Exploring New Worlds Here on Earth

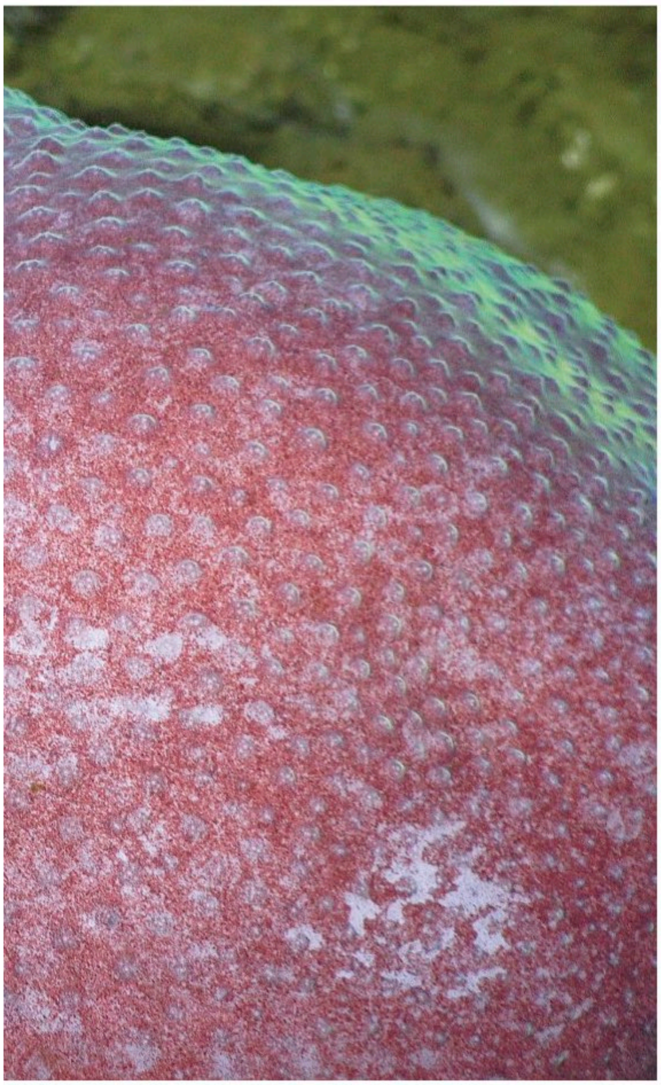
By Carlie Wiener and Shannon McClish, Schmidt Ocean Institute

The ocean is a mystery. It gives us every other breath, provides a habitable climate, grants us food and livelihoods; yet only five percent of the ocean has been explored. With every new discovery, we come to understand just how connected we are; ocean health is our health. The ocean is rapidly being altered due to a changing climate, absorbing almost a third of the carbon we emit. Effects on the ocean biology, chemistry, and physics must be understood for sustainable action and marine conservation. The need for ocean exploration is greater than ever before, requiring a united effort to advance technology, providing persistent and wide-spread data collection and analysis.

A deep-sea octopus is seen with ROV SuBastian reflected in its eye. Credit: Schmidt Ocean Institute.

A statistic we often hear is that more is known about the far side of the moon than about the ocean, but the more important question to highlight is *why* do we know more about the moon than we do about the deep-sea? How do we create the excitement and passion for the systems that we cannot view from the beach, environments not observed by a telescope? How do we engage with citizens outside of the coastal communities to bring understanding of ocean health? Many observe the vastness of the ocean, but few comprehend the scale of the deep-sea.

At nearly seven miles below the surface, the Ocean's dark cold depths, with crushing pressure appears like it would be inhospitable to life. However, this is not the case. Seemingly otherworldly habitats and uniquely adapted species are found in these secret places far away from the shorelines of our coasts. More than 90 percent of ocean habitat exists in the deep-sea, but little of it has been explored by humans. These difficult environments make deep ocean exploration technically challenging and, until recently, largely beyond human reach. But today, technology has allowed us to not only access these environments for study and research, but to share this exploration through live streaming video around the world.



A New Technology Wave for the Ocean

Driven by invention, ocean exploration has uncovered fundamental earth processes, inspired groundbreaking innovations, and challenged our very notions of life itself. The detection of the Mid Atlantic Ridge and the magnetic striping of the seafloor upon the invention of the magnetometer provided the missing piece in the theory of plate tectonics. Early remotely operated deep sea vehicles (ROV's) resulted in the discovery of the first hydrothermal vent communities, revealing life can exist in the dark. Global measurements from research vessels uncovered that the ocean not only controls weather, it is the dominant actor shaping climate over time, and has a memory centuries long.

The need for global ocean exploration is recognized by the upcoming UN Decade of Ocean Science for Sustainable Development, and the 2030 Sea Mapping initiative. Advancing ocean science is reliant on continued invention. This is the fundamental strategy of several global research organizations and privately-funded programs. The Schmidt Ocean Institute (SOI) is one of these leading programs, driven to ocean discovery through the use of new technology, open data, international collaboration, and broad communication. Schmidt Ocean Institute is the only philanthropically-funded, international seagoing facility dedicated to year-round open ocean research on its research vessel *Falkor*.

Many species and features of the deep sea can only be studied on the seafloor. New in-situ acoustic, chemical, and molecular sampling technology, swarm robotics, and software that uses machine learning to identify species, pushes exploration beyond what was previously possible. Interdisciplinary teams aboard the R/V *Falkor* are developing and applying new technology to bring the laboratory to the unknown. This year, scientists aboard *Falkor* tested new isotopic and chemical measurements at methane seeps to characterize how methane is released, and another group tested new equipment that can scan and characterize deep sea species.

However, to properly characterize and understand our ocean's dynamic processes, scientists must be able to observe with higher resolution and coverage in time and space than what

Schmidt Ocean Institute's research vessel Falkor. *Credit: Schmidt Ocean Institute.*

is currently possible with dedicated research ships alone. A multi-platform approach with low-cost autonomous vehicles deployed from research vessels in different mediums including underwater, sea surface, and air, can allow for a more comprehensive and complete picture of our oceanic systems. The cost-efficient robotic technologies available now and under development can allow us to achieve the levels of persistence and resolution of observations required for scalable ocean studies in a changing climate.

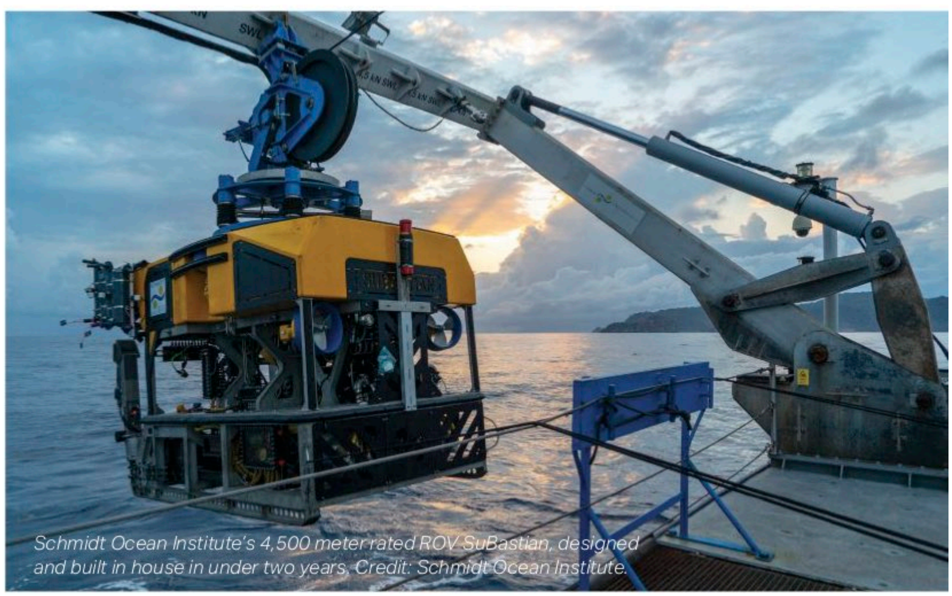
Schmidt Ocean Institute has focused on scalable ocean research supporting the use of coordinated robotics from *Falkor*, offering time at sea for both the collection of science and the development and testing of robots and smart software for autonomous marine surveys. In 2018, the Institute completed several expeditions devoted to developing and testing software that maximized informational contributions of multiple autonomous vehicles to the description of target habitats. For example, last year international collaborators on *Falkor* allowed for coordinated robotic systems that automate ocean observing to collect over half a million georeferenced images covering 77,453 m^2 of seafloor. Another unsupervised learning expedition completed a 3D seafloor reconstruction, analyzing 1.3 million seafloor images collected between autonomous unmanned vehicle deployments.

These projects demonstrate how throughput data processing and machine learning can multiply the productivity of ocean exploration. They allowed scientists to make quick and well-informed decisions on how to directly sample and conduct fine scale surveys to study rapidly changing marine habitats that would otherwise be virtually impossible to observe in detail. The resulting work is invaluable in planning operations, including the recovery of seafloor instruments, revisiting active bubble plumes, and making operation more efficient.

More ocean observations like these are critical to creating actionable science building our ability to understand and manage our ocean resources. Many conventional workflows for marine data processing are not automated, inhibiting the productivity of scientists and managers. Strategic focus on projects automating marine data analysis workflows is needed to accelerate the understanding of our rapidly changing marine habitats and multiply the conservation benefits.

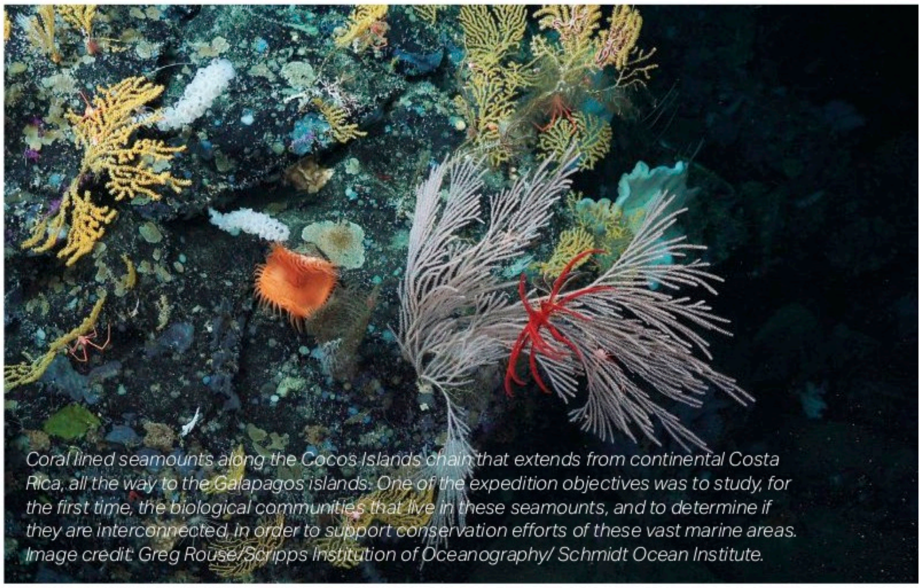
A Way Forward: Knowledge-Based Decision Making

One of the best ways to close this gap in infrastructure and data processing is through multidisciplinary international collaborations that merge oceanography with data informatics, computer sciences, engineering, local communities and ocean managers. The projects implemented on board *Falkor* aim to ac-



Schmidt Ocean Institute's 4,500 meter rated ROV SuBastian, designed and built in house in under two years. Credit: Schmidt Ocean Institute.

complish this with data-based science that can help answer ocean conservation questions. For example, *Falkor* operated off the coast of Costa Rica earlier this year expanding knowledge of deep-sea seamounts that had not been previously surveyed and providing justification for possible expansion of Cocos Islands National Park to the deep-seamount communities.



Coral lined seamounts along the Cocos Islands chain that extends from continental Costa Rica, all the way to the Galapagos islands. One of the expedition objectives was to study, for the first time, the biological communities that live in these seamounts, and to determine if they are interconnected, in order to support conservation efforts of these vast marine areas. Image credit: Greg Rouse/Scripps Institution of Oceanography/ Schmidt Ocean Institute.

One of the most important contributions science can make right now is to help managers understand how these deep-sea communities work, to better prepare and assess future changes. These answers will only come through exploration and collection of baseline studies of the deep. This foundational science is the type of work that is needed across the entire ocean. Mapping and surveying deep-ocean systems will present a better picture about why ocean species exist in certain places and help scientists and managers to better understand the sensitivity of these ecosystems and migration patterns to changes in ocean climate.

Ocean exploration has no one discipline or occupation; and needs to include everyone so that data becomes more than numbers and research catalyzes change. Ocean exploration is a formidable challenge, but the ocean is our home. It is essential to prioritize ocean discovery to learn about ourselves and our future, and turn from ocean exploitation that may close the book on the mystery we will never know.

During this time of environmental decline, ocean exploration can provide a new narrative, bringing a message of hope. Exploration provides the opportunity to showcase beautiful and mysterious parts of the ocean that are rarely observed to millions of people. The ocean is changing, but new data, science, and dedicated people can bring a fresh understanding and engagement with the deep-sea. Ocean exploration has an opportunity to accelerate this understanding and demonstrate our responsibility to care for the ocean, which remains a critical need for the ocean sciences, as well as our nation.

Hydrothermal vent fluid collects under the ledges and provides the chemical energy driving the entire ecosystem of microbes, scale worms, and riftia (tube worms) in the Gulf of California, Mexico. Credit: Schmidt Ocean Institute.