Overview of Open Source Codes to Assess Environmental Effects on Ocean Wave Farms

Chris Chartrand  
*Sandia National Laboratories, Albuquerque, NM, ccchart@sandia.gov*

Kelley Ruehl  
*Sandia National Laboratories, Albuquerque, NM*

Jesse Roberts  
*Sandia National Laboratories, Albuquerque, NM*

Sam McWilliams  
*Integral Consulting Inc., Santa Cruz, CA*

Kaus Raghukumar  
*Integral Consulting Inc., Santa Cruz, CA*

*See next page for additional authors*

Follow this and additional works at: [https://scholarworks.uno.edu/oceanwaves](https://scholarworks.uno.edu/oceanwaves)

Part of the Oceanography Commons

Chartrand, Chris; Ruehl, Kelley; Roberts, Jesse; McWilliams, Sam; Raghukumar, Kaus; Porter, Aaron; and McNatt, Cameron, "Overview of Open Source Codes to Assess Environmental Effects on Ocean Wave Farms" (2017). *Ocean Waves Workshop*. 3. [https://scholarworks.uno.edu/oceanwaves/2017/posters/3](https://scholarworks.uno.edu/oceanwaves/2017/posters/3)

This Event is brought to you for free and open access by ScholarWorks@UNO. It has been accepted for inclusion in Ocean Waves Workshop by an authorized administrator of ScholarWorks@UNO. For more information, please contact scholarworks@uno.edu.
Presenter Information
Chris Chartrand, Kelley Ruehl, Jesse Roberts, Sam McWilliams, Kaus Raghukumar, Aaron Porter, and Cameron McNatt

This event is available at ScholarWorks@UNO: https://scholarworks.uno.edu/oceanwaves/2017/posters/3
Overview of Open Source Codes to Assess Environmental Effects of Ocean Wave Farms

Chris Chartrand1, Kelley Ruehl1, Jesse Roberts1, Sam McWilliams2, Kaus Raghukumar2, Aaron Porter3, and Cameron McNatt4

1) Sandia National Laboratories, Albuquerque, NM
2) Integral Consulting Inc., Santa Cruz, CA
3) Mott MacDonald, Edmonds, WA, USA
4) Mocean Energy LLC, Greensboro, CA

*Corresponding author: ccchart@snl.gov

Introduction
The United States has a theoretical ocean wave energy resource potential of 1.594–2.640 TWh/year, enough to power between 143.5 and 237.6 million homes/year and contribute substantially to the United States’ energy portfolio [1]. However, wave energy converters (WECs) are currently in the early stages of research and development at low technology readiness levels. Open ocean deployment data is from demonstration-scale projects, not from utility-scale deployments. As a result, researchers, developers, and regulators rely heavily on numerical models to understand the environmental effects of wave farms.

A suite of open source codes has been developed by Sandia National Laboratories focused on simulating the energy extraction of WECs to better understand and predict their potential environmental effects.

Methods
SNL-SWAN is a modification of the open source SWAN code to include a WEC Module as an energy sink that extracts energy from the wave action balance equation according to the power performance of the WEC [2]. SNL-SWAN is used to simulate and predict the effect of wave farms of varying array sizes, configurations, and with different WEC types on the wave field. SNL-SWAN has been verified against well-respected wave energy models such as WAMMIT, as shown in Fig. 1 [3].

SNL-Delft3D is the Sandia modified version of Delft3D for MHK devices. Delft3D is an open source, multidimensional hydrodynamic and sediment transport model, capable of computing non-steady circulation, waves, and sediment transport phenomena resulting from forcing by tides and meteorological processes. Delft3D is developed and maintained by Deltas and comes with a suite of graphical tools to assist in grid-building, tidal analysis, bathymetric mapping tools, and rapid data analysis [4].

SNL-SWAN and SNL-Delft3D have been designed to be run together as a coupled simulation. The coupled Delft3D-SNL-SWAN (SNL-Delft3D) model allows for evaluating tidal and wave-driven circulation, including wave-current interactions that influence both nearshore circulation, wave parameters, and sediment transport.

Acknowledgments
Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy’s National Nuclear Security Administration under contract DE-NA0003525. This work was completed through technical support from Grace Chang, Sam McWilliams, Kaus Raghukumar, and Craig Jones of Integral Consulting, and Annie Dallman from Sandia National Laboratories.

Results
Performing a fully coupled Delft3D-SNL-SWAN model allows for an evaluation of changes in hydrodynamic and sediment transport parameters in the presence and absence of WECs in the environment. Two key parameters of importance to nearshore morphological change are maximum shear stress and bed elevation change. Fig 4 shows normalized changes in shear stress and bed elevation in the presence and absence of WECs for two wave events with the highest annual probability of occurrence at the Oregon Coast. The two cases shown are typical of summer and winter (Fig 4, normalized shear stress and Fig 5, bed elevation change) conditions on the Oregon Coast.

Conclusions
The development of SNL-SWAN and SNL-Delft3D-FLOW can quantify the interaction between device(s) and the hydrodynamic environment at a real-world site.

References

Further information
Link to software and SNL-SWAN
http://snl-waterpower.github.io/SNL-SWAN/

Links to software and SNL-Delft3D
http://energy.sandia.gov/snl/delft3d-cec/
https://github.com/SNL-WaterPower/SNL-Delft3D-CEC