Troy W. Heitmann, PhD

troyheit@hawaii.edu
Waimānalo, HI 96795

Results-driven Coastal Engineer and Wave Energy Specialist with a PhD in Ocean Engineering and 10+ years of combined experience in wave modeling and wave energy research. Expertise in coastal processes, fluid dynamics, and fluid-body interactions. Proficient in numerical modeling, programming, and ocean instrumentation. Recognized for exceptional data analysis skills and a track record of successful research projects. A unique blend of field and technical expertise.

Education

University of Hawai'i at Mānoa

- PhD in Ocean Engineering August 2023
  Advisor: Kwok Fai Cheung
  Title: "Enhanced Fully Nonlinear Boussinesq-Type Equations in Conserved Variable Form and Linear Analytic Properties with Compact Finite Difference Schemes"
- MS in Ocean Engineering May 2010
  Focus: Coastal Engineering
  Title: "Morphodynamic Classification of Beaches in Tropical Environments"

Florida Atlantic University

- BS in Ocean Engineering, May 2007
  Minor: Mathematics

Engineering Design and Instrumentation

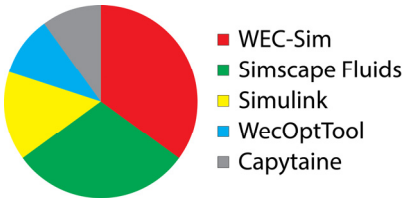
- Engineering CAD (Fusion 360)
- ParaView
- Microcontroller and microprocessor boards
- 3D Fused Deposition Modeling
- Machining (lathe, mill, bandsaw, etc.)
- Photogrammetry
- Structure From Motion (SFM)
- Computer Vision (OpenCV)
- Quantum Geographic Information System (QGIS)
- General Mapping Tools (GMT)
- Real-Time Kinematic (RTK) mapping

Advanced Computing

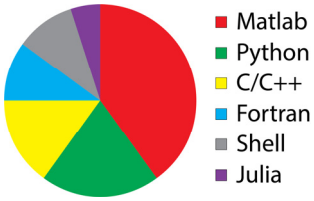
- High performance computing
  - Slurm and OpenPBS
- Parallel Computing (OpenMP, MPI, CUDA)
- Version Control
  - GitHub and GitLab
- Linux OS (Ubuntu, Centos, RedHat)
- Virtual Machines

Global and Coastal Wave Modeling

Wave Energy Converter Modeling



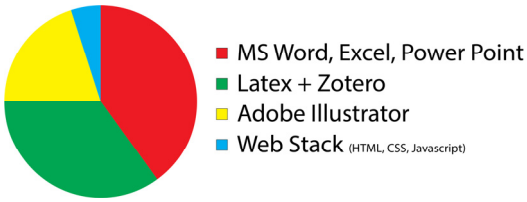
Programming Languages



Licenses/Certifications

- AAUS scientific scuba diver
- NAUI Divemaster
- FAA drone pilot
- EIT Certification (#1100011875)

Reporting and Dissemination



Work Experience

Hawai'i Natural Energy Institute: *Position* – Assistant Researcher (R3) 02/24 - present
Duties Included: I not only continue to fulfill the duties initiated during my time as a Research Specialist (see below), but have also taken on additional responsibilities focused on the strategic development of the Hawai'i Marine Energy Center (HMEC). Appointed as "Director of Outreach" (unofficial title), I play an instrumental role in developing HMEC's identity as a Pacific Island leader in marine energy. My role involves spearheading initiatives to enhance HMEC's visibility throughout Hawai'i and the US Affiliated Pacific Islands (USAPI), fostering partnerships with industry stakeholders, and leading efforts to expand marine energy research and infrastructure. Additionally, I am actively involved in improving STEM outreach and engagement, ensuring that HMEC's projects and objectives are communicated effectively to diverse audiences. In collaboration with fellow colleagues, these efforts have been documented in a Statement of Project Objectives (SOPO) submitted to the US Department of Energy (DOE). I also developed and submitted a SOPO for each of the two HMEC research projects I'll be leading, which are now anticipated to begin August 2024.

In Spring 2024, budget period one of the Hawai'i Oscillating Surge Wave Energy Converter (HAWSEC) project was completed and entered a "Go/No-Go" phase. My colleagues and I prepared a continuation application, documenting project outcomes and lessons learned, which we then presented to a review panel for evaluation. After receiving a conditional "Go", I drafted a medium-scale test plan to be executed at the National Renewable Energy Laboratory (NREL) for budget period two. However, the estimate from NREL indicated a significant cost overrun in our budget. To address this, I developed a strategy to bring the test capabilities to the University of Hawai'i, resulting in an 87% cost savings for the HAWSEC project and potential savings for future projects. Following this new plan, my colleagues and I created a SOPO for budget period two, which will culminate in a finalized medium-scale design, positioning our team favorably to secure future funding for further testing of the medium-scale device.

Lastly, in addition to my daily research activities, I continue to be actively involved in writing test plans and quarterly reports, participating in conferences, responding to funding opportunities, and serving as a technical reviewer in the TEAMER program.

Hawai'i Natural Energy Institute: *Position* – Research Specialist 08/23 – 01/24
Duties Included: Led the conceptualization and presentation of two research topics in response to a solicited proposal by the US Department of Energy (DOE). The first topic focuses on an innovative high flow hydraulic pump design tailored for seamless integration with a nearshore oscillating surge wave energy converter. The second topic assesses far-field impacts of wave energy converters on coastal processes, utilizing a high-fidelity phase-resolving wave model approach. Both topics received an informal research endorsement from DOE and were subsequently submitted in a written proposal. Anticipated funds, expected spring 2024, will support the advancement of the Hawai'i Marine Energy Center (HMEC).

In addition, I played a pivotal role in proposing the advancement of control strategies for existing wave energy converter (WEC) models under the HMEC proposal, leading to my participation in a workshop led by Sandia National Laboratories that focused on the integration of control theory into WEC designs. This

workshop, held at the Naval Sea Systems Command Carderock Division in Washington DC, significantly enhanced my expertise in optimizing WEC functionality.

Lastly, I continued to fulfill the duties initiated during my time as a Graduate Research Assistant (see below), ensuring successful completion of tasks outlined for budget period one of the DOE Hawai'i oscillating surge wave energy converter (HAWSEC) project. Specifically, I calibrated the hydraulic Simulink/Simscape Fluids power takeoff (PTO) model using data collected during laboratory testing at the Oregon State University O.H. Hinsdale wave basin. The PTO model was then coupled with a calibrated hydrodynamic WEC-Sim model for comprehensive validation. The results were disseminated in a comprehensive written report, serving as the culminating project deliverable for budget period one.

Dept. of Ocean and Resources Engineering: *Position* – Graduate Research Assistant 01/20 - 08/23
Duties Included: As a critical team member on the Hawai'i oscillating surge wave energy converter (HAWSEC) project funded by the US Department of Energy (DOE), I played a central role in the projects inception focusing on the design conceptualization of an oscillating surge wave energy converter (OSWEC) that could leverage the efficiencies of a hydro turbine in the power take-off (PTO) system.

My responsibilities extended to leading the detailed design of the OSWEC body, PTO unit, and framing using CAD software. Simultaneously, I took on the task of educating a new team member, enabling a seamless transition of CAD responsibilities. This strategic reallocation proved instrumental, allowing me to collaborate with another team member on the development of a hydrodynamic WEC-Sim model and a hydraulic Simulink/Simscape Fluids PTO model. Together, we achieved a major milestone independent of external support from the National Renewable Energy Laboratory (NREL), resulting in a very significant savings from the initially allocated funds. These savings were redirected under NREL towards the purchase of advanced instrumentation and technical support, contributing to an overall enhancement of the project.

My role encompassed WEC-Sim and Simscape model simulations for optimal component selection, leading procurement tasks with the support of research staff, and collaborating on fabrication and assembly with fellow team members upon the receipt of system components. In close collaboration with NREL staff, I identified instrumentation needs and data acquisition strategies to evaluate system performance. As a complement to these efforts, I designed a hydraulic bench test system capable of operating the PTO independently in a controlled environment, proving vital in subsequent model calibration efforts. To assess system performance, I actively contributed to devising an in-ocean test plan, executed as a system shakedown. Drawing from lessons learned, I assisted in formulating a comprehensive test plan, including the design of wave test spectra, for execution at the Oregon State University (OSU) O.H. Hinsdale wave basin.

Collaborating with OSU support staff, I led the system assembly, initial basin testing, and developed a series of system diagnostic tools to monitor performance. Throughout the initial testing phase, I successfully transferred operational knowledge to a fellow team member for continued operations after my departure. Additionally, I played a key role in post-test data analysis and the dissemination of results. Throughout the project lifecycle, I consistently presented updates in quarterly meetings and contributed to written reports presented to the DOE.

Beyond my responsibilities outlined on the HAWSEC project, I undertook the design and programming of a a low-cost data acquisition (DAQ) unit using an embedded microprocessor development board. The system design incorporated a real time clock for local reference, external temperature sensor to monitor housing conditions, and a step-down DC-DC voltage converter, enabling the use of an 80Ah marine battery for extended deployments. The principal objective of the DAQ was to log data streaming from an inertial motion reference unit through RS232 serial communication. The software, developed in Python, offered multiple operational modes. During lab testing, data streaming occurred over Wi-Fi using UDP sockets connected to client software that provided real-time graphical animation of the body motion. This visualization proved

invaluable for troubleshooting system performance. For field operations, particular emphasis was placed on optimizing the hardware power budget to extend deployment periods. The device was successfully deployed on a mooring float at sea, collecting data for subsequent mooring analysis by DNV. This additional project showcased my proficiency in hardware design, programming, and deployment logistics, contributing to the broader spectrum of my expertise in marine energy research.

The Link Foundation Ocean Engineering & Instrumentation PhD Fellowship 07/18 - 06/19

Duties Included: The fellowship was awarded in recognition of my innovative design proposal for a low-cost tilt current meter with pressure sensors, aiming to facilitate in-situ acquisition of wave-current data and advance the study of coastal processes. Despite sacrificing the depth profile accuracy associated with acoustic Doppler current profilers, the design substantially reduced instrument costs while maintaining the primary objective of estimating the frequency-direction variance density spectrum. I initiated the project by designing a custom frame using engineering CAD software, followed by the precision machining of raw materials. The fully submersible housing, accommodating hardware electronics and the power supply, was also custom designed adhering to O-ring seal principles. The sensor housing was 3D printed using a fused deposition modeling method. To ensure efficient data acquisition and processing with minimal latency, I developed custom software in the C language, optimizing the instrument's functionality and performance. A test rig was fabricated to conduct free decay tests, during which the body motion was filmed using underwater cameras. The video stream was processed using a tailor-made Python program interface to OpenCV to carry out the motion tracking. The body restoring force was heuristically calibrated prior to sea trial testing using lead ballast. I personally executed the deployment and recovery of the instrument with SCUBA, emphasizing my broad range of hands-on capabilities in the marine environment. Following successful instrument recovery, I conducted a comprehensive data analysis. Integral parameters derived from the spectrum were compared to observations from a nearby buoy, providing validation for the proof of concept. This fellowship project not only showcased my expertise in conceptualization, design, and implementation but also demonstrated a pragmatic approach to addressing challenges associated with cost-effective yet high-performing instrumentation for marine research.

Dept. of Earth Sciences: *Position* – Graduate Research Assistant 08/17 - 05/18

Duties Included: Building upon my previous experience in remote sensing, I designed a field experiment employing stereo-imaging techniques to monitor swash zone dynamics and evaluate run-up statistics. To ensure experimental control, I crafted a collection of custom-made ground control points. Real-time data processing was executed using a C++ algorithm I developed through the camera application programming interface and the results were logged for subsequent analysis. While the image acquisition and algorithm performed as intended during lab experiments, confirmed by ground control point analysis, the project encountered a significant challenge due to high signal-to-noise ratio experienced in the field. Specifically, the specular reflectivity of the water and spatial homogeneity of the sand posed difficulties in the depth reconstruction of the stereo imaging algorithm. Despite successful indoor testing, the proprietary nature of the reconstruction software and the complexity of system modifications required led to the recognition that further research was needed beyond the initial scope of work. The project concluded with the acknowledgment that, although the technology functioned as intended indoors, it was not yet mature enough for the intended application.

Dept. of Ocean and Resources Engineering: *Position* – Graduate Research Assistant 08/07 - 06/17

Duties Included: New to the challenges of high-performance computing, I initially focused on acquiring proficiency in the operation and maintenance of ocean forecast models, specifically WAVEWATCH III and SWAN, under the mentorship of seasoned experts. Working with the wave hindcast data, my first independent project concentrated on the cross-validation of a drifting Sentry Wave Buoy operated by the Navy. Recognizing the absence of diffraction-based physics in the governing equations, I conducted a case study comparing three different wave modes: SWAN, REFDIF, and CGWAVE. Leveraging the capabilities of the latter two to properly account for diffraction, I locally calibrated the directional spread in SWAN to minimize propagation errors. Although the results did not meet academic publishing standards, the project

proved successful in exposing me to several different models, each governed by a unique set of equations and applicable in different scenarios.

Equipped with the skills to independently operate WAVEWATCH III and SWAN, my research efforts turned toward hurricane inundation modeling, supported by the US Army Corps of Engineers. The focus was a comprehensive inter-comparison of two hurricane inundation packages. The package I ran, comprising WAVEWATCH III, SWAN, and NEOWAVE (specifically designed for operation in Hawai‘i), was compared with a package run by a collaborating team at the University of Notre Dame, which used SWAN and ADCIRC (a circulation model comparable to NEOWAVE but not yet validated for operation in Hawai‘i). Both models, driven by a parameterized hurricane model and coupled with the OTPS tidal prediction software, underwent a meticulous one-to-one comparison of physics-based results. The SWAN and ADCIRC package, endorsed by the US Army Corps of Engineers, was validated and later utilized in the development of a predicative ensemble model database for the state of Hawai‘i, offering invaluable insights in the event of a hurricane.

Highlighting my ability to navigate new academic challenges, I led a remote sensing project funded by the US Army Corps of Engineers. The project aimed to assess shoreline changes along Waikīkī, Hawai‘i, using principles of photogrammetry applied to timelapse photography. Each georeferenced image underwent an image filtering algorithm to pinpoint the shoreline position. This computationally intensive process utilized high-performance computing resources to construct a 2D timeseries of the shoreline position. Subsequently, I conducted an in-depth analysis of the data using empirical orthogonal functions (EOF) to identify temporal and spatial modes, organized in order of variance explained. The shoreline analysis was then cross-referenced with wave model results from SWAN to infer the impacts of hydrodynamic forcing on morphodynamic changes. A rigorous statistical analysis was executed, and the findings were presented in a comprehensive technical report, contributing valuable insights to assist the US Army Corps of Engineers in planning future beach nourishment projects.

🕮 Peer Reviewed Publications and Technical Reports

- Heitmann, T. W., Rajagopalan, K., Pappas, K., Nihous, G., Gedikli, E. D., Nichols, C., Raye, R, Cross, P., Model development and calibration of a hydraulic power take-off unit for wave energy converters. Renewable Energy 2024 (in preparation)
- Rajagopalan, K., Heitmann, T. W., Pappas, K., Nihous, G., Gedikli, E. D., Nichols, C., Raye, R, Cross, P., Hydrodynamic calibration and validation of an oscillating surge wave energy converter. Renewable Energy 2024 (in preparation)
- Heitmann, T. W., Rajagopalan, K., Pappas, K., Nihous, G., Gedikli, E. D., Cross, P., Validation of a coupled oscillating surge wave energy converter with hydraulic power take-off unit for high head hydro turbine applications. Renewable Energy 2024 (in preparation)
- Rajagopalan, K., Heitmann, T. W., Pappas, K., Nihous, G., Gedikli, E. D., Cross, P., Full scale projections for the Hawai‘i oscillating surge wave energy converter (HAWSEC). Renewable Energy 2024 (in preparation)
- Heitmann, T. W., Enhanced Fully Nonlinear Boussinesq-Type Equations in Conserved Variable Form and Linear Analytic Properties with Compact Finite Difference Schemes. PhD Dissertation 2023. *Synopsis*: A reformulation of the governing equations in conserved variable form is presented, which unites many theories under one umbrella. The new theoretical approach to enhancing nonlinear dispersion extends the relative depth range of practical application. As an implication, increasing the model domain extends the wave residence time resulting in prolonged exposure to numerical errors. A methodology to investigate numerical frequency dispersion in the context of compact finite difference schemes is presented to facilitate the mitigation of propagation errors prior to simulation.

- Lynett, P. J., Gately, K., Wilson, R., Montoya, L., Arcas, D., Aytore, B., Bai, Y., Bricker, J.D., Castro, M., Cheung, K. F., David, C. D., Dogan, G.G., Escalante, C., González-Vid, J.M., Grilli. S. T., Heitmann, T. W., Horrillo, J., Kanoglu, U., Kian, R., Kirby, J. T., Li, W., Macías, J., Nicolsky, D. J., Ortega, S., Pampell-Manis, A., Park, Y. S., Roeber, V., Sharghivand, N., Shelby, M., Shi, F., Tehranirad, B., Tolkova, E., Thio, H. K., Velioglu, D., Yalçıner, A. C., Yamazaki, Y., Zaytsev, A., Zhang, Y.J., Inter-Model Analysis of Tsunami-Induced Coastal Currents. Ocean Modeling 2017
- Li, N., Roeber, V., Yamazaki, Y., Heitmann, T. W., Bai, Y., Cheung, K. F., Integration of Coastal Inundation Modeling from Storm Tides to Individual Waves. Ocean Modeling 2014
- Roeber, V., Li, N., Heitmann, T. W., Yamazaki, Y., and Cheung, K. F. From source to sink: A modeling package for typhoon wave generation, propagation, and inundation. Journal of Japan Society of Civil Engineers, Ser. B2 (Coastal Engineering), Vol. 70, No. 2, 2014
- Heitmann, T. W., Cheung, K. F., Inter-comparison of Hurricane Surge Models for Applications in Tropical Environments. US Army Corps of Engineers. 2012
- Heitmann, T. W., Fletcher, C., Waikiki Remote Camera Image Analysis. US Army Corps of Engineers. 2010
- Heitmann, T. W., Morphodynamic Classification of Beaches in Tropical Environments. MS Thesis 2010

Presentations

- Heitmann, T. W., Cross, P., Pappas, K., Rajagopalan, K., 2024. Accelerating Hydraulic PTO Design and Validation through the HAWSEC Platform. UMREC+METS. Duluth, MN USA.
- Heitmann, T. W., Roeber, V., Cheung, K. F., Smith, D., 2014. Near-Shore Currents in Fringing Reef Environments. 34th International Conference on Coastal Engineering. Seoul, Korea.
- Heitmann, T. W., Cheung, K. F., 2014. Inter-comparison of Hurricane Surge Models for Applications in Tropical Environments. International Research Institute of Disaster Science. Sendi, Japan.
- Roeber, V., Heitmann, T. W., Cheung, K. F., Smith, D., 2014. Modeling of Near-Shore Currents Over Fringing Reefs with Shock-Capturing Boussinesq-Type Equations. Ocean Sciences. Honolulu, Hawai'i.
- Roeber, V., Li, N., Heitmann, T. W., Yamazaki, Y., Cheung, K. F., 2012. Modeling of Coastal Flood hazards at future sea levels. International Conference on Coastal Engineering, Santander, Spain.

Teaching Experience

Kapi'olani Community College: *Position* – Technical Advisor 08/21 – 05/23

Duties Included: I played a pivotal role in designing a college course funded by NSF Geopaths-Impact Grant awarded to Department of Math and Science. The course was dedicated to introducing young students to UAV applications in geoscience fields. Leveraging my previous experience in remote sensing, particularly with shoreline mapping, the course focused on beach surveys using photogrammetry and structure from motion techniques. This allowed students to construct digital elevation maps from UAV acquired photos. I conducted weekly lectures, covering both theoretical content immediately relevant to the project and detailed instructions on working with necessary software. To reinforce comprehension, students were given weekly homework assignments, which included practical tasks like constructing ground control points needed for surveys. This theoretical understanding was applied during weekend field surveys at the beach, where students collected data using 1) RTK-GPS land surveying techniques, and 2) executing UAV flight paths. Subsequently, they processed the data to create digital elevation maps, validating their results against land surveys. The course culminated in individual student presentations, where each student shared their findings and lessons learned through poster presentations. This final showcase was open to the general public, providing a platform for students to communicate their achievements.

Dr. Takahashi Juku, LTD: *Position* – Tutor 01/14 – 08/15
Duties Included: I instructed numerous students of various age groups in a one-on-one setting, ranging from preschoolers to juniors and seniors in high school. The material content covered a diverse range of subjects, from preparing younger students for private school entrance exams, to guiding older students through SAT/ACT standardized tests. I implemented personalized progress logs for each student, allowing them to advance at their own pace and ensuring individualized success.

University of Hawai'i Diving Safety Program: *Position* – Assistant Field Instructor 5/12 – 12/14
Duties Included: After achieving my Master Diver and Rescue Diver certifications with the University of Hawai'i Diving Safety Program (UHDSP), I extended my involvement by assisting the UHDSP with student training for scientific diver certifications. In contrast to recreational dive training, the emphasis in this educational setting lies in task loading teams, highlighting logistical planning, effective communication, and problem-solving in a stressful environment. On a weekly basis, I guided individual teams in orchestrating their dive plans on land, limiting verbal communication. During dry runs, I would introduce unforeseen scenarios to assist student reactions and adaptation, providing corrections as necessary to ensure safe procedures. In the water, I led the group as a safety diver, while evaluating their execution of the dive plan and delivering post-dive briefings that highlighted both commendable and improvable team aspects. I also provided individual student evaluations each week, monitoring their progress and assessing their ability to apply lessons learned throughout the course.

Outreach

STEM Pre-Academy: *Position* – Technical Advisor 06/24 - present
Duties Included: Coordinate with STEM Pre-Academy project managers to develop new marine energy toolkit ideas for integration into Hawai'i's middle school STEM curriculum. These ideas originate from full-scale marine energy research and innovation projects, which are then downscaled and simplified to highlight foundational principles of energy transfer and water wave mechanics. Participate in annual teacher workshops to help create a communication feedback loop, improving the educational quality of project ideas.

Kapi'olani Community College: *Position* – Technical Advisor 02/24 – present
Duties Included: In collaboration with community college professors, I play a lead advisory role in the content design for a new elective lab course called SCI 295ME, which provides students with hands-on research experience in marine energy. The course objectives include fostering an understanding of wave energy converters, power take-off systems, and laboratory test environments. It is designed to guide students through the engineering design process, encompassing problem identification, literature research, prototype design, and testing. Student teams are supervised in the creation, testing, and presentation of their wave energy projects, ensuring the course meets academic standards and aligns with institutional learning outcomes. Additionally, I've led guided tours to introduce students to ongoing marine energy research projects at UH Mānoa, inspiring them through valuable exposure to real-world applications and cutting-edge developments in the field.

Additional information will be provided upon request