WAVE ENERGY
Infrastructure Assessment in Oregon

Prepared for the Oregon Wave Energy Trust

OregonWaveEnergy TRUST

Prepared by Advanced Research Corporation

Advanced Research corporation

Authors: John Lavrakas, Jed Smith

Date: December 1, 2009

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Oregon Wave Energy Infrastructure Assessment

Understanding the infrastructure capabilities of the Oregon coast for the responsible development of wave energy. Funded by the Oregon Wave Energy Trust.

Prepared for:

OregonWaveEnergy TRUST

www.oregonwave.org

Prepared on behalf of Oregon Wave Energy Trust by:

Advanced Research corporation

www.oregonarc.com

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This document was prepared by Advanced Research Corporation on behalf of the Oregon Wave Energy Trust.

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About Oregon Wave Energy Trust

The Oregon Wave Energy Trust – (OWET) - with members from fishing and environmental groups, industry and government - is a nonprofit public-private partnership funded by the Oregon Innovation Council in 2007. Its mission is to serve as a connector for all stakeholders involved in wave energy project development - from research and development to early stage community engagement and final deployment and energy generation - positioning Oregon as the North America leader in this nascent industry and delivering its full economic and environmental potential for the state. OWET's goal is to have ocean wave energy producing 2 megawatts of power - enough to power about 800 homes - by 2010 and 500 megawatts of power by 2025. www.oregonwave.org

About Advanced Research Corporation

Advanced Research Corporation, located in the rural coastal community of Newport, Oregon, is a private company providing engineering and consulting services, with expertise in air, marine, space, and land technologies. It focuses in the areas of marine studies and applications, including renewable energy technology and ocean observation. It also specializes in Global Navigation Satellite Systems (GNSS) technologies and other positioning, navigation and timing (PNT) systems. www.oregonarc.com

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Executive Summary

The Oregon Wave Energy Trust (OWET) is tasked with positioning Oregon as North America's leader in the nascent industry of producing utility power from the energy contained in ocean waves. Its mission is to serve as a connector and facilitator for all stakeholders involved in wave energy project development and to ensure the responsible development of this energy technology.

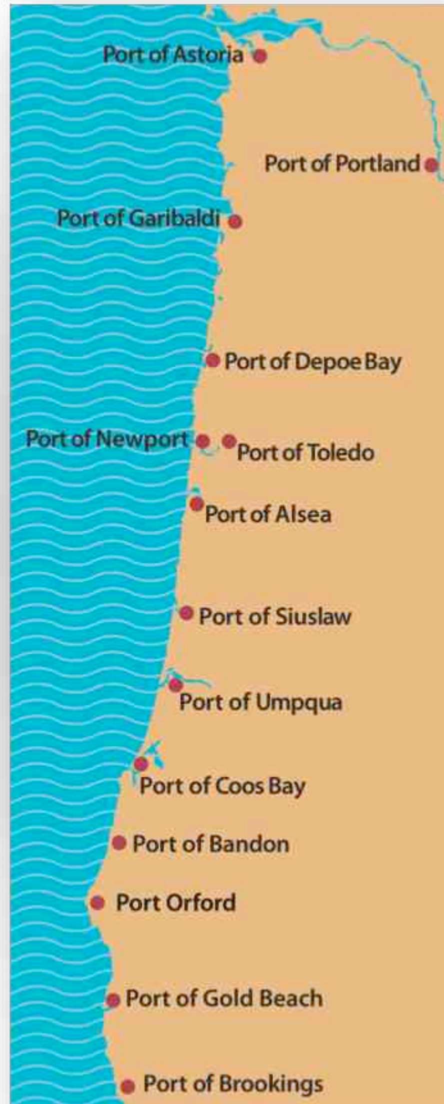
To better serve its stakeholders, OWET commissioned a gap analysis to assess the infrastructure needs of ocean renewable energy and compare those needs against the existing and planned infrastructure capabilities in Oregon. The Wave Energy Infrastructure Assessment in Oregon report summarizes the results of the assessment performed by Advanced Research Corporation and is intended to serve as a reference resource for a variety of readers: suppliers, wave energy developers, state and regional governments, economic development authorities, and educational institutions.

Oregon has a tremendous infrastructure capability to develop and deploy wave energy technology, not only into Oregon coastal waters, but also throughout the Pacific Northwest.

- Oregon has the manufacturing muscle, the transportation infrastructure, and a capable workforce.
- Gaps exist in infrastructure capability, notably the availability of deployment vessels and workforce with specialized skills for deployment at sea, which can be closed through strategic planning and assertive action both by regional coalitions and at the statewide level.
- Oregon is uniquely suited to support early test and demonstration activities, the state being the home to the Northwest National Marine Renewable Energy Center and the Hatfield Marine Science Center. Oregon also benefits from the forward-looking and practical initiatives fostered by OWET in investigating environmental, societal, economic, and cumulative effects resulting from wave energy development.
- In the next 10 years, the biggest demand on Oregon will be for test and demonstration of new technology off of the Oregon coast. After 10 years, full deployment of commercial wave energy systems is expected to be viable. Oregon's opportunity goes beyond developing and selling wave energy within Oregon. It includes the manufacturing and deployment of wave energy devices to other regions along the Pacific Rim, including California, Washington, Alaska, and Canada.
- Infrastructure jobs will result from the development of wave energy in Oregon, but in the early stages many of those jobs will be sporadic. It may take years for a steady stream of workforce activities to develop as the industry transitions from the test and demonstration phase to full commercial deployment.

This report identifies a set of prioritized, recommended actions to resolve infrastructure gaps, thereby supporting the development of wave energy products and services in Oregon.

The Oregon Coast



Recommendations for Immediate Implementation

- **Local regions** in Oregon should form regional coalitions to consider and implement steps uniquely adapted to their regions to prepare for wave energy deployment in Oregon.
- **Community colleges** on the Oregon Coast should incorporate courses and programs into their strategic plans that will provide workforce training to develop the various specialized skill-sets needed for wave energy test, demonstration, and deployment.
- **Area businesses** that are expecting to participate in the wave energy arena should become familiar with the technology, the processes, and the issues associated with their trades to close the gap in providing the needs of wave energy developers.
- **Barge, tug, and vessel operators** should become familiar with the processes and issues associated with deploying and recovering wave energy devices at sea.
- **Ports** should become familiar with the processes, needs, and issues of deploying, operating, and maintaining wave energy devices. They should also be able to provide interested businesses with a standard information packet detailing port capabilities and limitations.
- **Workforce organizations** should become familiar with the processes and issues associated with the transport and offloading of wave energy components and the deployment and retrieval of wave energy devices.
- **The Oregon Department of Transportation**, together with Business Oregon, should look at the transportation needs of wave energy developers and incorporate into their strategic plans actions to prepare roadways and railways for transporting wave energy components from manufacturing areas to the coast.
- **Wave energy developers** coming to Oregon need to understand the "Oregon Way" of doing business, namely, collaborating with local stakeholders prior to implementing new capability so as to harmonize the implementation into existing environmental, economic, and social infrastructure.
- **Wave energy developers** should prepare transportation, operations and maintenance, retrieval, and emergency plans to facilitate access to key Oregon infrastructure sectors.

Recommendations for Later Implementation

- **Ports and regions** should develop the infrastructure for deployment of wave energy equipment and services.
- **Community colleges** on the Oregon Coast should begin to implement workforce-training programs to provide the various specialized skill-sets needed for wave energy test, demonstration, and deployment.
- **Wave energy stakeholders** should work with the State of Oregon and coastal authorities to develop guidelines and plans for the deployment and retrieval of wave energy devices in Oregon waters.
- **Wave energy stakeholders**, in cooperation with the State of Oregon, U.S. Coast Guard, and port authorities, should develop and implement standardized emergency service procedures for operation within Oregon coastal waters.
- **The State of Oregon** should explore additional investment in the test facility provided by NNMREC to incorporate a business component that follows the model of the European Marine Energy Centre in Scotland.
- **Wave energy developers** should be open to provide relevant information about their devices and technology so governments, regions, and local businesses can prepare the framework and infrastructure needed to support the development and operation of the devices.

Introduction

In fulfillment of its mission to actively support the responsible development of wave energy capacity in Oregon, the Oregon Wave Energy Trust (OWET) engaged the services of Advanced Research Corporation to assess Oregon's infrastructure and its capability to meet the manufacturing and deployment needs of wave energy in Oregon.

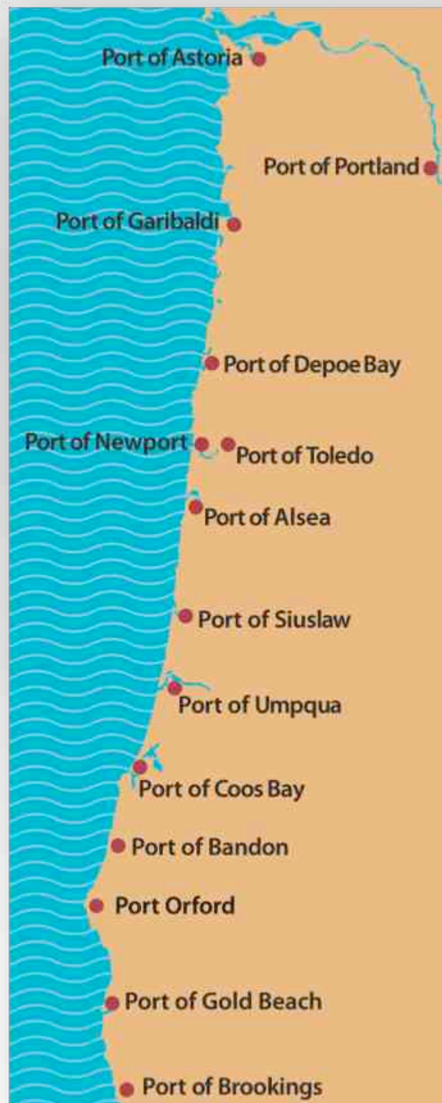
This assessment identifies the infrastructure needs of wave energy developers and compares these needs against the existing and planned infrastructure capabilities in Oregon. The work was performed over the period June through November 2009. In conducting this assessment, we interviewed twelve wave energy developers from Scotland, England, Ireland, Norway, Canada, and the U.S. states of New Jersey, Massachusetts, and Oregon. In addition we visited and interviewed representatives from four major ports on the Oregon coast, plus manufacturers, marine engineering and construction firms, and tug and barge operators. To gain a better understanding of workforce needs, we met with local members of the International Longshore and Warehouse Union and members of the local community. Finally, to understand Oregon's capabilities to support wave energy test and demonstration, we met with representatives from the Northwest National Marine Renewable Energy Center and the Hatfield Marine Science Center.

This document is the full report of our assessment and includes a prioritized set of recommendations for infrastructure additions and improvements to support the growth of Oregon's wave energy industry.

This document contains five sections and a set of appendices:

- Wave Energy Developers – provides an overview of the various technologies, focusing on offshore, nearshore, and onshore devices.
- Overview of Infrastructure Needs – describes infrastructure needs for each of the wave energy types (offshore, nearshore, and onshore), plus a discussion of test center needs
- Oregon's Infrastructure Capabilities – summarizes the manufacturing, transportation, assembly, deployment, maintenance, and retrieval capabilities Oregon has to meet the needs of wave energy developers. Also includes a summary of capabilities to support wave energy test and demonstration.
- Gap Analysis – assesses the capabilities and gaps in Oregon relative to the needs of wave energy developers.
- Summary and Recommendations – identifies prioritized steps that can be taken by various stakeholder groups to take advantage of or improve upon the infrastructure capability of Oregon and summarizes findings.

Locations included in Infrastructure Assessment



- Appendix A – Wave Energy Developer Overview – detailed information on the top wave energy developers around the world.
- Appendix B – Oregon Ports – detailed information on all the ports of the Oregon Coast and the Portland Metropolitan area.
- Appendix C – Oregon Suppliers – detailed summary of Oregon suppliers by category.
- Appendix D – Developer Questionnaire – the list of questions and topics addressed with each developer that was interviewed.
- Appendix E – Port Questionnaire – the list of questions and topics addressed with each port that was interviewed.
- Appendix F – Supplier Questionnaire – the list of questions and topics addressed with each supplier company, organization, and group that was interviewed.
- Appendix G – Glossary
- Appendix H – References

This document is intended to serve as a reference resource for many types of readers: suppliers, wave energy developers, state and regional governments, economic development authorities, and educational institutions. The value to each of these groups is described as follows:

- Suppliers, including manufacturers, labor unions, and transportation – the section on Wave Energy Developers provides an overview of the different technologies. The Overview of Infrastructure Needs section provides a detailed list of which infrastructure services and capabilities wave energy developers will need. The Wave Energy Developer Overview appendix provides specific technical descriptions and contact information on a selected set of the advanced developers.

- Wave energy developers – the section on Oregon's Infrastructure Capabilities provides a summary of capabilities for the ports and suppliers on the Oregon Coast and in the Portland metropolitan area for manufacturing, transportation, assembly, deployment, operations & maintenance, and retrieval. There is a handy reference in the Oregon Suppliers appendix providing summary descriptions and contact information.

- State and regional governments, and economic development authorities – the Gap Analysis section identifies shortfalls in Oregon's capabilities, which will need to be remedied for Oregon to be successful in developing the wave energy industry. The Summary and Recommendations section provides practical steps that can be taken to remedy these gaps.

- Educational institutions – the section on Overview of Infrastructure Needs section provides an overview of the skill sets required to develop and deploy wave energy technology in Oregon. The Summary and Recommendations section specifically provides guidance on steps educational institutions can take to train the workforce needed. These steps will be of special interest to community colleges and trade schools that seek to provide technical skills that focus on the wave energy industry.

Wave Energy Developers

With wave energy development in its infancy, there exists a wide range of technologies and company advancements in various stages of design, test, and demonstration. This study covers a significant sampling of technologies and incorporates the manufacturing and deployment needs of those companies deemed most advanced in their development. These companies were selected from a list of worldwide wave energy developers.

Advanced Research interviewed twelve developers overall. Each underwent a survey that took about an hour to complete. The questions used in the surveys are provided in Appendix D – Developer Questionnaire.

Technology Overview

A wide variety of wave energy conversion devices are in development today, each designed to address various challenges in the power conversion process. Developers are well aware of the tremendous forces of nature at play and the economic costs that threaten the viability of their deployment. Therefore the designs are chosen to specifically address these issues, such as reduced manufacturing costs, flexibility in transportation, ease of assembly, rapid deployment and retrieval , minimized operations and maintenance costs, and reduced environmental impacts.

For the purposes of this assessment, we have grouped the devices into three categories, based roughly on the location of their deployment: offshore, near-shore, and onshore. Each of these categories generally represents a common set of issues relating to manufacturing, deployment, and operations. For example, offshore devices must be towed out to their locations and moored to the ocean bottom, regardless of the specific technology. Onshore devices, on the other hand, are typically concrete structures deployed right at the shore or jetty. Near shore devices consist of devices that are attached to the seafloor in shallow waters and have components that flap back-and-forth or move up and down as waves move by.

Offshore Devices

Companies fielding offshore wave energy devices contacted in this study: Pelamis, Columbia Power Technologies, Fred Olsen, Ocean Power Technologies, Resolute Marine Energy, and WaveBob.

Attenuator

An attenuator is a floating device that works parallel to the wave direction and rides on top of the waves. The devices are often long and skinny, stretching over multiple wavelengths. Energy is extracted from the relative motion between the sections of the device.

Source: Pelamis Wave Power

Source: Ocean Power Technologies

Point Absorber

A point absorber is a floating structure that absorbs energy in all directions through its movements near the water surface. Some devices are built around a central spar and separate float while others operate from floating platforms with multiple floats below connected to actuators that extract the power. This type of device is anchored to the seafloor via a mooring system that usually incorporates drag-embedment or dead-weight anchors. Most generate electricity on the device either via a linear generator or via hydraulics powering small turbines.

Nearshore Devices

Companies fielding nearshore devices contacted in this study: Aquamarine Power and Carnegie/CETO.

Oscillating Wave Surge Converter

An oscillating wave surge converter extracts the energy caused by wave surges and the movement of water particles within them. The arm of the device acts like a pendulum oscillating back and forth with each wave. The energy is extracted by the pendulum activating a pump or linear generator. Of the devices that actuate pumps, some have turbines on the device, while others pump high-pressure water ashore to operate turbines there.

Source: Aquamarine Power

Submerged Pressure Differential

A submerged pressure differential device uses the induced pressure differential of each passing wave to pump water or actuate a linear generator. These devices are usually attached to the seafloor in relatively shallow water.

Source: WavePlane

Overtopping Device – Flush in

This type of overtopping device captures the water from the waves and channels it through low-head turbines. The forward kinetic energy in the wave is retained and used to channel the water past the low-head turbines. No reservoir is present in this device although water held in the channels can provide some potential energy capacity smoothing out energy production. These devices are usually sited in the near-shore environment.

Onshore Devices

Companies fielding onshore devices contacted in this study: Voith Hydro Wavegen Limited, Wave Energy (Norway).

Oscillating Water Column

An oscillating water column device is a partially submerged hollow structure open to the ocean on the bottom. Waves cause the water column inside to rise and fall, which in turn causes the trapped air to flow back and forth past a turbine. These devices can either be mounted on the shore, in the nearshore region if built upon a caisson structure, or incorporated into breakwater structures.

Source: Voith Hydro Wavegen

Overtopping Device – Wash up

This type of overtopping device captures the water from the waves and holds it in a reservoir above sea level. The forward kinetic energy of the wave is changed to potential energy in the reservoir via the ramp in the front of the device. As the captured water returns to the sea it flows through low-head turbines. These devices can either be mounted on the shore, in the nearshore region if built upon a caisson structure, or incorporated into breakwater structures.

Source: Wave Energy

Overview of Current Wave Energy Developers

A web search reveals a large number of active wave energy developers. However, since the wave energy field is still in early development, company selection based purely on project deployments falls short of gaining a broad understanding of future possibilities. To circumvent this issue, we compiled a worldwide list of wave energy developers and selected a subset of them according to the maturity of their technology. We based this on a set of four criteria: prototype development, deployment site, funding sources, and future schedule. The result of this assessment is provided in Appendix A – Developer Overview.

The criteria used are applied as follows:

I) **Prototype development** – prototype scale size is as compared to the current planned commercial device size. It is understood that as the field progresses, these sizes may increase, as has been seen in the wind industry.
   1. No prototype
   2. A prototype of scale 1:100 to 1:10
   3. A prototype of scale 1:9 to 1:2
   4. A full scale prototype

II) **Deployment site** – the location and level of effort used in testing and deploying prototypes.
   1. Test tank
   2. Test site – single device and temporary deployment
   3. Demonstration site – one or more close-to-full-scale devices operating beyond a single season continuously
   4. Commercial site – site has permitting for commercial operation in place and generates power to the grid

III) **Funding sources** – where the money is coming from to fund development and operations.
   1. Internal
   2. From grants or other governmental sources
   3. From investors and venture capital
   4. From utility companies having power purchase agreements in place and selling power to the grid

IV) **Future schedule** – used to get a better sense of the company's ability to look toward the future. It often gives insight to compare a company's past milestones and compare them with the actual results.
   1. No scheduling information available
   2. Scheduling information is available but only looks at prototyping
   3. Scheduling with reasonable expectations that may lead to commercial projects at some point in the future
   4. Scheduling with reasonable expectations that may lead to commercial projects within the next two years. This will require sites to have completed permitting and device demonstrations to have already occurred.

Selection Criteria

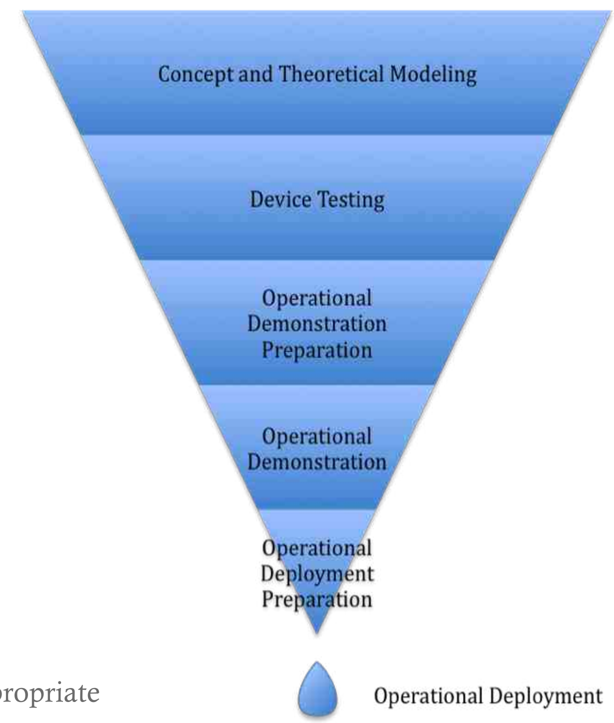
Prototype	None 1:100 to 1:10 scale 1:9 to 1:2 scale Full scale
Site	Test tank Test site Demonstration site Commercial site
Funding	Internal Grants Investors Utilities
Schedule	None Prototyping > 2 yr to commercial < 2 yr to commercial

Only publicly available information from the web was used in this selection. Some companies were more forthcoming with relevant public information than others, so it is possible that some were excluded which otherwise might have been included. By no means were the developers contacted in this assessment deemed to be solely those that are the furthest along. Rather the focus was on choosing a good mix of developers that covered the seven major types of wave energy converters. Others were chosen because of their interest in either deploying in Oregon or were already located there.

A final questionnaire was sent to the developers asking whether they agreed with the information presented. A common response was that some developers present an overly optimistic status and unrealistic milestones to the public, both through news articles and via their own websites. As best possible, this study tried to remove the hype and present only verifiable data.

Industry State-of-the-Art in the Development Cycle

The development cycle for wave energy devices is a demanding one, involving attrition at each step of the way. What is evident in examining the state of art of this technology is that numerous companies participate in the early phases of development, but over time, fewer and fewer are able to advance through each succeeding phase. In the end, only a handful remains able to move to the final phase of operational deployment. The various phases are illustrated in the figure below and described as follows:



1. **Concept and theoretical modeling**
    a. Development of initial models
    b. Validation of models using computer programs
2. **Device Testing and Proving**
    a. Wave tank testing
    b. Temporary deployment of fractional-scale models
    c. Temporary deployment of a full-scale prototype
    d. Long term deployment of a full-scale prototype
3. **Operational Demonstration Preparation**
    a. Regulatory permitting
    b. Stakeholder engagement
4. **Operational Demonstration**
    a. Long term deployment of an array of devices
    b. Demonstrate no adverse environmental impacts
    c. Assess effects on stakeholders
    d. Removal, salvage and emergency capability as appropriate
5. **Operational Deployment Preparation**
    a. Determine long-term operations & maintenance requirements and costs
    b. Development of operations & maintenance plans and contingency plans for long term operation
6. **Operational Deployment**
    a. Lifetime deployment of an array of devices
    b. Assessment of performance in a commercial operational environment

Overview of Infrastructure Needs

Developer needs in manufacturing, deployment, or operations and maintenance are best characterized by their distance from the coast and their stage of development, whether in a pre-commercial phase or fully operational.

To accommodate the widely varying infrastructure requirements from wave energy developers and to protect the proprietary information obtained from interviews with wave energy developers, this report groups infrastructure needs into four scenarios: test center scenario, full-scale deployment offshore scenario, full-scale deployment nearshore scenario, and a full-scale onshore breakwater scenario. The test center scenario is included because of its marked difference in infrastructure needs from the three operational scenarios. A table illustrating the unique infrastructure needs of each of the scenarios is provided to highlight the commonality and differences between the scenarios.

	Test Center	Offshore	Nearshore	Onshore Breakwater
Manufacturing	Manufacturer's input in component design. Steel and small scale composite	High volume output of large devices. Steel, large composite, and concrete	High volume output of large devices. Steel and large composite	On-site concrete manufacturing of large structures and modules. Concrete
Transportation	Truck, rail, standard barge	Truck, rail, custom barge	Barge, truck, rail	Truck for parts, rail for cement and gravel. Local site manufacturing
Assembly	Common site, not large—possibly provided by NNMREC	Dedicated land for assembly and deployment	Dedicated land for assembly and deployment	Land at the deployment for assembly and construction
Deployment	Device towed to site. Adaptable and knowledgeable workforce.	Device towed to site. Adaptable and knowledgeable workforce.	Device towed to site or deployed by jackup barge	Caisson towed to site or deployed off of beach
Operations & Maintenance	Provided by developer	Local workforce and service vessels. Dedicated site for onshore maintenance of devices	Local workforce and service vessels. Dedicated site for onshore maintenance of devices	Local workforce. On-site maintenance or possible onshore maintenance
Retrieval	Frequent—at end of device test period	Infrequent retrieval for maintenance	Infrequent retrieval for maintenance	At end of life
Emergency Services	Single device salvage or retrieval	Large array of devices salvage or retrieval	Multiple device salvage	N/A

The material provided in this report was largely obtained from interviews with numerous wave energy developers. The following companies provided inputs that were used in this section of the report:

- Aquamarine Power
- Columbia Power Technologies
- Fred Olsen
- Global Energy Horizons
- Natural Power
- Northwest National Marine Renewable Energy Center
- Ocean Power Technologies
- Pelamis
- Resolute Marine
- Voith Hydro WaveGen
- WaveBob
- Wave Energy Norway

Test Center Scenario

Oregon offers a tremendous opportunity for wave energy developers to test out their devices in U.S. waters. While there are many disincentives to fully fielding operational wave devices in the Northwest U.S. over the next 10 years—such as cheap power prices, large regulatory hurdles, and relatively few financial incentives—the U.S. market still beacons to international developers to come and demonstrate their technology here. Oregon offers particular benefits to developers not found in other states. These include its great wave resources, the state's openness and commitment to renewable energy technologies, and the strong marine scientific research community. Many of the developers interviewed expressed a strong interest in coming to Oregon if a test facility were present where they could perform operational demonstrations in North America.

There is a current need in the U.S. to provide developers test facilities to prove their devices to U.S. regulators, potential financiers, and ocean-use stakeholders. In Oregon, the Northwest National Marine Renewable Energy Center (NNMREC) has been established to address some of these issues.

NNMREC plans to develop a mobile test facility near Newport, Oregon that will allow developers to bring their device to the designated test berth site or the test berth could be towed to the developer's site. Bringing the device to the test berth site will reduce some of the risks associated with permitting by providing a common site to deploy that was agreed upon by stakeholders. The currently envisioned testing scenario is that the test berth and the device under test would have separate mooring systems independently deployed by NNMREC and the device developer, respectively. Through services provided by the Hatfield Marine Science Center, developers will be able to arrange for transparent environmental assessment capabilities providing third-party validations of the effects from wave energy devices.

Manufacturing

Developers favor Oregon as the site for manufacturing the larger components, such as spars or concrete forms, while reserving the right to import the specialized components containing proprietary technology.

Developers of devices in their early stages of development seek companies that can manufacture small quantity lots and are willing to interact with developers to suggest necessary modification and adapt to design changes as they occur. Many of the early devices are being constructed out of steel to provide more flexibility for modifications and changes to the design.

For the later demonstration tests, fewer design changes will be necessary. However, manufacturing companies that are willing to work with small numbers of devices is still necessary. Some developers are leaning towards cheaper construction materials such as fiber-reinforced plastics (FRPs) and structural concrete to lower production costs.

Transportation

Depending on the location of manufacturing it may be necessary to move large sections to the assembly and deployment sites, each designed to fit on standard flatbed trailers or railroad cars. Shipment via truck for smaller devices and sections is preferred due to costs and schedule flexibility. Projects that require lots of material, such as large piping, favor rail options.

Projects with extremely large devices would probably use of barges to transport devices and large components from manufacturing facilities to deployment facilities. This allows assembly of the final device to occur at the manufacturing facility, where access to large cranes and other complex equipment would be easier and perhaps cheaper.

Assembly

Areas to assemble and deploy test devices are needed on a short-term basis, such as days or weeks. For test center projects, buying or leasing the necessary land for assembly may not be feasible for most developers. Such areas should be provided by the test facility or existing nearby ports or industry.

Deployment

Standard barges outfitted with hoists and winches and towed by coastal tugs will perform deployment of devices directly into coastal waters. Since demonstration devices or arrays are of limited scope, custom vessels or barges are not economically viable, and not expected to be used.

For early testing, devices would only be deployed for short periods of time, such as weeks or months. As testing progresses into demonstration phases the devices would remain deployed for much longer periods, such as seasons or years, reducing the standby need for deployment capabilities.

Operations & Maintenance

Developers of test devices will generally provide monitoring of their own device performance, while the test facility is expected to provide environmental and power monitoring. There is interest from developers for access to third-party organizations able to perform assessments such as environmental impact studies that could be used for later commercial deployments.

For early short-term testing, the need for maintenance would not be a large requirement and would be handled by the developer. As testing moves into demonstration phases, developers will need skilled personnel to inspect the devices, perform preventative and corrective maintenance, as needed.

Waterfront space and manufacturing or repair capability will likely be required for adjustments, modifications, and repairs to test devices as designs evolve through the testing phase. Some of these tasks may be handled at sea, in which case sea-going equipment and skilled labor will be required. For devices more mature, these requirements will lessen, although unexpected events may rekindle the need. Arranging and providing these services will be the responsibility of the developer and likely not provided by the test center.

Device Retrieval

For early testing, device retrieval would be a frequent occurrence as developers install and remove devices in the test center as they work kinks out of the devices and their mooring systems. As testing moves into demonstration phases, retrieval would become less frequent. On the other hand, the sizes and quantities to remove would most likely increase, as the devices move from small-scale prototypes to full-scale devices, and are incorporated into larger arrays of multiple devices. Salvage of devices is a possibility due to the uncertainty of the technology and the complexity of the devices.

Retrieval will also include removal of all anchoring and mooring components of the test device. If the test berth is no longer needed in that area then it will also include the removal of its anchoring and mooring components as well.

Emergency and other abnormal situations

Emergency situations involving offshore devices include the following

- Device breaking loose from mooring and drifting into surf and onto beach
- Fisherman or boaters entering the operational, anchoring, and mooring area of the wave energy device and becoming entangled in the anchors or mooring lines
- Large sea mammal venturing into the operational, anchoring, and mooring area of the wave energy device and becoming injured by the devices or mooring lines

Other abnormal situations include the following:

- Fisherman losing gear into the operational, anchoring, and mooring area of the wave energy device (not life threatening)
- Wave energy device sinking to the bottom

Emergency services: US Coast Guard rescue services for people in peril; Oregon Department of Fish and Wildlife; salvage companies.

Divers: required for removal of sunken devices from the seafloor. Operating depths will depend on the device tested.

Offshore Scenario

The offshore environment is characterized by depths of 30m or more, up to 100m and may have sandy or rocky bottoms. The deployment zones range from 1 km to 5 km offshore. Devices are moored in place using either conventional drag-embedment or dead-weight anchors in multipoint mooring configurations. Electrical power is generated at the device and transmitted to shore by cables across on the ocean bottom.

Types of offshore wave energy devices include attenuators, point absorbers, and floating oscillating water column.

Manufacturing

Offshore devices range from several tonnes to over a thousand tonnes, with typical weights of a few hundred tonnes.

The material of choice for prototype devices has been steel. The material is strong, easy to modify and can be fabricated by a wide range of companies. However, as the field looks to the future, other materials are being considered to help reduce full-scale production costs and corrosion in salt water. Some developers are considering composite materials (FRPs) while others are considering structural concrete.

Wave energy developers of offshore devices plan to manufacture their devices in pieces, with separation between the mechanical and the electrical components. Respondents stated a need for local mechanical engineering and fabrication.

According to many developers, manufacturing of the electrical and proprietary components will take place outside of Oregon with the components shipped in.

Other services needed during the manufacturing process include corrosion protection, integration of various subsystems and intellectual property sensitive parts, as well as ballasting in the form of sand or concrete.

Manufacturing materials: steel fabrication, composites including fiber-reinforced plastics (FRP), structural concrete

Transportation

Developers are designing their devices for easy transportation by truck or rail, meaning that the size of the devices will conform to the standard transportation platforms. If these sizes are too constraining shipment is via custom barge. In this case final assembly usually takes place on the barge and removes the need for an assembly area near the deployment site.

With many of the smaller devices, components will be manufactured at large manufacturing centers and shipped to the assembly site on the coast.

Assembly

Offshore developers need assembly areas that provide sufficient area over the term of the assembly and launch, and are located close to water. Moving the device from the land to the water can either be accomplished via crane from a strong dock or bulkhead or, in the case of large devices, via a marine railway. Very large devices will be built in a drydock or on a custom barge that is also used to transport the device to the final site and deploy it.

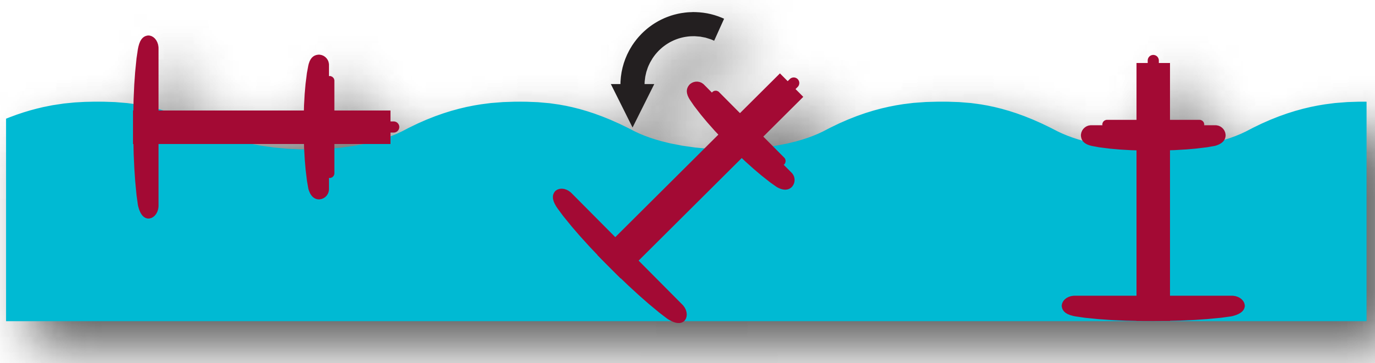
The typical assembly area will resemble a large building construction site. There will be a need for an office building, staging and storage of parts and equipment, utility hookups, and even covered work areas for some devices. The assembly site will also need a dock or mooring for final checkout of the device once the device is in the water. Developers will either lease or purchase the land.

Term of deployment: on the order of days or weeks for single demonstration units to year round for full-scale deployments

Deployment

Deployment of offshore devices involves transporting the devices from the land base or assembly area to the deployment site, which is located one to five km offshore. Deployment includes inserting the devices into the water, orienting them correctly, and installing and attaching mooring systems. There are two ways devices are transported to site.

One way is to tow them out to the site. Typically this involves orienting the spar horizontal in the water with a flotation collar used to hold the bottom end at water line. The device is then towed out to sea by means of a tugboat. With attenuators, the rotation is not necessary, as the draft of the device does not present the same issue in shallow harbors.



One means of deploying a point absorber device from a shallow harbor is to tow the device to its site horizontally and then rotate it into position.

The other method of deployment is to place the device onto a specially fitted barge or vessel and take it out to sea. The vessel must be outfitted with winches and cranes or be able to partially submerge for deploying the device into the water.

Deployment vessels:

- Coastal tugboat – to tow either the device or barge
- Anchor handling tug – to deploy the anchors and mooring system
- Cable deployment vessel – to install the power cable coming ashore and burry where necessary
- Custom barge – designed to haul and deploy wave energy devices
- Dive support vessel – to support divers to assemble and hook up the mooring system
- Survey vessel – to map out and determine bottom composition and topography

Divers: depths from 30m to 100m, requiring dry suits, mixed gas air, dual decompression chambers on surface

Operations & Maintenance

At this stage of development, a clear definition of O&M needs to support full scale operation is not available. Few of the developers interviewed had a detailed understanding of the processes and workforce requirements for the operations and maintenance functions, and in some cases, developers had given no consideration to O&M processes or needs. This was in part because developers were at too early a stage of test and demonstration. Nonetheless, an understanding of the attributes of offshore wave energy devices provides a general understanding of the maintenance needs. In one sense, offshore devices are akin to medium scale ocean going vessels. Devices range in diameter from 6 to 20 meters and in mass from 100 to 2,000 tonne.

Operations involve monitoring power levels, the health of the wave energy devices, and in some cases providing control functions. Developers have indicated staffing needs from no onsite personnel (autonomous operation) to 10 or more personnel available to support power monitoring and management. In most cases, developers are planning for remote monitoring of the wave energy devices using a combination of wireless and internet connectivity.

Maintenance requirements include a need for personnel skilled in mechanical and electrical equipment maintenance, replacement, and repair. Depending on the power take off mechanism used, the devices could have any combination of pumps, generators, pistons, and hydraulic systems housed in a climate controlled environment. The workforce will need to be able to provide their services at sea in less than optimal conditions as well as dockside. The number of personnel required can range from only one to a dozen or more workers on staff, depending on the complexity and size of the system.

Maintenance activities are heavily dependent on the types of device employed and the features developers have designed into their systems to minimize system maintenance. Maintenance functions include inspecting units (opening up of hatches and examining for leakage, rust, and other damage), performing preventative maintenance at sea (opening up of hatches and performing basic maintenance duties), replacing failed components on the wave energy devices at sea (opening up hatches and replacing failed components), and retrieval of wave energy devices for shore-based maintenance. In some cases storage and work areas are required near to the dock where devices will be returned for maintenance. Much of the maintenance activities are expected to be scheduled in the summer season, but a limited amount of work (inspections, emergency maintenance) will occur in the harsh winter months.

Device Retrieval

Device retrieval involves removal of the wave energy device from the ocean, and returning it to land. Periodic device recovery is expected to occur infrequently, on the order of every two to five years, and will involve scraping, repainting, maintenance and repair before being redeployed. If it is an end-of-life removal, retrieval will include removal of all anchoring and mooring components as well. Retrieval is performed for depot level maintenance or at end of life, which could occur at any time throughout the system lifespan. The retrieval process includes deactivation of the device, disconnection of the device from the grid, disconnection from the mooring systems, return to shore, and transfer to the maintenance yard for decommissioning.

Return of the device to shore is implemented either by hoisting the device onto a transportation vessel that returns the device to shore or towing the device to the shore. Smaller devices are expected to be towed back to shore with large devices (that require deep drafts) to be placed on semi-submergible barges. Since the depth of point absorber devices range from 25 to 50 meters, towed devices will have to be rotated into the horizontal position in order to enter the harbor.

Workforce requirements: certified able-bodied seamen; required to operate the recovery vessels and retrieve the wave energy devices.

Divers: required for removal of mooring components on some devices; operating in depths from 10m to 50m (possibly deeper)

Emergency and other abnormal situations

Emergency situations involving offshore devices include the following

- Device breaking lose from mooring and drifting into surf and onto beach
- Fisherman or boaters entering the operational, anchoring, and mooring area of the wave energy device and becoming entangled in the mooring lines
- Large sea mammal venturing into the operational, anchoring, and mooring area of the wave energy device and becoming injured by the devices or mooring lines

Other abnormal situations include the following:

- Fisherman losing gear into the operational, anchoring, and mooring area of the wave energy device (not life threatening)
- Wave energy device sinking to the bottom

Emergency services: US Coast Guard rescue services for people in peril; Oregon Department of Fish and Wildlife; salvage companies

Divers: required for removal of sunken device from seafloor; operating in depths from 30m to 100+m, requiring dry suits, mixed gas air, dual decompression chambers onboard

Nearshore Scenario

The nearshore environment is characterized by depths of 10m to 20m and may have sandy or rocky bottoms. The deployment zones range from 200m to 1.6km offshore. Devices are fastened in place by special fixtures such as mounting brackets and frames. Nearshore devices may generate electricity at the device and provide power to the shore through a cable. They may also generate high-pressure water that is provided to shore via a pipeline where is it converted to electrical power through a turbine. In this case the power conversion occurs on shore.

Types of devices include oscillating wave surge converters, submerged pressure differential and flush-in overtopping.

Manufacturing

Nearshore devices range from a tonne to several hundred tonnes in mass. The device bodies are made of steel that is formed, milled, and welded into structures built to survive the harsh conditions of a nearshore ocean environment. Some devices utilize buoyant actuators that are constructed of reinforced rubber, plastics, and foams. As the field looks to the future, other materials are being considered to help reduce full-scale production costs and corrosion in salt water.

Nearshore device developers will be looking for manufacturing experience both in fabricating device structures and other large components as well as large water pumps for the devices that pump high-pressure water ashore instead of electricity.

Other services needed during the manufacturing process include corrosion protection, integration of various subsystems and intellectual property sensitive parts, as well as onshore components such as water turbines and electrical power generation equipment.

Transportation

Due to the distance that is typical between the manufacturing site and the deployment site, devices will be manufactured in sections and transported to an assembly area. Sections will be sized to fit standard flat bed truck trailers or railroad cars or shipped on barges if the design dictates very large components. A few developers have even begun devising ways to fit their devices into containers for worldwide shipping. With the barge case, the complete device can be loaded onto the barge and towed out to the deployment site. One such example would be manufacturing the device in Portland, loading the device onto a barge and towing it out across the Columbia River bar to its deployment site on the coast.

Assembly

For devices that are constructed in sections, an assembly area is needed with close access to the waterway. The assembly area must have access to truck or railheads, as applicable, and its area must be sufficient to permit storage and assembly of sections. The assembly area must have equipment on site that supports the assembly of sections, including forklifts, cranes, and hoists. The assembly area must have access to the waterway where the fully configured device will either be loaded onto a vessel (such as a barge) or placed into the water to be floated out to its site.

In the case were the device pumps high-pressure water ashore; the assembly site must also be able to support the welding of pipe sections together. Pipe sections will arrive in 20-30m lengths that then need to be welded into long (500m or longer) sections before being floated out to the installation site.

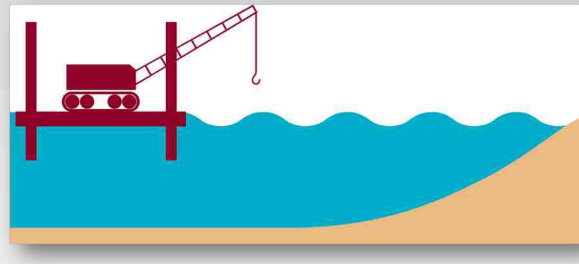
Deployment

Deployment will involve the initial placement and fastening of a frame or anchoring framework on the ocean floor. Some of the nearshore device manufacturers prefer rocky bottoms for increased stability and stronger holding. However, this will require setting rock anchors, drilling, and other complex underwater work.

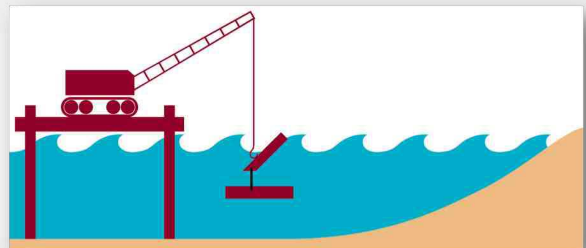
After the frame or anchoring framework is installed, the power collection unit is either floated and towed out to the ocean site or loaded onto a vessel, such as a barge, and taken out to the site. To date, the nearshore installations have utilized a jackup barge for the final placing of the device. A jackup barge allows for a stable platform that a crane can operate from in an area that can, at times, become the surf zone. As deployment experience progresses it may be possible to avoid the added cost of using a jackup barge through device design changes.

In the case were the device pumps high-pressure water ashore; the deployment site will also include the pipe landing, directional drilling equipment if necessary, and the onshore power generation facility. Directional drilling is used to provide a secure and protected way to get 50-100cm steel pipe through the surf zone to the device.

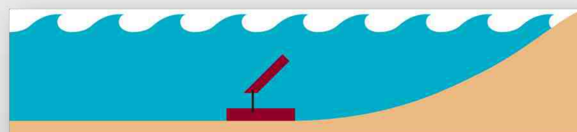
One method of deploying a nearshore device



First a jackup barge with crane is brought in



The jackup legs are lowered and raise the barge platform out of the surf. The crane then lowers in the anchors and device.



After the device is installed and secured to the seafloor the jackup barge is removed

Operations & Maintenance

At this stage of development, a clear definition of O&M needs to support full scale operation is not available. Few of the developers interviewed had a detailed understanding of the processes and workforce requirements for the operations and maintenance functions, and in some cases, developers gave no consideration to O&M processes or needs. This was in part because developers were at too early a stage of test and demonstration.

Operations activities involve monitoring power levels, the health of the wave energy devices, and in some cases providing control functions. Developers have indicated minimal staffing needs of one or two operations personnel available to support power monitoring and management. In most cases, developers are planning for integrated supervisory control and data acquisition (SCADA) systems for remote monitoring of the wave energy devices using a combination of wireless and internet connectivity.

Maintenance requirements include a need for personnel skilled in mechanical and electrical equipment maintenance, replacement, and repair. Depending on the power conversion mechanism used, the devices could have any combination of pumps, turbines, generators, pistons, and hydraulic systems. In addition, the workforce may need to provide their services at sea in less than optimal conditions. The number of personnel required can range from only one to a half dozen or more workers on staff, depending on the complexity and demands of the system.

Maintenance activities are heavily dependent on the type of device employed and the features developers have designed into their systems to minimize system maintenance. Maintenance functions include inspecting units (dives or inspecting onshore equipment), performing preventative maintenance at sea (dives to replace wear parts), replacing failed components on the wave energy devices at sea (dives to replace failed components), and retrieval of wave energy devices for shore-based maintenance (which may require a jackup barge and crane). In some cases storage and work areas are required near to the dock where devices will be returned for maintenance. With nearshore devices operating in areas that experience high sediment transport rates, it may be necessary to monitor and occasionally dredge around the device. Much of the maintenance activities are expected to be scheduled in the summer season, but a limited amount of work (inspections, emergency maintenance) will occur in the harsh winter months.

Device Retrieval

Device retrieval involves removing the wave energy device from the ocean, and returning it to land. Periodic device retrieval is expected to occur infrequently, on the order of every two to five years, and will involve scraping, repainting, maintenance and repair before being redeployed. If it is an end-of-life removal, recovery will include removal of all anchoring components, the filling of any boreholes and piping, and the removal of shore facilities. Retrieval is performed for depot level maintenance or at end of life, which could occur at any time throughout the system lifespan. The recovery process includes deactivation of the device, disconnection of the device from the grid, disconnection from and recovery of the anchoring systems, return to shore, and transfer to the maintenance yard for decommissioning. Return of the device to shore is implemented either by hoisting the device onto a transportation vessel with a crane on a jackup barge that returns the device to shore or floating the device and towing it to the shore.

Workforce requirements: certified able-bodied seamen; required to operate the recovery vessels and retrieve the wave energy devices.

Divers: required for removal of mooring components; operating in depths from 5m to 20m, requiring dry suits and basic dive support

Emergency and other abnormal situations

Emergency situations involving nearshore devices include the following

- Device breaking lose from anchors and washing onto the beach
- Fisherman or boaters entering the operational, anchoring, and mooring area of the wave energy device and becoming entangled in the devices
- Large sea mammal venturing into the operational, anchoring, and mooring area of the wave energy device and becoming injured by the devices
- Recreational user (such as a swimmer and surfer), accidentally drifting into the operational, anchoring, and mooring area of the wave energy device.

Other abnormal situations include the following:

- Fisherman losing gear into the operational, anchoring, and mooring area of the wave energy device (not life threatening)

Emergency services: US Coast Guard rescue services for people in peril; Oregon Department of Fish and Wildlife; salvage companies

Divers: required for recovery of mammals or gear from wave energy device on the seafloor; operating in depths from 5m to 30m, requiring dry suits and basic dive support

Onshore Breakwater Scenario

The onshore breakwater scenario involves installation of wave energy conversion devices into breakwaters and jetties or in a stand-alone caisson structure using large structures in shallow water to harness the wave's energy.

Onshore wave energy conversion systems are constructed as concrete bunkers or caissons that can either be built on land and floated out to site for installation, or can be assembled into sections and transported to the final location for assembly, where they are installed as a breakwater or jetty. Each component can be on the order of 10-20m in linear dimension, with the combined structures longer than a kilometer in length.

Types of onshore wave energy devices include oscillating water column and overtopping wash-up.

Manufacturing

The structures are built from structural concrete, designed to withstand the harsh ocean shore environment. Their design includes chambers into which water will flow. Incorporated into the chambers are either low-head water turbines or air turbines that generate the electricity. These turbines have a mass from a few hundred kilograms to a few tonnes and are usually constructed from steel or stainless steel and other metals.

Due to the size and ease of construction, the structural concrete structures are usually built close to the final installation location. A few manufactures however have designed each concrete module to be of an easily transportable size that link together to increase manufacturing flexibility. The turbines are small enough that transportation issues do not arise, indicating that turbine fabrication can occur at facilities far removed from their deployment site.

Manufacturing materials: Structural concrete, steel and stainless steel

Transportation

The structural concrete modules will not be transported far due to their size and mass. In the few instances where this may not be true, developers have envisioned ways to fit sections on trucks, rail cars, or barges. One other scenario is to manufacture the caissons in Portland and tow the completed structure as a unit down the Columbia River, over the bar, and to their site on the coast.

The turbines will need to be transported from a specialized facility in the Portland area or beyond. Due to their small size and mass there are no issues identified with fitting them on a truck or rail car.

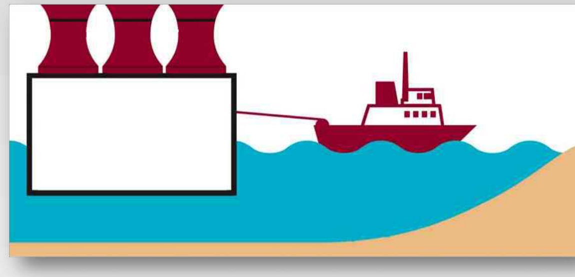
Assembly

In the cases where the wave energy device is incorporated into a breakwater or jetty, the assembly area becomes the onsite construction site and possible remote concrete facility. This type of build out is well understood and used worldwide. Concrete modules are fabricated onsite and transported a short distance to their final resting location. The turbine installation requires only a small lift or crane to install it.

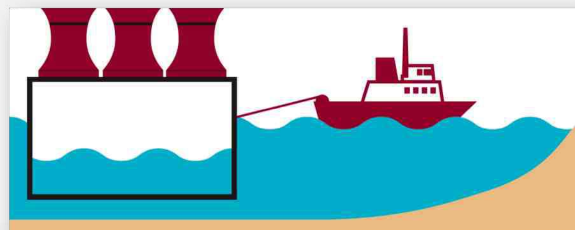
In the cases where the wave energy device is incorporated into a stand-alone caisson structure, a separate assembly area is needed. The requirements are similar to the above example where it is incorporated into a breakwater structure with the difference being the final site cannot be used, as it will be shallow water instead of the shore. Water access is required since the caisson will either be floated out or placed on a barge. A nearby concrete facility will be required to supply the vast amounts of concrete needed to fabricate the caissons.

In the cases where the structural concrete modules are manufactured away from the coast and shipped in, the assembly site will need to have room for staging and assembly of the final units. Water access is required so that the final unit can be floated out or placed on a barge.

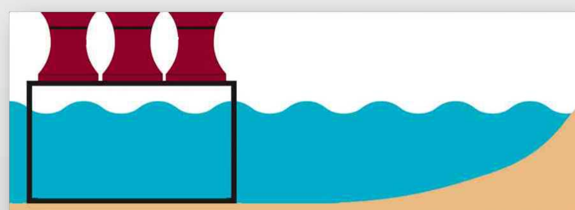
One method of deploying a caisson device



The internal chambers of the caisson are purged of water, causing it to float. It is towed from the harbor to the deployment site with a tugboat.



Once in location, the internal chambers in the caisson are flooded with water. This causes the caisson to sink to the bottom.



The device is then anchored to the bottom.

Deployment

In the cases where the wave energy device is incorporated into a breakwater or jetty, deployment involves moving the final units from their assembly location to their final resting location. This requires special tracks to be installed that the device can be moved down to the end of the installation or heavy cranes to lift the units into place.

Regardless of the installation type, there is the need to prepare the ocean floor for the installation. At a minimum, a survey of the area and sub-bottom is needed. Other possibilities are leveling the ocean floor, installing an anchoring system, and running power cables to the shore to transmit the generated electricity.

Deployment vessels: Tugboat, barge, survey, and diver support as needed

Operations & Maintenance

Breakwater wave energy systems are by design extremely simple and require little operation or maintenance effort. Operationally these systems will be monitored and controlled using SCADA technology that is connected to existing supervisory systems, such as those employed by the local power companies. The operational workload is expected to be less than one staff position.

Maintenance requirements include a need for personnel skilled in mechanical and electrical equipment maintenance, replacement, and repair. The only working parts are the turbines that convert water or air flow into electricity. Electrical equipment is housed in the breakwater structure and is therefore easily accessible on breakwater and jetty installations that connect to land. The equipment uses standardized parts, and therefore has well defined maintenance schedules and procedures.

Maintenance activities are minimal with this type of design. Maintenance functions include inspecting the structure and turbine units (outside and inside visual inspections), performing preventative maintenance (replacing mechanical and electrical components), replacing failed components (swapping out turbines or parts), monitoring sediment transport around the device and dredging when necessary (visual or subsurface surveys), and the cleaning of the device water chambers (diving or shoveling). These systems have been designed so a shutter can be placed over the device's water chamber entrances allowing workers access to the needed parts without the device operating. Installing the shutters requires a very small crane or winch.

Device Retrieval

Device retrieval involves deconstruction and removal of the breakwater wave energy system. This is highly unlikely, due to the fact that the installation of breakwater systems serve a dual purpose: to serve as a breakwater and to serve as a power generation source. Retrieval of the wave energy systems would only occur if the systems were deemed incapable of cost effectively supplying the utility needed. For breakwater systems this will often mean simply the removal of electrical components, but allowing the breakwater caissons to remain in place, serving their function as a breakwater. If the breakwater itself is to be removed, the level of effort will be equivalent to removal of any breakwater.

Emergency and other abnormal situations

Emergency situations involving onshore breakwater devices include the following

- Recreational user (such as a swimmer and surfer), accidentally drifting into the breakwater.
- Boater drifting into breakwater

The hazards of a breakwater wave energy system are equivalent to that of any breakwater, since these systems have no exposed moving parts. Emergency services would be the normal services offered by U.S. Coast Guard rescue operations. It is also possible that the device operator would need to install the device's shutters over the water chamber entrances to shut down operations of the machine.

Emergency services: US Coast Guard rescue services for people in peril

Oregon infrastructure providers are divided into three groups: the suppliers, ports, and the coastal communities. In addition, Oregon has a unique capability to provide direct support for wave energy test and demonstration.

Suppliers comprise those companies which can provide raw materials such as steel and concrete, fabricate parts out of the materials, transport the parts, assemble the parts into complete units, deploy the complete units at sea, operate and maintain the units, remove the units at the end of their lifespan, and provide emergency services should an unplanned event occur. This assessment interviewed a representative sampling of the suppliers in Portland and along the Oregon Coast. Each of the companies interviewed is identified in sections following. Appendix F – Supplier Questionnaire, provides a list of the questions asked in the interviews. Appendix C – Oregon Suppliers, provides a more complete list of Oregon Suppliers.

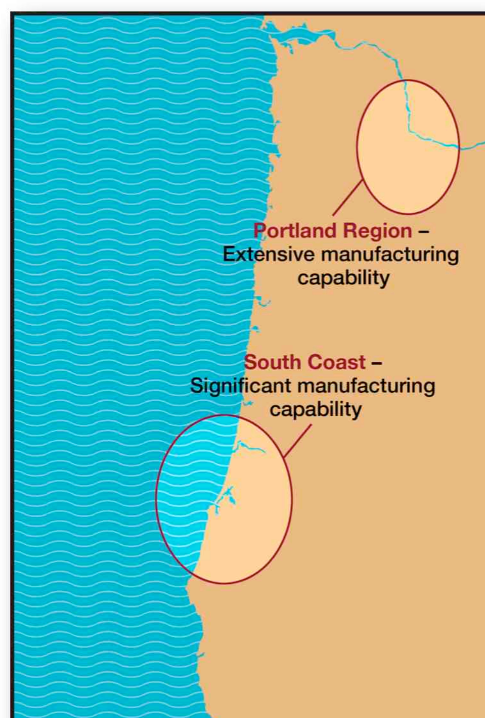
The four main ports along the Oregon coast that are most likely to become involved with wave energy, or already have, were interviewed. These were Port of Garibaldi, Port of Newport, Port of Umpqua, and Port of Coos Bay. The questions asked in the interviews are provided in Appendix F - Supplier Questionnaire of this report.

The community of Newport has been engaged because it is the one site along the Oregon coast that has had wave energy conversion devices implemented offshore. This engagement was performed to assess how the community could be utilized and engaged in future projects that would not only help for smoother processes but also provide additional local resources.

Oregon Suppliers

Oregon has the capability necessary to build, assemble, and operate wave energy devices. Deployment is the one area where Oregon resources come up short, but those resources can be sourced elsewhere on the west coast of the U.S.

Consistent with the scope of this project, only suppliers that operate within Oregon's borders were considered. The one exception being Vancouver Washington, which is located across the Columbia River from Portland, and is considered part of the greater Portland area.



Oregon's marine manufacturing regions

Manufacturing

Oregon has the industry necessary to build and launch even the largest devices envisioned by wave energy developers. Much of this capability is located in the greater Portland area, but some extensive facilities also exist in the South Coast region.

South Coast Region – This was once an area specializing in timber products with one only two coastal deepwater ports between San Francisco and Seattle.

Companies located here that were contacted during this assessment:

- Sause Brother's shipyard
- American Bridge
- Fred Wahl

Portland Region – This region holds one of the west coast's biggest shipyard and repair facility areas. Panamax dry-dock facilities exist as well as ocean and river barge construction facilities.

Companies located here that were contacted during this assessment:
- Oregon Iron Works
- Advanced American Construction
- Crescere Marine Engineering, Inc.
- Renewable Energy Composite Solutions, LLC.

Transportation

Road

The ease and flexibility of transporting equipment via road is highly desirable. However, due to the geography along the coast, not all roads in this region are created equally. Many are small, two lane roads crossing the coastal mountains with sharp turns, no shoulder, and multiple bridge crossings at which load widths and weights are restricted. The map at right depicts which roads are authorized for 4.3 m (14 foot) wide loads as long as the gross weight does not exceed 44.4 tonne (98,000 pounds). Oregon Department of Transportation (ODOT), the authoritative organization overseeing road transportation within Oregon has an array of requirements and limitations governing road usage, some of which are outlined below. For additional information see their site on Over-Dimension operations: http://www.oregon.gov/ODOT/MCT/OD.shtml. Specified weights and dimensions in this section are given in English Standard Units per ODOT documentation.

Oregon Roads authorized for 4.3m wide 44.4 tonne loads

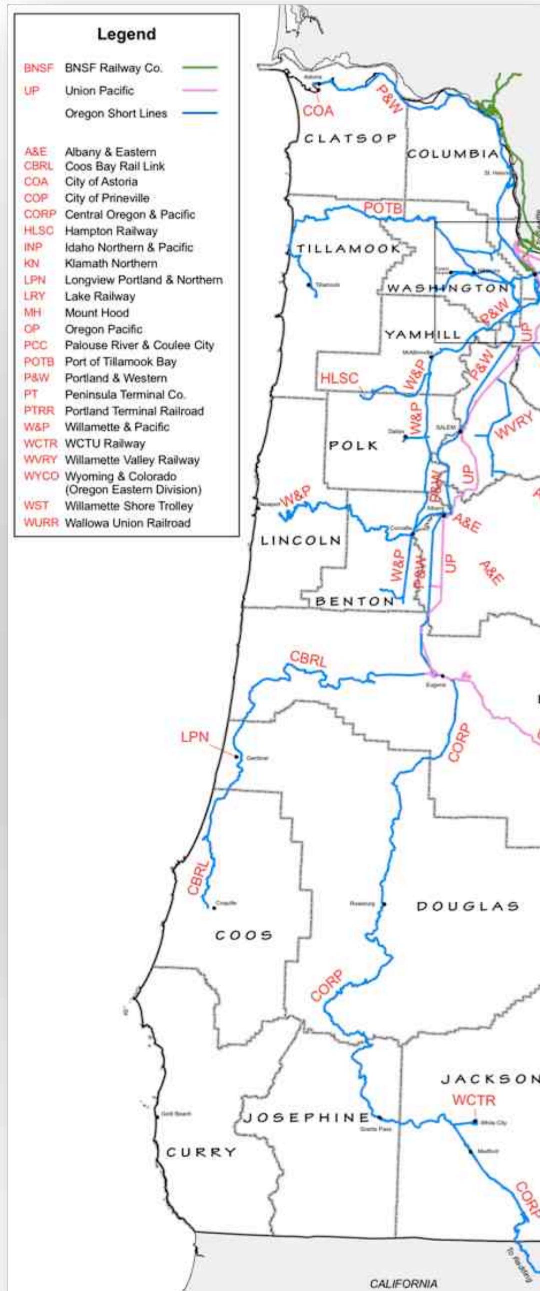
Oregon Department of Transportation:
- **Weights Not to Exceed**:
  - The manufacturer's side wall tire rating but not to exceed 600 pounds per inch of tire width
  - 21,500 pounds per single axle
  - 43,000 pounds per tandem axle
  - 98,000 pounds GW for 14 foot loads on coastal road
- **Dimensions Not to Exceed** (otherwise classified as a Super Load)
  - Height: 17 feet height
  - Width: 14 feet two-lane highway, or 16 feet on the Interstate
  - Length: 150 foot overall length
- **Pilot Vehicle Required** – Unless operating with a front and rear pilot vehicle, warning lights as described in OAR 734-082-0036 are required when width exceeds 10 feet on two-lane highways or 12 feet on four-lane highways. Loads exceeding 12 feet wide on two-lane highways must use a front pilot vehicle.

Rail

Due to timber interests during the last century, Oregon has a variety of rail lines that run out to the coast. The lines vary in their states of disrepair due to a lack of traffic and harsh weather experienced along the coast. Some, most notably the line servicing Coos Bay which has recently been purchased by the Port of Coos Bay, have projects with timelines awaiting upgrade.

As with roads, these rail lines cross the coastal mountain range, winding back and forth through numerous tunnels and bridges. Since these are short line railroads that do not see mainline traffic (class 1), upgrades and clearances are not at the same level as would be expected on U.S. mainline railroads. Double-stack container trains and 27.4m (90-foot) flatcars may prove impossible on many of lines to the coast. It should however be possible to get 19.8m (65-foot) flatcars and Plate F—5.2m high, 3.3m wide (17ft high, 10.6 ft wide;)—clearances on these lines. For a more detailed version of the map on the left see: http://www.oregon.gov/ODOT/RAIL

For additional information on plate sizes on U.S. railroads see: http://en.wikipedia.org/wiki/Loading_gauge



Oregon rail lines with access to the Oregon coast

Specific information on each coastal line:

- Portland & Western
  - Active and running to Tongue Point
- Port of Tillamook Bay
  - The rail line was washed out in 2007 and has not been repaired yet. There currently is not access between Cochran to Tillamook.
- Willamette & Pacific
  - Active and running to the Port of Toledo
- Coos Bay Rail Link
  - Currently undergoing a "Tunnel Maintenance & Rehabilitation Project", bid awarded June 2009.

Specific information the mainline (Class 1) railroads in Oregon:

- Union Pacific
  - Runs through the central valley to Portland.
  - http://www.uprr.com/aboutup/maps/index.shtml
- BNSF (Burlington Northern Santa Fe)
  - Runs through central Oregon to Portland and along the Columbia River to Longview Washington.
  - http://www.bnsf.com/

Waterway/Ocean

Transporting equipment over water is readily accessible in Oregon. The Columbia River provides deep-water access from the Portland metropolitan region to the ocean.

Many of the harbor entrances along the Oregon coast are river mouths that have bars that build up due to sediment transport. These bars can create dangerous conditions when large waves combine with strong river enhanced ebb currents, effectively closing down harbor access except to large vessels with experienced crew. These conditions are rarely encountered in the summer months except for very small recreational vessels.

U.S. Coast Guard vessel crossing the treacherous Columbia River bar (Source: U.S. Coast Guard)

Another aspect of most of the harbors along the coast being river mouths is that depths are often shallow and change frequently, even after dredging. The only deep-water ports along the coast are those of Coos Bay, Yaquina Bay, and the Columbia River to the Portland area. The U.S. Army Corps of Engineers dredges each of the harbors along the coast regularly, on a schedule and depth reflective of the amount of commercial traffic to each port.

Barge and towing companies exist in multiple locations along the coast and have the equipment and experience necessary for most inland, coastal, and ocean tasks.

Workforce

The International Longshore and Warehouse Union (ILWU) supply the longshoreman workforce for loading and offloading cargo. This workforce is authorized to work at publicly owned or operated ports on the Oregon coast, although personnel are not necessarily located permanently in all of these ports. Access to this workforce is obtained through any of the stevedoring firms identified in Appendix C – Oregon Suppliers, Supplier Index. Specialized training on any task or piece of equipment is provided by the Pacific Maritime Association (www.pmanet.org), which represents the ILWU.

It is possible to use non-unionized labor at privately owned and operated facilities along the coast.

Assembly

Access to land and facilities for wave energy assembly and deployment varies along the coast. Some ports have unoccupied or lightly occupied land in prime locations while others have focused their efforts on other economic revenue sources with little to no land to lease. A common occurrence along the coast is the conversion by ports of portions of their land to house RV parks along the water, which have become significant sources of revenue. Despite this, if wave energy demands for industrial water access increase, this land could be made available.

The following is a brief overview of four ports along the coast:

Land that could be leased from ports

- Coos Bay – Currently not much free land available. It is focused on building out an international terminal for container, cargo and possibly liquefied natural gas on its land.
- Umpqua – Currently not any land available.
- Yaquina – Currently has roughly 2 hectares available next to an extremely shallow bay. Development is currently underway to make it into an industrial park.
- Garibaldi – Has roughly 1 hectare that could be made available. It is currently being used to store crab pots that could be relocated.

Land with dock facilities that could be leased but is privately held

- Coos Bay – Southern Oregon Marine, Inc. operates a 40-hectare marine oriented construction and repair facility located 16km upstream from the harbor entrance.
- Umpqua – American Bridge Manufacturing operates a 16-hectare facility adjacent to the Umpqua River.
- Yaquina – No major facilities known to exist with immediate water access.
- Garibaldi – No major facilities known to exist with immediate water access.

Deployment

Offshore deployments along the Oregon coast have thus far been limited to pipe outflows and jetties. No major industry requiring ocean deployments, such as an offshore oil and gas industry, exists along the Oregon coast, or along the Northern California and Washington coasts either. Local experience and equipment has thus been focused on fishing, cargo, research, and salvage.

A few different companies operate coastal and offshore tugs in Oregon. The major companies are based out of the Portland/Astoria region and the Coos Bay region. The offshore vessels are primarily used for long-haul cargo transport along the coast and to Hawaii.

M/V Salvage Chief (Source: Fred Devine)

Fred Devine Diving and Salvage Company operates a variety of equipment including their M/V Salvage Chief located in Astoria. This vessel has been involved in the recovery of Finavera's AquaBuOY as well as numerous other offshore operations.

No offshore deployment vessels with dynamic positioning are stationed along the Oregon coast.

Large barge cranes, jack-up barges, and other necessary equipment are of limited availability. The Portland, Oregon and Seattle, Washington areas have most of the region's capabilities.

The United States has a highly mobile U.S. Coast Guard certified able-bodied seaman pool. During periods of high demand, such as following a hurricane in the Gulf of Mexico or abnormally high oil prices, staffing vessels in Oregon can be difficult. At other times, finding the necessary crew presents no trouble.

Maintenance

The Oregon coast is home to a variety of fishing fleets with experienced ocean going crews. With the decline in fishing stocks and quotas this workforce is interested in finding new employment.

Gaining access to large local repair facilities presents similar difficulties as leasing assembly areas. Coastal ports often have only limited dock space that they cannot afford to have tied up for long periods of time. Due to the long duration of wave energy device maintenance activities and the significant space such maintenance requires, in some cases dock space for maintenance will have to be negotiated relative to competing dock uses.

Small boat yards and repair facilities exist along the Oregon coast. They are accustomed to doing specialty projects of a small scope, such as fabricating a new part for a fishing vessel or repairing a broken spar. Thus, these shops would be able to adapt to the needs of wave developers for small fabrication and repair work. Larger repair work would require bringing in specialized equipment or returning wave energy device components back to manufacturing areas such as the Portland or the South Coast region.

Wave Energy Test and Demonstration Capabilities

Oregon is unique in having several active research complexes that support wave energy development. These include the Northwest National Marine Renewable Energy Center (NNMREC) and the Hatfield Marine Science Center.

Northwest National Marine Renewable Energy Center

NNMREC is one of only two United States Department of Energy marine renewable energy centers and is a partnership between Oregon State University and the University of Washington. The organization serves as a research center and an integrated, standardized test center for U.S. and international developers of wave and tidal energy. It offers a full range of capabilities to support wave and tidal energy development for the United States. NNMREC activities are structured to: facilitate device commercialization, inform regulatory and policy decisions, and close key gaps in understanding. Emphasis is placed on the following topic areas:

- Development of facilities to serve as an integrated standardized test Center for U.S. and international developers of wave and tidal energy;
- Evaluation of potential environmental and ecosystem impacts, focusing on the compatibility of marine energy technologies in areas with sensitive environments and existing users;
- Device and array optimization for effective deployment of wave and tidal energy technologies;
- Improved forecasting of the wave energy resource;
- Increased reliability and survivability of marine energy systems.

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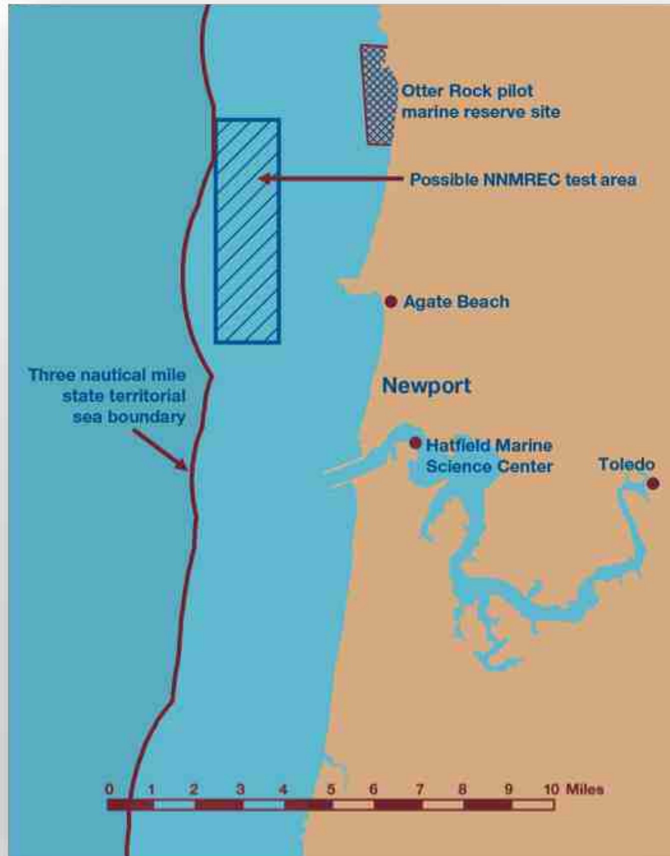
NNMREC utilizes the following existing facilities in Corvallis, Oregon:

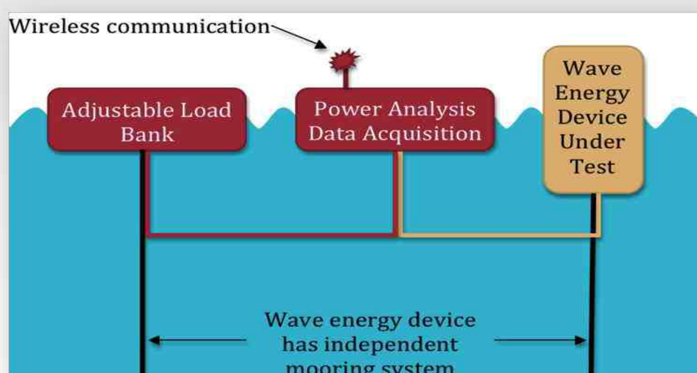
- Wallace Energy Systems & Renewable Facility - OSU – This facility provides research, testing and services related to machines and drives, power electronics, hybrid electric vehicles, power systems and renewables.
- O. H. Hinsdale Wave Research Laboratory - OSU - A leading center for research and education in coastal engineering and nearshore science with facilities that include a Large Wave Flume (104 m long), Tsunami Basin with multi-directional wavemaker, Circular Wave Basin for littoral transport, and Control Room for on-site researchers.

NNMREC is also in the process of establishing an ocean wave energy test facility in Newport, Oregon, consisting of a zoned area offshore for test and demonstration of wave energy devices. The figure at right illustrates a zone delineated as a potential area by the local fishermen's group, Fishermen Involved in Natural Energy (FINE). The final site will be approximately 1.6 by 1.6 km and has not yet been selected, but this chart illustrates the general area for the test facility. Newport has already been active in supporting the deployment of a number of wave energy devices for testing in coastal waters since 2007.

The NNMREC test facility will include up to five mobile test berths that can be used by developers. The mobile ocean test berths will include a power analysis and data acquisition (PADA) device and adjustable load bank that mimics an electrical grid as illustrated in the figure to the right. In the future, depending on demand and funding, NNMREC plans to modify this test facility into a grid-connected test and demonstration center.



The region approved by Fishermen Involved in Natural Energy (FINE) for the potential site of NNMREC test birth.



NNMREC test facility block diagram

Hatfield Marine Science Center

The Hatfield Marine Science Center (HMSC) in Newport, Oregon plays an integral role in marine and estuarine research and instruction, as a unique laboratory facility serving resident scientists and graduate students, and as a base for oceanographic research. It is Oregon State University's campus for research, education, and outreach in marine and coastal sciences. Through its partnerships, HMSC improves scientific understanding of marine systems, coastal processes and resources, and applies this knowledge to social, economic, and environmental issues. The HMSC brings OSU's diverse marine science programs together for effective collaboration and higher national and international visibility. Its role in wave energy development will include providing technical services for assessing environmental effects including biological, physical, acoustic, electromagnetic, and sediment.

Contact Info

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The HMSC campus is also home to numerous federal and state agencies involved in ocean research, including United States Department of Agriculture (USDA), Environmental Protection Agency (EPA), Oregon Department of Fish and Wildlife (ODFW), National Oceanic and Atmospheric Administration (NOAA), NOAA Fisheries Service (NMFS), Alaska Fisheries Science Center, NOAA Northwest Fisheries Science Center, NOAA Office of Oceanic and Atmospheric Research, and United States Fish and Wildlife Service (USFWS).

HMSC has been involved with wave energy along the Oregon Coast already. It serves as the primary research facility for NNMREC's environmental studies. A variety of studies and reports have been already been generated with more in the works. A "Wave Energy Ecological Workshop" was hosted in late 2007 that resulted in the "Ecological Assessment Briefing Paper" being published.
hmsc.oregonstate.edu/waveenergy/WaveEnergyEffectsBriefingPaper.pdf

The wave energy developer needs described in the Overview of Infrastructure Needs section were compared to the capabilities of Oregon as described in the Oregon's Infrastructure Capabilities section. From this comparison, a picture of Oregon's capabilities and shortfalls emerged. This section describes both the generous capabilities and significant gaps in Oregon to support wave energy development and are laid out in the following way:

Capabilities

- Oregon's South Coast
- Oregon's Central Coast
- Oregon's North Coast
- Portland Metropolitan Area

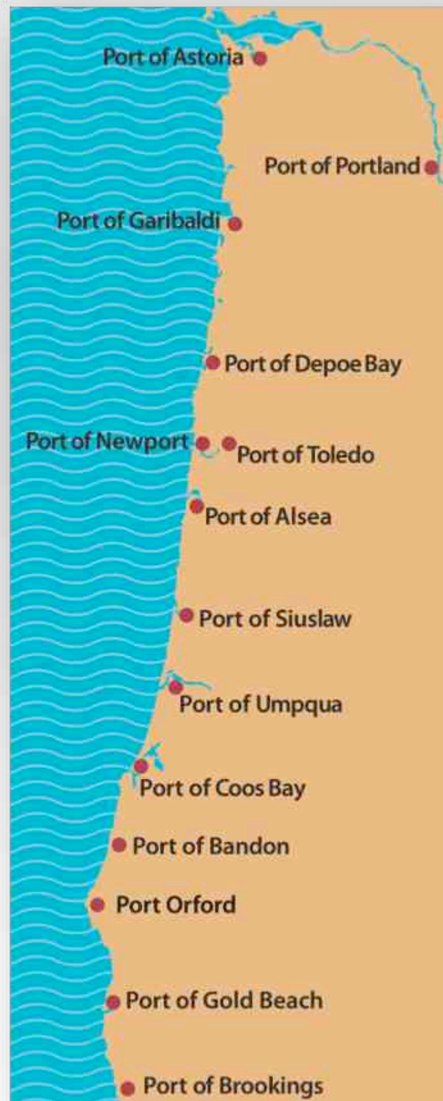
Gaps

- Deployment and Recovery Vessels
- Assembly Land
- Deployment Facilities
- Deployment Labor
- Assembly and Operations & Maintenance Workforce
- Transportation
- Emergency, Salvage, and Recovery

Other Issues

- The Oregon Way
- Regulations
- Emergency, Salvage, Recovery Planning, and Execution
- Weather Windows
- Regional Awareness of Wave Energy

Locations included in Infrastructure Assessment



Oregon's capabilities

To better frame the picture of Oregon's capabilities, we have broken the state up into four regions: the South Coast, the Central Coast, the North Coast, and the Portland Metropolitan area. Each region offers unique capabilities to support wave energy development. For example the Portland Metro area offers substantial manufacturing capability to produce wave energy devices and deployment vessels. The south Coast has assembly areas with excellent access to the ocean, strong manufacturing capability, and tug and barges to support deployment at sea.

Oregon's South Coast

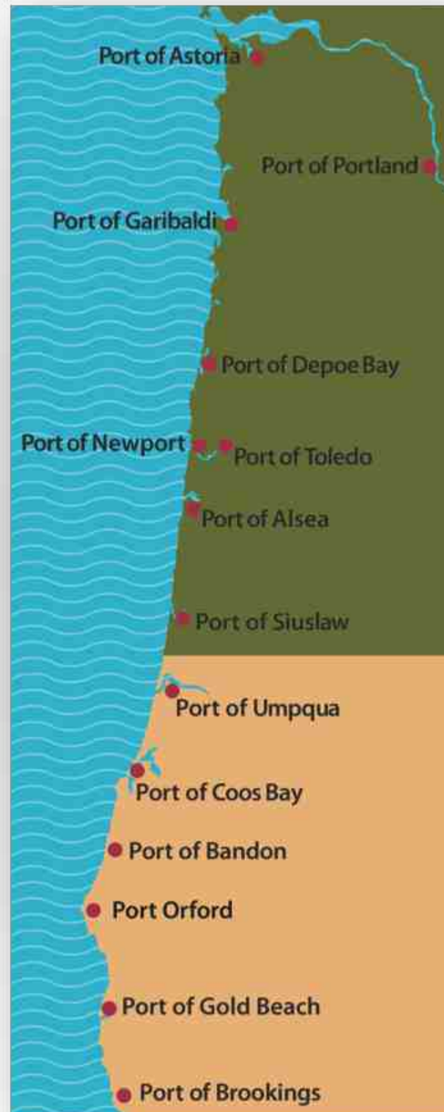
The South Coast has surprising capacity for manufacturing, assembly, and ocean access in and around the Ports of Umpqua and Coos Bay. This region has numerous marine related businesses, including naval architecture, marine engineering, vessel construction, tugboat and barge services, and stevedoring services. The Port of Coos Bay is limited in available space since the Port does not own the property on the waterfront and the recent land acquisition on the North Jetty is slated to become a container and cargo facility.

In Reedsport, at the Port of Umpqua, the company American Bridge is in the process of developing metal fabrication and finishing capabilities that are well suited to wave energy development, and has adequate area, capacity, and water access for the assembly and deployment of wave energy devices. There are other commercial assembly sites with easy access to waterways available in this region. Ports on the south Coast other than Coos Bay or Umpqua do not have the deep drafts or industrial capabilities necessary for the development of wave energy devices, namely, Brookings, Gold Beach, Port Orford, and Bandon.

Significant Regional Capabilities

- **Manufacturing capabilities in the region**
  - American Bridge
  - DB Western
  - Fred Wahl Marine Construction
  - Southern Oregon Marine
- **Transportation**
  - The Coos Bay Rail Link (currently under renovation by the Port of Coos Bay)
  - Deep-water harbor in Coos Bay
  - Stevedoring services
- **Assembly**
  - Former International Paper plant in Reedsport with unused ocean outfall and water access
  - American Bridge
  - Southern Oregon Marine
- **Deployment**
  - Sause Brothers tug and barge company
- **O&M**
  - Southwestern Oregon Community College (for training technicians)

South Coast Region



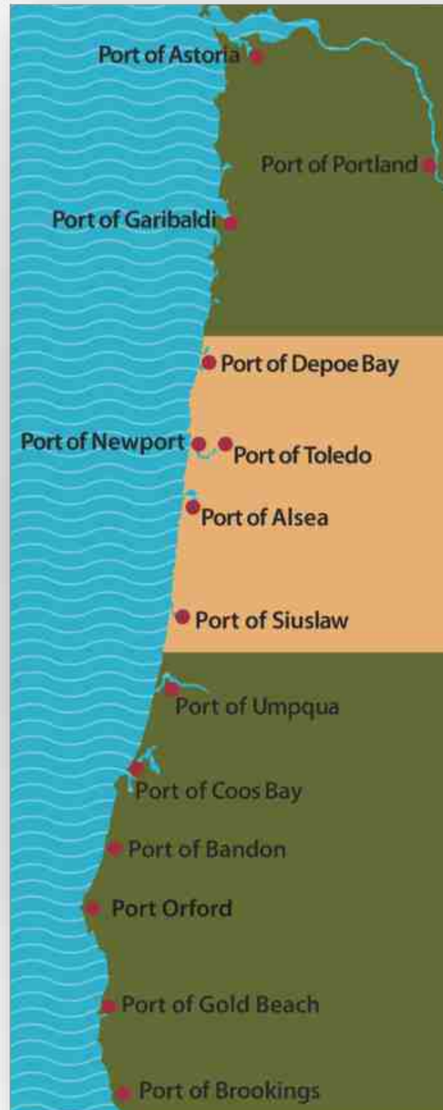
Oregon's Central Coast

The Central Coast has only one significant port for deployment, that of Newport. It has ready access to the ocean, sufficient area for assembly and deployment of wave energy devices, and an active science community. It is home to the Oregon State University's Hatfield Marine Science Center, which conducts significant ocean research, including mammal migration, ocean currents, acoustic research, and a wide array of fishery studies. The Hatfield campus is also host to the National Oceanic and Atmospheric Administration, Oregon Department of Fish and Wildlife, Environmental Protection Agency, National Fisheries Service. Ports of Alsea and Depoe Bay are not well suited to the development and deployment of wave energy devices in Oregon, due to limited harbor access and port facilities.

Significant Regional Capabilities

- **Transportation**
  - Rail line to Toledo (Portland and Western Railroad)
  - Deep water port at Newport
- **Assembly**
  - Port of Newport currently has 4 hectares of land plus some adjacent commercial space
  - Toledo boat yard (former Fred Wahl Marine)
- **Deployment**
  - Wiggins Towboat Company
- **O&M**
  - Oregon Coast Community College (potential for training technicians)
- **Other**
  - Test and Demonstration Services – Northwest National Marine Renewable Energy Center
  - Marine Science Services – Hatfield Marine Science Center (OSU)

Central Coast Region



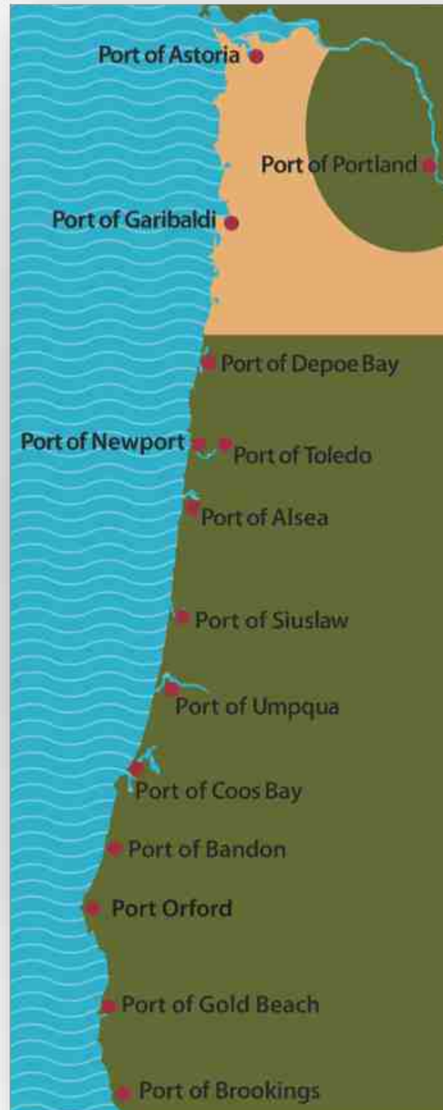
Oregon's North Coast

The North Coast, with its Ports of Garibaldi, Tillamook, and Astoria, provides adequate resources to support the assembly and deployment of wave energy devices. Garibaldi has suitable space for assembly, and adequate draft for deployment, but its wooden dock is inadequate to support the deployment of large-scale wave energy devices. Astoria is an active industrial and container port at the entrance to the Columbia River, providing tugboats, barges, diving, and salvage services. The North Tongue Point development at Astoria is currently being built out and will have available land with modern deep-water piers and rail access.

Significant Regional Capabilities

- **Assembly**
  - Some land in Garibaldi – 1 hectare currently used to store crab pots
  - Astoria has the North Tongue Point commercial area with deep water access
- **Deployment**
  - Easy access to heavy equipment in the Portland area
  - Close to M/V Salvage Chief
- **O&M**
  - Clatsop Community College (training for maritime vessel operations)
- **Device Retrieval**
  - Easy access to heavy equipment in the Portland area
  - Close to M/V Salvage Chief

North Coast Region

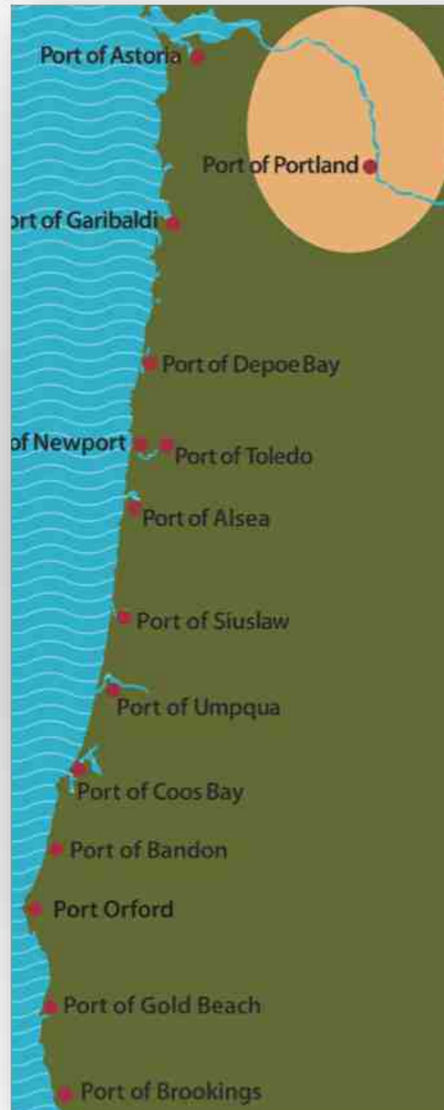


Portland Metropolitan Area

The Portland metropolitan area, including Vancouver, Washington, offers significant resources for the development and deployment of wave energy devices in Oregon. Portland is situated at the confluence of the Willamette and Columbia Rivers, providing ready access both to the manufacturing companies of the Willamette Valley and deployment capability to the Pacific Ocean and wave energy sites in the Pacific Northwest.

This region has extensive capacity for the design, engineering, and manufacturing of wave energy systems, whether in steel, composites, or concrete, as well as strong expertise in naval architecture, marine design, engineering, and construction.

Portland Region



Significant Regional Capabilities

- **Manufacturing**
  - Hundreds of manufacturers supporting steel, composite, and concrete
  - Numerous marine engineering firms
- **Transportation**
  - Columbia River provides deep water access to manufacturing sites
  - Certified pilots for crossing the Columbia River bar
  - Rail service access to several Oregon ports
- **Deployment**
  - Easy access to heavy equipment in the Portland area
  - Close to M/V Salvage Chief
- **Device Retrieval**
  - Close to M/V Salvage Chief and heavy equipment in Portland area

Oregon's gaps

Despite the tremendous depth of expertise and capacity within Oregon, there are some gaps that exist in its ability to meet the needs of wave energy deployment.

1. Deployment and Recovery Vessels

- **The Gap** – Oregon does not have the necessary vessels to support an offshore wave energy industry. The wave energy industry is beginning to rely on technology utilized by the offshore oil and gas industry, an industry not found in Oregon. As a result, many wave energy developers seek vessels to support operations not currently occurring off the Oregon coast, such as installing large mooring systems, underwater drilling, seafloor pipe lays, and handling large structures in a rough ocean environment.
- **Mitigating Factors**
  a. Vessels can be brought in from other parts of the Pacific Northwest or other areas in the world where these capabilities exist.
  b. Specialized vessels can be designed and built in Oregon to provide these services.

2. Assembly Land

- **The Gap** – Available areas for site assembly are limited in ports along the Oregon coast. In some cases land surrounding ports is privately owned. In other cases land is owned by the port, but may be allocated for different purposes. This problem is especially acute for developers in the early stages of development who wish to deploy test and demonstration devices in Oregon waters for short periods of time. The cost and time to survey, negotiate and lease suitable areas is substantial.
- **Mitigating Factors**
  a. Ports and private companies can work together to make available site assembly packages, with predefined services, costs, waterway access, and specifications to simplify their use by wave energy developers.
  b. RV sites on the waterfront exist at many ports on the Oregon coast that can be converted into assembly areas, either temporarily or permanently.
  c. Device assembly can be performed at a site away from the deployment area and then barged to the ocean site.

3. Deployment Facilities

- **The Gap** – Ports are limited in the availability of usable harbors, dock space, and deployment equipment. They lack the cranes and hoists needed to transfer wave energy devices into the water for deployment to sea.
- **Mitigating Factors**
  a. Early investigation, familiarization and negotiation with ports and private parties can work to resolve issues with access to working space.
  b. Ports and regional port services can obtain the equipment and trained workers necessary to be able to deploy wave energy devices.
  c. Engagement with the U.S. Army Corps of Engineers to discuss dredging issues.

4. Deployment Labor

- **The Gap** – Oregon does not have a wealth of U.S. Coast Guard certified able-bodied seamen for providing deployment and recovery services at sea. Developers and suppliers can pull from the national pool of able-bodied seamen; but at times of high demand, this pool may be too small or the seamen unwilling to relocate to Oregon for short durations.
- **Mitigating Factors**
  a. Certified seamen can be brought in from other states that actively employ them, such as the Gulf of Mexico states (Texas, Louisiana, Alabama, and Mississippi) or Alaska.
  b. During periods of high demand for certified seamen it may be necessary to increase contract wages or employ over-qualified personnel.
  c. Clatsop Community College has an active program for training personnel for sea duty, with a U.S. Coast Guard certified program. Proper advanced coordination with the college could ensure there are sufficient trained personnel for operations at sea.

5. Assembly and Operations & Maintenance Workforce

- **The Gap** – Wave energy development involves new technologies applied on top of many well-established skill areas. Local workforces will need specialized training to adapt their knowledge to these new technologies.
- **Mitigating Factors**
  a. Individual developers can provide the specialized training that is required to adapt to their new technology.
  b. Over time a cadre of specialized workers who understand the special needs and issues associated with wave energy development, operations, and maintenance will develop.
  c. Coastal educational institutions, such as community colleges, have an opportunity to develop courses that will provide the training required to educate the workforce on the specialized needs of wave energy development, operations and maintenance

6. Transportation

- **The Gap** – In some cases transportation may fall short of national expectations. Wave energy devices can be quite large, with transport masses of hundreds of tonnes and lengths of over 30m. Truck routes are available to all ports, but some of the coastal highways restrict the size and weight of cargo more tightly than normal on Oregon highways. Similar issues exist with the rail service to the coast where sizes may be restricted due to sharp turns and tunnels on the short-line railroads to the coast. Waterway access has limitations in some areas due to shallow harbors and weather restrictions due to rough conditions over river bars entering most harbors.
- **Mitigating Factors**
  a. Early engineering attention by wave energy developers to transportation limitations along the Oregon coast can greatly ease potential problems.
  b. Oregon has been investing in upgrading its main roadway arteries to coastal communities, and needs to continue this work with an eye toward the special needs of the wave energy industry.

7. Emergency and Device Retrieval

- **The Gap** – The retrieval of large wave energy devices that have either reached end of life or have failed to perform is an expensive undertaking and can easily exceed companies' financial resources, causing them to become insolvent and leaving the people of Oregon with the mess to clean up. Abandoned wave energy devices could discourage public support and have a devastating effect on the development of wave energy in Oregon territorial waters.
- **Mitigating Factors**
  a. Engage potential salvage companies to better understand the potential costs of removal and retrieval from both end-of-life and salvage events.
  b. Require wave energy developers to provide adequate bonds and insurance plans to cover recovery costs and other unexpected events.
  c. Eventual establishment of a statewide insurance fund into which all developers must contribute is a possible means to provide the needed protection at an affordable cost.

Other issues

A. The Oregon way

- **The Issue** – Developers must properly coordinate and engage local communities to ensure the success of their deployments. Failure to do so will result in misunderstandings and local opposition to the development and increased costs and delay. The model for collaboration with local communities is provided in the Oregon Solutions process established by the state legislature. This process fosters the development of "sustainable solutions to community-based problems that support economic, environmental, and community objectives and are built through the collaborative efforts of businesses, government, and non-profit organizations."
- **Mitigating Factors**
  a. Honest communication with local communities
  b. Support the process by locating a permanent company representative in the community to engage with stakeholders and become engaged in the community.

B. Regulations

- **The Issue** – Due to deployment in waters regulated by federal, state, and local authorities, wave energy developers will have significant hurdles to overcome in testing and deploying wave energy devices in Oregon waters.
- **Mitigating Factors**
  a. Oregon Wave Energy Trust provides guidance on the regulatory process through a report "Licensing and Permitting Requirements" obtainable through their website:
  http://www.oregonwave.org/templates/owet/documents/owet - licensing_permitting report.pdf
  b. Some local communities have taken proactive steps to clarify and even streamline the process for obtaining federal, state, and local permissions to test and deploy wave energy devices.
  c. Through coordination and cooperation with federal and local authorities, the state of Oregon could further streamline the application and approval process. This could eventually include development of a single application to be used to prepare all other applications.

C. Emergency and Recovery Planning and Execution

- **The Issue** – Public perception of this industry is important and currently cautiously positive along the Oregon coast. Such events as Finavera's complete removal of its test buoy off Newport are crucial for the continued support of other industries and the public.
- **Mitigating Factors**
  a. Develop workable contingency plans for any ocean deployment, making provisions for unavailability of specialized personnel, equipment, and vessels due to dangerous weather and competing needs.
  b. Honor prior commitments made to stakeholders regarding the actions to be taken to effect emergency, salvage, and recovery actions.

D. Weather Windows

- **The Issue** – The ocean off of Oregon can be treacherous throughout the winter months with strong storms developing quickly and frequently. The harbors on the Oregon coast are located on rivers that produce sand bars at their mouths that can significantly affect wave heights. Access to the waters off Oregon require special skills found only in local commercial fishermen, bar pilots, and the U.S. Coast Guard; yet even with these skills, there are times when access is not possible.
- **Mitigating Factors**
  a. In general, planning to deploy and retrieve wave energy devices during the summer months will minimize weather effects.
  b. In budget planning, make allowance for dead time resulting from adverse weather situations that can crop up at any time—even in the summer months.
  c. Develop workable contingency plans for any ocean deployment, making provisions for unavailability of specialized personnel, equipment, and vessels due to dangerous weather and competing needs.

E. Regional awareness of wave energy

- **The Issue** – Regions can either benefit or be harmed by the development of wave energy. As this new technology becomes a reality in Oregon, regional and local communities need to address how to gain the benefits of this new industry while protecting themselves from negative economic, environmental and social effects.
- **Mitigating Factors**
  a. Develop regional coalitions to look at the broad picture of bringing wave energy to Oregon and their region. Discuss strategies to incorporate wave energy technology that are appropriate for their region, accounting for the region's strengths and weakness. These could include manufacturing, assembly, deployment, operations, maintenance, and retrieval. Devise plans to educate the local workforce thereby ensuring their readiness to meet the needs of wave energy.
  b. Understand the long and short-term workforce needs of wave energy developers, whether to support the test and demonstration of single devices or the multiyear deployment and maintenance of an array of devices. Work with local workforce groups to ensure they have the training to provide the needed services.

Recommendations

Based on the assessment of infrastructure needs to develop wave energy in Oregon and of the infrastructure capabilities Oregon has, we provide recommendations to address gaps and ensure Oregon's readiness to participate in this developing industry. The recommendations contained in this report are those of the authors, and do not represent those of OWET.

For convenience, the recommendations include references to Gaps and Issues identified in the Gap Analysis section of this report.

Recommendations for Oregon for Immediate Implementation

We recommend the following steps be carried out as soon as possible:

- **Local regions** in Oregon should form regional coalitions to consider and implement steps uniquely adapted to their regions to prepare themselves for wave energy deployment in Oregon. These coalitions should consider each region's gaps and steps the region can take to close them. Coalition members should include area power companies, economic development agencies, county commissioners, colleges, and other organizations committed to job creation and business development. [Issue E]
- **Community colleges** on the Oregon Coast should incorporate into courses and programs their strategic plans that will provide workforce training to develop the various specialized skill-sets needed for wave energy test, demonstration, and deployment. A particular need will be training able-bodied seaman for work in the ocean. [Gap 4, Gap 5]
- **Area businesses** that are expecting to participate in the wave energy arena should become familiar with the technology, the processes, the issues associated with their trades, and begin to make overtures to potential wave energy developers. Businesses include steel, concrete, and composite manufacturers, stevedoring firms, riggers, marine vessel engineers and construction yards, welders, and divers. [Gap 1, Gap 2, Gap 3]
- **Barge, tug, and vessel operators** should become familiar with the processes and issues associated with deploying wave energy devices in the offshore and nearshore environments. A particular need will be the availability of ocean going tugs, and the use of vessels for deploying wave energy devices. [Gap 1, Gap 7]
- **Ports** should become familiar with the processes, needs, and issues of deploying, operating, and maintaining wave energy devices in the offshore, nearshore and onshore environments. A particular need will be assembly areas that have ready access to waterways for transporting wave energy devices out to the ocean. They should also be able to provide interested businesses with a standard information packet detailing port capabilities and limitations. [Gap 2, Gap 3, Issue C]
- **Workforce organizations** should become familiar with the processes and issues associated with the transport and offloading of wave energy components and the deployment and retrieval of wave energy devices in the ocean environment and in nearshore environments. Workforce types include longshoremen, divers, welders, and riggers. A particular need will be an understanding of the special requirements associated with wave energy devices, including vulnerabilities, timeframes, and proprietary protections. [Gap 3, Gap 4, Gap 5, Issue E]
- **The Oregon Department of Transportation**, together with Business Oregon, should look at the transportation needs of wave energy developers and incorporate into their strategic plans actions to prepare roadways and railways for transporting wave energy components from manufacturing areas to the coast. [Gap 6]

- **Wave energy developers** coming to Oregon need to understand the "Oregon Way" of doing business, namely, collaborating with local stakeholders prior to implementing new capability so as to harmonize the implementation into existing environmental, economic, and social infrastructure. It is crucial to engage the regional stakeholders in the project proposed, fostering open lines of honest communication. Developers should consider locating a permanent company representative in the community to engage with stakeholders and with the community. [Issue A]
- **Wave energy developers** should prepare transportation, operations and maintenance, retrieval, and emergency plans, including contingencies for possible anomalous scenarios. It is crucial to understand the costs and risks associated with anomalous events such as the sinking of a device or harm to an individual who has drifted into a device. This information is necessary to engage with stakeholders, emergency service agencies, and the public. Failure to think through these possible scenarios thoroughly and carefully in advance could be catastrophic for the company and detrimental to the industry. [Gap 6, Gap 7, Issue C, Issue D]

Recommendations for Oregon for Later Implementation

We recommend the following steps be implemented at a future time as appropriate:

- **Ports and regions** should develop the infrastructure for deployment of wave energy equipment and services. These include: upgrade ports, channel and harbor depths, docks, lifting, space infrastructure and the working facilities to support wave energy development. [Gap 3]
- **Community colleges** on the Oregon Coast should begin to implement workforce-training programs to provide the various specialized skill-sets needed for wave energy test, demonstration, and deployment. It is important to time the availability of a trained workforce to the need of the wave energy developer. [Gap 4, Gap 5]
- **Wave Energy Stakeholders** should work with the State of Oregon and coastal authorities to develop guidelines and plans for the deployment and retrieval of wave energy devices in Oregon waters. These should address coordination of resources, coordination with local stakeholder groups, notifications of authorities prior to installation, and recovery of damaged or lost devices. [Gap 7, Issue C]
- **Wave Energy Stakeholders**, in cooperation with the State of Oregon, U.S. Coast Guard, and port authorities, should develop and implement standardized emergency service procedures for operation within Oregon coastal waters. These procedures should provide a comprehensive plan of action for wave energy developers on steps they should take to secure emergency services in the event their devices are causing damage, destruction, or bodily harm to ocean users, marine mammals and other sea life, or shore communities. [Gap 4, Gap 5]
- **The State of Oregon** should explore an investment in the test facility provided by NNMREC to incorporate a business component that follows the model of the European Marine Energy Centre. Currently NNMREC's focus is on the research and development of wave energy devices. With added capability such a center could support the deployment and operation of wave energy systems, to the point of supplying power to the grid. The addition of a business component would also support the marketing effort of such an organization and could help in recovering costs. [Issue E]
- **The State of Oregon** should work with federal and local agencies to coordinate and simplify the regulatory application and approval process with the intent to minimize the level of effort by applicants bringing marine renewable energy to Oregon. The State of Oregon should also actively promote the awareness of such initiatives so developers know these steps have been taken. [Issue B]

- **Wave energy developers** should be open to provide relevant information about their devices and technology so governments, regions, and local businesses can prepare the framework and infrastructure needed to support the development and operation of the devices. Without this information the framework and trained workforce will not exist when the technology is ready to deploy. [Issue A, Issue E]

Issues and Risks

The importance of proper timing must be considered. The wave energy field is in its early stages of development, and to date there have been no permanent commercial deployments. It will take many years for viable commercial wave energy technology to develop. Correspondingly, it may take years for certain industries to realize the full benefit of wave energy opportunities. Some companies should not invest too early in the wave energy boon; else they will not realize a timely return on investment. Likewise community colleges should not offer courses sooner than when they are needed. Ports will need to free up land for wave energy deployment at the time they are needed. This risk can be mitigated with a comprehensive strategic plan that incorporates in part the appropriate timing for the availability of key products and services needed by the wave energy market.

Conclusions

Oregon has tremendous infrastructure capability to develop and deploy wave energy technology not only into Oregon coastal waters, but also throughout the Pacific Northwest. The following conclusions were reached as a result of this infrastructure assessment and are of importance to those who support Oregon's participation in the wave energy industry.

- From an infrastructure standpoint, Oregon is well suited to support the development and deployment of wave energy in the Pacific Northwest. It has the manufacturing muscle, the transportation infrastructure, and a capable workforce.
- Gaps exist in infrastructure capability, notably availability of deployment vessels and skilled workforce, which can be closed through strategic planning and assertive action by both regional coalitions and at the statewide level.
- Oregon is uniquely suited to support early test and demonstration activities, the state being the home to the Northwest National Marine Renewable Energy Center and the Hatfield Marine Science Center, Oregon also benefits from the forward-looking and practical initiatives fostered by OWET to investigate environmental, societal, economic, and cumulative effects by wave energy development.
- In the next 10 years, the biggest demand on Oregon will be for test and demonstration of new technology off of Oregon coasts. After 10 years, full deployment of commercial wave energy systems is expected to be viable. Oregon's opportunity goes beyond developing and selling wave energy within Oregon. It includes the manufacturing and deployment of wave energy devices to other regions along the Pacific Rim, including California, Washington, Alaska, and Canada.
- Infrastructure jobs will result from the development of wave energy in Oregon, but in the early stages many will be sporadic. It may take years for a steady stream of workforce activities to develop as the industry transitions from the test and demonstration phase to full commercial deployment.

Developer Overview

Wave Energy Conversion Device Developers

Oregon Wave Energy Infrastructure Assessment

Understanding the capabilities along the Oregon coast for the responsible development of wave energy. Funded by the Oregon Wave Energy Trust.

This document provides a summary of wave energy developer technology and capabilities for those developers considered mature in their development. The level of maturity is based on the size of devices being tested, the site of testing or demonstration, funding sources, and projected schedule for commercialization. This information is based on information in the public domain.

Selection criteria were used for the purpose of identifying those developers deemed more advanced in their development of wave energy technology. A detailed description of these criteria is provided in the Wave Energy Developers section of the Wave Energy Infrastructure Assessment in Oregon report. The assessments should not necessarily be interpreted to provide a current and correct statement of the developer's position, as many are withholding or not posting on the internet vital information.

Readers are advised not to use this data for investment purposes. The information included herein was provided by the companies themselves and has not been independently corroborated.

Developers have been selected according to the maturity of their technology and business operations. A composite score is given as the sum of the four category values, the highest numbers representing the most mature technologies and operations.

The developers are sorted alphabetically on the following pages.

Selection Criteria

Prototype	None 1:100 to 1:10 scale 1:9 to 1:2 scale Full scale
Site	Test tank Test site Demonstration site Commercial site
Funding	Internal Grants Investors Utilities
Schedule	None Prototyping > 2 yr to commercial < 2 yr to commercial

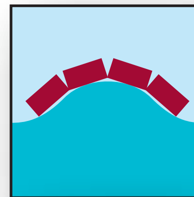
Advanced Research corporation

Conversion Types

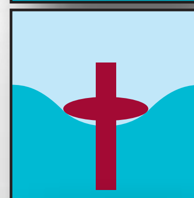
Wave energy conversion types:

The symbols provided for each conversion type are used as keys on the following pages to help in identifying the technology used.

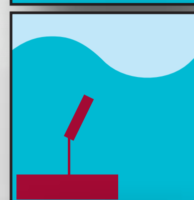
A. **Attenuator** - A floating device working parallel to the wave direction and effectively rides the waves. Movements along its length can be selectively constrained to produce energy. It has a lower area parallel to the waves in comparison to a terminator, so the device experiences lower forces.



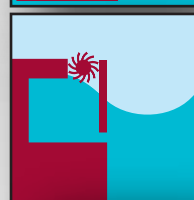
B. **Point Absorber** - A floating structure absorbing energy in all directions through movement at/near the water surface. The power take-off system may take a number of forms, depending on the configuration of displacers/reactors.



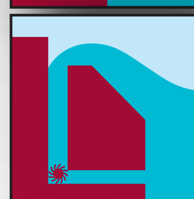
C. **Oscillating Wave Surge Converter** - This device extracts the energy caused by wave surges and the movement of water particles within them. The arm oscillates as a pendulum mounted on a pivoted joint in response to the movement of water in the waves.



D. **Oscillating Water Column** - A partially submerged hollow structure, open to the sea below waterline which allows the waves to cause the water column inside to rise and fall, which in turn causes the trapped air to flow back and forth past a turbine.

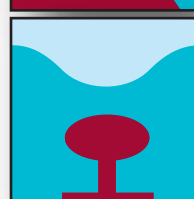


E. **Overtopping Device – Wash up** - Captures the water from the waves and holds it in a reservoir above sea level. The forward kinetic energy of the wave is changed to potential energy in the reservoir via the ramp in the front of the device. As the captured water returns to the sea it flows through low-head turbines.



F. **Overtopping Device – Flush in** - Captures the water from the waves and channels it through low-head turbines. The forward kinetic energy in the wave is retained and used to channel the water past the low-head turbines.

G. **Submerged Pressure Differential** - Typically located near shore and attached to the seabed. The motion of the waves causes the sea level to rise and fall above the device, inducing a pressure differential in the device. The alternating pressure can then pump fluid through a system to generate electricity.



Aquamarine Power

Overview

Aquamarine Power was founded in February 2005 in order to take forward the commercial development of Oyster.

State of Technology

The first full-scale Oyster was fabricated by Isleburn in Scotland in 2008. Installation of Oyster at the European Marine Energy Centre (EMEC) in Orkney will be managed by Fugro Seacore.

Future Milestone - First fully commissioned commercially available wave farm scheduled for 2013 in the UK

Next Milestone – Deploy their first 2MW commercial-scale array (with grant funding) at EMEC, 2011

September 2009 - 10 million first funding round to progress Oyster offshore testing

August 2009 – Oyster 1 prototype successfully installed at EMEC

February 2009 – Joint venture agreement in place with Airtricity, to develop up to 1GW of marine energy sites by 2020

Device Characteristics

Oyster consists of an Oscillator fitted with pistons and fixed to the near shore seabed. Each passing wave activates the Oscillator, pumping high-pressure water through a sub-sea pipeline to the shore. Onshore, conventional hydroelectric generators convert this high-pressure water into electrical power.

Size: Oyster 1: 18m x 12m x 2m

Mass: Oyster 1: just below 200 tonnes

Construction Material: Steel

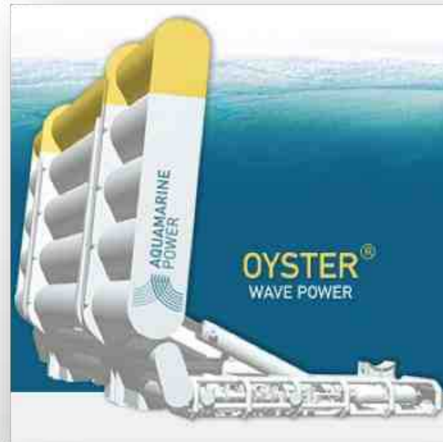
Electric Power Generation Location: Onshore, high pressure water

Rated Power Output per Device: Oyster 1: 315kW

Devices per Array: 3 - 300

Deployment Location: Near shore, 10-20m

Oyster



Contact:

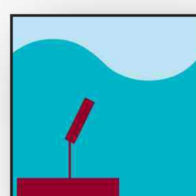
Aquamarine Power
10 Saint Andrew Square
Edinburgh EH2 2AF **Scotland**
Phone: +44 131 718 6011
E-mail: info@aquamarinepower.com
Web: www.aquamarinepower.com

Selection Criteria

Prototype:	Full scale
Site:	Demonstration site
Funding:	Investor
Schedule:	>2 yr to commercial

Type:

Oscillating Wave Surge Converter



AW-Energy

Overview

AW-Energy was founded in 2002 and has since then conducted extensive R&D and prototyping of the technology. Marine tests conducted with WaveRoller in the European Marine Energy Centre (EMEC) in Scotland and in Peniche Portugal have verified the surge energy generation potential and the suitability of WaveRoller in converting this energy source into electricity.

State of Technology

AW-Energy has had two 10kW prototypes installed off Portual. This development has been funded by €1 million venture capital from Fortum.

Next Milestone – There are preparations underway for a 300kW grid-connected demonstration project by 2011. A pre-commercial project could be completed around 2014.

October 2009 - AW-Energy has signed a $4.4M (3 million euros) contract with the European Union to demonstrate its technology.

June 2008 - Deployment of the second proto device in Peniche Portugal.

Device Characteristics

A WaveRoller device is a plate anchored on the sea bottom by its lower part. The back and forth movement of surge moves the plate, and the kinetic energy produced is collected by a piston pump. This energy can be converted to electricity by a closed hydraulic system in combination with a hydraulic motor/generator system on the device.

Size: Unspecified

Mass: Unspecified

Construction Material: Concrete foundation, composite & steel wings

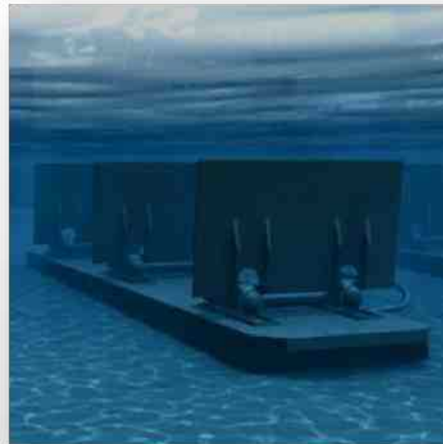
Electric Power Generation Location: On the device

Rated Power Output per Device: 300 kW

Devices per Array: Several to unlimited

Deployment Location: Near shore

WaveRoller



Contact:

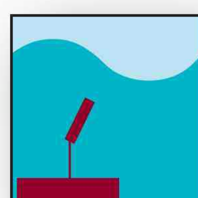
AW-Energy Oy
Kolamiilunkuja 6
FI-01730 Vantaa **Finland**
Phone: +358 9 7262404
E-mail: info@aw-energy.com
Web: www.aw-energy.com

Selection Criteria

Prototype:	1:100 – 1:10 scale
Site:	Demonstration site
Funding:	Investor
Schedule:	> 2 yr to commercial

Type:

Oscillating Wave Surge Converter



AWS Ocean Energy

Overview

AWS Ocean Energy is developing a range of marine energy technology solutions including the AWS-III a low-risk, multi-MW, wave energy converter developed using offshore oil & gas skills and the lessons learned from testing the AWS-I device offshore Portugal in 2004

State of Technology

The AWS-III has evolved from previous AWS designs to produce a practical and affordable device. Component level technology qualification and testing is ongoing in parallel with scale testing to validate numeric models of the optimized device.

Next Milestone – Construction of a full-system prototype will commence in 2010 and certified market-ready devices are expected to be available from 2013

Device Characteristics

The AWS-III is a large floating steel structure comprising multiple cells which use sub-sea compression of air to absorb power. Rubber diaphragms provide the absorber surface thus eliminating exposed moving parts and proven air turbines convert the pneumatic power to electricity.

Size: 60 - 90 m diameter, depending on resource

Mass: Unspecified

Construction Material: Steel and natural rubber

Electric Power Generation Location: On the device

Rated Power Output per Device: 2.4 - 4.0 MW

Devices per Array: As required, potentially 100+

Deployment Location: Offshore, 70 - 200 m water depths

Archimedes Waveswing

Image not available,
per company request

Contact:

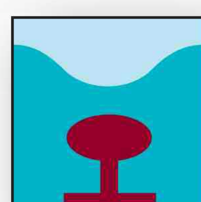
AWS Ocean Energy Ltd.
13 Henderson Road
Longman Industrial Estate
Inverness IV1 1SN **Scotland**
Phone: +44 146 372 5410
E-mail: info@awsocean.com
Web: www.awsocean.com

Selection Criteria

Prototype:	Full scale
Site:	Test site
Funding:	Investors
Schedule:	> 2 yr to commercial

Type:

Submerged Pressure Differential



BioPower Systems

Overview

BioPower Systems is a renewable energy technology company based in Sydney Australia. We are developing systems for both wave and tidal power conversion. The company is currently working on ocean-based pilot projects and follow-on market opportunities for its products and services.

State of Technology

Next Milestone - Unknown

August 2009 – BioPower has signed a Memorandum of Understanding (MOU) with Siemens Ltd to evaluate and develop joint opportunities for ocean power conversion.

May 2008 – BioPower has signed a Memorandum of Understanding (MOU) with Hydro Tasmania to test and demonstrate its bioWAVE and bioSTREAM ocean power conversion systems in Tasmania. BioWave will have a capacity of 250kW and will feed power into each island's distribution grid.

April 2008 – Completes $6 million capital raising

Device Characteristics

The wave power system, bioWAVE, is based on the swaying motion of sea plants in the presence of ocean waves. The hydrodynamic interaction of the buoyant blades with the oscillating flow field is designed for maximum energy absorption. In extreme wave conditions the bioWAVE automatically ceases operating and assumes a safe position lying flat against the seabed.

Size: Unknown

Mass: Unknown

Construction Material: Unknown

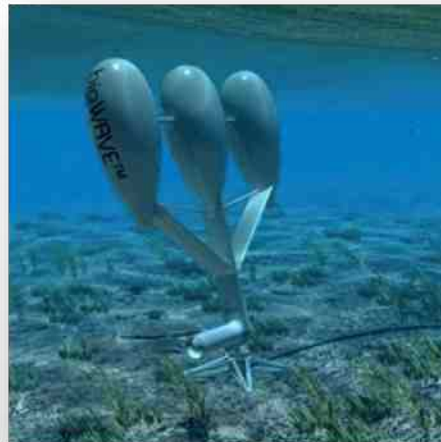
Electric Power Generation Location: On the device

Rated Power Output per Device: Unknown

Devices per Array: Unknown, 250kW, 500kW, 1MW arrays

Deployment Location: Nearshore

bioWAVE



Contact:

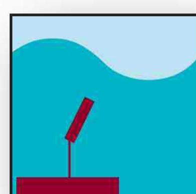
BioPower Systems Pty. Ltd.
Suite 213 National Innovation Centre
Australian Technology Park
4 Cornwallis St, Eveleigh NSW 2015 – **Australia**
Phone: +61 2 9209 4237
E-mail: info@biopowersystem.com
Web: www.biopowersystems.com

Selection Criteria

Prototype:	None
Site:	Test site
Funding:	Investors
Schedule:	Prototyping

Type:

Oscillating Wave Surge Converter



Carnegie Wave Energy

Overview

Carnegie Wave Energy Limited is focused on developing and commercializing its CETO wave energy technology which is capable of producing zero-emission power and desalinated water.

State of Technology

Next Milestone – Commercial scale demonstration starts in November 2009

March 2009 – Completed data collection and performance analysis on CETO II unit connected to the Fremantle test facility

February 2009 – Received AU $12.5M from Western Australian State Government

February 2008 – Successful deployment and initial operation of the first CETO II unit in Fremantle in Western Australia

Device Characteristics

CETO wave power converter is fully submerged and to pumps high-pressure seawater ashore where electricity is generated.

Size: Unknown

Mass: Unknown

Construction Material: Steel, rubber, and hyaline

Electric Power Generation Location: Onshore, pumps water

Rated Power Output per Device: Unknown

Devices per Array: Unknown

Deployment Location: Nearshore

CETO

Contact:

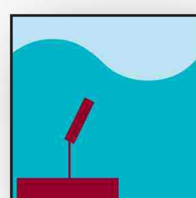
Carnegie Wave Energy Ltd.
1/16 Ord St., West Perth
Western Australia 6005, **Australia**
Phone: +61 8 9486 4466
Email: enquiries@carnegiecorp.com.au
Web: www.carnegiecorp.com.au

Selection Criteria

Prototype:	Full scale
Site:	Test site
Funding:	Investors
Schedule:	> 2 yr to commercial

Type:

Oscillating Wave Surge Converter



Checkmate Seaenergy

Anaconda

Overview

Checkmate Seaenergy Ltd is part of Checkmate Group. It is developing the Anaconda Wave Energy Convertor, which has finished proof of concept testing. The company was established during 2007 and currently has a number of engineers working full-time on the development program. This small team is based at the site of sister company Checkmate Flexible Engineering in Melksham, Wiltshire.

State of Technology

Next Milestone – Complete a round of fund raising with financial institutions and independent investors by early 2010

May 2009 – Proof of concept testing with a 1:25 scale device (0.3m diameter, 8m long) at Qinetiq's test tank.

October 2009 - Device underwent thorough performance testing at 1:25 scale at Glasgow and Strathclyde University. The data from the performance tests will be used by independent reviewers Black & Veatch.

Device Characteristics

Essentially, it is a very large water filled distensible rubber tube floating just beneath the sea surface at right angles to the waves, with a power take off at the stern. As a wave passes the bulge tube is lifted with the surrounding water and causes a bulge wave to be excited which passes down the tube's diameter like a pulse in an artery, gathering energy from the sea wave as it goes.

Size: 7.5m diameter, approximately 200m length

Mass: Unspecified

Construction Material: Bulge tube: rubber and rubber coated fabric

Electric Power Generation Location: On the device

Rated Power Output per Device: 1 MW

Devices per Array: variable, up to 50+

Deployment Location: Offshore, depths of 30+ m

Contact:

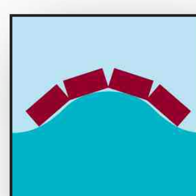
Checkmate Seaenergy Limited
Unit 6, Pegasus Way, Bowerhill,
Melksham, Wiltshire, SN12 6TR **UK**
Phone: +44 1795 580 333
Email: info@checkmateseaenergy.com
Web: www.checkmateuk.com

Selection Criteria

Prototype:	1:100-1:10 scale
Site:	Test tank
Funding:	Internal
Schedule:	Prototyping

Type:

Attenuator



Columbia Power Technologies

Overview

Columbia Power Technologies, LLC is an independent company founded in 2005 by Greenlight Energy Resources, Inc. In partnership with Oregon State University, the company is engaged in the development and commercialization of wave energy harvesting devices using novel, offshore, direct-drive permanent-magnet generator topologies.

State of Technology

Next Milestone – Unknown

September 2009 – Release of new buoy design at the 2009 Ocean Renewable Energy Conference IV. No mention on website yet.

2009-2010 – NAVFAC SBIR Phase III Grant

October 2008 – Successful Ocean Test off Newport

Device Characteristics

Size: Unknown

Mass: Unknown

Construction Material: Unknown

Electric Power Generation Location: On the device, linear generator

Rated Power Output per Device: Unknown

Devices per Array: Unknown

Deployment Location: Offshore, 40+m depths

Direct-Drive

Contact:

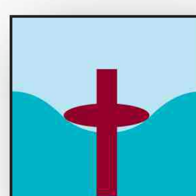
Columbia Power Technologies, Inc.
1148 Kelley Engineering Center
Room 3043
Corvallis, OR 97331
Phone: (541) 737 7875
Email: info@columbiapwr.com
Web: www.columbiapwr.com

Selection Criteria

Prototype:	1:100-1:10 scale
Site:	Test site
Funding:	Investor
Schedule:	None

Type:

Point Absorber



Dartmouth Wave Energy

Searaser

Overview

Company information unspecified

State of Technology

Next milestone – Two quarter scale prototypes to be deployed early to mid 2010

April 2009 – Sea trial of 1:10 scale prototype

Device Characteristics

Searaser is designed to pump water either straight through a sea-level turbine to generate electricity, or up to a cliff top reservoir, where the water could be stored until needed, then allowed to flow back down to the sea through turbines, generating electricity on demand.

Size: Unspecified

Mass: Unspecified

Construction Material: Unspecified

Electric Power Generation Location: Onshore, pumped water

Rated Power Output per Device: Unspecified

Devices per Array: Unspecified

Deployment Location: Unspecified

Contact:

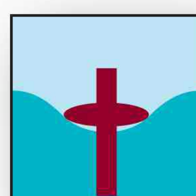
Dartmouth Wave Energy Limited
Derwent Lodge, South Town
Dartmouth, Devon TQ6 9BU **UK**
Phone: +44 1803 833 189
Email: searaser@tiscali.co.uk
Web: www.dartmouthwaveenergy.com

Selection Criteria

Prototype:	1:100-1:10 scale
Site:	Test site
Funding:	Internal
Schedule:	Prototyping

Type:

Point Absorber



Finavera Renewables

INACTIVE

Overview

The AquaBuOY technology, which has been independently evaluated and found commercially viable, has potential to generate electricity at a cost that is competitive with onshore and offshore wind farms and some fossil fuels, in the near to mid-term.

State of Technology

Finavera owns 100% of the AquaBuOY wave energy technology and is currently investigating financing options for direct investment into the wave energy subsidiary in order to avoid parent company dilution.

Feb 2009 - Filed applications to surrender its Federal Energy Regulatory Commission ("FERC") license for the Makah Bay Wave Energy Pilot Project in Washington and the Humboldt County Preliminary Permit for a proposed wave energy project in California. The permits were surrendered to allow Finavera to focus its resources on enhancing its near-term wind portfolio. The company retains all intellectual property associated with the AquaBuOY technology.

Oct 2008 - Finavera Renewables Inc. announces that the California Public Utilities Commission has recently denied Pacific Gas & Electric's application to approve a power purchase agreement for a 2 megawatt wave power project in Humboldt County, California.

Device Characteristics

Size: 1:4 scale test off Newport, Oregon was ~80 feet long

Mass: Unknown

Construction Material: Steel

Electric Power Generation Location: On the device

Rated Power Output per Device: Unknown

Devices per Array: Unknown

Deployment Location: Offshore

AquaBuOY

Contact:

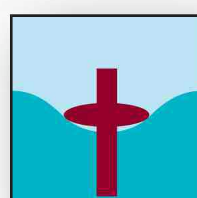
Finavera Renewables
595 Burrard Street, Suite 3113
Three Bentall Centre, PO Box 49071
Vancouver, BC V7X 1G4 **Canada**
Phone: +1 604 288 9051
Email: info@finavera.com
Web: www.finavera.com

Selection Criteria

Prototype:	1:9-1:2 scale
Site:	Test site
Funding:	Internal
Schedule:	None

Type:

Point Absorber



Floating Power Plant

Overview

Floating Power Plant A/S (FPP) was established in 2004. The concept of Poseidon was established back in 1980. In 1996 the development process was sped up and the concept has during the last decade undergone tests in scales of 8 and 17 meters concurrently with great focus on the engineering design.

State of Technology

Next Milestone – Unknown

2009 - Completed 4 months offshore test with very good results. Confirmed platform stability for mounting of windmills.

September 2008 - The demonstration plant named Poseidon 37 is 37 meters wide, 25 meters long, 6 meters high (to deck), weighs approximately 300 tonnes, and has a rated power of 140kW. The plant was launched in Nakskov Harbour in the summer of 2008 and installed in September.

Device Characteristics

The Poseidon concept is based on a large stabile floating platform, which work both as a platform for a wave energy converter concept and as a floating foundation for wind turbines. To harness the waves, there is a float that absorbs the inherent energy from the waves, and by use of a double function piston pump it transforms the energy from the wave into water pressure that is then sent through a turbine, thus generating electricity.

Size: 100-420m depending on location. 230m device described below:

Mass: Unknown

Construction Material: Steel

Electric Power Generation Location: On the device

Rated Power Output per Device: 10MW wind/wave combined

Devices per Array: Unknown

Deployment Location: Offshore

Poseidon

Contact:

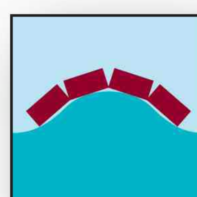
Floating Power Plant A/S
Vermundsgade 40A, 3
DK-2100 Copenhagen **Denmark**
Phone: +45 3391 9120
Email: info@floatingpowerplant.com
Web: www.floatingpowerplant.com

Selection Criteria

Prototype:	Full scale
Site:	Test site
Funding:	Internal
Schedule:	Prototyping

Type:

Attenuator



Fred Olsen Ltd.

BOLT

Overview

Fred Olsen Ltd. Currently has one commercial consent, a slot in Wave Hub, and 7 consents in various stages of permitting. They have strong partnerships with AAB (Sweden), Bosch-Rexroth (Norway/Germany) and SINTEF Marintek (a research institution).

State of Technology

Next Milestone – It is participating in the UK's Wave Hub project and planning on launching in early 2010. This will include a multiple device (farm) test.

Spring 2009 – BOLT, a full scale, electricity producing device was launched in the water for a multi-month test

February 2005 - A complete lab platform (scale 1:3) of the FO^3 device was constructed in Norway and launched

2004 – A 1:20 scale model of the FO^3 was tested in the Wave tank of the Ocean Basin Laboratory at SINTEF in Trondheim

Device Characteristics

The FO3 Wave Energy Converter is a floating platform with oscillating point absorbers. Energy is absorbed from the waves as they move the floating absorbers hanging beneath the platform up and down. This motion is used to drive a generator to produce electricity.

Size: 5.5m diameter

Mass: Unspecified Predominantly fiberglass (FRP)

Construction Material: Predominantly fiberglass (FRP)

Electric Power Generation Location: On the device

Rated Power Output per Device: 30kW

Devices per Array: Unspecified

Deployment Location: Unspecified

Contact:

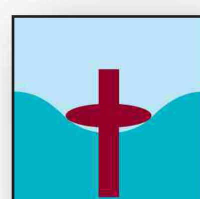
Fred Olsen Ltd
Fred Olsens gate 2
0152 Oslo, **Norway**
Phone: +47 22 34 10 00
Email: renewables@fredolsen.no
Web: None

Selection Criteria

Prototype:	Full scale
Site:	Test sites
Funding:	Internal
Schedule:	> 2 yr to commercial

Type:

Point Absorber



Green Ocean Energy

Wave Treader

Overview

Green Ocean Energy Ltd was established in 2005 and is an Aberdeen based renewable energy company which is developing wave and wind energy convertors. They are dedicated to developing technology which will allow the harnessing of energy from the Earth's oceans in a way which is harmonious to the environment but equally economically viable, thereby providing a clean and sustainable source of energy.

State of Technology

Next Milestone – Full scale prototype of Wave Treader deployed in Q2 2011

September 2009 – Received £100,000 of funding from the Scottish Enterprise Seed Fund, matched by £150,000 of private investment.

May 2009 - The scaled 12.5:1 demonstrator model of the wave power conversion device is undergoing testing at a wave tank at the New and Renewable Energy Centre (NaREC) and also at the University of Strathclyde.

Device Characteristics

Wave Treader is a WEC which attaches to the transition piece of an offshore wind turbine to combine wind and wave energy from one installation. Wave Treader comprises a fore and aft sponson which are attached to a vertical spar with an interface structure. The relative motion between the floating bodies is harvested by hydraulic cylinders mounted between the tops of the arms and the spar buoy. The cylinders pressurize hydraulic fluid that, after smoothing by accumulators, spins hydraulic motors and then electric generators.

Size: 50m x 20m x 20m draft, 20m long steel arms

Mass: Unspecified

Construction Material: FRP/GRP buoyant bodies, steel structure

Electric Power Generation Location: On the device, hydraulic

Rated Power Output per Device: 500kW

Devices per Array: ~30 devices, 15MW rated power

Deployment Location: Offshore

Contact:

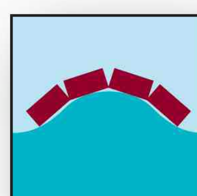
Green Ocean Energy Ltd.
28 Carden Place
Aberdeen AB10 1 UP **UK**
Phone: +44 1224 651 051
Email: info@greenoceanenergy.com
Web: www.greenoceanenergy.com

Selection Criteria

Prototype:	1:100-1:10 scale
Site:	Test tank
Funding:	Investor
Schedule:	Prototyping

Type:

Attenuator



OceanEnergy

OE Buoy

Overview

OceanEnergy Limited is a specialized commercial company developing wave energy technology. The company has over the past 7 years developed and tested its OE Buoy technology.

State of Technology

Next Milestone – The current development phase is of a ¾ scale device and then moving to the production phase and the construction of full-scale devices, building on the lessons of the phased program.

Sept 2009 – Ocean Energy has secured funding of €230,000 from Sustainable Energy Ireland.

Aug 2009 – Concluded 2.5 years of testing at the government test site in Galway Bay with a ¼ scale device.

Device Characteristics

The OE Buoy has been designed around the oscillating water column principle. To ensure survivability the platform has only a single moving part.

Size: Unknown

Mass: ¼ scale model is 28 tonnes.

Construction Material: Steel

Electric Power Generation Location: On the device

Rated Power Output per Device: up to 2MW

Devices per Array: Unknown

Deployment Location: Offshore

Contact:

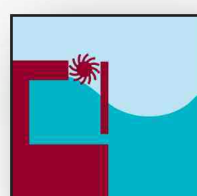
OceanEnergy Ltd
3 Casement Square,
Cobh, Co. Cork, **Ireland**
Phone: +353 21 481 6779
Email: info@oceanenergy.ie
Web: www.oceanenergy.ie

Selection Criteria

Prototype:	1:9-1:2 scale
Site:	Test site
Funding:	Investor
Schedule:	Prototyping

Type:

Oscillating Water Column



Oceanlinx

Offshore OWC

Overview

Since 1997 Oceanlinx has designed and deployed wave energy systems

State of Technology

Port Kembla (New South Wales, Australia) – A Power Purchase Agreement has been signed with Australian utility Integral Energy. Two units (floating and stationary) installed. Mk1 – 2005 to 2009. Mk2 2008 onward. Mk3 pre-commercial construction 2009, deployed 2010.

Portland (Victoria, Australia) – progressing the permitting stage for the deployment of multiple units into a wave energy array.

Rhode Island (USA) – a Memorandum of Understanding ("MOU") with Rhode Island State authority for a 1.5MW unit, followed by a 15 to 20MW electricity generating facility off the mainland.

GPP (Namibia) – a signed contract with GPP, part of the listed Southern African Utility SELCo for a 1.5MW unit.

Hawaii (USA) – A signed MOU with an island in Hawaii for up to 2.7MW.

Mexico – a proposed project at Rosarito in Baja California, to be jointly developed with CFE and DEFAESA (the renewable arm of Grupo R) from 2010.

Device Characteristics

As the wave passes the Oceanlinx device, the water inside the OWC rises and falls, compressing and displacing the air inside, driving it past a turbine that is housed at the narrowest point in the chamber.

Size: Unknown

Mass: Unknown

Construction Material: Unknown

Electric Power Generation Location: On the device

Rated Power Output per Device: ≥2.5MW (Mk3)

Devices per Array: Unknown

Deployment Location: Near shore

Contact:

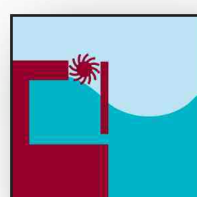
Oceanlinx Limited
Level2, 2A Lord St.
Botany, NSW, 2019 **Australia**
Phone: +61 2 9549 6300
Email: info@oceanlinx.com
Web: www.oceanlinx.com

Selection Criteria

Prototype:	Full scale
Site:	Demonstration site
Funding:	Utility
Schedule:	< 2 yr to commercial

Type:

Oscillating Water Column (OWC)



Ocean Power Technologies

Overview

Starting in 1994, OPT has focused on its proprietary PowerBuoy technology.

State of Technology

Atlantic City, New Jersey – The PB40 prototype has demonstrated over 24 months of successful ocean testing (no grid connection).

Oahu, Hawaii – October 2008, OPT ocean-tested its third PowerBuoy at the US Marine Corps Base Hawaii (MCBH) at Kaneohe Bay.

Santoña, Spain – The PB40ES was deployed for the project with Iberdrola S.A. in September 2008.

Orkney Isles, Scotland – The PB150, currently in fabrication, will be ready for deployment at the European Marine Energy Center at the end of 2009.

Reedsport, Oregon – The project is currently in the environmental permitting phase. OPT anticipates filing a Final License Application with the Federal Energy Regulatory Commission (FERC) in 2009

Coos Bay, Oregon – OPT will be engaging the project stakeholders in a collaborative process to lead to the submittal of the final license application for that project.

Device Characteristics

The rising and falling of the waves off shore causes the buoy to move freely up and down. The resultant mechanical stroking is converted via a power take-off to drive an electrical generator.

Size: PB150: 44m long, 11m diameter

Mass: Unknown

Construction Material: Unknown

Electric Power Generation Location: On the device

Rated Power Output per Device: PB150: 150kW

Devices per Array: Unknown

Deployment Location: Offshore

PowerBuoy

Contact:

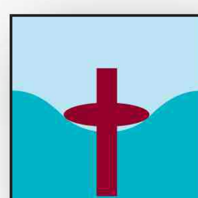
Ocean Power Technologies, Inc.
1590 Reed Rd.
Pennington, NJ 08534 **USA**
Phone: +1 609 730 0400
Email: info@oceanpowertech.com
Web: www.oceanpowertech.com

Selection Criteria

Prototype:	1:9-1:2 scale
Site:	Demonstration sites
Funding:	Investor
Schedule:	> 2 yr to commercial

Type:

Point Absorber



Grampus

Overview

Company information unknown

State of Technology

Next Milestone – Unknown

OWEL has completed a feasibility study, sponsored by a DTI Smart Award followed by a 2 year Initial Development Programme sponsored by a Carbon Trust Grant. These have confirmed the technical performance of the wave energy converter design and the commercial viability of the concept.

Nov 2008 - Offshore Wave Energy in association with IT Power Ltd announced a further stage in the development of their wave energy converter, 'Grampus'. This has been funded by a grant from the South West Regional Development Agency together with contributions from existing shareholders. New research into the geometric configuration of the Grampus, will focus on optimizing its performance and investigating its structural loading and mooring requirements.

Device Characteristics

The compressed air is accumulated in a reservoir and is then used to drive a turbine and thus generate power. The devices are inherently robust & are designed to be installed on floating platforms, moored offshore in sea areas where energetic wave spectra are found.

Size: Unknown

Mass: Unknown, large

Construction Material: concrete

Electric Power Generation Location: Unknown

Rated Power Output per Device: Unknown, 12MW platform

Devices per Array: Unknown

Deployment Location: Offshore

Contact:

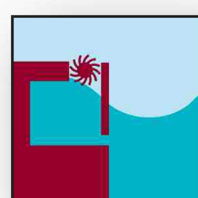
Offshore Wave Energy Limited
Tamaris House, Lezant
Launceston, Cornwall PL15 9PP **UK**
Phone: +44 870 112 1813
Email: owel@sycamoreinnovation.com
Web: owel.co.uk

Selection Criteria

Prototype:	1:100-1:10 scale
Site:	Test tank
Funding:	Grant
Schedule:	Prototyping

Type:

Oscillating Water Column



Orecon

Overview

Orecon was established in 2002 by Nicola Meek and Fraser Johnson who had been developing the wave energy technology since 2001. The company was formed as a "spin-out" from their postgraduate project at the University of Plymouth which included sea trials of a 12th scale concept prototype.

State of Technology

Next Milestone – Orecon's first wave-to-energy buoy is scheduled to be deployed off the Cornish coast in the summer of 2011.

May 2009 - Orecon signed an agreement with Portuguese developer Eneólica. The two companies are establishing a Joint Venture company to build and deploy Orecon's first full scale 1.5MW MRC wave energy buoy. The site will be connected to the Portuguese electricity grid.

May 2009 – Wave Hub chose Orecon as new device developer

Feb 2008 - Orecon secured major investment from a powerful syndicate of international Venture Capital investors led by Advent Ventures—a total of £12 million

2003 - A DTI SMART Award

Device Characteristics

Device Characteristics: The tension moored Multi Resonant Chamber concept combines OWC chambers with Dresser-Rand's HydroAir turbine technology to enable energy over a much broader spectrum of wave climate than the typical single chamber OWC.

Size: 45m x 31m x 14m (L,W,H)

Mass: 900tonnes

Construction Material: Mild steel

Electric Power Generation Location: On the device

Rated Power Output per Device: 1.5MW

Devices per Array: No limits

Deployment Location: Offshore, 50m+ depths

Orecon MRC

Contact:

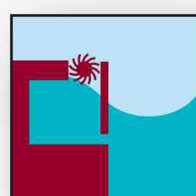
Orecon
2 Dreason, Bodmin Road
Bodmin, Cornwall, PL30 4BG, **UK**
Phone: +44 1208 269 374
Email: contact@orecon.com
Web: www.orecon.com

Selection Criteria

Prototype:	1:100-1:10 scale
Site:	Test sites
Funding:	Investor
Schedule:	> 2 yr to commercial

Type:

Oscillating Water Column (OWC)



Pelamis Wave Power

Overview

The Company was founded in 1998 with the aim of developing the Pelamis Wave Energy Converter. Since then the company has raised over £40million of investment and has been successful in bringing Pelamis technology to the commercial marketplace. The company now employs over 70 people and has headquarters in Edinburgh. There are further operations in Portugal. Pelamis Wave Power changed its name in September 2007 from Ocean Power Delivery.

State of Technology

Aguçadoura - Proven installation of three units (P1-A) on fully commissioned site infrastructure and successful export of power into the local grid

E.ON at EMEC – Under build, P2 Pelamis generators in 2010 grid connected.

Orcadian Wave Farm - Licenses, consents and funding granted

Device Characteristics

The Pelamis Wave Energy Converter is a semi-submerged, articulated structure composed of cylindrical sections linked by hinged joints. The wave-induced motion of these joints is resisted by hydraulic rams, which pump high-pressure fluid through hydraulic motors via smoothing accumulators. The hydraulic motors drive electrical generators to produce electricity. Power from all the joints is fed down a single umbilical cable to a junction on the seabed.

Size: 180m long, 4m diameter

Mass: Unknown

Construction Material: Mild steel, washed sand

Electric Power Generation Location: Unknown

Rated Power Output per Device: 750kW

Devices per Array: 35 units

Deployment Location: Offshore, 50m water depths

Pelamis (P2)

Contact:

Pelamis Wave Power Ltd.
31 Bath Rd, Leith,
Edinburgh EH6 7AH **Scotland**

Phone: +44 131 554 8444

Email: enquiries@pelamiswave.com

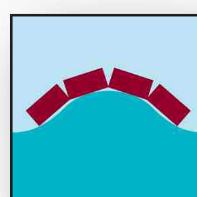
Web: www.pelamiswave.com

Selection Criteria

Prototype:	Full scale
Site:	Demonstration site
Funding:	Utility
Schedule:	< 2 yr to commercial

Type:

Attenuator



Resolute Marine Energy

Overview

The WEC design is an adaptation of systems being developed by RME for various offshore power applications. Normally, such systems are designed to generate electricity, so the air compressor feature of this project is unique. "These are exactly the kind of offshore power solution challenges we want to tackle" RME co-founder Bill Staby said. "To be successful, the burgeoning offshore aquaculture industry needs to automate routine tasks including cage positioning and feeding, and that requires a continuous power supply." "For a variety of reasons including environmental impact and safety, we think wave power is an ideal way to accomplish that and, by their support, others believe that may be true too."

State of Technology

August 2009 - Resolute Marine Energy, Inc. and Ocean Farm Technologies, Inc. awarded NOAA Phase II SBIR grant

May 2009 - Awarded DOE Phase I SBIR grant

January 2009 - RME commences prototype tests. The WEC deployment will cap six months of research and development supported by a Phase I SBIR grant from NOAA.

Device Characteristics

Size: Unspecified

Mass: Unspecified

Construction Material: Unspecified

Electric Power Generation Location: Unspecified

Rated Power Output per Device: Unspecified

Devices per Array: Unspecified

Deployment Location: Offshore

WEC

Contact:

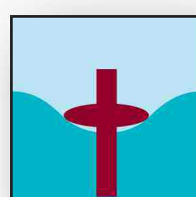
Resolute Marine Energy, Inc.
3 Post Office Square – 3rd Floor
Boston, MA 02109 USA
Phone: +1 617 600 3050
Email: wstaby@resolute-marine-energy.com
Web: www.resolute-marine-energy.com

Selection Criteria

Prototype:	1:9-1:2 scale
Site:	Test site
Funding:	Grant
Schedule:	Prototyping

Type:

Point Absorber



S.D.E.

Overview

S.D.E. is an engineering company. The company's objective is to build and operate sea wave power plants worldwide.

State of Technology

S.D.E built and tested eight energy modules with assistance from the government. A full-scale oceanfront model was operated in Israel and produced 40kW for almost one year.

Next Milestone – Develop partnerships with international concerns worldwide. Currently there are orders and letters of intent from Sri Lanka, Tanzania, India, The Gambia and Micronesia. Recently the company has received a 25 year signed concession from Zanzibar.

October 2009 - A Memorandum of Understanding, for building a 5MW Sea Wave Power Plant, Was Signed Between S.D.E Company and the Government of Gujarat, India

November 2008 - SDE said it has signed a 25-year agreement with an African country to build wave energy projects with a total capacity of 100 megawatts. The cost of the project is estimated at $100 million.

July 2008 - SDE has signed an agreement for selling sea wave power plants in China for an undisclosed sum. Construction of the power plants will be financed by investors from Hong Kong and China.

Device Characteristics

The technology is based on using the motion of the waves to create hydraulic pressure, which is then converted into electricity, while exploiting the full speed, height, depth and undercurrent of each wave, including both the rise and the fall of each wave.

Size: Unspecified

Mass: Unspecified

Construction Material: Unspecified

Electric Power Generation Location: On the device, hydraulic

Rated Power Output per Device: Unspecified

Devices per Array: Unspecified

Deployment Location: Onshore

Energy Modules

Contact:

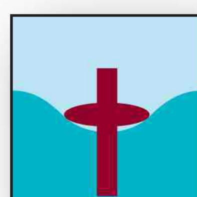
SDE Lt.
15A Lubetkin St.
Tel Aviv 67532 **Israel**
Phone: 972 37397 107
Email: abe@shani.net
Web: www.sde.co.il

Selection Criteria

Prototype:	Full scale
Site:	Test site
Funding:	Grant
Schedule:	None

Type:

Point Absorber onshore



Seabased

Overview

The company was founded in 2001 and was originally an innovation and patent holding company closely associated with the research being done at the Swedish Centre for Renewable Electric Energy Conversion at the Angstrom Laboratory, Uppsala University.

State of Technology

February 2009 – Fortum and a Swedish wave power equipment supplier Seabased Industry have submitted an application of interest to the Swedish Energy Agency for investment support of a full-scale wave power site with 500 aggregates and capacity of 10 MW, representing an estimated total investment of close to EUR 25 million. Fortum has together with the University of Uppsala previously invested in a test site for wave power outside the coast of Lysekil in Sweden.

Device Characteristics

The active element is a unique directly driven permanent magnet linear generator. The generator is designed to take advantage of the slow movement of the waves that is transferred to it via a buoy (point absorber) on the ocean surface. The movement of the waves causes the translator to move up and down within the stator, thus converting the kinetic energy of the wave to electric energy. The stroke length of the translator is limited by end stops at top and bottom. The encapsulated generators are anchored to the seabed using a concrete gravity foundation.

Size: Unknown

Mass: Unknown

Construction Material: Unknown

Electric Power Generation Location: On the device, linear generator

Rated Power Output per Device: Unknown

Devices per Array: Unknown

Deployment Location: Nearshore

Seabased

Contact:

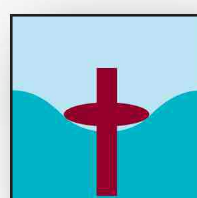
Seabased AB
Dag Hammarskjölds väg 52B
SE-751 83, Uppsala, **Sweden**
Phone: +46 18 472 30 90
Email: info@seabased.com
Web: www.seabased.com

Selection Criteria

Prototype:	Full scale
Site:	Test site
Funding:	Investor
Schedule:	> 2 yr to commercial

Type:

Point Absorber



Trident Energy

DECM

Overview

Trident Energy was founded in December 2003 to develop a commercial offering for the marine renewables market and commenced active R&D on its system in April 2004.

State of Technology

Next Milestone – Unknown

October 2009 – Successful recovery of the demonstration wave energy converter. It has been brought back into Lowestoft Harbour on the back of a crane barge.

September 2009 - A problem during the deployment phase led to the demonstration wave generator overturning as it was being taken out to sea to begin its yearlong offshore trial. The 80 tonne platform has been grounded three miles east of Southwold Harbour and made secure.

Summer 2009 – Trident Energy is currently working on its first offshore trials and will be deploying a system (20KW) off the east coast of England.

Device Characteristics

The system, known as the Direct Energy Conversion Method (DECM), has only one moving part. Floats placed in the sea are used to drive linear generators, resulting in the immediate generation of electricity. No hydraulic equipment or air compression is required.

Size: 16m tall, 3m above water

Mass: Unknown

Construction Material: Unknown

Electric Power Generation Location: On the device, linear generator

Rated Power Output per Device: Unknown

Devices per Array: Unknown

Deployment Location: Offshore

Contact:

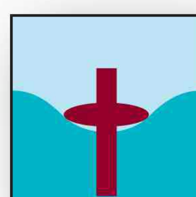
Trident Energy Limited
Token House, 11-12 Token House Yard
London, EC2R 7AS, **UK**
Phone: +44 7073 2963
Email: info@tridentenergy.co.uk
Web: www.tridentenergy.co.uk

Selection Criteria

Prototype:	Full scale
Site:	Test site
Funding:	Investor
Schedule:	Prototyping

Type:

Point Absorber



Wavebob

Overview

Wavebob is an Irish company established by physicist William Dick in 1999.

State of Technology

Next Milestone - Unknown

February 2009 - Vattenfall has acquired 51 % of the Irish site development company for ocean energy, Pandion Ltd, for EUR 500,000 (around SEK 5 million). The ocean energy developer Wavebob Ltd will hold the remaining 49 % of Pandion and the agreement brings opportunities for further partners to participate.

May 2008 - Wavebob Opens North American Operation

February 2008 - Wavebob Ltd., Ireland's leading wave-energy development company, has signed a research and development agreement with one of Europe's largest electricity providers, Vattenfall AB. The two companies will collaborate on bringing the prototype Wavebob device to readiness for a full-scale commercial wave farm. Wavebob Ltd. intends the device to be used at a later stage in a commercial wave farm off the west coast of Ireland.

Device Characteristics

The Wavebob is an axi-symmetric, self-reacting point absorber, primarily operating in the heave mode. It is specifically designed to recover useful power from ocean wave energy, and to be deployed in large arrays offshore.

Size: 20m diameter, 8m above water

Mass: Unknown

Construction Material: Extruded concrete units

Electric Power Generation Location: Unknown

Rated Power Output per Device: 500kW (N. Atlantic)

Devices per Array: Unknown

Deployment Location: Offshore

Wavebob

Contact:

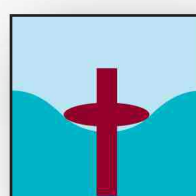
Wavebob Ltd.
H3, Maynooth Business Campus
Maynooth, Co. Kildare, **Ireland**
Phone: +353 1 651 0177
Email: online form
Web: www.wavebob.com

Selection Criteria

Prototype:	1:9-1:2 scale
Site:	Test site
Funding:	Investor
Schedule:	> 2 yr to commercial

Type:

Point Absorber



Wave Dragon

Overview

Invented by Erik Friis-Madsen, it has been developed with funding support from the European Union, the Welsh Development Agency, the Danish Energy Authority and the Danish Utilities PSO Program.

State of Technology

August 2009 – Wave Dragon is currently seeking venture capital for the first full-scale device.

April 2009 – EIS submitted for the Marloes Peninsula (Pembrokeshire) site for a 7MW device.

May 2008 - Maintenance and repairs are currently being done. The prototype will be re-deployed at the original test site (Denmark) in early autumn 2009 for final testing.

Welsh Demonstrator – EIS submitted. Expected device installation during 2011-2012.

EU Project "WD MW" – April 1st 2006 to March 31st 2009 (36 months). R&D contract with the European Commission to finalize design and realization of a multi-MW Wave Energy Convert.

Prototype testing in Denmark – A 1:4.5 scale prototype launched in 2003. Deployed off the coast of Denmark at Nissum Bredning, this test unit has accumulated over 20,000 grid-tied hours of experience.

Portugal – The initial project will be an approximately 50 MW wave farm.

Device Characteristics

Wave Dragon is a floating, slack-moored energy converter of the overtopping type.

Size: Unknown

Mass: 237 tonne prototype in Denmark

Construction Material: Unknown

Electric Power Generation Location: Unknown

Rated Power Output per Device: Unknown

Devices per Array: Unknown

Deployment Location: Offshore

Wave Dragon

Contact:

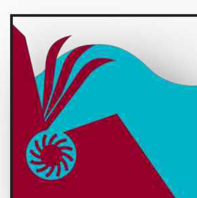
Wave Dragon ApS
Blegdamsvej 4
Dk-2200 Copenhagen N, **Denmark**
Phone: +45 3536 0219
Email: info@wavedragon.net
Web: www.wavedragon.net

Selection Criteria

Prototype:	1:9-1:2 scale
Site:	Demonstration site
Funding:	Investor
Schedule:	> 2 yr to commercial

Type:

Overtopping Device – Flush in



Wave Energy (Norway)

Overview

Wave Energy is a technology business. We develop, design and provide unique solutions to utilize the enormous power in the waves to produce electricity. The company was established in 2004, is Norwegian based and has its office in Tananger outside the city of Stavanger on the west coast of Norway.

State of Technology

Next Milestone – Full scale demonstration plant. Planning stage for a full scale demonstration plant in Svåheia in Eigersund south of Stavanger. Expected construction start 2010 and plant grid connection 2011.

Feb 2009 - Wave Energy is together with Hanstholm Harbour looking at the possibility to implement and conduct full-scale testing of the SSG Breakwater technology at Hanstholm Harbour.

Device Characteristics

The SSG-concept (Sea-wave Slot-cone Generator concept) is a wave energy converter based on the wave overtopping principle utilizing a total of three reservoirs placed on top of each other, in which the potential energy of the incoming wave will be stored. The water captured in the reservoirs then will run through turbines for electricity production.

The SSG wave energy technology can be built integrated into breakwaters or into other structures built for wave protection and sheltering.

Size: Will be dictated by the breakwater (integrated into breakwater)

Mass: As above

Construction Material: Concrete

Electric Power Generation Location: On the device

Rated Power Output per Device: Average of 1.5-2MW per 100m length

Devices per Array: Not applicable

Deployment Location: Onshore

SSG

Contact:

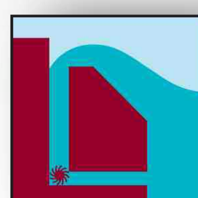
Wave Energy
Energiveien 16
N-4056 Tananger
Phone: +47 51 87 56 20
Email: monika.bakke@waveenergy.no
Web: waveenergy.no

Selection Criteria

Prototype:	1:9-1:2 scale
Site:	Test site
Funding:	Investor
Schedule:	> 2 yr to commercial

Type:

Overtopping Device – Wash up



Voith Hydro Wavegen

Overview

Wavegen was formed in 1990 and is based in Inverness Scotland. In 2000 the company became the first company to connect a commercial scale wave energy plant to the grid. Since 2005 it has been the center of competence for wave energy within Voith Hydro.

State of Technology

Wavegen has developed turbo-generators for incorporating into breakwaters, coastal defenses, land reclamation, port walls, and community power schemes. Installation or removal can be achieved using a small mobile crane. These turbines are the fifth generation and incorporate all the learning and cost reduction experience gained from previous designs and operation of the Limpet plant.

Mutriku – Breakwater wave power station being built in Spain in 2009. Will include 16 Wells turbines and provide a rated power of 300kW.

Siadar Wave Energy Project – Located on the Isle of Lewis, it is a joint project between RWE npower renewables and WaveGen. Will include up to 36 Wells turbines in a 200 m 'active' breakwater structure.

Device Characteristics

The technology is based on the oscillating water column (OWC) with a Wells turbine power take-off. The Wells turbine is a fixed pitch machine with only one direction of rotation.

Size: Turbine diameters: 750mm/1250mm/1800mm

Mass: Turbine: 700kg/2500kg/6100kg

Construction Material: Concrete, steel

Electric Power Generation Location: At the turbine

Rated Power Output per Device: 18.5kW/110kW/250kW

Devices per Array: Flexible

Deployment Location: Onshore or Near shore

Wavegen

Contact:

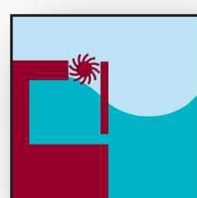
Voith Hydro Wavegen Limited
13a Harbour Road
Inverness, IV1 1SY, **Scotland**
Phone: +44 1463 238 094
Email: enquiries@wavegen.com
Web: www.wavegen.com

Selection Criteria

Prototype:	Full scale
Site:	Demonstration site
Funding:	Utility
Schedule:	< 2 yr to commercial

Type:

Oscillating Water Column



WavePlane

Overview

WavePlane A/S is a development company based in Aarhus, currently detail designing and building the first full-scale wave plane. Erik Skaarup invented the concept.

State of Technology

Next Milestone – Unknown

June 2009 – After Plane Wave's prototype wrecked and ran aground at Hanstholm in early 2009, work is now being done to renovate the prototype and redeploy it.

Dec 2008 – First full-scale prototype ready for deployment

Device Characteristics

In front, below the surface line, the wave plane is equipped with an artificial beach that makes the capture of the wave energy more efficient. The wave plane is symmetrical in its construction. On each side the water from the waves is caught in different heights through an inlet divided into separate levels. Further into this inlet the water is let tangentially into the turbine pipe. Through this process it is sought to maintain as much of the water's kinetic energy as possible in consideration of the manageable volume. The kinetic energy is converted into a rotating stream of water in the turbine pipe. From the turbine the water is led back into the sea. By means of a gear box the turbine runs a generator, which is connected to the electrical grid.

Size: Unknown

Mass: Unknown

Construction Material: Steel

Electric Power Generation Location: On the device

Rated Power Output per Device: Unknown

Devices per Array: Unknown

Deployment Location: Near shore

WavePlane

Contact:

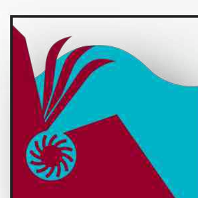
WavePlane A/S
c/o Anders Vejby
Holmevej 205
8270 Højbjerg, **Denmark**
Phone: +45 30 58 09 18
Email: av@waveplane.com
Web: www.waveplane.com

Selection Criteria

Prototype:	Full scale
Site:	Test site
Funding:	Grants
Schedule:	Prototyping

Type:

Overtopping Device – Flush in



Wave Star Energy

Overview

Wave Star Energy was formed in 2003. Their 1:10 scale test machine has been in constant operation for nearly 3 years delivering power to the grid. It has been through 15 storms without any damage.

State of Technology

Next milestone – Within the next 2 to 3 years the first commercial demonstration 500kW Wave Star wave energy machine is expected to have been finally tested and optimized after which it will be ready for delivery in the whole world. The final goal is to produce a full-scale 6MW Wave Star machine.

September 2009 – The first section of a commercial demonstration 500kW machine was launched. It is a shortened version of the complete machine with only two arms and floats. It is situated 300 meter off Hanstholm in the North Sea at a water depth of 7 meters.

Device Characteristics

On each side of the oblong machine hemisphere-shaped floats are partially submerged in the water. When a wave rolls in the floats are lifted one by one. The floats are each positioned at the base of their own hydraulic cylinder. When a float is raised, a piston in the cylinder presses oil into the machine's common transmission system with a pressure of up to 200 bars. The pressure drives a hydraulic motor that produces the electricity.

Size: 500kW device: 70m long, each float 5m diameter

6MW device: 140m long, each float 10m diameter

Mass: Unspecified

Construction Material: Steel and fiberglass

Electric Power Generation Location: On the device, hydraulic

Rated Power Output per Device: 5.5kW 1:10 scale; 500kw 1:2 scale;

6MW 1:1 scale

Devices per Array: Unspecified

Deployment Location: Near shore, 10-30m water depths

Wave Star

Contact:

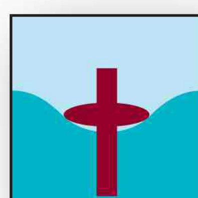
Wave Star Energy A/S
Gammel Vartov Vej 20
2900 Hellerup, **Denmark**
Phone: +45 4040 4696
Email: info@wavestarenergy.com
Web: www.wavestarenergy.com

Selection Criteria

Prototype:	1:10-1:2 scale
Site:	Demonstration site
Funding:	Investor
Schedule:	> 2 yr to commercial

Type:

Point Absorber



Appendix B

Oregon Ports

Infrastructure along the coast

Oregon Wave Energy Infrastructure Assessment

Understanding the infrastructure capabilities of the Oregon coast for the responsible development of wave energy. Funded by the Oregon Wave Energy Trust.

Information Sources:

This assessment was made using publicly available information and direct contact with ports to compile accurate information. For detailed information on ports, contact ports directly.

Primary Sources

- Coast Pilot (www.nauticalcharts.noaa.gov/nsd/cpdownload.htm)
- U.S. Army Corps of Engineers Port Series Reports (www.iwr.usace.army.mil/ndc/ports/ps/psbooks.htm)

Not intended for navigation purposes.

Organization:

Document shows ports arranged from South to North.

Overview

Entrance	Brief overview of the planned depths and entrances of each port
Wharves	The deep-water docks and wharves where applicable.
Infra-structure	Basic fabrication and repair capabilities in the near vicinity of the port
Contact	Contact information for the port in each area for additional information
Image	Aerial: Google Earth Chart: NOAA

Advanced Research corporation

Definitions

Controlling Depth
It is the least depth in a channel. It restricts use of the channel to drafts less than that depth.

Deep-Draft
For deep-draft non-container ships, the minimum required depth is 30 feet (9.1m). For high-speed container ships, it is 40 feet (12.2m). Shallow-draft crafts require a minimum of 12 feet (3.7m)

Depths
Are in feet below the low-water tidal datum of the charts.

Depths alongside wharves
In general, depths given alongside wharves are those reported by owners and/or operators of the waterfront facilities, and have not been verified by government surveys. Since these depths may be subject to change, local authorities should be consulted for current controlling depths.

Graving Dock
A form of dry-dock that is usually made of earthen berms and concrete, closed by gates or caisson, into which a vessel can be floated and the water pumped out.

Inoperable (drawbridge)
The drawbridge mechanism is inoperable and cannot raise the bridge.

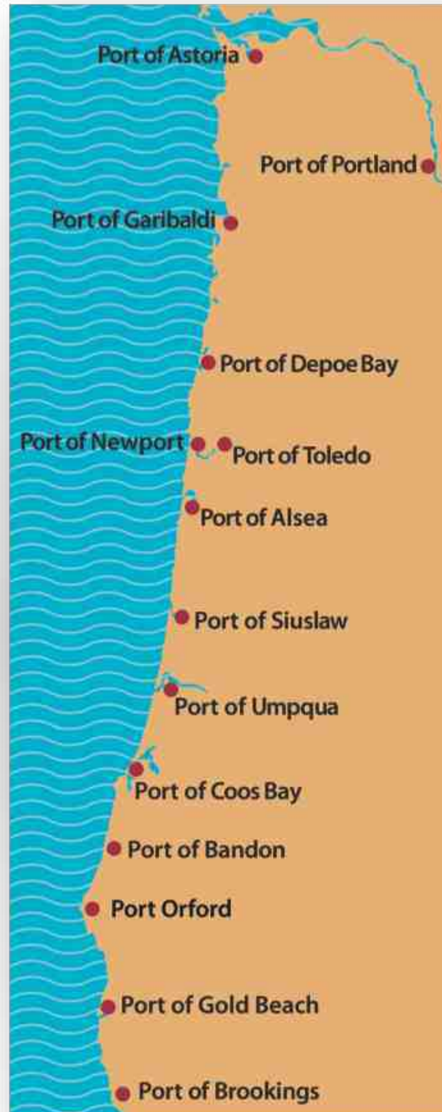
Marine Railway
A type of dry dock consisting of a cradle of wood or steel with rollers on which the ship may be hauled out of the water along a fixed inclined track leading up the bank of a waterway.

Swing Span Bridge
The swing span bridge turns on a vertical axis to allow ships to pass. It is balanced on a support called a pivot pier, usually in its center. Its span is measured by including the length of both arms.

Turning Basin
It is an open area at the end of a canal or narrow waterway to allow boats to turn around.

Vertical Clearance
Heights measured from mean high water for areas where tides are present.

The Oregon Coast



Port of Brookings

Entrance:

- Jetties - North and south
- Channels:
  - Entrance - dredged 14 feet (4.2m)
  - Access North and South – dredged 12 feet (3.7m)
- Turning Basin - dredged 14 feet (4.2m)
- Overhead limitations:
  - Power line, 46 foot (14m) clearance, 0.6 miles (1km) above the jetties
- Bridge limitations:
  - 59 foot (18m) clearance on a highway bridge

Wharf & Dock Capabilities

- Barge slip
- Small-craft marina

Infrastructure

- 60-ton (54.4 tonne) lift
- Marine supplies and launching ramp

Current Business & Operations

- Fishing (commercial & recreational)
- Tourism
- U.S. Coast Guard Station (Chetco River)

Port Projects

- unknown

Chetco River

Contact:

Port of Brookings Harbor Offices

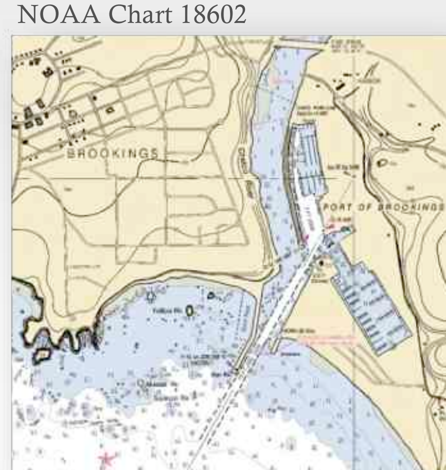
16408 Lower Harbor Road

Brookings, OR 97415

(541) 469-2218

www.port-brookings-harbor.org

NOAA Chart 18602



Port of Gold Beach

Entrance:

- Jetties - North and south
- Channels:
  - Entrance - dredged 13 feet (4m), 6 foot (1.8m) controlling depth (2007)
  - Access – 9 foot (2.7m) controlling depth to boat basin (2007)
- Overhead limitations:
  - Power line, 77 foot (23.5m) clearance, 0.2 miles (0.3km) East of bridge
- Bridge limitations:
  - 30 foot (9.1m) highway bridge clearance 0.8 miles above the mouth

Wharf & Dock Capabilities

- Small-craft marina

Infrastructure

- Marine supplies and launching ramp

Current Business & Operations

- Fishing (commercial & recreational)
- Recreation and tourism

Port Projects

- unknown

Rouge River

Contact:

Port of Gold Beach

P.O. Box 1126

Gold Beach, OR 97444

(541) 247-6269

www.portofgoldbeach.com

NOAA Chart 18601

Port of Port Orford

Entrance:

- Jetties – none
- Breakwater – 550 feet (167.6m)
- Channels – none
- Overhead limitations – none
- Bridge limitations – none

Wharf & Dock Capabilities

- Fishing boats are lifted to cradles on the wharf with large hoists. The wharf can accommodate vessels that are a maximum of 44 feet (13.4m) in length, 15 feet (4.6m) in width, and no more than 19 tons (17.2tonne). At times, shoaling causes the water depth alongside the wharf to be less than adequate for docking.

Infrastructure

- Crane – 15 ton (17.2tonne) and 25 ton (22.7tonne)

Current Business

- Fishing (commercial & recreational)

Port Projects

- **Cannery Building** – Seeking funding to replace the cannery building with one that will also house a near shore marine research facility (Pending)

Contact:

Port of Port Orford

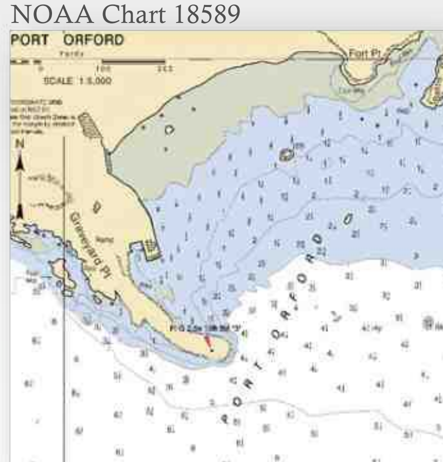
205 Dock Road

Port Orford, OR 97465

(541) 332-7121

www.portofportorford.com

NOAA Chart 18589



Port of Bandon

Entrance:

- Jetties – North and South
- Channels:
  - Entrance – dredged 13 feet (4m), subject to frequent change
  - Main to Basin – 12 foot (3.7m) controlling depth (1999)
- Overhead limitations:
  - Power line, 72 foot (22m) clearance, East of the bridge
- Bridge limitations:
  - Lift span highway bridge 3 miles above the entrance
    - 28 feet (8.5m) down, 74 feet (22.6m) up. Will be closed for painting for a year starting spring 2010.

Wharf & Dock Capabilities

- 310 foot (94.5m)
  - 12 foot wide (3.7m), concrete
  - Currently in use for sport crabbing and fishing as well as a wave attenuator for the boat launch ramp

Infrastructure

- 90 berth small-craft basin
- Marine supplies and launching ramp
- Railway connection 21 miles (33.8km) upriver at Coquille
  - 6 foot (1.8m) reported channel depths

Current Business & Operations

- Fishing (recreational) – transformed from commercial salmon fleet to a recreational destination
- Recreation & tourism
- U.S. Coast Guard Summer Station (Bandon)

Port Projects

- **Waterfront Improvement** – 25,000 sq ft (2,323m^2) boardwalk with glass enclosed picnic shelter and an amphitheater (Completed)
- **Marina Upgrade** – Seeking necessary funds to re-tool marina to meet the needs of today's sport, recreation, cruiser, and other vessel owners (Possible)

Coquille River

Contact:

Port of Bandon

P.O. Box 206

Bandon, OR 97411

(541) 347-3206

www.portofbandon.com

NOAA Chart 18588

Port of Coos Bay

Entrance:

- Jetties – North and South
- Channels:
  - Bar – dredged 47 to 37 feet (11.3-14.3m)
  - Main (entrance to Isthmus Slough)– dredged 37 feet (11.3m)
  - Isthmus Slough to Millington – 22 feet (6.7m)
- Turning Basins:
  - North Bend – dredged 37 feet (11.3m)
  - Coos Bay – dredged 37 feet (11.3m)
- Overhead limitations:
  - Power line, 167 foot (50.9m) clearance, 100 yards (91.4m) West of highway bridge
- Bridge limitations:
  - Central Oregon and Pacific Railroad bridge
    - 7.5 miles (12.1km) above the entrance, swing span, 197 foot (32.6m) horizontal clearance
  - Highway bridge
    - 8.1 miles (13km) above the entrance, 149 foot (37.5m) clearance

Wharf & Dock Capabilities

- Roseburg Forest Products Wood Chip Dock – 40’d, 1430’l (12.2m, 435.9m)
- Ocean Terminals Dock – 38’d, 750’l (11.6m, 228.6m)
- Weyerhaeuser Co. Dock – 30’d, 1440’l (9.1m, 438.9m)
- Oregon Chip Terminal Wharf – 36’d, 1086’l (11m, 331m)
- Sause Brothers, Bayshore Dock – 32’d, 735’l (9.8m, 224m)
- Glenbrook Nickel Co. Dock – 36’d, 576’l (11m, 175.6m)
- Georgia-Pacific & Coos Bay Docks – 35’d, 1226’l (10.7m, 373.7m)

Infrastructure

- Railway access – yes
- Marine Railway – 5000 ton (4536 tonne), 400x100 feet (121.9x30.5m)
- Dry dock – 200 foot (61m)
- Crane – 100 ton (90.7tonne) mobile cranes, 42 ton (38 tonne) gantry crane
- Commercial Air Service – yes, SkyWest/United Express

(Continued on the next page)

Coquille River

Contact:

Oregon International Port of Coos Bay

125 Central Ave., Suite 300

P.O. Box 1215

Coos Bay, OR 97420

(541) 267-7678

www.portofcoosbay.com

NOAA Chart 18587

Port of Coos Bay (continued)

Current Business & Operations

- Fishing
- Lumber
- Cargo
- Recreational and tourism
- U.S. Coast Guard Station (Coos Bay)
- U.S. Coast Guard Group/Air Station (North Bend)

Port Projects

- **North Spit Barge Slip** – Redeveloped barge slip to handle ocean going cargo barges (completed)
- **Rail Line Acquisition & Rehabilitation** – Procurement and restoration of freight rail service to the coast (2010)
- **Property Purchase** – The port is continuing its due diligence to acquire 1,300 acres on North Spit (pending)
- **LNG Terminal** – Single marine berth with an upland storage facility, North Spit (pending FERC permitting, expected 2013)
- **General Cargo Terminal** – North Spit (2013)
- **Container Terminal** – North Spit (2019)

Port of Umpqua

Entrance:

- Jetties – North and South
- Channels:
  - Entrance – dredged 26 feet (7.9m)
  - Main – dredged 22 feet (6.7m)
- Turning Basins – dredged 22 feet (6.7m), 9 foot (2.7m) controlling (2007)
- Overhead limitations:
  - Power line, 52 foot (15.8m) clearance, just West of highway bridge – 10 miles (16.1km) above the entrance
- Bridge limitations:
  - Highway bridge
    - 10 miles (16.1km) above the entrance, swing span – 36 feet (11m) closed
  - Railroad bridge
    - 10.3 miles (16.6km) above the entrance, swing span

Wharf & Dock Capabilities

- Gardiner
  - International Paper Oil Wharf – 20'd, 150'l (6.1m, 45.7m)
  - International Paper Wood Chip Wharf – 20'd, 350'l (6.1m, 106.7m)
- Reedsport
  - American Bridge Bulkhead
  - Fred Wahl Marine Construction – 24'd, 350'l (7.3m, 106.7m)
  - Salmon Harbor Wharf – 14'd, 100'l (4.3m, 30.5m)

Infrastructure

- Railway access – yes
- Marine Railway – 900 ton (816.5tonne), 150 feet (45.7m)
- Dry dock – no
- Tidal graving dock – 260 feet long, 60 feet wide (79.3x18.3m)

Current Business & Operations

- Fishing (commercial and recreational)
- Ship building
- Recreation & tourism
- U.S. Coast Guard Station (Umpqua River)

Port Projects

- **Reedsport Wave Park** – (2010)

Umpqua River

Contact:

Port of Umpqua

364 N. 4th St.

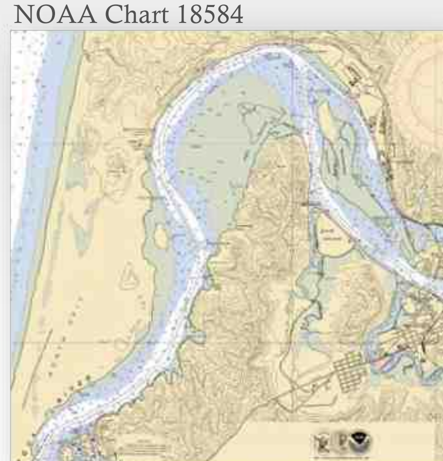
P.O. Box 388

Reedsport, OR 97467

(541) 271-2232

www.portofumpqua.org

NOAA Chart 18584



Port of Siuslaw

Entrance:

- Jetties – North and South, 300 feet (91.4m) wide
- Channels:
  - Entrance to Turning Basin– dredged 16 feet (5.5m)
  - Turning Basin to Mapleton – dredged 12 feet (3.7m)
- Turning Basin – dredged 16 feet (4.9m)
- Overhead limitations:
  - Power line, 88 foot (26.8m) clearance, 5.4 miles (8.7km) above the entrance
  - Power line, 75 foot (22.9m) clearance, at Cushman
- Bridge limitations:
  - Highway bridge (currently undergoing work, 2009)
    - 4.4 miles (7.1km) above the entrance, bascule span
  - Railroad bridge
    - 1 mile (1.6km) above Cushman, swing span

Wharf & Dock Capabilities

- Florence
  - International C-Food Marketing – 20'd, 240'l (6.1m, 73.2m)
  - Port of Siuslaw Transient Dock – 20'd, 800'l (6.1m, 243m)
  - Port of Siuslaw, West Basin Marina 54 slips – 20'd, (6.1m)
  - Port of Siuslaw, Easy Basin Marine 51 slips – 20'd (6.1m)
- Cushman
  - Kirby's Marine – 28'd, 500'l (8.5m, 152.4m)

Infrastructure

- Railway access – yes, Mapleton (2010 resumption of service)
- Marine Railway – 50 ton (45.2 tonne), 60 feet (18.3m)
- Hoist – yes, 2.5 ton (2.3tonne)
- Launching ramp

Current Business & Operations

- Fishing (commercial & recreational)
- Recreation & tourism (including RV Campground)
- U.S. Coast Guard Station (Siuslaw River)

Port Projects

- **Marina Dredging** (2009)
- **Transient Dock** – New, with 480/3 phase power (2009)
- **Industrial Park** – 40 acre (16.2 hectares) (2009)
- **Turning Basin Dredging** (2010)
- **Wharf Rehabilitation and Upgrade** (2010-2011)

Siuslaw River

Contact:

Port of Siuslaw

1499 Bay St.

P.O. Box 1220

Florence, OR 97439

(541) 997-3426

www.portofsiuslaw.com

Port of Alsea

Entrance:

- Jetties – none
- Channels:
  - Bar – 6 feet (1.8m), not dredged
- Overhead limitations - none
- Bridge limitations:
  - Highway bridge
    - 1 mile (1.6km) above the entrance, 66 foot (20.1m) clearance

Wharf & Dock Capabilities

- Small-craft only

Infrastructure

- Railway access – no
- Marine Railway – no
- Hoist – no
- Crane – no
- Launching ramp

Current Business & Operations

- Fishing (recreational)
- Recreation & tourism

Port Projects

- unknown

Alsea River

Contact:

Port of Alsea

365-A Port Street

P.O. Box 1060

Waldport, Oregon 97394

(541) 563-3872

www.portofalsea.com

NOAA Chart 18561

Port of Newport

Entrance:

- Jetties – yes, 330 yards (301.8m) apart
- Channels:
  - Entrance to first turn– dredged 40 feet (12.2m)
  - First turn to McLean Point – dredged 30 feet (9.1m)
  - McLean Point to Yaquina – dredged 18 feet (5.5m)
  - Yaquina to Toledo – dredged 10 feet (3m)
- Overhead limitations:
  - Power line, 77 foot (23.5m) clearance, 0.5 miles (0.8km) above Yaquina
- Bridge limitations:
  - Highway bridge
    - 129 foot (39.3m) clearance, 1.3 miles (2.1km) above the entrance

Wharf & Dock Capabilities

- Port of Newport, Berth 1 – 34'd, 620'l (10.4m, 189m) (inactive)
- Port of Newport, Berth 2 – 25-34'd, 110'l (7.6-10.4m, 33.5m)

Infrastructure

- Railway access – no
- Marine Railway – no
- Hoist – 15-ton (13.6tonne) and 70-ton (63.5tonne)
- Crane – two 60-ton (54.4tonne)
- Launching ramp
- Commercial Air Service – yes, SeaPort Air

Current Business & Operations

- Fishing (commercial – about 60% of business)
- Recreation, tourism, other (about 40% of business)
- Research – NOAA & OSU
- U.S. Coast Guard Station (Yaquina Bay)
- U.S. Coast Guard Air Facility (Newport)

Port Projects

- **RV Park** – Added a 143-space full hook-up RV Park (Completed)
- **NOAA Facility** – Installing the necessary infrastructure to host the Marine Operations Center-Pacific(2011)
- **International Terminal Project** – Removing environmental hazards and rebuilding the terminal dock facility (2011)
- **Newport Fisheries Center** – create a mixed-use facility that supports the fishing industry (Future)

Yaquina River

Contact:

Port of Newport

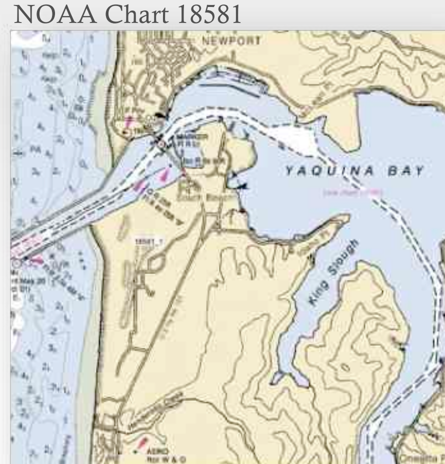
600 SE Bay Boulevard

Newport, OR 97365

(541) 265-7758

www.portofnewport.com

NOAA Chart 18581



Port of Toledo

Entrance:

- Jetties – yes, 330 yards (301.8m) apart
- River distance – 11.5 miles (18.5km) from the entrance
- Channels:
  - Entrance to first turn– dredged 40 feet (12.2m)
  - First turn to McLean Point – dredged 30 feet (9.1m)
  - McLean Point to Yaquina – dredged 18 feet (5.5m)
  - Yaquina to Toledo – dredged 10 feet (3m)
- Overhead limitations:
  - Power line, 77 foot (23.5m) clearance, 0.5 miles (0.8km) above Yaquina
- Bridge limitations:
  - Highway bridge
    - 129 foot (39.3m) clearance, 1.3 miles (2.1km) above the entrance

Wharf & Dock Capabilities

- 10 foot (3m) depths

Infrastructure

- Railway access – yes
- Marine Railway – no, potential future project
- Dry dock – 200 ton (181.4tonne)
- Hoist – 25 and 85 ton (22.7 and 77.1 tonne)
- Crane – 20 ton (18.1tonne)

Current Business & Operations

- Fishing (commercial & recreational)
- Boat repair
- Commercial & Industrial Leases
- Recreation & tourism

Port Projects

- **Dredging in Depot Slough** – channel dredging to allow large fishing vessels to come to Yaquina Boat Equipment (active)
- **Port of Toledo Boatyard** – purchase closed boat repair facility (pending)
- **Business Incubator Building** – 2010
- **Transient Dock** – 2010
- **Marine Railway** - potential future project

Yaquina River

Contact:

Port of Toledo

385 NW 1st St., Unit #1

Toledo, OR 97391

(541) 336-5207

www.portoftoledo.org

NOAA Chart 18581

Port of Depoe Bay

Entrance:

- Jetties – no
- Channels:
    - Entrance – 8 feet (2.4m) controlling 1986
    - Basin – 7 to 8 feet (2.1-2.4m)
- Overhead limitations – none
- Bridge limitations:
    - Highway bridge
        - 30 feet (9.1m) wide, 42 feet (12.8m) high
- Restrictions – vessels over 50 feet (15.2m) length require special waiver

Wharf & Dock Capabilities

- Small-craft only

Infrastructure

- Railway access – no
- Marine Railway – no
- Hoist – yes, ½ ton (0.45tonne)
- Launching ramp
- Marine fuel station
- Fish cleaning station

Current Business & Operations

- Fishing (commercial & recreational)
- Charter Fishing & Whale Watching
- Recreation & Tourism
- U.S. Coast Guard Station (Depoe Bay)

Port Projects

- None at present

Contact:

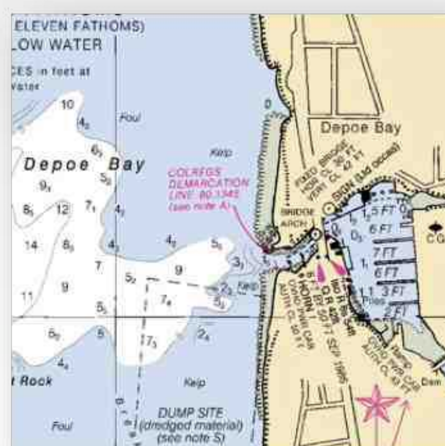
Port of Depoe Bay

P.O. Box 8

Depoe Bay, OR 97341

(541) 765-2361

www.ci.depoe-bay.or.us



Port of Garibaldi

Entrance:

- Jetties – North and South
- Channels:
  - Entrance – dredged 18 feet (5.5m)
  - Access to mooring basin – dredged 12 feet (3.7m)
  - Access to harbor – 14 feet (4.2m)
- Turning Basin – 18 feet (5.5m)
- Overhead limitations – none
- Bridge limitations – none

Wharf & Dock Capabilities

- Cargo dock – wood pilings – 30'd, ~120'l (9.1m, 36.6m)

Infrastructure

- Railway access – yes (no mainline access currently)
- Marine Railway – no
- Dry dock – no
- Hoist – no
- Crane – no
- Marine supplies and launching ramp

Current Business & Operations

- Fishing (commercial & recreational)
- Recreation & tourism
- U.S. Coast Guard Station (Tillamook Bay)

Port Projects

- Small Cruise Ship Port of Call – (potential)
- Expand Marina – Build seawall and expand marina (2014)
- Rebuild North Jetty – (2010)
- Rebuild South Jetty – (potential)

Tillamook Bay

Contact:

Port of Garibaldi

402 S. 7th St.

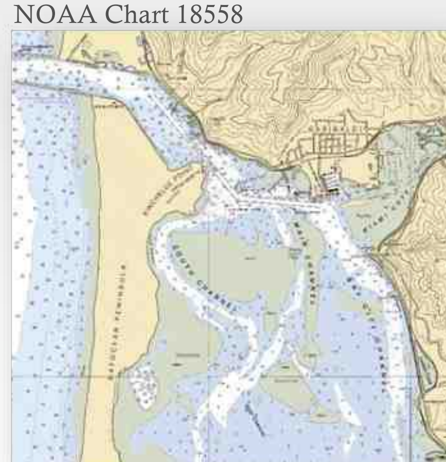
P.O. Box 10

Garibaldi, OR 97118

503-322-3292

www.portofgaribaldi.org

NOAA Chart 18558



Port of Astoria

Entrance:

- Jetties – North and South
- Channels:
  - Bar – dredged 48 feet (14.6m)
  - Entrance to Astoria – dredged 45 feet (13.7m)
- Overhead limitations – Minimum 216 foot (65.8m) clearance

Wharf & Dock Capabilities

- Astoria Wharehousing Wharf – 40'd, 320'l (12.2m, 97.5m)
- Fishhawk Fisheries – 40'd, 45'l (12.2m, 13.7m)
- Carmichael-Columbia Oil – 40'd, 200'l (12.2m, 61m)
- Bornstein Seafoods – 30'd, 250'l (9.1m, 76.2m)
- Ocean Foods of Astoria – 30'd, 260'l (9.1m, 79m)
- Pier 1 – 40'd, 1000+'l (12.2m, 300+m)
- Pier 2 – 25-35'd, 1000+'l (7.6-10.7m, 300+m)
- North Tongue Point, 5 piers each – 34'd, 1500'l (10.3m, 457.2m)

Infrastructure

- Railway access – yes, North Tongue Point
- Marine Railway – 400 tons (362.9tonne)
- Dry dock – no
- Hoist – 88 ton (79.8tonne)
- Complete salvage equipment is available
- Commercial Air Service – yes, SeaPort Air

Current Business & Operations

- Fishing (commercial & recreational)
- Cargo
- Cruise Ships
- Industrial (warehouse & office complex rentals)
- Boat repair and salvage
- U.S. Coast Guard Station (Astoria)
- U.S. Coast Guard Group/Air Station (Astoria)

Port Projects

- **North Tongue Point** – multi-use transportation logistics and intermodal facility with ample capacity for vessel operations as well as moorage on a long and short term basis (2009)
- **Skipanon LNG Facility** – receiving facility and three 150 foot (45.7m) tall tanks on 96 acres of port property (pending)

Columbia River

Contact:

Port of Astoria

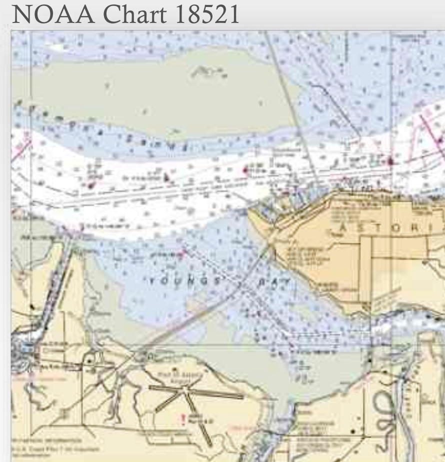
422 Gateway Ave., Suite 100

Astoria, OR 97103

(503) 325-4521

www.portofastoria.com

NOAA Chart 18521



Port of Portland

Entrance:

- Jetties – North and South
- Channels:
  - Bar – dredged 48 feet (14.6m)
  - Entrance to Vancouver – dredged 40 feet (12.2m)
- Overhead limitations – Multiple power cables and bridges

Wharf & Dock Capabilities

- The port has over 25 deep-draft piers and wharves.

Infrastructure

- **Portland is a major ship fabrication and repair center on the Pacific coast**
- Sufficient berthing space to accommodate longer term special project ship and barge activity
- Tug and barge fleet capable of positioning large project cargoes along the Columbia Rive and the coast
- Terminal 2 can handle special and oversize project cargoes, with dockside rail service
- Terminal 6 offers Panamax and Post Panamax container cranes to 85 tons (77.1tonne), with adjacent rail service
- Railway access – yes
- Marine Railway – yes
- Dry dock – yes, multiple
- Crane – Multiple, including fourteen whirley cranes from 45 to 120 tons (40.8-108.9tonne)

Current Business & Operations

- Cargo and container terminals
- Ship construction and repair
- Multiple heavy manufacturing firms capable of precision, large project fabrication and assembly
- U.S. Coast Guard Base, Sector Portland
  - Office of Regional Captain of the Port
- Commercial Air Service – yes, major airport (PDX)

Port Projects

- **Terminal 4 Sediment Cleanup** – Clean-up contaminated sediments at marine Terminal 4 (active)
- **Channel Deepening** – Increase the channel depth from Astoria to Portland/Vancouver to 43 feet (13.1m) from 40 feet (12.2m) (active, scheduled completion Dec 2010)

Columbia River

Contact:

Port of Portland

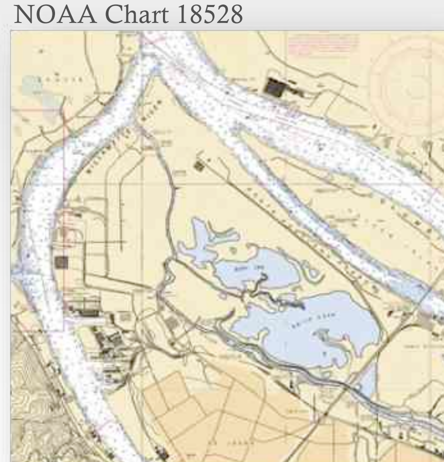
121 NW Everett St.

Portland, OR 97209

(503) 944-7220

www.portofportland.com

NOAA Chart 18528



Oregon Suppliers

Directory of manufacturers, fabricators, and suppliers

Oregon Wave Energy Infrastructure Assessment

Understanding the infrastructure capabilities of the Oregon coast for the responsible development of wave energy. Funded by the Oregon Wave Energy Trust.

The following pages contain a list of suppliers that are relevant for wave energy development. This list is not comprehensive, instead focusing on firms that are located along the Oregon Coast. It does contain some of the larger manufacturers, fabricators, and suppliers in the Portland area.

Suppliers comprise those companies which can provide raw materials such as steel and concrete, fabricate parts out of the materials, transport the parts, assemble the parts into complete units, deploy the complete units at sea, operate and maintain the units, remove the units at the end of their lifespan, and provide emergency services should an unplanned event occur.

Inclusion in this index does not imply endorsement of any of these suppliers.

Overview

Advanced American Construction
AAC provides full service diving services on a 24-hour, seven days a week, emergency and non-emergency response basis.

Website: www.callaac.com
8444 NW St. Helens Road
Portland, Oregon 97231
Telephone: 503-445-9000

Advanced American Diving Service, Inc.
Civil Engineering & Inspection

Email: deeb@advancedamericandiving.com
415 S. McLoughlin Blvd., Oregon City, Oregon, 97045
Telephone: 503-650-8207

Ben's Diving Service
Commercial Diving Service

Ben White
309 SE 5th St
Toledo, Oregon 97391
Phone: 541-961-8471

Doug's Diving Service
Cutting, Video, Salvage & Dock Repair

Website: www.dougsdiving.com
Email: doug@dougsdiving.com
PO Box 846, Garibaldi, Or, 97119
Telephone: 503-322-2200

Fred Devine Diving & Salvage Co.
Light & Heavy Salvage, All Types Of Underwater Works

Website: www.freddevinedivingandsalvage.com
Email: devinesalv@msn.com
6211 N Ensign, Portland, OR, 97217
Telephone: 503-283-5285
Contact: Marvin Smith

Orca Divers
P.O. Box 1654, Winchester Bay, OR, 97467
Telephone: 541-271-5455
Contact: Roger Hermansen

Richard Phillips Marine, Inc
Marine Construction/ Commercial Diving

Email: Rphillipsmarine@aol.com
33002 SE Ryder Lane, Boring, Oregon 97009, Oregon, 97009
Telephone: 503-663-3420
Contact: Gina Phillips, V.P.
Mobile: 503-476-5556

Large scale:

Ash Grove Cement Company

Ash Grove is the sixth largest cement manufacturer in the United States. The portland and masonry cements produced at these plants are used in the construction of highways, bridges, commercial and industrial complexes, single and multi-family homes, and a myriad of other structures.

Website: www.ashgrove.com
Western Division Office
5 Centerpointe Drive, Suite 350
Lake Oswego, Oregon 97035
Phone: 503-207-2100

Kiewit Pacific Co.

Kiewit is one of North America's largest construction and mining organizations. Projects constructed include ports, terminals, piers, docks, wharves, bulkheads, breakwaters and other marine work along coastal and inland waterways.

Website: www.kiewit.com
2200 Columbia House Blvd.
Vancouver, WA 98661
Phone: 360-693-1478

Ross Island Sand & Gravel CO

Manufactures ready-mixed concrete; dredging contractor; wholesales construction sand; manufactures dry mixture concrete earth and stone, sand, clays, dirt and soil, stone, limestone, basalt, pumice stone, gravel, and gypsum.

Website: www.pamplin.org
315 SE McLoughlin Blvd
Portland, Oregon 97202-5055
Phone: 503-239-5504

Wilson Curb Construction

Wilson Curb Construction is a private company categorized under Concrete Construction: Roads, Highways, Sidewalks, Etc. and located in Bend, OR.

62870 Boyd Acres Rd
Bend, Oregon 97701-8502
Phone: 541-389-4918

Small scale:

A1 Ready Mix Concrete

This is a full service concrete company with design and build capabilities that services all aspects of residential and commercial construction.

Website: www.a1readymix.com
Email: sales@a1readymix.com
Mailing address:
P.O box 1007
Seaside, Oregon 97138
Map Location:
2386 S.E Dolphin Ave.
Warrenton, Oregon 97146
Phone: 503-861-3900
503-738-0533

Accucut Concrete LLC

This is a poured concrete foundation and structure contractor, also providing concrete breaking, cutting, drilling, and sawing.

2744 Woodland Dr
Coos Bay, Oregon 97420-2052
Phone: 541-267-6529

Alder Creek Concrete and Construction

This is a residential, commercial, and industrial concrete contractor.

5612 Otter Way
Florence, Oregon 97439
Phone: 541-991-4306

Axmaker & Axmaker Corp.

General contractor, including concrete work

9883 NE Highland View Lane
Otis, Oregon 97368
Phone: 541-994-2046

Bay Park Mini Storage Slape Construction

Concrete contracting including cement and concrete, concrete breaking, drilling, lifting, polishing, scoring, staining

3645 Shoshone Lane,
Coos Bay, Oregon 97420
Phone: 541-267-4299

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Brookings Oregon Concrete Company

This company maintains a full contractor service by providing concrete and crushed rock products. It has received the Ecology Award, the Outstanding Reclamation for Small Operators, and a 2003 award for Salmon fisheries protection/enhancement.

Website: www.freemanrock.com
99031 South Bank Chetco River Rd,
Brookings, Oregon 97415
Phone: 541-469-2444

Central Coast Ready Mix

Ready Mix Concrete Supplier

1548 SE 23rd Dr.
Lincoln City, Oregon 97367-2240
Phone: 541-996-9990

Coast Wide Ready Mix Co (Coastwide Sand & Gravel)

Ready Mix Concrete Manufacturer

Upper Kilchis River Rd
Tillamook, Oregon 97141
Phone: 503-842-4437

Freeman Rock of Gold Beach Oregon

This company maintains a full contractor service by providing concrete and crushed rock products. It has received the Ecology Award, the Outstanding Reclamation for Small Operators, and a 2003 award for Salmon fisheries protection/enhancement.

Website: www.freemanrock.com
95437 Jerry's Flat Road
Gold Beach, Oregon 97444
Phone: (541) 247-9583

Knife River - Coast Region

Provider of site construction services, including ready mix concrete.

Website: www.kniferiver.com
3055 Ocean Boulevard
Coos Bay, Oregon 97420
Phone: 541-269-1915

Lincoln City Ready Mix

Concrete and concrete products dealer

2300 U.S. 101
Lincoln City, Oregon 97367-2047
Phone: 541-994-3901

Nehalem Bay Ready Mix (Mohler Sand & Gravel)

Provider of concrete, cement mixing

20890 Foss Road
Nehalem, Oregon 97131
Phone: 503-368-5157

Newport Ready Mix

Newport Ready Mix is a private company categorized under Ready-Mixed Concrete Manufacturers and located in South Beach, OR.

5045 S Coast Hwy
South Beach, Oregon 97366
Phone: 541-867-3127

Waldport Ready Mix (HQ of Newport)

Waldport Ready Mix is categorized under Ready-Mixed Concrete Manufacturers and located in Waldport, OR.

955 Alsea Hwy
Waldport, Oregon 97394
Phone: 541-563-3127

Other Resources:

Oregon Concrete & Aggregate Producers Association

www.ocapa.net
737 13th St. SE
Salem, Oregon 97301
Phone: 503-588-2430

MANTA Business Info

108 company profiles for Ready-Mixed Concrete Companies in Oregon

www.manta.com/mb_44_E8111_38/ready_mixed_concrete/oregon

Advanced American Construction

Heavy civil/marine construction – complete fleet of construction and marine equipment

Website: www.callaac.com
8444 NW St. Helens Road
Portland, Oregon 97231
Telephone: 503-445-9000

Astoria Marine Construction Co.

Astoria Marine Construction Co. is a private company categorized under Ship Builders and Repairers and located in Astoria, OR. Records show it was established in 1928 and incorporated in Oregon.

92134 Front Rd
Astoria, Oregon 97103-8353
Phone: 503-325-4121

Bergerson Construction Inc.

Bergerson Construction is located at the mouth of the Columbia River. Along with General/Civil construction, they specialize in Drilled Shafts, Piling and Shoring Systems in both land and marine applications

Website: www.bergerson-const.com
E-mail: info@bergerson-const.com
55 Portway St.
Astoria, Oregon 97103
Phone: 503-325-7130

Billeter Marine

Marine Contractor. Serving Entire West Coast, 30 Years Experience.

272 1st Ct
Coos Bay, Oregon 97420-4304
Phone: 541-269-8600

Cascade General (operated by Vigor Industrial)

NOTE: Cascade General has a Voyage Repair Station located in Astoria, Oregon at the mouth of the Columbia River. It provides a location for quick stop repairs on vessels trading anywhere on the West Coast.

Website: www.casgen.com
Email: info@casgen.com
Portland Shipyard
5555 North Channel Avenue
Building 71
Portland, Oregon USA 97217
Phone: 503-285-1111

Columbia Pacific Marine Works, Inc

Marine supply store

531 Gateway Ave
Astoria, Oregon 97103-6037
Phone: 503-325-4310

Florence Marine Construction

Marine contractor and designer

5940 Highway 126
Florence, Oregon 97439
Phone: 541-997-3760

Fred Wahl Marine Construction Inc.

New construction, full service yard, complete repairs, deck gear.

Website: www.fredwahlmarine.com
Email: reedsport@fredwahlmarine.com
100 Port Dock Road
Reedsport, Oregon 97467
Phone: 541-271-5720

Giddings Boat Works Inc.

Ship building and repairing; large fishing vessels

63106 Troller Rd
Coos Bay, Oregon 97420
Phone: 541-888-4712

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Reedsport Machine & Fabrication

Complete fabrication and boat repairs as well as onsite work, sand blasting, painting, and a complete machine shop facility. The company has 9,000 sq. ft. of under the roof floor space, with a total ground space of 2 acres. They have a 20' high x 20' wide x 50' long inside heated facility for sand blasting and painting. Boat haul-out facility, 60-ton travel lift. 15-ton on-site crane service available

Website: www.reedsportmachine.com
Email: ras.rmf@charterinternet.com
170 Bay Front Loop
Winchester Bay, Oregon 97467
Phone: 541-271-5414

Riverbend Marine Service (Siletz Boat) (Kaward Crane)

Pile driving in Newport, OR; Boat repair & moorage & marine construction, other heavy construction. Established in 1978

5262 Yaquina Bay Rd
Newport, Oregon 97365-9606

Phone: 541-265-9243

Sturgeon Bend Boat Works

Boat repair and marina.

1000 SW Altree Lane
Toledo, Oregon 97391
Phone: 541-336-4736

US Barge

US Barge is a U.S. West Coast, ocean-class barge builder. They offer turnkey production from start to finish through an in-house design/engineering team to internal outfitting services. Construction and launching occurs on the Willamette River, in downtown Portland, Oregon.

Website: www.usbarge.com
Email: info@usbarge.com
5555 N. Channel Ave.
Portland OR 97217
Phone: 503-247-1930

Vigor Marine, LLC

A wide range of repair services at a 60-acre (24.28 ha) yard on the Willamette River

Website: vigormarine.com
Email: info@vigormarine.com
5555 N Channel Ave
Portland, Oregon 97217
Phone: 503-247-1742

West Coast Contractors (WCC)/In-Depth Marine Construction

West Coast Contractors offers a comprehensive line of marine construction services: dredging; pile driving; demolition; pile extraction, dock dismantling; dock construction: concrete docks, timber docks; bridge construction; sheet piles & cofferdams.

Website: www.westcoastcontractors.com
Email: contactus@westcoastcontractors.com
1100 North Front St.
PO Box 1650
Coos Bay, Oregon 97420
Phone: 541-267-7689

Yaquina Boat Equipment

Services include: vessel repairs, maintenance, and conversions at their dock. They also manufacture hydraulic deck equipment and carry in stock marine supplies.

Website: www.yaquinaboat.com
508 Butler Bridge Road
Toledo, Oregon 97391
Phone: 541-336-5593

Zidell Marine Corporation

Zidell Marine Corporation manufactures and distributes industrial pipe fittings and constructs and leases barges.

Website: www.zidell.com
3121 SW Moody Avenue
Portland, Oregon 97239-4500
Phone: 503-228-8691

Berger ABAM Engineering, Inc.

Professional project management, engineering, construction management and support services

Website: www.abam.com/
E-mail: information@abam.com
700 Northeast Multnomah Street, Suite 900
Portland, Oregon 97232-4189
Phone: 503-731-6041

BRW Inc. (URS Corporation, EG&G Division)

This corporation offers a range of professional planning, engineering and architectural design, environmental, construction, and program and construction management services. It also provides system integration, operations and maintenance, management and a wide range of specialized technical services.

Website: www.brwinc.com
111 SW Columbia, Suite 1500
Portland, Oregon 97201-5850
Phone: 503-222-7200

BSM Consulting Engineers

BSM Consulting Engineers provide planning, programming and engineering design services for the waterfront marine, heavy civil and transportation market sectors.

Website: www.bsmengineering.com
E-mail: info@bsmengineering.com
801 Commercial Street
P.O. Box 502
Astoria, Oregon 97103
Phone: 503-325-8065

Crescere Marine Engineering, Inc.

Marine Contractors & Designers, Naval Architects, Marine Engineers, Design, Computer Aided Design Services

Email: tcelano@cresceremarine.com
8444 NW. St. Helens Rd.
Portland, Oregon 97231
Phone: 503-366-2660

Don Stevens Naval Architects

Don Stevens Naval Architects is a private company categorized under Marine Engineers and located in Portland, OR. Current estimates show this company has annual revenue of $500,000 to $1 million and employs a staff of approximately 1 to 4.

4385 SW Washouga Ave
Portland, Oregon 97239-1376
Phone: 503-244-7720

International Maritime Inc.

Marine consulting service

14758 Sitkum Ln
Myrtle Point, Oregon 97458-9692
Phone: 541-572-2313

Maritime Services Corporation

Maritime Services Corp. provides the marine industry with planning, design, engineering, construction and materials relating to new building and refurbishment of cruise ships, work boats, fishing vessels, ferries, fast ferries, offshore projects of all types, dining yachts and gaming vessels in the United States and abroad. In addition, Maritime provides project planning, scheduling and budgeting services as well as technical expertise. It also offers in-house design, engineering and manufacturing.

Website: www.mscor.com
Email: sales@mscor.com
3457 Guignard Drive
Hood River, Oregon 97031
Phone: 541-386-1010

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Milwee Associates, Inc.

Serves the marine, offshore, construction industries, and insurance with engineering and technical services relative to design and use of systems for marine salvage, diving, underwater work, towing, mooring, ocean mining and other ocean engineering disciplines. Does marine casualty management, ocean engineering operations planning, analysis and evaluation. Acts as expert witness in matters of ocean engineering, marine salvage, diving, underwater work systems and naval architecture.

4019 SW 55th Dr.
Portland, Oregon 97221-2025
Phone: 503-297-7474

Specialty Marine Contractors

Specialty Marine Contractors primary activity is the design and computer lofting of welded aluminum boats, accomplished in our office in the city of Scappoose, Oregon.

Website: www.specmar.com
Email: specmar@opusnet.com
PO Box 1081
Scappoose, Oregon 97056
Phone: 503-543-7562

US Barge

US Barge is a U.S. West Coast, ocean-class barge builder. They offer turn-key production from start to finish through an in-house design/engineering team to internal outfitting services. Construction and launching occurs on the Willamette River, in downtown Portland, Oregon.

Website: www.usbarge.com
Email: info@usbarge.com
5555 N. Channel Ave.
Portland OR 97217
Phone: 503-247-1930

AF Dick Manufacturing & Repair
Tool Repair, Milling, Fabricated Metal Products
92640 Abbott Rd
Astoria, Oregon 97103
Phone: 503-458-6292

Affordable Portable Welding
Vessel Repair, Stainless & Pipe Welders, Heavy Equipment Repair, Emergency Boat Repair. 50 Ft. boom truck available
91507 Railroad Rd.
Warrenton, Oregon 97146
Phone: 503-861-7946

American Bridge Manufacturing
Steel Fabricator; construction and rehabilitation of heavy marine works and any other type of structural or marine project that benefits from advanced construction engineering skills
Website: www.americanbridge.net
E-mail: info@americanbridge.net
135 American Bridge Way
Reedsport, Oregon 97467
Phone: 541-271-1100

Barclay Heating & Sheet Metal Co.
Sheet Metal Fabricator
1512 Front St
Tillamook, Oregon 97141-2029
Phone: 503-842-6292

Brian Bream Screw Machines
Specializes in fasteners; can make anything that can be "turned"
Website: www.brianbreamscrewmachines.com
Email: info@brianbreamscrewmachines.com
2455 Maple Leaf #6
North Bend, Oregon 97459-1690
Telephone: 541-751-0894

Buss Welding & Machine Inc.
Metal Fabricator
2175 Larson Rd
Tillamook, Oregon 97141
Phone: 503-842-7764

Coast Metal Fabrications
Fabricate steel, stainless steel, aluminum; above the water line fishing vessel repair
Website: www.coastmetalfabrication.com
Email: robert@coastmetalfabrication.com
602 commercial
Garibaldi, Oregon 97118
Phone: 503-322-3459

Coast Metal Works, Inc.
Metal Industries, Machinery, Tools, Welding, Steel & Aluminum Fabrication, General Welding
2710 Woodland Dr.
Coos Bay, Oregon 97420
Phone: 541-269-0116

Coastal Repair & Maintenance (CRM)
Structural Steel; Crane Service; In-shop & Portable Welding; Custom Design & Prototyping, Metal Fabrication
Website: coastalrepairandmaintenance.com
Email: coastalrepairmai@ipns.com
1725 N Roosevelt
Seaside, Oregon 97138
Phone: 503-717-8223

Columbia Pacific Marine Works Inc.
Boat Storage, Machine Shop Service, Welding & Fabrication
531 Gateway Ave.
Astoria, Oregon 97103
Phone: 503-325-4310

Coquille Sheet Metal Inc.
Sheet Metal; Stainless Steel Fabrication
586 State Highway 42
Coquille, Oregon 97423
Phone: 541-396-3221

Groth-Gates Heating and Sheet Metal
Full Service Custom Sheet Metal Work
Website: www.grothgates.com
218 NW 12th Street
Newport, Oregon 97365
Phone: 541-265-8636

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Halco
Full Original Equipment Manufacturing; Steel Fabrication, Stainless & Aluminum Welding, Shearing, Sandblasting & Metalizing, Punching, Portable & Shop, Machine Work, Forming

3826 SW Coast Hwy
South Beach, Oregon 97366
Phone: 541-867-8137

Haltiner Inc. (Haltiner Heating & Sheet Metal)
Custom Metal Fabrication

Website: www.haltinerheating.com
Email: haltiner@embarqmail.com
1709 First Street
Tillamook, Oregon 97141
Phone: 503-842-9315

Imperial Marine
Custom ornamental and other metal fabrication

Website: www.imperialmarinewelding.com
Email: imperialmarineservice@gmail.com
PO Box 363
305 Shell Ave.
Depoe Bay, Oregon 97341
Phone: 541-765-2535

Industrial Steel & Supply Co.
Steel, Hydraulics, Industrial Parts, Repair

Website: industrialsteel.net
526 Virginia Avenue
PO Box 387
North Bend, Oregon 97459
Phone: 541-756-5141

J & H Boatworks Inc.
Custom Boastbuilding & Metal Fabrication

Website: www.jhboat.com
Email: jhboat@charter.net
92519 Wireless Rd.
Astoria, Oregon 97103
Phone: 503-325-1197

Jac Mar Welding
Custom manufacturer of metal fabricators; Dock-side Ship Repairs; Welding

Website: www.jacmarcorp.com
Email: jacmarcorp@gmail.com
1877 Elk City Rd
Toledo, Oregon 97391-9533
Phone: 541-336-5841

Knutson Towboat Co.
Transportation, Marine, Construction, Machine Shop, Paint & Coatings

Website: www.knutsontowboat.com
Email: ktbadmin@knutsontowboat.com
400 N. Front Street; PO Box 908
Coos Bay, Oregon 97420
Phone: 541-267-3195

Lakeside Forge & Fabrication
Aluminum-Stainless Steel-Custom Fabricate; Welding Services

100 N 7th St
Lakeside, Oregon 97449
Phone: 541-759-2719

Mulder Sheet Metal
All Sheet Metal Construction; Sheet Metal Fabrication

Website: www.powrfab.com
Email: info@powrfab.com
155 NE 10th St
Newport, Oregon 97365-3104
Phone: 541-265-4269

Orca Divers
Metal Fabrication/Welding

870 Beach Blvd
Winchester Bay, Oregon 97467
Phone: 541-271-5455

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Oregon Iron Works, Inc.

OIW's Renewable Energy Program is highly involved in ocean energy, including both wave and tidal. This includes being a founding member and currently serving on the board of the Oregon Wave Energy Trust (OWET). OIW is currently manufacturing wave energy devices and looks forward to future ocean energy contracts.

Website: www.oriron.com
Email: sales@oregoniron.com
9700 S.E. Lawnfield Road
Clackamas, Oregon 97015
Telephone: 503-653-6300

P & L Heating & Sheet Metal Co.

Sheet Metal

2711 3rd St
Tillamook, Oregon 97141-2514
Phone: 503-842-7765

Riddell Sheet Metal

Vessel Support

110 NE 1st St
Newport, Oregon 97365-3056
Phone: 541-265-2366

Southern Oregon Marine, Inc.

SOMAR constructs, modifies, and maintains the Sause Brothers fleet of tugs and barges. The shipyard's skilled personnel can build or modify a vessel to customer specifications reliably and efficiently.

Website: www.sause.com/somar.htm
P.O. Box 1220
40 Ross Inlet Road
Coos Bay, Oregon 97420
Phone 541-269-2116

Sopko Welding Inc. (North Coast Crane Services)

Marine Fabrication and Equipment Repair. Sopko Welding is a 15,000 sq. ft. facility with 14 full-time employees. They are a diversified fabrication and equipment repair business serving residential, commercial and marine customers. They have a large fleet of portable service trucks with full welding capabilities and a boom truck to offer steel erection to its customers.

Website: www.sopkowelding.com
Email: info@sopkowelding.com
841 24th Avenue
Seaside, Oregon 97138
Phone: 503-738-9505

SRB Metals, Inc.

Metal Service Center providing horizontal, vertical & universal machining and milling services

3970 Evergreen Ave.
Depoe Bay, Oregon 97341
Phone: 541-764-2052

Tarheel Aluminum Inc.

Specialty Fabrication & Repairs; Steel, Stainless, Aluminum, Manufacturing, Assembly, Welding, Cutting, Shearing, Forming Sheet Metal or Structural Shapes

63130 Troller Rd.
Charleston, Oregon 97420
Phone: 541-888-6708

The Ogilvie Company Inc.

Steel Fabricator, Coating, General Contractor, Structural Metal Fabrication

34686 Hwy 101 Business
Astoria, OR
Phone: 503-325-5083

Western Fabrication

Stainless steel, aluminum & mild steel projects up to 1/4"; Custom sheet metal parts

92334 Riekkola Rd
Astoria, Oregon 97103-6654
Phone: 503-325-7520

Beaver State Plastics

Plastic Injection, Mold Making – Beaver State Plastics specializes in short and medium-run parts. They use a wide variety of plastic resins that best suits the performance of the product including high impact ABS, filled resins for strength, special resin for thick wall molding, nylon and thermoplastic elastomers.

Website: www.beaverstateplastics.com
Email: info@beaverstateplastics.com
2947 State Hwy 38
Drain, Oregon 97435
Phone: 541-836-2203

Quadel Industries

Quadel Industries specializes in custom plastic fabrication, including but not limited to rotational, extruded, or vacuum molding of virtually any plastic including vinyl, PVC, ABS, polystyrene, poly carbonate or polyethylene.

Website: www.quadel.net
Email: pam@quadel.net or jasonl@quadel.net
93759 Troy Lane
Coos Bay, Oregon 97420-6249
Phone: 541-269-7351

R.E.C.S. (Renewable Energy Composite Solutions, LLC)

RECS specializes in wind turbine and hydrokinetic composite component fabrication and manufacturing in the Pacific Northwest. For on and offshore wind turbines, and ocean, marine and tidal hydrokinetic components RECS delivers composite fabrication solutions.

Website: recscomposite.com
Email: info@recompositesolutions.com
4400 SE Columbia Way
Vancouver, WA 98661
Phone: 360-759-2345

Wells Plastic, Inc.

Custom molding for a wide variety of different industries

Website: www.wellsplastic.com
Email: bill@wellsplastic.com
P.O. Box 309
Florence, Oregon 97439-0011
Phone: 541-997-3839

MEI, LLC

Machinery moving, rigging, custom manufacturing, metal and plastic fabrication, powder coating

Website: www.meillc.com
Email: bill.mcginty@meillc.com
3474 18th Avenue SE
Albany, Oregon 97322
Phone: 541-917-3626

Metro Machinery Rigging Inc.

Rigging, machinery moving, and installation

Website: www.metrorigging.com
Email: info@metrorigging.com
19450 S.W.129th Ave.
Tualatin, Oregon 97062
Phone: 503-691-0868

Morgan Industrial Inc.

Morgan Industrial, Inc is a Northwest-based machinery moving and industrial contractor. Morgan Industrial has six different divisions, each specializing in their own line of work.

Website: www.morgan-industrial.com
Email: contactus@morgan-industrial.com
PO Box 226
North Plains, Oregon 97133
Phone: 503.647.7474

Wilhelm Trucking & Rigging Co.

Rigging solutions for machinery moving and installation.

Website: www.wilhelmtruck.com
Email: apaterson@wilhelmtruck.com
3250 NW St. Helens Road
P.O. Box 10363
Portland, Oregon 97296-0363
Phone: 503-227-0561

Other Resources

Shipyard Commerce Center (SCC)

Shipyard Commerce Center (SCC) offers flexible combinations of real estate and technical services to match the needs of each individual customer. Services include: complete project management; qualified, experienced personnel and workforce; full range of industrial, marine, and intermodal capabilities (heavy-lift, transload, vessel launching); wastewater treatment; environmental and safety consulting; fabrication and repair; electrical, sheet metal, pipe, boiler, machining, and rigging; technical expertise and certifications; surface preparation and coating.

Website: www.shipyardcc.com
Email: info@shipyardcommercecenter.com
5555 N. Channel Ave.
Portland, Oregon 97217
Phone: 503-247-1828

Crescent City Marine Ways & Dry Dock, Inc.

Crescent City Marine Ways & Dry Dock Inc. is a 66-year-old private company located in Portland, OR.

3710 NW Front Ave,
Portland, Oregon 97210
Phone: 503-222-1811

Jones Stevedoring Co.

Stevedoring, cargo handling and transportation logistics
Multiple locations; in the Oregon Area: Portland, Astoria, Coos Bay, Kalama, Longview, Newport, and Vancouver.

Website: www.jonesstevedoring.com

Astoria, Kalama, Longview:
Email: scullen@jonesstevedoring.com
58 Port Way
Longview, WA 98632
Phone: 360 425-6060

Portland, Vancouver:
Portland Email: dbeeber@jonesstevedoring.com
Vancouver Email: rgill@jonesstevedoring.com
2323 NW Suffolk St
Portland, Oregon 97210
Phone: 503-228-6601

Coos Bay, Newport:
Coos Bay Email: idoessing@jonesstevedoring.com
Newport Email: newport@jonesstevedoring.com
401 California Ave.
North Bend, Oregon 97459-3454
Phone: 541-756-4113

Ports of America

Provides container stevedoring, container terminal management and stevedoring. 185 acres, 3 berths, 9 Gantry Cranes (4 Post Panamax), On-Dock Intermodal Yard with annual capacity for 1,100 trains and more than 50 acres of yard space.

Web Site: www.portsamerica.com
7201 N. Marine Drive
Terminal 6
Portland, Oregon 97203
Telephone: 503-240-2233

Rogers Terminal & Shipping (aka Cargill Marine & Terminal, Inc.)

Rogers Terminal & Shipping is a private company categorized under Stevedoring Contractors and located in Portland, OR.

1750 NW Naito Pkwy
Portland, Oregon 97209-2532
Phone: 503-221-7960

Ssa Marine, Inc. (Coos Bay, Oregon location)

SSA Marine's operations provide for stevedoring services at three facilities within the Port of Coos Bay. They include two dedicated export woodchip bulk loaders and one general cargo (barge, forest products) break-bulk terminal. All the terminals are privately owned and operated.

Website: www.ssamarine.com

Astoria & Longview
Email: joe.abram@ssamarine.com
70 Port Way
Longview, WA 98632
Phone: 360-423-8100

Portland, Vancouver
Email: paul.huculak@ssamarine.com
3556 NW Front Avenue Suite 360
Portland, Oregon 97210
Phone: 503-248-0848

Coos Bay
Email: bud.grant@ssamarine.com
2275 North 8th and Teakwood
Coos Bay, Oregon 97420
Phone: 541/269-9351

Towing & Barge Companies

Bernert Barge Lines, Inc.

Bernert Barge Lines, Inc. is a private company categorized under River Transportation and located in Oregon City, OR. Established in 1949.

170 Harding Blvd
Oregon City, Oregon 97045-3225
Phone: 503-656-8288

Foss Maritime Company

Foss provides comprehensive marine transportation and logistical services from local harbor services throughout North America to ocean towing and project support in extreme environments throughout the world.

Website: www.foss.com
Email: info@foss.com
9030 NW St. Helens Road
Portland, Oregon 97231
Phone: 503-286-0631

Fred Devine Diving & Salvage Co.

Light & Heavy Salvage, All Types Of Underwater Works

Website: www.freddevinedivingandsalvage.com
Email: devinesalv@msn.com
6211 N Ensign, Portland, OR, 97217
Telephone: 503-283-5285
Contact: Marvin Smith

Gunderson Marine LLC (The Greenbrier Companies)

The Gunderson manufacturing site outside Portland on the Willamette River includes the largest side-launch marine facility on the West Coast. It builds ocean-going barges and other heavy marine equipment. Gunderson is a unit of The Greenbrier Companies.

Website: www.gbrx.com/
Email: gbrx.info@gbrx.com
1 Centerpointe Dr.
Lake Oswego, Oregon 97035-8623
Phone: 503-684-7000

Knutson Towboat Co.

Transportation, Marine, Construction, Machine Shop, Paint & Coatings

Website: www.knutsontowboat.com
Email: ktbadmin@knutsontowboat.com
400 N. Front Street; PO Box 908
Coos Bay, Oregon 97420
Phone: 541-267-3195

Sause Bros.

Provides a full range of services: from ocean towing, cargo handling, and ship assist, to marine construction, and repair.

Website: www.sause.com
Email: info@sause.com
155 E Market Ave.
Coos Bay, Oregon 97420
Phone: 541-269-5841

Wiggins Towboat

Wiggins Towboat offers a wide range of harbor tug. These include, but are not limited to: General Towing Services, Vessel Assist Services, Truckable Log Bronc Services, Marine Construction Assist and Ship/Barge Assist Services. Serving Toledo & Newport Waterfronts

Email: G.L.Snyder@wstowboat.com
P.O. Box 1230
Depoe Bay, Oregon 97341
Tug/Cell: (541) 270-6527
Office: (541) 765-3369

Zidell Marine Corporation

Zidell Marine Corporation manufactures and distributes industrial pipe fittings and constructs and leases barges.

Website: www.zidell.com
3121 SW Moody Avenue
Portland, Oregon 97239-4500
Phone: 503-228-8691

Developer Questionnaire

List of questions addressed to each wave energy developer

Oregon Wave Energy Infrastructure Assessment

Understanding the infrastructure capabilities of the Oregon coast for the responsible development of wave energy. Funded by the Oregon Wave Energy Trust.

The following pages contain a list of questions and topics addressed to each Wave Energy Conversion (WEC) developer. Questions were sent ahead of the interview that lasted from 30 minutes to an hour.

Companies interviewed include:

- Columbia Power Technologies
- C III S
- WaveBob
- Fred Olsen
- Natural Power
- Pelamis
- Resolute Marine
- Ocean Power Technologies
- Global Energy Horizons
- Aquamarine Power
- Voith WaveGen
- Wave Energy Norway

Overview

Preliminary assessment

Identify WEC unit

- Fabrication
- Transportation
- Assembly
- Deployment
- Operations
- Maintenance
- Salvage/Removal
- Emergency Response

Advanced Research corporation

Developer Questionnaire

Preliminary assessment questions:

- Do you have funding in place for each of your development phases? If not, describe the certainty with each of the phases would move forward.
- How far along are you on the permitting processes (both federal, state and local)? What has been accomplished, and what is left to be accomplished?

Exploratory questions

Manufacturing

- Describe the manufacturing process for your system.
- What special requirements do you have in manufacturing?
- If you install in Oregon, what manufacturing capabilities are you expecting from Oregon companies?

Transportation & Installation

- What special requirements do you have in transportation?
- What special requirements do you have in installation?

Location

- Where do you plan to manufacture
- If you install in Oregon, what manufacturing capabilities are you expecting from Oregon companies?
- What work do you have planned to occur in Oregon?
- What work do you plan to occur outside of Oregon?
- What work could go either way, depending on availability and cost effectiveness of services?

Management

- When do you plan to do your development?
- Describe the different phases of development and when they are expected to take place.
- Are there other limitations or restrictions you are aware of that will affect your deployment?
- How important is it to you that products and services be local? If so, which ones?
- Using the framework on the following pages, what are your current needs in each category?

Identifying each individual wave energy conversion unit

Physical

- Size
- Weight
- Site and Location requirements

Materials

- Materials used
- Local, state, federal restrictions (ex EPA)

Components

- Construction
- Maintenance

Identify current development needs

Building and fabrication

Material acquisition

- Steel & SS
- Other metals
- Concrete
- Plastics (standard & FRP composites) & foam

Developer Questionnaire

Product acquisition

- Cable (power & rigging)
- Hoses
- Hydraulics
- Specialty parts

Services acquisition

- Galvanization
- Painting (standard & anti-fouling)
- Cutting (plasma & water)
- Foundry & welding

Manufacturing site

- Size capabilities
- Weight capabilities
- Shipping capabilities
- Proximity needs
- Expected manufacturing rate and time required

Transportation to assembly site

Land

- Road capabilities (size, weight)
- Trucking requirements
- Crane capabilities

Air

- Airport capabilities (ex. runway length and loading)
- Freight service requirements
- Helicopter services

Ocean

- Port Requirements
    - Riggers
    - Crane service
    - Storage (time frame, size, security)
    - Operational hours
- Harbor Requirements
    - Channel depths
    - Bar pilot
    - Weather/tidal restrictions
- Shipping service requirements
    - Service options (tug/barge, ship)
    - Service capabilities (size, weight)
    - Service availability

Assembly site

- Riggers & welders
- Crane service
- Labor and technical expertise
- Offices and parking
- Storage and work facilities

Transportation to ocean site

- Port Requirements
    - Riggers
    - Crane service
- Shipping service requirements
    - Service options (tug/barge, ship)
    - Service capabilities (size, weight)
    - Service availability

Transportation to beach site

- Road requirements
- Rail requirements

Ocean site setup

Surveying

- Bathymetry
- Sub-bottom profiling
- Core samples

Preparation

- Mooring
    - Weighted block – capability to build and move
    - Piles – capability to install
    - Anchors – ability to site and set
- Power Cables
    - Ocean floor laying
    - Beach landing
    - Diving capabilities (human & ROV)

Installation

- Crane, tug, boat requirements
- Subsurface work (diving capabilities)
- Skilled labor requirements

Beach site setup

Surveying

- Sand movement, jetty stability, rock cliff composition
- Access

Preparation

- Building construction
- Boring capabilities
- Access construction

Installation

- Crane, riggers
- Skilled labor requirements

Operations

- Monitoring
  - Office buildings
  - Sensors (wave, wind, etc)
  - Skilled labor
- Power distribution (not included in this infrastructure assessment)

Maintenance

- At-sea maintenance
  - Repair vs. replacement of components or devices
  - PM vs. repairs
  - Surface vessels
  - Subsurface capabilities
- Port-side maintenance
  - Surface vessels
  - Subsurface capabilities
  - Spare part depot
  - Port capabilities
    - Facilities (storage, office, work space)
    - Staffing – skilled/educated labor

Salvage / Removal

- Surface vessels
- Subsurface capabilities
- Disposal capabilities (green vs. toxic)

Emergency Response

- Hazmat/Oil spill
- Storm damage
- Hazard to others/navigation
- Other
- Requirements for: vessels, expertise, specialty equipment

Management

Contracting Techniques

How much is planned for in-house vs. how much from outside?

Housing Needs

What are expected housing needs for the different phases of the project (fabrication to salvage)?

Experience Labor

What are the expected experienced labor needs for the different phases of the project?

Identify issues and risks associated with infrastructure needs

Identify importance of locality for each product or service

Identify importance of time-sensitivity for each product or service

Port Questionnaire

List of questions and topics addressed to each port

Oregon Wave Energy Infrastructure Assessment

Understanding the infrastructure capabilities of the Oregon coast for the responsible development of wave energy. Funded by the Oregon Wave Energy Trust.

The following pages contain a list of questions and topics addressed to each port interviewed. Interviews lasted from 45 minutes to an hour.

Each port was given the opportunity to expound upon their strengths and weaknesses that are relevant for wave energy development as well as other relevant areas for the future development of wave energy along the Oregon coast.

Ports interviewed include:

- Port of Coos Bay
- Port of Garibaldi
- Port of Newport
- Port of Umpqua

Overview

- Issues and Climate
- Current Operations
- Facilities & Capabilities
- Available Real Estate
- Areas of Expertise
- Future Plans
- Issues & Risks for Wave Energy

Advanced Research corporation

Port Questionnaire

- What is the climate for developing wave energy at this port? Is there good support?

- If not, describe where the issues are:
  - Fishermen openness? What groups discuss? FACT, FINE, SOORC
  - Community openness?

- Who are the local power companies here?

- Describe the port businesses (fishing, lumber, recreation, manufacturing, other) percentages, history, current business climate (up/down)

- Describe port operations
  - Describe one or two recent large scale projects your port has done (past 10 years)
  - Describe local contractor/manufacturing base
    - Concrete
    - Steel
    - Marine engineering services
    - Divers
    - Welders
    - Unions (skills/services, what reach)
    - Surveyors

- Describe port facilities and capabilities
  - Docks
  - Cranes
  - Ramps
  - Barges
  - Pilot vessels (required?)
  - Other vessels for hire

- Describe area transportation services
  - Rail
  - Truck
  - Marine
  - Air (helicopter services, as well as commercial air services)

- Describe available real estate that could be brought into service to support wave energy developers (areas for offices, short term assembly/manufacturing, power/water/sewage)

- Describe basic health and human services
  - Housing (adequate for long term, short term workers)
  - Family support (hospitals, child care, schools)

- Describe port expertise
  - Skilled trades
  - Training facilities

- Describe future plans
  - Normal plans (dredging, building upgrade/replacement)
  - Major plans (new terminals, new services)
  - When (conditional on winning bids?)
  - Game-changing or expansion of current capabilities

- What major challenges are you facing as a port?

- What issues and risks do you see to bringing wave energy to your port region?

- Based on these issues, what likely combination of financial or other support would remedy these issues?
  - Government projects
  - Government grants
  - Increased tax revenue
  - Local business investment
  - Other

Supplier Questionnaire

List of questions addressed to each supply company

Oregon Wave Energy Infrastructure Assessment

Understanding the infrastructure capabilities of the Oregon coast for the responsible development of wave energy. Funded by the Oregon Wave Energy Trust.

The following pages contain a list of questions and topics addressed to each supplier company, organization, or group interviewed.

Each company, organization, or group we interviewed was given the opportunity to expound upon their strengths and weaknesses as applied to wave energy development. While the question set was comprehensive and highly specific, many of the companies interviewed chose not to respond at the same level of detail. Thus specifics concerning such capabilities as crane capacities and water depths at docks were not made available to the authors.

Companies interviewed include:

- Advanced American Construction
- American Bridge
- Crescere Marine Engineering
- Fred Devine Diving and Salvage
- Fred Wahl Marine Construction
- Hatfield Marine Science Center
- International Longshore and Warehouse Union
- Northwest National Marine Renewable Energy Center
- Oregon Iron Works
- Oregon SeaGrant
- Sause Brothers

Overview

Advanced Research corporation

Supplier Questionnaire

Preliminary assessment question:

- Where are you located? If not in Oregon, then what would it require to locate a facility or offsite manufacturing facility in Oregon?

Exploratory questions:

Business

- How willing is your company to expand into the wave energy sector?
- How large is your company? (# of facilities, # of employees, yearly income)

Manufacturing

- Describe your general manufacturing process.
- What is your company's area of experience in?
- What special capabilities do you have?

Transportation

- What transportation infrastructure do/can you interface with?
- What onsite moving/loading capabilities do you have?

Location

- If you expand or relocate to Oregon, where will the new work force come from?

Management

- If a conflict between contract deadlines occurs, how do you respond?
- In 3-5 years do you foresee having the capacity to take on new work?

Detailed Framework

- Using the following framework, can you meet (fully or partially) some of the foreseeable requirements?

Materials

Concrete

- Buoy Ballast
  - Up to 200 cu yd (150 m3) per unit pumped into ballast cavities (100-400 units per site).
- Beach Structures
  - Need a supply of 65,000 cu yd (50,000 m3) if a device takes 105 cu yd (80 m3) of reinforced modular concrete per yard of length (1 m) and the device is 3000 ft long (1 km).
- Mooring Structures
  - Mooring blocks are expected to be up to 120 cu yd (90 m3) of reinforced concrete.

Metals

- Steel
  - Tubal structures could be up to 35ft (10m) in diameter and 80 ft (25m) lengths.
- Drag anchors and chain

Plastics

- FRP
  - Structures could be up to 65 ft (20m) in diameter and 80 ft (25m) lengths.
- Injection molded
  - Structures could be up to 7 ft (2m) in diameter and 16 ft (5m) in length.

Manufacturing Site

- If an offsite manufacturing facility were required, what land and other resources would be required?
- If an existing facility is used, does it have the capability to handle the size and numbers required?

Facility Capacities

- Weight
- Size
- Space

Transportation

- If manufacturing occurs at an existing facility what shipping options exist? (Ocean, road, rail)
- What loading capabilities exits at the facility (cranes, docks, etc)

Specialized Questions:

Specialized manufacturers (steel, concrete)

- What products or services do you provide?
- What experience do you have in projects with the needs and on the scale of wave energy projects?
- What is your current capacity?
- Where is your work located? Where are your manufacturing facilities?
- If applicable, could you relocate your plant to accommodate on-site wave energy development?
- What known future plans could support wave energy development (plans to expand)
- What known future plans could impede wave energy development (other large commitments that would conflict, plans to close down plants)

Marine engineering firms

- What products or services do you provide?
- What experience do you have in projects with the needs and on the scale of wave energy projects?
- What is your current capacity?
- Where are your facilities located?
- If applicable, could you relocate your operations to accommodate on-site wave energy development? If so, would it be temporary or permanent (hotel or housing, lease office space or set up mobile office)?
- What known future plans could support wave energy development (plans to expand)
- What known future plans could impede wave energy development (other large commitments that would conflict, plans to close down plants)

Abbreviations

EMEC – European Marine Energy Centre
EPA – Environmental Protection Agency
FACT – Fisherman Advisory Committee for Tillamook
FINE – Fishermen Involved in Natural Energy
FERC – Federal Energy Regulatory Commission
FRP – Fiber reinforced plastic
GW – Gross Weight
HMSC – Hatfield Marine Science Center
ILWU – International Longshore and Warehouse Union
kW – Kilowatt
M/V – Motor vessel
MW – Megawatt
N/A – Not applicable
NMFS – National Oceanic and Atmospheric Administration Fisheries Service
NNMREC - Northwest National Marine Renewable Energy Center
NOAA – National Oceanic and Atmospheric Administration
O&M – Operations and maintenance
ODFW – Oregon Department of Fish and Wildlife
OSU – Oregon State University
OWC – Oscillating water column
OWET – Oregon Wave Energy Trust
PM – Preventive maintenance
SCADA – Supervisory control and data acquisition
SOORC – Southern Oregon Ocean Resource Coalition
SS – Stainless steel
ROV – Remotely operated vehicle
RV – Recreational vehicle
U.S. – United States of America
USDA – United States Department of Agriculture
USFWS – United States Fish and Wildlife Service
WEC – Wave Energy Converter

Definitions

Attenuator – A floating device working parallel to the wave direction and effectively rides the waves. Movements along its length can be selectively constrained to produce energy. It has a lower area parallel to the waves in comparison to a terminator, so the device experiences lower forces.

Coastal Tug or Coastwise Tug – tugboats having the power, length, and freeboard forward to operate in coastal waters.

Marine Railway – A type of dry dock consisting of a cradle of wood or steel with rollers on which the ship may be hauled out of the water along a fixed inclined track leading up the bank of a waterway.

Oscillating Water Column – a partially submerged hollow structure, open to the sea below waterline which allows the waves to cause the water column inside to rise and fall, which in turn causes the trapped air to flow back and forth past a turbine.

Oscillating Wave Surge Converter – a wave energy device that extracts the energy caused by wave surges and the movement of water particles within them. The arm oscillates as a pendulum mounted on a pivoted joint in response to the movement of water in the waves.

Overtopping Device – Flush in – a wave energy device that captures the water from the waves and channels it through low-head turbines. The forward kinetic energy in the wave is retained and used to channel the water past the low-head turbines.

Overtopping Device – Wash up – a wave energy device that captures the water from the waves and holds it in a reservoir above sea level. The forward kinetic energy of the wave is changed to potential energy in the reservoir via the ramp in the front of the device. As the captured water returns to the sea it flows through low-head turbines.

Oregon Solutions – Oregon organization and process that fosters the development of "sustainable solutions to community-based problems that support economic, environmental, and community objectives and are built through the collaborative efforts of businesses, government, and non-profit organizations."

Panamax – the largest ships that can pass through Panama Canal.

Point Absorber – A floating structure wave energy device absorbing energy in all directions through movement at/near the water surface. The power take-off system may take a number of forms, depending on the configuration of displacers/reactors.

Submerged Pressure Differential – a wave energy device typically located near shore and attached to the seabed. The motion of the waves causes the sea level to rise and fall above the device, inducing a pressure differential in the device. The alternating pressure can then pump fluid through a system to generate electricity.

Bibliography & Important Links

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- HMSC Wave Energy Ecological Effect Workshop's "Ecological Assessment Briefing Paper": http://hmsc.oregonstate.edu/waveenergy/WaveEnergyEffectsBriefingPaper.pdf
- Northwest National Marine Renewable Energy Center: http://nnmrec.oregonstate.edu
- Oregon Department of Transporation: http://www.oregon.gov/ODOT
- Oregon Wave Energy Trust report on "Licensing and Permitting Requirements":
- http://www.oregonwave.org/templates/owet/documents/owet%20-%20licensing%20%20permitting%20report.pdf
- Over-Dimension operations: http://www.oregon.gov/ODOT/MCT/OD.shtml
- Pacific Maritime Association: www.pmanet.org
- Plate sizes on U.S. railroads see: http://en.wikipedia.org/wiki/Loading_gauge
- Towing Vessel Pilotage & Route Requirements: http://towmasters.files.wordpress.com/2009/02/federal_pilotage_requirements4.pdf
- Towmasters: the Master of Towing Vessels Assoc. Forum, Advocate of the tugboat captain. http://towmasters.wordpress.com/home/
- Union Pacific Railroad: http://www.up.com

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