In Reply Refer to:
13410-2007-F-0345

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street Northeast
Washington, D.C. 20426

Dear Ms. Bose:

This document transmits the United States Fish and Wildlife Service's (Service) biological opinion (Opinion) based on our review of the proposed Makah Bay Offshore Wave Energy Pilot Project, Project Number 12751-000, located in Clallam County, Washington, and its effects on brown pelicans (Pelecanus occidentalis) and marbled murrelets (Brachyramphus marmoratus) in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) (Act). Your May 25, 2007, request for formal consultation was received on May 29, 2007. Subsequently, your August 20, 2007, amended request for informal consultation was received on August 21, 2007.

This Opinion is based on information provided in the May 25, 2007, "Environmental Assessment for Hydropower License, Makah Bay Offshore Wave Energy Pilot Project, Project Number 12751-000," which also serves as the Biological Assessment for formal consultation; and your August 20, 2007, letter "Response to Information Request for Consultation under the Endangered Species Act and Marine Mammal Protection Act." A complete administrative record of this consultation is on file at this office.

If you have any questions about this Biological Opinion or your responsibilities under the Act, please contact Sally Butts at (360) 753-5832 or Jim Michaels at (360) 753-7767, of my staff.

Sincerely,

Ken S. Berg, Manager
Western Washington Fish and Wildlife Office
Biological Opinion
for the
Makah Bay Wave Energy Project

USFWS Reference: 13410-2007-F-0345

U.S. Department of the Interior
Fish and Wildlife Service
Western Washington Fish and Wildlife Office
Lacey, Washington

February 2008

Ken S. Berg, Manager
Western Washington Fish and Wildlife Office

Date 2/15/08
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CONSULTATION HISTORY

On May 29, 2007, the U.S. Fish and Wildlife Service (Service) received a request from the Federal Energy Regulatory Commission (Commission) to initiate formal consultation on the Makah Bay Offshore Wave Energy Pilot Project for bull trout (Salvelinus confluentus) and the marbled murrelet. Also, included in this communication from the Commission was a request for concurrence that the project would not adversely affect the bald eagle (Haliaeetus leucocephalus) and brown pelican (Pelecanus occidentalis). The Service responded to the Commission with a request for additional information in a letter dated June 29, 2007. The Service received a letter, dated August 20, 2007, from the Commission responding to our request for additional information. In that letter, the Commission revised their determination for bull trout to "no effect" based on the Service's June 29, 2007, input that the species does not occur in the project area. Also, the Commission withdrew their request for concurrence for the bald eagle due to the delisting of the species, as of August 8, 2007. Further, the Commission revised their determination for marbled murrelets to "not likely to adversely affect" and amended their request for formal consultation to informal consultation. The Service responded with a letter, dated September 12, 2007, indicating that we do not concur with the Commission's "not likely to adversely affect" determination for marbled murrelets and initiated formal consultation on August 21, 2007, with a complete consultation package. On January 9, 2008, the Service sent a letter to the Commission requesting a 30-day extension to complete consultation.

CONCURRENCE

The Service concurs with the Commission's determination that the proposed Makah Bay Wave Energy "may affect, but would not likely to adversely affect" brown pelicans. Although the distribution of brown pelicans overlaps the project area, adverse effects are unlikely to occur because brown pelicans are infrequently observed as far north as the Makah Bay area. Also, brown pelicans are more likely to forage closer to the shoreline than offshore where the wave energy conversion buoys (buoys) will be located. Because of this, brown pelicans would not be expected to be significantly affected by the ongoing operation of the buoys for the 5-year license term and would only be expected to be temporarily affected while foraging near shore during project construction and decommissioning. Brown pelicans would be expected to avoid active construction areas and move to alternate foraging sites during their migration through the action area. Pelicans search for forage by capturing fish by surface plunging. They sight their prey from the air, soaring and gliding above the water surface, and then dive head-first into the water to capture prey fish. It is expected that pelicans would avoid active construction areas as they search from the air for prey fish. Therefore, the effects to brown pelicans from the Makah Bay Wave Energy Project are expected to be insignificant and discountable.
BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

On November 8, 2006, AquaEnergy Group, Ltd. filed an application for a minor license to construct and operate the Makah Bay Offshore Wave Energy Pilot Project (Makah Bay Wave Energy Project or project). The 1.0-megawatt (MW) ocean wave energy conversion project would consist of four buoys, a submarine transmission line, and a shore station. The project would be located in Makah Bay of the Pacific Ocean in Clallam County, Washington. The project would occupy about one acre of land on the Makah Indian Reservation and about seven acres of lands, collectively, within the Olympic Coast National Marine Sanctuary (Sanctuary) administered by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration; Flattery Rocks National Wildlife Refuge administered by the U.S. Department of the Interior, U.S. Fish and Wildlife Service; and state-owned aquatic lands administered by the Washington Department of Natural Resources. The project would generate an average of about 1,510 megawatt-hours of energy annually. On May 2, 2007, Finavera Renewables Ocean Energy, Ltd. (Finavera) filed a letter informing the Commission that they officially changed their name from AquaEnergy to Finavera. From this point forward in this Biological Opinion, the applicant will be referred to as Finavera.

Project Facilities

The project would consist of: (1) four, 250-kilowatt (kW), steel wave energy conversion buoys and an associated mooring/anchoring and electrical connection system placed 3.7 miles offshore from Hobuck Beach in water depths of about 150 ft (Figure 1); (2) a metal shore station that would be about 15 ft long by 15 ft wide by 10 ft high and located just inland of Hobuck Beach (on the Makah Indian Reservation) adjacent to an existing power line for interconnection; the shore station would contain equipment necessary to connect to the electrical grid; (3) a driveway and parking area at the metal shore station; and (4) a 3.7-mile long, direct current submarine transmission line connecting the power cable from one of the four buoys known as the "collection buoy" to the metal shore station. Each buoy would have a float diameter of 19.5 ft and float height of 16.4 ft (approximately 6.6 ft would be visible above water) and would contain the following components:

- two single-acting hose pumps, 35 ft in length with an inner diameter 16 to 18 in, mounted vertically inside of an acceleration tube attached to the bottom of the buoy float. The acceleration tube would have a length of 98 ft and a diameter of 15 ft. The hose pumps would be configured in a closed-loop hydraulic system filled with 1,850 gallons of fresh water (there would be no interaction between the closed-loop freshwater system and the outside seawater). The maximum output from both hose pumps would be 34 gallons per second (125 liters) at 215 pounds per square inch;

- one Pelton turbine with a maximum water capacity of 34 gallons per second at 215 pounds per square inch and housed within the float portion of the buoy. The turbine rotation speed (revolutions per minute) would vary based on incoming water pressure. Pressure nozzles
regulating the turbine would be automatic or remotely controlled via an electro-hydraulic system:

- one 200- to 400-liter water accumulator connected to the hydraulic system on the pressure side; its role would be to even out the pressure and flow rate of the water feeding into the Pelton turbine;

- one 480-volt, alternating current variable speed synchronous generator, with a maximum output of 250 kW and an estimated average output of about 46 kW (assuming an average wave resource of 8.5 kW per foot [28 kW per meter] wave front).

- controls, sensors, radio frequency data link, and sealed-foamed chambers to insure positive buoyancy. Sensing instruments would monitor: wave height and period; buoy heave; piston position in the acceleration tube; piston force; mooring forces; water flow (nozzle); water pressure in different parts of the hydraulic loop; turbine revolutions per minute; generator output, volts, and amperes; accumulator pressure; and inside buoy temperature. All sensing equipment would be radio frequency-capable to allow for wireless internet connection. All instruments would be equipped with a battery backup system in the event of primary power failure; and

- navigational instruments, including a navigational light with battery backup and radar reflector, and a global positioning system transmitter in case of break away.
Figure 1. Configuration of Finavera’s proposed AquaBuOY mooring and anchoring system. In place of the concrete anchors shown in the figure, Finavera proposes to use vertical load anchors (VLAs). (Finavera 2006).

The buoy closest to the shore, referred to as the collection buoy or hub, would collect electricity generated from the other three buoys. In addition to the equipment previously described for each buoy, the collection buoy would hold: (1) a 1-MW, 480 volt/12 kilovolt (kV) transformer; and (2) a 1-MW, 12-kV rectifier. From the hub, a tethered riser umbilical power cable, dimensioned to handle the maximum combined electric output of 1 MW at 12 kV, would deliver the energy to the direct current submarine transmission line. The transmission line would lead from the tethered riser to the shore connection. Each buoy hull would be tethered by a tension cable to four surface floats, each approximately 4 ft in diameter. The ocean surface occupied by the total of four buoys and 10 surface floats would be about 60 ft by 240 ft. The surface floats would be connected to sub-surface mooring buoys, located just above the seafloor, by a cable fastened to a chain. The mooring system for each buoy would terminate with a chain running from the sub-surface buoy to a connection to the sea-bed placed approximately in a square pattern on the ocean floor with the buoy approximately centered on the surface above. Heave forces acting on the surface floats and mooring buoys would be dampened by lifting the chain slack between the two, which would provide ample mooring in storm conditions. The sub-surface floats would also serve to prevent chain scouring of the seafloor.

Finavera would use vertical load anchors (VLAs) with a near vertical leg connection to the sub-surface mooring buoy that in turn would be connected to the buoy array. VLAs are a recent development in the off-shore industry, developed to withstand the major loads associated with
floating offshore production systems. VLAs are embedded into the substrate of the ocean floor compared with traditional concrete anchors that rest on the surface of the ocean floor and cover a significantly greater surface area than VLAs. The mooring system would cover a rectangular area approximately 625 by 450 ft on the ocean floor.

The transmission line is anticipated to be approximately 8 inches in diameter and would be anchored to the ocean floor until it approaches the shoreline. From 10 to 30 ft in depth below mean low tide to shore (a distance of about 1,200 ft from shore), the transmission line would be buried using horizontal directional drilling (HDD), a technique frequently used for other cable projects. HDD is often preferred to open trenching, especially in intertidal areas, because it does not expose the surface of the seabed and intertidal zone to wave action, and thus, minimizes erosion and suspension of sediment. The portion of the transmission line not buried by HDD would be anchored to the seafloor using screw-type, or other appropriate anchors and the portions of line could be alternately buried or exposed at various times depending on shifting sand on the seafloor, especially in areas of 56 feet or less depth.

The shore station would house the electrical conditioning equipment necessary to connect to the utility grid. This equipment would include a 1-MW, 0.4-kV rectifier; a 1-MW, 0.4-kV inverter; 0.4 kV/12 kV transformer; 12-kV, 50-ampere switchgear with a connection to the transmission cable; and 12-kV, 50-ampere switchgear with a connection to the primary distribution line. From this station, the power would be directly connected to the nearby existing Clallam County Public Utility District 12-kV distribution line. The electrical interconnection would be located in close proximity to Makah Passage Road.

All of the generating components of the project (including buoy hulls, anchors and mooring auxiliaries, energy converters, and turbine-generator housing) would be fabricated in off-site shipyards and machine shops. Members of the local community would participate in the installation, monitoring and testing. While in machine shops, the buoys would be fitted with internal systems, such as hose pumps, and hydraulic and electronic controls.

Project Operation

The acceleration tube of the buoy houses an internal piston (a neutrally buoyant disk) at the vertical midpoint of the acceleration tube. Two steel, reinforced rubber hoses filled with freshwater connect the top and bottom of the piston to the top and bottom of the acceleration tube. As the buoy rises in response to a wave, the top rubber hose stretches, causing the volume of the hose to decrease and the water inside to come under pressure. The pressurized water is directed by a high-pressure water accumulator to the nozzles of the Pelton turbine and associated generator. When the buoy falls in response to the passing wave, the bottom hose elongates, which again results in a pressurized flow of water being directed to the nozzles of the Pelton turbine and associated generator.

Electricity generated by the buoys would be collected at the collection buoy, converted to direct current, and transmitted to the shore station via the 3.7-mile long submarine transmission cable. The buoys would operate passively. Finavera would visit the buoys about two to five times per
year by boat out of Neah Bay for maintenance. At all other times, the buoys would be monitored using online buoy telemetry equipment. The land-based station would be visited about six times per year by vehicle.

**Project Construction and Installation**

The buoys would consist of fabricated modular components. Construction activities involving hazardous processes or materials (e.g., metal cutting, oil, or paint) would be accomplished in existing shore-based shops and shipyards. Most of the system interconnections would be preassembled. Boats designed to deploy anchoring systems would be used to place the VLAs in the seabed. The VLA is a special design of a drag embedment anchor that can be triggered so that the angle of the load line through the centroid of its fluke (the centroid angle) increases from about 65 degrees to a final angle of 90 degrees “vertical” to its fluke. When its final centroid angle is reached, the VLA is at its ultimate holding capacity for a given depth of embedment. In addition to its minimal ocean floor impact, VLAs are designed to be retrieved by use of an unlocking device, a chain shank, and a streamlined fluke.

Boats or barges would be used to transport assembled buoys, anchors, hoses, and transmission cables and other hardware to the site approximately 3.7 miles offshore where water depth is about 150 ft. The buoy launch would be accomplished either by towing the buoys or transporting them to the site aboard crane-equipped buoy tender vessels. Installing the sea-to-shore transmission line is a specialty job that would be subcontracted to a marine construction firm. The line would be anchored to the ocean floor to prevent movement along the sea floor. The actual anchoring method would be determined with input and agreement from the transmission cable installation company, the Sanctuary, and the Washington Department of Natural Resources (WDNR) prior to installation. From depths of 10 to 30 ft below mean low tide to the shoreline, the transmission cable would be bored horizontally under the beach using HDD methodology. The transmission cable would continue through the surf zone and underground to the grid interconnection behind Hobuck Beach.

The HDD contractor would use specialized equipment to drill in a pipe conduit along the route of the transmission cable below the seabed. Boring would be done with a track-based horizontal boring rig that would incrementally add sections of pipe as the shaft or “drill string” would progress into the ground. When the shaft would come out at its destination, the bit would be removed from the end and the transmission cable would be attached at that end. The shaft would then be pulled back the way it came towards the drilling rig, thereby allowing the cable or conduit to be pulled back with it. Typically with HDD, water, mud, or gel is pumped into the drilling shaft while drilling. In the case of putting in an electrical or fiber cable through a beach, pressurized water can greatly speed the drilling process. With some rigs water is immediately recovered, filtered, and put back into a reservoir tank. The precise process that would be used for this project would be determined once a contractor specializing in HDD is selected.
Most of the shore station equipment would be housed in a fabricated metal building (approximately 10 ft high with a floor plan measuring 15 ft by 15 ft) that would be erected with small equipment. The construction of the shore station would occur at the same time as the placement of the in-water components.

Construction of the shore facilities would require some earthwork (foundation preparation); however, this work would not occur within 200 ft of the water line and no fill would be required. The shore station would be landscaped to blend with the local flora. The only impervious surface would be about 200 ft² for the shore station.

The buoys would be deployed in phases. First, a single buoy would be launched and tested for survivability. Subsequently, the three additional power buoys and the transmission cable would be deployed over a period of approximately two months. Once all subsystems would be in place and interconnected, system integration and testing would commence and continue until the power plant would be declared operational.

Conservation Measures

Finavera will implement the following measures, including additional measures required by the Commission, during project construction and operation for the protection of environmental resources. For each of the plans described below, Finavera will prepare the plans in consultation with the appropriate Federal and State agencies and the Makah Tribe. The conservation measures are as follows:

- develop and implement a detailed project design and installation plan, including provisions for: (1) determining the final design and installation methods for the buoy and submarine transmission line anchoring systems; (2) using HDD to deploy the transmission cable from the shore station out to a depth of 10 to 30 ft below mean low tide; and (3) designing the buoys to be a closed-system and to include a heavy-duty plastic conical attachment to be placed over the above-water portion of the buoys to prevent seal and sea lion haul-out and seabird roosting;

- conduct an eelgrass survey for purposes of determining the depth to which to deploy the submarine transmission line using HDD in order to avoid disturbing macro-algae/eelgrass beds;

- develop and implement a project facilities inspection and maintenance plan that includes provisions for: (1) at least bi-annual visits to the buoys for purposes of retrieving entangled derelict fishing gear from the buoys mooring and anchoring system and (2) notifying the Sanctuary within 24 hours of becoming aware of the need for any emergency response or repair to project facilities, providing 24-hour updates to the Sanctuary of the progress of any response, and providing a written report summarizing the emergency response within 30 days;
- develop and implement an anti-fouling paint effectiveness plan to determine the type of anti-fouling paint to use on the buoys to avoid marine growth while at the same time protecting nearby, non-target marine resources from the toxic effects of the paint;

- develop and implement plans for: (1) monitoring for marine mammal entanglement and collision; (2) continuous cetacean acoustic monitoring; (3) assessing the effectiveness of the buoy seal and sea lion excluder device; and (4) monitoring seabird use and behavior around the buoys;

- develop and implement a plan for a project exclusion zone to protect the project facilities from fishing, trawling, and other in-water disturbances that could snag project cables or the submarine transmission line;

- develop and implement a water quality monitoring plan for in-water project construction activities, including provisions to monitor the HDD process for any seepage of drilling fluid and take corrective actions to avoid continued seepage of the drilling fluid into the surrounding bed stratum and water column;

- develop a fuel and oil spill control, prevention, and countermeasures plan to be implemented during proposed project construction, operation, and maintenance activities and including provisions for: (1) inspecting vessels and equipment used during construction and maintenance for fuel and hydraulic leaks on a daily basis while at the project; and (2) containing and removing petroleum or other oil products in the event of a spill or leak;

- develop and implement a plan to conduct an on-site noise assessment of the project buoys and associated anchoring and mooring equipment to be conducted within one year of the start of project operations and including a provision for determining potential noise attenuation measures (e.g., sound insulating material) to implement in the event that noise levels would exceed thresholds for adverse effects on marine mammals or fish. Note: This conservation measure also includes marbled murrelets, as clarified in the Commission’s August 20, 2007, letter (page 14) that indicates that seabirds are included in this conservation measure;

- develop and implement a plan to conduct a baseline and post-installation hard substrate benthic community survey along the proposed submarine transmission line route;

- develop and implement a plan to conduct an on-site electromagnetic field assessment within one year of the start of project operations;

- include in the proposed detailed design engineering and installation plan, a provision for a marine mammal and marbled murrelet observer to be present during in-water construction and installation activities. The plan would be developed in consultation with the National Marine Fisheries Service (NMFS), the Service, the Washington Department of Fish and Wildlife (WDFW), the Sanctuary, and the Makah Nation and would include provisions for an observer to note when marine mammals and marbled murrelets are within 1,000 ft of the path of construction vessels and barges. The plan would define protocols for altering or shutting
down construction and installation if marine mammals and marbled murrelets would be within 500 ft of the vessel. Also, the plan would define speed restrictions for construction vessels entering and leaving Makah Bay:

- develop and implement a shore station erosion control, revegetation, and noxious weed control plan for land-based project construction activities;

- remove existing marine debris and derelict fishing gear from the immediate project area prior to project construction and installation and provide an annual report to the Commission, NMFS, the Service, WDFW, and the Makah Nation detailing any derelict fish gear or marine debris removed from the project and any animals found entangled in derelict fishing gear or marine debris so that appropriate corrective actions can be identified and implemented, if needed;

- include in the proposed Interpretive and Education Plan, a provision for placing an interpretive display within the proposed project boundary at the shore station with the following information: (1) a map depicting marine habitats and associated species within the project area; (2) the type of marine debris potentially present in the project area, the effects such debris has on the marine environment and commercial/recreational fishing vessels, and solutions that Finavera is implementing to limit the amount of debris at the project; and (3) information informing the public of the exclusion zone and its purpose;

- include in the proposed plan for a project exclusion zone, provisions to: (1) mark the four buoys with low-intensity navigation or hazard lights visible to 1.0-nautical mile, and (2) consult with the U.S. Coast Guard and the Sanctuary on the painting of the project buoys in a way that considers the aesthetic character of the Sanctuary as well as the safety of the public and project facilities;

- add a license condition to: Notify by telephone the Director of the Commission’s Office of Energy Projects (OEP), NMFS, the Service, WDFW, Sanctuary, and the Makah Nation of any project-related conditions causing or that may cause injury or mortality to any federally listed threatened or endangered species or marine mammal afforded protection under the Marine Mammal Protection Act, as soon as practicable after becoming aware of the threat or incident without unduly interfering with any necessary or appropriate emergency response or other action procedure for protecting the affected resource. Upon initial notification, the licensee would consult with the OEP Director, agencies, and tribe on the immediate course of action to take to prevent injury or eliminate the threat and implement such measures as the OEP Director so directs, including immediate shutdown of all project operations; the licensee would follow with a written report within 7 days documenting the incident, noting the causes of the incident, and identifying measures or actions that would be taken to prevent further occurrences of injury or mortality. The Commission reserves its right to, at the sole discretion of the OEP Director, direct the licensee to commence project removal if no practical course of action can be taken to eliminate or minimize, as appropriate, project-related injuries to or mortality of federally listed threatened and endangered species and marine mammals afforded protection under the Marine Mammal Protection Act.
We expect to work with Finavera and stakeholders to develop the specific protocols for the marine mammal marbled murrelet observer on board construction vessels, the protocols for altering or shutting down construction and installation, and defining speed restrictions for construction vessels entering and leaving Makah Bay.

Also, we expect to work with Finavera and stakeholders to develop the specific protocols for inspections of the project components. These inspections should provide site-specific data on potential effects to marbled murrelets or other marine species under the jurisdiction of the Service.

Other conservation measures that are a part of the proposed project are not included in this Opinion because they are not relevant to this formal consultation.

Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR section 402.02). In delineating the action area, we evaluated the farthest reaching physical, chemical, and biotic effects of the action on the environment. The action area includes the marine site where the four buoys will be located (Figure 2). This area is approximately 3.7 miles offshore from Hobuck Beach, west of the northwest corner of the Olympic Peninsula, Clallam County, Washington. The footprint of the buoy site, including mooring lines and anchors, is approximately 625 ft by 450 ft, or approximately 7 acres. The action area also includes a 3.7-mile corridor from one of the buoys (i.e., the collection buoy that transmits electricity from all four buoys) to the shore on Hobuck Beach. This corridor includes the electrical transmission line that will be attached to the ocean floor, but the corridor also includes the travel ways for boats and barges during the construction and maintenance of the offshore buoys. In addition, the travel ways to and from port (Port Angeles and Neah Bay) for boats and barges to the marine site are part of the action area. Finally, the action area includes the terrestrial site for the electrical substation on Hobuck Beach. The substation footprint is approximately 15 ft long by 15 ft wide by 10 ft in height. Within the action area, noise, sediment, and electro-magnetic fields may emanate from the construction and operation of the buoys and/or transmission line. These additional areas are also considered part of the action area.
STATUS OF THE SPECIES: (Rangewide)

STATUS OF THE SPECIES: Murrelet

Legal Status

The murrelet was federally listed as a threatened species in Washington, Oregon, and northern California effective September 28, 1992 (57 FR 45328 [October 1, 1992]). The final rule designating critical habitat for the murrelet (61 FR 26256 [May 24, 1996]) became effective on June 24, 1996. The Service recently proposed a range-wide revision to the 1996 murrelet critical habitat designation (71 FR 53838 [September 12, 2006]). A final rule is expected in September 2007. The species' decline has largely been caused by extensive removal of late-successional and old-growth coastal forests which serve as nesting habitat for murrelets. Additional listing
factors included high nest-site predation rates and human-induced mortality in the marine environment from gillnets and oil spills.

The Service determined that the California, Oregon, and Washington distinct population segment of the murrelet does not meet the criteria set forth in the Service's 1996 Distinct Population Segment policy (61 FR 4722 [May 24, 1996]). However, the murrelet retains its listing and protected status as a threatened species under the Act until the original 1992 listing decision is revised through formal rule-making procedures, involving public notice and comment.

Critical habitat was designated for the murrelet to address the objective of stabilizing the population size. To fulfill that objective, the Marbled Murrelet Recovery Plan (U.S. Fish and Wildlife Service 1997a) (Recovery Plan) focuses on protecting adequate nesting habitat by maintaining and protecting occupied habitat and minimizing the loss of unoccupied but suitable habitat (U.S. Fish and Wildlife Service 1997a:119). The Recovery Plan identified six Conservation Zones throughout the listed range of the species: Puget Sound (Conservation Zone 1), Western Washington Coast Range (Conservation Zone 2), Oregon Coast Range (Conservation Zone 3), Siskiyou Coast Range (Conservation Zone 4), Mendocino (Conservation Zone 5), and Santa Cruz Mountains (Conservation Zone 6).

As explained in the Endangered Species Consultation Handbook (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998) and clarified by Memorandum (U.S. Fish and Wildlife Service 2006), jeopardy analyses must always consider the effect of proposed actions on the survival and recovery of the listed entity. In the case of the murrelet, the Service's jeopardy analysis will consider the effect of the action on the long-term viability of the murrelet in its listed range (Washington, Oregon, and northern California), beginning with an analysis of the action's effect on Conservation Zones 1 and 2 (described below).

**Conservation Zone 1**

Conservation Zone 1 includes all the waters of Puget Sound and most waters of the Strait of Juan de Fuca south of the U.S.-Canadian border and extends inland 50 mi from the Puget Sound, including the north Cascade Mountains and the northern and eastern sections of the Olympic Peninsula. Forest lands in the Puget Trough have been predominately replaced by urban development and the remaining suitable habitat in Zone 1 is typically a considerable distance from the marine environment, lending special importance to nesting habitat close to Puget Sound (U.S. Fish and Wildlife Service 1997a).

**Conservation Zone 2**

Conservation Zone 2 includes waters within 1.2 mi of the Pacific Ocean shoreline south of the U.S.-Canadian border off Cape Flattery and extends inland to the midpoint of the Olympic Peninsula. In southwest Washington, the Zone extends inland 50 mi from the Pacific Ocean shoreline. Most of the forest lands in the northwestern portion of Zone 2 occur on public (State, county, city, and Federal) lands, while most forest lands in the southwestern portion are privately owned. Extensive timber harvest has occurred throughout Zone 2 in the last century, but the
greatest loss of suitable nest habitat is concentrated in the southwest portion of Zone 2 (U.S. Fish and Wildlife Service 1997a). Thus, murrelet conservation is largely dependent upon Federal lands in northern portion of Zone 2 and non-Federal lands in the southern portion.

Life History

Murrelets are long-lived seabirds that spend most of their life in the marine environment, but use old-growth forests for nesting. Detailed discussions of the biology and status of the murrelet are presented in the final rule listing the murrelet as threatened (57 FR 45328 [October 1, 1992]), the Recovery Plan, Ecology and Conservation of the Marbled Murrelet (Ralph et al. 1995), the final rule designating murrelet critical habitat (61 FR 26256 [May 24, 1996]), and the Evaluation Report in the 5-Year Status Review of the Marbled Murrelet in Washington, Oregon, and California (McShane et al. 2004).

Physical Description

The murrelet is taxonomically classified in the family Alcidae (alcids), a family of Pacific seabirds possessing the ability to dive using wing-propulsion. The plumage of this relatively small (9.5 in to 10 in) seabird is identical between males and females, but the plumage of adults changes during the winter and breeding periods providing some distinction between adults and juveniles. Breeding adults have light, mottled brown under-parts below sooty-brown upperparts contrasted with dark bars. Adults in winter plumage have white under-parts extending to below the nape and white scapulars with brown and grey mixed upperparts. The plumage of fledged young is similar to the adult winter plumage (U.S. Fish and Wildlife Service 1997a).

Distribution

The range of the murrelet, defined by breeding and wintering areas, extends from the northern terminus of Bristol Bay, Alaska, to the southern terminus of Monterey Bay in central California. The listed portion of the species’ range extends from the Canadian border south to central California. Murrelet abundance and distribution has been significantly reduced in portions of the listed range, and the species has been extirpated from some locations. The areas of greatest concern due to small numbers and fragmented distribution include portions of central California, northwestern Oregon, and southwestern Washington (U.S. Fish and Wildlife Service 1997a).

Reproduction

Murrelet breeding is asynchronous and spread over a prolonged season. In Washington, the murrelet breeding season occurs between April 1 and September 15 (Figure 3). Egg laying and incubation occur from late April to early August and chick rearing occurs between late May and late August, with all chicks fledging by early September (Hamer et al. in litt. 2003).

Murrelets lay a single-egg clutch (Nelson 1997), which may be replaced if egg failure occurs early (Hiebert et al. 2003; McFarlane Tranquilla et al. 2003). However, there is no evidence a second egg is laid after successfully fledging a first chick. Adults typically incubate for a 24-
hour period, then exchange duties with their mate at dawn. Hatchlings appear to be brooded by an adult for one to two days and are then left alone at the nest for the remainder of the rearing period, except during feedings. Both parents feed the chick, which receives one to eight meals per day (Nelson 1997). Most meals are delivered early in the morning while about a third of the food deliveries occur at dusk and intermittently throughout the day (Nelson and Hamer 1995a). Chicks fledge 27 to 40 days after hatching. The initial flight of a fledgling appears to occur at dusk and parental care is thought to cease after fledging (Nelson 1997).

Figure 3. The seasonal changes in the relative proportion of breeding and non-breeding murrelets in the marine and terrestrial environments within Washington State (Conservation Zones 1 and 2)

Vocalization

Murrelets are known to vocalize between 480 Hertz and 4.9 kilohertz and have at least 5 distinct call types (Suzanne Sanborn, pers. comm. 2005). Murrelets tend to be more vocal at sea compared to other alcids (Nelson 1997). Individuals of a pair vocalize after surfacing apart from each other, after a disturbance, and during attempts to reunite after being separated (Strachan et al. 1995).

1 Demographic estimates were derived from Peery et al. (2004) and nesting chronology was derived from Hamer and Nelson (1995) and Bradley et al. (2004) where April 1 is the beginning of the nesting season, September 15 is the end of the nesting season, and August 6 is the beginning of the late breeding season when an estimated 70 percent of the murrelet chicks have fledged.
Murrelets in the Marine Environment

Murrelets are usually found within 5 miles (8 kilometers) from shore, and in water less than 60 meters deep (Ainley et al. 1995; Burger 1995; Strachan et al. 1995, Nelson 1997; Day and Nigro 2000; Raphael et al. 2007). In general, birds occur closer to shore in exposed coastal areas and farther offshore in protected coastal areas (Nelson 1997). Courtship, foraging, loafing, molting, and preening occur in marine waters. Beginning in early spring, courtship continues throughout summer with some observations even noted during the winter period (Speckman 1996; Nelson 1997). Observations of courtship occurring in the winter suggest that pair bonds are maintained throughout the year (Speckman 1996; Nelson 1997). Courtship involves bill posturing, swimming together, synchronous diving, vocalizations, and chasing in flights just above the surface of the water. Copulation occurs both inland (in the trees) and at sea (Nelson 1997).

Loafing

When murrelets are not foraging or attending a nest, they loaf on the water, which includes resting, preening, and other activities during which they appear to drift with the current, or move without direction (Strachan et al. 1995). Strachan et al. (1995) noted that vocalizations occurred during loafing periods, especially during the mid-morning and late afternoon.

Molting

Murrelets go through two molts each year. The timing of molts varies temporally throughout their range and are likely influenced by prey availability, stress, and reproductive success (Nelson 1997). Adult (after hatch-year) murrelets have two primary plumage types: alternate (breeding) plumage and basic (winter) plumage. The pre-alternate molt occurs from late February to mid-May. This is an incomplete molt during which the birds lose their body feathers but retain their ability to fly (Carter and Stein 1995; Nelson 1997). A complete pre-basic molt occurs from mid-July through December (Carter and Stein 1995; Nelson 1997). During the pre-basic molt, murrelets lose all flight feathers somewhat synchronously and are flightless for up to two months (Nelson 1997). In Washington, there is some indication that the pre-basic molt occurs from mid-July through the end of August (Chris Thompson, WDFW, pers. comm. 2003).

Flocking

Strachan et al. (1995) defines a flock as three or more birds in close proximity which maintain that formation when moving. Various observers throughout the range of the murrelet report flocks of highly variable sizes. In the southern portion of the murrelet’s range (California, Oregon, and Washington), flocks rarely contain more than 10 birds. Larger flocks usually occur during the later part of the breeding season and may contain juvenile and subadult birds (Strachan et al. 1995).

Aggregations of foraging murrelets are probably related to concentrations of prey. In Washington, murrelets are not generally found in interspecific feeding flocks (Strachan et al. 1995). Strong et al. (in Strachan et al. 1995) observed that murrelets avoid large feeding flocks
of other species and presumed that the small size of murrelets may make them vulnerable to kleptoparasitism or predation in mixed species flocks. Strachan et al. (1995) point out that if murrelets are foraging cooperatively, the confusion of a large flock of birds could reduce foraging efficiency.

**Foraging Behavior**

Murrelets are wing-propelled pursuit divers that forage both during the day and at night (Carter and Sealy 1986; Gaston and Jones 1998, Henkel et al. 2003, Kuletz 2005). Murrelets typically forage in pairs, but have been observed to forage alone or in groups of three or more (Carter and Sealy 1990; Strachan et al. 1995; Speckman et al. 2003). Strachan et al. (1995) believe pairing enhances foraging success through cooperative foraging techniques. For example, pairs consistently dive together during foraging and often synchronize their dives by swimming towards each other before diving (Carter and Sealy 1990) and resurfacing together on most dives. Strachan et al. (1995) speculate pairs may keep in visual contact underwater. Paired foraging is common throughout the year, even during the incubation period, suggesting that breeding murrelets may temporarily pair up with other foraging individuals (non-mates) (Strachan et al. 1995; Speckman et al. 2003).

Murrelets can make substantial changes in foraging sites within the breeding season, but many birds routinely forage in the same general areas and at productive foraging sites, as evidenced by repeated use over a period of time throughout the breeding season (Carter and Sealy 1990, Whitworth et al. 2000, Becker 2001, Hull et al. 2001, Mason et al. 2002, and Piatt et al. 2007). Murrelets are also known to forage in freshwater lakes (Nelson 1997). Activity patterns and foraging locations are influenced by biological and physical processes that concentrate prey, such as weather, climate, time of day, season, light intensity, up-wellings, tidal rips, narrow passages between islands, shallow banks, and kelp (Nereocystis spp.) beds (Ainley et al. 1995; Burger 1995; Strong et al. 1995; Speckman 1996; Nelson 1997).

Juveniles are generally found closer to shore than adults (Beissinger 1995) and forage without the assistance of adults (Strachan et al. 1995). Kuletz and Piatt (1999) found that in Alaska, juvenile murrelets congregated in kelp beds. Kelp beds are often with productive waters and may provide protection from avian predators (Kuletz and Piatt 1999). McAllister (in litt. in Strachan et al. 1995) found that juveniles were more common within 328 ft of shorelines, particularly, where bull kelp was present.

Murrelets usually feed in shallow, near-shore water less than 30m (98 ft) deep (Huff et al. 2006), but are thought to be able to dive up to depths of 47 m (157 ft) (Mathews and Burger 1998). Variation in depth and dive patterns may be related to the effort needed to capture prey. Thick-billed murres (*Uria lomvia*) and several penguin species exhibit bi-modal foraging behavior in that their dive depths mimic the depth of their prey, which undergo daily vertical migrations in the water column (Croll et al. 1992 and Butler and Jones 1997). Kadri and Collopy's (1999) data suggest murrelets follow this same pattern as they forage for fish that occur throughout the water column but undergo daily vertical migrations (to shallower depths at night and back to deeper depths during the day). Murrelets observed foraging in deeper water likely do so when
upwelling, tidal rips, and daily activity patterns concentrate prey near the surface (Strachan et al. 1995).

The duration of dives appears to depend upon age (adults vs. juveniles), water depth, visibility, and depth and availability of prey. Murrelet dive duration ranges from 8 seconds to 115 seconds, although most dives last between 25 and 45 seconds (Day and Nigro 2000, Jodice and Collopy 1999, Thoresen 1989, Watanuki and Burger 1999).

Adults and subadults often move away from breeding areas prior to molting and must select areas with predictable prey resources during the flightless period (Carter and Stein 1995; Nelson 1997). During the non-breeding season, murrelets disperse and can be found farther from shore (Strachan et al. 1995). Little is known about marine-habitat preference outside of the breeding season, but use during the early spring and fall is thought to be similar to that preferred during the breeding season (Nelson 1997). During the winter there may be a general shift from exposed outer coasts into more protected waters (Nelson 1997), for example many murrelets breeding on the exposed outer coast of Vancouver Island appear to congregate in the more sheltered waters within the Puget Sound and the Strait of Georgia in fall and winter (Burger 1995). However, in many areas, murrelets remain associated with the inland nesting habitat during the winter months (Carter and Erickson 1992) and throughout the listed range, murrelets do not appear to disperse long distances, indicating they are year-round residents (McShane et al. 2004).

Prey Species

Throughout their range, murrelets are opportunistic feeders and utilize prey of diverse sizes and species. They feed primarily on fish and invertebrates in marine waters although they have also been detected on rivers and inland lakes (Carter and Sealy 1986; 57 FR 45328 [October 1, 1992]). In general, small schooling fish and large pelagic crustaceans are the main prey items. Pacific sand lance (Ammodites hexapterus), northern anchovy (Engraulis mordax), immature Pacific herring (Clupea harengus), capelin (Mallotus villosus), Pacific sardine (Sardinops sagax), juvenile rockfishes (Sebastas spp.) and surf smelt (Osmeridae) are the most common fish species taken. Squid (Loligo spp.), euphausiids, mysid shrimp, and large pelagic amphipods are the main invertebrate prey. Murrelets are able to shift their diet throughout the year and over years in response to prey availability (Becker et al. 2007). However, long-term adjustment to less energetically-rich prey resources (such as invertebrates) appears to be partly responsible for poor marbled murrelet reproduction in California (Becker and Beissinger 2006).

Breeding adults exercise more specific foraging strategies when feeding chicks, usually carrying a single, relatively large (relative to body size) energy-rich fish to their chicks (Burkett 1995; Nelson 1997), primarily around dawn and dusk (Nelson 1997, Kuletz 2005). Freshwater prey appears to be important to some individuals during several weeks in summer and may facilitate more frequent chick feedings, especially for those that nest far inland (Hobson 1990). Becker et al. (2007) found murrelet reproductive success in California was strongly correlated with the abundance of mid-trophic level prey (e.g. sand lance, juvenile rockfish) during the breeding and postbreeding seasons. Prey types are not equal in the energy they provide; for example parents delivering fish other than age-1 herring may have to increase deliveries by up to 4.2 times to
deliver the same energy value (Kuletz 2005). Therefore, nesting murrelets that are returning to their nest at least once per day must balance the energetic costs of foraging trips with the benefits for themselves and their young. This may result in marbled murrelets preferring to forage in marine areas in close proximity to their nesting habitat. However, if adequate or appropriate foraging resources (i.e., "enough" prey, and/or prey with the optimum nutritional value for themselves or their young) are unavailable in close proximity to their nesting areas, marbled murrelets may be forced to forage at greater distances or to abandon their nests (Huff et al. 2006, p. 20). As a result, the distribution and abundance of prey suitable for feeding chicks may greatly influence the overall foraging behavior and location(s) during the nesting season, may affect reproductive success (Becker et al. 2007), and may significantly affect the energy demand on adults by influencing both the foraging time and number of trips inland required to feed nestlings (Kuletz 2005).

**Predators**

At-sea predators include bald eagles (*Haliaeetus leucocephalus*), peregrine falcons (*Falco peregrinus*), western gulls (*Larus occidentalis*), and northern fur seals (*Callorhinus ursinus*) (McShane et al. 2004). California sea lions (*Zalophus californianus*), northern sea lions (*Eumetopias jubatus*), and large fish may occasionally prey on murrelets (Burger 2002).

**Murrelets in the Terrestrial Environment**

Murrelets are dependent upon old-growth forests, or forests with an older tree component, for nesting habitat (Hamer and Nelson 1995; Ralph et al. 1995; McShane et al. 2004). Sites occupied by murrelets tend to have a higher proportion of mature forest age-classes than do unoccupied sites (Raphael et al. 1995). Specifically, murrelets prefer high and broad platforms for landing and take-off, and surfaces which will support a nest cup (Hamer and Nelson 1995). The physical condition of a tree appears to be the important factor in determining the tree’s suitability for nesting (Ralph et al. 1995); therefore, presence of old-growth in an area does not assure the stand contains sufficient structures (i.e., platforms) for nesting. In Washington, murrelet nests have been found in conifers, specifically, western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), Douglas-fir (*Pseudotsuga menziesii*), and western red cedar (*Thuja plicata*) (Hamer and Nelson 1995; Hamer and Meekins 1999). Nests have been found in trees as small as 2.6 ft in diameter at breast height on limbs at least 65 ft from the ground and 0.36 ft in diameter (Hamer and Meekins 1999).

Murrelet populations may be limited by the availability of suitable nesting habitat. Although no data are available, Ralph et al. (1995) speculate the suitable nesting habitat presently available in Washington, Oregon, and California may be at or near carrying capacity based on: 1) at-sea concentrations of murrelets near suitable nesting habitat during the breeding season, 2) winter visitations to nesting sites, and 3) the limitation of nest sites available in areas with large amounts of habitat removal.

Murrelets have been observed visiting nesting habitat during non-breeding periods in Washington, Oregon, and California (Nelson 1997; Naslund 1993) which may indicate adults are
defending nesting sites and or stands (Ralph et al. 1995). Other studies provide further insight to the habitat associations of breeding murrelets, concluding that breeding murrelets displaced by the loss of nesting habitat do not pack in higher densities into remaining habitat (McShane et al. 2004). Thus, murrelets may currently be occupying nesting habitat at or near carrying capacity in highly fragmented areas and/or in areas where a significant portion of the historic nesting habitat has been removed (Ralph et al. 1995).

Unoccupied stands containing nesting structures are important to the population for displaced breeders or first-time breeding adults. Even if nesting habitat is at carrying capacity, there will be years when currently occupied stands become unoccupied as a result of temporary disappearance of inhabitants due to death or to irregular breeding (Ralph et al. 1995). Therefore, unoccupied stands will not necessarily indicate that habitat is not limiting or that these stands are not murrelet habitat (Ralph et al. 1995) and important to the species persistence.

Radar and audio-visual studies have shown murrelet habitat use is positively associated with the presence and abundance of mature and old-growth forests, large core areas of old-growth, low edge and fragmentation, proximity to the marine environment, total watershed area, and increasing forest age and height (McShane et al. 2004). In California and southern Oregon, areas with abundant numbers of murrelets were farther from roads, occurred more often in parks protected from logging, and were less likely to occupy old-growth habitat if it was isolated (more than 3 miles or 5 km) from other nesting murrelets (Meyer et al. 2002). Meyer et al. (2002) also found at least a few years passed before birds abandoned fragmented forests.

Murrelets do not form dense colonies which is atypical of most seabirds. Limited evidence suggests they may form loose colonies or clusters of nests in some cases (Ralph et al. 1995). The reliance of murrelets on cryptic coloration to avoid detection suggests they utilize a wide spacing of nests in order to prevent predators from forming a search image (Ralph et al. 1995). However, active nests have been seen within 328 ft (100 m) of one another in the North Cascades in Washington and within 98 ft (30 m) in Oregon (Kim Nelson, OSU, pers. comm., 2005). Estimates of murrelet nest densities vary depending upon the method of data collection. For example, nest densities estimated using radar range from 0.007 to 0.104 mean nests per acre (0.003 to 0.042 mean nests per ha), while nest densities estimated from tree climbing efforts range from 0.27 to 3.51 mean nests per acre (0.11 to 1.42 mean nests per ha) (Nelson 2005).

There is little data available regarding murrelet nest site fidelity because of the difficulty in locating nest sites and observing banded birds attending nests. However, murrelets have been detected in the same nesting stands for many years (at least 20 years in California and 15 years in Washington), suggesting murrelets have a high fidelity to nesting areas, most likely at the watershed scale (Nelson 1997). Use of the same nest platform in successive years as well as multiple nests in the same tree have been documented, although it is not clear whether the repeated use involved the same birds (Divoky and Horton 1995; Nelson and Peck 1995; Nelson 1997; Manley in litt. 2000; Hebert et al. 2003). The limited observed fidelity to the same nest depression in consecutive years appears to be lower than for other alcids, but this may be an adaptive behavior in response to high predation rates (Divoky and Horton 1995). Researchers have suggested fidelity to specific or adjacent nesting platforms may be more common in areas
where predation is limited or the number of suitable nest sites are fewer because large, old-growth trees are rare (Nelson and Peck 1995; Singer et al. 1995; Manly 1999).

Ralph et al. (1995) speculated that the fidelity to nest sites or stands by breeding murrelets may be influenced by the nesting success of previous rearing attempts. Although murrelet nesting behavior in response to failed nest attempts is unknown, nest failures could lead to prospecting for new nest sites or mates. Other alcids have shown an increased likelihood to relocate to a new nest in response to breeding failure (Divoky and Horton 1995). However, murrelets likely remain in the same watershed over time as long as stands are not significantly modified (Ralph et al. 1995).

It is unknown whether juveniles disperse from natal breeding habitat (natal dispersal) or return to their natal breeding habitat after reaching breeding age (natal philopatry). Natal dispersal distance can be expected to be as high or higher than other alcids given 1) the reduced extent of the breeding range, 2) the overlap between the wintering and breeding areas, 3) the distance individuals are known to move from breeding areas in the winter, 4) adult attendance of nesting areas during the non-breeding season where, in theory, knowledge of suitable nesting habitat is passed onto prospecting non-breeders, and 5) the 3-year to 5-year duration required for the onset of breeding age allowing non-breeding murrelets to prospect nesting and forage habitat for several years prior to reaching breeding age (Divoky and Horton 1995). Conversely, Swartzman et al. (1997 in McShane et al. 2004) suggested juvenile dispersal is likely to be low, as it is for other alcid species. Nevertheless, the presence of unoccupied suitable nesting habitat on the landscape may be important for first-time nesters if they disperse away from their natal breeding habitat.

Murrelets generally select nests within 37 mi (60 kilometers (km)) of marine waters (Miller and Ralph 1995). However, in Washington, occupied habitat has been documented 52 mi (84 km) from the coast and murrelets have been detected up to 70 mi (113 km) from the coast in the southern Cascade Mountains (Evans Mack et al. 2003).

When tending active nests during the breeding season (and much of the non-breeding season in southern parts of the range), breeding pairs forage within commuting distance of the nest site. Daily movements between nest sites and foraging areas for breeding murrelets averaged 10 mi in Prince William Sound, Alaska (McShane et al. 2004), 24 mi in Desolation Sound, British Columbia, Canada (Hull et al. 2001), and 48 mi in southeast Alaska. In California, Hebert and Golightly (2003) found the mean extent of north-south distance traveled by breeding adults to be about 46 mi.

Murrelet nests have been located at a variety of elevations from sea level to 5,020 ft (Burger 2002). However, most nests have been found below 3,500 ft. In Conservation Zone 1, murrelets have exhibited “occupied” behaviors up to 4,400 ft elevation and have been detected in stands up to 4,900 ft in the north Cascade Mountains (Peter McBride, WDNR, pers. comm. 2005). On the Olympic Peninsula, survey efforts for nesting murrelets have encountered occupied stands up to 4,000 ft within Conservation Zone 1 and up to 3,500 ft within Conservation Zone 2. Surveys for murrelet nesting at higher elevations on the Olympic Peninsula have not been conducted.
However, recent radio-telemetry work detected a murrelet nest at 3,600 ft elevation on the Olympic Peninsula in Conservation Zone 1 (Martin Raphael, USFS, pers. comm. 2005).

Population Status in the Coterminous United States

Population Abundance

Research on murrelet populations in the early 1990s estimated murrelet abundance in Washington, Oregon, and California at 18,550 to 32,000 (Ralph et al. 1995). However, consistent population survey protocols were not established for murrelets in the coterminous United States until the late 1990s following the development of the marine component of the Environmental Monitoring (EM) Program for the NWFP (Bentivoglio et al. 2002). As a consequence, sampling procedures have differed and thus the survey data collected prior to the EM Program is unsuitable for estimating population trends for the murrelet (McShane et al. 2004).

The development of the EM Program unified the various at-sea monitoring efforts within the 5 Conservation Zones encompassed by the NWFP. These efforts along with efforts in Conservation Zone 6 have resulted in annual estimates of murrelet abundance for each Conservation Zone (Bentivoglio et al. 2002; Peery et al. in litt. 2002; Huff et al. 2003; Lance 2004), with the annual overall population estimated at 18,097 (2000), 22,200 (2001), 23,700 (2002), and 22,300 (2003).

Population Trend

Estimated population trends within each Conservation Zone or for the entire coterminous population are not yet available from the marine survey data. Trend information will eventually be provided through the analysis of marine survey data from the EM Program (Bentivoglio et al. 2002) and from survey data in Conservation Zone 6 once a sufficient number of survey years have been completed. Depending on the desired minimum power (80 or 95 percent), at least 8 to 10 years of successive surveys are required for an overall population estimate and thus detection of an annual decrease, while 7 to 16 years are required for Conservation Zones 1 and 2 (Huff et al. 2003).

In the interim, demographic modeling has aided attempts to analyze and predict population trends and extinction probabilities of murrelets. Incorporating important population parameters and species distribution data (Beissinger 1995; Beissinger and Nur 1997 in U.S. Fish and Wildlife Service 1997a; Cam et al. 2003; McShane et al. 2004), demographic models can provide useful insights into potential population responses from the exposure to environmental pressures and perturbations. However, weak assumptions or inaccurate estimates of population parameters such as survivorship rates, breeding success, and juvenile-to-adult ratios (juvenile ratios), can limit the use of models. Thus, a cautious approach is warranted when forecasting long-term population trends using demographic models.
Most of the published demographic models used to estimate murrelet population trends employ Leslie Matrix modeling (McShane et al. 2004). Two other more complex, unpublished models (Akcakaya 1997 and Swartzman et al. 1997 in McShane et al. 2004) evaluate the effect of nest habitat loss on murrelets in Conservation Zone 4 (McShane et al. 2004). McShane et al. (2004) developed a stochastic Leslie Matrix model (termed “Zone Model”) to project population trends in each murrelet Conservation Zone. The Zone Model was developed to integrate available demographic information for a comparative depiction of current expectations of future population trends and probability of extinction in each Conservation Zone (McShane et al. 2004). Table 1 lists rangewide murrelet demographic parameter values from four studies all using Leslie Matrix models.

Table 1. Rangewide murrelet demographic parameter values based on four studies all using Leslie Matrix models

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<tbody>
<tr>
<td>Juvenile Ratios</td>
<td>0.10367</td>
<td>0.124 or 0.131</td>
<td>0.089</td>
<td>0.02 - 0.09</td>
</tr>
<tr>
<td>Annual Fecundity</td>
<td>0.11848</td>
<td>0.124 or 0.131</td>
<td>0.06-0.12</td>
<td>(See nest success)</td>
</tr>
<tr>
<td>Nest Success</td>
<td></td>
<td></td>
<td>0.16-0.43</td>
<td>0.38 - 0.54</td>
</tr>
<tr>
<td>Maturation</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2 - 5</td>
</tr>
<tr>
<td>Estimated Adult Survivorship</td>
<td>85 % - 90%</td>
<td>85 % - 88 %</td>
<td>82 % - 90 %</td>
<td>83 % - 92 %</td>
</tr>
</tbody>
</table>

Regardless of model preference, the overall results of modeling efforts are in agreement, indicating murrelet abundance is declining (McShane 2004:6-27). The rates of decline are highly sensitive to the assumed adult survival rate used for calculation (Beissinger and Peery in litt. 2003). The most recent modeling effort using the “Zone Model” (McShane et al. 2004) suggests the murrelet zonal sub-populations are declining at a rate of 3.0 to 6.2 percent per year.

Estimates of breeding success are best determined from nest site data, but difficulties in finding nests has led to the use of other methods, such as juvenile ratios and radio-telemetry estimations, each of which have biases. The nest success data presented in Murrelet Table 1 under McShane et al. (2004) was derived primarily from radio telemetry studies; however the nests sampled in these studies were not representative of large areas and specifically did not include Washington or Oregon. In general, telemetry estimates are preferred over juvenile ratios for estimating breeding success due to fewer biases (McShane et al. 2004), but telemetry data are not currently available for Washington or Oregon. Therefore, it is reasonable to expect that juvenile ratios derived from at-sea survey efforts best represent murrelet reproductive success in Washington, Oregon, and California.

Beissinger and Peery (in litt. 2003) performed a comparative analysis using data from 24 bird species to predict the juvenile ratios for murrelets of 0.27 (confidence intervals ranged from 0.15 to 0.65). Demographic models suggest murrelet population stability requires a minimum of 0.18 to 0.28 chicks per pair per year (Beissinger and Nur 1997 in U.S. Fish and Wildlife Service
The lower confidence intervals for both the predicted juvenile ratio (0.15) and the stable population juvenile ratio (0.18) are greater than the juvenile ratios observed for any of the Conservation Zones (0.02 to 0.09 chicks per pair) (Beissinger and Nur 1997 in U.S. Fish and Wildlife Service 1997a; Beissinger and Peery in litt. 2003). Therefore, the juvenile ratios observed in the Conservation Zones are lower than predicted and are too low to obtain a stable population in any Conservation Zone. This indicates murrelet populations are declining in all Conservation Zones and will continue to decline until reproductive success improves.

Demographic modeling, the observed juvenile ratios, and adult survivorship rates suggests that the number of murrelets in Washington, Oregon, and California are too low to sustain a murrelet population. The rate of decline for murrelets throughout the listed range is estimated to be between 2.0 to 15.8 percent (Beissinger and Nur 1997 in U.S. Fish and Wildlife Service 1997a; McShane et al. 2004).

Murrelets in Washington (Conservation Zones 1 and 2)

Population estimates

Historically, murrelets in Conservation Zones 1 and 2 were “common” (Rathbun 1915 and Miller et al. 1935 in U.S. Fish and Wildlife Service 1997a), “abundant” (Edson 1908 and Rhoades 1893 in U.S. Fish and Wildlife Service 1997a), or “numerous” (Miller et al. 1935 in McShane et al. 2004). Conservation Zone 1, encompassing the Puget Sound in northwest Washington, 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). The 2003 population estimate (with 95 percent confidence intervals) for Conservation Zone 1 is 8,500 (6,000 - 11,300) and Conservation Zone 2 is 3,400 (2,000 - 4,900) (Huff et al. 2003). In Conservation Zone 2, a higher density of murrelets occurs in the northern portion of the Zone (Huff et al. 2003) where the majority of available nesting habitat occurs. In Conservation Zone 1, higher densities of murrelets occur in the Straits of Juan de Fuca, the San Juan Islands, and the Hood Canal (Huff et al. 2003), which are in proximity to nesting habitat on the Olympic Peninsula and the North Cascade Mountains.

Although population numbers in Conservation Zones 1 and 2 are likely declining, the precise rate of decline is unknown. The juvenile ratio derived from at-sea survey efforts in Conservation Zone 1 is 0.09. The juvenile ratios was not collected in Conservation Zone 2; however, the juvenile ratio for Conservation Zone 3 is 0.08. Therefore, it is reasonable to infer that the juvenile ratio for Conservation Zone 2 is likely between 0.08 and 0.09. These low juvenile ratios infer there is insufficient juvenile recruitment to sustain a murrelet population in Conservation Zones 1 and 2. Beissinger and Peery (in litt. 2003) estimated the rate of decline for Conservation Zone 1 to be between 2.0 to 12.6 percent and between 2.8 to 13.4 percent in Conservation Zone 3. It is likely that the rate of decline in Conservation Zone 2 is similar to that of Conservation Zones 1 and 3.

Juvenile ratios in Washington may be skewed by murrelets coming and going to British Columbia. At-sea surveys are timed to occur when the least number of murrelets from British
Columbia are expected to be present. However, recent radio-telemetry information indicates 1) murres nesting in British Columbia forage in Washington waters during the breeding season (Martin Raphael, USFS, pers. comm. 2005) and could be counted during at-sea surveys; and 2) adult murres foraging in Washington during the early breeding season moved to British Columbia in mid-June and mid-July (Bloxton and Raphael 2005) and would not have been counted during the at-sea surveys. The movements of juvenile murres in Washington and southern British Columbia are unclear. Therefore, until further information is obtained regarding murrelet migration between British Columbia and Washington, we will continue to rely on the at-sea derived juvenile ratios to evaluate the population status in Conservation Zones 1 and 2.

**Habitat Abundance**

Estimates of the amount of available suitable nesting habitat vary as much as the methods used for estimating murrelet habitat. McShane et al. (2004) estimates murrelet habitat in Washington State at 1,022,695 acres, representing approximately 48 percent of the estimated 2,223,048 acres remaining suitable habitat in the listed range. McShane et al. (2004) caution about making direct comparisons between current and past estimates due to the evolving definition of suitable habitat and methods used to quantify habitat. As part of the ongoing pursuit to improve habitat estimates, information was collected and analyzed by the Service in 2005 resulting in an estimated 751,831 acres in Conservation Zone 1 and 585,821 acres in Conservation Zone 2 (Table 2).

<table>
<thead>
<tr>
<th>Conservation Zone</th>
<th>Estimated acres of suitable murrelet habitat by land management category</th>
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<tbody>
<tr>
<td></td>
<td>Federal</td>
</tr>
<tr>
<td>Puget Sound (Zone 1)</td>
<td>650,937</td>
</tr>
<tr>
<td>Western Washington Coast Range (Zone 2)</td>
<td>485,574</td>
</tr>
<tr>
<td>Total</td>
<td>1,136,511</td>
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</tbody>
</table>

*Estimated acres of private land represents occupied habitat. Additional suitable nesting habitat considered unoccupied by nesting murrelets is not included in this estimate.

Estimated acreages of suitable habitat on Federal lands in Table 2 are based on modeling and aerial photo interpretation and likely overestimate the actual acres of suitable murrelet habitat because 1) most acreages are based on models predicting spotted owl nesting habitat which include forested lands that do not have structures suitable for murrelet nesting, and 2) neither modeling or aerial photo interpretation can distinguish microhabitat features, such as nesting platforms or the presence of moss, that are necessary for murrelet nesting. The amount of high quality murrelet nesting habitat available in Washington, defined by the Service as large, old, contiguously forested areas not subject to human influences (e.g., timber harvest or urbanization).
is expected to be a small subset of the estimated acreages in Table 2. Murrelets nesting in high-quality nesting habitat are assumed to have a higher nesting success rate than murrelets nesting in fragmented habitat near humans.

Other Recent Assessments of Murrelet Habitat in Washington

Two recent assessments of murrelet potential nesting habitat were developed for monitoring the Northwest Forest Plan (Raphael et al. 2006). This study provides a provincial-scale analysis of murrelet habitat derived from vegetation base maps, and includes estimates of habitat on State and private lands in Washington for the period of 1994 to 1996. Using vegetation data derived from satellite imagery, Raphael et al. (2006) developed two different approaches to model habitat suitability. The first model, or the Expert Judgment Model, is based on the judgment of an expert panel that used existing forest structure classification criteria (e.g., percent conifer cover, canopy structure, quadratic mean diameter, forest patch size) to classify forests into four classes of habitat suitability, with Class 1 indicating the least suitable habitat and Class 4 indicating the most highly suitable habitat. Raphael et al. (2006) found that across the murrelet range, most habitat-capable land (52 percent) is classified as Class 1 (lowest suitability) habitat and 18 percent is classified as Class 4 (highest suitability) habitat. In Washington, they found that there were approximately 954,200 acres of Class 4 habitat in between 1994 and 1996 (Table 3). However, only 60 percent of known nest sites in their study area were located in Class 4 habitat.

The second habitat model developed by Raphael et al. (2006) used the Biomapper Ecological Niche-Factor Analysis model developed by Hirzel et al. (2002). The resulting murrelet habitat suitability maps are based on both the physical and vegetative attributes adjacent to known murrelet occupied polygons or nest locations for each Northwest Forest Plan province. The resulting raster maps are a grid of 269 ft²-cells (25 m²-cells) (0.15 acres per pixel). Each cell in the raster is assigned a value of 0 to 100. Values closer to 100 represent areas that match the murrelet nesting locations while values closer to 0 are likely unsuitable for nesting (Raphael et al. 2006). These maps do not provide absolute habitat estimates, but rather a range of habitat suitability values, which can be interpreted in various ways. Raphael et al. (2006) noted that the results from the Ecological Niche Factor Analysis (ENFA) are not easily compared to results from the Expert Judgment Model because it was not clear what threshold from the habitat suitability ranking to use. Raphael et al. (2006) elected to display habitat suitability scores greater than 60 (HS >60) as a "generous" portrayal of potential nesting habitat and a threshold greater than 80 (HS >80) as a more conservative estimate. In Washington, there were over 2.1 million acres of HS >60 habitat, but only 440,700 acres of HS >80 habitat (Table 3). It is important to note that HS >60 habitat map captures 82 percent of the occupied nests sites in Washington, whereas the HS >80 habitat map only captures 36 percent of the occupied nests in Washington.
Table 3. Comparison of different habitat modeling results for the Washington nearshore zone (0 to 40 mi inland or Northwest Forest Plan Murrelet Zone 1)

<table>
<thead>
<tr>
<th>Murrelet Habitat Model</th>
<th>Habitat Acres on Federal Reserves (LSRs, Natl Parks)</th>
<th>Habitat Acres on Federal Non-Reserves (USFS Matrix)</th>
<th>Total Habitat Acres on Federal Lands</th>
<th>Total Habitat Acres on Non-Federal Lands (City, State, Private, Tribal)</th>
<th>Total Habitat Acres - All Ownership</th>
<th>Percent of Total Habitat Acres on Non-Federal Lands</th>
<th>Percent of Known Murrelet Nest Sites in Study Area Occurring in this Habitat Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFA* HS &gt;80</td>
<td>284,300</td>
<td>18,600</td>
<td>302,900</td>
<td>137,800</td>
<td>440,700</td>
<td>31%</td>
<td>36%</td>
</tr>
<tr>
<td>EJM* Class 4</td>
<td>659,200</td>
<td>40,700</td>
<td>699,900</td>
<td>254,300</td>
<td>954,200</td>
<td>11%</td>
<td>60%</td>
</tr>
<tr>
<td>EJM Class 3 and Class 4</td>
<td>770,600</td>
<td>54,700</td>
<td>825,300</td>
<td>535,200</td>
<td>1,360,500</td>
<td>16%</td>
<td>65%</td>
</tr>
<tr>
<td>ENFA HS &gt;60</td>
<td>927,000</td>
<td>85,300</td>
<td>1,012,300</td>
<td>1,147,100</td>
<td>2,159,400</td>
<td>53%</td>
<td>82%</td>
</tr>
</tbody>
</table>

*ENFA Ecological Niche Factor Analysis  EJM Expert Judgment Model Results were summarized directly from Tables 4 and 5 and Tables 9 and 10 in Raphael et al. (2005) All habitat estimates represent 1994-1996 values.

Because the HS >60 model performed best for capturing known murrelet nest sites, Raphael et al. (2006) suggest that the ENFA HS >60 model yields a reasonable estimate of potential murrelet nesting habitat. However, we found that large areas in southwest Washington identified in the HS >60 model likely overestimates the actual suitable habitat in this landscape due to a known lack of old-forest in this landscape. Despite the uncertainties associated with interpreting the various map data developed by Raphael et al. (2006), it is apparent that there is a significant portion of suitable habitat acres located on non-Federal lands in Washington, suggesting that non-Federal lands may play a greater role in the conservation needs of the species than has previously been considered. Using the most conservative criteria developed by Raphael et al. (2006) the amount of high-quality murrelet nesting habitat on non-Federal lands in Washington varies from 11 percent to as high as 31 percent (Table 3).

Raphael et al. (2006) note that the spatial accuracy of the map data are limited and that the habitat maps are best used for provincial-scale analysis. Due to potential errors in vegetation mapping and other potential errors, these maps are not appropriate for fine-scale project mapping. These data have not been published in their final form yet, although they have been available on the internet for public review and use since May 2005.

Conservation Zone 1

The majority of suitable murrelet habitat in Conservation Zone (Zone) 1 occurs in northwest Washington and is found on Forest Service and National Park Service lands, and to a lesser extent on State lands. The majority of the historic habitat along the eastern and southern shores of the Puget Sound has been replaced by urban development resulting in the remaining suitable habitat further inland from the marine environment (U.S. Fish and Wildlife Service 1997a).
Conservation Zone 2

Murrelet nesting habitat north of Gray's Harbor in Zone 2 occurs largely on State, Forest Service, National Park Service, and Tribal lands, and to a lesser extent, on private lands. Alternatively, the majority of habitat in the southern portion of Zone 2 occurs primarily on State lands, with a small amount on private lands.

Threats

Murrelets remain subject to a variety of anthropogenic threats within the upland and marine environment. They also face threats from low population numbers, low immigration rates, high predation rates, and disease.

Threats in the Marine Environment

Threats to murrelets in the marine environment include declines in prey availability; mortality associated with exposure to oil spills, gill net and other fisheries; contaminants suspended in marine waters; and visual or sound disturbance from recreational or commercial watercrafts (57 FR 45328 [October 1, 1992]; U.S. Fish and Wildlife Service 1997a; Ralph et al. 1995; McShane et al. 2004).

Prey Availability

Many fish populations have been depleted due to overfishing, reduction in the amount or quality of spawning habitat, and pollution. As of 2004, only 50 percent of the Puget Sound herring stocks were classified as healthy or moderately healthy, with north Puget Sound's stock being considered depressed and the Strait of Juan de Fuca's stocks being classified as critical (WDFW 2005). Natural mortality in some of these stocks has increased (e.g. the mean estimated annual natural mortality rate for sampled stocks from 1987 through 2003 averaged 71 percent, up from 20 to 40 percent in the late 1970s) (WDFW 2005). There is currently only one commercial herring fishery which operates primarily in south and central Puget Sound (WDFW 2005) where herring stocks are healthier. Unfortunately, the decline of some herring stocks may be affecting the forage base for murrelets in Puget Sound. There is limited information available for the coastal herring populations, but these populations appear to have relatively high levels of abundance (WDFW 2005). There are herring fisheries in Willapa Bay and Grays Harbor, but no direct harvest is allowed in the coastal waters.

While there are commercial and recreational fisheries for surf smelt, the amount of harvest does not appear to be impacting the surf smelt stocks (Bargmann 1998). There are no directed commercial fisheries for sand lance (Bargmann 1998). Anchovies are taken commercially within coastal and estuarine waters of Washington. While the current harvest level doesn’t appear to be impacting anchovy stocks, there is no current abundance information (Bargmann 1998).

In addition to fishing pressure, oceanographic variation can influence prey availability. While the effects to murrelets from events such as El Niño have not been well documented, El Niño
events are thought to reduce overall prey availability and several studies have found that El Niño
events can influence the behavior of murrelets (McShane et al. 2004). Even though changes in
prey availability may be due to natural and cyclic oceanographic variation, these changes may
exacerbate other threats to murrelets in the marine environment.

Shoreline development has affected and will continue to effect coastal processes. Shipping,
bulkheads, and other shoreline developments have contributed to the reduction in eelgrass beds
and other spawning and rearing areas for forage.

Oil Spills

Murrelet mortality from oil pollution is a conservation issue in Washington (U.S. Fish and
Wildlife Service 1997a). Most oil spills and chronic oil pollution that can affect murrelets occur
in areas of high shipping traffic, such as the Strait of Juan de Fuca and Puget Sound. There have
been at least 47 oil spills of 10,000 gal or more in Washington since 1964 (WDOE 2004).
However, the number of oil spills has generally declined since passage of the U.S. Oil Pollution
Act in 1990. The estimated annual mortality of murrelets from oil spills in Washington has
decreased from 3 to 41 birds per year (between 1977 and 1992) to 1 to 2 birds per year (between

Since the murrelet was listed, the amount of oil tanker and shipping traffic has continued to
increase (U.S. Fish and Wildlife Service 1997a; Burger 2002). Large commercial ships,
including oil tankers, cargo ships, fish processing ships, and cruise ships, enter Washington
waters more than 7,000 times each year, bound for ports in Puget Sound, British Columbia,
Grays Harbor, and the Columbia River (WDOE 2004). Additionally, 4,500 tank-barge transits,
160,000 ferry transits, and military vessel traffic occur in these same waters each year (WDOE
2004). Individually these vessels may carry up to 33 M gal of crude oil or refined petroleum
products, but collectively, they carry about 15.1 B gal across Puget Sound waters each year
(WDOE 2004). These numbers are expected to increase as the human population and commerce
continues to grow. Currently, there are State and Federal requirements for tug escorts of laden
oil tankers transiting the waters of Puget Sound east of Dungeness Spit. However, the Federal
requirements do not apply to double-hulled tankers and will no longer be in effect once the
single-hull tanker phase-out is complete (WDOE 2005). Washington State is considering
revising their tug escort requirements (WDOE 2005); however, the current tug escort
requirements remain in place until the Washington State Legislature makes a change.

The U.S. Coast Guard rated the Dungeness area in the Strait of Juan de Fuca as being in the top
five high-risk areas of the United States for being impacted by oil spills (U.S. Fish and Wildlife
Service 2005). Therefore, even though the threat from oil spills appears to have been reduced
since the murrelet was listed, the risk of a catastrophic oil spill remains, and could severely
impact adult and/or juvenile murrelets in Conservation Zones 1 and 2.
Gillnets

Murrelet mortality from gillnet fishing has been considered a conservation issue in Washington (U.S. Fish and Wildlife Service 1997a; Melvin et al. 1999). Murrelets can also be killed by hooking with fishing lures and entanglement with fishing lines (Carter et al. 1995). There is little information available on murrelet mortality from net fishing prior to the 1990s, although it was known to occur (Carter et al. 1995). In the mid 1990s, a series of fisheries restrictions and changes were implemented to address mortality of all species of seabirds, resulting in a lower mortality rate of murrelets (McShane et al. 2004). Fishing effort has also decreased since the 1980s because of lower catches, fewer fishing vessels, and greater restrictions (McShane et al. 2004), although a regrowth in gill net fishing is likely to occur if salmon stocks increase. In most areas, the threat from gill net fishing has been reduced or eliminated since 1992, but threats to adult and juvenile murrelets are still present in Washington waters due to gill net mortality (McShane et al. 2004).

Entanglement in derelict fishing nets, which are nets that have been lost, abandoned or discarded in the marine environment, may also pose a threat. Derelict gear can persist in the environment for decades and poses a threat to marine mammals, seabirds, shellfish, and fish. A recent survey estimated 3,900 derelict nets need to be removed from Puget Sound (Northwest Straits Foundation 2007) and each year the number of new derelict nets increases faster than the number removed. Over 50 percent of the derelict nets in Puget Sound occur in waters where murrelet densities are the highest in Washington. Derelict fishing gear also occurs along the Washington coast and the outer Straits of Juan de Fuca. While this high energy environment may reduce the time a derelict net remains suspended compared to a lower energy environment like the inner Puget Sound where gear may persist for years (NRC 2007), the amount of time a derelict net poses a threat to marine species depends on the length and type of the net and cause of entanglement.

Marine Contaminants

The primary consequence from the exposure of murrelets to contaminants is reproductive impairment. Reproduction can be impacted by food web bioaccumulation of organochlorine pollutants and heavy metals discharged into marine areas where murrelets feed and prey species concentrate (Fry 1995). However, murrelet exposure is likely a rare event because murrelets have widely dispersed foraging areas and they feed extensively on transient juvenile and subadult midwater fish species that are expected to have low pollutant loads (McShane et al. 2004). The greatest exposure risk to murrelets may occur at regular feeding areas near major pollutant sources, such as those found in Puget Sound (McShane et al. 2004).

Disturbance

In coastal and offshore marine environments, vehicular disturbance (e.g., boats, airplanes, personal watercraft) is known to elicit behavioral responses in murrelets of all age classes (Kuletz 1996; Speckman 1996; Nelson 1997). Aircraft flying at low altitudes and boating activity, in particular motorized watercraft, are known to cause murrelets to dive and are thought
to especially affect adults holding fish (Nelson 1997). It is unclear to what extent this kind of disturbance affects the distribution, movements, foraging efficiency, and overall fitness of murrelets. However, it is unlikely this type of disturbance has decreased since 1992 because the shipping traffic and recreational boat use in the Puget Sound and Strait of Juan de Fuca has continued to increase.

Marine projects that include seismic exploration, pile driving, detonation of explosives and other activities that generate percussive sounds can expose murrelets to elevated underwater sound pressure levels (SPLs). High underwater SPLs can have adverse physiological and neurological effects on a wide variety of vertebrate species (Yelverton et al. 1973; Yelverton and Richmond 1981; Stevens et al. 1999; Fothergill et al. 2001; Cudahy and Ellison 2002; U.S. Department of Defense 2002; Popper 2003). High underwater SPLs are known to injure and/or kill fish by causing barotraumas (pathologies associated with high sound levels including hemorrhage and rupture of internal organs), as well as causing temporary stunning and alterations in behavior (Turnpenny and Nedwell 1994; Turnpenny et al. 1994; Popper 2003; Hastings and Popper 2005). During monitoring of seabird response to pile driving in Hood Canal, Washington, a pigeon guillemot (Cepphus columba) was observed having difficulty getting airborne after being exposed to underwater sound from impact pile driving (Entranco and Hamer Environmental 2005). In controlled experiments using underwater explosives, rapid change in SPLs caused internal hemorrhaging and mortality in submerged mallard ducks (Anas platyrhynchos) (Yelverton et al. 1973). Risk of injury appears related to the effect of rapid pressure changes, especially on gas filled spaces in the bodies of exposed organisms (Turnpenny et al. 1994). In studies on ducks (Anas spp.) and a variety of mammals, all species exposed to underwater blasts had injuries to gas filled organs including eardrums (Yelverton and Richmond 1981). These studies indicate that similar effects can be expected across taxonomical species groups.

Physical injury may not result in immediate mortality. If an animal is injured, death may occur several hours or days later, or injuries may be sublethal. Sublethal injuries can interfere with the ability of an organism to carry out essential life functions such as feeding and predator avoidance. Diving birds are able to detect and alter their behavior based on sound in the underwater environment (Ross et al. 2001) and elevated underwater SPLs may cause murrelets to alter normal behaviors, such as foraging. Disturbance related to elevated underwater SPLs may reduce foraging efficiency resulting in increased energetic costs to all murrelet age classes in the marine environment and may result in fewer deliveries or lower quality food being delivered to nestlings.

**Threats in the Terrestrial Environment**

**Habitat**

Extensive harvest of late-successional and old-growth forest was the primary reason for listing the murrelet as threatened. Due primarily to extensive timber cutting over the past 150 years, at least 82 percent of the old-growth forests existing in western Washington and Oregon prior to the 1840s have been harvested (Booth 1991; Teensma et al. 1991; Ripple 1994; Perry 1995). About 10 percent of pre-settlement old-growth forests remain in western Washington (Norse 1990;
Although the Northwest Forest Plan has reduced the rate of habitat loss on Federal lands, the threat of continued loss of suitable nesting habitat remains on Federal and non-Federal lands through timber harvest and natural events such as wildfire, insect outbreaks, and windthrow.

Natural disturbance has the potential to affect the amount and quality of murrelet nesting habitat. Wildfire and windthrow result in immediate loss of habitat and can also influence the quality of adjacent habitat. Global warming, combined with long-term fire suppression on Federal lands, may result in higher incidences of stand-replacing fires in the future (McShane et al. 2004). As forest fragmentation increases, the threat of habitat loss due to windthrow is likely to increase. In addition, insects and disease can kill complete stands of habitat and can contribute to hazardous forest fire conditions.

Between 1992 and 2003, the loss of suitable murrelet habitat totaled 22,398 acres in Washington, Oregon, and California combined, of which 5,364 acres resulted from timber harvest and 17,034 acres resulted from natural events (McShane et al. 2004). The data presented by McShane represented losses primarily on Federal lands, and did not include data for most private lands within the murrelets’ range. Habitat loss and fragmentation is expected to continue in the near future, but at an uncertain rate (McShane et al. 2004). Raphael et al. (2006) recently completed a change analysis for marbled murrelet habitat on both Federal and non-Federal lands for the period from 1992 to 2003, based on stand disturbance map data developed by Healey et al. (2003). Raphael et al. (2006) estimated that habitat loss ranging from 60,000 acres up to 278,000 acres has occurred across the listed range of the species, with approximately 10 percent of habitat loss occurring on Federal lands, and 90 percent occurring on non-Federal lands. The variation in the acreage estimates provided by Raphael et al. (2006) are dependant upon the habitat model used (Table 3) to evaluate habitat change over time.

Gains in suitable nesting habitat are expected to occur on Federal lands over the next 40 to 50 years, but due to the extensive historic habitat loss and the slow replacement rate of murrelets and their habitat, the species is potentially facing a severe reduction in numbers in the coming 20 to 100 years (U.S. Forest Service and U.S. Fish and Wildlife Service 1994b; Beissinger 2002). In addition to direct habitat removal, forest management practices can fragment murrelet habitat; this reduces the amount and heterogeneous nature of the habitat, reduces the forest patch sizes, reduces the amount of interior or core habitat, increases the amount of forest edge, isolates remaining habitat patches, and creates “sink” habitats (McShane et al. 2004). There are no estimates available for the amount of suitable habitat that has been fragmented or degraded since 1992. However, the ecological consequences of these habitat changes to murrelets can include effects on population viability and size, local or regional extinctions, displacement, fewer nesting attempts, failure to breed, reduced fecundity, reduced nest abundance, lower nest success, increased predation and parasitism rates, crowding in remaining patches, and reductions in adult survival (Raphael et al. 2002).
Predation

Predation is expected to be the principal factor limiting murrelet reproductive success and nest site selection (Nelson and Hamer 1995b; Ralph et al. 1995). Murrelets are believed to be highly vulnerable to nest predation compared to other alcids and forest nesting birds (Nelson and Hamer 1995b; U.S. Fish and Wildlife Service 1997a). Murrelets have no protection at nest sites other than the ability to remain hidden. Nelson and Hamer (1995b) hypothesized that small increases in murrelet predation will have deleterious effects on murrelet population viability due to their low reproductive rate (one egg clutches).

Known predators of adult murrelets in the forest environment include the peregrine falcon (Falco peregrinus), sharp-shinned hawk (Accipiter striatus), common raven (Corvus corax), northern goshawk (Accipiter gentilis), and bald eagle (Haliaeetus leucocephalus). Common ravens and Stellar’s jays (Cyanocitta stelleri) are known to take both eggs and chicks at the nest, while sharp-shinned hawks have been found to take chicks. Common ravens account for the majority of egg depredation, as they appear to be the only predator capable of flushing incubating or brooding adults from a nest (Nelson and Hamer 1995b). Suspected nest predators include great horned owls (Bubo virginianus), barred owls (Strix varia), Cooper’s hawks (Accipiter cooperi), northwestern crows (Corvus caurinus), American crows (Corvus brachyrhynchos), and gray jays (Perisoreus canadensis) (Nelson and Hamer 1995b; Nelson 1997; Manley 1999). Predation by squirrels and mice has been documented at artificial nests and these animals cannot be discounted as potential predators on eggs and chicks (Luginbuhl et al. 2001; Raphael et al. 2002; Bradley and Marzluff 2003).

Losses of eggs and chicks to avian predators have been determined to be the most important cause of nest failure (Nelson and Hamer 1995b; McShane et al. 2004). The risk of predation by avian predators appears to be highest in complex structured landscapes in proximity to edges and human activity, where many of the corvid (e.g., crows, ravens) species are in high abundance. Predation rates are influenced mainly by habitat stand size, habitat quality, nest placement (on the edge of a stand versus the interior of a stand), and proximity of the stand to human activity centers. The quality of murrelet nest habitat decreases in smaller stands because forest edge increases in relation to the amount of interior forest, while forest stands near human activity centers (less than 0.62 mi or 1 km), regardless of size, are often exposed to a higher density of corvids due to their attraction to human food sources (Marzluff et al. 2000). The loss of nest contents to avian predators increases with habitat fragmentation and an increase in the ratio of forest edge to interior habitat (Nelson and Hamer 1995b; McShane et al. 2004). For example, Nelson and Hamer (1995b) found successful nests were farther from edges (greater than 55 m) and were better concealed than unsuccessful nests.

The abundance of several corvid species has increased dramatically in western North America as a result of forest fragmentation, increased agriculture, and urbanization (McShane et al. 2004). It is reasonable to infer that as predator abundance has increased, predation on murrelet chicks and eggs has also increased, and murrelet reproductive success has decreased. It is also reasonable to assume that this trend will not be interrupted or reversed in the near future, as forest fragmentation, agriculture, and urbanization continue to occur.
Other Threats

Murrelets are subject to additional threats from diseases, genetics, low population numbers, and low immigration rates. To date, inbreeding (mating between close genetic relatives) and or hybridizing (breeding with a different species or subspecies) have not been identified as threats to murrelet populations. However, as abundance declines, a corresponding decrease in the resilience of the population to disease, inbreeding or hybridization, and other perturbations may occur. Additionally, murrelets are considered to have low recolonization potential because their low immigration rate makes the species slow to recover from local disturbances (McShane et al. 2004).

The emergence of fungal, parasitic, bacterial, and viral diseases has affected populations of seabirds in recent years. West Nile virus disease has been reported in California which is known to be lethal to seabirds. While the amount of negative impact this disease may bring is unknown, researchers agree that it is only a matter of time before West Nile virus reaches the Washington seabird population. Effects for murrelets from West Nile virus and other diseases are expected to increase in the near future due to an accumulation of stressors such as oceanic temperature changes, overfishing, and habitat loss (McShane et al. 2004).

Murrelets may be sensitive to human-caused disturbance due to their secretive nature and their vulnerability to predation. There are little data concerning the murrelet’s vulnerability to disturbance effects, except anecdotal researcher observations that indicate murrelets typically exhibit a limited, temporary behavioral response (if any) to noise disturbance at nest sites and are able to adapt to auditory stimuli (Singer et al. 1995 in McShane et al. 2005; Long and Ralph 1998; Golightly et al. 2002). In general, responses to auditory stimuli at nests sites have been modifications of posture and on-nest behaviors (Long and Ralph 1998). While the unique breeding biology of the murrelet is not conducive to comparison of the reproductive success of other species, studies on other alcid and seabird species have revealed detrimental effects of disturbance to breeding success and the maintenance of viable populations (Cairns 1980; Pierce and Simons 1986; Piatt et al. 1990; Beale and Monaghan 2004).

Research on a variety of other species, including other seabirds, indicate an animal’s response to disturbance follows the same pattern as its response to encountering predators, and anti-predator behavior has a cost to other fitness enhancing activities, such as feeding and parental care (Frid and Dill 2002). Some authors indicate disturbance stimuli can directly affect the behavior of individuals and indirectly affect fitness and population dynamics through increased energetic costs (Carney and Sydeman 1999; Frid and Dill 2002). Responses by murrelet adults and chicks to calls from corvids and other potential predators include no response, alert posturing, aggressive attack, and temporarily leaving a nest (adults only) (McShane et al. 2004). However, the most typical behavior of chicks and adults in response to the presence of a potential predator is to flatten against a tree branch and remain motionless (Nelson and Hamer 1995b; McShane et al. 2004). Therefore, researcher’s anecdotal observations of little or no physical response by murrelets are consistent with the behavior they will exhibit in response to a predator. In addition, there may have been physiological responses researchers cannot account for with visual observations. Corticosterone studies have not been conducted on murrelets, but studies on other
avian species indicate chronic high levels of this stress hormone may have negative consequences on reproduction or physical condition (Wasser et al. 1997; Marra and Holberton 1998 in McShane et al. 2004).

Although detecting effects of sub-lethal noise disturbance at the population level is hindered by the breeding biology of the murrelet, the effect of noise disturbance on murrelet fitness and reproductive success should not be completely discounted (McShane et al. 2004). In recently completed analyses, the Service concluded the potential for injury associated with disturbance (visual and sound) to murrelets in the terrestrial environment includes flushing from the nest, aborted feeding, and postponed feedings (U.S. Fish and Wildlife Service 2003). These responses by individual murrelets to disturbance stimuli can reduce productivity of the nesting pair, as well as the entire population (U.S. Fish and Wildlife Service 1997a).

**Conservation Needs**

The Recovery Plan outlines the conservation strategy for the species. In the short-term, specific actions necessary to stabilize the population include maintaining occupied habitat, maintaining large blocks of suitable habitat, maintaining and enhancing buffer habitat, decreasing risks of nesting habitat loss due to fire and windthrow, reducing predation, and minimizing disturbance.

Long-term conservation needs include increasing productivity (abundance, the ratio of juveniles to adults, and nest success) and population size; increasing the amount (stand size and number of stands), quality, and distribution of suitable nesting habitat; protecting and improving the quality of the marine environment; and reducing or eliminating threats to survivorship by reducing predation in the terrestrial environment and anthropogenic sources of mortality at sea. The Service estimates recovery of the murrelet will require at least 50 years (U.S. Fish and Wildlife Service 1997a).

The Recovery Plan states that four of the six Conservation Zones (Zones) must be functional in order to effectively recover the murrelet in the short- and long-term; that is, to maintain viable populations that are well-distributed. However, based on the new population estimates, it appears only three of the Zones contain relatively robust numbers of murrelets (Zones 1, 3, and 4). Zones 1 and 4 contain the largest number of murrelets compared to the other four Zones. This alone would seem to indicate a better condition there, but areas of concern remain. For example, the population in Zone 4 was impacted when oil spills killed an estimated 10 percent of the population (Bentivoglio et al. 2002; Ford et al. 2002), small oil spills continue to occur in Zone 1, and the juvenile ratios in both of these Zones continue to be too low to establish stable or increasing populations (Beissinger and Peery in litt. 2003).

Murrelets in Zones 3, 5, and 6 have suffered variously from past oil spills which killed a large number of murrelets (Zone 3) (Ford et al. 2001), extremely small population sizes (Zones 5 and 6), and alarmingly low reproductive rates (Zone 6) (Peery et al. in litt. 2002). These factors have brought the status of the species to a point where recovery in Zones 5 and 6 may be precluded.
(Beissinger 2002). The poor status of murrelet populations in the southern Zones emphasizes the importance of supporting murrelet populations in Zones 1 and 2 in order to preserve the opportunity to achieve murrelet recovery objectives.

Conservation Strategy

Marine Environment

Protection of marine habitat is a component of the recovery strategy. The main threat to murrelets in the marine environment is the loss of individuals through death or injury, generally associated with oil spills and gill-net entanglements. The recovery strategy recommends providing protection within marine waters in such a way as to reduce or eliminate murrelet mortality (U.S. Fish and Wildlife Service 1997a). The recovery strategy specifically recommends protection within all waters of Puget Sound and Strait of Juan de Fuca, and within 1.2 mi of shore along the Pacific Coast from Cape Flattery to Willapa Bay. However, newer information indicates the majority of murrelet activity along the Washington Coast occurs within 5 mi (8 km) of shore (Raphael et al. 2007), suggesting that protections should be extended to encompass this area. Management strategies could include exclusion of vessels, stricter hull requirements, exclusion of net fisheries, or modification of fishing gear.

In Washington State, the Washington Fish and Game Commission requires the use of alternative gear (i.e., visual alerts within the upper 7 ft of a multifilament net), prohibits nocturnal and dawn fishing for all non-treaty gill-net fisheries, and closes areas to gill-net fishing in order to reduce by-catch of murrelets. The Olympic Coast National Marine Sanctuary was established in 1994 along the outer Washington coast from Cape Flattery south to approximately the Copalis River and extending between 25 mi and 40 mi offshore. Oil exploration and development are prohibited within this Sanctuary (U.S. Department of Commerce 1993).

Terrestrial Habitat Management

The loss of nesting habitat (old-growth/mature forest) has generally been identified as the primary cause of the murrelet population decline and disappearance across portions of its range (Ralph et al. 1995). Logging, urbanization, and agricultural development have all contributed to the loss of habitat, especially at lower elevations.

The recovery strategy for the murrelet is contained within the Marbled Murrelet Recovery Plan (Recovery Plan) (U.S. Fish and Wildlife Service 1997a) relies heavily on the Northwest Forest Plan (NWFP) to achieve recovery on Federal lands in Washington, Oregon, and California. However, the Recovery Plan also addresses the role of non-Federal lands in recovery, including Habitat Conservation Plans, State forest practices, and lands owned by Native American Tribes. The importance of non-Federal lands in the survival and recovery of murrelets is particularly high in Conservation Zones, where Federal lands, and privately held conservation lands (e.g., The Nature Conservancy Teal Slough, Elsworth, Washington), within 50 mi of the coastline are sparse, such as the southern half of Conservation Zone 2.
Lands considered essential for the recovery of the murrelet within Conservation Zones 1 and 2 are 1) any suitable habitat in a Late Successional Reserve (LSR), 2) all suitable habitat located in the Olympic Adaptive Management Area, 3) large areas of suitable nesting habitat outside of LSRs on Federal lands, such as habitat located in the Olympic National Park, 4) suitable habitat on State lands within 40 mi of the coast, and 5) habitat within occupied murrelet sites on private lands (U.S. Fish and Wildlife Service 1997a).

Northwest Forest Plan

When the U.S. Forest Service (USFS) and Bureau of Land Management incorporated the NWFP as the management framework for public lands, a long-term habitat management strategy for murrelets (U.S. Forest Service and Bureau of Land Management 1994a,b) was established. The NWFP instituted pre-project surveys of murrelet habitat in areas planned for timber harvest and the protection of existing habitat at sites determined through surveys to be occupied by murrelets. In the short-term, all known-occupied sites of murrelets occurring on USFS or Bureau of Land Management lands under the NWFP are to be managed as Late Successional Reserves (LSRs). In the long-term, unsuitable or marginally suitable habitat occurring in LSRs will be managed, overall, to develop late-successional forest conditions, thereby providing a larger long-term habitat base into which murrelets may eventually expand. Thus, the NWFP approach offers both short-term and long-term benefits to the murrelet.

Over 80 percent of murrelet habitat on Federal lands in Washington occurs within land management allocations that protect the habitat from removal or significant degradation. Scientists predicted implementation of the NWFP would result in an 80 percent likelihood of achieving a well-distributed murrelet population on Federal lands over the next 100 years (U.S. Forest Service and U.S. Fish and Wildlife Service 1994b). Although the NWFP offers protection of known-occupied murrelet sites, concerns over the lingering effects of the historic widespread removal of suitable habitat will remain until the habitat recovers to late-successional characteristics. Habitat recovery will require over 100 years in many LSRs.

Habitat Conservation Plans

Four Habitat Conservation Plans (HCP) addressing murrelets in Washington have been completed for private/corporate forest land managers within the range of the murrelet: West Fork Timber Corporation (Murray Pacific Corporation 1993, 1995; U.S. Fish and Wildlife Service 1995) (Mineral Tree Farm HCP); Plum Creek Timber Company (Plum Creek Timber Company 1996, 1999; U.S. Fish and Wildlife Service 1996b, 1999) (Cascades HCP, I-90 HCP); Port Blakely Tree Farms, L.P. (Port Blakely Tree Farms 1996; U.S. Fish and Wildlife Service 1996c) (R.B. Eddy Tree Farm HCP); and Simpson Timber Company (Simpson Timber Company 2000; U.S. Fish and Wildlife Service 2000a) (Olympic Tree Farm HCP). Habitat Conservation Plans have also been completed for two municipal watersheds, City of Tacoma (Tacoma Public Utilities 2001; U.S. Fish and Wildlife Service 2001) (Green River HCP) and City of Seattle (U.S. Fish and Wildlife Service 2000b; City of Seattle 2001) (Cedar River HCP), and the Washington Department of Natural Resources (U.S. Fish and Wildlife Service 1997b) (WDNR HCP). The
HCPs which address murrelets cover approximately 500,000 acres of non-Federal (private/corporate) lands, over 100,000 acres of municipal watershed, and over 1.6 million acres of State-managed lands. However, only a portion of these lands contain suitable murrelet habitat.

The WDNR HCP addresses murrelets in Conservation Zones 1 and 2. All of the others address murrelets in Conservation Zone 1. Most of the murrelet HCPs in Washington employ a consistent approach for murrelets by requiring the majority of habitat to be surveyed prior to timber management. Only poor-quality marginal habitat (with a low likelihood of occupancy) is released for harvest without survey. All known occupied habitat is protected to varying degrees, but a "safe-harbor-like" approach is used to address stands which may be retained as, or develop into, suitable habitat and become occupied in the future. This approach would allow future harvest of habitat which is not currently nesting habitat.

*Washington State Forest Practices Regulations*

Under Washington Forest Practices Rules, which apply to all non-Federal lands not covered by an HCP (WFPB 2005), surveys for murrelets are required prior to the harvest of suitable nesting habitat. These criteria vary depending on the location of the stand. For stands found to be occupied or known to be previously occupied, the WDNR makes a decision to issue the permit based upon a significance determination. If a determination of significance is made, preparation of a State Environmental Policy Act Environmental Impact Statement is required prior to proceeding. If a determination of non-significance or mitigated determination of non-significance is reached, the action can proceed without further environmental assessment. (A more detailed discussion of the Washington Forest Practices regulations is provided in the murrelet Environmental Baseline).

*Tribal Management*

The management strategy of the Bureau of Indian Affairs for the murrelet focuses on working with Tribal governments on a government-to-government basis to develop management strategies for reservation lands and trust resources. The Bureau of Indian Affairs' management strategy typically focus on avoiding harm to murrelets when feasible, to facilitate the trust responsibilities of the United States. However, other factors must be considered. Strategies must foster Tribal self-determination, and must balance the needs of the species and the environmental, economic, and other objectives of Indian Tribes within the range of the murrelet (Renwald in litt. 1993). For example, one of the Bureau of Indian Affairs' main goals for murrelet protection includes assisting Native American Tribes in managing habitat consistent with tribal priorities, reserved Indian rights, and legislative mandates.

*Summary*

Demographic modeling results indicate murrelet populations are declining within each Conservation Zone and throughout the listed range. The juvenile to adult ratios observed at sea in the Conservation Zones are too low to obtain a stable population in any Conservation Zone, which indicates murrelet abundance in all Conservation Zones will continue to decline until
reproductive success improves. In other words, there is insufficient recruitment of juveniles to sustain a murrelet population in the listed range of the species.

Some of the threats to the murrelet population may have been reduced as a result of the species’ listing under the Act, such as the passage of the Oil Pollution Act and implementation of the NWFP. However, no threats have been reversed since listing and in some areas threats, such as predation and West Nile Virus, may be increasing or emerging. Threats continue to contribute to murrelet population declines through adult and juvenile mortality and reduced reproduction. Therefore, given the current status of the species and background risks facing the species, it is reasonable to assume that murrelet populations in Conservation Zones 1 and 2 and throughout the listed range have little resilience to deleterious population-level effects and are at high risk of extirpation.

Considering the life history characteristics of the murrelet, with the aggregate effects of inland habitat loss and fragmentation and at-sea mortality, the species’ capability to recover from lethal perturbations at the population or metapopulation (Conservation Zone) scale is extremely low. The low observed reproductive rates make the species highly susceptible to local extirpations when exposed to repeated perturbations at a frequency which exceeds the species’ loss-replacement rate. Also troublesome is the ineffectiveness of recovery efforts at reversing the ongoing lethal consequences in all demographic classes from natural and anthropogenic sources. Despite the relatively long potential life span of adult murrelets, the annual metapopulation replacement rates needed for long-term metapopulation maintenance and stability is currently well below the annual rate of individuals being removed from each metapopulation. As a result, murrelet metapopulations are currently not self-sustaining or self-regulating.

Accordingly, the Service concludes the current environmental conditions for murrelets in the coterminous United States appear to be insufficient to support the long-term conservation needs of the species. Although information is not sufficient to determine whether murrelets are nesting at or near the carrying capacity in the remaining nest habitat, activities which degrade the existing conditions of occupied nest habitat or reduce adult survivorship and/or nest success of murrelets will be of greatest consequence to the species. Actions resulting in the further loss of occupied nesting habitat, mortality to breeding adults, eggs, or nestlings will reinforce the current murrelet population decline throughout the coterminous United States.

ENVIRONMENTAL BASELINE (in the action area)

Regulations implementing the Act (50 CFR section 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects in the action area that have undergone section 7 consultation, and the impacts of State and private actions which are contemporaneous with the consultation in progress.
As described earlier in the Project Description, the action area includes the marine site where the four buoys will be located, an area approximately 625 ft by 450 ft, or approximately 7 acres. The action area also includes a 3.7-mile corridor from one of the buoys (i.e., the collection buoy that transmits electricity from all four buoys) to the shore on Hobuck Beach. This corridor includes the electrical transmission line that will be attached to the ocean floor, but the corridor also includes the travel ways for boats and barges during the construction and maintenance of the offshore buoys. In addition, the travel ways to and from port (Port Angeles and Neah Bay) for boats and barges to the marine site are part of the action area. Finally, the action area includes the terrestrial site for the electrical substation on Hobuck Beach. Within the action area, noise, sediment, and electro-magnetic fields may emanate from the construction and operation of the buoys and/or transmission line. These additional areas are also considered part of the action area.

Hobuck Beach on Makah Bay (i.e., the western coast of the northwestern corner of the Olympic Peninsula) is mostly undeveloped. There are a few access roads near the shoreline and beach but there are no other significant structures or developments. The area from the shoreline out to the marine site, where the buoys will be anchored 3.7 miles offshore, is open marine water with no developments. The marine site is located within the Sanctuary and also within the Flattery Rocks National Wildlife Refuge.

**Status of Marbled Murrelets in the Action Area**

The action area is at the northernmost end of Conservation Zone 2, as identified in the Marbled Murrelet Recovery Plan (U.S. Fish and Wildlife Service 1997a), along the northwest corner of the Olympic Peninsula. As described in the Status of the Species, the population estimate of marbled murrelets in Zone 2, as of 2003, was 3,400 birds, based on at-sea surveys. More recent estimates from Lance and Pearson (2007) indicate there are 2,381 marbled murrelets (95% confidence interval - 1,672 - 3,430) on the Washington Coast (Zone 2). The northern part of Zone 2 has a higher number and density of birds than the southern part, because the majority of available nesting habitat occurs in the northern part of Zone 2. The action area surrounding the portion of the project that is on shore (i.e., adjacent to the electrical substation) is not likely to be used by marbled murrelets because the area surrounding the substation has a few beach access roads nearby and also there is no contiguous mature forest habitat for more than 0.5 mile that would serve as suitable marbled murrelet habitat. Beyond the on-shore action area, greater than 0.5 mile inland, there are relatively large, contiguous blocks of mature forest habitat that would provide suitable marbled murrelet habitat and that may be occupied by marbled murrelets.

At-sea surveys have been conducted annually in the action area since 2000 by WDFW and other cooperators (Lance and Pearson 2007) following the methods developed by the Marbled Murrelet Effectiveness Monitoring program (Raphael et al. 1999, 2004; Miller et al. 2006). Marbled murrelets are surveyed each year from mid-May through the end of July. Within Conservation Zone 2, the action area is further identified by the WDFW survey protocol as Stratum 1 which extends from the northwest tip of Washington south to Point Grenville at the southern end of the Quinault Indian Reservation. Stratum 1 is further divided into Primary Sampling Units (PSU). The action area overlaps portions of PSU 1 and PSU 2, but is entirely encompassed within these two PSUs (Figure 3). Each PSU has two survey units: a nearshore unit and an offshore unit.
The nearshore unit begins approximately 0.22 miles (351 meters) from shore and extends out to approximately 0.93 miles (1,500 meters) offshore. The offshore unit begins where the nearshore unit ends and extends out to approximately 3.11 miles (3,500 meters) offshore. Between 2004 and 2006, the number of marbled murrelets observed in PSU 1 and PSU 2 ranged from zero to 28 birds per sampling effort (Table 2, Lance and Pearson 2007). The density of marbled murrelets in Stratum 1 ranged from 0.47 to 1.33 birds per m$^2$ (1.23 to 3.44 birds per km$^2$), as estimated from surveys from 2000 through 2006 (Table 3, Lance and Pearson 2007). No observations of juvenile marbled murrelets were observed during the 2005 and 2006 at-sea surveys (Lance and Pearson 2007).

Survey efforts described above end at approximately 3.11 miles offshore. However, it is expected that the density of marbled murrelets at 3.7 miles offshore (where the buoys would be located) would be the same or slightly less (Scott Pearson, WDFW, 2008, pers. comm. via phone with Sally Butts). We note that the surveys by Lance and Pearson (2007) are intended to establish density and population estimates and are not designed to establish the distribution or extent of marbled murrelets off the coast of Washington. Further, the surveys by Lance and Pearson (2007) are conducted only from mid-May through the end of July. Marbled murrelet densities could be more or less at other times of the year and in different years. Thompson (1999) found densities substantially higher and lower than Lance and Pearson (2007) off the coast of Washington during winter surveys. However, for the purpose of the environmental baseline and effects analyses in this Opinion, we assume that densities of marbled murrelets are those described above for Stratum 1 and reported in Lance and Pearson (2007). Finally, the depth of water at the offshore buoy site is approximately 150 feet and within the range of water depths for foraging marbled murrelets and their prey fish (see Status of Species for more information).

The action area consists of an approximately 7-acre marine site where the buoys will be located along with a 3.7-mile transmission line where construction and boat and barge traffic will take place. Assuming a corridor of 1 mile in width from the shoreline on Hobuck Beach out to the marine site, the action area is approximately 3.7 m$^2$ (9.58 km$^2$). Extrapolating (i.e., scaling down) the density information in the above paragraphs to the size of the action area, the Service estimates that 12 to 33 marbled murrelets may occur in the action area at any given time.
Conservation Role of the Action Area

The action area provides marine habitat for marbled murrelet courtship and breeding activities, loafing behavior, foraging by adults and juveniles, and foraging by adults for chicks on-shore on nest trees. The Status of the Species identifies the juvenile to adult ratios observed at sea as too low to obtain a stable population of marbled murrelets in any of the Conservation Zones, including Zone 2. No juveniles were observed in the action area, which falls within Zone 2, during at-sea surveys in 2005 and 2006 (Lance and Pearson 2007). Because there is a larger concentration of marbled murrelets in the northern portion of Conservation Zone 2 (U.S. Fish and Wildlife Service 1997a), which includes the action area, the conservation role of the action area is to provide marine habitat that supports breeding and foraging opportunities to increase juvenile survivorship and recruitment.
Condition of the Action Area

The action area is entirely within the Olympic Coast National Marine Sanctuary and overlaps a portion of the Flattery Rocks National Wildlife Refuge as well as Makah Nation’s usual and accustomed fishing grounds. Within the sanctuary and refuge, there is a limited amount of ongoing boat activity to conduct research and monitoring of natural resources (National Oceanic and Atmospheric Administration 2007).

The Status of the Species provides a general discussion of threats to marbled murrelets in the terrestrial and marine environment. In the action area, there is ongoing commercial, subsistence, and recreational fishing for a variety of fish and other marine species. An annual report of fisheries is produced by the National Oceanic and Atmospheric Administration (72 FR 66048 [November 27, 2007]). Off the coast of Washington and Oregon, there are gillnet fisheries for herring, smelt, shad, sturgeon, bottom fish, mullet, perch, and rockfish; purse seining for sardine, herring, smelt, squid, and salmon (Washington only); longline/set line for North Pacific halibut; and shrimp pot trap. Off the coast of Washington, Oregon, and California, there are salmon troll fisheries, groundfish and bottomfish longline/set line fisheries, and groundfish trawl. Additionally, the Makah Nation conducts a gillnet fishery off the Washington coast and within the action area.

Between 2005 and 2007, the Olympic Coast Marine Sanctuary, in cooperation with the Makah Tribe and the Northwest Straits Commission, conducted a derelict fishing gear removal project near Neah Bay (Natural Resources Consultants, Inc. 2007). Three derelict gillnets and one derelict purse seine net were removed during the project. In 2005, two crab pots were removed and other crab pots and crab lines also were identified during the survey work. No entangled animals were found in the purse seine that was removed but a total of 52 animals (17 live and 35 dead) were entangled in the two gillnets that were removed. Of the dead animals, there was one California sea lion (Zalophus californianus), one harbor porpoise (Phocoena phocoena), and six dead harbor seals (Phoca vitulina). Eight dead seabirds also were removed from the two gillnets including three dead cormorants (Phalacrocoracidae spp.) and five common loons (Gavia immer). The remaining dead animals were fish.

The project report indicates that derelict fishing gear is not a significant long-term threat to the Olympic Coast National Marine Sanctuary. The four nets that were removed were in water depths ranging from 18 to 45 ft indicating they were in the nearshore environment. Also, the depths of water where surveys took place ranged from 10 to 105 ft. The report acknowledged that derelict survey and removal work generally should not be attempted in exposed waters of the Olympic Coast National Marine Sanctuary when ocean conditions meet or exceed Beaufort sea condition scale 5 or higher (20 knots of wind, 1 meter of wave height). These exposed waters would describe the 3.7-mile offshore marine site where the buoys would be anchored in water depths of approximately 150 ft where surveys have not been conducted. Based on the extent of fisheries off the coast of Washington, we acknowledge that it is possible for derelict fishing gear to become snagged on the buoys and mooring lines in the action area.
The Makah Nation has conducted one official whaling event in 1999 and has a pending application for a waiver from the Marine Mammal Protection Act to conduct future whaling activities (Makah Nation 2007). The Makah Nation also conducts commercial forestry operations and is currently engaged in consultation, through the Bureau of Indian Affairs, with the Service on an action to harvest timber on Makah tribal lands that may affect marbled murrelets.

The condition of the action area also is affected by broader environmental threats, such as chemical pollution (i.e., oil spills) and climate change (Snover et al. 2005). Marbled murrelets are affected by chemical pollution and climate change in the marine environment in ways that affect the food chain, ocean temperatures, and water quality. However, the specific effects to marbled murrelets and marbled murrelet marine habitat are not well understood.

**EFFECTS OF THE ACTION**

**Site Construction, Installation, Decommissioning**

**Boat and Barge Transport**

During the first year of the project, boats and barges would be used to transport equipment (buoy components, mooring lines, and anchors) from shore to the marine site approximately 3.7 miles offshore. Multiple transport trips would be made between June and September when the waters are the calmest for installation of the buoys. Additionally, the installation of the electrical transmission line from shore out to the marine site would require boat and barge transport of equipment during the same time of year. The buoys would be transported to the offshore marine site either by towing the buoys or transporting them to the site aboard crane-equipped buoy tender vessels. For the purpose of analyzing the effects of boat and barge transport on marbled murrelets, we assume that several support boats and one barge would be used during construction, installation, and decommissioning.

Marbled murrelet adults and juveniles are known to be on the water in the action area during the time of project construction and installation, between June and September. Several construction vessels (i.e., boats and a barge) would likely travel in the vicinity of marbled murrelets on the water engaging in foraging and loafing activities. Foraging activities would include adults and juveniles foraging for prey fish to feed themselves and also adults foraging to feed chicks on nests in trees in the terrestrial environment. Additionally, it is possible for courtship activities between adults to be disrupted by construction vessel activities. Disturbance to marbled murrelets would be from the visual, sound, and physical presence of construction vessels.

To reduce the risk of construction vessels disturbing or colliding with marbled murrelets on the water, Finavera has committed to having an observer on board construction vessels to note when marbled murrelets are within 1,000 ft. Per the conservation measures in the Project Description, protocols will be defined in consultation with the Service and other resource agencies for altering or shutting down construction and installation if marbled murrelets are observed within 500 ft of...
a vessel, including defining speed restrictions for construction vessels entering and leaving Makah Bay. Although we expect this conservation measure to reduce the risk of adverse effects to marbled murrelets, protocols established to survey for marbled murrelets in the marine environment (Raphael 1999, 2004; Miller et al. 2006) would require a substantially greater effort to effectively detect marbled murrelets in various weather conditions and at distances greater than 164 ft (50 meters) from construction vessels. It is possible that some marbled murrelets will be missed by the one observer on board construction vessels and that construction vessels may be traveling at speeds greater than 10 knots per hour, the limit established in survey protocols to detect marbled murrelets on the water. As such, it is possible that several boats and a barge could disturb marbled murrelet adults and juveniles on the water from June through September.

In a study of marbled murrelets following the Exxon Valdez oil spill, the number of marbled murrelets showed a negative relationship with boat traffic during offshore surveys (Kuletz 1996). At one study location, the number of murrelets dropped from > 60 marbled murrelets with zero or one boat observed on or near survey transects to < 20 murrelets with three up to eight boats. The other survey location showed the drop from > 35 murrelets with zero or one boat observed to < 3 murrelets with three or four boats.

Speckman et al. (1996) conducted a study of marbled murrelet response to small boat traffic. They observed that most marbled murrelets paddled away from the boats or dove into the water to avoid the boats. Only a few birds flew away in reaction to the boats. However, they observed eight separate events where marbled murrelets were holding fish in their bills and swallowed the fish when approached within 16 to 131 ft (4 to 5 to 40 meters) by the survey boats. This reaction to approaching boats is noteworthy in that marbled murrelets observed on the water holding fish in their bills are thought to be waiting for the appropriate time of day (dusk or dawn) to deliver the fish to chicks on inland nests (Carter and Sealy 1987; Strachan et al. 1995). An adult breeding marbled murrelet must catch an appropriate size and species of fish, possibly hold it in its bill until dawn or dusk, then fly inland to a nest that may be up to 52 miles away in Washington (Evans-Mack et al. 2003). If the marbled murrelet swallows the fish instead of delivering the fish to a chick on the nest, boat activity could result in a delayed feeding attempt.

In addition to the above potential effects, marbled murrelets undergo a flightless molt approximately between August and October. Any construction vessels that encounter marbled murrelets between August through September, when construction activities would take place, could have adverse effects on individual molting birds because they would be limited to paddling or diving away from construction vessels. At the end of the project operations, it is expected that the marine site would be decommissioned and construction vessel effects would be similar to those noted above for project construction and installation.

Based on the information in the Environmental Baseline on the estimated number of marbled murrelets in the action area and our understanding of marbled murrelet responses, the Service anticipates that marbled murrelet adults and juveniles will be exposed to boat and barge traffic during the first and last year of the project when site construction and decommissioning would occur. At this time, we cannot establish a likelihood that this potential for disturbance will significantly disrupt normal behaviors.
Vertical Load Anchor Installation

The four buoys will be anchored to the seafloor with Vertical Load Anchors (Figure 1). The installation of the anchors will occur along with installation of the buoys, between June and September of the first year of the project. Ten VLAs in total will be installed in the seafloor between and at the ends of the four buoys. The VLAs will be embedded into and below the seafloor so the only area of the surface of the seafloor occupied by the VLAs will be the diameter of the cable that connects each embedded VLA to each mooring float. The installation of the VLAs will be in substrate composed mostly of silt and sand. Although the design and installation of VLAs is expected to create less environmental impact to the seafloor than traditional anchoring methods and equipment, some turbidity near the seafloor is expected during the installation of the VLAs. Once the VLAs are securely embedded in the seafloor, silt and sand would be expected to settle quickly and waters near the seafloor and VLAs would not remain turbid through the life of the project. The same turbidity effects would be expected when the VLAs are removed from the seafloor when the project is decommissioned.

The short-term generation of turbid waters during VLA installation and decommissioning would have insignificant effects on marbled murrelets and forage fish because the turbidity would be near the seafloor and persist for only a short amount of time (i.e., sporadically within a month during summer at the beginning and ending of the project).

Transmission Line Installation and Horizontal Directional Drilling

The transmission line, approximately 8 inches in diameter, from the shore substation to the marine site will be secured to the seafloor with two different methods. From the shore out to approximately 98 ft in water depth and about 1,200 ft from shore, the transmission line will be installed subsurface using HDD to minimize impacts to the nearshore seafloor. Beyond the area of HDD installation, the remainder of the transmission line will be anchored to the seafloor mostly in silt and sand, with a few anchor points in hard substrates and rocks.

The HDD work is expected to create localized turbidity near the HDD entry and exit routes for several days during the summer months. Also, during the summer months, the anchoring of the remainder of the transmission line out to the buoys would also create some turbidity in the water as sand and silt on the seafloor is disturbed. This portion of the transmission line also has the potential to continue to create some turbidity throughout the life of the project as the transmission line would be buried and uncovered by sand and silt from daily and seasonal shifts in the seafloor. Any slack in the transmission line would be expected to increase the potential for localized turbidity when the seafloor naturally shifts and settles.

The presence of construction vessels for the installation of the transmission line including HDD is addressed above in the Boat and Barge Transport section of effects. The turbidity generated from the installation, anchoring, and the HDD of the transmission line is not expected to significantly disrupt normal behaviors of individual marbled murrelets and forage fish because turbidity would be near the seafloor and persist for only a short amount of time, up to two months.
during the summer. Decommissioning of the transmission line would result in similar insignificant effects on marbled murrelets at the end of the life of the project.

On-Shore Substation

The effects to individual marbled murrelets and marbled murrelet habitat from the construction of the on-shore electrical substation are discountable. Although the location of the substation is along a mostly undeveloped stretch of Hobuck Beach on Makah Bay, there is no contiguous mature forest habitat within 0.5 mile of the substation location. The specific footprint where the substation will be located will not remove any forested habitat except possibly some woody shrub vegetation or a few individual trees. Sound and visual disturbance to marbled murrelets from the construction of the substation is unlikely because of the distance to contiguous mature forest habitat, greater than 0.5 mile from the substation location. No effects to marbled murrelets are anticipated from the ongoing existence and operation of the substation.

Buoy Operations

The day-to-day operation of the four buoys and the presence of the mooring lines and transmission line to shore have the potential to adversely affect marbled murrelets.

Noise

The four buoys have the potential to generate noise, both above and below the water surface. Also, there is an internal turbine within each buoy and also two hydraulic hose pumps that circulate pressurized water within an acceleration tube in each buoy. Additionally, the mooring lines and transmission line have the potential to generate noise, though it is expected to be substantially less than noise associated with the buoys. Because there are no available data on the noise that would be generated with the buoys and the specific internal equipment within each buoy, as well as the mooring lines and transmission line, Finavera will be required by the Commission to conduct an on-site noise assessment within the first year of project operation.

Marbled murrelets could be affected by the noise, both above and below the water surface, generated from the buoys, mooring lines, and transmission line. Additionally, marbled murrelet forage fish could also be affected by noise below the water surface. Both adult and juvenile marbled murrelets could be disturbed while engaging in foraging, loafing, and courtship activities within the action area throughout the 5-year license term of the project. The Commission’s Environmental Assessment for this project indicates that noise generated from the buoys, mooring lines, and transmission line is expected to range from 90 to 160 decibels (dB) based on information from off-shore wind turbines and barge traffic during construction of off-shore facilities. The Environmental Assessment also notes that it is expected that noise from the project would be more likely to occur at the lower end of the decibel range and project noise would be dampened by ambient ocean noise.

There is very little information on the effects of sound, both above water and underwater, on marbled murrelets. Anecdotal information collected during monitoring of a pile diving project
on Hood Canal, Washington, revealed a behavioral response with a pigeon guillemot (Cepphus columba), an alcid related to marbled murrelets (Entrainco and Hamer Environmental 2005). The bird dove within 246 ft (75 meters) of the pile driving activity, presumably to forage, and quickly surfaced and was observed having difficulty getting airborne and shook its head. The bird eventually flew away from the project area, but probably experienced an increased vulnerability to aerial predators and temporarily reduced foraging efficiency. Other information on sound effects comes from studies of fish. Turpenny et al. (1994) demonstrated an avoidance reaction in brown trout when the fish were exposed to sound above 150 dB. Their report references Hastings’ safe limit recommendation to avoid injury to fish as 150 dB. Fewtrell (2003) showed behavioral responses (e.g., faster swimming speeds, tighter grouping of fish) when fish were exposed to sound levels that exceeded 158 dB. For the purpose of analyzing the effects of noise from buoy operations on marbled murrelets, we assume that noise louder than 150 dB would significantly disrupt behaviors of marbled murrelet adults and juveniles engaged in foraging, loafing, and courtship activities within the action area.

We assume that noise generated from the project will be at the lower end of the range of 90 to 160 dB, that project noise would be dampened by ocean noise, and we do not expect the project noise to exceed the 150 dB threshold where we would anticipate adverse effects to marbled murrelets. Although marbled murrelets may be present during the proposed action, the duration of disturbance and characteristics of the sound generated are extremely unlikely to measurably affect marbled murrelets. Also, Finavera’s on-site noise assessment that would be conducted within the first year of project operations would include measures to modify the project if noise exceeds the levels anticipated in the Commission’s Environmental Assessment. As such, we expect noise effects to marbled murrelets to be discountable.

Electromagnetic Fields

The proposed 12-kV transmission cable, that connects the buoys to the on-shore substation, would transmit direct current of up to 1 MW with an average of 0.184 MW. The cable would contain a metal sheath to prevent or limit the emission of electric fields. Additional electrical cables would transmit alternating current from the proposed generating buoys to the collector buoy that connects to the transmission line then to the shore substation. These cables would transmit a maximum of 250 kW each. The Commission’s Environmental Assessment (page 59) cites a modeling exercise conducted by the U.S. Army Corps of Engineers that found that magnetic fields attenuated to background levels within about 10 to 20 ft above the seafloor of a 33-kV and a 115-kV cable, each buried to a depth of 6 ft. Although the proposed project would only bury the transmission cable for approximately 1,200 ft with HDD methods, the modeling exercise also looked at cables emitting magnetic fields well above the proposed project’s 12-kV cable.

Both the transmission cable and the cables connecting the buoys to the transmission cable may generate some electromagnetic field within some distance of the cables. However, the effects to marbled murrelets and forage fish are expected to be insignificant and discountable because (1) the transmission line would contain a metal sheath to limit the emission of electric fields, (2) the electromagnetic fields are expected to attenuate to background levels within tens of feet from the
cable, and (3) the main transmission cable (with the greatest potential for electromagnetic effects) is along the seafloor.

Entanglement

Derelict fishing gear and the entanglement of marine mammals, fish, seabirds, and other marine organisms occurs in Washington waters within Puget Sound and also on the outer Washington coast (Natural Resources Consultants, Inc. 2007; Northwest Straits Foundation 2007). As described in the Environmental Baseline section, an annual report of fisheries is produced by the National Oceanic and Atmospheric Administration (72 FR 66048 [November 27, 2007]). Off the coast of Washington and Oregon, there are gillnet fisheries for herring, smelt, shad, sturgeon, bottom fish, mullet, perch, and rockfish; purse seining for sardine, herring, smelt, squid, and salmon (Washington only); longline/set line for North Pacific halibut; and shrimp pot/trap. Off the coast of Washington, Oregon, and California, there are salmon troll fisheries, groundfish and bottomfish longline/set line fisheries, and groundfish trawl. Additionally, the Makah Nation gillnets off the Washington coast and within the action area.

As addressed in the Status of the Species section, all of these fisheries have the possibility of losing gear. The derelict fishing gear removal project near Neah Bay, described in the Environmental Baseline, found dead marine mammals and dead seabirds (including cormorants and loons) entangled in gillnets (Natural Resources Consultants, Inc. 2007). It is possible that foraging marbled murrelets that dive for forage fish at the location of the buoys and mooring lines could become entangled and die in derelict gear that snags on the buoys or mooring lines. We acknowledge that it is also possible that animals found in derelict gear could become entangled prior to the derelict gear snagging on the buoys and mooring lines and further that entangled animals would likely decompose or be eaten by other marine animals prior to identifying or removing the derelict gear. The Service expects that entanglement of derelict fishing gear is more likely with the buoys and the array of mooring lines than with the transmission line. However, both situations are possible.

The Commission is requiring Finavera to remove derelict fishing gear from the project area prior to project construction and implementation. Also, Finavera is committed to conducting bi-annual visits to the buoys for the purposes of retrieving entangled derelict fishing gear from the buoys mooring and anchoring system. This measure will help to reduce the length of time that gear, if found, would be entangled on the project components. However, once the buoys and mooring lines are installed, newly snagged derelict fishing gear could persist for weeks or months before the bi-annual visits (i.e., inspections) take place during the life of the project. Marbled murrelets are expected to forage in the vicinity of the buoys and mooring lines throughout the year. Also, it is possible that the project components could attract forage fish, similar to the creation of an artificial reef. During the time between bi-annual visits to the buoys, foraging marbled murrelets, as well as other marine life, exposed to the derelict and snagged fishing gear could become entangled, die and decompose before a bi-annual visit would take place.
We acknowledge the possibility of net entanglement on the project components and subsequent entanglement of a marbled murrelet in snagged derelict fishing gear. However, at this time, we cannot establish a likelihood of this occurring.

**Anti-fouling Compounds and Fuel Spills**

Anti-fouling compounds are proposed to be applied to all in-water project components to prevent or reduce marine growth and decay of project components. As noted in the Commission’s Environmental Assessment, anti-fouling compounds are known to be harmful to non-target marine organisms, especially in areas where anti-fouling compounds become concentrated (e.g., marinas where boats congregate). The Commission also notes that Finavera will seek resource agency approval of the anti-fouling compounds that will be used. Even so, anti-fouling compounds used in the proposed project could be harmful to marbled murrelets, particularly through food chain effects of marbled murrelets eating forage fish and forage fish eating smaller marine organisms that would be expected to be the most susceptible to the toxic effects of anti-fouling compounds. However, the effects to marbled murrelets are expected to be insignificant and discountable because of the relatively small footprint of the project area and the limited potential for anti-fouling compounds to concentrate and cause toxic effects to marbled murrelets and forage fish.

Fuel leaks or spills would not occur with the buoys or other project equipment. The buoy design is a closed-loop freshwater hydraulic system that does not use fuels or hydraulic (oil) fluids. The only fuel or oil leaks or spills that are possible would be from construction vessels or boats used to visit the project site during maintenance inspections and monitoring visits. However, Finavera is required to develop a fuel and oil spill control, prevention, and countermeasures plan for boats or barges used during construction and operation of the project. Therefore, we do not expect adverse effects to marbled murrelets from fuel or oil spills due to the very low likelihood of an accidental fuel or oil spill from boats or barges used during construction and maintenance and monitoring visits to the project site.

**Collision and Lighting Effects**

We do not expect marbled murrelets to collide with the buoys or mooring lines. The approximate height of the buoys above the water surface is only six feet. The buoys would have low-intensity navigation or hazard lights visible to 1.0-nautical mile. These lights would likely be identical to the U.S. Coast Guard lights on all other low-level navigational buoys off the coast of Washington. We know of no adverse effects to marbled murrelets from low-intensity, standard navigational lights on buoys in the marine environment. Collisions with the underwater portion of the buoys and the mooring lines also are not expected as these project components, with their large size and coloration, should be easily visible to marbled murrelets.

**Maintenance and Monitoring**

Maintenance and monitoring of the buoys and transmission line would involve periodic boat trips from the shore to the marine site to inspect the equipment and perform maintenance and
monitoring tasks. Between two and five trips per year to the marine site are anticipated to conduct maintenance and monitoring tasks. Boat traffic could disturb marbled murrelets that are foraging, loafing, and breeding in the action area.

However, the operation of boats for maintenance and monitoring activities would not be likely to significantly disrupt marbled murrelets because boat activities would not be prolonged and would occur infrequently (approximately two to five times per year), typically involving only one small boat.

CUMULATIVE EFFECTS

Commercial, subsistence, and recreational fishing will continue to occur in the action area and have the potential to directly or indirectly affect marbled murrelets. The condition of the action area also is affected by broader environmental threats, such as chemical pollution (i.e., oil spills) and climate change (Snover et al. 2005). These threats are reasonably certain to occur in the action area and may affect marbled murrelets through changes in the food chain, ocean temperatures, and water quality changes, among other environmental effects.

The action area is located within the Cascadia Subduction Zone where earthquakes and tsunamis are possible (Pacific Northwest Seismic Network 2007). Seismic activity could affect marbled murrelets in the action area at some time in the future, but the type of effect and extent are unknown.

CONCLUSION

As described in the Effects of the Action, marbled murrelets will be adversely affected during the construction, implementation, and decommissioning of the proposed Makah Bay Wave Energy Project. While there is a potential for disturbance from boat and barge traffic during project construction, installation, and decommissioning, and a potential for entanglement in derelict fishing gear on the buoys, mooring lines, and transmission line, we cannot establish a likelihood that these potential disturbances would occur. Therefore, we do not expect that the action is likely to reduce the numbers, reproduction, or distribution of marbled murrelets within their listed range.

After reviewing the current status of the marbled murrelet, the environmental baseline for the action area, the effects of the proposed Makah Bay Wave Energy Project, and the cumulative effects, it is the Service's biological opinion that the Makah Bay Wave Energy Project, as proposed, is not likely to jeopardize the continued existence of the marbled murrelet. Critical habitat for this species has been designated in Washington State, however, marine environments are not included in the designation. Therefore, this action does not result in the destruction or adverse modification of marbled murrelet critical habitat.
INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. *Harass* is defined by the FWS as an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR § 17.3). *Harass* is defined by the FWS as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR § 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

AMOUNT OR EXTENT OF TAKE

The Service does not anticipate that the proposed action will result in the incidental take of marbled murrelets. Therefore, no incidental take is authorized and no reasonable and prudent measures are required.

The Service is to be notified within three working days upon locating a dead, injured or sick endangered or threatened species specimen. Initial notification must be made to the nearest U.S. Fish and Wildlife Service Law Enforcement Office. Notification must include the date, time, precise location of the injured animal or carcass, and any other pertinent information. Care should be taken in handling sick or injured specimens to preserve biological materials in the best possible state for later analysis of cause of death, if that occurs. In conjunction with the care of sick or injured endangered or threatened species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. Contact the U.S. Fish and Wildlife Service Law Enforcement Office at (425) 883-8122, or the Service’s Western Washington Fish and Wildlife Office at (360) 753-9440.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. The following conservation measures are recommended:
- Restrict the speed of all boat and barge vessels, during the marbled murrelet breeding season (April 1 through September 15), to 10 knots per hour or less, as safety conditions allow, throughout all project activities for the entire project term to increase the likelihood that the on board observer will detect marbled murrelets.

- Conduct underwater inspections at least every 90 days, as safety conditions allow, to monitor the buoys, mooring lines, the anchoring system, and the transmission line by a remotely operated vehicle or with divers to identify and remove entangled derelict fishing gear. Inspections should document the occurrence of any seabirds captured in the nets and identify seabirds to species, if possible.

- Use a silt curtain or other appropriate barrier to minimize sediment effects to marbled murrelet forage fish from HDD operations and the anchoring of the transmission line.

- Suspend all project construction, installation, and decommissioning activities involving construction vessels from 2 hours before sunset until 2 hours after sunrise, during the marbled murrelet breeding season (April 1 through September 15), to reduce the risk of disturbing foraging adult breeding marbled murrelets.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

**REINITIATION NOTICE**

This concludes formal consultation on the action outlined in the request. As provided in 50 CFR section 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.
LITERATURE CITED


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U.S. Fish and Wildlife Service. 1997b. Intra-FWS concurrence memorandum and biological opinion on the proposed issuance of an incidental take permit (PRT-812521) for northern spotted owls, marbled murrelets, gray wolves, grizzly bears, bald eagles, peregrine falcons, Aleutian Canada geese, Columbian white-tailed deer, and Oregon silverspot butterflies, and the approval of the implementation agreement for the Washington State Department of Natural Resources Habitat Conservation Plan (FWS Reference: 1-3-96-FW-594; X-Reference: 1-3-9-HCP-013).


U.S. Fish and Wildlife Service. 2000b. Biological and conference opinion for the proposed issuance of a section 10(a)(1)(B) incidental take permit (PRT-TE020907-0) to the City of Seattle (Seattle Public Utility) for the Cedar River Watershed Habitat Conservation Plan. April 19, 2000.


