**GENERAL CURRICULUM CONCEPTS**

**Marine Exploration and Underwater Robotics or ‘Be an Underwater Robotics Engineer’**

**Section One – Introduction to Marine Exploration and Underwater Robotics.**

**Week One - Why do we need to explore the Ocean?**

Exploration is key to increasing our understanding of the ocean, so we can more effectively manage, conserve, regulate, and use ocean resources that are vital to our economy and to all of our lives.

Even though the ocean covers approximately 70% of Earth’s surface and plays a critical role in supporting life on our planet, from the [air we breathe](https://oceanexplorer.noaa.gov/facts/oceanproduction.html) and the food we eat to [weather and climate patterns](https://oceanexplorer.noaa.gov/facts/climate.html), our [understanding of the ocean remains limited](https://oceanexplorer.noaa.gov/facts/explored.html).

Ocean exploration is about making discoveries, searching for things that are unusual and unexpected. As the first step in the scientific process, the rigorous observations and documentation of biological, chemical, physical, geological, and archaeological aspects of the ocean gained from exploration set the stage for future research and decision-making.

Through ocean exploration, we collect data and information needed to address both current and emerging science and management needs. Exploration helps to ensure that ocean resources are not just managed, but managed in a sustainable way, so those resources are around for future generations to enjoy. Exploration of the [U.S. Exclusive Economic Zone](https://oceanexplorer.noaa.gov/facts/useez.html) is important for national security, allowing us to set boundaries, protect American interests, and claim ocean resources.

Unlocking the mysteries of ocean ecosystems can reveal [new sources for medical](https://oceanexplorer.noaa.gov/facts/medicinesfromsea.html) therapies and vaccines, food, energy, and more as well as inspire inventions that mimic adaptations of deep-sea animals. Information from ocean exploration can help us understand how we are affecting and being affected by changes in Earth’s environment, including changes in weather and climate. Insights from ocean exploration can help us better understand and respond to earthquakes, tsunamis, and other hazards.

The challenges met while exploring the ocean can provide the impetus for new technologies and engineering innovations that can be applied in other situations, allowing us to respond more effectively in the face of an ocean crisis, such as an oil spill. And, ocean exploration can improve ocean literacy and inspire young people to seek [critical careers](https://oceanexplorer.noaa.gov/edu/careers.html) in science, technology, engineering, and mathematics.

As a species, humans are naturally inquisitive — curiosity, desire for knowledge, and quest for adventure motivate modern explorers even today. And if all of these examples don’t provide enough reasons to explore the ocean, well, ocean exploration is also just cool

**What are Underwater Robots?**

Over the last few decades, engineers have developed many underwater robots capable of meeting the challenges that the deep sea imposes upon explorers. They allow us to dive to depths where utter darkness, crushing pressures, and extreme cold temperatures prevent humans from going. Underwater robots, such as remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs), are essential tools for ocean exploration. These robots explore areas of the ocean that are too dangerous or too difficult for humans to go. Underwater robots come in various shapes and sizes and can be outfitted with numerous sensors and tools to collect data from deep-sea environments.

**Week Two - Why are Underwater Robots important?**

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Underwater robotics has made major advances over the past decade. Key technological gains include an affordable global telecommunication network that provides sufficient bandwidth to download data and remotely control AUVs from anywhere on the planet, the miniaturization of electronics and development of compact sensors, improved batteries, and the maturation of platforms capable of conducting a wide range of missions.

The AUVs being used in the ocean today generally come in three flavors: profiling floats, buoyancy-driven gliders, and propeller vehicles.

**Week Three - What are the challenges with Marine Exploration and using Underwater Robots?**

The Dangers Potentially dangerous situations are inherent during all stages of ROV operations. During launch and recovery, deck crew and ROV engineers are on the back deck of the ship assisting with operations. In rough weather (i.e., wind over ~25 knots or 29 miles per hour and waves over ~6 feet), the ship’s movements could become so extreme that the deck crew could lose their footing on deck, or the ROVs could swing unsafely while being lifted by the crane. It is part of the dive supervisor’s job to minimize the operational risks for personnel and equipment on deck, so if conditions are too rough to safely deploy the ROVs, the ROV dives will be aborted, and mission personnel will instead turn their focus to seafloor mapping.

The dangers of operations are not limited to launch and recovery. While the ROVs are descending or ascending in the water column, the cable that attaches the ROVs to the ship could become entangled in the ship’s propellers or rudders or if the ship is not moving properly through the water. When the ROVs are on the seafloor, operators must be careful that the currents do not push the vehicles into geological features. The dive supervisor helps manage ship speed and movements, and assesses overall conditions to prioritize safety for personnel, the ROVs, and the ship.

The Decision-Making There is no precise formula that we can use to decide whether or not it is safe to dive. When preparing for a deepwater ROV dive, the navigator, dive supervisor, and ship operators study the three major forces acting on the ship. These major forces are the wind, the seas (i.e., the waves), and the currents. At most dive locations around the world, the wind and seas are the predominant forces. If these two forces are minimal, the dive supervisor and commanding officer usually give the “green light” for a dive. This is often not the case in the waters of the Atlantic off the Southeastern U.S. because of the Gulf Stream, which is a strong ocean current that extends along the eastern coast of the United States and Canada, bringing warm water from the Gulf of Mexico into the Atlantic Ocean.

**Section Two – Underwater Robotics and Marine Exploration in Practice**

**Week Four – How do we explore the Ocean?**

Technologies used to explore the ocean are very similar to the ones used to explore outer space and include submersibles, remotely operated vehicles (ROVs), satellites, rovers, diving/scuba gear, buoys, mega corers, water column samplers, and sonar for mapping.

The first instrument used for deep-sea investigation was the sounding weight, used by British explorer [Sir James Clark Ross](https://en.wikipedia.org/wiki/Sir_James_Clark_Ross).[[4]](https://en.wikipedia.org/wiki/Deep-sea_exploration#cite_note-history1-4) With this instrument, he reached a depth of 3,700 m (12,139 ft) in 1840.[[5]](https://en.wikipedia.org/wiki/Deep-sea_exploration#cite_note-5) The *Challenger* expedition used similar instruments called Baillie sounding machines to extract samples from the sea bed.[[6]](https://en.wikipedia.org/wiki/Deep-sea_exploration#cite_note-6)

In the 20th century, deep-sea exploration advanced through a series of technological inventions, ranging from the [sonar](https://en.wikipedia.org/wiki/Sonar) system, which can detect the presence of objects underwater through the use of sound, to manned [deep-diving submersibles](https://en.wikipedia.org/wiki/Deep-submergence_vehicle). Despite these advances in deep-sea exploration, the voyage to the ocean bottom is still a challenging experience. Scientists are working to find ways to study this extreme environment from the shipboard. With more sophisticated use of [fiber optics](https://en.wikipedia.org/wiki/Fiber_optics), [satellites](https://en.wikipedia.org/wiki/Satellite), and remote-control robots, scientists hope to, one day, explore the deep sea from a computer screen on the deck rather than out of a porthole

**Week Five – What is the value of marine exploration?**

Information from ocean exploration can help us understand how we are affecting and being affected by changes in Earth's environment, including changes in weather and climate. Insights from ocean exploration can help us better understand and respond to earthquakes, tsunamis, and other hazards.

Deep water canyons and seamounts impact water movement as well as the currents that regulate climates around the world. Both of these geographical feature's help regulate the temperatures of surrounding waters by allowing cold and warm waters to mix and nutrients to stir-up. This leads to high levels of biodiversity and biomass, creating habitats suitable for many of our most commercially fished species. The deep valleys of canyons suspend nutrient particles in mid-water, allowing for blooms of plankton and krill to accumulate, attracting schools of tuna, sharks, and whales. Meanwhile, seamounts disrupt nutrient-rich currents, deflecting them towards the surface, creating upwelling and a hotspot for feeding in an otherwise barren sea.

The deep-sea also acts as the Earth’s largest carbon sink. Throughout the entirety of the ocean there exists a mechanism that scientists refer to as a “biological pump.” Made entirely of living organisms, this pump moves carbon from the surface of the ocean into the deep-sea, separating it over prolonged periods of time and ultimately reducing the impact of anthropogenic carbon release. It is also the site of microbial oxidation of methane, another extremely potent greenhouse gas that contributes significantly to global warming. Without this pump in action, the effects of climate change would already be shattering, and the earth would likely be uninhabitable.

**Week Six – What is the history of Marine Exploration? What are the environmental or health issues?**

Oceanography is a relatively young field of science. The era of formal oceanographic studies began with the *H.M.S. Challenger* Expedition (1872-1876), the first voyage to comprehensively collect data related to ocean temperatures, chemistry, currents, marine life, and seafloor geology. The first AUV was developed at the Applied Physics Laboratory at the University of Washington as early as 1957 by Stan Murphy, Bob Francois and later on, Terry Ewart. The "Special Purpose Underwater Research Vehicle" was used to study diffusion, acoustic transmission, and submarine wakes.

Other early AUVs were developed at the Massachusetts Institute of Technology in the 1970s. One of these is on display in the Hart Nautical Gallery in MIT. At the same time, AUVs were also developed in the Soviet Union (although this was not commonly known until much later).

According to The Remotely Operated Vehicle Committee of the Marine Technology Society: “Exactly who to credit with developing the first ROV will probably remain clouded, however, there are two who deserve credit. The PUV (Programmed Underwater Vehicle) was a torpedo developed by Luppis-Whitehead Automobile in Austria in 1864, however, the first tethered ROV, named POODLE, was developed by Dimitri Rebikoff in 1953.”

In late 1960s, the U.S. Navy began developing robots to help locate and recover underwater ordnance. By the 1980s, commercial companies began utilizing the technology to aid in the oil and gas industry. Now, ROVs are used in all manner of exploration and commercial applications, from dam and water-tank inspections to evidence recovery, pipeline maintenance, aquaculture and drowning-victim recovery.

[Exploring the Deep Sea History of Seafloor Mapping | Nautilus Live](https://www.youtube.com/watch?v=V8DDwHtVbPQ&t=144s)

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**Section Three – Underwater Robotics and Marine Exploration companies**

**Week Seven – What are the different types of underwater robots**

Underwater robots, such as remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs), are essential tools for ocean exploration. These robots can explore areas of the ocean that are too dangerous or too difficult for humans to go. Underwater robots come in a variety of shapes and sizes and can be outfitted with numerous sensors and tools to collect extensive amounts of data from deep-sea environments.

ROV’s are tethered to and operated from a ship allowing humans to explore the ocean without being in the vehicle.

AUV’s are unoccupied, untethered, battery-powered vehicles used to collect data for underwater research.

ROV’s and AUV’s are used for commercial uses to map the seafloor, explore deep sea canyons, search for and explore sunken ship wrecks or aircraft wrecks, for research to collect water, rocks, plants and animals from deep sea locations. There are many military uses as well

Use the exploration vehicle summary sheet from NOAA for students to learn more about different ROV’s and AUV’s

**Week Eight – Marine exploration and regulations and laws**

# https://www.epa.gov/oceans-and-coasts

Ocean Dumping Management

The Marine Protection, Research and Sanctuaries Act (MPRSA), also known as the Ocean Dumping Act, regulates the transportation and dumping of any material into ocean waters.

**Week Nine - Occupations and Education in Underwater Robotics and Marine Exploration**

Ocean careers <http://www.oceancareers.com/2.0/index.php>

Engineers, Educators, biologists

**Week Ten – The business and management of Underwater Robotics**

Types of companies

<https://bluerobotics.com>

<https://www.go-bgc.org> Adopt-a-float.

**Practical Sessions - Building an Underwater Robot.**

Students can design and build a robot depending on grade level.

Simple underwater robot [Making a simple UW robot.pdf](https://altasea-my.sharepoint.com/:b:/g/personal/ahill_altasea_org/EdNoUg8JloxGuPninW0c50AB3riB0GG8Zm-Vj_nFseWa6w?e=8E1gSJ)

More complex robot [RiseNet Intro to ROVs Learning Card\_Final-2.pdf](https://altasea-my.sharepoint.com/:b:/g/personal/ahill_altasea_org/ESxwur6X2PROgFlNfRf-Xf0BXETgffvDQKt37CXcH7pWzw?e=WnCAQb)

[**https://seaperch.org**](https://seaperch.org)for kits, lessons and NGSS standards

[**https://mateii.org/rov-competition/**](https://mateii.org/rov-competition/)robotics competition

Field trip to Blue Robotics or another engineering company. Engineers could come over for one of the construction weeks to help the kids.