PNNL-19081

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Marine and Hydrokinetic Energy Development
Technical Support and General Environmental Studies

Report on Outreach to Stakeholders for Fiscal Year 2009

AE Copping
SH Geerlofs

January 2010

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62, Oak Ridge, TN 37831-0062;
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov

Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161
ph: (800) 553-6847
fax: (703) 605-6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm

This document was printed on recycled paper.
(9/2003)

PNNL-19081

Marine and Hydrokinetic Energy Development Technical Support and General Environmental Studies

Report on Outreach to Stakeholders for Fiscal Year 2009

AE Copping
SH Geerlofs

January 2010

Prepared for
the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

In response to the Energy Independence and Security Act (EISA) of 2007, the U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE) Waterpower Program Office developed a program on marine and hydrokinetic (MHK) energy development. During fiscal year 2009 (FY09) the EERE Waterpower Program provided support to Pacific Northwest National Laboratory (PNNL) to enable staff to interact with the MHK industry, regulators, and other stakeholders to learn more about the challenges of accelerating the MHK industry to a sustainable source of energy and to make connections among those groups.

PNNL staff carried out a program of stakeholder outreach during FY09 to accomplish the following:

- Identify the breadth of individuals and groups with a stake in MHK development to understand which groups have the ability to affect the course and success of MHK industrial development.
- Develop an understanding of the key environmental and socioeconomic issues facing MHK development.
- Identify stakeholders who can provide information about key environmental issues and outcomes of MHK development.
- Develop and deliver unbiased information about MHK development for the interested public.

Stakeholders were initially identified and contacted informally, and each contact led to others. Conferences and workshops were a rich source of contacts. Using standard outreach techniques, PNNL staff parsed the stakeholders into three groups:

- an essential group without whose involvement the industry cannot progress (essential)
- influential stakeholders who may have an impact on the outcome of a technology, siting or permitting processes, or who have influence over essential players (influential)
- stakeholders interested in the outcome of the MHK industry due to place-based interests or concerns (interested).

Specific activities and products generated during FY09 included

- a capitalization survey of the largest U.S. MHK companies
- a survey of the regulatory landscape
- a modeling report on Tacoma Narrows tidal energy.

Lessons learned from PNNL's outreach effort include the following:

- Each stakeholder group has important information to contribute to the understanding of what is needed to develop the MHK industry, in terms of technical perspectives as well as acceleration to market.
- The MHK industry in the United States and in other countries with active MHK endeavors is an important source of information about the technologies, project proposals, and challenges of developing a sustainable MHK industry.

- The industry generally has limited insight into regulatory needs for siting and permitting processes.
- The MHK industry in the United States is severely undercapitalized, which can exacerbate a potential adversarial relationship with regulatory agencies and other stakeholders as they struggle to meet environmental assessment and siting needs.
- The regulatory community is struggling to develop appropriate regulatory processes and steps to permit MHK devices.
- Influential stakeholders, including Indian Tribes, major nongovernmental organizations, elected officials, and place-based groups, have little understanding of MHK technologies and limited knowledge of the regulatory environment that will be needed to establish the industry.

Future directions that will help to accelerate the development of a sustainable MHK industry in the United States include the following:

- a broad-based education and outreach program
- interaction with individuals in the industry, as well as regulatory and resource management agencies
- participation in ongoing planning exercises, including coastal and marine spatial planning and regional ocean planning
- a framework and roadmapping activities that help to organize information.

Acronyms and Abbreviations

DOE	U.S. Department of Energy
EERE	Energy Efficiency and Renewable Energy
FY	fiscal year
K	thousand
kW	kilowatt(s)
MHK	marine and hydrokinetic
MW	megawatt(s)
NGO	nongovernmental organization
PNNL	Pacific Northwest National Laboratory

Contents

Tables

1.0 Introduction

In response to the Energy Independence and Security Act of 2007 (EISA), the U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE) directed its Waterpower Program Office to establish a program focused on marine and hydrokinetic (MHK) energy development. The program seeks to assist the MHK industry with deploying devices and ensuring the delivery of renewable energy to the national grid by concentrating on two elements: 1) marine and hydrokinetic energy technology development and 2) marine and hydrokinetic energy technology market acceleration.

The energy of ocean waves, tides, currents, thermal gradients, and flowing rivers makes the development of MHK an attractive source of renewable energy. As development of MHK systems ramps up, the environmental issues associated with the devices, cabling, and shoreside installations have arisen as major challenges, presenting significant barriers to siting and permitting (Musial 2008; Boehlert et al. 2008). Regulators and stakeholders are raising concerns about the potential effects of pilot-scale devices; moving to commercial development will raise a host of new concerns and questions.

During fiscal year 2009 (FY09), the EERE Waterpower Program provided support to Pacific Northwest National Laboratory (PNNL) to enable staff to interact with the MHK industry, regulators, and other stakeholders to learn more about the challenges of accelerating the MHK industry to a sustainable source of electricity and to make connections among those groups.

MHK technology developers and site-specific project developers are headquartered throughout the United States. However, particular regions of the country are more conducive to MHK development than others, due to the availability of harvestable resources and the proximity to load sources. In particular, the Pacific coastline has significant harvestable wave resources as well as some of the most accessible tidal resources in close proximity to load centers, particularly in the Puget Sound. Other factors that concentrate interest in MHK development in the Pacific Northwest include the establishment of one of two national marine renewable energy centers by EERE/Waterpower Program Office at Oregon State University and the University of Washington. For these reasons, a significant proportion of the stakeholder outreach carried out by PNNL has centered along the Pacific coast, with additional outreach to the MHK industry across the country and abroad.

1.1 Background, Purpose, and Scope

The establishment of commercial-scale harvest of power from ocean tides, waves, and rivers is a relatively new concept. The quest for technologies and configurations of devices that will support a viable industry is at an early stage, and has not yet undergone the inevitable consolidation of technologies or been proven under harsh ocean and large river conditions (Musial 2008). Similarly stakeholders with an interest in MHK energy development have not self-sorted into neat manageable groups with clear messages or concerns. The challenge of parsing MHK stakeholders into logical groups, understanding their needs, and fashioning outreach messages and vehicles to deliver useful information on the emerging industry requires a number of techniques.

The process of understanding stakeholder interests, gaining their trust in order to act as a neutral broker of science-based information, and providing value-added knowledge to them, falls under the classic definition of outreach (Cairns 2004; Suman et al. 1999; Pomeroy and Douvereb 2008). The additional challenge of MHK development beyond the traditional extension process, stems from there being little record of the identity of major and minor players in the MHK field.

During FY09, PNNL staff conducted a program of stakeholder outreach to better understand the desires and concerns of each major and minor group in relation to MHK development. The objectives of the outreach process were as follows:

- Identify the breadth of individuals and groups with a stake in MHK development to understand which groups have the ability to affect the course and success of MHK industrial development.
- Develop an understanding of the key environmental and socioeconomic issues facing MHK development.
- Identify stakeholders who can provide information about key environmental issues and outcomes of MHK development.
- Develop and deliver unbiased information about MHK development for the interested public.

1.2 Report Contents and Organization

The ensuing sections of this report, document PNNL's FY09 activities working with interested MHK stakeholders. The outreach process is described and major stakeholder groups are identified; lessons learned are discussed; and future directions are recommended. Appendixes contain supplemental materials, including a capitalization survey of the largest U.S. MHK companies (Appendix A), a survey of the regulatory landscape (Appendix B), and a modeling report on Tacoma Narrows tidal energy (Appendix C).

2.0 Working with Stakeholders During FY09

PNNL staff contacted and met with a wide variety of stakeholders during FY09, with an emphasis on the MHK industry, regulators, project developers, and researchers. In the process of establishing contact with individuals and institutions within these categories, the staff also met with many other stakeholders, thereby growing the list of contacts and the information base at each step. Conferences and workshops were a rich source of new contacts, particularly the Global Marine Renewable Energy Conference in Washington DC (April 2009), Water Power in Spokane, Washington (July 2009), and Coastal and Estuarine Research Federation in Portland, Oregon (October 2009). Meetings with other national laboratories and the MHK industry, research symposia with university researchers, and meetings organized by nongovernmental organizations (NGOs) helped establish additional contacts and educate PNNL staff in the desires of industry, the interests of researchers, and the concerns of regulators, environmental groups, and the public. Telephone interviews and surveys and one-on-one meetings served to provide a wealth of information and identify the direction for future assessments.

Understanding the breadth of stakeholders requires the equivalent of a Delphi method, whereby each contact provides additional contacts and reasons for approaching additional interested parties (Linstone and Turoff 2002). Careful listening is needed to understand the relationship individual or groups of stakeholders have to MHK. Stakeholders can be parsed coarsely into one of the following three groups:

- an essential group without whose involvement the industry cannot progress (essential)
- influential stakeholders who may have an impact on the outcome of a technology, siting or permitting processes, or who have influence over essential players (influential)
- stakeholders interested in the outcome of the MHK industry due to place-based interests or concerns (interested).

Members of each group must be approached differently, with respect for their starting position, knowledge base, and level of commitment to the desired outcome. Major messages and information delivered to each group must remain consistent, but should be tailored to the interests and needs of each group. Although parsing of these stakeholders into these groups, based on their relationships to or influences on the MHK industry, is affected by political processes and influences, the project reported here stayed away from direct political involvement or discussion.

2.1 Major Stakeholder Groups

Stakeholders were classified by the sectors they represent and were later assigned as being *essential*, *influential*, or *interested*. Major sectors are shown in Table 1 with examples of stakeholders with whom PNNL directly interacted in FY09. Examples of activities and outcomes working with these groups are shown in Table 2; the appendices contain more details about the products or outcomes. Table 3 parses the stakeholders into *essential*, *influential*, or *interested* groups. Clearly, many groups of stakeholders may progress from being interested to influential, or from influential to essential at various stages of industry development.

Table 1. Stakeholder Groups with Whom PNNL Interacted During FY09

Sector	Subsector	Stakeholders
Industry	MHK technology developers	• Ocean Power Technology • Verdant Power • Open Hydro • Ocean Resource Power Company • HydroGreen • Clean Current • Voith Hydro
	Project developers	• Snohomish PUD • Pacific Gas and Electric • Ocean Power Technologies
	Public and private utilities	Utilities throughout WA and BC, notably: SnoPUD, City of Port Angeles, Clallam PUD, BC Hydro
	Instrument and equipment manufacturers, ocean engineers	• Biosonics • Voith • Sound and Sea Technology
Regulators, Resource Agencies	• NOAA Fisheries • State and regional agencies • FERC • MMS	• NOAA – PNW and Alaska Region • WA State agencies (WDFW, Ecology, Governor's Office of Regulatory Assistance) • West Coast Gov's Agreement on Ocean Health • FERC region and national • MMS region and national
Other Stakeholders	• Tribes • Policy bodies • Public groups • NGOs	• WA Tribes • Local governments, • WA legislators • Marine Resources Committees • Restore America's Estuaries, People for Puget Sound,
U.S. Navy	• Navy Northwest • NAVFAC • Pacific Command	
Researchers	• NNMREC: Oregon State University and University of Washington • Powertech Labs • Dept Fisheries Oceans Canada – Atlantic and Pacific • Biological, physical oceanographers, social scientists at other universities	• OSU Hatfield Marine Science Center • UW Mechanical Engineering and APL

APL = Applied Physics Laboratory; BC = British Columbia; FERC = Federal Energy Regulatory Commission; MMS = Minerals Management Service; NAVFAC = Naval Facilities Engineering Command; NGO = nongovernmental organization; NOAA = National Oceanic and Atmospheric Administration; NNMREC = Northwest National Marine Renewable Energy Center at UW; OSU = Oregon State University; PNW = Pacific Northwest; PUD = Public Utility District; UW = University of Washington; WA = Washington State; WDFW = .Washington Department of Fish and Wildlife

Table 2. Interactions and Outcomes of Working with Stakeholder Groups During FY09

Stakeholder Group	Interactions	Outcomes
Industry	• Industry survey, informal discussions • Discussions with regulators, stakeholders, project proponents • Survey of renewable/MHK interest • Discussions of capabilities	• Better understandings of the state of readiness of industry technologies, capitalization. • Incremental progress attaining common ground between regulators and industry, particularly project developers. • Semi-quantitative data on capitalization of seven largest U.S. MHK companies (see Appendix A)
Regulators, Resource Agencies	• Discussion of environmental assessment and monitoring needs • Analysis of federal and state regulations • Environmental needs, spatial planning, communications • Environmental needs	• Incremental progress understanding regulatory requirements for environmental assessments, monitoring. • Improved understanding of regulatory map (see Appendix B) • Engagement with coastal and marine spatial planning for renewable ocean energy. • Partnering with NOAA Fisheries on tidal workshop
Other Stakeholders	• Environmental assessment and monitoring needs • Presentations of MHK, environmental issues	• Improved broad understanding of MHK industry and project objectives
U.S. Navy	• Coordination on PS project • Discussions on MHK nationally • MHK presentation, Environmental assessment of OTEC	• Incremental coordination of baseline environmental assessment plans for Navy Puget Sound project with SnoPUD project. • Improved understanding of Navy interests in MHK • Allowing Navy to propose environmental work under DOE
NNMREC	• Discussion of complementary environmental capabilities • Teaming on PS projects, Memorandum of Understanding	• Developed close working relationship with OSU and UW personnel, Center directions. • Joint field work planned with UW on tidal projects • Partnering with OSU and UW on tidal workshop
Other DOE Researchers	• Discussions of tidal properties at Tacoma Narrows, modeling runs	• Differential estimate of tidal power at Tacoma Narrows, research direction for FY10 (see Appendix C).

NNMERC = UW's Northwest National Marine Renewable Energy Center; NOAA = National Oceanic and Atmospheric Administration; OSU = Oregon State University; OTEC = Ocean Thermal Energy Conversion; PS = Puget Sound; PUD = Public Utility District; UW = University of Washington

Table 3. Stakeholder Groupings, Based on Relationship to MHK Industry Development

Group	Stakeholder Sector	Representative Stakeholders	Comments
Essential	MHK Industry in the United States	OPT, Verdant, ORPC, HydroGreen, etc.	
	Regulators	FERC, MMS, NOAA Fisheries, USFWS, state regulatory agencies	Need to come to consensus on regulatory needs, assist regulators in determining acceptable risks
	Federal funding agencies	DOE, MMS, NOAA	R&D investment for pilot deployment and environmental studies is needed immediately
Influential	Federal and state resource management agencies	NOAA, USFWS, state resource agencies	Agencies will supply information to allow regulators to understand acceptable levels of risk
	Tribes		Treaty Tribes have legal rights to protect marine resources and harvest rights, can be highly influential.
	Regional governance bodies	WCGA	
	International MHK Industry, regulators	Open Hydro, Clean Current, MCT, etc., United Kingdom and European Union regulatory bodies	Provide examples and track record for industry, regulators, other stakeholders
	Public and private utilities		Utilities become essential players as the industry gets closer to generating power
	Private investors		Private investment becomes essential as devices are proven effective
Interested	Place-based NGOs Interested public	People for Puget Sound Marine Resources Committees	Often express concern over "industrialization of ocean." Concerns are generally highly linked to locations, place-based. Can be very open to education on importance of industry, renewables. Can also become very influential and litigious.

DOE = U.S. Department of Energy; FERC = Federal Energy Regulatory Commission; MMS = Minerals Management Service; MCT = Marine Current Turbines; NGO = nongovernmental organization; NOAA = National Oceanic and Atmospheric Administration; OPT = Ocean Power Technologies, Inc.; ORPC = Ocean Renewable Power Corporation; USFWS = U.S. Fish and Wildlife Service; WCGA = West Coast Governors' Agreement (on Ocean Health).

3.0 Lessons Learned

In the absence of sufficient published literature on the subject, information about the practical aspects of MHK devices, development of the industry, interactions with the environment, and potential conflicts with regulatory authorities can be informed by those most closely tied to the industry. Each of the major stakeholder groups (industry, project developers, regulators, resource management agencies, NGOs, and other interested parties) has information and perspectives to contribute. During FY09, PNNL staff were able to glean considerable understanding of the industry and its development, in addition to forging important contacts with a myriad of stakeholders.

The MHK industry (device developers and project proponents) in the United States and particularly in other countries with active MHK endeavors, is an important source of information about the technologies, project proposals, and challenges of developing a sustainable MHK industry. In most cases, the industry has limited insight into what the regulatory community needs to create a sense of security that will lead to a smooth siting and permitting process. Coupled with the need to press hard to develop an undercapitalized industry, this lack of insight can lead to an adversarial relationship with regulatory agencies and the resource agencies upon which the regulators depend.

The regulatory community is facing new challenges in making MHK projects conform to existing authorities and mandates that determine required compliance actions. Advice and consultation with resource management agencies that provide scientific guidance to regulators has not eased the burden on regulators, as is reflected by the inability of resource managers to determine the appropriate level of environmental data needed to determine the likely effects of MHK development. In addition, the regulatory and management sectors have little understanding of the technologies or requirements for siting and operating MHK installations.

Influential stakeholders, including Indian Tribes, major NGOs, elected officials, and place-based groups, have little understanding of the requirements of the MHK technologies and projects, and in many cases, limited knowledge of the regulatory and legislative mandates that direct the regulatory environment.

4.0 Future Directions

To accelerate the development of a sustainable MHK industry in the United States, it will be necessary to develop a joint vocabulary and knowledge base among industry, regulators and resource managers, elected officials, interested organizations and individuals, and the public. The process of developing this joint understanding will require a sustained effort in outreach and education, as well as ensuring that lines of communication are increased and maintained among the key players. Specific actions that will assist in this endeavor include the following:

- a broad-based education and outreach program
- interaction with individuals in the industry and regulatory and resource management agencies
- participation in ongoing planning exercises, including coastal and marine spatial planning and regional ocean planning

- a framework and roadmapping activities that help to organize information.

4.1 Education and Outreach

When developing educational materials and vehicles tailored for each of the major groups and subgroups, certain materials and vehicles can be used for several groups, but there is no “one size fits all” solution. For example, journal articles and presentations at scientific and industry conferences and workshops reach many proponents, researchers, and resource managers, as well as some regulators. NGOs, elected officials, Tribes, and interested members of the public are best reached through venues familiar to them; for example, service club meetings, environmental conferences and meetings, and gatherings specific to certain locales. Outreach programs must be concerned with listening to participants as much as providing them with information; understanding the concerns and positions of each group of stakeholders allows for better tailoring of materials and planning of future interactions. There continues to be misconception of basic issues associated with MHK devices, their placement in the water, and the potential for wide-spread effects from MHK devices.

4.2 Interaction with Individuals

Group interaction does not always allow for the honest and open exchange of information, particularly due to the novelty and uncertainty of MHK development. Many individuals are reluctant to voice support, dissenting opinions, confusion, or outright hostility in an open forum. Meeting with individuals, particularly among the MHK technology and project development industries, are likely to yield a clearer picture of the current level of trust and to help pave the way for improved understanding and relations in future. This past year, PNNL staff have found that a broad range of stakeholders have been very generous with their time and provided valuable information from many perspectives on the industry development, regulation, and related concerns.

4.3 Planning Exercises

Until very recently the concept of accommodating renewable energy as a designated use in coastal, riverine, or ocean waters was not under consideration. Planning organizations at the national, regional, and state level are scrambling to add consideration of MHK installations to their plans. Engagement of proponents, researchers, and agency staff familiar with the MHK industry will support the inclusion of useful, accurate, and timely information on renewable energy in ongoing plans. Key activities include coastal and marine spatial planning at the national, regional (e.g., West Coast Governors’ Agreement on Ocean Health), and state level; ocean and coastal planning exercises by states (e.g., updates of Oregon Ocean Plan); data collection effects at the national and state level (e.g., development of the Marine Cadastre by Minerals Management Service and National Oceanic and Atmospheric Administration); and key NGO activities (e.g., ecoregional planning by The Nature Conservancy).

4.4 Frameworks and Roadmaps

Activities underway and envisioned under DOE sponsorship can help lead the way to an improved understanding and path forward to accelerate the MHK industry to market. Regulatory roadmaps and the stakeholder environmental framework developed by Pacific Energy Ventures, the risk-informed framework on environmental effects and the international impacts database to be developed by PNNL, and the technology roadmap developed by the National Renewable Energy Laboratory, are examples of key tools that will move the industry forward. Each tool must be developed and vetted with the broadest range of stakeholders to ensure that the end results are useful and accessible for the intended audiences. Additional efforts to provide hands-on tools should also be sought in outreach discussions with stakeholders.

5.0 References

Boehlert, G, W, GR McMurray, and CE Tortorici (eds). 2008. Ecological effects of wave energy in the Pacific Northwest. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Tech. Memo. NMFS-F/SPO-92, 174 pp., Newport, Oregon.

Cairns, J. 2004. A synopsis of the book Striking a balance: Improving stewardship of marine areas (by the U. S. National Research Council, the operating arm of the U. S National Academies of Science and Engineering). J. Environ. Sci. 12(4):506 – 509.

Energy Independence and Security Act of 2007, Public Law110-140.

Linstone, HA and M Turoff (eds). 2002. "Chapter 3. General Applications," in *The Delphi Method: Techniques and Applications*. Available at: http://is.njit.edu/pubs/delphibook/.

Musial, W. 2008. *Status of Wave and Tidal Power Technologies for the United States*. TechReport NREL/TP-500-43240, National Renewable Energy Laboratory, Golden. Colorado.

Pomeroy, R and F Douvereb. 2008. The engagement of stakeholders in the marine spatial planning process. Marine Policy. 32(5):816-822 doi:10.1016/j.marpol.2008.03.017

Suman, D, M Shivlani, and JW Milon. 1999. Perceptions and attitudes regarding marine reserves: a comparison of stakeholder groups in the Florida Keys National Marine Sanctuary. Ocean & Coastal Management 42:1019-1040

Appendix A

Marine and Hydrokinetic Energy Device Industry Survey on Capitalization

Appendix A

Marine and Hydrokinetic Energy Device Industry Survey on Capitalization

Purpose: To obtain information about the financial aspects of commercialization for major U.S. marine and hydrokinetic technology developers.

Methods: On March 19, 2009, PNNL staff conducted phone interviews with the following seven U.S. hydrokinetic technology development companies (as recommended by Rob Whitson, representing the U.S. Department of Energy [DOE], Energy Efficiency and Renewable Energy [EERE] Waterpower Program; company web addresses listed below): Aquantis, Columbia Power Technologies, HydroGreen Energy, Natural Currents Energy Services, Ocean Renewable Power Corporation, Free Flow Power, and Verdant Power. Financial information is available on the internet for Ocean Power Technologies, the only publicly traded company in the group. Ocean Power Technologies and Columbia Power Technology are the only wave power companies in the group.

We structured the interviews around the following three questions:

- How much capital has been invested in your company to date?
- How much capital do you currently have access to?
- How much capital will it take for your product to be commercially viable?

In general, the companies we spoke with are operating on very small amounts of money, in the range of $2 to $10 million. The publicly traded Ocean Power Technologies is the exception, with $85 million of cash, cash equivalents, and investments on hand as of January 31, 2009. Open Hydro, out of the Ireland, was also consistently mentioned as the exception, with nearly $85 million in capital.

Funds have been and are being raised via private investment, venture capital, "angel" donors, state grants and loans, federal grants and loans, and contracts. Most respondents indicated that fundraising is difficult right now, with most venture capital on the sideline due to the global recession. Reinstatement of the production tax credit for the hydrokinetic industry in the 2009 Omnibus Appropriations bill is a positive development, but the general investment climate is making access to meaningful funds difficult.

Answers to the third question varied, depending on the definitions used for commercial viability. Companies made a clear distinction between the capital needed to take the next step (in most cases several devices installed in the water producing power and providing proof of concept) and true utility-scale commercial viability. In-water testing and technology certification will be essential to move past reliance on equity capital and into a situation where projects can be debt financed through banks. For the most part, companies see the need for anywhere between $4 and $25 million to take this step. The anticipated costs for a true utility-scale build-out varied widely.

Marine and Hydrokinetic Companies Surveyed:

- Aquantis, Inc. (subsidiary of Clipper Wind Power)
  http://aquantistech.com
- Ocean Power Technologies, Inc.
  http://www.oceanpowertechnologies.com
- Columbia Power Technologies, Inc.
  http://www.columbiapwr.com
- Free Flow Power Corporation *[Unable to contact, website no longer active]*
  http://www.free-flow-power.com
- HydroGreen Energy, Inc.
  http://www.hgenergy.com
- Natural Currents Energy Services
  http://www.naturalcurrents.com
- Ocean Renewable Power Corporation (ORPC)
  http://www.oceanrenewablepower.com
- Verdant Power
  http://www.verdantpower.com

Survey results for each company are listed in the following tables.

Table A.1. Aquantis, Inc. (Ocean Current Technology)

		Comments
Contact Name, Position	James Dehlsen, Chairman of the Board for Clipper Windpower	Aquantis is a "sister" company of Clipper Wind
Telephone No.	805-684-2495	
Email	mryan@dehlsenassociates.com (admin assistant)	
Capital Investment to Date	$2.1 million + undisclosed grant funds from California Energy Commission and the DOE.	
Cash on Hand	Current budget is approximately $1 million/year. Clipper is bankrolling the company.	
Capital Needed to Market	$26 million total—anticipate the need for 70% of this to come from government the rest for private equity.	$26 million would pay for continued engineering ($4.8 million) building the device ($17.25 million) and commercial testing and certification ($4.6 million). Once the device is commercially certified, Aquantis anticipates it would be "bankable" and able to move forward with

		commercial projects.

Table A.2. Ocean Power Technology (OPT; wave energy generation)

		Comments
Contact Name, Position	Financial information available online	OPT is a publicly traded company and its 2008 annual report provides a financial summary.
Telephone No.	609-730-0400	
Email	info@oceanpowertech.com	
Capital Investment to Date	OPT went public in 2007; since that time it has invested $27 million in operating expenses and has realized revenues of $7.3 million	
Cash on Hand	As of January 31, 2009: $85.6 million	Operated at a net loss of $14.7 million in fiscal year (FY) 2008.
Capital Needed to Market	OPT is already bringing its product to market. It has a strategic partnership with the U.S. Navy and another with Lockheed Martin to develop a utility-scale project in North America. Contract backlog of $6.9 million	

Table A.3. Columbia Power Technologies (wave power technology)

		Comments
Contact Name, Position	Matt Hantzmon, VP Bus. Dev	
Telephone No.	434-242-2727	
Email	mhantzmon@columbiapwr.com	
Capital Investment to Date	$11.25M	$8 million from the Navy, $750K from DOE, the rest private equity and angel investment.
Cash on Hand	Running on a $1 million/year budget.	At these funding levels, they anticipate a full-scale ocean demonstration by 2017.
Capital Needed to Market	An estimated $20 million is needed for a full-scale ocean deployment of a machine with a nameplate capacity of close to 1 MW.	With $20 million, a full-scale ocean demonstration could come as soon as 2012.

Table A.4. Free Flow Power (run of river generators)

		Comments
Contact Name, Position	Daniel Irvin, President	
Telephone No.	646-712-2155	
Email	dirvin@free-flow-power.com	
Capital Investment to Date	Free Flow has raised capital through private investment to carry them through the first stages of turbine design and Federal Energy Regulatory Commission (FERC) application.	
Cash on Hand	Nearly all hydrokinetic companies are experiencing difficulties attracting new private investment. In general, Free-Flow is on schedule with FERC permits and moving toward turbine testing next year.	
Capital Needed to Market	In general, the industry needs to prove that its technology is bankable, that it can be debt financed. To do this will require successful in-water testing and certification. A relatively small amount of government funds would be helpful to achieve this.	The Production Tax Credit passed in the 2009 Omnibus should make a big difference, but the recession is still dragging everyone down.

Note: Free Flow Power declined to share specific financial information, but gave permission to describe its financial position and that of the industry in general terms.

Table A.5. HydroGreen Energy

		Comments
Contact Name, Position	Mark Stover, Government Affairs	
Telephone No.	877-556-6566	
Email	mark@hgenergy.com	
Capital Investment to Date	Series-A funding closed in April 2008−$2.6 million. Series-B funding is set to close soon for an undisclosed amount; internet reports state it will be around $70 million.	
Cash on Hand	Operating on the initial $2.6 million, plus contracts.	HydroGreen (HG) installed the nation's first FERC-permitted hydrokinetic project co-located with an existing dam on the Mississippi River in the Town of Hastings, Minnesota. The project is barely profitable but is a proof of concept. HG is spending approximately $600 thousand of its own money to carry out environmental research and fish mortality studies.
Capital Needed to Market	Difficult to say, it would depend on the structure of the deal. Technology is ready for market now but for permitting and conducting necessary studies on a large-scale build-out, costs could be as much as $4500 per kW installed	Other things needed: stimulus, Renewable Portfolio Standards, Production Tax Credits, other tax credits and policy to encourage industry growth, partnerships on environmental research to answer some of the generic (non-site specific) research questions.

Table A.6. Natural Currents (tidal power)

		Comments
Contact Name, Position	Roger Bason, President	
Telephone No.	845-691-4008	
Email	rbason@naturalcurrents.com	
Capital Investment to Date	Since 2001, $5 million invested in three field deployments, 12 FERC permits, and technology testing	
Cash on Hand	Not disclosed	
Capital Needed to Market	$6 million to bring small-scale systems into commercialization and gear up for production of a 1.5-MW tidal turbine. $15−$20 million to engage at the utility scale. By 2020, to develop 35% of current FERC permit sites and provide 1000 MW of power, it would cost an estimate $1 million/MW, or $100 million.	

Table A.7. Ocean Renewable Power Corporation (in-stream river flow and tidal generation)

		Comments
Contact Name, Position	John Cooper, CFO	Devices in Maine, Alaska, in various stages of development and deployment
Telephone No.	207-772-7707	
Email	jcooper@oceanrenewablepower.com	
Capital Investment to Date	$4.7 million raised and invested to date, all private investment except for $750,000 in grants from Massachusetts and Maine.	
Cash on Hand	Trying to raise additional funds now, have an earmark in the FY 2009 omnibus spending bill through the Maine delegation, but uncertain how that money will filter down.	
Capital Needed to Market	$4 million needed to get through testing and complete FERC process. Funding by April would allow deployment of equipment by summer to run necessary field testing. The goal is to commercialize a device that would produce 1 MW in a 6-knot current.	Once equipment is operational, Ocean Renewable anticipates an extremely competitive cost of 8 cents per kW installed for a 20-MW project, including permitting.

Table A.8. **Verdant Power (Tidal)**

		Comments
Contact Name, Position	Kevin Lynch, CFO	Roosevelt Island Tidal Energy (RITE) project in New York's East River, also in Canada, working with Navy in the Pacific Northwest
Telephone No.	301-261-7615	
Email	klynch@verdantpower.com	
Capital Investment to Date	$18 million—plus another $6 million in early R&D funding through the State University of New York, DOE, and New York State.	Most of the investment to date has gone into the RITE project in New York's East River ($12 million).
Cash on Hand	Raising money through private equity, angel donors, hedge options, government grants. "Meaningful" supplies of capital seemed to have dried up with recession.	
Capital Needed to Market	$100 million	If the objective is to mature to a level where banks are comfortable investing in site development, it will be necessary to achieve 20 MW of capacity. Currently Verdant estimates it costs between$10−$20 million to produce a single MW, and thinks costs will soon reach $5 million. 20 MW at $5 million equals $100 million.

Appendix B

Regulatory Issues for Offshore Wind and Marine and Hydrokinetic Projects in State and Federal Waters

Appendix B

Regulatory Issues for Offshore Wind and Marine and Hydrokinetic Projects in State and Federal Waters

The roles of the Army Corps of Engineers (USACE), the Federal Energy Regulatory Commission (FERC), and state governments in permitting marine renewable energy projects in state waters are briefly outlined here. Fundamentally, the roles of USACE and FERC do not change in state or federal waters. The Clean Water Act, the Rivers and Harbors Appropriation Act, the National Environmental Policy Act, the Marine Mammal Protection Act, the Endangered Species Act, and the Migratory Bird Treaty Act apply throughout the waters of the United States. FERC was established to provide federal oversight to non-federal hydropower projects; hence, FERC licensing requirements would apply in state waters for marine and hydrokinetic (MHK) projects.

Offshore wind and marine hydrokinetic projects within the 3-mile coastal zone involve another regulatory layer through a state' administration of the Coastal Zone Management Act (CZMA). The CZMA establishes the regulatory framework for state and local management of impacts on and uses of the coastal zone. Federal activities outside of a state's 3-mile coastal zone may still be subject to state regulation under the CZMA if those activities are found to affect state waters.

B.1 USACE Regulations that Would Apply to Offshore Wind and MHK in State Waters

The USACE regulatory power over offshore wind power and MHK facility siting in state and federal waters derives from Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. The USACE also consults with other agencies to draft an environmental impact statement under the National Environmental Protection Act of 1969 (NEPA), with the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration (NOAA) under Section 7 of the Endangered Species Act, with USFWS and NOAA on impacts on marine mammals under the Marine Mammal Protection Act, and with USFWS on the Migratory Bird Treaty Act.

Section 404 of the Clean Water Act regulates the discharge of fill or dredged materials in U.S. waters, including wetlands, and applies to state and federal waters.

Section 10 of the Rivers and Harbors Appropriation Act requires USACE approval of any obstruction to navigation within the navigable waters of the United States. The Act applies to state and federal waters; however, a Section 10 permit does convey a property right.

B.2 FERC Role in State Waters

The Federal Power Act gives FERC the licensing authority for nearly all non-federal hydropower projects. As an extension of this existing authority, FERC has asserted its jurisdiction over ocean hydrokinetics out to the 12-mile territorial sea, which includes state (to 3-mile limit) and federal waters.

Until recently, under the FERC process, applicants applied for preliminary licenses to study the feasibility of siting a hydrokinetic facility in a given location. Permits do not authorize construction, but rather allow a developer to apply for construction permits in the future. Developers collect information and submit a series of progress and findings reports to FERC, ultimately working toward a full license application. FERC takes the lead agency role in coordinating other agencies in a NEPA analysis.

B.3 FERC/Department of Interior Memorandum of Understanding

There has been disagreement between FERC and the Minerals Management Service (MMS). MMS has jurisdiction over oil and gas leasing activities on the outer continental shelf, and had asserted this same jurisdiction over MHK projects. A Memorandum of Understanding (MOU) signed between the Department of the Interior (DOI) and FERC in March 2009 established that FERC has jurisdiction to issue licenses and exemptions from licensing for the construction and operation of MHK projects on the Outer Continental Shelf (OCS) and will conduct necessary analyses, including those under NEPA related to those actions. FERC's licensing process involves other relevant federal land and resource agencies, but FERC will not issue a license or exemption for an OCS MHK project until the applicant has first obtained a lease, easement, or right-of-way from MMS for the site. The MOU also eliminated FERC’s preliminary license process described above. At this point, it is unclear how the two agencies will proceed.

B.4 Energy Policy Act of 2005, Section 388

Section 388 of the Energy Policy Act of 2005 established a framework for offshore wind permitting and siting involving all appropriate agencies. The bill amends the OCS Lands Act to authorize the Secretary of the Interior, in consultation with other federal agencies, to grant leases, easements, or rights-of-way on the OCS for certain activities, including the development of wind energy. Federal agencies with permitting authorities under existing federal law maintain their jurisdiction.

USACE will continue to carry out Section 404 and Section 10 reviews; FERC maintains authority to license facility operation; and NOAA maintains authority to regulate impacts on marine species. Section 388 gives the DOI significant authority through the MMS to establish a system to collect lease and royalty payments for facility siting. While Section 388 does not designate a lead agency for the NEPA process, the recent MOU between DOI and FERC establishes that DOI, through MMS, will take the lead in preparing environmental impact statements.

Section 388 also provides for consultation between DOI and state governments that might be affected by a lease, permit, or right-of-way issued for an offshore wind project. States maintain their jurisdiction over the coastal zone under the CZMA (see below).

B.5 State Jurisdictional Authority

States have jurisdictional authority and title to submerged lands from the shore to 3 miles out to sea, under the Submerged Lands Act of 1953. The federal government maintains regulatory power and the power to preempt state law in this zone for “commerce, defense, navigation, and international affairs.”

The CZMA establishes the regulatory framework for states to manage the coasts, waters, and bottom-lands within the coastal zone. Federal regulations and federally permitted activities in the coastal zone, with certain exceptions, must be consistent with a state's Coastal Zone Management Plan. Federal activities outside of the coastal zone are subject to consistency with the CZMA if those activities impact state waters; for example, offshore oil drilling in federal waters could have an impact on state waters if there is a spill. This gives states some authority under the CZMA to influence federally permitted activities beyond the 3-mile zone.

The implication for offshore wind and MHK projects is that activities within 3 miles would fall under the regulatory and permitting jurisdiction of a state's Coastal Zone Management Plan. It also means that states could argue to be involved in permitting offshore energy projects beyond the coastal zone if they can make a case for there being an impact on state waters. While some states choose to centralize coastal zone management under one agency, most divide authority between networks of parallel agencies, each with its own responsibilities, woven together and linked through MOUs and policy guidance.

B.6 References

Clean Water Act. 33 USC § 1251 et seq., Public Law 95-217, December 27, 1977.

Coastal Zone Management Act, Public Law 92-583, 16 U.S.C. 1451-1456, October 27, 1972.

Endangered Species Act of 1973, 16 USC 1531-1544, 87 Stat. 884.

Energy Policy Act of 2005, Public Law 109-58.

Energy Independence and Security Act of 2007, Public Law110-140.

Federal Power Act, 16 USC 791-828c; Chapter 285, June 10, 1920; 41 Stat. 1063, as amended.

Marine Mammal Protection Act, 16 USC, Chapter 31 – Marine Mammal Protection

Migratory Bird Treaty Act, 16 USC 703-712; Ch. 128; July 13, 1918; 40 Stat. 755, as amended.

National Environmental Policy Act of 1969, as amended, Public Law 91-190, 83 Stat. 852 (1969).

Outer Continental Shelf Lands Act, 43 USC § 1331 et seq; 43 U.S.C. § 1801 et seq.

Rivers and Harbors Appropriation Act of 1899, 33 USC 403; Chapter 425, March 3, 1899; 30 Stat. 1151.

Appendix C

Velocity Validation of Puget Sound Model at Tacoma Narrows

The contents of the appendix derives from an internal Pacific Northwest National Laboratory Memorandum: "Velocity Validation of Puget Sound Model at Tacoma Narrows." June 2, 2009. Project 54866, From Zhaoqing Yang to Andrea Copping.

Appendix C

Velocity Validation of Puget Sound Model at Tacoma Narrows

C.1 Model Setup

The Pacific Northwest National Laboratory (PNNL) Puget Sound Model is a three-dimensional (3-D) hydrodynamic model developed using the unstructured grid Finite Volume Coastal Ocean Model (FVCOM) developed by the University of Massachusetts (Chen et al. 2003). FVCOM is a 3-D hydrodynamic model that can simulate wetting-drying and tide- and density-driven circulation in an unstructured, finite element framework. The unstructured grid model framework of FVCOM is well suited to Puget Sound, which has complex shoreline geometry and complicated dynamic physical processes in the intertidal zone. An unstructured grid for the FVCOM model of Puget Sound (Figure C.1) was generated with open boundaries specified at the entrance of the Strait of Juan de Fuca and north of Georgia Strait. A close-up of the model grid in the Tacoma Narrows area of Puget Sound is shown in Figure C.2. The average cell size in the entire Puget Sound is 880 m. The total number of nodes and triangular elements in the model are 118,356 and 214,098, respectively, in the horizontal plane. Ten uniform vertical layers were specified in the water column in a sigma-stretched coordinate system.

Under this task, the high-resolution PNNL Puget Sound Model was validated against observed Acoustic Doppler Current Profiler (ADCP) data, collected by Tacoma Power, with processing assistance from the University of Washington Northwest National Marine Renewable Energy Center (NNMREC). ADCP data were collected at three stations in Tacoma Narrows for a period of more than 2 months from May 30, 2007 to August 2, 2007 (Figure C.3). The PNNL Model validation was conducted for the period of June and July 2007. The sampling of data was conducted using a bin interval of 1 meter over the entire water column. Model results and ADCP data were extracted and compared at surface, mid-layer, and bottom layers.

For this validation, the PNNL Model was driven by tides along the open boundaries and 19 major river inflows throughout the Sound. Given that the dominant currents in Tacoma Narrows are driven by tides, for simplicity, meteorological forcing (wind stress and heat flux) was not considered in this model simulation. The PNNL Model was run at 2.5-second time steps and hourly results were outputted for comparison with observed ADCP data.

C.2 Model Validation

ADCP data were first processed to remove bad data points above the water surface. The first data points below the water surface were defined as the surface velocities and the data points closest to the ADCP sensors were defined as bottom velocities. The mid-point velocities between surface and bottom velocities were defined as mid-layer velocities. Simulated results were extracted at the surface layer, mid-layer, and bottom layer from the stretched sigma layers at three cells nearest to the ADCP locations. Model validation was done through comparisons of major components of velocities.

Figure C.1. FVCOM Model Grid in Puget Sound

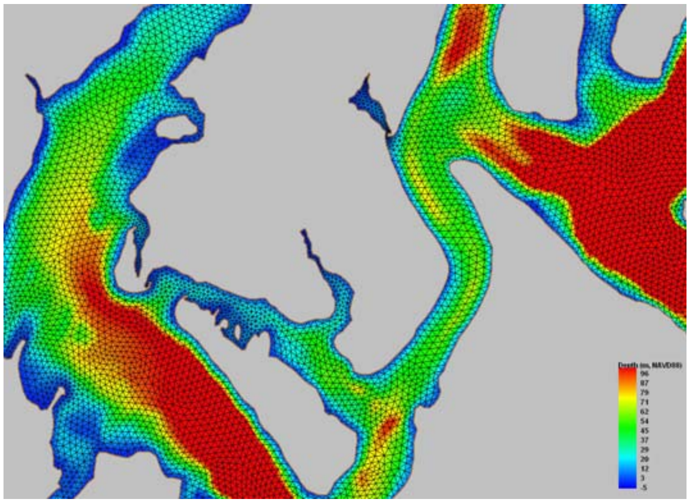
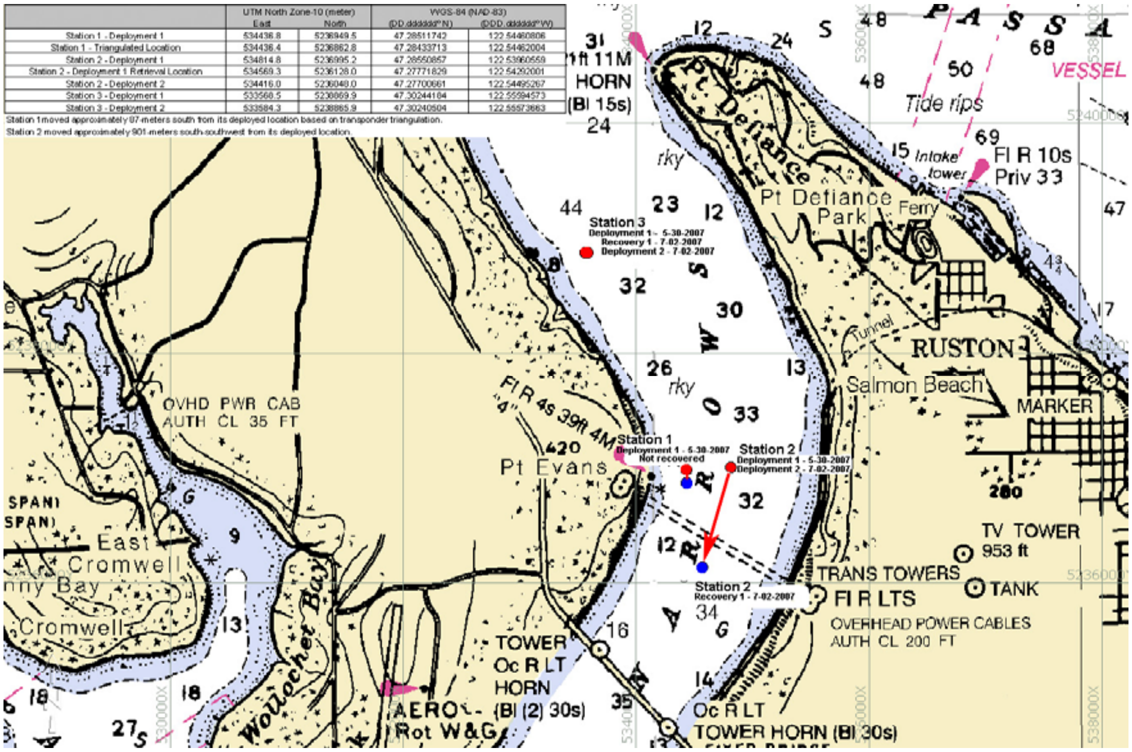


Figure C.2. Model Grid in the Region of Tacoma Narrows



	UTM North Zone-10 (meter)		WGS-84 (NAD-83)	
	East	North	(DD.dddddd° N)	(DDD.dddddd° W)
Station 1 - Deployment 1	534436.8	5236949.5	47.28511742	122.54460806
Station 1 - Triangulated Location	534436.4	5236862.8	47.28433713	122.54462004
Station 2 - Deployment 1	534814.8	5236995.2	47.28550857	122.53960559
Station 2 - Deployment 1 Retrieval Location	534569.3	5236128.0	47.27771829	122.54292001
Station 2 - Deployment 2	534416.0	5236048.0	47.27700661	122.54495267
Station 3 - Deployment 1	533568.5	5238869.9	47.30244104	122.55594573
Station 3 - Deployment 2	533584.3	5238865.9	47.30240504	122.55573663

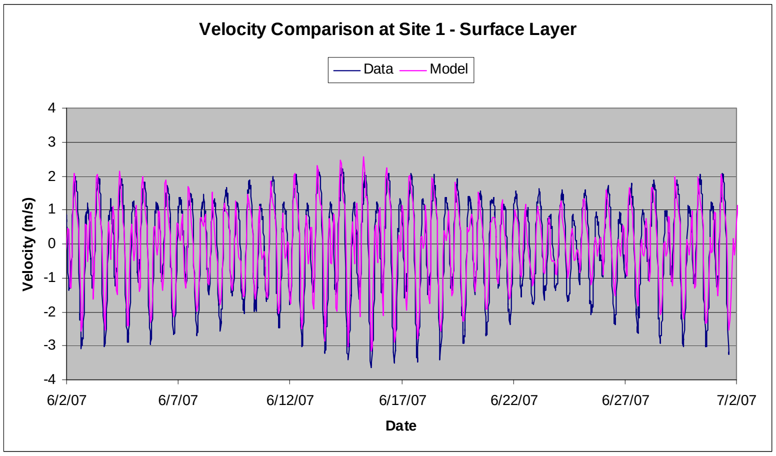
Station 1 moved approximately 87-meters south from its deployed location based on transponder triangulation.
Station 2 moved approximately 901-meters south-southwest from its deployed location.

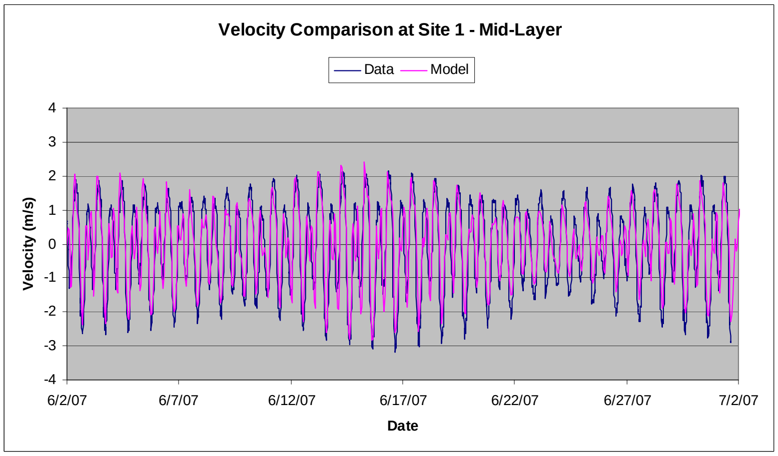
Figure C.3. ADCP Station Location Sites 1, 2, and 3, in Tacoma Narrows

Velocity data at Site 1, located on the west side of the channel, is available from May 30 to July 1, 2007. Comparisons of velocities at Site 1 are shown in Figure C.4. Predicted velocities were comparable to the observed data. However, the model slightly under-predicted the velocity magnitudes during flood tides (negative values). Comparisons of predicted and observed velocity data at Site 2 during ADCP deployment 1 (May 30 to July 1, 2007) are shown in Figure C.5.

Model results generally are in good agreement with the observed data. At the surface layer, a non-tidal velocity component was observed, which was probably due to the effects of wind and freshwater discharge. Velocity comparisons at Site 2 during deployment 2 (July 2 to August 1, 2007) are presented in Figure C.6.

Model results are similar to deployment 1 and predicted velocities matched the data reasonably well. We can also see that velocities at Site 2 are stronger than those at Site 1 because Site 2 is located at the center of the channel. At Site 3, data during deployment 1 were only available for a few days. Therefore, we only compared model results during the period of deployment 2 at Site 3. Figure C.7 shows that the model under-predicted velocities at Site 3 although it captured the tidal asymmetry (stronger flood tide indicated by negative values). The tidal asymmetry is primarily induced by the bend of the channel (similar to the effect of a headland), which resulted in strong flood and weak ebb currents at the upstream nearshore region of the bend (or headland).





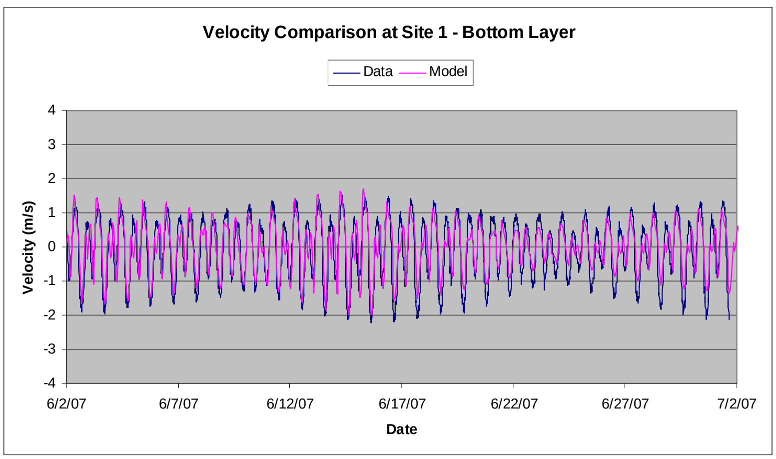


Figure C.4. Velocity Comparisons at Site 1 (deployment 1)

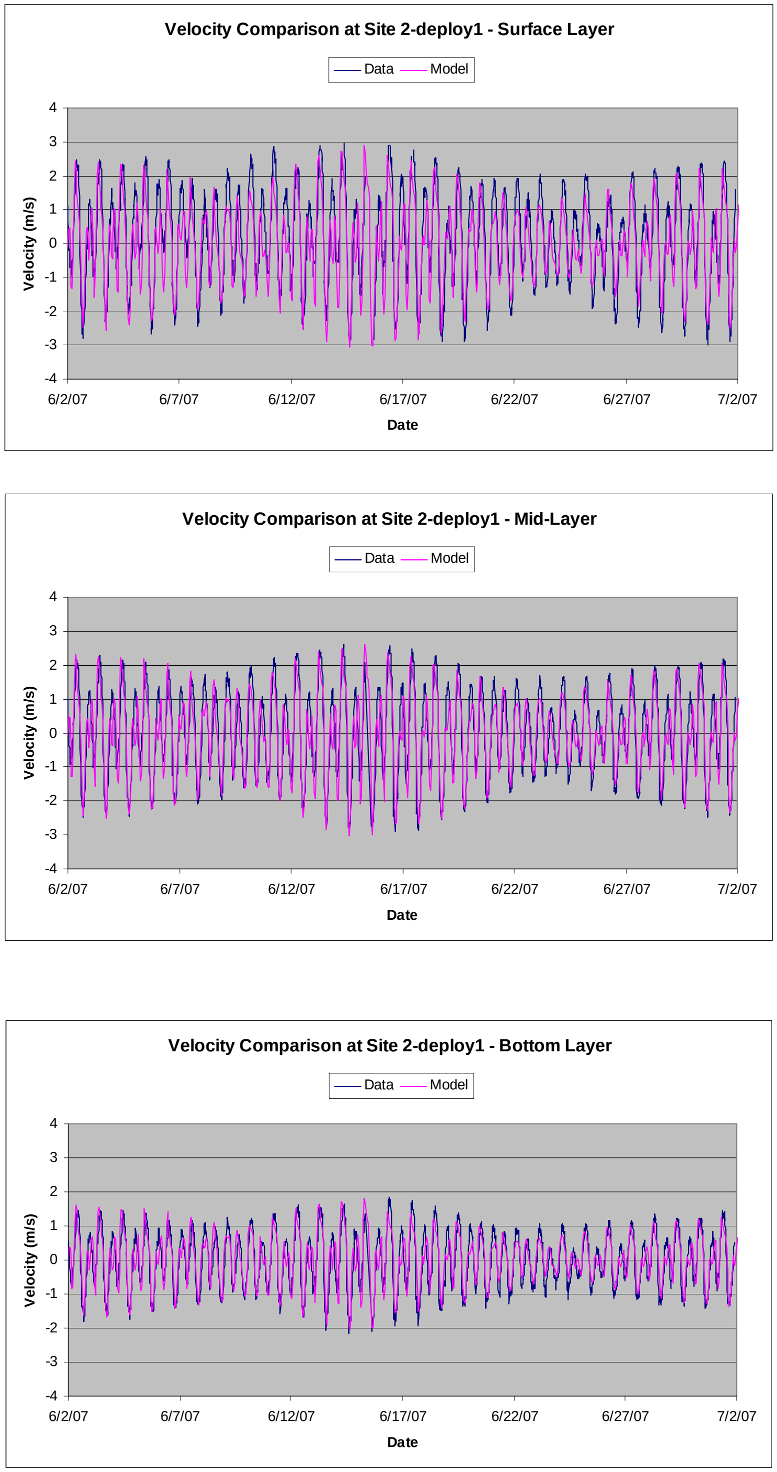


Figure C.5. Velocity Comparisons at Site 2 (deployment 1)

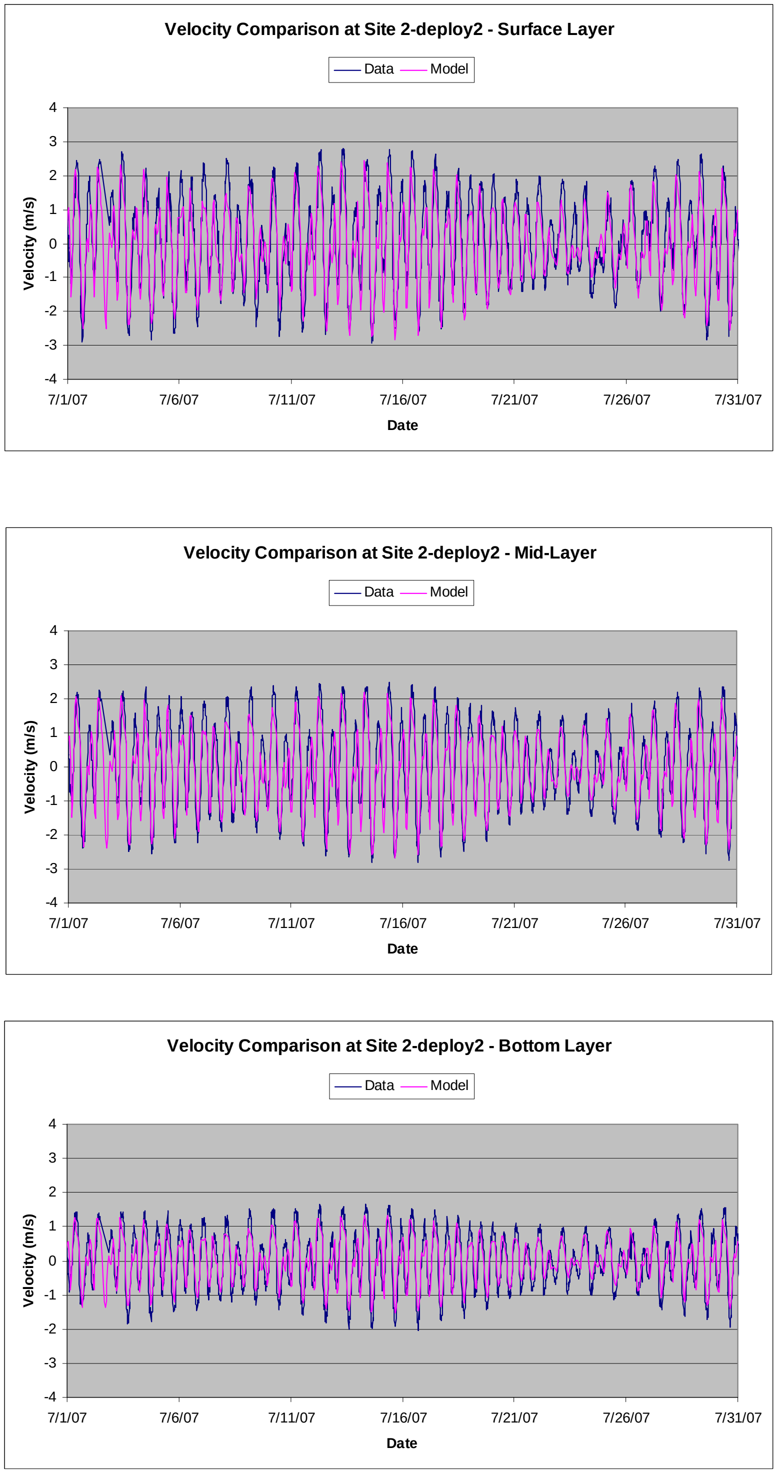
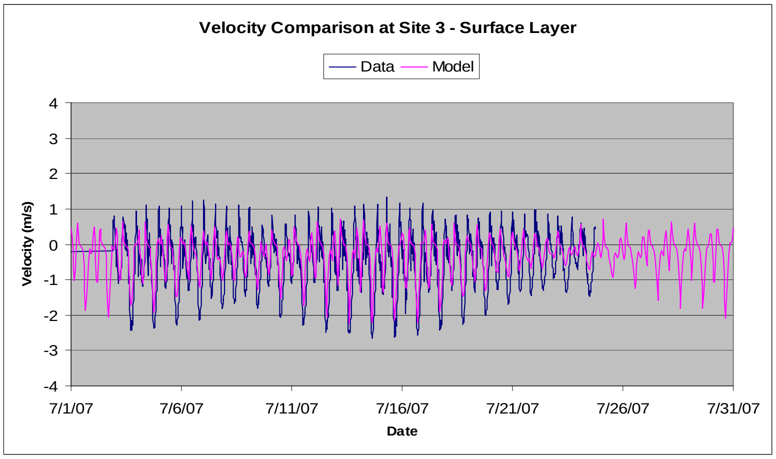
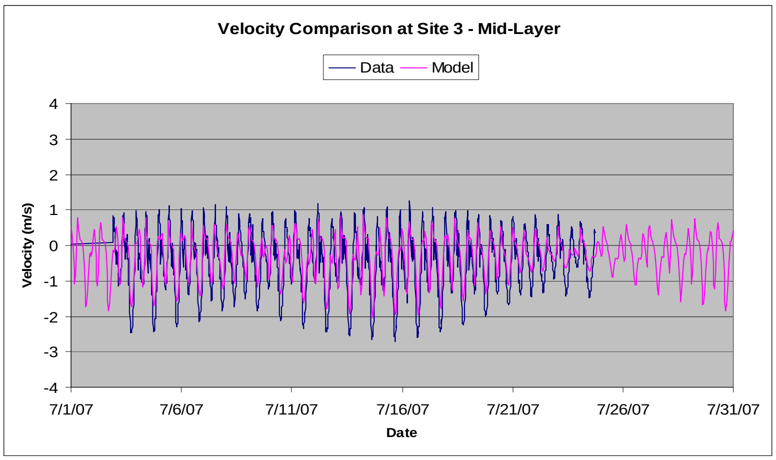


Figure C.6. Velocity Comparisons at Site 2 (deployment 2)





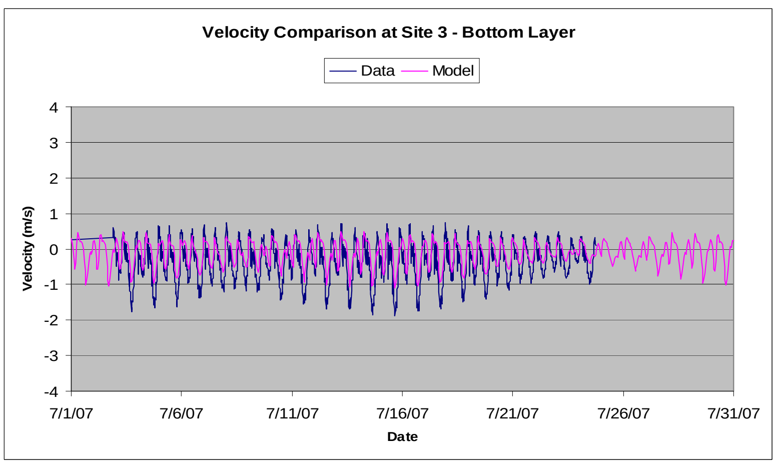


Figure C.7. Velocity Comparisons at Site 3 (deployment 2)

C.3 Summary and Next Steps

The velocity predictions from the PNNL Puget Sound Model at Tacoma Narrows matched the observed data reasonably well. However, errors exist due to a number of factors in the model setup and data processing:

- ADCP data at the surface and bottom layers were extracted from the water surface and the bottom; each data point represents a 1-meter interval. However, the PNNL Model results are distributed evenly over 10 vertical layers. At water depths greater than 10 meters (water depths at Sites 1, 2, and 3 are about 35, 55, and 65 meters), the model results integrate the velocity over a much thicker layer than the ADCP data.
- No wind and temperature effects were considered in the model run. Tacoma Narrows is a wide channel in which surface currents could be subjected to wind effects and surface heating.
- Due to the relatively short simulation time (2 months), the density (salinity) stratification simulated in the Sound may not have been fully developed, so that the baroclinic motion may not be well reproduced.
- The horizontal 2-D velocity distribution (Figure C.8) shows that there is strong transverse shear in Tacoma Narrows, especially near Site 3. Less than ideal locations chosen for model and data comparison could be a major factor accounting for the less satisfactory velocity validation at Site 3.

To increase the accuracy of velocity predictions, the following steps should be followed:

- Increase the number of vertical layers in the model (perhaps to 30 layers).
- Increase the grid resolution in the Tacoma Narrows region.
- Incorporate wind and heat flux terms and activate the temperature simulation module within the model.
- Fine tune the bottom roughness and friction coefficients.
- Conduct a longer-term (year-round) simulation. This is necessary for a large system such as Puget Sound, which has a long residence time for water
- Check quality assurance/quality control data locations and quality. In particular, check model bathymetry, especially near the ADCP data collection locations.

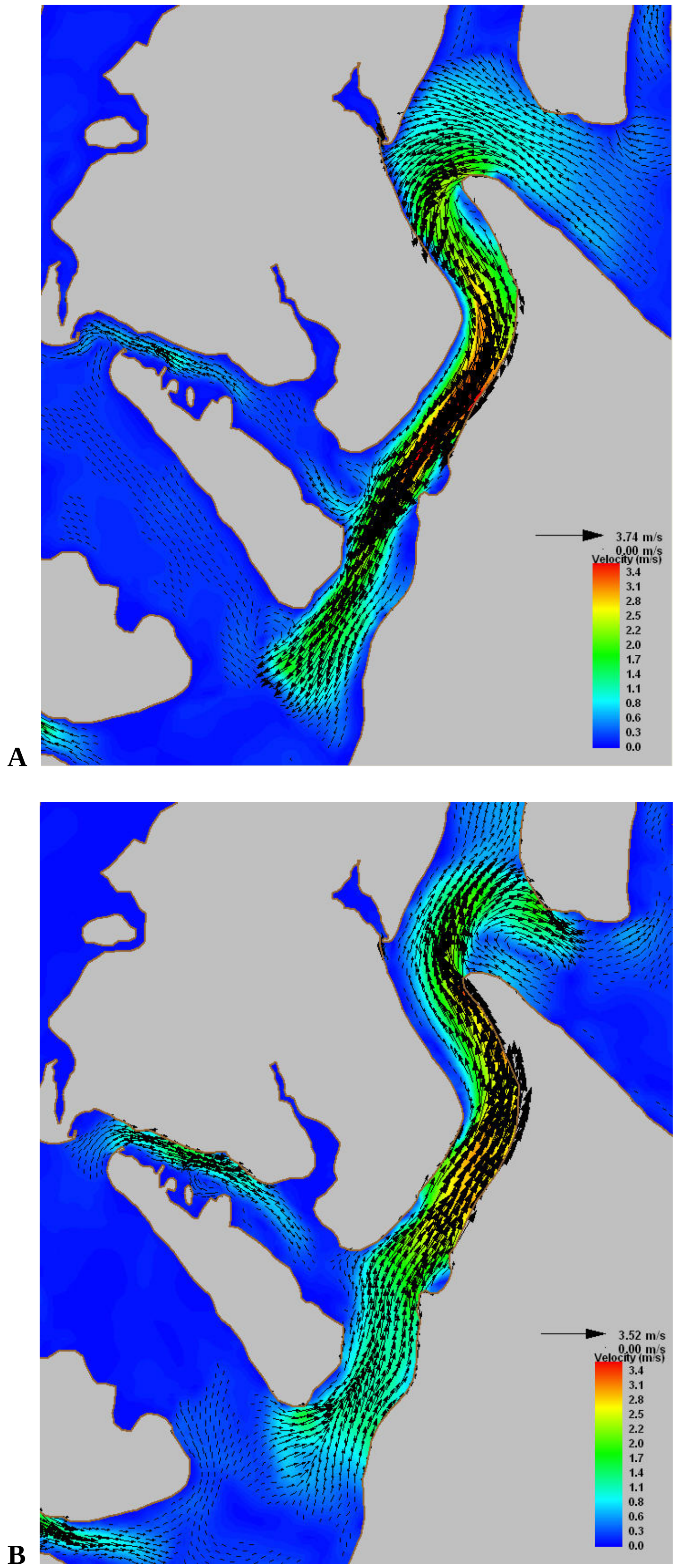


Figure C.8. Horizontal 2-D Velocity Distributions During Flood Tide (A) and Ebb Tide (B)

C.4 Reference

Chen C, H Liu, RC Beardsley. 2003. "An Unstructured, Finite-Volume, Three-Dimensional, Primitive Equation Ocean Model: Application to Coastal Ocean and Estuaries." *J. Atm. & Oceanic Tech*. 20:159-186.

Distribution

No. of
Copies

\# Name
Organization
Address
City, State and ZIP Code

\# Organization
Address
City, State and ZIP Code
Name
Name
Name
Name
Name (#)

\# Name
Organization
Address
City, State and ZIP Code

No. of
Copies

 # Foreign Distribution

\# Name
Organization
Address
Address line 2
COUNTRY

\# **Local Distribution**
Pacific Northwest National Laboratory

Name	Mailstop
Name	Mailstop
Name	Mailstop
Name	Mailstop
Name	(PDF)

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** *Since 1965*

U.S. DEPARTMENT OF
ENERGY

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99352
1-888-375-PNNL (7665)
www.pnl.gov