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# A Landscape Assessment of North American Wave and Wind Facilities

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Abstract

The National Full-Scale Testing Infrastructure for Community Hardening in Extreme Wind, Surge, and Wave Events (NICHE) is a National Science Foundation (NSF) Mid-Scale Research Infrastructure 1 project that aims to meet a critical need for full-scale testing for natural hazards resilience in the 21st century. The current project serves to establish an integrated design testbed (IDT) that will facilitate the design of the full-scale NICHE facility. This paper provides an overview of a landscape assessment of wave and wind facilities across North America that will inform the design of the physical experimentation portion of the IDT and eventual NICHE. The landscape assessment illustrates a comprehensive study of wave and wind facilities by expanding upon their research, capabilities, specifications, and equipment. In doing so, the paper intends to detail the critical need for a facility like NICHE in the nation's research infrastructure while providing a database for wave and wind research that can promote future research and collaboration.

*Keywords*: Wind tunnel, Wave flume, Wave basin, Resilience, Full-scale testing, Structural engineering

## Introduction

The combination of the risks posed by climate change with the increasing migration of people to coastal areas invites the potential for humanitarian and economic catastrophe in the event of a natural disaster (IPCC, 2022). These climatic and social trends present the need for urgent and swift action to ensure the resilience of coastal communities, particularly against the threats of sea-level rise and tropical cyclones. According to the National Oceanic and Atmospheric Administration Office for Coastal Management, "Of the 310 billion-dollar weather disasters between 1980 and 2021, tropical cyclones have caused the most damage: over $1.1 trillion total" (NOAA Office for Coastal Management, 2022, Tropical Cyclones: The Highest Costs section). Additionally, nine of the ten costliest tropical cyclones in U.S. history have occurred in the last 20 years (NOAA National Centers for Environmental Information, 2023). Climate change may worsen losses from tropical cyclones, as model projections of tropical cyclone activity under two degrees Celsius of anthropogenic warming indicate the following: high confidence in sea level rise resulting in higher tropical cyclone inundation levels; medium-to-high confidence in an increase in tropical cyclone precipitation rates, leading to a higher risk of flooding; medium to high confidence that the global average of tropical cyclone intensity will increase; and medium to high confidence in an increase in the global proportion of tropical cyclones that reach very intense (category 4-5) status (Knutson et al., 2020). Under this heightened threat, people and property may be increasingly at risk of harm or damage.

To help mitigate impacts from current meteorological threats and those that loom in the future, it is essential to prioritize the necessary efforts and resources to protect communities along the coast. One example of these critical efforts and resources is extensive physical and computational testing on structures in wave and wind facilities to help strengthen building codes and construct stronger, more resilient communities. Wave and wind facilities have long been used to improve the performance and resilience of structures by simulating natural phenomena from their calmest to most intense behaviors. By recreating extreme wind events, such as hurricanes and tornadoes, wind tunnels contribute to the implementation of new methods and materials for construction that can better withstand damaging winds (Gurley et al., 2006; Kopp et al., 2010). Similarly, wave basins and wave flumes reproduce high water events, such as tsunamis and storm surge, to help inform strategies for damage mitigation and the protection of life and property (Park et al., 2017; Tomiczek et al., 2020).

While testing these phenomena separately produces valuable results and insight, it fails to accurately replicate reality. For example, wave and wind impacts are often simultaneous in a landfalling tropical cyclone or other major coastal storm event. Thus, to replicate the impacts of this coupled threat more accurately, aerodynamic and hydrodynamic loads should be applied to a structure simultaneously during physical or computational testing. However, subjecting scaled-down models or subcomponents of structural systems to a coupled aerodynamic and hydrodynamic load introduces a scaling conflict (Heller, 2011). When applied to a scaled-down test subject, wave and wind loadings are governed by different scaling factors. This scaling conflict makes small-scale coupled loading testing physically impossible, leaving few feasible solutions. A viable alternative lies in full-scale testing, eliminating the scaling conflict imposed by scaled-down test subjects and providing real-world validation that an idealized numerical model may struggle to illustrate. A full-scale testing approach serves as the motivation for the broader project this landscape assessment is intended for, the National Full-Scale Testing Infrastructure for Community Hardening in Extreme Wind, Surge, and Wave Events (NICHE).

The NICHE is a collaborative effort between nine universities, one industry partner, and the federal government to help foster community resilience against natural disasters (Perez, 2022). The NICHE aims to reproduce some of the most hazardous conditions in a changing climate and solve the scaling limitations of current wave and wind testing. The NICHE solution entails constructing a full-scale wave and wind testing facility to subject structures to wind speeds up to 200 mph and waves over 7 feet (Cusick, 2022). Testing at full-scale largely eliminates similitude and scaling conflict concerns. With peak capabilities reaching the values mentioned above, the worst conditions coastal communities may face in a changing climate are replicated, thus providing an accurate environment to test and engineer for resilience.

In 2021, the National Science Foundation funded a Mid-Scale Research Infrastructure 1 (MsRI-1) proposal for the NICHE (National Science Foundation, 2021). This proposal sought to create an integrated design testbed (IDT) that would eventually help inform the design of the full-scale facility to test the impact of extreme waves and wind on structures. The proposal detailed an IDT consisting of field observations, computational modeling, and physical experimentation. The physical experimentation component of the IDT served as the motivation for the landscape assessment outlined in this paper. The proposed landscape assessment would facilitate a thorough selection process of facilities to conduct physical experiments for the physical design testbed (PDT) portion of the IDT that would inform the design of the final, full-scale NICHE facility. The landscape assessment was therefore governed with three objectives in mind: (a) to establish a network of scientific facilities and foster community awareness of the NICHE project and its goals, (b) to validate facility capabilities and equipment, therefore informing a comprehensive summary of facilities across the region, and (c) to assess interest and feasibility of retrofitting/upgrading a facility to host PDT testing.

While the landscape assessment would help inform options to host PDT testing for the NICHE project, it would also provide a critical compilation of information currently nonexistent in the wave and wind physical experimentation community. To the authors' knowledge at the time of this publication, a comprehensive summary of wave and wind facilities in North America has not been published in the scientific literature. Thus, sharing the results of the landscape assessment for the NICHE project can better inform the wave and wind research community by detailing crucial information regarding facility capabilities and dimensions. Providing such information can foster new research collaborations and a broad, well-informed scientific network.

The landscape assessment outlined in this paper provides a comprehensive summary of more than 40 wave and wind facilities across North America. The results of the assessment compile relevant research capabilities, such as test section dimensions, maximum wind speeds, and significant wave heights across the 40+ facilities in the survey. Compiling this information validates the urgent need for a full-scale facility like NICHE, as none of the facilities meet the proposed scale and capabilities of NICHE. Qualitatively, conversations with facility managers and staff also identify additional aspects to consider for such a large project. These include power consumption, staffing issues, sources of funding and support, and interdisciplinary contributions. Expressed interest and the feasibility of retrofitting/upgrading the facility for PDT testing are also included. Regarding the landscape assessment's role in the broader NICHE project, the paper discusses the selection process for the facilities that will host PDT testing and the five facilities that were selected. While many facilities were explored as potential options, the NICHE team moved forward with a select few that offered an ideal overlap in facility research focus, retrofitting/upgrade feasibility, disciplinary expertise, and overall project logistics.

## Methods

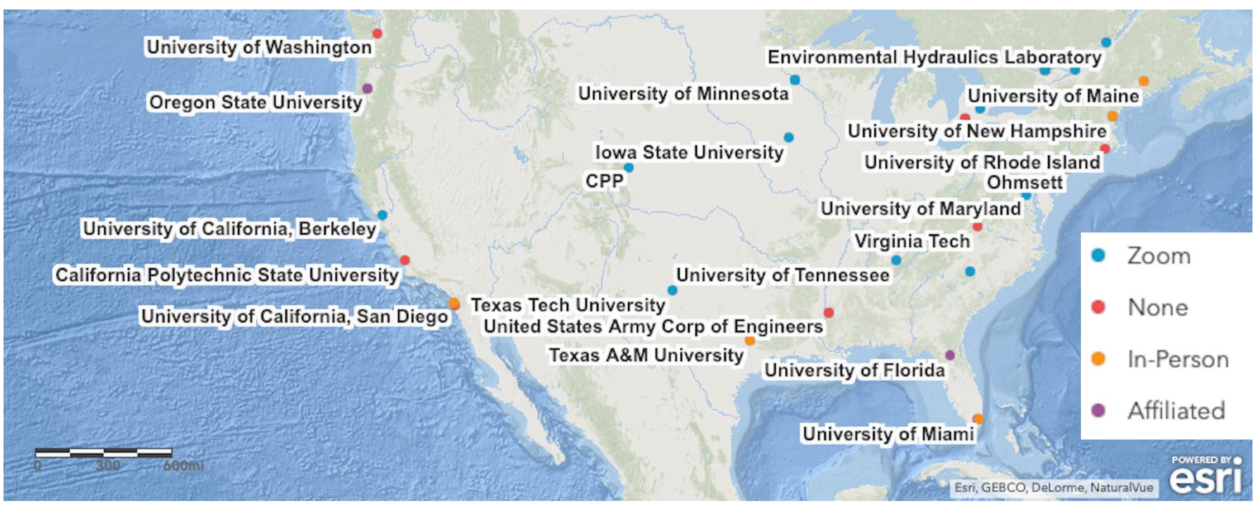


**Figure 1.** *Wave and wind facilities investigated in North America as part of NICHE Landscape Assessment.*

The landscape assessment preliminarily identified more than 50 potential facilities to investigate that would help inform the design of the IDT and NICHE. Information and capabilities on these facilities were collected through three methods: compiling ancillary documentation available through the public domain, Zoom interviews conducted with facility managers and staff, and site visits. The team conducted Zoom interviews with 20 facilities and visited nine (another four were already affiliated with members of the NICHE project).

To compare facilities across the landscape assessment, relevant capabilities, features, and instrumentation were selected to be represented. Wind tunnel capabilities were compared by the maximum wind speed across the test section in meters per second. Relevant features and instrumentation included turntables, flow manipulators, Scanivalve and data acquisition systems, Cobra and Omni probes, and particle image velocimetry. Wave facilities were more difficult to compare on a standardized basis due to the varying initial conditions and inputs for each facility and the scarcity of information provided. Therefore, the landscape assessment for wave facilities compared significant wave heights across various wave types, wave periods, and water depths. For this paper, the largest significant wave height produced by the facility was used. Additionally, the significant wave height also had to be assumed for some facilities based on the provided maximum wave height. The significant wave height is typically assumed to be about half of the maximum wave height (Key West, FL Weather Forecast Office, 2009). Relevant features and instrumentation for these facilities included mechanisms for wave generation, wave absorption, wave gauges, particle image velocimetry, data acquisition systems, load cells, and more.

Additional notes were also collected describing any struggles or successes the facility experienced. These included limited hours of operation, availability to host new projects, and any other information that would be relevant for the IDT and full-scale NICHE. It should also be noted that of the 50+ facilities that were initially identified, some were not included in the tables below. Some facilities did not disclose specific capabilities that were sought or did not have the desired capabilities.

## Results

**Table 1.** Wave-Only Facilities

| Name | Location | Affiliation | Interview Type | Test Section Length (m) | Test Section Width (m) | Test Section Depth (m) | Significant Wave Height (m) | Retrofit and/or host testing? |
|---|---|---|---|---|---|---|---|---|
| Cornell University Long Stroke Wave Tank | Ithaca, New York | University | In-Person/ Zoom | 32 | 0.6 | 0.9 | 0.3 | Yes |
| Environmental Hydraulics Laboratory Large Scale Wave Flume | Québec City, Québec, Canada | Government | Zoom | 120 | 5 | 5 | 0.9 | DQ |
| National Research Council Canada Coastal Wave Basin | Ottawa, Ontario, Canada | Government | Zoom | 63 | 14.2 | 1.4 | 0.3 | DQ |
| National Research Council Canada Large Area Basin | Ottawa, Ontario, Canada | Government | Zoom | 50 | 30 | 1.4 | 0.4 | DQ |
| National Research Council Canada Large Wave Flume | Ottawa, Ontario, Canada | Government | Zoom | 97 | 2 | 2.8 | 1.3 | DQ |
| National Research Council Canada Multidirectional Wave Basin | Ottawa, Ontario, Canada | Government | Zoom | 36 | 30 | 3 | 0.8 | DQ |
| National Research Council Canada Steel Wave Flume | Ottawa, Ontario, Canada | Government | Zoom | 64 | 1.2 | 1.2 | 0.3 | DQ |
| Ohmsett – The National Oil Spill Response Research and Renewable Energy Test Facility | Leonardo, New Jersey | Industry | None | 203.3 | 19.8 | 3.4 | 0.5 | N/A |
| Oregon State University Directional Wave Basin | Corvallis, Oregon | University | Team-Affiliated | 48.8 | 26.5 | 2.1 | 0.4 | No |

| Name | Location | Affiliation | Interview Type | Test Section Length (m) | Test Section Width (m) | Test Section Depth (m) | Significant Wave Height (m) | Retrofit and/or host testing? |
|---|---|---|---|---|---|---|---|---|
| Oregon State University Large Wave Flume | Corvallis, Oregon | University | Team-Affiliated | 104 | 3.7 | 4.6 | 0.9 | Yes |
| United States Army Corps of Engineers Wave Flume 1 and 2* | Vicksburg, Mississippi | Military | None | 63 | 1.5 / 3 | 1.5 | 0.2 | N/A |
| University of California Berkeley Physical Model Test Facility | Berkeley, California | University | Zoom | 64 | 2.4 | 1.8 | 0.05 | Yes |
| University of California San Diego Glass Channel | La Jolla, California | University | In-Person | 33 | 0.5 | 0.5 | 0.1 | No |
| University of New Hampshire Wave/Tow Tank | Durham, New Hampshire | University | In-Person | 36.6 | 3.7 | 2.4 | 0.3 | Maybe |
| University of Rhode Island Wave Tank | Narragansett, Rhode Island | University | None | 30 | 3.6 | 1.8 | 0.2 | N/A |

**Indicates that basin or flume may have two test section configurations. The values associated with each configuration are shown with a slash (/).*

**Table 2.** Wind-Only Facilities

| Name | Location | Affiliation | Interview Type | Test Section Width (m) | Test Section Height (m) | Maximum Wind Speed (m/s) | Retrofit and/or host testing? |
|---|---|---|---|---|---|---|---|
| California Polytechnic State University Low Speed Wind Tunnel Laboratory | San Luis Obispo, California | University | None | 1.2 | 0.9 | 58 | N/A |
| Concordia University Boundary Layer Wind Tunnel | Montreal, Québec, Canada | University | Zoom | 1.8 | 1.8 | 14 | DQ |
| CPP Wind Engineering Consultants Wind Tunnel | Windsor, Colorado | Industry | Zoom | 3.7 | 2.4 | 21 | No |
| Florida International University Wall of Wind | Miami, Florida | University | Team-Affiliated | 6 | 4.3 | 70 | Yes |
| Insurance Institute for Business and Home Safety Windstorm Facility | Richburg, South Carolina | Industry | Zoom | 19.8 | 9.15 | 58 | No |
| Iowa State University Aerodynamic/Atmospheric Boundary Layer Tunnel* | Ames, Iowa | University | Zoom | 2.4 | 1.8 / 2.2 | 50 / 40.2 | Yes |
| National Research Council Canada 9 m Wind Tunnel Research Facility | Ottawa, Ontario, Canada | Government | None | 9.1 | 9.1 | 55 | DQ |
| Rowan Williams Davies and Irwin Inc. Anton Davies B12/7 Wind Tunnel Facility | Guelph, Ontario, Canada | Industry | Zoom | 3.7 | 2.1 | 20 | DQ |
| Rowan Williams Davies and Irwin Inc. Glenn Schuyler C12/7 Wind Tunnel Facility* | Guelph, Ontario, Canada | Industry | Zoom | 3.7 / 1.8 | 2.1 | 20 / 30 | DQ |

| Name | Location | Affiliation | Interview Type | Test Section Width (m) | Test Section Height (m) | Maximum Wind Speed (m/s) | Retrofit and/or host testing? |
|---|---|---|---|---|---|---|---|
| Rowan Williams Davies and Irwin Inc. Peter Irwin A24/8 Wind Tunnel Facility* | Guelph, Ontario, Canada | Industry | Zoom | 7.3 / 2.4 | 2.4 | 20 / 33.5 | DQ |
| San Diego Wind Tunnel | San Diego, California | Industry | None | 3.7 | 2.4 | 120.7 | N/A |
| Texas A&M University Oran W. Nicks Low Speed Wind Tunnel | College Station, Texas | University | In-Person | 3.1 | 2.1 | 89.4 | No |
| Texas Tech University Boundary Layer Wind Tunnel | Lubbock, Texas | University | Zoom | 1.8 | 1.2 | 40 | No |
| University of Florida Boundary Layer Wind Tunnel | Gainesville, Florida | University | Team-Affiliated | 6 | 3 | 18 | Yes |
| University of Maryland Glenn L. Martin Wind Tunnel | College Park, Maryland | University | Zoom | 3.4 | 2.4 | 102.8 | No |
| University of Minnesota Boundary Layer Wind Tunnel* | Minneapolis, Minnesota | University | Zoom | 1.5 / 2.4 | 1.7 / 2.4 | 45 / 19 | Yes |
| University of New Hampshire Flow Physics Facility | Durham, New Hampshire | University | In-Person | 6 | 2.8 | 14.5 | Maybe |
| University of Tennessee Low Speed Wind Tunnel | Tullahoma, Tennessee | University | Zoom | 0.5 | 0.4 | 76.2 | No |
| University of Washington Kirsten Wind Tunnel | Seattle, Washington | University | None | 3.7 | 2.4 | 90 | N/A |
| Virginia Polytechnic University Stability Wind Tunnel | Blacksburg, Virginia | University | None | 1.8 | 1.8 | 80 | N/A |

| Name | Location | Affiliation | Interview Type | Test Section Width (m) | Test Section Height (m) | Maximum Wind Speed (m/s) | Retrofit and/or host testing? |
|---|---|---|---|---|---|---|---|
| Western University Boundary Layer Wind Tunnel 1 | London, Ontario, Canada | University | None | 2.4 | 2.2 | 15.3 | DQ |
| Western University Boundary Layer Wind Tunnel 2* | London, Ontario, Canada | University | None | 3.4 / 5 | 2.5 / 4 | 27.8 / 10 | DQ |

**Indicates that tunnel may have two test section configurations. The values associated with each configuration are shown with a slash (/).*

**Table 3.** Wave and Wind Facilities

| Name | Location | Affiliation | Interview Type | Test Section Length (m) | Test Section Width (m) | Test Section Depth (m) | Maximum Wind Speed (m/s) | Significant Wave Height (m) | Retrofit and/or host testing? |
|---|---|---|---|---|---|---|---|---|---|
| Texas A&M University Offshore Technology Research Center | College Station, Texas | University | In-Person | 45.7 | 30.5 | 5.8 | 12 | 0.5 | Maybe |
| University of California San Diego Scripps Ocean Atmosphere Research Simulator (SOARS) | La Jolla, California | University | In-Person | 36 | 2.4 | 2.4 | 45 | 0.5 | Yes |
| University of Maine Alfond $W^2$ Ocean Engineering Lab | Orono, Maine | University | In-Person | 30 | 9 | 5 | 12 | 0.4 | Maybe |
| University of Miami Alfred C. Glassell, Jr. SUSTAIN Laboratory | Miami, Florida | University | In-Person | 23 | 6 | 2 | 69 | 0.3 | Yes |
| University of Michigan Wind Wave Tank | Ann Arbor, Michigan | University | Zoom | 35 | 0.7 | 1.2 | 30 | 0.1 | Yes |

- ***DQ*** *indicates Disqualified, as these facilities were located outside of the United States. A decision was made by the NICHE team that PDT testing had to be conducted within the U.S. to avoid potential obstacles with international regulations regarding research, importing/exporting equipment, etc.*

- ***Yes*** *indicates the facility staff and/or faculty expressed interest in the NICHE project and retrofitting their facility to host PDT testing.*

- ***No** indicates the facility staff and/or faculty expressed that they were not interested in retrofitting their facility to host PDT testing for the NICHE project.*

- ***Maybe** indicates the facility staff and/or faculty provided a hesitant or unsure response regarding retrofitting their facility to host PDT testing for the NICHE project.*

## Discussion

As illustrated in the discussion and figures below, a wide range of capabilities and dimensions were found for wave, wind, and combined facilities.

### Landscape Assessment Analysis

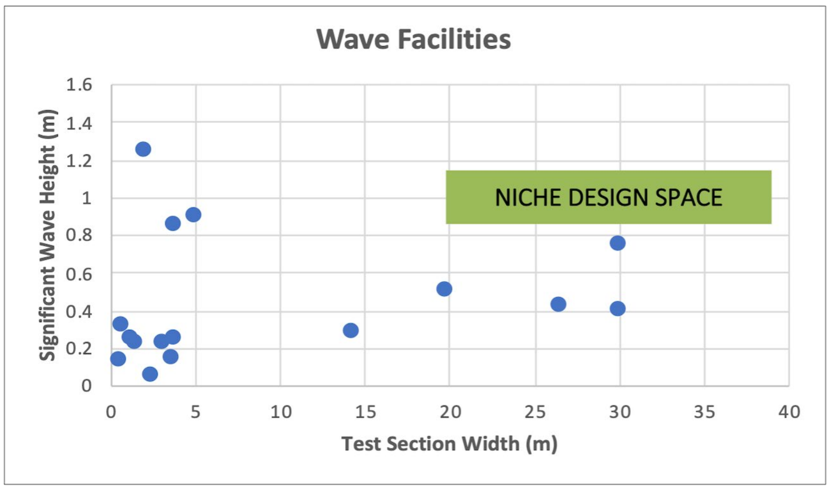


**Figure 2.** *Test section width and significant wave height plotted for each wave facility.*

#### wave facilities.

For the wave facilities assessed, multiple facilities were found to have capabilities or dimensions that met the proposed NICHE design, however, no facilities met both. The National Research Council Canada Large Area Basin, the National Research Council Canada Multidirectional Wave Basin, and the Oregon State University Directional Wave Basin fell within the proposed NICHE test section width. The Environmental Hydraulics Laboratory Large Scale Wave Flume, National Research Council Canada Large Wave Flume, and Oregon State University Large Wave Flume met or exceeded the proposed significant wave height. About half of the wave facilities investigated advertised significant wave heights below 0.4 meters and test section widths below five meters.

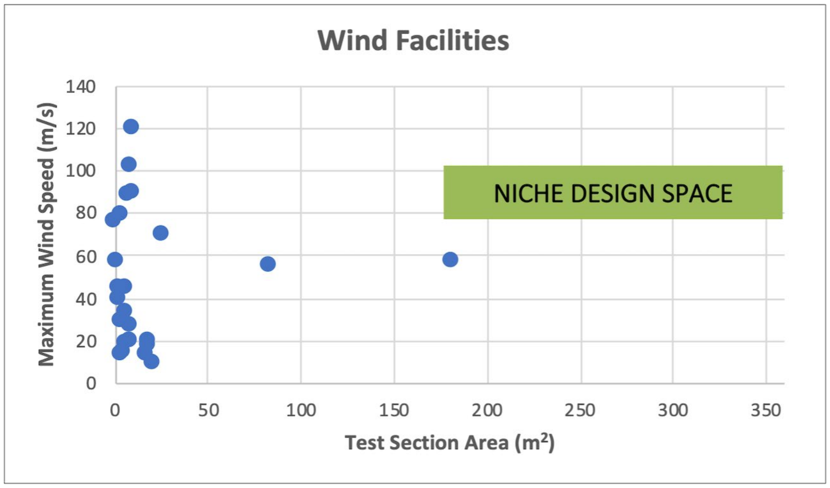


**Figure 3.** *Test section area and maximum wind speed plotted for each wind facility.*

**wind facilities.**

The wind facilities investigated had a large range in maximum wind speeds, with few meeting or exceeding the proposed NICHE design space. These included the San Diego Wind Tunnel, Texas A&M University Oran W. Nicks Low-Speed Wind Tunnel, University of Maryland Glenn L. Martin Wind Tunnel, University of Washington Kirsten Wind Tunnel, and Virginia Polytechnic University Stability Wind Tunnel. Most wind tunnels had test section areas less than 50 meters squared, with only the Insurance Institute for Business and Home Safety Windstorm Facility falling within the proposed NICHE dimensions.

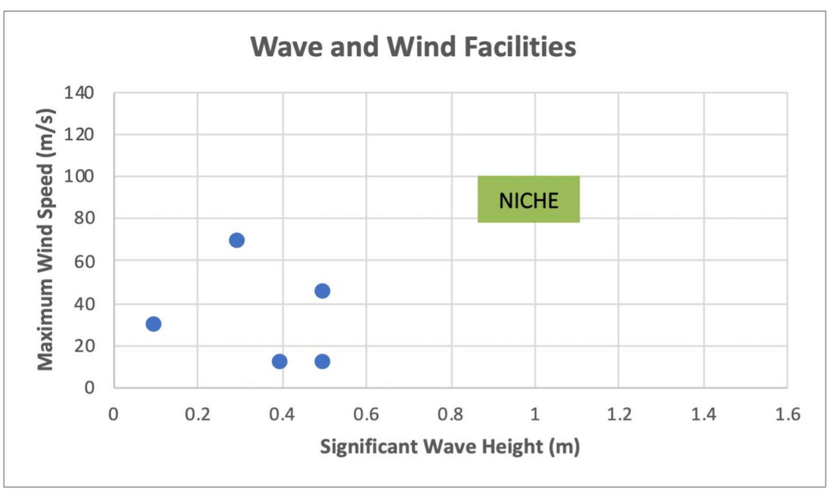


**Figure 4.** *Significant wave height and maximum wind speed plotted for each combined wave and wind facility.*

#### wave and wind facilities.

Lastly, the number of combined wave and wind facilities analyzed in the assessment emphasized the conflict where access to a small number of facilities impedes the compelling need for testing simultaneous impacts. Furthermore, all five facilities fell well short of the proposed capabilities of the NICHE. It should be noted, however, that the University of Miami Surge-Structure-Atmosphere Interaction (SUSTAIN) Laboratory achieved Category 5 wind speeds (70 m/s). Additionally, the University of California San Diego Scripps Ocean Atmosphere Research Simulator (SOARS) recently opened in the Summer of 2022 and boasted a state-of-the-art closed-circuit facility.

#### additional considerations.

Qualitatively, the landscape assessment also identified important information that would be relevant for the design and operation of the full-scale NICHE. For example, during an in-person visit to the University of New Hampshire Flow Physics Facility, staff mentioned that the wind tunnel could only operate at night, when electricity was cheaper, due to the large amount of power and associated costs needed to run. Such a challenge at the world's largest scientific quality boundary-layer wind tunnel is important to consider when running at the unprecedented scale at which the NICHE will be operating. Other facilities that were interviewed also detailed challenges with staffing and personnel, conflicts with the partnered university, declining use of the facility, and more. That being said, there were many positive takeaways as well. The in-person visit with SOARS yielded a future partnership for NICHE physical experimentation testing. In meeting with the Principal Investigators, whose primary research interests focused on oceanography, the NICHE team was introduced to additional expertise in a field relevant to NICHE's research goals.

All in all, the findings from the landscape assessment, as shown in the tables and figures, clearly defined a need for research capabilities in wave and wind facilities that are larger and faster than what is currently offered.

### Considerations for Hosting NICHE PDT Testing

#### selection process.

To select the best possible candidates for PDT testing, the NICHE team considered each facility with two points in mind: 1) feasibility, cost, and logistics of retrofitting and upgrading the facility and 2) whether facility research foci and faculty expertise overlapped with NICHE objectives. Point 1 was presented as a question to facility staff during interviews to gauge expectations for potential future upgrades. While most facilities expressed interest in the NICHE project, many expressed an inability to accommodate such upgrades and testing, eliminating their consideration in the selection process.

If facilities expressed interest and were confident in their ability to retrofit and upgrade their facility to host NICHE PDT testing, their research foci and faculty expertise were then considered. While all of the facilities in the landscape assessment were wind and wave facilities, many focused on research areas outside of the NICHE's mission of natural hazards research and engineering for community resilience. Other research foci and expertise included areas such as renewable energy or aeronautical vehicles. Conversations with the staff and faculty of these facilities proved to be valuable and insightful, however, the NICHE team prioritized facilities with similar research foci.

During the selection process, it was also found that the international or domestic location of the facility would be an important consideration. Regulations regarding research, funding, and transportation of materials across borders would have likely imposed significant obstacles to conducting testing outside the United States. This consideration thus disqualified Canadian options, such as Western University's wind tunnels and the National Research Council Canada facilities.

**selected facilities.**

After conducting the landscape assessment and undergoing the selection process, the NICHE team decided to move forward with PDT testing at five different facilities. These included the University of Florida Boundary Layer Wind Tunnel, Oregon State University Large Wave Flume, University of California San Diego Scripps Ocean Atmosphere Research Simulator, University of Miami Alfred C. Glassell, Jr. SUSTAIN Laboratory, and a new wind generation system at Florida International University that has yet to be built. All the facilities expressed an interest in the NICHE project and upgrading/retrofitting their facilities for PDT testing. Additionally, the research foci of the facilities and expertise of facility staff illustrated a clear overlap with the NICHE project goals and objectives. The University of Florida and Florida

International University facilities and staff provided experience in extreme wind physical testing. Oregon State previously hosted storm surge and wave absorption projects at their facility. The University of Miami and the University of California San Diego both boasted state-of-the-art wave and wind facilities and will also be able to provide insights on running such a facility.

Not all facilities that expressed interest in NICHE were selected for PDT testing. However, the process of compiling capabilities and meeting with staff helped strengthen a scientific network of wave and wind research experts and created a thorough, well-informed database of wave and wind research facilities. Furthermore, faculty and staff of facilities who expressed interest, but were not selected, were later considered for advisory roles to provide future insight and direction on the project. All in all, the tests run at the five facilities will provide a diverse range of boundary conditions, capabilities, and environments which will be key in supporting the design of a future NICHE facility.

## Conclusion

A landscape assessment of wave and wind facilities has been presented, detailing the dimensions and capabilities of more than 40 facilities across North America. This assessment sought to achieve three primary objectives for the NICHE project, which included a) establishing a network of scientific facilities and fostering community awareness of the NICHE project and its goals, (b) validating facility capabilities and equipment, and (c) assessing interest and feasibility of retrofitting/upgrading a facility to host physical design testbed testing. This assessment included visiting nine facilities and interviewing 20 on Zoom. After speaking with facility managers, reviewing ancillary documentation (photos, personnel directories, renderings, research publications), and considering facility capabilities, the NICHE team is moving forward with PDT testing at five different sites. These sites include the University of Florida Boundary Layer Wind Tunnel, Oregon State University Large Wave Flume, University of California San Diego Scripps Ocean Atmosphere Research Simulator, University of Miami Alfred C. Glassell, Jr. SUSTAIN Laboratory, and a new wind generation system at Florida International University. Using multiple facilities for PDT testing allows for a range of testing under different conditions and scales while enabling collaboration and input from various institutions, people, and fields.

In addition to the NICHE objectives, the landscape assessment provided valuable insights into wave and wind structural testing. While a broad range of capabilities was illustrated in this assessment, so was the need for a new facility to test the coupled impacts of extreme waves and wind on full-scale structures. Furthermore, conversations with laboratory managers and a review of facility documentation helped inform an exhaustive database of each facility's research foci, instrumentation, contact points, strengths, and limitations. Compiling such knowledge can help forge new collaborations and empower new interdisciplinary research opportunities.

Overall, when considering the primary objectives achieved for the NICHE project and the additional insights that came with it, the landscape assessment proved successful by thoroughly informing a decision on a path forward regarding PDT testing and fostering a broad community and well-informed database of wave and wind research facilities.

## Acknowledgements

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