SAND2018-14298C

AGU Fall Meeting 2018
Abstract Number: GC23E-1253

Seasonal Effects of Wave Energy Converter (WEC) Array Environmental Risk Assessments

Kaus Raghukumar[1], Sam McWilliams[1], Ann Dallman[2], Craig Jones[1], Jesse Roberts[2]
[1]Integral Consulting, Inc.
[2]Sandia National Laboratories

Introduction

- Methodologies and modeling tools are necessary to assess site the potential environmental effects of wave energy converter (WEC) arrays.
- Sandia National Laboratories and Integral Consulting have developed:
  - SNL-SWAN, a modified version of the open-source model SWAN (Simulating WAves Nearshore),
  - associated methodologies to assess impacts of wave energy converter (WEC) arrays,
  - SNL-SWAN coupled with a hydrodynamic and sediment transport model such as Delft3D-Flow, developed by Deltares Inc, to allow for the direct investigation of WEC array effects on the physical environment (Delft3D-SNL-SWAN).
- Environmental impact analysis of a WEC farm requires characterization of the environmental conditions at the site of interest to determine the 'risk' associated with specific wave conditions (Figure 1).
- Seasonal characteristics and 'risk' can also be analyzed

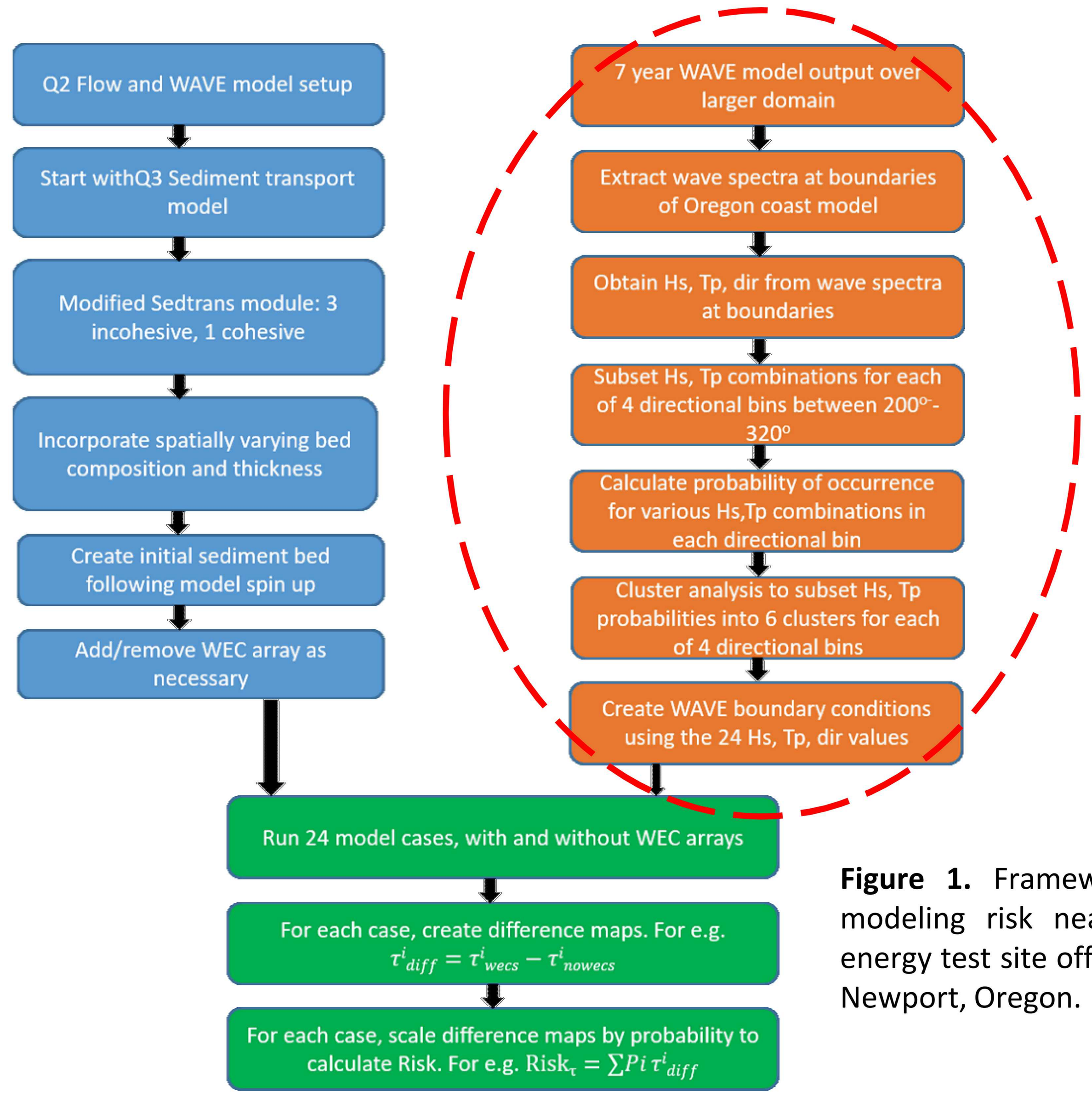

Figure 1. Framework for modeling risk near wave energy test site offshore of Newport, Oregon.

Methods

- A seven-year wave record [1] is analyzed to yield a multi-dimensional wave occurrence distribution, first separated by season.
- Data is then binned by direction; bins selected by considering the distribution of wave direction at the site (wave rose in Figure 2); 4 4 bins selected for this analysis

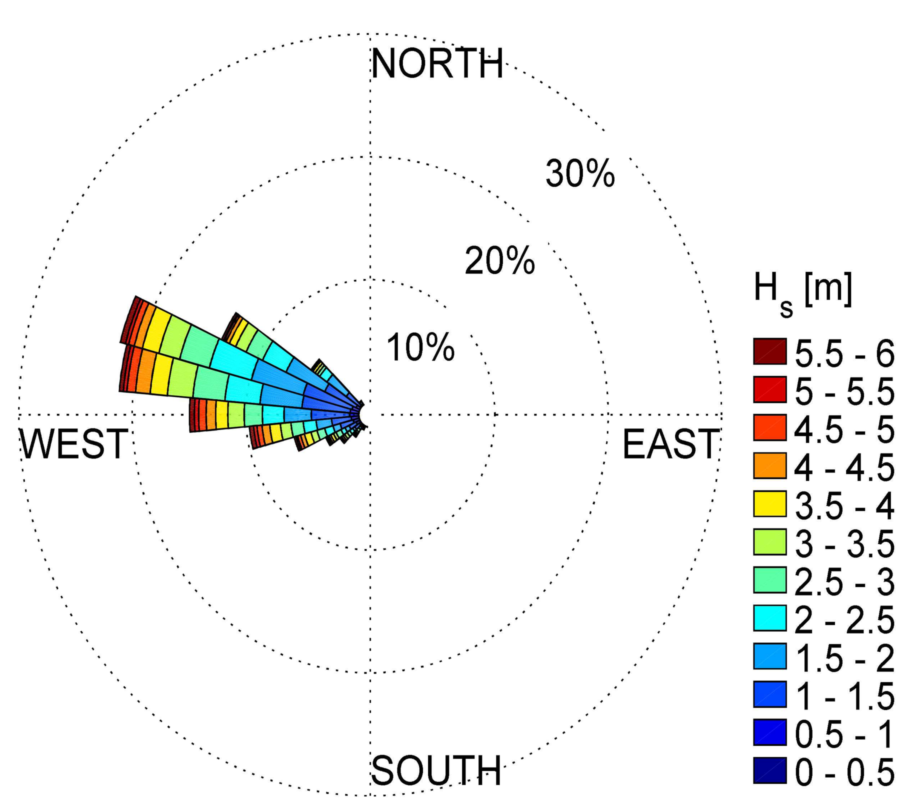

Figure 1. Wave rose over the full length of data (seven years) at -124.4, 44.7.

Methods (cont'd)

- Then individual JPDs of significant wave height and peak period are calculated in each directional bin, for each season.
- Often testing or simulating every sea state within a joint probability distribution (JPD) is not feasible, therefore a subset of conditions need to be selected.
- Discrete wave events are chosen using k-means cluster analysis [2].
- These set of conditions (cluster centroids), along with the probability of occurrence of each cluster, represent a comprehensive set of conditions over the record in a probabilistic sense.

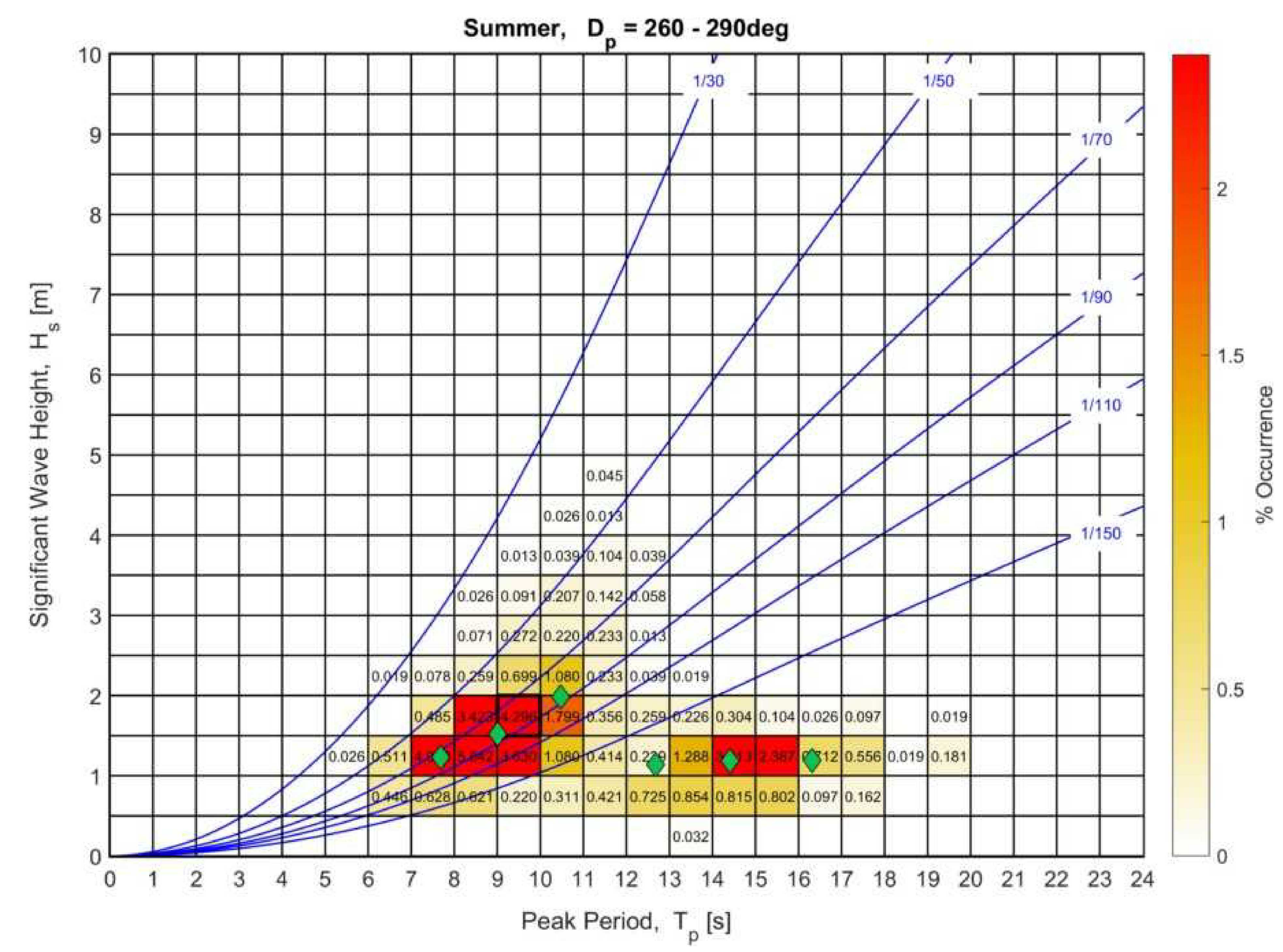

Figure 3. JPD for seven years of data within the summer season, in the direction vector Dp = 260-290°, along with cluster centroids (green diamonds) and cluster boundaries (dotted green lines).

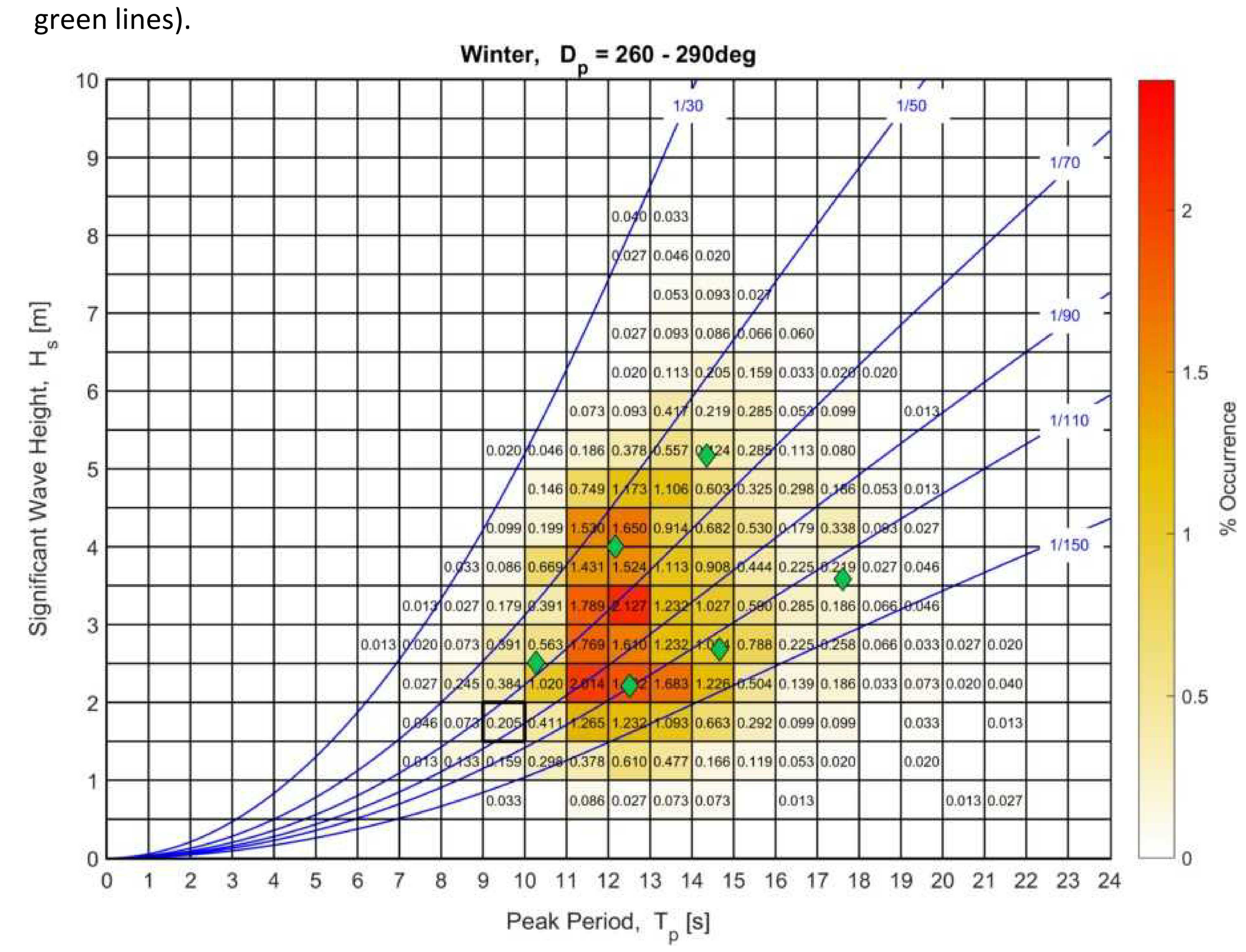

Figure 4. Similar to Figure 3, but for the winter season.

- An example of two JPDs for summer and winter for the 260° - 290° directional bin highlights the differences between the seasonal conditions (Figures 3 & 4).
- The probability of occurrence within any combination of a direction bin, season, and full record can be considered for the risk assessment.

Seasonal Risk Results

- Figure 5 shows the modeled risk results when applied to examine the effect of seasonal variability on sediment mobility.
- As expected, there are modest changes to sediment mobility in the lee of a WEC array during the Summer, Fall and Spring (compared to the baseline case without a WEC array).
- Larger changes are seen in the Winter, due to more energetic, and frequent wave events.
- These changes in winter include the potential for decreased mobility (i.e., reduced erosion) in the lee of the WEC array.

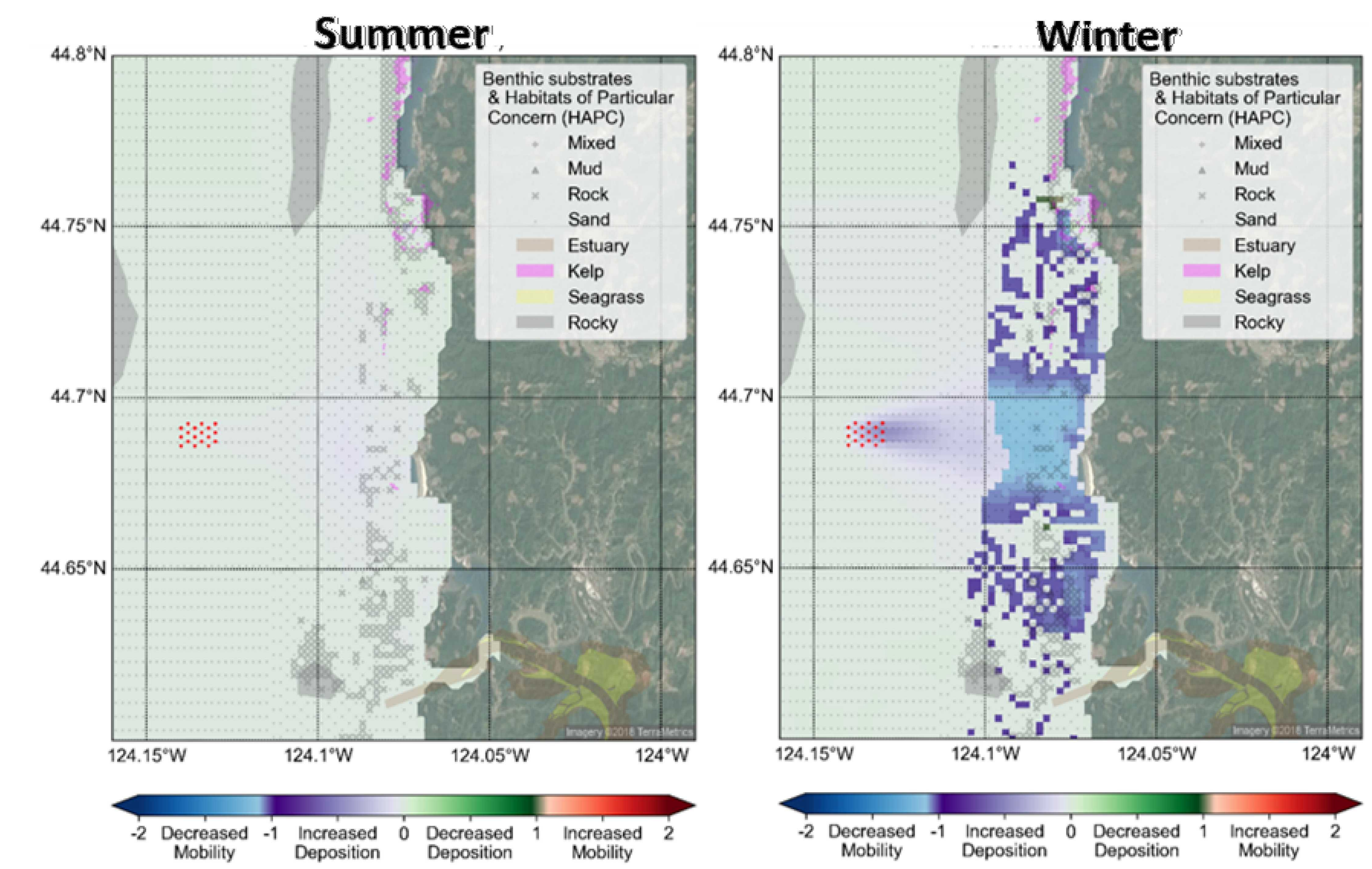

Figure 5. Similar to Figure 3, but for the winter season. Habitats of interest are also demarcated on the map, with locations as defined by CMECS [3].

Conclusions

- A methodology is described for characterizing the wave environment in a condensed manner and selecting sea states for representative cases to model.
- Factors such as the number of sea states to select and directional bins depend on the individual site and WEC array being studied.
- Seasonal characteristics are also explored, where differences in sediment mobility are found to be the largest in winter, as expected.
- Full application of a Spatial Environmental Assessment Tool (SEAT) assessment is detailed in [4]).

References

1. García-Medina, Gabriel, Özkan-Haller, H. Tuba, Ruggiero, Peter. "Wave resource assessment in Oregon and southwest Washington, USA," Renewable Energy Vol. 64 (2014): pp. 203-214.
2. Bull, D., and A. Dallman. 2017. Wave Energy Prize experimental sea state selection. ASME 2017 36th International conference on ocean, offshore and arctic engineering, Vol. 10: Ocean Renewable Energy.
3. Coastal and marine Ecological Classification Standards (CMECS), May 2016 https://iocm.noaa.gov/cmecs/, Federal Geographic Data Committee.
4. Jones, C., Chang, G., Raghukumar, K., McWilliams, S., Dallman, A., Roberts, J. "Spatial Environmental Assessment Tool (SEAT): A Modeling Tool to Evaluate Potential Environmental Risks with Wave Energy Converter Deployments." Energies Vol. 11(8) (2018).

Acknowledgements

This work was funded by the U.S. Department of Energy's Water Power Technologies Office.
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.