CWATER

MARINE RESEARCH COMPLEX

Woods Hole Oceanographic INSTITUTION

Summary

A **C**omplex for **W**aterfront **A**ccess **T**o **E**xploration and **R**esearch (CWATER) will create a next-generation, world-class, sustainable marine research facility that will enable fundamental advances in ocean science, engineering and education through the 21st Century for the entire oceanographic community.

Since its founding in 1930, the Woods Hole Oceanographic Institution (WHOI), located in Woods Hole, Massachusetts, has become a national and international leader in ocean science and engineering, including basic and applied research, education, and operations. The existing WHOI Iselin waterfront complex has become an essential part of the nation's research infrastructure. Today, it supports the operation and maintenance of research vessels from the Academic Research Fleet (managed by the University-National Oceanographic Laboratory System, UNOLS) and around the world and provides access to the sea, both directly and via support for the expanding suite of technologies developed to explore the frontiers of ocean science.

Built in 1969 with funding from the National Science Foundation (NSF) (Fye, 1964), the existing complex is reaching the end of its 50-year design life. Maintenance costs have increased rapidly over the last decade and its functionality is no longer optimal. In a feasibility study (Moffatt & Nichol, 2018) supported by a grant from the Commonwealth of Massachusetts, WHOI determined that redevelopment is feasible and essential to meeting the needs of the institution and the greater oceanographic community for the remainder of this century. A second state grant which is just getting underway was awarded to WHOI to support further planning efforts, including resiliency, preliminary designs, site characterization and permitting. Based on these studies, WHOI plans to transition to a new waterfront research complex that will provide critical, upgraded infrastructure that will advance our nation's oceanographic research capabilities. CWATER has strong scientific merit, helps fulfill significant community research priorities, and provides a platform for training the next generation of ocean research practitioners.

CWATER incorporate sea-level rise and coastal resiliency measures and will be designed to serve as a model for other marine centers and facilities. This will have an important, far-reaching impact because the community is looking to WHOI to provide leadership in the critical area of waterfront infrastructure sustainability and CWATER provides a platform to do so. A strategic approach may include lessons learned from the reconstruction of waterfront infrastructure from Hurricane Sandy which utilized a process called Rebuild by Design (RBD). RBD, a collaboration of the Netherlands Special Water Envoy, the U.S. Department of Housing and Urban Development, the Rockefeller Foundation and cities in the N.Y. area, employs a transformative approach to climate change. Rather than the traditional "rebuild in kind," RBD incorporates resilience into reconstruction efforts.

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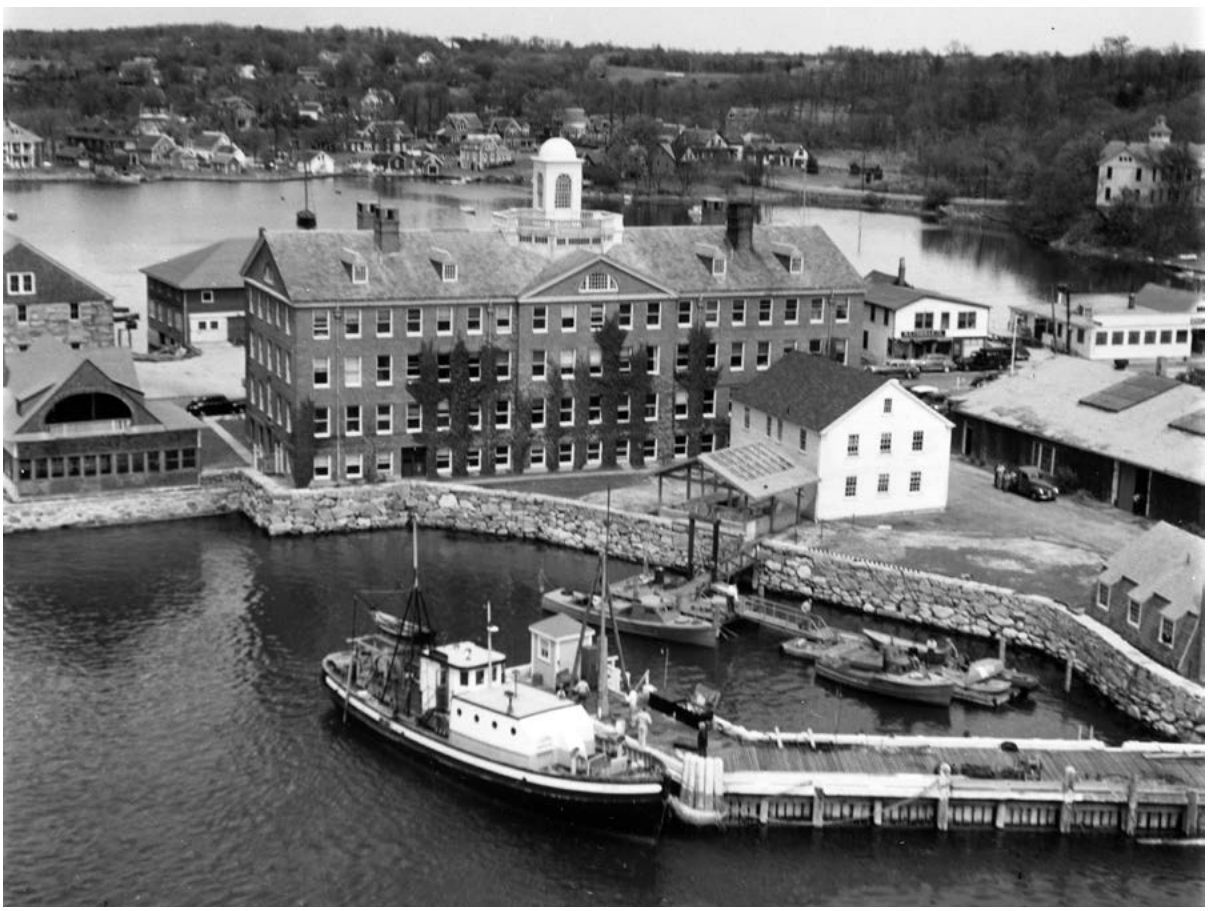


WHOI's marine facilities have evolved over the past 80 years to meet the needs of a growing and changing technology base to support oceanographic research.

Setting

For nearly a century, the Village of Woods Hole has been a center for marine science, research, exploration, and education in the U.S., with far-reaching impacts around the world. Since 1930, it has been home to WHOI, the world's largest independent non-profit organization dedicated to ocean research, exploration, education, and public outreach.

Woods Hole is home to the National Oceanic and Atmospheric Administration's Northeast Fisheries Science Center (NOAA NEFSC), the Marine Biological Laboratory (MBL), the Sea Education Association (SEA), the U.S. Geological Survey (USGS) Coastal & Marine Science Center, the U.S. Coast Guard Southeast Sector New England, the Woods Hole Research Center, and the Steamship Authority. There are also dozens of marine technology companies in the area, including Hydroid and Teledyne Webb, many of them spin-offs from WHOI that continue to benefit from and expand the marine science ecosystem locally and nationally. As such, Woods Hole is a unique epicenter for the "Blue Science and Technology Economy."

Since it's inception, Woods Hole has had its face turned to the sea. Starting with subsistence fishing and continuing to its current status as an internationally recognized center for oceanographic research and education, the sea permeates the culture of the community. CWATER is part of the natural evolution of Woods Hole; it will enable the next generation of oceanographic research and education while reinforcing the strong connection of the community, and nation, to the sea that surrounds us.

The current WHOI marine facility is a national resource that includes a one-acre port with scientific and engineering test wells, a 10,000-square-foot fabrication shop, high bays, a scientific diving operation, and comprehensive marine research laboratories that benefit from direct access to the sea. The facility provides direct deep-water access for submersible testing and coastal oceanography; serves as the homeport for two Navy-owned, WHOI-operated research vessels; and is used continuously by WHOI, our oceanographic neighbors, and other private and government institutions, as well as by the public for educational and research purposes.

WHOI's Iselin Marine Facility is an integral part of the scientific and cultural community of Woods Hole.

The current WHOI marine facility is a national resource that includes a one-acre port with scientific and engineering test wells, a 10,000-square-foot fabrication shop, high bays, a scientific diving operation, and comprehensive marine research laboratories that benefit from direct access to the sea.

Research Community Priority

Access to the sea is fundamental to the ocean science enterprise. The modernization of WHOI's waterfront research facilities is built on the simple premise that investment in core scientific infrastructure supporting access to the sea will provide the foundation on which ocean and earth science will be able to grow into the next century. It has been demonstrated repeatedly that such investments result in discoveries and insights that change our understanding of ocean and coastal processes across the disciplines of scientific research, engineering, and technological development that drive the innovation economy.

The importance of infrastructure to enable access to the sea has been highlighted in numerous reports over the past two decades, a few of which are highlighted below. These reports speak directly to the relevance of CWATER to the national scientific and technological interest.

Science and Technology for America's Oceans: A Decadal Vision (***NSTC 2018***). This report rightly notes that "access to the sea has always been a fundamental hurdle for marine research as the ocean can be a harsh, unforgiving, and dangerous environment." It continues by stating that "our research infrastructure is critical to our Nation's leadership role in ocean science. The infrastructure and technology necessary for successful ocean research include ships, submersibles, aircraft, satellites, land-based radar, moorings and cabled buoys, and various unmanned underwater, surface, and airborne vehicles. Research infrastructure also includes land-based facilities, i.e., state of the art laboratories, to support deployed ocean assets and to receive, analyze, and manage incoming data using high-performance computing and communications networks that support wide access to and use of information."

Sea Change: 2015-2015 Decadal Survey of Ocean Sciences (***NRC 2015***). *Sea Change* identified eight priority ocean science questions within three larger themes. The report concludes that achieving these science goals has a "high reliance on infrastructure," and points out that, "Ships provide invaluable access to the sea and are an essential component of ocean research infrastructure. Evolving science needs, cost pressures, and newer technologies...have changed the oceanographic research toolbox. However, they have not lessened the reliance on highly capable ships." The NRC notes that the UNOLS fleet is "critical and indispensable for addressing the majority of the science priorities," while "high demand for the Global [Class] ships in part reflects the growth of complex multi-investigator projects that require relatively large science parties." It goes on to recognize the broader suite of tools that facilitate access, including the National Deep Submergence Facility (NDSF), and especially

These studies, and the role of UNOLS, make clear that oceanography requires access to the sea, which in turn requires research infrastructure.

unmanned vehicles, which are important to almost all decadal science priorities, while also "[r]ealizing science priorities will require access to a broader mix of vehicles than just NDSF." The report also acknowledges that "Field stations and marine laboratories play a vital role in the decadal science priority themes."

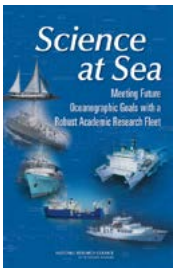
Critical Infrastructure for Ocean Research and Societal Needs in 2030 (***NRC 2011***). The report defines U.S. ocean research infrastructure as the full portfolio of platforms, sensors, datasets and systems, models, supporting personnel, facilities, and enabling organizations that the nation can bring to bear to answer questions about the ocean, and that is (or could be) shared by or accessible to the ocean research community as a whole. One of its highest priority recommendations is the need to "implement a comprehensive, long-term research fleet plan to retain access to the sea." The report notes that, "Ships, satellite remote sensing, arrays of in situ observations, and shore-based laboratories are the foundation for ocean research infrastructure," and "shore-based laboratory facilities will continue to be required as a natural extension to ship-based sampling, for analytical work, and coastal observations."

Science at Sea: Meeting Future Oceanographic Goals with a Robust Academic Research Fleet (***NRC 2009***). Seagoing science needs and challenges were also highlighted in this NRC report, which pointed out that, "Key to the study of these issues is the U.S. academic research fleet, which provides an essential, enabling resource for the nation. Scientific demands on the U.S. academic fleet are likely to increase in future years." The report further recognizes that, "[The] fleet of the future will be required to support increasingly complex, multidisciplinary, multi-investigator research projects, including those in support of autonomous technologies, ocean observing systems, process studies, remote sensing, and modeling. Adaptable, technologically advanced Global Class vessels will be needed."

Future Needs in Deep Submergence Science (***NRC 2004***). NDSF provides access to state-of-the-art underwater vehicles including the human-occupied submersible *Alvin* and the robotic vehicles *Jason* and *Sentry*. The importance of the NDSF vehicles to oceanography and ocean engineering is the main message of this report, and NDSF was also mentioned favorably in *Sea Change* (NRC 2015). A key conclusion of this report is the need for NDSF vehicles for deploying, operating and maintaining ocean observing infrastructure, while other reports (e.g., NSF DESCEND-16 workshop, 2016), articulate the importance of the NDSF vehicles and argue for federal support for the advancement of technologies that will "foster new avenues for exploration and advance our understanding…of processes in the ocean."

University-National Oceanographic Laboratory System (***UNOLS***) was established in 1972 by the oceanographic community in recognition of the need for shared-use research infrastructure to obtain access to the sea. UNOLS provides a system for access and scheduling, as well as standards for scientific resources, operations and safety for research vessels, aircraft, seismic systems and submersibles. UNOLS recognizes shore support facilities as a key part of the research infrastructure and has established winch pools, wire pools, technician pools and the associated shore-based management, operation and maintenance through academic operating institutions. All of these elements comprise the UNOLS "system." The importance of UNOLS to the oceanographic community, including both academia and the U.S. Navy, is broadly recognized and articulated in numerous publications (NRAC 2003; NRC 2015; etc.). WHOI is a leading UNOLS operator and CWATER is being designed to help strengthen its enabling research infrastructure.

These studies, and the role of UNOLS, make clear that oceanography requires access to the sea, which in turn requires research infrastructure in the form of ships, aircraft, submersibles, remotely operated and autonomous underwater vehicles, autonomous surface vehicles, ocean observing systems, and their associated shore facilities. NSF's Regional Class Research Vessel (RCRV) program, with three new ships funded by Congress, reinforces the recognized importance of access to the sea for future decades, as well. Shore-based waterfront research infrastructure, such as CWATER, also provides direct access to the sea with on-site, over-the-side capabilities, seawater test wells, observing systems, labs and shops that benefit from such proximity.



Scientific access to the sea is imperative– The NRC and other organizations have released multiple reports supporting the need for ocean science infrastructure. A full list of references appears at the end of this report.

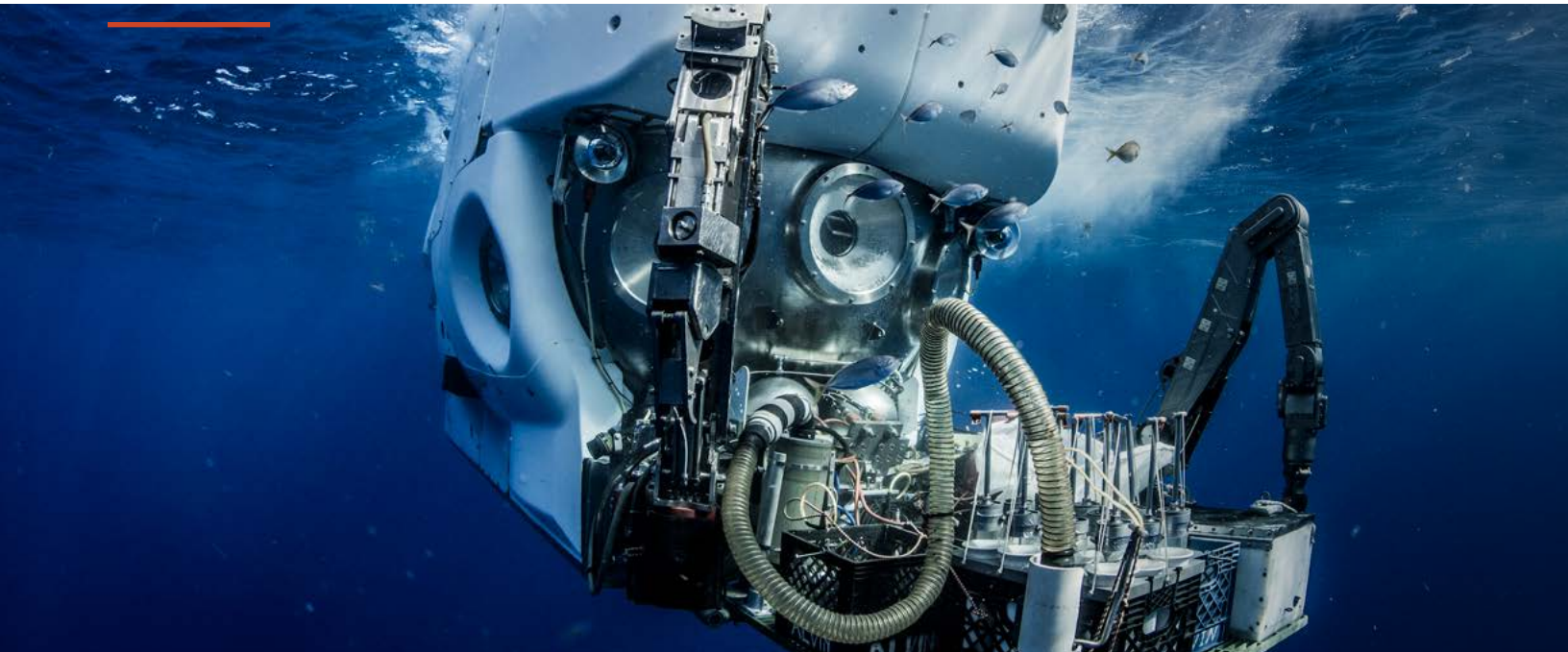
Scientific Justification

WHOI's existing marine facility, named for pioneering oceanographer Columbus Iselin, is the foremost waterfront research complex on the U.S. East Coast and is the hub for access to the sea for WHOI researchers and the greater oceanographic community.

The facility is the origination for global oceanographic research missions and is particularly well-situated for missions to the North Atlantic and Arctic. The current complex includes a dock, test wells, shops, laboratories, and flexible high bay space. Iselin Dock has over 700 linear feet of deep-water berth, more than one acre of open deck, and is capable of docking two large ships and several smaller vessels. It is the homeport for the Navy-owned, NSF-funded, WHOI-operated research vessels *Atlantis* and *Neil Armstrong*, and the WHOI-owned coastal research vessel *Tioga*. During the period 2014 to 2018, WHOI conducted 100 missions on the *Neil Armstrong* and *Atlantis* led by chief scientists from 36 institutions with participation from 250 universities, government agencies, and private organizations. Sixty-one of these missions mobilized or demobilized (or both) from the WHOI complex. The *Tioga* made 388 trips from Iselin between 2013 and 2017.

The facility is also regularly and extensively used by other research vessels, including recent visits by the academic research vessels *Marcus Langseth*, *Sikuliaq*, and *Connecticut;* the NOAA research vessels *Henry B. Bigelow* and *Auk;* and commercial/private research vessels *Falkor*, *Alucia*, *Discovery*, and *Scarlett Isabella*, among others. The Sea Education Association also uses WHOI's waterfront facilities each year to support and mobilize the tall ship *Corwith Cramer* for its summer undergraduate research cruises, as well as periodic orientation and training cruises for WHOI graduate students. *Atlantis, Neil Armstrong, Marcus Langseth*, and *Sikuliaq* are part of the UNOLS academic fleet. In addition to these, the UNOLS vessels *Thomas G. Thompson, Endeavor*, and *Atlantic Explorer* made port calls and utilized the complex, as well as specialized WHOI services, in 2019.

WHOI, along with the University of Rhode Island (URI) and University of New Hampshire (UNH), comprise the East Coast Oceanography Consortium (ECOC). The ECOC oversees the management of the *Endeavor*, with URI as the lead operator. When *Endeavor* is retired in 2021, it will be replaced by the new UNOLS Regional Class Research Vessel (RCRV) *Resolution*. One



For more than 50 years, the human-occupied vehicle *Alvin* has called WHOI home, even if it spends much of its time at sea, and returned to WHOI marine facilities for periodic maintenance and overhauls.

of WHOI's key contributions to the ECOC is access to the resources of the waterfront research complex.

WHOI's facilities also support scientific and engineering development from its test well; is home to the shipboard scientific systems group (SSSG) test lab, a 10,000-square-foot fabrication shop, and a scientific diving operation; and also provides direct access to Buzzards Bay and Vineyard Sound for submersible testing and coastal oceanography. The facility is also the staging area for the Atlantic-based coastal and global ocean observing arrays that are part of NSF's $386 million investment in the shared use infrastructure of the Ocean Observatories Initiative (OOI). In addition to being an implementing organization for the construction of OOI, WHOI was recently selected to oversee operation and maintenance of the entire system, including the Atlantic-based coastal Pioneer Array and the global Irminger Sea and Gulf of Alaska arrays, which are in their first year of a 5-year, $44 million/year O&M program and that will potentially operate for decades. WHOI has conducted 15 OOI construction, deployment, operation, and maintenance cruises from the facility since 2015.

WHOI is the designated NDSF operator and develops, engineers, builds, operates, and maintains the NDSF vehicles on behalf of the user community. NDSF is a major user of the waterfront research complex. When not deployed, the research submersible *Alvin* is maintained in the "*Alvin* High Bay," where its recent $40 million overhaul was performed. The NDSF vehicles *Jason* and *Sentry* regularly use the high bay space and over-the-side capabilities for upgrades, testing, and training. Non-NDSF vehicles such as the *Nereus*, the *Nereid Hybrid Tether* vehicle, and the NSF-funded *Nereid Under Ice* vehicle also depend on the complex.

WHOI also hosts the East Coast Winch Pool and Wire Pool on behalf of UNOLS. The Iselin complex is regularly used for wire winding and winch testing and maintenance before loading aboard a vessel or shipment to another port for mobilization. Recent visits by the research vessels *Thomas G. Thompson* and *Sikuliaq* also included extensive maintenance to the ships' winches and wires.

The WHOI Ocean Systems Laboratory (OSL) is based in the Iselin complex where the assembly, testing, maintenance, and upgrade of the REMUS family of autonomous underwater vehicles (AUVs) takes place. Proximity to the sea is critical to the efficiency of the work of OSL, both from an engineering and operational perspective and as a teaching lab. The REMUS family of AUVs are now the world leaders in commercially available AUV technology and are sold through the WHOI spin-off company Hydroid. OSL continues to provide R&D support and training from the waterfront complex to Hydroid and their largest end-user customer, the U.S. Navy.

The complex also hosts WHOI's Center for Marine Robotics' "DunkWorks" rapid prototyping center. DunkWorks is an open-access, fee-based facility, funded in part by a state grant, which provides advanced machining, 3D printing, and training to its members, most of whom use these services to rapidly advance underwater sensor and vehicle development that require direct access to the sea. Members come from WHOI, other Woods Hole research organizations, businesses, and local schools.

Staging and deployment for operations and maintenance cruises to the Ocean Observatories Initiative's Pioneer and Irminger Sea Arrays takes place from the WHOI marine facility. A key focus of OOI research is sea-level rise, which will also be a critical consideration of the design of the new facility. Learn more about OOI at www.whoi.edu/OOI

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Broader Impacts

EDUCATION

Part of WHOI's mission, along with key sponsors NSF, U.S. Navy, NOAA, and other U.S. government agencies, is to help create the next generation of ocean scientists, engineers, technicians, and seafarers. This effort starts with the youngest of budding scientists and spans to WHOI's joint PhD program with MIT and post-doctoral programs. CWATER will be an essential resource to these education and student training programs, which will benefit from access and exposure to the sea. WHOI's education and student training programs are listed below, followed by representative at-sea training examples:

- *K-12*: Regular class trips to the dock facility and to ships tied up there, as well as specialized programs such as Girls in Ocean Engineering and Science (GOES) Woods Hole Sea Grant and Earthwatch Girls in Science.
- *Undergraduate:* Summer Student Fellowship Program for immersion in ocean science and engineering; Partnership Education Program (with NOAA and other Woods Hole science organizations), a four-week course followed by a research experience for undergraduates with a goal of increasing diversity; Semester at WHOI for-credit research experience.
- *Graduate:* MIT-WHOI Joint Program in Oceanography and Applied Ocean Science & Engineering, 5-year PhD program (and 2-year M.S. program for U.S. Navy officers); competitive summer Geophysical Fluid Dynamics Program.
- *Post-Doctoral:* Competitive Postdoctoral Scholar and Fellows Programs.

MIT-WHOI Joint Program* (*JP*) *Class Work: Classes regularly use the facility for student training. Biological Oceanography (Course 7.470), required of all biological oceanography students, provides instruction in collecting plankton samples and taking environmental readings from the test well. Principles of Ocean Instrument Systems (Course 2.688), required of all Applied Ocean Science and Engineering students, holds teaching labs for instruction with in-water sensors (deployment, maintainenance, recovery, data processing, etc.) and autonomous vehicles.

Joint Program Research Cruises: First-year students gain seagoing experience by planning and executing a research cruise on R/V *Neil Armstrong*. Students conduct pre-cruise meetings and interface with ship operations; assemble equipment in the high bay and other flexible project space; mobilize the ship; sail on the cruise; demobilize the ship; and analyze the data and prepare final reports. (LaCapra 2018)

Scientific Diver Training: The waterfront research complex is the site for the WHOI scientific diving program, which trains research practitioners in the use of diving as a scientific tool and provides certification in accordance with the American Association of Underwater Scientists (AAUS). The complex houses the Dive Safety Officer (DSO), training facility, and dive locker, enabling direct access to the sea for training dives and equipment testing. The WHOI dive program has 52 AAUS-certified divers, annually trains 10 to 15 new divers and oversees more than 1200 dives worldwide, including over 300 at Iselin. WHOI also provides AAUS training and certification for cadets at the Massachusetts Maritime Academy and collaborates with the dive program at neighboring MBL.

K-12 Programs at WHOI: GOES program, funded through an NSF CAREER grant, invites rising 6th grade

A hallmark of WHOI's mission is to bring its science to bear on the task of training future generations of scientists, engineers, decision-makers, and members of society. Learn more about WHOI's educational initiatives here: *www.whoi.edu/education*

The annual Woods Hole Science Stroll attracts several thousand visitors to Woods Hole and to the Iselin Marine Facility each summer to learn about the research and marine activities of local institutions.

girls from diverse backgrounds to attend a four-day intensive institute that provides hands-on exposure to the tools of ocean science and engineering. Another week-long, residential program called Girls in Science, for high school sophomores and juniors from underrepresented groups is being offered in 2019, funded by Woods Hole Sea Grant in partnership with WHOI and the Earthwatch Institute. Both programs rely on the Iselin waterfront complex.

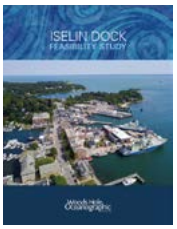
Science Stroll: Every year WHOI, MBL, SEA, Woods Hole Research Center, and NOAA, among others, host an "open house" in the village of Woods Hole to highlight the scientific activities of local research and maritime institutions. The free event attracts thousands of visitors of all ages and provides opportunities to interact with ocean scientists, engineers, technicians, and students. Iselin is central to this important outreach event, featuring ship and submersible tours, and many booths that highlight experiments and programs.

MAJOR PROGRAM SUPPORT

The WHOI waterfront complex at Iselin serves as a base of operations for the NSF-funded Northeast Shelf Long Term Ecological Research (NES-LTER) site, established in 2017 under a 5-year renewable grant in collaboration with scientists from NOAA, URI, Wellesley College, and UMASS Dartmouth. The NES-LTER is using research infrastructure at the WHOI-owned Martha's Vineyard Coastal Observatory (MVCO) and the OOI Pioneer Array, which are operated and maintained from the WHOI waterfront complex. In addition to supporting the four cruises per year through the LTER study area, the proposed ocean observing capabilities that CWATER will support on site will further enhance the NES-LTER.

Like major programs of the past (Ridge 2000; GLOBEC; WOCE; JGOFS), many multidisciplinary research programs will originate at the WHOI waterfront in the coming years. For example, OSNAP (Overturning in the Subpolar North Atlantic Program) is an international program designed to provide a continuous record of the full-water column, trans-basin fluxes of heat, mass and freshwater in the subpolar North Atlantic. NASA, in collaboration with NSF, is supporting EXPORTS (Export Processes in the Ocean from Remote Sensing) that will provide critical information for quantifying the export and fate of upper ocean net primary production, and relies on UNOLS vessels. WHOI has also received philanthropic funding to support the Ocean Twilight Zone, via the TED Audacious Project, a 6-year, $35 million effort using innovative technologies to document the ocean's mysterious midwaters.

The CWATER Project



A feasibility study supported by Mass SEC developed a road map to create a next-generation, world-class, sustainable waterfront marine research complex.

FEASIBILITY STUDY

CWATER is a realistic and constrained project. A feasibility study was conducted with a $500,000 grant from the Massachusetts Seaport Economic Council (SEC), which was supplemented with $155,000 of WHOI institutional funds. The study developed a road map to create a next-generation, world-class, sustainable waterfront marine research complex. Trade studies were performed to provide technical, economic, and risk analyses for the key variables, identify pros and cons, and enable fundamental decisions about design and implementation. The results of the study are summarized as follows:

- Uncertainty in sea level rise projections suggests constraining CWATER design life to 50 years.
- The requirements analysis, assessment of permitting, and cost estimates suggest that retaining the current research pier footprint is optimal.
- The site available for the shoreward portion of the marine complex has an adequate footprint, accessibility, and provision for resilience to support a facility of 3 or 4 stories that will house the required laboratories, high bays, shops, operations, dive centers, and public spaces.
- The cost estimate for CWATER in 2018 dollars is $75 million.
- Construction plans were developed for phasing options, from which the time required to implement the project was determined to be between 36 to 45 months.

Analysis performed by an expert permitting consultant as part of the feasibility study, indicates the project can readily be permitted (Moffatt & Nichol, 2018). NEPA, NHPA, ESA and other Federal reviews will be performed under the auspices of the USACE Section 10/404 process as the lead agency.

A key part of the permitting process, as well as good practice reflecting WHOI's mission, is involvement with the community. To this end, we established an advisory committee in 2017 as a mechanism to ensure a continuing dialogue with the community, focusing on shared values and access, and to obtain input on WHOI's strategic facilities plans, focusing particularly on CWATER. Key committee stakeholders and partners include the MBL, NOAA NEFSC, USGS, Woods Hole Business Association, Woods Hole Community Association, and the Woods Hole Museum and Library. WHOI also partnered with the Town of Falmouth for the two State grants and our commitment to community engagement has resulted in a CWATER project plan that complements the goals in the Town of Falmouth's Local Comprehensive Plan (Town of Falmouth Planning Board, 2016), including providing better public access and use.

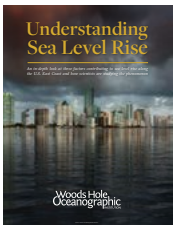
The results of the Feasibility Study and guidance from the Advisory Committee formed the basis for a second successful $1 million planning grant from the Massachusetts SEC; the award was just received and work is set to begin. The scope will include site investigations, further sea level rise analysis, an assessment for a sustainability and adaptability, preliminary design, permitting consultation, and applications. The results of the second SEC grant will move CWATER closer to the detailed design phase.

The WHOI dock is a regular staging ground for maintenance of the OOI Pioneer mooring array.

VISION FOR THE FUTURE

The current complex was designed and constructed for a 50-year lifespan and it is now more than 50 years old. The existing complex is an amalgamation of functions and tasks that are not fully optimized, reflecting 50 years of mission accretion and change. Recent engineering studies indicate accelerating deterioration and recommendations to restrict certain activities such as the movement of heavy machinery and crane lifts. These restrictions are increasingly limiting the complex's ability to meet the demands of modern waterfront operations.

The proposed CWATER marine facility will expand and enhance the nation's infrastructure in support of ocean research, engineering, education, and outreach.



A recent WHOI-authored report on sea-level rise underscored the uncertainties surrounding forecasts. The report may be downloaded here: *go.whoi.edu/sealevel*

CWATER will provide critical new and upgraded infrastructure for oceanographic research for the next 50 years or longer, capable of supporting the changing needs of scientists, engineers, mariners, educators and other stakeholders.

The proposed CWATER marine facility will significantly expand and enhance the nation's infrastructure in support of ocean research, engineering, education, and outreach. Multiple federal and other advisory committee studies over the past two decades have prioritized the need for shared-use infrastructure to advance oceanographic science by enabling access to the sea. CWATER speaks directly to this need. CWATER will benefit national security, scientific, and economic interests, based on past and current usage by virtually every sector of the oceanographic community.

Our plans for CWATER include the following essential features and improvements over the current facility:

FEATURE	CWATER IMPROVEMENT/UPGRADE OVER ISELIN
50-year design life	No change; chosen due to sea-level rise uncertainty and construction realities.
Adaptability	Significant improvements to accommodate future sea-level rise.
Dock design	No change; current dock is appropriate and can be permitted with the same footprint.
Vessel berthing	No change in large ship berths; upgraded utilities; significant upgrade for small boat and non-vessel vehicle access.
Test well	Larger; new fixed crane; new permanent laboratory with power and bandwidth.
AUV laboratories	Significantly upgraded and purpose-built with bridge cranes; easy access to the dock, security system, facility for vehicle transporting, testing, etc.
Operations center	New; for marine operations, telepresence, and observing; for operational, educational, and outreach purposes.
High and low bays	Significantly expanded; flexible, purpose-built work spaces with utilities, bridge cranes, direct access to dock.
Prototyping lab	Upgraded to accommodate new machines and workspaces.
Science tech lab	Upgraded for shipboard scientific systems technical support for seagoing equipment, bench testing, and technician training.
Dive locker	Significant upgrade for equipment maintenance, training, habitability.
Observing systems	New; will complement MVCO, OOI/Pioneer, and LTER projects. Will provide oceanographic and meteorological data for site characterization and outreach.
Education and training	New space for education, meetings, observing systems data presentations, and public access.

Only a holistic approach that includes radical engagement will provide a long term, resilient solution.

STRATEGY FOR RESILIENCE

The current complex has become vulnerable to sea-level rise and storm surge. A key outcome of the feasibility study was recognition of the importance of resiliency to all aspects of the project. The study concluded that CWATER should be built to adapt to sea-level rise, a strategy that will benefit WHOI, its research partners and collaborators and the local community. It is also our goal that CWATER will be a model for other communities throughout the state and nation that will be building facilities in the future that must be on or adjacent to the coast.

We are intrigued about the possibilities of the Rebuild by Design (RBD) process used for the reconstruction response to Hurricane Sandy in the New York area. Described in references such as *Too Big* (Ovink and Boeijenga, 2018), *Rebuilding with Resilience* (Grannis, 2016) and *Rebuild by Design* (Gendall, editor, 2015), the process features a holistic approach, competition, radical engagement among stakeholders and defined resilience values. While the applicability of RBD to CWATER may not may not be exact, there are many elements that fit well. This is particularly true when CWATER is viewed in the context of greater Woods Hole: A resilient solution must incorporate strategies for the entire community. Only a holistic approach that includes radical engagement will provide a long-term, resilient solution.

REFERENCES CITED

Developing Submergence Science for the Next Decade (DESCEND-2016). (2016) *Workshop Proceedings*. 103 pp. https://www.unols.org/sites/default/files/DESCEND2%202016%20FINALFINAL_small.pdf

Fye, P. (1964) *Woods Hole Oceanographic Institution Application to the National Science Foundation for a specialized facilities grant for the construction of Waterfront Facilities.* 31 pp.

Grannis, J. (2016). *Rebuilding with resilience. Lessons from the Rebuild by Design Competition After Hurricane Sandy*. Georgetown Climate Center, 94 pp.

Gendall, J. (editor) (2015). *Rebuild by Design*. Rockefeller Foundation, 249 pp.

LaCapra, V. (2018) *Students Get Their Sea Legs. Orientation cruise provides introduction to ocean research.* Oceanus Magazine. https://www.whoi.edu/oceanus/feature/whoi-students-get-their-sea-legs/

Moffatt & Nichol (2018). *Iselin Dock Feasibility Study: Final Report Prepared for the Woods Hole Oceanographic Institution*. Newton, MA

National Research Council. (2004) *Future Needs in Deep Submergence Science: Occupied and Unoccupied Vehicles in Basic Ocean Research*. https://doi.org/10.17226/10854.

National Research Council. (2009) *Science at Sea: Meeting Future Oceanographic Goals with a Robust Academic Research Fleet*. https://doi.org/10.17226/12775.

National Research Council. (2011) *Critical Infrastructure for Ocean Research and Societal Needs in 2030*. http://doi.org/10.17226/13081

National Research Council. (2015) *Sea Change: 2015-2025 Decadal Survey of Ocean Sciences*. https://doi.org/10.17226/21655.

National Science and Technology Council. (2016) *Science and Technology for America's Oceans: A Decadal Vision*. Committee on the Environment, Subcommittee of Ocean Science and Technology. November, 2016. 61 pp. https://www.whitehouse.gov/wp-content/uploads/2018/11/Science-and-Technology-for-Americas-Oceans-A-Decadal-Vision.pdf

Naval Research Advisory Committee, Office of Naval Research. (2006) *Report to Congress Requirements and Plans for University-National Oceanographic Laboratory System (UNOLS) Fleet Renewal* https://www.onr.navy.mil/-/media/Files/history/nrac-reports/2006_rpt_unols.ashx?la=en

Ovink, H and Boeijenga, J. (2018) *Too Big. Rebuild by Design: A Transformative Approach to Climate Change*. Naioio Publisheres, 269 pp.

Town of Falmouth Planning Board. (2016) *Guiding the Development of Falmouth for the next 50 years, Local Comprehensive Plan.* http://www.falmouthmass.us/DocumentCenter/View/4441/LCP-doc-all-elements

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