Guide to
Graduate Study and Research in
Ocean and Resources Engineering
University of Hawaii at Manoa

Rev: Fall 2004

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BACKGROUND

Hawaii's unique location, climate and marine-oriented activities make the University of Hawaii at Manoa an ideal place for education and research in ocean and resources engineering. The graduate program in ocean engineering at the University of Hawaii at Manoa was initiated in the Fall of 1966. It became an academic department in the College of Engineering in July 1968. In July 1977, the Department was accredited for its Master of Science program by the Engineer's Council for Professional Development (ECPD), now known as the Accreditation Board for Engineering and Technology (ABET). In October 1988, the University of Hawaii at Manoa officially integrated all marine-oriented programs into the School of Ocean and Earth Science and Technology (SOEST). The Department of Ocean Engineering and the Hawaii Natural Energy Institute of the College of Engineering became part of SOEST to form the technology component of this school. In July 1999, the department changed its name to Ocean and Resources Engineering (ORE) to better reflect the research thrust of the faculty.

Educational and research emphasis is placed on coastal engineering, offshore engineering, and ocean resources engineering. These areas are of vital importance to the State of Hawaii, the nation, and the world. Coastal engineering deals with coastal and harbor problems, sediment transport, nearshore environmental engineering, and coastal flood hazards. Offshore Engineering is concerned with structures and systems used in the deeper parts of the ocean, including the continental shelf. It includes hydrodynamics of fluid-body interaction, seakeeping and dynamic responses of ships and platforms, and hydroelasticity of very large floating structures, such as floating airports. Ocean resources engineering is concerned with the engineering systems to develop the energy, mineral, and living resources of the oceans, the use of the ocean for waste disposal, and the environmental and economic aspects of these activities. The educational and research programs in the department have a good balance between numerical and laboratory modeling as well as field observation. A total of 183 MS and 49 PhD students were graduated during the period 1966 to 2003.

ACADEMIC PROGRAM

Program Objectives

The Department of Ocean and Resources Engineering offers a graduate program leading to the Master of Science (MS) and Doctor of Philosophy (PhD) degrees. The goal of the program is to prepare students for the engineering profession and to conduct research in support of the education program. The objectives of the program at the MS level are to produce graduates who, during the first few years following the graduation,

1. are effective and creative engineers applying knowledge of mathematics and science to the solution of practical engineering problems;
2. have general understanding of and ability to work in the ocean and resources engineering disciplines;
3. are proficient in one or more of the ocean and resources engineering disciplines;
4. are aware of professional, managerial, legal, ethical, and other non-technical issues commonly encountered in engineering practice;

5. can communicate and work effectively with peers, clients, and the general public in promoting new ideas, products, or designs; and
6. can adapt to the changing needs and technology of the ocean and resources industry.

The program at the PhD level shares these objectives with the additional emphasis to produce graduates, who

7. are productive researchers conducting original research and developing new technology in ocean and resources engineering, and
8. have the experience to publish in refereed journals.

This additional emphasis prepares the PhD graduates to pursue research careers in industry or academia. These objectives along with the curriculum described in this guide were developed in collaboration with the advisory panel members listed in Appendix A.

MS Degree

The Ocean and Resources Engineering program at the MS level has the following requirements:

- Pre-program,
- MS General Exam,
- Core, option-area, and elective courses, and
- MS thesis or independent project.

The pre-program, which includes a general education component, one year of college-level mathematics and science, and one and one-half years of basic engineering topics, provides students a broad education background and covers technical and non-technical issues commonly encountered by engineers in professional practice. Students with an undergraduate engineering degree would satisfy the pre-program requirements. About 20% of the students in the program do not have an undergraduate engineering degree. The Department requires these students to make up the deficiencies by taking basic engineering courses listed in Appendix B.

The MS degree can be earned under either Plan A (thesis) or Plan B (independent project) option. The program requires a minimum of 30 academic credits. At least 24 credits must be earned in advanced courses numbered 600 or above. Up to two credits of directed reading and six transferred credits can be counted toward the MS requirements. Students, who satisfy the pre-program requirements, are required to take the General Examination during the first semester of their full-time enrollment to test their knowledge in mathematics, science, and basic engineering, and their preparation for the graduate-level coursework. Passing the exam advances the students to master's candidacy. Students, who passed the Fundamentals of Engineering (FE) examination within the last three years are exempted from taking the General Examination.

The core, option-area, and elective courses offered by the Department are listed in Appendix B. The core courses provide the students a broad understanding of the ocean and resources engineering disciplines that include hydrostatics, oceanography, water waves, fluid-structure interaction, and underwater acoustics. The laboratory course connects materials covered in the classroom with observations made and data gathered in the ocean. The option-area courses prepare students for specialization in

coastal, offshore engineering, or ocean resources engineering. The capstone design project is team-taught by faculty members and practicing professional engineers. Its objective is to familiarize students with the planning and design of a real-life engineering project in a consulting firm setting. Students are required to read a number of engineering case studies and write a paper on issues related to ethics and professional practice. All students are required to attend 15 seminars that cover the latest development and research related to ocean and resources engineering. The core and option-area courses and seminar requirement amount to 25 academic credits and the remaining credits are to be chosen to form a coherent plan of study.

Students complete their study with a Plan A thesis or Plan B independent project. The Plan A thesis is research oriented and students receive six academic credits for the work. The Plan B independent project focuses on engineering application or design and carries three academic credits. Both require a proposal outlining the subject area, objectives, proposed methodology, sources of data, and anticipated results that must be approved by a committee of at least three graduate faculty members. The project provides students an opportunity to explore and contribute to the development of the latest technology in an ocean and resources engineering discipline. The work results in a thesis or a report that demonstrates both mastery of the subject matter and a high level of communication skills. The student must present and defend the work at a final examination, which provides the faculty a final opportunity to test the student's understanding and ability to integrate his or her work at the MS level.

PhD Degree

Students pursuing the PhD degree are required to achieve a broad understanding of the principal areas of ocean and resources engineering, as well as a thorough understanding of a specific area. Students must, at a minimum, possess the knowledge covered by the core and required courses of the MS degree in ocean and resources engineering.

All intended candidates for the PhD degree must take a written qualifying examination before or during the third semester of full-time enrollment. In addition to covering the basic undergraduate fundamentals, the 6-hour examination tests the students' understanding of the coursework at the MS level. Students receiving an average of 75% or above pass the exam, and below that, will be judged on a case-by-case basis by the faculty.

After passing the qualifying examination and being advanced to candidacy, the students must take a comprehensive examination, which tests their ability to carry out original research and preparation for the selected dissertation topic. The examination has a five-day (Monday through Friday) written component and an oral component in the following week. The written component is equivalent to a take-home exam. The students have access to books, computers, and software, but must not discuss the questions with anyone other than the exam committee members. The oral examination provides the students an opportunity to address issues that may arise from the written part and to defend the novelty of the proposed research.

The dissertation topic must be approved by a committee consisting of a minimum of five graduate faculty members with at least one from outside the Department. In addition, the Department Chair may appoint a member to the committee. The student is encouraged to publish the research work in refereed journals in order to obtain feedback from the research community and to develop a publication track record prior to graduation. The student must present and defend the dissertation at a final examination.

Timeline

The minimum residency requirement for an MS degree at the University of Hawaii at Manoa is two semesters full-time. Based on Graduate Division statistics, the average time to complete an MS degree in Ocean and Resources Engineering is 2.5 years. The following chart outlines the typical timeline to satisfy the requirements in the MS program. Since the core and option-area courses are offered in the fall-spring semester sequence, most students begin their enrollment in the fall semester. Students with an undergraduate engineering degree proceed directly to the program coursework and take the General Examination during their first semester. Most of them complete the degree requirements between 16 months and two years. Students with pre-program deficiencies typically spend three years full-time to complete the program.

Requirements	Academic Year			Academic Year			Academic Year		
	Fall	Sp	Sum	Fall	Sp	Sum	Fall	Sp	Sum
Pre-program									
General Examination									
Program Coursework									
Approval of research topic									
Final Examination									

The minimum residency requirement for a PhD degree is three semesters full-time. Based on Graduate Division statistics, the average time to complete a PhD degree in Ocean and Resources Engineering is 5.5 years. Most students finish the program in four to five years. The following chart shows the typical timeline to satisfy the PhD program requirements. Most students admitted into the PhD program have already satisfied the pre-program requirements and proceed directly to the program coursework. Students normally take the PhD Qualifying Examination after a year of coursework and take the Comprehensive Examination within three years after enrollment.

Requirements	Academic Year			Academic Year			Academic Year			Final Sem
	Fall	Sp	Sum	Fall	Sp	Sum	Sum	Fall	Sp	
Program Coursework										
PhD Qualifying Exam										
PhD Comprehensive Exam										
Final Examination										

Students failing any one of the general, qualifying, comprehensive, and final examinations twice will be dropped from the program. Students, who do not complete all requirements within seven years after admission, will be automatically dropped from the program. Reinstatement for a limited period of time is possible only upon submission of a petition by the department chair providing a detailed degree plan and new limited timeline to completion of all degree requirements.

FACULTY

Departmental Faculty

The Department of Ocean and Resources Engineering has four full-time faculty positions held by

- K.F. Cheung, PhD, PE, Chair and Professor – Coastal and offshore engineering, hydrodynamics, computational methods, water wave mechanics, sediment transport.
- R.C. Ertekin, PhD, Professor – Hydrodynamics, hydroelasticity, computational methods, nonlinear water waves, offshore mechanics.
- H.J. Krock, PhD, PE, Professor – Environmental engineering, mixing and transport, water quality, ocean thermal energy conversion, hydrogen.
- G. Pawlak, PhD, Assistant Professor – coastal mixing processes, fluid dynamics, sediment transport.

The Department has strong ties with the Hawaii Undersea Research Laboratory. Two of their staff have faculty appointments in the Department.

- B.D. Greeson, PhD, US Navy Captain (Ret.), USCG Certified Chief Engineer, Specialist, Hawaii Undersea Research Laboratory—Offshore engineering, hydrodynamics, ROV/submersible operations
- J.C. Wiltshire, PhD, Associate Specialist and Acting Director, Hawaii Undersea Research Laboratory — acoustics, marine mineral deposits, marine mining technology.

All departmental faculty members are also graduate faculty with the University of Hawaii Graduate Division and are responsible for the education and research programs in the Department.

Cooperating Graduate Faculty

The Department also has a number of cooperating faculty members from various academic and research units at the University of Hawaii. These include

- J.M. Becker, PhD, Associate Professor, Geology and Geophysics;
- R.H. Knapp*, PhD, PE, Professor, Mechanical Engineering;
- A. Malahoff, PhD, DSc, Professor, Oceanography; Director of Hawaii Undersea Research Laboratory (HURL);
- S.H. Masutani, PhD, PE, Associate Researcher, Hawaii Natural Energy Institute;
- M.A. Merrifield*, PhD, Associate Professor, Oceanography;
- G. Nihous, PhD, Associate Researcher, Hawaii Natural Energy Institute;
- H.R. Riggs, PhD, Professor, Civil and Environmental Engineering;
- J.R. Smith, PhD, Assistant Researcher, Hawaii Undersea Research Laboratory; and
- J. Yu*, PhD, Associate Professor, Hawaii Natural Energy Institute.

Their research areas include acoustics, applied mathematics, coastal processes, environmental engineering, finite element method, nonlinear water waves, ocean currents, ocean resources, seafloor mapping, sedimentology, and structural mechanics. The cooperating graduate faculty members give seminars of their research projects and serve on student research committees. Some of them (*) teach courses in the Department.

Affiliate Graduate Faculty

Four affiliate graduate faculty members from the engineering and scientific communities are currently serving on the faculty:

- D. Rezachek, PhD, PE, Rezachek & Associates, Honolulu, Hawaii.
- J. Van Ryzin, PhD, PE, President, Makai Ocean Engineering, Inc., Kailua, Hawaii.
- D. Vithanage, PhD, PE, Technical Director and Vice President, Oceanit Laboratories, Inc., Honolulu, Hawaii.

These practicing professionals volunteer their time and bring in real-world engineering experience to the academic program. They give seminars of their engineering projects, serve on student research committees, and participate in the capstone design project.

RESEARCH FACILITIES

Computing Facility

The Department of Ocean and Resources Engineering and the faculty operate four AIX and five Linux systems and a network of Pentium-based PCs. All students are given computer accounts on at least one of the Unix systems and the PC network. All PCs are installed with Win NT and MS Office. The Department has a joint research project with the Maui High Performance Computing Center (MHPCC), which provides computer accounts to research assistants working on the project.

The Department maintains a number of software packages that are available to the students for coursework and research. These include

- AutoDesk Mech, Map Series, Civil Series, V1Z4, and Express Viewer
- AutoCAD 2004
- Automated Coastal Engineering System (ACES)
- Coastal Engineering Manual (CEM)
- COMET (Computational Fluid Dynamics)
- COSMOS/M (finite element)
- Matlab
- MathCAD
- Mathematica (symbolic algebra)
- Microstation SE
- Photoshop
- Tecplot (graphics)
- Visual Fortran

Students taking ORE 630 are also given access to the finite element package ANSYS, which is maintained by the Department of Mechanical Engineering.

Environmental Fluid Dynamics Laboratory

The Department of Ocean and Resources Engineering's Environmental Fluid Dynamics Laboratory (EFDL) focuses on the study of coastal marine processes including turbulent dispersal of pollutants and nutrients, wave dynamics, and sediment transport. In addition, the laboratory is home to the Environmental Fluid Dynamics Education Laboratory, which serves as a center for teaching of fluids phenomena in support of courses within ORE and SOEST and is available to the general University community. Laboratory instrumentation includes an acoustic doppler velocimeter (ADV), which obtains high frequency, single point, 3-component velocity measurements. A laser-based Particle Imaging Velocimetry (PIV) system obtains two-dimensional fluid velocity via laser imaging techniques. An Argon-Ion laser with digital still and video cameras is used for flow visualization and measurement.

The EFDL currently houses four experiment tanks, which are used for both research and teaching demonstrations. These include a 10-meter long, 30 x 10 cm wave channel and a rotating table. The tanks allow demonstration of a range of fluid flow phenomena including wave breaking, down-slope currents, internal waves in stratified fluids along with rotational effects such as spin-up, Ekman flow and geostrophy.

Field Work and In-Ocean Experiment

The Department maintains research facilities at Kewalo Basin and Snug Harbor for field work and in-ocean experiments. These facilities include field research equipment and instrumentation, access to a 17 ft motorboat and an 18-m coastal research vessel, as well as machine shop support. A 7 acre in-ocean test range off Kewalo Basin extends from 5 to 20 meters depth with test platforms equipped with land-based power supply outlets and data connections. Field equipment includes SCUBA diving gear, acoustic current profilers, current meters, wave gauges, anemometers, buoys, and mooring equipment. The field research facilities support study of ocean and coastal structures and materials, wave dynamics and sediment transport.

The Hawaii Undersea Research Laboratory (HURL) is one of six national laboratories comprising the National Oceanic and Atmospheric Administration's National Undersea Research Program. HURL operates two deep diving (2000m) submersibles, the PISCES IV and PISCES V, and a remotely operated vehicle. The ROV and submersibles operate off the 225-foot research vessel, Kaimikai-O-Kanaloa, obtained for the university and largely supported by HURL. The submersibles, ROV and their mothership conduct a wide range of engineering and science research activities. Time on the submersibles and ROV is available to the faculty and students through submission of proposals. In addition, many students in the Ocean and Resources Engineering program find thesis projects, financial support, and advisors studying various aspects of the dynamics of submersible and ROV operations as well as new instrumentation, control and equipment applications. HURL and the Department of Ocean and Resources Engineering have a very close working relationship at all levels.

ADMISSION, INITIAL ASSESSMENT, AND ADVISING

Students are admitted for graduate study on the basis of their scholastic records. Degree candidates for the MS program usually have a bachelor's degree in an engineering discipline that provides an adequate background in mathematics, physics, chemistry, and mechanics. Students with mathematics, physics or other science backgrounds may be admitted to the program, but are required to take specific

undergraduate engineering courses to satisfy the pre-program requirements as outlined in Appendix B. Students seeking admission to the PhD program should have an MS in engineering or equivalent qualification. However, exceptionally well-qualified students with a BS in engineering, who do not have a master's degree, may petition to be admitted to the PhD program directly.

Students submit their admission applications to the University of Hawaii Graduate Division, which will perform initial screening to assure satisfaction of the university admission requirements. The department chair then evaluates the applicants and determines their admissibility to the Ocean and Resources Engineering program. The department chair also provides consultation to applicants and matches applicants of research assistantships with research projects. Official scores in the GRE General Test are required for all PhD applicants. Entering non-native English speaking students are required to have taken a TOEFL examination to evaluate their English language abilities. Depending on their TOEFL scores, these students will be individually evaluated at the University of Hawaii English Language Institute and assigned English-as-Second-Language (ESL) courses if necessary. Detailed requirements for admission are set forth in the General and Graduate Information Catalog, available at the University of Hawaii bookstore for a nominal fee. The deadlines for submission of applications are February 15 (foreign students) and March 15 (U.S. students) and August 15 (foreign) and September 15 (U.S. students) for Fall and Spring semesters, respectively.

Upon admission, the department chair meets with each incoming student at a preliminary conference to discuss the program requirements and determine any pre-program deficiencies. The University of Hawaii Graduate Division requires that all transfer credits must not be used in obtaining a prior degree and must be approved during the first semester of enrollment. The Ocean and Resources Engineering program allows up to six transfer credits of courses taken elsewhere. These courses must be equivalent to the core and option-area courses of the program and approved by the instructors upon evaluation of the course notes, assignments, and exam questions. The department chair will then recommend to the Associate Dean of Graduate Division to approve the transfer credits. The student identifies an area of study from one of the three option areas, and selects an academic advisor from the departmental faculty, who specializes in that area of study. The department chair serves as the advisor to the students without an undergraduate engineering degree until they satisfy the pre-program requirements and select academic advisors from their areas of study. The academic advisors review the coursework of the students every semester until they progress to the research stage and are advised by their research advisors, who are also tasked to monitor the students for three years after their graduation. All the information is recorded in the student progress form, which provides data for subsequent program assessments.

FINANCIAL SUPPORT AND RESEARCH PROJECTS

Financial support is available for a number of students in the form of graduate assistantships (research and teaching), which include tuition waivers and a subsidized fringe benefit package. A limited number of tuition waiver scholarships are also available. Research projects not only provide financial support for graduate assistants, but also furnish students with an opportunity to participate in engineering studies to familiarize themselves with current theoretical, numerical, and experimental methods.

Research projects awarded to the department during 1996 – 2004 include

- Analytical Investigation of the Wave Induced Response of Very Large Floating Structures, National Science Foundation;
- Analytical Process for a GPS Directional Wave Buoy, Army Research Office via Makai Ocean Engineering, Inc., Honolulu, Hawaii;
- Cold Seawater Air Conditioning Study, Department of Business, Economic Development, and Tourism, State of Hawaii;
- Environment for Design of Advanced Marine Vehicles and Operations Research, ONR Ship Science and Technology Division;
- Evaluation of a Sand Washing Procedure for the Proposed Renovation of the Natatorium, Leo A. Daly, Inc., Honolulu, Hawaii;
- Evaluation of Pneumatically Stabilized Platforms, ONR/DARPA;
- Evaluation of Tsunami Evacuation Maps for Hawaii, National Tsunami Hazard Mitigation Program;
- Field Observations of Wave Flow Over a Rough Boundary, University of Hawaii Research Council;
- Inverse Algorithm for Tsunami Inundation Forecasts, NOAA Sea Grant;
- Hindcast of Hurricane Winds and Waves Based on Coastal Sedimentary Records, Bermuda Biological Station for Research, Inc.;
- Molokai Fishpond: Circulation Study, NOAA Sea Grant;
- Motion Initiation and Transport of Tropical Island Beach Sand, NOAA Sea Grant;
- Numerical and Laboratory Modeling of the Pneumatically Stabilized Platform, ONR/DARPA;
- Observations of Tidal Headland Eddies in Deep Water, National Science Foundation via University of Washington;
- Refraction-diffraction of Directionally Spread, Nonlinear, Random Waves in the Nearshore Environment, NOAA Sea Grant;
- Real-time Simulation Package for Storm Surge and Wave Runup, NASA Office of Earth Science;
- Tsunami Forecast System and Evacuation Map for Hawaii, National Tsunami Hazard Mitigation Program;
- The Study of the Spatial Coherence of Surface Waves by the Nonlinear Green-Naghdi Model in Deep Water, ONR Mobile Offshore Base Program; and
- Wave Boundary Layer over an Irregular Bottom, ONR.

In addition, the departmental and cooperating faculty members are involved in a number of research projects outside the department that also provide support to students in Ocean and Resources Engineering.

Most PhD students in the Department are supported by graduate assistantships throughout their study, while MS students engaged in the Plan A thesis option usually receive support after the first year of coursework. Applications for financial support

should be submitted to the Department by March 1 for the Fall semester and September 1 for the Spring semester.

PLACEMENT DATA

Statistics from the 1993 – 2002 graduates provide a clear picture of where the students are coming from and where they are heading after graduation. Approximately 50% of the students were recruited from US mainland, 45% from foreign countries, and 5% from Hawaii (those who went through high school or undergraduate education in Hawaii). However, 40% of the graduates found work or continued to study in Hawaii, 50% moved to US mainland, and 10% returned to their countries of origin. Almost all of the graduates obtained employment or continue to study in the ocean and resources engineering disciplines and 90% of them remain in the same disciplines as of Spring 2003.

Career opportunities for graduates in ocean and resources engineering exist in several areas. Approximately 55% of the 1993 – 2002 graduates found work in private industry including oil companies, consulting and environmental service firms, classification societies, and construction firms in the US. About 20% of them joined or continued their employment with federal agencies such as the Army Corps of Engineers, Navy Civil Engineer Corps, and Pacific Missile Range Facility; and 5% found work with the State of Hawaii and the University of Hawaii. Another 10% entered PhD programs at US universities. The 10% of graduates, who returned to their countries of origin, mostly work for government agencies and research institutes.

FOR FURTHER INFORMATION, WRITE:

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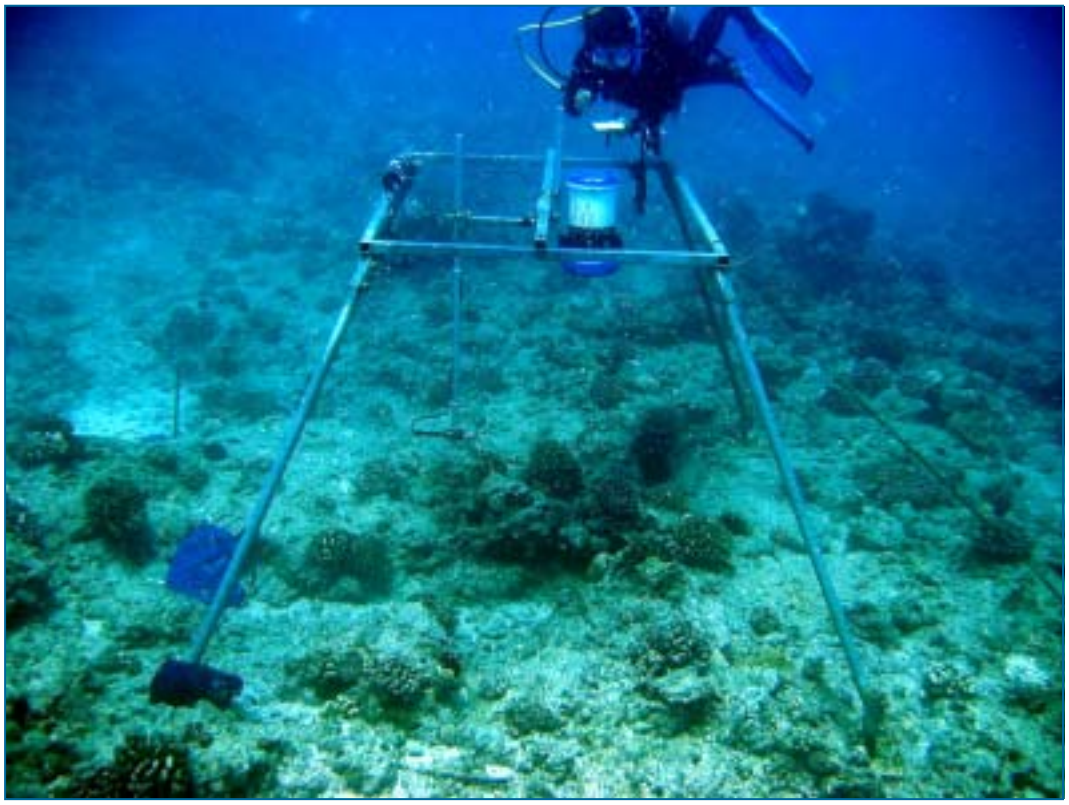


ORE PhD candidate Marion Bandet adjusts instruments on the WBLP platform during a field observation (Courtesy of Prof. Geno Pawlak).

APPENDIX A. ADVISORY PANELS

The Ocean and Resources Engineering faculty regularly assess and update the education objectives, program outcomes, assessment processes, and academic program with input from surveys of alumni and their employers as well as panels of professionals representing the ocean and resources engineering communities. The last cycle of assessment was completed in Spring 2002 and an updated academic program was implemented in Fall 2002. The following local and international panels participated in the last cycle of assessment and provided input to the education objectives and academic program described in this guide.

Local Professional Advisory Panel

1. Karin Lynn, PE (Chair), Captain, Civil Engineer Corps, US Navy Regional Requirements Officer, Pearl Harbor, Hawaii.
2. Jose Andres, PhD, PE, Vice President, Makai Ocean Engineering Inc., Waimanalo, Hawaii.
3. Roger Babcock, PhD, PE, Associate Professor, Department of Civil and Environmental Engineering, University of Hawaii, Honolulu, Hawaii.
4. Paul Bienfang, PhD, Senior Vice President, CEATEC U.S.A., Honolulu, Hawaii.
5. Warren Bucher, PhD, Vice President, Oceanit Laboratory Inc., Honolulu, Hawaii.
6. Gary Godshak, Director of Hawaii Operations, Orincon, Kailua, Hawaii.
7. Robert Rocheleau, PE, President, Sea Engineering Inc., Waimanalo, Hawaii.
8. Elaine Tamaye, President, Ed Noda and Associates, Honolulu, Hawaii.
9. Gabriel Zee, PhD, Vice President, Pacific Marine and Supply Company, Honolulu, Hawaii.

International Professional Advisory Panel

1. Thomas Mathai, PhD (Chair), Senior Analyst, The Glosten Associates, Inc., Seattle, Washington.
2. Willem Bakker, Visiting Scientist, WL | Delft Hydraulics, Delft, The Netherlands. Formerly, Head of Research and Development (Flushing) Directorate General of Public Works and Water Management (Rijkswaterstaat), The Hague, The Netherlands.
3. Roger Basu, PhD, Manager, Advanced Analysis Department, ABS Americas, Houston, Texas.
4. Sander Calisal, PhD, PEng, Professor, Department of Mechanical Engineering, University of British Columbia, Vancouver, B.C., Canada; Associate Editor, ASME Journal of Offshore Mechanics and Arctic Engineering.
5. Subrata Chakrabarti, PhD, PE, President, Offshore Structure Analysis, Inc., Plainfield, Illinois; Editor, Applied Ocean Research.
6. Zeki Demirbilek, PhD, PE, Research Hydraulic Engineer, Army Engineer Research and Development Center, U.S. Army Corps of Engineers, Vicksburg, Mississippi; Editor, ASCE Journal of Waterway, Port, Coastal, and Ocean Engineering.

7. John Halkyard, ScD, PE, Vice President, Deepwater Research and Development, CSO Aker Maritime, Inc., Houston, Texas.
8. Paul Palo, PhD, PE, Mechanical Engineer, Ocean Facilities Department, Naval Facilities Engineering Service Center, Port Hueneme, California.
9. Tar-Zen Su, PhD, Associate Professor, Marine Engineering Department, National Taiwan Ocean University, Keelung, Taiwan.
10. Pieter Wybro, PhD, PE, President, Sea Engineering Inc., Houston, Texas.

APPENDIX B. COURSEWORK REQUIREMENTS

The Department of Ocean and Resources Engineering offers a graduate program and relies on the students' undergraduate education to fulfill the pre-program requirements that include

1. a general education component including economics, management, and humanities;
2. one year (32 credits) of college level mathematics and basic science; and
3. one and one-half years (48 credits) of basic engineering science and design.

These requirements cannot be satisfied with graduate-level courses. Students with undergraduate engineering degrees normally satisfy these requirements and can directly proceed to the graduate-level Ocean and Resources Engineering program. Students with undergraduate degrees in mathematics and science will be required to make up deficiencies in basic engineering courses including

- computer aided design (CAD),
- statics,
- dynamics,
- fluid mechanics,
- solid mechanics, and
- probability and statistics,

and elective courses in the following subjects depending on the student's intended option area in the Department:

- surveying,
- hydraulics,
- civil engineering materials,
- structural mechanics,
- geotechnical engineering,
- environmental engineering,
- corrosion engineering,
- thermodynamics,
- heat transfer,
- material science and engineering, and
- advanced engineering mathematics.

The Department of Ocean and Resources Engineering offers a graduate program that includes a core program, an option-area program, electives, and a dissertation, thesis or independent project. The 15-credit core program covers

- ORE 411 Buoyancy and Stability (3 credits)
- ORE 601 Ocean Engineering Laboratory (3)
- ORE 603 Oceanography for Ocean Engineers (3)
- ORE 607 Water Wave Mechanics (3)
- ORE 609 Hydrodynamics of Fluid-Body Interaction (3)

The students select a 9-credit option-area program in coastal engineering, offshore engineering, or ocean resources engineering.

For coastal engineering, students take

- ORE 661 Coastal and Harbor Engineering (3)
- ORE 664 Near-shore Processes and Sediment Transport (3)
- ORE 783B Capstone Design Project – Coastal (3)

For offshore engineering,

- ORE 612 Dynamics of Ocean Structures (3)
- ORE 630 Structural Analysis in Ocean Engineering (3)
- ORE 783C Capstone Design Project – Offshore (3)

For ocean resources engineering,

- ORE 677 OTEC Systems (3)
- ORE 678 Marine Mineral Resources Engineering (3)
- ORE 783D Capstone Design Project – Ocean Resources (3)

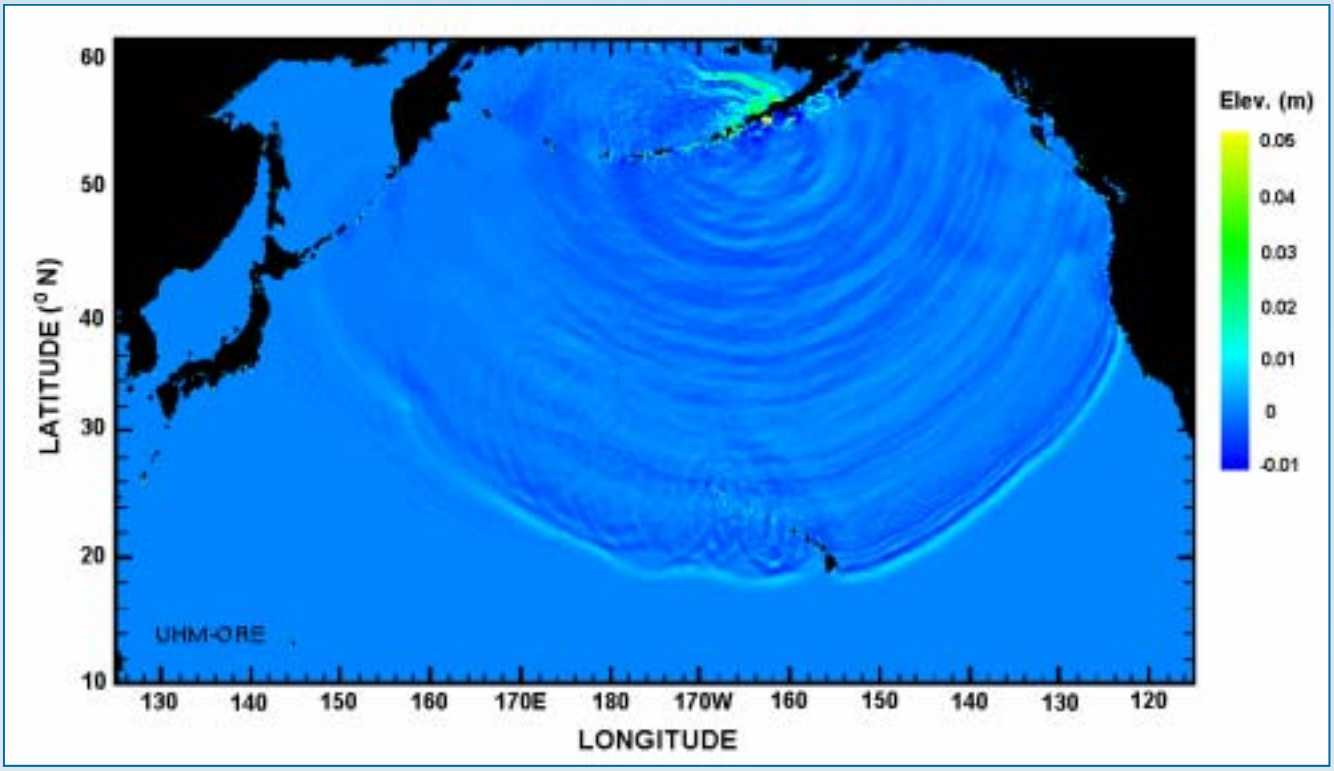
In addition, all students must take the 1-credit ORE 792 Seminar by attending 15 seminars that are related to ocean and resources engineering.

Although the University of Hawaii Graduate Division requires a minimum of 30 credits for graduation, most students take more than the required minimum, averaging around 33 credits.

Students are encouraged to take courses in other option areas as electives. In addition, the Department offers the following electives:

- ORE 608 Probability and Statistics for Ocean Engineers (3)
- ORE 620 Marine Bio-process Engineering (3)
- ORE 621 Bioreactor Design (3)
- ORE 641 Environmental Fluid Dynamics (3)
- ORE 642 Marine Environmental Remediation (3)
- ORE 699 Directed Reading or Research (V)
- ORE 707 Nonlinear Water Wave Theories (3)
- ORE 766 Numerical Analysis of Hydrodynamic Problems (3)
- ORE 791 Special Topics (V)

Other departments offer a number of courses relevant to ocean and resources engineering. These courses are approved on an individual basis as electives by the academic advisor.



Pre-computed tsunami from the Alaska-Aleutian source region (Courtesy of ORE PhD candidate Yong Wei).

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