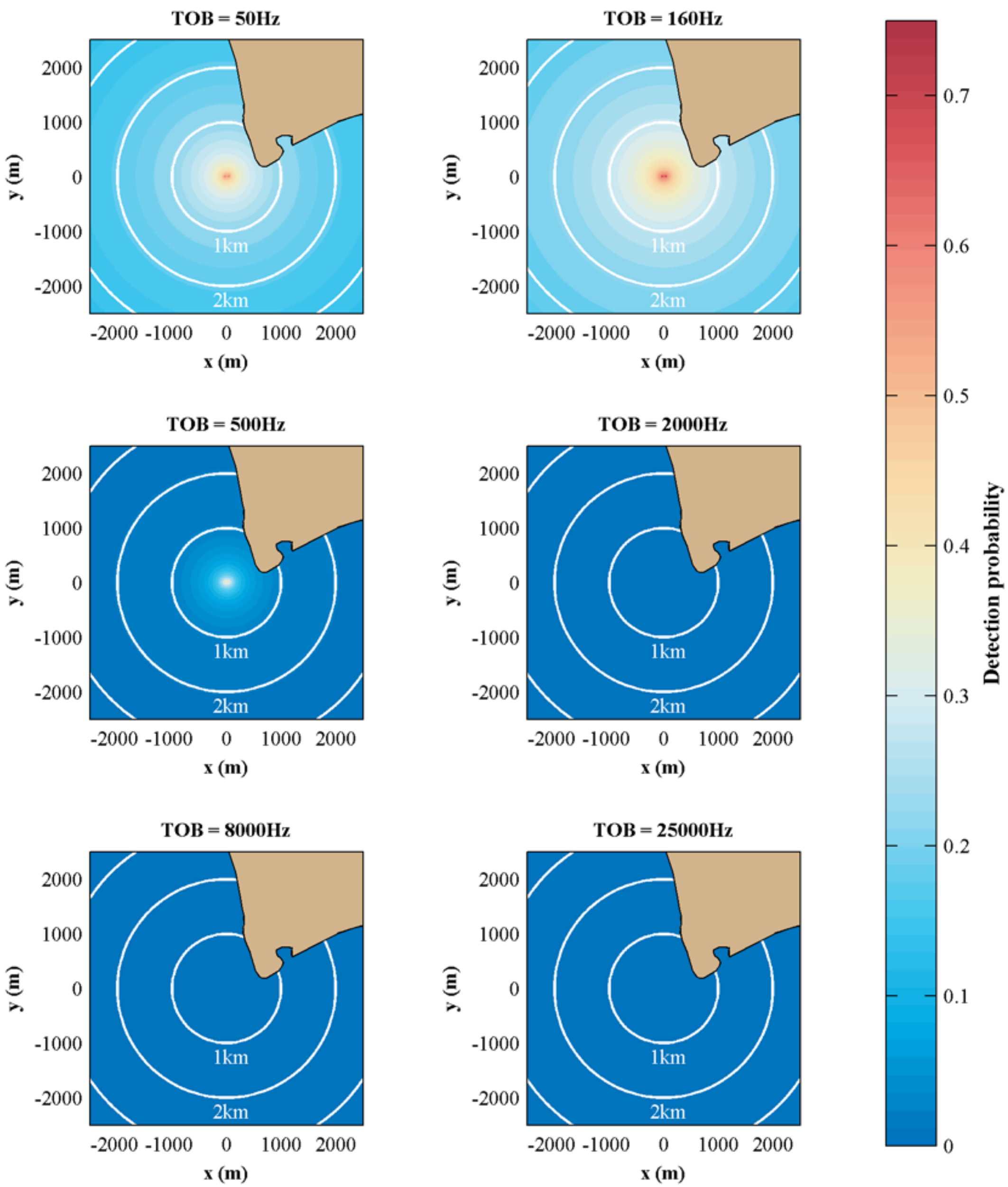
During the installation or removal of the OpenHydro turbines, noise levels are expected to be similar to other shipping activities in Admiralty Inlet (Bassett et al. 2012*a*) and possibly much lower, given the high incidence of ferry and tanker traffic in the area. During construction, noise would be temporary and short term; as discussed above, it is anticipated that the at-sea installation activities would take approximately 20 days. During maintenance operations, noise would be intermittent and short term. Because noise associated with Project installation or maintenance would be short term and temporary in comparison to the very heavy shipping noise in Admiralty Inlet, it is not expected to cause adverse effects to marine mammals. Maximum source levels during installation activities are estimated to be 178 dB re 1 µPa @ 1 m.

Turbine operation - As is demonstrated in Figure 3-37, the noise generated from turbine operation will attenuate with distance (both radially and vertically), primarily due to the spreading of the acoustic pressure wave (absorption of sound by sea water is negligible at frequencies below 1 kHz). As discussed above, Hastings and Popper (2005) reported that fish show a startle response to impulsive sounds as low as 160 dB (re 1µPa). Additional studies found that continuous sound levels of between 150 to less than 189 dB (re 1µPa) (different levels evaluated in the different studies within this range) did not affect the species evaluated, rainbow trout, goldfish, pollock, Atlantic cod, Atlantic herring, and spotted wolfish (Smith et al. 2004a, Wysocki et al. 2007, Jørgensen et al. 2005). TTS may occur at noise levels expected to be produced by the operating turbine at peak tidal velocities, but it is important to note that almost all studies conducted to date to evaluate effects of noise on fish have been conducted in cages or tanks, and that "...these observations in no way indicate how an unrestrained animal would behave when exposed to the same sound. ...Fish in cages are highly restricted in movements, not only by cage walls but also often by crowding. It is highly likely that fish 'sense' the limits of their (caged) environment and this strongly alters the responses of the fish to a potentially noxious stimulus. Whereas in the wild a fish may respond to a loud sound by rapidly swimming away, this is impossible in a cage, and the fish may sense that they cannot move far and thus show no response whatsoever" (Popper and Hastings 2009).

Pacific Northwest National Laboratory conducted laboratory exposure studies of juvenile Chinook salmon (*Onocorhynchus tshawytascha*) in which the subjects were exposed to simulated turbine noise at 159 dB re 1µPa (broadband), continuously for 24 h (Halvorsen et al., 2011). This rms SPL corresponds to the 93rd operating percentile for the turbine source level and the Sound Exposure Level (SEL) for this duration of exposure is a worse than worst-case exposure scenario. This is because (1) tidal currents are cyclical, at this location passing through two ebb and flood cycles of unequal strength in a 24 h period and (2) given that the turbine diameter is 6 m, there is no physical "source" at which a receiver would be exposed to 159 dB re 1µPa at 1 m distance. Practically speaking, a fish at 6 m distance from the turbine center might be exposed to this level of sound (briefly) during the fastest currents predicted to occur in Admiralty Inlet (but these are sustained on the order of minutes, not hours). The hearing of subjects was examined post-exposure and necroscopies were performed. Experimental results indicated that non-lethal, low levels of tissue damage may have occurred, but that noise exposure did not lead to PTS or TTS. Consequently, exposure to turbine noise generated by this project is unlikely to cause injury in fish.

Polagye et al. (2012*a*) also considered the potential for detection of noise by fish in the project area relative to ambient noise. Atlantic cod, which have better hearing sensitivity than Atlantic (or Pacific) salmon, were taken as representative of hearing generalists. Detection of turbine noise corresponds to times in which the "signal excees" (received levels of turbine noise relative to ambient noise) is positive and received levels exceed hearing thresholds in a given one-third octave band. Figure 3-39 shows the probability of Atlantic cod detecting turbine noise in one-third octave bands at different ranges from the project at 30 m depth relative to the surface. Probabilities will be slightly higher at close range at the 45 m depth contour (hub height) and slighty low higher in the water column. Detection is presented as a probability given the time distribution of turbine noise and time distribution of ambient noise. For frequencies below 1 kHz turbine noise and ambient noise are uncorrelated. At frequencies greater than 1 kHz turbine noise and ambient noise are correlated since strong currents mobilized gravel and shell hash on the seabed. For one-third octave bands with center frequencies exceeding 500 Hz, detection is unlikely under any combination of turbine noise and ambient noise due to increasing hearing thresholds. At lower frequencies, detection of turbine noise is only likely (i.e., probability exceeding 50%) within a few hundred meters of the project. This establishes an upper bound for the extent of potential behavioral disturbance (i.e., zone of responsiveness is equal to or, more likely, smaller than the zone of detection). The reasons for the relatively low detection probability is that, under most operating conditions, the turbine is relatively quiet and ambient noise at low frequencies (i.e., < 1 kHz) is dominated by shipping at this location (Bassett et al., 2012*a*).

FIGURE 3-39
PROBABILITY OF FISH (ATLANTIC COD, HEARING GENERALIST) DETECTING TURBINE NOISE

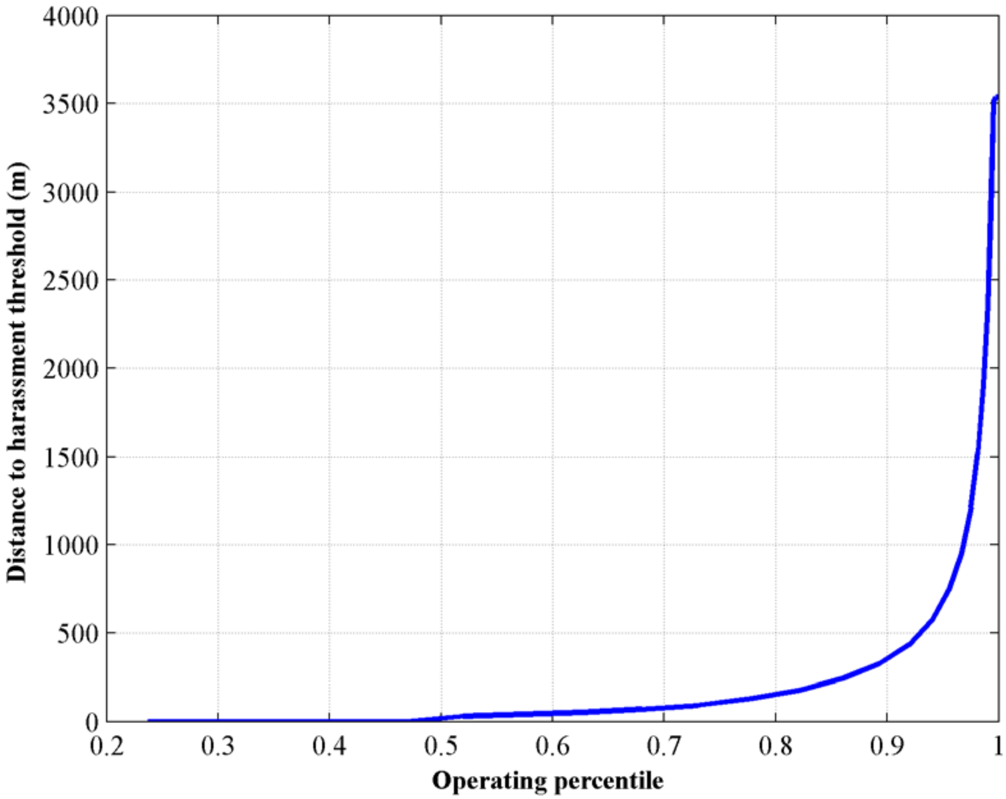


Source: Polagye et al. (2012*a*)
Note: 30 m depth relative to surface

Based on the analysis described above, the District expects the noise levels produced by the turbines to be detectible in close proximity to the turbine, but Project operations will not create noise at levels that will negatively affect fish, except perhaps in the immediate Project area during peak tidal velocities, when avoidance may occur. It is also worth noting that sound from the Project may provide a cue to fish, alerting them to the presence of the turbine and allowing them to make course corrections to avoid the turbine. As discussed in Polagye et al. (2012*a*), the warning distance (minimum distance to 100% detection probability) for Atlantic cod would range from several hundred meters during the quietest ambient conditions to less than 50 m during the loudest ambient noise conditions.

NOAA specifies that received SPL of 120 dB (re 1 µPa) is Level B harassment for non-impulsive sounds and has the potential for behavioral disturbance to cetaceans and pinnipeds (letter from NMFS to the District dated July 23, 2009). Figure 3-40 shows the distance from the Project to this isobel as a function of operating percentile.

FIGURE 3-40
DISTANCE FROM PROJECT CENTER (MID-POINT BETWEEN TURBINES) TO LEVEL B HARASSMENT THRESHOLD FOR BROADBAND (25 HZ – 25 KHZ) SOUND PRESURE LEVELS



Source: Personnal communication, Brian Polagye, NNMREC, February 2012 (after Polagye et al., 2012*a*)

The turbines deployed in Admiralty Inlet will incorporate a braking mechanism. The brake may be applied during maintenance activities or to mitigate environmental impacts in extreme circumstances. Any transient noise associated with engaging the brake will be depend on the time required to decelerate the turbine to a braked state (e.g., rapid braking is likely to create more noise than slow braking). The braking mechanism being incorporated into the Project turbines is of a new design and, therefore, there are no existing measurements of the noise associated with engaging the brake. As part of post-installation acoustic monitoring being undertaken by the District, the acoustic transient associated with engaging the brake will be characterized (both intensity and frequency composition). Any acoustic transient associated with disengaging the brake will be similarly characterized.

The likelihood of exposure to Project-associated noise is also influenced by overlap in both the spatial and temporal distribution of species with the Project. In Admiralty Inlet, juvenile and adult salmonids and some marine mammals (e.g., SRKW and humpback whales; see Appendix G) are migratory; while migratory species would be expected to transit through the Admiralty Inlet area, their exposure to Project-associated noise would be infrequent and for a very short period. In contrast harbor porpoise are known to spend longer periods of time in Admiralty Inlet and therefore could be exposed to the project-associated noise more frequently.

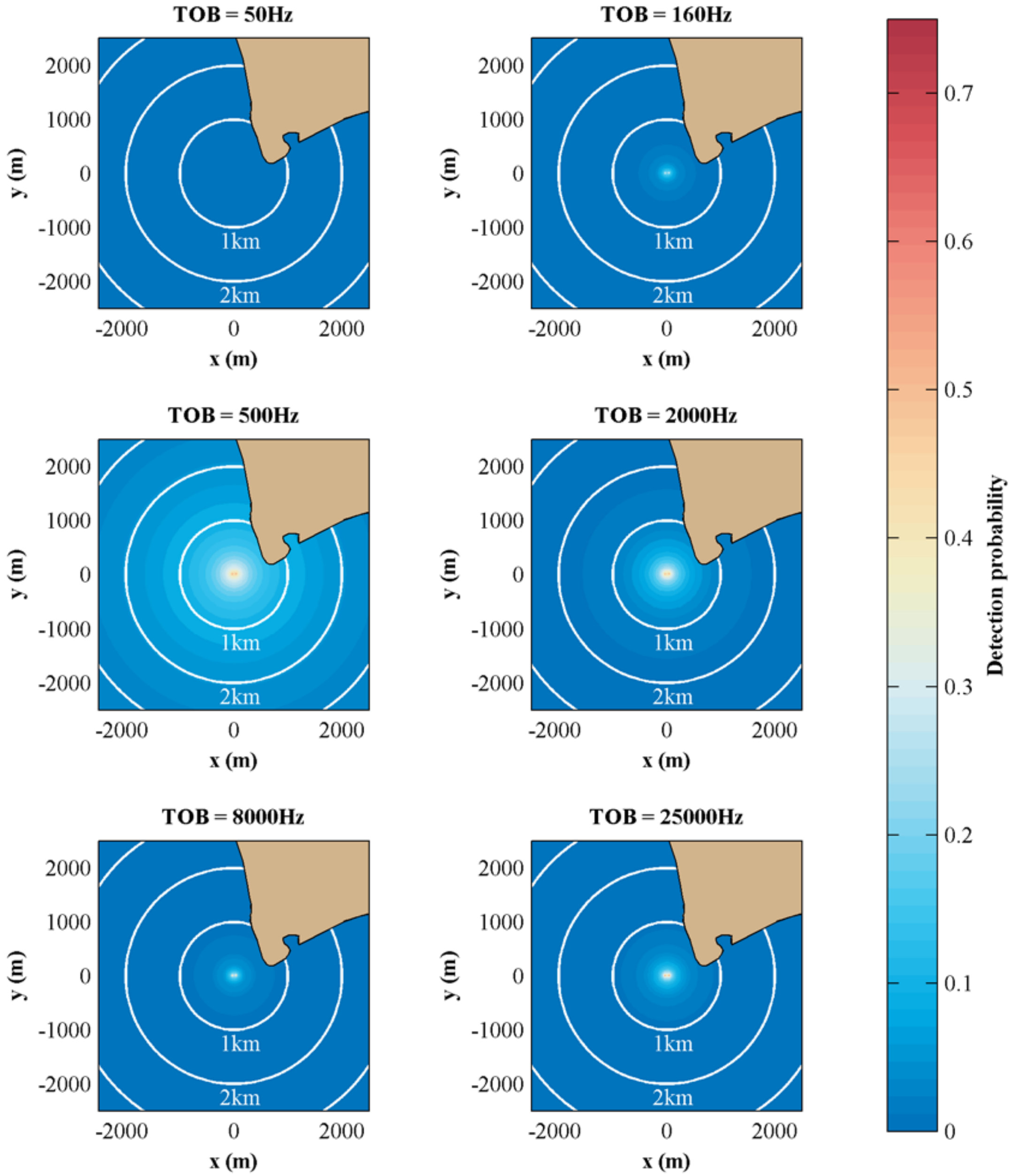
During Project operation, the OpenHydro turbines will generate continuous non-impulsive sound. This is significant because, as discussed above, NOAA specifies that received SPL of 120 dB (re 1 µPa) is Level B harassment for non-impulsive sounds and has the potential for behavioral disturbance to cetaceans and pinnipeds (letter from NMFS to the District dated July 23, 2009).

Polagye et al. (2012*a*) assessed the probability of detecting turbine noise relative to ambient noise (i.e., signal excess) for three classes of marine mammals: mid-frequency cetaceans (represented by killer whales), high-frequency cetaceans (represented by harbor porpoises), and pinnipeds (represented by harbor seals). The probability of these classes of marine mammal detecting turbine noise was investigated for six one-third octave bands: 50 Hz, 160 Hz, 500 Hz, 2 kHz, 8 kHz, and 25 kHz. The first four bands correspond to "tonal clusters" in which turbine noise is at a relative maximum and, therefore, more likely to be detected against ambient noise. The final two bands are important for marine mammal communication. Figure 3-41, 3-42, and 3-43 show the probability of marine mammals detecting noise from project operations at varying distances.

In general, the probability of these marine mammals detecting turbine noise is less than 50% at ranges beyond a few hundred meters. This is a combination of sound attenuation (spreading and absorption), hearing thresholds, and the ambient noise baseline (turbine noise and shipping noise have similar spectral profiles). Mid-frequency cetaceans, high-frequency cetaceans, and pinnipeds are most likely to detect turbine noise at frequencies of a few hundred Hz. While detection of turbine noise at higher frequencies is possible, it is only likely at very close range to the Project. Detection does not necessarily imply responsiveness, but this analysis establishes an upper bound for the possibile zone of responsiveness.

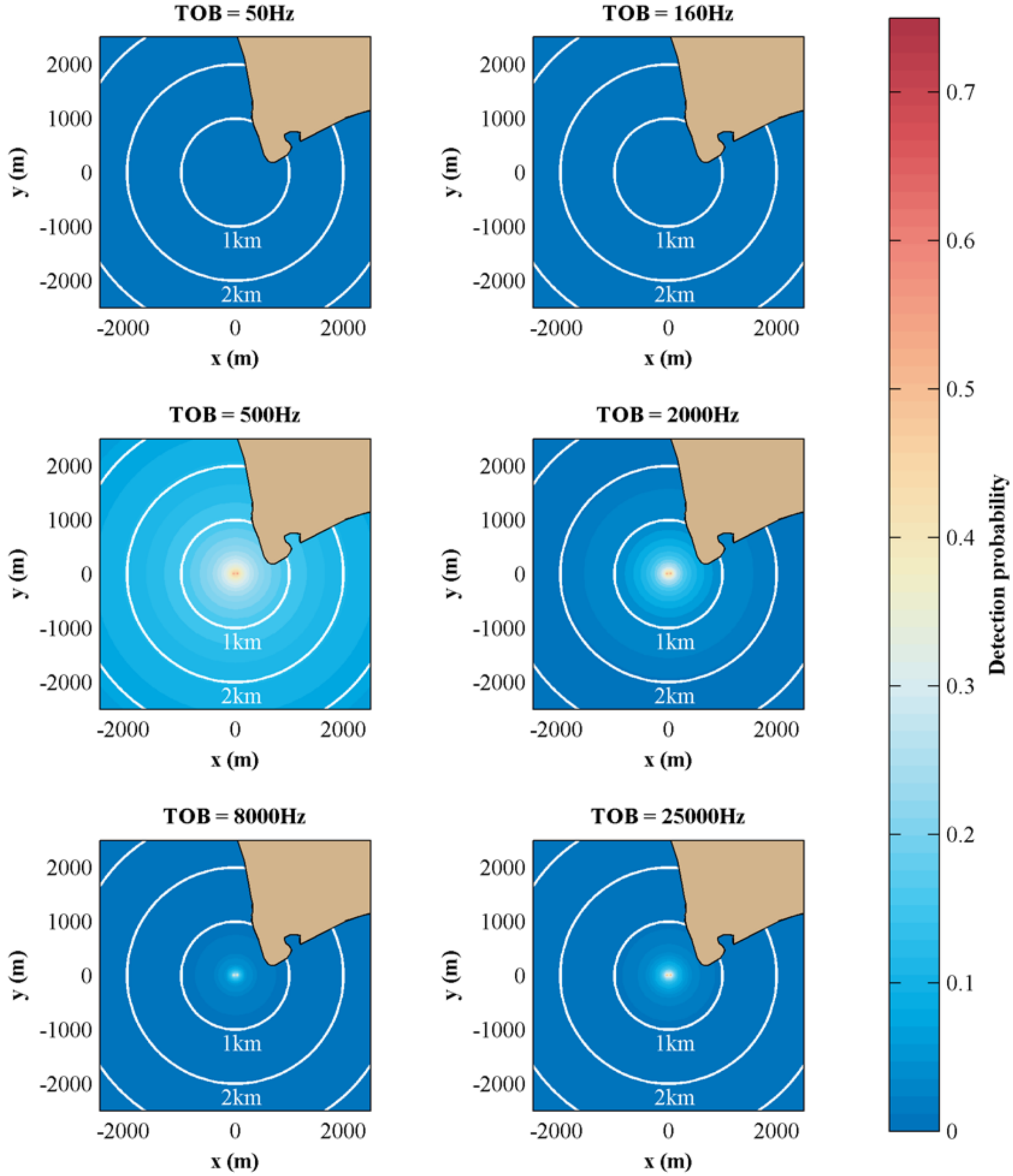
Polagye et al. (2012*a*) did not evaluate noise detection by low-frequency cetaceans because no audiograms for this class of marine mammals exist (Southall et al., 2007). However, based on the results for fish hearing presented in 5.3.3, low-frequency cetaceans would be expected to detect turbine noise at greater range than other cetaceans or pinnipeds (e.g., high probability of detecting noise at distances out to 1 km from the Project site).

FIGURE 3-41
PROBABILITY OF MID-FREQUENCY CETACEANS (KILLER WHALE) DETECTING TURBINE NOISE



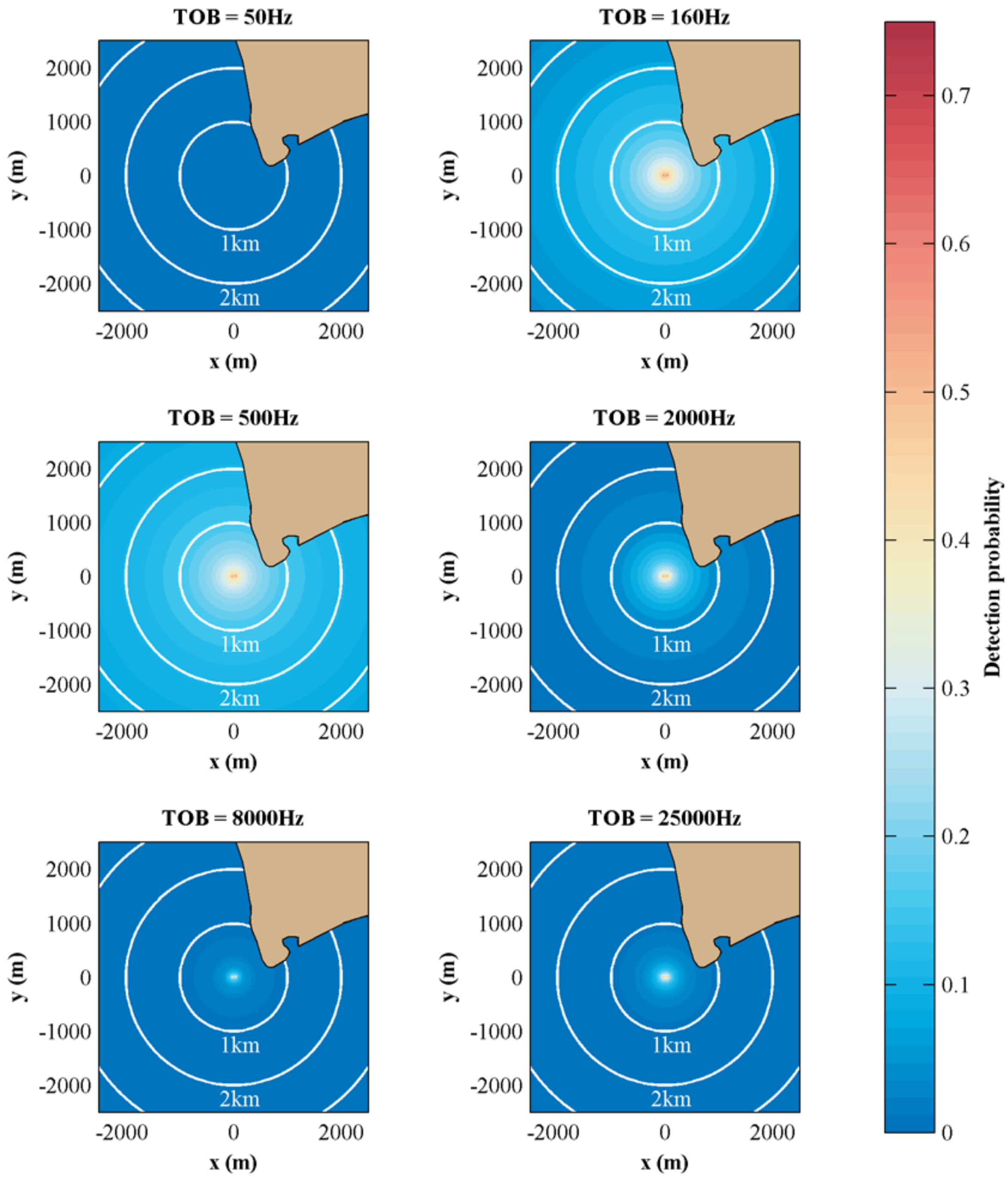
Source: Polagye et al. (2012*a*)
Note: 30 m depth relative to surface

FIGURE 3-42
PROBABILITY OF HIGH-FREQUENCY CETACEANS (HARBOR PORPOISE) DETECTING TURBINE NOISE



Source: Polagye et al. (2012*a*)
Note: 30 m depth relative to surface

FIGURE 3-43
PROBABILITY OF PINNIPEDS (HARBOR SEAL) DETECTING TURBINE NOISE



Source: Polagye et al. (2012*a*)
Note: 30 m depth relative to surface

Southall et al. (2007) propose a series of acoustic weightings to more accurately account for relative hearing sensitivities by marine mammal class. While these weightings were intended to evaluate the risk for acoustic injury (i.e., Level A harassment), they may also provide instructive guidance for behavioral responsiveness (personal communication, Brandon Southall, 2012). Relevant to this Project are low frequency cetaceans, mid frequency cetaceans, high frequency cetaceans, and pinnipeds in water. These "M-weightings" lead to reductions in received levels of noise at the limits of species hearing. The estimated hearing ranges for these four classes of marine mammals are presented in Table 3-26.

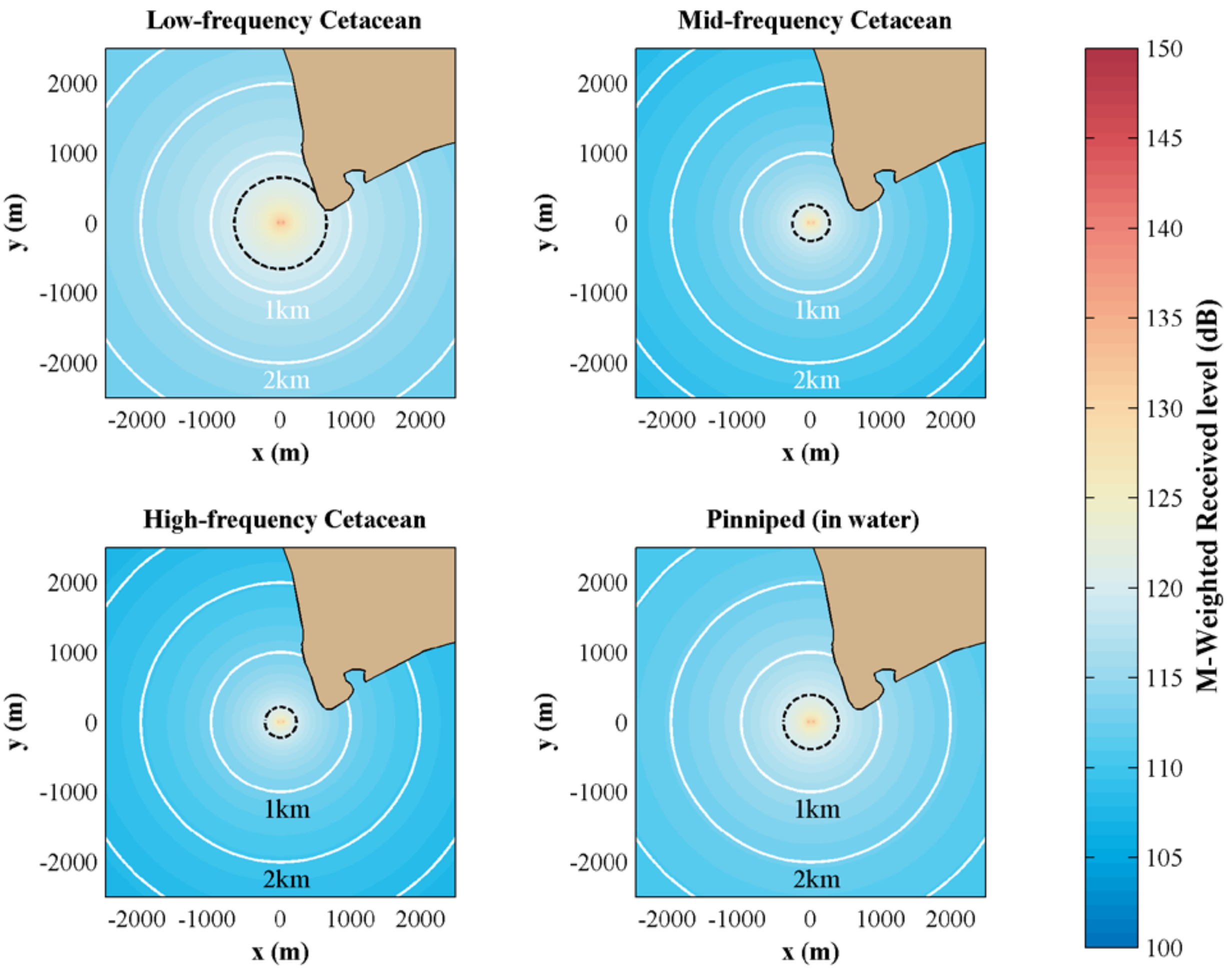
TABLE 3-26
HEARING FREQUENCY LIMITS BY MARINE MAMMAL CLASS

Class	Example Species	Low Frequency Limit	High Frequency Limit
Low frequency cetacean	Minke whale	7 Hz	22 kHz
Mid frequency cetacean	Killer whale	150 Hz	160 Hz
High frequency cetacean	Harbor porpoise	200 Hz	180 kHz
Pinnipeds (in water)	California sea lion	75 Hz	75 kHz

Source: Southall et al. 2007

The M-weightings are applied to the turbine spectra shown in Figure 3-36 to produce received level maps by species class. While this method is not yet part of the standard practice by NMFS to evaluate species behavioral response, the results of the exercise are instructive and are presented in Figure 3-44 for source levels associated with the 95th operating percentile (2.3 m/s inflow velocity). When the M-weightings are applied, the difference in received levels by species class is significant. For low frequency cetaceans, the noise from turbine operation occurs primarily within their hearing range and received levels are similar to a broadband receiver. The received levels for mid frequency cetaceans, high frequency cetaceans, and pinnipeds are lower, as summarized in Table 3-27, because their hearing is less sensitive at lower frequency.

FIGURE 3-44
M-WEIGHTED RECEIVED SOUND PRESSURE LEVELS
FOR MARINE MAMMAL CLASS AT 95TH OPERATING PERCENTILE



Source: Personal communication, Brian Polagye, NNMREC, February, 2012 (after Polagye et al., 2012*a*)
Note: Black lines represent the 120 dB (re 1µPa) isobel for each marine mammal class. White lines represent 1000 meter contours from the Project center point.

TABLE 3-27
DISTANCE TO NMFS LEVEL B HARASSMENT THRESHOLD
BY MARINE MAMMAL CLASS AT 95TH OPERATING PERCENTILE

Marine Mammal Class	Distance to 120 dB (re 1 µPa) isobel
Broadband	675 m
Low frequency cetacean (e.g. minke whale)	650 m
Mid frequency cetacean (e.g., killer whale)	260 m
High frequency cetacean (e.g., harbor porpoise)	220 m
Pinnipeds (e.g. California sea lion)	390 m

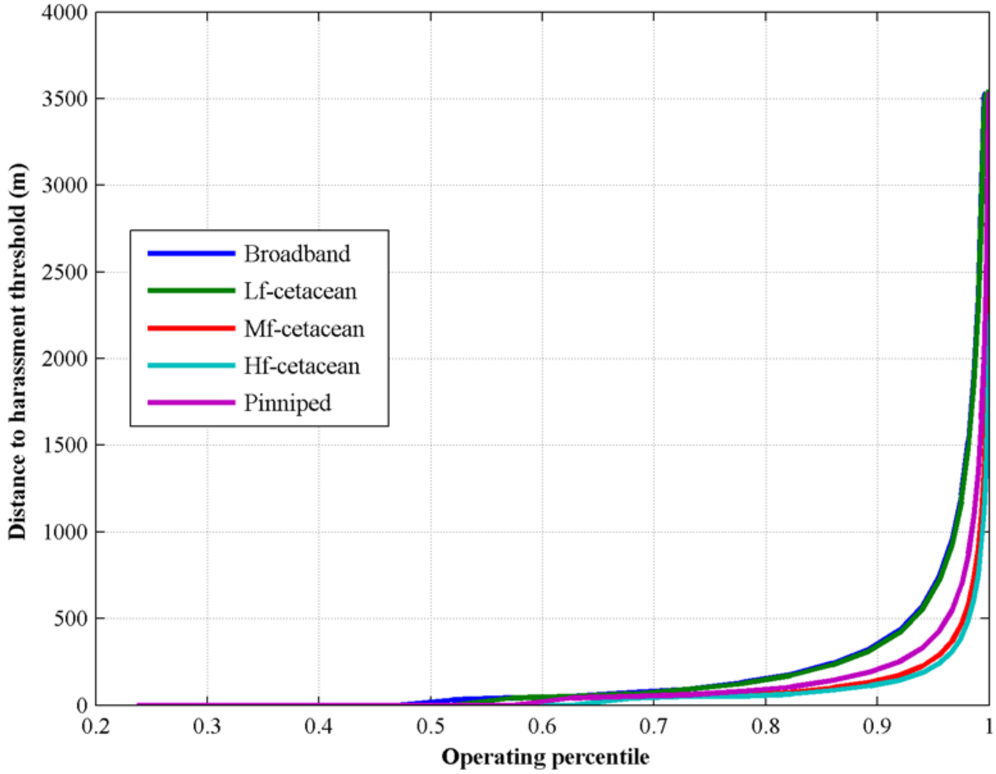
Source: Personal communication, Brian Polagye, NNMREC, February 2012 (after Polagye et al., 2012*a*)
Note: Distance to 120 dB isobel is calculated from project center point.

As shown in Table 3-27, when the tidal turbines are operating at the 95th operating percentile, the four marine mammal species classes would be exposed to NMFS Level B Harassment threshold over a distance range of 220 meters (harbor porpoise) to 650 meters (minke whale) (pers. comm. Brian Polagye, NNMREC, February 2012).

At lower operating percentiles, exposure distances are smaller than those discussed above. The estimated probability distribution for the distance to the M-weighted 120 dB isobel as a function of operating percentile is shown in Figure 3-45. At the 80^{th} oprating percentile, M-weighted turbine noise drops below the harassment threshold at less than 200 m and within 50 m at the 50^{th} operating percentile. Consequently, the 95^{th} percentile exposure level described here is precautionary in terms of defining the affected area. Because the rms pressure for turbine noise is expected to vary with power extracted, rms pressure depends on the cube of current velocity and sound pressure level on the sixth power of current velocity. Consequently, during the periods of strongest currents, the turbines are expected to produce significantly more noise than during median currents.

We note that neither broadband nor M-weighted received levels account for detection of received levels relative to ambient levels. For example, median broadband levels at this location are 117 dB (Bassett et al., 2012*a*) due to high levels of shipping traffic. For ambient noise levels above the median, ambient noise would serve to further limit the area of which received levels are both detectable and exceed 120 dB.

FIGURE 3-45
METER DIAMETER OPENHYDRO TURBINES
IN ADMIRALTY INLET



Source: Personal communication, Brian Polagye, NNMREC, February 2012 (after Polagye et al., 2012*a*).

Based on the analysis described above, the proposed action will not materially alter the ambient noise level within Admiralty Inlet because of:

- The limited Project duration - maximum 5 year operation period;
- The predominance of vessel traffic noise associated with passenger ferries and cargo vessels (Bassett et al., 2012*a*) and, at high currents, bedload transport (Bassett et al., 2012*b*), which generally limits marine mammal detection of turbine noise to within a few hundred meters of the Project (Polagye et al., 2012*a*);
- The dependence of turbine noise on current velocity – turbine noise will only ensonify an area greter than 100 m to Level B harassment (120 dB re 1μPa) 25 percent of the time.

One of the main purposes of pursuing a FERC Pilot License is to collect the environmental information needed to more completely evaluate the potential effects of hydrokinetic technologies *in-situ* rather than rely on theoretical evaluations and models. The District therefore proposes to implement a post-deployment underwater noise study that will involve conducting *in-situ* measurements of the acoustic emissions of the operating OpenHydro turbines. The results will be reviewed with the MARC to evaluate potential effects to listed species and other marine life. The Marine Mammal Monitoring plan will also evaluate behavioral responsiveness to the project (i.e., attraction, avoidance, changes in activity state) as a consequence of exposure to turbine noise.

Conclusions - Noise associated with Project installation, maintenance, or removal may cause fish species to avoid the Project area, but because these activities would be short term and temporary, it is not expected to cause adverse effects to fish species. Because noise associated with Project installation or maintenance, would be short term and temporary, especially in comparison to the very heavy shipping noise that is so prevalent in the heavily used Admiralty Inlet, it is not expected to cause adverse effects to marine mammals.

Noise produced by project operation is not expected to affect fish (Popper and Hastings 2009, Hastings and Popper 2005). With regard to marine mammals, operational noise will be well below levels of NOAA Level A harassment (potential to injure). When the tidal turbines are operating at the 95th percentile velocity, the four marine mammal species classes would be exposed to NMFS Level B Harassment threshold over a distance range of 220 meters (harbor porpoise) to 650 meters (minke whale) (pers. comm. Brian Polagye, NNMREC, February 2012). At lower operating percentiles, exposure distances are smaller than those discussed above. The estimated cumulative probability distribution of sound pressure level for a single six-meter turbine is shown above in Figure 3-36.

To accurately assess the operational noise, the District will implement the post-installation underwater noise plan, and will evaluate the results with the MARC.

Electromagnetic Fields

The Project will transmit electrical power generated from the OpenHydro turbines to the onshore electrical grid via two subsea trunk cables. The cables will be laid on the seabed for about 2 km from the turbines to the HDD bore. To avoid adverse impacts to the sensitive shoreline areas, near-shore habitat, and benthic species, the trunk cables will be installed under the seabed by HDD from a minimum depth of 18 meters.

The trunk cables transmit power at 6 kV (or less), 3 phase Alternating Current (AC) on three dedicated cores in the trunk cables. Turbine control and monitoring signals and environmental data are on dedicated single mode fiber optic elements within the trunk cables. Low voltage power for turbine control and the environmental monitoring system are provided by 2 kV or less dedicated low power elements in the trunk cables. A typical cable arrangement is shown in Figure 2-5. The cables will be roughly 10 centimeters in diameter, double armored to withstand installation and normal seafloor hazards.

During Project operations, EMF may be emitted from the subsea cables from the acceleration or fluctuation of charged particles. Some marine life have specialized organs sensitive to EMF which allow for prey detection and migratory navigation. NMFS has indicated concern that electro-sensitive species, such as sharks, skates, rays, salmon, and green sturgeon, will detect EMF from the Project and it might alter their migration or feeding behavior (NMFS letters to the District dated July 6, 2009 and December 8, 2008).

As the subsea transmission cables will already have conventional shielding, which will prevent emissions of electric fields from the cables (Scottish Executive 2007, Valberg 2005), the District believes there are no concerns regarding this component of EMF.

Our Analysis

EMF is created from both natural and anthropogenic sources. Natural sources include the earth's magnetic field and different biochemical, physiological, and neurological processes within organisms. Even sea current passing through the earth's geomagnetic field produces EMF. Anthropogenic sources of EMF include radio and TV transmitters, radar, and subsea telecommunications and electrical transmission cables. Subsea transmission cables are numerous and have been in use for many years all over the world.

EMF consists of two components, electric (E) and magnetic (B) fields. B fields may create a second induced component, a weak electric field, called an induced electric (iE) field. An iE field is generated by the flow of particles (water) or organisms through a B field. The strength of E and B fields depends on the magnitude and type of current flowing, through the transmission cable. Model simulations have shown that a shielded transmission cable does not emit an E field, however, B fields cannot be shielded. Induced electric fields within close proximity to a transmission cable are within the range of detection of some electro-sensitive species (Centre for Marine and Coastal Studies [CMCS] 2003).

Elasmobranchs (sharks, skates, and rays) and some other marine life have specialized organs sensitive to EMF which allow for prey detection and migratory navigation. Organisms that can detect B fields are presumed to do so by either by detecting iE fields or by using magnetite. These species detect iE fields passively (sensing the iE fields produced by ocean currents passing through the magnetic field of the earth) or actively (sensing the organism's own iE field produced by swimming through the earth's magnetic field) (Paulin 1995; von der Emde 1998).

In the U.K. researchers conducted an EMF study to determine if electro-sensitive fish respond to controlled EMF with the characteristics and magnitude of EMF associated with offshore wind farm power cables (Gill et al. 2009). The researchers evaluated the response of 2 shark species and 1 ray species to a buried subsea cable running along the seabed. Researchers used 2 mesocosms, cages 40 meters in diameter, and deployed them at depths of 10 to 15 meters. A subsea cable passed under the experimental cage, and the other cage served as a control. While the researchers concluded some of the elasmobranchs responded to the EMF emitted in terms of both the overall spatial distribution of one of the species tested and at the finer scale level of individual fish of different species, they stated that this response was variable within the species and also during times of cable switch on and off, day and night. The study did not evaluate, and therefore could not assess, whether the EMF from subsea cables will have either positive or negative effects on elasmobranchs (Gill et al. 2009).

Detection of E and B fields by marine life does not necessarily translate to an effect. In the EIS for an array of subsea cables for a proposed offshore wind energy project in Massachusetts, MMS (2009) concluded that E fields from the 60 Hz cables would be contained within the shielding and would not adversely affect the aquatic community. The MMS also concluded that there would be no adverse effects to marine life from the B fields emitted from the cables, as the magnitude of the B fields in the vicinity of the transmission cable would be limited to an extremely small space and fall off rapidly within a few feet of the cable (MMS 2009). The World Health Organization (2005) reports that "none of the studies performed to date to assess the impact of undersea cables on migratory fish (e.g., salmon and eels) and all the relatively immobile fauna inhabiting the sea floor (e.g., mollusks), have found any substantial behavioral or biological impact." Though in an experiment conducted in the Baltic Sea, Westerberg and Lagenfelt (2008) found that migrating European eels slowed their swim speed when passing by a subsea AC power cable. There was no significant difference in swimming speed of the same eels in intervals north of south of the cable, however, swimming speed in the location of the cable (middle interval) was significantly slower. It was not possible to find any alternative factor besides the presence of the cable that could explain the slower swimming speed (Westerberg and Lagenfelt 2008).

OpenHydro has invested heavily in both time and resources in the development of the insulation system of the turbine generator over a period of five years. It is the most crucial aspect of the machine. OpenHydro is certain that no electric currents will escape from the generator into the sea water. The generator is electrically isolated from ground. In the event of an electrical fault a protection system will de-energize the system so that no ground leakage current continues to flow (FERC AIR response dated June 24, 2011).

It is also important to note that the turbines themselves will not produce a detectable magnetic field. The arrangement of the components within the OpenHydro generator is designed to maximize the efficiency of the dynamo effect. This is achieved through the use of the Stator Back Iron which is specified to focus the magnetic flux onto the generator coils, thereby also minimizing any escaping magnetic flux. Because of the multi-pole nature of the magnetic field, even in the absence of any shielding, the maximum magnetic field outside the generator envelope would be similar to the natural background magnetic field of the Earth. The Stator Back Iron and the steel components of the generator structure, provide sufficient shielding to ensure that the external magnetic fields produced by the generator will be much smaller than the natural background magnetic field of the Earth. Further, given OpenHydro's practical experience of turbine assembly and handling of magnets, they can confirm that no magnetic field is detectable outside of the turbine structure once it is fully assembled (FERC AIR response dated June 24, 2011).

The subsea trunk cables will be installed via HDD from land to a minimum depth of 18 meters. From the HDD exit to the turbines, the trunk cables will be laid on the surface of the seabed, and it is along this segment of the cables that marine species can be exposed to EMF. The likelihood of exposure to EMF associated with the Project for migratory fish species, such as salmonids, is limited by the fact that the species are likely transiting through the Admiralty Inlet area and would be exposed to any Project-associated EMF for a very short period.

The Project subsea cables will be shielded, thus eliminating emissions of E fields.

To support the permitting of this Project, Dr. Edward Spooner, a professor at Durham University in England evaluated the B fields that would be produced by the Admiralty Inlet Project. For assessing the B field around the proposed trunk cables it is reasonable to adopt a threshold of acceptability as the earth's natural magnetic field at mid latitudes, which is 40 Amp per meter (A/m; equivalent to an induction of 50 μT). The magnetic field surrounding an isolated current-carrying conductor is described by Ampere's Law, which states that the lines of magnetic field are circles centered on the conductor. The strength of the field at a distance, r, from the conductor is equal to:

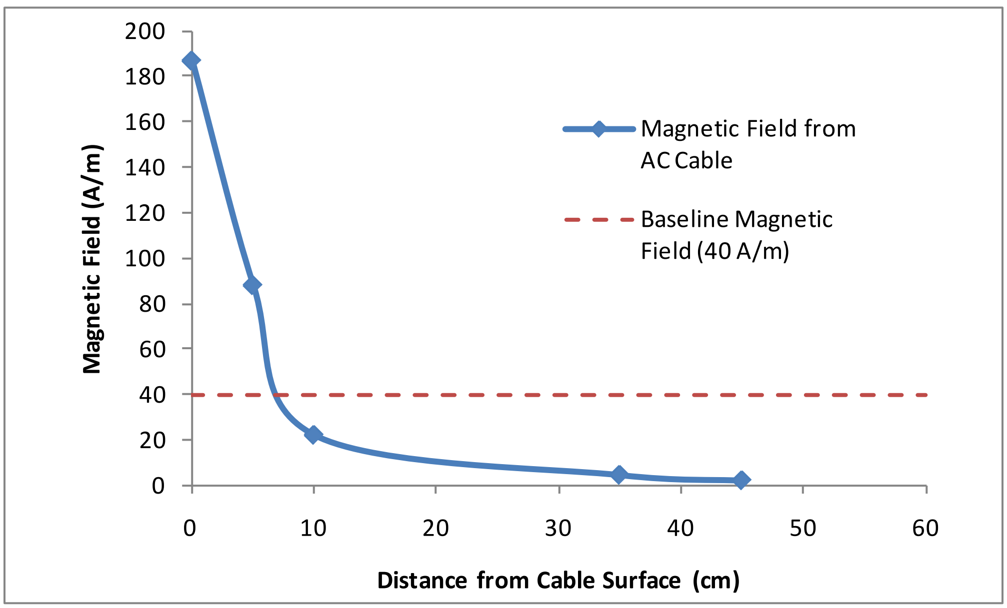
current / 2πr (Amp per meter) or μ0 x current / 2πr (Tesla)

The maximum power output from the turbines is approximately 700 kW of electrical energy at peak tidal currents. However, the maximum power is expected to be capped at 300 kW (150 kW per turbine) to limit stress on the subsea cable, cable connections, and power conversion equipment. The combined maximum power corresponds to a three-phase alternating RMS current value of 14 amps (20 amps peak) at 12,470 Volts.

The currents in the AC cable's three cores alternate, but they do not rise and fall together. Each current undergoes a smooth cyclic pattern of forward and reverse. In a 60 Hz system the cycle lasts for 16.66 milliseconds. The current in one core peaks at time 0; the current in the second core peaks at time 5.55 millisecond (1/3 of the period); and the current in the third core peaks at 11.11 millisecond (2/3 of the period). At any instant, the three currents add to zero and so no return current in the sea is present. The magnetic field produced by the set of three currents is a pattern of constant shape and magnitude but as the three currents change the pattern rotates.

The combined effect of the three cores and the steel armor wires cannot be calculated simply; rather, analysis requires use of the magnetic finite element technique in two-dimensional form with steady direct current. Results from this analysis examining the case of a three-core cable which is being proposed for the Admiralty Inlet Project are shown in Figure 3-46.

FIGURE 3-46
MAGNETIC FIELD DECLINE WITH DISTANCE FROM CABLE SURFACE



Note: Cable diameter is 10 centimeters. Dashed line shows Earth's background natural magnetic field, 40 A/m.
Source: FERC AIR response dated June 24, 2011.

The magnetic field at the surface of the cables (cable diameter is 10 centimeters) is about 187 A/m. It declines rapidly as illustrated in Figure 3-46 so that 5 centimeters (2 inches) from the cable surface the magnetic field is about 88 A/m, and at 10 centimeters (3.9 inches) from the cable surface, it is 22A/m. Everywhere beyond a distance of about 8 centimeters (3.1 inches) from the surface of the cables, the B field is less than that of the Earth's natural magnetic of 40 A/m field and so can be considered negligible.

The cables will lay onto of the seabed for approximately 2 km between the turbines and the HDD bore. The amount of cable lying on the seabed (approximately 2 km for each cable), relative to the vast scale of Admiralty Inlet, represents an exceedingly small area over which a fish would need to be swimming within 3.1 inches of the cables to experience a magnetic field greater than the earth's natural magnetic field.

At sea, green sturgeon have been shown to swim regularly throughout the water column and at depths at which the turbines would be located (Erickson and Hightower 2007). In San Francisco Bay, an estuary such as Puget Sound, Kelly et al. 2007 observed green sturgeon generally avoided the deepest waters, spending the majority of their time in the shallower regions of the estuary at a mean depth of 5.3 m. Fish were recorded swimming at depths between the surface and 24 m (mean=5.3 m) in waters that were up to 58 m deep (Kelly et al. 2007). Pacific salmonids feed on schools of small pelagic fish and invertebrates and their movement is typically based on following available food resources. Pacific salmon habitat use has been shown to vary based upon seasonal changes to food resources (Hinke et al. 2005), and it is therefore expected that the likelihood of salmonids swimming within 3.1 inches of the cables is also very small.

In conclusion, the Project subsea cables will be shielded to eliminate emissions of E fields. The turbine generators will not emit any E fields, and any B field emission from the turbine generators will be much smaller than the earth's magnetic field, and therefore will not be detectable. The Project is small and any electromagnetic fields emitted by the subsea cables (B or iE fields) will be extremely localized and minor, and similar to the numerous subsea cables that have been deployed in marine waters in the U.S. and throughout the world. The lack of negative effects is supported by many reports, which indicate that while electro-sensitive species may be able to detect the EMF generated by subsea cables, the effects of the EMF on these species does not appear to be significant (Sound & Sea 2002; Scott Wilson Ltd. and Downie 2003; CMCS 2005; Scottish Executive 2007; World Health Organization 2005; Mineral Management Service 2009; MMS 2009, Westerberg and Lagenfelt 2008). These conclusions were also reached by NMFS for a tidal energy project in Alaska, Ocean Renewable Power Company's Cook Inlet Tidal Energy Project (FERC Project No. 12679): NMFS stated that the agency "agrees that the current transmitted from the 1- to 5-MW turbine arrays, shielded by armored cable and trenching associated with the latter, are not likely to cause significant effects" (NMFS letter to FERC dated May 14, 2009). For reference purposes, the maximum combined output of the two Admiralty Inlet Project turbines would be 300 kW.

Because the length of cables exposed on the seabed is small (2 km for each cable) compared to other cables spanning Puget Sound and compared to the scale of Admiralty Inlet, the likelihood of these species passing within 3.1 inches of the cable - the distance needed to experience a magnetic field greater than the earth's natural magnetic field - results in the likelihood of exposure to EMF being *de minimis*. This analysis indicates that the effects of EMF on individual fish, as well as populations, will be discountable and insignificant.

3.3.2.3 Cumulative Effects

Other recent, on-going, or proposed non-federal activities in the area that have the potential to cumulatively affect marine resources over the next ten years (the proposed license term for the pilot Project) include the following:

- Commercial fishing,
- Vessel traffic,
- Other proposed tidal energy projects,
- Subsea cables, and
- Other industrial/urban development in Puget Sound.

Continued or increased commercial fishing pressure has the potential to decrease targeted fish and shellfish populations. Commercial fishing in the area has declined two-thirds in the past few decades, indicating overfishing of a variety of species. Fishing gear also poses a threat to marine mammals and other bycatch species from entanglement in gear, both actively fished and derelict.

Admiralty Inlet serves as a main route for all shipping traffic for the ports of Everett, Seattle, Tacoma, and Olympia, and Admiralty Inlet is also traversed by the Port Townsend-Coupeville ferry. Whale watching is popular in other areas of Puget Sound. As the population of the country and the Puget Sound area (see below) continues to grow over the next ten years, it is expected that shipping, ferry use, whale watching, recreational watercraft use, and other vessel traffic in Puget Sound will increase, all of which has the potential to negatively affect use of Puget Sound by marine mammals and other marine species.

The District’s proposed pilot-scale Project does not represent significant effects on the marine resources of the area. Commercial scale tidal energy projects potentially built in the next ten years could result in cumulative effects to marine resources, specifically through the production of operational noise (resulting in avoidance of project areas or disruption of habitat use patterns), potential blade strike, and increased availability of in-water structure/habitat (resulting in changes in marine community). These potential effects, when applied to a number of commercial scale projects, could result in potential effects over a larger area than the constructed projects themselves. Given the pace of development of ocean energy projects in the U.S., it is unlikely that commercial tidal energy projects will be constructed in Puget Sound within the proposed license term.

Subsea cables, including two telecom cables (named PC-1 and PC-2) that cross west of the Admiralty Inlet Project area running from northwest to southeast, represent forms of development comparable to the subsea cable component of the proposed Project. Additional development of telecommunications and power cables across marine waterbodies along the west coast is likely.

Like much of Puget Sound, Whidbey Island has seen a trend of increasing urbanization. Approximately 4 million people, or 70 percent of the population of Washington State, live within the Puget Sound Watershed. The population within the region is growing at an estimated rate of 50,000 people per year and projections suggest that 1.4 million new residents will reside within the region by 2025 (PSAT 2007b; see Section 3.3.8, Socioeconomics). Considerable areas of shoreline and nearshore development occur in Puget Sound, including urban areas (e.g. Everett, Seattle, Tacoma, and Olympia), port and marina facilities, naval bases, shoreline roads, seawalls, and aquaculture. In addition, human activities can occur far from the shore, but if still within the watershed of Puget Sound, can affect marine life (e.g. logging effects on erosion/water quality and availability of riparian woody debris). The burgeoning population of people in Puget Sound and their daily activities represent the greatest source of impact to the Puget Sound marine community over the next ten years and beyond.

Potential cumulative effects of the project on threatened and endangered species, discussed in the draft Biological Assessment, Appendix G, will be the same as those identified here.

It is important to note that the purpose of the Admiralty Inlet Tidal Pilot Project is to explore the feasibility of tidal energy generation; the District is striving to offset the impacts of the intense developmental pressure in the Puget Sound region, specifically by providing a renewable source of energy to meet the growing energy demand. In evaluating the cumulative effects, a strong case can be made that the accelerated development of renewable energy projects in Washington and the U.S. will result in decreased emissions of greenhouse gases and, consequently, in cumulative environmental benefits to marine resources in Puget Sound.

3.3.3 Terrestrial Resources

3.3.3.1 Affected Environment

All land components of the proposed project will be sited on private land located east of Admiralty Head. The shore landing site is between Crockett Lake and the northern portion of Admiralty Bay, which is within the Ebey’s Landing National Historical Reserve. The subsea trunk cables will emerge from underground, having passed below the nearshore seabed and the littoral zone via HDD, at a purpose-built vault.

As discussed above in Section 3.3.1, Geologic and Soil Resources, when the Fraser Glacier receded, Whidbey Island was left with areas of very uneven topography as well as several large, shallow lakes. When the lakes dried up, they left behind boggy areas of very fertile soil. While forests grew over most of the rest of the island, the prairies remained open, supporting grassland communities. Ebey’s Prairie is one of three such prairies on Whidbey Island located in former lake beds and located adjacent to the terrestrial component of the project. The area around Admiralty Head also includes several marshy zones and lagoons, including Crockett Lake, which support a wide variety of wildlife (Sound and Sea Technology 2009).

Whidbey Island is located in the Olympic Peninsula's rain shadow, a dry region in the lee of the Olympic Range. As a result, Whidbey Island’s western beaches and the adjacent bluffs support many species of plants and animals not found in other parts of the Pacific Northwest, including cactus. The glacial lakes still present on the island, many of which are now brackish or salt lagoons, also host unique assemblages of species of both plants and animals (Sound and Sea Technology 2009).

To characterize the terrestrial resources in the greater Project area (outside of the project footprint), the following are described:

- Vegetation,
- Wildlife, and
- State special-status plants and wildlife.

Vegetation

Admiralty Head and the surrounding areas of Whidbey Island contain two vegetative zones as defined by the Washington Gap Analysis Project, Puget Sound Douglas-fir and Woodland/Prairie Mosaic (Washington Gap Analysis Project 1996). The Puget Sound Douglas-fir zone is a Douglas-fir dominated forest zone of the low, flat Puget Sound region. Woodland/Prairie Mosaic is localized in western Washington grasslands and woodlands in dry lowlands in and around Puget Sound. These zones have been heavily converted to both agriculture and development. The remaining forests are now a patchwork of hardwood, mixed, and early seral conifer forests. There are only a few small areas of moderate richness of at-risk species (notably the prairies and woodlands of the southern Puget Sound), as most species sensitive to anthropogenic impacts have been extirpated from these zones (Cassidy et al. 1997).

The Ebey's Landing National Historical Reserve, encompassing 17,500 acres, contains the land-based components of the Project (Figure 1-1). In a study assessing the land use changes in the reserve over the last two decades, the most significant vegetative change was the conversion of active agriculture to grassland. There was an 11 percent gain in grassland (143 acres), a 14 percent loss of pasture (190 acres) and a 1 percent gain in cropland (32 acres) (NPS 2003*a*). These changes can primarily be attributed to the decline of active farming, especially dairy grazing, with fields becoming fallow or converting to residential lawns. Large areas where cropland or pasture have been converted to grassland are in the eastern portion of Coupeville, on the hill north of Ebey's Prairie near the cemetery, on Grasser's Hill, and on the Fort Casey uplands (NPS 2003*a*).

Fort Casey State Park, west of the terrestrial project components, lists the potential plants that occur in the park. Plant life found in the park include: Douglas fir, hemlock, spruce, alder, apple, cherry, daisy, foxglove, lupines, paintbrush, rhododendron, rose, berries, ferns, moss and lichens, and thistle (Washington State Parks and Recreation Commission 2009).

The terrestrial portion of the project does not contain any wetlands. The marine portion of the project is a marine wetland (as is all of Puget Sound). Marine vegetation is discussed in Section 3.3.2, Marine Resources.

Wildlife

The Ebey's Landing National Historical Reserve Naturalist's Guide defines four wildlife habitats in the project vicinity: woodland, prairie/open, wetland/lagoon, and beach/bluff. Woodland habitats are dense forests containing mostly alder and second- and third-growth Douglas-fir and western red cedar. The understory is composed of salal and rhododendron.

Some forested areas are steep-sided with glacial depressions called kettles, some over 200 feet deep (NPS 2003*b*). One third of the prairie/open habitat yields vegetables, grain, forage, and seed crops, while the rest is a mixture of pasture, woodland, wetlands, and farmsteads (NPS 2003*b*). The reserve's brackish lagoons and adjacent wetland marshes attract numerous species of migratory waterfowl and shorebirds. In spring, some 90 different species rest and feed in the marshy grasslands around Crockett Lake (NPS 2003*b*). Fort Casey lists the potential wildlife that occurs in the park. The species include: chipmunk, coyote, deer, foxes, otter, rabbits, raccoons, skunks, squirrels, crows and ravens, ducks, eagles, geese, gulls, hawks, herons, hummingbirds, jays, owls, quail, woodpeckers, and wrens (NPS 2003*a*).

State Special-Status Plants and Wildlife

The Washington Natural Heritage Program (WNHP), within the Washington Department of Natural Resources, maintains GIS records of high-quality natural communities and state-listed and federally listed plant species in Washington State. Results of the District's query of the WNHP database for current records in the vicinity of the Admiralty Inlet is presented in Table 3-28.

TABLE 3-28
LIST OF KNOWN RARE PLANTS OCCURRING IN
ISLAND COUNTY, WASHINGTON

Scientific Name	Common Name	State Status
Agoseris elata	Tall agoseris	Sensitive
Castilleja levisecta	Golden paintbrush	Endangered
Cicuta bulbifera	Bulb-bearing water-hemlock	Sensitive
Fritillaria camschatcensis	Black lily	Sensitive
Meconella oregana	White meconella	Threatened
Ranunculus californicus	California buttercup	Threatened
Sericocarpus rigidus	White-top aster	Sensitive

Source: WNHP 2009

WDFW datasets include its PHS and Wildlife Heritage databases, which include digital records of important wildlife habitats and sensitive and other wildlife occurrences at Admiralty Inlet. PHS and Wildlife Heritage database records in the vicinity of Admiralty Inlet include the following for terrestrial resources:

- Bald eagle
- Band-tailed pigeon
- Cliffs/bluffs
- Estuarine zone
- Great blue heron
- Lagoons
- Long-legged myotis
- Old-growth/ mature forest
- Osprey
- Peregrine falcon
- Purple martin
- Slough
- Urban open natural space
- Waterfowl concentrations
- Wetlands

Based on WDFW PHS and Wildlife Heritage data, Washington GAP occurrence data, and information on species habitat requirements, a number of special-status wildlife species (state-listed species not listed under the ESA) could potentially occur in the vicinity of Admiralty Inlet (Table 3-29). Wildlife species listed under the ESA are further described in the draft BA (Appendix G).

TABLE 3-29
SPECIAL-STATUS TERRESTRIAL WILDLIFE KNOWN TO OCCUR OR POTENTIALLY OCCURRING IN THE ADMIRALTY INLET VICINITY

Common Name	Scientific Name	Federal Status	State Status	Habitat Requirements
Golden eagle	*Aquila chrysaetos*	none	SC	During the nesting season, they require open areas with large, rocky cliffs or large trees, such as Ponderosa pines. They are often found in alpine parkland and mid-elevation clear-cuts, as well as in shrub-steppe areas and open forests.
Bald eagle	*Haliaeetus leucocephalus*	FCo	ST	They are generally found in coastal areas or near large inland lakes and rivers that have abundant fish and shores with large trees. WDFW records for all permit sites.
Northern goshawk	*Accipiter gentilis*	FCo	SC	They inhabit mature coniferous forests, often on moderate slopes, especially at mid- to high elevations. They are often found along the forest edge, and will use mixed coniferous and deciduous forests as well.
Merlin	*Falco columbarius*	none	SC	Breed in places with trees for nests and open areas for hunting. Found in small numbers near openings in coniferous forests in the Puget Sound area and Cascades. In winter, they are found in coastal areas, estuaries, agricultural lands, and suburban towns.
Peregrine falcon	*Falco peregrinus*	FCo	SS	They are typically found hunting in open areas, especially along the coast and near other bodies of water that provide habitat for their prey. They nest on cliffs and man-made cliff-like structures. WDFW records for Deception Pass, Guemes Channel, and Speiden Channel.
American peregrine falcon	*Falco peregrinus anatum*	FCo	SS	This subspecies has similar habitat requirements as the Peregrine Falcon. Primarily inhabit inland North America.
Arctic peregrine falcon	*Falco peregrinus tundrius*	FCo	SS	This subspecies has similar habitat requirements as the Peregrine Falcon. Does not breed in Washington.
Peal's peregrine falcon	*Falco peregrinus pealei*	FCo	SS	They are found along the coast and in Puget Sound. This subspecies has similar habitat requirements as the Peregrine Falcon.
Sandhill crane	*Grus canadensis*	none	SE	In Washington, they nest in wetlands with emergent vegetation in areas that are surrounded by coniferous forests. During migration and in winter they live in more open prairie, agricultural fields, and river valleys.
Yellow-billed Cuckoo	*Coccyzus americanus*	FC	SC	Only rarely seen in summer in western Washington. Generally live in western North America along forested stream-sides.

Common Name	Scientific Name	Federal Status	State Status	Habitat Requirements
Vaux's swift	*Chaetura vauxi*	none	SC	They usually roost and nest around either coniferous or mixed forest, in natural cavities such as hollow trees. Foraging habitat is open sky over woodlands, lakes, and rivers, where flying insects are abundant.
Purple martin	*Progne subis*	none	SC	In Washington State, open land near water is their primary nesting and foraging habitat. They can be found in developed areas, along waterfronts, and in fields, wetlands, and clearings. WDFW records for Admiralty Inlet, Agate passage, Deception Pass, and Rich Passage.
Oregon vesper sparrow	*Pooecetes gramineus affinis*	FCo	SC	They are commonly found in dry grasslands and agricultural fields at low to moderate elevations. They nest on the ground in a small depression, often near the base of a grass clump, weed, or shrub.
Streaked horned lark	*Eremophila alpestris strigata*	FC	SE	They inhabit open ground with short grass or scattered bushes. It is primarily found on prairies, sandbars, and grassy ocean dunes in western Washington. Nest sites are usually on open ground next to a clump of grass or similar feature.

3.3.3.2 Environmental Effects

The Project's terrestrial component is very small, and resource agencies and stakeholders have not raised specific concerns related to Project effects on terrestrial resources. To minimize effects to the littoral and nearshore environment, the District will employ HDD to bring the subsea trunk cables ashore from a minimum depth of 18 meters to a purpose-built vault (approximately 55 meters shoreward from the OHWM). An approximately 9-meter back haul cable will run underground from the vault to a constructed control room, and an approximately 70-meter back haul cable will run from the control room to the PSE grid. The District has sited the Project to connect to the grid at a location that is close to shore, that has been previously developed, and that requires no new roads.

Although well water is available at the site, it is likely that drilling water for HDD will be trucked into the site. The bentonite slurry/dredging spoils can easily be recovered into an excavated temporary sump pit, expected to be less than 1.8 meters (6 feet) deep, no more than 6 meters (20 feet), and with a width of approximately 2.4 meters (8 feet). The final engineering design of the site will dictate the actual dimensions. Natural terrestrial vegetation will be left intact as much as possible during site preparation activities, and following construction, the HDD laydown area and any other disturbed areas will be returned to its pre-installation condition. Fuel and lubricant leakages may inadvertently be discharged from vehicles during construction and facility maintenance activities. The District will implement best management practices to reduce the potential for a discharge and minimize impacts.

Our Analysis

The presence of construction-related equipment and terrestrial installation activities will represent a minor, temporary, and short-term effect to the land portion of the Project. The terrestrial components will be located on private land. By leaving existing vegetation intact as much as possible during site preparation activities, and by restoring the HDD laydown area and back haul trench surface areas to pre-installation conditions, the District will minimize effects to the terrestrial part of the Project.

Other than the construction and presence of the termination vault and the control room, all project components will be under restored ground, and consequently will not affect wildlife and vegetation resources. In conclusion, other than temporary and short term effects of construction, the District has successfully minimized Project effects to terrestrial resources by carefully siting the Project, including grid connection close to shore, using HDD to install underground electrical transmission, and reduced the need for above-ground structures (only the control room will be above ground).

3.3.4 Threatened and Endangered Species

On November 5, 2008, FERC designated the District as the non-federal representative for informal consultation with federal agencies pursuant to Section 7 of the ESA and the Magnuson-Stevens Fishery Conservation and Management Act for the Project. The description of ESA-listed species (includes: current status, life history, and presence in the Project area) and potential effects to these species are evaluated in the draft Biological Assessment, which is presented in Appendix G.

3.3.5 Recreation, Ocean, and Land Use

3.3.5.1 Affected Environment

The Project is located within Island County. Major land and water uses in the Project area include recreation, commercial fishing, transportation, and commerce. The main urban area in the Project area is Port Townsend, which is located on the opposite side of Admiralty Inlet from the Project. Much of Admiralty Inlet’s western shoreline is characterized by forest and light residential development, while a majority of the eastern half of the channel, particularly along the Whidbey Island shore, is characterized by forest and agriculture (City of Port Townsend 2007).

Below, we discuss recreation, ocean, and land use of the Project area as follows:

- Recreation Use
    - Puget Sound Overview
    - Admiralty Inlet
    - Current and Future Recreation Needs
- Navigation and Fishing
- Coastal Management

Recreation Use

Puget Sound Overview

Puget Sound is a national tourist destination, and tourism generates an estimated $5.2 billion in revenue and 68,000 jobs annually (WDOE 2007*c*). The Puget Sound Partnership reports that this represents nearly 80 percent of the statewide revenues from tourism and travel and 75 percent of all tourism related jobs. Public access to Puget Sound has been identified as an important issue (ICOR 2002). Only 425 miles or 19 percent of Puget Sound's shoreline are publicly accessible. However, as only half of these public shores have upland access points, only ten percent of Washington's inland marine waters are readily accessible (Trust for Public Land 2005).

Approximately 390,000 people participate in a wide range of recreational activities in, on, or around Puget Sound at least once a year. Activities include kayaking, scuba diving, windsurfing, fishing, whale watching, and boating (WDOE 2006). Recreational boating provides relaxation and enjoyment for thousands of Puget Sound area residents and visitors. Residents own more than 165,000 powerboats, 21,500 sailboats, and 45,000 canoes, kayaks, inflatable boats, and other personal watercraft. There are 331 launch sites for small boats throughout the region and an additional 244 marinas that have a total of over 39,000 mooring slips (PSAT 2003).

In Puget Sound and the Strait of Juan de Fuca, over 450 sites have been identified where the public may enter the water (WDOE 2002). The surface temperature and waves at these locations make swimming difficult; however, state studies have indicated that beachcombing is a popular activity with many residents (ICOR 2002). Despite cold water temperatures and generally limited visibility, SCUBA diving is a popular pastime in Puget Sound. Washington State ranks fourth in the nation in terms of per capita dive participation, and there are consequently a large number of charter operations and dive shops in the vicinity (Washington Scuba Alliance, 2007). The Washington State Parks and Recreation Commission established the Underwater Park System to preserve unique marine resources in Washington as well as to provide quality dive sites for recreational purposes.

An important and unique component of recreational SCUBA diving within Puget Sound is the exploration of sunken ships. Puget Sound has several sunken ships that are both historically significant and accessible to divers by way of SCUBA. One such ship, the *S. S. Governor*, is located within Admiralty Inlet. This ship is regarded as a site of historical importance and is also a popular deep water dive site for experienced divers, and its cultural debris cover slightly more than 0.4 hectares of seafloor (Polagye et al. 2007).

Admiralty Inlet

Admiralty Inlet includes several known recreational resources within its confines. In total, at least 13 parks are designated in the vicinity of Admiralty Inlet. Information describing nine of these parks - seven states, one county, and one local - is provided below based on information provided by Washington State Parks and Recreation Commission (2008*a*-*g*).

- ***Fort Worden State Park*** - Fort Worden State Park, a 176-hectare multi-use public space that includes a marine park with over 3.2 km of saltwater shoreline, is located in Port Townsend directly across Admiralty Inlet from the Project. The park, punctuated by historic nineteenth-century military fort buildings, is set atop a high bluff overlooking Puget Sound. Fort Worden offers a variety of activities including hiking, biking, boating, diving, fishing, swimming, water skiing, and crabbing. The park also includes an underwater marine component; an artificial reef, composed of tires and concrete, was constructed within the park to improve the quality of recreational diving by providing additional habitat for marine organisms. Camping is available at two campgrounds. (Washington State Parks and Recreation Commission 2008*a*).

- ***Fort Casey State Park*** - Fort Casey State Park, a 189-hectare park with a lighthouse and views of both Admiralty Inlet and the Strait of Juan de Fuca, is located at Admiralty Head, located to the south of the proposed Project's terrestrial components. The park includes more than 3.2 km of saltwater shoreline and adjacent nearshore habitat. Activities at Fort Casey State Park include hiking, beachcombing, bird watching, boating, fishing, and diving. The park also includes an underwater marine component. The park offers picnic and camping facilities. The picnic grounds include 68 unsheltered picnic tables, and the campground includes 35 tent sites, a restroom, and a shower. In addition, the park has an amphitheater and fire circles, and offers interpretive activities (Washington State Parks and Recreation Commission 2008*b*).

- ***South Whidbey Island State Park*** - South Whidbey Island State Park is a 140-hectare park with 1,370 m of saltwater shoreline on Admiralty Inlet, and is located on Whidbey Island about 13 km southeast of the Project. The park is open year-round for camping and day use. Activities at South Whidbey Island State Park include hiking, saltwater fishing, saltwater swimming, clamming, crabbing, and wildlife viewing. The park contains 46 tent spaces, eight utility spaces, one dump station, two restrooms (one ADA), and four showers. One group camp site with water, vault toilets, and accommodations for up to 100 people is also available. The park is closed December to January, and all campsites are on a first-come, first-served basis (Washington State Parks and Recreation Commission 2008*c*).

- ***Mystery Bay State Park*** - Mystery Bay State Park is a four-hectare park with 209 m of saltwater shoreline on Mystery Bay, located on Marrowstone Island about 11 km south of the Project. The park is open year-round for day use only. Overnight camping is not available. The park offers a variety of activities including boating, diving, clamming, crabbing, and oyster collecting. The site has 208 m of moorage, and watercraft can be launched at the park's boat ramp with a daily or annual permit from the State Parks headquarters in Olympia. The park provides one kitchen shelter without electricity as well as four unsheltered picnic tables. (Washington State Parks and Recreation Commission 2008*d*).

- ***Fort Flagler State Park*** - Fort Flagler State Park is a 317-hectare park bound on three sides by more than 5.6 km of saltwater shoreline, located on the north side of Marrowstone Island about 7 km due south of the Project. Formerly an established military fort, the park includes many historic nineteenth-century buildings. It is open year-round for day use but is closed to camping from November 1 to March 1. Fort Flagler offers a number of activities including boating (with mooring available along 78 m of shoreline), hiking, biking, saltwater fishing, swimming, water skiing, clamming, and crabbing. The launching of watercraft is allowed from the park's two boat ramps with a $5 daily permit. The park provides 19 sheltered and 40 unsheltered picnic tables, and one kitchen shelter without electricity which is available on the west side of the Island (Washington State Parks and Recreation Commission 2008*e*).

The Park contains 101 standard tent sites, 14 utility spaces, one dump station, four restrooms (one ADA), and eight showers (two ADA). Two primitive group campsites are also available. The scout area group campsite accommodates a maximum of 40 people and includes a fire ring, one open-sided shelter, and one vault toilet. The wagon wheel area group campsite includes two vault toilets and no hookups.

Fort Flagler State Park also offers unique indoor accommodations at the Fort Flagler Environmental Learning Center (ELC), the Hospital Steward's House, the Waterway House, and two Non-commissioned Officers' Quarters - north and south. The Fort Flagler ELC consists of Camp Hoskins (capacity of 180), Camp Richmond (capacity 52), and Camp Wilson (capacity 29). All of the Fort Flagler ELC accommodations are dormitory camp arrangements and include restroom and shower facilities, a dining hall, and a kitchen.

- ***Old Fort Townsend State Park*** - Old Fort Townsend State Park is a 149-hectare park that includes more than 1,190 m of saltwater shoreline on Port Townsend Bay. It is open year-round for day use, with camping permitted only during the summer. Activities at Old Fort Townsend State Park include boating, hiking, diving, saltwater fishing, and crabbing. The park offers 40 campsites, one dump station, two restrooms, and one shower. Three picnic shelters and 43 picnic tables are also available at the park. The boat launches located nearest to Old Fort Townsend State Park are at Port Townsend, Fort Flagler, and Hadlock. Daily and annual moorage permits are available (Washington State Parks and Recreation Commission 2008*f*).

- ***Fort Ebey State Park*** - Originally built for coastal defense in World War II, Fort Ebey is now a 261-hectare state park with five kilometers of saltwater coastline on Whidbey Island, located on Whidbey Island about 8 km north of the Project. Activities at the park include hiking, biking, freshwater fishing, paragliding, surfing, and seaweed harvesting. Watercraft can be launched from the park with a $5 daily permit. The park is open year round for camping and day use. The park contains 40 standard campsites, ten utility spaces with electricity and water hook-ups, one restroom (ADA), and two showers (one ADA). One campsite is available solely to those traveling by human powered watercraft on the Cascadia Marine Trail. Group camping accommodations are also available for up to 75 people. The Park has 25 unsheltered picnic tables located at the Gun Battery, the beach area, and the Point Partridge area. Two log picnic shelters are available for reservation. These shelters include two covered picnic tables, two uncovered picnic tables, and two large outdoor grills. One shelter is located at the Gun Battery Picnic area and can accommodate up to 150 people. The other shelter is located at the beach area and can accommodate up to 100 people (Washington State Parks and Recreation Commission 2008*g*).

- ***North Beach Park*** - North Beach Park offers access to the shoreline of the Strait of Juan de Fuca and is both owned and operated by Jefferson County. Boat watching, beachcombing, and dog walking are popular activities in the park (City of Port Townsend 2008*a*).

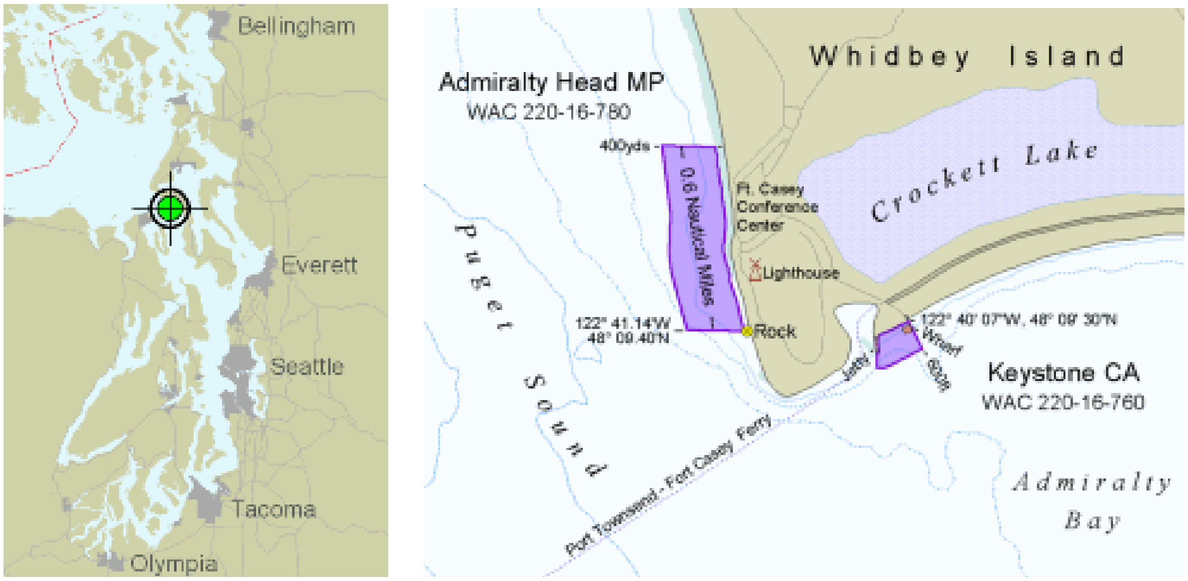
- ***Chetzemoka Park*** - Chetzemoka Park comprises approximately two hillside hectares commanding a view of the Cascade Mountains. The keystone of Port Townsend's parks, this Victorian park was established in 1904. Chetzemoka Park includes 25 parking spaces, several picnic areas, a shelter, a playground, restrooms, and a bandstand (City of Port Townsend 2008*b*).

Ebey's Landing National Historical Reserve, a large swath of Central Whidbey Island from Penn Cove on the eastern shore to Admiralty Head on the west side of the island, was designated as the nation’s first National Historical Reserve (a unit of the National Park System). The Project cable makes landfall on private land located within the Ebey's Landing National Historical Reserve. The area combines history, natural resources, and views of Puget Sound from bluffs that rise from the waters of Puget Sound; dense forests and prairies; and lakes and lagoons. The woods and coastal areas offer hiking, boating, picnicking, camping, and other outdoor activities. Bird watching is also a popular activity (Sound and Sea Technology 2009).

The Washington Department of Fish and Wildlife has established Marine Protected Areas throughout the Puget Sound Region for the protection and preservation of species and habitat, and to also serve as designated areas where recreation occurs. Marine Protected Areas were developed for the benefit of fish and wildlife resources as many of the protected areas serve as “no-take” marine areas. Two marine protected areas, Keystone Conservation Area and Admiralty Head Marine Preserve, are near the Project (Figure 3-47) (WDFW 2007).

The Keystone Conservation Area is located along the southern shore of Fort Casey State Park (Figure 3-45). It includes the eastern side of the jetty into Keystone Ferry harbor and extends eastward to the eastern row of pilings under an old military dock. The jetty is a man-made structure composed of large revetment boulders that creates high-relief, structurally complex habitat within the site. The area is a well-known dive location and is frequented by recreational divers and student researchers. Keystone is a fully protected marine reserve for non-tribal citizens; thus, recreational and commercial fishing and harvesting is prohibited, as is the taking of invertebrates species (WDFW 2007). The subsea trunk cables avoid the Keystone Conservation Area, passing to the south.

FIGURE 3-47
KEYSTONE CONSERVATION AREA AND ADMIRALTY HEAD MARINE PRESERVE



Source: WDFW 2007.

The Admiralty Head Marine Preserve incorporates a near shore kelp bed that grows upon a mix of rocks, boulders, and ridges of hardpan and bedrock just north of Fort Casey State Park (Figure 3-47). The reserve extends offshore from the extreme low water mark and extends down to depths of 12.2 meters (MLLW).[29] Admiralty Head is considered a partially protected marine reserve for non-tribal citizens. Recreational and commercial fishing/harvesting activities are generally prohibited, although dive fishing for sea urchins and sea cucumbers is allowed (WDFW 2007).

The Cascadia Marine Trail, a National Recreation Trail designed for non-motorized boats, intersects Admiralty Inlet (WWTA 2008). This salt water trail extends 225 km from the Canadian border in the north to Olympia in the south. It was built through the cooperative efforts of the Washington State Parks and Recreation Commission, Washington Water Trails Association, Washington State Department of Natural Resources and other state and local government agencies. While there are currently more than 50 campsites that are part of the trail, the stated goal is to establish a campsite every 8 to 13 km along the length of Puget Sound's shoreline. The trail was designated a National Recreation Trail in 1994 and selected as one of 16 National Millennium Trails by the White House in 2000 (WWTA 2008).

Current and Future Recreation Needs

For over two decades, the state of Washington has had a statewide comprehensive outdoor recreation plan (SCORP). Washington State legislation (RCW 79A.25.020(3) has mandated that

---

[29] The subsea cable will be routed outside of the marine reserve.

the Interagency Committee for Outdoor Recreation (IAC) (now the Recreation and Conservation Office [RCO]) must "prepare and update a strategic plan for the acquisition, renovation, and development of recreational resources and the preservation and conservation of open space" (RCW 79A.25.020).

TABLE 3-30
ESTIMATED CHANGE IN PARTICIPATION RATES COMPARED TO CURRENT LEVELS

Activity	10 Year Change	20 Year Change
Walking	+23%	+34%
Hiking	+10%	+20%
Outdoor team and individual sports	+6%	+12%
Nature activities	+23%	+37%
Sightseeing	+10%	+20%
Bicycle riding	+19%	+29%
Picnicking	+20%	+31%
Motor boating	+10%	No Estimate
Non-pool swimming	+19%	+29%
Visiting a beach	+21%	+33%
Canoeing/kayaking	+21%	+30%
Downhill skiing	+21%	No Estimate
Cross-country skiing	+23%	No Estimate
Snowmobile riding	+42%	No Estimate
Fishing	-5%	-10%
Camping - primitive dispersed	+5%	No Estimate
Camping - backpacking	+5%	+8%
Camping - developed (RV style)	+10%	+20%
Off-road vehicle riding	+10%	+20%
Hunting-shooting	-15%	-21%
Equestrian	+5%	+8%

The RCO subsequently released a SCORP document in 2008 that focused on defining and measuring success in outdoor recreation management (WRC 2008).

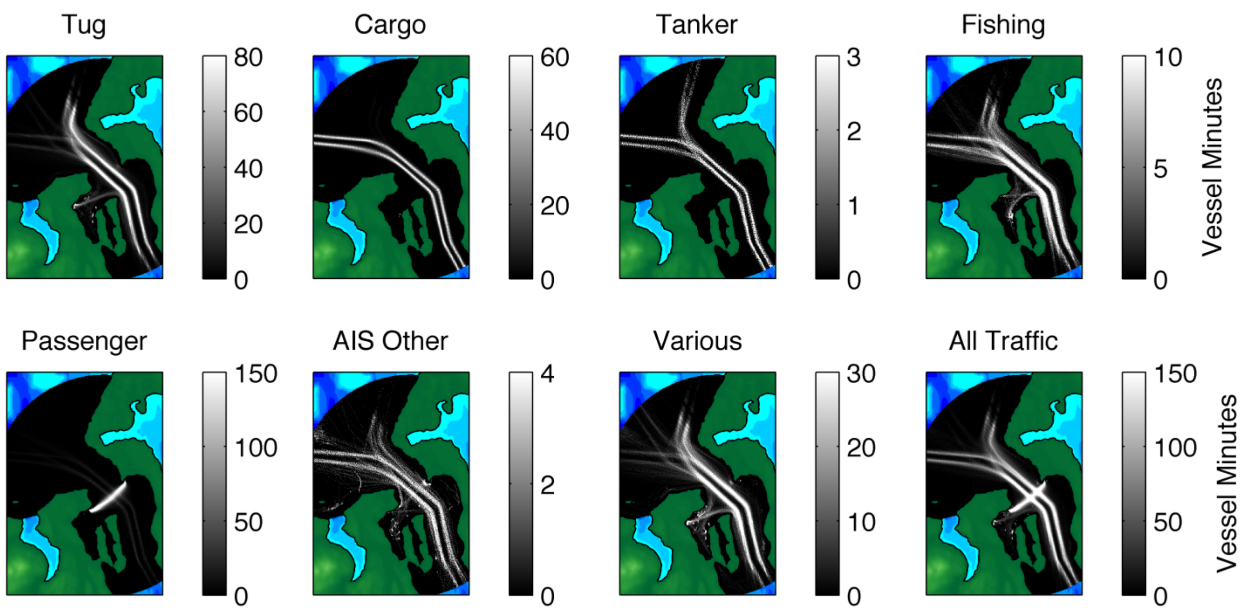
<u>Navigation</u>

Maritime travel on Puget Sound is heavy. All maritime traffic bound for, or departing from, the ports of Seattle, Everett, Tacoma, and Olympia also transits through the Inlet via a major shipping lane in the middle of Admiralty Inlet (NOAA 2007*a*) (Figure 3-48 through 3-50). The Port Townsend-Coupeville ferry runs about 1.5 km from the turbine deployment site (Figure 3-47). During the summer, ferries make 10 round trips across Admiralty Inlet. The U.S. Navy also has a strong presence in Admiralty Inlet. Across Admiralty Inlet from the project is the Admiralty Bay Mining Range, a restricted area 7/R-6701; no anchors, fishing gear, grapnels, or dumping of non-buoyant objects are allowed in this area. In addition, many small commercial craft also operate throughout the Project area.

FIGURE 3-48
SHIPPING TRAFFIC IN NORTHERN ADMIRALTY INLET

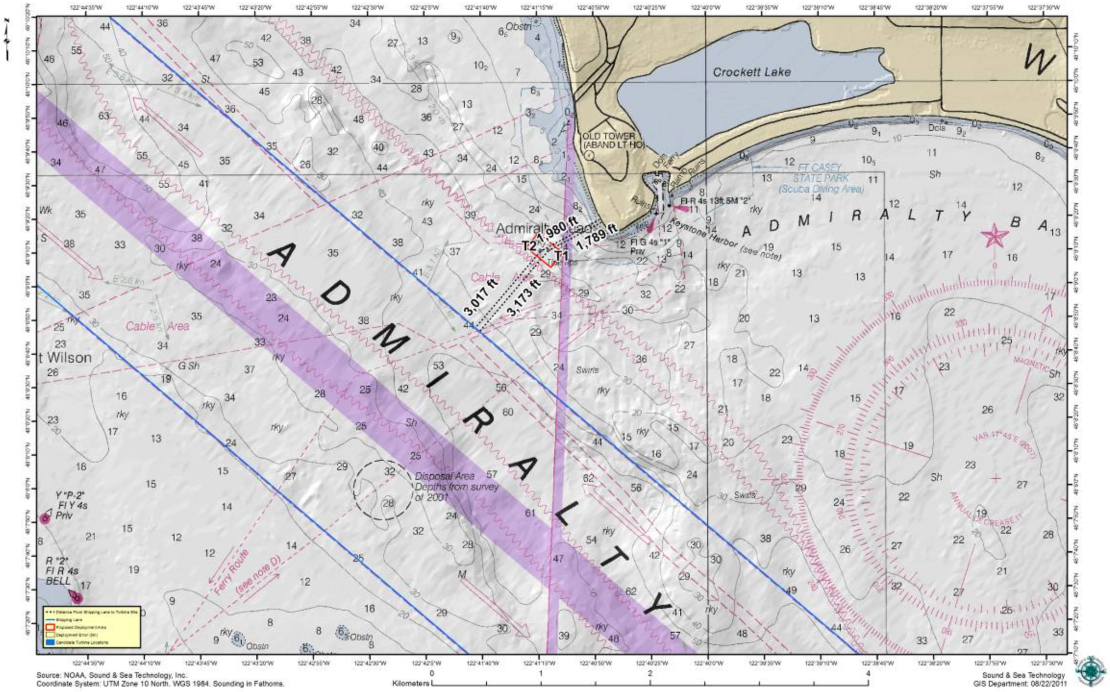
Source: Polagye et al. 2007.

FIGURE 3-49
VESSEL TRAFFIC DENSITY IN ADMIRALTY INLET



Source: Bassett et al., (2012*a*)
Note: "Vessels Minutes" refers to the number of minutes in a year that a vessel of a particular class is present in a 100 m x 100 m horizontal cell.

FIGURE 3-50
VESSEL TRAFFIC SERVICE (VTS) RESTRICTED SHIPPING LANES AND SEPARATION ZONE - NEAR THE ADMIRALTY INLET PROJECT



Source: Pers. comm. Larry Armbruster, Sound & Sea Technology, August 2011.

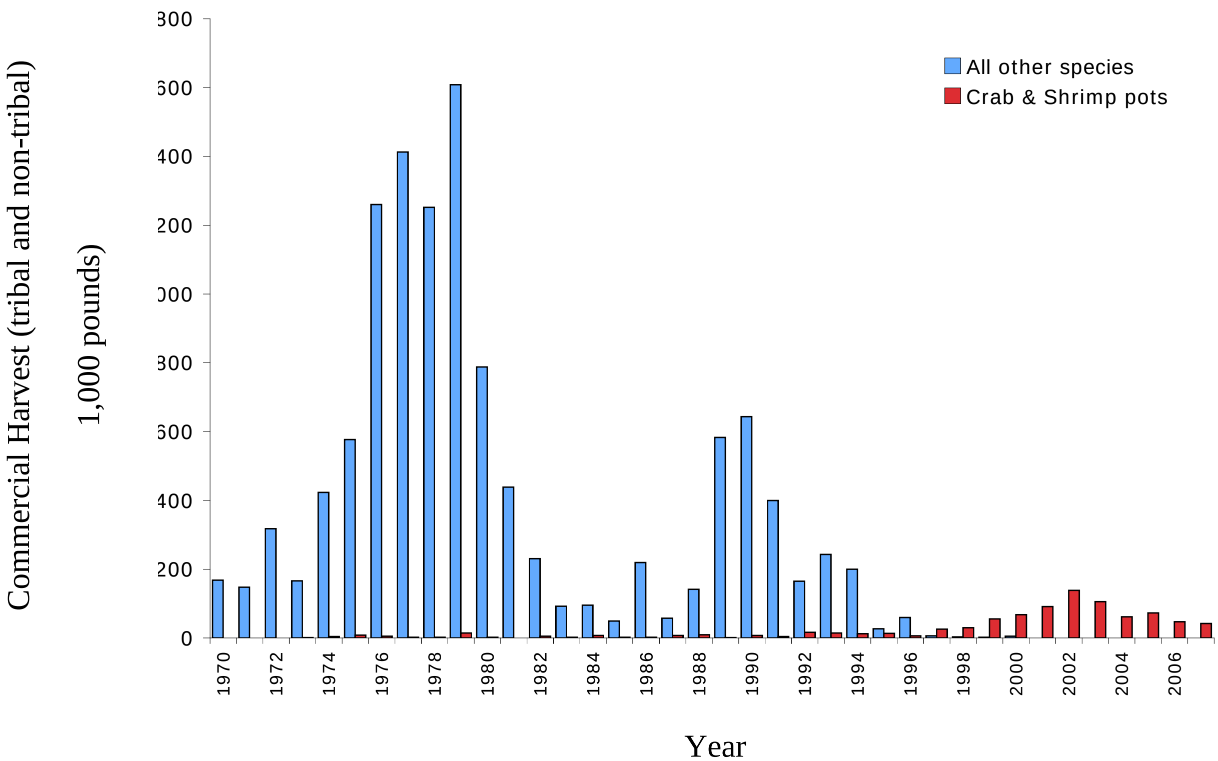
The ports of Puget Sound provide a gateway to the world, with Seattle and Tacoma in 2006 having a combined container traffic that ranked third among all U.S. ports after Los Angeles/Long Beach and New York City (American Association of Port Authorities 2006). In 2005 more than $70 billion worth of goods traveled through these two ports (Trade Development Alliance of Greater Seattle 2005).

Commercial and Sport Fishing

Commercial fishing is an important economic interest for Washington. The State's fishing and aquaculture industries are sustained by the catch and harvest of salmon, clams, oysters, herring, cod, trout, perch, sole and flounder, as well as algae, sea urchin roe, geoducks, and sea cucumbers. The net economic value of commercial salmon fishing has been estimated at over $7 million annually, while the average commercial revenue of shellfish (including crab, shrimp, mussel, oysters, and geoduck clams) has been estimated at $59.3 million annually (IE 2006).

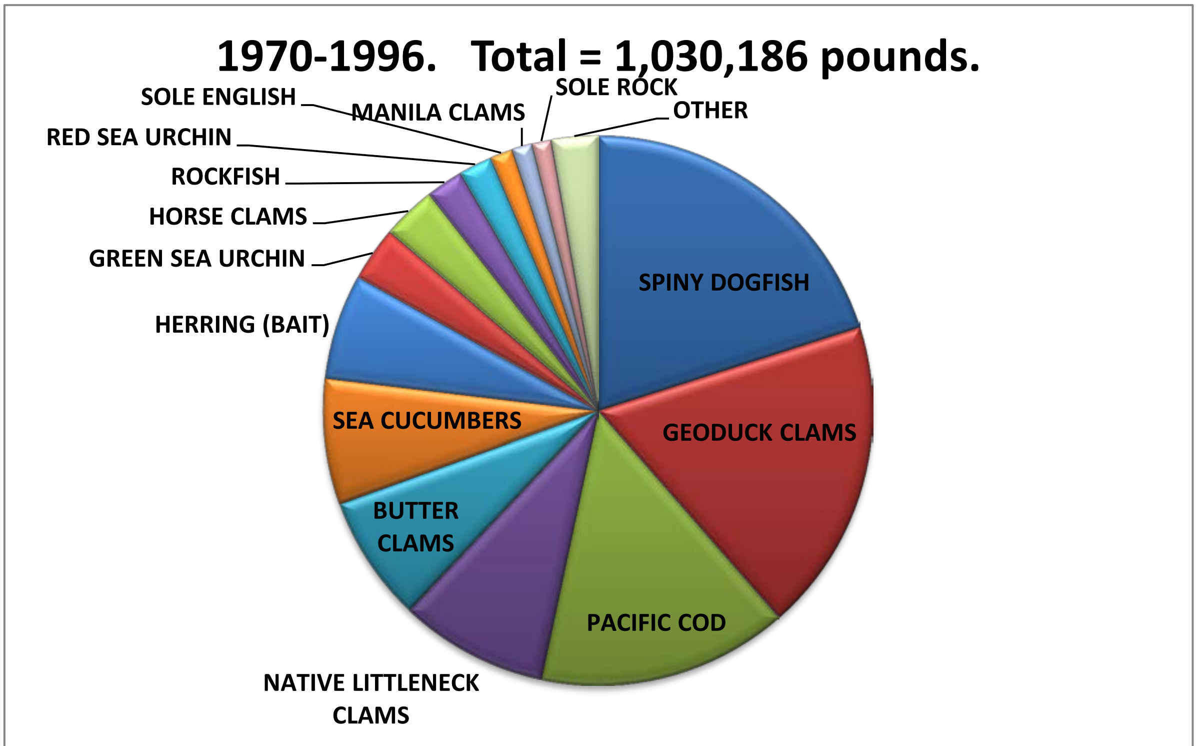
Annual commercial harvest (tribal and non-tribal) in Admiralty Inlet of crab and shrimp and all other species excluding clams, in nearshore marine areas for 1970-2007 is shown in Figure 3-51. As indicated in Figures 3-51 and 3-52, commercial fishing in Admiralty Inlet has declined significantly: from an annual average of 1,030,186 pounds during 1970-1996 to 346,628 pounds during 1997 to 2007 (Figure 3-52) - a reduction of two-thirds. In recent years, the primary commercial species have been those taken by scuba divers (geoduck clams, sea urchins, and sea cucumbers) and pots (Dungeness crab) (Figure 3-52). Thirty thousand pounds of herring, the fourth largest fishery in Admiralty Inlet, have also been captured by lampara net/round haul seines (Pers. comm., G. Ruggerone, NRC, Inc. with L. Hoines, WDFW). These, and other types of fishing gear used for the commercial harvest in Admiralty Inlet, are listed in Table 3-31. Commercial fishing for salmon ended in Admiralty Inlet in the early 1990s because this area is non-terminal (mixed stocks passing through). In addition to herring, three other species of fish have been commercially harvested in Admiralty Inlet from 1997 to 2007: spiny dogfish, sole rock, and starry flounder, but in very small amounts (annual harvest range of 146 to 573 pounds); herring represents 97 percent of the fish caught in Admiralty Inlet (Table 3-32) (Pers. comm., G. Ruggerone, NRC, Inc. with L. Hoines, WDFW).

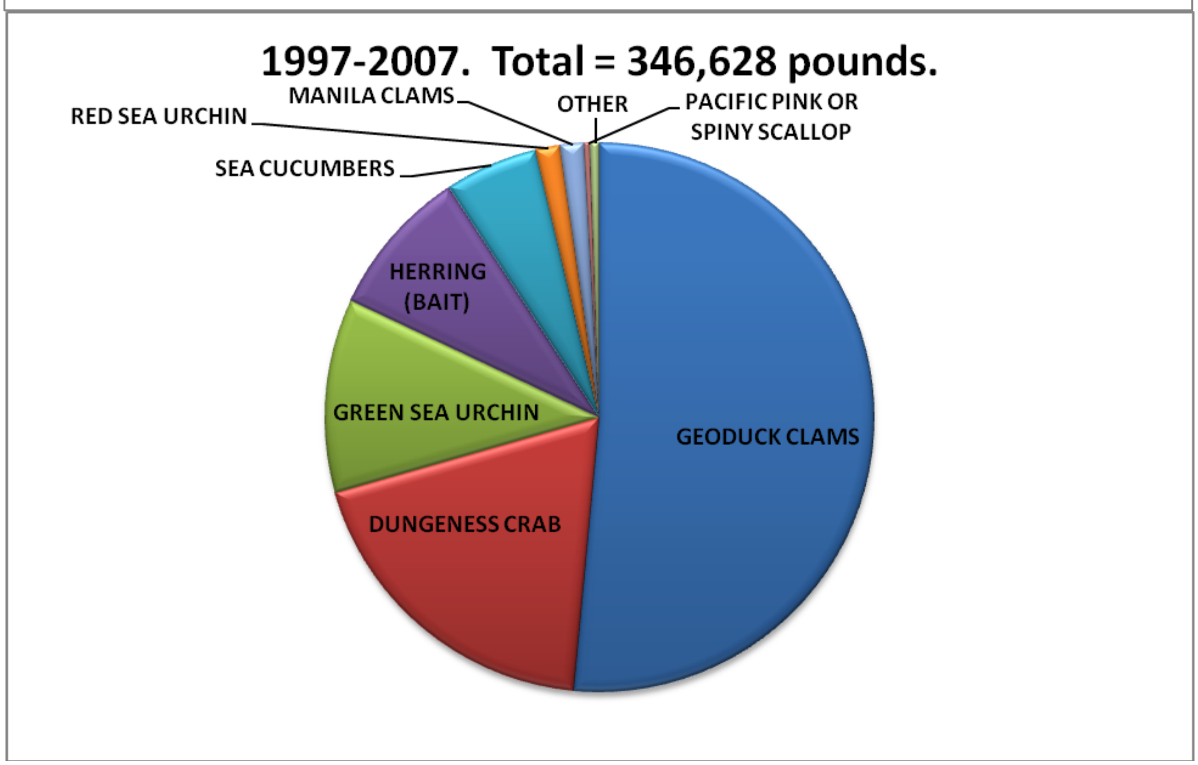
FIGURE 3-51
ANNUAL COMMERCIAL HARVEST (TRIBAL AND NON-TRIBAL) OF CRAB AND SHRIMP AND ALL OTHER SPECIES IN ADMIRALTY INLET 1970-2007



Note: Statistical area 25b, excluding clams in nearshore marine areas**.** Source: Pers. comm. L. Hoines, WDFW, with G. Ruggerone, NRC, Inc.

FIGURE 3-52
ANNUAL COMMERCIAL HARVEST (TRIBAL AND NON-TRIBAL) OF MARINE FISH AND SHELLFISH (LBS) DURING 1970-1996 AND 1997-2007





Source: Pers. comm. G. Ruggerone, NRC, Inc. with L. Hoines, WDFW.

TABLE 3-31
ANNUAL COMMERCIAL HARVEST (TRIBAL AND NON-TRIBAL) OF MARINE FISH AND SHELLFISH (LBS) IN ADMIRALTY INLET BY GEAR TYPE DURING 1997-2007

Gear Type	Pounds Harvested
Mechanical clam gear (geoduck)	178,485
Shellfish pot (crab)	66,350
Dip bag net	64,391
Lampara round haul	30,418
Clam digger	5,001
Set net	571
Otter trawl	491
Beam trawl	466
Shellfish pot (non-crab)	452

Source: Pers. comm. G. Ruggerone, NRC, Inc. with L. Hoines, WDFW.

TABLE 3-32
ANNUAL COMMERCIAL HARVEST (TRIBAL AND NON-TRIBAL) OF MARINE FISH (LBS) IN ADMIRALTY INLET DURING 1997-2007

Species	Pounds Harvested
Herring (bait)	30,418
Spiny dogfish	573
Sole rock	346
Starry flounder	146

Source: Pers. comm. G. Ruggerone, NRC, Inc. with L. Hoines, WDFW.

Sportfishing for salmon, sturgeon, and other marine fish is a popular activity throughout Puget Sound. The value of recreational fishing is estimated to be $57 million annually (WDOE 2008). Salmon are a particularly important species with 618,274 fishing trips for salmon made in Puget Sound and a resulting catch of 375,558 salmon according to the Washington Department of Fish and Wildlife (IE 2006).

Sport fishermen frequently troll for Chinook salmon, including resident “blackmouth” Chinook salmon during winter in Admiralty Inlet (www.salmonuniversity.com). A very popular location is mid-channel bank at the north end of Marrowstone Island and Oak Bay near the south end of Marrowstone Island. Sportfishing also occurs along the east side of Marrowstone Island and near Admiralty Head. Chinook salmon are often hooked while fishing with downriggers near the bottom, often in water that is approximately 50-140 ft depending on location. The average sport catch of salmon in Admiralty Inlet (Area 9) during 2000 to 2006 is shown in Table 3-33 (pink salmon are only captured in odd-numbered years) (Pers. comm. G. Ruggerone, NRC, Inc. with S.

Thiesfeld, WDFW).

TABLE 3-33
AVERAGE SPORT CATCH OF SALMON IN ADMIRALTY INLET (AREA 9) DURING 2000 TO 2006

Species	Number
Chinook	2,480
Coho	16,641
Chum	233
Pink (odd years)	16,168
Sockeye	11

Source: Pers. comm. G. Ruggerone, NRC, Inc. with L. Hoines, WDFW.

Targeted groundfish species from sportfishing in Puget Sound include cabezon, flatfish, greenlings, lingcod, Pacific cod, rockfish, and sablefish, and incidental fish include Pacific hake, Pacific tomcod, ratfish, skate, soupfin, spiny dogfish, walleye pollock, wolf-eel, and wrymouth (WDFW 2010*a*).

The recreational value of shellfishing has been estimated to be approximately $42 million a year (WDOE 2008). Crabbing is one of Puget Sound's most popular recreational fisheries with recreational crabbers collecting over one million pounds of Dungeness crabs annually. The most popular species is Dungeness crab, which is caught using pots, ring nets, and bare hands. The catch by recreational crabbers in Puget Sound more than doubled from 806,034 pounds in 1996 to 1,706,906 pounds in 2003 according to estimates by WDFW. Prior to 1996 recreational harvest estimates were not made. In Admiralty Inlet, Marine Area 9, recreational catch of Dungeness crab are currently limited to size (greater than 6.25 inches), male, and hardshell only (WDFW 2010*b*). Other crabs frequently caught include the red rock crab and shore crab.

Coastal Management

Shoreline Management

Washington's Shoreline Management Act (SMA) was adopted by public referendum in 1972. Its stated goal was "to prevent the inherent harm" associated with "an uncoordinated and piecemeal development of the State's shorelines." The SMA establishes management policy that encourages water-dependent uses, protects the quality of the natural environment and local waters, promotes public access, and increases recreational opportunities (WDOE 2007*d*). Permitted uses of the State's shorelines are to be designed and conducted in a manner that minimizes, insofar as practical, any damage to the ecology and environment of the shoreline area or any interference with the public's use of the water (WDOE 2007*d*).

Under the SMA, "shorelines of the State" (RCW 90.58.030(2)) are defined, in part, as the State's marine waters and the adjacent shorelands that extend 61 meters (200 feet) landward from the ordinary high water mark (OHWM). The State has generally interpreted the OHWM as being equivalent to the mean high water mark.

In addition, the SMA affords special consideration to "Shorelines of Statewide Significance." The preferred uses for these shorelines include those that: (1) recognize and protect statewide interest over local interest; (2) preserve the natural character of the shoreline; (3) result in more long term than short term benefit; (4) protect the resources and ecology of the shoreline; (5) increase public access to publicly owned shoreline areas; and (6) increase recreational opportunities for the public within the shoreline area. Shorelines of statewide significance are defined as including all the waters of Puget Sound and the Strait of Juan de Fuca, as well as specific Puget Sound shorelines (WDOE 2007*d*).

Under the SMA, each city and county that encompasses some portion of the "shorelines of the State" must adopt a Shoreline Master Program (SMP). This program must be based on state laws and rules but be tailored to the specific geographic, economic, and environmental needs of the community. The SMP is essentially a comprehensive and environmentally oriented shoreline plan and zoning ordinance that is applicable to shoreline areas and customized to local circumstances. The WDOE provides technical guidance for creating SMPs and reviews the final documents (WDOE 2007*d*). Currently each of Washington's 39 counties and more than 200 cities administer Shoreline Master Programs.

Coastal Zone Management

In 1976, Washington became the first state to design and implement a federally approved Coastal Zone Management (CZM) program. The CZM program is a voluntary state and federal partnership that encourages states to adopt their own management programs to meet the federal goals of protection, restoration, and appropriate development of coastal zone resources. Washington's CZM program is based primarily upon the Shoreline Management Act of 1971 and to a lesser degree on other state land use and resource management laws. Washington's program document, Managing Washington's Coast, was approved by NOAA in 2001 (WDOE 2001).

Washington's Coastal Zone Management Act (CZMA) recognizes ten "Areas of Particular Concern." These areas occur where resource features are considered to be of greater than local significance, where particular concerns are identified, or where the potential for more than one major land or water use exists. No "Areas of Particular Concern" are within the Project area or within adjacent waters.

3.3.5.2 Environmental Effects

The placement and operation of the Project represents a new use of Admiralty Inlet. Other uses of Admiralty Inlet in the vicinity of the marine portion of the Project include transportation, commerce, defense, commercial fishing, and recreation. During consultation, stakeholders have identified the need to evaluate how, if at all, the Project affects these existing uses (e.g., WDFW letter to the District dated June 16, 2009, NMFS letter to the District dated December 8, 2008, and summary of September 16, 2009 meeting between FERC and Swinomish Indian Tribe and Skagit River System Cooperative).

On August 30, 2009, the District participated in a meeting attended by the U.S. Coast Guard, the U.S. Navy, the USACE, the Puget Sound Pilots' Association, and the American Waterways

Operators (AWO) (a tug and tow industry association) to discuss harbor and navigation safety issues for the proposed Project, as well as the Navy's proposed tidal energy project on the west side of Admiralty Inlet, off of Marrowstone Island, which is currently on hold. The Puget Sound Pilots and the tug and tow industry are the major Puget Sound organizations concerned operationally with regard to navigation safety. In the August 30, 2009 meeting the Puget Sound Pilots indicated that they would likely have little concern regarding the Project site because of the proposed water depth at the turbine deployment location. The American Waterways Operators indicated that there was still some concern about the site despite the depth (minutes of August 30, 2009 meeting, prepared by M. McCallister, Sound and Sea Technology, distributed October 14, 2009). In a subsequent letter filed with FERC on May 27, 2010, AWO stated that the high strength synthetic tugboat lines, the ropes used to connect tugboats to the objects it pulls, may dip at least 100 feet or more under water, potentially providing very little space between the slackened line and the proposed turbines. On December 16, 2010, the District met again with USCG, AWO, Western Tugboat, NNMREC, and Sound & Sea Technology to discuss project navigational safety considerations. Following the December 16, 2010 meeting, the District engaged Sound & Sea Technology to work with the other attendees to an assessment of the risks to navigation posed by the Project; this assessment is included as an attachment in Appendix E.

In order to preclude the potential for development of a hazardous navigation situation, the District discussed the potential for establishment of a Regulated Navigation Area (RNA) with the U.S. Coast Guard, Sector Puget Sound. At this time the Coast Guard is not requiring an RNA. There will be no surface buoys, or other markers of the area. The Coast Guard will instead allow their Vessel Traffic Service command center to manage any transiting vessels operating in the area outside established shipping lanes. Because of the currents and fishing restrictions, there is little reason that anyone would attempt to anchor in the area.No specific aids to navigation are proposed in relation to the Project. The District will further coordinate with the USCG to mark the installed Project and the cable route on electronic and other navigation charts. Such chart demarcation will alert boaters that recreational and commercial fishing and anchoring of vessels is not permitted.

On June 16, 2011, PC Landing Corp. submitted a letter expressing concerns about the proximity of the Project to undersea communication cables owned by PC Landing. PC Landing subsequently filed, on July 25, 2011, a Motion to Accept Late Filed Comments expressing those same concerns. The PC-1 cable, connecting Harbour Point in Puget Sound to Japan is the closest cable to the Project. The PC-1 cable was buried to depths of 0.2 to 1.0 meters. The turbines are located 104 and 150 meters east of PC-1.

To minimize effects on other uses of Admiralty Inlet, the District has located the turbines well outside of the shipping channel and away from the Port Townsend-Coupeville ferry route between Port Townsend and Admiralty Head on Whidbey Island (Figure 3-49 and 3-51 above) and at sufficient depths to allow for acceptable navigational clearances even for deep draft shipping vessels. Additionally, the District has located the turbines well away from the PC-1 telecommunications cable (104 and 150 meters east). Prior to installation of any equipment and test devices, the District will:

- Coordinate with the USCG to mark the installed Project and the cable route on electronic and other navigation charts;

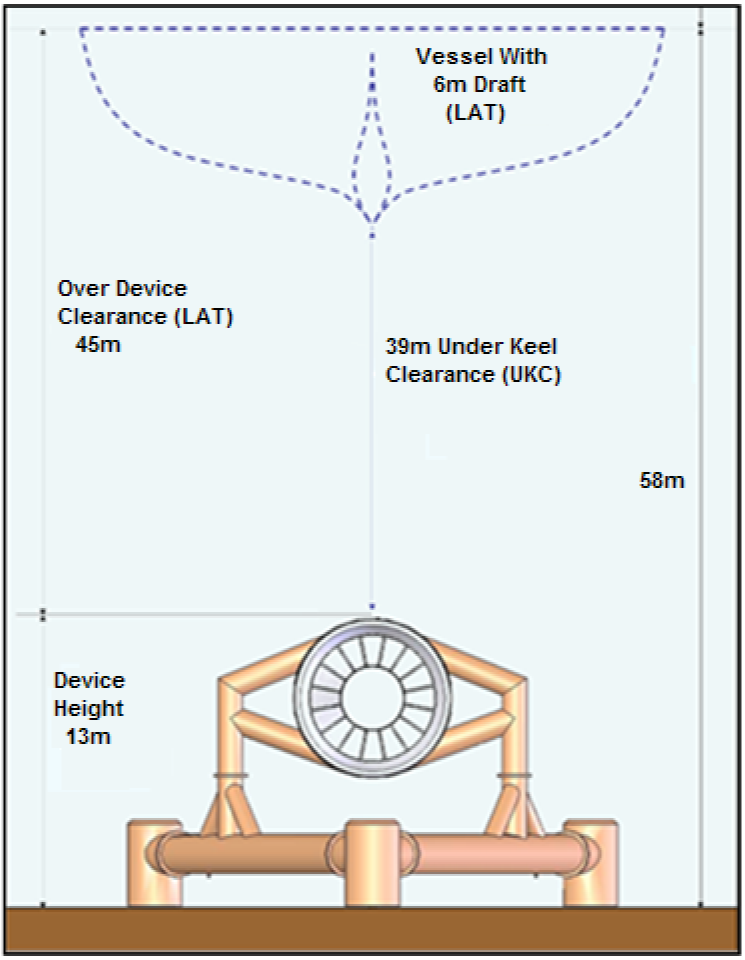
- File a notice to mariners with the USCG, 13th District Command;
- Distribute informational materials on the project to local commercial fisherman in coordination with Washington Sea Grant; and
- Distribute informational materials on the Project to local recreational users (e.g. Puget Sound Anglers, Whidbey Island marine resource committee) in coordination with the Port Townsend and Central Whidbey Chambers of Commerce and the Washington State Parks and Recreation Commission.

Our Analysis

The Project's two turbines will be located at approximately 58 meters depth and will rise 13 meters above the seabed. Therefore, the top of the turbine will be at a depth of approximately 45 meters. The turbines will be deployed approximately 920 meters outside of the shipping lanes (Figure 3-50), though tugs and barges sometimes use the waters outside the shipping lanes to avoid conflict with faster moving vessels in the Traffic Separation Zone. While not deep draft vessels by convention, tugs may have substantial slack in their tow lines which, according to AWO, may sag 100 feet (letter from AWO to FERC dated May 27, 2010). The District believes that, by working closely with the USCG, and properly identifying the turbines on navigation charts, the risk of the project interfering with tug boat operations can be minimized. The Port Townsend-Coupeville ferry draft requires only about 6 meters overhead clearance (Pers. comm. Brian Polagye, University of Washington, and Richard McCurdy, President, Puget Sound Pilots, 2007) and will not be affected by the turbines' siting.

To minimize effects to navigation, the OpenHydro turbines will be deployed at sufficient depths to allow for acceptable navigational clearances even for deep draft vessels in the main shipping channel of Admiralty Inlet. Figure 3-53 reflects navigational clearances for the installation of a 6-meter diameter OpenHydro turbine at the site. The maximum draft for ships traveling outside the Admiralty Inlet shipping lane is 6 meters. This will ensure a minimum clearance of 39 meters for passing ships (Figure 3-53). This will limit the potential for interference with both commercial and recreational vessels. OpenHydro has carried out Navigational Risk Assessments at other project sites, and determined that, when compared with other surface piercing offshore structures such as oil platforms or wind turbines, there is a significantly lower risk of OpenHydro turbines causing collision with vessels.

FIGURE 3-53
NAVIGATIONAL CLEARANCE (NOT TO SCALE)



The USCG currently discourages vessels from anchoring in Admiralty Inlet (minutes of August 30, 2009 meeting, prepared by M. McCallister, Sound and Sea Technology, distributed October 14, 2009). The District will further coordinate with the USCG to mark the installed Project on future navigation charts. Such chart demarcation will alert boaters that recreational and commercial fishing and anchoring of vessels is not permitted in the turbine area.

The USCG Sector in Puget Sound requested that the District conduct a navigational risk assessment. The risk assessment, which is incorporated into the Safeguard Plan (Appendix E), identified significant risk factors, collected relevant risk data, determined which maritime operations lead to potential problems involving vessel safety, identified safeguards to reduce risks, and made recommendations for further actions that may be taken within the capabilities of the marine community to further reduce or eliminate risk.

Using a specialized deployment barge, the turbine and supporting subsea base can be transported to the site and the entire structure lowered, as one, to the seabed within a single tidal cycle (less than 6 hours). The time required for Project installation can therefore be minimized, resulting in minimal disruption of existing marine use of the area.

As indicated above, commercial fishing in Admiralty Inlet has declined two-thirds from 1970-1996 to 1997-2007. In recent years, the primary commercial species have been species taken by scuba divers (geoduck clams, sea urchins, and sea cucumbers) and pots (Dungeness crab). Thirty thousand pounds of herring have also been captured by lampara net/round haul seines and represent 97 percent of the fish caught in Admiralty Inlet (Pers. comm., L. Hoines, WDFW, with G. Ruggerone, NRC, Inc.). Three other species, spiny dogfish, sole rock, and starry flounder have been harvested, but in very small amounts (annual harvest range of 146 to 573 pounds) (Pers. comm., L. Hoines, WDFW, with G. Ruggerone, NRC, Inc.).

While fishing vessels transiting the Project area will be permitted, commercial fishing would be restricted near the project. This restriction of commercial fishing activities over project components is necessary because of the risk to human safety and to prevent fishing gear from snagging on the turbines. Because of the low level of commercial fishing in Admiralty Inlet and the small footprint of the Project, the District does not expect that the Project presence will negatively affect commercial fishing activity.

The District has been in contact with PC Landing Corp. and Alcatel-Lucent (the cable maintenance and repair company) concerning the proposed activity in proximity to the PC-1 cable. The District has evaluated sites on both sides of PC-1 and for several reasons the proposed Project was sited to the east of PC-1 eliminating the complication of a cable crossing. However, PC Landing Corp. remains concerned about the proximity of the proposed Project to its cable. Additional detail regarding the District’s discussions with PC Landing Corp., including the District’s written responses to comments regarding the PC-1 cable, are included in Attachment 1 of Appendix N.

The concerns center on potential damage to the PC-1 cable due to installation, operation, and maintenance activities. In addition they are concerned about constraints on potential future repair operations on PC-1. The primary risk ICPC guidelines suggest a 500 meter separation for construction activities away from telecommunications cables and they have suggested a 1400 meter separation from fixed offshore wind farms. Pacific Crossing has requested the 1400 meter separation. Neither the 500 nor 1400 meter separations are possible for the proposed project due to physical constraints of the bathymetry, shoreline, and current resources. The shoreline is less than 1400 m to the east of the cable and sites more than 1400 m to the west of the cable would increase the cost and risk for the cable run for the pilot project and place the project in the Traffic Separation Zone. Additionally, moving further from shore would reduce the effectiveness of shoreline observers to monitor marine mammal responsiveness to Project operations.

The District has taken steps to mitigate PC Landing Corp. concerns. The project is being implemented with two trunk cables to shore, one from each turbine. This greatly simplifies the installation process and reduces the time on site in proximity to PC-1. In addition the installation will be accomplished by a “live boat” operation meaning there is no requirement for anchors that could drag and damage PC-1 during installation. The installation process has been demonstrated to be capable of placing the turbines at a precise position ±5 meters. The installation process has been demonstrated to take less than one hour. In addition, a cable route to shore was selected that minimizes parallel cables and increases the separation of project trunk cables to PC-1. All pre-installation survey work is being done with strict guidance on anchor constraints and all contractors are made aware of PC-1 location and operational constraints. Note also that the inter-turbine separation of 70 m is significantly smaller than the distance between the turbines and the PC-1 cable, which speaks to OpenHydro's deployment capabilities.

Operations will not impact PC-1 since there is not bottom or surface activity during operation. The primary cable safety concern of PC Landing Corp. is turbine movement that could impact the cable. The turbines are on a subsea gravity base designed to resist sliding and overturning moments exerted by the maximum tidal and storm surge currents. There is virtually no likelihood of the turbines being able to translate over 100 meters toward PC-1 due to operations as the current direction is parallel to PC-1 not perpendicular to it. System monitoring will detect any vibration or movement of the turbines.

During the first month of operations an ROV survey will be conducted to assure the turbine has not moved from the baseline survey on installation. The survey will be repeated every three months for the first year to assure there is no movement. ROV inspections will occur at least quarterly for the first year of the demonstrations. The project plans to install and proof test, to maximum loading, two semi-permanent anchors well to the east of PC-1 and the turbine sites for the project duration. These anchors will be used to stabilize ROV and other support vessels that perform inspections and maintenance activities and eliminate the need for vessel deployed anchors. The anchors will help to stabilize the support vessels and they will be pushed west into position over the turbines with a Z drive tug. Either the anchors or the tug are capable of positioning the vessels resulting in a redundant capability assuring no vessel anchors will be deployed and assuring Pacific Crossing that no anchors will be dragged across PC-1. None of the ROV or maintenance operations will take place over PC-1 assuring nothing is dropped on the PC-1 location.

PC Landing Corp. has a repair and maintenance contract for the cable with Alcatel-Lucent. There is ongoing dialogue with Alcatel-Lucent to discuss the project and the potential repair concerns. Cable repairs are made by grappling the damaged section of cable, cutting it, and retrieving both ends to the cable ship. A new section of cable is spliced to both of the cut ends and the new section is re-laid on the bottom in a "bite" that forms a half-loop on the bottom, usually parallel to the original cable.

Project presence in the area will limit where the repair ship can grapple. They may grapple to the north or further away to the south. The grapple will have to be made so not to impact the Project turbines or the trunk cables. Regardless of the proposed Project, use of a grapnel in the Project area is not generally recommended due to the presence of inactive cables associated with Fort Casey that run perpendicular to the direction of the tidal currents.

During a PC-1 cable repair the cable ship will dynamically maintain position over the cut cable area and anchors are not required. The only project constraint during repair is to assure that PC-1 cable is not dragged into the area of the turbine. The constraint to not drag PC-1 exists anyway since that would cause additional PC-1 cable damage and it is not environmentally acceptable. This issue should cause PC Landing Corp. no additional concern.

Following a repair to the PC-1 cable, it will have to be re-laid and re-buried. The project will constrain Pacific Crossing to re-lay the repair section to the west of the existing cable route. They will want to re-lay as parallel to the existing cable as possible to minimize cross current forces on the cable as much as possible. Alcatel-Lucent has indicated they can accommodate that constraint. There will be no impact on the burying operation.

The District continued discussions with PC Landing through the exchange of letters in late 2011 and early 2012. On August 12, 2011, PC Landing's maintenance contractor Alcantel-Lucent requested information from the District. The District responded in writing on September 14, 2011. On November 17, 2011, PC Landing providing the District with questions and a request for certain data related to the Project. PC Landing's inquiry focused on the District's analysis of alternative sites for the Project, on the characteristics of the seabed, and the overall impact of the Project on PC Landing's operations, among other things. The District responded in writing on January 12, 2012, providing additional information supporting the process the District employed to select the proposed Project site and supporting the District's conclusion that the Project as proposed will have no significant impact on the operatio or repair of the cables owned by PC Landing. Upon review of the District's January 12 response, PC Landing provided the District with additional questions on February 13, 2012. This exchange of letters is attached to Appendix N, and includes the District's response to the February 13 letter.

The Project has mitigated the issues to the maximum extent possible by siting the turbines to eliminate the need for a trunk cable to cross PC-1 and to place the turbines as far from PC-1 as possible. In addition the project has taken steps to eliminate vessel anchoring in the area and use only preinstalled and proof tested anchors well to the east for maintenance and inspection operations throughout the demonstration period.

In conclusion, the District anticipates that the proposed Project will present no risk to either competing marine users or vessel operations within Admiralty Inlet. As stated above, the top of the turbine will be at a depth of approximately 45 meters and the turbines will be deployed approximately 920 meters outside of the shipping lanes (Figure 3-50). In addition, the District has developed a navigation risk assessment (Appendix E) in consultation with the USCG. The District continues to consult with Pacific Landing Corp. to ensure that there are no negative effects to the operation and maintenance of the PC-1 cable.

3.3.5.3 Cumulative Effects

Based on the information reviewed and collected in support of this license application and consultation with stakeholders, over the next ten years, the proposed term of the Project, the District has identified commercial fishing and navigation as having the potential to be cumulatively affected by the proposed Project in concert with other activities in the Project area. Other recent, on-going, or proposed activities in the area that have the potential to cumulatively affect commercial fishing and navigation over the next ten years include the following:

- Existing commercial fishing - continued or increasing pressure on targeted fish and shellfish populations (commercial fishing in the area has declined two-thirds in the past couple decades).

- Vessel traffic - Admiralty Inlet serves as a main route for all shipping traffic for the ports of Everett, Seattle, Tacoma, and Olympia and Admiralty Inlet is also traversed by the Port Townsend-Coupeville ferry. As the population in the Puget Sound continues to grow over the next ten years, it is expected that shipping and other watercraft use of Puget Sound will increase.
- Other proposed tidal energy projects - fishing and navigation restriction areas associated with the proposed Navy demonstration project off Marrowstone Island, the development of which is currently on hold, and the District’s proposed pilot Project do not represent significant effects on marine uses of the area, but if additional commercial-scale tidal projects were permitted and built within the next ten years, cumulative effects on navigation and fishing in the area could result.
- Subsea cables, including two telecom cables (PC-1 and PC-2) that cross west of the Admiralty Inlet Project deployment area running from northwest to southeast, may cause gear entanglement or anchorage hazards.

3.3.6 Cultural and Tribal Resources

3.3.6.1 Affected Environment

Section 106 of the 1966 National Historic Preservation Act (NHPA), as amended, and its implementing regulations found in 36 CFR §800, require that federal agencies take into account the effects that their undertakings may have on historic properties. To accomplish this, the historic properties[30] within a project’s Area of Potential Effects (APE) must be identified, the potential effects of the Project on these properties must be assessed, and the options for treating such effects must be considered. This section provides the results of data gathering using existing, relevant, and reasonably available information to identify significant cultural remains and locations currently documented within the Project’s APE.

A project’s APE is defined as “...the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if any such properties exist” [Under 36 CFR § 800.16(d)]. Under 36 CFR § 800.4(a)(1), the APE is identified and documented early in the planning process and is thus considered to be a preliminary designation until concurrence is obtained from the State Historic Preservation Officer (SHPO). On August 8, 2011, the Washington Department of Archaeology and Historic Preservation (DAHP) concurred with the proposed determination of the revised APE as submitted by the District on August 3, 2011, and defined below:

For the purposes of this analysis, the District defines the APE as submerged areas and terrestrial areas.

Submerged areas - Admiralty Inlet:

- Turbine deployment site - bed of Puget Sound (approximately 800,000 square feet)

---

[30] Historic property is defined as cultural resources, including prehistoric or historic sites or districts, buildings, structures or objects, that are eligible for or listed on the National Register of Historic Places (36 CFR 800.16(l)).

- Electrical transmission cable route from the horizontal directional drilling (HDD) exit point to the turbines, including 20-feet on each side of the cables. The cables will be directly laid on the sea bed
- Electrical transmission cable route HDD portion from the ordinary high water mark to the HDD exit point, including 10-feet on each side of the HDD bore
- Anchor mooring system

Terrestrial areas - private property:

- Electrical transmission cable route HDD portion from the entry point (bore pit) to the ordinary high water mark, including 10-feet on each side of the HDD bore
- Bore pit for the HDD. The pit is expected to be approximately 6-feet deep, 20-feet long, and 8-feet wide
- Control room footprint (approximately 800 square feet)
- Equipment staging and parking area, approximately 75-feet by 120-feet

Cultural History

Prior to the arrival of Europeans, the Puget Sound basin was populated by a number of native peoples. Some of the tribal groups and lineages that historically occupied the area have dispersed or been subsumed by other tribal groups. The native peoples who inhabited Puget Sound at the beginning of the historic period represent five relatively distinct ethnic groups: the Central Coast Salish, the Northern and Southern Lushootseed, the Twana, and the Clallam peoples. These groups in turn represent five major linguistic stocks, including the Clallam, the North Straits, the Nooksack, the Lushootseed, and the Salishan language families. Within these major stocks were 16 coastal languages and seven languages spoken in the interior of Washington. Of the tribes identified within the Puget Sound, 19 are federally recognized (DON 2006).

Regionally, tribes had similar subsistence patterns based on fishing in the ocean and the rivers, the gathering of other marine resources, hunting of game, and the gathering of various native plants. Salmon is of primary importance to the tribes, both for subsistence purposes and for ceremonial and religious purposes (DON 2006). Ancestral groups relied on salmon and considered the fish a symbol of their tribal and individual identity (DON 2006). Shellfish are also a traditional resource used for subsistence and for symbolic, ceremonial, religious, and other cultural purposes. Several Puget Sound tribes retain the right to harvest various intertidal shellfish in traditional gathering grounds (DON 2006).

One of the most profound influences imposed on the Project area was the arrival of European fur traders (Cole and Darling 1990). Following decimation of the coastal sea otter population, fur traders sought opportunities to barter with the tribes for beaver, raccoon, bear, and deer. (Goetz and Tingwall 2006). Washington Territory was organized in 1853 under Governor Isaac Stevens. Stevens arranged a series of treaties with regional Indian tribes. Tribal people were forcibly relocated to reservations in the mid-1850s (Willis and Sharley 2005).

Fort Casey was built at the turn of the century as part of a "triangle of fire" designed to guard the entrance to Puget Sound (Fort Worden on the Olympic Peninsula and Fort Flagler on Marrowstone Island were the other two points of the triangle). The Coast Artillery Corps troops were never engaged, and most of the site became a state park in 1954. The Admiralty Head

Lighthouse on the north end of Fort Casey was built to help guide ships into Puget Sound (Sound and Sea Technology 2009).

Review of Archaeological Work Done in the Area

The District conducted a records search at the DAHP between November 11 and 28, 2007. The DAHP office houses all cultural resources data (e.g., archaeological survey reports, archaeological site records, etc.) for the state of Washington. The records inspected at the DAHP office include archaeological site records, base maps depicting archaeological site and survey locations, archaeological investigation reports (i.e., letter reports, survey reports, site testing and evaluation reports), the NRHP, Washington Register, Washington Historical Landmarks, and Washington Points of Historic Interest.

The area included in the records search included all lands within ¼ mile radius of the marine and terrestrial components of the Project. The records search indicates no previously recorded archaeological sites within the APE. There is one previously recorded site within ¼ mile of the APE: the Schulke/Steadman House, located at 13254 SR-20.

A Cultural Resources Study was conducted by AMEC Environmental & Infrastructure (AMEC) during January, 2012. Historic debris scatter was identified in the vicinity of the Schulke/Steadman house, including glass bottle fragments, stoneware fragments, and a military uniform button dating from approximately 1854-1885. Pre-contact lithic material including three rocks were also identified along the beach. Additional details are contained in the AMEC report, Appendix M. The Project is not anticipated to have adverse effects on cultural resources. On February 23, 2012, the District submitted a letter to DAHP requesting concurrence with the determination of “No Adverse Effects to Cultural Resources.”

Ebey’s Landing National Historic Reserve was identified as a historic register district according to Washington DAHP’s online architectural and archaeological database, WISAARD. This historic district is defined as the area “south of Oak Harbor, roughly six miles either side of Coupeville” in Island County (WISAARD 2011). Ebey’s Landing is the nation’s first historical reserve, created in 1978 to protect a rural working landscape and community on Central Whidbey Island. The reserve includes 17,500 acres, 17 farms, over 400 historical structures, native prairies, two state parks, miles of shoreline, a network of trails, and the second oldest town in Washington. The reserve is managed by a 9-member Trust Board (National Park Service 2011). The proposed APE falls within this reserve, however the project will not affect any historic structures.

On February 28, 2012, DAHP responded, agreeing with the APE as mapped in the APEC report and agreeing that the Project as proposed will have “NO ADVERSE EFFECT” on National Register eligible or listed historic and cultural resources. Documentation of the District’s consultation with DAHP is contained in Appendix M.

Tribal Resources

As noted above, Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended, and its implementing regulations found in 36 CFR § 800, require federal agencies to take into account the effects of their undertakings on historic properties, which include locations and resources of traditional importance to potentially affected Indian tribes. To accomplish this, cultural resources within the the District's proposed APE must be identified, potential project effects must be assessed, and options for treating effects on significant resources must be considered. This section provides the results of data gathering using existing, relevant, and reasonably available information to identify significant cultural resources currently documented within the District's proposed APE.

The following Indian tribes may be potentially affected by the Project: the Jamestown S'Klallam Tribe, the Lower Elwha Klallam Tribe, the Lummi Nation, the Port Gamble S'Klallam Indian Tribe, the Suquamish Tribe, the Sauk-Siattle Indian Tribe, the Swinomish Indian Tribal Community, the Upper Skagit Indian Tribe, and the Tulalip Tribes of Washington. These tribes have interests in the Project based upon their reserved treaty fishing rights. Several of these Indian tribes exercise their reserved treaty fishing right in Admiralty Inlet. There are no tribal lands affected by the Project.

These Indian tribes' reserved treaty fishing rights stem from several Stevens Treaties that were negotiated by Governor Isaac Stevens in the 1850s with numerous Pacific Northwest Indian tribes. Under these treaties, several Indian tribes ceded their aboriginal lands to the United States and accepted in return reservations located in Western Washington. In return for relinquishing claims to substantial tracts of land, the tribes received from the United States certain payments and promises of assistance. In conveying their claims to title, the Tribes also reserved for themselves certain rights and entitlement, including the right to continue to harvest fish. For example, Article V of the Treaty of Point Elliot reserved to the Tulalip Tribe "[t]he right of taking fish at usual and accustomed grounds and stations . . . in common with all citizens of the Territory. . . ."

3.3.6.2 Environmental Effects

Area Indian tribes have indicated concern about how the Project will affect marine resources, endangered species, water quality, and commercial fishing (summary of September 16, 2009 meeting between FERC and Swinomish Indian Tribe and Skagit River System Cooperative, letter from Tulalip Tribe to the District dated March 1, 2007, letter from the Suquamish Tribe to the District dated March 8, 2009). These issues are discussed in corresponding prior sections. Construction of the proposed Project also has the potential to affect historic and cultural resources, which we evaluate below.

Our Analysis

The proposed Project will include marine and terrestrial components sited in the vicinity of cultural resources and historical properties. The District contracted Fugro to conduct a marine geophysical study, which included a magnetometer survey to identify anomalies that may represent historical resources. The study, conducted between June 25 and 30, 2009, also included high-resolution multibeam bathymetric, sub-bottom profiling, side-scan sonar, and bottom grab surveys. No magnetic anomalies were observed at the turbine deployment area or along the subsea cable route and no objects were identified on the seabed (Fugro 2009, additional information on the geophysical study is contained in Section 3.3.1.1 and Appendix A).

The District contracted Golder Associates during May 25-26, 2011, to conduct a seismic reflection survey of the revised cable route to the new shore landing location southeast of the original proposed location at Camp Casey. No geophysical anomalies were observed within the survey route (Golder 2011, additional information on the geophysical survey conducted by Golder Associates is contained in the pre-installation studies located in Appendix L).

The District contracted AMEC to conduct a cultural resources assessment of the terrestrial and subsea components of the project during January, 2012 (Appendix M). AMEC conducted a thorough review of the project area and concluded that the project will have “No Adverse Effects to Historic Properties.” As described above, the DAHP has concurred with the conclusion of No Adverse Effects.

Terrestrial Project components consist of a shore landing cable, a termination vault, an approximately 9-meter trenched back haul cable to the control room, a control room, and an approximately 70-meter trenched back haul cable to the PSE grid.

The District has selected a tidal power technology and deployment methodology that will have minimal effect to the marine and terrestrial components of the Project area. The gravity-based OpenHydro turbines will be placed on the seabed and the subsea trunk cables will be laid on the seabed and from a depth of at least 18 meters will transition to under the seabed through an HDD bore onshore to a termination vault and then continue underground (trenched) to the control room and to the grid connection, all through previously disturbed grounds on private property. There will be no new roads, further avoiding potential effects to cultural or historic resources.

Based on the existing information on cultural resources, the small size of the Project, and the fact that the terrestrial project occurs on previously developed grounds, the District concludes that the Project will not have an adverse effect on any cultural resources. The District has requested concurrence with this conclusion from the cultural offices of the impacted tribal governments, but has not yet received a response. The District’s letters requesting concurrence are included in Appendix M.

3.3.7 Aesthetic Resources

3.3.7.1 Affected Environment

Residents and visitors are drawn to many parts of Puget Sound to enjoy its scenic vistas, relax on its shores, and to observe wildlife. Other areas of Puget Sound have been developed, resulting in urban and municipal areas, shore roads, and infrastructure associated with industry, ports/shipping, and defense.

The basin was shaped by the carving and till deposition of glaciers that retreated as recently as 13,000 years ago (Booth and Goldstein 1994). Located between the Olympic Mountains to the west and the Cascade Mountains to the east, the basin is surrounded by valley walls that descend through rolling hills before reaching the lowlands that form the periphery of the Sound itself. The estuary has over 4,000 km of shoreline that encompass 7,250 square kilometers of inland marine waters (Gelfenbaum et al. 2006). These waters are fed both by the Pacific Ocean and by the rivers and major streams that drain the adjacent watershed.

The topography of the basin greatly contributes to the aesthetics of the region. Views of the Sound and its many tributaries as well as of the surrounding mountains, particularly Mount Rainier and Mount Baker, are highly valued (PSRC 2006). Numerous local, state and national parks, as well as wildlife refuges and scenic viewpoints, have been established within and around Puget Sound.

Admiralty Inlet is a wide channel bordered on the northern side by Whidbey Island. The shoreline is largely undeveloped and includes both forested areas and bluff-backed sandy beaches (National Park Service 2008). Seven state parks, as well as several county and local parks, provide viewpoints from which to observe the waters of Puget Sound and the neighboring landscape. Most of the land on Admiralty Head is occupied by Fort Casey State Park and Ebey's Landing National Historic Reserve. The Olympic and Cascade Mountains are both visible from Admiralty Inlet (Larsen 2003).

3.3.7.2 Environmental Effects

Resource agencies and stakeholders have not raised specific concerns related to project effects on aesthetics. Coastal viewscapes are important in Puget Sound and are valued by residents and visitors. By selecting to deploy OpenHydro tidal turbines, the District purposefully chose a technology that sits on the seabed, is not visible from the surface, and that can be deployed quickly (each turbine can be deployed in one tidal cycle, which is less than 6 hours). In order to further minimize effects to aesthetic resources, the District proposes to deploy all terrestrial project components, other than the control room, underground. The District has sited the Project to connect to the grid at a location that is very close to shore, that has been previously developed, and that requires no overhead transmission lines and no new roads. Natural terrestrial vegetation will be left intact as much as possible during site preparation activities, and following construction, the HDD laydown, trenched, and other disturbed areas will be returned to pre-installation conditions.

Our Analysis

The Project's two turbines will be located at approximately 58 meters depth and will rise 13 meters above the seabed. Therefore, the top of the turbine will be at a depth of approximately 45 meters. The Project will transmit electrical power generated from the OpenHydro turbines to the onshore electrical grid via a subsea transmission cable, connecting to the grid in the Ebey's Landing National Historic Reservation, on private land just east of Admiralty Head. The trunk cable will be deployed in an HDD bore beginning at minimum depth of 18 meters and continuing under the littoral zone to land. The cable will continue underground for the remaining portion of the terrestrial part of the Project. The only above ground structure will consist of the control room.

During project construction, a turbine deployment barge, cable laying barge, tugs, ROV, and small support vessels will be required to deploy the OpenHydro Turbines. Each unit can be installed within a single tidal cycle (less than 6 hours). The primary visual disturbance will be during the HDD process. The terrestrial HDD activities are expected to take approximately 45 days, and includes deployment, drilling, demobilization, and restoration of the grounds. At sea installation activities are expected to take 20 days and include the following actions: assist land-based HDD installation crew with exit of the HDD bore hole, installation of the trunk cables through the HDD bore, laying trunk cables on seabed, and deployment of turbines. The presence of construction-related equipment will represent a minor, temporary, and short term effect to aesthetics in the area. The marine vessels needed to deploy the turbines and cable will be less of a visual impact than that associated with daily shipping traffic through Admiralty Inlet. By leaving natural terrestrial vegetation intact as much as possible during site preparation activities, and by restoring the HDD laydown, trench, and other disturbed areas to pre-installation conditions, the District will minimize effects to terrestrial aesthetics.

Other than the construction and presence of the control room, all project components will be either underwater or underground, and consequently not visible. Operation of the Project will therefore not affect aesthetics of the area, neither for marine or terrestrial components of the Project. In conclusion, the project technology allows for, and has been designed to have negligible effects on aesthetic resources.

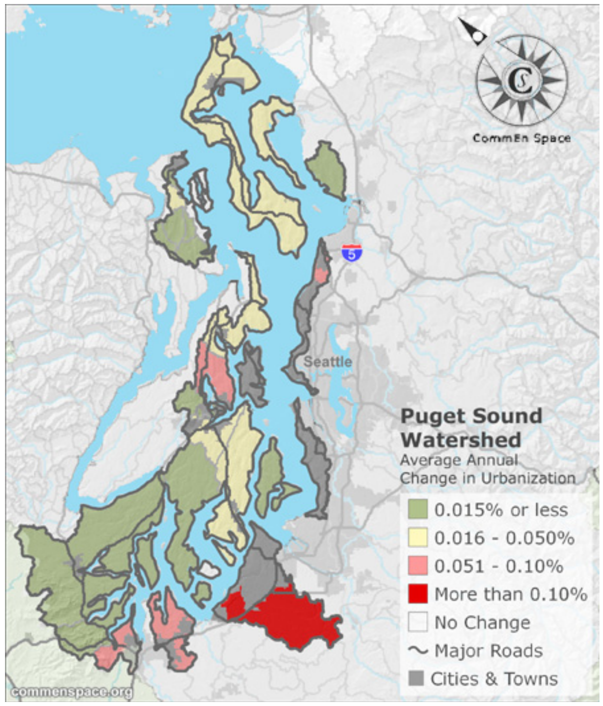
3.3.8 Socioeconomics

3.3.8.1 Affected Environment

The Project area is primarily located in the marine environment. The terrestrial portion of the Project will be located on private land with the Ebey's Landing National Historic Reserve. The dominant land types are forest and residential, and a more detailed discussion of land use within the Project area is provided in Section 3.3.5.

Approximately 4 million people, or 70 percent of the population of Washington State, live within the Puget Sound Watershed. The population within the region is growing at an estimated rate of 50,000 people per year and projections suggest that 1.4 million new residents will reside within the region by 2025 (PSAT 2007*b*). Like much of Puget Sound, Whidbey Island has seen a trend of increasing urbanization (Figure 3-54). Information on recent population trends for Island County is presented in Table 3-34. The statewide population density in 2005 was 36 persons per square kilometer.

FIGURE 3-54
PUGET SOUND WATERSHED AVERAGE ANNUAL CHANGE IN URBANIZATION, 1995-2000



Source: EPA 2007

TABLE 3-34
POPULATION TRENDS WITHIN ISLAND COUNTY

Parameter	Value
1990 Total Population	60,195
2010 Total Population (Est.)	78,506
Percent Change in Population 1990 - 2010	+24%
Land Area in Square Kilometers	540
Density (Persons per Square Kilometer) 2010	150
Housing Units 2010	40,234

Sources: Washington Office of Financial Management, U.S. Bureau of the Census 2012*a*

The median household income in Washington in 2010 was $57,244, and the per capita income was $29,733 (US Census Bureau 2012a). The average unemployment rate for the state of Washington was 9.1 percent in 2011, compared to the national average of 8.9 percent that same year. Washington unemployment dropped to 8.5 percent during the month of December, 2011 (U.S. Dept. of Labor 2012). Income statistics for Island County are presented in Table 3-35.

TABLE 3-35
ECONOMIC STATISTICS FOR PROJECT AREA

Parameter	Value
Median Household Income, 2010	$57,190
Per Capita Income, 2010	$29,079
Poverty Status, Percent of Population, 2010	8.0%
Annual Average Unemployment Rate, 2011	8.8%
Annual Job Growth, 2010	1%

Sources: U.S. Bureau of the Census 2012 (income, poverty status); Washington State Employment Security Department (unemployment, job growth)

Puget Sound plays an integral role in the region's economy. Within Puget Sound an estimated 142,000 firms provide 1.8 million jobs in a variety of industries (WDOE 2007c). Shipping and transportation, fishing and shellfish harvesting, recreational boating, and tourism are some of the many industries that depend on Puget Sound. Table 3-36 provides employment and payroll data based on 2008 data for key business sectors in Island County.

The main employers are retail trade, health care and social assistance, accommodation and food services, and construction.

TABLE 3-36
ISLAND COUNTY EMPLOYMENT DATA (2009)

Industry code description	Number of Employees	Annual Payroll ($1,000)
Retail trade	2,272	55,983
Health care and social assistance	2,384	86,226
Accommodation and food services	1,758	24,411
Administrative and support and waste management and Remediation Services	348	8,646
Construction	1,062	36,341
Other services (except public administration)	767	14,656
Professional, scientific, and technical services	568	27,626
Finance and insurance	537	24,291
Manufacturing	587	23,248
Information	NA	NA
Arts, entertainment, and recreation	365	5,791
Real estate and rental and leasing	275	6,512
Educational services	224	4,777
Wholesale trade	NA	5,282
Transportation and warehousing	159	7,115
Utilities	56	2,394
Management of companies and enterprises	NA	2,061
Forestry, fishing, hunting, and agriculture support	22	584

Industry code description	Number of Employees	Annual Payroll ($1,000)
Mining, quarrying, and oil and gas extraction	NA	570
Industries not classified	NA	67

Source: U.S. Census Bureau 2012b; NA - not available

3.3.8.2 Environmental Effects

Resource agencies and stakeholders have not expressed any concerns regarding socioeconomic issues associated with this Project. The District expects development of the Project to result in socioeconomic benefits including the production of renewable energy and economic stimulus for industries that will support the fabrication of the Project components including the steel foundation, installation of the Project, maintenance operations, and environmental monitoring.

Our Analysis

While fishing vessels transiting the Project area will be permitted, commercial fishing would be restricted near the project. This restriction of commercial fishing activities over Project components is necessary because of the risk to human safety and to prevent fishing gear from snagging on the turbines. As discussed in Section 3.3.5, Recreation, Ocean, and Land Use, because of the low level of commercial fishing in Admiralty Inlet and the small footprint of the Project, the District does not expect that the Project presence will negatively affect commercial fishing activity.

The District's service territory is growing rapidly, with projections estimating 8,000 to 10,000 new connections per year and a resulting annual load increase of 15 to 20 average megawatts (aMW). In November 2006 with the passing of Initiative 937, Washington State became the second state to pass a Renewable Portfolio Standard (RPS). The RPS requires qualifying utilities, including the District, to obtain a percentage of their electricity from new renewable resources by certain dates, as well as to undertake all cost-effective energy conservation. The RPS requires at least 3 percent by 2012, 9 percent by 2016, and 15 percent by 2020 and each year thereafter. The policy statement associated with the Washington State RPS maintains that: "Making the most of our plentiful local resources will stabilize electricity prices for Washington residents, provide economic benefits for Washington counties and farmers, and create high-quality jobs in Washington." The District believes that delivering on this vision will require the intensive evaluation of *all* potentially viable renewable energy resources available to the region. This approach is consistent with the District's Climate Change Policy, which states:

> *Snohomish County PUD will provide electric, water and associated services to its customers in an environmentally responsible way while increasing economic value, financial stability and operational safety and security for our ratepayers. Snohomish County PUD faces significant challenges and some uncertainty in serving community growth while at the same time addressing the issue of global climate change.*
>
> *Climate change is a serious global problem, and we believe that it should be addressed through the development of thoughtful and forward-looking legislation*

> *that actually results in the reduction of greenhouse gas emissions in a workable and cost-effective manner. It is also important that any legislative solutions promote and provide incentives for the development and application of innovative technologies as part of a climate change strategy.*
>
> *The Northwest's investments in energy efficiency and renewable hydroelectricity have yielded substantial environmental benefits. We will continue this legacy by meeting customer growth through conservation and a diverse mix of renewable technologies including, but not limited to, wind, tidal, solar, biomass, and geothermal.*
>
> *Using our natural resources more efficiently and wisely makes good environmental and economic sense. Therefore, legislation to reduce greenhouse gas emissions, if done correctly, should not negatively impact the nation's economy or competitiveness.*

The District estimates that even with a robust conservation program it will still need to acquire approximately 140 aMW from renewable energy resources by 2020 to meet both its load growth and RPS requirements. The District believes that meeting this energy challenge will require a richly diversified portfolio of conservation initiatives and renewable energy resources, of which tidal energy has the potential to contribute significantly. The District's tidal energy efforts are consistent with national energy policy priorities, represent one of the primary tidal energy research efforts in the United States, and continue to have the strong support of the U.S. Department of Energy's Advanced Water Power Projects program.

The operation of the Project will provide emission-free electricity, and will contribute to the energy production portfolio of both urban and remote rural areas. The anticipated output of the two turbines is approximately 216,000 kWh annually.

The Admiralty Inlet Pilot Tidal Project will provide economic stimulus in the Puget Sound area through the work needed to fabricate the steel foundation, install the turbines and subsea cables, support operations and maintenance, and conduct environmental monitoring. While the two turbine rotors will be manufactured at OpenHydro's facilities in Ireland, the subsea bases will be constructed in the Puget Sound area. For reference purposes, Cherubini Metal Works in Nova Scotia was awarded a $1.7 million (CAN) contract in April 2009 to manufacture the subsea base for the 10-meter diameter OpenHydro turbine, which was deployed in the Bay of Fundy on November 12, 2009, and to provide support services to the Project. As of September 2009, approximately 24 workers at Cherubini had been employed by the project since the award (Nova Scotia Power 2009).

Local marine service companies will be contracted to support Project deployment and maintenance activities, area university research, and scientific and engineering companies will support environmental monitoring studies, and local ports will be used to support Project activities. These services have been used during pre-installation activities, and additional services will be required during Project construction and post-deployment operations, maintenance, and monitoring efforts during the proposed 10-year pilot license term.

The District's dedication to this pioneer technology has helped Washington position itself in a leadership position for the development of this new industry, a potentially important pillar in the developing green economy. This Project has already helped develop engineering and research expertise specific to ocean energy. For example, the NNMREC is a DOE-funded partnership between the University of Washington and Oregon State University. The mission of NNMREC is to close key gaps in understanding of marine energy and to inform the public, regulators, research institutions, and device and site developers. In coordination with the District, NNMREC researchers at the University of Washington Applied Physics Lab have conducted analysis at Admiralty Inlet, including site characterizations, hydrodynamic modeling, evaluations of effects of power extraction, and the following marine biology studies:

- Telemetry study to monitor the movement of tagged fish,
- Acoustic Doppler current profiling,
- Water quality monitoring,
- Passive acoustic monitoring for odontocetes (killer whales and harbor porpoise),
- Ambient noise monitoring,
- Testing antifouling paints,
- ROV video investigations, and
- Seafloor grab samples.

The Project has thus provided research opportunities for professors and graduate students, and educational opportunities that will help develop the expertise needed for a next generation of renewable energy jobs.

If the development and operation of the proposed pilot Project demonstrates that tidal energy is an effective way of bringing clean, competitively priced electricity to commercial and residential consumers in Washington State and other coastal states, the state of Washington will be well situated to expand and benefit from the expertise gained from this Project. This expertise can than be leveraged in the development of new projects not only in the Puget Sound Region, but throughout the world. A benefit of hosting an early stage project, such as that proposed in this license application, is the potential to make Washington a center for tidal expertise and development.

In conclusion, the future use of the Project's power, its displacement of non-renewable fossil-fueled generation, and its contribution to a diversified generation mix will help meet a need for renewable power in the region and the the District service territory during the pilot license term. Economic stimulus will result from Project construction and post-deployment operations, maintenance, and monitoring efforts during the proposed 10-year pilot license term. Consequently, the development of the Project represents a positive socioeconomic effect.

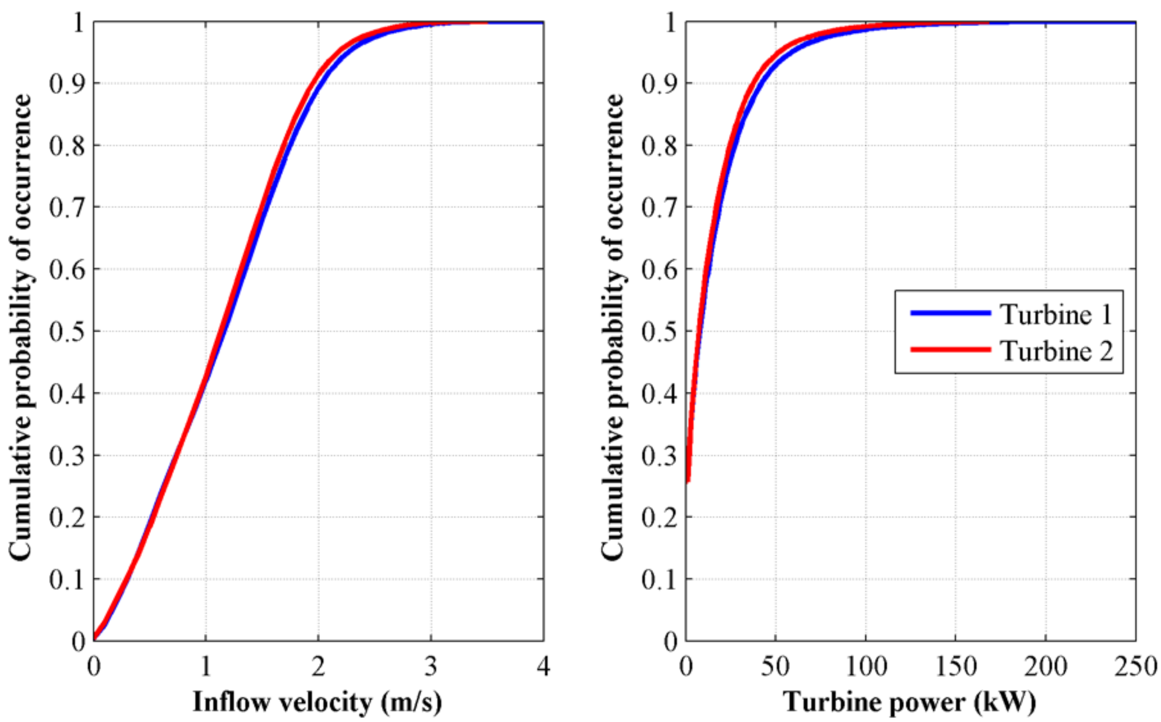
3.4 No-action Alternative

Under the no-action alternative, the proposed Project would not be built, and there would be no change in the existing environment. No renewable energy would be generated, and power that would have been generated from this renewable technology would instead continue to be provided from the existing generating resource mix. The Project would not be available to help the District and the State of Washington meet its renewable energy generation goal of 15 percent by 2020, nor would this Project provide information that might help facilitate the development of other hydrokinetic generating technologies in Washington and elsewhere. No economic benefits would accrue to the Puget Sound region.

4.1 Power and Economic Benefits of the Project

The Project will generate electrical power from two tidal energy turbines. The predicted peak power generated will be approximately 350 kW per turbine, for a total predicted peak capacity of 700 kW[31]. The average power output will be approximately 14 kW per turbine for an expected average annual generation of approximately 217 MWh. A histogram of the expected water velocity and power generation is presented in Figure 4-1. Because the tidal resource is driven by the gravitational interaction between the sun, moon, and earth's oceans, seasonal variations in operating time and power generation are limited (i.e., the dominant periodicity is over the fortnightly neap and spring cycle). Variations in the percentage of time the project will operate on a monthly basis are presented in Figure 4-2 on the basis of harmonic constituent predictions from Doppler profiler measurements.

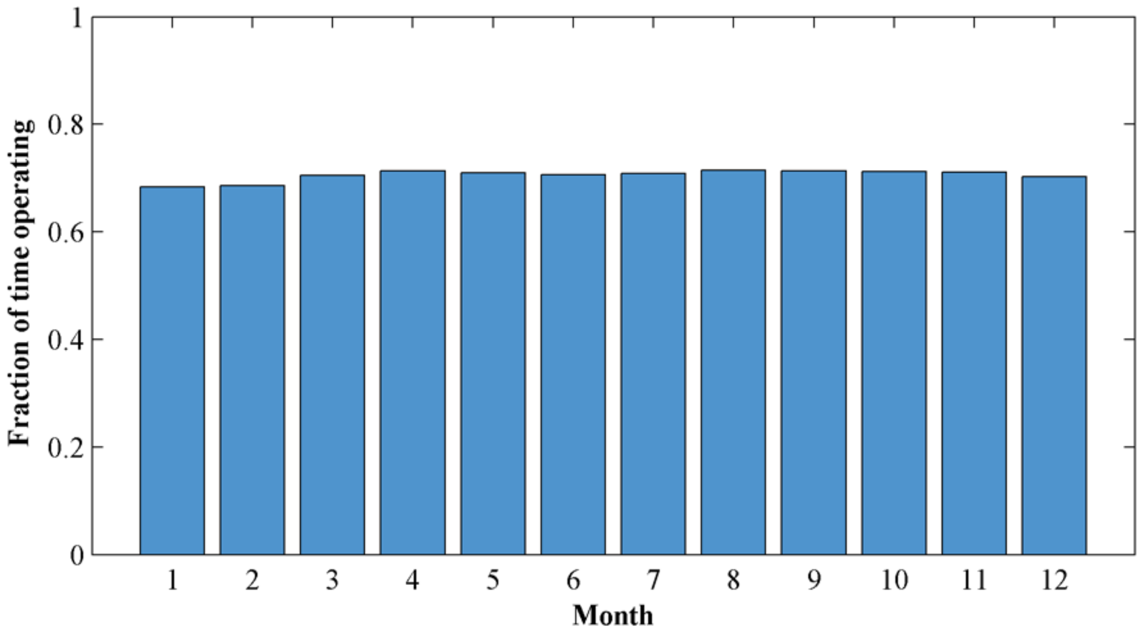
FIGURE 4-1
HISTOGRAM OF TURBINE OPERATING STATES



Source: Pers. comm. Brian Polagye, NNMREC, February, 2012.

[31] Peak power generation potential will be associated with turbulent "gusts" up to 30% higher than maximum velocities averaged over a 5 minute period. This power generation state will occur a *de minimus* portion of the time and sustained peak power generation is likely to be ~310 kW.

FIGURE 4-2
SEASONAL VARIATION IN PERCENTAGE OF TIME OPERATING



Source: Pers. comm. Brian Polagye, NNMREC, February, 2012.

The District intends to sell the power from the Project during the term of the pilot license to Puget Sound Energy.

As a public utility the District will not receive any benefit from federal production or investment tax credits, but may receive a financial benefit from the sale of renewable energy credits.

4.2 Comparison of Alternatives

Despite the economic downturn, Snohomish County continues to exhibit population growth. In 2010 the District received 3,100 requests for new electric service connections, and the growth is expected to continue. The District is planning to meet this growth through conservation and renewable, non-greenhouse-gas-emitting energy resources, including geothermal, biomass, tidal, wind and solar. The utility has created an Integrated Resource Plan (IRP), which provides a long-term strategy regarding future energy resources. It establishes an action plan that ensures enough resources are available, at a reasonable cost, to meet future energy loads. The IRP is a mechanism by which the District evaluates and compares potential energy resources. The IRP is updated every two years.

The District's current energy portfolio is comprised of approximately 85 percent traditional river hydropower, 8 percent wind, 5 percent landfill gas and biomass, with the remainder from third party contracts. While the District is pursuing the addition of small/low-impact hydropower to its portfolio, it is not anticipated that any additional large/traditional hydropower will be available to meet load growth needs. With approximately 8 percent wind, the District already has the highest penetration of wind energy on a percentage basis of any utility in the Northwest. Adding additional unpredictable wind resources is not currently desirable due to integration concerns. The District is also pursuing the exploration of geothermal energy in/near its service territory, however to date no geothermal electrical energy production has ever been brought on line in the state of Washington and there remains a lack of data to characterize the local geothermal resource. The marginal solar resource in western Washington coupled with the high current cost of solar technology limit the likely contribution of solar energy for the District's current planning horizon.

Because of the challenges and uncertainties associated with these other renewable resources, the District considers the responsible investigation of clean, predictable, local tidal energy to be important in planning for future energy resource needs.

4.3 Cost of Environmental Measures

The estimated cost for pre-installation environmental studies already completed, planned, or in progress is approximately $1.4 million. These studies include acoustic Doppler current profiling, tidal current modeling and far field effects analysis, underwater acoustics studies, water quality studies, aquatic species studies, marine mammal study, and oceanographic/bathymetrical/benthic studies. It should be noted that the $1.4 million estimate does not include the substantial value of the study efforts conducted for the Admiralty Project by NNMREC as part of the NNMREC's deliverables to the U.S. Department of Energy. It is estimated that this value totals an additional $350,000 for a total pre-installation study cost of approximately $1,750,000.

As part of this Project, the District proposes to undertake certain measures designed to gather environmental and operational data regarding the operation of the turbines. This information will be utilized to evaluate the Project and may result in modifications to the Project's operations including, in unusual circumstances, ceasing operation. Due to the pilot nature of the Project, most of the proposed monitoring plans are the first application of the technology in this fashion. Thus, providing precise estimates for individual monitoring plans is extremely difficult. However, the District estimates that the total cost to acquire, install, operate, and maintain the equipment required for the proposed monitoring plans, and conduct the activities described in the proposed monitoring plans, over a period of five years will total approximately $6.5 million.

The District is also committing to remove the Project and restore the site before the end of the pilot project license unless a standard license is granted. The proposed Financial Assurance Plan in Appendix I demonstrates that the District has the motivation and financial resources to complete any removal and restoration efforts that may be required.

Section 5

Conclusions and Recommendations

5.1 Comparison of Alternatives

As discussed in Section 2.1 and 3.4, if the Admiralty Inlet Pilot Tidal Project is not developed (No-Action alternative), the minor environmental effects associated with construction and operation of the proposed demonstration Project would not occur. Electrical generation from the hydrokinetic resources of Puget Sound would not occur, and the power that would have been generated from this renewable technology would instead continue to be provided to residents and businesses in western Washington from the existing generating resource mix. The Project would not be available to help the State of Washington meet its renewable energy generation goal of 15 percent new renewables by 2020, nor would this Project provide information that might help facilitate the development of other hydrokinetic generating technologies in Washington and elsewhere. Project-related economic benefits to the Puget Sound region would not accrue.

5.2 Comprehensive Development and Recommended Alternative

Sections 4(e) and 10(a)(1) of the FPA require the Commission to give equal consideration to the power development purposes and to the purposes of energy conservation, the protection, mitigation of damage to, and enhancement of fish and wildlife, the protection of recreational opportunities, and the preservation of other aspects of environmental quality. Any license issued shall be such as in the Commission's judgment will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for all beneficial public uses. This section contains the basis for, and a summary of, our recommendations for licensing the Admiralty Inlet Pilot Tidal Project.

The District's tidal energy efforts represent one of the primary tidal energy research efforts in the United States, continue to have the strong support of the U.S. Department of Energy's Advanced Water Power Projects program, and are consistent with national energy policy priorities. On December 10, 2009, in an address to the United Nations Conference on Climate Change in Copenhagen, Secretary of the Interior Ken Salazar stated the following:

> *I am here today in Copenhagen on behalf of President Obama to deliver a simple message: the United States of America understands the danger that climate change poses to our world and we are committed to confronting it. Together with our partners in the international community, we will help build a strong, achievable, carbon reduction strategy. And we will deploy American technology, American vision, and American ingenuity for the benefit of our planet and all peoples. …We must manage our lands and oceans for these three new functions - renewable energy production, carbon capture and storage, and climate adaptation - if we are to tackle the climate crisis. …On renewable energy: the truth is - until now - America's vast deserts, plains, forests and oceans have been largely unexplored for their vast clean energy potential.*

The Admiralty Inlet Pilot Tidal Project represents such an application of technology, vision, and ingenuity, here in the United States, to produce renewable energy from the country's oceans. Projects such as the Admiralty Inlet Pilot Tidal Project represent the early steps in exploring ways to harness tidal energy, and given the pressing need to develop new renewable energy sources, in Washington State and in the U.S., to reduce greenhouse gas emissions, rely less on foreign fuel sources, and to meet growing energy demands, the District urges the Commission to select the District's proposed alternative.

With a capacity of approximately 700 kW, the Admiralty Inlet Project would provide approximately 216,000 kWh annually of clean renewable ocean energy. The successful development of the Admiralty Inlet Project would demonstrate the potential of an emergent renewable energy industry segment with the goal of bringing clean, competitively priced electricity to commercial and residential consumers in Washington State and other coastal U.S. states. From the future use of the Project's power, its displacement of non-renewable fossil-fueled generation and its contribution to a diversified generation mix, the Project will help meet a need for renewable, emission free, and environmentally responsible energy in the Puget Sound region.

OpenHydro has worked closely with several key partners in delivering projects using OpenHydro tidal turbines through the permitting processes and to date has achieved permits for projects in the United Kingdom, the Channel Islands, and in Canada. These permitted projects have included the assessment of the possible environmental effects of the OpenHydro Turbine and have led to a number of pre-construction environmental studies, environmental impact assessments, real time monitoring, and other post construction surveys of the operating OpenHydro turbine deployed at the EMEC test facility in Scotland. From environmental monitoring of the surface-piercing OpenHydro turbine at EMEC, no occurrences have been recorded indicating any harm has been caused to marine life, and the levels of underwater noise, seabed recovery, and marine animal interaction with the piled test structure have been shown to be well within acceptable environmental limits. The non-operational OpenHydro subsea unit, also deployed at EMEC, has caused no effect to the navigational traffic and the level of seabed impact has been shown to be negligible[32].

The OpenHydro turbine is designed to be as environmentally benign as possible, having only one moving part, requiring no oils, grease, or lubricants, and causing no visual impact. Deployment is targeted at locations where water depths are such that the devices will cause no interference to marine navigation.

The District proposes to construct and operate the Project as proposed in this document and to implement the following environmental measures:

- Use HDD to deploy subsea trunk cable from on land to a depth of 19 meters to avoid impacts to eelgrass or near-shore sensitive areas, and deploy terrestrial transmission underground to grid connection;

- Minimize potential terrestrial and cultural effects by siting the terrestrial component of the Project so as to connect to the grid at a location that is close to shore and has been previously developed;

[32] A dummy subsea turbine was deployed to test OpenHydro's installation strategy using an installation barge.

- Minimize effects to shipping by siting the Project outside of the shipping channel and sufficient depths to allow for acceptable navigational clearances even for deep draft shipping vessels;
- Minimize use of antifouling paint - only the turbine blades and rotor outer ring will be coated with antifouling paint (non-flaking paint to be used);
- Conduct installation work only during WDFW-approved work windows;
- Implement near-turbine monitoring and identification of aquatic species (see Appendix A);
- Implement acoustic monitoring of turbine operational noise and to detect toothed whales in the Project vicinity (see Appendix A);
- Implement marine mammal monitoring during Project construction, operation, and removal(see Appendix A);
- Utilize Doppler profilers and Doppler velocimeters to monitor tidal currents at the project site. Doppler frequencies will be at least 450 kHz;
- Implement benthic habitat monitoring (see Appendix B);
- Monitor for derelict gear and remove as necessary (see Appendix C);
- Conduct water quality monitoring as necessary (see Appendix D);
- Implement a Project Safety Plan (part of the Project Safeguard Plans, see Appendix E);
- Implement a Navigation Safety Plan (part of the Project Safeguard Plans, see Appendix E);
- Implement an Emergency Shutdown Plan, if needed (part of the Project Safeguard Plans, see Appendix E);
- Implement a Project Removal Plan, if needed (part of the Project Safeguard Plans, see Appendix E); and
- Implement an adaptive management process to modify project and project operations, as necessary, based on monitoring results.

As outlined in this document and summarized in Table 5-1, constructing and operating the Project, with the proposed measures, would result in minor, highly localized effects to benthic habitat and biota; minor, local disturbance to marine organisms; negligible effects to terrestrial soils, navigation, fishing, and other uses of this part of Admiralty Inlet; minor positive effects to the local/regional economy; and negligible effects to terrestrial, cultural, and aesthetic resources.

The District's purpose in developing the Admiralty Inlet Pilot Tidal Project is to explore the feasibility of tidal energy generation. The District is striving to offset the impacts of the intense developmental pressure in the Puget Sound region, specifically by providing a renewable source of energy to meet the growing energy demand. A strong case can be made that the accelerated development of renewable energy projects in Washington State and in the U.S. will result in decreased emissions of greenhouse gases and, consequently, in environmental benefits to marine resources in Puget Sound. In addition, economic stimulus will result from Project construction and post-deployment operations, maintenance, and monitoring efforts during the proposed 10-year pilot license term.

TABLE 5-1
ADMIRALTY INLET PILOT TIDAL PROJECT SUMMARY OF POTENTIAL ENVIRONMENTAL EFFECTS

Section	Issue	Potential Effect	Response
Geology and Soils	Benthic disturbance from placement of turbines and deployment of subsea cable. Terrestrial disturbance of soils.	Minor effect to benthic habitat from placement of turbines and deployment of subsea cable. Negligible effect to terrestrial soils from installation of the multi-purpose vault and presence of construction vehicles and HDD process.	Turbine foundation design and deployment methods will minimize benthic disturbance (e.g., no pilings). Subsea cable deployed underground using HDD from on land to a minimum depth of 18 meters will minimize benthic disturbance.
Marine Resources	Changes to hydrodynamics	The turbines will remove energy from the water as it flows past the rotor. Negligible effect.	Modeling has shown that far-field effects would be immeasurably small and detectable effects would only occur in the immediate vicinity of the turbines. Project operation is not expected to represent a significant effect to either the tidal flow in the Project area (near- or far-field) or the marine environment.
	Effects to water quality	Potential effects of the Project on water quality include (1) spills during construction, operation, and maintenance; (2) fluid leakage from Project components; and (3) leachate from antifouling paint. Effects expected to be negligible.	The District proposes to minimize Project effects to water quality by: (1) requiring that all contractors have spill response plans and their own insurance; (2) avoiding use of fluids and oils - no oil- or fluid-filled electrical components will be located underwater; and (3) minimizing use of antifouling paint - only the turbine blades and outer rotor ring each unit will require antifouling paint. The short time required for deployment also minimizes potential effects to water quality.
	Blade strike	Potential for marine mammals and fish to be struck by turbine blades during operation. Effects expected to be negligible; to be confirmed by monitoring.	• The response of fish and marine mammals to the presence of the turbines may be avoidance, attraction, or injury/mortality if the animal comes in contact with the rotating turbine. The likelihood of harm to individuals or populations is low because of the following: • The small Project size relative to the cross sectional volume of Admiralty Inlet at the deployment site (0.05 percent). • Within the context of the many human uses of Admiralty Inlet, the pilot Project represents a *de minimis* footprint on the margins of the inlet, will rotate only 70 percent of the time, and is not expected represent a risk to marine life currently passing through Admiralty Inlet. • No evidence of injury or mortality of marine life from almost four years of monitoring the EMEC OpenHydro turbine. • 100 percent survival and no injury of Atlantic salmon and no evidence of strike injuries of American shad in the EPRI (2010) flume entrainment study. • 99 percent survival of a variety of species and size fish in the Hydro Green Energy entrainment study (Normandeau 2009). • The majority of water flows around, not through, the turbine blades (Wilson et al. 2007, CREST Energy Limited 2006). • Turbine design characteristics that minimize risk of blade strike: • Low rpm/rotor speed, • Closed shroud (enclosed blade tips), and • Open rotor center. • The inherent ability of fish to avoid colliding with larger underwater features (AECOM 2009, Bouffanais et al. 2011, Liao 2007, Coutant and Whitney 2000). • The important safeguards have been developed to ensure that, in the event the near-turbine monitoring of the pilot Project show that unexpected adverse effects to marine life are occurring from blade strike, the turbines can be immediately shut down to cease turbine rotation.
	Habitat alteration - construction impacts	Potential impacts to the benthic community from construction and placement of Project components on the seabed. Effects expected to be negligible.	Due to the relatively small size of the Project, the District does not believe the deployment of the Project represents a significant impact on benthic organisms. Any effects to benthic marine life and habitat should be small and temporary. The presence of the gravity-based foundations may slightly reduce available bottom habitat and temporarily displace proximal habitat usage during installation. Subsea cable installation will avoid affecting the near-shore habitats by HDD installation.
	Habitat alteration - changes to marine community composition	In-water Project components may provide areas of shelter, structure, or cover - habitat typically colonized by biofouling organisms and habitat sought by fish for protection from predators. Effects expected to be minor.	The District believes that the scale of the proposed Project is too small to have any measureable effect on species from introduction of habitat and that an effect to populations of affected species is unlikely. The monitoring studies allow for characterization of use of the area by marine life during the term of the Project license.
	Marine debris entanglement	Derelict fishing gear may snag on turbine structures and pose an entanglement risk to marine life in the vicinity of the Project. Effects expected to be negligible.	The District will periodically inspect the turbines as part of the Safeguard Plan, and in addition, will be able to view much of the turbine and gravity base structure from the video cameras installed on one of the turbines as part of the Near-Turbine Monitoring Plan. If the District observes derelict fishing gear snagged on the Project works, the District will remove the gear.
	Noise/vibration	Minor impacts to marine mammals and fish during construction, operation, and maintenance.	Underwater noise from construction will be minor and temporary - no pile driving will occur. The District expects the noise levels produced by the turbines to be above ambient noise conditions, and that Project operations will not create noise at levels that will negatively affect marine life in the Project area (Admiralty Inlet, serving as a main route for all Puget Sound shipping traffic, is already a noisy environment). To accurately assess the operational noise, the District will implement the post-installation underwater noise plan, and will evaluate the results within the adaptive management framework being established for the Project.
	EMF	Expect negligible impacts to marine life from Project generated EMF.	The proposed subsea cable will be shielded and grounded to prevent E-field emissions. The Project is small and any electromagnetic fields emitted by the subsea cable (B and iE fields) are expected to be extremely localized and minor, and similar to the numerous subsea cables that have been deployed in marine waters in the U.S. and throughout the world. The lack of negative effects is supported by many reports, which indicate that while electro-sensitive species may be able to detect the EMF generated by subsea cables, the effects of the EMF on these species does not appear to be significant.

Section	Issue	Potential Effect	Response
Terrestrial Resources	Habitat alteration	Potential effect to habitat - negligible.	Other than temporary and short term effects of construction and presence of equipment and the purpose-built vault, all terrestrial Project components will be deployed underground, with the exception of the control room. Consequently, there will be negligible effects to terrestrial wildlife and vegetation.
Threatened and Endangered Species	See Marine Resources above and draft BA (Appendix G)	See Marine Resources above and draft BA (Appendix G)	See Marine Resources above and draft BA (Appendix G)
Recreation, Ocean Use, and Land Use	Navigation	Potential to inhibit navigation - negligible.	The turbines will be deployed outside of the shipping channel and at sufficient depths to allow for acceptable navigational clearances, even for deep draft vessels that pass through Admiralty Inlet. The short time required for Project installation (less than 6 hours to deploy each turbine) will minimize disruption of existing marine use of the area.
	Project Regulated Navigation Area.	Fishing and anchoring restricted in Project area around turbines and subsea cable - negligible.	Because of the low level of commercial fishing in Admiralty Inlet and the small footprint of the Project, the District does not expect that the Project presence will negatively affect commercial fishing activity. The USCG currently discourages vessels from anchoring in Admiralty Inlet. The District will coordinate with the USCG to mark the immediate area around the two turbines on future navigation charts.
Cultural Resources	Potential for Project construction to disrupt cultural resources	Negligible effect.	During the marine geophysical studies of the Project area, no magnetic anomalies (often associated with historical resources) or objects were detected in the Project area. The District has selected a tidal power technology and deployment methodology that will have minimal effect to the marine environment, and use of HDD for Project cable deployment will avoid disruption of nearshore and terrestrial areas. A cultural resources assessment of the project area was conducted and the District believes the project will have no adverse effects on cultural resources. The District is consulting with DAHP to request concurrence with this determination.
Aesthetic Resources	Potential for negative effects to aesthetics of the area	Negligible effect.	Other than the construction and presence of the purpose-built vault, all Project components will be either underwater or underground, and consequently not visible, with the exception of the control room. Operation of the Project will therefore not affect aesthetics of the area, either for marine or terrestrial components of the Project.
Socioeconomic Resources	Potential for positive effect to local/regional economy	Minor positive effect.	The future use of the Project's power, its displacement of non-renewable fossil-fueled generation, and its contribution to a diversified generation mix will help meet a need for power in the region and the the District service territory during the pilot license term. Economic stimulus will result from Project construction and post-deployment operations, maintenance, and monitoring efforts during the proposed 10-year pilot license term. Consequently, the development of the Project represents a positive socioeconomic effect.

To enhance these environmental measures, the proposed action includes an adaptive management process that the parties will use to oversee and evaluate results of pre-installation and monitoring studies. These results would be used in combination with an understanding of the ecosystem and information from other relevant sources to make adjustments to study methods as appropriate and to manage or change aspects of the Project operation, as necessary, to avoid or minimize unexpected or undesirable impacts on resources. The adaptive management process allows for immediate action where necessary to address a critical adverse effect of the Project, should that occur.

5.3 Unavoidable Adverse Effects

The Project will result in some level of localized substrate disturbance and soil displacement from construction of offshore and onshore Project components. The District will implement best management practices for erosion and sediment control during Project construction and restore terrestrial components of the Project to pre-construction conditions. The District believes that with the implementation of these measures and the installation practices of the gravity foundations, HDD, and placing terrestrial transmission underground, all of which serves to minimize potential environmental effects, the Project will have no significant adverse impacts to the benthic and terrestrial geologic environment.

The anti-fouling paint used on the turbine blades and rotor outer ring will leach slowly. Only a small portion of the turbine will be painted, and because of the small portion of the water column cross section occupied by the turbines (approximately 0.05 percent), the small amount of leachate, and the volume of water passing through Admiralty Inlet, the leachate will be dispersed and represent negligible effects to the marine community.

Deployment of the Project turbines and transmission cable will cause a minor disturbance to the seabed habitat and benthic organisms. During construction, slow-moving benthic organisms may be covered, disturbed, injured, or killed by the placement of Project components on the seabed, while more mobile organisms will likely avoid the immediate area. Construction disturbance will be short-term and represent only a temporary disturbance, and habitat around the turbines and along the transmission cable will be recolonized by benthic organisms.

The District expects that noise and vibrations from deployment operations (barge and tug activities) will likely result in a minor disturbance to fish, marine mammals, and other marine organisms. These effects will be temporary and short term, potentially resulting in avoidance of the area.

As discussed above, the District expects that the potential for marine life being injured or killed by turbine strike is minimal and any effect to populations is unlikely for a number of reasons: the majority of water flows around, not through, the turbine blades; the turbine design characteristics minimize risk of blade strike; the small Project size relative to the cross-sectional volume of Admiralty Inlet; the small scale of the Project relative to the heavy shipping and other industrial uses of Admiralty Inlet; and the inherent ability of fish and marine mammals to avoid colliding with larger underwater features. However, if a fish or marine mammal swims into a spinning turbine, injury or death could result. The District's proposed near-turbine monitoring study will allow for evaluation of how marine life behave near the Project turbines and will allow for characterization of the risk of blade strike. In the event that the District discovers that the pilot Project is causing adverse effects to marine life from blade strike, the turbines can be immediately shut down to cease rotor rotation.

The District expects that the changes to the local habitat associated with the deployment of the OpenHydro turbines may attract fish. While artificial structures may enhance local fisheries, concern has also been raised that artificial habitat may not serve as well as natural habitats. If fish are attracted to the turbine structure, especially in numbers similar to that seen at the OpenHydro project at EMEC in Scotland during slack tide, it can be expected that predators, such as marine mammals may consequently be attracted to the turbine structure to feed. As indicated by the EMEC analysis, it appears that fish leave the turbine area as the tidal velocity increases and the turbine starts turning; this would suggest little risk to fish or marine mammals if they are not present when the turbine is rotating. The District believes that the scale of the proposed Project is too small to have any measureable effect on species by introduction of habitat and that an effect to populations of affected species is unlikely. The proposed Near-Turbine Monitoring Plan will allow evaluation of Project effects on distribution and abundance of key species, and determination of whether adverse impacts result from the Project.

The Project works could snag marine debris, such as derelict fishing gear, which in turn could entangle passing marine life. The District has proposed methods for the monitoring of, and if found, the removal of derelict gear.

The area associated with the turbines and subsea cable will no longer be available for use for recreational or commercial fishing. Because the affected area is very small, and there is relatively little fishing that currently occurs in the area, the effect is not expected to be significant.

5.4 Recommendations of Fish and Wildlife Agencies

If Section 10(j) recommendations are submitted, then pursuant to the FPA, FERC will be required to make a determination that the recommendations of the federal and state fish and wildlife agencies are consistent with the purpose and requirements of Part I of the FPA and applicable law. Section 10(j) of the FPA states that whenever FERC believes that a fish and wildlife agency recommendation may be inconsistent with the purposes and requirements of the FPA or other applicable law, FERC and the agency shall attempt to resolve any such inconsistency, giving due weight to recommendations, expertise, and statutory responsibilities of such agency.

5.5 Consistency with Comprehensive Plans

The licensee has reviewed Federal and Washington State comprehensive plans considered by FERC under Section 10(a)(2)(A) of the FPA, 16 U.S.C. § 803 (a)(2)(A). Those plans considered geographically relevant to the District's permit areas are listed below; plans located during the District's PAD information gathering efforts or provided by interested parties are listed as well. The District believes the responsible development of a pilot TISEC installation is not inconsistent with the goals outlined in any of these documents.

Federal Plans

National Marine Fisheries Service, Seattle, Washington; Pacific Fishery Management Council, Portland, Oregon. 1978. Final environmental impact statement and fishery management plan for commercial and recreational salmon fisheries off the coasts of Washington, Oregon and California commencing in 1978. Department of Commerce. March 1978. 157 pp.

Pacific Fishery Management Council. 1988. Eighth amendment to the fishery management plan for commercial and recreational salmon fisheries off the costs of Washington, Oregon, and California commencing in 1978. Portland, Oregon. January 1988.

U.S. Fish and Wildlife Service. Undated. Fisheries USA: the recreational fisheries policy of the U.S. Fish and Wildlife Service. Washington, D.C.

Washington State and Local Plans

Hood Canal salmon management plan. Seattle, Washington. October 1985.

Interagency Committee for Outdoor Recreation. 1991. Washington State trails plan: policy and action document. Tumwater, Washington. June 1991.

Interagency Committee for Outdoor Recreation. 1995. State of Washington outdoor recreation and habitat: Assessment and policy plan 1995-2001. Tumwater, Washington. November 1995.

Interagency Committee for Outdoor Recreation. 1995. Voices of Washington. Olympia, Washington. November 1995. 20 pp.

Interagency Committee for Outdoor Recreation. 2002. An assessment of outdoor recreation in Washington State. A State Comprehensive Outdoor Recreation Planning (SCORP) Document 2002-2007. Olympia, Washington. October 2002.

Island County Comprehensive Plan. 1998. Growth Management Act Comprehensive Plan. Adopted September 28, 1998.

National Marine Fisheries Service, Seattle, Washington; Pacific Fishery Management Council, Portland, Oregon. 1978. Final environmental impact statement and fishery management plan for commercial and recreational salmon fisheries off the coasts of Washington, Oregon and California commencing in 1978. Department of Commerce. March 1978. 157 pp.

Pacific Fishery Management Council. 1988. Eighth amendment to the fishery management plan for commercial and recreational salmon fisheries off the costs of Washington, Oregon, and California commencing in 1978. Portland, Oregon. January 1988.

State of Washington, State of Oregon, State of Idaho, Confederated Tribes of the Warm Springs Reservation of Oregon, Confederated Tribes of the Umatilla Indian Reservation, Nez

Perce Tribe, and Confederated Tribes and Bands of the Yakima Indian Nation. 1987. Settlement Agreement pursuant to the September 1, 1983, Order of the U.S. District Court for the District of Oregon in Case No. 68-513. Columbia River fish management plan. Portland, Oregon. November 1987.

Washington State Department of Community Development, Office of Archaeology and Historic Preservation. 1987. Resource protection planning process -- southern Puget Sound study unit. Olympia, Washington. 62 pp.

Washington State Department of Community Development, Office of Archaeology and Historic Preservation. 1989. Resource protection planning process -- study unit transportation. 45 pp. and appendices.

Washington State Department of Ecology. 1994. State wetlands integration strategy. Olympia, Washington. December 1994. 80 pp. and appendices.

Washington State Department of Fish and Wildlife, Puyallup Indian Tribe, and Muckleshoot Indian Tribe. 1996. Recovery Plan for White River Spring Chinook Salmon. Olympia, Washington. 81 pp. July.

Washington State Department of Fisheries, Point No Point Treaty Council, and U.S. Fish and Wildlife Service. 1986. Settlement agreement pursuant to the July 2, 1986, Order of the U.S. District Court for the Western District of Washington in Case No. 9213.

Washington State Department of Fisheries. 1987. Comprehensive resource production and management plan -- White River Spring Chinook. Olympia, Washington.

Washington State Department of Fisheries. 1988. Comprehensive resource production and management plan -- Green River Summer/Fall Chinook interim plan. Olympia, Washington. 15 pp.

Washington State Department of Fisheries. 1988. Comprehensive resource production and management plan -- Nooksack-Samish goals/objectives. Olympia, Washington. 5 pp.

Washington State Department of Fisheries. 1988. Comprehensive resource production and management plan -- South Sound goals/objectives. Olympia, Washington.

Washington State Department of Fisheries. 1988. Comprehensive resource production and management plan -- Nooksack River Spring Chinook plan. Olympia, Washington. 16 pp.

Washington State Department of Game. 1987. Strategies for Washington's wildlife. Olympia, Washington. May 1987.

Washington State Department of Natural Resources. 1987. State of Washington natural heritage plan. Olympia, Washington. 108 pp. and appendices.

Washington State Department of Natural Resources. 1997. Final habitat conservation plan. Olympia, Washington. September 1997.

Washington State Department of Wildlife. Point No Point Treaty Council. 1987. 1987-88 winter and summer Steelhead forecasts and management recommendations. Olympia, Washington. December 1987. 19 pp. and appendices.

Washington State Recreation and Conservation Office. 2008. Defining and Measuring Success: The Role of State Government in Outdoor Recreation. A State Comprehensive Outdoor Recreation Planning Document (SCORP). June 2008.

Section 6

Finding of No Significant Impact

Constructing and operating the Admiralty Inlet Pilot Tidal Project would result in minor, highly localized effects to benthic habitat and biota; minor, local disturbance to marine organisms; negligible effects to terrestrial soils, navigation, fishing, and other uses of this part of Admiralty Inlet; minor, positive effects to the local/regional economy; and negligible effects to terrestrial, cultural, and aesthetic resources. The District's proposed marine resource monitoring and assessment activities will allow for monitoring potential effects to marine resources of concern. To enhance these proposed environmental measures, the proposed action includes an adaptive management process that the parties will use to oversee and evaluate results of pre-installation and monitoring studies. These results would be used in combination with an understanding of the ecosystem and information from other relevant sources to make adjustments to study methods as appropriate and to manage or change aspects of the Project operation, as necessary, to avoid or minimize unexpected or undesirable impacts on resources. The adaptive management process allows for immediate action where necessary to address a critical adverse effect of the Project, should that occur.

On the basis of our analysis, we conclude that issuance of a Pilot License for the Project, as proposed by the District, would not constitute a major federal action significantly affecting the quality of the human or natural environment.

Section 7
Literature Cited

Abernethy C.S., B.G. Amidan, G.F. Cada. 2003. Fish passage through a simulated horizontal bulb turbine pressure regime: A supplement to "Laboratory studies of the effects of pressure and dissolved gas supersaturation on turbine-passed fish." U.S. Department of Energy. PNNL-13470-B.

AECOM. 2009. Environmental Assessment Registration Document -Fundy Tidal Energy Demonstration Project Volume I: Environmental Assessment. Project Number 107405. June 2009.

AMEC. 2012. Cultural Resources Assessment of the Pilot Tidal Energy Project, Island County, Washington. AMEC Environment & Infrastructure Short Report No. 31. Survey date January 5, 2012. February 22, 2012.

Airamé, S., S. Gaines, and C. Caldow. 2003. Ecological linkages: Marine and estuarine ecosystems of central and northern California. National Oceanic and Atmospheric Administration (NOAA), National Ocean Service. Silver Spring, Maryland. Available online at: ccma.nos.noaa.gov/products/biogeography/canms_cd/data/pdfs/ELR.pdf.

Akamatsu, T., D. Wang, K. Wang, Y. Naito. 2005. Biosonar behavior of free-ranging porpoises. Proc. R. Soc. B 2005 272, 797-801. April 22, 2005. Angliss, R.P. and Outlaw, R.B. 2006. Steller Sea Lion (*Eumetopias jubatus*): Eastern U. S. Stock Assessment Report. NOAA-TM-AFSC-168.

Amaral S., N. Perkins, G. Hecker, D. Dixon, P. Jacobson. 2010. Development of theoretical models for estimating hydrokinetic turbine strike probability and survival. Symposium on Hydrokinetic Electricity Generation and Fish: Asking the Right Questions, Getting Useful Answers. Pittsburgh (PA): Annual Meeting of the American Fisheries Society.

American Association of Port Authorities. 2006. North American Port Container Traffic - 2006. Online: http://aapa.files.cms-plus.com/PDFs/2006_North_American_Container_Traffic.pdf. Accessed January 2008.

Au, W., W.L., Kastelein, R.A., Rippe, T. & Schooneman, N.M. 1999. Transmission beam pattern and echolocation signals of a harbor porpoise (*Phocoena phocoena*). Journal of the Acoustical Society of America. 106 (6), 3699-3705. *Cited in* Tollit, Philpott, and Thomson 2009.

Barlow, J. 1988. Harbor porpoise, *Phocoena phocoena*, abundance estimation for California, Oregon, and Washington: I. Ship Surveys. Fishery Bulletin 86:417-432.

Bassett, C. 2010. Underwater Ambient Noise at a Proposed Tidal Energy Site in Puget Sound, Masters thesis, University of Washington.

Bassett, C.S., J. Thomson, and B. Polagye. 2010. Characteristics of underwater ambient noise at a proposed tidal energy site in Puget Sound, *MTS/IEEE Oceans 2010*, Seattle, WA, September 20-23, 2010.

Bassett, C.S., Polagye, B., Holt, M., and Thomson, J.M. 2012. A vessel noise budget for Admiralty Inlet, Puget Sound, WA (USA), To be submitted to the *J. Acoust. Soc. Am.*.

Bassett, C.S., J.M Thomson, and B. Polagye. 2012. Shifting gravel and cobbles as a source of ambient noise, In preparation for submission to *J. Ocean. Eng.*

Bassett, H. R., Baumann, S., Campbell, G. S., Wiggins, S.M. & Hildebrand, J. A. 2009. Dall's porpoise (*Phocoenoides dalli*) echolocation click spectral structure. Journal of the Acoustical Society of America. 125 (4), 2677. *Cited in* Tollit, Philpott, and Thomson 2009.

Bauer, G.B. 1986. The behaviour of humpback whales in Hawaii and modification of behaviour induced by human intervention. Unpublished doctoral dissertation, University of Hawaii. *Cited in* LGL and JASCO Research 2005.

Bauer, G.B. and L.M. Herman. 1986. Effects of vessel traffic on the behavior of humpback whales in Hawaii. Report from Kewalo Basin Marine Mammal Laboratory, University of Hawai'i, Honolulu, for the U.S. National Marine Fisheries Service, Honolulu, HI, 151 pp. *Cited in* LGL and JASCO Research 2005.

Beach, D. and M. T. Weinrich. 1989. Watching the Whales. Oceanus 32(1). *Cited in* LGL and JASCO Research 2005.

Bishaw, Alemayehu and John Iceland. 2003. Poverty 1999: Census 2000 Brief. Available online at: www.census.gov/prod/2003pubs/c2kbr-19.pdf. Accessed January 24, 2008.

Blaxter, J.H.S., and D.E. Hoss. 1979. The effect of rapid changes of hydrostatic pressure on the Atlantic herring *Clupea harengus* L. II. The response of the auditory bulla system in larvae and juveniles. J. Exp. Mar. Biol. Ecol. 41:87-100.

Boehlert, G.W., G.R. McMurray, and C.E. Tortorici (Eds.). 2008. Ecological Effects of Wave Energy Development in the Pacific Northwest. U.S. Dept. of Commerce, NOAA Technical memorandum NMFS-F/SPO-92. 174 p.

Booth. D. B. and B. Goldstein. 1994. Patterns and processes of landscape development by the Puget lobe ice sheet: Washington Division of Geology and Earth Resources, Bulletin 80, pp. 207-218.

Bouffanais R., G.D. Weymouth, D.K.P. Yue. 2011. Hydrodynamic object recognition using pressure sensing. Proceedings of the Royal Society (A) 467:19-38.

Bourgeois, Joanne, and Samuel Y. Johnson. 2001. Geologic evidence of earthquakes at the Snohomish delta, Washington, in the past 1,200 years. Geological Society of America. GSA Bulletin Vol. 113, pp. 482-494. Available online at:

earthquake.usgs.gov/regional/pacnw/paleo/Snohom_gsa/index.php. Accessed November 2007.

Brewer, Scott, Jay Watson, Dave Christensen, and Richard Brocksmith. 2005. Hood Canal & Eastern Strait of Juan de Fuca: Summer Chum Salmon Recovery Plan. Hood Canal Coordinating Council. November 15, 2005.

Buckley, R. 1982. Marine habitat enhancement and urban recreational fishing in Washington. Marine Fisheries Review. June-July 1982. 44 (6-7).

Burgner, R.L. 1991. Life history of sockeye salmon. *In*: C. Groot and L. Margolis Eds. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver, B.C., pp. 3-117.

Cada G.F., L.A. Garrison, R.K. Fisher, Jr. 2007. Determining the effect of shear stress on fish mortality during turbine passage. Hydro Review 26(7):52-59.

Cada, G. 2008. The Potential Environmental Impacts of Marine and Hydrokinetic Renewable Energy Technologies. USDOE Report to Congress, Public Review Draft. 123 p. Caldwell, D.W. 1998. Roadside Geology of Maine. Mountain Press Publishing Company. Missoula, Montana.

Calambokidis, John, James Darling, Volker Deecke, Patrick Gearin, Merrill Gosho, William Megill, Christina M. Tomback, Dawn Goley, Caitlyn Torpova, and Brian Gisborne. 2002. Abundance, range and movements of a feeding aggregation of gray whales (*Eschrichtius rob*ustus) from California to southeastern Alaska in 1998. J. Cetacean Res. Manage. 4(3):267-276, 2002.

Calambokidis, John, Robin Baird. 1994. Status of marine mammals in the Strait of Georgia, Puget Sound and the Juan de Fucca Strait and Potential human impacts. Symposium on the Marine Environment. January 13 and 14, 1994.

Carlson, T., J. Elster, M. Jones, B. Watson, A. Copping, M. Watkins, R. Jepsen, and K. Metzinger (2012) Assessment of Strike of Adult Killer Whales by an OpenHydro Tidal Turbine Blade, Pacific Northwest National Laboratory technical report, PNNL-21177 (prepared for U.S. Department of Energy), February, 2012.

Carretta, James V., Karin A. Forney, Mark S. Lowry, Jay Barlow, Jason Baker, Dave Johnston, Brad Hanson, Marcia M. Muto, Deanna Lynch, and Lilian Carswell. 2008*a*. NOAA Technical Memorandum NMFS, U.S. Pacific Marine Mammal Stock Assessments: 2008. Dall's Porpoise (*Phocoenoides dalli*): California/Oregon/Washington Stock. Revised: December 15, 2008.

Carretta, James V., Karin A. Forney, Mark S. Lowry, Jay Barlow, Jason Baker, Dave Johnston, Brad Hanson, Marcia M. Muto, Deanna Lynch, and Lilian Carswell. 2008*b*. NOAA Technical Memorandum NMFS, U.S. Pacific Marine Mammal Stock Assessments: 2008. Minke Whale (*Balaenoptera acutorostrata*): California/Oregon/Washington Stock. Revised: December 15, 2008.

Carretta, James V., Karin A. Forney, Mark S. Lowry, Jay Barlow, Jason Baker, Dave Johnston, Brad Hanson, Marcia M. Muto, Deanna Lynch, and Lilian Carswell. 2007. NOAA Technical Memorandum NMFS, U.S. Pacific Marine Mammal Stock Assessments: 2008. California Sea Lion (*Zalophus californianus californianus*): U.S. Stock. Revised October 30, 2007.

Carretta, James V., Karin A. Forney, Mark S. Lowry, Jay Barlow, Jason Baker, Dave Johnston, Brad Hanson, Marcia M. Muto, Deanna Lynch, and Lilian Carswell. 2006. NOAA Technical Memorandum NMFS, U.S. Pacific Marine Mammal Stock Assessments: 2008. Harbor Porpoise (*Phocoena phocoena*): Washington Inland Waters Stock. Revised: December 15, 2006.

Cassidy, K. M., M. R. Smith, C. E. Grue, K. M. Dvornich, J. E. Cassady, K. R. McAllister, and R. E. Johnson. 1997. Gap Analysis of Washington State: An evaluation of the protection of biodiversity. Volume 5 in Washington State Gap Analysis - Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds.). Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, 192 pp.

Cavagnaro, R., B. Polagye, J. Wood, and D. Tollit. 2012. Harbor porpoise echolocation activity in Admiralty Inlet, Puget Sound, WA. In preparation.

Centre for Marine and Coastal Studies, University of Liverpool (CMCS). 2005. Electromagnetic Field Review: The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms - a review. COWRIE Report EM Field 2-06-2004.

Centre for Marine and Coastal Studies, University of Liverpool (CMCS). 2003. A baseline assessment of electromagnetic fields generated by offshore wind farm cables. COWRIE Report EMF - 01-2002 66.

City of Anacortes. 2007. Shoreline master program record. Available online at: www.cityofanacortes.org/Planning/smp_record.htm. Accessed December 2007.

City of Port Townsend. 2007. Shoreline master program. City of Port Townsend, Port Townsend Washington.

City of Port Townsend. 2008*a*. Jefferson County Parks. Available online at: www.ptguide.com/recreation/county.html. Accessed January 2008.

City of Port Townsend. 2008*b*. Parks and Camping in Port Townsend. Available online at: www.ptguide.com/recreation/city.html. Accessed January 2008.

Cole, D. and D. Darling. 1990. History of the early period. *In* W. Suttles and W.C. Sturtevant (Eds.) Handbook of North American Indians, Vol. 7: The Northwest Coast. Washington, D.C.: Smithsonian Institution.

Cook C.L., D.J. Coughlin. 2010. Rainbow trout Oncorhynchus mykiss consume less energy when swimming near obstructions. Journal of Fish Biology 77:1716-1723.

Coutant C.C. and R.R. Whitney. 2000. Fish behavior in relation to passage through hydropower turbines: A review. Trans. Am. Fish. Soc. 129:351-380.

Crawford, George, Hal Mofjeld, and Craig Weaver. 2001. Summary: Puget Sound Tsunami/Landslide Workshop, January 23 and 24, 2001. Available online: nctr.pmel.noaa.gov/Ws20010123/. Accessed November 2007.

CREST Energy Limited. 2006. Kaipara Harbour Marine Turbine Electricity Generation Project. Application for Resources Consents and Assessment of Environmental Effects. July 2006. *Cited in* AECOM 2009.

Dawson, J. and McClure, B. 2009. The District County PUD No. 1 - Admiralty Inlet Tidal Pilot Energy Project Mobile Hydroacoustic Survey No. 1 and 2. BioSonics, Inc.

Dean, F.E., E.M. Jurasz, V.P. Palmer, E.H. Curby, and D.L. Thomas. 1985. Analysis of humpback, whale (*Megaptera novaeangliae*) blow interval data/Glacier Bay Alaska, 1976-1979. Report from the University of Alaska, Fairbanks, AI<, for the U.S. National Park Service, Anchorage, AK, 224 pp. *Cited in* LGL and JASCO Research 2005.

Dehnhardt, Guido, Björn Mauck, Wolf Hanke, Horst Bleckmann. 2001. Hydrodynamic Trail-Following in Harbor Seals (Phoca vitulina) Science 6 July 2001: Vol. 293. no. 5527, pp. 102-104.

Department of the Navy (DON). 2006. Marine resources assessment for the Pacific Northwest operating area. Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, Hawaii. Contract No. N62470-02-D-9997, CTO 0029. Prepared by Geo-Marine, Inc., Plano, Texas.

Drake J., E. Berntson, J. Cope, R. Gustafson, E. Holmes, P. Levin, N. Tolimieri, R. Waples, S. Sogard. 2010*a*. Update to Preliminary Scientific Conclusions of the Review of the Status of 5 Species of Rockfish: Bocaccio (*Sebastes paucispinis),* Canary Rockfish *(Sebastes pinniger),* Yelloweye Rockfish *(Sebastes ruberrimus)*, Greenstriped Rockfish *(Sebastes elongatus)* and Redstripe Rockfish *(Sebastes proriger)* in Puget Sound, Washington National Marine Fisheries Service, Northwest Fisheries Science Center. Seattle, Washington. 225p.

Drake, J., R. Emmett, K. Fresh, R. Gustafson, M. Rowse, D. Teel, M. Wilson, P. Adams, E. Spangler, R. Spangler. 2010*b*. Status Review Update for Eulachon in Washington, Oregon, and California. Prepared by the Eulachon Biological Review Team. National Marine Fisheries Service, Northwest Fisheries Science Center.

Easterbrook, Don J. 1999. Surface processes and landforms, Second Edition. Prentice Hall, Upper Saddle River, New Jersey.

Electric Power Research Institute (EPRI). 2010. Assessment of the environmental effects of hydrokinetic turbines on fish: desktop and laboratory flume studies. Quarterly technical progress report no. 2.

Emmet, R. L., M. E. Monaco, S. A. Hinton and S. L. Stone. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries, Volume II: Species life history summaries. Rockville, Maryland: Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Federal Energy Regulatory Commission (FERC). 2007. Environmental Assessment for Hydropower License. Makah Bay Offshore Wave Energy Pilot Project. FERC Project No. 12751-000. May 21, 2007.

Finlayson, David. 2006. The Geomorphology of Puget Sound Beaches. Prepared in support of the Puget Sound Nearshore Partnership. October 2006. Available online at: pugetsoundnearshore.org/techical_papers/geomorphology.pdf. Accessed November 2007.

Fraenkel. Peter. 2006. Marine Current Turbines: Pioneering the Development of Marine Kinetic Energy Converters. Proc. IMechE, Vol. 221, Part A: J. Power and Energy. Published November 17, 2006.

Fugro. 2009. Bathymetric and geophysical survey site characterization Admiralty Inlet Pilot Tidal Project. Prepared for Snohomish County PUD No. 1 (SnoPUD). Survey period: June 25 to 30, 2009. Report Number: 0902J001. Vol. 1 of 1: draft final.

Garrood, D., and B. Polagye. 2011. Underwater noise during marine construction operations. Sound and Sea Technology and University of Washington Northwest National Marine Renewable Energy Center. August 2011.

Gelfenbaum, G., T. Mumford, J. Brennan, H. Case, M. Dethier, K. Fresh, F. Goetz, M. van Heeswijk, T. M., Leschine, M. Logsdon, D. Myers, J. Newton, H. Shipman, C. A. Simenstad, C. Tanner, and D. Woodson. 2006. Coastal habitats in Puget Sound: A research plan in support of the Puget Sound Nearshore Partnership: Puget Sound Nearshore Partnership Report No. 2006-1. Published by the USGS, Seattle, Washington.

Giger, R. 1972. Ecology and management of coastal cutthroat trout in Oregon. Oregon State Game Comm. Fish Res. Report. No. 6.

Gill, A.B., Huang, Y., Gloyne-Philips, I., Metcalfe, J., Quayle, V., Spencer, J. & Wearmouth, V. 2009. COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2: EMF-sensitive fish response to EM emissions from sub-sea electricity cables of the type used by the offshore renewable energy industry. Commissioned by COWRIE Ltd (project reference COWRIE-EMF-1-06).

Gilmore, R, R. Englebretson, R. Handlers, and S. Brand. 1996. Puget Sound area heavy weather port guide. Naval Research Laboratory, Monterey, CA.

Goetz and Tingwall. 2006. Cultural resources report, Indian Point property cleanup project, Jefferson County, Port Townsend, Washington. On file at Washington State Department of Archaeology and Historic Preservation.

Golder Associates, Inc. 2011. Geophysical Investigation for Admiralty Inlet Turbine Project. Prepared for Public Utility District No. 1 of Snohomish County (Snohomish PUD). September 6, 2011. Survey Dates: May 25-26, 2011.

Gooch, S., Thomson, J., Polagye, B., and Meggitt, D. Site Characterization for Tidal Power. 2009. Oceans 2009, Biloxi, MI, October 26-29, 2009.

Good, T. P., R. S. Waples, and P. Adams (Eds.). 2005. Updated status of federally listed ESUs of west coast salmon and steelhead. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-66.

Good, T.P., J.A. June, M.A. Etnier, and G. Broadhurst. 2009. Ghosts of the Salish Sea: threats to marine birds in Puget Sound and the Northwest Straits from derelict fishing gear. Marine Ornithology 37: 67-76.

Gorlov A. 2010. Helical turbine and fish safety. [Internet]. [Cited 18 January 2011.] Available from: http://www.mainetidalpower.com/files/gorlovrevised.pdf.

Greene, G. 2011. Habitat Characterization of the SnoPUD Turbine Site – Admiralty Head, Washington State – Final Report. June 1, 2011.

Guiry, M. 2007. The seaweed site. Available online at: www.seaweed.ie and www.algaebase.org/index.lasso. Accessed November 2007.

Gustafson R.G., W. H. Lenarz, B. B. McCain, C. C. Schmitt, W. S. Grant, T. L. Builder, and R. D. Methot. 2000. Status review of Pacific hake, Pacific cod, and walleye pollock from Puget Sound, Washington. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-44. Available online at: www.nwfsc.noaa.gov/publications/techmemos/tm44 and www.nwfsc.noaa.gov/publications/techmemos/tm44/environment.htm. Accessed October 2007.

Hall, A. 2004. Seasonal abundance, distribution, and prey species of harbour porpoise (*Phocoena phocoena*) in southern Vancouver Island waters. MSc thesis, UBC. *Cited in* Tollit et al. 2010.

Hart, S. 2005. Marine Biofouling Consequences Seasonally, Spatially, and with Depth. Exploration and Production: The Oil and Gas Review 2005- Issue 2. Available online at: www.touchoilandgas.com/marine-biofouling-consequences-seasonally-a694-1.html. Accessed June 2007.

Hastings, M. C., Reid, C. A., Grebe, C. C., Hearn, R. L. & Colman, J. G. 2008. The effects of seismic airgun noise on the hearing sensitivity of tropical reef fishes at Scott Reef, Western Australia. Underwater Noise Measurement, Impact and Mitigation, Proceedings of the Institute of Acoustics 30 (5). *Cited in* Popper and Hastings 2009.

Hastings, M.C. and A.N. Popper. 2005. Effects of Sound on Fish. (Subconsultants) Submitted by Jones & Stokes to California Dept. of Transportation Contract No. 43A0139. Task Order 1.

Hazelwood, R. and Connelly, J. 2005. Estimation of underwater noise - a simplified method. International J. Soc. Underwater Technology, 26, 51-57.

Heard, W.R. 1991. Life history of pink salmon (*Oncorhynchus gorbuscha*). *In* C. Groot and L. Margolis (Eds.), Pacific salmon life histories, pp. 121-230. Univ. British Columbia Press, Vancouver.

Hinke, J. T., D. G. Foley, C. Wilson, and G. M. Watters. 2005. Persistent habitat use by Chinook salmon (*Oncorhynchus tshawytscha*) in the coastal ocean. Marine Ecology Progress Series. 304: pp. 207-220.

Hydro Green Energy, LLC. 2010a. Hydro Green Energy Hastings, MN Fish Study. [Online] URL: http://www.hgenergy.com/hastings_fish_study.html. Accessed October 2010.

Hydro Green Energy, LLC. 2010b. Hydro Green Energy Hastings, MN Fish Study. [Online] URL: http://www.hgenergy.com/hastingsinstallation.html. Accessed October 2010.

Industrial Economics, Incorporated (IE). 2006. Economic impacts associated with critical habitat designation for southern resident population of killer whales. Prepared for NOAA Fisheries, Northwest Fisheries Science Center, Seattle, Washington.

Interagency Committee for Outdoor Recreation (ICOR). 2002. An assessment of outdoor recreation in Washington State. A State Comprehensive Outdoor Recreation Planning (SCORP) Document 2002-2007. Olympia, Washington. October 2002.

James, Thomas S., John J. Clague, Kelin Wang, and Ian Hutchinson. 2006. Postglacial rebound at the Northern Cascadia Subduction Zone. Geodynamics, GSC Contribution Series 1998125. Available online at: gsc.nrcan.gc.ca/geodyn/rebound_e.php. Accessed November 2007.

Jeffries, S., H. Huber, J. Calambokidis, and J. Laake. 2003. Trends and status of harbor seals in Washington State: 1978-1999. J. Wildl. Manage. 67(1):208-219.

Jeffries, Steven J, Patrick Gearin, Harriet R. Huber, Don L. Saul, and Darrell A. Pruett. 2000. Atlas of Seal and Sea Lion Haulout Sites in Washington. February 2000.

Johnson, F.G. and R.R. Stickney (editors). 1989. Fisheries. Kendall/Hunt Publishing Company. Dubuque, Iowa.

Johnson, S. Y., S. V. Dadisman, J. R. Childs, and W. D. Stanley. 1999. Active Tectonics of the Seattle Fault and Central Puget Sound, Washington: Implications for earthquake Hazards. GSA Bulletin, v. 111, no. 7, pp. 1042-1053. Available online at: earthquake.usgs.gov/regional/pacnw/activefaults/sfz/. Accessed November 2007.

Johnson, S.Y., C. J. Potter, J.M. Armentrout, J.J. Miller, C. Finn, and C.S. Weaver. 1996. The southern Whidbey Island fault: An active structure in the Puget Lowland, Washington, Geol. Soc. Am. Bull., 108 (3), 334-354.

Jørgensen, R., Olsen, K. K., Falk-Petersen, I. B. & Kanapthippilai, P. 2005. Investigations of Potential Effects of Low Frequency Sonar Signals on Survival, Development and Behaviour of Fish Larvae and Juveniles. Norway: Norwegian College of Fishery Science, University of Tromsø. *Cited in* Popper and Hastings 2009.

Jurasz, C.M. and V.P. Jurasz. 1979. Feeding modes of the humpback whale, *Megaptera novaeangliae*, in southeast Alaska. Scientific Reports of the Whales Research Institute 31, 69-83. *Cited in* LGL and JASCO Research 2005.

Keizer, J. and T. Nelson. 2007. Salmon University. Online: http://salmonuniversity.com/. Accessed November 2007.

Ketten, D.R. 2000. Cetacean ears. Pages 43-108 In: Au, W.W.L., Popper, A.N. & Fay, R.R., Eds. Hearing in Whales and Dolphins. Springer Verlag NY.

Kozloff, E. N. 1993. Seashore life of the northern Pacific coast: An illustrated guide to northern California, Oregon, Washington, and British Columbia. Seattle: University of Washington Press.

Krahn, M. M., P. R. Wade, S. T. Kalinowski, M. E. Dahlheim, B. L. Taylor, M. B. Hanson, G. M. Ylitalo, R. P. Angliss, J. E. Stein, and R. S. Waples. 2004. Status review of southern resident killer whales (*Orcinus orca*) under the Endangered Species Act. NOAA Technical Memorandum NMFS-NWFSC-54, U.S. Department of Commerce, Seattle, Washington.

Kubodera T, Koyama Y, Mori K. 2007. Observations of wild hunting behaviour and bioluminescence of a large deep-sea eight-armed squid, *Taningia danae*. Proc. R. Soc. B 274:1029-1034.

Larsen, Jeff. 2003. Short Trips: A little state ferry leads to big rewards. Seattle Post-Intelligencer, February 27. Online: http://seattlepi.nwsource.com/getaways/110204_shorttrips27.shtml. Accessed January 2008.

LGL Ecological Research Associates and JASCO Research. 2005. Assessment of the Effects of Underwater Noise from the Proposed Neptune LNG Project. October 12, 2005.

Liao J.C. 2007. A review of fish swimming mechanics and behaviour in altered flows. Philosophical Transactions of the Royal Society (B) 362:1973-1993.

Ljungblad, D. K., B. Würsig, S. L. Swartz, and J. M. Keene. 1988. Observations on the behavioral responses of bowhead whales (*Balaena mysticetus*) to active geophysical vessels in the Alaskan Beaufort Sea. Arctic 41:183-194. *Cited in* NMFS 2008a.

Love, M.S., D.M. Scroeder, W. Lenarz, A. MacCall, A.S. Bull, L. Thorsteinson. 2006. Potential use of offshore marine structures in rebuilding an overfished rockfish species, bocaccio (*Sebastes paucispinis*). Fish. Bull. U.S. 104:383-390.

Malme, C. I., B. Würsig, J. E. Bird, and P. Tyack. 1988. Observations of feeding gray whale responses to controlled industrial noise exposure. Pages 55-73 in W. M. Sackinger, M. O. Jeffries, J. L. Imm, and S. D. Treacy, editors. Port and ocean engineering under arctic conditions, Volume III. University of Alaska, Fairbanks, Alaska. *Cited in* NMFS 2008*a*.

Malme, C. I., P. R. Miles, C. W. Clark, P. Tyack, and J. E. Bird. 1984. Investigations on the potential effects of underwater noise from petroleum industry activities on migrating whale behavior/Phase II: January 1984 migration. BBN Report 5586, Bolt Beranek and Newman, Inc., Cambridge, Massachusetts, for U.S. Minerals Management Service, Anchorage, Alaska, NTIS PB86-218377. *Cited in* NMFS 2008a.

Malme, C. I., P. R. Miles, C. W. Clark, P. Tyack, and J. E. Bird. 1983. Investigations on the potential effects of underwater noise from petroleum industry activities on migrating whale behavior. BBN Report 5366, Bolt Beranek and Newman, Inc., Cambridge, Massachusetts, for U.S. Minerals Management Service, Anchorage, Alaska, NTIS PB86-174174. *Cited in* NMFS 2008a.

Matthews, K.R. 1990. An experimental study of the habitat preferences and movement patterns of copper, quillback, and brown rockfishes (*Sebastes* spp.). Environmental Biology of Fishes 29: 161-178. *Cited in* NMFS letter to Snohomish dated July 23, 2009.

McCurdy, R. 2007. President, Puget Sound Pilots. Personal communication.

McGary, N. and J. Lincoln. 1977. Tide Prints: surface tidal currents in Puget Sound. University of Washington Press. 1977. *Cited in* Polagye et al. 2007.

Michel, J., H. Dunagan, C. Boring, E. Healy, W. Evans, J. Dean, A. McGillis and J. Hain. 2007. Worldwide Synthesis and Analysis of Existing Information Regarding Environmental Effects of Alternative Energy Uses on the Outer Continental Shelf. OCS Report MMS 2007-038. Minerals Management Service, U.S. Department of the Interior, Washington, DC.

Mills, Frederick, H.J. and Deane Renouf. 1986. Determination of the vibration sensitivity of harbour seal *Phoca vitulina* (L.) *vibrissae*. Journal of Experimental Marine Biology and Ecology. Volume 100, Issues 1-3, Pages 3-9. September 1986.

Minerals Management Service (MMS). 2007. Draft Programmatic EIS for alternative energy development and production and alternative use of facilities on the Outer Continental Shelf. U.S. Department of the Interior. March 2007. Available online at: ocsenergy.anl.gov/documents/dpeis/index.cfm. Accessed June 2007.

Minerals Management Service (MMS). 2009. Cape Wind Energy Project Final Environmental Impact Statement. January 2009.

Mofjeld, H.O., and Larsen, L.H. 1984. Tides and tidal currents in the inland waters of Western Washington. NOAA Tech. Memo. ERL PMEL-56 (PB84-237379), Seattle, 52 pp.

Moore, S.E. and J.T. Clarke. 2002. Potential impact of offshore human activities on gray whales (*Eschrichtius robustus*). J. Cetacean Res. Manage. 4(1):19-25.

Morton, B. 2005. Fishing perturbations and beached corals in the Cape d'Aguilar Marine Reserve, Hong Kong (2000-2002) and a summary of data obtained from January 1996 to March 2003. Marine Pollution Bulletin 50: 1273-1286. *Cited in* Good et al. 2009.

Mueller-Blenkle, C., P.K. McGregor, A.B. Gill, M.H. Andersson, J. Metcalfe, V. Bendall, P. Sigray, D.T. Wood, & F. Thomsen. 2010. Effects of Pile-driving Noise on the Behaviour of Marine Fish. COWRIE Ref: Fish 06-08, Technical Report 31st March 2010.

Mumford, T.F. 2007. Kelp and Eelgrass in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-05. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

National Academy of Science (NAS). 2003. Ocean Noise and Marine Mammals. Prepared by the Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals, Ocean Studies Board, Division on Earth and Life Studies. The National Academies Press, Washington, D.C. Available online at: www.nap.edu/catalog.php?record_ id=10564. Accessed October 21, 2008.

National Marine Fisheries Service (NMFS). 2005*a*. Humpback whale: eastern north Pacific stock assessment. National Marine Fisheries Service.

National Marine Fisheries Service (NMFS). 2005*b*. Green Sturgeon (Acipenser medirostris) status review update. NMFS Southwest Fish Sci Ctr, Santa Crux, CA. 31 p. Available online at www.nmfs.noaa.gov/pr/species/ statusreviews.htm. Accessed December 27, 2009.

National Marine Fisheries Service (NMFS). 2008*a*. Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*). National Marine Fisheries Service, Northwest Region, Seattle, Washington.

National Marine Fisheries Service (NMFS). 2008*b*. Recovery Plan for the Steller Sea Lion (*Eumetopias jubatus*). Revision. National Marine Fisheries Service, Silver Spring, MD. 325 pages.

National Northwest Marine Renewable Energy Center (NNMREC). 2009*a*. Seabed characterization in Admiralty Inlet. Northwest National Marine Renewable Energy Center University of Washington. September 8, 2009.

National Northwest Marine Renewable Energy Center (NNMREC). 2009*b*. Underwater Ambient Noise in Admiralty Inlet: Spectral Levels, Sound Pressure Levels and Permanent Noise. Christopher Bassett, Jim Thomson, Brian Polagye. September 8, 2009. Northwest National Marine Renewable Energy Center University of Washington Seattle, Washington. Report # 2. December 15, 2009.

National Northwest Marine Renewable Energy Center (NNMREC). 2011. Estimated received noise levels for marine mammals from an OpenHydro turbine in Admiralty Inlet, Washington. Technical Report: UW-2011-01. University of Washington, Seattle, Washington. January 2011.

National Oceanic and Atmospheric Association (NOAA). 1995*a*. Proposed threatened status for three contiguous ESUs of Coho Salmon ranging from Oregon to through Central California. Federal Register, Vol. 60. No. 142.

National Oceanic and Atmospheric Association (NOAA). 1995*b*. West Coast pink salmon petition determination. Federal Register, Vol. 60. No. 192.

National Oceanic and Atmospheric Association (NOAA). 1999. Status review of coastal cutthroat trout from Washington, Oregon, and California. Conservation Biology Division Northwest Fisheries Science Center. Technical Memorandum, NMFS-NWFSC-37.

National Oceanic and Atmospheric Association (NOAA). 2005*b*. Status review and update for Puget Sound Steelhead. 2005 Puget Sound steelhead biological review team. July 26, 2005.

National Oceanic and Atmospheric Association (NOAA). 2007*a*. Coast Pilot 7 - 39th Edition. Office of Coast Survey, National Ocean Service, Silver Spring, Maryland.

National Oceanic and Atmospheric Association (NOAA). 2009*a*. Tides and Currents Port Townsend observation buoy 94449000

National Oceanic and Atmospheric Association (NOAA). 2009*b*. California Sea Lion (*Zalophus californianus*). [Online] URL: http://www.nmfs.noaa.gov/pr/species/mammals/pinnipeds/californiasealion.htm. Accessed July 28, 2009.

National Oceanic and Atmospheric Association (NOAA). 2009*c*. Northern Elephant Seal (Mirounga angustirostris). Available online at: www.nmfs.noaa.gov/pr/species/mammals/pinnipeds/northernelephantseal.htm. Accessed July 27, 2009.

National Oceanic and Atmospheric Association (NOAA). 2009*d*. Dall's Porpoise (Phocoenoides dalli). Available online at: www.nmfs.noaa.gov/pr/species/mammals/cetaceans/dallsporpoise.htm. Accessed July 27, 2009.

National Oceanic and Atmospheric Association (NOAA). 2009*e*. Minke Whale (Balaenoptera acutorostrata). Available online at: www.nmfs.noaa.gov/pr/species/mammals/cetaceans/minkewhale.htm. Accessed July 27, 2009.

National Park Service (NPS). 2003a. Ebey's Landing National Historical Reserve. An analysis of land use change and cultural landscape integrity. April 2003.

National Park Service (NPS). 2003b. Ebey's Landing National Historical Reserve. Naturalist's Guide Spring and Summer, Fall and Winter.

National Park Service (NPS). 2008. Ebey's Landing National Historical Reserve. Available online at: www.nps.gov/archive/ebla/lpp2.htm. Accessed January 2008.

National Park Service (NPS). 2011. Ebey’s Landing Historical Reserve information. Available online at: www.nps.gov. Accessed July 2011.

Natural Resource Consultants, Inc. (NRC). 2008. Remote operated vehicle deepwater crab pot removal feasibility study. Seattle, Washington.

Neitzel D.A., D.D. Dauble, G.F. Cada, M.C. Richmond, G.R. Guensch, R.P. Mueller, C.S. Abernethy, B. Amidan. 2004. Survival estimates for juvenile fish subjected to a laboratory-generated shear environment. Transactions of the American Fisheries Society 133:447-454.

Neitzel, D.A., M.C. Richmond, D.D. Dauble, R.P. Mueller, R.A. Moursund, C.S. Abernethy, G.R. Guensch, and G.F. Cada. 2000. Laboratory studies on the effects of shear on fish. U.S. Department of Energy, Idaho Operations Office, DOE/ID-10822, Idaho Falls, Idaho.

Normandeau Associates. 2009. An estimation of survival and injury of fish passed through the Hydro Green Energy hydrokinetic system, and a characterization of fish entrainment potential at the Mississippi Lock and Dam No. 2 hydroelectric project (FERC No. 4306), Hastings, MN, Final Report. Prepared for Hydro Green Energy, LLC. December 2009. Available at: http://www.hgenergy.com/Hastings%20Agencies%20Review%20Draft%2012-21-09.pdf.

Northwest Straits Foundation (NWSF). 2007. Derelict fishing gear priority ranking project [Unpublished report]. Mt. Vernon, Washington: NWSF. 40 pp. *Cited in* Good et al. 2009.

Northwest Straits Foundation (NWSF). 2012. Program Accomplishments 2002-Present. [Online] URL: http://www.derelictgear.org/Progress.aspx. Accessed January 2012.

Northwest Straits. 2009. Northwest Straights marine conservation initiative. Available online at: www.nwstraits.org/. Accessed September 2009.

Northwest Straits. 2008. Island County forage fish spawning data and habitat suitability. November 1, 2008.

Nova Scotia Power. 2009. NS Power and OpenHydro unveil in-stream tidal turbine. Press release. Available online at: www.nspower.ca/en/home/aboutnspi/mediacentre/NewsRelease/2009/tidalturbine.aspx. Accessed September 23, 2009.

Ogden, J.C. 2005. Hydrokinetic and wave energy technologies and offshore marine resources. White paper delivered at the Hydrokinetic and wave energy technologies technical and environmental issues workshop. Held at Resolve, Washington, D.C. October 26 to 28, 2005.

Orcanetwork.org. 2007. Whale sightings occurring from 2001-2007. Available online at: orcanetwork.org/. Accessed November 2007.

Pacific Fishery Management Council (PFMC). 1998. The Coastal Pelagic Species Fishery 206 Management Plan: Amendment 8. Pacific Fishery Management Council, Portland, Oregon (December 1998). http://www.pcouncil.org/cps/cpsfmp.html.

Pacific Fishery Management Council (PFMC). 1999. Identification and description of essential fish habitat: Amendment 14 to the Pacific coast salmon plan. Appendix A. Portland, Oregon: Pacific Fishery Management Council.

Pacific Fishery Management Council (PFMC). 2000. Amendment 14 to the Pacific Coast Salmon Plan (1997): Incorporating the regulatory impact review/initial regulatory flexibility analysis and final supplemental environmental impact statement. Pacific Fishery Management Council.

Pacific Fishery Management Council (PFMC). 2003. Fishery management plan and environmental impact statement of U.S. West Coast fisheries for highly migratory species. Also, Appendix F: U. S. West Coast highly migratory species life history and essential fish habitat. Available online at: www.pcouncil.org/hms/fmp/HMS_AppF.pdf. Accessed September 2007.

Pacific Fishery Management Council (PFMC). 2005. Amendment 19 (essential fish habitat) to the Pacific Coast groundfish fishery management plan for the California, Oregon, and Washington groundfish fishery. November 2005. 97 pages + appendices. http://pcouncil.org/groundfish/gffmp/gfal9/ A18-19Final.pdf. *Cited in* NMFS letter dated December 12, 2008.

Pacific Fishery Management Council (PFMC). 2007. Preseason report 1. Stock abundance analysis for 2007 Ocean Salmon Fisheries. (Document prepared for the Council and its advisory entities.)

Pacific Fishery Management Council (PFMC). 2008. Pacific Coast groundfish fishery management plan for the California, Oregon, and Washington groundfish fishery as amended through Amendment 19. July 2008.

Pacific States Marine Fisheries Commission (PSMFC). 1996. Green Sturgeon. Available online at: www.psmfc.org/habitat/edu_gsturg_fact.html. Accessed October 16, 2007.

Palsson, W. A., J. C. Hoeman, G. G. Bargmann, and D. E. Day, D. E. 1997. 1995 status of Puget Sound bottomfish stocks (revised). WDFW Report No. MRD97-03. Available from Washington Department of Fish and Wildlife, Olympia, Washington. *Cited* in Gustafson et al., 2000.

Palsson, W. A., W., T. Northup, and M. Barker. 1998. Puget Sound groundfish management plan. Washington Department of Fish and Wildlife, 43 p.

Palsson, W., T. Tsou, G. Bargmann, R. Buckley, J. West, M. Mills, Y. Cheng, and R. Pacunski. 2009. The Biology and Assessment of Rockfishes in Puget Sound. Fish Management Division, Fish Program Washington Department of Fish and Wildlife September 2009.

Palsson, W.A., T.S. Tsou, G.G. Barbman, R.M. Buckley, J.E. West, M.L. Mills, Y.W. Cheng, and R.E. Pacunski. 2008. The biology and assessment of rockfishes in Puget Sound. Washington Department of Fish and Wildlife, Olympia Washington.

Paulin, M.G. 1995. Electroreception and the compass sense of sharks. Journal of Theoretical Biology, Vol. 174, No. 3 pp. 325-339. *Cited in* Valberg 2005.

Pearcy, W. G. 1997. Salmon Production in Changing Ocean Domains, *in* Strouder, D. J., P. A. Bisson, and R. J. Naiman, (Eds.). Pacific salmon and their ecosystems: status and future options, Chapman and Hall, New York, pp. 331-352.

Penttila, D. 2007. Marine Forage Fishes in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-03. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Polagye, B., B. Van Cleve, A. Copping, K. Kirkendall. 2011. Environmental effects of tidal energy development. Proceedings of a scientific workshop March 22-25, 2010. NOAA technical memorandum NMFS F/SPO-116.

Polagye, B., C. Bassett, J. Wood, and S. Barr. 2012*a*. Detection of tidal turbine noise: A pre-installation case study for Admiralty Inlet, Puget Sound, Washington (USA). In preparation.

Polagye, B., Cavagnaro, R., Wood, J., and Tollit, D. 2012*b*. A study of harbor porpoise responsiveness to vessel traffic noise. In preparation.

Polagye, B., and Thomson, J. 2012. Tidal energy resource characterization: methodology and field study in Admiralty Inlet, Puget Sound, US. Submitted to *Proc. IMechE, Part A: J. Power and Energy.*

Polagye, B., J. Thomson, NNMREC. 2010. Admiralty Inlet Water Quality Survey Report: April 2009 - February 2010. University of Washington, Seattle, Washington. May 29, 2010.

Polagye, B., M. Previsic, and R. Bedard. 2007. Tidal In-Stream Energy Conversion (TISEC): Survey and Characterization of SnoPUD Project Sites in the Puget Sound. EPRI North American Tidal In Stream Power Feasibility Demonstration Project: EPRI 2007.

Polagye, B., M. Kawase, and P. Malte (2009) In-stream tidal energy potential of Puget Sound, Washington, *Proc. IMechE, Part A: J. Power and Energy*, 223(5).

Popper, A. N., Halvorsen, M. B., Kane, E., Miller, D. D., Smith, M. E., Song, J., Stein, P. & Wysocki, L. E. 2007. The effects of high-intensity, low-frequency active sonar on rainbow trout. Journal of the Acoustical Society of America 122, 623-635. *Cited in* Popper and Hastings 2009.

Popper, A. N., Smith, M. E., Cott, P. A., Hanna, B. W., MacGillivray, A. O., Austin, M. E. & Mann, D. A. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. Journal of the Acoustical Society of America 117, 3958-3971. *Cited in* Popper and Hastings 2009.

Popper, A.N. and M.C. Hastings. 2009. The effects of anthropogenic sources of sound on fishes. Jour. Fish. Biol. 75, pp. 455-489.

Previsic, M., Polagye, B., and Bedard, R. 2007. System Level Design, Performance, Cost and Economic Assessment - Admiralty Inlet Washington Tidal In-Stream Power Plant. EPRI - TP - 006 SnoPUD. October 8, 2007.

Proctor, C. M., J. C. Garcia, D. V. Galvin, G. B. Lewis, L. C. Loehr, and A. M. Massa. 1980. An ecological characterization of the Pacific Northwest coastal region. Volume 2. U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-79/14.

Puget Sound Action Team (PSAT). 2003. Mission to Protect and Restore Puget Sound: A progress report. Seattle, Washington.

Puget Sound Action Team (PSAT). 2005. Regional Nearshore and Marine Aspects of Salmon Recovery. June 28, 2005.

Puget Sound Action Team (PSAT). 2007a. Puget Sound Update: Ninth Report of the Puget Sound Assessment and Monitoring Program. Olympia, Washington.

Puget Sound Action Team (PSAT). 2007*b*. State of the Sound 2007. Olympia, Washington.

Puget Sound Partnership (PSP). Undated. Puget Sound facts. Available online at: www.psp.wa.gov/. Accessed November 2007.

Puget Sound Regional Council (PSRC). 2006. VISION 2020 Update draft environmental impact statement (DEIS). Seattle, Washington.

Puget Sound Water Quality Authority (PSWQA). 1992. Update of the Puget Sound environmental atlas. Seattle: PSWQA.

Puget Sound Water Quality Authority. 1987. Puget Sound Environmental Atlas, Volumes 1 and 2. Prepared by Evans-Hamilton, Inc. and D. R. Systems, Inc., Seattle, Washington.

Raymond EH, Widder EA. 2007. Behavioral responses of two deep-sea fish species to red, far-red, and white light. Mar. Ecol. Prog. Ser. 350:291-298.

Richardson, W. J., C. R. Greene, Jr., C. I. Malme, and D. H. Thomson. 1995. Marine Mammals and Noise. Academic Press, London.

Scholik, A.R., and Yan, H.Y. 2002. The effects of noise on the auditory sensitivity of the bluegill sunfish, *Lepomis macrochirus*. Comp. Biochem. Physiol. A 133, 43-52.

Scholik, A.R. & Yan, H.Y. 2001. Effects of underwater noise on auditory sensitivity of a cyprinid fish. Hearing Research 152, 17-24. Cited in Popper and Hastings 2009.

Schusterman, Ronald J. and Richard F. Balliet. 1970. Visual Acuity of the Harbour Seal and the Steller Sea Lion Under Water. Nature, Vol. 226, No. 5245, pp. 563-564, 1970.

Scott Wilson Ltd. and Downie, A.J. 2003. A review of possible marine renewable energy development projects and their natural heritage impacts from a Scottish perspective. Scottish Natural Heritage Commissioned Report F02AA414.

Scottish Executive. 2007. Scottish Marine Strategic Environmental Assessment. March 2007.

Seamap. 1992. WDFW Puget Sound ambient monitoring program summer 92. Washington Dept. of Fish and Wildlife. Geospatial data presentation form: vector digital data. Online: http://seamap.env.duke.edu/datasets/detail/229-/. Accessed November 2007.

Shared Strategy for Puget Sound (SSPS). 2007. Puget Sound Salmon Recovery Plan. Shared Strategy Development Committee. Plan adopted by the National Marine Fisheries Service. January 19, 2007.

Smith, M.E., Kane, A.S. & Popper, A.N. 2004a. Noise-induced stress response and hearing loss in goldfish (*Carassius auratus*). Journal of Experimental Biology 207, 427-435. *Cited in* Popper and Hastings 2009.

Smith, M.E., Kane, A.S. & Popper, A.N. 2004b. Acoustical stress and hearing sensitivity in fishes: does the linear threshold shift hypothesis hold water? Journal of Experimental Biology 207, 3591-3602. *Cited in* Popper and Hastings 2009.

Sound & Sea Technology Ocean Engineering. 2002. Wave Energy Technology Project (WET) Environmental Impacts of Selected Components. Prepared for Belt Collins Hawaii. Report 02-06. August 23, 2002.

Sound and Sea Technology. 2009. Geology and Natural Resources of Whidbey Island, Washington Landing Site for Snohomish PUD Tidal Power Project.

Southall Brandon L., A. Bowles, W. Ellison, J. Finneran, R. Gentry, C. Greene Jr., D. Kastak, D. Ketten, J. Miller, P. Nachtigall, J. Richardson, J. Thomas, and P. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations.

Southall, B., Berkson, J., Bowen, D., Brake, R., Eckman, J., Field, J., Gisiner, R., Gregerson, S., Lang, W., Lewandoski, J., Wilson, J., and Winokur, R. 2009. Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U.S. federal agencies. Interagency Task Force on Anthropogenic Sound and the Marine Environment of the Joint Subcommittee on Ocean Science and Technology. Washington, DC.

Speich, S. M., and T. R. Wahl. 1989. Catalog of Washington seabird colonies. USDI Fish. And Wildl. Serv. Biol. Rep. 88(6). 510 pp.

Swanson, D.A., K. A. Cameron, R. C. Evarts, P. T. Pringle, and J. A. Vance. 1989. Cenozoic volcanism in the Cascade Range and Columbia Plateau, Southern Washington and Northernmost Oregon. American Geophysical Union. AGU Field Trip Guidebook T106, July 3-8, 1989. Available online at: vulcan.wr.usgs.gov/Volcanoes/PacificNW/AGU-T106/rainier.html. Accessed November 2007.

Thompson, S., D. McDermond, U. Wilson, and K. Montgomery. 1985. Rhinoceros auklet burrow count on Protection Island, Washington. Murrelet 66:62-65.

Thomson, J., Polagye, B., Durgesh, V., and Richmond, M. 2012. Measurements of turbulence at two tidal energy sites in Puget Sound, WA (USA), Accepted for publication in *J. Ocean. Eng.*

Tollit, D.J., E. Philpott, R. Joy, B. Polagye, and J. Thomson. 2010. Admiralty Inlet Hydrophone Monitoring Study: 2009/2010 Deployments - Final Report June 15th 2010. Prepared for Snohomish PUD June 18, 2010.

Tougaard J, Carstensen J, Henriksen OD, Skov H, Teilmann J. 2003. Short-term effects of the construction of wind turbines on harbour porpoises at Horns Reef. Technical report to Techwise A/S, HME/362-02662. Hedeselskabet, Roskilde. Also available at: www.hornsrev.dk

Tougaard, J., Poulsen, L.R., Amundin, M., Larsen, F., Rye, J. and Teilmann, J. 2006. Detection function of T-PODs and estimation of porpoise densities. In Proceedings of the workshop; Static acoustic monitoring of cetaceans. Held at the 20th Annual Meeting of the European Cetacean Society, Gdynia, Poland 2 April 2006. (ed. R. Leeney and N. J. C. Tregenza). ECS Newsletter No 46. Special Issue July 2006. *Cited in* Tollit et al. 2010.

Trade Development Alliance of Greater Seattle. 2005. Foreign Waterborne Trade through U.S. Ports: 2005. Available online at: www.portseattle.org/downloads/seaport/2005%20 Summary.pdf. Accessed October 2007.

Trust for Public Land. 2005. Puget Sound Shoreline Strategy: A Conservation Vision for Puget Sound. Seattle, WA.

Tyack, P.L. and C.W. Clark. 1998. Quick-look: playback of low-frequency sound to gray whales migrating past the central California coast - January 1998. Unpublished report. *Cited in* NMFS 2008*a*.

U.S. Census Bureau. 2012a. State and County QuickFacts: Washington. Available online at: http://quickfacts.census.gov/qfd/states/53/53029.html. Accessed January 2012.

U.S. Census Bureau. 2012b. County Business Patterns. Online: http://censtats.census.gov/cgi-bin/cbpnaic/cbpsect.pl. Accessed January 2012.

U.S. Coast Guard. 2007. Navigation and Vessel Inspection Circular No. 02-07. Available online at: www.uscg.mil/hq/g-m/nvic/0-07/NVIC02-07.pdf. Accessed November 14, 2007.

U.S. Dept. of Agriculture, Natural Resources Conservation Service. 2009a. Web Soil Survey. Available online at: websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx. Accessed October 2009.

U.S. Dept. of Agriculture, Natural Resources Conservation Service. 2009b. Soil Data Mart. Available online at: soildatamart.nrcs.usda.gov/Report.aspx?Survey =WA029&UseState=WA. Accessed October 2009.

U.S. Department of Labor. 2012. Bureau of Labor Statistics. Online: http://data.bls.gov/pdq/SurveyOutputServlet. Accessed January 2012.U.S. Environmental Protection Agency (EPA). 2007. Puget Sound Georgia Basin Ecosystems Indicators. Available online at: www.epa.gov/region10/psgb/indicators/. Accessed October 2007.

U.S. Fish and Wildlife Service (USFWS). 1997. Recovery plan for the threatened marbled murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California. Portland, Oregon. 203 pp.

U.S. Fish and Wildlife Service (USFWS). 2000. Recovery plan for the golden paintbrush (*Castilleja levisecta*). U.S. Fish and Wildlife Service, Portland, OR. 51 pp.

U.S. Fish and Wildlife Service (USFWS). 2003. Endangered and threatened wildlife and plants; 5-year review of the marbled murrelet and the northern spotted owl. Federal Register. Volume 68, No. 76.

U.S. Fish and Wildlife Service (USFWS). 2004. Draft recovery plan for the coastal-Puget Sound distinct population segment of bull trout (*Salvelinus confluentus*). Volume I (of II): Puget Sound management unit. Portland, Oregon. 289 + xvii pp.

U.S. Fish and Wildlife Service (USFWS). 2007. 5-Year Review Summary and Evaluation for the golden paintbrush (Castilleja levisecta). Western Washington Fish and Wildlife Office, Lacey, Washington. 39 pp.

U.S. Geological Survey (USGS). 2002. Description: Olympic Mountains. Available online at: vulcan.wr.usgs.gov/Volcanoes/Washington/OlympicMountains/description_olympic_mountains.html. Accessed November 2007.

U.S. Geological Survey (USGS). 2006*a*. Seismic hazards investigation in Puget Sound: Puget Sound earthquake origin and occurrence. Online: http://walrus.wr.usgs.gov/ships/pastquak.html. Accessed November 2007.

U.S. Geological Survey (USGS). 2006*b*. Lifelines and earthquake hazards in the greater Seattle area. U.S. Department of the Interior, Western Earth Surface Processes Team, Geologic Division, U.S. Geological Survey. Online: http://geomaps.wr.usgs.gov/pacnw/lifeline/eqhazards.html. Accessed November 2007.

U.S. Geological Survey (USGS). 2007. Seattle Fault Zone - stratigraphy: Active tectonics of the Seattle fault and Central Puget Sound, Washington - implications for earthquake hazards. Available online at: earthquake.usgs.gov/regional/pacnw /activefaults/sfz/sfzstrat.php#tertiary. Accessed November 2007.

U.S. Ocean Action Plan (USOAP). 2004. US Ocean Action Plan: the Bush administration's response to the US Commission on Ocean Policy. Washington, DC: US Department of State. 39 pp. *Cited in* Good et al. 2009.

Valberg, P.A. 2005. Memorandum Addressing Electric and Magnetic Field (EMF) Questions - Draft. Cape Wind Energy Project, Nantucket Sound. 16 pgs.

Von de Emde, G. 1998. Electroreception, in the physiology of fish, (Editor D.H. Evans): CRC Press, pp. 313-343.

Wahl, Terence R., Steven M. Speich. 1994. Distribution of Foraging Rhinoceros Auklets in the Strait of Juan de Fuca, Washington. Northwestern Naturalist, Vol. 75, No. 2. (Autumn, 1994), pp. 63-69.

Washington Department of Fisheries (WDF), Washington Department of Wildlife (WDW), and Western Washington Treaty Indian Tribes (WWTIT). 1993. 1992 Washington State salmon and steelhead stock inventory (SASSI). Wash. Dep. Fish Wildlife, Olympia, 212 p. + 5 regional vols. (Available from Washington Department of Fish and Wildlife, P.O. Box 43151, Olympia, Washington 98501.)

Washington Dept. of Fish and Wildlife (WDFW). 2000. Salmonid stock inventory - coastal cutthroat trout. Blakely, A., B. Leland and J. Ames (Eds.).

Washington Dept. of Fish and Wildlife (WDFW). 2006. Fish and wildlife geographic information system digital data documentation. Olympia, Washington.

Washington Dept. of Fish and Wildlife (WDFW). 2007. Marine protected areas within Puget Sound: Admiralty Head marine preserve. Available online at: wdfw.wa.gov/fish/mpa/puget_sound/05a.htm. Accessed October 2007.

Washington Dept. of Fish and Wildlife (WDFW). 2010a. Recreational Groundfish. Available online at: http://wdfw.wa.gov/fish/bottomfish/index.htm. Accessed August 2010.

Washington Dept. of Fish and Wildlife (WDFW). 2010*b*. Recreational Crab Fishing. Available online at: http://wdfw.wa.gov/fish/shelfish/crab/. Accessed August 2010.

Washington Employment Security Department. 2006. Washington State labor market and economic report 2006. Olympia, Washington.

Washington GAP Analysis Project. 1996. Washington Vegetation Zones, Version 6, August 1996.

Washington Natural Heritage Program (WNHP). 2009. Washington Natural Heritage Information System List of Known Occurrences of Rare Plants in Washington February 2009 Island County.

Washington Scuba Alliance. 2007. Dive site development program. Available online at: www.wascubaalliance.org/data/DiveSiteDevelopmentProgram.pdf. Accessed October 2007.

Washington State Department of Ecology. (WDOE). 1992. Marine Water Column Ambient Monitoring Plan - Final Report. Olympia: Environmental Investigations and Laboratory Services Program, Ambient Monitoring Section.

Washington State Department of Ecology. (WDOE). 2001. Managing Washington's Coast. Washington State's Coastal Zone Management Program. February 2001.

Washington State Department of Ecology. (WDOE). 2002. Beach Environmental Assessment Communication and Health Program interim list.

Washington State Department of Ecology. (WDOE). 2004. Waste Water Discharge Permits in Washington State. Online: http://www.ecy.wa.gov/biblio/wqr019.html. Accessed January 2008.

Washington State Department of Ecology. (WDOE). 2006. Washington State coastal zone management section 309 assessment and strategy, 2006. Olympia, Washington.

Washington State Department of Ecology. (WDOE). 2007a. Puget Sound shorelines, Puget Sound under ice. Accessed Online October 2007 URL: http://www.ecy.wa.gov/programs/sea/pugetsound/tour/geology.html.

Washington State Department of Ecology. (WDOE). 2007*b*. Marine Waters: PSAMP Monitoring - Marine Flights. Online: http:///www.ecy.wa.gov/programs/eap/mae_wat/flights.html. Accessed January 2008.

Washington State Department of Ecology. (WDOE). 2007*c*. The Puget Sound economy. Document 06-01-006. March 2006, Rev. 2/07.

Washington State Department of Ecology. (WDOE). 2007*d*. Shoreline Management. Online: http://www.ecy.wa.gov/programs/sea/sma/. Accessed May 2007.

Washington State Department of Ecology. (WDOE). 2008. Focus on Puget Sound. Economic Facts. Publication No. 06-01-006 (rev. 10/08). Accessed Online February 2010 URL: http://www.ecy.wa.gov/pubs/0601006.pdf

Washington State Department of Natural Resources (WDNR). 2000. Soils Map (DNR 2000) DNR. 2000. Washington State Soils. GIS Vector Data.

Washington State Department of Natural Resources (WDNR). 2007. Puget Sound submerged vegetation monitoring project: 2005 monitoring report. Prepared by Gaeckle, J., P. Dowty, B. Reeves, H. Berry, S. Wyllie-Echeverria and T. Mumford. Online: http://www.dnr.wa.gov/htdocs/aqr/nshr/pdf/2005_symp_report.pdf. Accessed November 2007.

Washington State Department of Natural Resources (WDNR). Division of Geology and Earth Resources. 2005. Geology Map (DNR 2005) DNR. 2005. Geology of Washington State. GIS Vector Data.

Washington State Parks and Recreation Commission. 2008*a*. Fort Worden State Park and Conference Center. Available online at: www.parks.wa.gov/fortworden/. Accessed January 2008.

Washington State Parks and Recreation Commission. 2008*b*. Fort Casey State Park. Available online at: www.parks.wa.gov/parkpage.asp?selectedpark=Fort%20Casey. Accessed January 2008.

Washington State Parks and Recreation Commission. 2008*c*. South Whidbey State Park. Available online at: www.parks.wa.gov/parkpage.asp?selectedpark=South%20Whidbey. Accessed January 2008.

Washington State Parks and Recreation Commission. 2008*d*. Mystery Bay State Park. Available online at: www.parks.wa.gov/parkpage.asp?selectedpark=Mystery%20Bay. Accessed January 2008.

Washington State Parks and Recreation Commission. 2008*e*. Fort Flagler State Park. Available online at: www.parks.wa.gov/parkpage.asp?selectedpark=Fort%20Flagler. Accessed January 2008.

Washington State Parks and Recreation Commission. *2008f*. Old Fort Townsend State Park. Available online at: www.parks.wa.gov/parkpage.asp?selectedpark= Old%20Fort%20Townsend. Accessed January 2008.

Washington State Parks and Recreation Commission. 2008*g*. Fort Ebey State Park. Available online at: www.parks.wa.gov/parkpage.asp?selectedpark=Fort%20Ebey. Accessed January 2008.

Washington State Parks and Recreation Commission. 2009. Wildlife, plants and environment at Fort Casey. Accessed online URL: http://www.parks.wa.gov/parks/?selectedpark= Fort%20Casey&subject =wildlife. Accessed on August 25, 2009.

Washington State Recreation and Conservation Office (WRC). 2008. Defining and Measuring Success: The Role of State Government in Outdoor Recreation A State Comprehensive Outdoor Recreation Planning Document (SCORP). June 2008.

Washington Water Trails Association (WWTA). 2008. Posey Island State Park. Available online at: www.wwta.org/trails/CMT/campsites/san_juans/site.asp?site=Posey_Island. Accessed January 2008.

Watkins, W.A. 1986. Whale reactions to human activities in Cape Cod waters. Marine Mammal Science 2(4): 251-262. *Cited in* LGL and JASCO Research 2005

Westernberg, H., I. Lagenfelt. 2008. Sub-sea Power Cables and the Migration Behaviour of the European Eel. Fisheries Management and Ecology, Volume 15 pp 369-375.

Widder E.A., Robison B.H., Reisenbichler K.R., Haddock S.H.D. 2005. Using red light for *in-situ* observations of deep-sea fishes. Deep-Sea Res. I 52:2077-2085.

Williams K., Rooper C.N., Towler R. 2010. Use of stereo camera systems for assessment of rockfish abundance in untrawlable areas and for recording pollock behavior during midwater trawls. Fish. Bull. 108:352-362.

Williams, G.D., R.M. Thom, M.C. Miller, D.L. Woodruff, N.R. Evans, and P.N. Best. 2003. Bainbridge Island Nearshore Assessment: Summary of Best Available Science. PNWD-3233. Prepared for the City of Bainbridge Island: Bainbridge Island, Washington; by Battelle Marine Sciences Laboratory: Sequim, Washington.

Willis and Sharley. 2005. Cultural resources investigations of the proposed Chimacum Creek beach improvement and fill removal project at the Chimacum Creek Estuary, Jefferson County, Washington. On file at Washington State Department of Archaeology and Historic Preservation.

Wilson, B., R. Batty, F. Daunt, and C. Carter. 2007. Collision risks between marine renewable energy devices and mammals, fish and diving birds. Report to the Scottish Executive. Scottish Association for Marine Science, Oban, Scotland, PA37 1QA, 110 p.

Wilson, U.W. 1977. A study of the biology of the rhinoceros auklet on Protection Island, Washington. Unpubl. M.S. thesis. Univ. Washington. Seattle. 98 pp.

WISAARD. 2011. Washington Information System for Architectural and Archaeological Records Data. Department of Archaeology and Historic Preservation online database. Accessed July 2011.

World Health Organization. 2005. Electromagnetic fields and public health: Effects of EMF on the Environment. International EMF Project, Information sheet. February 2005. Available online at: www.who.int/peh-emf/publications/facts/envimpactemf_infosheet.pdf.

Wysocki, L. E., Davidson, J. W. III, Smith, M. E., Frankel, A. S., Ellison, W. T., Mazik, P. M., Popper, A. N. & Bebak, J. 2007. Effects of aquaculture production noise on hearing, growth, and disease resistance of rainbow trout *Oncorhynchus mykiss*. Aquaculture 272, 687-697. *Cited in* Popper and Hastings 2009.