



IMPACT 20 REPORT 9

SCALING UP
MARINE SCIENCE
& CONSERVATION

-  Charting The Unknown
-  Catalyzing Science
-  Advancing Technology
-  Conservation Impacts
-  A Global Dialogue
-  At Sea Creativity
-  Expeditions that Inspire



Cover Image

ROV SuBastian is deployed off *Falkor* during the Observing Seafloor Methane Seeps at the Edge of Hydrate Stability expedition off the West Coast of North America. It was the first study to simultaneously collect a wide range of data at cold seep sites in the Pacific Northwest, seeking to address crucial knowledge gaps of these deep-sea systems.

Current Page Image

Falkor departs Honolulu Harbor, heading to sea to begin the Genetic Connections at Necker Ridge expedition, in which scientists sought to better understand seamount communities and the connection between different Pacific deep-sea ecosystems.

NUMBERS AND METRICS

2013 - 2019



1,385
Science
Days



392,356
Km traveled
(almost 10x
around the world)



863
Scientists



289
Students



1,358
CTD Casts



ROV SUBASTIAN



309
SuBastian dives



2,406
ROV Samples
Collected



80
AUV flights



394
AUV Dives
and other
autonomous
vehicles



39,000,000
INDIVIDUAL SENSOR
OBSERVATIONS since
2013



1,123 GB
OF DATA DOWNLOADED
from public geoscience archives
in 2019



1,000,000+ KM²
OF SEAFLOOR MAPPED



1,093
DAYS OF METEOROLOGICAL
DATA submitted to public
archives



CHARTING THE UNKNOWN

Exploration and investigation filled our 11 R/V *Falkor* expeditions in 2019 with astounding discoveries, including landscapes of hydrothermal vent fields, new species, and important revelations about the way our ocean works. This past year, Schmidt Ocean Institute (SOI) expanded its work both in the ocean and within the community. Our efforts have focused on understanding the ocean in deep, unexplored, or vulnerable regions.

In October, SOI reached a major milestone, mapping more than one million square kilometers of ocean floor, providing maps that are open-source and available to all, as well as assisting

government protection plans in regions like the Cocos Island Marine Park in Costa Rica.

SOI's driving mission to characterize the ocean while supporting technologically advanced facilities has allowed for the development of new instruments that will expand scientists' abilities to understand the ocean. This includes unmanned aerial vehicles with automated vertical takeoff / landing that can map the temperature and color of the ocean surface at image scales of less than ten centimeters, as well as an in-situ species sampling tool that enables rapid characterization of deep-sea organisms.



In addition to our at-sea work SOI has proudly joined several global efforts aiming to bring the ocean science community together to characterize, map, and better understand our ocean at a greater pace and scale. This includes contributing mapping data to the global Seabed 2030 initiative, of which we are a partner, and the UN Decade of Ocean Science for Sustainable Development, where SOI has engaged in early planning efforts. In November, SOI convened the first Philanthropic Oceanographic Research Vessel Operators Working Group meeting for partnership building, assembling the 11 research ship operating entities.

Additionally, SOI contributed to global dialogue, including a Transforming Ocean Data discussion at the Ditchley Foundation, the White House Summit on Partnerships in Ocean Science and Technology, and the decadal ocean observation planning meeting, OceanObs '19. In a special *Falkor*-hosted event, we celebrated 16 successful expeditions over the last 8 years with the University of



Left Image

ROV SuBastian can be seen reflected in the eye of this deep-sea octopus during the Temperature Truths: Searching For Microbial Community Structure expedition. In early 2019, researchers headed to the Gulf of California on *Falkor* to study undergoing changes. The area is an important site for advancing understanding of deep ocean hydrothermal ecosystems.

Circle

Eric and Wendy Schmidt. Photo credit: Spencer Brown

Hawaii, advancing the frontier of global ocean research.

With 350 ROV SuBastian dives and 64 expeditions since 2013 SOI continues to share discoveries through live streaming, remote exchanges, student opportunities, and an artist program. These combined efforts have made SOI a globally established name that was presented the 2019 Public Awareness award by the international Marine Technology Society and has been recognized four times in the annual Marine Technology Reporter (MTR) 100. SOI co-founder Wendy Schmidt was also recognized as number one in the 2019 MTR 100 for her innovation and leadership in the ocean sciences.

As illustrated in the following pages, SOI continues to deliver on our vision for a well-characterized and understood ocean. We hope to continue inspiring and educating while supporting innovative technology development and exploring unknown realms of the ocean.



Most people don't think about the bottom of the ocean. When you look at a map, the ocean is portrayed as flat blue with very few features. However, this couldn't be further from what the ocean floor looks like. There are still so many things we do not know about the topography or the ecosystems that cover the largest part of our earth.

*- Wendy Schmidt
Co-founder Schmidt Ocean
Institute*



2019 WHERE WE HAVE BEEN



01 COSTA RICAN DEEP SEA CONNECTIONS

#CostaRicaDeep
Location: Isla del Cocos National Park, Costa Rica
Date: January 6 - January 27



06 NECKER RIDGE: BRIDGE OR BARRIER?

#BridgeOrBarrier
Location: Necker Ridge, the Northwestern Hawaiian Islands
Date: August 31 - September 21



02 MICROBIAL MYSTERIES: LINKING MICROBIAL COMMUNITIES AND ENVIRONMENTAL DRIVERS

#MicrobialMysteries
Location: The Gulf of California, Mexico
Date: February 11 - March 14



07 DESIGNING THE FUTURE

#DesigningTheFuture
Location: Oahu, Hawaii, USA
Date: October 12 - October 17



03 SEEKING SPACE ROCKS

#SeekingSpaceRocks
Location: Olympic Coast, Washington, USA
Date: May 29 - June 7



08 LISTENING FOR CRYPTIC WHALES SPECIES

#ListeningToWhales
Location: Hawaiian Islands, USA
Date: October 21 - October 26



04 OBSERVING SEAFLOOR METHANE SEEPS AT THE EDGE OF HYDRATE STABILITY

#HuntingBubbles
Location: U.S. Pacific Northwest continental margin
Date: June 12 - July 3



09 MAPPING THE GAPS

#MappingTheGaps
Location: Transit from Honolulu, Hawaii to Suva, Fiji
Date: October 31 - November 14



05 DEEP CORAL DIVERSITY AT EMPEROR SEAMOUNT CHAIN

#DeepCoralDiversity
Location: Emperor Seamount chain, Pacific Ocean
Date: July 26 - August 26



10 STUDYING THE SEA-SURFACE MICROLAYER 2

#AirToSea
Location: Fiji
Date: November 20 - December 23





 **CATALYZING
SCIENCE**



“This is an amazing natural laboratory to document incredible organisms and better understand how they survive in extremely challenging environments... we were continually surprised, catching our breath, and in awe of nature’s majesty.”

*- Dr. Samantha Joye
University of Georgia*



ROV SuBastian uses sensors held by its manipulator arms to measure the temperature at a hydrothermal vent in the Guaymas Basin. The expedition led by Dr. Samantha Joye revealed that these harsh conditions were teeming with biodiversity. This black smoker vent was named “Falkor’s Fountain.”



ENLIGHTENED SEAMOUNT DISCOVERIES

Researchers working on R/V *Falkor* made remarkable discoveries and scientific advancements throughout 2019, broadening the scientific community's understanding of unique ecosystems and fueling future ocean exploration.

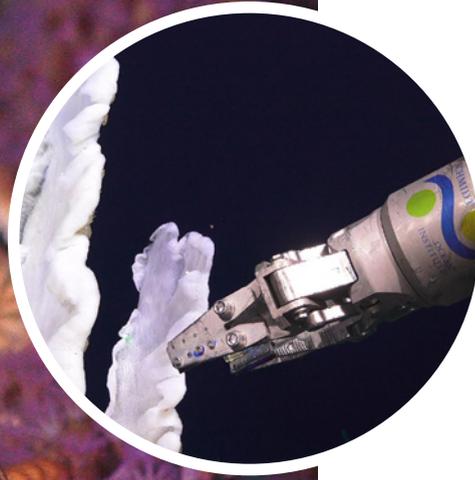
The first surveys of never-before-seen seamounts around Isla del Coco National Park, a UNESCO World Heritage Centre in Costa Rica, led to the discovery of four novel deep-sea corals and six ocean species, providing insight into unexplored deep-sea biogeology. The science team constructed a complete characterization of each seamount, including how oxygen dynamics control community structure. The findings have led to a call to protect these specialized ecosystems (**#CostaRicaDeep**).

Coral genomic studies across the Emperor Seamounts provided the first complete assessment of coral diversity across the Main Gap in the Mid-Pacific. This new data indicates an important boundary of deep coral species, including Octocorals, between the Aleutian and Hawaiian Ridges.

A boundary as sharp as what was observed (over a distance of 100 to 125 miles) is an unheard of occurrence in the deep sea. Octocorals provide essential habitat for deep-sea fish and other organisms; several new corals species were also discovered, including a new type of bamboo coral (**#DeepCoralDiversity**).



Beautiful underwater landscapes seen during the ROV dives in the Cocos Island National Park off Costa Rica. This expedition represents the first time that seven of the seamounts in the area were surveyed.



10 NEW SPECIES

4 new species of deep-sea corals and 6 other species were discovered in the seamounts around Isla del Coco National Park, representing the first surveys of communities below 500 m depth in the region.

Another expedition in Hawaiian waters focused on coral diversity along Necker Ridge. The data retrieved will provide a better understanding of seamount communities and the connection between Pacific deep-sea ecosystems. The science team has started geochemistry measurements to characterize the modern water column and create paleoceanographic reconstructions. They are looking at deep-sea coral distributions to reconstruct past changes in ocean pH, and nutrient changes over decades (#BridgeOrBarrier).



Main Image

Close up of a particularly puzzling octocoral, likely in the family Plexauridae, but new to all the biologists on board. It was found at the summit of Nintoku Guyot. Numerous brittlestars are wrapped around the branches.

Circle

ROV SuBastian takes a sample of a glass sponge, believed to be *Tretopleura* sp. during the "Necker Ridge: Bridge or Barrier?" expedition carried out over September and October of 2019.



CRYPTIC WHALES

In a search for a species of beaked whale never seen by researchers, scientists used a combination of tools, including environmental DNA (eDNA) analysis and acoustics, for an unprecedented study of the elusive mammal. During the cruise, three Drifting Acoustic Spar Buoy Recorders (DASBRs) designed by NOAA were deployed at sites around the Hawaiian Islands. The acoustic data was coupled with continuous CTD sampling, allowing for the acoustic detection of the beaked whales to be associated with genetic information from water samples. The data are still being analyzed, but knowledge of these whale communities is essential for their protection and reducing negative human impacts on the whale population (#ListeningToWhales).



Main Image

Kym Yano processes water samples taken by the CTD in the wet lab. Fine filters collect stray cells from animals, which are then folded, placed in a solution and packed for analysis on dry land.

Circle

Working in collaboration with the *Falkor* crew, the science team successfully recovers the first DASBRs (Drifting Acoustic Spar Buoy Recorder) deployed during the 'Listening For Cryptic Whales Species' cruise.





UNCOVERING NEW WORLDS

Large mineral towers, cold seeps, and oil chimneys were discovered in the Sonora Margin and Guaymas Basin in the Gulf of California. Surprisingly, these harsh and seemingly inhospitable conditions were teeming with biodiversity. Creatures thrived in the metal-laden minerals and highly sulfidic fluids collected across these features. Among these newly discovered geological formations, previously unknown features were also revealed: flanges angled downward that act as pooling sites for discharged fluids, creating the illusion of a mirror for those observing the super-heated (366°C) fluids beneath them (see image on pg.10). The first-of-its-kind sampling of vent fluids and microbial ecology represents a crucial step towards characterizing the relationship between hydrothermal system environment and ecology and how such diverse communities are supported (**#MicrobialMysteries**).

The first study to simultaneously collect a wide range of data at cold seep sites in the Pacific Northwest was completed aboard *Falkor* to address crucial knowledge gaps of deep-sea systems.



12 DIVES

and 116 hours at Guaymas Basin captured 23,027 images and collected 394 samples.



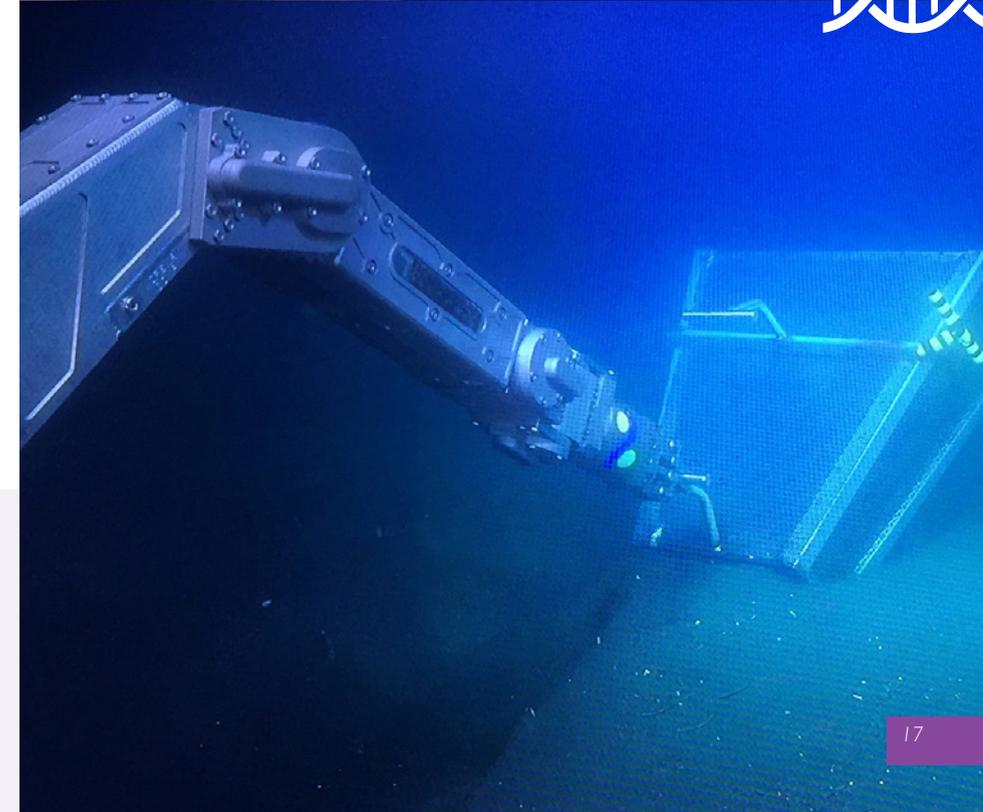
Hydrothermal vent fluid collects under the ledges and provides the chemical energy driving an entire ecosystem of microbes, scale worms, and riftia (tube worms) on the seafloor of the Gulf of California.

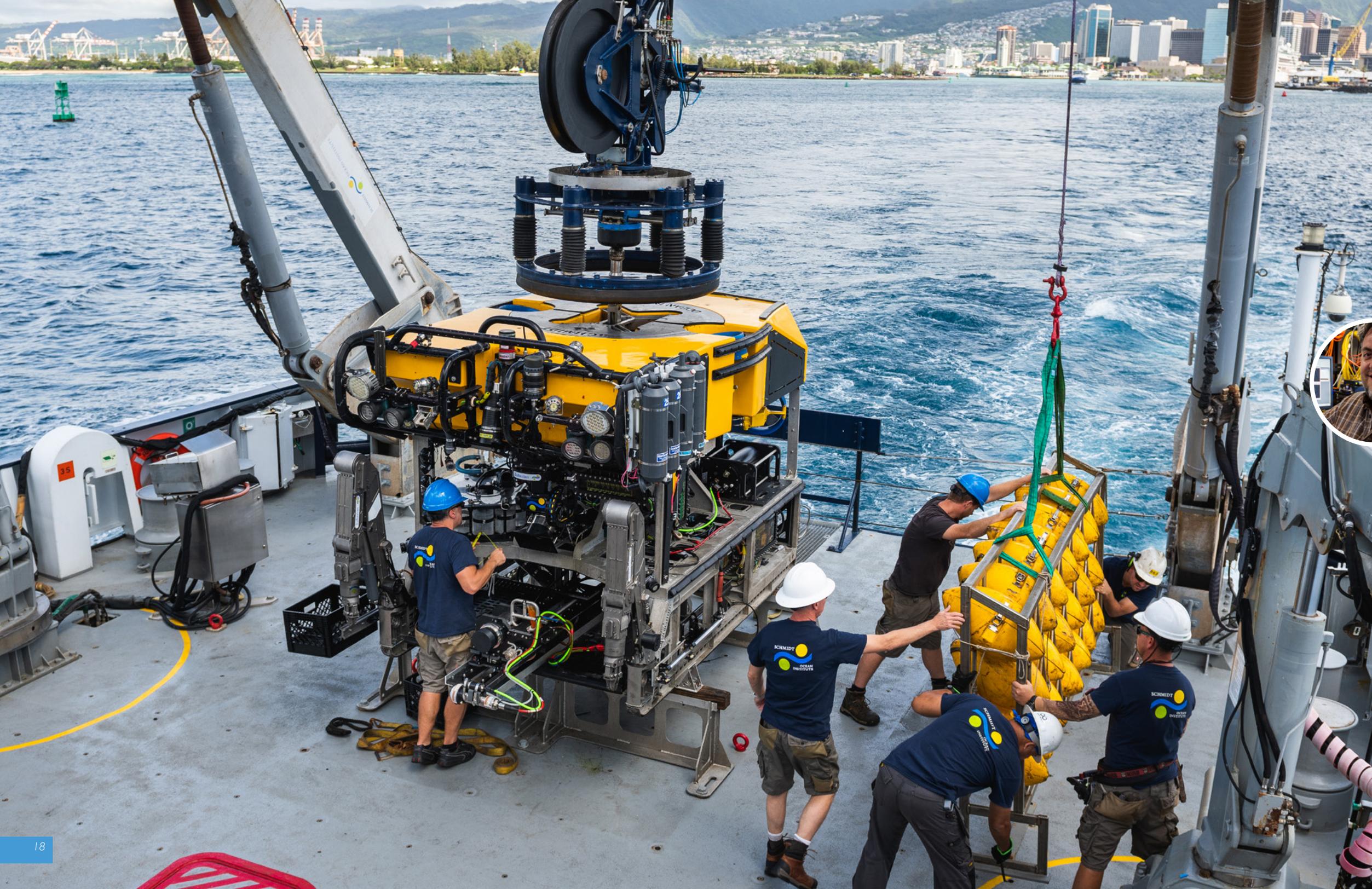


During the **#SeekingSpaceRocks** expedition, the team used many types of sifting devices in their search for meteorite fragments, including this large scoop known as the "star sieve."

The science team constructed an in-situ laboratory that produced unprecedented knowledge of gas hydrate degradation, seafloor seepage, and aerobic oxidation of methane seep systems at the edge of stability. Extensive mapping revealed new water column gas plumes that could be traced to seafloor seeps, highlighting their role in injecting carbon and other nutrients into the ocean (**#HuntingBubbles**).

Additionally, on a quick expedition in the summer, a team of NASA scientists found a one cubic millimeter, unmelted fragment of a meteorite during a three-day search aboard *Falkor* in the Olympic Coast National Marine Sanctuary. The sample allowed the team to measure the unusual, metal-rich silicated iron meteorite, but further testing is still needed to confirm the meteorite type. If confirmed, this will represent the eighth "meteorite fall" of this type seen to date, and one of 261 found in total (out of over 63,000 known individual falls) (**#SeekingSpaceRocks**).





ADVANCING TECHNOLOGY



“We are now able to discover, identify, and track features in ways which have never been done before, and in extraordinary detail. We have real-time data that allows us to react at a moment’s notice.”

*- Dr. Christopher Zappa
Lamont-Doherty Earth
Observatory, Columbia
University*



Leaving Hawaii, the R/V *Falkor* is guided by a pilot boat to ensure her safe departure. On deck, equipment is secured and prepared for the work ahead.



On the Aft Deck, Adam Newell (Engineer/Pilot, L3 Latitude) moves one of the UAVs (Unmanned Aerial Vehicles) from its transportation crate to the flight deck above.



TECHNOLOGY UNLOCKS THE UNEXPLORED

Technological innovation aboard *Falkor* blazed paths in several hard to reach ocean environments and expanded oceanographic knowledge with new data of unprecedented spatial and temporal resolution.

Expanding on the inaugural 2016 Sea-Surface Microlayer expedition, Unmanned Aerial Vehicle operations reached new heights with fully automated vertical takeoff and landing from *Falkor* during the last expedition of 2019, allowing scientists to study features of the sea-surface microlayer at scales of 10 cm or less in near real time.

Using highly accurate sensors on the aircraft the science team was able to map the temperature and color of the ocean surface. The expanded observation abilities led to finding large rafts of pumice from an underwater volcanic eruption in Tonga. Understanding this top layer of the ocean is essential for improving models of sea-surface temperature and its impact on global temperatures, storms, and fisheries (#AirtoSea).



3 UNMANNED AIRCRAFT

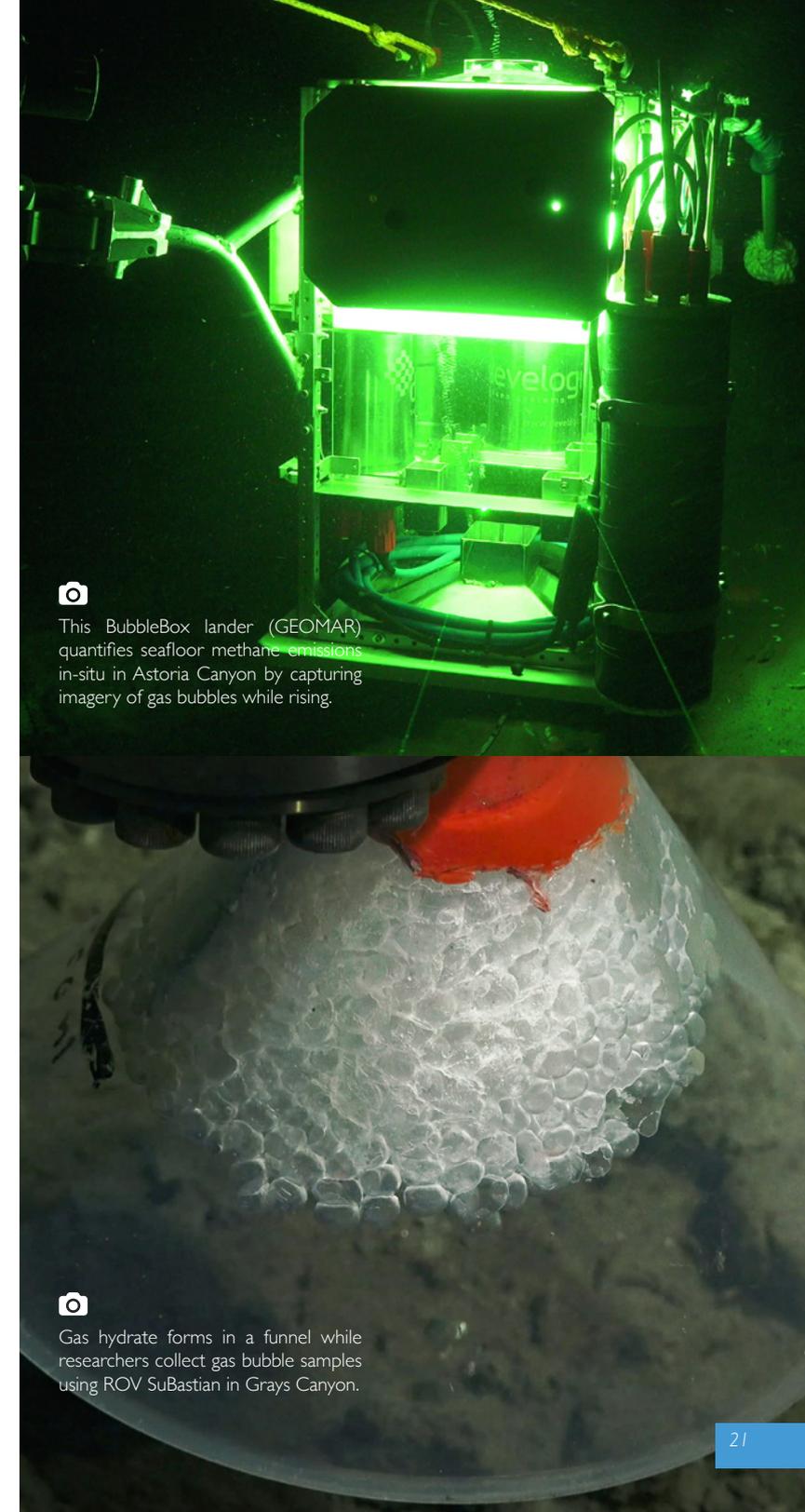
Were flown with four different payloads over a period of five weeks to study the ocean surface. Over vehicles flew 240 hours, collecting 43 TB of data, and covering a distance of more than 19,000 km.

Unprecedented biological and chemical studies of vent systems in the Gulf of California applied developing technology, including radiation tracking devices, as well as sediment and fluid samplers mounted on ROV SuBastian, to obtain geochemical data across a gradient of fluid flux regimes and water depths. Additionally, the Oxford Nanopore MinION sequencing system assessed microbial omics data on board *Falkor* in real time (#MicrobialMysteries).

First-time datasets on methane emissions and oxidation rates were achieved with two types of technologically innovative landers: one with in-situ incubation chambers for determining the rates of microbial methane oxidation in the water column (designed by Dr. Martens, University of North Carolina), and the other with capabilities for measuring the size, shape, number, and rise velocity of gas bubbles as they emerged from the seafloor (designed by Dr. Greinert, GEOMAR). The measurements gathered will inform scientists about the destruction of methane by microbial processes at the actual depths and temperatures where the microbes live (#HuntingBubbles).

240 L OF WATER FILTERED

filtered in less than one hour using a novel high-throughput filtration system providing a greater than 1000x improvement in comparison to conventional filtration for viruses.



This BubbleBox lander (GEOMAR) quantifies seafloor methane emissions in-situ in Astoria Canyon by capturing imagery of gas bubbles while rising.



Gas hydrate forms in a funnel while researchers collect gas bubble samples using ROV SuBastian in Grays Canyon.



CATALYZING INNOVATION

An in-situ species sampling tool that enables rapid characterization of deep-sea organisms was successfully tested aboard *Falkor* in preparation for a full expedition in 2020. Monterey Bay Aquarium Research Institution's DeepPIV (particle image velocimetry) system and the new low-pressure hydraulic engine developed by the University of Rhode Island were integrated onto ROV *SuBastian* over the course of six dives. Combined with new soft robotic manipulators created by Harvard University, the complete system will help to characterize fragile organisms such as deep-sea jellyfish, ctenophores, siphonophores, and glass sponges.

The science team was able to create a technology-based workflow for extracting morphological, behavioral, and genetic information on delicate species of the deep midwater environment. During midwater tests, the scientists accomplished a revolutionary achievement providing visual perspectives of fluids moving through living organisms. The team expects to make advances in the fields of 3D scanning and reconstruction, flow visualization, and bioinspired robotics (**#DesigningTheFuture**).

During a transit of opportunity, a new autonomous instrument designed by the University of Hawaii was tested to measure the rate of nitrogen fixation in the ocean surface along the equator. The instrument is in development with the goal of building a self-operating machine that traces the amount of hydrogen produced by algae species as a result of biological nitrogen fixation. The nitrogen cycle is critical to ocean ecosystems functioning by supporting new primary production in this nutrient limited environment. The science team used this expedition as a trial for the new instrumentation and to gather data for further technology modifications (**#MappingtheGaps**).

Additional seafloor mapping during the expedition also helped to contribute to the global collection of mapping data. In October, SOI signed a Memorandum of Understanding with [The Nippon Foundation-GEBCO Seabed 2030 Project](#) to share all of its collected mapping data with the project. According to the Seabed 2030 Project, about 32 million square kilometers or 15% of the ocean has been mapped. The million square kilometer milestone is a big one for SOI, accounting for 3% of this mapping contribution and the discovery of 14 new underwater geological features.



Main Image

In the Control Room, Dr. Kakani Katija (Co - Principal Investigator; MBARI), describes the complex maneuvering for ROV *SuBastian* to perform using MBARI's DeepPIV (particle image velocimetry) system. MBARI's DeepPIV can measure fluid motion, and dye visualizations reveal animal-fluid interactions.

Circle Image

SOI's Director of Operations Eric King and The Nippon Foundation-GEBCO Seabed 2030 former Acting Director Graham Allen sign the Seabed 2030 Memorandum of Understanding at the Royal Society in London.



CONSERVATION IMPACTS



“If the deep sea is all one big unit, then you can put a few protected areas wherever convenient and that would take care of it, but if it is, in fact, divided up into a bunch of biogeographic units then it is important to have a protected area in each one.”

- Dr. Les Watling
University of Hawaii



While exploring the Emperor Seamount chain, ROV SuBastian came across amazing locations, such as this steep cliff face with numerous Charitometridae crinoids, small cup corals, and Stylasteridae hydrocorals.



RESEARCH FOR OUR FUTURE

Responsible management of the ocean requires an understanding of diverse ecosystems.

Expeditions in 2019 revealed the extreme diversity found in deep-sea mounts in Costa Rica, the Central and Western Pacific, and the waters around Hawaii. The characterization of these systems is critical as they become increasingly targeted by anthropogenic endeavors.

The Vice Minister for the Environment and head of Conservation International in Costa Rica toured *Falkor* and joined scientists for a discussion about needed protections on local seamounts. As a result of the deep-sea corals found during the Costa Rican Deep expedition, there is evidence that these seamounts provide essential habitat for at least four new species of corals and six other animals that were discovered. Creating a new marine protected area from the mainland to Isla del Coco is one strategy to shelter these ecosystems from impacts of fishing or potential mining activities.

Some of the largest trash aggregations seen by the science party were found at 3,000 meters depth. While unfortunate, the footage is now being used to illuminate the impact of marine trash including an international deep-sea trash campaign showing that just because you cannot see it does not mean it is not there (#CostaRicaDeep).



Left Bottom Image

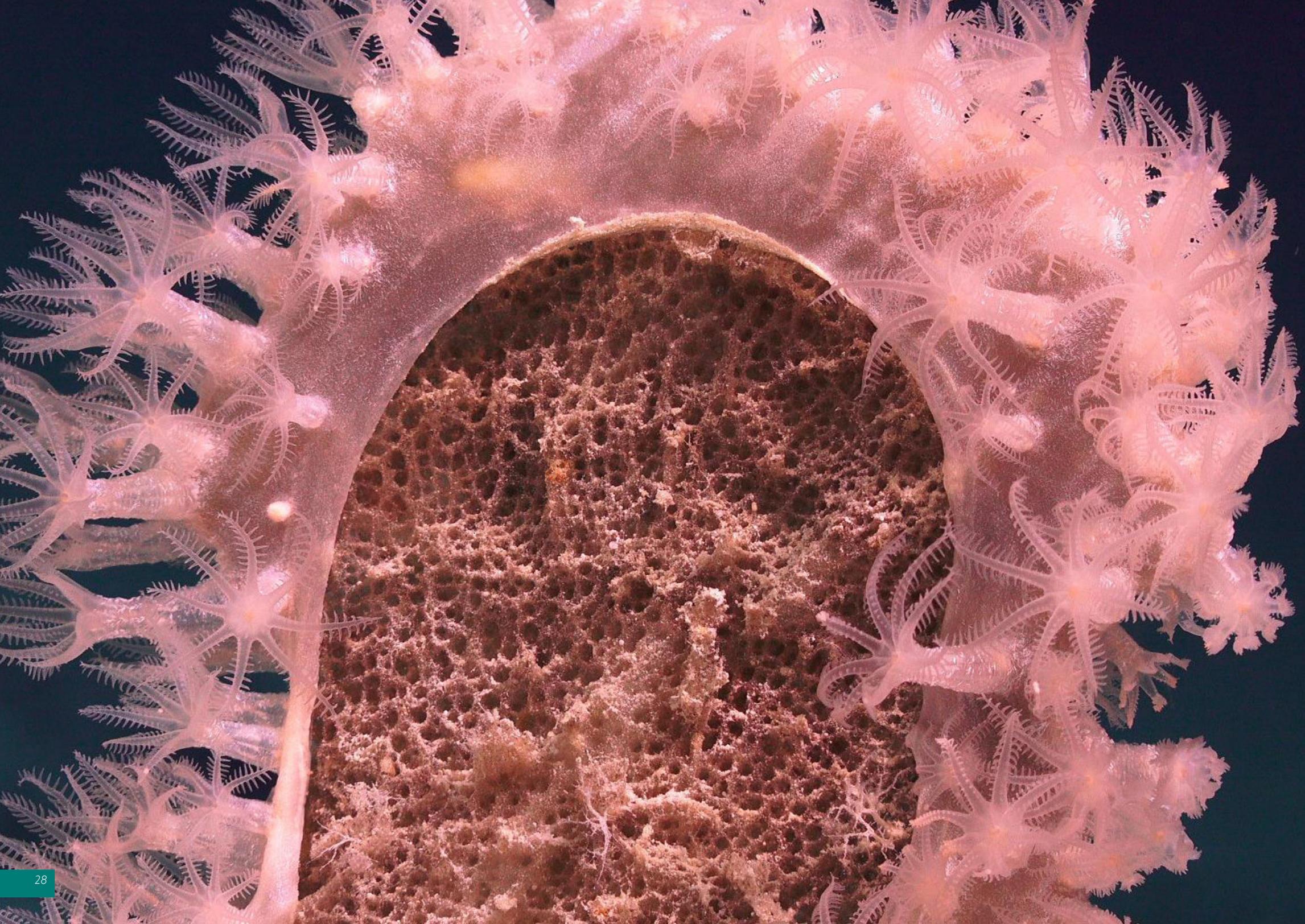
This area has never been seen by human eyes, but has been affected: Trash 3500m down - over 2 miles deep. Plastic bags and plastic yogurt cups are easily identified in this rubbish heap discovered by ROV SuBastian at a site off Isla del Cocos.

Top Image

Falkor in the Cocos Island National Park off Costa Rica - a UNESCO World Heritage Centre.

Bottom Image

Costa Rica's Vice Minister of Oceans and Water Haydee Rodriguez toured R/V Falkor. On board, she was given presentations about the research and science taking place on the #CostaRicanDeep expedition. Haydee, a lawyer with background in Environmental Law, left the ship inspired to bring the ocean closer to people and transform knowledge into policy.



New understandings of complex deep-sea coral communities along the Emperor Seamount Chain, discovered during the Deep Coral Diversity expedition can contribute to essential protection of deep-sea biodiversity. These findings have implications for determining how many protected areas are needed in deep waters, particularly in this active region left vulnerable due to coral harvesting, deep-sea fishing, and potential mining. The information will also help resource managers in updating policy to protect the different regions of coral (**#DeepCoralDiversity**).

Additional characterization of seamount communities along Necker Ridge will provide a better understanding of the connection between Pacific deep-sea ecosystems that could soon face impacts from human activity such as cobalt-rich, manganese crust mining. Understanding seamount diversity is critical in predicting effects that mining endeavors would have on ocean ecosystems (**#BridgeorBarrier**).



During the "Bridge Or Barrier" expedition, the team came across this unusual situation that appeared to be a deceased sponge being taken over by Stoloniferan octocorals. This expedition was the first time many of the Necker Ridge seamounts were explored with an ROV.



A GLOBAL DIALOGUE

SOI believes engaging with the world-wide community and sharing new knowledge is crucial to advancing ocean science.



Schmidt Ocean Institute was invited to testify before the United States House of Representatives Committee on Science, Space and Technology's Environment Subcommittee to discuss Ocean Exploration. Dr. Carlie Wiener was selected to be one of four witnesses to discuss the current state of the U.S. ocean exploration enterprise. This hearing allowed the congressional members of the subcommittee to learn how ocean exploration can benefit society, make observations of changes in ocean conditions, and to serve as a starting point for potential legislation.



A GLOBAL DIALOGUE

In 2019, SOI worked to expand the community with several programs promoting accessible engagement with the research conducted on *Falkor*. These included 54 ship-to-shore video connections that fostered discussions between scientists, classrooms, and institutions around the globe - overall reaching more than 3,700 people.

We also welcomed ocean managers and the public to tour *Falkor* in Costa Rica, Mexico, Hawaii, and Fiji through specialized and public ship tour days, as well as remotely through community events like the International MATE ROV competition, high school career days, and the University of Hawaii School of Oceanography, Earth Science, and Technology Open House.

In May, SOI was invited to testify before the [United States House of Representatives Committee on Science, Space, and Technology's Environment Subcommittee](#) to discuss the current state of ocean exploration. This hearing allowed congressional members of the subcommittee to learn how ocean exploration can benefit society, and to serve as a starting point for potential cooperation and future legislation.

Internationally, SOI is participating in the preparatory phase for the United Nations Decade of Ocean Sciences for Sustainable Development, and attended its first planning session in Copenhagen, presenting about SOI's outreach on a communications panel.

Other community events included SOI's participation in the decadal ocean observation conference held in September, including co-organizing the Breaking Waves Breaking Barriers Women's Panel that was attended by 400 participants. Additionally, SOI hosted a celebration on *Falkor* with the University of Hawaii, highlighting 16 successful expeditions completed while working together.

SOI was also engaged in an ocean data think tank at the Ditchley Estate in London and organized the inaugural Philanthropic Ocean Research Vessel Working Group meeting in November. The working group was a two-day gathering of senior managers from the world's leading philanthropically supported research vessels to share ideas and common challenges while exploring opportunities to leverage resources for greater impact.



Top Left Image

A Ship-to-Shore call during the #HuntingBubbles expedition between *Falkor* and the Smithsonian Museum in Washington DC.

Top Right Image

The first Philanthropic Ship Operators Working Group meeting hosted by SOI took place in November of 2019 at the new Alma Station building.

Bottom Image

Breaking Waves, Breaking Barriers: Celebrating Women's Instrumental Role in Ocean Science, Leadership, and Mentorship.

This event sponsored by SOI brought together ocean scientists from across the globe to discuss the important role women have served in shaping oceanography.

As part of the OceanObs'19 conference week, the event opened with an introduction by Wendy Schmidt, then had a discussion and reception paying tribute to great women scientists while inspiring future generations for a more inclusive, robust, and forward-leaning discipline.





SPREADING THE WORD

Through numerous publications and press, SOI brought awareness to critical ocean issues and discoveries from *Falkor* expeditions. Notable discoveries were shared in popular publications such as WIRED Magazine, Smithsonian Magazine, FOX News, IFL Science, and Yahoo News. Several staff wrote articles that were highlighted in Marine Technology Reporter and ECO Magazine, and SOI's Leonard Pace served as the editor for a special issue of [Frontiers Research](#) focused on Emerging Technologies with High Impact for Ocean Sciences, Ecosystem Management, and Environmental Conservation, which now has nearly 30,000 views.

Scientific findings as a result of *Falkor* expeditions are now being showcased in several museum exhibits. SOI was proud to be a part of an exhibition by London's world-famous Barbican Centre entitled "AI: More than Human", featuring pioneering research that took place during the New Approaches To Autonomous Exploration At The Costa Rican Shelf Break 2018 expedition.

Other new exhibits featuring SOI research included the Top 10 New Species at the Heilbronn Experimental Science Centre in Germany, a deep sea and cold seeps exhibit at the Cite de la Mer, European Center of Marine Education and a deep ocean adventure exhibit at the National Museum of Marine Biology and Aquarium in Taiwan.

SOI was honored by the Marine Technology Society with the 2019 Public Awareness award for our dedicated outreach with ROV SuBastian, and later listed, along with co founder Wendy Schmidt, on Marine Technology Reporter's annual 100 list for leading innovators in ocean technology.

Through SOI's online platforms, we were able to reach more than three million people through Facebook, Twitter, YouTube, and Instagram. Weekly posts such as #SciArtFriday and #TechTuesday highlighted the unique work of researchers and artists participating aboard *Falkor*. Over 27 days' worth of footage from ROV dives were live-streamed on YouTube.

THE NEXT GENERATION

SOI supports ocean science today while simultaneously creating a foundation for the future by providing opportunities that inspire and elevate the next generation. In 2019, eight Student Opportunities participants experienced research first-hand aboard *Falkor* while learning and being part of teams led by international scientists using premier oceanographic tools and methods. For the majority of students, this was their first exposure to both living and working at sea. Students practiced science writing through their contribution to blogs published on the SOI website and shared their knowledge by leading ship-to-shore programs.

In 2019, SOI welcomed its fourth science communications intern, University of Hawaii graduate student Shannon McClish. Through training and mentoring, Shannon has been actively involved in crafting SOI publications including an article in ECO magazine, community outreach, and analyzing social media metrics. "Working with the SOI communications team has not only provided me with invaluable skills but ignited a passion for science communication and oceanographic research," said Shannon. "Interacting with the team at SOI has instilled in me the power creativity and collaboration in conducting and sharing scientific knowledge."

Top Left Image
On the small boat, Kyra Thompson (Student Opportunities Participant) and Cindy Pease Roe (Artist-At-Sea) have a unique experience - a ride in the open water to get a fantastic view of the *R/V Falkor*.

Left Circle
SOI's Co-Founder Wendy Schmidt was given the #1 spot in the 14th Annual "MTR100," which recognizes subsea leaders, innovators, and technologies. She was also featured on the cover of the Marine Technology Reporter Magazine issue announcing the list of 100 honorees.

Top Right Image
Communications intern Shannon McClish explains ROV SuBastian livestreams during a School of Ocean & Earth Science & Technology open house to grade school students at the University of Hawai'i at Mānoa.

Right Circle
The exhibition "Stoffwechsel" in the Experimental Science Center in Heilbronn, Germany features an Innovations Box with the "Top 10" newly discovered species. The exhibit features SOI footage of *Pseudoliparis swirei* - the "Ghostfish" Mariana snailfish discovered in 2014 during an expedition aboard *R/V Falkor*.



AT SEA CREATIVITY

“Building on the exchange of methods and practices alongside in-depth conversations with the scientific team, my creative process has become an experiment of my own.”

- Adrien Segal



Left Page

Artist-At-Sea Annabel Slater takes notes and sketches on her tablet while sitting on a deep-sea lander on the aft deck of Research Vessel *Falkor*.

Right Page

In *Falkor*'s wet lab, Artist-at-Sea Kishan Munroe works on his composition, a mixed-media piece incorporating aspects of collage and photography.



AT SEA CREATIVITY

SOI's Artist-at-Sea program continues to expand with twelve participating artists in 2019, including a dedicated artist transit. The program collectively brings together the experiences of scientists and artists, allowing them to exchange knowledge, inspiration, and broadening perspectives.

Exemplifying the intersection of art, science, and technology, artists Alyson Ogasian and Shona Kitchen integrated their 3D printed designs onto the experimental cameras placed on ROV *SuBastian*. Another artist, David Bowen, used a CNC machine to carve bathymetry data into various substrates, while also using 3D printing to illustrate seafloor maps collected during his time on *Falkor*. In another approach to transforming complex ocean features, Christine Lee used oceanographic data to guide threaded shapes that describe coral structure. And artist Cindy Pease Roe created a 'whale talisman' constructed completely of collected debris to highlight the increasing problem of waste in the ocean.

The knowledge embodied by a selection of the art pieces was shared in several public exhibits at the Mokupāpapa Discovery Center in Hawaii and in collaboration with Science Gallery Detroit (DEPTH exhibit) at the Michigan Science Center. Both exhibits included grand opening events with artist participants. The DEPTH exhibit in Michigan also included several ship-to-shore connections with *Falkor*, an SOI hosted panel on ocean science art collaborations, and an experimental music performance by the Detroit Sound Bureau using ROV *SuBastian* footage at the [Toyota Engineering 4D Theater](#).





“The paint moved, the canvas moved, my body weight moved – there was a constant shift in the center of gravity that all the elements needed to adjust to. It was rather a fun way to be introduced to movement at sea through the lens of liquid paint.”
-Bailey Ferguson



EXPANDING EXPERIENCES

The continued work of previous Artists-at-Sea participants is also a testament to the power of the program. In 2019, artist alumni expanded upon their time aboard the *Falkor* with new pieces, exhibitions, and collaborations.

Artist Lauren Salm’s entire work has shifted to a more abstract style after being inspired by the seafloor mapping imagery she worked with while on *Falkor*. Not only has she created additional paintings surrounding the seafloor mapping theme, but she has recently partnered with Columbia University’s Lamont-Doherty Earth Observatory to put on an exhibit of bathymetry-inspired work in honor of the 100th anniversary of oceanographic cartographer Marie Tharp’s birth. Tharp was instrumental in creating the first scientific map of the Atlantic Ocean floor.

Another artist, Adam Swanson, is now collaborating with researchers on Lake Superior organizing public talks and working on new pieces about water quality in the region. Gideon Gerlt’s time aboard *Falkor* inspired him to create

a public art program in Alaska, while artist Bailey Ferguson’s experience motivated her to create a series of paintings that celebrate the complex biodiversity of coral reefs. Previous participant Rebecca Rutstien’s work has now been featured in several popular publications including *Hakai*, *Muse*, *SciArt*, and *Vice* Magazines.

Scientists and artists who have worked together aboard *Falkor* continue to collaborate. Artist Lily Simonson and Dr. Peter Girguis have started a new project with Dr. Betsy Pugel of NASA based on their shared time during the 2018 [Characterizing Venting and Seepage along the coast of California expedition](#). Previous program participants have also reached across expeditions, as Bailey Ferguson (2019) and Michelle Schwengala (2016) collaborated for an interdisciplinary art piece now on display in Los Angeles. The project was inspired by their separate times on board, the shared wonder of exploring, and the overall importance of protecting the deep sea.



Left Corner Image

The Opening Day Event of the exhibit DEPTH in Detroit was a multimedia performance led by a 40-minute video of highlights from ROV SuBastian’s dives, including vibrant life of the deep sea, massive coral pagodas, thermal vents and unexpected signs of human life. With a live audio-visual performance from Detroit Bureau of Sound, the one-night-only experience closed to rave reviews.

Center Image - Left Page

Cindy Pease Roe (Artist-At-Sea) begins fine-tuning her sculpture which now hangs from the ceiling of the Dry Lab. With a tail, fins, eyes and even teeth... suddenly her work of art comes to life.

Center Images - Right Page

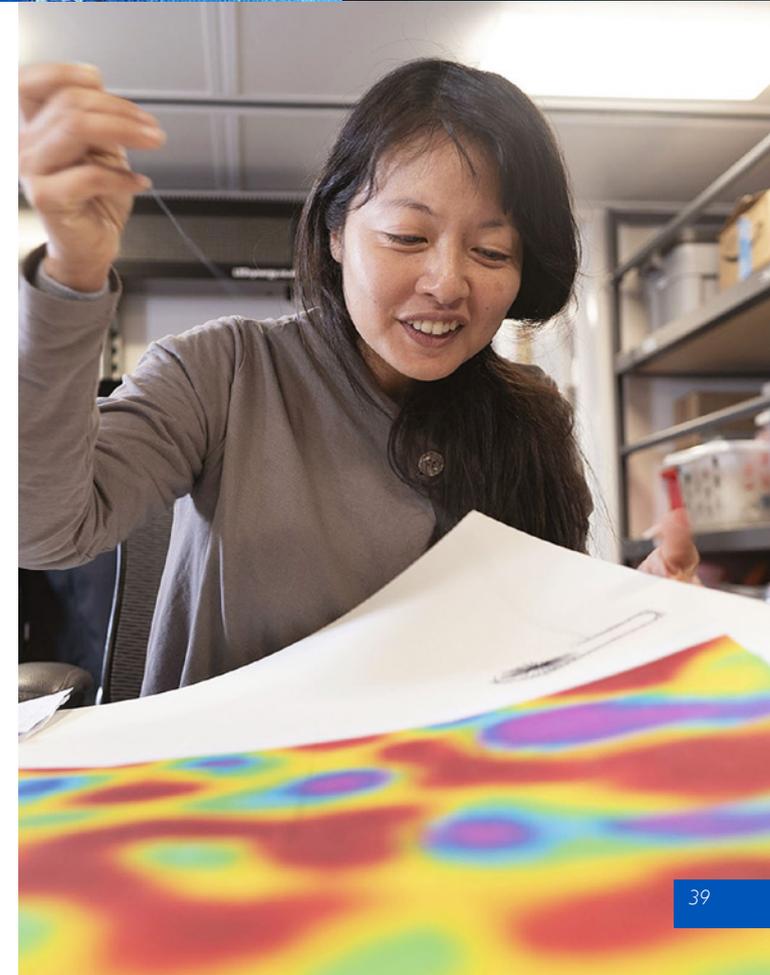
Artist-at-Sea Bailey Ferguson’s daily exercise to document the ship’s movement were “movement painting” pieces. Her method was applying fluid acrylics to a sheet of canvas laid flat on the floor.

Right Corner Image

Part art gallery, part science lab and part theater, the DEPTH exhibit explored the world’s connection to water. Put on by Science Gallery Detroit - a partnership with Michigan State University to pioneer science programs aimed at 15-25 year olds that are integrated with art, design, and technology - the exhibit contained many pieces by Artist-at-Sea participants.

Right Bottom Image

Artist-at-Sea Christine Lee at work, threading the shapes of the different eddies in this region inside the diameter of one of *Falkor*’s portholes.





EXPEDITIONS THAT INSPIRE

“Our work will help important habitats by providing a baseline of the incredible species and ecosystems found in the deeper areas that don’t always attract the attention that they deserve. One of the most important things we can do right now is to understand how these communities work.”

- Wendy Schmidt, SOI Co-founder



Rimicaris falkorae is a new species of the alvinocaridid shrimp, discovered living among deep-sea hydrothermal vents (3,630–3,912 m deep) on the Mariana Back Arc Spreading Centre, northwestern Pacific. The shrimp was named in part after R/V *Falkor*.

Discoveries and collaboration inspired by SOI expeditions continue to make waves around the world, sparking new questions and invigorating ocean science.

A new shrimp species discovered in 2016 during the [Searching for Life in the Mariana Back-Arc](#) was confirmed in 2019 and named in honor of *Falkor*: *Rimicaris falkorae*. The May edition of the *Journal of Crustacean Biology* officially published the discovery. A new sponge species was also confirmed following the 2015 [Perth Canyon expedition](#). A second species of Calyptorete was described over 90 years after the genus was first established due to the pristine sample collected with ROV SuBastian. An earlier expedition on another research vessel used sleds and trawls that previous samples damaged.

Methods developed on *Falkor* were implemented around the globe in 2019. The long-range AUVs and software toolchain first used during the 2018 [Exploring Fronts with Multiple Robots expedition](#) was successfully applied to study freshwater plumes from coastal rivers in Porto and Setúbal, as well as a study of the Sesimbra Canyon in Portugal. Method development by Dr. Blair Thorton and team on the [Adaptive Robotics at Barkley Canyon and Hydrothermal Ridge expedition](#) improved effective data gathering of deep-sea ecosystems. Their method was implemented on data collected during a survey of cold-water corals by the RRS Discovery. Participants presented findings at Scientific Conferences in Germany, Italy, France, Norway, Portugal, Spain, United States, Canada, Russia, China, and Australia.



New hypotheses on microbial function within low oxygen environments have evolved from the result of the [Solving Microbial Mysteries with Autonomous Technology expedition](#) now being pursued in multiple new proposals. Furthermore, the fieldwork experience during the expedition introduced Student Opportunities participants Elisabeth Boles and Susan Mullen to ocean research, both of whom are now pursuing oceanography in graduate school at Stanford and Berkeley.

Data analysis from the [2015 Tasman sea expedition](#) led to an unprecedented understanding of the Tasman Sea internal tide and a new method for interpreting highly energetic ocean systems. Dr. Amy Waterhouse's observations identified little decay of the internal tide beam due to mixing and successfully quantified the effect of mesoscale activity on the internal tide beam.

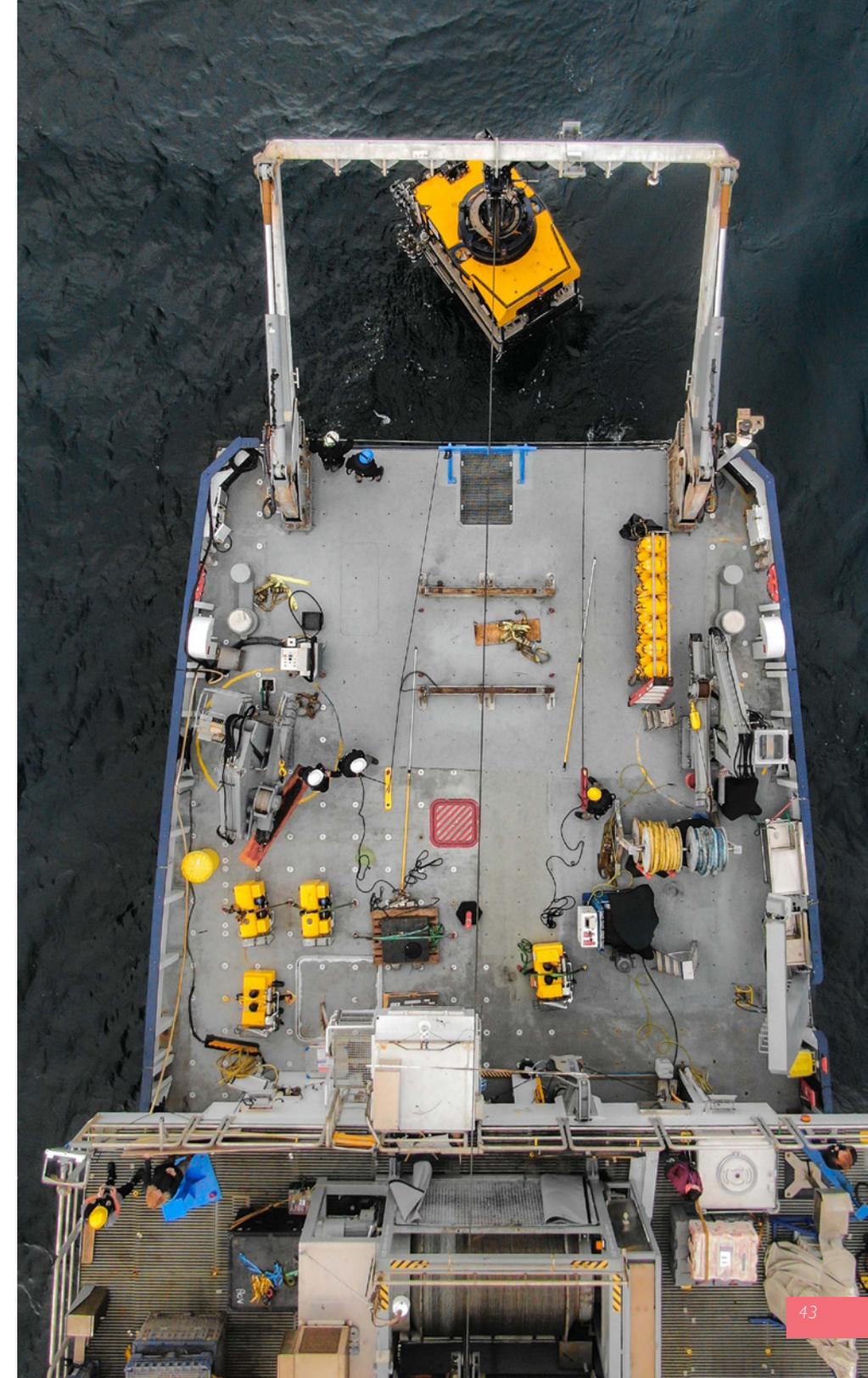


ID Elisabeth Boles checks a connection on an in situ incubator prototype to be used in Oxygen Deficient Zones (ODZs) off Mexico.

Inspiration has extended far beyond traditional publications, as SOI participants continued to conduct numerous post-cruise outreach programs in schools ranging from elementary to graduate, as well as museums, scholarly presentations, and even important informal public dialogues. Dr. Julie Huber shared her work on deep-sea astrobiology on the Bill Nye podcast. Dr. Joao Borges De Sousa has presented to thirteen groups across Portugal, advocating for multiple coordinated autonomous vehicles based on his successful [Exploring Fronts with Multiple Robots expedition](#). And Dr. Chris German (WHOI) has forged a partnership with the Geophysics Lab at Tahiti where he will return for an NSF-funded cruise based on his in-port work on *Falkor*.



ROV SuBastian is launched to study seeps off the U.S. Pacific Northwest continental margin.



2019 CRUISES



#CostaRicaDeep
Principal Investigator: Erick Cordes



#HuntingBubbles
Principal Investigator: Dr. Carolyn Ruppel



#DeepCoralDiversity
Principal Investigator: Dr. Les Watling



#ListeningToWhales
Principal Investigator: Dr. Ann Allen



#MappingTheGaps
Principal Investigator: Dr. Sam Wilson



#MicrobialMysteries
Chief Scientist: Samantha Joye



#SeekingSpaceRocks
Principal Investigator: Marc Fries



#DesigningTheFuture
Principal Investigator: Dr. Brennan T. Phillips



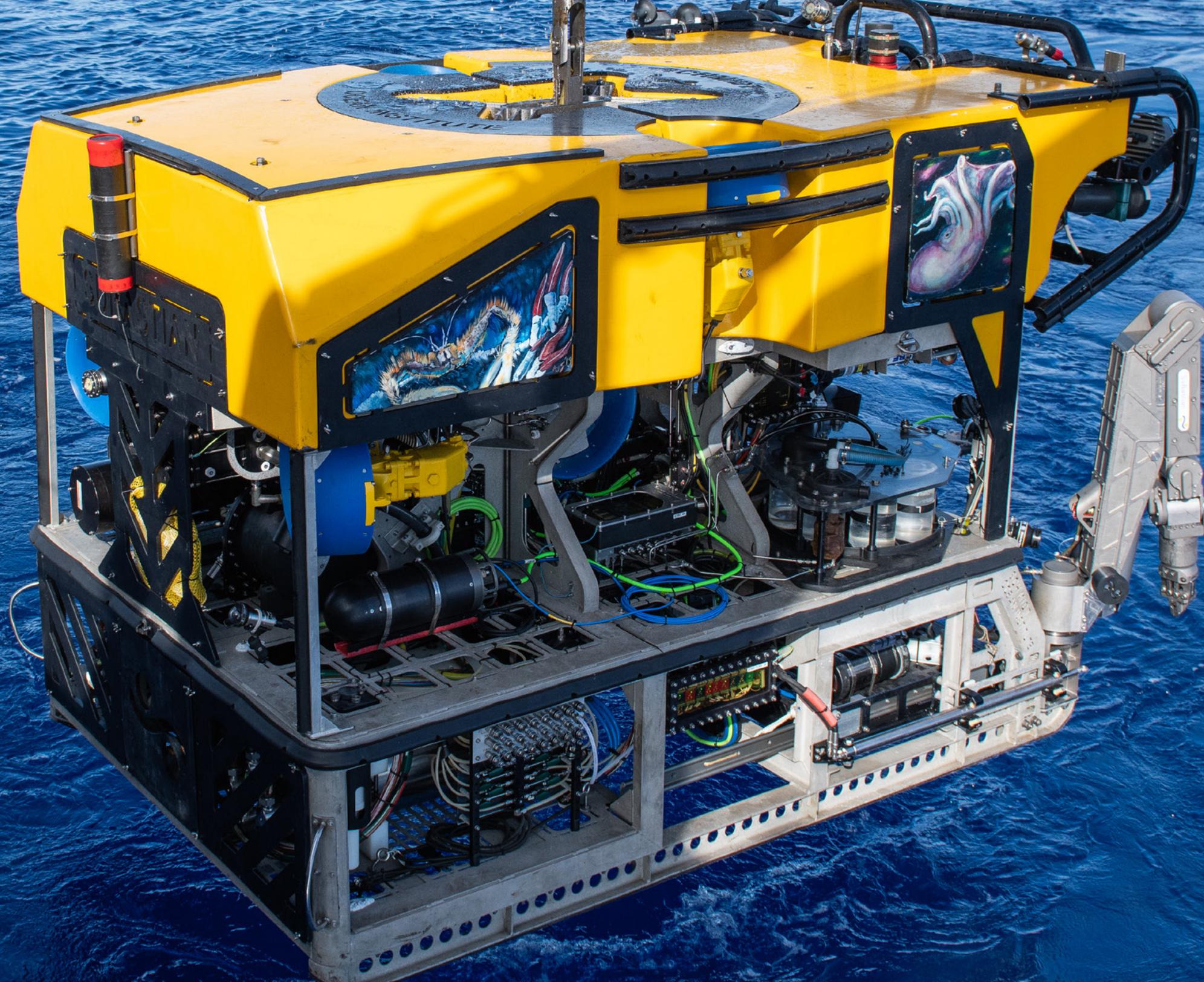
#BridgeOrBarrier
Principal Investigator: Dr. Amy Baco-Taylor



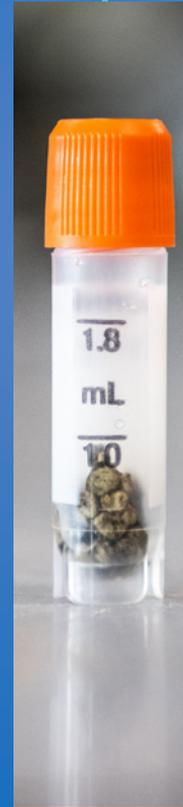
#AirToSea
Principal Investigator: Dr. Christopher Zappa

PARTNERS





ROV SuBastian enters Hawaiian waters on its second deployment of the Designing the Future expedition



2019

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