Water Power Technologies Office

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

NSF OOI Presentation

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DOE's Office of Energy Efficiency and Renewable Energy

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Water Power Technologies Office Overview

The U.S. Department of Energy's Water Power Technologies Office (WPTO) **enables research, development, and testing of emerging technologies** to advance marine energy as well as next generation hydropower and pumped storage systems for a flexible, reliable grid.

Hydropower Program

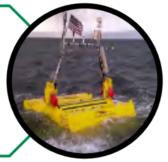

Non-Powered Dams and Conduits


New Low-Impact Projects


Pumped Storage


Upgrades

Marine & Hydrokinetics Program

Wave


Tidal


River Current


Ocean Current


Federal Agency Partners

BOEM Bureau of Ocean Energy Management

Bureau of Reclamation

Federal Energy Regulatory Commission

U.S. Fish & Wildlife Service

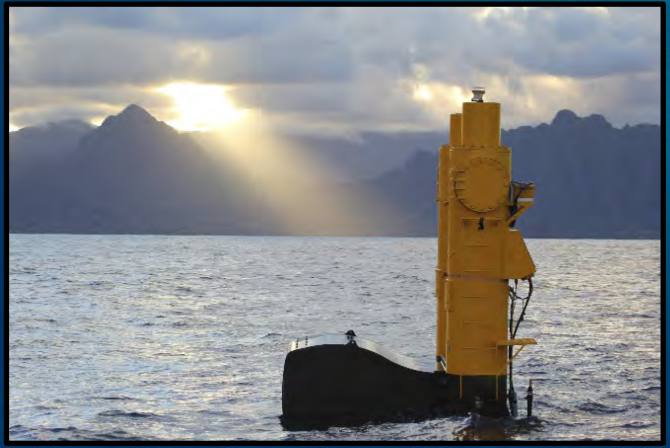
United States Environmental Protection Agency

NOAA

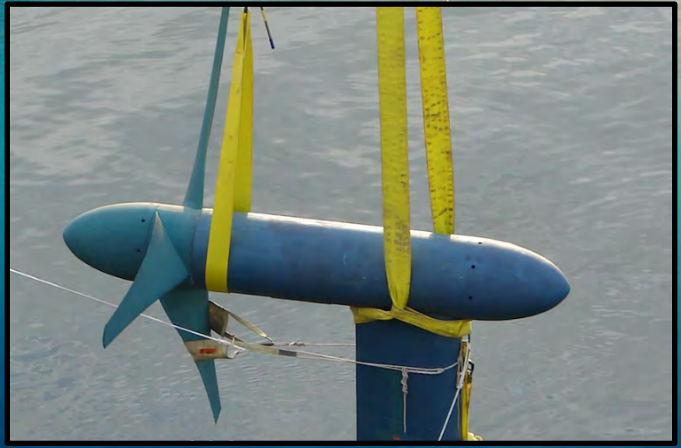
U.S. Army Corps of Engineers

United States Navy

Marine & Hydrokinetics (MHK)



Wave



Tidal

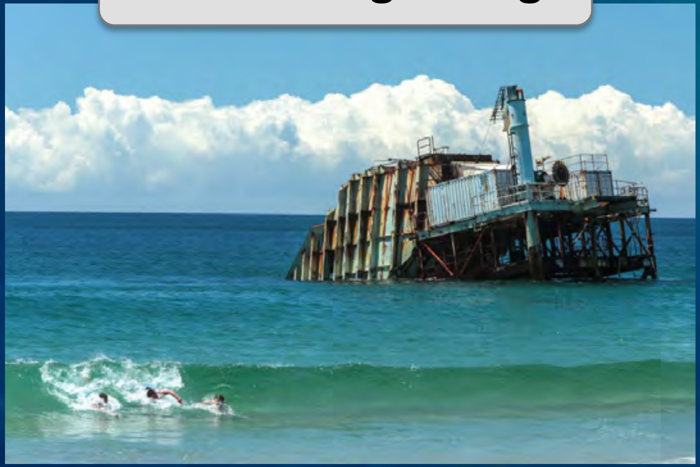
River Current

Ocean Current

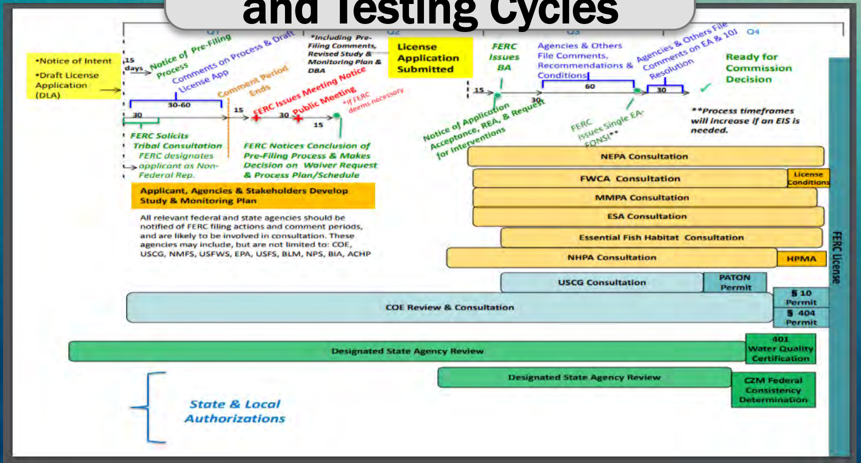
Ocean Thermal

Challenges to Developing Marine Energy Technologies

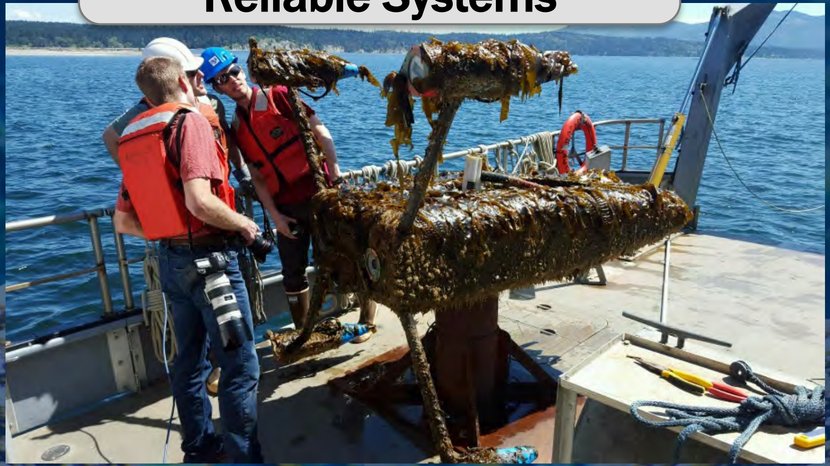
Difficult Engineering



Prolonged Design and Testing Cycles



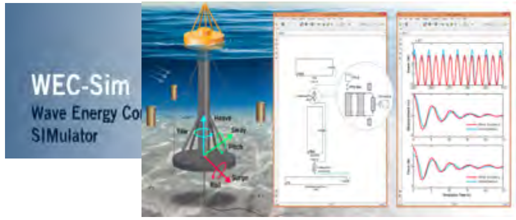
Installing and Operating Reliable Systems

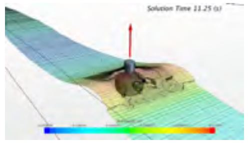


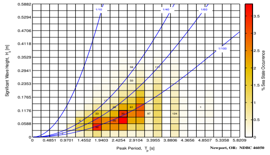
Technology / Market Information & Supply Chains

WPTO's Approach

Foundational R&D







Data Access and Analytics

MHK
Marine and Hydrokinetic Data Repository

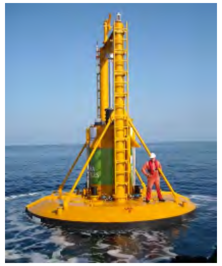
TETHYS ENGINEERING

Reducing Cost

Increasing TRL

Technology-Specific Design & Validation

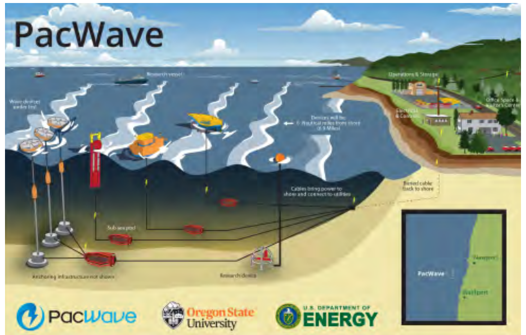
Wave



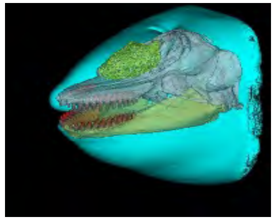
Tidal/Current

Reducing Barriers to Testing

Access to Testing Infrastructure



Enabling R&D

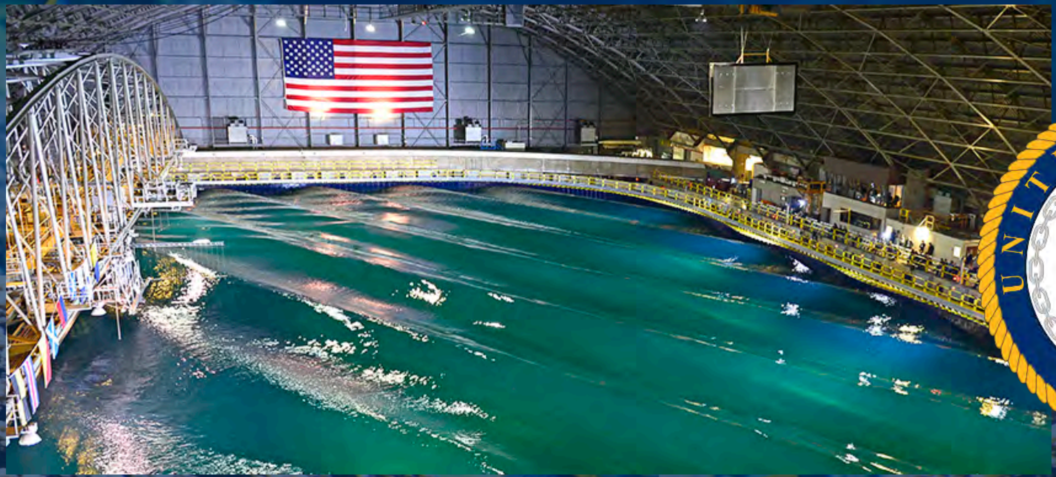


COST-EFFECTIVE MARINE ENERGY

WPTO's Existing Interagency Collaborations in Marine Energy

2020 Build to Scale Grant:

- $4M Industry Challenge for Blue Economy entrepreneurship and commercialization
- Selections to be announced in August or September



Partnering with the Navy to test marine energy devices at sites like the Maneuvering and Seakeeping Basin in Maryland and the open water U.S. Wave Energy Test Site in Hawaii

U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

POWERING
the BLUE ECONOMY™

Powering the Blue Economy

The Powering the Blue Economy initiative seeks to understand the power requirement of emerging coastal and maritime markets and advance technologies that could integrate marine renewable energy to relieve these power constraints and promote economic growth.

Power at Sea: From ocean exploration and navigation to fish cultivation, many marine-based applications and markets are located far from shore—sometimes in deep water. Delivering power to these systems can be expensive and difficult. Powering systems that use energy derived from the ocean offers a cost-effective alternative.

Resilient Coastal Communities: Marine energy can help support coastal communities, making them more resilient in the face of extreme events such as tsunamis, hurricanes, floods, or droughts. Many marine energy applications are ideally suited to coastal development by offering relatively easy access for installation and operation and maintenance activities.

PBE Goals

WPTO has set out three interwoven goals for PBE to quantify the value of marine energy in the blue economy, support individuals and companies in the development of prototypes and solutions to provide power in these markets, and partner with the end-users who need these solutions and ultimately can make them successful. The PBE initiative goals are:

Goal 1: Understand end-user needs and **quantify the value of marine energy** in emerging ocean markets uniquely suited to marine renewable energy technology attributes.

Goal 2: **Accelerate marine energy technology readiness** through near-term opportunities, supporting WPTO marine renewable energy strategy and mission.

Goal 3: Enable broader blue economy goals by **developing solutions to meet energy challenges facing private and public sector blue economy partners**, including unlocking the potential of new ocean-enabled technologies, enhancing scientific capabilities in the ocean, and the development of more resilient coastal and island communities.

Investing in Four Quadrants to Support a Thriving Marine Energy Industry in the Blue Economy

Lab and Testing Facilities

Enhancing and providing access to prototyping, pilot, and demonstration facilities

Vehicles: TEAMER, Lab Calls, FOAs

End Users & Adoption

Connecting to major market adopters and accelerating industry involvement, including investment

Vehicles: FOAs, Subcontracts through Labs, Prizes, SBIRs

Startups and Entrepreneurs

Funding to develop prototypes and develop commercial-ready products

Vehicles: Prizes, SBIRs

Research and Development

Foundational and crosscutting research

Vehicles: AOPs, Seedlings, FOAs

Activities to Date

2019

March: Publish the PBE Report

June: Launched Waves to Water Prize

July: Launched Marine Energy Collegiate Competition

October: Initiated Use Case Analysis for Ocean Observing Systems at Labs

November: Launched Ocean Observing Prize

December: Smaller-Scale SBIR Call & Marine Debris Call

2020

January: Awarding of 18 seed projects at the labs to support research in PBE, including aquaculture, Arctic energy, and UUV/AUVs.

February: Launch of joint solicitation with U.S. Department of Commerce to support entrepreneurs in the blue economy.

April: Awarding of 13 small business to support co-developed systems in the blue economy.

June: Announced theme of Ocean Observing DEVELOP Competition.

Rest of 2020 - 2021

Awarding of joint Commerce grant.

New round of seed project calls to support PBE.

Initiation of 10 research topics at the labs, including small-scale WEC modeling.

Release of other SBIR solicitations.

Awarding of prizes in Waves to Water, Ocean Observing Prize

Launch of network to support remote communities and resiliency planning.

Ocean Observing – *Opening Soon*

Overview

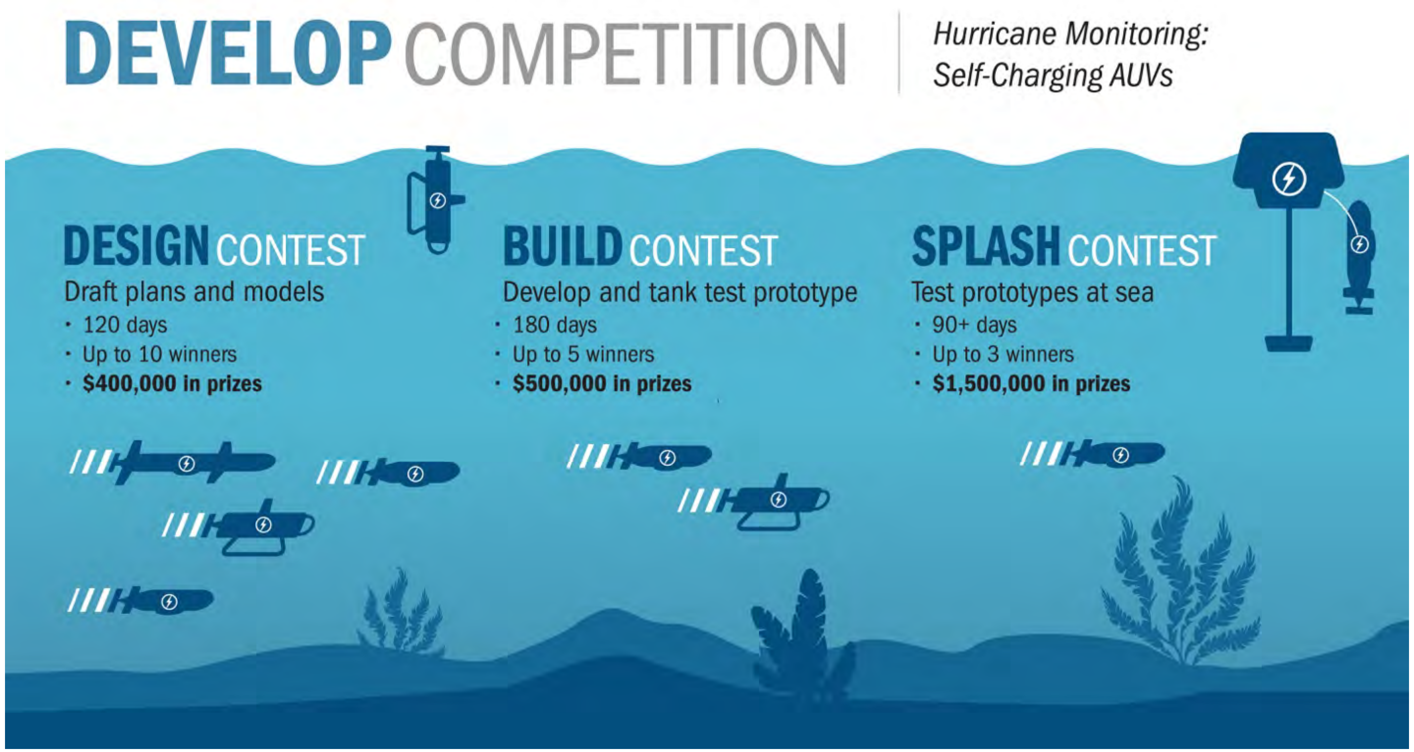
The *Powering the Blue Economy™: Ocean Observing Prize* is a **$3M** contest that challenges innovators to develop solutions that *integrate marine renewable energy with ocean observation platforms* to revolutionize our ability to monitor, manage, and understand the ocean.

Supporters

- U.S. Department of Energy Water Power Technologies Office
- NOAA's Integrated Ocean Observing System

Prize Goals

- Enable collection of valuable *data*
- Generate sufficient *power* from co-located marine resources
- Accelerate *commercialization* of marine energy systems
- Grow a *community* of innovators



SBIR/STTR – FY2020 Co-Development at Smaller Scales

- **Oscilla Power, Inc.** (Seattle, WA) *Integrated Wave Power Charging Capability for Ocean Observing Vehicles*: Ocean-based observing operations are currently limited by access to power. Oscilla's project will center on development of a wave-powered, self-charging capability for autonomous underwater vehicles (AUVs) to extend the range of their missions, which could potentially enable unlimited ocean-based observing as well as more comprehensive surveillance for military operations.
- **Ocean Motion Technologies, Inc.** (San Diego, CA) *Leveraging Co-Development for the Energy Capture Subsystem of a Small-Scale Adaptive Wave Energy Converter:* Current small-scale power supplies at sea perform sub-optimally due to high maintenance costs in the harsh marine environment, and these challenges severely limit the potential to utilize the ocean. This project plans to fabricate a cost-effective, adaptive ocean wave energy device that can optimize its power output based on ambient environments.
- **Triton Systems, Inc.** (Chelmsford, MA) *Wave Energy Harvesting to Power Ocean Buoys:* Many activities within the Blue Economy benefit from unattended, powered buoy and mooring systems. However, available power for these buoys is currently limited; the proposed project will focus on developing a wave energy converter (WEC) design that can potentially double the available power and increase the capability of many types of buoys used in the ocean today.
- **3newable LLC** (Portola Valley, CA) *Preventing Biofouling of Oceanographic Sensors Using Ultraviolet Illumination Powered by a Compact Wave Energy Converter:* Oceanography measurements cease when power is unavailable or when growth of unwanted organisms (biofouling) blocks sensors. 3renewable's wave energy generator design harnesses the motion of ocean waves to generate electricity to power ultraviolet light emitting diodes that prevent biofouling, thereby reducing the number of expensive ship visits for maintenance.

Optimizing Li-Based Energy Storage for Marine Energy

Project Summary

- Key Question
  - How do existing and novel lithium storage technologies perform and can they be improved for key PBE applications and environments (arctic mission, millions of partial charge cycles)?
- Simulation
  - Arctic weather buoy mission and modular WEC PTO output
- Emulation
  - Benchtop testing of charge/discharge with realistic input and load
- Testing
  - Testing of system in PNNL's arctic lab (seawater, ice, cold air)

Anticipated Outcome

- Determination of suitable battery types and housing designs to meet mission demands

Use Case 1: High-Latitude Coastal Weather Buoy

Summary

- Shelikof Strait, Alaska
  - Wave is the strongest and most persistent resource in this location
- A relatively small wave energy converter (WEC) integrated with or near the buoy has the potential to:
  - Increase sensing capabilities
  - Increase sampling rate
  - Increase communications frequencies
  - Minimize reliance on battery systems.

Self-Contained Ocean Observations Payload parameters:

- Designed for a 2-year operation
- High latitude – limited solar resource
- Serviced every 12—18 months
- Currently power limited
- Typically used for atmospheric or oceanographic sensing
  - Additional sensing may increase forecasting capabilities.

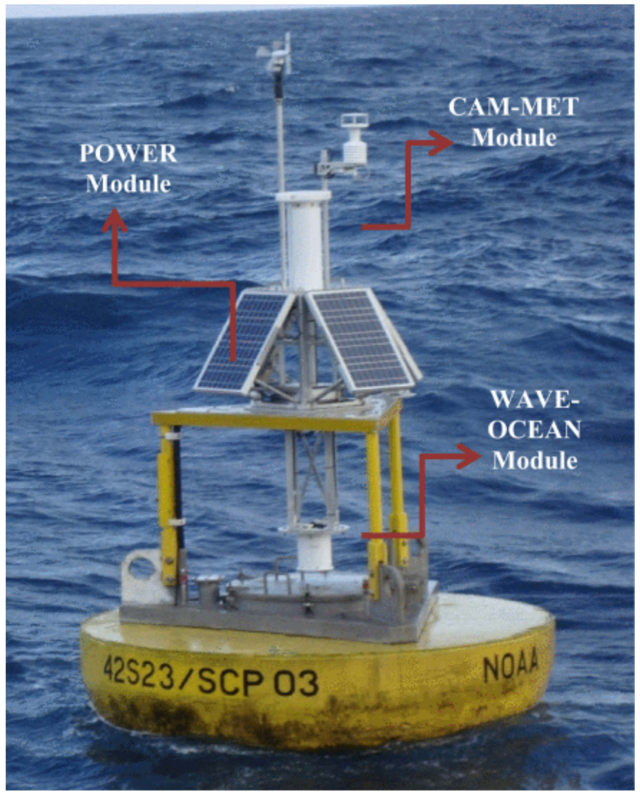


Image source: P. E. Craig Kohler, L. LeBlanc and J. Elliott, "SCOOP - NDBC's new ocean observing system," *OCEANS 2015 - MTS/IEEE Washington*, Washington, DC, 2015, pp. 1-5.

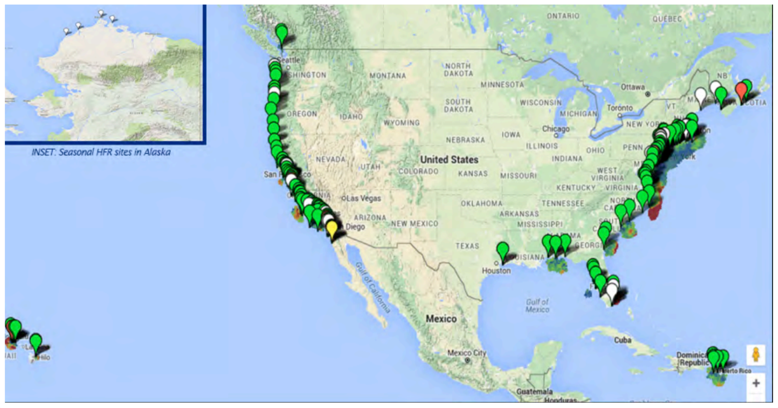
Use Case 2: High-Frequency Radar

Summary

- Cook Inlet, Alaska
  - No grid power available
  - Strong tidal resource
  - Identified as a critical location gap by the Integrated Ocean Observing System (IOOS)
- A relatively small 2.5-meter tidal turbine with a relatively small battery bank likely used for:
  - Increased resiliency
  - Increased sampling.

High-Frequency Radar Parameters:

- Serviced every 6 months
- Currently power limited
- Large range of end uses that have been identified as critical for resiliency, such as:
  - Measuring coastal currents
  - Monitoring water quality
  - Performing search and rescue
- Decommissioned holding station at this location may provide an ideal high-frequency platform.



Map of high-frequency radar sites in the United States, courtesy of IOOS.NOAA.gov

Image Source: Coastal and Marine Sciences Institute & Bodega Marine Laboratory. https://marinescience.ucdavis.edu/bml/bmr/facilities

Use Case 3: Autonomous Underwater Vehicle Docking Station

Summary

- Northwest Atlantic Ocean
  - Ocean Observatories Initiative Coastal Pioneer Array
  - Strong wave energy resource
- WEC power, potentially supplementing other renewable energy sources, has the potential to:
  - Increase range
  - Decrease operation costs
    - Reduce vessel/crew time
  - Increase utilization of autonomous underwater vehicles (e.g., weather monitoring, or other resident autonomous underwater vehicle applications).

Pioneer Array docking parameters include:

- Two-day mission, 5-day charging
- Large potential for avoided cost reduction
  - Large operation costs
- Large range of potential missions
- Power requirements that depend on several factors.

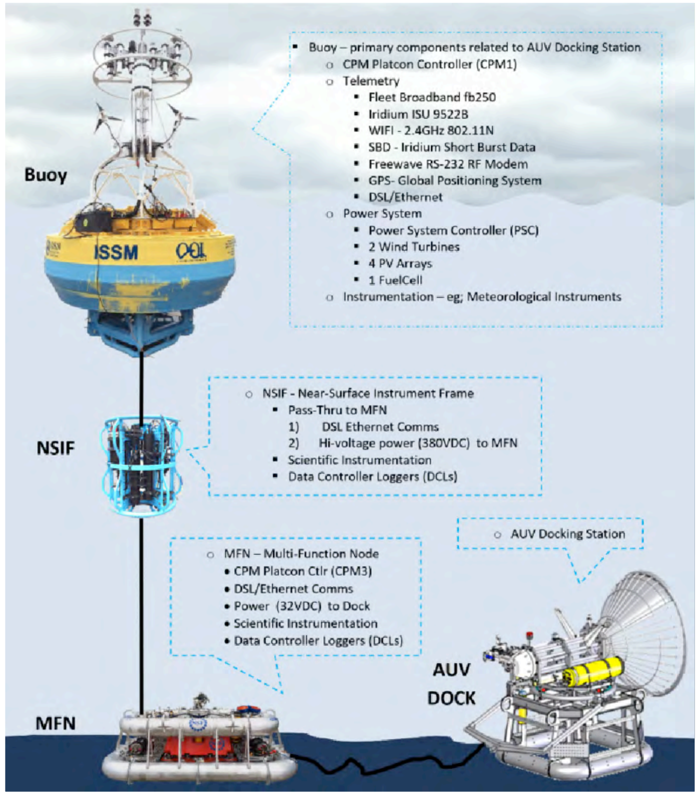


Image courtesy of: Woods Hole Oceanographic Institute, Ocean Observatories Initiative.

Use Case 4: Deep Ocean Tsunami Detection

Summary

- Northwest Atlantic Ocean
  - Strong wave energy resource
- WEC power, potentially supplementing other renewable energy sources, has the potential to:
  - Increase system reliability
    - Redundancy
    - Automated maintenance
  - Provide additional sensing capabilities.

Atlantic DART-II surface buoy parameters:

- Rely on battery power
- Provide two-way satellite communication
- Deploy between 1 and 2 years
- Include approximately 1-year service intervals
- Require low power
  – Sub-Watt.

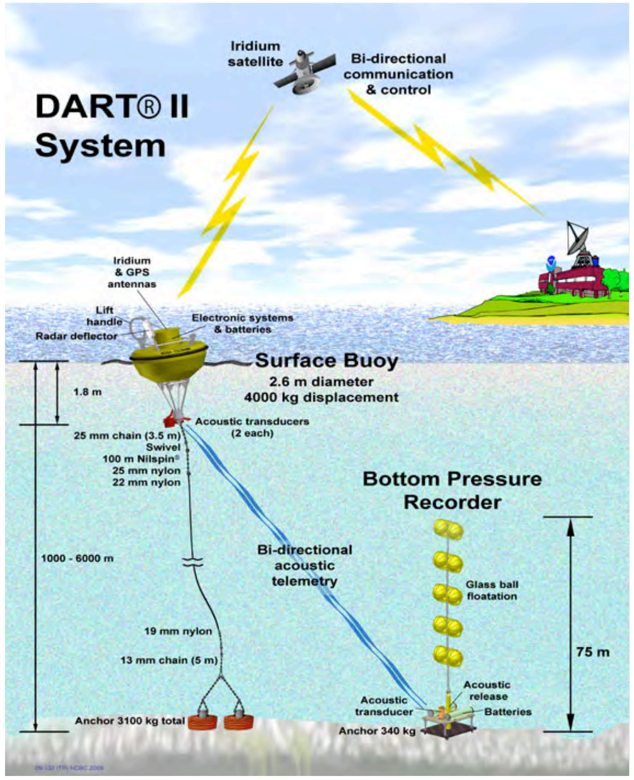


Image Source: National Oceanic and Atmospheric Administration's National Data Buoy Center DART Description: https://www.ndbc.noaa.gov/dart/dart.shtml

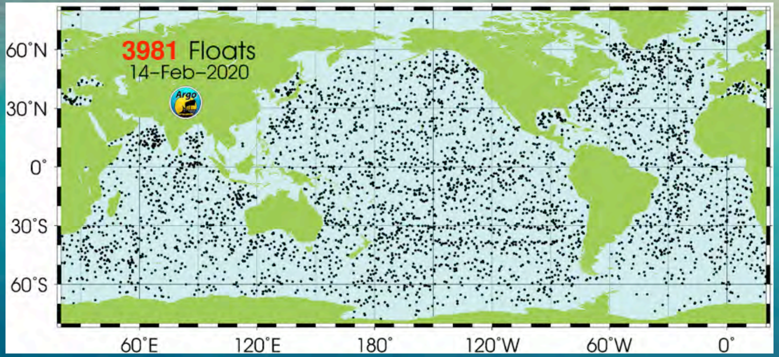
Use Case 5: Powering a Drifting Profiler

Summary

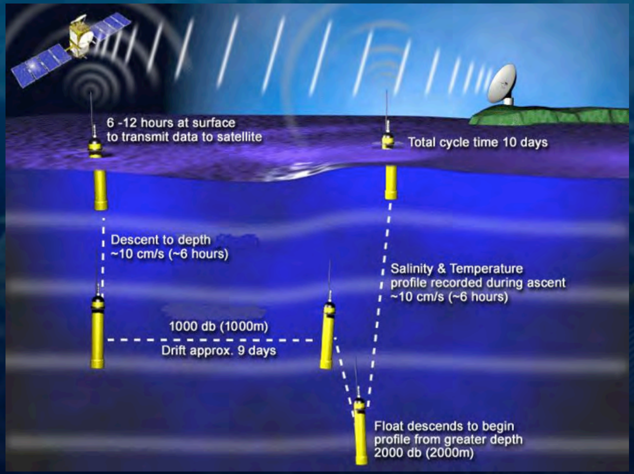
- Location agnostic
    - Large variance in energy resource
        - Wave, tidal, solar, salinity, thermal, and so on
- Likely not a one-size-fits-all approach. But, an energy solution may:
    - Increase the sampling rate
    - Increase the number of profiles
    - Reduce service intervals and/or replacements
    - Enable additional sensing.

Argo Profiler parameters:

- Battery limited, ultimately leading to sampling limits
    - 1.1–1.4 kilowatt-hours (kWh) (core ARGO fleet)
    - Approx. 1.9 kWh (Deep ARGO)
- Once the battery dies, the device either sinks or ends up as debris (flotsam)
    - Approximately 800/year
- A variety of sensing needs
    - Temp, salinity, currents, pH, and so on
- Typically a 10-day profile interval to get 200–250 profiles.



Map of floats that have delivered data within 30 days (Courtesy of University of California San Diego)



Typical park and profile mission of ARGO float (Courtesy of University of California San Diego)