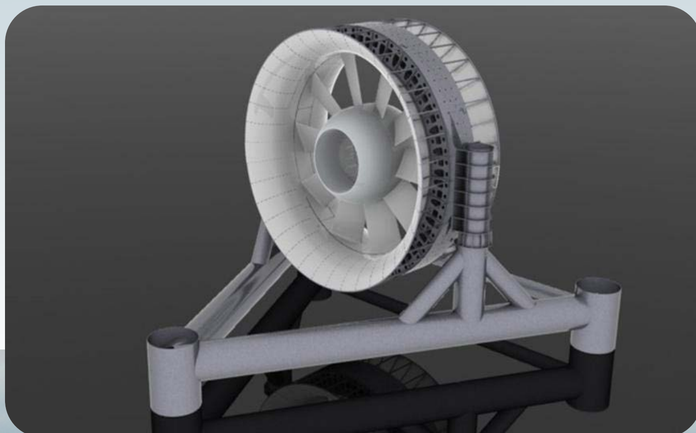
ADMIRALTY INLET PILOT TIDAL PROJECT

FERC PROJECT NO. 12690

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



VOLUME IV

APPENDIX G

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:

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National Renewable Energy Laboratory
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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

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Appendix G

Applicant-Prepared Draft Biological Assessment

ADMIRALTY INLET PILOT TIDAL PROJECT
(PROJECT NO. 12690)

DRAFT BIOLOGICAL ASSESSMENT

PUBLIC UTILITY NO. 1 OF SNOHOMISH COUNTY
Everett, Washington

February 29, 2012
(revised April 16, 2012)

ADMIRALTY INLET PILOT TIDAL PROJECT
(FERC PROJECT NO. 12690)
DRAFT BIOLOGICAL ASSESSMENT

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(FERC PROJECT NO. 12690)
DRAFT BIOLOGICAL ASSESSMENT

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List of Acronyms

°C ....degrees Celsius
°F...degrees Fahrenheit
A/m ....Amp per meter
AC ....Alternating Current
ACS.......................................American Cetacean Society
ADCP....................................Acoustic Doppler Current Profiler
AIR..Additional Information Request
ARRA ....American Recovery and Reinvestment Act
B ....magnetic field
BIA..Bureau of Indian Affairs
BRT.......................................Biological Review Team
CDFO ....Department of Fisheries and Ocean Canada
CFD ....computational fluid dynamic
CI...confidence interval
cm..centimeter
cm/s ....centimeters per second
CMCS ....Centre for Marine and Coastal Studies
CPDF....................................cumulative probability density function
dB ....decibel
DLA ....Draft License Application
DON......................................U.S. Department of the Navy
DPS ....Distinct Population Segment
E ....electric field
EA ....Environmental Assessment
EEZ ....Exclusive Economic Zone
EFH.......................................Essential Fish Habitat
EIAs ....Environmental Impacts Assessments
EIS...Environmental Impact Statement
EMF ....electromagnetic field
EPRI......................................Electric Power Research Institute
ESA ....Endangered Species Act

ESU..evolutionarily significant unit
Facilitation Parties ....the District, NMFS, USFWS, and WSDNR
FERC or Commission............Federal Energy Regulatory Commission
FLA..Final License Application
FMO.......................................foraging, migration, and overwintering
FMPs......................................fishery management plans
ft ....feet
GRP..glass reinforced plastic
HAPCs ....Habitat Areas of Particular Concern
HDD.......................................Horizontal Directional Drilling
HVAC ....Heating Ventilating and Air Conditioning
Hz...hertz
iE..induced electric
kHz...kilohertz
km ....kilometer
km^2 ....square kilometer
kPa ....kilopascal
kV...kilovolt
kW..kilowatts
m ....meter
m/s..meters per second
m^2 ....square meters
MARC....................................Marine Aquatic Resource Committee
MHHW ....mean higher high water
MLLW ....mean lower low water
mm ....millimeter
MMPA ....Marine Mammal Protection Act
MMS ....Minerals Management Service
MSA.......................................Magnuson-Stevens Fishery Conservation and Management Act
mV...millivolt
MWh ....megawatt hours
NAS..National Academy of Science
NDT ....non-destructive testing

NMFS.....................................National Marine Fisheries Service
NNMREC ....National Northwest Marine Renewable Energy Center
NOAA....................................National Oceanic and Atmospheric Administration
NWPCC ....Northwest Power and Conservation Council
NWSF ....Northwest Straits Foundation
ODFW...................................Oregon Department of Fish and Wildlife
OPT.......................................Ocean Power Technologies
OSU.......................................Oregon State University
PAM......................................passive acoustic monitoring
PCEs......................................primary constituent elements
PFMC....................................Pacific Fishery Management Council
PNNL....................................Pacific Northwest National Laboratory
PNPTT ....Point No Point Treaty Tribes
POST.....................................Pacific Ocean Salmon Tracking
ppt ....parts per trillion
Project ....Admiralty Inlet Pilot Tidal Project (FERC No. 12690)
PSE..Puget Sound Energy
PSMFC..................................Pacific States Marine Fisheries Commission
PSUs......................................Primary Sampling Units
PTMSC ....Port Townsend Marine Science Center
REEF ....Reef Environmental Education Foundation
RL..received levels
rms...root mean squared
ROV ....remotely operated vehicle
rpm ....revolutions per minute
SAR.......................................smolt-to-adult return
SaSI ....Salmonid Stock Inventory
SCADA ....Supervisory Control and Data Acquisition
SEL ....Sound Exposure Level
SMRU ....Sea Mammal Research Unit, Ltd.
The District ....Public Utility District No. 1 of Snohomish County
SPL..Sound Pressure Level
SRKW...................................Southern Resident killer whale

SSPS....................................... Shared Strategy for Puget Sound
TISEC .... tidal instream energy conversion
TL.. total length
TOB....................................... One-third octave band
TTS .... temporary threshold shift
USACE .... U.S. Army Corps of Engineers
USEPA.................................. U.S. Environmental Protection Agency
USFWS .... U.S. Fish and Wildlife Service
USOAP .... U.S. Ocean Action Plan
WDF...................................... Washington Department of Fisheries
WDFW.................................. Washington Department of Fish and Wildlife
WSDNR................................ Washington State Department of Natural Resources
WWTIT................................. Western Washington Treaty Indian Tribes
μPa .... micropascal
μT.. micro Tesla

Section 1
Introduction

Public Utility District No. 1 of Snohomish County (the District) is engaged in the permitting process to develop the Admiralty Inlet Pilot Tidal Project (Federal Energy Regulatory Commission [FERC or Commission] 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).

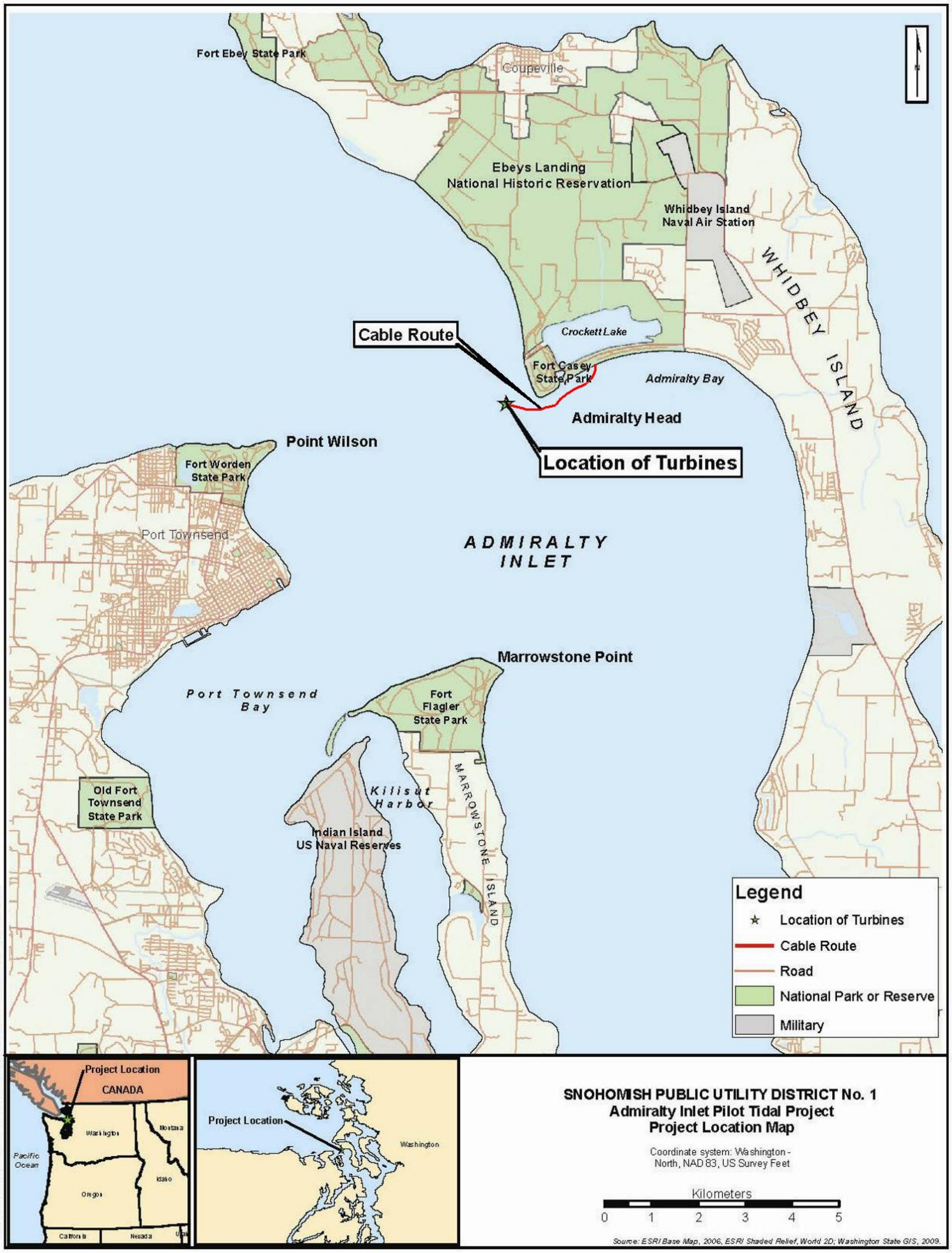
This Project would temporarily place two 6-meter diameter OpenHydro turbines (actual rotor diameter will be 4.7 meters) in a high-current area approximately 58 meters deep and 1 kilometer offshore of Admiralty Head, Washington. With an estimated capacity of 680 kilowatts (kW),[1] the Project would provide approximately 216,000 kilowatt-hours (kWh) annually of clean renewable ocean energy. Power would be transferred to the grid via a seabed cable to Whidbey Island. The cable deployment will utilize Horizontal Directional Drilling (HDD) from a minimum depth of 18 meters to land to avoid disturbing nearshore 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. The only anchors proposed for this Project are described in section 2.2.1.4 and will be used to assist in monitoring and maintenance activities. The turbines and their foundations are specifically designed to be completely removable for scheduled maintenance or other needs.

1.1 Project Background

While the Project will produce a modest amount of energy, the driving purpose 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] Expected 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



The Project is envisioned to represent a multi-year pilot demonstration effort for tidal energy deployment in Admiralty Inlet as shown below in Table 1-1. Phase I feasibility studies have been completed, and the results of that effort warrant progressing to Phase II for a pilot demonstration project at the Admiralty Inlet site.

TABLE 1-1
PROJECT PHASES

Phase	Duration	Key Assumptions	Date
Phase I Tidal Energy System Definition and Economic Feasibility Study	2 years	Survey seven sites in Puget Sound; characterize tidal instream energy conversion (TISEC) device selections; perform preliminary design, performance analysis, and economic assessment of a selected site; identify site -specific environmental and regulatory issues; measure current velocity profiles; and initiate current velocity modeling.	Completed (2007-2008)
Phase II **Pilot Project Engineering Design and Permitting**	**2 years**	**TISEC plant design, environmental studies, permitting, and construction plans for Admiralty Inlet Pilot Project.**	**2009-2011**
Phase III Demonstration Project Construction	1 year	Construction of 700-kW Admiralty Inlet Pilot Project	2011-2013
Phase IV Demonstration Project Operation and Evaluation	Up to 5 years	Project operations and associated performance/cost and environmental effects data gathering and analysis/evaluation.	2013-TBD

The Project has received substantial funding from the Bonneville Power Administration as well as a grant from the U.S. Department of Energy Advanced Water Power Projects program. Key Project partners include the University of Washington (Departments of Mechanical Engineering and Oceanography, the Applied Physics Laboratory, and the new Northwest National Marine Renewable Energy Center), the Electric Power Research Institute (EPRI), the National Renewable Energy Laboratory, and U.S. Department of Energy Pacific Northwest National Laboratory (PNNL) (Marine Sciences Laboratory).

1.2 Existing ESA Consultation

Since applying for a preliminary permit for the Project site on June 15, 2006, the District has engaged in extensive technical assistance with National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and other governmental, private, and tribal representatives. This included soliciting input from the NMFS and USFWS and other stakeholders in the development of its pre-installation study plans and (post-installation) monitoring plans.

The discussions with agencies, tribes, and other stakeholders can be broken into two categories. The first category of consultations can be characterized as general presentations and discussions of the Project as a whole or of large aspects of the Project. These discussions were held with all stakeholders, including many held at town halls and other local forums to solicit feedback from members of the public most likely to be impacted by the Project. The majority of these discussions are documented in the District's biannual preliminary permit progress reports submitted to the Commission.

The second category of consultations was discussions focused on a specific species or potential impact. These discussions were primarily held with agencies and tribes, and ultimately identified all of the potential Project impacts, the likelihood of significant harm from those impacts, and the need for measures to mitigate or monitor species' interaction with the turbines or other Project facilities. The District primarily worked with these agencies and tribes in formulating pre-installation study plans and reporting on the results of those investigations. To assist in resolving disputes between the District and some stakeholders, the group utilized a professional facilitator during discussions during 2010.

On November 5, 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 Endangered Species Act (ESA) and the Magnuson-Stevens Fishery Conservation and Management Act for the Project. As the Commission's non-federal representative, the District informally consulted with the appropriate agencies and tribes as part of the various consultations described herein during implementation of pre-installation study plans and the reporting of results.

The following summary of the consultation efforts leading up to the filing of the Final License Application does not include consultation that occurred via email or phone. Supporting consultation documents are available upon request.

The District requested lists of threatened and endangered species from USFWS and the National Oceanic and Atmospheric Administration (NOAA) in a letter dated December 3, 2007. The USFWS directed the District to their online listing of Washington species and, most recently, NOAA provided a list of species in a letter to the District and FERC, dated August 11, 2010. Each species was assessed for potential to occur in the Project area based on habitat requirements and known distributions. 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 1-2).

TABLE 1-2
LIST OF FEDERALLY PROTECTED ESA SPECIES POTENTIALLY OCCURRING IN THE PROJECT AREA

Common Name (Stock)	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

Common Name (Stock)	Scientific Name	Federal Status	Relevant Recovery Plans and Status Reports
Green Sturgeon (Southern DPS)	*Acipenser medirostris*	CH T	NMFS 2005*c*
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*a*
Marine Mammals			
Orca (Southern Resident Killer Whale)	*Orcinus orca*	CH E	NMFS 2008*c*; Krahn et al. 2004
Humpback Whale (North Pacific)	*Megaptera novaeangliae*	E	NMFS 2005*e*, 1991
Steller Sea Lion (Eastern)	*Eumetopias jubatus*	CH T	NMFS 2008*e*; 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
Sources: Letter from NMFS dated December 8, 2008 and July 6, 2009; email from NMFS (Alicia Bishop dated August 11, 2010).

The vast majority of stakeholder comments on the Final License Application 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 Action Area

2.1 Action Area

Puget Sound is a semi-enclosed body of water in which salt water from the nearby 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, Kitsap County) and Whidbey Island (Island County), where the northwestern end of Puget Sound connects to the Strait of Juan de Fuca.

The anticipated deployment site will be located approximately 1 kilometer west-southwest of Admiralty Head in water depth of approximately 58 meters (Figure 2-1). Turbine 1 (eastern turbine) will be located at approximately latitude 48.152867° N, longitude -122.686162° W, and Turbine 2 (western turbine) will be located at approximately 48.152842° N, longitude -122.687099° W. This location was based on the results of the feasibility studies, Acoustic Doppler Current Profiler (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.

For purposes of ESA Section 7 consultations, *Action area* is defined to mean all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02). The action area is further defined as the geographic extent of the potential physical, biological, and chemical effects of the project above the baseline conditions. The Project action area is the Project footprint[2] and an area around the turbine deployment location to a distance of 675 meters. This distance is chosen because it is the furthest extent at which marine mammals would be exposed to sound pressure levels of 120 dB (re 1µPa) based on the 95th operating percentile. This sound pressure level is the NMFS Level B Harassment threshold for marine mammals and was calculated for when the turbines are operating at 2.3 m/s. This is discussed further in Section 5.4.2. The Project action area encompassing the subsea transmission cables is 20 meters wide, as the subsea transmission cables are anticipated to be spaced approximately 6 meters, and therefore the 20 meter corridor should encompass the cables.

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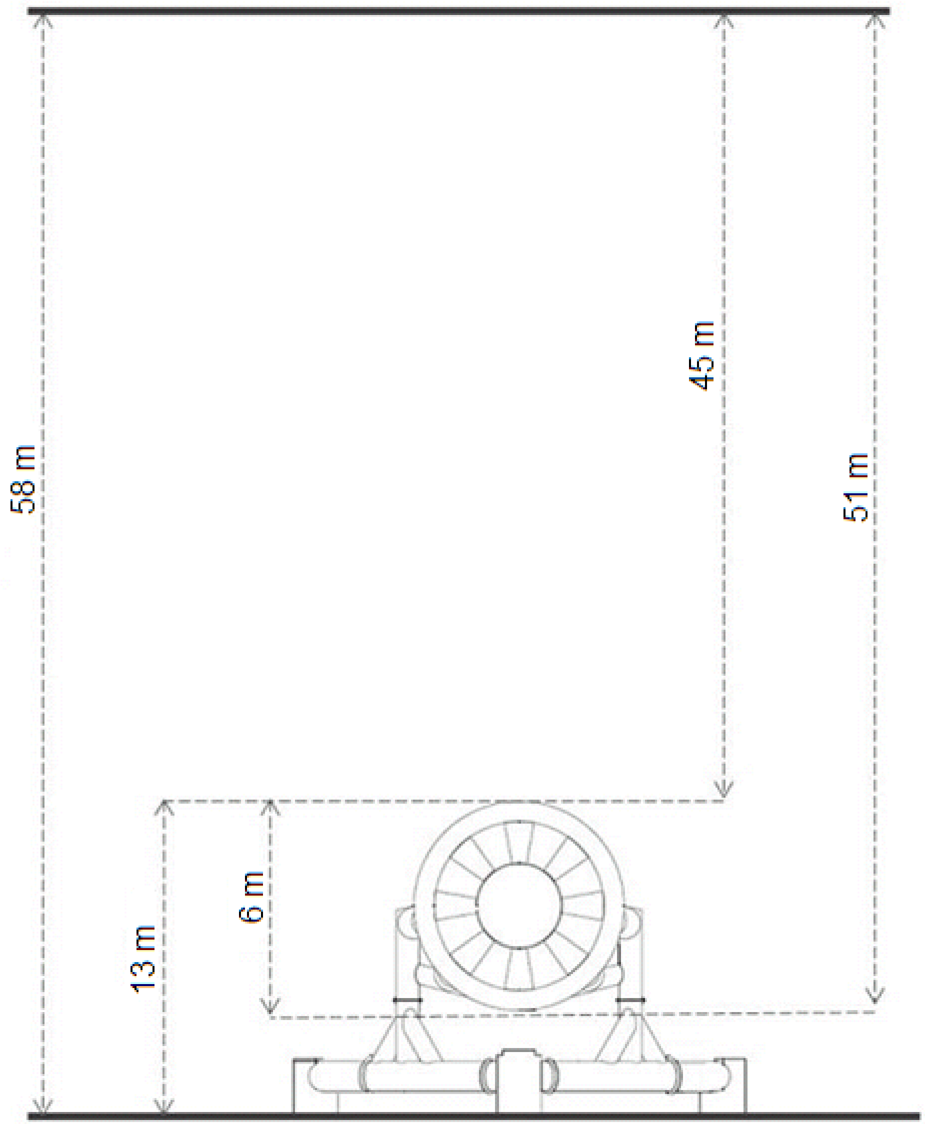
[2] As described in Section 2.2, the Project components include: two turbines, a subsea cable, and a terrestrial transmission line (including the cable termination vault and Power Conditioning and Control building).

FIGURE 2-1
DIMENSIONS OF TURBINES IN RELATION TO DEPTH AT DEPLOYMENT SITE



Note: Figure not to scale

2.2 Description of Proposed Action

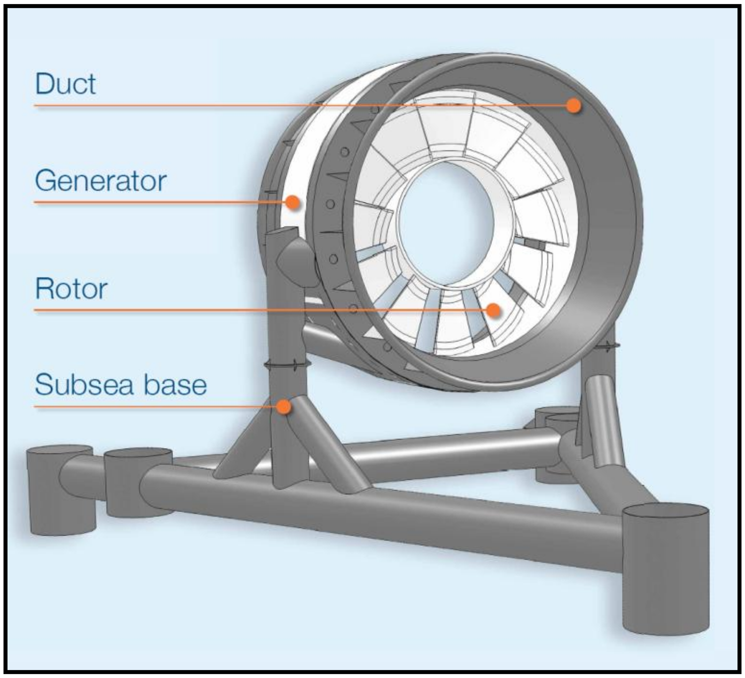
2.2.1 Proposed Project Facilities

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 2-2). 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 2-2
OPENHYDRO TURBINE[3]



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 ESA-listed species:

- 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 ESA-listed species (not whales).

The turbines will have a diameter of 6 meters (actual rotor diameter will be 4.7 meters) and will be rated between 250-400 kW each. The turbine will have 10 rotor blades (edges of rotor blades are enclosed) and the following approximate dimensions[4]:

- Height of turbine - 13 meters above the seabed,
- Centerline of turbine - 10 meters above the seabed,

[3] 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.
[4] The hydrodynamic design of the turbine is under continual revision as the technology develops and the number of blades and turbine dimensions may be subject to change.

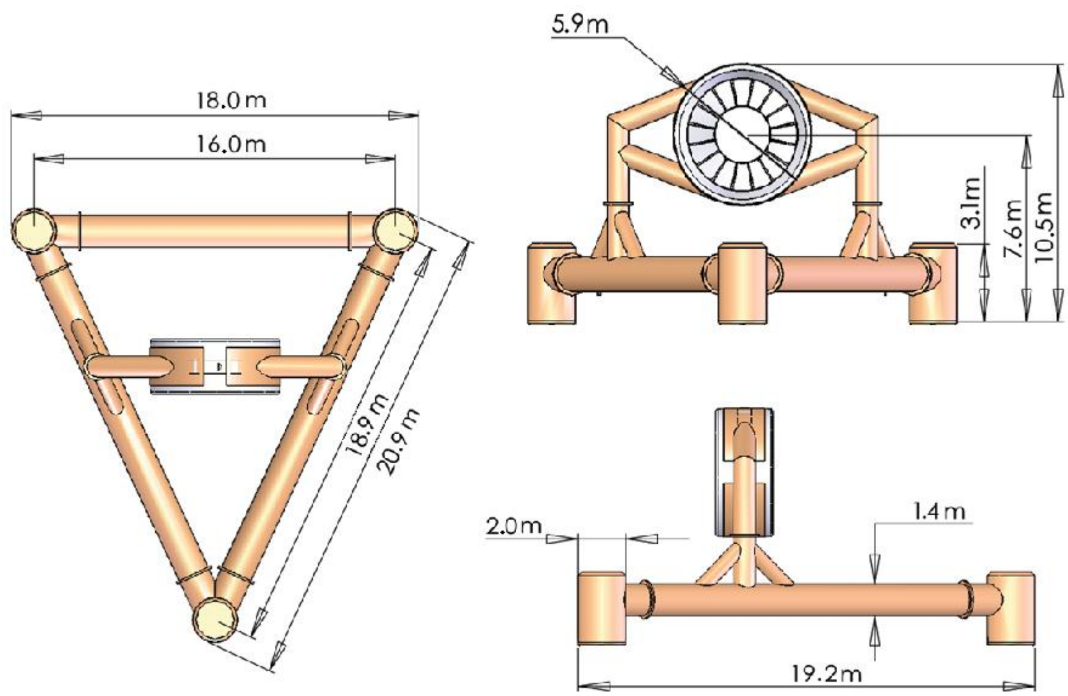
- Venturi/duct diameter - 5.9 meters,
- Turbine stator diameter - 5.9 meters,
- Turbine rotor diameter - 4.7 meters, and
- Turbine inner ring diameter - 2.2 meters.

2.2.1.2 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 2-3 shows the plan, front, and side elevation views of the 6-meter turbine and subsea base. Figure 2-4 shows a constructed unit that was deployed in Nova Scotia.

FIGURE 2-3
OPENHYDRO TURBINE (PLAN, FRONT, AND SIDE VIEWS)



Note: Dimensions in meters

FIGURE 2-4
TRIAL ASSEMBLY OF 10 METER OPENHYDRO TURBINE AND SUBSEA BASE (DARTMOUTH, NOVA SCOTIA, CANADA)

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.

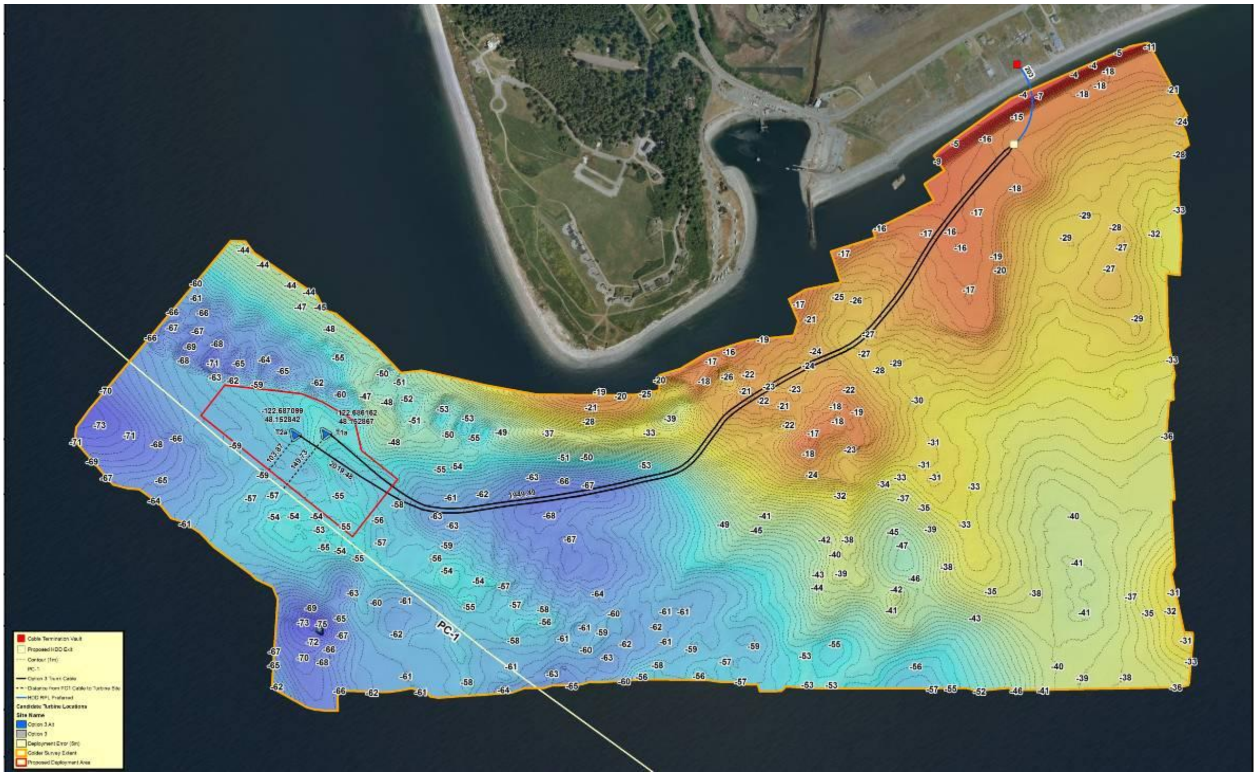
No seabed preparation, multiple operations or time-consuming drilling, piling or pinning work is required. The subsea base foundation is designed to penetrate the cobbled top layer of seabed. The footprint of the structure will be three legs, covering a maximum area of approximately 10 square meters. 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.

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 on private land within the Ebey's Landing National Historic Reservation, just east of Admiralty Head. The general configuration of the cables and shore landing is shown in Figure 2-5. The two trunk cables will be routed through a single HDD bore from on land to a minimum depth of 18 meters. From the HDD exit underwater, the cables will continue on the surface of the seabed to the turbines.

FIGURE 2-5

PROJECT TRANSMISSION ROUTE

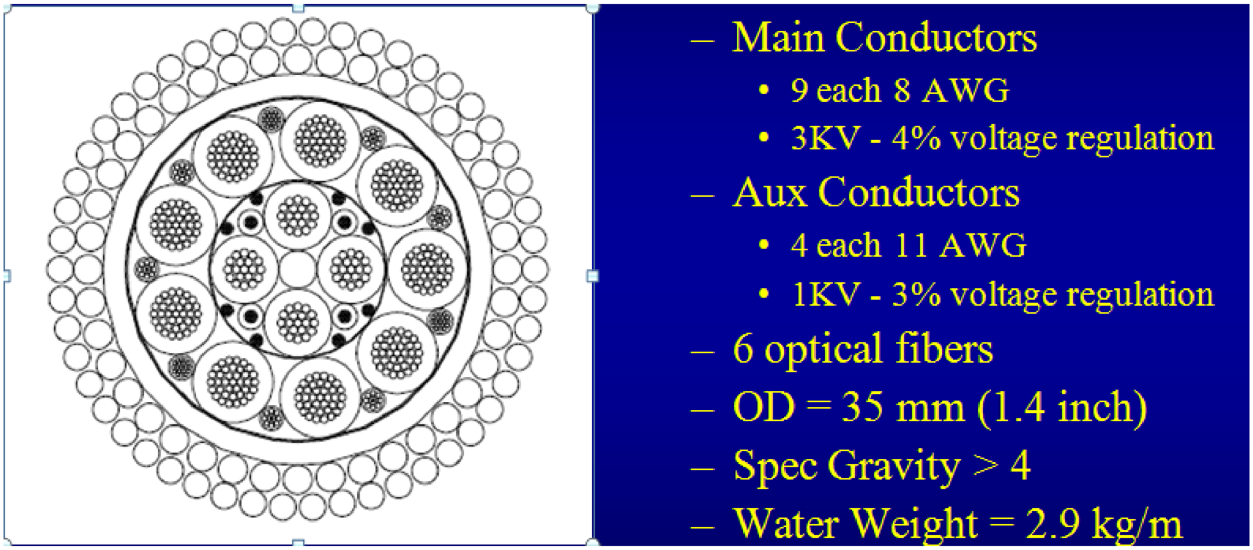


Note: Soundings in meters

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 2-6.

FIGURE 2-6

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 specifically designed with a high Specific Gravity in order 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 cable 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 cable may have to be pinned to the bottom. This is done with weighted sacks or other cable stabilization techniques used in the industry (personal communication, 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

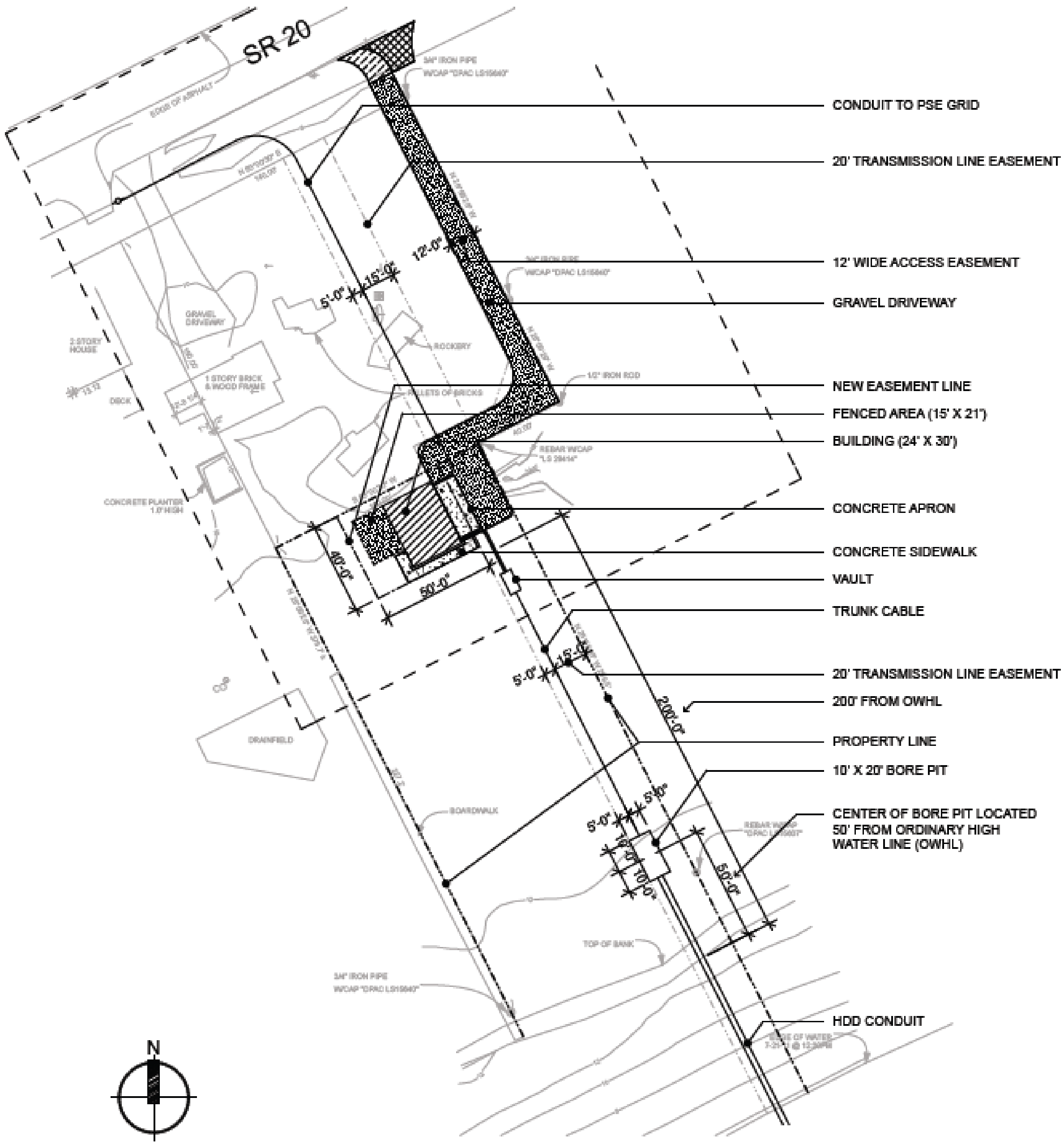
A two anchor mooring system is planned to be installed for installation and operations support. The anchors are installed to the east of the turbine locations so that they are positioned far away from the existing PC-1 telecommunications cable. The anchors are embedment type with gravity suppressor weights 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 cable leading to the Cable termination vault,
- Cable termination vault,
- Underground cable from the cable termination vault to the control room,
- Control room, and
- Underground cable from the control room to the PSE grid (Figure 2-7).

FIGURE 2-7
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 2-8
REPRESENTATION OF CONTROL ROOM SITE

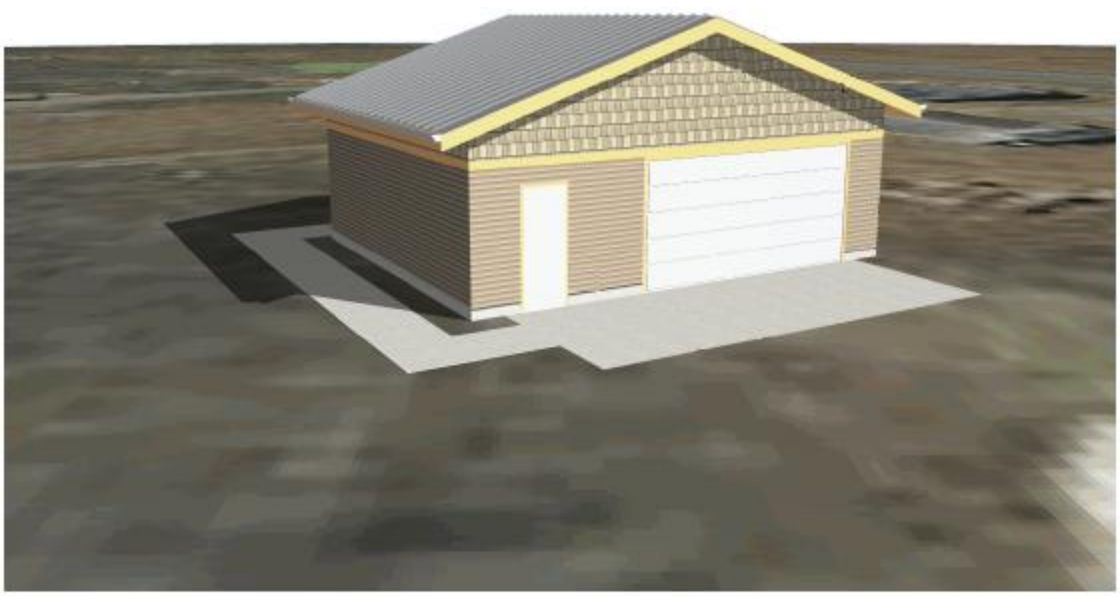
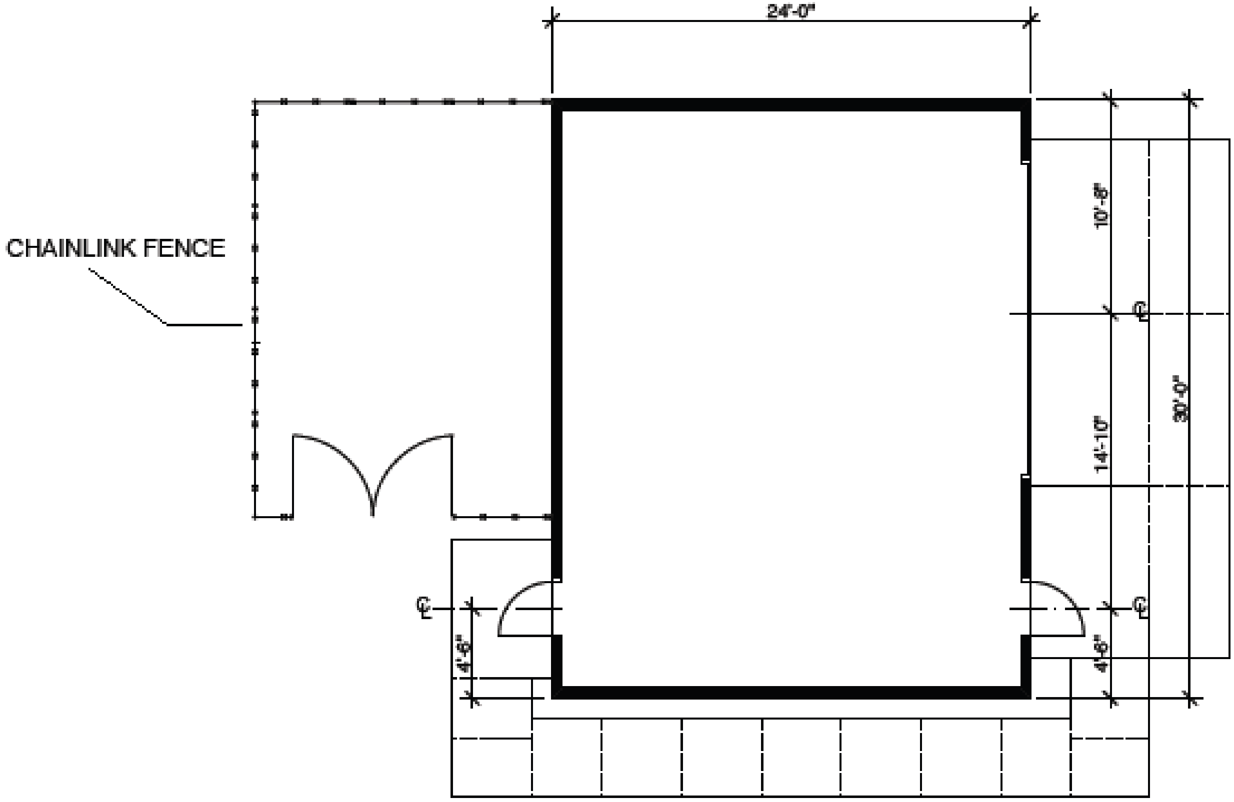


FIGURE 2-9
CONTROL ROOM PLAN



Back Haul Cable to the PSE Grid

From the below ground cable penetration at the control room, the AC power cable will be run underground 70 meters to the 12-kilovolt 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 construction and HDD operation. It then proceeds offshore where the deployment of the 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 2-7. 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.

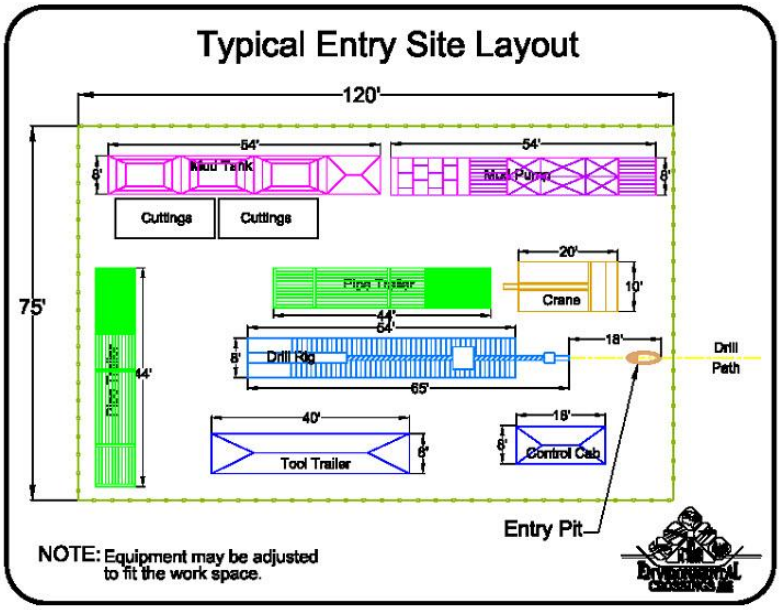
Shore Landing - HDD Operations

Overview

The shore landing of the subsea trunk 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. 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 2-10
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, usually 6 to 8 foot in diameter and 4 to 5 feet deep, will be excavated at the bore entry. 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 2-11
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.

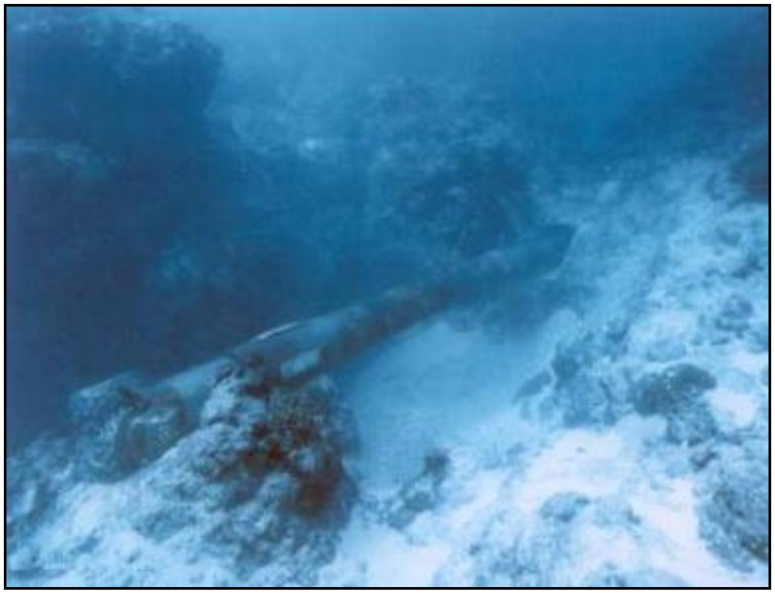
The total time to deploy, drill, demobilize, and restore the grounds typically takes approximately 45 days.

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 it is possible for drilling mud to escape onto the surface or into the water (called a fracout). While no fractures are expected in this glacially deposited substructure, the driller will monitor for a fracout. 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 fracout. 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 2-12
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[5].

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,
- Remotely operated vehicle (ROV), and
- Small support vessels.

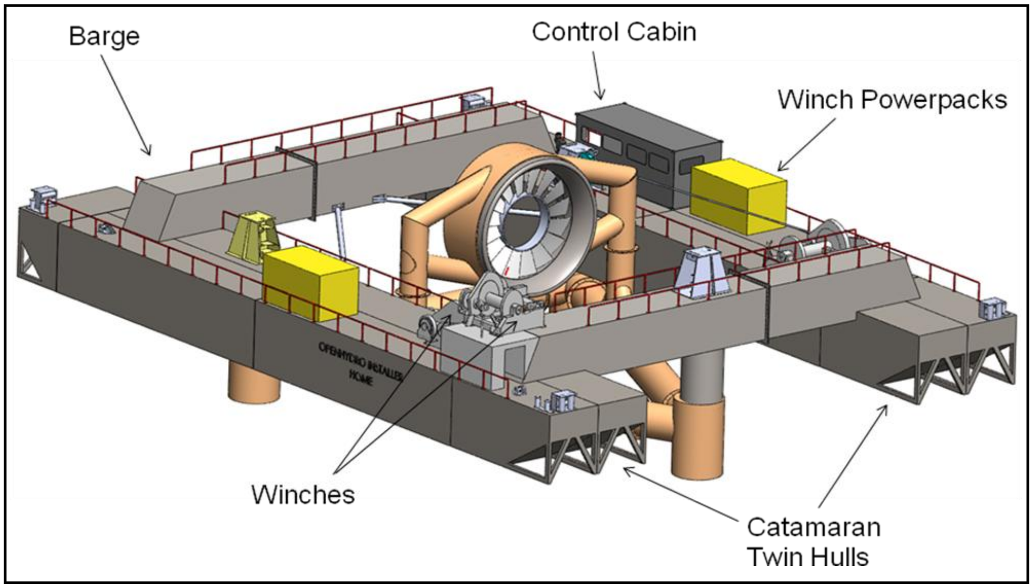
The turbines will be installed using a specialized heavy lift turbine installation barge. Initial testing of the deployment methodology occurred with the successful deployment of a test unit at the EMEC facility in 2008 and a subsequent deployment of an operational unit occurred in Nova Scotia in November 2009.

[5] 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.

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 2-13
HEAVY LIFT OPENHYDRO TURBINE INSTALLATION BARGE

FIGURE 2-14
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 four-point 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

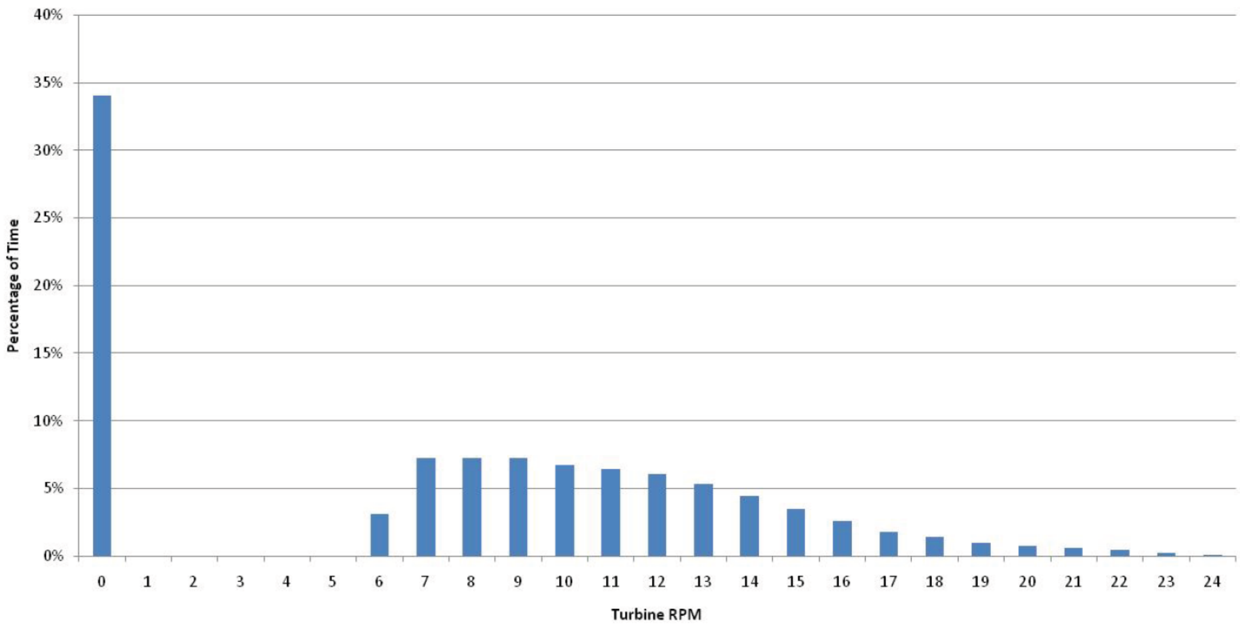
The two turbines will be deployed for up to five years. During that time, the turbines are expected to rotate 70 percent of the time (when sufficiently high water velocities to rotate the turbines will occur).

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 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 revolutions per minute (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 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 20 rpm (Figure 2-15).

FIGURE 2-15
CUMULATIVE 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).

OpenHydro has developed an electrical braking system for its turbines which has been tested at EMEC. While this system does not physically stop the turbines, it slows rotation to less than 5 rpm and generation is ceased, thereby making the turbine electrically safe. From testing of six meter turbines at EMEC, OpenHydro estimates that, when the electrical brake is applied to the turbine, rotation will be approximately 5 rpm at the maximum tidal current flow, which would equate to a tip speed of 1.2 meters per second (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 in-balances. The tilt sensors will monitor the turbine for long-term settling.

- ROV - An ROV will be used to inspect the turbines and the area in the vicinity of the turbines on an as-needed basis.

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 in order to survive in the marine environment and to minimize operational cost it is essential that the units both 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
- 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

Pending the results from the above inspections it may be necessary to recover the turbine and return it to port for maintenance. The planned maintenance schedule for removing the turbine for maintenance is five years after deployment. 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 a grid power outage, an uninterruptible power supply and power conditioner will provide continuous power to the control 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 non-destructive testing (NDT) weld tests.

If required:

1. Replace anodes as required, and
2. Repairs to Subsea Base / umbilical connection if required.

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 after five years 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, and
- 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.

The turbine 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 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 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 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 transmission cables from on land to a minimum depth of 18 meters to avoid impacts to eelgrass and sensitive near-shore areas;
- 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 very close to shore, that has been previously developed, and that requires no overhead transmission lines and no new roads;
- Minimize effects to shipping by siting the Project outside of the shipping channel and away from the Port Townsend-Coupeville ferry route and at sufficient depths to allow for acceptable navigational clearances even for deep draft shipping vessels;
- Minimize use of antifouling paint - only the turbine rotor and portions of the stator and venturi duct of each unit will require antifouling paint (non-flaking paint to be used);
- Conduct installation work only during WDFW-approved work windows;
- Implement a Near-Turbine Monitoring Plan;
- Implement a Benthic Habitat Monitoring Plan;
- Implement an Acoustic Monitoring Plan;
- Implement a Derilict Gear Monitoring Plan;
- Conduct benthic habitat monitoring;
- Implement a Marine Mammal Monitoring Plan during Project construction, operation, and removal using shore observers and passive acoustic hydrophones;
- Utilize Doppler profilers and Doppler velocimeters to monitor tidal currents at the Project site. Doppler frequencies will be at least 450 kHz;
- Implement a Water Quality Monitoring Plan, including monitoring during Project construction and removal;
- Implement a Horizontal Directional Drilling (HDD) Plan during HDD activities;
- Implement a Project Safety Plan;
- Implement a Navigation Safety Plan;
- Implement an Emergency Shutdown Plan, if needed;
- Implement a Project Removal Plan, if needed; and
- Implement an Adaptive Management Program to modify project and project operations, as necessary, based on monitoring results.

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 and monitoring studies (pre- and post-installation). 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.

Section 3
Environmental Baseline

The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

3.1 Admiralty Inlet and Project Location

The District conducted a geophysical study in June, 2009 (Sound and Sea Technology 2009). The seabed along the cable route appears to be composed primarily of cobbles and pebbles, as well as some coarse sand. In the turbine deployment area, videography and grab samples showed that the seafloor is covered by gravel, cobbles, and boulders. The video footage found no sediment deposition in the turbine deployment areas, and the substrate was mostly cobble 6 to 18 centimeters in diameter (National Northwest Marine Renewable Energy Center [NNMREC] 2009*a*). Strong currents have apparently removed fine grain sands, silts, and clays from the seafloor, leaving coarse sands, gravels, and boulders (Fugro 2009).

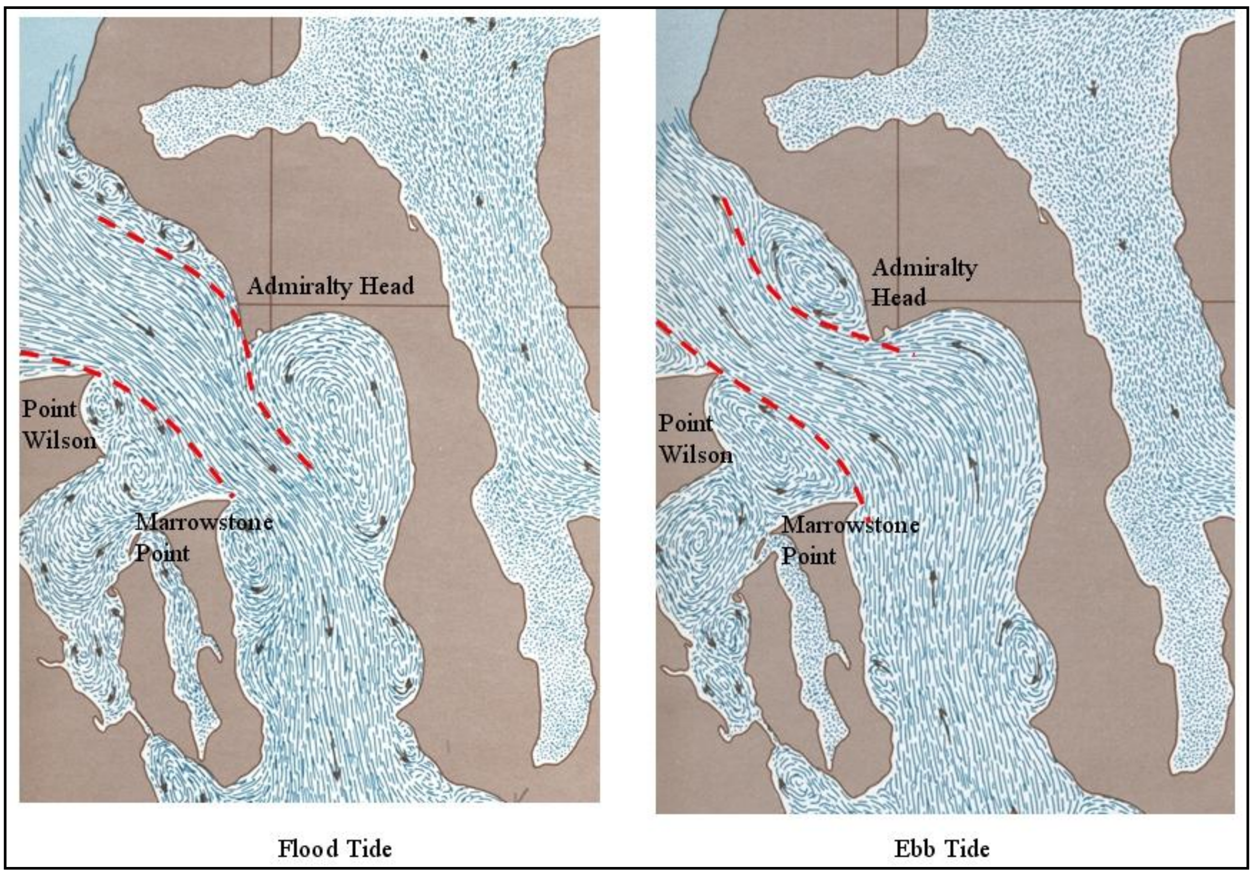
To further characterize the site-specific benthic habitat and community, ROV surveys in the Project area were conducted in August and late September and early October 2010. As observed in the NNMREC ROV study and the geophysical study described above, the Project area was dominated by coarse grain substrate (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).

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 3-1. Strong currents occur within the site because the relatively narrow and shallow channel reduces the cross-sectional area (213,000 to 317,000 square meters) and regulates flow. Currents in the central portion of the inlet are effectively bi-directional, and velocities of 2.6 m/s (Polagye et al. 2007) and 2.2 m/s (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 3-1).

TABLE 3-1
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 3-1
FLOOD AND EBB EDDIES IN NORTHERN ADMIRALTY INLET*



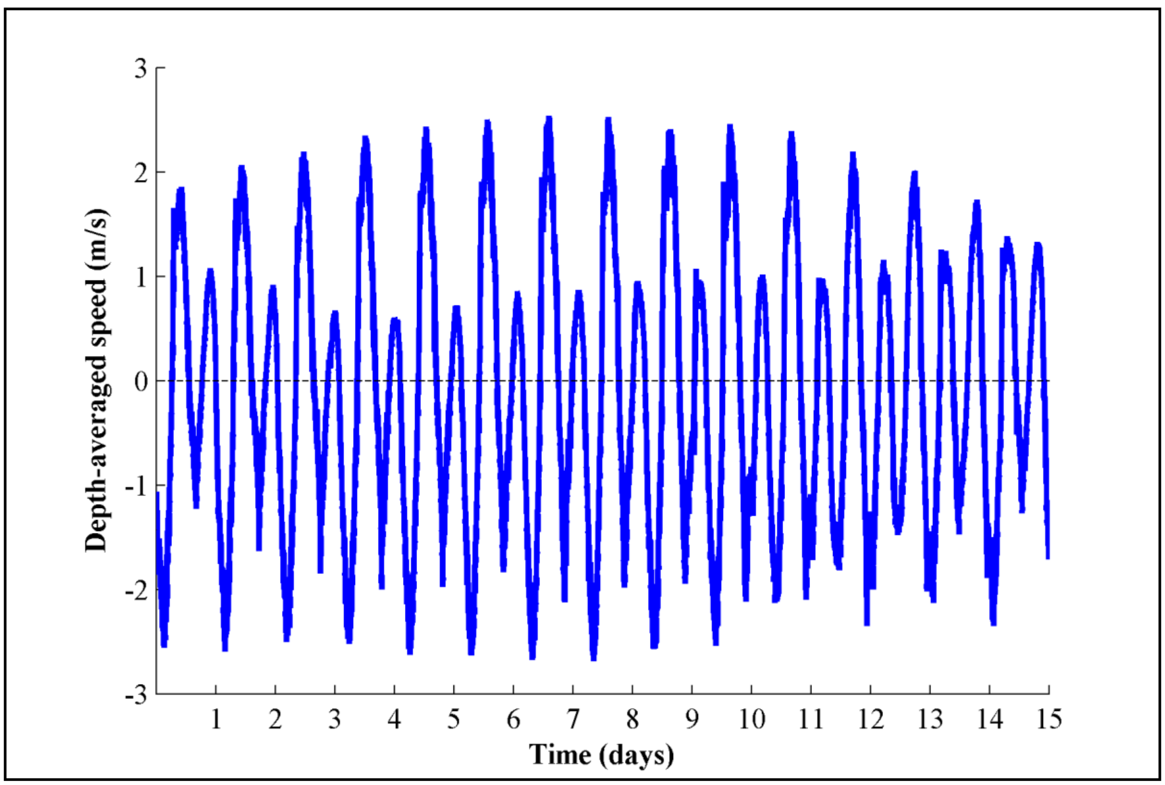
* The eddy-free region on ebb and flood are marked by dashed red lines.
Source: McGary and Lincoln 1977

To characterize the tidal resource at the Project site, the University of Washington Northwest National Marine Renewable Energy Center (NNMREC) conducted stationary and mobile ADCP surveys in the Project area. NNMREC deployed stationary ADCPs on several Sea Spiders at the site beginning site on April 9, 2009 and has since recovered data on many occasions. 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, maximum and mean kinetic power density, vertical shear, directionality, and ebb/flood asymmetry.

The mean, depth-averaged, water velocity is plotted in Figure 3-2 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.

In order to understand the annual tidal profile of the site, the tidal velocity was predicted for the year 2009 in 10 minute intervals. The maximum predicted harmonic velocity is 3.24 m/s. The average tidal velocity magnitude is 1.135 m/s.

FIGURE 3-2
REPRESENTATIVE DEPTH-AVERAGED VELOCITY PLOT FROM STATIONARY MEASUREMENTS IN THE PROJECT AREA



Invertebrates that inhabit Admiralty Inlet include dock shrimp, Alaskan pink shrimp, giant barnacle, Dungeness crab, red rock crab, green sea urchin, red sea urchin, sunflower star, red sea cucumber, pink scallop, northern horse mussel, California market squid, gigantic anemone, and warty sea squirt (personal communication, W. Palsson, WDFW).

The most numerous fish sampled during 50 WDFW Admiralty Inlet trawls from 1987 to 2008 at trawl depths of 31 to 60 meters (102 to 198 feet), a depth range within which the turbines will be, were: spotted ratfish (65 percent of the catch), 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)[6].

All species of anadromous salmonids originating from the Skagit River, Stilliguamish 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).

Marine mammal species that are observed in central Puget Sound include harbor porpoise, Dall’s porpoise, killer whale, Minke whale, gray whale, California sea lion, Steller sea lion, harbor seal, and northern elephant seal[7]. 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).

From WDFW vessel surveys conducted from 1992 through 2004, the following were the most numerous shorebird and seabird species observed within 0.4 kilometers (0.25 mile) of Admiralty Inlet: bufflehead, common murre, rhinoceros auklet, glaucous-winged gull, Heermann's gull, western grebe, surf scoter, and American wigeon (Seamap 1992).

3.2 Cable Route and Landing

The entire terrestrial portion of the Project is contained on private land within the Ebey’s Land Historical Reserve. All the terrestrial components will be buried with the exception of the control room.

3.3 Activities Currently Affecting Listed Species in the Action Area

Habitat within the action area remains in a natural state. While no specific development actions have occurred for the Project action area, recreational fishing and vessel traffic represent activities that can result in the take of listed fish species.

6 No summary report has been developed, and therefore, G. Ruggerone called W. Palsson, specifically for this Project, regarding the referenced data.

7 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).

Commercial fishing for salmon ended in Admiralty Inlet in the early 1990s because this area is non-terminal (mixed stocks passing through) (personal communication, L. Hoines, WDFW, with G. Ruggerone, NRC, Inc.). Sport fishermen frequently troll for Chinook salmon, including resident Chinook salmon during winter in Admiralty Inlet, including at the Project site (Salmon University 2011). Chinook salmon are often hooked while fishing with downriggers near the bottom, often in water that is approximately 15 to 42 meters (50 to 140 feet) depending on location. The average sport catch of salmon in Admiralty Inlet (Area 9) during 2000 to 2006 is shown in Table 3-2 (pink salmon are only captured in odd-numbered years) (personal communication, S. Thiesfeld, WDFW with G. Ruggerone, NRC, Inc.).

TABLE 3-2
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

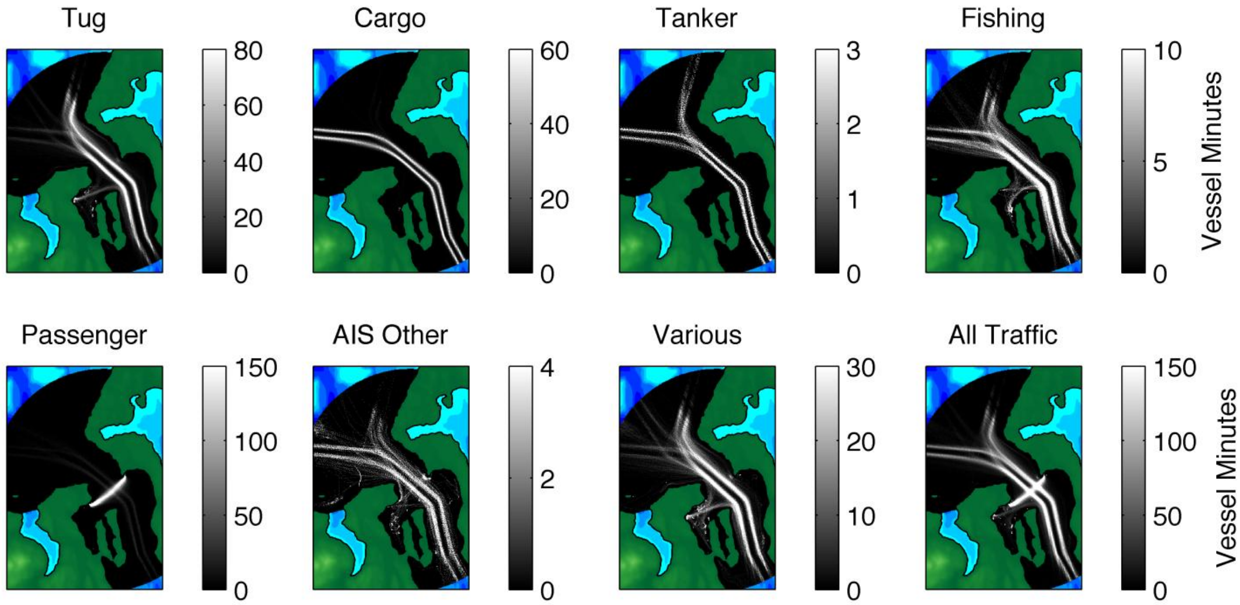
Source: Personal communication, S. Thiesfeld, WDFW, with G. Ruggerone, NRC, Inc.

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 3-3 and 3-4). The Port Townsend-Coupeville ferry runs about 1.5 kilometers from the turbine deployment site. 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 3-3
SHIPPING TRAFFIC IN NORTHERN ADMIRALTY INLET

Source: Polagye et al. 2007

FIGURE 3-4
VESSEL TRAFFIC DENSITY IN ADMIRALTY INLET



Source: Bassett et. al, (submitted)

The Project action area is outside of both the shipping lanes and ferry route - the turbines will be deployed approximately 920 meters outside of the shipping lanes; however, tugs and barges sometimes use the waters outside the shipping lanes. Whale watching is popular in other areas of Puget Sound, though not in the Project area.

Section 4

Listed Species and Critical Habitat

4.1 Listed Species

Species considered for inclusion in this section were drawn from consultation with NMFS and USFWS. The District requested species lists from NMFS and USFWS 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 listed species in a letter to the District and FERC, dated July 6, 2009. On August 11, 2010, NMFS provided an updated list of listed species in an email correspondence. Each species was assessed for potential to occur in the Project area based on habitat requirements and known distributions. 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 4-1).

TABLE 4-1
LIST OF FEDERALLY PROTECTED ESA SPECIES POTENTIALLY OCCURRING IN THE PROJECT AREA

Common Name (Stock)	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*c*
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*a*
Marine Mammals			
Orca (Southern Resident Killer Whale)	*Orcinus orca*	CH E	NMFS 2008*c*; Krahn et al. 2004
Humpback Whale (North Pacific)	*Megaptera novaeangliae*	E	NMFS 2005*e*, 1991
Steller Sea Lion (Eastern)	*Eumetopias jubatus*	CH T	NMFS 2008*e*; Angliss and Outlaw 2006
Birds			
Marbled Murrelet	*Brachyramphus marmoratus*	CH T	USFWS 2003, 1997

Common Name (Stock)	Scientific Name	Federal Status	Relevant Recovery Plans and Status Reports
Plants			
Golden Paintbrush	*Castilleja levisecta*	T	USFWS 2007, 2000

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

Each species is discussed below relative to known or expected distributions, habitat requirements, existing biological opinions, status reports, recovery plans, and designated critical habitat.

4.2 Puget Sound Chinook Salmon

4.2.1 Current Status

NMFS listed the Puget Sound evolutionarily significant unit (ESU) of Chinook salmon (*Oncorhynchus tshawytscha*) as a threatened species on March 24, 1999 (64 FR 14308-14328) and reaffirmed the listing on June 28, 2005 (70 FR 37160-37204). The Puget Sound ESU includes all naturally spawned populations of Chinook salmon from rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca from the Elwha River eastward, including rivers and streams flowing into Hood Canal, South Sound, North Sound and the Strait of Georgia in Washington, as well as 26 hatchery programs. Factors threatening naturally spawned Chinook salmon throughout its range are numerous and varied. The present depressed condition is the result of several long-standing, human-induced factors including habitat degradation, water diversions, harvest, and artificial propagation (64 FR 14316). Recovery efforts for the Puget Sound population of Chinook salmon are addressed in the Puget Sound Salmon Recovery Plan (Shared Strategy for Puget Sound [SSPS] 2007).

4.2.2 Life History and Presence in the Action Area

Chinook salmon exhibit two life histories: ocean-type and stream-type. Ocean-type Chinook salmon generally migrate from freshwater to the marine environment as sub-yearlings; however, if environmental conditions are not conducive to outmigration, they may remain in freshwater for their entire first year (Meyers et al. 1998). Populations of Puget Sound Chinook salmon exhibit a great deal of variation in the timing of outmigration by juveniles (SSPS 2007). Stream-type Chinook salmon generally remain in freshwater for two years, sometimes three years before entering saltwater. Ocean-type Chinook utilize estuaries and coastal waters, whereas, stream-type Chinook utilize freshwater systems and a variety of habitats within these systems (Meyers et al. 1998).

The Puget Sound Chinook salmon ESU is composed of 31 historically quasi-independent populations, 22 of which are believed to be extant currently (NOAA 2005a). The populations presumed to be extirpated are mostly early returning fish; most of these are in mid to southern Puget Sound or Hood Canal and the Strait of Juan de Fuca (Good et al. 2005). The 22 distinct stocks of Chinook salmon in the Puget Sound ESU, including spring-, summer-, and summer/fall or fall-run stocks. Spring-, summer-, and fall-run stocks show similarities in life histories, including emigration timing, age at maturation, and ocean migration. Upon entering saltwater, Chinook salmon remain at sea for one to six years, but more commonly two to four years, before returning to their natal streams to spawn. While at sea, Chinook salmon exhibit coastally oriented ocean migration patterns. Chinook salmon originating from Puget Sound tributaries predominantly mature as three or four-year olds (SSPS 2007).

Adult Chinook salmon from Puget Sound tributaries return to their natal streams, or in some cases, nearby streams with similar characteristics during late March to early December (SSPS 2007). Most adult summer-run fish returning to natal rivers or streams migrate through Admiralty Inlet. Summer- and fall-run Chinook salmon predominate in Puget Sound tributaries because spring-run Chinook salmon have become depressed (Myers et al. 1998). Summer-run Chinook salmon return in June and July and spawn in September. Fall-run Chinook salmon return in August and spawn from late September through January (WDFW et al. 1993, *cited in* Meyers et al. 1998). Spawning peaks from mid to late August to mid October (SSPS 2007).

Admiralty Inlet is an important environment for both juvenile and adult Chinook salmon. Juvenile Chinook use the shoreline and nearshore habitats in Puget Sound, including Whidbey Island, for foraging and rearing, prior to moving off-shore to deeper waters.

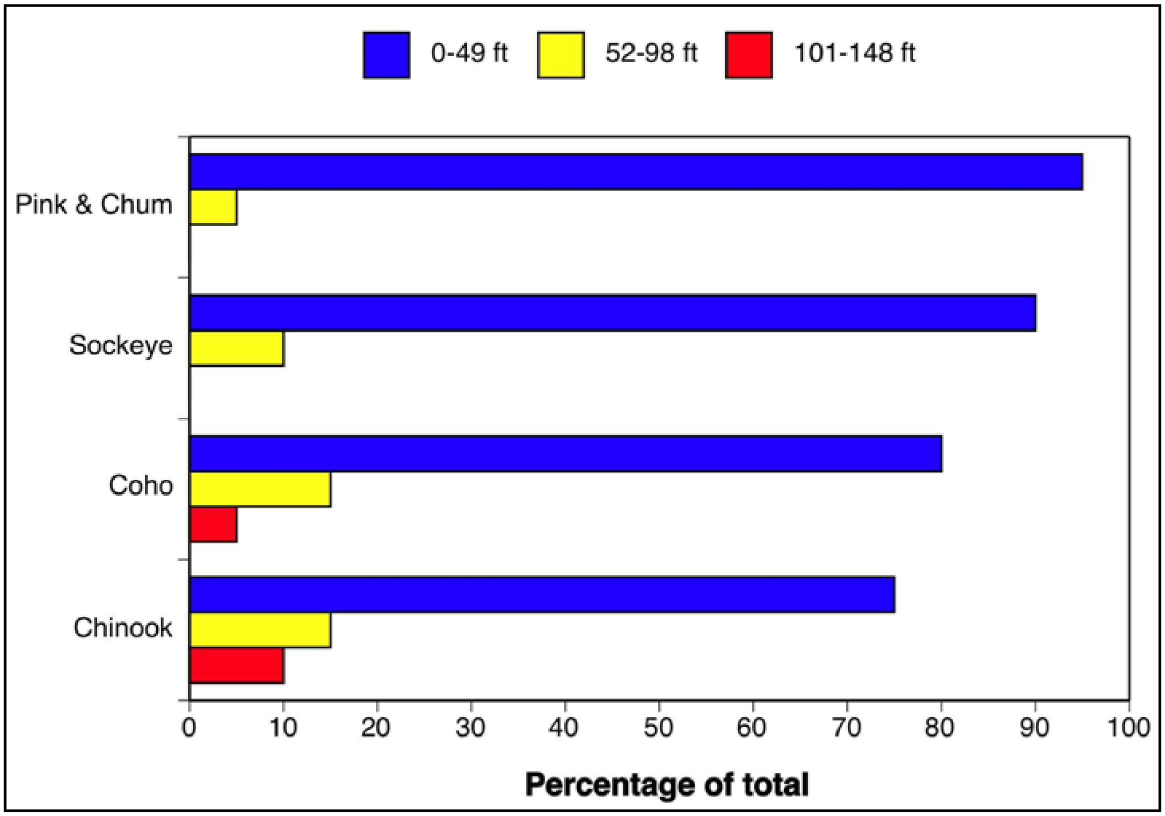
The Department of Fisheries and Ocean Canada (CDFO) examined the depth distribution of juvenile salmon in Puget Sound and the Strait of Georgia: CDFO has conducted over 158 tows since the late 1990s using the following methods:

- 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.).

The CDFO study results found that, similar to other salmonids, most juvenile Chinook salmon occupy shallower depths of the water column (personal communication, R. Sweeting, CDFO with G. Ruggerone, NRC, Inc.). Figure 4-1 shows the depth distribution for juveniles of five salmonid species sampled during the CDFO study. Approximately 75 percent of all juvenile Chinook salmon were located in the top 15 meters (49 feet) of the water column. Approximately, 15 percent and 10 percent of the juvenile Chinook salmon were captured at the 16 to 30 meter (52 to 98 feet) and the 31 to 45 meter (101 to 148 feet) depth intervals, respectively[8]. Although the age of these fish has not been analyzed, the CDFO noted that larger fish tended to be deeper in the water column. Also, juvenile Chinook salmon were observed to occupy deeper waters than other salmonids (Figure 4-1) (personal communication, R. Sweeting, CDFO, with G. Ruggerone, NRC, Inc.).

8 As will be discussed in Section 5, effects analysis, the two Admiralty Inlet turbine rotors will be located at a depth of 43 to 53 meters.

FIGURE 4-1
DEPTH DISTRIBUTION OF JUVENILE SALMON IN THE STRAIT OF GEORGIA AND PUGET SOUND



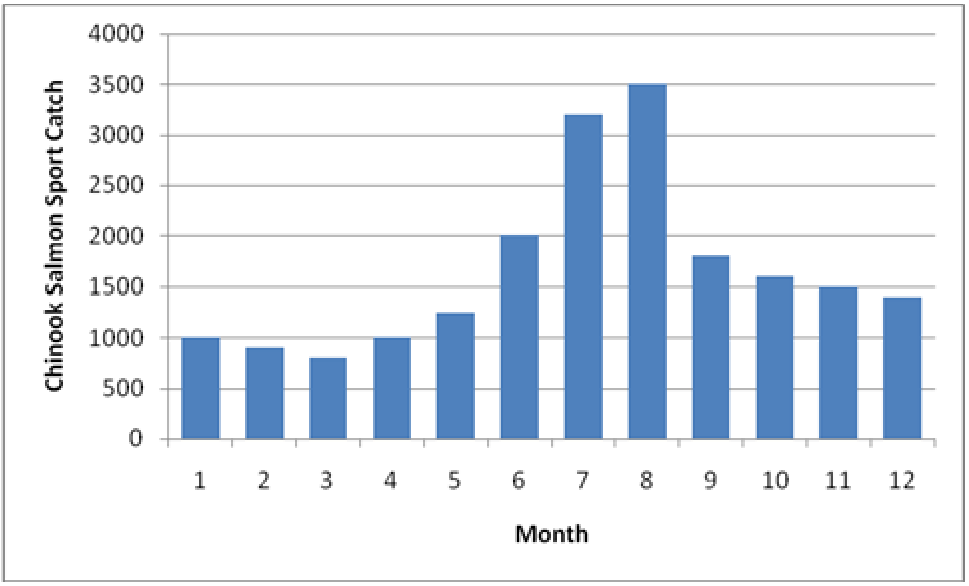
Source: Personal communication, R. Sweeting, CDFO

Hinke et al. (2005*a*) assessed tracking and archival tag data collected on 15 adult Chinook salmon to determine preferred areas and physical parameters off the California and Oregon coast. They found that salmon can travel over 160 kilometers, to depths of over 76 meters, and in water temperatures ranging from 8°C to 12°C (46 to 53°F). They identified that water temperature was a limiting factor to habitat selection; however, habitat use varied within that range based upon seasonal changes in food resources. Hinke et al. (2005*b*) found that Chinook salmon used deeper water in the winter and during warm conditions, while shallower nearshore areas were used during younger life stages and also when the waters themselves were highly productive (e.g., food resources). The repeated use of a habitat was not entirely reliable for predicting the presence of salmon, and they concluded that the exact locations of salmon were driven by the tides and currents that affect the range of water temperature and location of nekton (Hinke et al. 2005*a*). Further information of tides and currents in Admiralty Inlet can be found in Section 3.1.

Adult Chinook salmon migrate through Admiralty Inlet on their return to natal streams. SSPS (2007) reports adult Chinook holding off the southern tip of Whidbey Island prior to entering natal rivers or streams. Monthly sport harvest of salmonids in Admiralty Inlet provides an index of seasonal abundance of salmonids in the Project area (Figure 4-2). Data show that the primary period of activity for all salmon is from July to October. Peak activity of Chinook salmon in

Admiralty Inlet is July and August; however, this may be influenced by increased recreational fishing in summer months (Figure 4-2).

FIGURE 4-2
AVERAGE SPORT CATCH OF SALMON (INDIVIDUALS) PER MONTH IN ADMIRALTY INLET (STATISTICAL AREA 9), 1967-2006



Source: Personal communication, with G. Ruggerone, NRC, Inc. with S. Thiesfeld, WDFW

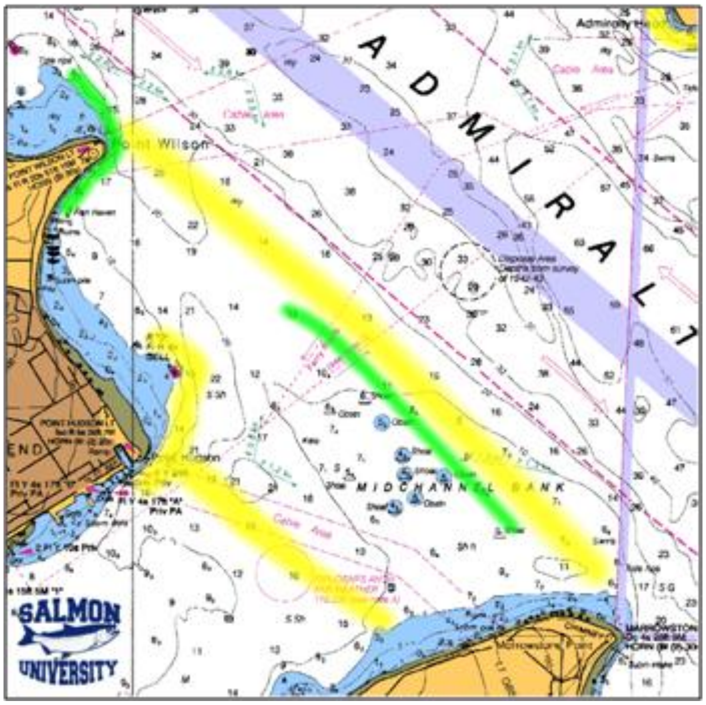
Patterns of adult Chinook salmon in Admiralty Inlet can also be inferred from recent tracking of Chinook salmon depths with acoustic tags. Two adult Chinook salmon captured and tagged at the Ballard Locks in Seattle were detected by a receiver (45 observations combined) in Admiralty Inlet from August 18 to 26, 2005 (personal communication, F. Goetz, USACE with G. Ruggerone, NRC, Inc.). Depth of the first fish averaged 8.8 meters (29 feet) (range: 3.9 to 19.2 meters [13 to 63 feet]) and the second fish averaged 12.2 meters (40 feet) (range: 8.5 to 14.9 meters [28 to 49 feet]).

The abundance of Chinook salmon in inland waters (Georgia Strait, Strait of Juan de Fuca, and Puget Sound) and Puget Sound, has varied in the last several decades. Based on information from 1990 to 2006, the abundance of United States and Canadian stocks of Chinook salmon in inland waters ranged from 2 to 4 million individuals, depending on the season and whether it was considered a good or poor year for Chinook (NMFS 2009a). Abundance estimates include Chinook salmon two to five years of age. In 2002, which was considered a good year, abundance estimates in inland waters ranged between approximately 3.5 million and 4.4 million. By contrast, in a poor year (1994), abundance estimates in inland waters ranged between approximately 2.4 million to 3.0 million (NMFS 2009a).

The WDFW 2005 Stock Strength Summaries (B. Sanford, personal communication, WDFW, June 2005), which includes data from 2000 to 2004, reported an average of 221,649 adult Chinook returned to Puget Sound each year. Of this total, 163,496 individuals were of hatchery-origin, and comprised approximately 74 percent of the total count.

Sport anglers frequently troll for Chinook salmon during winter in Admiralty Inlet (salmonuniversity.com). Sportfishing occurs near Admiralty Head as well as the west side of Admiralty Inlet. Figure 4-3 shows the approximate locations of salmon trolling and jigging locations. Average annual total sport catch of salmon in Admiralty Inlet during 2000 though 2006 was 1,124 kilograms (personal communication, G. Ruggerone, NRC, Inc. with S. Thiesfeld, WDFW).

FIGURE 4-3
APPROXIMATE LOCATIONS OF SALMON TROLLING (YELLOW) AND JIGGING (GREEN)



Source: salmonuniversity.com

Chinook salmon are often hooked while fishing with downriggers near the bottom, often in water that is approximately 15 to 43 meters (50 to 140 feet) depending on location. Sport anglers along the west side of Admiralty Inlet note that captured Chinook salmon often had been feeding on sandlance, which may burrow in sand (personal communication, G. Ruggerone, NRC, Inc.).

4.2.3 Critical Habitat Designations

NMFS designated critical habitat for Puget Sound Chinook salmon on September 26, 2005, with the designations effective January 2, 2006. Critical habitat includes all nearshore marine areas, including areas adjacent to islands, the Strait of Georgia (south of the United States-Canada border), Puget Sound, Hood Canal, and the Strait of Juan de Fuca (to the western end of the Elwha River delta) from the line of extreme high tide out to a depth of 30 meters (70 FR 52630-52858). Admiralty Inlet and the Project action area are included in the critical habitat designation.

Nearshore marine areas "contiguous with the shoreline from the line of extreme high water out to a depth no greater than 30 meters relative to mean lower low water" constitute critical habitat for Puget Sound Chinook salmon (70 FR 52684). NMFS (70 FR 52685) identified the primary constituent elements (PCEs) for nearshore marine areas, including Admiralty Inlet, as areas that:

- Are free of obstruction;
- Have certain water quality and quantity conditions; and
- Provide sufficient forage, including aquatic invertebrates and fishes that support growth and maturation.

4.3 Hood Canal Summer-run Chum Salmon

4.3.1 Current Status

NMFS listed the Hood Canal Summer-run evolutionarily significant unit (ESU) of chum salmon (*Oncorhynchus keta*) as a threatened species on March 24, 1999 (64 FR 14308-14328) and reaffirmed the listing on June 28, 2005 (70 FR 37160-37204). Factors threatening naturally spawned chum salmon throughout its range are numerous and varied. The present depressed condition is the result of several long-standing human-induced factors including habitat degradation, water diversions, harvest, and artificial propagation (64 FR 14513). This ESU includes all naturally spawned populations of summer-run chum salmon in Hood Canal and its tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington, as well as eight hatchery programs.

4.3.2 Life History and Presence in the Action Area

Summer-run chum salmon in Hood Canal and the Eastern Strait of Juan de Fuca are unique among chum salmon in that the return of adults to natal streams occurs in the late summer and the migration of fry to the estuarine environment occurs in late winter and early spring (Brewer et al. 2005). WDFW and Point No Point Treaty Tribes (PNPTT) (2000) define summer-run chum salmon as those chum salmon with an average peak spawning before November 1.

Returning adults begin entering natal rivers and streams in the late summer and spawn in the lower reaches of mainstem streams soon after arrival. Spawning typically occurs from late August through late October (Brewer et al. 2005).

Fry emerge between early February and May, with peak emergence on March 22 for the Hood Canal population (Ames et al. 2000). Fry migrate immediately downstream to the subestuary (mouth of the natal river or stream), likely entering the same night as emergence. Emigration from freshwater to brackish and marine waters can be brief, sometimes less than 12 hours. Similar to that of other salmonids, emergence and fry emigration to the estuary (i.e., Hood Canal) likely occurs over several weeks. Simenstad (2000) reported chum fry reside in subestuaries for one week or less and suggested that residence time is briefer in smaller subestuaries than in larger, more complex subestuaries. Simenstad (2000) suggested that better feeding conditions and lower water velocities associated with marshes and dendritic channels may result in longer residence times in the larger, more complex subestuaries.

Upon departing the natal subestuary, chum fry inhabit shallow nearshore areas of Hood Canal. They have been observed in the top 2 to 3 centimeters of the surface and extremely close to shore. Initially widely dispersed, chum fry form loose aggregations oriented to the shoreline within a few days of arriving in Hood Canal; aggregations occur only during daylight and tend to break up after dark and re-grouping at dawn the following morning (Brewer et al. 2005). Chum juveniles migrating during February and March occupy sublittoral seagrass beds for about one week (Simenstad and Wissmar 1985). Hood Canal chum salmon reside in the nearshore environment until they reach a size of 40 to 50 millimeters, at which time they move to deeper offshore areas (Brewer et al. 2005).

Residence in the estuary appears to be the most critical life phase for chum salmon. Chum salmon are considered second to Chinook salmon in their dependence upon estuarine waters. Upon reaching a threshold size, chum entering Hood Canal and the Strait of Juan de Fuca appear to migrate seaward very rapidly (Tynan 1997). Seaward movement may be “active” migration in response to low food availability or predator avoidance, or “passive” migration brought on by south-southwest weather systems that accelerate surface flows and move migrating juveniles northward (WDFW and PNPTT 2000). Juvenile summer-run chum salmon likely migrate in schools northward along the Hood Canal shoreline and then westward adjacent to the Strait of Juan de Fuca shoreline to reach Pacific Ocean rearing areas (Brewer et al. 2005).

In 1993, WDFW and Western Washington Treaty Indian Tribes (WWTIT) recognized 16 stocks of summer-run Hood Canal chum salmon. Due to new genetic and other information, WDFW, in 2002, divided the population into 12 stocks. In the late 1960s, there were more than 40,000 summer-run Hood Canal chum salmon. From 1968 to 1991, escapement rates for summer-run chum salmon ranged from 200 to 43,000 (WDFW and WWTIT 1993).

In 1974, WDFW began maintaining databases for summer-run Hood Canal salmon. These databases record summer-run Hood Canal chum salmon escapement and run size and represent both hatchery and wild estimates. Between 1974 and 2007, the population has ranged from 870 (1993) to 95,077 (2004) individuals. Escapement totals have ranged from a low of 429 (1990) to a high of 69,995 (2004) adult spawners. In 2007, WDFW reported the population of Hood Canal summer-run chum salmon at 12,689 individuals, with escapement totaling 10,781 individuals (WDFW 2009).

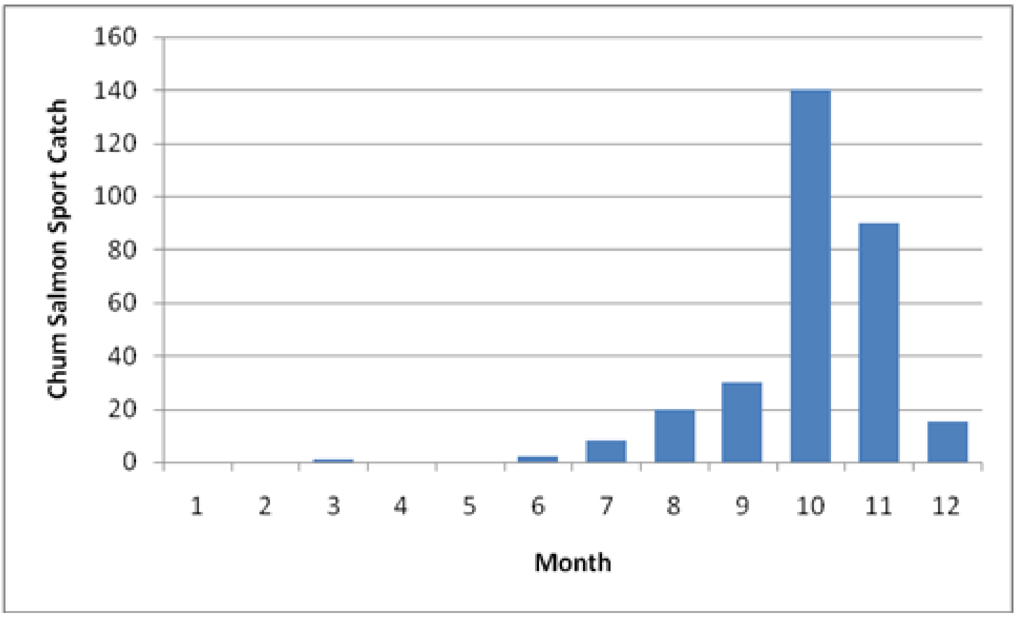
The range of the summer-run ESU is limited and relatively well defined. Sequim Bay, Discovery Bay, and nearshore areas along Admiralty Inlet and Hood Canal all represent designated critical habitat for these salmonids. Amounting to 607 kilometers of coastal environment, this critical habitat is primarily located along marine shorelines, which is consistent with chum salmon’s obligatory and predominant use of oceanic and estuarine waters (NOAA 2005*a*). Admiralty Inlet contains critical habitat that is an extension of that from Hood Canal. The Inlet constitutes an important marine habitat that is frequently used by both juveniles and adults (Good et al. 2005). Since spawning occurs within Hood Canal (Good et al. 2005), Admiralty Inlet provides a migratory pathway for species migrating into Puget Sound.

The CDFO found the depth distribution of juvenile chum salmon (results were combined with pink salmon) in mid-channel area of Puget Sound and the Strait of Georgia. Approximately 95 percent of fish were located in the top 15 meters of the water column (study details discussed in

Section 4.2.2). Approximately 5 percent of chum and pink were recorded at the 16 to 30 meters depth interval (Figure 4-1). No chum salmon were recorded deeper in the water column (personal communication, G. Ruggerone, NRC, Inc. with R. Sweeting, CDFO).

Figure 4-4 shows chum salmon present in the Project area from June through December, with a recording in March. Data indicate peak activity of chum salmon in Admiralty Inlet is October and November.

FIGURE 4-4
AVERAGE SPORT CATCH OF CHUM SALMON PER MONTH IN ADMIRALTY INLET (STATISTICAL AREA 9), 1967-2006



Source: Personal communication, G. Ruggerone, NRC, Inc. with S. Thiesfeld, WDFW

Of the 12 stocks of chum salmon, 6 stocks are rated extinct (these stocks were not rated in 1992), 4 depressed, 1 critical, and 1 healthy. Escapement estimates from 2003 for the four stocks, considered depressed due to chronically low escapement totals, range from 854 to 12,733 (WDFW and Point No Point Treaty Tribes 2007). The higher escapement estimate for the Big/Little Quilcene stocks was a direct result of hatchery supplementation. The escapement estimate for the critical-rated Lilliwaup Creek stock was 353 in 2003 (WDFW and Point No Point Treaty Tribes 2007). Due to continued good escapement levels, the Union River stock is considered healthy. Escapement estimates for this stock was 11,916 in 2003 (WDFW and Point No Point Treaty Tribes 2007).

4.3.3 Critical Habitat Designations

NMFS designated critical habitat for Hood Canal summer-run chum salmon on September 26, 2005, with the designations effective January 2, 2006. Critical habitat includes both freshwater and marine waters. Nearshore marine areas “contiguous with the shoreline from the line of extreme high water out to a depth no greater than 30 meters relative to mean lower low water” constitute critical habitat for Hood Canal summer-run chum salmon (70 FR 52684). Therefore, marine areas at the Project from the shoreline out to a depth of 30 meters are designated critical habitat for Hood Canal summer-run chum salmon. NMFS (70 FR 526685) identified the PCEs for nearshore marine areas, including Admiralty Inlet, as areas that:

- Are free of obstruction;
- Have certain water quality and quantity conditions; and
- Provide sufficient forage, including aquatic invertebrates and fishes that support growth and maturation.

4.4 Puget Sound Steelhead

4.4.1 Current Status

Puget Sound Distinct Population Segment (DPS) steelhead (*Oncorhynchus mykiss*) was listed as a threatened species on May 11, 2007. The DPS includes all naturally spawned anadromous winter-run and summer-run steelhead populations, in streams in the river basins of the Strait of Juan de Fuca, Puget Sound, and Hood Canal, Washington, bounded to the west by the Elwha River (inclusive) and to the north by the Nooksack River and Dakota Creek (inclusive), as well as the Green River natural and Hamma Hamma winter-run steelhead hatchery stocks. The primary listing factors for steelhead are the present or threatened destruction, modification, or curtailment of its habitat or range; barriers to fish passage and adverse effects on water quality and quantity resulting from dams, the loss of wetland and riparian habitats, and agricultural and urban development (72 FR 26732).

4.4.2 Life History and Presence in the Action Area

Steelhead, the sea-run form of freshwater rainbow trout, display a wide range of life history diversity that enables the species to persist in highly variable environments. The diversity of life history characteristics include the potential presence of resident and anadromous forms, varying periods of freshwater and ocean residency, summer and winter adult return timing to freshwater, and plasticity of life history between generations (WDFW 2008).

Steelhead range from Kamchatka Peninsula, Russia to southern California (NMFS 2005*b*). Steelhead can be found throughout the water column from the surface to depths of 200 meters (DON 2006). Water temperature preferences vary by life cycle stage, but 10°C is generally optimal with 24°C representing the upper threshold (DON 2006).

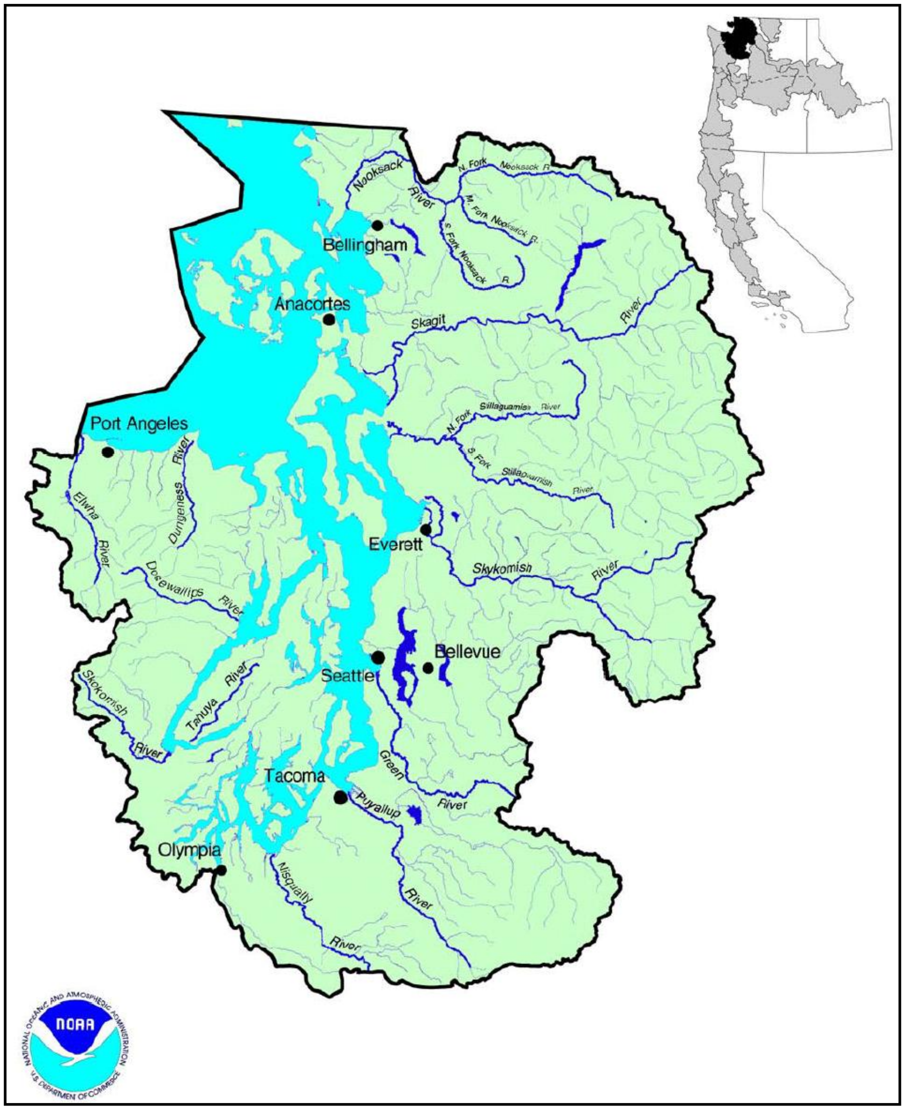
There are two life-history types of anadromous steelhead: summer-run and winter-run. The difference in the steelhead runs is the timing of adult freshwater entry for spawning. Summer-run enter freshwater at an early stage of maturation, typically from May to October. Once they reach headwaters they wait several months until spring to spawn. Winter-run steelhead is the predominant run in Puget Sound. In contrast to summer-run, winter-run enter freshwater from November to April and spawn from March to June. While spawning of summer and winter-run may overlap temporally, summer-run typically spawn further upstream (Behnke 1992, Busby et al. 1996). Summer-run spawning locations suggest that the migration timing allows the fish to access areas that the winter-run would be unable due to high velocity flow in the winter.

Unlike other Pacific salmon, steelhead are iteroparous, capable of repeating spawning. In contrast to semelparous Pacific salmon (spawn once in lifetime), steelhead females do not guard their redds (nests) but return to the ocean following spawning (Burgner et al. 1992). In some cases, anadromous steelhead yield offspring of the freshwater rainbow trout variation (72 FR 26722). Reproductive interactions may occur between steelhead and resident rainbow trout (WDFW 2008).

Steelhead reside in freshwater for their first one to three years before emigrating to the ocean (NMFS 2005*b*). Seaward migrations of juveniles typically occur from April to May (WDFW 2008). Steelhead oceanic migration patterns are poorly understood. Evidence from tagging and genetic studies indicates that Puget Sound steelhead travel to the central North Pacific Ocean (French et al. 1975, Hartt and Dell 1986, Burgner et al. 1992). Puget Sound steelhead feed in the ocean for one to three years before returning to their natal stream to spawn. Adult steelhead on the central coast of British Columbia spend considerable time at the surface, based on telemetry. The geometric mean depth was 1.6 meters, and on average the fish spent 72 percent of the time in the top one meter of the water column. The maximum depth observed was 30 meters (Ruggerone et al. 1990).

The Puget Sound steelhead DPS includes more than 50 stocks of summer- and winter-run fish (WDFW 2008). The Puget Sound ESU includes streams ranging from the Canadian border (Nooksack River basin), south through Puget Sound and Hood Canal, north and west to the Elwha River, which empties into the eastern Strait of Juan de Fuca (Figure 4-5).

FIGURE 4-5
MAP OF PUGET SOUND STEELHEAD ESU



Source: WDFW 2008

The Puget Sound DPS steelhead have experienced a substantial decline in abundance for the last 20 years. The WDFW Salmonid Stock Inventory (SaSI) provides a central repository for information on the abundance, status, and stock origin of naturally spawning salmonids in Washington. In 2002, the SaSI report rated steelhead populations; they listed 5 (20 percent) populations as Healthy, 19 as Depressed (76 percent), and 1 (4 percent) as Critical (WDFW 2008). A status assessment could not be completed for 27 populations (52 percent) because of insufficient data (Table 4-2). The five Healthy populations are distributed throughout the Puget Sound ESU: (1) Samish Winter; (2) South Fork Skokomish Summer; (3) Tolt Summer; (4) Green Winter; and (5) Discovery Bay Winter.

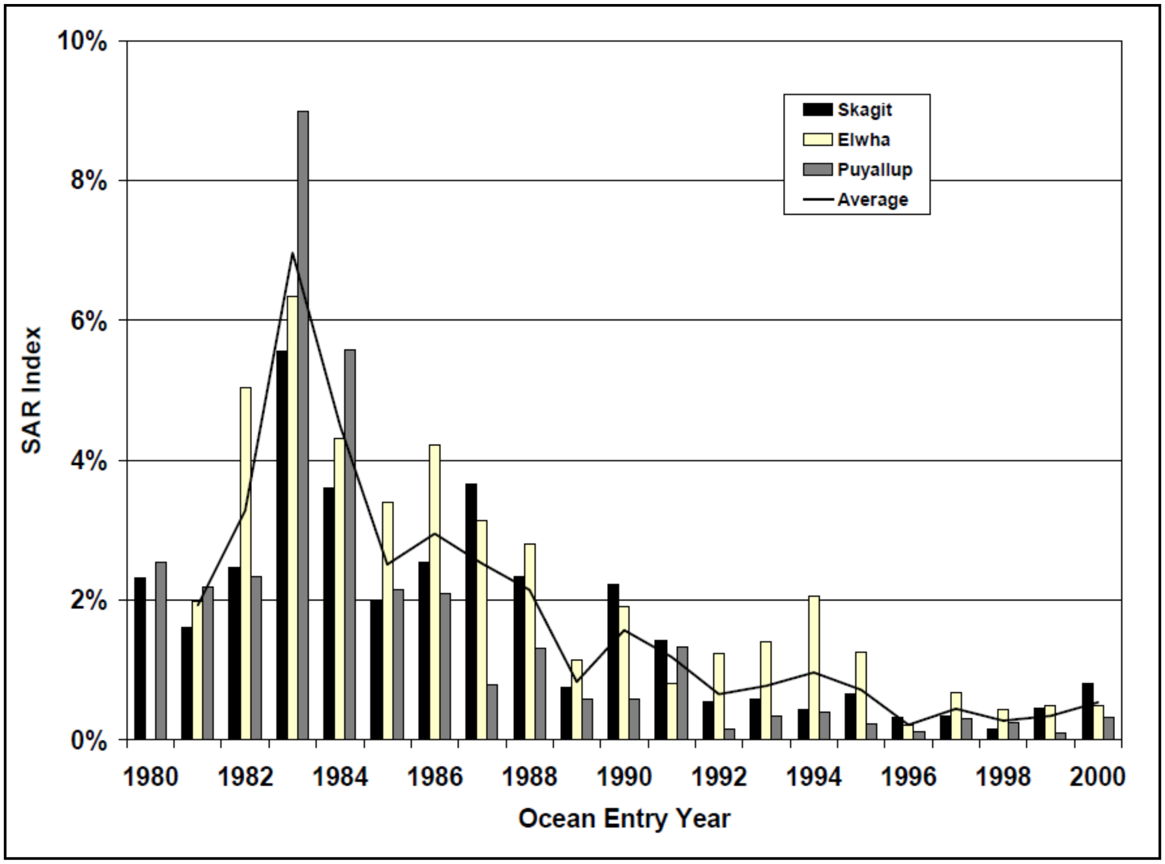
TABLE 4-2
SASI STATUS OF STEELHEAD POPULATIONS IN THE PUGET SOUND REGION

Run timing	No. of populations	Populations with unknown status	Populations with known status			
			Number	Healthy (%)	Depressed (%)	Critical (%)
Summer	16	12	4	2 (50%)	2 (50%)	0 (0%)
Winter	36	15	21	3 (14%)	17 (81%)	1 (5%)
All	52	27	25	5 (20%)	19 (76%)	1 (4%)

Source: WDFW 2008

This decline in abundance is supported from the analysis of escapement and reductions in smolt-to-adult return (SAR) rates to natal streams. Only 21 percent of the Puget Sound steelhead populations had an increase in the average escapement from 1999 through 2004 relative to the period 1994 through 1998; 67 percent of the populations had a reduction in the average escapement (WDFW 2008). Indices for the SAR rate were estimated for hatchery releases of winter steelhead into the Skagit River, the Puyallup River, and the Elwha River (Figure 4-6). All three rivers showed a similar pattern with the largest SAR indices occurring for smolts entering the ocean in 1983. The average SAR index declined from a peak of 7.0 percent for smolts entering the ocean in 1983 to 0.2 percent in 1996. The average SAR index has remained at a low level since that time, ranging from 0.2 percent to 0.5 percent for hatchery smolts entering the ocean in the period from 1997 through 2002 (WDFW 2008).

FIGURE 4-6
SMOLT-TO-ADULT RETURN INDICES FOR HATCHERY-ORIGIN WINTER STEELHEAD SMOLTS RELEASED INTO THE SKAGIT, ELWHA, AND PUYALLUP RIVERS



Source: WDFW 2008

In the spring of 2008, as part of a Pacific Ocean Salmon Tracking (POST) research effort, a line of 13 acoustic tag receivers was deployed across Admiralty Inlet (approximately 9.7 kilometers south of the Project), and steelhead smolts were tagged with acoustic transmitters and released from four Puget Sound Rivers, the Nisqually, Puyallup, Green, and Skagit (F. Goetz, USACE, Seattle District, personal communication with Greg Ruggerone, NRC, Inc.). The tracking was part of the larger POST Project. Receivers were deployed throughout Puget Sound both seasonally and year-round. The transmitters had a range of detection from 100 to 300 meters and an average detection range of 200 meters. In 2008, a line of 13 receivers was deployed across Admiralty Inlet. The receivers were spaced at 400 meter intervals between receivers, with the end receivers 200 meters from shore. Receiver position is identified from east to west, with position number one being 200 meters offshore of Whidbey and position 13 as 200 meters offshore of Marrowstone Island (personal communication, G. Ruggerone, NRC, Inc. with F. Goetz, U.S. Army Corps of Engineers [USACE], Seattle District). Steelhead detections occurred from May 12 to June 28, 2008 with the greatest number detected on June 15. Sixteen percent of the steelhead were detected on the eastern third of the inlet, 58 percent in the center third, and 25 percent on the western third (personal communication, G. Ruggerone, NRC, Inc. with F. Goetz, USACE, Seattle District). While depth of migrating steelhead smolts was not recorded by

POST, it is worthwhile to note that maturing steelhead in British Columbia spent 95 percent of the time in the top six meters of the water column (Ruggerone et al. 1990).

4.4.3 Critical Habitat Designations

Critical habitat has not yet been designated for this species.

4.5 Bull Trout

4.5.1 Current Status

The USFWS listed the Coastal-Puget Sound DPS of bull trout (*Salvelinus confluentus*) as a threatened species on November 1, 1999 (64 FR 58910-58933). Primary listing factors include present or threatened destruction, modification, or curtailment of its habitat or range, specifically barriers, timber harvesting, agricultural practices, and urban development (64 FR 58921).

The Puget Sound Management Unit is one of two management units comprising the Coastal-Puget Sound DPS of bull trout. The Puget Sound Management Unit includes all watersheds within the Puget Sound basin and the marine nearshore areas of Puget Sound.

The Project is not located within any of the eight identified core areas; however, marine areas of Puget Sound are identified as important foraging, migration, and overwintering (FMO) habitat. Although there is insufficient information to assign FMO habitats to a specific core area, these areas are considered essential to the anadromous life history form of bull trout, which is unique to the Coastal-Puget Sound DPS (USFWS 2004). Admiralty Inlet is considered bull trout FMO habitat since it is included in the Main Basin, one of five regions constituting marine FMO habitat areas in Puget Sound (USFWS 2004).

4.5.2 Life History and Presence in the Action Area

Bull trout are members of the char group within the family Salmonidae. Bull trout closely resemble Dolly Varden (*Salvelinus malma*), a related species. Genetic analyses indicate, however, that bull trout are more closely related to an Asian char (*S. leucomaenis*) than to Dolly Varden (Pleyte et al. 1992).

Bull trout exhibit four distinct life history types: resident, fluvial, adfluvial, and anadromous. The fluvial, adfluvial and resident forms exist throughout the range of the bull trout (Rieman and McIntyre 1993). These forms spend their entire in freshwater. The anadromous life history form is currently known only to occur in the Coastal-Puget Sound region within the coterminous United States (Volk 2000). Technically, the Coastal-Puget Sound population segment is amphidromous, meaning individuals often return seasonally to freshwater as subadults, sometimes for several years, before returning to their natal tributary to spawn. These subadult bull trout move into marine waters and return to freshwater to take advantage of seasonal forage opportunities to feed on salmonid eggs, smolts, or juveniles (SSPS 2007). Multiple life history types may be expressed in the same population, and this diversity of life history types is considered important to the stability and viability of bull trout populations (Rieman and McIntyre 1993). While juvenile bull trout are limited to freshwater, subadult and adult bull trout occur in Puget Sound. In a study to assess spatial and temporal distribution of bull trout in estuarine and nearshore marine waters of Puget Sound, tagged adult and subadult bull trout were found in depths ranging from 1 to 20 meters, over all substrate types (Goetz et al. 2003).

Bull trout are believed to have more specific habitat requirements than other salmonids (Rieman and McIntyre 1993). Growth, survival, and long-term persistence are dependent upon habitat characteristics such as cold water, complex instream habitat, a stable substrate with a low percentage of fine sediments, high channel stability, and stream/population connectivity. Stream temperature and substrate type, in particular, are critical factors for the sustained long-term persistence of bull trout. Spawning is often associated with the coldest, cleanest, and most complex stream reaches within basins; however, bull trout may exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1995), and should not be expected to occupy all available habitats at the same time (Rieman et al. 1997).

For migratory life history types, juveniles tend to rear in tributary streams for one to four years before migration downstream into a larger river, lake or estuary and/or nearshore marine area to mature (Rieman and McIntyre 1993). The timing and extent of movements and spawning migrations varies substantially among populations of bull trout (SSPS 2007).

The majority of growth and maturation for anadromous bull trout occurs in estuarine and marine waters. In marine waters of Washington, bull trout feed on Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus pretiosus*) (Goetz et al. 2004; WDFW et al. 1997). Bull trout normally reach sexual maturity in four to seven years and may live longer than 12 years (USFWS 2004). Unlike Chinook and chum salmon, bull trout have the ability to spawn more than once in a lifetime. Bull trout spawn annually or bi-annually in headwater areas, and return to larger rivers, lakes or estuaries to forage. Repeat spawners are extremely important to the long-term persistence of bull trout populations; they typically have greater fecundity, and these survivors have multiple opportunities to contribute to the gene pool (SSPS 2007).

As noted in 4.5.1, Admiralty Inlet provides important FMO habitat for bull trout. Marine FMO habitat for Coastal-Puget Sound bull trout includes portions of Puget Sound and associated nearshore and estuarine areas. These habitats provide an abundance of preferred prey species, including juvenile trout, salmon, and forage fish species such as sandlance, surf smelt, and herring. Bull trout are dependent upon productive forage fish spawning beaches and intertidal habitats such as eelgrass beds and large woody debris present in nearshore areas. Both subadult and adult bull trout have been observed using tidally influenced areas (USFWS 2004). Bull trout in the Coastal-Puget Sound population segment also move through marine areas to gain access to independent streams to forage or take refuge from high flows (SSPS 2007).

4.5.3 Critical Habitat Designations

On October 18, 2010 the USFWS revised the critical habitat for bull trout, with the designations effective November 17, 2010. The proposed critical habitat for nearshore marine areas is based on the photic zone. Critical habitat for nearshore marine areas extends from the mean higher high water line offshore to the depth of 10 meters (33 feet) relative to the MLLW. This distance equates to the average depth of the photic zone and is considered the habitat most consistently used by bull trout in marine waters (75 FR 63973). Critical habitat is not designated within Admiralty Inlet and therefore is not located within the Project area.

The PCEs in the 2010 final rule are similar to those described in the 2005 final designation (70 FR 56236); however, the 2010 final rule includes an additional PCE related to the presence of nonnative fish that may prey on, compete with, or inbreed with bull trout (75 FR 63931). The nine PCEs for bull trout are listed below:

1. Springs, seeps, groundwater sources, and subsurface water connectivity (hyporehic flows) to contribute to water quality and quantity and provide thermal refugia.

2. Migratory habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

3. An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

4. Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes with features such as large wood, side channels, pools, undercut banks and substrates, to provide a variety of depths, gradients, velocities, and structure.

5. Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures at the upper end of this range.

6. Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival.

7. A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, they minimize departures from a natural hydrograph.

8. Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

9. Few or no nonnative predatory, inbreeding, or competitive species present.

4.6 Green Sturgeon

4.6.1 Current Status

Based on a preliminary genetic analysis and suspected fidelity to natal rivers, the North American green sturgeon (*Acipenser medirostris*) was split into two DPS under ESA by NMFS in 2003: Northern and Southern (68 FR 4433; January 29, 2003). The Northern DPS consists of green sturgeon populations originating from coastal watersheds northward of, and including, the Eel River in northern California. NMFS determined that the Northern DPS did not warrant listing as an endangered or threatened species; however, concerns regarding lack of data on population structure and status resulted in the Northern DPS being listed as a Species of Concern (first in 68 FR 4433 January 29, 2003 and reaffirmed in 71 FR 17757; April 7, 2006).

The Southern DPS consists of green sturgeon populations originating from watersheds south of the Eel River in California. NMFS determined that green sturgeon from the Sacramento River and Delta system have declined substantially and that the Southern DPS would likely become endangered in the near future if ongoing threats were not addressed. Past and ongoing federal, state, and local protective efforts have contributed to the conservation of the Southern DPS, but NMFS believes these efforts alone do not sufficiently reduce the extinction risks faced by the Southern DPS (NMFS 2008*a*). On April 7, 2006 (71 FR 17757), NMFS issued a final rule listing the green sturgeon Southern DPS as a threatened species under the ESA based on the following listing factors: reduction of access to spawning areas, concentration of adults into one spawning area, destruction, modification or curtailment of habitat, and inadequacy of existing regulatory mechanisms.

4.6.2 Life History and Presence in the Action Area

Green sturgeon are a long-lived anadromous fish species with a wide distribution range along the Pacific coast from Ensenada, Mexico to southeast Alaska, though the population is more concentrated between northern California and Willapa Bay, Washington (PSMFC 1996). In Washington, large numbers have been reported in Grays Harbor and Willapa Bay, but actual abundance data is not available (74 FR 52300).

Green sturgeon are thought to have a maximum age of 60 to 70 years (NMFS 2007*b*). This species reaches maturity at 15 to 19 years of age (Van Eenennaam et al. 2006) and spawns every two to five years (Adams et al. 2002, Erickson and Webb 2007). Green sturgeon is a large species with mature fish ranging from 139 to 223 centimeters in length and can weigh up to 350 pounds (159 kilograms) (NMFS 2007*c*), however, adults greater than 2 meters in length and 90 kilograms in weight are not common (Skinner 1982).

Based on information from some genetic analyses, limited tagging studies, and commercial fishing reports, green sturgeon are believed to make some extensive movements from natal rivers, generally in a northerly direction (NMFS 2005*b*, Adams et al. 2002, Erickson and Hightower 2007, Israel and May 2007, Lindley et al. 2008). Data collected from seven out-migrating green sturgeon tagged with pop-off archival tags in the Rogue River indicates that green sturgeon were more active at night, generally inhabited depths of 40 to 70 meters, and occasionally made rapid ascents to the surface. These fish traveled from 221 to 968 kilometers prior to the tag release (Erickson and Hightower 2007). Lindley et al. (2008) found that tagged green sturgeon made extensive seasonal spring and fall migrations along the continental shelf and suspected the existence of an important overwintering area between Cape Spenser, Alaska and Vancouver Island. Peak migration rates exceeded 50 kilometers per day during the spring time southward migration (Lindley et al. 2008).

Available information from off-shore commercial trawling efforts indicate green sturgeon remain within the 110-meter depth contour line (Erickson and Hightower 2007, NMFS 2005*c*). Additional commercial and scientific collection efforts indicate green sturgeon of mixed stock often concentrate in bays and estuaries all along the Pacific coast, but especially within the

Columbia River Estuary, Willapa Bay, and Gray's Harbor, with highest numbers occurring in August. NMFS (2010a) has conducted several stomach analyses of green sturgeon in the area, including eight taken in 2000 in Willapa Bay and nine taken in the same location 2004. Gut contents included ghost shrimp (*Neotrypaea californiensis*), fish (including lingcod [*Ophiodon elongatus*]), Dungeness crab (*Cancer magister)*, crangonid shrimp, and small amounts of polychaetes, clams, and amphipods (Dumbauld et al. 2008).

Information on the population status of the Southern DPS green sturgeon is scarce. Some adults and juvenile green sturgeon persist in the Sacramento River, thus NMFS concluded the population was not in imminent risk of extinction; however, threats to the population continue (71 FR 17757; April 7, 2006). The primary threat is attributed to the decrease in spawning habitat to a single population in the upper Sacramento River. Migration barriers and water diversion projects have reduced or eliminated what was thought to have been historical spawning habitat in the nearby Feather and San Joaquin River systems. Water quality degradation due to thermal and potential contaminants within the Sacramento River system are also considered factors in the population decline and continued threats to the Southern DPS. While there is no focused fishery for green sturgeon, incidental catches and mortality from commercial and recreational fishing industry, in part targeting white sturgeon, were also listed as a threat (71 FR 17757, April 7, 2006; Erickson and Webb 2007). Invasive species, such as the striped bass, also pose a potential risk, as they are known to prey on juvenile green sturgeon.

Puget Sound is closely monitored due to a large commercial and recreational fishing effort; however, very few green sturgeon have been observed there (NMFS et al. 2010). Two Southern DPS green sturgeon were confirmed in the vicinity of Whidbey Island in 2006 (NMFS 2009b): two acoustic tags detected near Anacortes in Rosario Strait—just north of Whidbey Island and two detected near Scatchet Head at the south end of Whidbey Island (these may be the same two fish) (email from NOAA to the District dated April 11, 2011). Acoustic receivers deployed in the Strait of Juan de Fuca have also had few detections of green sturgeon. The low detection rate may be due to relatively few tagged green sturgeon, relatively few receiver arrays located in the area, and the fact that the receiver arrays were installed and operated to monitor other species and may not have been programmed or positioned for optimal green sturgeon monitoring (NMFS et al. 2010).

Spawning frequency for green sturgeon is not well known, but the best information suggests that adults spawn every two to four years (Lindley et al. 2008; 70 FR 17386; Erickson and Webb, 2007). The Sacramento River is the only area where spawning by Southern DPS green sturgeon has been confirmed and where all life stages of the Southern DPS are supported (NMFS 2008*a*). Adult green sturgeon occur in the Sacramento River when temperatures are between 8 to 14°C (Moyle 2002). The upper Sacramento River area from upstream of the Red Bluff Diversion Dam to the Keswick Dam is largely recognized as the main spawning reach for adult Southern DPS green sturgeon (NMFS 2008*a*). Spawning likely begins in March and extends through early summer (Brown 2007). Southern DPS adults and/or subadults have been observed at the mouths of tributaries to the Sacramento River but not in the tributaries. No juveniles, larvae, or eggs have been observed in surveys within the tributaries (NMFS 2008*a*). Although the upper Sacramento River is believed to be the primary spawning area for adult Southern DPS fish, spawning also occurs in the lower Sacramento River (NMFS 2008*a*). Juvenile green sturgeon may remain in natal rivers for one to four years and then migrate out into the ocean, where they spend most of their lives in coastal areas (NMFS 2007*b*). Coastal bays and estuaries are believed to serve as important summer habitats for subadult and adult green sturgeon, supporting migration, feeding, and growth (Moser and Lindley 2007; Lindley et al. 2008). Because Puget Sound is a large, closed system, green sturgeon entering the area may reside for extended periods. One tagged green sturgeon was detected over several months over a two year period, suggesting the fish was foraging and perhaps holding or resting in the area (NMFS 2009). Green sturgeon will spend 3 to 20 years at sea before reaching sexual maturity and return to natal rivers to spawn (NMFS 2008*a*).

4.6.3 Critical Habitat Designations

Critical habitat for the green sturgeon Southern DPS was proposed by NMFS in September 2008 (73 FR 52084; September 8, 2008), and finalized on October 9, 2009. The Critical Habitat Review Team determined that each green sturgeon DPS would be likely to occur in their natal river systems; however, would likely be limited to estuaries only in non-natal river systems (NMFS 2008*a*). Specific areas proposed for designation include the coastal United States marine waters from Monterey, California to Graves Harbor, Alaska out to the 110-meter depth contour, that:

- Meet the definition of critical habitat as defined by the ESA,
- Contain confirmed Southern DPS fish, and
- Are in need of protection in order to conserve and protect the Southern DPS.

Primary constituent elements for nearshore coastal marine areas include:

- Migratory pathway necessary for the safe passage within marine habitats and between estuarine and marine habitats,
- Nearshore marine waters with adequate dissolved oxygen levels and acceptably low levels of contaminants, and
- Abundant prey items for subadults and adults, which may include benthic invertebrates and fishes (74 FR 52348).

Admiralty Inlet and Puget Sound are not included in the final critical habitat designation, as it was determined that the economic benefits of exclusion outweigh the benefits of inclusion and exclusion will not result in the extinction of the species (74 FR 52300, October 9, 2009).

4.7 Bocaccio

4.7.1 Current Status

On April 22, 2009, NMFS determined that the bocaccio (*Sebastes paucispinis*) populations in the Georgia Basin (Puget Sound and the Strait of Georgia) are a DPS and are “at high risk” of extinction throughout all its range. NMFS listed bocaccio as endangered on April 28, 2010 (75 FR 22276). In a previous status review MacCall and He (2002) identified two DPSs of coastal bocaccio, a Southern DPS and a Northern DPS. The Georgia Basin DPS, identified in the April 2010 listing, represents a third DPS.

The primary factors responsible for the decline of bocaccio are overutilization for commercial and recreational purposes; degradation of water quality, including low dissolved oxygen and elevated contaminant levels; and loss of rocky habitat, loss of eelgrass and kelp, and introduction of non-native species that modify habitat (75 FR 22276).

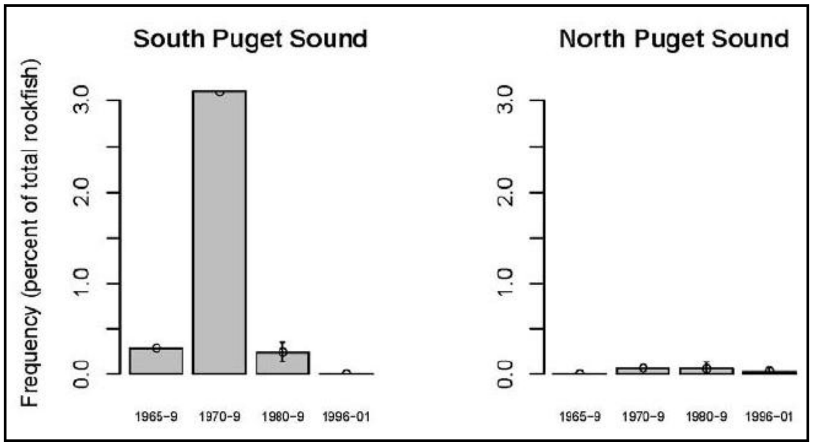
4.7.2 Life History and Presence in the Action Area

Bocaccio is a deepwater rockfish species often associated with steep slopes consisting of sand or rocky substrates and occurring in Central Puget Sound, Tacoma Narrows, and Ports Gardner and Susan, and along the Strait of Juan de Fuca (Miller and Borton 1980). They range from Baja California to the Gulf of Alaska, but are most common from Baja California to Oregon (Love et al. 2002). They are most frequently located between 50 and 250 meters deep, but are found as deep as 475 meters (Orr et al. 2000). Deep-benthic habitats for rockfish primarily include boulder, bedrock, and hardpan outcroppings, in the South Sound; deep rocky habitats are not as common, but do occur, in Admiralty Inlet (NMFS letter dated July 23, 2009). Bocaccio are suspected to live as long as 54 years (Drake et al. 2008).

Approximately 50 percent of adults mature in four to six years (MBC 1987). Bocaccio spawn in the fall, generally between August and November (74 FR 18516). Fecundity ranges from 20,000 to over 2 million eggs, which is significantly more than many other rockfish species (Love et al. 2002). Bocaccio larvae feed on larval krill, diatoms, and dinoflagellates (74 FR 18531). Pelagic juveniles feed on fish larvae, copepods, and krill. Larvae and juvenile pelagics tend to frequent surface waters and tend to remain there for three to six months until moving to deeper waters of 18 to 30 meters (Carr 1983, Feder et al. 1974, Johnson 2006, Love and Yoklavich 2008). Adults are generally associated with hard substrate but will venture into mud flats (74 FR 18531). The main predators of bocaccio are marine mammals (Committee on the Status of Endangered Wildlife in Canada 2002).

There is no single reliable historic or current population estimate for bocaccio within the Puget Sound/Georgia Basin DPS; however, a dramatic decline in abundance is apparent (Drake et al. 2010*b*). Bocaccio have always been infrequently caught in recreational fisheries in Puget Sound (Figure 4-7). They have never been observed in WDFW bottom trawls, video, or dive surveys in Puget Sound (Palsson et al. 2009). Bocaccio appear to have declined in frequency in Puget Sound relative to other species from the 1970s to present. From 1975 to 1979 bocaccio were reported as an average of 4.63 percent of the total rockfish catch. From 1980 to 1989 they were 0.24 percent of the rockfish catch, and from 1996 to 2007, bocaccio have not been observed out of the 2,238 rockfish identified in the dockside surveys of the recreational catches (74 FR 18531). In 2008, however, several bocaccio were reported by recreational anglers in the Central Sound (WDFW unpublished data *cited in* NMFS et al. 2010).

FIGURE 4-7
FREQUENCY OF BOCACCIO IN
RECREATIONAL CATCHES IN PUGET SOUND, 1965-2001



Source: Drake et al. 2008

In 2008, WDFW conducted fishery-independent estimates of rockfish species using research trawls, drop camera surveys, and ROV surveys within the rocky habitats of the San Juan Island region. Population estimates for bocaccio are shown in Table 4-3 (NMFS et al. 2010). The surveys did not detect bocaccio in Puget Sound proper during the survey. However, bocaccio have historically been present there and caught in other recreational fisheries from 2004 to 2008. The lack of bocaccio in the Puget Sound proper is likely due to a number of factors including: (1) population of the species is depleted, (2) lack of rocky benthic areas in Puget Sound proper may lead to densities of each species that are naturally less than those in the San Juan region, and (3) the study design may not have been powerful enough to detect the species (NMFS et al. 2010).

TABLE 4-3
WDFW POPULATION ESTIMATE FOR BOCCACIO

WDFW Survey Method	North Sound	Puget Sound Proper	Percent Standard Error (or variance)	
Bottom Trawl[1]	Not detected	Not detected	NA	NA
Drop Camera[2]	Not detected	Not detected	NA	NA
Remotely Operated Vehicle[3]	4,487 (San Juan Region)		100	

Source: NMFS et al. 2010.
[1] The bottom trawl surveys generally sampled over non-rocky substrates where yelloweye rockfish, canary rockfish and bocaccio are less likely to occur compared to steep-sloped, rocky habitat (Drake et al. 2010*b*).
[2] The drop camera surveys sampled habitats less than 120 feet, which is potential habitat for juveniles, but less likely habitat for adults of the three listed species.
[3] ROV surveys were conducted exclusively within the rocky habitats of the San Juan Island region in 2008.

4.7.3 Critical Habitat Designations

Critical habitat has not yet been designated for this species (75 FR 22276).

4.8 Canary Rockfish

4.8.1 Current Status

On April 22, 2009, NMFS determined that the canary rockfish (*Sebastes pinniger*) populations in the Georgia Basin are discrete from coastal populations and are a DPS. NMFS concluded that the Georgia Basin DPS is at "moderate risk" of extinction throughout its range based on a steep decline in abundance in Puget Sound. NMFS listed canary rockfish as threatened on April 28, 2010 (75 FR 22276).

The primary factors responsible for the decline of canary rockfish are overutilization for commercial and recreational purposes; degradation of water quality, including low dissolved oxygen and elevated contaminant levels; and loss of rocky habitat, loss of eelgrass and kelp, and introduction of non-native species that modify habitat (FR 22276).

4.8.2 Life History and Presence in the Action Area

The canary rockfish is a large rockfish that reaches up to 2.5 feet in length and 10 pounds in weight. As with most rockfish, canary rockfish live long lives, and mature and reproduce slowly, making them vulnerable to overfishing. Canary rockfish can live up to 69 years off the west coast of the United States (Palsson et al. 2009).

The canary rockfish occupies rocky and coarse habitats that occur throughout Puget Sound (Miller and Borton 1980), and their range extends from the western Gulf of Alaska to northern Baja California (Boehlert 1980; Mecklenburg et al. 2002). Larval and pelagic juveniles are typically found in surface waters (Love et al. 2002), but canary rockfish tend to move into deeper water as they age. Adults inhabit waters 160 to 820 feet (50 to 250 meters) deep (Orr et al. 2000), but have been found up to 1,400 feet (425 meters) deep (Boehlert 1980).

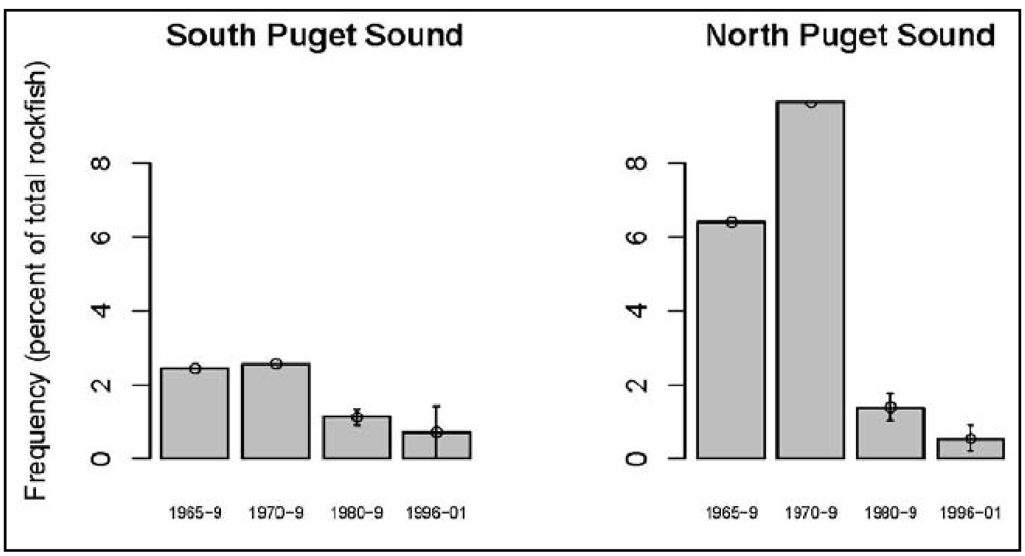
Canary rockfish reach sexual maturity around ages 7 to 9 for males and 7 to 12 for females (Echeverria 1987; Lea et al. 1999). Canary rockfish spawn annually with females producing between 260,000 and 1,900,000 eggs per year (74 FR 18516). Off Oregon and Washington coasts, parturition peaks in December and January (Barss 1989; Echeverria 1987).

Canary rockfish larvae feed on primarily crustacean larvae, invertebrate eggs, and copepods (Moser and Boehlert 1991; Love et al. 2002). Juveniles consume prey such as crustaceans, barnacle cyprids, and euphasiid eggs and larvae (Gaines and Roughgarden 1987; Love et al. 1991). Predators of juveniles include other fishes (e.g., lingcod, cabezon, salmon, and other rockfish), birds, and porpoise (Ainley et al. 1981; Love et al. 1991; Miller and Geibel 1973; Morejohn et al. 1978; Roberts 1979). Adults feed on crustaceans and small fishes (Cailliet et al. 2000; Love et al. 2002). Predators of adults include yelloweye rockfish, lingcod, salmon, sharks, dolphins, and seals (Antonelis, Jr. and Fiscus 1980; Merkel 1957; Morejohn et al. 1978; Rosenthal et al. 1982).

There is no single reliable historic or current population estimate for canary rockfish within the Puget Sound/Georgia Basin DPS; however, a dramatic decline in abundance is apparent (Drake et al. 2010*b*). Palsson et al. (2009) note a precipitous decline in several species of rockfish in Puget Sound, including bocaccio, yelloweye rockfish and canary rockfish, and concluded that fishery removals (including bycatch from other fisheries) are highly likely to limit recovery of depleted canary rockfish populations in Puget Sound. In addition, they establish habitat disruption, derelict fishing gear, low dissolved oxygen, chemical toxicants and predation as moderate threats to Puget Sound rockfish populations. The total rockfish population in the Puget Sound region is estimated to have declined around 3 percent per year for the past several decades, which corresponds to an approximate 70 percent decline in the time period ranging from 1965 to 2007 (Drake et al. 2010*b*)

Canary rockfish are infrequently observed in Puget Sound from 1996-2001 recreation data, they were reported at a frequency of 0.73 percent (sample size 550) in south Puget Sound, and 0.56 percent (sample size 1,718) in northern Puget Sound (Drake et al. 2008). These percentages are lower than historical percentages of catch from 1969 to 1989 (Figure 4-8). Since 2002 fishing for canary rockfish has been prohibited.

FIGURE 4-8
FREQUENCY FOR CANARY ROCKFISH IN RECREATIONAL CATCHES IN PUGET SOUND, 1965-2001



Source: Drake et al. 2008

Another data source included in the trend analysis is sightings of rockfish by recreational scuba divers throughout Puget Sound as part of a program by REEF.org that trains recreational divers to identify and record fish species during recreational dives. From 1998 to 2000 there were no canary rockfish observed (100 to 130 dives per year). Since dives were increased to 400 to 1,000 dives per year beginning in 2001, canary rockfish have been reported consistently in 0.5 to 3.6 percent of dives (REEF 2008).

In their 2008 studies consisting of research trawls, drop camera surveys, and ROV surveys, WDFW estimated the population of canary rockfish shown in Table 4-4 (NMFS et al. 2010). It was estimated that the canary rockfish population is approximately 16,100 in the North Sound, based on the bottom trawl method, and a population of approximately 2,751 in the North Sound, based on the drop camera method. A canary rockfish population estimate of approximately 1,648 was estimated by the ROV method. Canary rockfish were not detected in the Puget Sound proper region (NMFS et al. 2010).

TABLE 4-4
WDFW POPULATION ESTIMATE FOR CANARY ROCKFISH

WDFW Survey Method	North Sound	Puget Sound Proper	Percent Standard Error (or variance)	
Bottom Trawl[1]	16,100	Not detected	260.6 (variance)	NA
Drop Camera[2]	2,751	Not detected	89.3	NA
Remotely Operated Vehicle[3]	1,648 (San Juan Region)		100	

Source: NMFS et al. 2010.
[1] The bottom trawl surveys generally sampled over non-rocky substrates where yelloweye rockfish, canary rockfish and bocaccio are less likely to occur compared to steep-sloped, rocky habitat (Drake et al. 2010*b*).
[2] The drop camera surveys sampled habitats less than 120 feet, which is potential habitat for juveniles, but less likely habitat for adults of the three listed species.
[3] ROV surveys were conducted exclusively within the rocky habitats of the San Juan Island region in 2008.

Although canary rockfish were not detected in Puget Sound proper, canary rockfish have historically been present there and caught in other recreational fisheries from 2004 to 2008. The lack of canary rockfish in the Puget Sound proper is likely due to a number of factors including: (1) the population of the species is depleted, (2) the lack of rocky benthic areas in Puget Sound proper may lead to densities of each species that are naturally less than those in the San Juan region and (3) the study design may not have been powerful enough to detect the species (NMFS et al. 2010).

4.8.3 Critical Habitat Designations

Critical habitat has not yet been designated for this species (75 FR 22276).

4.9 Yelloweye Rockfish

4.9.1 Current Status

On April 22, 2009, based upon stock assessments in adjacent coastal waters, NMFS determined that the yelloweye rockfish (*Sebastes ruberrimus*) populations in the Georgia Basin are a DPS and have a depleted status, and are therefore likely to become endangered in the foreseeable future throughout all its range. As a result NMFS listed yelloweye rockfish as threatened on April 28, 2010 (75 FR 22276).

The primary factors responsible for the decline of yelloweye rockfish are overutilization for commercial and recreational purposes; degradation of water quality, including low dissolved oxygen and elevated contaminant levels; and loss of rocky habitat, loss of eelgrass and kelp, and introduction of non-native species that modify habitat (FR 22276).

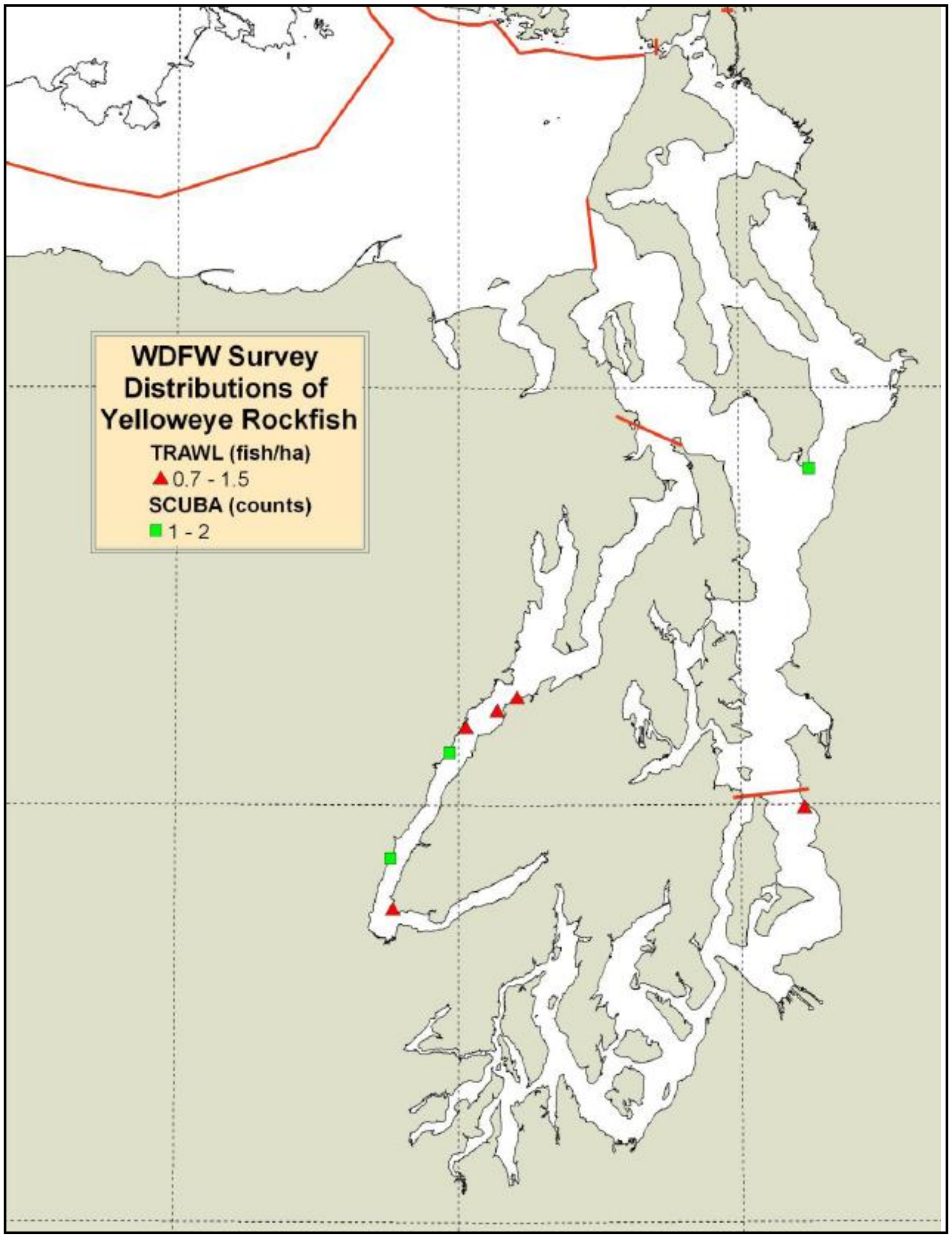
4.9.2 Life History and Presence in the Action Area

Yelloweye rockfish range from Mexico to the Aleutian Islands, Alaska, but are most common from central California to the Gulf of Alaska (Clemens and Wilby 1961, Eschmeyer et al. 1983, Hart 1973, Love 1996). Yelloweye occur in waters 25 to 475 meters deep (Orr et al. 2000) but are most commonly located between 91 to 180 meters (Love et al. 2002), and inhabit rocky pinnacles (Washington 1977, Love et al. 2002) and boulder fields (Wang 2005). Yelloweye are one of the largest species of rockfish, weighing up to 25 pounds (Love at al. 2002). Yelloweye are also one of the longest-lived rockfish, reaching ages of at least 118 years (Love 1996, Love et al. 2002, O'Connell 1987).

Yelloweye rockfish are a slow maturing species, with an average age maturity ranging from 19 to 22 years (Palsson et al. 2009). Females internally fertilize and are capable of storing sperm for several months before fertilization occurs, generally between September and April (Wyllie-Echeverria 1987). Fecundity ranges from 1.2 to 2.7 million eggs, significantly more than other rockfish species (Love et al. 2002). In Puget Sound juvenile yelloweye occupy primarily shallow waters with high relief zones (Love et al. 1991, Richards et al. 1985). Juveniles prey on fish larvae, copepods, and krill (74 FR 18516). Adults move into deeper waters and continue to associate with rocky, high relief areas (Carlson and Straty 1981, Love et al. 1991, Richards et al. 1985), and generally have a small range from their home (Coombs 1979, DeMott 1983, Love et al. 2002). Adult yelloweye are opportunistic feeders and are able to eat much larger prey than other rockfish. Adults feed on smaller yelloweye, and typically feed on sand lance, gadids, flatfish, shrimp, crab, and gastropods (Love et al. 2002, Yamanaka et al. 2006). Predators of yelloweye include salmon and killer whales (Ford et al. 1998, Love et al. 2002).

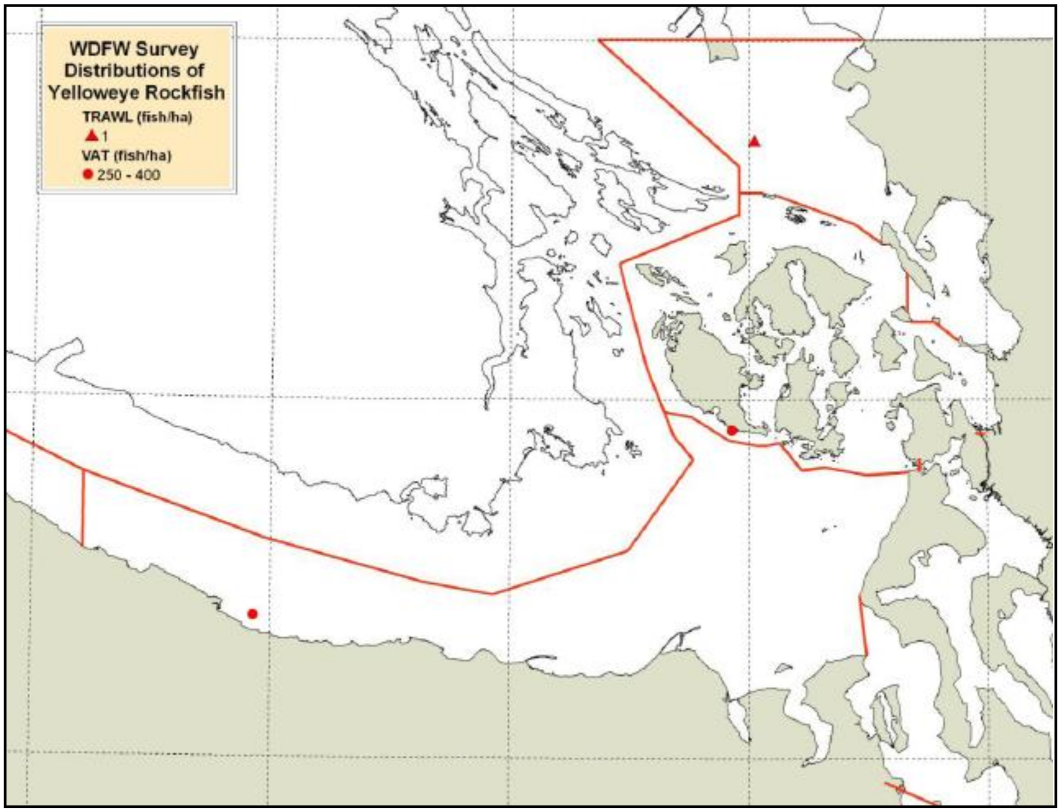
There is no single reliable historic or current population estimate for yelloweye rockfish within the Puget Sound/Georgia Basin DPS; however, a dramatic decline in abundance is apparent (Drake et al. 2010*b*). In recreational catches in North and South Puget Sound, yelloweye have accounted for 4.43 percent of harvest in 1965-1967, 0.31 percent from 1980-1989, and 1.56 percent in 1996-2007) (Palsson et al. 2009). Yelloweye rockfish are infrequently captured in trawls and underwater video surveys. Hood Canal has the greatest frequency of yelloweye, with observations in both trawls and scuba surveys. From trawl, video, and scuba surveys yelloweye rockfish have been recorded at the south end of Whidbey Island and in southern Puget Sound (Palsson et al. 2009) (Figures 4-9 and 4-10).

FIGURE 4-9
DISTRIBUTION OF YELLOWEYE ROCKFISH IN NORTH PUGET SOUND DETERMINED FROM WDFW TRAWL, VIDEO, AND SCUBA SURVEYS



Source: Palsson et al. 2009

FIGURE 4-10
DISTRIBUTION OF YELLOWEYE ROCKFISH IN SOUTH PUGET SOUND DETERMINED FROM WDFW TRAWL, VIDEO, AND SCUBA SURVEYS



Source: Palsson et al. 2009

In their 2008 studies consisting of research trawls, drop camera surveys, and ROV surveys WDFW estimated the population of yelloweye rockfish shown in Table 4-5 (NMFS et al. 2010). Researchers estimated a yelloweye rockfish population of approximately 600 in the Puget Sound proper region with the bottom trawl method. Yelloweye rockfish were not detected at all in the North Sound (via bottom trawl or drop camera method) or Puget Sound proper (via the drop camera method). Approximately 50,656 yelloweye rockfish were estimated by the ROV method in the San Juan Region.

TABLE 4-5
WDFW POPULATION ESTIMATE FOR YELLOWEYE ROCKFISH

WDFW Survey Method	North Sound	Puget Sound Proper	Percent Standard Error (or variance)	
Bottom Trawl[1]	Not detected	600	NA	400 (variance)
Drop Camera[2]	Not detected	Not detected	NA	NA
Remotely Operated Vehicle[3]	50,656 (San Juan Region)		29	

Source: NMFS et al. 2010.
[1] The bottom trawl surveys generally sampled over non-rocky substrates where yelloweye rockfish, canary rockfish and bocaccio are less likely to occur compared to steep-sloped, rocky habitat (Drake et al. 2010*b*).
[2] The drop camera surveys sampled habitats less than 120 feet, which is potential habitat for juveniles, but less likely habitat for adults of the three listed species. Because juvenile yelloweye rockfish are less dependent on rearing in shallow nearshore environments, the likelihood of documenting them with drop camera surveys less than 120 feet is less than for canary rockfish and bocaccio.
[3] ROV surveys were conducted exclusively within the rocky habitats of the San Juan Island region in 2008.

Although yelloweye rockfish were detected in Puget Sound proper within bottom trawl surveys, the WDFW estimate is not considered to be a complete estimate due to the following factors: (1) populations of the species is depleted, (2) lack of rocky benthic areas in Puget Sound proper may lead to densities of each species that are naturally less than the San Juan region and (3) the study design may not have been powerful enough to detect the species (NMFS et al. 2010).

4.9.3 Critical Habitat Designations

Critical habitat has not yet been designated for this species (75 FR 22276).

4.10 Eulachon

4.10.1 Current Status

On March 13, 2009, NMFS published a federal register notice describing a DPS of eulachon (*Thaleichthys pacificus*), which encompasses all populations within the states of Washington, Oregon, and California and extends from the Skeena River in British Columbia south to the Mad River in Northern California (NMFS 2009a). In March, 2010 (effective May 17, 2010), NMFS listed eulachon as threatened (75 FR 13012).

The primary factors responsible for the decline of the Southern DPS of eulachon are the destruction, modification, or curtailment of habitat; dams and water diversions in rivers inhabited by eulachon; sediment dredging in areas inhabited by eulachon; overutilization for commercial, recreational, scientific, or educational purposes; and the inadequacy of existing regulatory mechanisms (75 FR 13012).

4.10.2 Life History and Presence in the Action Area

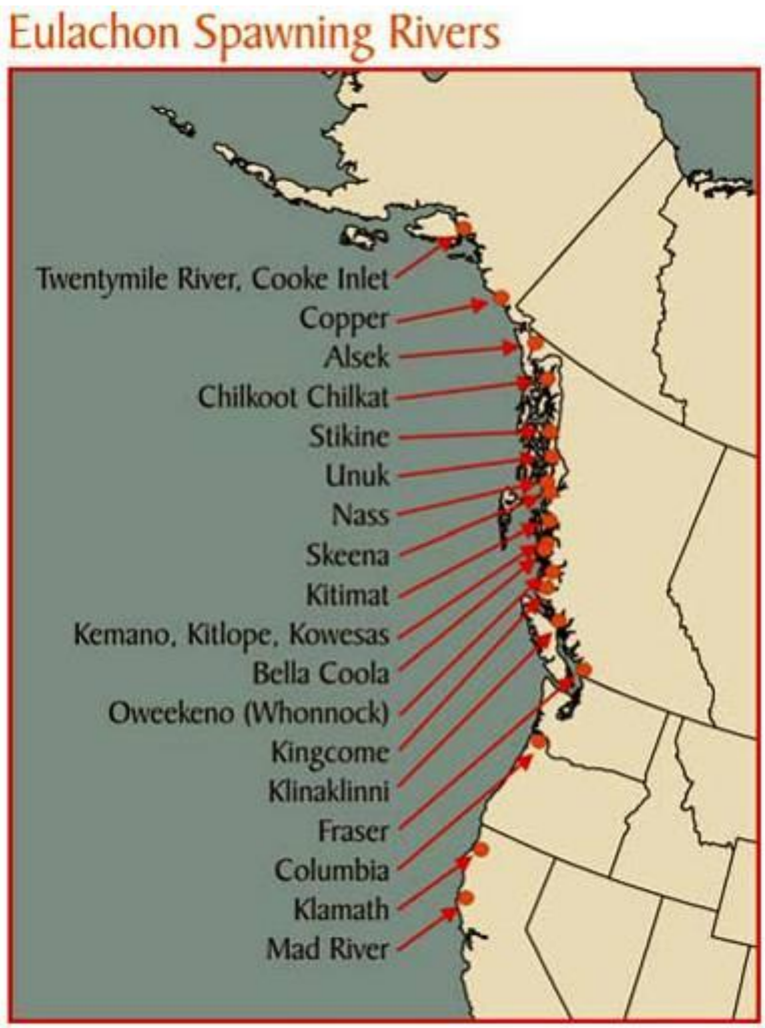
Eulachon is an anadromous smelt, which spawns in the lower portions of certain rivers draining into the northeastern Pacific Ocean ranging from Northern California to the southeastern Bering Sea in Bristol Bay, Alaska (Hubbs 1925, Schultz and DeLacy 1935, McAllister 1963, Scott and

Crossman 1973, Wilson et al. 2006). In the continental United States, most eulachon originate in the Columbia River Basin. Other areas in the United States where eulachon have been documented include the Sacramento River, Russian River, Humboldt Bay and several nearby smaller coastal rivers (i.e., Mad River), and the Klamath River in California; the Rogue River and Umpqua Rivers in Oregon; and infrequently in coastal rivers and tributaries to Puget Sound in Washington (Figure 4-11) (WDFW 2010a).

Eulachon spend 95 to 98 percent of their lives at sea (Hay and McCarter 2000). In the ocean, juvenile eulachon move from shallow nearshore areas to deeper waters on the continental shelf. Larvae and young juveniles distribute widely in coastal waters, where, along with adults, they inhabit the ocean bottom in waters 20-150 meters deep (Hay and McCarter 2000) and sometimes as deep as 182 meters (Barraclough 1964).

Historical information dating back to 1858 indicates that eulachon were present in Puget Sound (Drake et al. 2010*a*). A 2007 WDFW technical report entitled “Marine Forage Fishes in Puget Sound” (Pentilla 2007) presents detailed data on the biology, status, and trends of surf smelt and longfin smelt in Puget Sound, but states that “there is virtually no life history information within the Puget Sound Basin” available for eulachon. Similarly, detailed notes provided by WDFW and ODFW as part of the ESA status review provide no evidence of spawning stocks of eulachon in Puget Sound rivers (WDFW and ODFW 2008).

FIGURE 4-11
EULACHON SPAWNING RIVERS



Source: WDFW 2010a.

Eulachon typically spend three to five years in saltwater before returning to freshwater to spawn from late winter through mid spring. Eggs are fertilized in the water column, and after fertilization the eggs sink and adhere to the river bottom, typically in areas of gravel and coarse sand. Eulachon eggs hatch in 20 to 40 days and the larvae are then carried downstream and are dispersed by estuarine and ocean currents shortly after hatching. After the yolk sac is depleted, eulachon feed on pelagic plankton. Juvenile eulachon move from shallow nearshore areas to mid-depth areas (NOAA 2010). Adult eulachon weigh an average of 0.1 pounds and are 15 to 20 centimeters long with a maximum recorded length of 30 centimeters. They are an important link in the food chain between zooplankton and larger organisms, including small salmon, lingcod, and other fish (NWPCC 2004).

Eulachon are a small fish, rich in calories and important to marine and freshwater food webs, with historical importance to commercial and recreational fishermen as well as indigenous people from northern California to Alaska. In Washington, by permanent rule, commercial fishing for eulachon in the Columbia and Cowlitz Rivers is restricted. Current harvest levels are orders of magnitude lower than historic harvest levels, and a relatively small number of vessels operate in this fishery. No significant fishing for eulachon occurs in the Klamath River or in British Columbia rivers north of the Fraser River (75 FR 13012). The states of Oregon and Washington have modified sport fishing regulations due to declining eulachon abundance (WDFW and ODFW 2001). In the past, eulachon were an important food source for Canadian First Nations and many Native American tribes from northern California to Alaska. In more recent history, tribal members in the United States harvest eulachon under recreational fishing regulations adopted by the states. The CDFO typically authorizes a small subsistence fishery for First Nation members, primarily in the Fraser River.

4.10.3 Critical Habitat Designations

Critical habitat has not yet been designated for this species (75 FR 13012).

4.11 Southern Resident Killer Whale

4.11.1 Current Status

NMFS listed the Southern Resident killer whale (SRKW) DPS as endangered on November 18, 2005 (70 FR 69903-69912). Prior to the ESA listing, NMFS determined the SRKW stock as a depleted species under the Marine Mammal Protection Act (MMPA) in May, 2003 (68 FR 31980-31983). While designated as a depleted species under the MMPA, NMFS developed a proposed conservation plan for the SRKW in October, 2005 (NMFS 2005*d*). NMFS addressed comments on the proposed conservation plan and incorporated ESA components into the plan, which led to the development of a proposed recovery plan for the SRKW in November, 2006. Incorporating comments and recent research on this species, NMFS finalized a recovery plan for the SRKW in January 2008 (NMFS 2008*c*).

Listing factors that continue to pose a threat or risk to killer whales within Puget Sound include: depleted prey abundance (salmon), low genetic diversity due to inbreeding, underwater noise pollution (e.g., from commercial, recreational, and research vessels), disease, and environmental contaminants (70 FR 69908).

4.11.2 Life History and Presence in the Action Area

The killer whale is the largest member of the Delphinidae family. Considered to be the most widely distributed of all cetaceans, killer whales occur in all oceans but are most common in coastal waters and at higher latitudes. In the North Pacific, killer whales occur in waters off Alaska and southward along the North American coast and continental shelf (Wiles 2004). In Washington, killer whales can be found in the inland waters around the San Juan Islands, including Haro Strait, Boundary Passage, and the eastern portion of the Strait of Juan de Fuca from late spring to early fall (Heimlich-Boran 1988, Felleman et al. 1991, Olson 1998, Ford et al. 2000). Less time is generally spent elsewhere, including other parts of the Strait of Juan de Fuca, Puget Sound, and the outer coast. Movements during the winter and early spring are poorly known, but many animals shift their activity to outer coastal areas or depart the state (Wiles 2004).

Killer whales follow one of three life history forms or ecotypes. These forms include resident (which is a colloquial term referring not necessarily to site fidelity but rather to centralized movement patterns), transient, and offshore. The specific diet of pods varies both by location and by resident or transient behavior. Resident pods generally eat fish with few attacks on marine mammals, while transient pods are more prone to aggressive attacks on larger prey. Killer whale pods probably seek out and forage in areas where salmon mostly occur, especially those associated with migration salmon (Heimlich-Boran 1986, 1988, McCluskey 2006). Many of the important foraging sites, as reported by Hauser (2006), are major corridors of migrating salmon. During early autumn, SRKW pods expand their routing movements into Puget Sound, likely to take advantage of salmon runs (Osborne 1999).

The SRKW DPS is one of four distinct and recognized communities of resident killer whales in the northeastern Pacific, whose range extends from Alaska to California (Krahn et al. 2002, 2004). This population segment consists of three pods (one or more matriline groups traveling together), designated J, K, and L, that reside for part of the year in the inland waterways of Washington State and British Columbia (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound), principally during the late spring, summer, and fall (Bigg 1982, Ford et al. 2000, Krahn et al. 2002). Pods have visited coastal sites off Washington and Vancouver Island (Ford et al. 2000), and are known to travel as far south as central California and as far north as the Queen Charlotte Islands. Pods can be found in the Puget Sound year-round, but during fall, winter and spring, SRKWs are more prone to excursions and can be seen as far south as California. Winter and early spring movements and distribution are largely unknown for the population (NMFS 2008*c*).

SRKW ranges are best known from late spring to early autumn, when survey and observational effort is greatest. During this period, all three SRKW pods are regularly present in the Georgia Basin (including Georgia Strait, San Juan Islands, and Strait of Juan de Fuca) (NMFS 2008*c*; Whale Museum 2009*a*). The K and L pods typically arrive in May or June and spend most of their time in Georgia Basin until departing in October or November. While in inland waters during warmer months, all of the pods concentrate their activity from the south side of San Juan Islands through Haro Strait northward to North and South Pender Islands and Boundary Passage. Less time is generally spent elsewhere, including Admiralty Inlet west of Whidbey Island and Puget Sound (Hauser 2006; NMFS 2008*c*).

SRKWs spend 95 percent of their time underwater, nearly all of which is between the surface and a depth of 30 meters (Baird 2000; Baird et al. 2003, 2005). Ford et al. (2000) report four behavioral states in killer whales, including foraging, traveling, resting, and socializing. Resident killer whales spend approximately 50 to 67 percent of time foraging, either actively feeding or searching for food (Ford 1989). While traveling, killer whales swim in a tight formation, consistently swimming in a specific direction, often surfacing and diving simultaneously (Ford et al. 2000). This behavior is commonly observed among killer whales moving between locations such as feeding areas (Wiles 2004). Traveling comprises approximately 4 to 8 percent of northern resident killer whale behavior (Ford 1989), while SRKW reportedly spend more time traveling than northern residents (Heimlich-Boran 1988), perhaps due to longer distances between their feeding sites (Ford et al. 2000). Resting, often occurring after foraging, comprises approximately 10 to 21 percent of resident killer whale behavior (Ford 1989; Heimlich-Boran 1988). During resting behavior, killer whales swim slowly, usually abreast, and in a tight formation, and surface and dive in unison (Ford et al. 2000). Socializing includes physical interactions, displays (e.g. breaching, tail slapping, spyhopping), and vocalizations (Ford et al. 2000). During the summer residents spend approximately 12 to 15 percent of their time socializing (Ford 1989; Heimlich-Boran 1988).

The typical swimming pattern of foraging and traveling killer whales is a sequence of three to five shallow dives lasting 10 to 35 seconds each followed by a long dive, with surface blows of 3 to 4 seconds occurring after each dive (Erickson 1978, Morton 1990, Ford and Ellis 1999). Baird et al. (2003, 2005) reported SRKW in inshore water of southern British Columbia and Washington averaged about 0.7 to two dives per hour made below 30 meters, with such dives occurring more often during the daytime. These represented 5 percent of all dives and occupied less than 2.5 percent of an animal's total dive time. During the day, dives greater than 150 meters deep were made on average about once every five hours (Baird et al. 2003, 2005). Since dives below 30 meters represented only 2.5 percent of an animal's dive time, it can be safely assumed that dives to 150 meters represent an extremely small portion of a whale's dive time.

Since 1974, when annual censuses were initiated by the Department of Fisheries and Oceans Canada and later assumed by the Center for Whale Research in 1976, the population of SRKWs ranged between 67 and 96 individuals. The L pod is the largest of the three pods, while J and K pods have similar numbers. As of November 2009, the estimated population totals 87 individuals - 41 in L pod, 27 in J pod, and 19 in K pod (Center for Whale Research 2009). Survival of killer whales is age-specific, with higher mortality rates among young calves and low mortality rates among reproductive females. Generally, males have a lower life expectancy and higher mortality rates compared to females (Northwest Fisheries Science Center 2008). Over the past three decades, on average, 3.3 calves were born each year, with an approximate 81 percent survival rate. Since 1978, there has been an average of 3.25 deaths per year (Northwest Fisheries Science Center 2008).

As shown in Figure 4-12, SRKWs are distributed widely throughout the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound including Admiralty Inlet. The majority of sightings occur at locations off San Juan Island, where there have been 750-1,550 sightings from 1993-2005. At locations in Admiralty Inlet in the vicinity of the Project, between 6 and 25 sightings of SRKW were recorded from 1990 to 2005 (NMFS 2009a).

To better characterize SRKW and other ESA-listed marine mammal usage of the greater Project area, the District conducted marine mammal monitoring (Tollit et al. 2010a), which included the following components (results summarized after):

a) Described historical trends in migratory movements. A historical data review and analysis of SRKW sightings in the Whale Museum's Orca Master database was queried for information on number and seasonality of movements through the area to aid in the assessment of potential disruption effects (e.g., exclusion from Admiralty Inlet).

b) Described historical habitat use in the study area. A historical data review of supplementary sightings databases summarized available information on route (i.e., which side of Admiralty Inlet is used) and behavior (i.e., whether animals are traveling or foraging) in the study area.

c) Described current seasonal presence of SRKWs in the immediate Project area and level and variability of background (ambient) noise. Collected year-round, 24/7 information on seasonal presence of SRKW in the immediate area of the Project site using PAM techniques (a streaming cabled hydrophone at Port Townsend and autonomous data storing hydrophones moored to the seafloor). Efficacy and sensitivity of the hydrophones were assessed by using the planned observer program detailed below and short playback studies at the Project site. The autonomous hydrophone also collected data on level and variability of background (ambient) noise to assist in marine mammal noise impact assessments (e.g., calculation of radii of audibility).

d) Described current SRKW transit patterns through the study area. Collected new information on number of transits through the area using scheduled land observations, land and boat-based volunteers and a review of PAM data. This provided up-to-date information on migratory movements and complemented the historical review.

e) Described current study area habitat use by individual pods during key seasons, and whether foraging occurs in the vicinity of the Project. Conducted surveys using both boat and land-based visual observations on group numbers, pod identification, route, and behavioral state during transit through the study area.

f) Described vertical depth distribution of observed SRKW. Opportunistically collected dive depth information on SRKW in the vicinity of the proposed installation site using a vertical hydrophone array. Hydrophone arrays only provided information when whales were actively calling or clicking, and therefore represented a sample of the overall dive profile of SRKW rather than a complete description. Data from the hydrophone arrays was used to support Project risk analyses and the development of encounter-rate estimates (Wilson et al. 2007).

g) Collected incidental information on other ESA-listed marine mammal presence during boat and land observation studies to provided supplementary data to existing data, including presence/absence, relative use levels, and group sizes across species in the vicinity of the Project site.

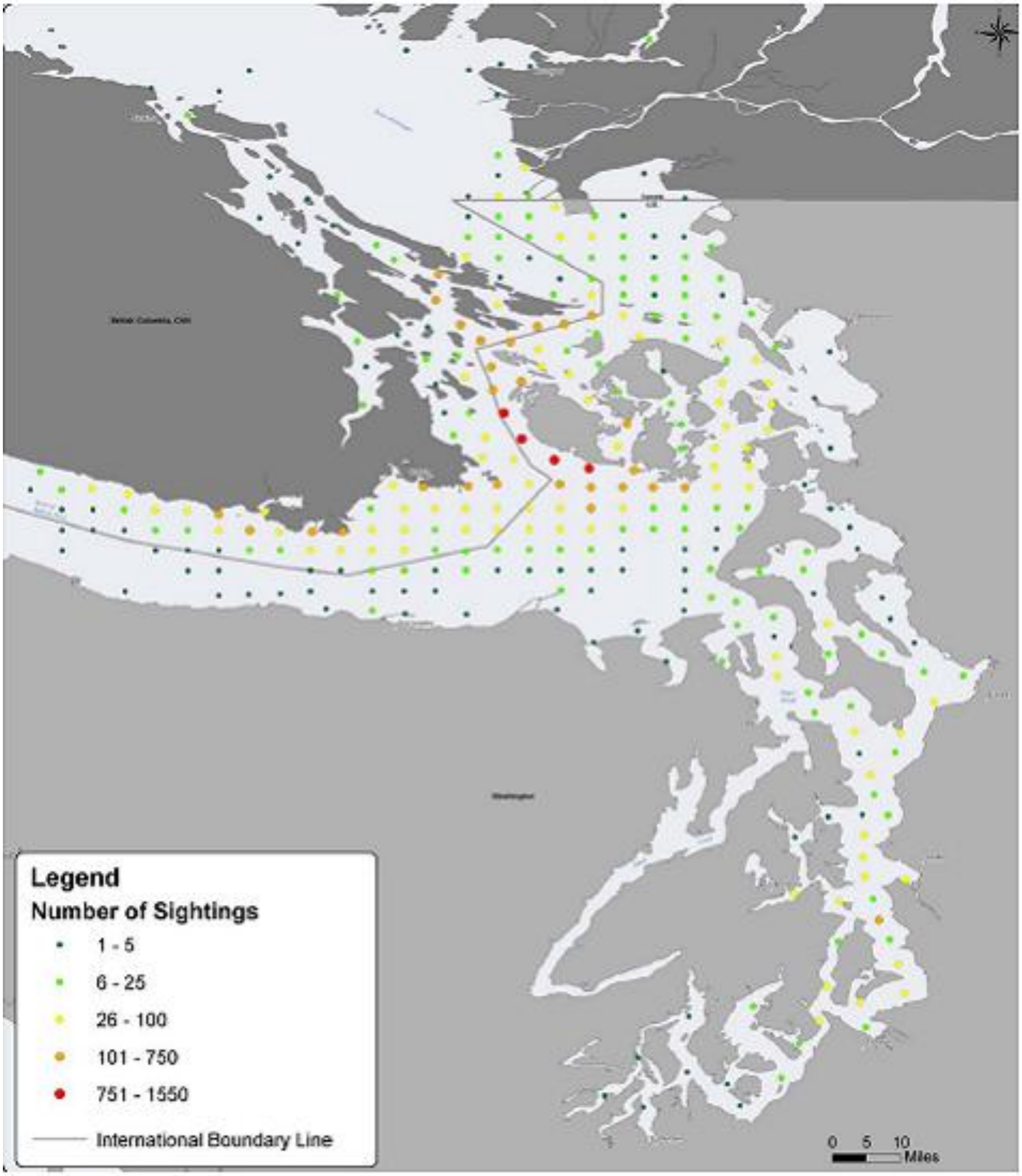
h) Observed current usage of nearest haul-out (Marrowstone Island) by Steller sea lions. Haul-out counts were not meant to represent a systematic assessment of marine mammal populations, but rather were planned in order to take advantage of the fact that there was a vessel in the vicinity; they were intended to supplement historical data (e.g., WDFW surveys, NMFS stock assessments) and results of other field studies (i.e., land-based observations).

Since the 1970s, the Whale Museum in Friday Harbor, Washington has maintained a database of whale sightings. The database, termed the Orca Master, is considered the most comprehensive long-term dataset of broad-scale whale distribution in inland waters. The District contracted the Whale Museum to conduct a historical review to describe SRKW habitat use within the Project vicinity and aid in providing data to assess encounter risk with the Project turbines.

From January, 1990, through December, 2008, the Orca Master database recorded 2,532 sightings of SRKW in Puget Sound “proper” (south of Deception Pass and Admiralty Inlet), and of those, 196 occurred within five nautical miles of the proposed Project (Whale Museum 2009*b*). The Whale Museum (2009*b*) and NMFS (NMFS letter to the District dated December 8, 2008) assume that SRKW transit through Admiralty Inlet, not Deception Pass[9], and overall these numbers indicate that many transits through Admiralty Inlet are not directly observed in the region of the Project.

[9] The Orca Master databases only contain one record of SRKW passing through Deception Pass (Whale Museum 2009*b*).

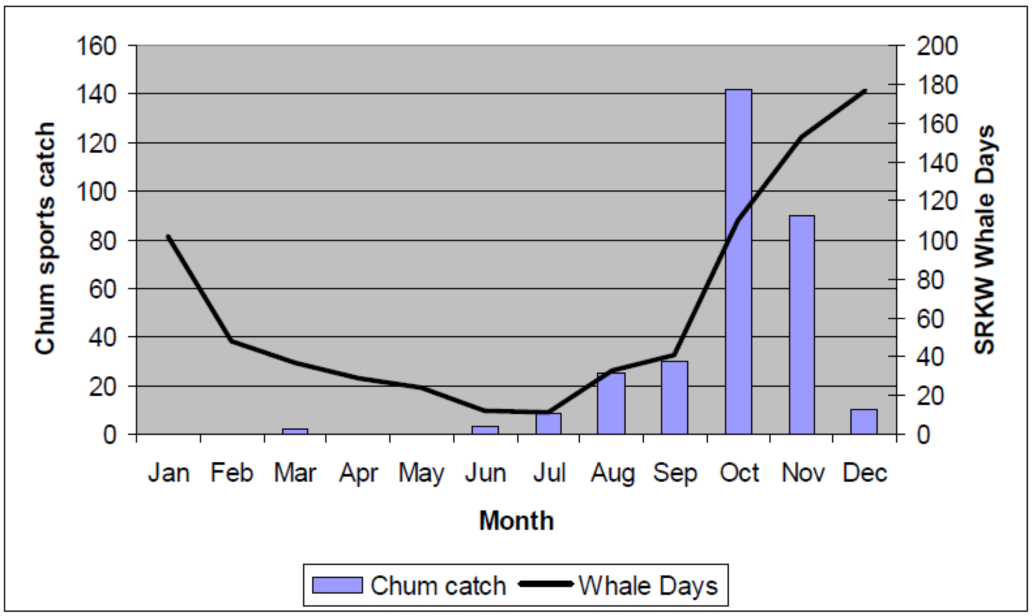
FIGURE 4-12
DISTRIBUTION OF SRKW SIGHTINGS FROM 1993 TO 2005



Note: Multiple sightings of whales in the same location on the same day were eliminated.
Source: NMFS 2009a.

The sightings in the Orca Master database include multiple reports of the same pod on the same day. A more valuable metric is whale days, which are the number of days SRKWs were sighted, because whale days account for repeat counts on the same pods. From the years 2001-2008, which represent the time period during which more comprehensive monitoring has been occurring, there were an average of 60.5 whale days per year in Puget Sound, and 70 percent of these whale days were concentrated in the months of October through January (Figure 4-13). The seasonality of the SRKW usage of Puget Sound is likely due to the timing of chum salmon runs in Puget Sound (Figure 4-13). The number of transits through Admiralty Inlet was estimated to be 42 per year (maximum 54, minimum 31), which equates to 21 forays (each foray representing two transits: a pod entering, then leaving Puget Sound). All three pods use Puget Sound, with J pod the most common, followed by K pod. Given reported pod associations during forays into Puget Sound it was estimated that a total of 1,442 SRKW animals transit through Admiralty Inlet in a year. During these transits, SRKW are more likely to use the western side of Admiralty Inlet, although the eastern portion is used as well. During these transits SRKW are often traveling, but also exhibit social and foraging behavior (Whale Museum 2009*b*).

FIGURE 4-13
SRKW WHALE DAYS COMPARED TO CHUM CATCH



Source: Whale Museum 2009*b*; personal communication, Whale Museum with S. Thiesfeld, WDFW.

The District's field monitoring effort occurred between October, 2009, and April, 2010, and focused on how marine mammals, with a focus on SRKW, utilize the Project area. The study area centered on the waters of northern Admiralty Inlet and was monitored both by boat and from land via a vantage point on Admiralty Head, approximately 1 kilometer from the proposed pilot Project deployment site. The visual observation data collected during this study were used to complement and combine with results from passive acoustic monitoring (PAM) efforts from two hydrophones already mounted on the seafloor in the Project area, as well as a cabled hydrophone located near Port Townshend. Data were gathered during these multi-faceted field studies conducted between October 2, 2009, and April 30, 2010 (Tollit et al. 2010b).

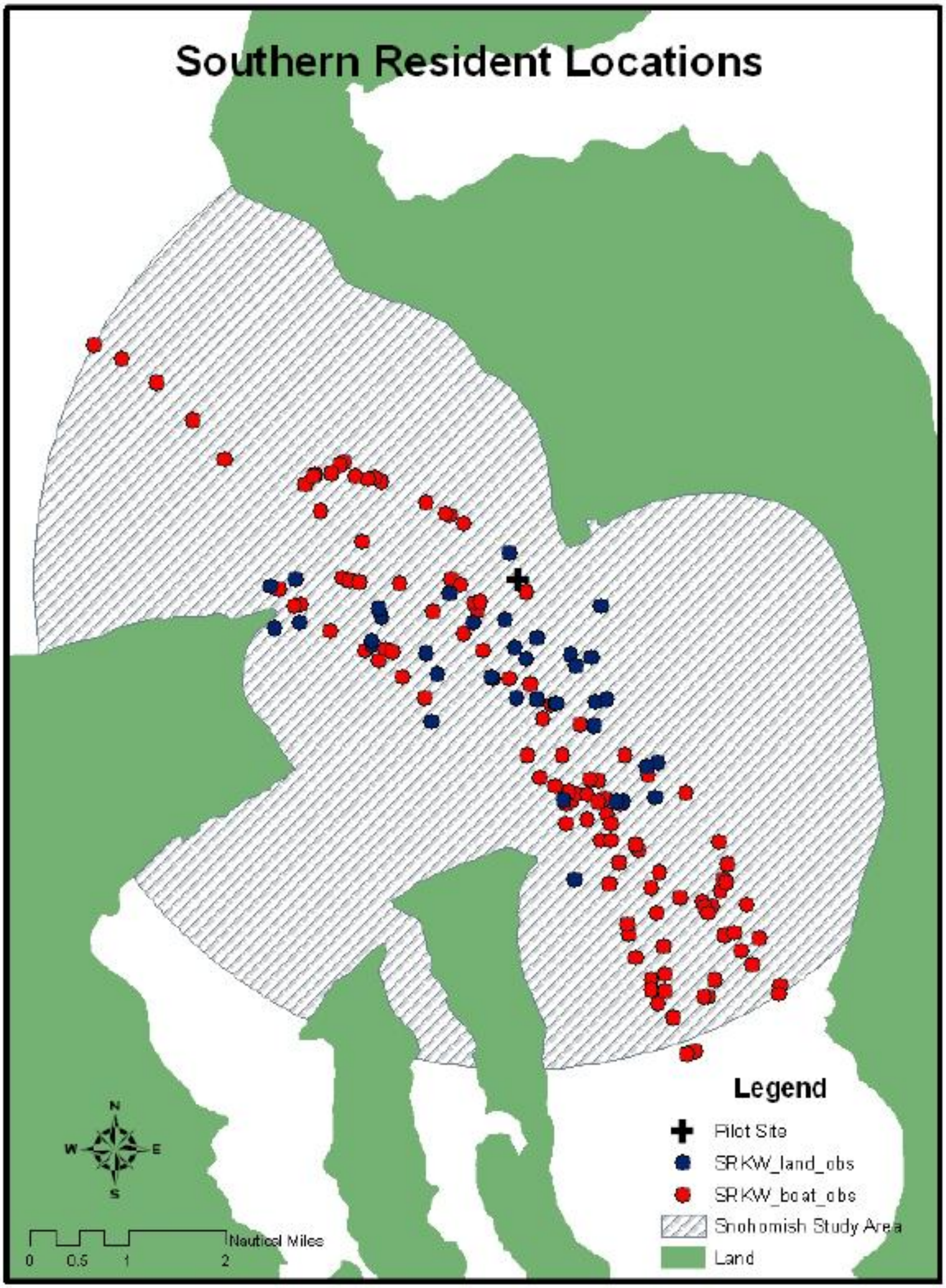
During the study period, 116 two-hour land observation surveys were completed which also drew upon information from 13 fast land responses including many observations outside the study area, providing assistance with pod identification and supplemented transit information. SRKW were seen in the study area by land based observers on three observer days (October 10, 20, and 21, 2009 and one fast response day [December 6, 2009]). During the study period, an estimated 22 SRKW transits[10] were observed. Of the 22 times that SRKW transited the study area, the SRKW were detected acoustically via the automated algorithm of the Port Townsend Marine Science Center (PTMSC) hydrophone (14 times, 64 percent) and/or by human listeners (10 times, 45 percent) (Tollit et al. 2010b).

This study used opportunistic sighting information and PAM to successfully collect new data on seven (of the estimated 22) SRKW transits observed through Admiralty Inlet. Opportunistic dive depth information was collected in the vicinity of the proposed installation site using a vertical hydrophone array. The vertical array was deployed and used to collect recordings during seven of the SRKW transits. Of the 189 total minutes recorded, localized calls or clicks were recorded during a total of 104 minutes (55 percent). A total of 655 calls and clicks were localized at depths from the surface down to 142 meters; however, 80 percent of the vocalizations were produced at depths of 30 meters or less, with little difference in average depth by behavior category. During the closest approach to the proposed project site (October 21, 2009), while the focal group was categorized as foraging, depths from 23 to 58 meters were recorded from eight calls and clicks. This study indicated that there is great variability in the amount SRKWs vocalize when transiting through the study area (0 to 92 percent of recording time). Periods of little or no vocal activity were witnessed, most notably on October 10, 2009, when the pods were described as undertaking slow (thought to be restful) travel (Tollit et al. 2010b).

Seven boat-based follows were conducted as SRKW transited the study area beaten October, 2009 and April, 2010. Boat-based follows were conducted on October 10, 20, and 21, 2009; December 6, 7, and 22, 2009; and January 2, 2010. During each of the seven boat-based follows, SRKW were observed in Admiralty Inlet. Location data of the focal group of whales showed a wide use of the study area by the whales traveling through the shipping lanes and generally west and southwest of the Project site; land-based observations provided similar data (Figure 4-14). All three SRKW pod matrilines were observed transiting the study area. J pod was observed on six occasions, K pod on four occasions, and L pod on three occasions (all in October, 2009). On October 21, 2009, all three pods spent more than four hours in the study area, moving through the inlet to the north and then circling back for a double transit pass in one day; also on this day, the whales were observed (by boat and land) foraging close (~275 meters) to the Project site. The same SRKW approach was detected by the C-POD during the PAM study (Tollit et al. 2010b) and by the Port Townsend hydrophone. In summary, during transits, a total of 11.5 hours of focal sampling were conducted. During this time, SRKW spent most of their time in the study area traveling (74 percent), while the remainder of the time was spent foraging (21 percent) and socializing (5 percent) (Tollit et al. 2010b).

10 A transit of Admiralty Inlet is defined as any crossing (entry or exit) of the line connecting Admiralty Head and Point Wilson.

FIGURE 4-14
BOAT-BASED AND LAND-BASED LOCATIONS OF SRKW



Source: Tollit et al. 2010a.

4.11.3 Critical Habitat Designations

NMFS designated critical habitat for the SRKWs on November 29, 2006 (71 FR 69054-69070). Critical habitat includes three distinct marine areas identified as the Summer Core Area, Puget Sound Area, and the Strait of Juan de Fuca Area (71 FR 69054), and includes "waters relative to a contiguous shoreline delimited by the line at a depth of 6.1 meters (20 feet) relative to extreme high water". These three areas constitute the majority of Washington's northwestern coastline, excluding a few small areas. Admiralty Inlet lies within the Puget Sound Area. The following PCEs for SRKWs critical habitat were identified in the critical habitat ruling (71 FR 69061):

- Water quality to support growth and development;
- Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and
- Passage conditions to allow for migration, resting, and foraging.

4.12 North Pacific Humpback Whale

4.12.1 Current Status

The humpback whale (*Megaptera novaeangliae*) was listed as endangered in 1970 as a result of commercial whaling (35 FR 18319; December 2, 1970). There has been a prohibition on taking humpback whales since 1966. Shore-based whaling apparently depleted the humpback whale stock off California twice: once prior to 1925 (Clapham et al. 1997) and again between 1956 and 1965 (Rice 1974). A recovery plan was issued for the humpback whale in 1991 (NMFS 1991).

4.12.2 Life History and Presence in the Action Area

The humpback whale occurs in all oceans, with the possible exception of the Arctic (NMFS 1991). Humpback whales in the North Pacific feed in coastal waters from California to Russia and in the Bering Sea. The estimated pre-1905 population of humpback whales in the North Pacific was about 15,000 (NMFS 2008*d*). As a result of the whaling industry, populations were reduced to about 1,200 whales by 1966. Following restrictions on the whaling industry as a whole, and prohibition of taking of humpback whales since 1966, populations of humpback whale have been increasing. Population estimates suggest an increase of 6 to 7 percent annually over the last 20 years (NMFS 2005*e*). The North Pacific humpback population is estimated to be 6,000 whales (Calambokidis et al. 1997).

While the International Whaling Commission recognizes only one Pacific stock of humpbacks, research suggests at least three populations within the United States Exclusive Economic Zone (NMFS 2005*e*):

- Eastern North Pacific Stock - a stock residing in Central America and Mexico in winter/spring that move along the West Coast to British Columbia in summer/fall;

- Central North Pacific Stock - a winter/spring population residing in the Hawaiian Islands that migrate to north British Columbia or southern Alaska through Prince Williams Sound west to Kodiak; and

- Western North Pacific Stock - a winter/spring population in Japan that migrates to the Bering Sea and Aleutian Islands in summer/fall.

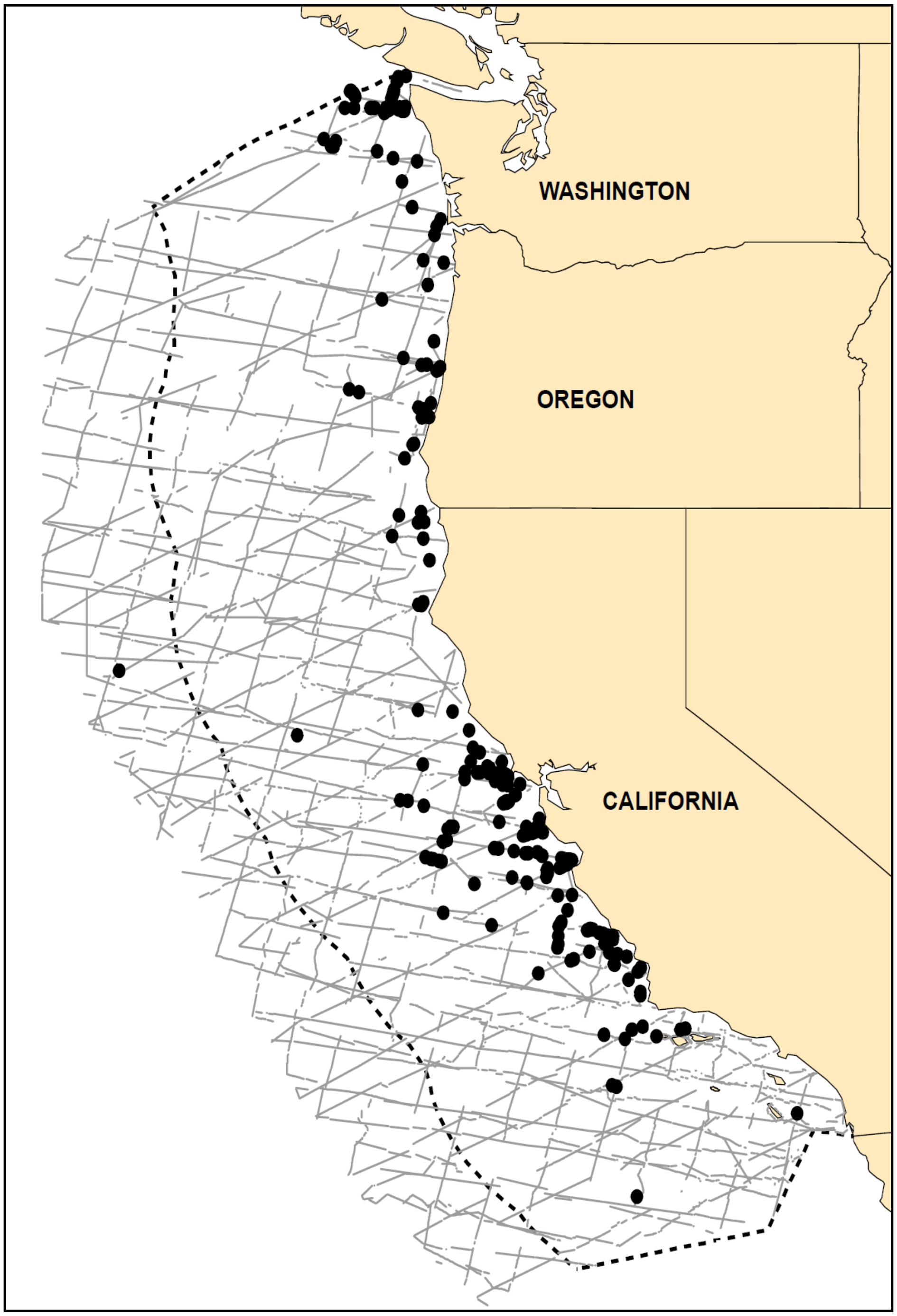
The three identified stocks appear to follow general migrational trends for feeding and mating. In the North Pacific humpbacks feed in coastal waters from California to Russia and in the Bering Sea and migrate south to wintering destinations off Mexico, Central America, Hawaii, southern Japan, and the Philippines where calving and mating occurs (NMFS 2008*d*). However, calf sitings and back-dating suggest that mating may occur at low rates throughout the year, possibly during migrations (NMFS 1991). Movement along the western United States coastline primarily occurs during summer and fall; however, historical whale observations have been made in every month except February, March, and April (NMFS 1991).

Humpback whales can grow to a length of 15 meters and weigh 23,000 to 36,000 kilograms and reach sexual maturity at around 12 meters in length or 6 to 10 years of age (American Cetacean Society [ACS] 2004). Females of reproductive age generally bear a calf every two to three years or up to five years (NMFS 1991).

Within the summer feeding areas, humpback whales' distribution is likely driven by locations of dense patches of prey which vary inter-annually, seasonally, diurnally, and daily (NMFS 1991). Humpback whales feed on small crustaceans (krill), and various species of small fish (anchovies, herring, pollock, mackerel, sandlance). Each whale may consume nearly a ton of food per day while feeding and filter huge volumes of seawater. Feeding behavior is diverse and can vary from use of columns, clouds or nets of expelled bubbles to concentrate prey; herding, and possibly disabling prey by maneuvering, flicking or pounding with flukes and flippers; using the water surface as a barrier to prevent the escape of prey; feeding in formation ("echelon feeding"); acoustic cues to synchronize feeding lunges; and short and long-term cooperation between individuals (NMFS 1991; Weinrich et al. 1992).

Generally, humpback sightings in northwest coastal waters are relatively uncommon (Figure 4-15). Barlow and Forney (2007) estimated 1,096 humpbacks in California, Oregon, and Washington waters based on summer/fall ship line-transect surveys in 2001. Forney (2007) estimated 1,769 humpbacks in the same region based on a 2005 summer/fall ship line-transect survey, which included additional fine-scale coastal strata not included in the 2001 survey.

FIGURE 4-15
HUMPBACK WHALE SIGHTINGS FROM SHIPBOARD SURVEYS OFF CALIFORNIA, OREGON, AND WASHINGTON, 1991-2005



Source: NMFS 2008*d*.

4.12.3 Critical Habitat Designations

Critical habitat has not been designated for the humpback whale.

4.13 Steller Sea Lion

4.13.1 Current Status

NMFS listed the Steller sea lion as threatened on April 5, 1990 (55 FR 12645). In May 1997, based on biological information collected since the species was listed in 1990, NMFS reclassified the species as two DPS, the western and eastern stock (NOAA 2007*b*). The western stock occurs from the western Gulf of Alaska west to Japan, while the eastern stock is found from Alaska south along the West Coast states of California, Oregon and Washington (NOAA 2007*b*). The western stock was reclassified as an endangered species under the ESA, while the eastern stock remained classified as a threatened species (62 FR 24345-24355). NMFS published the first recovery plan for the Steller sea lion in December 1992 (NMFS 1992). In March 2008, NMFS issued the final revised recovery plan for the species (NMFS 2008*e*).

Primary listing factors included decline in prey abundance and quality (62 FR 24353). While the eastern DPS is improving, threats still exist. In order of relative importance, these include environmental variability, competition with fisheries, predation from killer whales, toxins, inadvertent commercial take, Alaskan native harvest, disease, and adverse interactions associated with tourism and research (NMFS 2008*e*).

4.13.2 Life History and Presence in the Action Area

The eastern DPS of Steller sea lions has been increasing at approximately 3 percent per year since the late 1970s through 2002 (Pitcher et al. 2007). Overall, the eastern DPS appears to be similar in size to historical levels of the early 1900s, with large population increases in southeastern Alaska balancing out declines in the southern portion of its range (Pitcher et al. 2007).

Sea lion habitat includes both marine waters and terrestrial rookeries (i.e., breeding grounds and haulouts), with the primary factor influencing habitat selection being prey availability. Males are the primary occupants of haulout sites. Although Steller sea lions may be found on gravel or cobble beaches, their preferred terrestrial habitat typically consists of exposed rocky shorelines associated with shallow well mixed waters, average tidal speeds, and gradual bottom slopes. Rookeries are nearly exclusively located on offshore islands and reefs (NMFS 2008*e*).

Breeding primarily occurs from late May to early July in rookeries situated on remote islands, rocks, and reefs (NMFS 2008*e*). Females remain with pups for one week after birth and then leave for varying lengths of time to feed. During June and July, Steller sea lions show high fidelity to their natal rookeries. Outside of June and July, however, Steller sea lions can travel great distances to feed. Foraging Steller sea lions have been observed traveling up to 1,770 kilometers from their natal grounds at travel rates exceeding 160 kilometers/day (NMFS 2008*e*).

The highest concentrations of Steller sea lions are found in southeast Alaska and British Columbia. South of Alaska, the largest reproductive sub-population of Steller sea lions can be found in northern California and southern Oregon. There are no rookeries within Washington State; however, adolescent and adult Steller sea lions can be found along the coast throughout the year (NMFS 2008*e*, Pitcher et al. 2007). Some Steller sea lions are born at a few sites along the outer coast of Washington, but not in Puget Sound (personal communication, P. Browne, HDR, with S. Jeffries, WDFW, July 7, 2009). There are four haulouts, including two major sites (sites with greater than 50 animals) in Washington, which are regularly used during the breeding season. Steller sea lions at these sites are assumed to be immature animals and non-breeding animals associated with rookeries from other areas. Juvenile Steller sea lions from southeastern Alaska and Oregon have been observed in Washington (NMFS 2008*e*, Pitcher et al. 2007). Steller sea lions are observed in Puget Sound in the fall, winter, and spring. During summer, sea lions are found in their breeding grounds. From 1983 to 1986, Steiger and Calambokidis (1986) observed Steller sea lions overwintering in South Puget Sound, south of Tacoma Narrows. The first sightings occurred in late fall and early winter, with numbers peaking in April or May, with the last sightings in May (Steiger and Calambokidis 1986).

Steller sea lion use of Puget Sound, and the Project area, appears to be increasing in recent years. In 2000, Jeffries et al. (2000) surveyed the area in and around Marrowstone Island, located in Admiralty Inlet, just south of the Project, and did not find any signs of habitat usage or haulout. Since 2000, a steady use of a site on the northeast side of the island has occurred (Figure 4-16). This site consists of scattered intertidal rocks and is located 8.4 kilometers south of the deployment area. Three to 15 sea lions have been observed at this site over the last five years (personal communication, T. Loughlin, NRC, Inc. and P. Browne, HDR with S. Jeffries, WDFW). Three other sites at which Steller sea lions have been observed are located 37 to 58 kilometers north of the Project, and 5 to 50 Steller sea lions have been observed at these sites (Figure 4-16) (personal communication, P. Browne, HDR with S. Jeffries, WDFW, July 2009; Jeffries et al. 2000).

Between October 2009 and April 2010, the District conducted marine mammal pre-installation field studies to evaluate how marine mammals utilize the Project area. The field studies included land-based and boat-based visual observations of marine mammals in the study area (a 5-nautical-mile radius from the proposed pilot Project deployment site). During the seven-month field study, a total of 2,145 sighting locations were recorded of seven species. Steller sea lions were observed on 66 percent of the survey days and represented 17 percent of the total marine mammal sightings. Overall, 362 sightings of Steller sea lion were observed over 77 separate days. Steller sea lions were sighted mainly within about 1 kilometer of the observation point (bluffs at Fort Casey, near Admiralty Head) and were more frequently observed in the inshore zone (71 percent of observations). Typically, lone Steller sea lions were observed; however, interquartile range was 1 to 2, with a maximum group size of 14 observed. Sightings of Steller sea lions sometimes included observations of surface feeding behavioral events (Tollit et al. 2010a).

FIGURE 4-16
STELLER SEA LION HAULOUT LOCATIONS IN THE VICINITY OF THE ADMIRALTY INLET PILOT TIDAL PROJECT

Source: Jefferies et al. 2000, personal communication, P. Browne, HDR, with S. Jefferies, WDFW, July 2009

4.13.3 Critical Habitat Designations

On August 27, 1993, NMFS designated critical habitat for both the western and eastern DPS of Steller sea lions. Critical habitat includes certain areas and waters of Alaska, Oregon, and California (58 FR 45269-45285; however, critical habitat has not been designated in Washington. Primary constituent elements were not identified in the critical habitat listing; however, critical habitat essential features included certain rookeries, haulouts, associated areas, and foraging areas (58 FR 45272).

4.14 Marbled Murrelet

4.14.1 Current Status

The USFWS listed the marbled murrelet (*Brachyramphus marmoratus*) as threatened under the ESA on September 28, 1992 (57 FR 45328-45337). In 1997, the USFWS finalized a recovery plan for this species (USFWS 1997). Once thought to be abundant in the Pacific Northwest, marbled murrelets are now only considered common during certain times of the year (USFWS 1997). Listing factors for marbled murrelet include loss and modification of nesting habitat primarily due to commercial timber harvesting, threats from mortality associated with gill net fishing operations, and effects of oil spills (57 FR 45328)

A five-year review of the marbled murrelet was completed on September 1, 2004 to ensure accuracy of the species' ESA classification (73 FR 57314-57317). This review found that the California, Oregon, and Washington marbled murrelet population was not a DPS; however the USFWS believes the analysis of the discreteness of this population segment was flawed (73 FR 57314-57317). The USFWS initiated a rangewide status review of the marbled murrelet on October 2, 2008 to determine if delisting the California, Oregon, and Washington population is warranted (73 FR 57314-57317). On January 21, 2010, USFWS concluded that the Washington/Oregon/California population of marbled murrelet is in fact a DPS and it should continue to be listed as a threatened species under ESA (75 FR 3423).

4.14.2 Life History and Presence in the Action Area

The marbled murrelet is a long-lived small seabird of the Alcidae family that inhabits the eastern Pacific coastline from Alaska to southern California (73 FR 12067 12068). Spending much of its life at sea, but using old-growth forests for nesting, the marbled murrelet is generally found in association with calm, shallow coastal waters and bays typically less than 1-1.6 kilometers from shore (Seattle Audubon Society 2007). In general, murrelets occur closer to shore in exposed coastal areas and farther offshore in protected coastal areas (Nelson 1997).

Marbled murrelets forage for prey by diving and swimming underwater, propelling themselves with their wings (Seattle Audubon Society 2007). They generally forage in nearshore waters shallower than 30 meters but are capable of diving to depths of up to 47 meters (Mathews and Burger 1998). During summer, fish form a significant part of their diet, with typical prey including Pacific sand lance (*Ammodytes hexapterus*), Pacific herring (*Clupea harengus*), northern anchovy (*Engraulis mordax*), smelts (*Osmeridae*), and sea perch (*Cymatogaster aggregata*) (USFWS 1997). While adult and sub-adult marbled murrelets primarily feed on the larval and juvenile stages of prey fish, chicks are normally fed larger second-year fish (Seattle Audubon Society 2007; USFWS 1997). During winter and spring, fish are less important and invertebrates such as euphausiids, mysids, and gammarid amphipods may represent a considerable fraction of their total diet (USFWS 1997). As such, marbled murrelets are considered opportunistic feeders, requiring primarily that their prey fall within certain size classes (USFWS 1997). Although some uncertainty remains regarding the actual composition of the marbled murrelet’s diet in the Pacific Northwest, it appears that the most common food source for both adults and chicks across their entire range is the Pacific sand lance (USFWS 1997; Speich and Wahl 1995).

Unlike other members of the Alcidae family, marbled murrelets nest from late March to late September, in coniferous old-growth forests or stands that may be as many as 70 to 80 kilometers inland (Seattle Audubon Society 2007; USFWS 1997, 2006). Due to its sheltered waters, mixed rock and sandy shorelines, and its proximity to old-growth forests, Puget Sound is used heavily during the breeding season (Strong 1995; USFWS 1997). During the breeding season (mid-May to late July), murrelets are concentrated where food and nearby nesting habitat are abundant, including the Strait of Juan de Fuca, the south shore of Lopez Island, the southwest shore of Lummi Island, Obstruction and Peavine passes between Orcas and Blakely islands in the San Juans, Point Wilson, Point Roberts, Cattle Point, Green Point, Tongue Point, and Dungeness Wildlife Refuge and Spit (Seattle Audubon Society 2007; Speich and Wahl 1995).

It is also believed to be a vital wintering area for populations of marbled murrelets moving south from British Columbia to take advantage of the basin’s protected bays and channels (Speich and Wahl 1995; USFWS 1997). Areas of winter concentration include Sequim, Discovery and Chuckanut Bays; the waters around the San Juan and Whatcom County islands; and the inland waters east of and including Admiralty Inlet (Seattle Audubon Society 2007; Speich and Wahl 1995).

Hampered by their non-gregarious nature, the relative isolation of their nests, and their generally low density, approximations of the number of marbled murrelets in Washington are problematic (Piatt et al. 2007). However, statewide estimates currently range from a breeding population of approximately 5,000 to almost 9,800, while within Puget Sound, population estimates range from 1,490 to 2,580 (Seattle Audubon Society 2007; WSDNR 2006).

Marbled murrelet presence in the action area is documented by several sources. The marine mammal pre-installation field studies conducted between October 2009 and April 2010, included objectives to observe the presence of marbled murrelet in the study area. During that study, five marbled murrelets were sighted on one occasion (December 10, 2009) (Tollit et al. 2010a). The most accurate information comes from the consistent sampling method used to estimate population size and trends under the *Northwest Forest Plan Murrelet Effectiveness Monitoring Plan* (Raphael et al. 2007). The proposed action is located within Conservation Zone 1 (Puget Sound) and includes marine habitat. For the purposes of the *Northwest Forest Plan Murrelet Effectiveness Monitoring Plan*, Conservation Zone 1 is subdivided into three strata and each stratum is divided into “Primary Sampling Units” (PSUs). Each PSU is a rectangular area approximately 20 kilometers long composed of inshore and offshore subunits that are sampled between May 15 and July 31 each year (Raphael et al. 2007).

Conservation Zone 1, encompassing the waters of Puget Sound, contains one of the larger murrelet populations in the species' listed range, and supports an estimated 41 percent of the murrelets in the coterminous United States (Huff et al. 2003). Since 2000, the estimated population size for Conservation Zone 1 has ranged from a low of 5,500 murrelets in 2004 to a high of 9,700 in 2002. The most recent (2007) estimated population size for Conservation Zone 1 is 6,985 murrelets (4,105 - 10,382 95 percent CI). Since 2000, the estimated murrelet density in Conservation Zone 1 has ranged from 1.56 to 2.78 murrelets per km^2. Admiralty Inlet occurs within stratum 2 in Conservation Zone 1. At-sea population surveys estimated marbled murrelet densities for stratum 2 varied from 1.12 to 2.43 murrelets per square kilometer between 2000 and 2007 (Huff et al. 2003; Falxa et al. 2008) (Table 4-6).

TABLE 4-6
MARBLED MURRELET POPULATION DENSITIES IN STRATUM 2 OF CONSERVATION ZONE 1

Year	Density (birds/km^2)	Source
2000	1.12	Huff et al. 2003
2001	1.76	
2002	1.86	
2003		
2004	1.52	Falxa et al. 2008
2005	2.43	
2006	1.42	
2007	1.22	

Population numbers in Conservation Zone 1 are likely declining, however, the precise rate of decline is unknown. The juvenile ratio derived from at-sea survey efforts is 0.09 in Conservation Zone 1. Although the juvenile ratio appears low, exact numbers are still unknown as juvenile ratios in Washington may be skewed by murrelets coming and going to British Columbia (USFWS 2008).

4.14.3 Critical Habitat Designations

The USFWS designated 32 critical habitat units for the marbled murrelet in California, Oregon, and Washington in June 24, 1996 (61 FR 26256-26320), and proposed to revise the designated critical habitat by removing acreage in California and Oregon on July 31, 2008 (73 FR 44678-44701). PCEs for marbled murrelet include: individual trees with potential nesting platforms, and forested areas within 0.8 kilometers (0.5 miles) of individual trees with potential nesting platforms, and with a canopy height of at least one-half the site-potential tree height. No critical habitat for marbled murrelet occurs in the Project area (USFWS 2009).

4.15 Golden Paintbrush

4.15.1 Current Status

The USFWS listed the golden paintbrush (*Castilleja levisecta*) as a threatened species on June 11, 1997 (62 FR 31740-31748). Primary listing factors were loss of habitat and encroachment of native and nonnative woody species (62 FR 31743). A final recovery plan for the species was issued by the USFWS in August 2000 (USFWS 2000).

4.15.2 Life History and Presence in the Action Area

Golden paintbrush is a member of the figwort family. Golden paintbrush is a short-lived perennial herb. The plant often has from 5 to 15 unbranched stems. The stems may be erect or spreading, in the latter case giving the appearance of being several plants, especially in tall grass. Plants are up to 30 centimeters (12 inches) tall and are covered with soft, somewhat sticky hairs (WSDNR 1997, USFWS 2000). Plants emerge in early March. By mid-April, the plant is in bud, flowering generally begins the last week in April and continues until early June. Fruits mature from June to mid-July; by mid-July, the plants are in senescence. Capsules persist on the plants well into August. Based on historical collections and observations by the authors, flowering seems to occur about the same time throughout the species' range (USFWS 2000). It is thought that golden paintbrush reproduces exclusively by seed since vegetative spread has never been observed or reported (USFWS 2000). Seeds are probably shaken from the seed capsules and fall a short distance from the parent plant. The seeds are light and could possibly be dispersed short distances by the wind (USFWS 2000).

Golden paintbrush is endemic to the Pacific Northwest. The historic range of the species extends from the Puget Trough physiographic province in Washington and British Columbia to as far south as the Willamette Valley of Oregon (WSDNR 1997, USFWS 2000). However, assessments of the species' status in its range found the plant extirpated from many of the recorded sites. Golden paintbrush has been extirpated from the prairies and grasslands of the Willamette Valley because these habitats have disappeared (62 FR 31740-31748).

In Washington, golden paintbrush occurs at elevations from sea level to approximately 91 meters (300 feet) above sea level. The species generally occurs on flat, open grasslands that are characterized by mounded topography, and on steep coastal bluffs that are grass dominated. Low deciduous shrubs are commonly present as small to large thickets. In the absence of fire, which is thought to have played a key role in maintaining the open prairie habitats occupied by golden paintbrush, some of the sites have been colonized by trees and shrubs, as well as non-native shrubs (WSDNR 1997, USFWS 2000).

USFWS (2000) identifies 11 extant populations of golden paintbrush, nine in Washington, and two in British Columbia. In Washington, the populations occur in Thurston County (1), San Juan County (3), and Island County (5 populations on Whidbey Island). The five populations on Whidbey Island occur on the following sites: Admiralty Inlet Natural Area Preserve (formerly Bocker Environmental Reserve), Fort Casey State Park, West Beach, Forbes Point, and Ebey's Landing. Three sites are less than one acre and two are approximately 1 acre in size (USFWS 2000). Fort Casey State Park is the closest site to the Project area.

USFWS (2007) reports only two of the 11 extant populations (one in Thurston County, Washington and one in British Columbia) are stable (i.e.,. population of at least 1,000 individuals for at least five years), while the remaining nine populations are considered to be declining. Overall, the abundance of the species remains constant, with some populations increasing and others declining (USFWS 2007). The population size and trend for the five populations on Whidbey Island between 1999 and 2006 are shown in Tables 4-7 and 4-8).

TABLE 4-7
POPULATION SIZE FOR GOLDEN PAINTBRUSH POPULATIONS ON WHIDBEY ISLAND

Site	1999	2000	2001	2002	2003	2004	2005	2006	Average
Admiralty Inlet (Naas)	277	97	97	98	122	59	120	94	121
Fort Casey State Park	175	151	166	185	307	235	260	760	280
West Beach	797	463	167	53	54	82	130	189	197
Forbes Point	1,572	1,882	1,834	711	765	532	123	260	960
Ebey's Landing	1,079	7,627	-	-	-	-	669	214	2,397

Note: Numbers represent the number of flowering plants (counted or extrapolated) that are naturally occurring. Plants from seedings or outplantings are excluded.
Source: USFWS (2007)

TABLE 4-8
POPULATION TRENDS FOR GOLDEN PAINTBRUSH POPULATIONS ON WHIDBEY ISLAND

Site	10-year recovery trend	5-year recovery trend
Admiralty Inlet (Naas)	Increasing in the short term	Increasing in the short term
Fort Casey State Park	Increasing in the short term	Increasing in the short term
West Beach	Stable	Stable
Forbes Point	Declining	---
Ebey's Landing	Stable	Declining

Source: USFWS (2007)

4.15.3 Critical Habitat

Critical habitat has not been designated for golden paintbrush.

Section 5
Direct and Indirect Effects of the Action

5.1 Purpose of Analysis

The purpose of this analysis is to provide information to support the Services' determinations as to whether the Project is likely to jeopardize the continued existence of federally listed species, or would result in the destruction or adverse modification of designated critical habitats for those species. To facilitate this process, the District considered the effects of the action on listed species and their critical habitat within the action area. There is high uncertainty around the environmental effects of tidal energy development (Polagye et al., 2011) and a primary reason for conducting this pilot project is to resolve some of these uncertainties through post-installation monitoring. The rationale for specific post-installation monitoring activities is discussed in Attachment 1 to Appendix A.

Effects are defined as "the direct and indirect effects of an action on the species or critical habitat together with the effects of other activities that are interrelated or interdependent with that action that will be added to the environmental baseline" (50 CFR 402. 02). Effects are classified as either direct or indirect depending on the causal mechanism and how quickly they affect the species in question. Direct effects result from the agency action and the interrelated and interdependent actions. Indirect effects are caused by or result from the proposed action, are later in time, and are reasonably certain to occur.

5.2 Method of Analysis and Section Organization

Fourteen federally listed species that could occur in the Project area including nine fish, three mammals, one bird, and one plant (Table 4-1). Potential environmental effects to these federally listed species are discussed below in the following groups:

- Fish,
- Marine mammals,
- Birds, and
- Plants.

To facilitate the effects analysis, for each of these groups, the District has identified potential effects (stressor) of the Project that may affect an ESA -listed species. For each potential effect, the District provides a description of the stressor, a description of the expected exposure to the stressor, the likelihood of exposure to the stressor, and the risk to individuals and populations of ESA-Listed species.

5.3 Fish

Based on discussions with stakeholders, including specific meetings with NMFS and USFWS to discuss potential Project effects on ESA-listed species for development of this document, the District has identified the following potential effects of Project deployment and operation on ESA-listed fish:

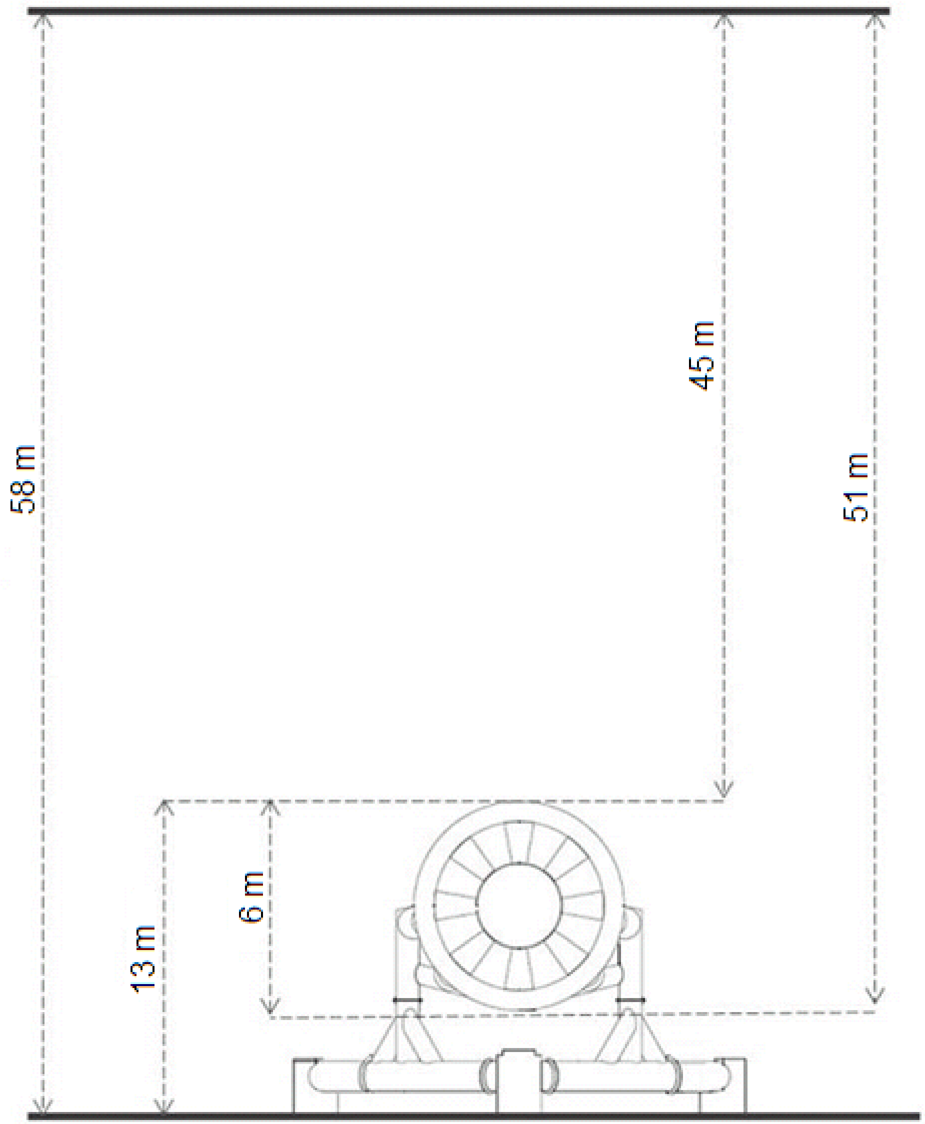
- blade strike,
- habitat alteration (also represents indirect effects),
- underwater noise,
- marine debris entanglement, and
- EMF.

5.3.1 Blade strike

Description of Stressor

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 5-1). 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 60 to 70 percent of the time. This creates a risk of injury or mortality.

FIGURE 5-1
DIMENSIONS OF TURBINES IN RELATION TO DEPTH AT DEPLOYMENT SITE



Note: Figure not to scale

Exposure to Stressor

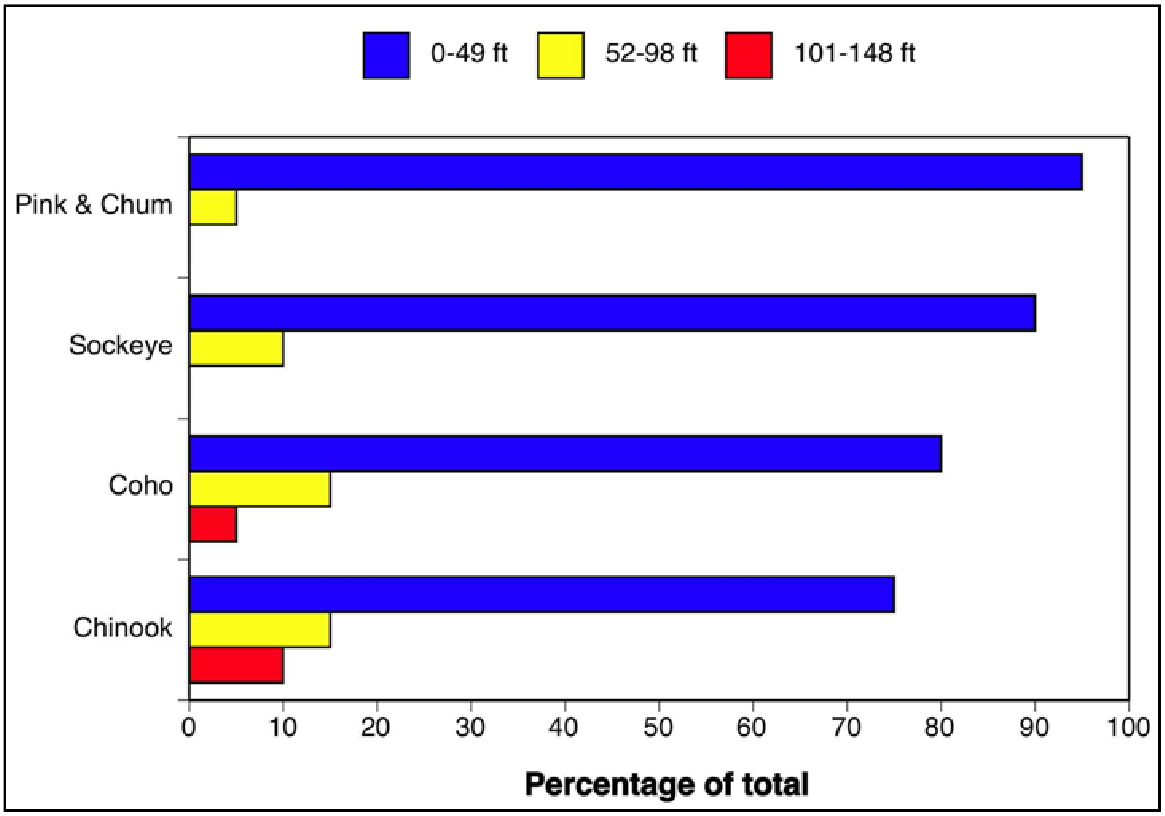
A variety of ESA-listed fish species occurring in Admiralty Inlet, both resident and migratory species, have the potential to occur in the vicinity of the OpenHydro turbines. There is concern that, if ESA-listed fish species come in contact with the turbine rotors, injury or mortality may result. The likelihood of exposure to blade strike for ESA-listed fish 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 and outbound juvenile 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. A longer exposure would occur for migratory species, if they delay their migration by holding in the project area; for example, salmon are known to hold off the southern tip of Whidbey Island before entering their home rivers (SSPS 2007). In contrast resident species, such as ESA-listed rockfish, could be exposed to the turbines more frequently.

Juvenile salmonids - As discussed in Section 4.2.2 and 4.3.3, Life History and Presence in the Project Area for Puget Sound Chinook salmon and Hood Canal summer-run chum salmon, respectively, the CDFO examined the depth distribution of juvenile Pacific salmon in areas of Puget Sound and the Strait of Georgia. CDFO has conducted over 158 tows since the late 1990s in Puget Sound and many more in the Strait of Georgia using the following methods:

- Survey tows generally consisted of durations up to 15 minutes and occurred on either side the shipping lanes in water 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.).

The CDFO study results found that juvenile Pacific salmon occupy shallower depths of the water column (personal communication, R. Sweeting, CDFO with G. Ruggerone, NRC, Inc.). Figure 5-2 shows the depth distribution for juveniles of five salmonid species sampled during the 158 tows during the CDFO study.

FIGURE 5-2
DEPTH DISTRIBUTION OF JUVENILE SALMON IN THE STRAIT OF GEORGIA AND PUGET SOUND



Source: Personal communication, R. Sweeting, CDFO

Table 5-1 summarizes depth information for capture of juvenile Chinook and chum salmon in the Strait of Georgia and Puget Sound.

TABLE 5-1
DEPTH DISTRIBUTION OF JUVENILE CHINOOK AND CHUM SALMON IN THE STRAIT OF GEORGIA AND PUGET SOUND

Depth	Percentage of salmon sampled at depth range	
	Chinook salmon*	Chum salmon*
surface - 15 m (49 ft)	75	95
16-30 m (52-98 ft)	15	5
31-45 m (101-148 ft)	10	0

* Source: Personal communication, R. Sweeting, CDFO

As these results demonstrate, ESA-listed juvenile salmon would not be expected to use water column depths associated with the Project turbines. All juvenile salmon were captured at depths of 45 meters or less, and the top of the turbine is located at a depth of 47.5 meters (Figures 5-1 and 5-2). Juvenile bull trout do not inhabit Puget Sound (SSPS 2007, Goetz et al. 2003). As stated in Section 4.4.2, juvenile steelhead in British Columbia spent 95 percent of the time in the top six meters of the water column (Ruggerone et al. 1990), and given the CDFO results cover depth distribution for five Pacific salmon species (Figure 5-2), the District concludes that it can be expected that juvenile Puget Sound steelhead would also occupy shallower depths of the water column, above the deployment depths of the turbine rotors. In summary, juvenile salmon are not expected to occupy water column depths associated with the Project turbines.

Adult salmonids - All the ESA-listed adult salmonids considered in this document are expected to occur in the Project area[11] and, given the depths these species are known to swim while at sea (Hinke et al. 2005*a*, Ruggerone et al. 1990, Goetz et al. 2003, Ishida et al. 2001), potentially at the depths of the turbine rotors. Feeding on schools of small pelagic fish and invertebrates, salmonids grow rapidly in the ocean (OSU 2006). Oceanic movement of Pacific salmonids is typically based on following available food resources; their habitat use has been shown to vary based upon seasonal changes to food resources (Hinke et al. 2005b, Beamish et al. 2005). Therefore, unless the turbines concentrate prey species, the District would not expect that salmon would be attracted to the Project turbines. While it is not expected that ESA-listed adult salmonids would be attracted to the turbines, they could encounter the turbines as they move through Admiralty Inlet to their spawning tributaries.

Eulachon - Eulachon feed on pelagic plankton (NOAA 2010). A concentration of pelagic plankton would not be expected to be associated with the presence of the two turbines, and therefore, it is not expected that eulachon would be attracted to the turbines. However, as discussed in Section 4.10.2, eulachon larvae, young, and adults inhabit the ocean bottom in waters 20-150 meters deep (Hay and McCarter 2000) and sometimes as deep as 182 meters (Barraclough 1964). Therefore, all life stages of eulachon could be exposed to the Project turbines during their movements through and around Admiralty Inlet.

Green sturgeon - Green sturgeon are benthic feeders (Dumbauld et al. 2008). The presence of the project turbines is not expected to result in a concentration of benthic prey items for green sturgeon, and therefore it is not expected that green sturgeon would be attracted to the turbines.

In an email from NMFS to the District dated April 11, 2011, NMFS stated that “If feet around turbine foundations have reduced flow velocity fields, fine-grained sediments could deposit and become colonized by animals sturgeon eat.” The video footage from an ROV found no sediment deposition in the turbine deployment areas: the substrate was mostly cobble 6-18 cm in diameter. The NNMREC modeling effort evaluated hydrodynamic effects of the Admiralty Inlet Project (Polagye 2009). From model results, it was concluded that “The far-field effects of extraction from an array this size 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 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

[11] Admiralty Inlet is the key marine migration corridor for all species of anadromous salmonids originating from the Skagit River, Stilliguamish 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. For chum salmon, considerable production comes from numerous small tributaries in the South Puget Sound and Hood Canal regions. All these rivers are major salmon producers, collectively producing in excess of a million adult fish each year. Both out-migrating juveniles, and returning adults pass through Admiralty Inlet (personal communication, A. Bishop, NMFS, January 25, 2011).

in the project area (near or far field) or the marine environment, and it is expected that green sturgeon will not be attracted to the cobble substrate at the project location to feed.

However, as discussed in Section 4.6.2, green sturgeon do use habitat at depths of the Project (Erickson and Hightower 2007, NMFS 2005*c*), and subadult[12] and adult green sturgeon could be exposed to the Project during their movements through and around Admiralty Inlet.Rockfish - Bocaccio, canary rockfish, and yelloweye rockfish are attracted to high relief structure (NMFS letter dated July 23, 2009, Miller and Borton 1980, Washington 1977, Love et al. 2002) and because the Project turbines would represent high relief structure, these rockfish species may be attracted to the OpenHydro devices, in particular, to the foundations. As discussed in Section 4, from studies including bottom trawls, quantitative video surveys, and dive surveys conducted by WDFW and other researchers to determine rockfish species and habitat distribution:

- Bocaccio have never been observed during WDFW bottom trawl, video, or dive surveys in Puget Sound (Palsson et al. 2009) but their occurrence has been documented in the Central Puget Sound Basin (personal communication, D. Tonnes, NMFS, January 12, 2011);

- Yelloweye are infrequently observed in WDFW trawl and video surveys, and no more than 20 yelloweye have ever been observed in WDFW annual recreational fishery samples; and

- Canary rockfish are infrequently observed in quantitative video surveys and over the past four decades, canary rockfish have become less frequent in recreational catches in Puget Sound (Palsson et al. 2009).

While the surveys detected no bocaccio and few yelloweye and canary rockfish in Puget Sound proper, the WDFW estimates are not considered to be complete estimates due to the following factors: (1) populations of the species are depleted, (2) lack of rocky benthic habitats in Puget Sound proper may lead to densities of each species that are naturally less than the rocky habitats of the San Juan region and (3) the study design may not have been powerful enough to detect the species (NMFS et al. 2010).

WDFW conducted ROV surveys exclusively within the rocky habitats of the San Juan Island region in 2008 (NMFS et al. 2010). From study results WDFW estimated populations for these three species in the San Juan Region as follows: 4,487 Bocaccio (Table 4-3), 1,648 canary rockfish (Table 4-4), and 50,656 yelloweye rockfish (Table 4-5) (NMFS et al. 2010). The high abundance of these species in the San Juan Region in comparison to in Puget Sound, could be explained by the prevalence of rocky habitat in the San Juan Region, while rocky habitat is not common in Puget Sound (NMFS et al. 2010). Admiralty Inlet also has rocky habitat and could therefore be expected to represent better habitat for the three listed rockfish species than does Puget Sound.

[12] As discussed in section 4.6.2, Green sturgeon will spend 3 to 20 years at sea before reaching sexual maturity (NMFS 2008*a*).

Therefore, based on their habitat use, these three ESA-listed rockfish species could be expected to occur in Admiralty Inlet, which unlike much of Puget Sound, has rocky habitat at the location where the Project turbines will be deployed.

Likelihood of Exposure

The previous section concluded that all life stages of ESA -listed rockfish, as well as transiting eulachon (all life stages), subadult and adult green sturgeon, and adult salmonids passing through Admiralty Inlet, may be exposed to the OpenHydro turbines. In the event that these ESA -listed species and life stages are exposed to the turbines, it is unlikely that this exposure will result in blade strike based upon the following factors:

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

<u>Frequency of interaction with turbines</u> - The likelihood of exposure to blade strike for ESA-listed fish 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. A longer exposure would occur for migratory species, if they delay their migration by holding in the project area; for example, salmon are known to hold off the southern tip of Whidbey Island before entering their home rivers (SSPS 2007). In contrast resident species, such as ESA-listed 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, as stated above, 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 5-2). 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 coming in contact with a moving blade.

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, turbine sweep area would be 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 ESA-listed species:

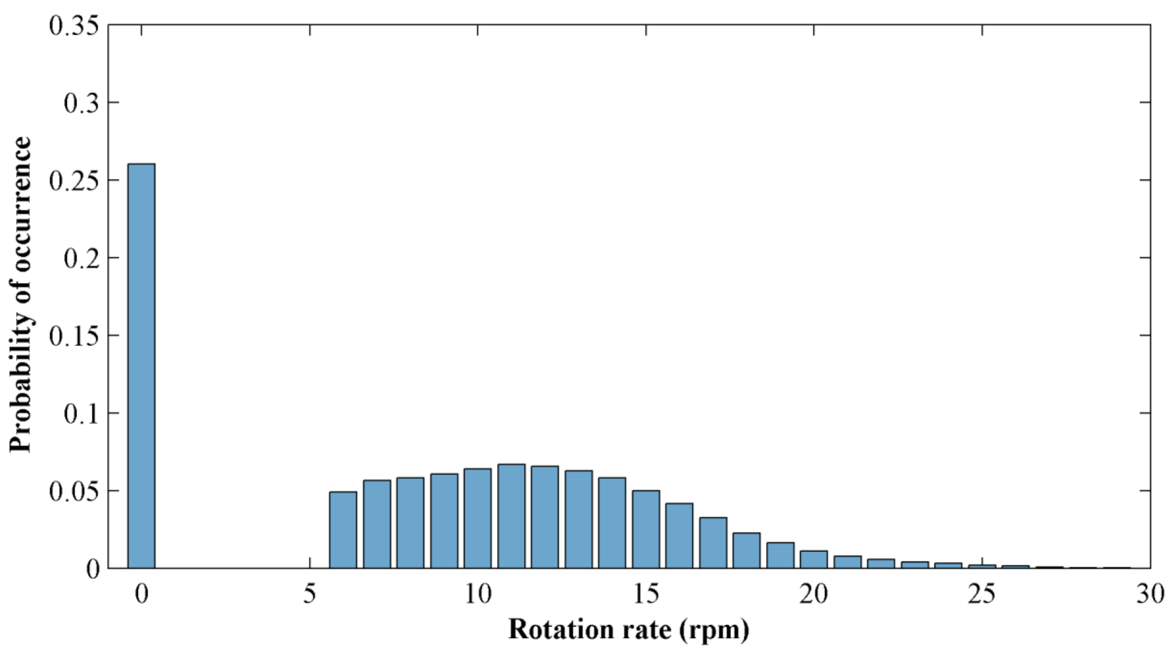
- closed-shroud of the turbine structure (no exposed blade tips),
- open-centered rotor, and
- runs at low speed without cavitation.

The closed shroud prevents ESA-listed species 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) which allows adequate space for ESA-listed fish 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 16 RPM, with a maximum rotational speed of 24 RPM (Figure 5-3). 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 60-70 percent of the time.

FIGURE 5-3
CUMULATIVE PROBABILITY DISTRIBUTION OF ROTATIONAL RATE FOR 6-METER -DIAMETER OPENHYDRO TURBINES IN ADMIRALTY INLET



Source: Personal communication, Nick Murphy, OpenHydro, June 3, 2011.

<u>Abilities of fish and marine mammals to detect large underwater features</u> - The demonstrated ability of fish to avoid in-water large structures and the fact that ESA-listed species can pass through 99.95 percent of cross -section of Admiralty Inlet at the Project location without encountering the flow field of the proposed turbines also minimize the risk of a fish coming in contact with a moving blade.

There is little evidence that fish 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 upstream extends approximately 10 meters upstream of the turbine during the modeled operating condition (personal communication, Nick Murphy, OpenHydro, memo December 2010).

Species that are conditioned to avoid 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). 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. 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, and Cada 2008) 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 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 October 2009).

To characterize fish 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 October 2009). Figure 5-4 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 numbers. 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 October 2009).

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 not be present only when the turbine is still or rotating at low speed.

FIGURE 5-4
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 *Pollachius pollachius*) 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 October 2009.

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[13]. 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 (Normandeau 2009) 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). The Hydro Green Energy turbines are ducted horizontal axis turbines that are similar to the OpenHydro turbine (Figure 5-5). Researchers deployed 502 balloon and radio tagged fish, representing five

[13] 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.

species and two size classes[14]. 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 5-3]), 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.

[14] 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 5-5
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 Environmental Assessment (EA) (AECOM 2009) report 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 5-6:

1) at the center of the opening

2) at the perimeter of the blades on the interior of the hub

3) along the outside edge of the turbine, but inside portions of the support structure

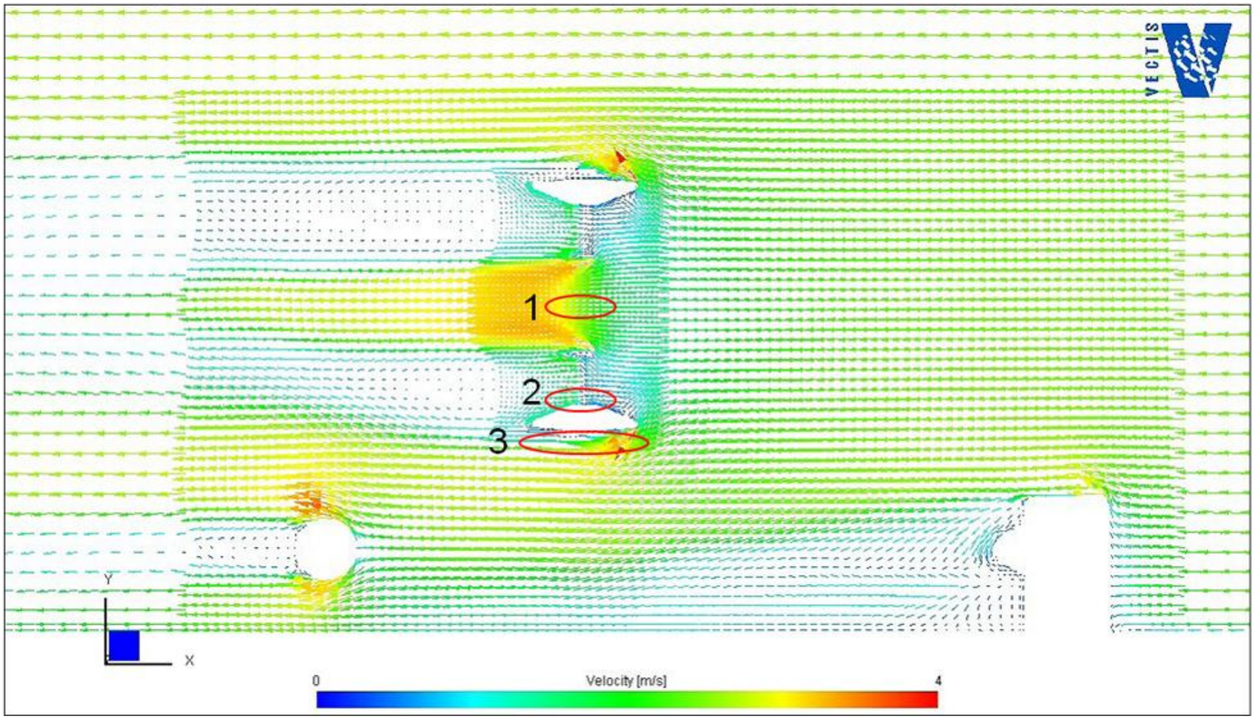
Kinetic power extraction increases pressure in the upstream direction and generally decreases pressure at the open center along the sides of the rotor shroud (Figure 5-6). CFD results are shown for 2.5 m/s free stream current velocity, which corresponds to a relatively strong tidal exchange in northern Admiralty Inlet (Figure 5-3). The pressure change is greatest at the blade perimeter (-4.5 kPa), followed by the open center (-3.0 kPa) (Table 5-2). Along the outside edge of the turbine the pressure change increases slightly (1.5 kPa) (Table 5-2). 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 5-2). 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).

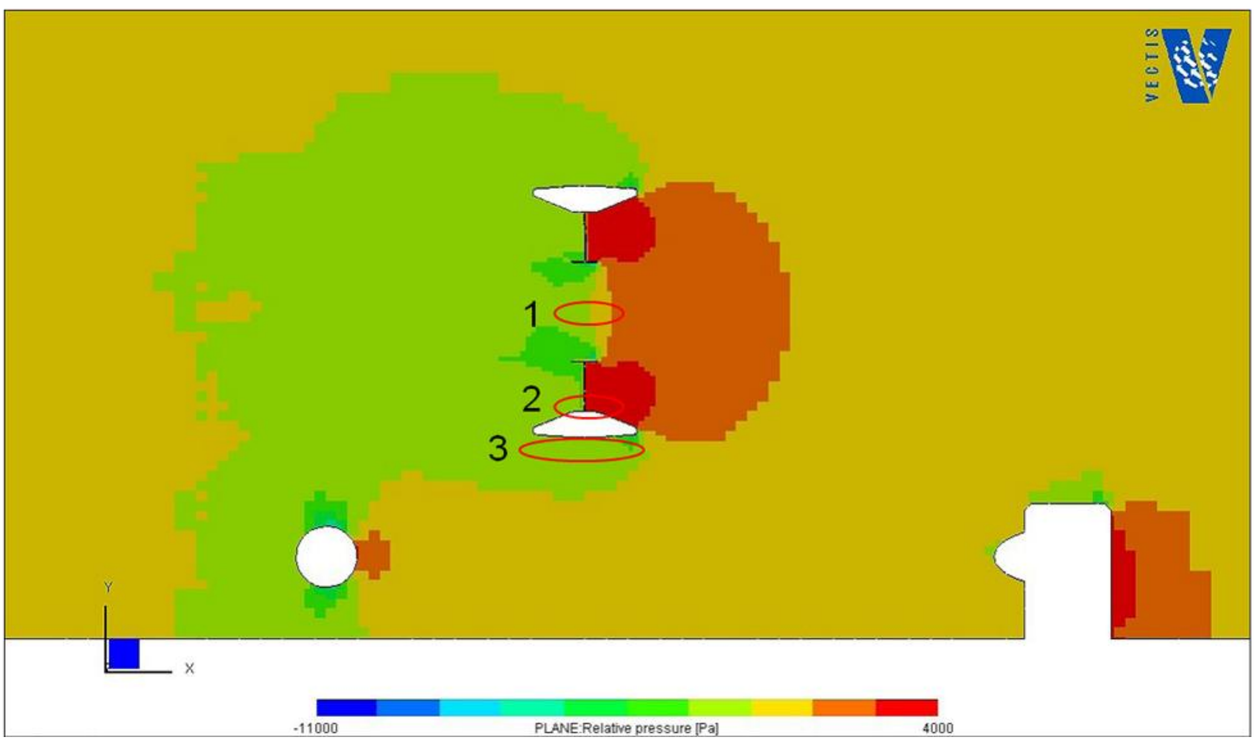
TABLE 5-2
PRESSURE AND VELOCITY CHANGE IN A 2.5 M/S FLOW AT LOCATIONS AS INDICATED IN FIGURE 5-6

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 5-6
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 5-2. 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 5-3).

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 5-3
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
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 24 rpm is the maximum rotor speed, typical rotor speeds will be more between 6-16 rpm, and less than or equal to 14 rpm 90% of the time.
[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. 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 total length [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 5-3[15].

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 (Baxter 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

[15] 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 6 meters wide.

(-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 indicate the maximum flow velocity in the vicinity of the rotor to be 4 m/s or less in free 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 Δy = 1.8 cm[16]) 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[17]), 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 5-3).

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). 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).

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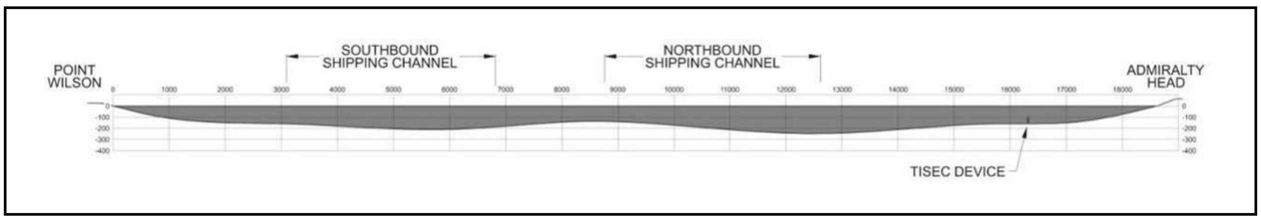
[16] The spatial resolution of 1.8 cm was selected to approximate the minimum width of juvenile salmonids tested in laboratory facilities (Neitzel et al. 2000).

[17] 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.

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.

Project scale and context - ESA-listed salmonids, green sturgeon, and eulachon are migratory. Adult salmonids heading to Puget Sound to spawn in natal rivers, and transiting green sturgeon and eulachon, would be expected to transit through Admiralty Inlet, and possibly at the depths of the turbines. However, the chance of these species interacting with one of the two turbines is very small. 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 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 5-7 shows a scaled cross -section of Admiralty Inlet with one OpenHydro turbine depicted.

FIGURE 5-7
SCALED CROSS-SECTION OF ADMIRALTY INLET AND OPENHYDRO TURBINE



The District's proposed near-turbine monitoring study - 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 fish 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 ESA-listed and other species, and the moving turbine rotor.

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. NNMREC is currently leading the effort to develop, in consultation with the District and resource agency staff, sampling methods to characterize the interactions between marine life and the OpenHydro turbines, which will be included as part of the Near-Turbine Monitoring Plan. 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 lighting. 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[18]. 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 information regarding the Near-Turbine Monitoring Plan is contained in Appendix A

Proposed safeguards to protect ESA-listed species - Important safeguards have been developed to ensure that, in the event the pilot Project is causing unexpected adverse effects to ESA-listed species 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 is 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 differences in species assemblage, system performance, and behavioral changes from lighting. Each of these triggers is described in Appendix A.

The District will follow the procedures described in the Adaptive Management Framework Plan 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.

[18] 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).

Risk to Individuals and Populations of ESA-Listed Fish

The response of ESA-listed fish to the presence of the turbines may be avoidance, attraction, or injury/mortality if the fish comes in contact with the rotating turbine. Except for the three ESA-listed rockfish species, which could be attracted to the turbine structure, the other ESA-listed fish species are highly mobile/migratory and are not likely to be attracted to the turbines; their potential to interact with the turbines is unlikely or of very short duration, as described below.

- ESA-listed juvenile salmonids are expected to occur in water column depths less than that at which the Project turbines will be deployed (CDFO study, Figure 5-2, personal communication, R. Sweeting, CDFO with G. Ruggerone, NRC, Inc.).

- In the marine environment, salmonids are feeding on schools of small pelagic fish and invertebrates; salmonids typically follow available food resources, their coastal habitat use has been shown to vary based upon seasonal changes to the type and distribution of food resources (Hinke et al. 2005b). It is not expected that they would be attracted to the Project turbines as their food resources are highly mobile and not likely to be attracted to the turbines.

- Eulachon feed on pelagic plankton (NOAA 2010). A concentration of pelagic plankton would not be expected to be associated with the presence of the two turbines, and therefore, it is not expected that eulachon would be attracted to the turbines.

- Green sturgeon are benthic feeders (Dumbauld et al. 2008). The presence of the project turbines is not expected to result in a concentration of benthic prey items for green sturgeon, and therefore it is not expected that green sturgeon would be attracted to the turbines.

For rockfish, which may be attracted to the Project structures, and other ESA-listed fish species that may be exposed to the turbines by swimming through and around Admiralty Inlet, 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, at the device scale, 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 minimus* footprint on the margins of the inlet, will rotate only 70 percent of the time, and is not expected represent a risk to ESA-listed species 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[19] 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.
- 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 ESA-listed species are occurring from blade strike, the turbines can be immediately shut down to cease turbine rotation.

The District therefore expects that the potential for ESA-listed fish 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.

5.3.2 Habitat Alteration

Description of Stressor

The presence of Project components in the water column and on the seafloor will alter habitat in the immediate Project area and create new habitat features resulting in potential changes in marine community composition (use patterns, attraction, and aversion) that could have a potential effect on ESA-listed fish. Specifically, the OpenHydro turbines may change local habitat by adding high-relief structure to an area of low relief; this represents a direct effect of

[19] 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 Project. Areas of shelter, structure, or cover are typically sought by fish for protection from predators (Johnson and Stickney 1989).

Increased presence or colonization by marine life that otherwise would not occur in a particular area may attract predators (Ogden 2005) and increase predation on ESA-listed fish and, as NMFS noted in their letter dated July 23, 2009, specifically rockfish stocks, which have low productivity. This would be a potential indirect effect of the Project. 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).

Exposure to Stressor

The likelihood of exposure of ESA-listed fish to the Project and its associated habitat change is also influenced by overlap in both the spatial and temporal distribution of species with the Project. Migratory species/life stages, such as inbound adult salmonids and outbound juvenile salmonids, are expected to be transiting through the Admiralty Inlet area and would be exposed to the potential stressor infrequently and for a very short period of their life. A longer exposure would occur for migratory species, if they delay their migration by holding in the project area; for example, salmon are known to hold off the southern tip of Whidbey Island before entering their home rivers (SSPS 2007). In contrast resident species, such as ESA-listed rockfish, could be exposed to the stressor more frequently.

ESA-listed rock fish species and forage species that are likewise structure-oriented may be attracted to the turbine structures. These species may also be attracted to prey species that are using the structures, or the invertebrate community that may develop on the structures.

As discussed in Sections 4 and 5.3.1, ESA-listed juvenile salmonids are not expected to use water column depths associated with the Project turbines (CDFO studies - personal communication, R. Sweeting, CDFO with G. Ruggerone, NRC, Inc.; SSPS 2007; Goetz et al. 2003).

All the ESA-listed adult salmonids considered in this document are expected to occur in the Project area as it is a migratory corridor, and, given the depths these species are known to swim while at sea (Hinke et al. 2005*a*, Ruggerone et al. 1990, Goetz et al. 2003, Ishida et al. 2001), potentially at the depths of the turbine rotors. Feeding on schools of small pelagic fish and invertebrates, salmonids grow rapidly in the ocean (Oregon State University 2006). Oceanic movement of Pacific salmonids is typically based on following available food resources; their habitat use has been shown to vary based upon seasonal changes to food resources (Hinke et al. 2005*a*). Therefore, unless the turbines concentrate prey species, the District would not expect that salmon would be attracted to the Project turbines. While it is not expected that ESA-listed adult salmonids would be attracted to the turbines, they could encounter the turbines as they move through Admiralty Inlet (e.g., adults of many Puget Sound populations have to pass through Admiralty Inlet to reach their natal streams).

Eulachon feed on pelagic plankton (NOAA 2010). A concentration of pelagic plankton would not be expected to be associated with the presence of the two turbines, and therefore, it is not expected that eulachon would be attracted to the turbines. However, as discussed in Section

4.10.2, eulachon larvae, young, and adults inhabit the ocean bottom in waters 20-150 meters deep (Hay and McCarter 2000) and sometimes as deep as 182 meters (Barraclough 1964). Therefore, all life stages of eulachon could be exposed to the Project turbines during their movements through and around Admiralty Inlet.

Green sturgeon are benthic feeders (Dumbauld et al. 2008). The presence of the project turbines is not expected to result in a concentration of benthic prey items for green sturgeon (see discussion in Section 5.3.1), and therefore it is not expected that green sturgeon would be attracted to the turbines. However, as discussed in Section 4.6.2, green sturgeon do use habitat at depths of the Project (Erickson and Hightower 2007, NMFS 2005*c*), and subadult and adult green sturgeon could be exposed to the Project during their movements through and around Admiralty Inlet.

Likelihood of Exposure

As previously discussed, all life stages of ESA -listed rockfish, as well as transiting eulachon (all life stages), subadult and adult green sturgeon, and adult salmonids passing through Admiralty Inlet, may be exposed to the OpenHydro turbines. It can be expected that predators, such as marine mammals[20], may consequently be attracted to the turbine structure to feed on prey species that are present.

Risk to Individuals and Populations of ESA-Listed Fish

As discussed above, the turbines represent the addition of high-relief structure in an area of low relief. Rockfish or structure oriented forage species may be attracted to the turbine structures, and in turn their predators may also be attracted to the area.

However, 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 5-7]) and the temporary nature of the deployment, the Project will represent a discountable and insignificant amount of both (1) habitat that ESA-listed rockfish 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 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 and it is lacking in the area.

However, because there are very few tidal turbines deployed in the world and the biological and ecological significance of the project’s changes to habitat are not understood, there is uncertainty about how marine species will respond to the presence of the two tidal turbines. The Benthic Habitat, Near-Turbine, Marine Mammal, and Derelict Gear monitoring plans are expected to provide information about whether species are attracted to Project structures. For example, the

[20] As shown by Snohomish’s pre-installation passive acoustic monitoring, harbor porpoise represent a predator that are currently 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. 2010b).

video cameras mounted on the turbines as part of the Near-Turbine Monitoring Plan will monitor part of the turbine face for biofouling and viewing of species that approach the turbine. The benthic habitat monitoring plan, will monitor the benthic habitat in the vicinity of the two turbines, cable route, 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. The District will consult with the Admiralty Inlet 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 actions occur (safeguards) in the event negative effects are determined. These triggers, and the actions required in response, are described either in Appendix A or in the individual monitoring plans appended to this Final License Application.

5.3.3 Underwater Noise

Description of Stressor

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 2008, Scottish Executive 2007, MMS 2007, Michel et al. 2007) and has been raised by resource agencies involved with the Admiralty Inlet Project licensing process. Operation, as well as, Installation, maintenance, and removal of the Project would generate underwater noise.

<u>Installation, maintenance, and removal</u> - Underwater noise will be generated from at sea actions including installation, maintenance, and removal of the Project. Noise during these operations, outlined in greater detail in Section 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 30 days and include the following actions: assist land-based HDD installation crew with exit of the HDD bore hole, deployment of turbines, and laying trunk cable 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, three 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.

<u>Turbine operation</u> - 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).

The spatial extent of 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.

Exposure to Stressor

The likelihood of exposure to noise associated with the Project for ESA-listed fish is influenced by overlap in both the spatial and temporal distribution of species with the Project. As discussed above, migratory species/life stages, such as inbound adult salmonids and outbound juvenile salmonids, are expected to be transiting through the Admiralty Inlet area and would be exposed to any Project-associated noise, associated with installation, operation, and maintenance, infrequently and for a very short period (i.e., as they are swimming past the project towards natal rivers during spawning migrations, or to the ocean during the smolt outmigration). A longer exposure would occur for migratory species, if they hold in the project area; for example, salmon are known to hold off the southern tip of Whidbey Island before entering their home rivers (SSPS 2007). It is also unknown to what degree eulachon or green sturgeon would use the project area, but it is expected that they would be exposed to project related noise as well. resident species, such as ESA-listed rockfish, could be exposed to the stressor (elevated noise) more frequently.

The spatial extent of ESA-listed fish species' exposure to underwater noise associated with the Project will depend on the intensity of the source sound pressure level, distance of the fish from the noise source (e.g. installation vessel is located at the surface and the operating turbine is located in the lower part of the water column) propagation of the noise, and ability of the individual species to detect and differentiate Project associated noises from other sources of ambient noise. Therefore, all life stages of ESA-listed fish that occur in this spatial extent have the potential to detect noise associated with the Project. For example, even though, as discussed above, juvenile salmonids are not expected to swim at the depths that the turbines will be located[21], the noise will propagate away from the turbines and it is expected that juvenile salmonids swimming in the upper water column in the Project area could detect turbine noise under some ambient noise conditions. Fish swimming closer to the surface will be exposed to boat noise during deployment and retrieval, and fish swimming deeper in the water column will be exposed to noise during periods when the turbines are operating. The spatial extent is discussed in further detail below in the Likelihood of Exposure section.

[21] As discussed in Sections 4.2.2 and 5.3.1, approximately 75 percent of all juvenile Chinook salmon were located in the top 15 meters (49 feet) of the water column. Approximately, 15 percent and 10 percent of the juvenile Chinook salmon were captured at the 16 to 30 meter (52 to 98 feet) and the 31 to 45 meter (101 to 148 feet) depth intervals, respectively. The top of the turbines will be located at a depth of 47.5 meters.

Likelihood of Exposure

Many fish species use sound in communication, navigation, predator/prey interactions, and hazard avoidance. These organisms have biological receptors that are sensitive to Sound Pressure Level (SPL), particle velocity, and the frequency of sound. 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.

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 or broadband 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 root-mean-square (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 temporary threshold shift (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[22] (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"[23]. Internal organs showed no damage resulting from the sound exposure (Jørgensen et al., 2005).

<u>Installation, maintenance, and removal</u> - The primary noise produced during Project installation, maintenance, and removal operations would be from boat engines (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 5-4 through 5-6. 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 5-4
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[24]
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	On site < 5 days, operating intermittently.	174 dB

22 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.
23 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%.
24 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.

	apparatus.		
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 5-5
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 5-6
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
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 5-7 and 5-8. 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 5-7
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 5-8
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 5-9. 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 5-9
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

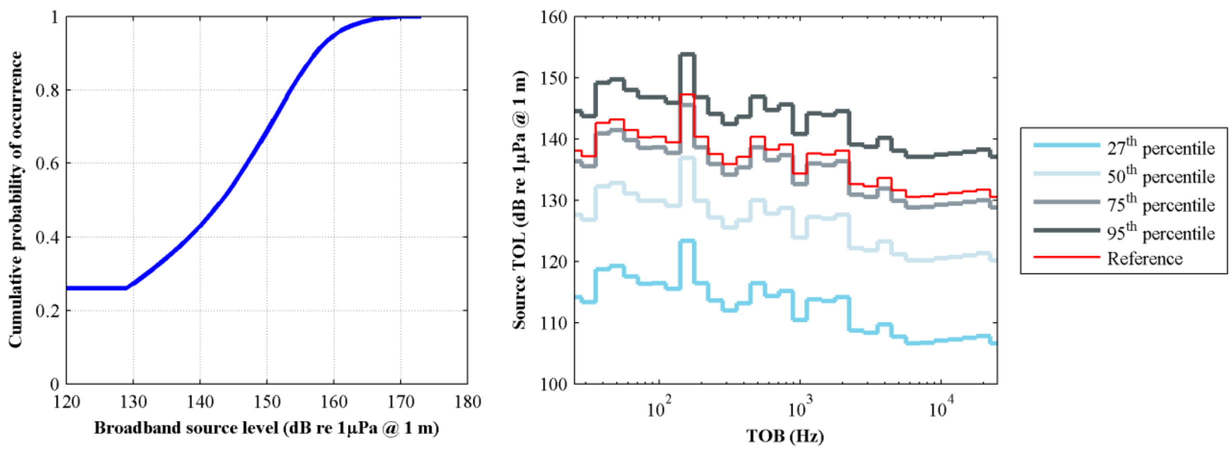
Source: Garrood and Polagye 2011

Turbine operation - During operation, the majority of the noise will be produced by the rotation of the turbine blades. The noise intensity is expected to depend on the current velocity and, by extension, on rotational rate because this turbine operates at a constant tip speed ratio. The turbine begins to rotate at 0.7 m/s water velocity. This noise will be a continuous, broadband source and, like construction noise, is presented as an rms value.

Polagye et al. (*in prep*) 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 5-8 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 5-8
PROBABILITY DISTRIBUTION OF TURBINE SOURCE LEVELS. (LEFT) BROADBAND (25 HZ – 25 KHZ). (RIGHT) ONE-THIRD OCTAVE SOURCE LEVELS FOR SELECT OPERATING PERCENTILES.

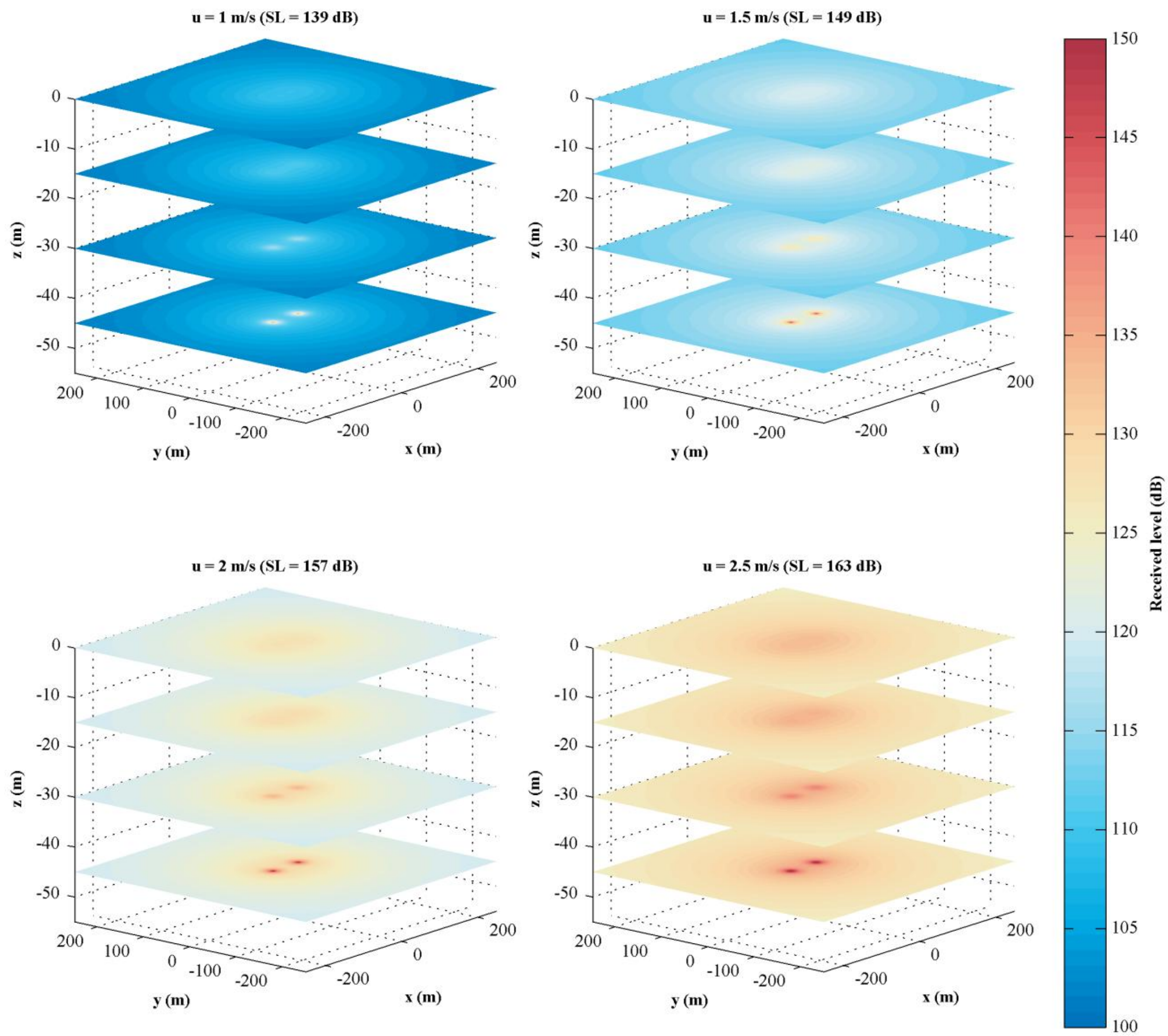


Source: Polagye et al. (in prep)

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 5-9 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.

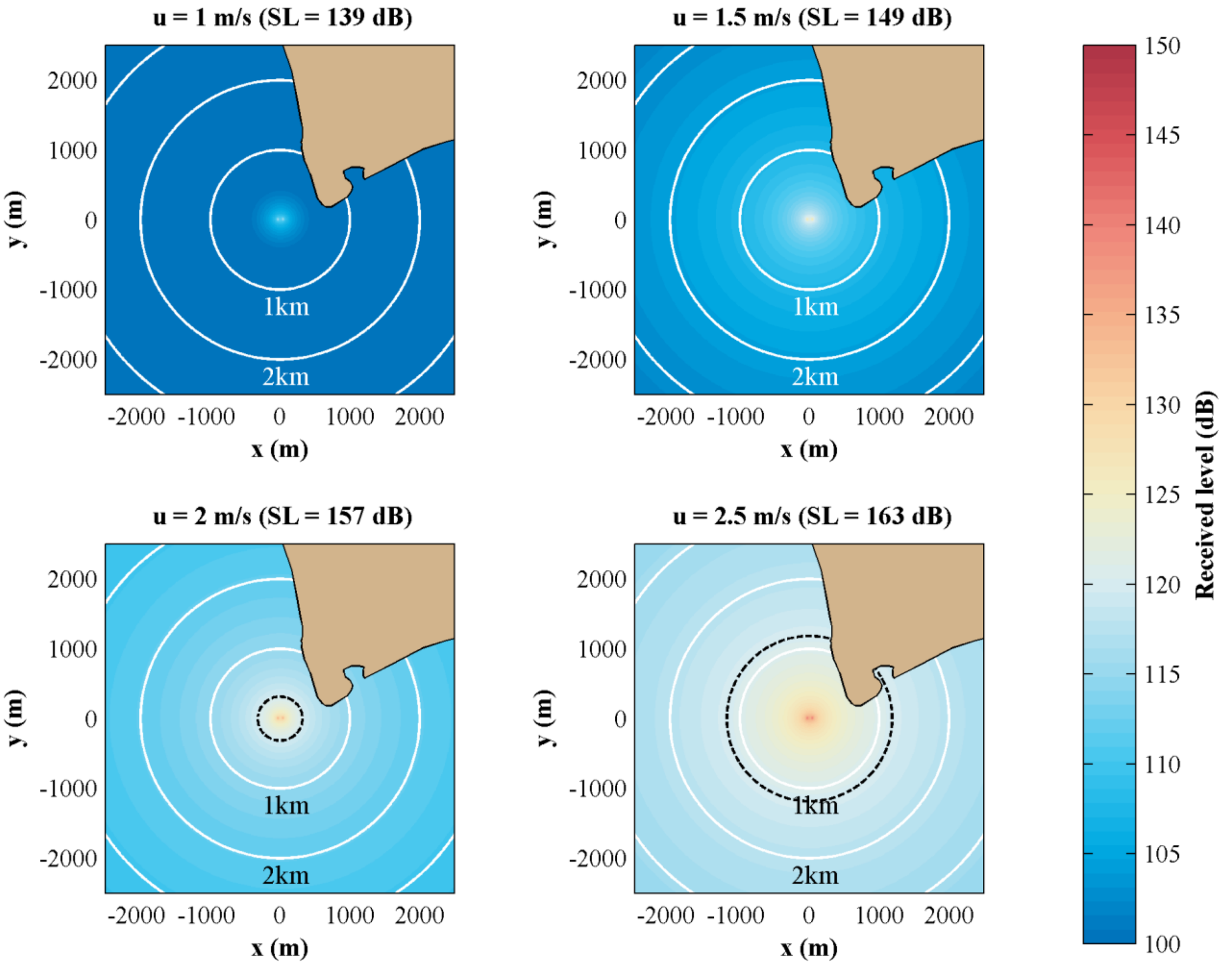
FIGURE 5-9
RECEIVED BROADBAND SOUND PRESSURE LEVELS AT CLOSE RANGE TO THE PROJECT AT VARIOUS DEPTHS



Source: Adapted from Polagye et al. (in prep)

Note: Turbine hub height is 45 m relative to the surface.

FIGURE 5-10
RECEIVED BROADBAND SOUND PRESSURE LEVELS IN THE VICINITY OF THE PROJECT



Source: Polagye et al. (in prep)

Note: 30 m depth relative to surface; dashed black lines denote the 120 dB re 1µPa isobel (Level B harassment threshold for marine mammals)

Risk to Individuals and Populations of ESA-Listed Fish

As described in this section, noise produced by the Project, except for in the immediate vicinity of the operating turbine at peak tidal velocities, will be discountable and insignificant to ESA-listed fish[25]. Noise associated with Project installation, maintenance, or removal which is expected to be no greater than 178 dB (re 1 µPa) (Garrood and Polagye 2011) over a frequency range of 20 Hz to 10 kHz (Richardson et al. 1995) may cause ESA-listed fish species to avoid

[25] Per the joint USFWS & NMFS (1998) Section 7 Consultation Handbook: "discountable" effects are those that are extremely unlikely to occur; "insignificant" effects relate to the size of the impact and do not reach the scale where take occurs.

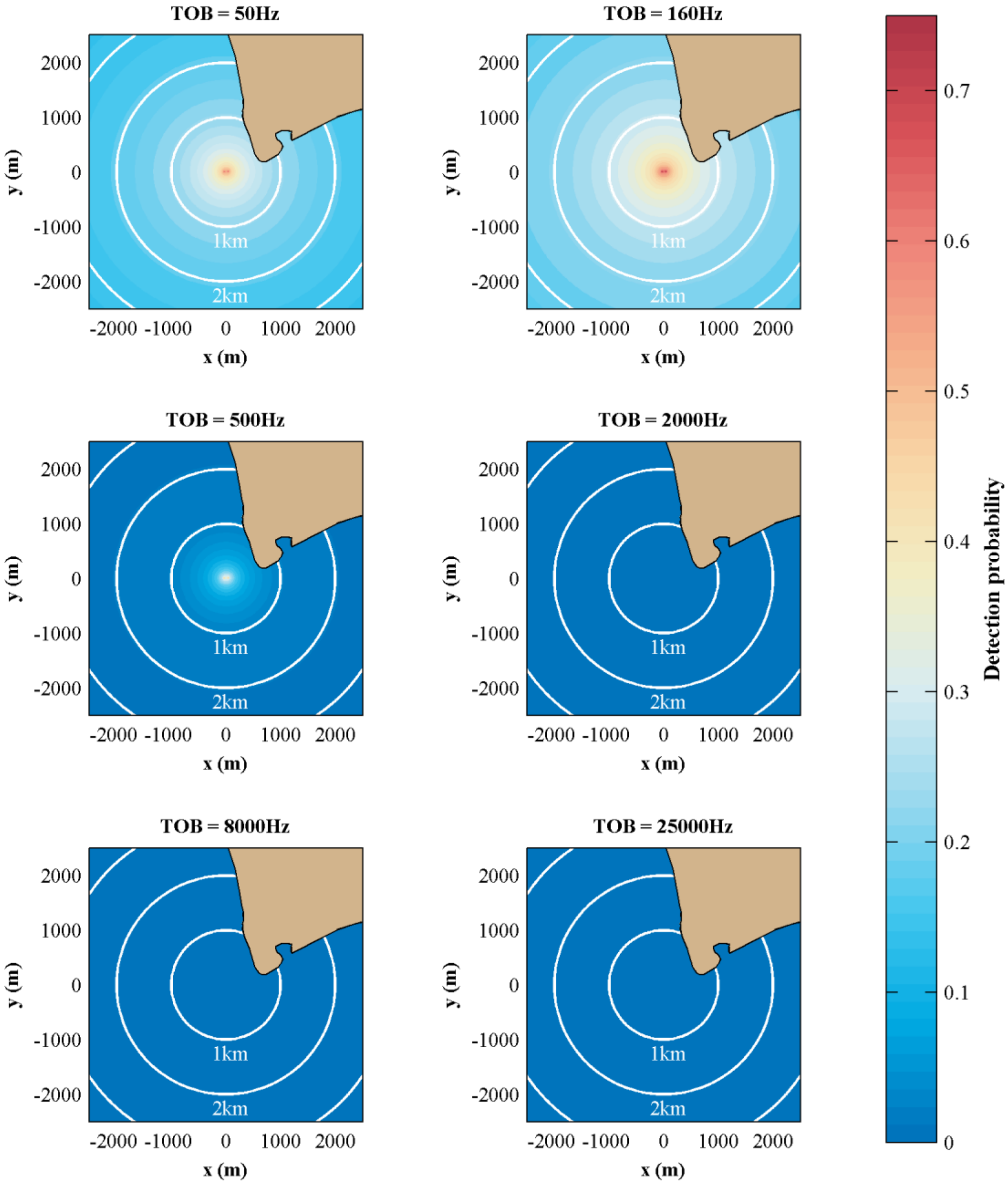
the immediate Project area, but because these activities would be short term and temporary, it is not expected to cause adverse effects to ESA-listed fish species.

As is demonstrated in Figures 5-8 and 5-10, 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. (in prep) 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 5-10 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., submitted).

FIGURE 5-11
PROBABILITY OF FISH (ATLANTIC COD, HEARING GENERALIST) DETECTING TURBINE NOISE



Source: Polagye et al. (in prep)

Note: 30 m depth relative to surface

As stated, noise from turbine operation will be a continuous, non-impulsive source. 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 the 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. (in prep), 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.

The turbines deployed in Admiralty Inlet will incorporate a braking mechanism. The brake may be applied during maintenance activities. 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.

To confirm the District’s expectation that noise produced by the Project will not negatively affect ESA-listed fish or other marine species, 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. The results from the monitoring study will be compared to the results of the pre-installation underwater noise study. In addition, to minimize environmental effects during Project construction, the District will conduct marine installation work during WDFW-approved work windows.

5.3.4 Marine debris entanglement

Description of Stressor

In dynamic tidal sites, there is the potential for any freely floating debris to be carried within the water column or along the bottom in the tidal flow. As a result, debris may contact or become entangled on the turbine or gravity base foundation. Derelict fishing gear has been identified as a specific concern. In the 1950s 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). There is a concern that derelict fishing gear may snag on turbine structures and pose an entanglement risk to marine life, including ESA-listed fish, in the vicinity of the Project.

During the course of discussions with stakeholders during 2009, 2010, and 2011, the concern for marine debris becoming entangled with the subsea transmission cables was not raised. The District believes the concern was not raised due to the nature of subsea cables and the high unlikelihood that marine debris will get caught on the cables. A summary of the trunk cables and why marine debris is not likely to get caught on the cables follows:

Trunk cables will be bottom-laid and sheathed in an abrasion-resistant polymeric protective coating. The cables will be deployed in such a manner that there will be no hockles (bends or loops), suspensions or protrusions that could potentially entangle drifting debris – they will lay flat on the seabed. Any seafloor feature large enough to cause a suspension will be assiduously avoided during cable deployment.

The extreme weight of the cables (anticipated SG of approximately 7), the cables' small diameter and the swift, turbulent current flow in the Admiralty Inlet/Admiralty Bay area, all are factors expected to contribute to rapid burial of the cables such that there is little likelihood that debris entrapment will be possible.

The full length of the cable path will be tracked by ROV video camera during deployment to ensure a successful lay, and current plans call for a second ROV check of the cable run approximately one year post-deployment. There are no additional plans to monitor the cables for fouling.

The following discusses potential entanglement with project structures other than the trunk cable.

Exposure to Stressor

ESA-listed fish species and life stages that are expected to occur in the near-turbine vicinity could be exposed to any derelict fishing gear or marine debris entangled on the turbine structures. As discussed above in Sections 4 and 5.3.1, the three ESA-listed rockfish species, both juvenile and adult, could be expected to use the habitat created by the turbines. ESA-listed juvenile salmonids are not expected to use water column depths associated with the Project turbines.

As discussed in Sections 4 and 5.3.1, adult salmonids and all life stages of green sturgeon, and eulachon have been found at sea at depths that overlap the turbine depths in Admiralty Inlet. While these species' feeding patterns and prey make it unlikely that they would be attracted to the turbines, they could encounter the turbines as they move through Admiralty Inlet.

The likelihood of exposure to derelict gear snagged on Project works for ESA-listed fish is influenced by overlap in both the spatial and temporal distribution of species with the Project. As discussed above, 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 Project very infrequently. A longer exposure would occur for migratory species, if they delay their migration by holding in the project area; for example, salmon are known to hold off the southern tip of Whidbey Island before entering their home rivers (SSPS 2007). In contrast resident species, such as ESA-listed rockfish, could be exposed to derelict gear that may snag on a turbine more frequently.

Likelihood of Exposure

The likelihood of exposure would depend on the type of fishing gear that becomes entangled on the turbine. For example, a gill net could entangle fish, the specific size of which would depend on the mesh size and how the net is positioned; however, an entangled line would likely not entangle fish. If debris becomes entangled on the turbines, all ESA-listed fish species and associated marine life stages could be exposed if swimming past the turbines. If prey became entangled, ESA-listed fish that are predators of the entangled prey could be attracted to the area and subsequently also be at risk of entanglement, or predators could be attracted to the area and feed on ESA-listed species that are also in the area.

The likelihood of exposure is also dependent on the likelihood of derelict gear becoming entangled on the turbine in the first place. Commercial and recreational fishing activities have resulted in the presence of numerous abandoned 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).

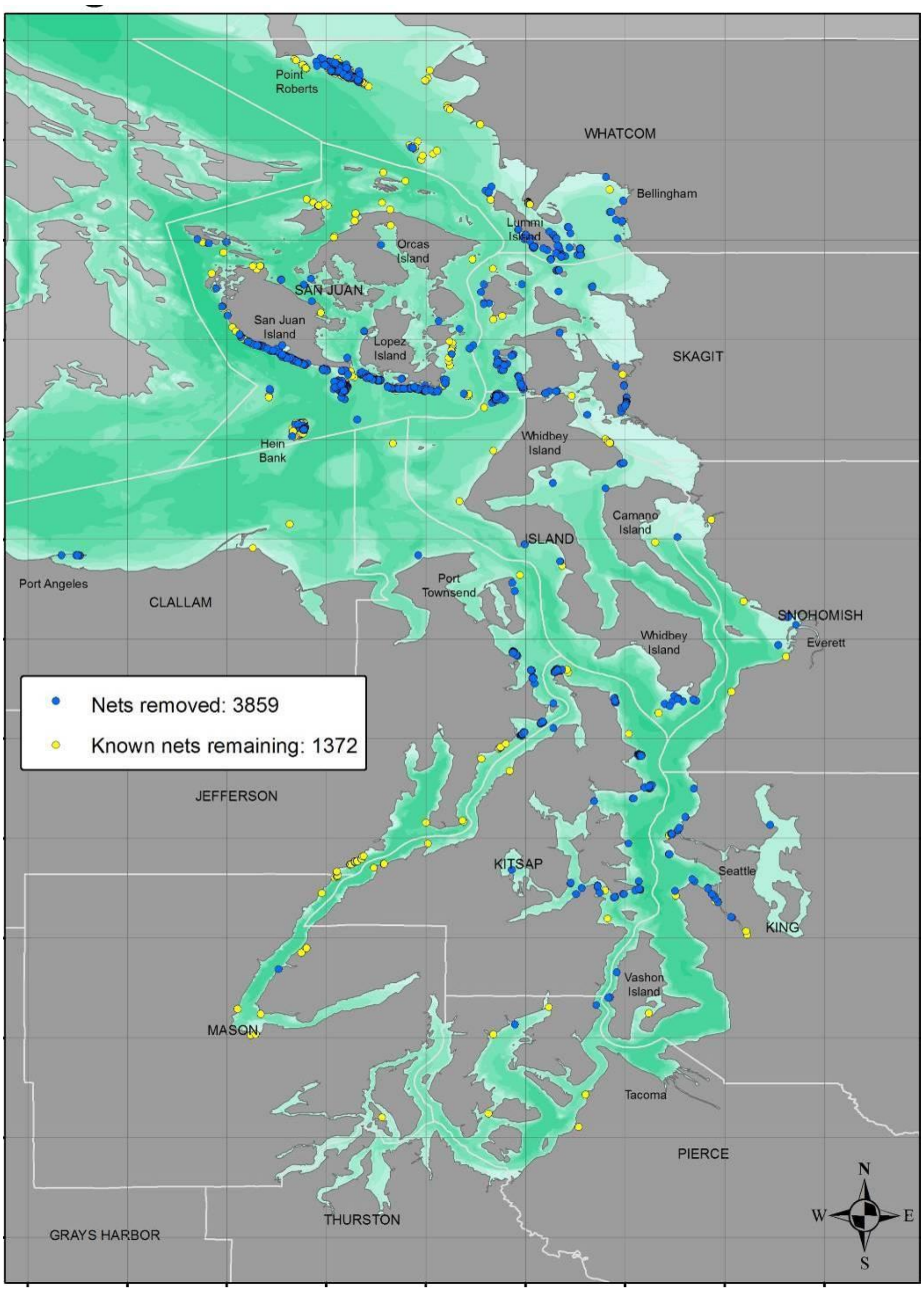
Good et al. (2009) reported that for the 902 derelict fishing nets recovered since 2002 from the United States portions of the Juan de Fuca Strait and Puget Sound, there were 876 gillnets, 23 purse seines, 2 trawl nets, and 1 aquaculture net. Most gillnets were recovered by divers from depths less than 22 meters, with a maximum depth of 42.7 meters (Good et al. 2009)[26].

The Northwest Straits Marine Conservation Initiative was recently 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 3,000 high priority derelict nets and fulfill 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 2009). 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. 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 5-12 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.

[26] 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 5-12
KNOWN AND REMOVED DERELICT FISHING GEAR IN PUGET SOUND AS OF DECEMBER 31, 2010



Source: NWSF 2011

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 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 six hours it is considered unlikely that any debris would remain attached to the turbine for extended periods 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. The District will utilize an ROV to inspect Project structures for accumulation of derelict gear, with findings recorded by video camera. During the first year following Project installation, the District will deploy an ROV a minimum of once every three months. For the duration of the Pilot License after the first year and so long as the Project structures are within the water, the District will deploy an ROV at least twice annually.[27] The District will review video data collected during each deployment for evidence of derelict gear, and will notify the MARC as to the result of its review of video data within seven days following the deployment. There will also be an ability to monitor, in real time, a portion of the turbine face using the stereo cameras implemented 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 as soon as possible. This would be undertaken with a work class ROV[28], equipped with a video camera, manipulator skid, grabber arm, and rotary disc cutter or other cutting device for gear removal deployments. The degree of intervention would be influenced by the size, position, and weight of the derelict object and also the prevailing weather conditions. 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 (personal communication, Larry Armbruster, Sound and Sea Technology, July 2010).

Also, the general area around and between the two turbines will be marked on navigational charts, minimizing 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 ESA-listed fish species.

Risk to Individuals and Populations of ESA-Listed Fish

While injury or mortality from entanglement in derelict gear caught on Project turbines could occur to ESA-listed rockfish that may be attracted to the turbines; adult salmonids and all life stages of green sturgeon, and eulachon passing through the Project area; or forage species that become entangled in derelict gear caught on Project turbines, the District expects the risk to be discountable and insignificant because:

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[27] Based upon the results of the plan monitoring, Snohomish, with the approval of the MARC, may modify the frequency of the ROV deployments.

[28] Safety considerations preclude the use of divers near Project turbines (personal communication, Nick Murphy, OpenHydro, 2009), and much of the Project is below depths at which diver removal of derelict gear is typically conducted (NRC 2008).

- 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 (NWSF 2011), lessening the chance of derelict fishing gear snagging on Project turbines.[29]

- There would be a very low exposure of ESA-listed fish species passing by the turbines, with the exception of any individuals of the three rockfish species, which could potentially be attracted to the turbines (as discussed above given the fact that ESA-listed species can pass through 99.95 percent of cross -section of Admiralty Inlet at the Project location without encountering the proposed turbines and the demonstrated ability of fish and marine life to avoid in-water large structures [e.g., the turbines]).

- The general area around and between the two turbines will be marked on navigational charts. 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 a portion of the turbine face using the stereo 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 (Section 2.2.3.2).

- The District will consult with the Admiralty Inlet 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 ESA-listed species of derelict gear that is “ghost fishing” at an unknown site, the Project does not pose a risk to ESA-listed fish individuals or populations, because the site will be regularly monitored and gear will be promptly removed if detected.

[29] 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.

5.3.5 Electromagnetic Fields

Description of Stressor

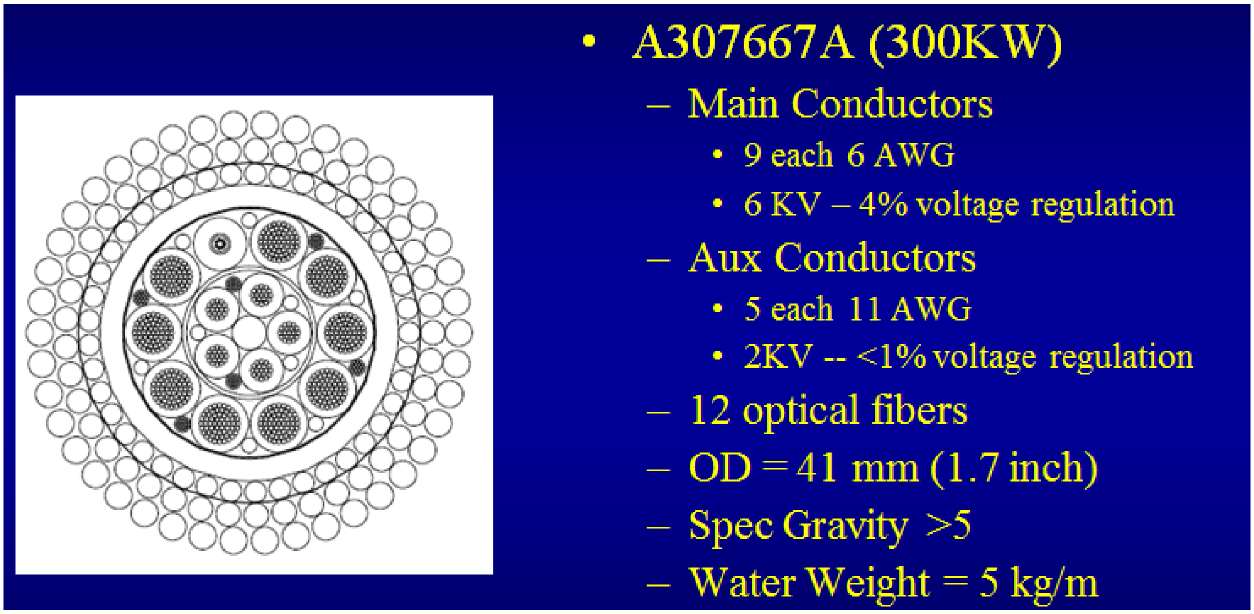
EMF is created from both natural and anthropogenic sources. Natural sources include the earth's magnetic field and different biochemical, physiological, and neurological processes within organisms. Even sea currents passing through the earth's geomagnetic field produces EMF. Anthropogenic sources of 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).

The transmission of electrical power (the acceleration or fluctuation of charged particles) generated from the OpenHydro turbines to the onshore electrical grid via a subsea trunk cable represents a source of EMF. 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 onshore to a minimum depth of 18 meters. From the HDD exit underwater, the trunk cables will be laid on the seabed for approximately 2 km and connect to the turbines. The Project transmission components are shown above in Figures 2-5 and 2-7.

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. The typical cable configuration shown in Figure 5-13 is representative of the trunk cables that will be utilized. They are roughly 10 centimeters in diameter, double armored to withstand installation and normal seafloor hazards.

FIGURE 5-13
TYPICAL TRUNK CABLE



Resource agencies are concerned that ESA-listed salmonids and southern DPS green sturgeon will detect EMF from the Project and it might alter their migration behavior (NMFS letters to the District dated July 6, 2009, and December 8, 2008).

Exposure to Stressor

Pacific salmon and green sturgeon are migratory ESA-listed fish species that pass through Admiralty Inlet and could be exposed to EMF created by the Project. Organisms that can detect B fields are presumed to do so by either by detecting iE fields or by using magnetite. These species detect induced electric 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 its Biological Assessment for the Reedsport OPT Wave Park (FERC No. 12713), OPT (2010) provided the following summary of response information for salmon and green sturgeon.

- Pacific Salmon - Research has suggested that there are several potential mechanisms that Pacific salmon use for navigation including orienting to the earth's magnetic field, utilizing a celestial compass (sun and moon), and using the odor of their natal stream to migrate back to their original spawning grounds (Groot and Margolis 1998; Quinn et al. 1981). Crystals of magnetite have been found in four species of Pacific salmon, though not in sockeye salmon (Mann et al. 1988; Walker et al. 1988). These magnetite crystals are believed to serve as a compass that orients to the earth's magnetic field. Yano et al. (1997) investigated the effects of artificial B fields on oceanic migrating chum salmon (*Oncorhynchus keta*). In this study, chum salmon were fitted with a tag that generated an artificial B field around the head of the fish. There was no observable effect on the horizontal and vertical movements of the salmon when the tag's magnetic field was altered. Quinn and Brannon (1982) further conclude that while salmon can apparently detect B fields, their behavior is likely governed by multiple stimuli as demonstrated by the ineffectiveness of artificial B field stimuli.

Similar results were also found in studies conducted on another salmonid, Atlantic salmon (*Salmo salar*). Results of research of effects of EMF showed that navigation and migration of Atlantic salmon is not expected to be impacted by the magnetic field produced by an underwater cable (Scottish Executive 2007).

- Green Sturgeon - Green sturgeon are a long-lived, slow-growing fish and the most marine-oriented of the sturgeon species. Although they are members of one of the oldest classes of bony fish, the skeleton of sturgeons is composed mostly of cartilage. Like elasmobranchs, sturgeons are weakly electric fish that can utilize electroreceptor senses, as well as others, to locate prey. In the one report related to Sterlet sturgeon (*Acipenser ruthenus*) and Russian sturgeon (*A. gueldenstaedtii*) behavior in the presence of electric fields, Basov (1999) found varying behavior at different electric field frequencies and intensities:

    - At 1.0 to 4.0 hertz at 0.2 to 3.0 mV per centimeter, responses were searching for source and active foraging
    - At 50 hertz at 0.2 to 0.5 mV per centimeter, response was searching for source
    - At 50 hertz at 0.6 mV per centimeter or greater, response was avoidance

Likelihood of Exposure

To avoid adverse impacts to the sensitive shoreline areas, near-shore habitat, and benthic species, the District will install the subsea transmission cables under the seabed by HDD from onshore to a minimum depth of 18 meters (the trunk cables will exit the HDD bore hole about 2 km from the turbines). EMF will not be of concern for the cables that are under the seabed from the shore to the HDD bore hole exit.

The transmission cable will exit the HDD bore and continue along the seabed surface for approximately 2 km and will connect to the turbines. It is along the portions of the cables that lay on the surface of the seabed that ESA-listed species can be exposed to EMF. The likelihood of exposure to EMF associated with the Project for migratory ESA-listed fish species - green sturgeon and 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. A longer exposure would occur for migratory species however, if they delay their migration by holding in the project area; for example, salmon are known to hold off the southern tip of Whidbey Island before entering their home rivers (SSPS 2007)

OpenHydro has invested heavily in both time and resources in the development of the insulation system for 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 and 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 (District 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 in order 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 (District FERC AIR response dated June 24, 2011).

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:

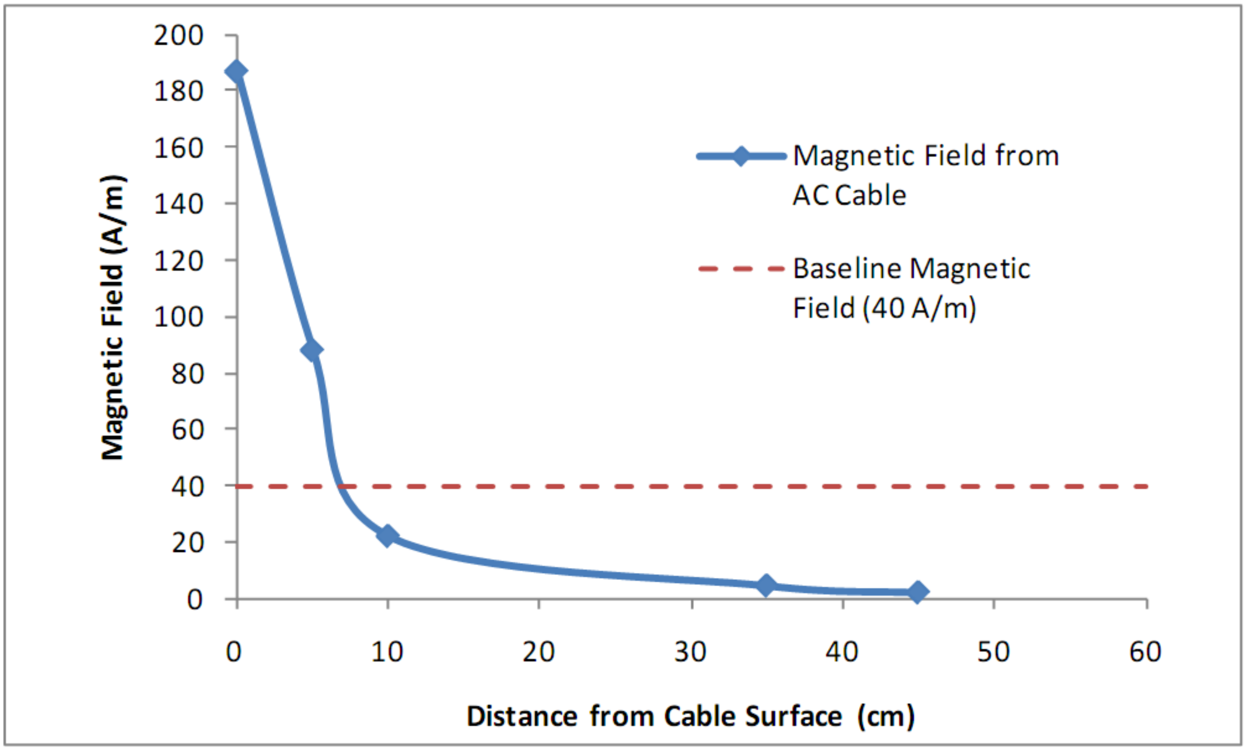
$$\text{current} / 2\pi r \quad \text{(Amp per meter)} \qquad \text{or} \qquad \mu 0 \times \text{current} / 2\pi r \quad \text{(Tesla)}$$

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 5-14.

FIGURE 5-14
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 5-13 so that 5 centimeters (2 inches) from the cables surface (note, figure shows distance from cable center, not the cable surface) the magnetic field is about 88 A/m, and at 10 centimeters (3.9 inches) from the cables surface, it is 22 A/m. Everywhere beyond a distance of about 8 centimeters (3.1 inches) from the surface of the cable, the 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, relative to 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. 2005b), and it is therefore expected that the likelihood of ESA-listed salmonids swimming within 3.1 inches of the cable is also very small.

Risk to Individuals and Populations of ESA-Listed Fish

As described in this section, EMF produced by the Project will be discountable and insignificant to ESA-listed fish. In the United Kingdom, researchers recently 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 two shark species and one ray species to a buried subsea cable running along the seabed. Researchers used two 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, Westernberg 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 (Westernberg and Lagenfelt 2008).

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 (exceeding the earth's background magnetic field within only 8 centimeters [3.1 inches] of the surface of the cable), 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; Westernberg 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 approximately 700 kW.

Because the length of cables exposed on the seabed is relatively small (2 km for each cable) compared to other cables spanning Puget Sound and compared to the scale of Admiralty Inlet, and because green sturgeon and Pacific salmon would not be attracted to the turbines (discussed above) and their habitat use is throughout the water column, 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 minimus*. This analysis indicates that the effects of EMF on individual Pacific salmon and green sturgeon, as well as populations of the same, will be discountable and insignificant.

5.3.6 Critical Habitat

Critical habitat for two fish species, Puget Sound Chinook salmon and Hood Canal summer-run chum salmon, occurs at the Project. As discussed above, critical habitat for both species is nearshore marine areas "contiguous with the shoreline from the line of extreme high water out to a depth no greater than 30 meters relative to mean lower low water" (70 FR 52684). For both species, NMFS identified PCEs for nearshore marine areas, including Admiralty Inlet, as areas that:

- Are free of obstruction,
- Have certain water quality and quantity conditions, and
- Provide sufficient forage, including aquatic invertebrates and fishes that support growth and maturation (70 FR 52685).

As discussed above in Section 5.3.1, the proposed Project represents 0.05 percent of the cross - sectional area 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 relation to the size of the two proposed turbines, and the Project does not obstruct salmon movement. The Project will not affect water quality or quantity, nor will it affect salmon forage. The District concludes that the Project would not affect critical habitat of Puget Sound Chinook salmon and Hood Canal summer-run chum salmon.

5.4 Marine Mammals

SRKW, humpback whale, and Steller sea lion are the ESA-listed marine mammals that are known to pass through the Project area. Based on consultation with stakeholders, including a meeting on August 5, 2010 with NMFS and USFWS to discuss potential Project effects on ESA-listed species for development of this document, the District has identified the following potential direct effects of Project deployment and operation on ESA-listed marine mammals:

- blade strike,
- underwater noise, and
- marine debris entanglement.

No indirect effects have been identified.

5.4.1 Blade strike

Description of Stressor

Each OpenHydro turbine is 6 meters in diameter (actual rotor diameter will be 4.7 meters) and will sit at a depth of approximately 58 meters 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 51 to 45 meters. The turbine is expected to reach a maximum rotational speed of approximately 29 RPM, though typical rotational speeds will range from 6 to 20 RPM (Figure 5-3). As with ESA-listed fish species (see Section 5.3.1), there is concern that SRKW, humpback whale, or Steller sea lion or the species they forage on, may swim into one of the two operating rotors, resulting in injury or mortality.

Exposure to Stressor

SRKW will occur in the Project area; as stated in Section 4.7.2, the Whale Museum (2009*b*) estimates that the number of SRKW transits through Admiralty Inlet is 42 per year (range of 31 to 54), with a total of 1,442 individual SRKW transits through Admiralty Inlet per year. SRKW spend up to 50 to 67 percent of their time foraging, using echolocation, passive listening, and well developed vision to locate prey (NOAA 2006). As discussed above, during seven observed SRKW transits through Admiralty Inlet in October and December 2009 and January 2010, SRKW spent most of their time in the Project area travelling (74 percent) (Tollit et al. 2010a).

Humpback whales are infrequent and sightings in northwest coastal waters are uncommon, occurring one to two times per year in Admiralty Inlet (Osborne et al. 1988). Historically, Steller sea lions have been considered uncommon and seasonal in Puget Sound, typically observed in fall, winter, and spring. Five to fifteen have been observed at Marrowstone Island, approximately 8.4 kilometers south of the deployment area during the last five years (personal communication, P. Browne, HDR with S. Jeffries, WDFW, July 2009). Steller sea lions were frequently observed in the Project vicinity during the Project's marine mammal monitoring conducted from October 2009 to April 2010 (observed on 66 percent of the survey days during which observers were in the field) (Tollit et al. 2010a).

Preliminary results of SRKW dive depths in the Project area, recorded as part of the District's marine mammal monitoring conducted as part of this Project, indicate that SRKW do dive to depths at which the turbines will be located (Tollit et al. 2010a). However, past studies have shown that a large majority of SRKW dives occur to depths less than 30 meters (Baird 2000, Baird et al. 2003, 2005). Baird et al. (2003, 2005) reported an average of about 0.7 to two dives per hour made below 30 meters, with such dives occurring more often during the daytime. These represented 5 percent of all dives and occupied less than 2.5 percent of an animal's total dive time. Humpback whales and Steller sea lions both dive regularly to the turbine deployment depths.

Likelihood of Exposure

The previous section concluded that SRKW, humpback whales, and Steller sea lions may be exposed to the OpenHydro turbines. The response of these species to the presence of the turbines may be avoidance or injury/mortality if the animal comes in contact with the rotating turbine. In the event that these species are exposed to the turbines, the District's assessment finds it is unlikely that this exposure will result in blade strike. The District's assessment is based on the following analytical components:

- Frequency of interaction with turbine;
- Turbine design, speed, and operation frequency;
- Abilities of marine mammals to detect large underwater features;
- Monitoring results from EMEC;
- Project scale; and
- If necessary, implementation of Adaptive Management components of Near-Turbine Monitoring Plan.

<u>Frequency of interaction with turbines</u> - The likelihood of exposure to blade strike for ESA-listed marine mammals would be influenced by overlap in both the spatial and temporal distribution of species with the Project. In Admiralty Inlet, SRKW and humpback whales are both migratory and are therefore expected to be transiting through the Admiralty Inlet area and would be exposed to the turbines infrequently. In contrast Steller sea lions are known to spend longer periods of time in Puget Sound and therefore could be exposed to the stressor more frequently[30].

<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 ESA-listed marine mammals coming in contact with a moving blade.

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 marine mammal 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, and therefore turbine sweep area would be 13.5 square meters for both turbines. Further, there are a

[30] As discussed in Section 4.13.2, while Steller sea lions are born at a few sites along the outer coast of Washington, but not in Puget Sound (personal communication, P. Browne, HDR, with S. Jeffries, WDFW, July 7, 2009), there are four haulouts, including two major sites (sites with greater than 50 animals) in Washington, which are regularly used during the breeding season.

number of design characteristics of the OpenHydro turbine that are expected to minimize the risk of blade strike on ESA-listed marine mammals:

- 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 mammals 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. The OpenHydro turbine is designed with an open center (2.2 meters) which allows adequate space for Steller sea lions to pass through the center of the turbine. In addition, the majority of water flows around, not through, the turbine blades (Wilson et al. 2007, CREST Energy Limited 2006) (discussed further in Section 5.3.1).

Regarding the turbine speed, the OpenHydro turbines will rotate at slow speeds. The typical rotational speeds will range from 6 to 16 RPM, with a maximum rotational speed of 24 RPM (Figure 5-3, above). 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 60 to 70 percent of the time.

<u>Abilities of marine mammals to detect large underwater features</u> - SRKW, humpback whales, and Steller sea lions, are highly sensitive of their surrounding environment. There is little evidence that 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 obstruction, and most species are able to avoid moving vessels as well (AECOM 2009). 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 have well-adapted underwater vision (Schusterman and Balliet 1970) and can detect changes in pressure or vibrations in the water through the use of their vibrissae (Dehnhardt et al. 2001, Mills and Renouf 1986). 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).

As discussed in section 5.3.3, the noise produced by Project operation is within the hearing thresholds of SRKW, humpback whales, and Steller sea lions. Therefore, it is expected that these species will detect and may avoid the OpenHydro turbines, as discussed further in this section.

<u>Monitoring Results from EMEC</u> - There has been extensive environmental monitoring conducted on the OpenHydro turbine deployment at EMEC to characterize marine life response 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). 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.

Project scale - Given the demonstrated ability of marine mammals to avoid in-water large structures and the fact that ESA-listed marine mammals can pass through 99.95 percent of cross - section of Admiralty Inlet at the Project location without encountering the proposed turbines (see Figure 5-7 in Section 5.3.1), it appears unlikely that the presence of the Project will pose a risk to ESA-listed marine mammals or their prey.

Monitoring and safeguards - The District is committed to avoiding or minimizing the potential effects of the Project on SRKW and other marine mammals. The District's Proposed Action requires the implementation of the Near-Turbine Monitoring Plan and Marine Mammal Monitoring Plan to characterize the species present in the immediate vicinity of the turbine and whether or not those species are interacting directly with the turbine rotor and to improve the understanding of how marine mammals interact with operating tidal turbines (specifically, whether marine mammals are attracted to or actively avoid the turbines).

Consequences of strike - 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.

Risk to Individuals and Populations of ESA-Listed Marine Mammals

The response of SRKW, humpback whale, or Steller sea lions to the presence of the turbines may be avoidance due to noise or injury/mortality if the animal comes in contact with the rotating turbine. The District expects that these species will not be injured or killed by turbine strike for the following reasons:

- Frequency of interaction with turbines - SRKW and humpback whales are both migratory and are therefore expected to be transiting through the Admiralty Inlet area and would be exposed to the turbines infrequently;
- Turbine design, speed, operation frequency - as discussed in the previous subsection, 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 ESA-listed marine mammals coming in contact with a moving blade;

- The inherent ability of marine mammals to avoid colliding with larger underwater features;
- No evidence of approach by, or injury or mortality of, marine mammals from almost four years of monitoring the EMEC OpenHydro turbine;
- The small Project size relative to the cross -sectional volume of Admiralty Inlet at the deployment site (0.05 percent);
- A recent assessment of potential injury to killer whales from blade strike concluded that the consequences are, at most, minimal bruising;[31] and
- Careful monitoring of the turbines through the Near-Turbine Monitoring Plan, and monitoring of marine mammls through the Marine Mammal Monitoring Plan, will allow for confirmation of the District's conclusions that SRKW will either avoid the turbines or in any case not be attracted to them.

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.

5.4.2 Underwater Noise

Description of Stressor

As discussed above, the installation, maintenance, and the presence and operation of the Project will result in generation of underwater noise (see Section 5.3.3). For the Admiralty Inlet Project, NMFS has indicated concern 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).

Exposure to Stressor

All three ESA-listed marine mammal species could potentially hear noise associated with installation, maintenance, or removal of the Project, and/or noise produced by operation of the turbines (see Section 5.3.3). The exposure to Project associated noise for ESA-listed marine

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

mammals is also influenced by overlap in both the spatial and temporal distribution of species with the Project, which is discussed further in the next section.

Likelihood of Exposure

In our analysis, the likelihood of ESA-listed marine mammal species potentially being affected by the noise associated with the Project consists of the following:

- Noise exposure criteria,
- Noise and marine mammals,
- Ambient noise measurements,
- Spatial exposure, and
- Temporal exposure.

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 in this section are rms 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 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 Mammals - Many marine mammals species use sound in communication, navigation, predator/prey interactions, and hazard avoidance. 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 ESA-listed marine mammals, especially SRKW. 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 taxanomic 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 most 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) (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 Clarke 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 kilometer, 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).

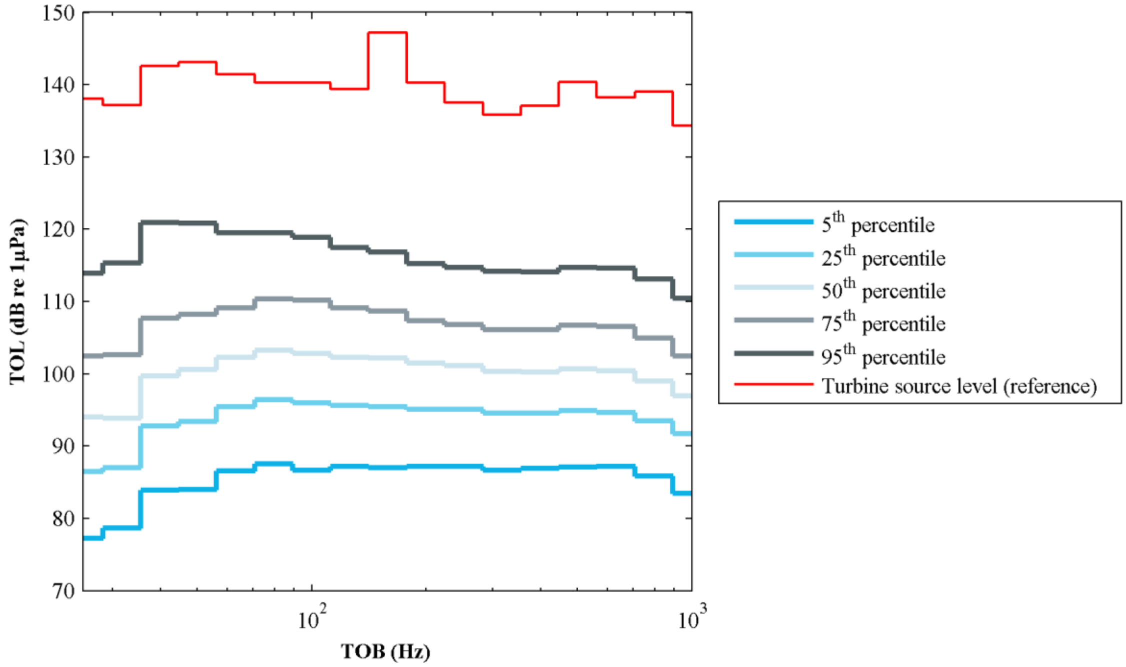
Studies on behavioral responses of pinnipeds to non-impulsive sounds suggested that exposures between 90 and 140 dB (re 1 μPa) generally do not appear to induce strong behavioral responses in water. No data exist regarding exposures at higher levels (Southall et al. 2007).

Ambient Noise Conditions - 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 μPa^2/Hz) for usual marine traffic (10 to 1,000 Hz), and 20 to 80 dB (re 1 μPa^2/Hz) for breaking waves and associated spray and bubbles (100 to 25,000 Hz) (Richardson et al. 1995).

As discussed in Bassett et al. (in prep), 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.

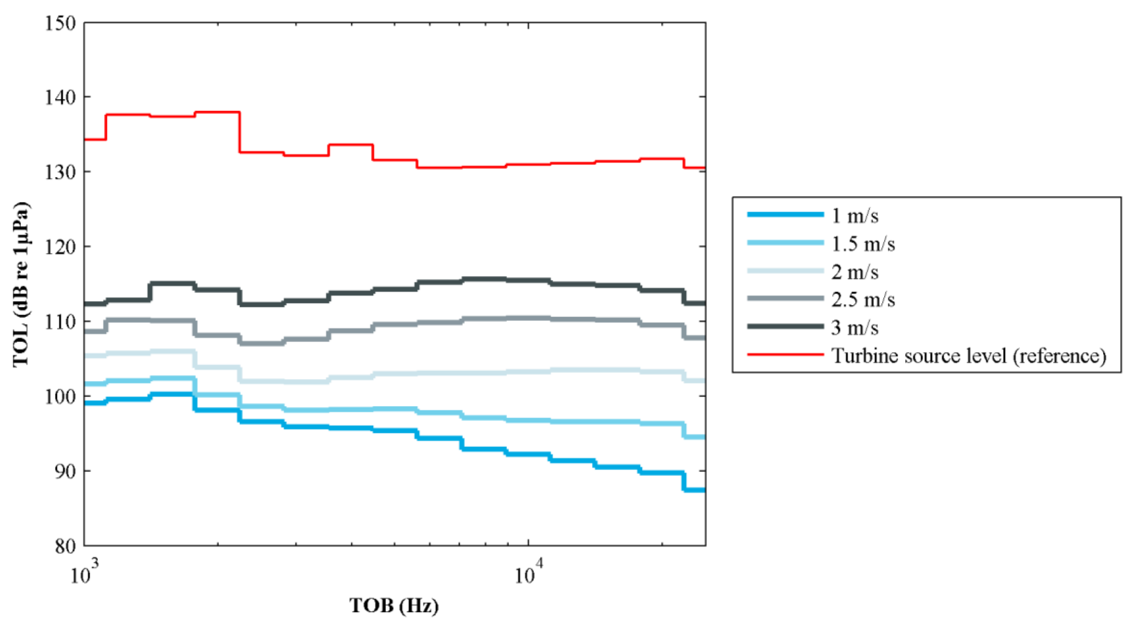
This understanding of ambient noise has been developed through three years of ambient noise monitoring in Admiralty Inlet by NNMREC. Measurements have included fixed hydrophones deployed on instrumentation packages, drifting hydrophones deployed from spar buoys or surface vessels, monitoring of vessel 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. (submitted), and Bassett et al. (in prep). Low-frequency (25 Hz – 1 kHz) ambient noise probability distributions are presented in Figure 5-15 by one-third octave band. Figure 5-16 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. (submitted) 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., in prep). 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 5-15
PERECENTILE ONE-THIRD OCTAVE LEVELS (TOLS) FOR AMBIENT NOISE (25 HZ – 1 KHZ)



Source: Polagye et al., (in prep) using data presented in Bassett et al., (submitted)

FIGURE 5-16
MEDIAN ONE-THIRD OCTAVE LEVELS (TOLS) FOR AMBIENT NOISE (1 KHZ – 25 KHZ) AS A FUNCTION OF CURRENT VELOCITY



Source: Polagye et al., (in prep) using data presented in Bassett et al., (in prep)

<u>Spatial Exposure</u> - As discussed in Section 5.3.3, the maximum rms source level noise produced during Project installation and maintenance would be 178 dB (re 1µPa @ 1 meter) and be concentrated between 20 Hz to 10 kHz.

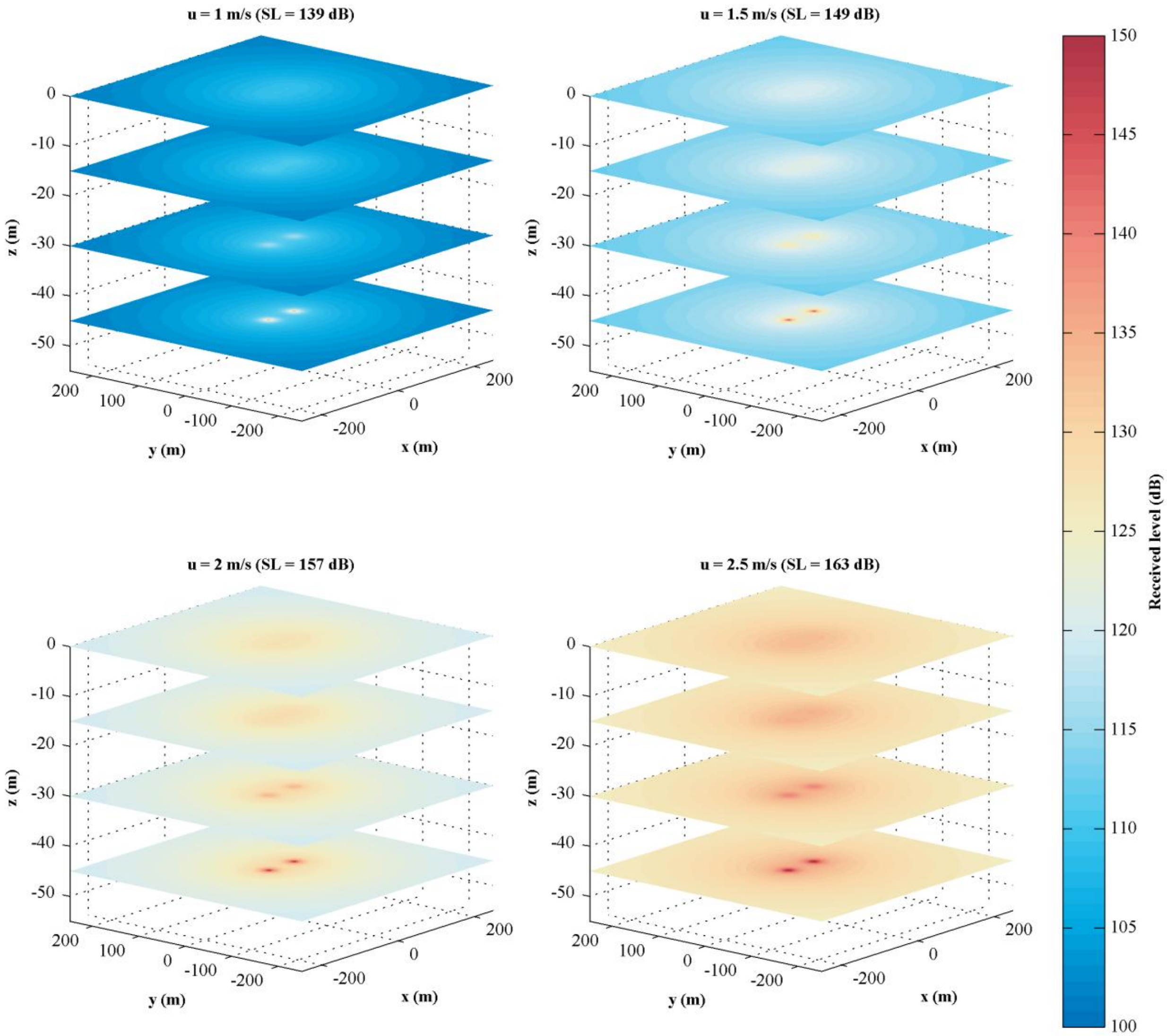
As discussed in Section 5.3.3, Polagye et al. (in prep, draft attached) includes a re-analysis of turbine noise data collected from EMEC and extrapolates these data to predict the temporal distribution of source levels, detection probabilities for turbine noise, and the "warning distance" associated with turbine noise.

Received levels during other operating conditions are estimated using the approach suggested by Hazelwood and Connelly (2005), in which the source level is assumed, to the first order, to increase proportionally with the power extracted by the turbine.

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 5-18 shows the distance to the 120 dB re 1µPa isobel as a function of operating percentile for the turbines. Only beyond the 75th operating percentile does broadband noise from the turbines exceed the threshold for Level B harassment beyond 100 m.

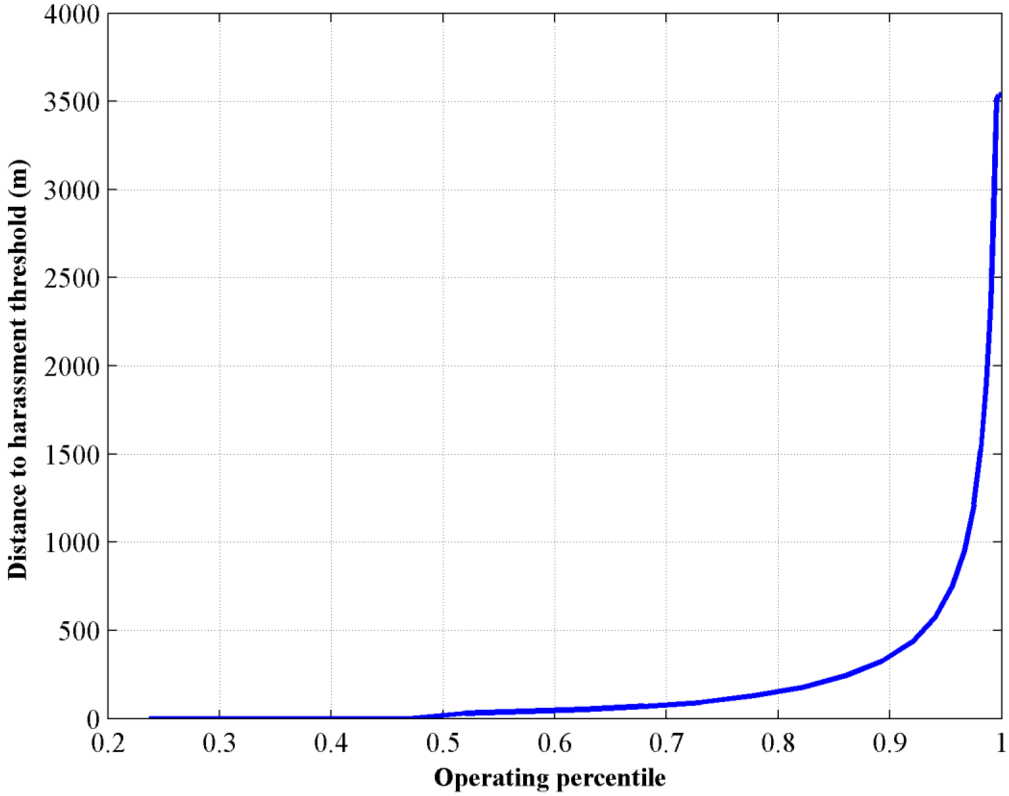
The turbines deployed in Admiralty Inlet will incorporate a braking mechanism. The brake may be applied during maintenance activities or to mitigate environmental impacts (e.g., engaging the brake when Southern Resident killer whales are known to be present in the project area). Any transient noise associated 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.

FIGURE 5-17
RECEIVED BROADBAND SOUND PRESSURE LEVELS AT CLOSE RANGE TO THE PROJECT AT VARIOUS DEPTHS



Source: Polagye et al. (in prep)
Note: Turbine hub height is 45 m relative to the surface.

FIGURE 5-18
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., in prep)

<u>Temporal Exposure</u> - The likelihood of exposure to Project-associated noise for ESA-listed marine mammals is also influenced by overlap in both the spatial and temporal distribution of species with the Project. In Admiralty Inlet, SRKW and humpback whales are both migratory and are therefore expected to be transiting through the Admiralty Inlet area and would be exposed to the Project-associated noise infrequently and for a short period (i.e., less than one hour). In contrast Steller sea lions are known to spend longer periods of time in Admiralty Inlet and therefore could be exposed to the project-associated noise more frequently and over longer periods.

Risk to Individuals and Populations of ESA-Listed Marine Mammals

Resource agencies have identified SRKW to be the ESA-listed marine mammal of greatest concern with regard to the Admiralty Inlet Project. Considerable work on killer whale response to sound has been done in Puget Sound (NMFS 2008*c*). Erbe (2002) “predicted that the sounds of fast boats are audible to killer whales at distances of up to 16 kilometers, mask their calls up to 14 kilometers away, elicit behavioral responses within 200 meters, and cause temporary hearing impairment after 30-50 minutes of exposure within 450 meters. For boats moving at slow speeds, the estimated ranges fall to 1 kilometer for audibility and masking, 50 meters for behavioral reactions, and 20 meters for temporary hearing loss."

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. submitted). During construction, noise would be temporary and short term - as outlined in Section 2, 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, 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 ESA-listed marine mammals. Maximum source levels during installation activities are estimated to be 178 dB (re 1µPa at 1 meter).

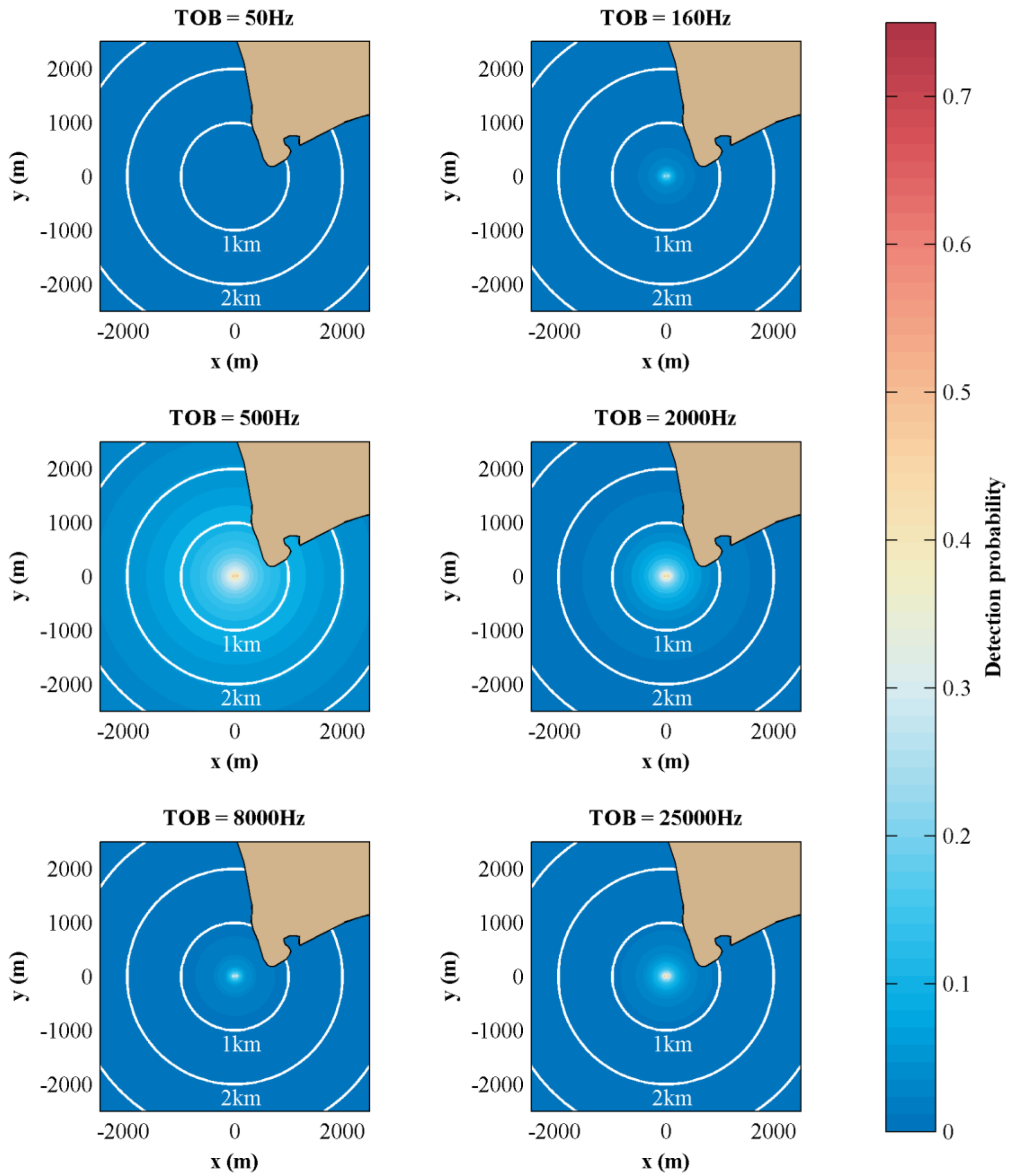
During Project operation, the OpenHydro turbines will generate continuous, non-impulsive sound. It is significant in that, as discussed above, NOAA specifies that a received SPL of 120 dB (re 1 µPa) is Level B harassment for non-impulsive sounds and has the potential for behavioral disturbance to cetaceans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

Polagye et al. (in prep) 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 5-19, 5-20, and 5-21 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.

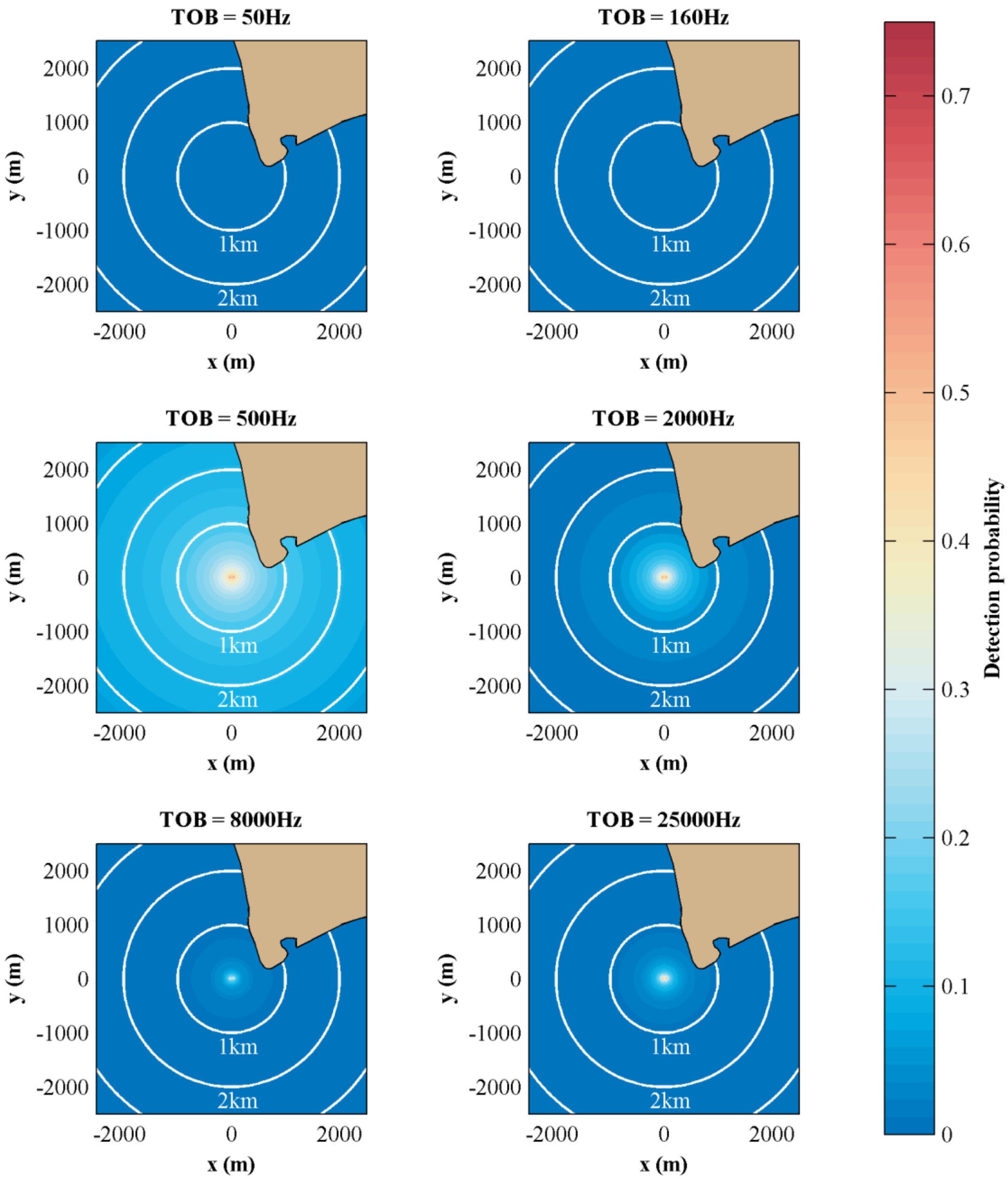
Polagye et al. (in prep) did not evaluate noise detection by low-frequency cetaceans because no audiograms for this class of marine mammals exist (Southall et al., 2007). However, based on the results for fish hearing presented in 5.3.3, low-frequency cetaceans would be expected to detect turbine noise 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 5-19
PROBABILITY OF MID-FREQUENCY CETACEANS (KILLER WHALE) DETECTING TURBINE NOISE



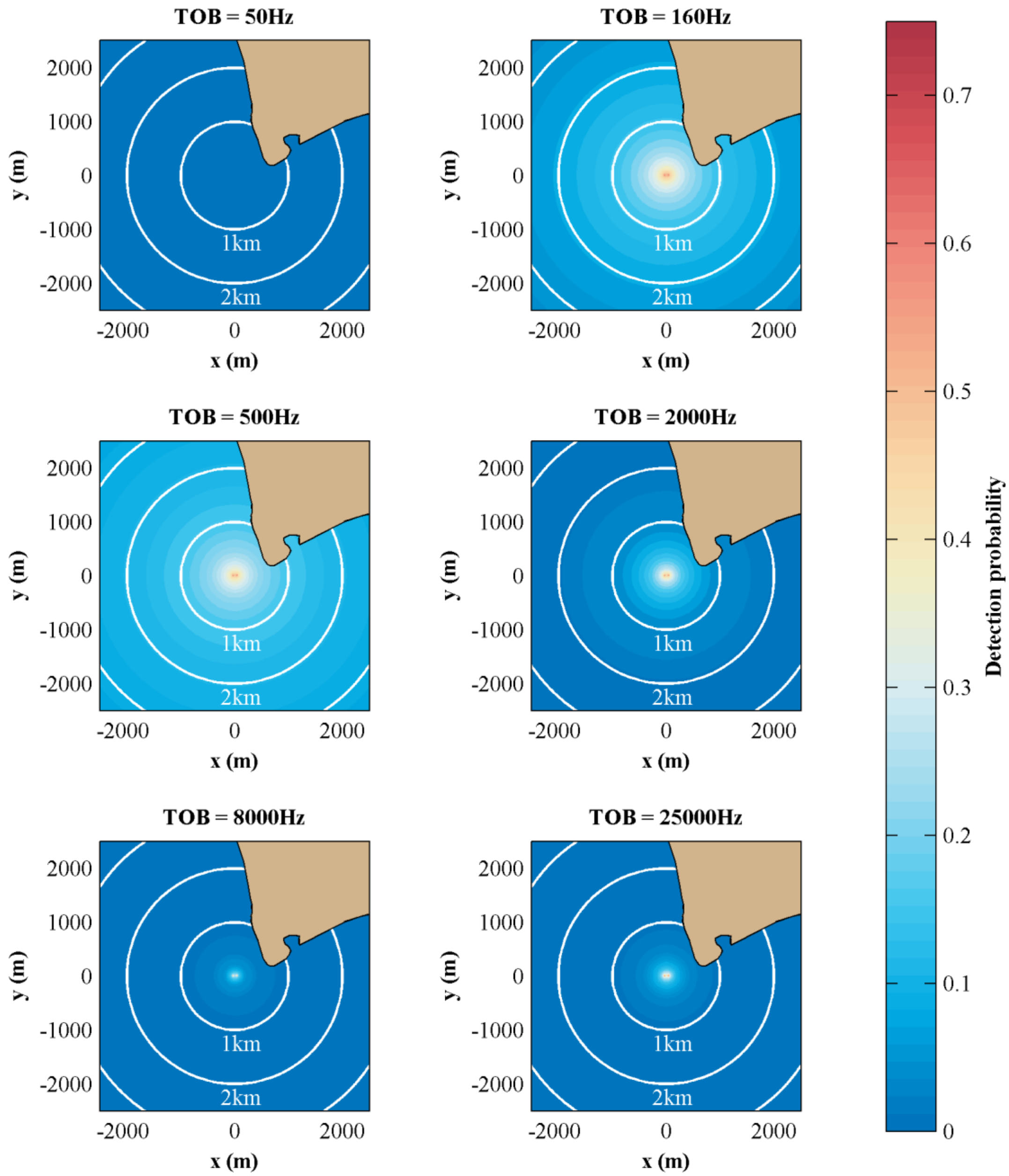
Source: Polagye et al. (in prep)
Note: 30 m depth relative to surface

FIGURE 5-20
PROBABILITY OF HIGH-FREQUENCY CETACEANS (HARBOR PORPOISE) DETECTING TURBINE NOISE



Source: Polagye et al. (in prep)
Note: 30 m depth relative to surface

FIGURE 5-21
PROBABILITY OF PINNIPEDS (HARBOR SEAL) DETECTING TURBINE NOISE



Source: Polagye et al. (in prep)
Note: 30 m depth relative to surface

Southall et al. (2007) proposes 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 frequency ranges. The estimated hearing ranges for these four classes of marine mammals are presented in Table 5-10.

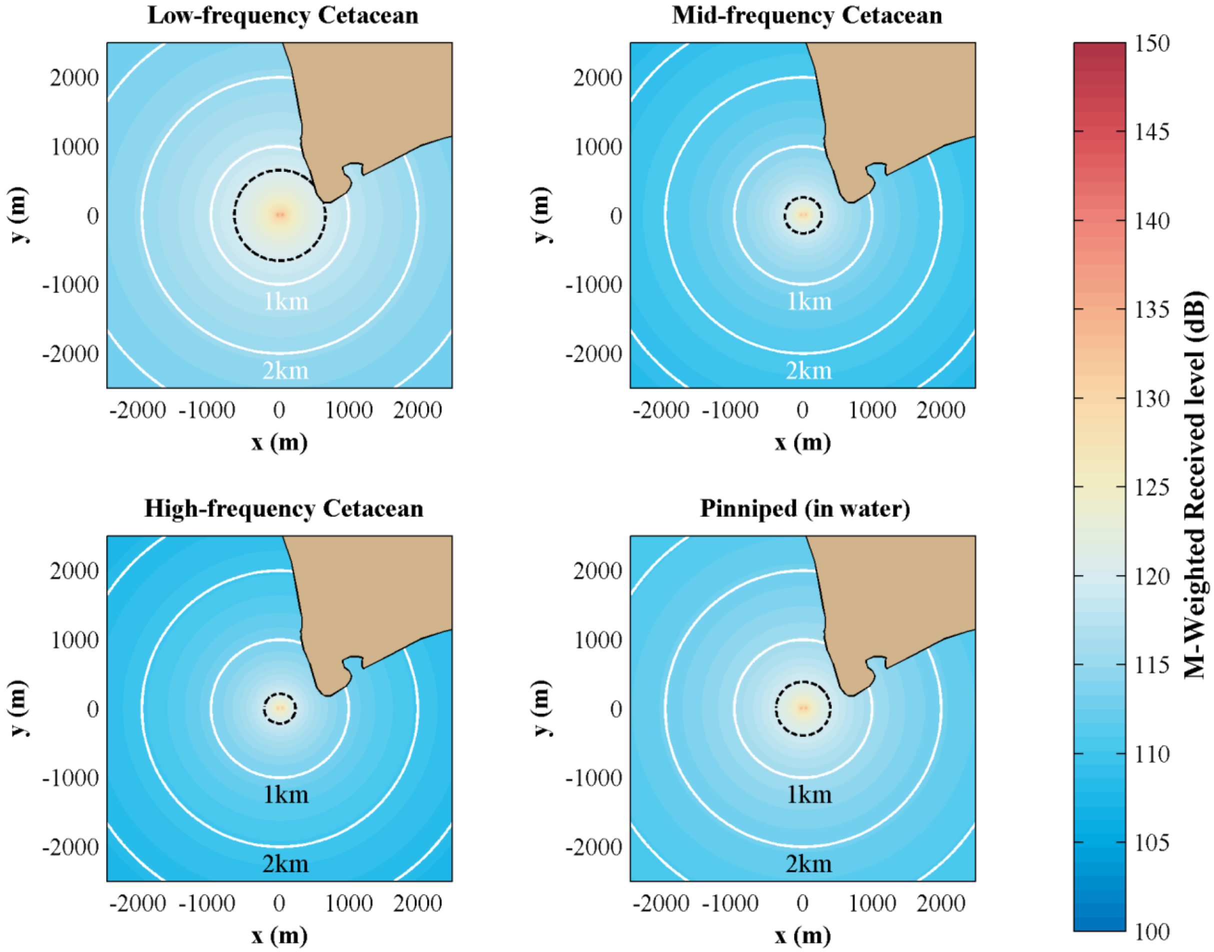
TABLE 5-10
HEARING FREQUENCY LIMITS BY MARINE MAMMAL CLASS

Class	Example Species	Low Frequency Limit	High Frequency Limit
Low frequency cetacean	Humpback whale	7 Hz	22 kHz
Mid frequency cetacean	Southern resident killer whale	150 Hz	160 Hz
High frequency cetacean	Harbor porpoise	200 Hz	180 kHz
Pinnipeds (in water)	Steller sea lion	75 Hz	75 kHz

Source: Southall et al. 2007

The M-weightings are applied to the turbine spectra discussed in section 5.3.3 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 5-22 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 the received level map is much the same as for broadband noise. However, because of poorer hearing sensitivity at lower frequencies, the received levels for mid frequency cetaceans, high frequency cetaceans, and pinnipeds are lower, as summarized in Table 5-11, because their hearing is less sensitive at lower frequency.

FIGURE 5-22
M-WEIGHTED RECEIVED SOUND PRESSURE LEVELS
FOR MARINE MAMMAL CLASSES AT 95TH OPERATING PERCENTILE



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

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 5-11
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., humpback whale)	650 m
Mid frequency cetacean (e.g., SRKW)	260 m
High frequency cetacean	220 m
Pinnipeds (e.g., Steller sea lion)	390 m

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

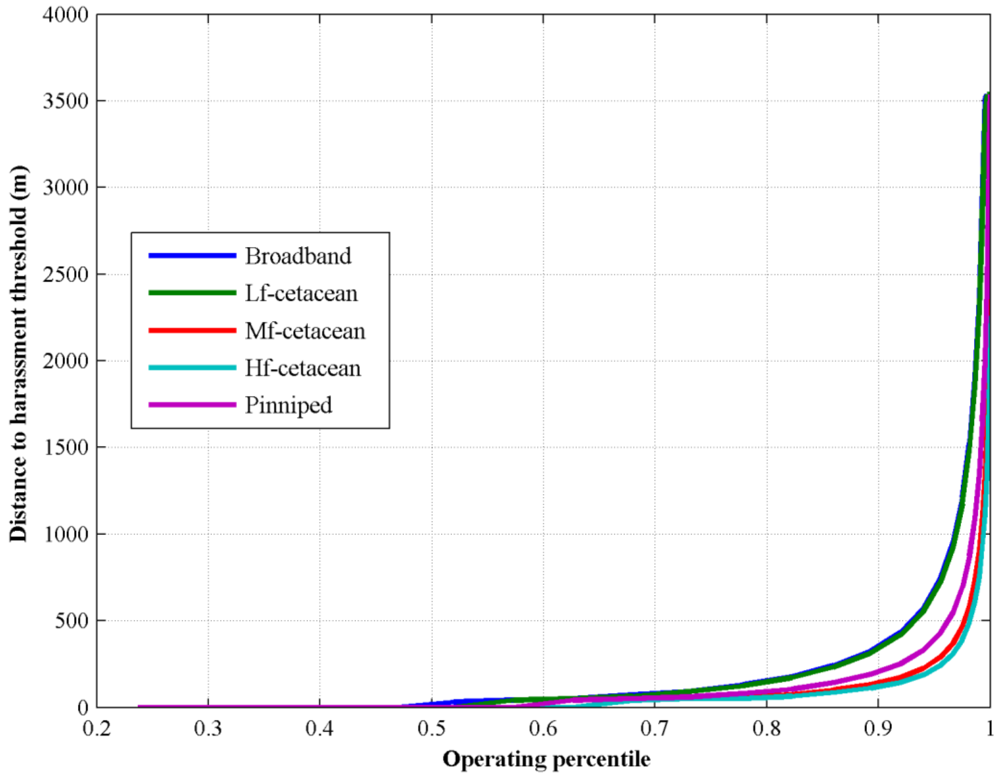
As shown in Table 5-11, when the tidal turbines are operating at the 95th operating percentile the three ESA-listed marine mammal species classes would be exposed to NMFS Level B Harassment threshold as follows:

- humpback whale - within 650 meters
- SRKW - within 260 meters
- Steller sea lion - within 390 meters

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 5-23. At the 80th oprating percentile, M-weighted turbine noise drops below the harassment threshold at less than 200 m and within 50 m at the 50th operating percentile. Consequently, the 95th 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., submitted) 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 5-23
DISTANCE TO HARASSMENT THRESHOLD AS FUNCTION OF OPERATING PERCENTILE FOR SIX-METER DIAMETER OPENHYDRO TURBINES IN ADMIRALTY INLET



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

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 - proposed 5 year operation period;
- The predominance of vessel traffic noise associated with passenger ferries and cargo vessels (Bassett et al., submitted) and, at high currents, bedload transport (Bassett et al., in prep), which generally limits marine mammal detection of turbine noise to within a few hundred meters of the Project (Polagye et al., in prep);
- 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, change in behavioral state) as a consequence of exposure to turbine noise.

5.4.3 Marine Debris Entanglement

Description of Stressor

As discussed in Section 5.3.4, there is a concern that derelict fishing gear may snag on turbine structures and pose an entanglement risk to ESA-listed species. As also discussed in Section 5.3.4, there is not at this time concern that derelict fishing gear will snag on the subsea trunk cable.

Exposure to Stressor

ESA-listed SRKW, humpback whales, and Steller sea lions all swim at depths in which the turbines will be located. Individuals swimming in the near-turbine vicinity could be exposed to any derelict fishing gear or marine debris entangled on the turbine structures.

Likelihood of Exposure

In Admiralty Inlet, SRKW and humpback whales are both migratory and are therefore expected to be transiting through the Admiralty Inlet area and would be exposed to the any snagged derelict gear very infrequently and for a short period of time. Steller sea lions are known to spend longer periods of time in Admiralty Inlet and therefore could be exposed to the stressor more frequently. The likelihood of exposure would also depend on the type of fishing gear that becomes entangled on the turbine. If debris becomes entangled on the turbines, all ESA-listed marine mammals could be exposed if swimming past the turbines. If prey became entangled, SRKW or Steller sea lions could be attracted to the area and subsequently also be at risk of entanglement.

As discussed above in Section 5.3.4 regarding derelict gear and fish, the District believes the likelihood of derelict gear entangling on Project works is unlikely for the following reasons:

- 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 (NWSF 2011), lessening the chance of derelict fishing gear snagging on Project turbines.[32]

[32] 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.

- There would be a very low exposure of ESA-listed marine mammals passing by the turbines (as discussed above given the fact that ESA-listed species can pass through 99.95 percent of cross -section of Admiralty Inlet at the Project location without encountering the proposed turbines and the demonstrated ability of marine mammals to avoid in-water large structures [e.g., the turbines]).

- Navigational restriction areas will be established in the general area around and between 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 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 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 (Section 2.2.3.2).

- The District will consult with the Admiralty Inlet MARC to evaluate the effectiveness of monitoring methods described above and determine whether adjustments to monitoring methods are necessary.

Risk to Individuals and Populations of ESA-Listed Marine Mammals

Injury or mortality could occur to the three ESA-listed marine mammal species discussed in this section and their prey if they become entangled in derelict gear caught on Project turbines. However, because of the ongoing derelict gear removal initiative in Puget Sound, operational characteristics of the turbines that minimize the likelihood of derelict gear snagging on the turbine structures, the mitigation measures outlined above, and the adaptive management framework being implemented for the Project, the risk of derelict fishing gear entangling on the turbines and jeopardizing individual ESA-listed marine mammals or their prey (or populations of the same) is negligible.

5.4.4 Critical Habitat

Of the three ESA-listed marine mammals discussed, critical habitat has been designated only for SRKW. Along with the majority of Washington’s northwestern coastline, critical habitat for SRKW occurs at the Project area and includes “waters relative to a contiguous shoreline delimited by the line at a depth of 6.1 meters (20 feet) relative to extreme high water” (71 FR 69054). The following PCEs for SRKWs critical habitat were identified in the critical habitat ruling (71 FR 69061):

- Water quality to support growth and development;
- Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and
- Passage conditions to allow for migration, resting, and foraging.

The Project will not affect water quality. As discussed above, the Project would not affect SRKW prey species or passage conditions (Sections 5.3.1, 5.3.2, 5.4.1, and 5.4.2). The District concludes that the Project would not affect critical habitat of SRKW.

5.5 Birds

Description of Stressor

Marbled murrelets are an ESA-listed seabird that is likely to occur in the Project area. Resource agencies have expressed concern regarding impacts to marbled murrelets (USFWS letter to the District dated March 10, 2009) and are specifically concerned that murrelets may become entangled in derelict fishing gear associated with the proposed Project (NMFS letter to the District dated December 8, 2008, and USFWS letter to the District dated February 25, 2010). No indirect effects have been identified.

Exposure to Stressor

Due to its sheltered waters, mixed rock and sandy shorelines, and its proximity to old-growth forests, Puget Sound is used heavily by marbled murrelets during the breeding season (Strong 1995, USFWS 1997). Puget Sound is also believed to be a vital wintering area for populations of marbled murrelets moving south from British Columbia to take advantage of the basin’s protected bays and channels (Speich and Wahl 1995; USFWS 1997). Areas of winter concentration include Sequim, Discovery, and Chuckanut Bays; the waters around the San Juan and Whatcom County Islands; and the inland waters east of and including Admiralty Inlet (Seattle Audubon Society 2007, Speich and Wahl 1995). Large numbers of marbled murrelets have been recorded in the Project vicinity during winter months (USFWS letter to the District dated March 10, 2009). The marine mammal pre-installation field studies conducted between October 2009 and April 2010 included objectives to observe the presence of marbled murrelets in the study area. During that study, only five marbled murrelets were sighted on one occasion (December 10, 2009) (Tollit et al. 2010a).

Likelihood of Exposure

Marbled murrelets generally forage in nearshore waters shallower than 30 meters but are capable of diving to depths of up to 47 meters (Letter from USFWS to the District dated February 25, 2010). The top of the OpenHydro turbine structure will be at a depth of 47.5 meters and MLLW. Therefore, approximately the top 2 m of the turbine will be within the maximum dive depth of murrelets during MLLW. Because murrelets generally forage in nearshore waters shallower than 30 meters (Seattle Audubon Society 2007, WSDNR 2006, USFWS 1997), and the turbines would be below the maximum dive depth, the District expects that the exposure of diving murrelets will be *de minimus*. The District believes that if any derelict fishing gear becomes caught on the Project structures it will be below the foraging depth of marbled murrelets. In addition, as mentioned previously, the District will monitor for, and remove, any derelict fishing gear observed snagged on the Project.

Risk to Individuals and Populations of Marbled Murrelets

Derelict fishing gear poses a threat of entanglement to ESA-listed species, including marbled murrelets and their prey. Because marbled murrelets forage in waters shallower than the depths at which the tops of the turbines will be located and consequently, if any derelict fishing gear becomes caught on the Project structures, it will be below the foraging depth of marbled murrelets, and because the District will monitor for, and remove, any derelict fishing gear observed to be snagged on the Project, the risk of derelict fishing gear entangling on the turbines and entangling marbled murrelets is negligible.

As discussed above in Section 4.14.3, no critical habitat for marbled murrelet occurs in the Project area (USFWS 2009).

5.6 Plants

Description of Stressor

Terrestrial Project components will consist of a 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. Ground disturbance associated with Project construction represents a potential disturbance of terrestrial vegetation. No indirect effects have been identified.

Exposure to Stressor

Resource agencies have not expressed specific concerns to potential effects to ESA-listed plants. Golden paintbrush is the only ESA plant that occurs in the vicinity of the terrestrial portion of the Project - five populations of golden paintbrush occur on Whidbey Island.

Likelihood of Exposure

The closest of the five populations of golden paintbrush on Whidbey Island is located in Fort Casey State Park. In 2006 the Fort Casey State Park population consisted of 760 flowering plants (USFWS 2007).

The District will install the terrestrial components of the Project underground. The transmission cables will come ashore on private property within Ebey's Landing National Historic Reserve. The installation of a majority of the terrestrial components of the Project underground will help avoid adverse impacts to the terrestrial nearshore area. 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. Although well water is available at the site, it is likely that drilling water required for HDD will be trucked into the site. Natural terrestrial vegetation will be left intact as much as possible during site preparation activities, and following construction, the HDD laydown area and 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.

The presence of construction-related equipment will represent a minor, temporary, and short-term effect to the land portion of the Project. Because the entire terrestrial portion of the Project is contained within already developed areas on private property the land has limited value as terrestrial habitat, and is unlikely to support golden paintbrush.

Risk to Individuals and Populations of Golden Paintbrush

Golden paintbrush, like any plant, can be disturbed by ground clearance and construction activities. However, all terrestrial transmission components of the Project will be underground: from offshore to the termination vault, the transmission cable will be installed using HDD, from the vault to the control room approximately 9 meters of underground cable will be deployed by trenching, and from the control room to the PSE grid connection point approximately 70 meters of underground cable will also be deployed by trenching. No new roads or overhead transmission components will be required. By carefully siting the Project, including grid connection, close to shore, leaving existing 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 not affect golden paintbrush.

As discussed above in Section 4.15.3, critical habitat has not been designated for golden paintbrush.

5.7 Interrelated and Interdependent Actions

Interrelated actions are actions that are part of a larger action and depend on the larger action for their justification (50 CFR §402.02). Interdependent actions are actions having no independent utility apart from the proposed action (50 CFR §402.02). There are no activities that are interrelated to, or interdependent with, the proposed Project.

5.8 Conclusion

5.8.1 Fish

ESA -Listed Salmonids

The District concludes that the Project is not likely to adversely affect ESA-listed Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, Puget Sound steelhead, and bull trout because the Project effect on these ESA -listed species is discountable and insignificant.

As discussed above in Section 4.2.2 and 5.3.2, results from an extensive CDFO study conducting over 158 tows in Puget Sound and many more in the Strait of Georgia, demonstrate that juvenile Pacific salmon are not expected to use water column depths associated with the Project turbines (personal communication, R. Sweeting, CDFO with G. Ruggerone, NRC, Inc.). Juvenile bull trout do not inhabit Puget Sound (SSPS 2007, Goetz et al. 2003). Feeding on schools of small pelagic fish and invertebrates, salmonids grow rapidly in the marine environment (OSU 2006). Oceanic movement of Pacific salmonids is typically based on following available food resources; their habitat use has been shown to vary based upon seasonal changes to food resources (Hinke et al. 2005b). So, unless the turbines concentrate prey species, the District would not expect that adult salmonids would be attracted to the Project turbines. Adult salmonids could encounter the turbines, however as they move through Admiralty Inlet (e.g., adults of many Puget Sound populations have to pass through Admiralty Inlet to reach their natal streams).

The two turbines will be deployed for five yeas. 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). As discussed in Section 5.3.1, the District expects that the likelihood that ESA-listed salmonids will be injured or killed by turbine strike is discountable or insignificant for the following reasons:

- ESA-listed juvenile salmonids are not expected to use water column depths associated with the Project turbines and adults are not expected to be attracted to the Project turbines.
- ESA-listed salmonids are migratory and adults heading to Puget Sound to spawn in natal rivers would be expected to transit through Admiralty Inlet, with the likelihood of passing through one of the two turbines being very small.
- 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 minimus* footprint.
- 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[33] 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,

[33] As indicated above, there was some mortality of shad in both the treatment and control fish, though the researchers noted that shad are notoriously sensitive to handling and holding, and that the observed mortality level represents a typical problem as warmer temperatures occur in June, when the study was conducted.

  - 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 ESA-listed species are occurring from blade strike, the turbines can be immediately shut down to cease turbine rotation.

The effect of noise associated with Project installation, operation, maintenance, and removal is expected to be discountable or insignificant (see Section 5.3.3). To confirm the District's expectation that noise produced by the Project will not negatively affect ESA-listed fish or marine mammals, 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. In addition, to minimize environmental effects during Project construction, the District will conduct marine installation work during WDFW-approved work windows.

The risk of derelict fishing gear entangling on the turbines and jeopardizing ESA-listed salmonids or their prey is unlikely because of the ongoing derelict gear removal initiative in Puget Sound, operational characteristics of the turbines that minimize the likelihood of derelict gear snagging on the turbine structures, the mitigation measures outlined above (e.g., exclusion area around the turbine, Derelict Gear Monitoring Plan, and the ability to monitor much of the turbine face from the video cameras installed as part of the Near-Turbine Monitoring Plan), and the adaptive management framework being implemented for the Project (see Section 5.3.4). In contrast to the known risks to ESA-listed species of derelict gear that is "ghost fishing" at an unknown site, the Project does not pose a risk to ESA-listed salmonids because the site will be regularly monitored and gear will be promptly removed if detected.

ESA-listed salmonids would not be exposed to EMF over the portion of the cables, which will be deployed by HDD from a minimum depth of 18 meters to the shore. The Project subsea cables will be shielded to eliminate emissions of E fields for the portions of the cable that run along the seabed (2 km from the HDD bore hole exit to the turbines). The Project is small (maximum theoretical capacity of 700 kW) and, as demonstrated by the analysis in Section 5.3.5, any electromagnetic fields emitted by the subsea cables (B or iE fields) will be extremely localized and minor, exceeding the earth's background magnetic field within only 8 centimeters (3.1 inches) of the surface of the cables. The amount of cable lying on the seabed, relative to vast scale of Admiralty Inlet, represents an extremely 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. Because Pacific salmonids feed on schools of small pelagic fish and invertebrates and their movement is typically based on following available food resources, the likelihood of ESA-listed salmonids being affected is discountable or insignificant.

Designated Critical Habitat for Puget Sound Chinook salmon and Hood Canal Summer-run Chum Salmon

The District also concludes that the Project is not likely to affect critical habitat of Puget Sound Chinook salmon and Hood Canal summer-run chum salmon (see Section 5.3.6).

Green Sturgeon

The District concludes that the Project is not likely to adversely affect ESA-listed Green Sturgeon because the Project effect on this ESA -listed species is discountable and insignificant. Green sturgeon are benthic feeders (Dumbauld et al. 2008). The presence of the project turbines is not expected to result in a concentration of benthic prey items for green sturgeon, and therefore it is not expected that green sturgeon would be attracted to the turbines (see Sections 5.3.1 and 5.3.2). In estuaries, 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). However, as discussed in Section 4.6.2, green sturgeon, at sea at least, do swim use habitat at depths at which the project will occur (Erickson and Hightower 2007, NMFS 2005*c*), and green sturgeon could be exposed to the Project during their movements through and around Admiralty Inlet. Puget Sound is closely monitored due to a large commercial and recreational fishing effort; however, very few green sturgeon have been observed there. For example, only two observations of green sturgeon were confirmed in Puget Sound in 2006 (NMFS et al. 2010). Acoustic receivers deployed in the Strait of Juan de Fuca have also had few detections of green sturgeon (NMFS et al. 2010). As discussed in Section 5.3.1, given the small number of green sturgeon expected to be in Admiralty Inlet; the Project size relative to the cross -sectional volume of Admiralty Inlet at the deployment site (0.05 percent), which further decreases the chances that green sturgeon will swim through the turbines; and the additional reasons listed above in the discussion of this topic (in this section) for salmonids, the District concludes that the risk of green sturgeon being injured or killed by blade strike is discountable and insignificant.

The Project’s subsea cables will be laid for 2 km from the HDD bore exit to the turbines. The cables will be shielded to eliminate E field emissions. EMF emitted by the subsea cables (B or iE fields) will be extremely localized and minor, exceeding the earth’s background magnetic field within only 8 centimeters (3.1 inches) of the surface of the cables. The amount of cable lying on the seabed, relative to vast scale of Admiralty Inlet, represents a relatively 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. The likelihood of green sturgeon being negatively affected by magnetic fields associated with the Project is discountable and insignificant.

Noise associated with Project installation, operation, maintenance, and removal is not expected to cause adverse effects to green sturgeon (see Section 5.3.3). The risk of derelict fishing gear entangling on the turbines and jeopardizing green sturgeon is discountable and insignificant for the reasons explained above for salmonids (in this section; also Section 5.3.4).

Rockfish

The District concludes that the Project is not likely to adversely affect ESA-listed Bocaccio Rockfish, Canary Rockfish, and Yelloweye Rockfish because the Project effect on these ESA-listed species is discountable and insignificant. From studies including bottom trawls, quantitative video surveys, and dive surveys conducted by WDFW in Puget Sound and other researchers Bocaccio, canary rockfish, and yelloweye rockfish have been infrequently observed, if at all. However, these three species are attracted to high relief structure; could be expected to occur in Admiralty Inlet, which unlike much of Puget Sound, has rocky habitat; and therefore, may be attracted to the OpenHydro turbines. For the reasons listed at the beginning of this section (salmonids; also see Section 5.3.1), it is expected that rockfish will avoid being struck by the turbines, and as results of the research that has been conducted at the OpenHydro turbine at EMEC, the EPRI (2010) flume entrainment study, and the Hydro Green Energy entrainment study (Normandeau 2009), no injury of mortality of rockfish is expected even if they did swim through the rotor when it was rotating.

Rockfish or structure-oriented forage species may be attracted to the turbine structures, and in turn, their predators may also be attracted to the area. 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 one or a few individuals but no effect to populations. Because of the small size of this pilot-scale Project relative to the surrounding waters, the District does not expect that the Project will affect the marine community composition in, and use of, the area (see Section 5.3.2).

Noise associated with Project installation, operation, maintenance, and removal is not expected to cause adverse effects to rockfish (see Section 5.3.3). The risk of derelict fishing gear entangling on the turbines and jeopardizing rockfish is discountable and insignificant for the reasons explained above for salmonids (see Section 5.3.4).

Eulachon

The District concludes that the Project is not likely to adversely affect ESA-listed Eulachon because the Project effect on this ESA -listed species is discountable and insignificant. Eulachon feed on pelagic plankton (NOAA 2010). A concentration of pelagic plankton would not be expected to be associated with the presence of the two turbines, and therefore, it is not expected that eulachon would be attracted to the turbines (see Sections 5.3.1 and 5.3.2). However, as discussed in Section 4.10.2, eulachon larvae, young, and adults could be exposed to the Project turbines during their movements through and around Admiralty Inlet. In the event that an individual did swim through the rotor, it is expected that they would not be injured for the reasons discussed above in this section (also see Section 5.3.1). Noise associated with Project installation, operation, maintenance, and removal is not expected to cause adverse effects to eulachon (see Section 5.3.3). The risk of derelict fishing gear entangling on the turbines and jeopardizing eulachon is discountable and insignificant for the reasons explained above for salmonids (also see Section 5.3.4).

5.8.2 Marine Mammals

Southern Resident Killer Whale

The District concludes that the Project is likely to adversely affect ESA-listed Southern Resident Killer Whale because the noise produced during operation of the turbine will exceed NOAA's 120 dB Level B harassment threshold for marine mammals for some periods during the year, expected to be limited to occurrences of high water velocity.

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 Turbine 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.[34] 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.

Careful monitoring of the turbines through the Near-Turbine Monitoring Plan, and implementation of the Marine Mammal Monitoring Plan will provide for confirmation of the District's conclusions that SRKW will either avoid the turbines or in any case not be attracted to them. These monitoring plans will serve as important safeguards to ensure that unanticipated effects do not occur (see Section 5.4.1). Further, the Near-Turbine Monitoring Plan will be able to detect prey aggregations in close proximity to the turbine rotor that might serve to attract SRKW to the turbine.

[34] *See Assessment of Strike of Adult Killer Whales by an OpenHydro Tidal Turbine Blade*, Pacific Northwest National Laboratory/Sandia National Laboratories, at 27-28 (Feb. 28, 2012) (prepared for the U.S. Department of Energy).

Because noise associated with Project installation, maintenance, or removal would be short term and temporary (installation or removal of a turbine will take less than one tidal cycle), especially in comparison to the very heavy shipping noise that is so prevalent in Admiralty Inlet, it is not expected to cause adverse effects to SRKW. Based on the analysis presented in Polagye et al. (in prep), operational noise will therefore be well below levels of NOAA Level A harassment and only exceed Level B harassment at ranges greater than 100 m 25% of the time. As shown in Figure 5-19, SRKW are only likely to detect turbine noise (i.e., detection probability exceeding 50%) within a few hundred meters of the turbines when considered over all operating states and ambient noise levels. 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 to confirm the noise produced by the Project (see Section 5.4.2) and post-installation monitoring of SRKW transits through Admiralty Inlet to identify avoidance, attraction, or change in behavioral state as a consequence of exposure to project noise.

The risk of derelict fishing gear entangling on the turbines and jeopardizing SRKW is discountable and insignificant for the reasons explained above for salmonids (also, see Section 5.4.3).

Designated Critical Habitat for SRKW

The District concludes that the Project is not likely to affect critical habitat of SRKW (see Section 5.4.4).

Humpback Whale

The District concludes that the Project is not likely to affect ESA-listed Humpback whale. Humpback whales are uncommon in northwest coastal waters, occurring one to two times per year in Admiralty Inlet (Osborne et al. 1988). Considering the low exposure of humpback whales to the Project, and given the demonstrated ability of humpback whales to avoid swimming into large structures (e.g., large rock outcroppings jutting from the seabed), and the fact that a passing whale can use 99.95 percent of cross -section of Admiralty Inlet at the Project location without encountering the proposed turbines (see Figure 5-7 in Section 5.3.1), the Project is not likely to affect the ESA -listed humpback whale.

The risk of derelict fishing gear entangling on the turbines and jeopardizing humpback whales is unlikely for the reasons explained above for salmonids (also, see Section 5.4.3).

Steller Sea Lion

The District concludes that the Project is likely to adversely affect the ESA-listed Steller Sea Lion because the noise produced during operation of the turbine will, at times, exceed NOAA’s Level B harassment threshold for marine mammals, which is 120 dB. While Steller sea lions have historically been considered uncommon and seasonal in Puget Sound, typically observed in fall, winter and spring, Steller sea lions were frequently observed in the Project vicinity during the Project’s marine mammal monitoring conducted from October 2009 to April 2010 (observed on 66 percent of the survey days during which observers were in the field) (Tollit et al. 2010a). The nearest haulout is Marrowstone Island, which is located approximately 8.4 kilometers south of the deployment area (Figure 4-16).

Steller sea lions are highly sensitive of their surrounding environment. In addition to the turbine design characteristics which will help marine mammals avoid being struck by the turbine blades, there is little evidence that Steller sea lions collide with large stationary objects in the ocean. For example, 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). Species, such as Steller sea lions, 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. For these reasons and many of those already listed above (see Section 5.4.1), the risk of Steller sea lions being injured or killed by colliding with a rotating turbine is discountable and insignificant.

Based on the analysis presented in Polagye et al. (in prep), operational noise will be below levels for Level A harassment and only exceed Level B harassment at ranges greater than 100 m 25% of the time. As shown in Figure 5-21, Steller sea lions are only likely to detect turbine noise (i.e., detection probability exceeding 50%) within a few hundred meters of the turbines when considered over all operating states and ambient noise levels.

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 to confirm the noise produced by the Project (see Section 5.4.2).

The risk of derelict fishing gear entangling on the turbines and jeopardizing Steller sea lions is discountable and insignificant for the reasons explained above for salmonids (also, see Section 5.4.3).

5.8.3 Birds

The District concludes that the Project is not likely to adversely affect ESA-listed Marbled Murrelets because the Project effect on this ESA -listed species is discountable and insignificant. Marbled murrelets forage in waters shallower than the depths at which the tops of the turbines will be located and consequently, if any derelict fishing gear becomes caught on the Project structures, it will be below the foraging depth of marbled murrelets. For this reason and those presented above for salmonids (also, see Section 5.5), the risk of derelict fishing gear entangling on the turbines and entangling marbled murrelets is discountable and insignificant.

As discussed above in Section 4.14.3, no critical habitat for marbled murrelet occurs in the Project area (USFWS 2009).

5.8.4 Plants

By carefully siting the Project, including grid connection, close to shore, leaving existing 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 not affect golden paintbrush (see Section 5.6).

5.8.5 Findings

The District concludes that the Project is Not Likely to Adversely Affect the ESA-listed fish species discussed in this document, humpback whale, marbled murrelet, and golden paintbrush. Noise from the Project will exceed received SPL 120 dB (re 1 μPa), the level that is considered Level B harassment by NOAA for non-impulsive sounds. Because noise at this level has the potential for behavioral disturbance to SRKW and Steller sea lions, which unlike humpback whales, occur regularly in Puget Sound, the District concludes that the Project is Likely to Adversely Affect SRKW and Steller sea lions. Because the potential adverse effects to SRKW and Steller sea lions is expected to be limited to the Level B noise harassment, and the Project action is not likely to result in any other adverse impact to these listed species, the proposed action is not expected to, directly, or indirectly, reduce appreciably the likelihood of survival and recovery of these species in the wild by reducing the reproduction, numbers, or distribution of these species.

Section 6
Cumulative Effects

Cumulative effects are those effects of future state and private activities, not involving federal activities that are reasonably certain to occur within the action area (50 CFR § 402.02). Cumulative effects do not include future federal or federally authorized action, which would be subject to future ESA section 7(a)(2) consultations.

Though commercial fishing has declined significantly in the last 20 years (personal communication, G. Ruggerone, NRC, Inc. with L. Hoines, WDFW), commercial fishing and crabbing will continue in Admiralty Inlet, as will recreational fishing. Maritime travel on Puget Sound is heavy and will continue, with all maritime traffic bound for, or departing from, the ports of Seattle, Everett, Tacoma, and Olympia transiting through Admiralty Inlet via a major shipping lane in the middle of the inlet. The Port Townsend-Coupeville ferry will continue to run about 1.5 kilometers from the turbine deployment site, with about 10 round trips occurring across Admiralty Inlet during summer. Use of the area by small commercial and recreational craft will also continue. The two subsea telecom cables (named PC-1 and PC-2) that cross west of the Admiralty Inlet Project area running from northwest to southeast, will remain in Admiralty Inlet.

When considered cumulatively, the cumulative effects described above are likely to have a small negative effect on federally listed species and designated critical habitat. However, there are no known specific future non-federal activities within the action are that would cause significantly greater impacts on a listed species or designated critical habitat than presently occur.

Section 7
Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), established procedures designed to identify, conserve, and enhance Essential Fish Habitat (EFH) for those species regulated under a federal fisheries management plan. The MSA requires federal agencies to consult with NMFS on all actions, or proposed actions, authorized, funded, or undertaken by the agency, that may adversely affect EFH (MSA '305(b)(2)). EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity” (16 U.S.C. 1802(10)).

The objective of this EFH assessment is to determine whether the proposed Project “may adversely affect” designated EFH for relevant commercial, federally managed fisheries species within the proposed Project area. It also describes conservation measures proposed to avoid, minimize, or otherwise offset potential adverse effects to designated EFH resulting from the proposed action.

7.1 Project Description

A description of the Admiralty Inlet Pilot Tidal Project is located in Section 2, Proposed Action and Action Area. The section includes information on the OpenHydro turbines, underwater transmission cable, and terrestrial components of the Project.

7.2 Identified Essential Fish Habitat and Habitat Areas of Particular Concern

EFH is determined by identifying spatial habitat and habitat characteristics that are required for each federally managed fish species through a cooperative effort by NMFS, regional fishery management councils, and federal and state agencies. These descriptions provide the basis for assessing development and activities in marine areas. The Project area is EFH for Pacific groundfish, Pacific salmon, and coastal pelagic species (NMFS letter to the District dated February 26, 2010), 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.

There are 89 groundfish, 3 salmon and 5 coastal pelagic species specifically identified in the FMPs on the Pacific coast, though not all these species are found in the Project area.

EFH Habitat Areas of Particular Concern (HAPCs) are discrete subsets of EFH. HAPCs, as provided in the EFH regulations, are types or areas of habitat within EFH that are identified based on one or more of the following considerations: the importance of the ecological function provided by the habitat; the extent to which the habitat is sensitive to human-induced environmental degradation; whether, and to what extent, development activities are or will be stressing the habitat type; or the rarity of the habitat type. An HAPC designation does not confer additional protection or restriction upon an area, but helps prioritize conservation efforts, and should be considered in an analysis of an area's sensitivity.

HAPCs include both geographic areas and habitat types. In some cases, HAPCs identified by means of specific habitat type may overlap with the designation of a specific area. HAPCs based on habitat type may vary in location and extent over time and include estuaries, canopy kelp, seagrass, rocky reefs, and areas of interest. Areas of interest are discrete areas that are of special interest due to their unique geological and ecological characteristics.

The Project area is within HAPC for federally managed Pacific groundfish (NMFS letter to the District dated February 26, 2010). The following is an overview of EFH for the three EFH groupings.

7.2.1 Pacific Groundfish

The Pacific Coast Groundfish FMP provides for management of more than 80 species that typically live on or near the bottom of the ocean (PFMC 2008). Information on the life histories and habitats of these species varies in completeness, so while some species are well-studied, there is relatively little information on certain other species. Therefore, the FMP does not include descriptions identifying EFH for each life stage of the managed species, but rather includes a description of the overall area identified as groundfish EFH. PFMC (2008) defines EFH for Pacific groundfish as:

- Depths less than or equal to 3,500 meters to MHHW or the upriver extent of saltwater intrusion, defined as upstream and landward to where ocean-derived salts measure less than 0.5 parts per trillion (ppt) during the period of average annual low flow;
- Seamounts in depths greater than 3,500 meters as mapped in the EFH assessment GIS; and
- Areas designated as HAPCs not identified by the above criteria.

This EFH identification is a precautionary approach because uncertainty still exists about the relative value of different habitats to individual groundfish species/life stages, and thus the actual extent of groundfish EFH (PFMC 2008).

As mentioned above, the Project area is within HAPC for Pacific groundfish. Specifically, estuaries, kelp beds, seagrasses, rocky reefs, and areas of interest are the HAPCs designated under the MSA within the Project boundary; these are defined below (letter from NMFS to the District, dated July 6, 2009).

Estuaries - The inland extent of the estuary HAPC is defined as MHHW line, or the upriver extent of saltwater intrusion, defined as upstream and landward to where ocean-derived salts measure less than 0.5 ppt during the period of average annual low flow. The seaward extent is an imaginary line closing the mouth of a river, bay, or sound; and to the seaward limit of wetland emergents, shrubs, or trees occurring beyond the lines closing rivers, bays, or sounds. This HAPC also includes those estuary-influenced offshore areas of continuously diluted seawater (Cowardin et al. 1979).

Canopy Kelp - The canopy kelp HAPC includes waters, substrate, and other biogenic habitat associated with canopy-forming kelp species (e.g., *Macrocystis* spp. and *Nereocystis* spp.).

Seagrass - The seagrass HAPC includes those waters, substrate, and other biogenic features associated with eelgrass species (*Zostera* spp.), widgeongrass (*Ruppia maritima*), or surfgrass (*Phyllospadix* spp.).

Rocky Reefs - The rocky reefs HAPC includes those waters, substrates and other biogenic features associated with hard substrate (bedrock, boulders, cobble, gravel, etc.) to MHHW. ROV sampling of the turbine installation site show extensive rocky reef habitat.

Areas of Interest - All waters and sea bottom in Washington state waters from the three nautical mile boundary of the territorial sea shoreward to MHHW.

Of these five HAPCs, the placement and operation of the Project would only affect Rocky Reefs and Areas of Interest.

7.2.2 Pacific Coast Salmon

The Pacific Coast Salmon FMP guides management of commercial and recreational salmon fisheries off the coasts of Washington, Oregon, and California. The Pacific salmon fishery includes Puget Sound Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), and Puget Sound pink salmon (*O. gorbuscha*).

The PFMC has designated both freshwater and marine EFH for these salmon species. Since the proposed Project occurs only in marine waters, the identification and analysis of EFH focuses on designated marine EFH. Pacific salmon distribution in marine areas is generally defined because it is extensive, varies seasonally and inter-annually, and has not been sampled in many marine areas (PFMC 2000). Since salmonid distribution in the EEZ is generally defined and the demarcation of a specific or uniform westward boundary within the EEZ that would cover the distribution of essential marine habitat is difficult and would contain considerable uncertainty, the PFMC has taken a conservative approach to designate the extent of marine EFH for Pacific salmon (PFMC 2000).

In marine areas, designated EFH for Pacific salmon extends from nearshore and tidal submerged environments within state territorial waters out to the full extent of the EEZ (370.4 km) offshore of Washington, Oregon, and California north of Point Conception (PFMC 2000). Pacific salmon EFH also includes marine areas off Alaska designated as EFH by the North Pacific Fishery Management Council. Puget Sound is designated EFH for Chinook, coho, and pink salmon.

Marine EFH supports three life stages of Pacific salmon including (1) estuarine rearing, (2) ocean rearing, and (3) juvenile and adult migration. Features of estuarine and marine habitats that are essential to these life stages include the following: (1) adequate water quality, (2) adequate temperature, (3) adequate prey species and forage base (food), and (4) adequate depth, cover, marine vegetation, and algae in estuarine and near-shore habitats (PFMC 2000).

7.2.3 Coastal Pelagic Species

Coastal pelagic species are schooling fish that are associated with the open ocean and coastal areas and migrate in coastal waters. The Coastal Pelagics Species Fishery Management Plan consists of five species of which the following three had EFH identified in the Project area by NMFS (letter to the District dated July 6, 2009): Pacific sardine, northern anchovy, and Pacific mackerel (PFMC 1998).

PFMC (1998) defines the east-west boundary of EFH for coastal pelagics as all marine waters out to the EEZ with water temperatures between 10^{o}C to 26^{o}C. The southern boundary is the United States-Mexico maritime boundary. The northern boundary is defined as the position of the 10^{o}C isotherm, which varies seasonally and annually. Admiralty Inlet includes the five coastal pelagic species and is considered EFH when temperatures are between 10^{o}C and 26^{o}C (PFMC 1998).

7.3 Potential Effects of the Action on EFH

Stakeholders have expressed concerns over the potential impacts to EFH from the proposed pilot Project and have identified the need to assess the effects of operation of the Project. Potential effects to EFH include changes to habitat in the immediate Project area resulting from the introduction of Project components and creation of new habitat features. Placement of 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). Project infrastructure may be colonized by benthic marine life including biofouling organisms, which may attract foraging groundfish. This change of local habitat may, therefore, result in increased colonization, or new colonization, by marine life that otherwise would not occur in a particular area, which may also attract predator species. As described in Section 5, 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), habitat change attributable to the Project would be on a small spatial scale and the effect to seabed habitat will be insignificant. The District anticipates that the Project will not adversely affect Project area fish or the local marine community. The Project subsea cables will be shielded to eliminate emissions of E fields. The Project is small and any electromagnetic fields emitted by the subsea cables (B or iE fields) will be extremely localized and minor, exceeding the earth’s background magnetic field within only 8 centimeters of the surface of the cables, and similar to the numerous subsea cables that have been deployed in marine waters in the U.S. and throughout the world. As discussed in Section 5, the effects of EMF to fish species, including EFH species, will be insignificant.

A potential effect to EFH that was not identified for ESA-listed species is the potential direct effects to the seabed (groundfish EFH) that may result from placement of Project components on the seafloor. Although the installation of the subsea transmission cable represents an alteration of the seafloor, it is not expected to result in significant direct effects to the groundfish EFH or the benthic communities. The 10 cm diameter cables will be laid on the seabed from the turbines to the HDD exit, spanning a distance of approximately 2 km. At the HDD exit, located at a minimum depth of 18 meters, the cables will continue through the HDD bore hole beneath the seabed until they reach shore. The HDD cable installation techniques will avoid adverse impacts to sensitive shoreline areas and near-shore habitat. No dredging or open trenching will be performed underwater during cable installation activities, thereby eliminating the potential for associated sediment suspension and transport.

Installation of underwater Project infrastructure may result in the cover, disturbance, injury, or death of immobile or slow moving benthic organisms in the path of the transmission cables or directly beneath the turbine base foundation. However, the footprint of the turbines and the cables represents a relatively small area of disturbance and the duration of Project infrastructure installation is anticipated to be very short, with each turbine being deployed in less than a tidal cycle and the cables being deployed in less than a month. Minor disturbance is expected to occur to benthic communities, and it is expected that benthic organisms will quickly recolonize the affected area. Bottom-dwelling fish and other mobile organisms, such as rockfish, would likely avoid the Project area during construction activities.

The marine EFH component for Pacific salmon species and coastal pelagic fish species includes an extensive area of the open ocean. The proposed Project area represents 0.05 percent of the cross -section of the Admiralty Inlet. The small Project area does not provide notable or critical habitat for the represented species, and the presence of the Project will not prohibit movement of EFH species through the Project area or affect their prey species.

It is anticipated that any effects of the Project on EFH will be minor and temporary. In the event that unexpected adverse effects are detected, the various monitoring and safeguard plans, which will be implemented within an adaptive management framework, will allow for mitigation of identified effects.

7.4 Essential Fish Habitat Conservation Measures

The Project is not expected to result in any significant effects to EFH, and therefore, no habitat conservation measures are proposed. However, the District proposes to implement the following environmental measures which will benefit EFH:

- Use HDD to deploy transmission cable from a minimum depth of 18 meters to shore to avoid adverse impacts to nearshore and shoreline habitats;
- Lay the transmission cables on the seabed to avoid the need for dredging or open trenching, thereby eliminating potential sediment suspension or transport;
- Conduct installation work only during WDFW-approved work windows;
- Conduct near-turbine monitoring and identification of aquatic species (part of Monitoring Plan);

- Monitor for derelict gear and remove as necessary (part of the Derelict Gear Monitoring Plan);
- Conduct benthic habitat monitoring (part of the Benthic Habitat Monitoring Plan);
- Conduct environmental monitoring during Project construction and removal (part of the Water Quality Monitoring Plan);
- Finalize an Emergency Shutdown Plan (part of Project Safeguard Plans); and
- Implement adaptive management to modify Project and Project operations, as necessary, based on monitoring results and consultation with the MARC.

7.5 Effects Determination

The proposed Project will cause some disturbances to benthic habitat caused by the placement of the turbines and cables on the seabed. The total seabed interface area (contact footprint) for each turbine will be approximately 10 square meters in an area comprised primarily of gravel, cobble, and boulders. The turbine base foundation and the cables laid on the seafloor may result in the cover, disturbance, injury, or death of immobile or slow-moving benthic organisms. However, mobile organisms, such as most fish, are anticipated to easily relocate to avoid Project installation activities. Because Project installation activities are anticipated to be relatively benign and short in duration, benthic communities and mobile organisms and fish are anticipated to quickly recolonize the area upon completion of Project installation. The affected Project area is small, representing 0.05 percent of the cross -section of the area, and the proposed Project is not anticipated to prohibit movement of EFH species through the action area or affect their prey species. Aside from minor bottom disturbance, the installation and operation of the Project is not expected to adversely affect EFH.

Section 8
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