WAVECO

Autonomous Ocean Observation

Compiled by Waveco, January 2022

1. INTRODUCTION

Ocean and atmospheric observation is highly relevant due to the global climate crisis and the life crises in the ocean. This is confirmed by the fact that the UN, in the start of the demanding global energy transition, has proclaimed the decade 2021 to 2030 as the decade of ocean science for sustainable development, under the slogan "The science we need for the ocean we want."

It is only since the late twentieth century, thanks to the technological evolution, that autonomous ocean observation have reached a volume and spatial distribution that allow us to track a wide range of global and regional phenomena.

With this overview, we want to show that this is a large field, with large investments, most often public, but also philanthropic and commercial. We also want to show that a major issue for further development of the area is focused on the supply of energy for offshore devices.

2. ABOUT POWER REQUIREMENTS

Monterey Bay Aquarium Research Institute on power issues

Electrical power for instrumentation, communication, and propulsion for autonomous oceanographic monitoring and experimentation can be a significant limiter of what can be done. Although the ongoing trend of lower power electronics helps, there are some physical limitations that cannot be overcome. Examples are the energy needed for the propulsion of mobile platforms, the energy needed for radio communications, and the energy needed for processes required by some instrumentation such as heating and the pumping of fluids. For these reasons any advances in energy storage or capture that can be applied to the types of platforms used in oceanographic research can create significant advances in capabilities.

3. THE UNITED NATIONS

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

DECADE CHALLENGES ADDRESSED

CHALLENGE 1: Understand and beat marine pollution

CHALLENGE 2: Protect and restore ecosystems and biodiversity

CHALLENGE 3: Sustainably feed the global population

CHALLENGE 4: Develop a sustainable and equitable ocean economy

CHALLENGE 5: Unlock ocean-based solutions to climate change

CHALLENGE 7: Expand the Global Ocean Observing System

CHALLENGE 8: Create a digital representation of the Ocean

CHALLENGE 9: Skills, knowledge and technology for all

CHALLENGE 10: Change humanity's relationship with the ocean

The United Nations has proclaimed a Decade of Ocean Science for Sustainable Development (2021-2030) to support efforts to reverse the cycle of decline in ocean health and gather ocean stakeholders worldwide behind a common framework that will ensure ocean science can fully support countries in creating improved conditions for sustainable development of the Ocean.

The marine realm is the largest component of the Earth's system that stabilizes climate and support life on Earth and human well-being. However, much of the ocean is now seriously degraded, with changes and losses in the structure, function and benefits from marine systems. In addition, the impact of multiple stressors on the ocean is projected to increase as the human population grows towards the expected 9 billion by 2050.

The UN designation of 2021-2030 for the decade of marine research is rooted in a number of challenges. It will require greatly increased activity, both in maritime observation and global measures if these challenges are to be solved.

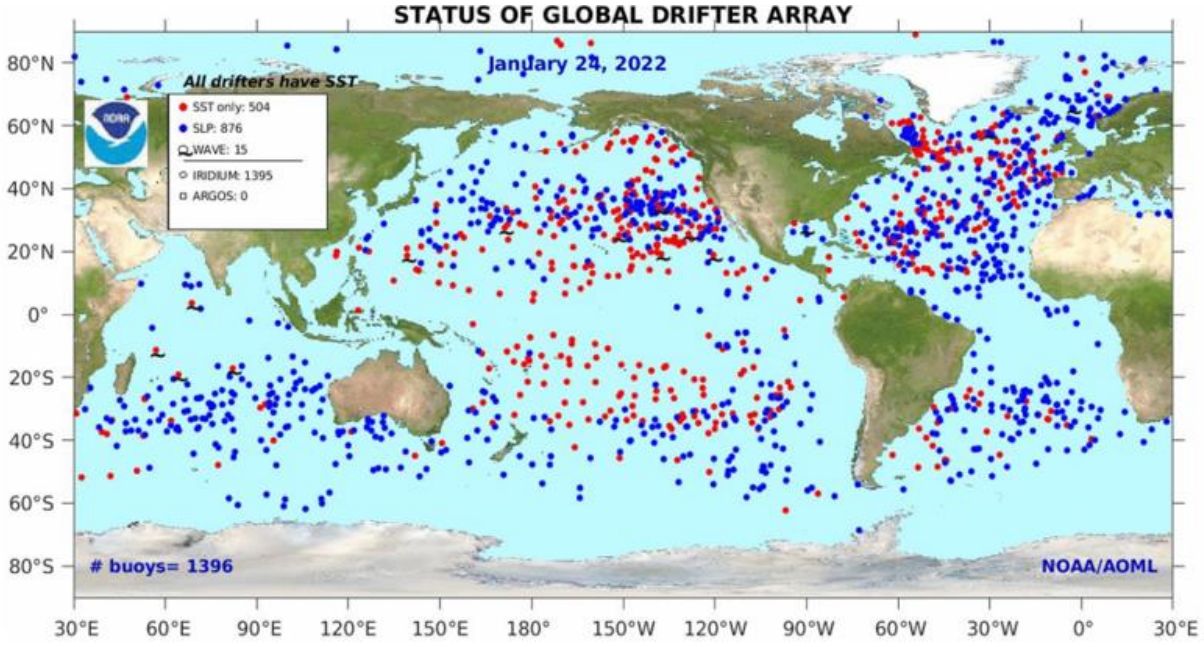
4. AUTONOMOUS OCEAN OBSERVATION DEVICES

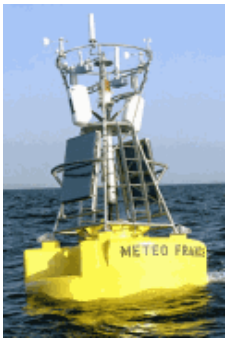
Data buoys

Data buoy observations make significant contributions to our ability to model, understand and describe global weather and climate. The data collected complements or validates data from other platforms, such as from voluntary observing ships or weather satellites.

Drifting Buoys

Drifting buoys are generally attached to some form of drogue or sea-anchor, are easy to deploy, are relatively inexpensive to operate and reliably measure the atmosphere and ocean surface conditions, for an average of 18 months. The scientific design for the global surface drifting buoy array originally called for 1250 buoys to be maintained worldwide. One buoy is necessary, approximately every 500 kilometres over the entire global ocean to calibrate and validate existing and new satellites. Since the buoys run out of power, sink or drift ashore, there is a need for an annual replenishment of several hundred buoys that are released from ships or planes.





Moored Buoys

Are anchored at fixed locations and regularly collect observations from many different atmospheric and oceanographic sensors. Moored buoys are usually deployed to serve national forecasting needs, maritime safety needs or to observe regional climate patterns.

Moored buoys are normally relatively large and expensive platforms. They can vary from a few meters in height and breadth, to over 12 meters.

Tropical Moored Buoys

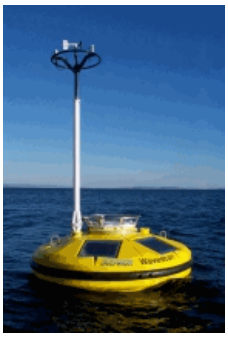
A major part of the DBCP's moored buoy network is the Tropical Moored Buoy Implementation Panel array, which has arrays of moorings in each ocean basin and are used to monitor large scale phenomenon such as El Niño and the Southern Oscillation, showing the importance in the annual variability of global climate.

Most of the buoys in these arrays are the ATLAS mooring, a taut wire surface mooring with a tube-like float. It is deployed in depths of up to 6000 meters. Measurements from the mooring include surface variables, as well as subsurface temperatures down to a depth of 500 meters. This array and its planned expansion is the result of international collaboration between scientists from France, Japan, Korea, Indonesia, Western Africa, India and the USA.

If a moored buoy goes adrift it represents a potential loss of costly equipment and a possible hazard to navigation. For this reason a backup location system is used to ensure that an alert is sent if the buoy leaves a certain area.

Ice Buoys

Ice buoys have been used extensively in Arctic and Antarctic regions to track ice movement and are available commercially for deployment by ships or aircraft. Such buoys are equipped with low temperature electronics and lithium batteries that can operate at temperatures down to -50°C.

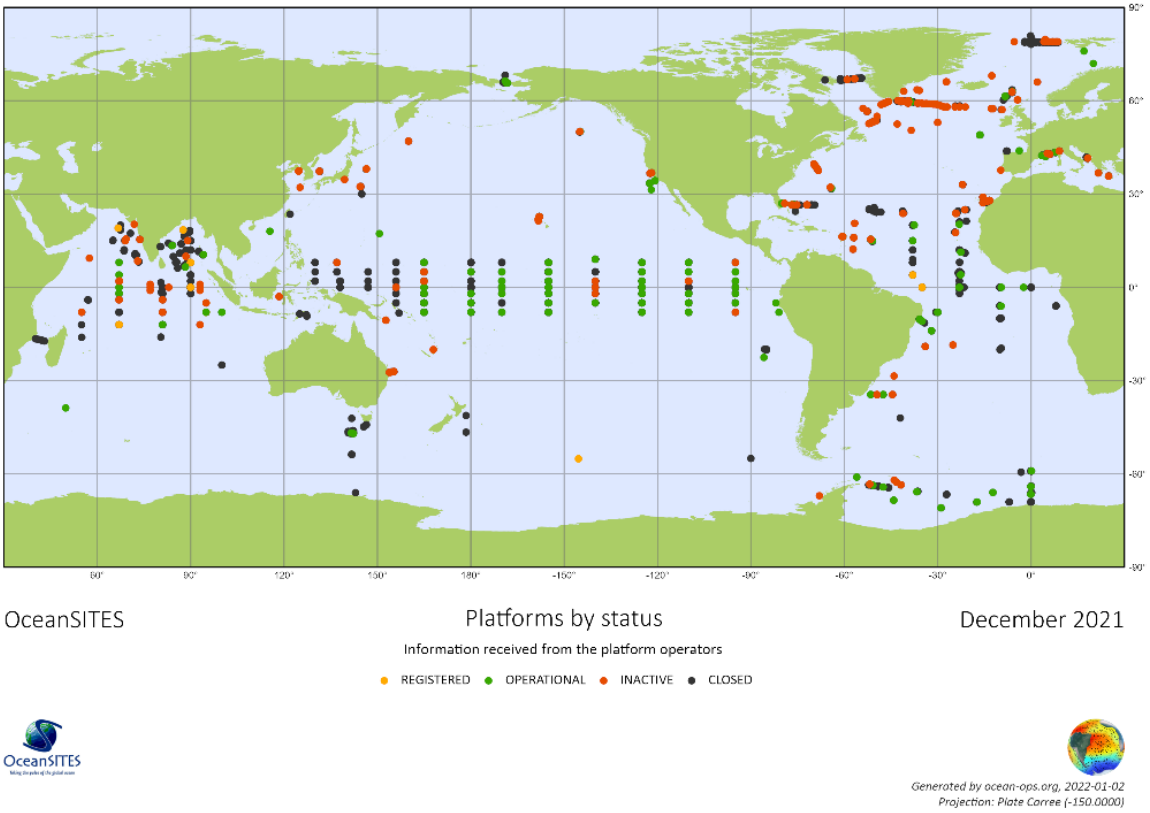


Wave Buoys

Many different sorts of Wave Buoys exist to capture and model information about ocean dynamics on the surface. These buoys measure the frequency and size of wave energy (known as the spectra) from which significant wave height, dominant wave period, and average wave period are derived. Even the direction of wave propagation is measured on many moored buoys. This information can be used to greatly improve the prediction and warnings for dangerous storms.

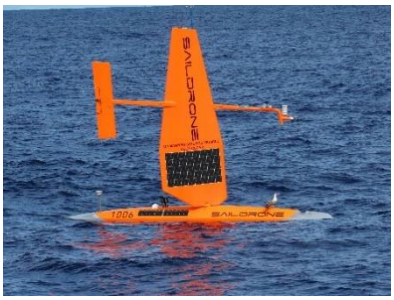
OceanSITES stations

OceanSITES is a worldwide system of long-term, open-ocean reference stations measuring dozens of variables and monitoring the full depth of the ocean from air-sea interactions down to the seafloor. It is a network of stations or observatories measuring many aspects of the ocean's surface and water column using, where possible, automated systems with advanced sensors and telecommunications systems, yielding high time resolution, often in real-time, while building a long record. Observations cover meteorology, physical oceanography, transport of water, biogeochemistry, and parameters relevant to the carbon cycle, ocean acidification, the ecosystem, and geophysics.



Surface drones

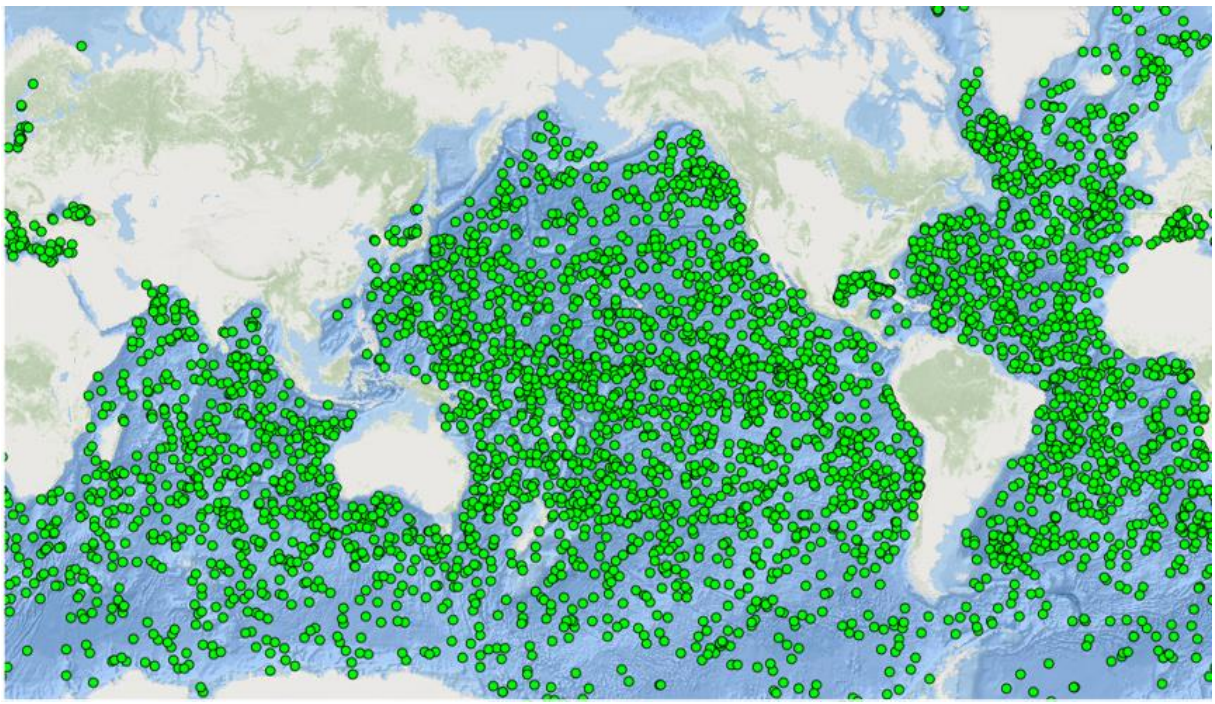
These are small unmanned boats equipped with the necessary automation for navigation, position, communication and observation. There are many types and sizes. They are propelled by wind, waves, electric or diesel engines. The example shown here, Saildrone, is also discussed below, under Related Technology.



5. DEVICES FOR SUB-SURFACE OBSERVATIONS

Argo floats

These are autonomous free-drifting platforms gathering data at mid-depth and surfacing from time to time to transmit. The map below shows the present location of 3928 floats (January 2022). Argo is an international program that collects information from inside the ocean using a fleet of robotic instruments that drift with the ocean currents and move up and down between the surface and a mid-water level. Each instrument (float) spends almost all its life below the surface.



The present location of 3928 floats (January 2022)

Underwater Gliders

Gliders are an ocean observing system used to serve a variety of targeted subsurface observing missions. They can monitor water currents, temperature, tagged animals and conditions that reveal effects from storms, impacts on fisheries, and the quality of our water.

They use variable buoyancy in the same way as a profiling float, but unlike a float, which can only move up and down, an underwater glider is equipped with hydrofoils that allow it to slide forward as it goes down or up through the water. Each time it reaches the surface, it sends the data it has collected so far via the satellite system.

Sub-surface drones

The picture shows Kongsberg Maritime's Hugin robot. It is about six meters long and has a diameter of 75 cm. The weight is between 1000 and 1500 kg depending on the model. And of course it is equipped with a large number of sensors, varying according to the nature of the assignment.

It has battery-powered propulsion and an operation time of between 1 to 3 days. This is an expensive sea observation platform, but offers great opportunities, especially for mapping purposes, as they can dive to several thousand meters deep.

6. RESEARCHERS ABOUT AUTOMAR

Waveco has contacted a number of key marine research institutions and asked what value a stationary, anchorless buoy can have for their research.

Norwegian Institute of Marine Research

Dr. Geir Huse, Research Director - Marine ecosystem and resources / Research Director - Marine Ecosystems and Resources, Institute of Marine Research, Bergen, Norway, April 2018.

Translated from Norwegian by Waveco:

«Thanks for the information on the plans of a self-positioning buoy for marine research. This is an exciting idea if you make it work as intended! The area of use we see as most interesting for us is to function as a relay station for acoustic real-time data transfer between subsea instruments and shore. Plus surface measurements. It is in the open sea / outer coast such a buoy will have its strength. Both installation of instruments and mobile / satellite transmission of data from instruments must be planned from the start. Price will be an important issue for how much use such a platform could have. We would like to take part in testing such a craft if you build it.»

Scripps Institution of Oceanography

Dr. Matthias Lankhorst, Scripps Institution of Oceanography, La Jolla, California, USA, September 2018.

«Nice idea. For a scientific use, it must be able to carry a decent sensor payload (e.g. meteorology sensors above the water, and some sensors clipped along the tether below). We do have anchored buoys that make such measurements. In order for your product to replace these, your product would need to:

- carry such payloads in the upper ca. 75 m
- have demonstrated endurance of 1 year
- be cheaper than the standard buoy (consider initial build and operational costs)

What might work in your favour is that an anchored buoy requires more ship time to recover and deploy, and ship time is expensive.»

Monterey Bay Aquarium Research Institute (MBARI)

Michael Kelly, Director Marine Operations, MBARI, September 2018.

«I think there's definitely a market for a stationkeeping wave energy device. In my opinion, autonomous wave energy devices delivering 100's watts of continuous power will be the first production market for wave energy. Lower energy devices also have a market, but I think the low purchase price point would be difficult to meet. Stationkeeping devices overcome the challenges of expensive and heavy moorings for deep-water applications. Unless autonomous vehicles for scientific and military applications can recharge from their environment, mid-ocean recharging communications stations are the logical solution. I don't consider such a device as competing with a *WaveGlider* (discussed below), as a WaveGlider does better transiting longer distances and has a limited solar power supply for sensors and instruments.

Fiskevegn AS

Trond-Inge Kvernevik, CEO, January 2018

Fiskevegn is an international supplier of equipment and fishing gear and supplies for deep-sea demersal longline vessels, which operate in the world's most challenging ocean areas, predominately in cold temperate and arctic/antarctic waters. Fiskevegn currently allocates some EUR 1 MILL/yr to R&D activities besides hosting or participating in industry research programs. Fiskevegn is an active member of COLTO, an industry association that promotes sustainable fishing practises in the Antarctic and chairs COLTO's Science-Industry Working Group, and occasionally provides expert advice to intergovernmental organizations on sustainable industry development.

Application	Strengths	Weakness
Hydrographic data for fisheries	Ability to address areas of interest defined by industry rather than by public research institutions Rapid/real-time delivery of industry relevant data Potential for integration with established Fishing Bridge Information Systems	Limited number due to unit cost; threshold to engage industry and fishing software providers

7. RELATED TECHNOLOGY

Ocean Power Technologies Inq. (OPT), USA

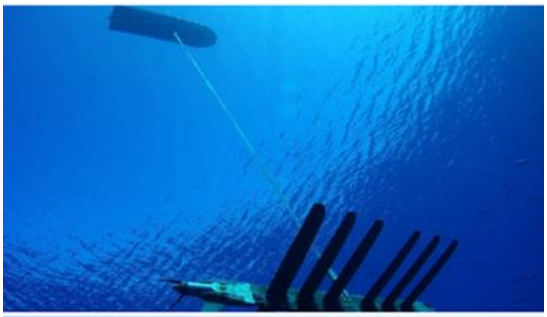
Home - Ocean Power Technologies

MONROE TOWNSHIP, N.J., April 06, 2018 (GLOBE NEWSWIRE) -- Ocean Power Technologies, Inc. (Nasdaq:OPTT) announced today that it will be discussing its anchorless PowerBuoy™ at the Navy Forum for SBIR/STTR Transition in National Harbor, Maryland on Monday, April 9th. The Navy Forum has been a long-standing venue for connecting SBIR/STTR-funded technologies with other governmental entities, defense suppliers, and other potential partners and collaborators. OPT's anchorless PowerBuoy™ is a sponsored project by the Department of Defense Office of Naval Research, focused on a motion based, wave energy harvesting technology that is steerable to accommodate multiple concepts of operation such as self-propelling from a distance, and ship-based launch, operation, and recovery. The device leverages proven OPT designs and capabilities such as energy storage and wave energy analysis.

Ocean Power Technologies' website as of 2022 contains nothing about an "Anchorless Power Buoy". Only an anchored PowerBuoy, image right.

Wave Glider

Liquid Robotics (liquid-robotics.com)



Wave Glider is popular with researchers, due to its easy handling, reliability and relatively low cost.

From the website: “Liquid Robotics designs and manufactures the Wave Glider, the first wave and solar powered unmanned ocean robot. We address many of the planet’s greatest challenges, by transforming how to assess, monitor, and protect the ocean. We solve critical problems for defense, commercial, and science customers.”

Liquid Robotics uses wave energy to propel the surf-board sized vessel forward. Sensors, communications and other instruments are powered by a combination of solar panels and batteries.

Wave Glider is constantly moving slowly forward and is used for measurements along a trajectory. The manufacturer claims that it can circle around a fixed position and thus simulate measurements from a fixed position. But the space available for solar panels and batteries limits the duration of the cruises to about 6 months, depending on the number and types of sensors. Therefore, it will not compete with Automars ability to perform stationary presence for longer time periods.

Defence News 2016:

The U.S. Navy contracted for the Wave Glider in 2016, spending $10 million on the system and related services and gear. Each unit costs between $250,000 and $300,000, not counting advanced sensors added as government-furnished equipment, a Liquid Robotics represenative said. Link

Sailbuoy

Offshore Sensing - Sailbuoy - Home

As the name suggests, Norwegian Sailbuoy is driven by the wind. It is designed to address different needs by the ability to integrate a selection of sensors. Like all other such devices, the duration of the cruises and the number and type of sensors are limited by the space for solar panels and batteries.

Saildrone

Saildrone: Any Sensor. Anytime. Anywhere.

Saildrone is a much larger sailing observation platform, with greater speed and greater capacity. It is widely used for autonomous single-beam and multibeam bathymetric data collection for navigation and charting, telecommunications, offshore energy, and physical oceanography to 7000 m depth.

The company offers three sizes with features shown in the table below.

Saildrone Explorer	Saildrone Voyager	Saildrone Surveyor
Specifications	**Specifications**	**Specifications**

• 23 feet (7 m) long
• Solar & wind powered
• Wind propulsion 3 knots avg.
• >365 days endurance
• Cameras, ML
• Atmospheric and oceanographic array
	• 33 feet (10 m) long
	• Diesel/electric
	• Wind propulsion 4 knots avg.
	  • 5 knots cruise speed
	  • 8 knots sprint speed
	• >180 days endurance
	• Radar, cameras, ML
	• 150 m profiling winch
		• 72 feet (22 m) long
		• Diesel/electric
		• Wind propulsion 5 knots avg.
		  • 6 knots cruise speed
		  • 10 knots sprint speed
		• >180 days endurance
		• Radar, cameras, ML
		• 500 m profiling winch

8. LIST OF INSTITUTIONS AND PROGRAMS

List of oceanographic institutions and programs - Wikipedia

List of meteorology institutions - Wikipedia

Autonomous underwater vehicle - WikiMili, The Best Wikipedia Reader