Electricity Innovation Institute

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E2I EPRI Survey and Characterization of Potential Offshore Wave Energy Sites in Oregon

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1. Introduction

The purpose of this report is to identify and characterize potential offshore sites in Oregon for a 1,500 MWh annual energy output (500kW at 40% capacity factor) wave energy power plant feasibility demonstration and an envisioned 300,000 MWh per year (100 MW at 40% capacity factor) commercial plant. Sufficient data are provided to enable the Oregon State Advisory Group to select a single site for a subsequent concept-level design, performance analysis and cost estimate.

Seven potential sites, each corresponding to a coastal county, are characterized in this report, as listed below (in order of north to south) and mapped in Figure 1. Also listed for each county is the best-equipped harbor for servicing wave energy devices or staging offshore service vessels:

- Clatsop County – Astoria
- Tillamook County – Garibaldi
- Lincoln County – Newport
- Lane County – Cushman
- Douglas County – Reedsport
- Coos County – Coos Bay
- Curry County – Brookings

Section 2 of this report describes the various site characteristics that were used to evaluate the potential suitability of a given county coastline for siting an offshore wave power plant. Section 3 provides a characterization of each the seven counties in terms of attributes such as marine industry, harbor infrastructure, potential conflicts, public acceptance and unique opportunities. The wave energy resource, bathymetry and coastal grid interconnection data for all counties is summarized in Section 4. The detailed wave energy resource characterization data, the bathymetry and surficial geology data and the grid interconnect data are contained in Appendices A, B and C, respectively. Section 5 of this report describes the competing uses of sea space. Finally, a list of references cited is provided as Section 6.

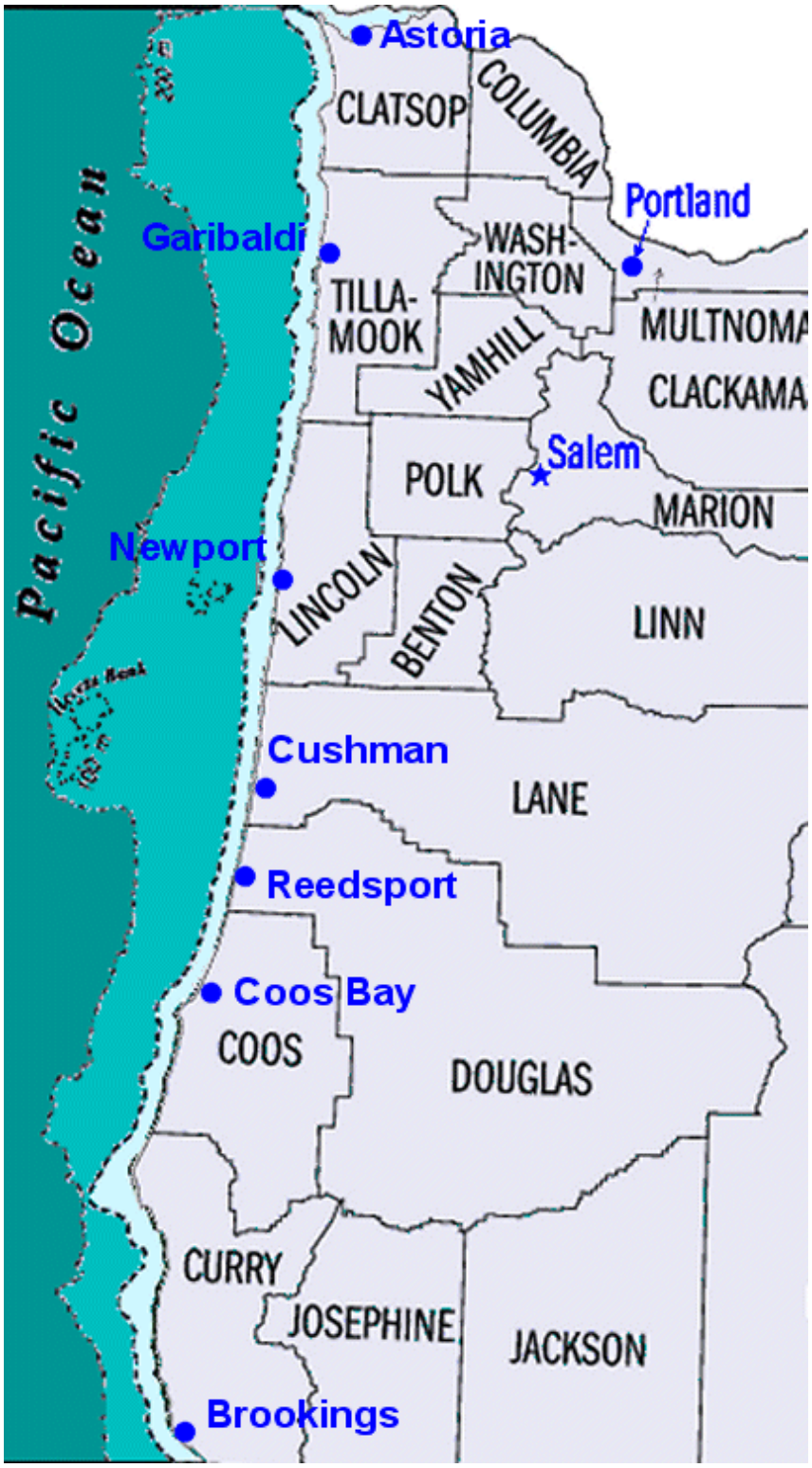


Figure 1. Oregon map showing seven coastal counties and the best harbor in each county for servicing a potential wave energy power plant. The first dotted line represents state-controlled waters within 3-nautical-mile limit. The second dotted line represents the continental shelf (200 m depth or less).

2. Site Selection Criteria

The site selection criteria used in this assessment are:

- Wave energy resource characteristics attributes (little if any sheltering by coastal features and deep water relatively close to shore as the bathymetry at a site can have a significant effect on the local wave energy due to refraction, shoaling and other wave transformation processes. Sea state "hot" spots (ie, areas of wave focusing) are desirable. Short distance to the required depth is also desirable.
- Candidate site bathymetry and surficial geology to minimize any potential problems in system mooring and cable routing (bottom material, potential for sediment mobility under severe conditions, and bottom changes over time)
- Coastal utility grid and substation loads and capacities and availability of onshore grid interconnection point with a capability of handling the 1,500 MWh per year pilot plant supply and with potential for growth to a 300,000 MWh per year commercial plant.
- A potential pathway from the 1,500 MWh per year pilot plant to a commercial scale plant
- Regional electricity cost, demand and growth forecasts
- Regional shipyard labor and infrastructure for device fabrication and assembly
- Local service vessels and waterfront infrastructure for system deployment, retrieval, and offshore servicing or in-harbor repair
- Minimal conflict with competing uses of sea space (shipping lanes, fishing grounds, and protected marine areas) and likelihood of public acceptance
- Regulatory complexity (federal, state and local)
- Unique site opportunities; e.g., an existing floating platform, an existing power transmission cable connected to a grid substation, an existing easement (e.g., a treated sewage pipe) or other factor that would make the site desirable (e.g., minimize the cost, minimize the schedule, transition plan from pilot to commercial, etc) for either the pilot or commercial application

3. Site Characterizations

3.1. Clatsop County – Astoria

Clatsop County is located in the northwest corner of Oregon and is bordered by the Columbia River in the north, Columbia County in the east, and Tillamook County in the south. The towns of Astoria and Warrenton (site of Fort Clatsop) are significant national historic regions located at the terminal end of the Lewis & Clark Trail. Today, the principle industries driving the economy are commercial fishing, tourism, and forest products. The Port of Astoria, created in 1914, is one of Oregon's 23 port districts. Major employers are the U.S. Coast Guard, James River Corporation, and Willamette Industries.

There are two cities with potential wave energy fabrication yards on the Columbia River: Astoria, located 12 miles from the River entrance, and Portland, located on the Willamette River 9 miles above its junction with the Columbia River and a total of 97 miles from the Columbia River entrance. Deployment of wave energy devices fabricated in these cities or retrieval of a device for in-harbor service at repair facilities in these cities will have to cross the Columbia River Bar.

The Columbia River Bar can be dangerous due to sudden and unpredictable changes in the currents, often accompanied by high breakers. It is reported that ebb currents on the north side of bar attain velocities of 6 to 8 knots, and that strong northwest winds sometimes cause currents that set north in the area outside the jetties.

Since forestry is one of the main industries in the region, floating and submerged logs (deadheads or sinkers) are a constant source of danger in the vicinity of the Columbia River entrance and in the river itself. This danger is increased during the spring high-water freshet stage on the Columbia, which occurs in the latter part of May.

The entrance to Columbia River is marked by two jetties. The south jetty extends 2.7 miles seaward from the northwest end of Clatsop Spit; the westernmost mile (seaward end) of this jetty is submerged. The north jetty extends 800 yards seaward from the shoreline on the north side of the entrance. Federal project channel depths in the Columbia River are 48 feet over the bar, and then 40 feet to the Broadway Bridge at Portland.

Astoria, in Clatsop County at Mile 12 on the Oregon side of the Columbia River has both rail and highway connections to the interior. U.S. Highway 101 extends north and south, and U.S. Highway 30 extends inland to Portland. Astoria is served by the Burlington Northern Railroad. The Clatsop County Airport, on the southwest outskirts of Astoria, is served by a charter airline that handles passengers and freight. Tugs to 3,600 hp and barges of various size and application also are available in Astoria.

The Port of Astoria is a municipal corporation embracing all of Clatsop County, and on the Columbia River extends from the river entrance to Westport, about 38 miles upstream. The port owns a substantial part of the waterfront at Smith Point (Figure 2), and operates a well-equipped modern terminal with three piers.

Figure 2. Port of Astoria, Smith Point and Columbia River Bridge.

Water, telephone, and electrical shore power connections are available at most of the berths. General cargo at the port is usually handled to and from vessels by ships' tackle or mobile crane service to 250 tons is available. Mobile crane service to 30 tons and derrick barge crane service to 110 tons is available from Bergerson Construction Company. The largest marine railway in the Astoria area can handle vessels to 400 tons. For a complete description of port facilities refer to Port Series No. 33, published by the U.S. Army Corps of Engineers (Reference ___).

At Mile 88, the Columbia River meets the Willamette River, its largest tributary below the Cascade Mountains. The federal project depth in Willamette River is 40 feet to Broadway Bridge in Portland (about 9 miles from its confluence with the Columbia), and thence, maintained by the Port of Portland, 30 feet between Broadway Bridge and Ross Island.

The mean tide range at Astoria is 6.6 feet, and the diurnal range of tide is 8.4 feet. A range of about 12 feet may occur at the time of maximum spring tides. The mean tide range at Portland is 1.8 feet, and the diurnal range of tide is 2.4 feet.

Portland is the principal city of the Columbia River system and one of the major ports on the Pacific coast. The port has over 25 deep-draft piers and wharves on both sides of the Willamette

River between its junction with the Columbia and Ross Island (Figure 3). In addition there are extensive facilities for small craft and barges south of Hawthorne Bridge and at North Portland Harbor, south of Hayden Island. Dock assist tugs to 3,600 hp are available in Portland.

Figure 3. Port of Portland, Broadway Bridge in foreground.

The Port of Portland owns four marine terminals and the Port of Portland Ship Repair Yard, and dredges the channel between Broadway and Ross Island Bridges; it also assists the Corps of Engineers with other dredging in the Willamette and Columbia Rivers. The port also operates an international airport and three general aviation airports.

The Port of Portland operates four modern marine terminals, all of which have rail trackage, water, and electrical shore power connections. All wharves have highway connections. Floating and shore-based mobile cranes of up to 75-ton capacity also are available. For a complete description of facilities, refer to Port Series No. 34, published by the U.S. Army Corps of Engineers.

Portland Ship Repair Yard, on Swan Island on the E side of Willamette River, is the major repair facility at the Port of Portland. The yard is operated by the port and used by private marine contractors on a tariff basis. There are three floating drydocks here, including the largest on the Pacific coast, which has an overall length of 982 feet, a length over the keel blocks of 902 feet,a clear width of 185 feet, a depth of 35 feet over the keel blocks, and a lifting capacity of 87,000 tons; a 20-ton whirley crane is mounted on a wingwall.

Complete repair facilities and services are available at the yard, including steam, compressed air, AC and DC power, and fourteen whirley cranes from 45 to 120 tons, running on three separate craneways. The yard has 6,000 feet of ship repair berths to a maximum alongside draft of 40 feet, and 3,000 feet of layup berths for idle vessels.

Another repair facility, with two marine ways and a floating drydock, is on the E bank of the Willamette River just N of the St. Johns Bridge. The marine ways have a capacity of up to 1,500 tons, and the drydock has a length of 494 feet and a width of 81 feet with a capacity of 5,500 tons. A whirley crane with a capacity of 25 tons is accessible to the drydock, the marine ways, and nearby moorage.

Small craft drydocks (to 70 tons, 55 feet long, and 16 feet wide) are available in North Portland Harbor.

It is important to note that device deployment from fabrication yards or device retrieval to repair yards in Portland will have to contend with several railroad and highway bridges, some fixed and some with draws. Device tows must be able to pass safely underneath the fixed span or raised draw and between the bridge piers on either side of the span or draw.

Fishing is Astoria's number one industry. Like many west coast fishing communities, Astoria's primary historic catch was salmon and was home of drag fishing, which developed in the 1950s. Today, additional species such as groundfish, sardines, tuna, shrimp and crab contribute to Astoria's overall landings. Gear strategies applied by Astoria fishermen have also evolved due to recent conservation efforts. Technological changes in fishing gear include the use of tangle nets in the place of gillnets, in the hopes of reducing by-catch. Fishing continues to be "essential to the backbone" of Astoria's economic growth. The importance of the industry to local community members is reflected in its many commercial fishing organizations such as Salmon for All, the Columbia River Fisherman's Proactive Union, the Fishermen's Wives Association and the Pacific Marine Conservation Council.

3.2. Tillamook County – Garibaldi

Tillamook County is comprised of 1,125 square miles situated on the east shore of Tillamook Bay. Unlike most west coast counties, logging did not dominate Tillamook's economy. Its rich grasslands and mild climate were ideal for dairy herds, and pioneers produced the finest butter in the country, and Tillamook Cheese has become world famous.

The current industry of the county includes agriculture, lumber, fishing, and recreation. Dairy farming dominates the agricultural industry, with 165 dairy farms and 25,000 cows. The lumber industry in the recent past is becoming a more significant economic force due to reforestation. Other industries of importance are the fishing, oyster, holly and tourism industries

The entrance to Tillamook Bay is 42 miles south of the Columbia River, and 60 miles north of the entrance to Yaquina Bay. The bay itself has a tidal area of about 13 square miles, most of

which is exposed as a succession of sand and mud flats at low tide. There is no commercial vessel traffic in the bay except for fishing boats and pleasure craft.

The Tillamook Bay entrance is protected by jetties. A dredged entrance channel crosses the bar and leads between the jetties, thence the channel continues through the north end of Tillamook Bay to a turning basin just west of Miami Cove. An access channel leads northward from this turning basin to a mooring basin at the town of Garibaldi. In July 2002-June 2003, the controlling depths were 15 feet in the entrance and through the channel to Garibaldi, thence 9 feet along the N edge of the turning basin in the approach to the mooring basin; thence in 1996-2000, a depth of 10 feet was available in the access channel to the mooring basin with depths of 6 to 9 feet in the basin. The project for the turning basin is inactive and has not been maintained for several years.

Garibaldi has a boat basin for commercial and sport fishing vessels. Berths for about 200 craft, electricity gasoline, diesel fuel, water, ice, a launching ramp, and marine supplies are available at the basin. A drydock in the basin can handle craft to 100 tons, 68 feet long, or up to 9 feet in draft.

3.3. Lincoln County – Newport

Lincoln County is located in the central portion of the Oregon Coast. It is surrounded by five counties from north to south that include: Tillamook, Yamhill, Polk, Benton, and Lane. Current industries in Lincoln County include fishing, government, and forestry, and it is one of the most popular tourist destinations on the Oregon Coast. Newport has one of the largest fishing fleets and working waterfronts in Oregon as well as the Oregon Coast Aquarium and the Hatfield Marine Science Center. Retirees are an increasing demographic group moving into the area.

Yaquina Bay entrance is about 34 miles north of the Siuslaw River entrance. The bay is a tidal estuary, the harbor itself being merely the widening of Yaquina River just inside the entrance. Jetties 330 yards apart protect the entrance to Yaquina Bay. During the summer, when the swell is approximately parallel with the coast, the bar is comparatively smooth, being partially sheltered by Yaquina Head. In winter, however, the heavy swell makes the bar very rough.

A Federal project provides for a 40-foot deep entrance channel, thence 30 feet from the first turn in the channel to and in the turning basin at McLean Point, thence 18 feet to Yaquina, thence 10 feet to Toledo at the head of the project. Controlling depths may be considerably less than these project depths.

A fixed highway bridge across the channel, about 1.3 miles above the entrance, has a clearance of 129 feet. Newport, just inside the N entrance point, is the principal town on the bay and river. The town has a considerable fishing industry with several small fish-processing plants. The municipal airport is about 4 miles south of Newport. A U.S. highway (Route 101) extends north

and south along the coast, and a State highway leads to the interior. The mean tide range at Newport is 6.0 feet, and the diurnal range is 8.0 feet.

There are two deep-draft wharves in Yaquina Bay (Figure 4). The wharf at McLean Point, about a mile east of the highway bridge has two berths. Berth 1, just north of the turning basin, has 465 feet of berthing space, with an alongside depth of 30 to 32 feet, and a deck height of 21 feet. Berth 2 (barge dock), just northeast of the turning basin, has 250 feet of berthing space, with an alongside depth of 27 feet, and a deck height of 14 feet. A concrete extension connected to berth 2 has 140 feet of berthing space in line with Berth 1, with an alongside depth of 35 feet, and a deck height of 14 feet.

Figure 4. Yaquina Bay, Mclean Point wharves and Newport boat basin are in background; commercial moorage is in foreground.

The Port of **Newport** operates a boat basin that can handle small craft up to 80 feet on the south side of the bay about 350 yards east of the bridge. The basin is protected to the north and west by jetties. In December 2001, the controlling depth in the Newport boat basin was 9 feet, except for shoaling to 5 feet in the southwest corner of the turn in the channel. Gasoline, berths, diesel fuel, electricity, water, and ice are available. Hull, engine, and shaft repairs can be made.

The Port of Newport also operates a commercial moorage on the north shore about 0.7 mile above the highway bridge. This moorage area is protected from the main channel by a detached breakwater parallel to the shore, marked by a light at each end. Berths, electricity, gasoline, and diesel fuel are available. Marine supplies can be obtained in Newport. There are several marine

repair facilities on the river above Newport, including a full-service facility at Oneatta Point, 3.8 miles above the entrance to the bay, which has two travel lifts (one 15-ton and one 70-ton) and two 60-ton cranes.

Both Depoe Bay and Newport play an important role in Lincoln County's fishing industries. Two marinas, the Depoe Bay Marina and the Waldport Marina, contain the largest charter fleet on the Oregon Coast. The Depoe Bay Marina is largely a recreational fishing port and can accommodate a total of 137 boats. The Waldport Marina, located in Alsea Bay, has only 20 slips.

In contrast to Depoe Bay's sport fishery, Newport is one of the largest commercial fishing ports in Oregon. Like Depoe Bay, Newport was founded on salmon fishing, which remains an important industry. Commercial fishermen commonly land Dungeness crab, blackcod, halibut, albacore tuna, pink shrimp, Pacific whiting and a variety of groundfish. In 1998, Newport was ranked 11th among all fishing ports in the United States in seafood landings, with 118 million pounds of landed fish.

Oregon Coast Community College offers already offers commercial fishery workforce training and has strong links to Oregon State University, which operates Hattfield Marine Science Center at South Beach.

3.4. Lane County – Florence / Cushman

Lane County is located on the central coastline of Oregon. The county's 4,620 square miles are more than double the area of the State of Delaware, but most of the county is far from the coast. It is one of only two Oregon counties (Douglas County being the other) to extend from the Pacific Ocean to the Cascade Mountains.

The principal industries of Lane County include agriculture, higher education, technology, recreation, RV manufacturing and tourism. Most of these activities do not have much impact on coastal communities. The main activities that influence coastal residents are timber, tourism, agriculture, and an influx of retirees moving onto the area.

The jettied entrance to Siuslaw River is approximately 22 miles N of Umpqua River entrance. The bar at the entrance is narrow, and the depths vary greatly because of storms and freshets. The entrance and south jetty shoals tend to build during late winter and spring.

A Federal project provides for an 18-to 16-foot depth in the entrance channel to the highway bridge at Florence; thence 16 feet in the turning basin; thence 12 feet to Cushman. Florence is a small town on the north bank of Siuslaw River 4.4 miles above the entrance. A bascule highway bridge with a clearance of 17 feet crosses the river from Florence to Glenada, a small settlement on the south bank of the river.

A cannery wharf, and a small port-operated boat basin and marina are at **Florence**; fish are shipped by truck. Another marina, about 0.15 mile W of the bridge, has about 80 berths, dockside electricity, gasoline, water, ice, launching ramp, and marine supplies; minor engine

repairs can be made. Siuslaw Marina, about 0.3 mile E of the bridge, has over 250 berths, gasoline, diesel fuel, water, ice, some marine supplies, and launching ramps.

Cushman, on the north bank of the river 2 miles above Florence, ships lumber and shingle products by rail and barge. A small-craft repair facility here has a marine railway that can handle craft to 60 feet long, for engine and hull repairs. A 50-ton hoist is also available for handling small craft. About 50 berths with electricity, water, and a launching ramp are available. Wet and dry winter storage is also available at this facility. A large marine supply firm is at Cushman. An overhead power cable with a clearance of 75 feet crosses the river at Cushman. The railroad bridge across the river, 1 mile above Cushman, has a swing span with a clearance of 15 feet.

Lane County has a long history of commercial fishing. Today, both commercial and recreational fishermen moor at the Port of Siuslaw. The port provides 51 slips for commercial vessels and 49 for recreational customers. Commercial fishermen that operate out of the Port of Siuslaw typically target sablefish, salmon, crab and tuna.

Aside from being "good business for the town," fishing is a big part of the community's social fabric, with strong environmental awareness. Local community members have been involved in Oregon Department of Fish and Wildlife's Salmon Trout Enhancement Program (STEP) since 1981, a voluntary program created by the Oregon Legislature to focus on habitat restoration in streams and rivers

3.5. Douglas County – Reedsport

Douglas County is located just north of Coos County, south of Lane County, and extends west from the Pacific Ocean to the Cascade Mountains. Douglas county contains the entire Umpqua River watershed within its boundaries, and nearly 2.8 million acres of commercial forestlands. The Federal Government owns more than 50% of the county's land.

Douglas County's economy is primarily based on logging, agriculture, and recreation. Approximately 25 to 30 percent of the labor force is employed in the forest products industry which includes numerous sawmills, veneer plants, one pulp and particle board plant, and numerous shingle, shake, pole and other wood plants. Agriculture is another important industry, encompassing field crops, orchards, and livestock.

The jettied entrance to the Umpqua River (Figure 5) is approximately 20 miles north of Coos Bay. A Federal project provides for depths of 26 feet in the Umpqua River entrance channel, thence 22 feet to Gardiner and Reedsport, and 22 feet in the turning basin at Reedsport. The channel over the bar is reported shoalest usually during September. Later in the season the river cuts a deeper channel through the bar. Depths in the channels and basins may vary considerably between dredging operations.

Reedsport is located on the southwest bank of the Umpqua River, 10 miles upstream of the jettied river entrance, and is a station on the railroad and the principal town on the river. The U.S. Route 101 highway bridge crossing the river at the upper end of the turning basin at

Reedsport has a swing span with a clearance of 36 feet. The railroad bridge, 500 yards above the highway bridge, has a swing span with a clearance of 16 feet. Gasoline, diesel fuel, water, and fuel oil for launches may be obtained at Reedsport. There is a machine shop at Reedsport, with a marine railway that can handle craft to 150 feet. This firm also operates a tidal graving dock across the river, 260 feet long and 60 feet wide.

East Basin, located on the east side of Umpqua River, 2.3 miles above the entrance, is entered through a dredged channel that leads from the main river channel to a turning basin, about 0.4 mile above the entrance, and continues for an additional 0.23 mile to the head of the project. In February 1998, the mid-channel controlling depth was 15 feet from the main river channel to the turning basin about 0.4 mile southward, thence depths of 10 to 16 feet were in the basin, thence 12 feet at mid-channel to just within 450 feet of the head of the project, thence gradual shoaling to 2 feet at the southernmost end. Berths with electricity, gasoline, diesel fuel, water, ice, launching ramps, marine supplies, and an 8-ton crane are available in the basin; hull, engine, and electronic repairs can be made.

Figure 5. Umpqua River entrance, Reedsport in background.

Winchester Bay Marina is made up of both commercial and recreational fishing boats. The commercial vessels comprise about 20% of the marina while the remaining 80& are recreational users. Even though the fishery at Winchester Bay is primarily recreational, it remains an important industry to the local economy. Salmon Harbor Marina is also focused on recreational fishing, with immediate access to the Umpqua River and Pacific Ocean. The Harbor contains 750 moorage slips for short-term or long-term occupancy. Recreational fishermen that

moor in both the Winchester Bay and Salmon Harbor marinas, typically land Chinook salmon, striped bass, steelhead, sturgeon, chad, pink fin perch, small mouth bass and Dungeness crab

3.6. Coos County – Coos Bay

Coos County is located just north of Curry County in the southeast corner of the state. The county's primary industries consist of forest products, fishing, agriculture, shipping, tourism, and recreation. Additional products that play an important role in the economy include dairy farming, cranberries, and myrtle wood manufacturing. There are several port districts that also contribute to the county's economy: Port of Coos Bay founded in 1909, Port of Coquille River founded in 1912, and Port of Bandon founded in 1913. Coos Bay is considered the best natural harbor between San Francisco Bay and the Puget Sound.

Coos Bay is about 54 miles north of Brookings and is one of the most important harbors between San Francisco and the Columbia River. It is considered to be a "principal port" on the U.S. West Coast and is one of the largest forest products ports in the world.

From its jettied entrance, Coos Bay extends northeast for 8 miles, and then bends southeast for about 4 miles to the mouth of Isthmus Slough. A Federal project provides for a 47-to 37-foot channel across the bar, thence 37 feet to the mouth of Isthmus Slough, thence 37 feet to a point 1.1 miles above the mouth of Isthmus Slough, and thence, 22 feet to Millington, 14.7 miles above the entrance to the bay. Turning basins at North Bend and Coos Bay have project depths of 37 feet.

The most favorable time for crossing the bar is late on a rising tide, and occasionally it is passable only at this time. There is usually a longshore current just off the jetties, and velocities of 3 to 3.5 knots have been observed between Blunts Reef and Swiftsure Bank.

The cities of Coos Bay and North Bend are served by U.S. Highway 101 and the Southern Pacific Railroad. Two state highways connect to Interstate Highway 5 inland. North Bend Municipal Airport, served by a major airline, is just northwest of North Bend.

The Southern Pacific Railroad bridge across Coos Bay, 7.5 miles above the entrance, has a swing span with a clearance of 12 feet. In 2003, the swing span could only be opened by tug. A fixed highway bridge, 8.1 miles above the entrance, has a clearance of 123 feet across the main channel. The mean range of tide at Coos Bay is 5.6 feet, and the diurnal range of tide is 7.3 feet. A range of about 12 feet may occur at the time of maximum tides.

The Port of Coos Bay has more than 10 deep-draft piers and wharves with about 15 deep-draft berths. All facilities have direct highway connections, and most have direct railroad connections. Water is available at most of the wharves, but electrical shore power connections are available at less than half of them. For a complete description of the port facilities refer to Port Series No. 33, published by the U.S. Army Corps of Engineers (Reference ___). Tugs to 2,000 hp are available and are used for docking and mooring. The two pilot boats, the largest tugs available, do most of the dock assist work in the port.

Most marine supplies and services are available at Coos Bay. Fuel oil is available at two fuel piers; however, most bunkering is done at the vessel's berth by tanker truck. Diesel oil and water are available. Above-the-waterline repairs can be made at several machine shops on the waterfront. A drydock at Coos Bay can handle vessels to 1,000 tons, 220 feet long, and 45 feet wide. The largest marine railway can handle vessels to 400 tons, 120 feet long, 32 feet wide, and 12 feet in draft.

South Slough extends 4 miles S from its junction with Coos Bay near the jettied entrance. A dredged channel extends S from the junction for about 0.6 mile to the Charleston Boat Basin, thence for 0.5 mile to a highway bascule bridge. In September 2003, the controlling depth was 16 feet (17 feet at mid-channel) to the basin, thence 16 feet to the highway bascule bridge, except for lesser depths extending about 230 feet below the bridge.

Charleston Boat Basin, operated and maintained by the Port of Coos Bay, is 0.3 mile N of Charleston, across the slough from Barview (Figure 6). In September 2003, the controlling depth was 16 feet (17 feet at mid-channel) from the entrance to the basin, thence depths of 8 to 16 feet were available in the basin with lesser depths along its northern edge. The basin is used by commercial and sport fishermen. About 500 berths with electricity, gasoline, diesel fuel, water, ice, a launching ramp, and marine supplies are available. A pumpout station and wet and dry winter boat storage are available in the basin. A repair facility at the basin has a drydock that can handle vessels to 300 tons, 90 feet long, and 30 feet wide, and a marine railway that can handle craft 70 feet long, 22 feet wide, and 6 feet draft for hull and engine repairs. Electronic repairs can also be made at the basin.

Charleston, nine miles west on Cape Arago Highway, is an old waterfront fishing village, with a busy commercial fishing fleet. It contains more than 150 boats that during various seasons of the year land Dungeness crab, halibut, shrimp, salmon, tuna, and a variety of ground and rockfish including sole, cod, flounder, mackerel and snapper.

Figure 6. Charleston Boat Basin, Port of Coos Bay.

3.7. Curry County – Brookings

Curry County is situated along the Pacific Coast in the southwest corner of Oregon. It is bounded on the south by California, on the west by the Pacific Ocean, on the north by Coos County, and on the east by Josephine County. The county originally contained about 1,650 square miles.

The Port of **Brookings** is located just inside the jettied entrance to the Chetco River (see figure 7), about 4 miles north of the California-Oregon border and about 16 miles north of Point St. George, CA. In November 2002, the controlling depths were 11 feet for a mid-width of 100 feet in the entrance channel to the Brookings turning basin, thence 8 to 13 feet in the basin. An overhead power cable crossing the river about 0.6 mile above the jetties, has a clearance of about 46 feet. The coast highway bridge (U.S. Route 101) has a clearance of 59 feet.

Upper and lower small-craft basins adjacent to the turning basin are used primarily by commercial fishing boats and pleasure craft. The upper basin has over 500 berths, most with electricity; gasoline, diesel fuel, water, ice, marine supplies, and a launching ramp are available. Berths with electricity and water are reported to be available in the lower basin. A 60-ton lift and wet and dry winter storage also are available.

Figure 7. Port of Brookings

Curry County's coastal scenery and standing timber attract visitors to participate in recreational claming, crabbing, and fishing in both freshwater and saltwater. The Port of Brookings is one of the largest fishing communities on the Oregon coast. Today, shrimp, crab, ground fish and salmon make up most of the ports landings. The Port of Brookings Harbor's mooring facilities include 750 berths and 485 linear feet of transit dock for the non-home porting vessels. The port is a "Harbor of Refuge" for all vessels in the 100 to 150 foot class needing shelter from inclement weather. The port also accommodates vessels that range from 24 to 110 feet. A unique aspect of this Port is that it functions in four areas: property management, tourism, commercial and recreational fishing. The Port manages a business loan program, is involved in telecommunications, assists in the development of medical infrastructure, and advocates and secures funding for community improvement projects. This port district covers over four hundred square miles and represents over 75% of the entire population of Curry County.

4. Wave Energy Resource Characterization, Bathymetry and Grid Interconnect Overview

4.1. Wave Energy Resource Characterization

The State of Oregon has an excellent offshore wave energy resource.

There are three primary sources for wave energy-related data (i.e., wave height, wave period, wave direction, etc) as described below and located as shown in Figure 8 :

1. The National Oceanic and Atmospheric Administration (NOAA) operate meteorological buoys in the North Atlantic, North Pacific, Gulf of Mexico and Great Lakes. The NOAA buoys off Oregon are shown in the following figure

2. Another major source of wave measurements is the Coastal-Marine Automated Network (C-MAN) run by the National Data Buoy Center (NDBC) for the National Weather Service. C-MAN buoys off Oregon Atlantic are also shown

3. Wave hindcast models are computer programs that numerically generate and propagate wave energy based on input atmospheric pressure from historical meteorological charts. Hindcasting is used to predict winds that would have occurred for a given set of past pressure distributions, and these winds are then used to numerically generate the associated waves. Sophisticated wave hindcast has been developed by the U.S. Army Corps of Engineers. The Army's hindcast model is referred to as the Wave Information System (WIS) and is available on the Web.

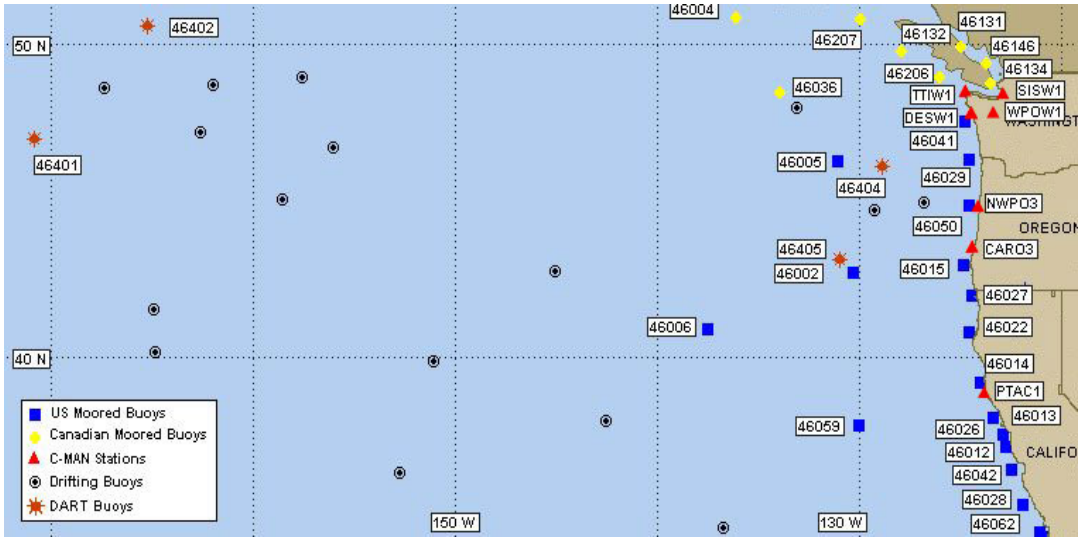


Figure 8. Locations of Oregon Wave Energy Characterization Sources

Figure 9 shows the wave power per meter of wave crest width available off the coast of Oregon at a depth of 10 meters (leftmost curve with square shape data points) and in very deep water outside the continental shelf. (rightmost curve with diamond shaped data points).

4

4.3. Grid Interconnection

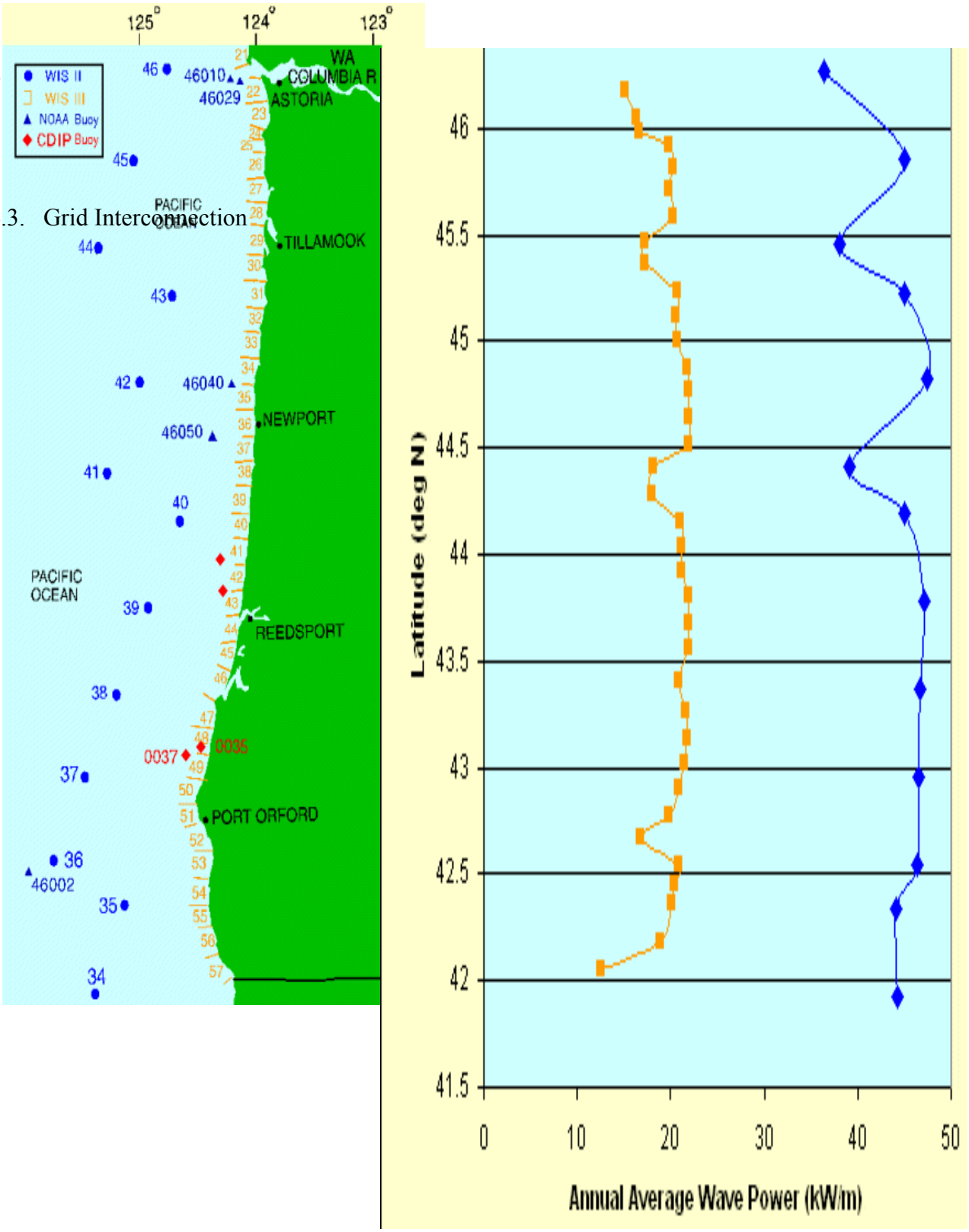


Figure 9. Oregon Annual Average Wave Power (squares are at 10 meter depth and diamonds at in very deep water off the continental shelf)

The two upper most dips are unexplained. The lowermost dip seen in the 10 meter deep data is caused by shading from Port Orford coastline.

Temporal data

Month-to-month variations in wave energy flux for Astoria, Washington is plotted in Figure 10. The high mean monthly fluxes during the winter are due to a few individual storms that have peak wave fluxes as high as 200 kW/m.

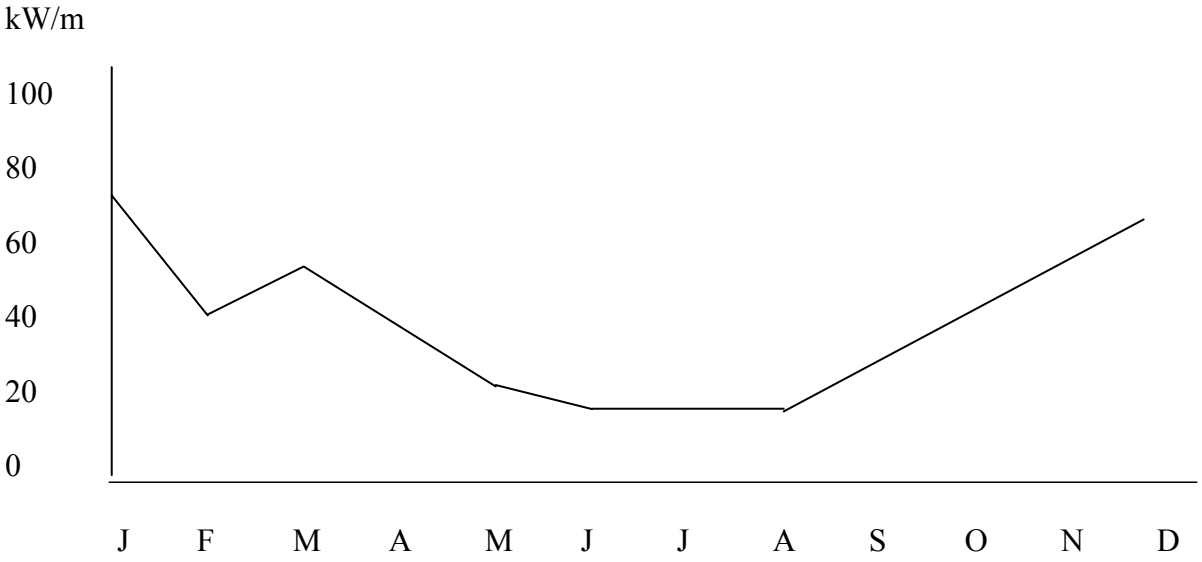


Figure 10. Month-to-Month Variation in Wave Energy Flux off the coast of Astoria, Washington

Detailed wave energy charactization data will be provided in Appendix A.

4.2. Bathymetry and Surficial Geology

Subsection to be prepared later. This subsection will contain an overview and the details will be in Appendix B.

4.3. Grid Interconnect Data

The coastal Oregon electric grid is shown in Figure 11. Details of each coastal substation is provided in Appendix C.

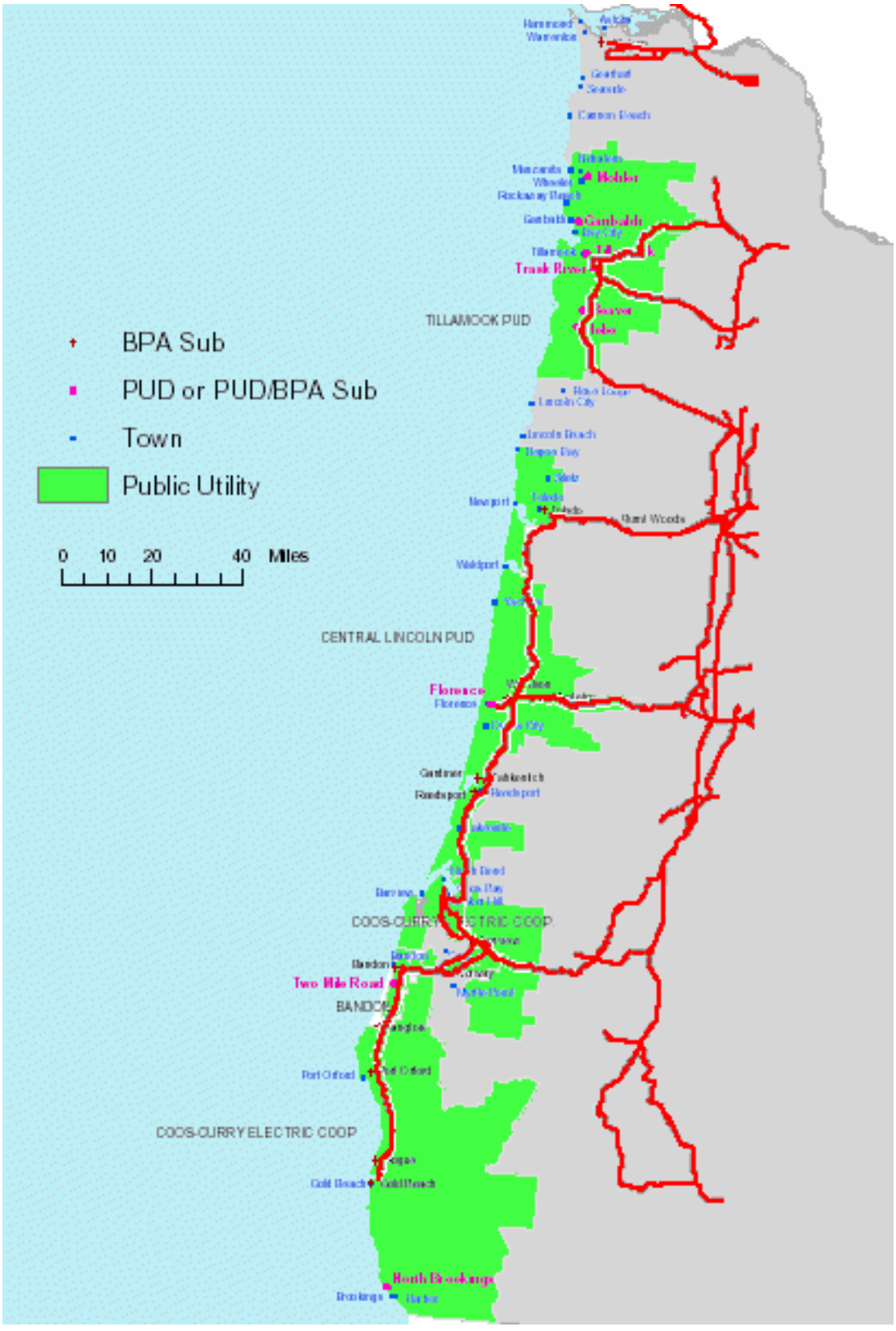


Figure 11. Oregon Coastal Electrical Grid

5. Competing Uses of Sea Space

Oregon's ocean area stretches approximately 360 miles from the Columbia River entrance to the California border, and is subject to a wide variety of existing uses, including commercial shipping, submarine telecommunications cable routing, offshore disposal sites for dredge spoil, commercial and sport fishing, and a wide variety of environmentally sensitive areas where wave power plant siting should be either avoided or chosen with detailed attention to potential impacts.

Section 4.1 identifies shipping lanes and other ocean uses that are entirely incompatible with the siting of a wave power plant. Section 4.2 characterizes Oregon's ocean fisheries, which apart from two localized crab fisheries, tends to not be restricted to any particular area. This makes it a challenge to identify particular offshore areas that are always heavily fished by commercial vessels. The state's commercial fishing industry is well organized, however, and there are several organizations that should be approached for early discussions so as to minimize conflict once a particular site and wave energy conversion technology have been selected to move forward into the conceptual design and economic study phase.

5.1. Shipping Lanes and Other Excluded Areas

5.1.1. Shipping Lanes

Based on the West Coast Offshore Vessel Traffic Risk Management Project, co-sponsored by the Pacific States/British Columbia Oil Spill Task Force and the U.S. Coast Guard Pacific Area, it is recommended that, where no other traffic management areas exist such as port Traffic Separation Schemes, vessels of 300 gross tons or larger transiting along the coast anywhere between Cook Inlet and San Diego should voluntarily stay a minimum distance of 25 nautical miles offshore, which would be well beyond the site of any wave power plant having an economically feasible submarine power cable transmission distance to shore.

Shipping traffic off the California-Oregon-Washington coast frequently must navigate in thick weather. Between San Francisco and Portland, fog and haze occur 15-25% of the time. Fog reduces visibilities to less than 0.5 mile (0.9 km) on about 3 to 8 days per month. Dead reckoning courses are long, and the effect of currents is uncertain. Coast Pilot 7 suggests vessels transiting off the Coast of Oregon proceed on rhumb lines through the following positions:

40°26' N, 124°32' W; off Blunts Reef, California

42°50' N, 124°44' W; off Cape Blanco, Oregon

46°11' N, 124°12' W; off the Columbia River entrance

To reduce the destruction of fishing gear by inshore vessels and to reduce the fouling of propellers and shafts by fishing gear, the Oregon State University Extension Service has coordinated an agreement between barge towing companies and trap fishermen (crab and black cod) to establish towboat lanes along the Pacific Coast between Half Moon Bay, California and Destruction Island, Washington. Oregon State University Extension Service has been contacted

to obtain a copy of the agreement, which shows trap fishing areas and towboat lanes, and this will be included in final Oregon site assessment report, with rhumb line navigation routes noted in the first paragraph also marked on the map.

5.1.2. Submarine Cables and Pipelines

In July 1998, concerned Oregon commercial fishermen negotiated a cooperative agreement with WCI Cable, Inc. and Alaska Northstar Communications, LLC, two related fiber-optic cable companies who operate submarine cables that make landfall in Tillamook County. The Oregon Fishermen's Undersea Cable Committee Agreement is the first effort by these two industries to describe and delineate their shared use of ocean space, and is based on the belief that a fisherman who possibly has snagged a cable is less likely to continue hauling on the snagged gear and jeopardizing the cable if a mechanism is provided (via toll-free phone) to quickly and fairly compensate the fisherman for sacrificed gear, as well as releasing the fisherman from civil liability due to ordinary negligence. Such a cooperative approach is more likely to prevent damage to cables than harsh civil and criminal penalties, while accommodating the right of commercial fishermen to fish the seas over and around a fiber-optic cable.

Five different cables are covered by the Oregon Fishermen's Undersea Cable Committee Agreement, as charted in Figure 12. Three cables are landed at Nedonna Beach, and two cables are landed near Rockaway Beach, just north of the entrance to Tillamook Bay.

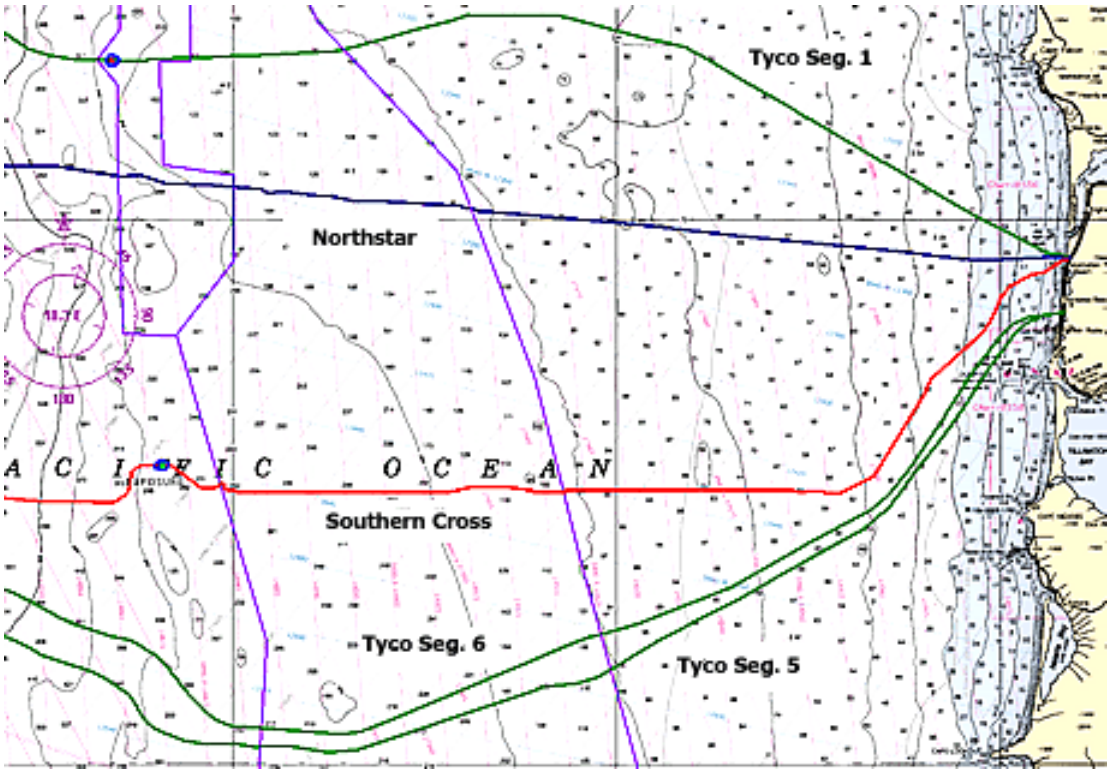


Figure 12. Submarine cables making landfall just north of Tillamook Bay, covered by the Oregon Fishermen's Undersea Cable Committee Agreement.

A sixth cable in Tillamook County, referred to as the North Pacific Cable, lands at Pacific City (see Figure 13), which is approximately 40 km (25 miles) south of Rockaway Beach. This cable is owned and operated by PT Cable, Inc., and is not covered by the Oregon Fishermen's Undersea Cable Committee Agreement, but relies on enforcement of legal penalties, as described at http://www.ptcable.com/ptc/npc/npcwht.htm, to prevent damage.

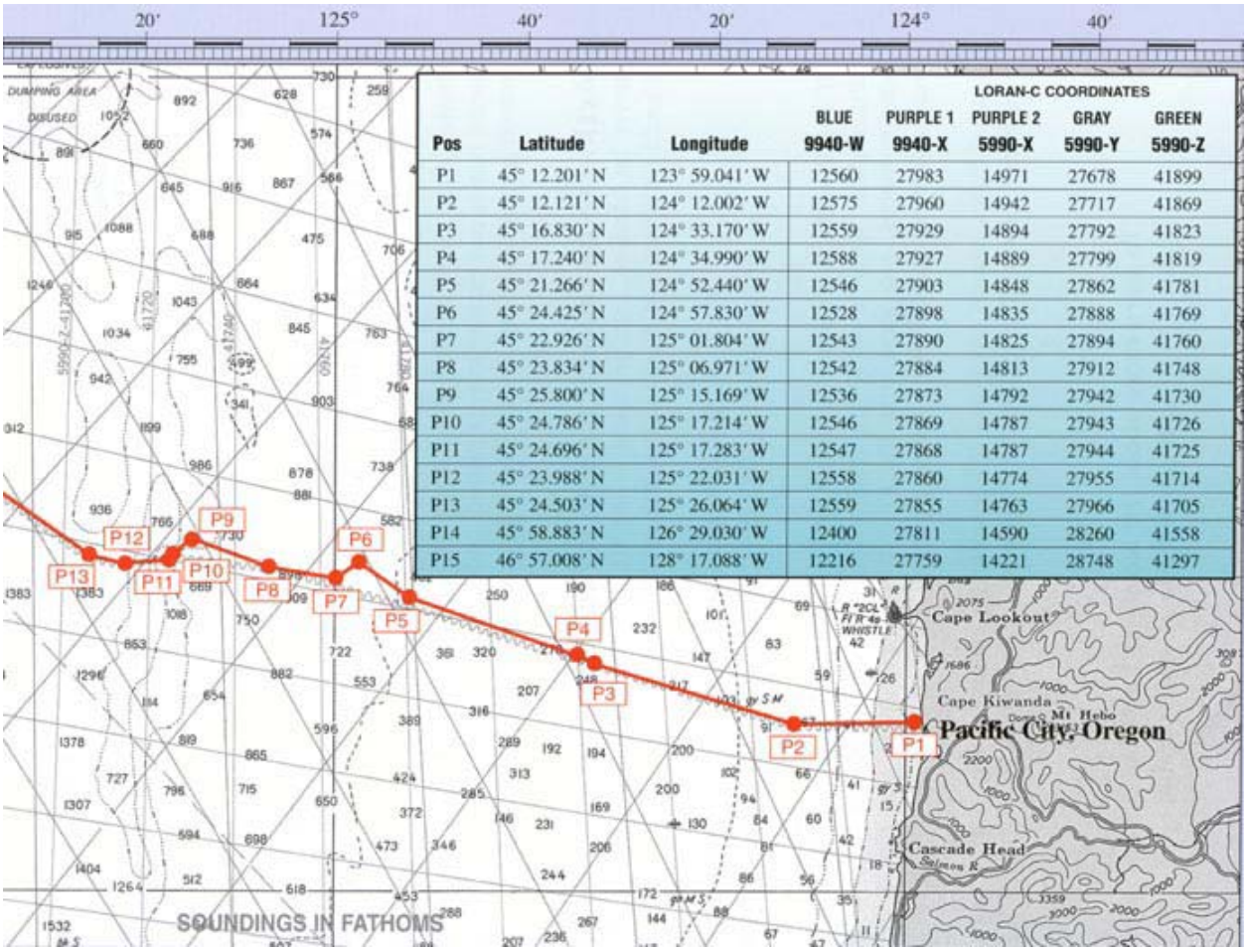


Figure 13. Location chart for the North Pacific Cable that is landed at Pacific City in southern Tillamook County.

In Coos County, AT&T operates four cables that are landed north of Bandon, just south of Coos Bay. The first two cables were laid through prime commercial fishing grounds, and subsequent plans for more cables led to a series of meetings between AT&T and the Coos Bay Trawlers' Association, who had expressed concerns to the governor's office. As a result of these meetings, AT&T agreed to establish a fund for enhancing the affected fisheries. The Bandon Submarine Cable Council was founded in 1999 to manage this fund and to deal with cable issues affecting the regional fishing community. The four Bandon cables are charted in Figure 14.

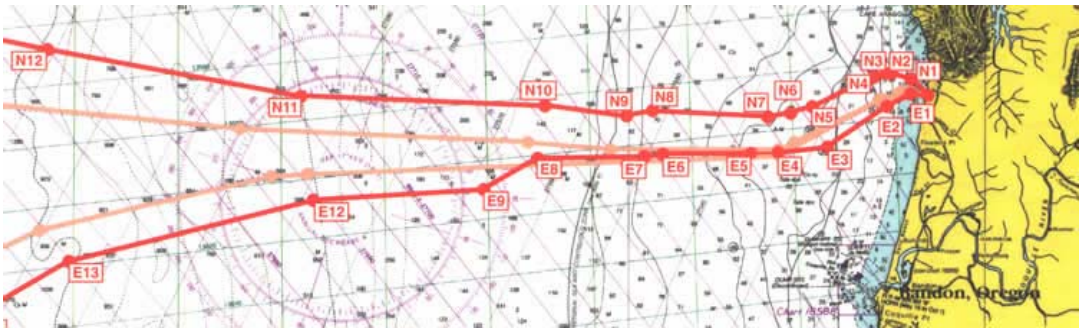


Figure 14. Location chart for four AT&T submarine cables that are landed north of Bandon, just south of Coos Bay.

5.1.3. Ocean Disposal Sites

Ocean disposal involves transporting dredged material offshore on a barge or in a hopper dredge to be dumped in open ocean waters. The U.S. Environmental Protection Agency (EPA) regulates the permitting of such sites. EPA-permitted dredge disposal sites are designated outside several of Oregon's important ports, including the Columbia River entrance, Tillamook Bay, Depoe Bay (Lincoln County, north of Newport), Yaquina Bay (Newport), and Coos Bay.

5.1.4. Military Warning Areas

Military Warning Areas are ocean areas that the U.S. Department of Defense uses for training exercises or other military operations. They may have restrictions on use by non-military vessels, over-flight by commercial or private aircraft, and/or civilian communications. No Military Warning Areas have been identified off the Oregon coast.

5.2. Commercial and Sport Fishing Grounds

Between early December and mid-August, heavy concentrations of commercial crab traps and associated gear are placed off the Columbia River entrance and off Coos Bay, anywhere between the shoreline and the 30-fathom (55-meter) depth contour. For this reason, and also considering the high density of shipping traffic entering or exiting these two principal ports, the coastal stretch extending 10 nautical miles north and 10 nautical miles south of the entrances to the Columbia River and Coos Bay, from the shoreline out to the 30-fathom depth contour, be withdrawn from consideration as potential wave power plant sites.

Apart from these two specific areas, it is not possible to identify other specific fishing grounds where wave power plants should not be sited. Commercial fishing effort can be characterized by the species targeted, which to a certain extent determines the size of vessel used. For example, offshore trawling for groundfish and whiting involves vessels that are two to three times longer than the 30-foot boats used for offshore trolling (targeting salmon and albacore), and such large vessels tend to be concentrated in the harbors that can accommodate their berthing length and channel draft – principally Astoria (Warrenton), Newport, and Coos Bay (Charleston).

Year to year, however, and even season to season, fishing families and businesses tend to shift the species they target, and the species themselves tend to shift their geographic ranges. This makes it difficult to specify any particular shelf area that is more likely than another to have a high concentration of trolling or trawling activity by commercial fishing vessels.

Oregon's fishing communities are well organized when it comes to dealing with other competing uses of sea space, such as submarine telecommunications cables, which can be snagged by fishing gear, resulting in costly down-time and repairs for the cable operator. The Oregon Fishermen's Undersea Cable Committee and the Bandon Submarine Cable Council are two such groups that originated with the commercial fishing industry. Therefore, it is recommended that these groups be approached for their guidance on how to work with local fishing communities to avoid location of wave power plants on popular fishing grounds, or to develop cooperative agreements similar to those developed with the submarine telecommunications cable industry (see Section 4.1.2) so as to promptly and fairly compensate vessel-owners financially for fishing gear that has to be sacrificed in order to avoid more costly damage to wave energy devices, moorings, or device-interconnecting cables.

5.3. Environmentally Sensitive Areas

Subsections arranged from landward (where visual impact is main concern) to shoreline (power cable crossing) to nearshore to offshore.

5.3.1. Oregon Islands National Wildlife Refuge and Wilderness Area

From nearly every viewpoint on the Oregon coast, colossal pinnacles, clusters of rocks, and flat ledges can be seen jutting out of the Pacific Ocean, all of which are protected as part of the Oregon Islands National Wildlife Refuge (NWR). The refuge includes 1,853 rocks, reefs and islands, as well as two headland areas, spanning a distance of 320 miles. These protected offshore formations are found along most of the Oregon coast, except for the stretch of coastline between Florence and Coos Bay.

Thirteen species of seabirds nest on the rocks, islands, and headlands in this refuge, which provides sanctuary for 1.2 million nesting seabirds. The refuge also provides pupping and haul-out sites for harbor seals, California sea lions, Steller sea lions and Northern elephant seals. The wildlife found on offshore rocks and islands is extremely susceptible to human disturbance, and so they are closed to public entry year-round.

Coquille Point, one of the headland units of Oregon Islands NWR, overlooks a series of offshore rocks of nearly every shape and size, which support thousands of seabirds and harbor seals. A paved trail winds over the headland and offers interpretive panels on local wildlife and Native American history. Stairways provide visitor access to the beaches on either side of the headland as permitted by tide levels. The Coquille Point unit is located in the city of Bandon and receives over 400,000 visitors a year.

Offshore wave power development projects should be particularly sensitive to potential visual impacts off Coquille Point, and other popular vantage spots for viewing Oregon's offshore rocks and islands along the coast highway (U.S. Route 101), as well as in the vicinity of the two other National Wildlife Refuges described in Section 4.3.3, below.

5.3.2. Cape Meares and Three Arch Rocks National Wildlife Refuges

Cape Meares National Wildlife Refuge was established in 1938 to protect one of the last remnants of coastal old growth forest. Huge Sitka spruce and western hemlock, some over 200 feet tall and hundreds of years old, provide habitat for federally threatened bird species, including bald eagles and marbled murrelets. The headland boasts spectacular panoramic views of the Pacific Ocean. Three Arch Rocks NWR and Oregon Islands NWR can easily be viewed from Cape Meares, making it the only viewpoint on the Oregon coast where three National Wildlife Refuges can be seen at once. As shown in Figure 15, Cape Meares NWR and Oceanside are located on the Three Capes Loop Road, about ten miles west of Tillamook.

Figure 15. Location of Cape Meares and Three Arch Rocks National Wildlife Refuges.

To prevent disturbance to extremely sensitive seabirds, Three Arch Rocks NWR is closed to public entry year-round, and waters within 500 feet of the refuge are closed to all watercraft from 01 May through 15 September.

5.3.3. Siuslaw National Forest and Oregon Dunes National Recreational Area

The Siuslaw National Forest is a very diverse and productive region extending from Tillamook to Coos Bay along the Oregon coast (see Figure 16). The forest encompasses over 630,000 acres of unique and varying ecosystems.

The Forest is situated within the Oregon Coast Range, a mountain range that runs north to south from the Columbia River to north central California. The Siuslaw National Forest is bordered on the east by the Willamette Valley and the west by the Pacific Ocean and is one of only two national forests located in the lower 48 states to claim oceanfront property. Marys Peak, the highest peak in the Coast Range at elevation 4,097, is a prominent view west of Corvallis. Pacific Coast Scenic Byway Highway 101 runs parallel along the west side of the Forest and the Pacific Ocean, while Highways 26, 6, 18, 22, 20, 34, 126 and 38 provide access from the Portland metro area and central and southern Willamette Valley.

Four major rivers flow out of the Siuslaw National Forest into the Pacific Ocean: the Nestucca, Alsea, Siuslaw, and Umpqua providing excellent habitat for anadromous fish. Many other smaller streams and tributaries add to the annual route salmon and steelhead take to their ancestral spawning ground.

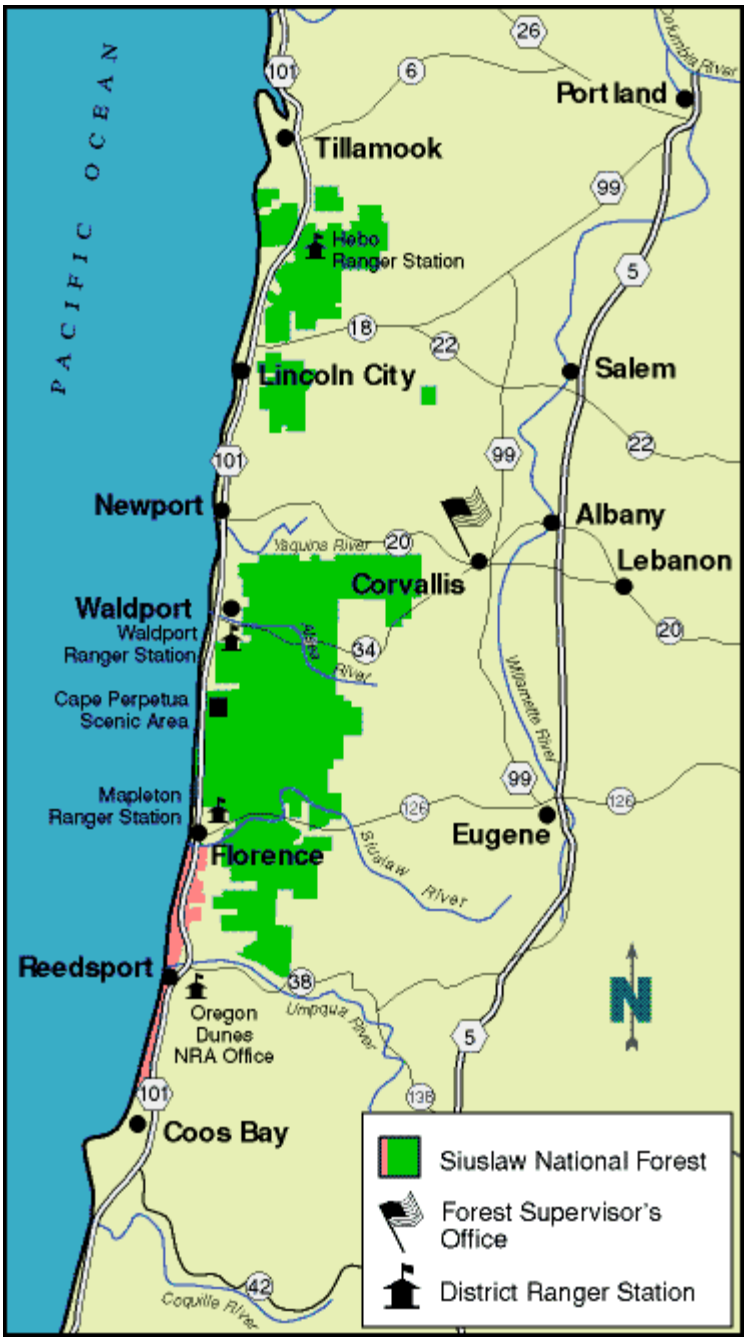


Figure 16 Siuslaw National Forest

5.3.4. Scientific Research Reserves

Landfalling submarine power cables should avoid these areas. While some research reserves are quite localized and easily avoided, others cover extended sections of coastline, and these are charted in Figures 17, 18, 19 and 20.

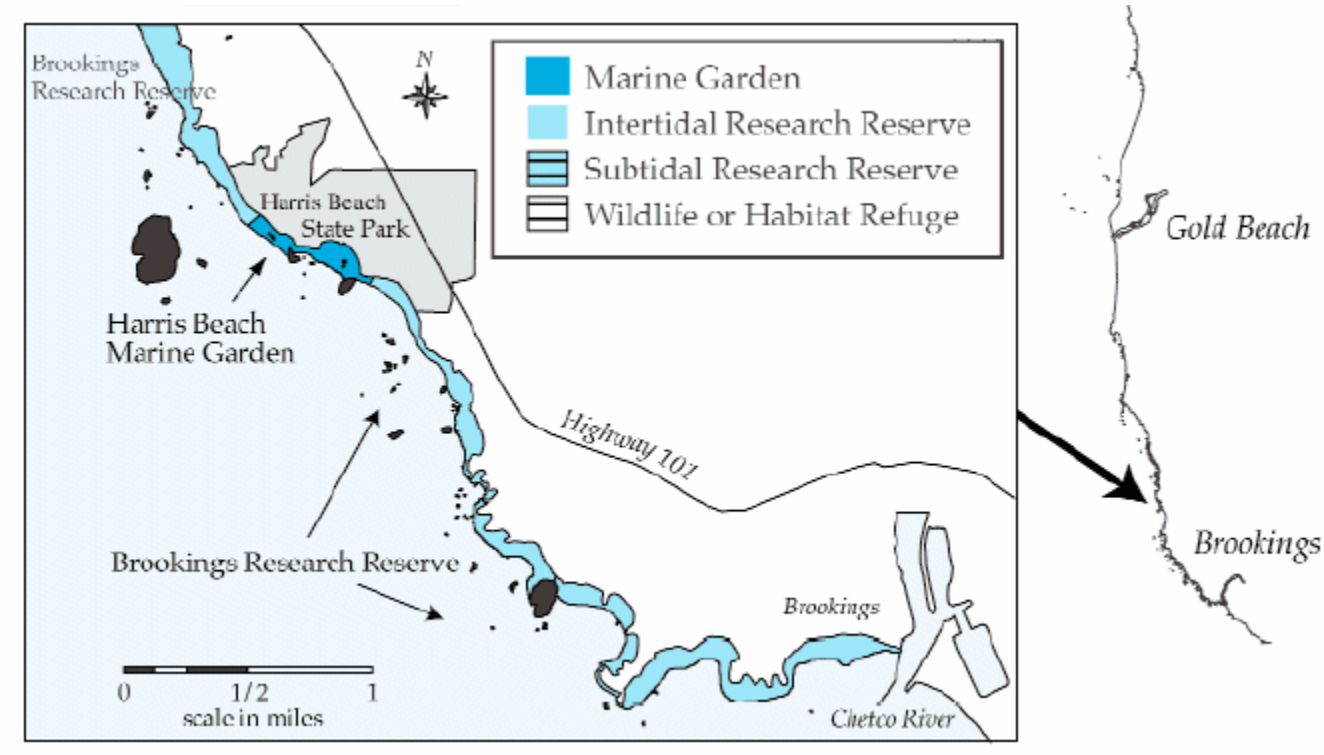


Figure 17. Harris Beach Marine Gardens and Brookings Research Reserve, just north of Brookings

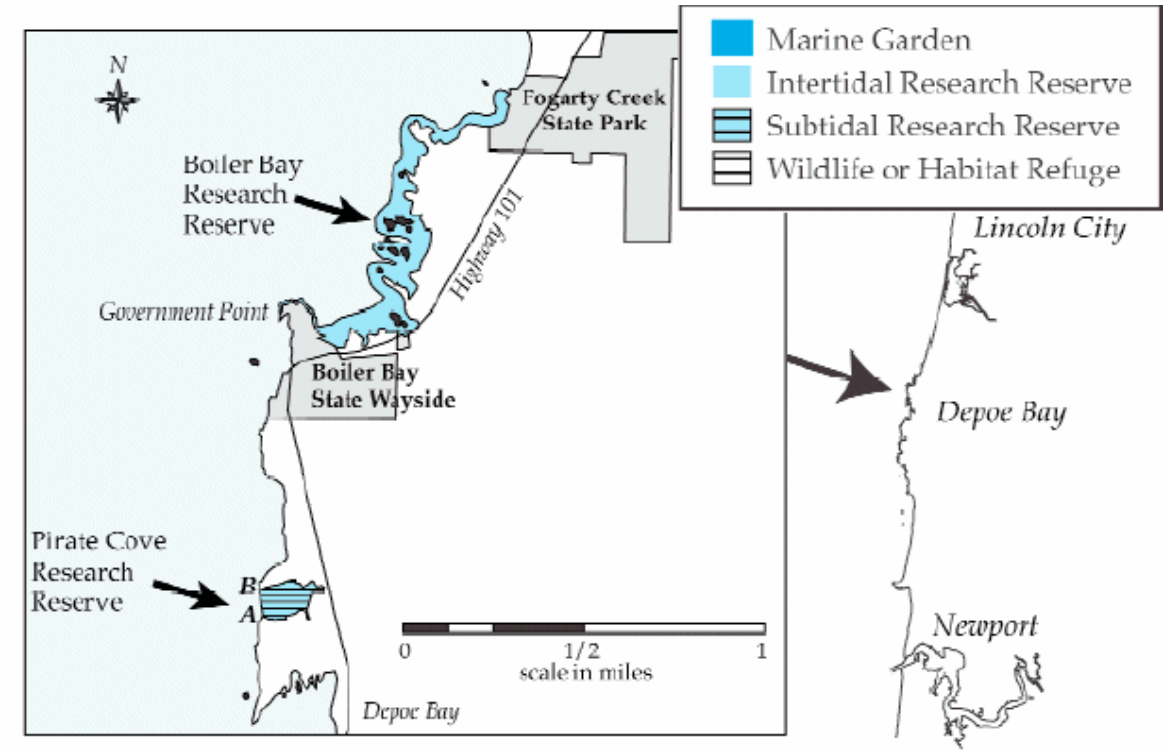


Figure 18. Boiler Bay and Pirates Cove Research Reserves, just north of Depoe Bay

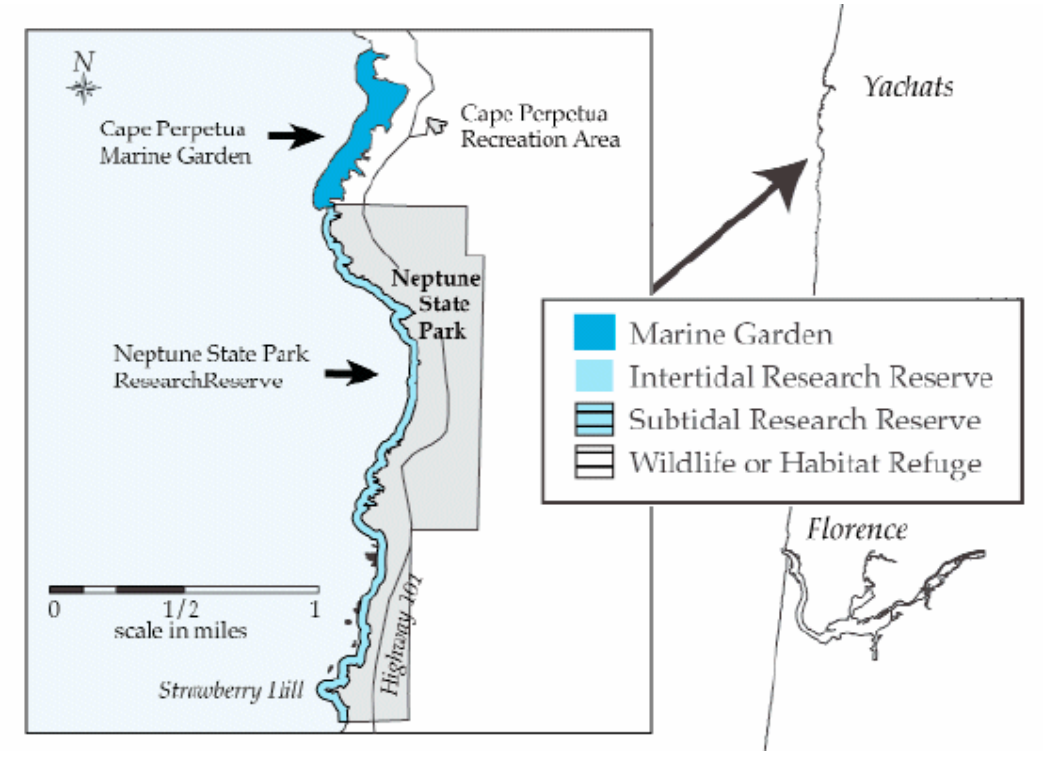


Figure 19. Cape Perpetua Marine Garden and Neptune State Park Research Reserve, just south of Yachats

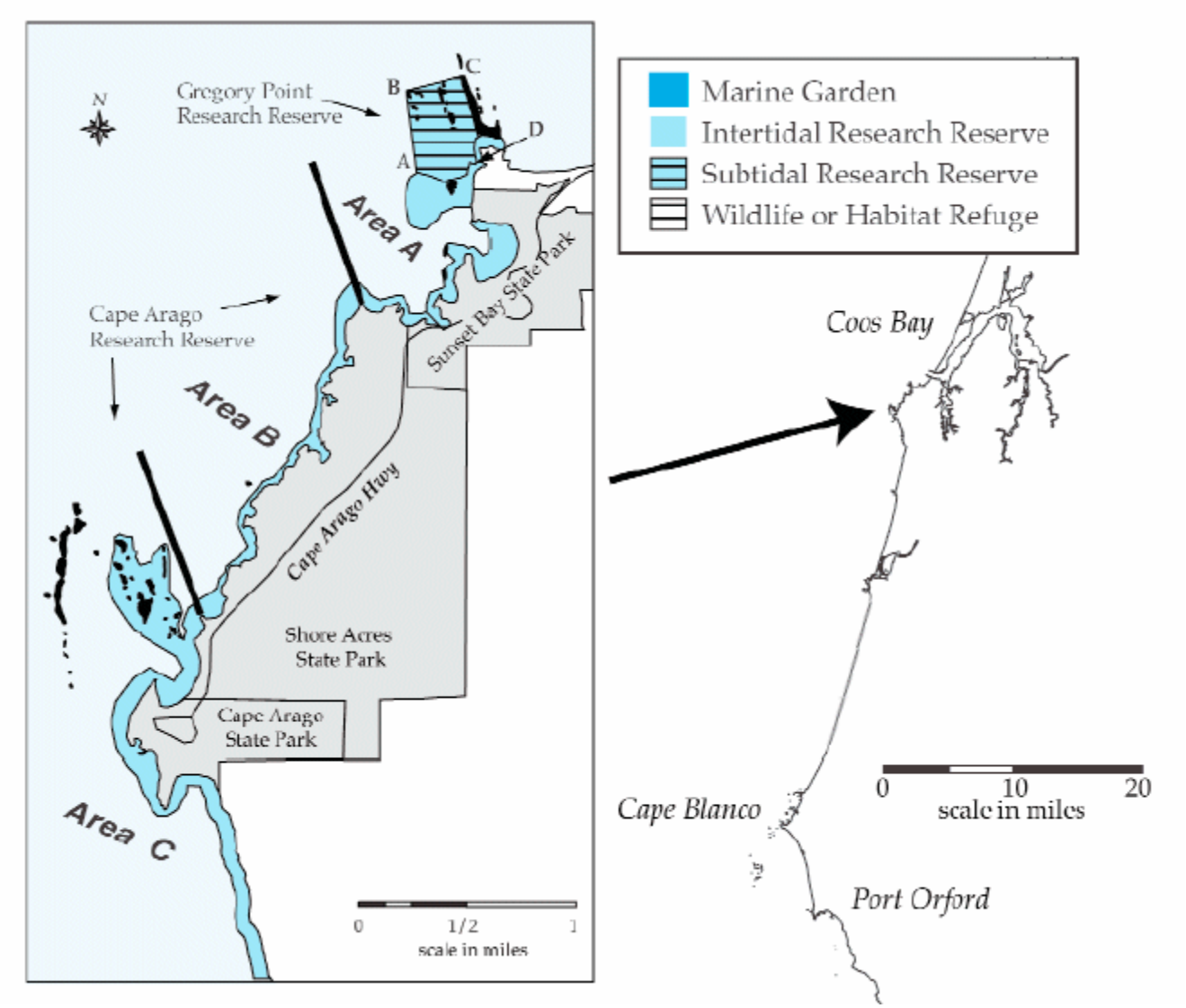


Figure 20. Gregory Point and Cape Arago Research Reserves, just south of the entrance to Coos Bay

5.3.5. Nearshore Rocky Reefs

Oregon faces growing pressure to utilize the living marine resources of nearshore, subtidal, rocky reefs. New fishery regulations have closed extensive offshore areas to trawling and that pressure will undoubtedly shift to the nearshore environment where rocky reef habitats are vulnerable to trawl damage. Declines in nearshore salmon and urchin fisheries, and the new live-fish fishery and expansion of open-access hook and line fisheries have increased pressures on nearshore rockfish populations. Non-fishery pressures include dredge material disposal, mineral and gas exploration, kelp harvest, and increased recreational uses.

Because these reefs are in state waters, Oregon is responsible for managing them to sustain their long-term use and productivity. In 1995, the Oregon Department of Fish and Wildlife initiated a

multi-year project to survey and characterize Oregon's nearshore (<50 m deep) rocky reefs. The importance of habitat to reef species cannot be over-stated and is now widely accepted in the scientific community and is the focus of major research efforts in other Pacific coastal states. The degree to which species-habitat relationships is understood by resource managers is essential to protecting critical habitat, developing population indices for species at risk, and maintaining a healthy and productive sustainable system.

Nearshore rocky reef areas surveyed by the Oregon Department of Fish and Wildlife as part of their Marine Habitat Project are mapped in Figure 21. The most extensive reef is Siletz Reef, located north of Newport, off Lincoln County. There also are several large reefs off of Curry County, between Cape Blanco and the Rogue River entrance. Cape Perpetua Reef is a complex of low-relief rock patches ranging in size from 3 feet in diameter to large rock shelves hundreds of feet long. Located north of the Siuslaw River entrance, off northern Lane County, Cape Perpetua Reef is one of the most pristine and undisturbed reefs along the Oregon coast. In addition to their environmental sensitivity, these rocky bottoms would provide poor anchoring ground and for engineering reasons also should be avoided as mooring sites for wave energy devices or corridors for laying submarine power cables.

5.3.6. Offshore Rocky Banks and Canyons

Oregon's continental shelf is narrow in comparison with worldwide averages and ranges from about 17 kilometers (10 miles) off Cape Blanco to 74 kilometers (46 miles) off the central coast. In general, the shelf is steepest where it is most narrow. The depth of the shelf "break" where there is a relatively abrupt steepening of the seafloor gradient, marking the top of the continental slope, is generally taken to be the 200-meter depth contour.

Farther offshore than the subtidal reefs described above, Oregon's continental shelf has several prominent, rocky, submarine banks of varying size. Four major banks create locally shallow areas amidst the otherwise deeper water of the shelf: Nehalem Bank, Stonewall Bank, Heceta Bank, and Coquille Bank. Nehalem Bank is located northwest of Tillamook Bay, just south of Astoria Canyon. Stonewall Bank and Heceta Ban are charted in Figure 22. Coquille Bank is located due west of Point Arago, just south of Coos Bay, at 124°50' W.

Two prominent submarine canyons breach the outer edge of Oregon's continental shelf. These canyons formed during periods of lowered sea level, when the Columbia and Rogue Rivers drained across what is now the continental shelf. The Astoria Canyon cuts into the outer shelf about 16 kilometers (10 miles) west of the Columbia River. The Astoria Fan, a large depositional feature on the eastern Cascadia Basin, lies at the base of the canyon. The Rogue Canyon is much smaller than the Astoria Canyon. It begins near the edge of the shelf offshore of the Rogue River and feeds directly down the continental slope onto the deep ocean floor of the Cascade Basin.

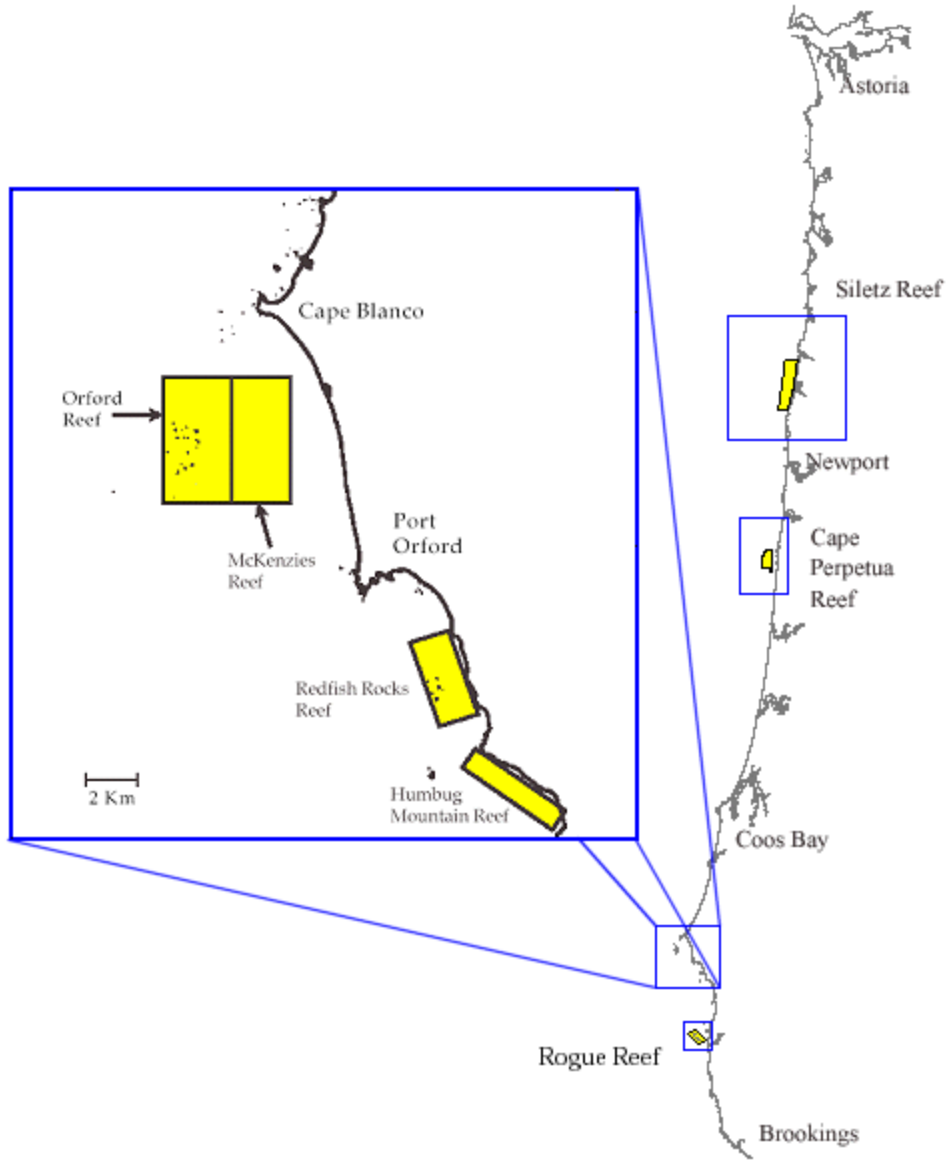


Figure 21. Location of subtidal, nearshore rocky reefs surveyed by the Marine Habitat Project of the Oregon Department of Fish and Wildlife.

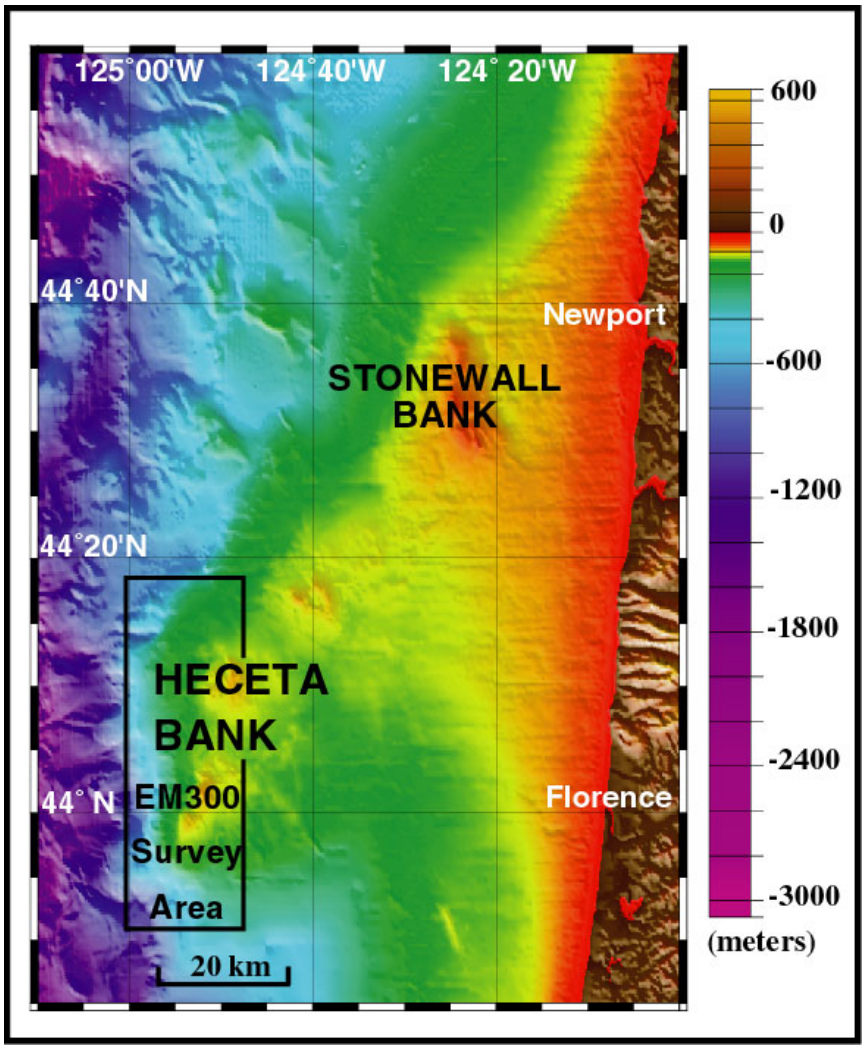


Figure 22. Location of Heceta Bank and Stonewall Bank on the outer continental shelf off the Oregon Coast, between Florence and Newport.

Heceta Bank, Stonewall Bank, Coquille Bank, Astoria Canyon, and Rogue Canyon are of such importance to state fisheries that the Oregon Department of Land Conservation and Development has prohibited commercial marine minerals exploration and lease sales in these areas under its Ocean Resources Management Plan (http://www.lcd.state.or.us/coast/offshore/op_policies.html). Non-proprietary academic and public agency scientific research on marine minerals are permitted if the Oregon Department of Fish and Wildlife determines that such research activities will not cause significant adverse effects on fisheries or sensitive marine populations or habitats. In the absence of a specific state policy for offshore ocean wave energy conversion, it is assumed that mooring a wave power plant or laying a submarine power cable also would be prohibited in these areas. Since wave refraction at the head of a submarine canyon tends to disperse wave energy, and since rocky banks offer poor holding ground for anchors, these areas would not be preferred sites in any case.

5.4. Regulatory Agencies and Permitting Requirements

The core of ocean management in Oregon is its Ocean Plan, which covers a wide variety of ocean management issues in both state and federally governed waters, and recommended future state policies and management interests.

The Ocean Plan created a starting place for more detailed planning and policy formulation for Oregon's territorial sea, which is the three-mile ribbon of ocean along the shoreline under the state's jurisdiction. A 23-member Ocean Policy Advisory Council gives policy advice to the governor and state agencies, and provides a public forum for discussing ocean-use issues.

This ocean management program has helped Oregon develop policies for issues such as federal oil and gas leasing and offshore minerals mining, directing commercial uses, protecting marine habitat, addressing overuse, and managing sand and water quality. This would be the natural entry point for developing regulatory policies and planning with regard to offshore ocean wave power development.

6. References

To be provided later

Appendix A. Wave Energy Resource Characterization

To be provided later

Appendix A. Bathymetry and Surficial Geology

To be provided later

Appendix C. Grid Interconnection Data

Coastal substation (from north to south) interconnection data is presented in this appendix. There are 12 coastal substations as listed below

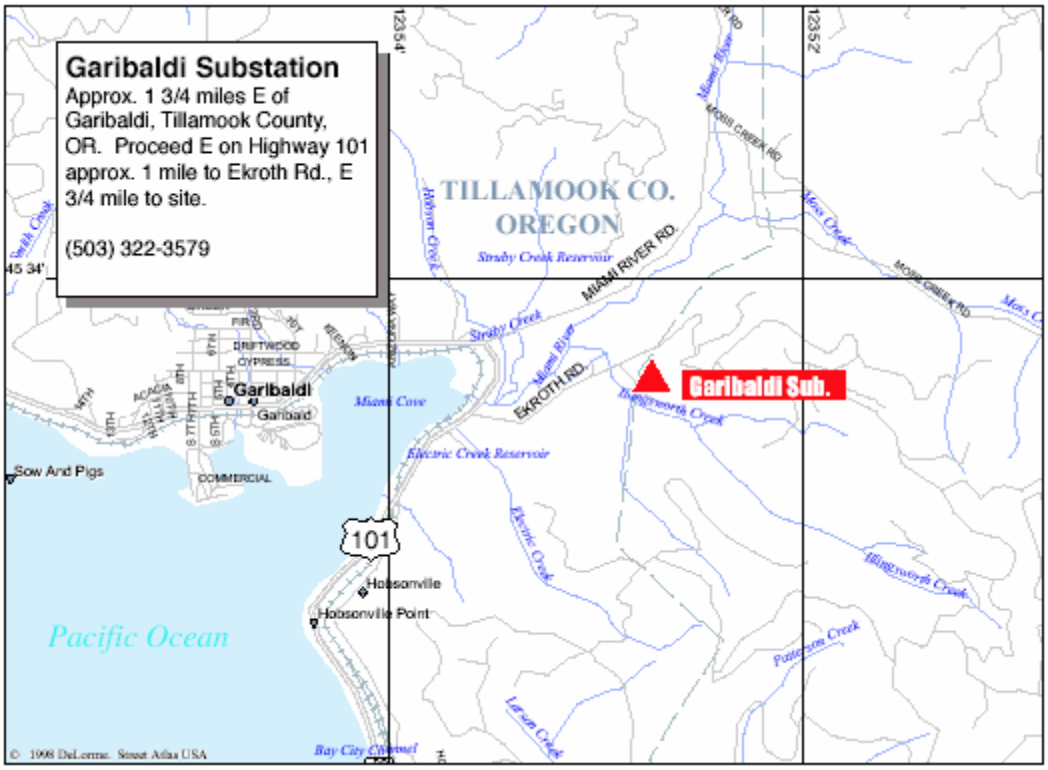
Owner	Name	lat_ deg	lat_ min	lat_ sec	long_ deg	long_ min	long_ sec
Tillamook County PUD	Garibaldi	45	33	37	123	52	49
Tillamook County PUD and BPA	Tillamook	45	27	29	123	49	44
Bonneville P	Toledo	44	37	15	123	55	24
Central Lincoln PUD	Florence	43	58	57	124	4	60
Bonneville P	Gardiner	43	44	30	124	6	47
Bonneville P	Tahkenitch	43	44	34	124	5	0
Bonneville P	Reedsport	43	41	45	124	7	27
Bonneville P	Bandon	43	6	24	124	23	48
City of Bandon and BPA	Two Mile Road	43	3	29	124	24	2
Bonneville P	Port Orford	42	46	9	124	27	57
Bonneville P	Gold Beach	42	24	34	124	24	59
Coos-Curry Electric Cooperative, Inc and BPA	North Brookings	42	4	54	124	18	44

The following pages, one per substation, provides interconnection details and a location map.

Garibaldi Substation

Voltages: 115 kV, 24.9 kV
Customers served: Tillamook PUD (owned by TPUD)

Transformer capacity
T-1658, 3-phase 115/24.9 kV, 15/25 MVA, OA/FA



Tillamook Substation

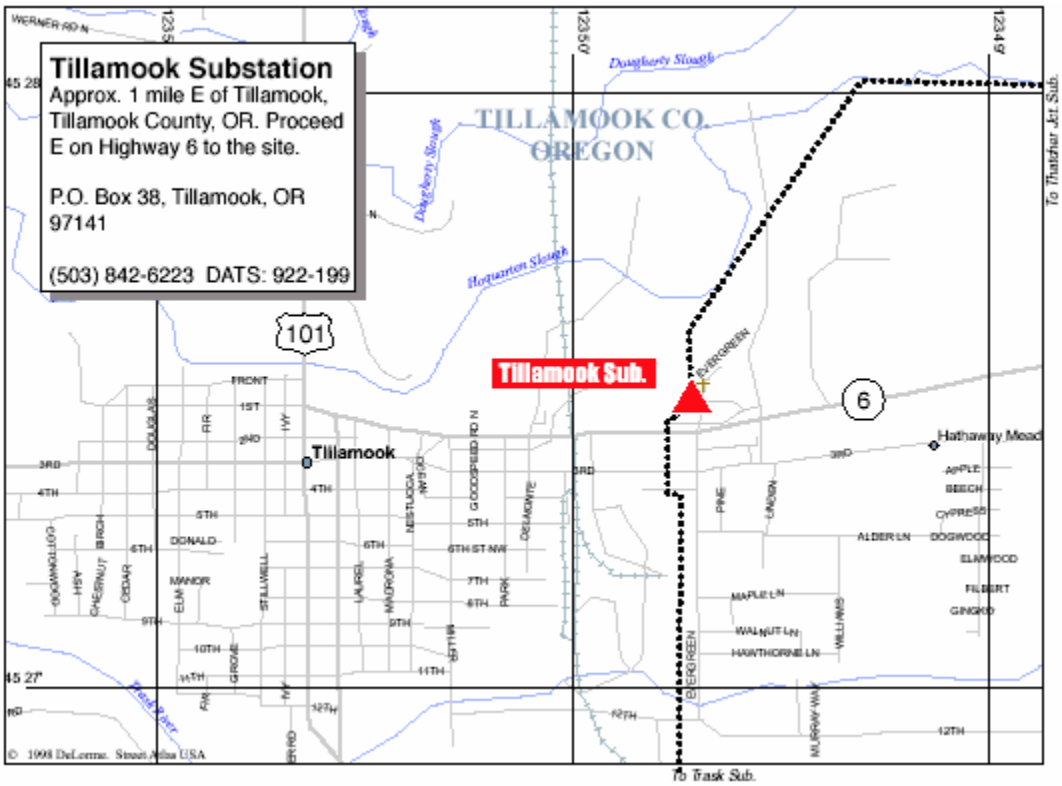
Voltages: 230 kV, 115 kV, 24.9 kV, 12.5 kV
Customers served: Tillamook PUD

Transformer capacity
T-1585, 3-phase 230/115 kV, 280 MVA
T-1424, 3-phase 115/24.9 kV, 20/27/33.3 MVA, OA/FA/FOA
T-1054, 3-phase 115/12.5 kV, 20/26.7/33.3 MVA, OA/FA/FA

Shunt capacitors
25.2 MVAR group rated at 115 kV
32.4 MVAR group rated at 115 kV

Voltage schedules:
12.5 kV bus, high 13 kV, low 12.4 kV
24.9 kV bus, high 26.2 kV, low 24.8 kV
115 kV bus, high 118 kV, low 116 kV
230 kV bus, high 242 kV, low 230 kV

SCADA: Yes
Note: BPA has a 115 kV tie with Pacificorp



Toledo Substation

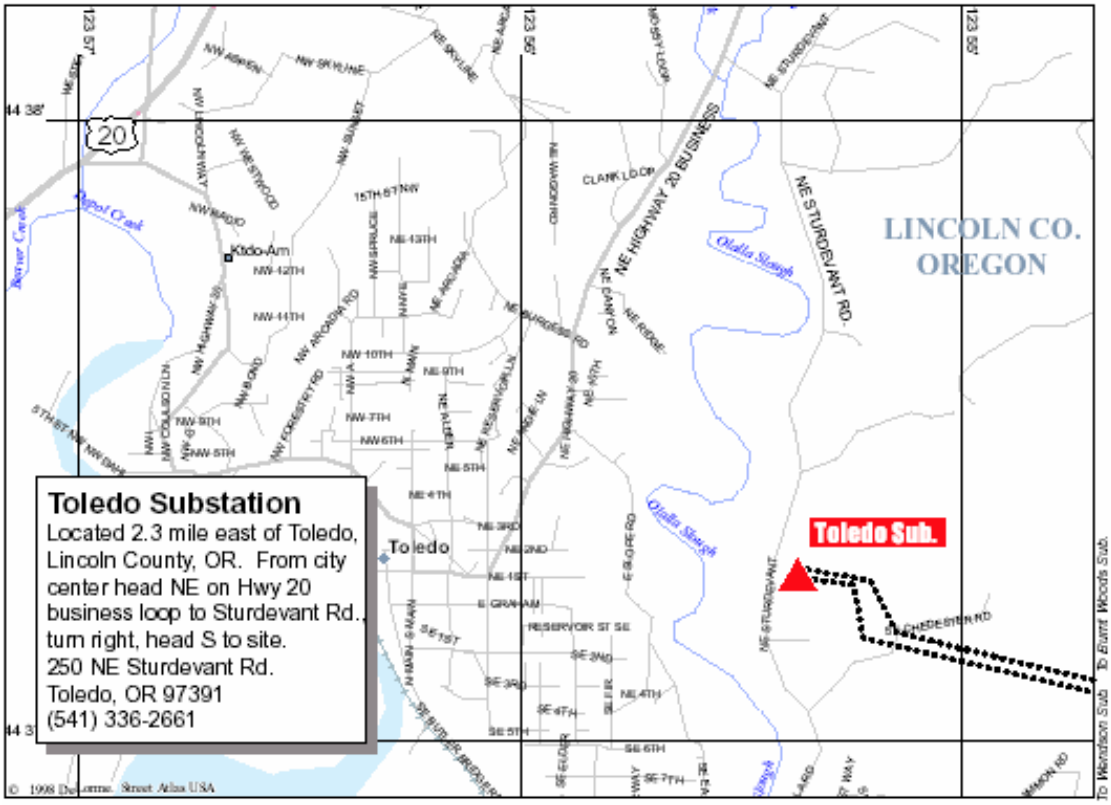
Voltages: 230 kV, 69 kV
Customers served: Central Lincoln PUD, Consumers Power Inc.

Transformer capacity
T-1715, 3-phase 230/69 kV, 140/200 MVA, OA/FA
T-1627, 3-phase 230/69 kV, 140/200 MVA, OA/FA

Shunt capacitors
45 MVAR group rated at 230 kV
39 MVAR group rated at 69 kV
16.8 MVAR group rated at 72 kV
16.8 MVAR group rated at 72 kV

Voltage schedules
69 kV bus, high 70 kV, low 68 kV
230 kV bus, high 242 kV, low 230 kV

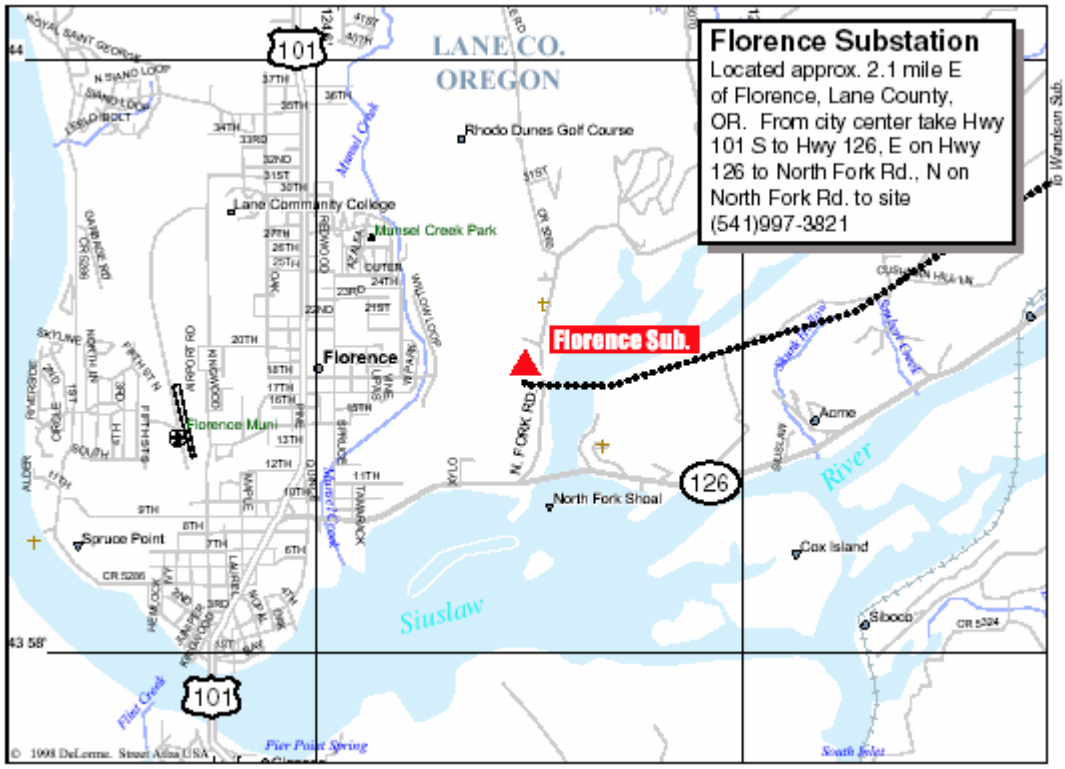
SCADA: Yes
Note: This substation serves a 70 MW Georgia Pacific Paper Mill Load.



Florence Substation

Voltages 115 kV, 12.5 kV
Customers served: Central Lincoln PUD (owned by CLPUD)

Transformer capacity
Two banks of 3-phase 115/12.5 kV, 12/16/20 MVA, OA/FA/FOA



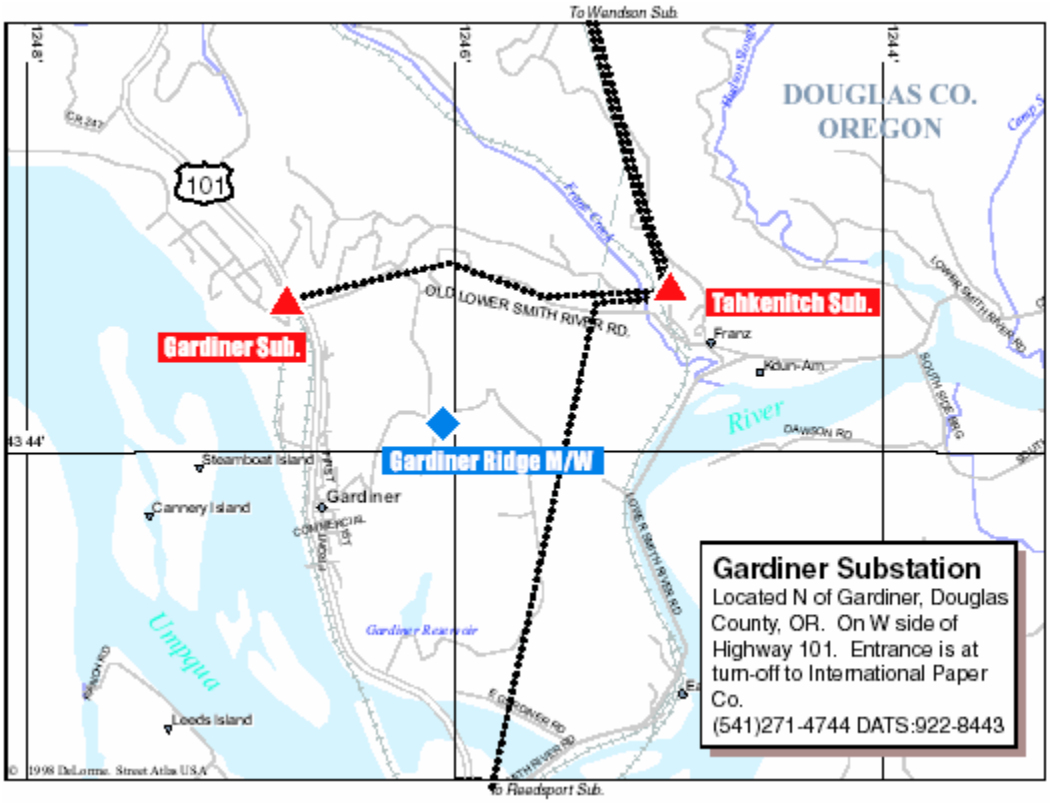
Gardiner Substation

Voltages: 115 kV, 13.8 kV
Customer served: Douglas Electric Cooperative, Central Lincoln PUD

Transformer capacity
T-1156, 3 phase 115/13.8 kV, 12/16 MVA, OA/FA
T-1051,1052,1053, 3 single phase 110/13.8 kV bank, 4/4.8 MVA, OA/FA

SCADA: No

Note: T-1051 is deenergized. CLPUD does not normally take service from Gardiner, as the International Paper load has been inactive.



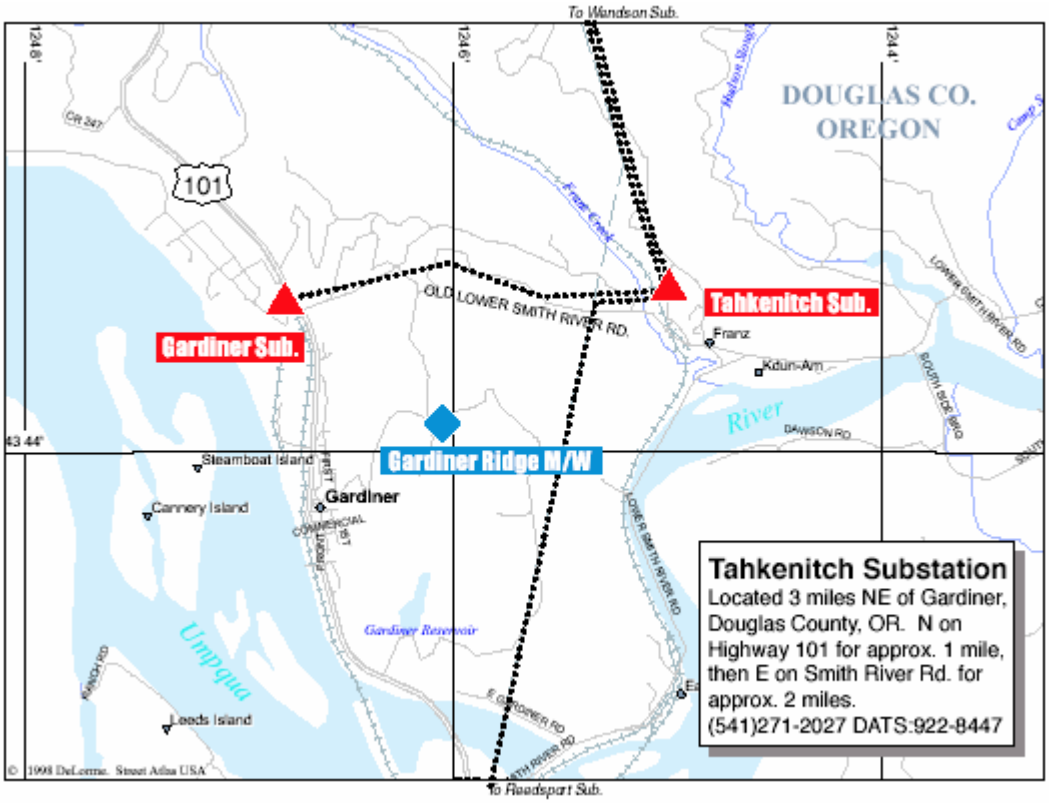
Tahkentich Substation

Voltages: 230 kV, 115 kV,
Customers served: Main Grid Substation (Central Lincoln, Douglas Electric Coop, Coos Curry Electric Coop)

Transformer capacity
T-1671, 230/115 kV, 140/200 MVA, OA/FA
Shunt capacitors
Two groups of 24.3 MVAR rated at 118.6 kV

Voltage schedules
115 kV bus, High 119 kV, Low 116 kV
230 kV bus, High 242 kV, Low 230 kV

SCADA: Yes



Reedsport Substation

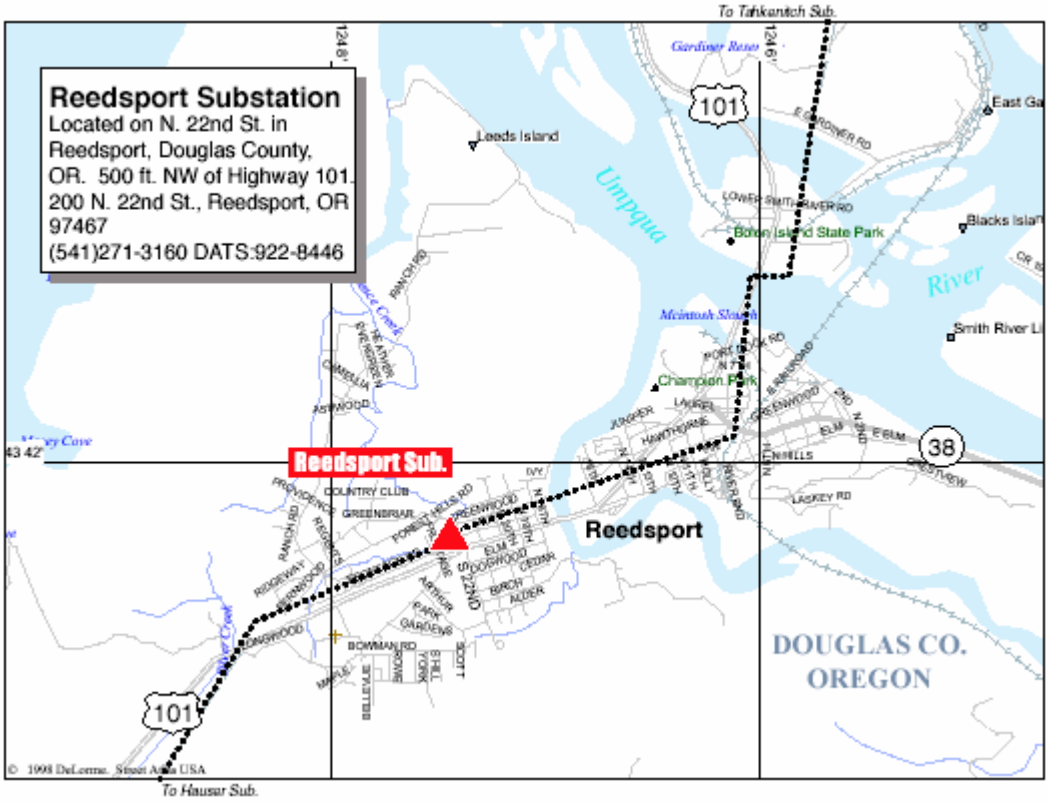
Voltages: 115 kV, 12.5 kV
Customers served: Central Lincoln PUD, Douglas Electric Cooperative

Transformer capacity
T-1431, 3-phase 115/12.5 kV, 13/17/22 MVA, OA/FA/FA
Central Lincoln PUD, 3-phase115/12.5 kV, 12/16/20 MVA, OA/FA/FA

Shunt capacitors
12 MVAR group rated @ 124.71 kV

Voltage schedules
12.5 kV bus, high 13.2 kV, low 12.7 kV
115 kV bus, high 118 kV, low 116 kV

SCADA: Yes



Bandon Substation

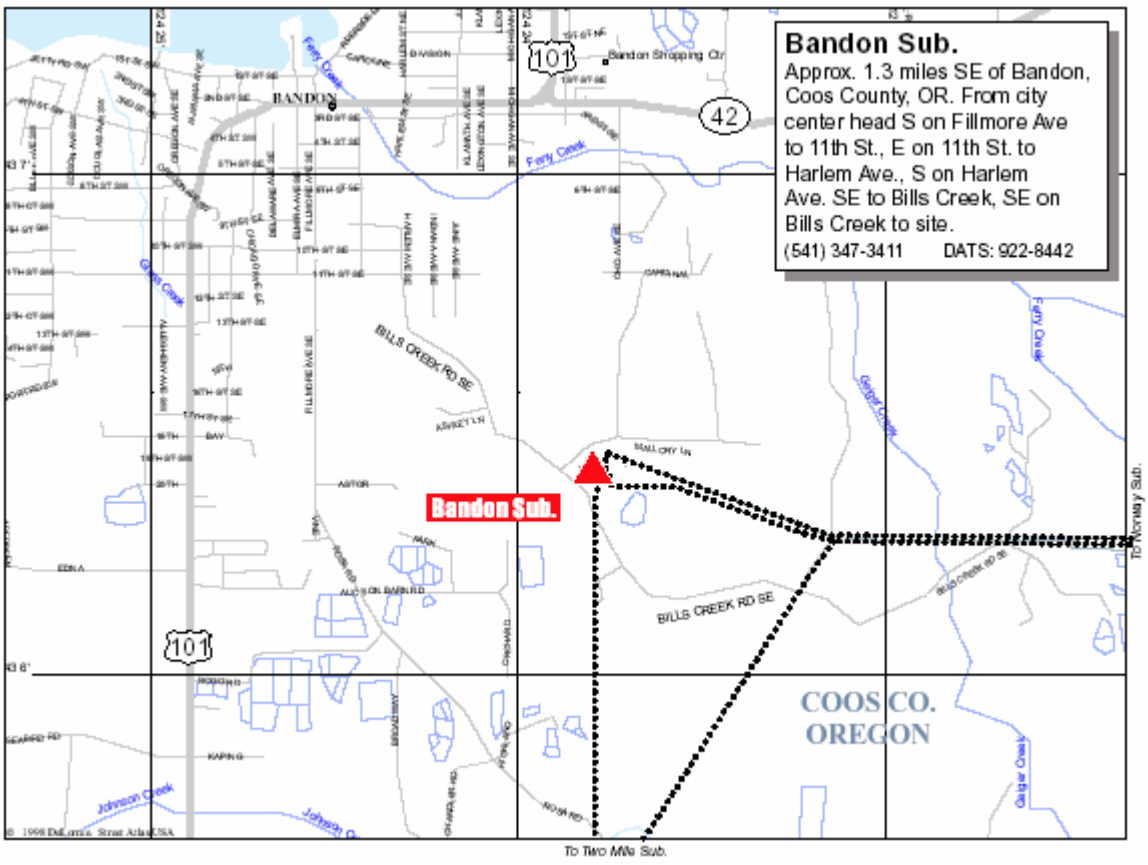
Voltage 115/12.5 kV
Customers served: Bandon, Coos Curry, Pacificorp

Transformer capacity
T-1100, 3-phase 6/7.5 MVA, OA/FA
T-848, 3-phase 6/8.0 MVA OA/FA

Shunt capacitors
2 groups of 12.6 MVAR each rated at 118.47 kV

Voltage schedules
12.5 kV bus, High 13.1 kV, Low 12.5 kV
115 kV bus, high 119 kV, low 117 kV

SCADA: Yes



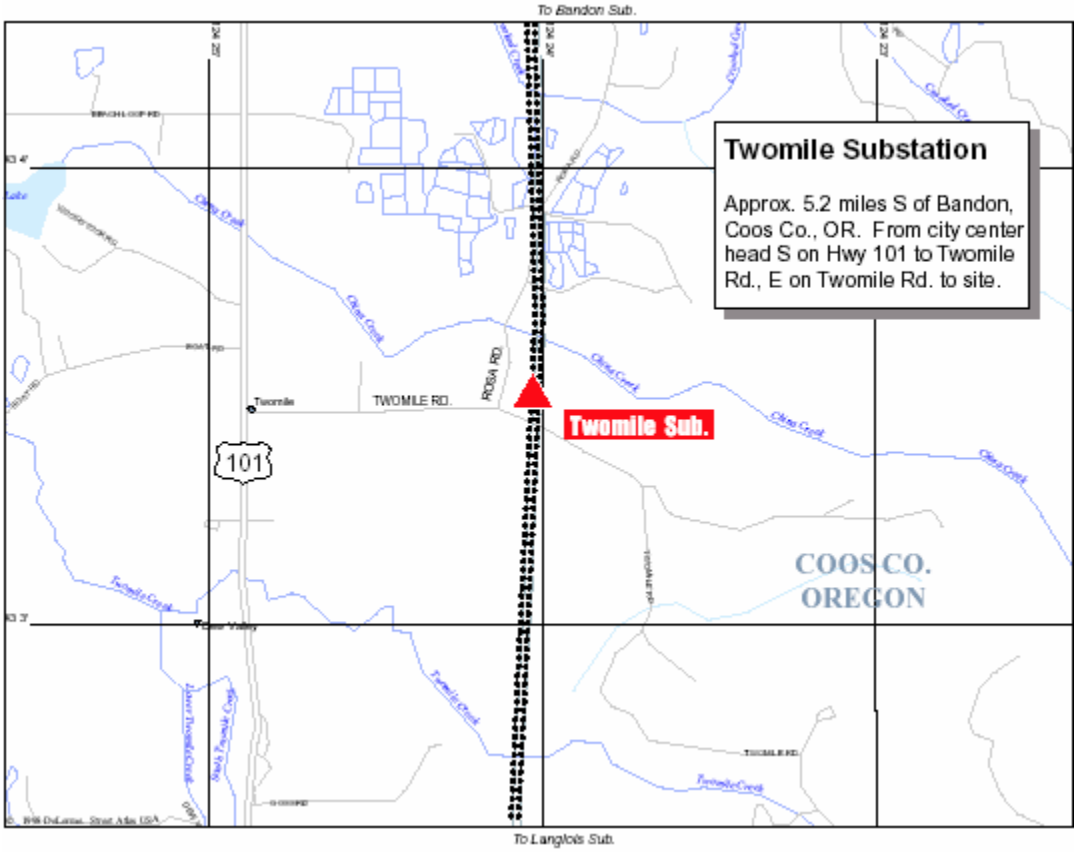
Two Mile Road

Voltages: 115 kV, 12.5 kV
Customers served: City of Bandon

Transformer capacity
T-1745, 3-phase 115/12.5 kV, 15/20/25 MVA, OA/FA/FA

Voltage regulation: The City has two 12.5 kV voltage regulators

SCADA: No

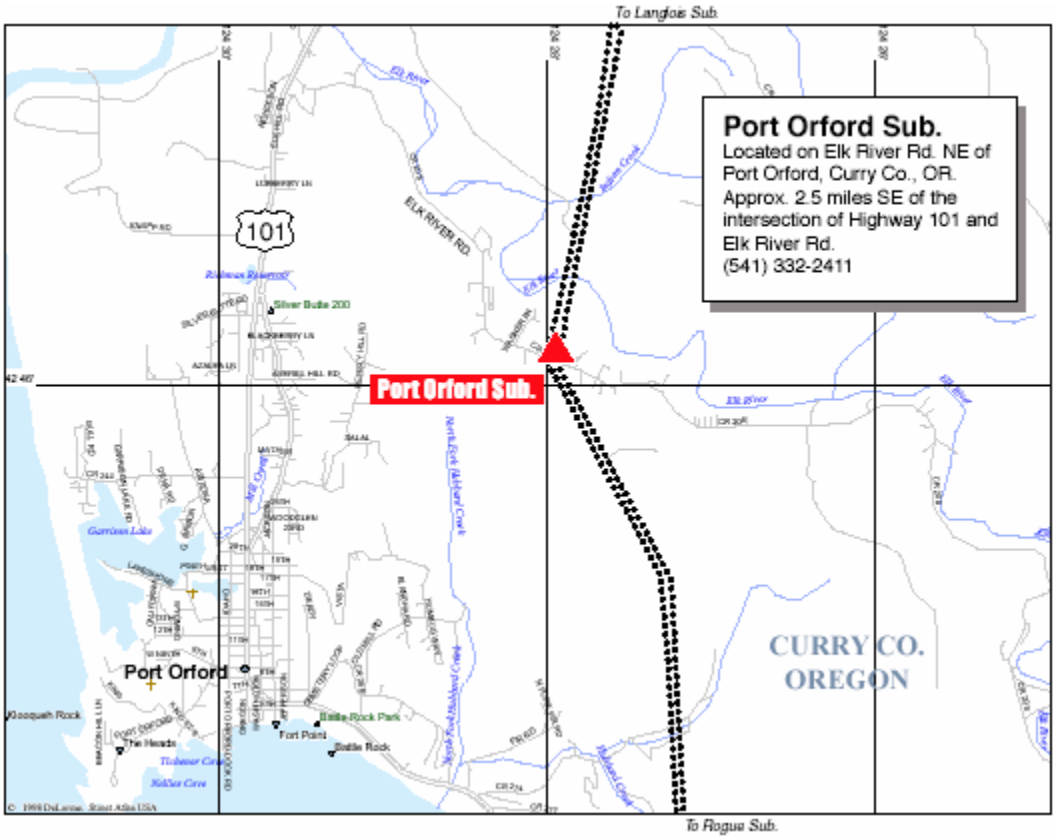


Port Orford Substation

Voltages: 115 kV, 12.5 kV
Customer served: Coos Curry Electric Cooperative

Transformer capacity
T-845, 3-phase115/12.5 kV, 6/8 MVA, OA/FA

SCADA: No

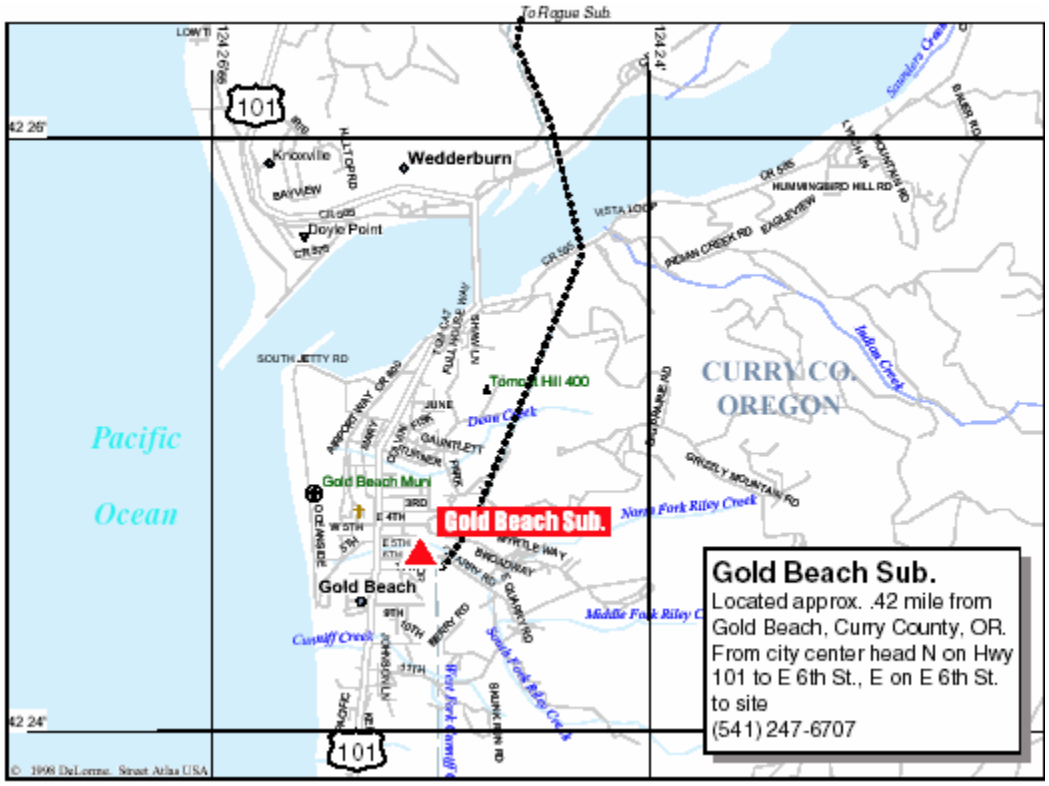


Gold Beach Substation

Voltages: 115 kV
Customer served: Coos Curry Electric Cooperative

Transformer capacity
No BPA voltage transformation.
Coos Curry, 3-phase 115/12.5 kV 12/16/20 MVA, OA/FA/FA

SCADA: No



North Brookings Substation

Voltages: 115 kV, 12.5 kV
Customers served: Coos Curry Electric Cooperative (owned by CCEC)

Transformer capacity
3-phase 115/12.5 kV, 12/16/20 MVA, OA/FA/FA

Shunt capacitors (owned and O&M by BPA)
9.75 MVAR group rated at 124.7 kV

SCADA: No