

EVOLUTION



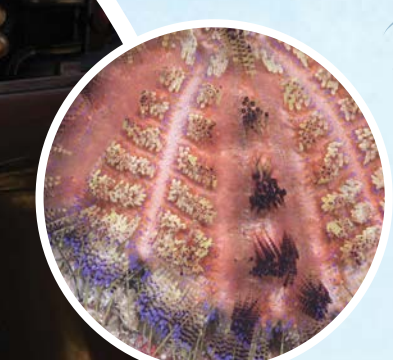
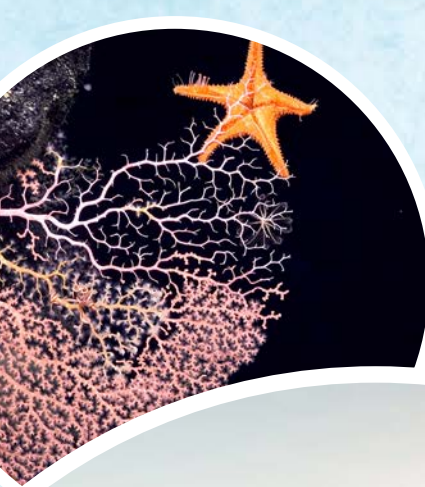
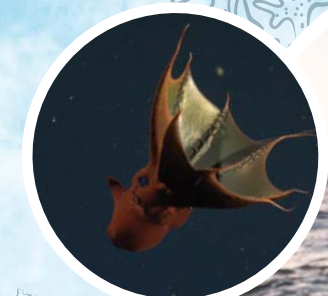
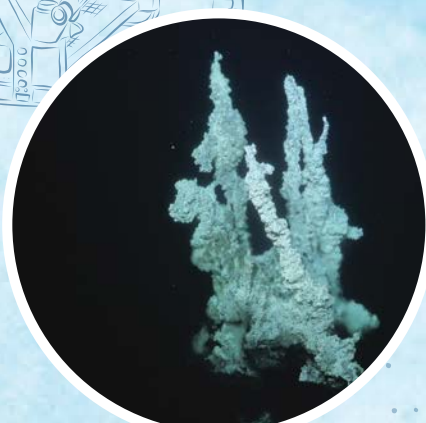
SCHMIDT



OCEAN INSTITUTE

IMPACT REPORT 2021





EVOLUTION

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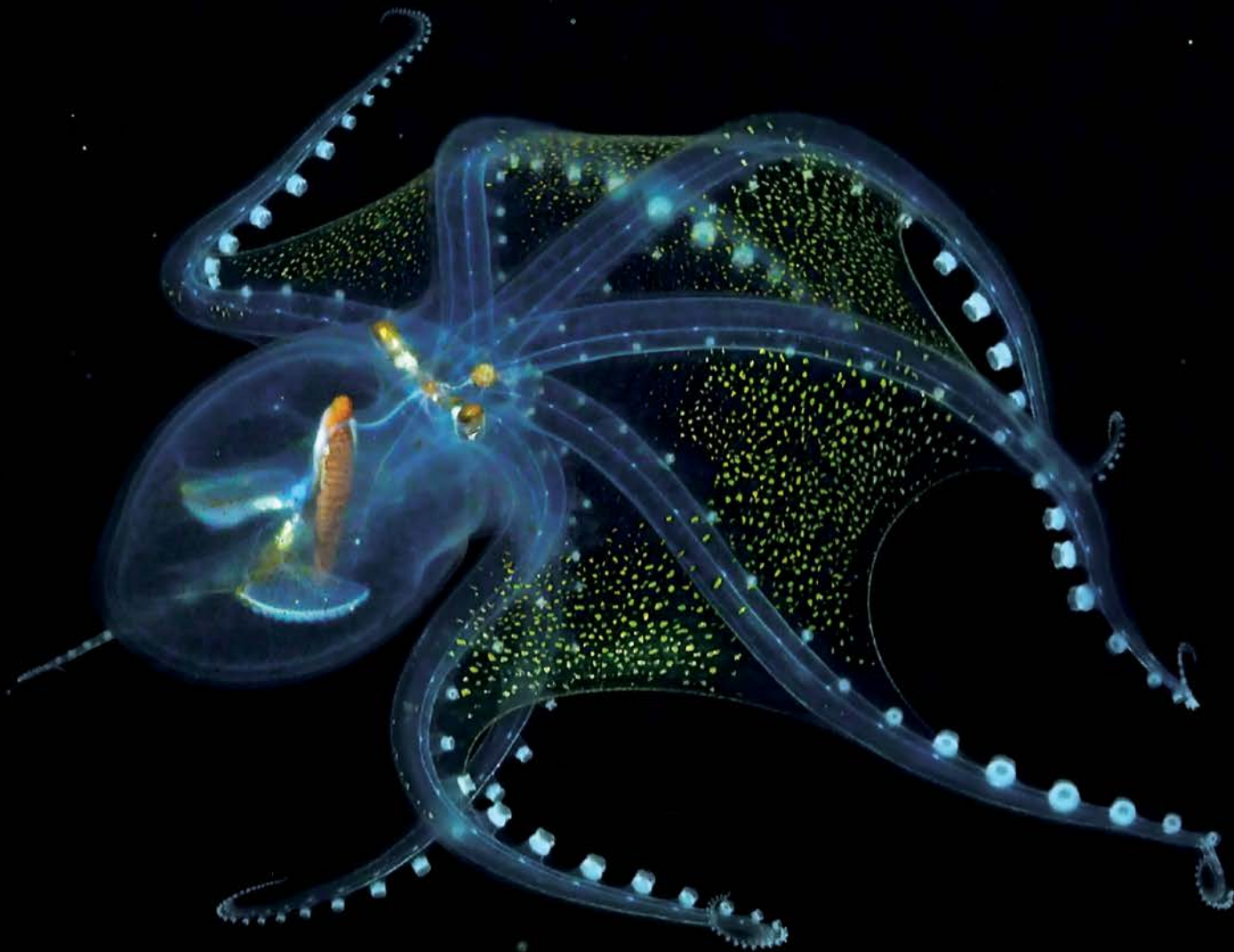
A change in the characteristics of a species over time.

In 2021, R/V *Falkor* traveled across the Pacific and Atlantic Oceans, passing the baton to R/V *Falkor* (too). This transition marks a new era of oceanographic research, an evolutionary step for the Schmidt Ocean Institute.



Two individual glass octopuses were observed, resulting in the first-ever high-quality recordings of the species.

Photo by: ROV SuBastian / Schmidt Ocean Institute;



A WORD FROM OUR FOUNDERS

Since we created Schmidt Ocean Institute (SOI) in 2009, it has felt like a living, breathing creature. SOI lives on the water, in the deep sea, and on land, wherever humans may be endeavoring to understand our ocean. It evolves and grows and improves with time, connecting more people to the ocean, strengthening networks of scientists, and communicating with the world about the wonders it holds.

Our research vessel – named for the luckdragon, R/V *Falkor* – was not new when it came into our hands. It was our talented shipbuilders, staff, and crew, alongside participating scientists from collaborating institutions, who evolved it from its former purpose-protecting fisheries as *Seafalke*—into a state-of-the-art floating laboratory for marine science. Even when the renovated R/V *Falkor* first hit the water in 2012, we knew that we would have to keep evolving to remain state-of-the-art and to continue to offer the best opportunities for science and learning. We updated equipment, incorporated new technologies, and built an underwater robot, SuBastian. Thanks to the scientists from around the world who joined our expeditions,

we found dozens of new species and a towering coral reef spanning hundreds of meters, and garnered new insights into how the deep sea works. In 2016, R/V *Falkor* produced a high resolution map of a newly created landmass, the undersea portion of a volcano that first appeared in January 2015. This is the same Tongan landmass that erupted in 2022. In the past year, we led numerous expeditions, mapped nearly 120,000 square kilometers of seafloor, pursued new collaborations, and advanced the field of ocean science.

Last year marked another momentous step in our evolution: we launched an ambitious strategic plan for the decade and acquired a new vessel to transform into the most technologically advanced research ship in the world. In 2022, the world will meet R/V *Falkor* (too). We see our work as a neverending story – and, much like the tale from which the name *Falkor* comes, life continues. We hope you will read on to learn more about the past year, and join us in all the years to come, as we continue to grow and evolve, deepening our understanding of, and connection to, our ocean.

Eric and Wendy Schmidt





EXECUTIVE DIRECTOR'S NOTE



In science, the word evolution has a very particular meaning. It is a change in the characteristics of a species over time. This year witnessed a step-change in the evolution of the Schmidt Ocean Institute (SOI), and, during my second year at the helm of SOI, I am proud to work alongside our extraordinary and dedicated staff, crew, Advisory Board, and principals who made this possible

In March we finalized the first Schmidt Ocean Institute Conceptual Framework and Strategic Implementation Plan in March, just before acquiring our new 110-meter research vessel, R/V *Falkor (too)*. The 10-year Strategic Framework, One Ocean - Seven Continents, Seven Topics - One Decade, builds upon SOI's foundation and provides a pathway to the future that merges research, technology development, and broader engagement

across seven topical areas that are essential to exploring and answering critical questions to characterize our ocean.

Instrumental in continuing our collaborative research in the next decade and beyond is our new R/V *Falkor (too)*. This vessel, with three times the interior capacity of R/V *Falkor* and more than six times the deck space, is currently at Freire Shipyard in Vigo, Spain, where advanced scientific labs and equipment are being added, including the largest gondola and sonar array on a research vessel.

As the world continued to navigate the pandemic for another year, R/V *Falkor* was crossing oceans in 2021 as it sailed from Australia - across the Pacific and the Atlantic - to pass the baton to R/V *Falkor (too)* in Spain, completing seven expeditions along the way.



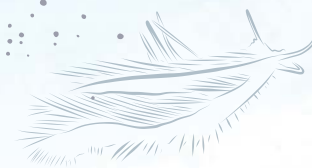
With scientists from around the world, we mapped almost 120,000 square kilometers of seafloor, performed almost 80 dives with ROV SuBastian, and collected 97 terabytes of data that have been submitted to public data repositories. From flying the Seabed 2030 flag and Pinging in the New Year by collecting the first seafloor mapping data of the UN Decade in Australia, to gathering the first high quality footage of a glass octopus in the Phoenix Islands, R/V *Falkor* and the work done onboard inspired the world.

And in recognition of the operational excellence on R/V *Falkor* throughout the last two years, we were proud to accept the AltaSea Explorers Award in October.

Underlying our activities are valuable partnerships - from working with scientists and artists who sail with

us to collaborating with incredible organizations. Building connections and collaborations are a key piece of amplifying our impact, and 2021 was no exception. We were delighted to formalize new partnerships with Nekton, the Guy Harvey Ocean Foundation, and the Marine Technology Society/IEEE Oceanic Engineering Society. We shared our expertise in technology and communications with our partners in the UN Decade of Ocean Science as we collectively work towards a decade of improved understanding of our beautiful and mysterious ocean ecosystem.

Additionally, we expanded our cooperative work with the Ocean Exploration Trust and NOAA's Office of Exploration and Research on the Deep Ocean Education Project to bring educational resources to a larger audience.



This chimney structure was formed by minerals precipitating from the hydrothermal fluids as they come in contact with the ocean's cold water. Documented between Auka and the JaichMaa 'ja'ag Vent Fields, Dive 473.

Photo by: ROV SuBastian / Schmidt Ocean Institute

Throughout the year, we engaged the community with numerous conferences, podcasts, ship-to-shore connections, and other events, reaching an audience of over 52,000 people. In February, we hosted our first virtual Symposium with our Advisory Board, who moderated the sessions, providing space for our alumni and networks to connect and share their research 'Beyond the Cruise'. Working with Nekton allowed us to better envision new avenues for engaging public audiences with the ocean, as evidenced by the Oceans Rising white paper and workshop we conducted in July. In November, we premiered our short film, "Climate Under Pressure," and hosted a panel discussion on this topic at COP26 in Glasgow, emphasizing the need to include the deep ocean in the international dialogue on climate change.

Our outstanding communications team earned three MarComm Awards (including a Platinum Award for the 2020 Impact Report!) and a film festival award for our film on the Ningaloo Canyons expedition.

This year we expanded our commitment to diversifying voices in oceanography with several new initiatives, including providing support to scientists with dependents at home and broadening access to field work for scientists. Our Artist-at-Sea program brought artists onboard from the regions where R/V *Falkor* was operating and we funded previous Artist-at-Sea Taloi Havini's first international solo exhibit at the Ocean Hall in Venice, Italy.

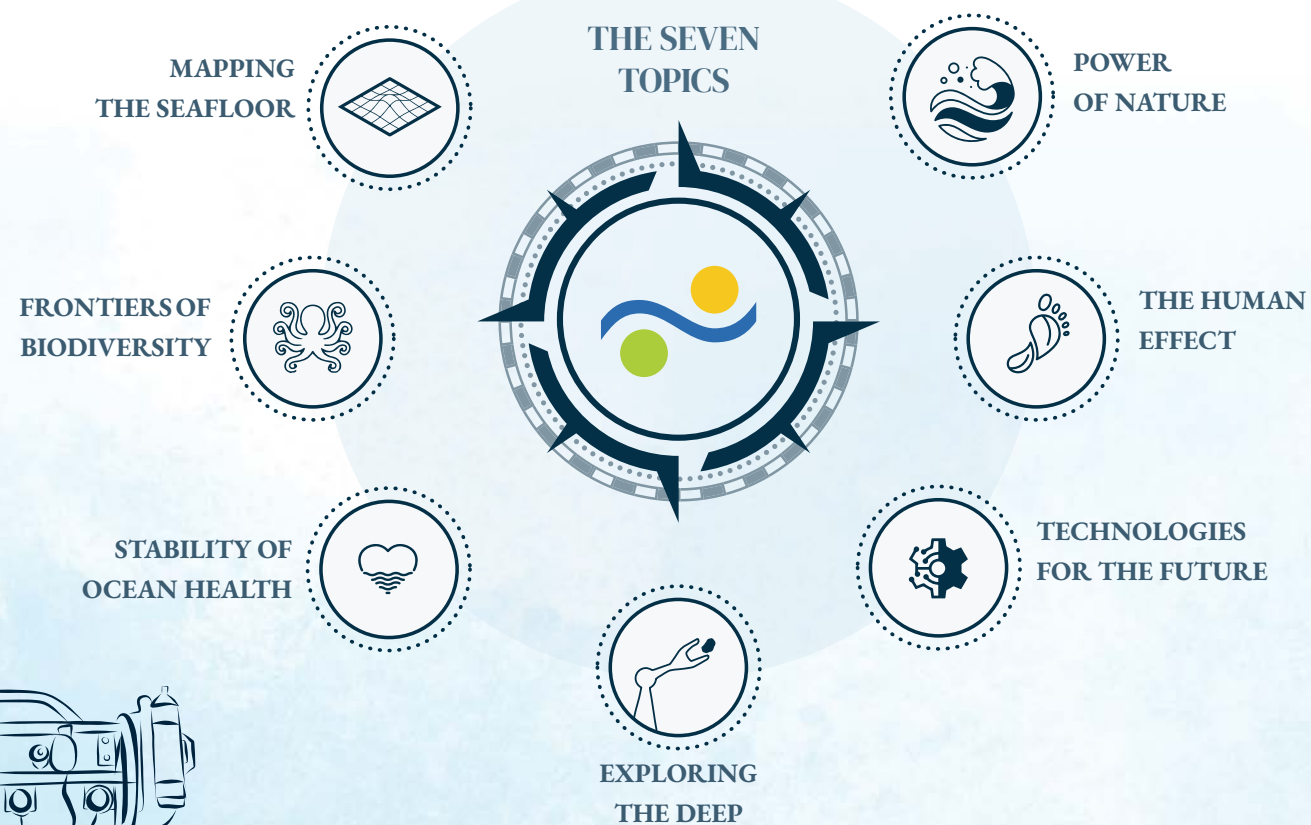
These are just some of the activities covered in this report. 2021 was the start of the Ocean Decade, with people and groups coming together from around the globe to make the Ocean a priority – biodiversity, seafloor mapping, and ocean sciences for sustainable development. We look forward to the future, implementing our new strategic framework to boldly explore our unknown ocean, and commencing operations to support research and technology development onboard the R/V *Falkor* (too). If ever there was a time for this evolution, this is it.



PATHWAY TO THE FUTURE

ONE OCEAN. SEVEN CONTINENTS. SEVEN TOPICS. ONE DECADE.

Schmidt Ocean Institute's Strategic Framework for the coming decade was launched in 2021, sharing plans to merge research, technology development, and broader engagement to explore and answer critical questions about the ocean. With a vision of committing to seven topics that are essential to understanding the ocean, we will boldly explore our one unknown ocean as it touches upon all seven continents.



PASSING THE BATON

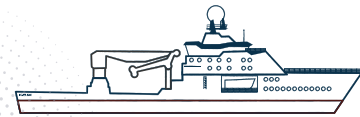
This year, R/V *Falkor* passed the baton to Schmidt Ocean Institute's new research vessel, *Falkor (too)*. The newly acquired 110-meter vessel has impressive characteristics, including a state-of-the-art propulsion system designed to keep the ship stationary in extreme seas, and is currently undergoing a year-long conversion at a shipyard in Vigo, Spain to add laboratories and a broad suite of science systems.

One hundred forty kilometers of new cables are being pulled through the ship and will contribute the most comprehensive data network and communication systems ever embedded in an oceanographic research vessel. R/V *Falkor (too)* will also carry one of the world's largest gondolas under the hull, hosting a vast array of the most advanced scientific echosounders and sonar. Along with the science systems, this array will allow scientists to study the entire water column

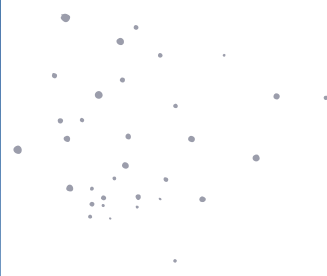
from the surface to 11,000 meters depth and even 200 meter depth into the rock under the seabed.

The interior areas of R/V *Falkor (too)*'s main deck will be renovated into offices, seven different laboratories, and a robotics mission control room. The ship's accommodation cabins, lounges, messroom, and meeting spaces are being upgraded to provide comfort for everyone aboard.

These conversions, based on months of planning and execution by the skilled shipyard, operations team, crew, and many others, will transform R/V *Falkor (too)* into a sophisticated oceanographic research vessel, providing a platform for international collaboration and worldwide exploration of our deep ocean. The possibilities for how scientists, engineers, artists, and community stakeholders may utilize this vessel are nearly limitless.



ABOUT R/V *FALKOR(too)*



150 tons



can be lifted by a single
overboard handling crane

97 berths



8 lab spaces
including a main lab, wet lab,
dirty wet lab, hydro lab, cold lab,
seawater lab, computer/electronics lab,
and robotics lab



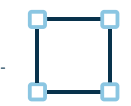
**4 months
at-sea
endurance**



2 moon pools



one inside hangar and one on aft deck



960 square meters

of aft deck space



140 kilometers

of AV/IT cable



30 metric tons

supported by A-frame off the stern



5 types

of dedicated science gas lines to the labs



**3 multibeam
echosounder arrays**

EM 124, EM 712 & EM 2040
plus 17 other sounders

BY THE NUMBERS


53,716KM
sailed


7
EXPEDITIONS

with more than **170** science days


119,188 KM²
of seafloor mapped

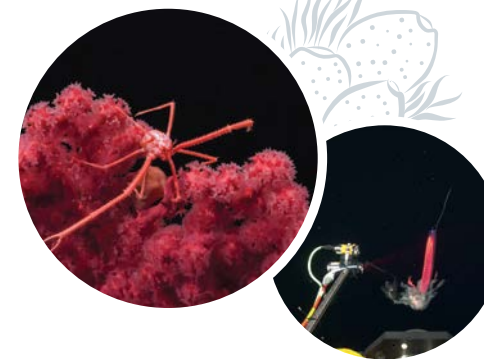

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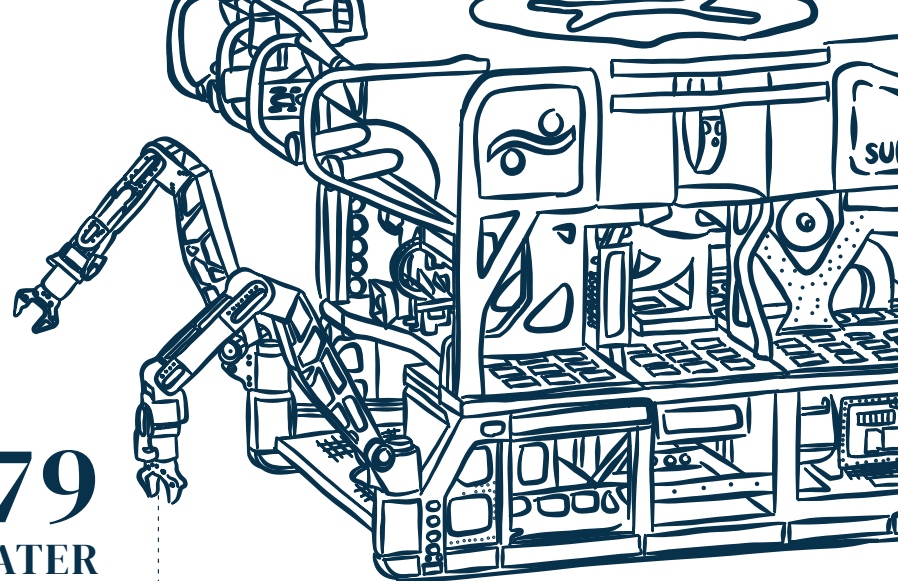
SCIENTISTS
hosted, representing
35 organizations


& 23
EARLY CAREER
scientists conducted
research on R/V *Falkor*


OVER
52,000
PEOPLE CONNECTED

via **60** presentations
& podcasts, and **44** ship-to-shores




79
**UNDERWATER
ROBOTIC DIVES**
totaling **791** hours
exploring the deep sea



1,979
SAMPLES
and more than
**97 TERABYTES
OF DATA**
to advance scientific
understanding

Science accomplishments
shared through

70 BLOGS
78 SCIENCE PUBLICATIONS
400+ PRESS STORIES



Reached more than **7 million**
people on Facebook, Twitter and Instagram

 Schmidt Ocean Institute
 @ Schmidt Ocean



Researchers process sediment push cores on the aft deck of Research Vessel Falkor. The science team is conducting research on the DDT Dumpsite off the coast of Los Angeles.

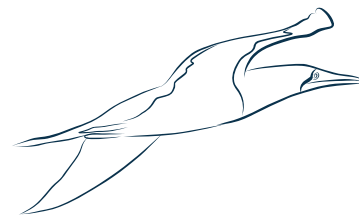
Photo by: Brady Lawrence

CROSSING OCEANS

In 2021, R/V *Falkor* completed expeditions in Australia, traveled to the Phoenix Islands for a month of exploration, and then continued on its eastward journey across the Pacific to support research in Southern and Baja California. Seven expeditions resulted in nearly 2,000 sample collections and almost 800 hours of ROV diving.

PINGING IN THE NEW YEAR: MAPPING THE TASMAN AND CORAL SEAS

January/February
Tasman and Coral Sea, Australia

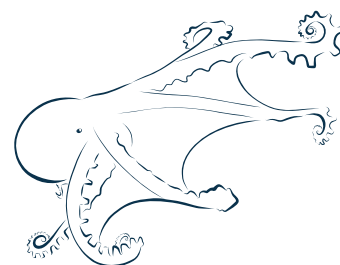
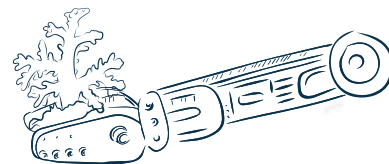


SEAFLOOR TO SEABIRDS IN THE CORAL SEA

February/March
Coral Sea Marine Park, Australia

AUSTRALIAN MESOPHOTIC CORAL EXAMINATION

April
Ashmore Reef Marine Park, Australia



DISCOVERING DEEP SEA CORALS OF THE PHOENIX ISLANDS

June/July
Pacific Remote Islands National Marine
Monument, Phoenix Islands

“Studies like these help to demonstrate the value of marine protected areas and conservation. Although most of the deep sea is unknown and unseen, it is clear that it has transformative potential both for the ocean and for ourselves.”

Dr. Randi Rotjan, Boston University



BIODIVERSE BORDERLANDS: MINERAL-RICH HABITATS OF SOUTHERN CALIFORNIA

July/August
Southern California Borderland, USA



DESIGNING THE FUTURE 2

August
Southern California Borderland, USA



INTERDISCIPLINARY INVESTIGATION OF THE PESCADERO BASIN

October/November
Gulf of California, Mexico



PINGING IN THE NEW YEAR: MAPPING THE TASMAN AND CORAL SEAS



#CoralSeafloor

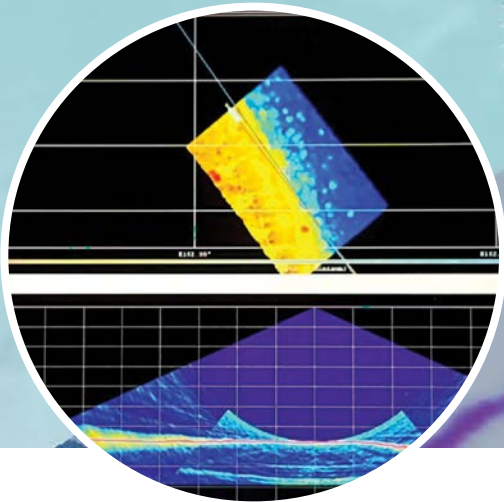
12/28/20 – 01/26/2021

Brisbane, Australia

Chief Scientist: Dr. Robin Beaman

Co-Chief Scientist: Dr. Helen Bostock

James Cook University, University of Queensland, The University of Sydney, University of Wollongong, Geoscience Australia, CSIRO, Parks Australia, The Nippon Foundation-GEBCO Seabed 2030 Project, Birdlife Australia



30
days at sea



3
CTD casts

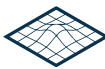


40,555
km² mapped

Expedition Objectives



Map, explore, and characterize new seamounts in the Coral and Tasman seas



Improve understanding of plateau and seamount geomorphology



Build an inventory of the number of seabirds, species present, and their observed behavior

R/V *Falkor* ended 2020 and began 2021 on a month-long investigation in the Tasman and Coral seas to conduct uninterrupted, broad-scale seafloor mapping, and to observe the concentration of seabirds in the area. Additionally, new protocols were tested for sampling marine microplastics in seawater. The mapping efforts concentrated on a large, previously unmapped survey area over the Chesterfield Plateau and along the chain of Tasmanid Seamounts within the northern Tasman Sea. A magnetometer was also towed during select, long transects to provide further insight into the geological formation of the northern Tasman Sea basin and the adjacent Chesterfield Plateau. At-sea seabird observation data were collected using standard protocols to establish baselines in the region. The goal of the seabird study was to better understand species distribution over space and time, which is often influenced by seafloor features and ocean productivity.

An improved understanding of plateau and seamount geomorphology relative to the basin’s tectonic setting resulted, which is important for understanding the evolution of the ocean basins.

Extensive mapping revealed the detailed complexity of large, individual seamounts, such as the presence of underwater landslides and steep canyon features, and also revealed smaller, finer-scale volcanic features, such as parasitic cones. The new seafloor data enabled scientists to gain a better understanding of the spatial relationship between large-scale seafloor features in the Coral and Tasman seas. The data will also improve volcanic rock analysis, helping to explain the volume of magma produced at the time these seafloor features originated, which is crucial for better understanding the geological changes that have occurred on Earth.

The finer-scale volcanic cones mapped around Cato Reef provide evidence for the extent of volcanic activity during the formation of the seamount.

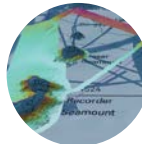
The detailed multibeam bathymetry and backscatter maps were collected in an ecologically important part of Australia’s marine estate. Results from the expedition will help marine managers at Parks Australia identify areas of important conservation value and establish baseline knowledge of the area’s geology, geomorphology, and biodiversity. The data will help inform decisions on managing human influences in these deep ecosystems, such as commercial fishing activities.



R/V *Falkor* collected the first multibeam data ping of the UN Decade of Ocean Science for Sustainable Development, which began on January 1, 2021.



R/V *Falkor* was the first ship to fly the Seabed 2030 initiative flag while collecting seafloor mapping data.



Mapping data revealed a complex seafloor – submarine landslides, gravity slumps, channels and broad valleys, sand waves, scour marks, volcanic pinnacles, and pock marks.



More than 15,000 seabirds were observed during the voyage from more than 20 different species.

Photo by Eric Woehler

SEAFLOOR TO SEABIRDS IN THE CORAL SEA



#CoralSeafloor

02/06/2021 – 03/06/2021

Brisbane, AUS

Chief Scientist: Dr. Derya Güler

Co-Chief Scientists: Dr. Helen Bostock,

Dr. Robin Beaman

The University of Queensland, The University of Tasmania - Institute for Marine and Antarctic Studies, The University of Wollongong, James Cook University, The University of Oslo - Centre for Earth Evolution and Dynamics, Ben-Gurion University of the Negev, The University of Sydney, Geoscience Australia, Birdlife Australia, eXXpedition

Expedition Objectives



Collect seafloor bathymetric and magnetic data to examine the tectonic evolution of the Eastern Australian margin



Sample seawater to quantify the presence of microplastics



Survey seabirds to gain an understanding of ocean health in the Coral Sea



The onboard science team was made up of nine early career researchers, including the Chief Scientist.

Photo by Philipp Guenther



Approximately 37,000 square kilometers of bathymetric data will contribute to the Seabed2030 Initiative.

Photo by Philipp Guenther



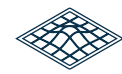
29

days at sea



4

CTD casts



37,000

km² mapped



100

samples filtered for microplastics



3,300+

individual seabirds were observed from over 17 different species.

Additionally, maps created will provide insight into Parks Australia's management needs for defining IUCN Special Purpose Zones. The analysis of the data collected during this voyage will enable researchers to better understand the northernmost boundaries of the submerged Zealandia continent, and when and how the Cato and Tasman basins opened.

The seafloor mapping data collected unveiled new features, such as plateaus and ridges, which are important for reconstructing the geologic history of this region. Key areas mapped include Kenn and Wreck reefs and an unmapped trawl zone that disproved a charted shoal's depth from a rogue sounding dating back to 1962.



The onboard Acoustic Doppler Current Profiler (ADCP) acquired surface ocean current vectors and velocities of the water column up to 800 meters depth for the duration of the expedition.

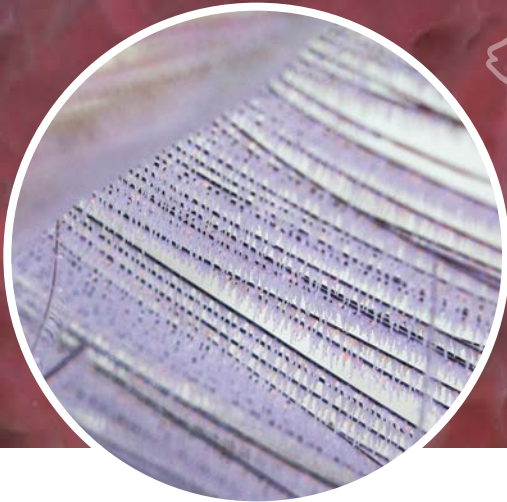
Photo by Francisco Gelves



The mapping data will be used to develop research proposals for future geophysical surveys and core samples collections to better understand the region.

Photo by Philipp Guenther

AUSTRALIAN MESOPHOTIC CORAL EXAMINATION



#TwilightCoral

04/09/2021 – 04/27/2021

Darwin, Australia

Chief Scientist: Dr. Karen Miller

Co-Chief Scientist: Dr. Nerida Wilson

Australian Institute of Marine Science, Western Australian Museum,
University of Western Australia, Curtin University



19

days at sea



2

CTD casts



965

km² mapped



14

ROV dives
(148 dive
hours)



965

specimens collected
(270 sampling
events)



56

water samples for
eDNA analysis from
21 different sites

Expedition Objectives



Understand connectivity between
mesophotic coral populations



Improve understanding of the
biodiversity and biology of
mesophotic reefs



Test new methods and technologies
for monitoring the health of
mesophotic coral ecosystems

While the waters of Australia are famous for shallow coral systems like the Great Barrier Reef, the deeper mesophotic (or twilight) coral ecosystems remain largely unknown and undocumented. Mesophotic coral ecosystems exist in depths between 50 and 200 meters and are hard to study without advanced technology like Remotely Operated Vehicles (ROVs). Mesophotic coral ecosystems are important as they hold unique biodiversity, provide ecosystem services and are a potential refuge for shallow water-species when they are facing stressors such as climate change.

The primary goal of the voyage was to learn more about mesophotic reefs on Australia's NW shelf, particularly in Ashmore Reef Marine Park.

The research conducted by Dr. Miller and collaborators helped scientists and park managers better understand the diversity and significance of the mesophotic reef ecosystems. A better understanding of these ecosystems will help inform managers of the importance of protecting and managing the naturally valuable ecosystems of the park.

R/V *Falkor* circumnavigated Ashmore Reef Marine Park, fully mapped its entire mesophotic zone, and ROV SuBastian captured 4K imagery of the incredible ecosystem diversity including Halimeda beds, coral habitats, sponge gardens, and sand banks. The team conducted 148 hours of ROV surveys and tested the use of hyperspectral and 3D model imaging

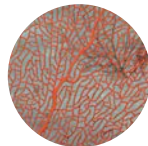
systems to assess the health of the mesophotic communities and assist in identification of marine species. Additionally, the team obtained and filtered 56 water samples for eDNA and collected over 100 mesophotic coral samples for onshore genetic and physiological studies

Several new species may have been documented at Ashmore Reef and new records were made in Australia for several other species. One such record was a range extension for the Great Spotted Cowrie (*Perissersoa guttata*).



The team rediscovered the lost sea snakes of Ashmore Reef with over 50 sightings of four different species of sea snakes, including one as deep as 145 meters.

Short-nosed Sea Snake | Dive 406



The team found no evidence of coral damage, which demonstrates the marine park designation is helping preserve Ashmore reef's mesophotic zone ecosystems.

Gorgonian coral | Dive 405



Observations showed the mesophotic zone of Ashmore Reef is diverse, vibrant, and healthy.

Olive Sea Snake | Dive 406



Several new species records for Western Australia were found, including the great spotted cowrie (*Perissersoa guttata*). Complete details of new species records will require additional laboratory assessment to confirm taxonomic status.

Photo by Connor Ashleigh

DISCOVERING DEEP-SEA CORALS OF THE PHOENIX ISLANDS 2



#PhoenixIslandsCoral

06/05/2021 – 07/08/2021


Honolulu, HI, USA


Chief Scientist: Dr. Randi Rotjan


Co-Chief Scientists: Dr. Tim Shank
and Dr. Jonathan Kagan

Boston University, Woods Hole Oceanographic Institution, Boston Children's Hospital, Harvard Medical School, Conservation International, NOAA Deep Sea Coral Research and Technology Program, United States Geological Survey (USGS), USFWS Pacific Remote Islands Marine National Monument, Republic of Kiribati, Phoenix Islands Protected Area Conservation Trust

Expedition Objectives

 Map, explore, and characterize new seamounts in the high seas

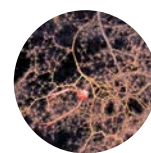
 Characterize, identify, and describe deepwater corals, sponges, and their inter-species associates, predators, and surrounding microbes in the environment

 Investigate deepwater coral and sponge immune responses and possibility for infection



Generated the largest deepwater microbial culture collection from the Central Pacific Ocean.

Photo by Erik Olsen



Documented over 10 associations (species pairs) between corals and other invertebrates that had not been documented or published prior to this expedition.

Squat lobster on a golden coral



34

days at sea



6

CTD casts



44,745

km² mapped



21

ROV dives



600

ROV samples collected

The expedition conducted the first-ever comprehensive survey of deep sea coral and sponge predation to investigate how corals respond to grazing scars and wounding. A series of novel experiments were conducted onboard R/V *Falkor* to determine how the immune systems of corals and sponges reacted to a variety of different microbial stimuli.

The results of this research will be multi-faceted and will make important contributions to the understanding of deep sea ecology, deepwater biogeography, and conservation in the equatorial Pacific.

The mapping, visual data, and new research conducted on the cruise will be helpful to Marine National Monument managers as they develop management plans and priorities



Mapped five new seamounts in ABNJ and five new seamounts within the US EEZ surrounding the Howland and Baker unit of the PRIMNM.

Photo by Erik Olsen



Created a new piece of experimental ROV Equipment: the "Coral Push Popinator 3000" – designed by the SOI ROV team and deployed twice in the deep sea.



BIODIVERSE BORDERLANDS: MINERAL-RICH HABITATS OF SOUTHERN CALIFORNIA



#BiodiverseSCB

07/26/2021 – 08/06/2021

San Diego, CA, USA


Chief Scientist: Dr. Lisa Levin


Co-Chief Scientists: Dr. Paul Jenson,


Dr. Greg Rouse, Dr. Kira Mizel


Scripps Institution of Oceanography, UC San Diego; U.S. Geological Service (USGS)

Expedition Objectives

 Generate baseline descriptions of animal and microbial community structure across mineral-rich ecosystems in the Southern California Borderland

 Explore and map areas not previously visited within the California Borderland region

 Establish mineral baselines in the sites where marine minerals are known or expected to occur

 Examine biopharmaceutical potential of the animal microbiomes

Researchers from Scripps Institution of Oceanography and the United States Geological Survey (USGS) set out to conduct work in the Southern California Borderland (SCB). The rugged, steep topography and low-oxygen conditions of the SCB are suitable for precipitation and formation of iron-manganese (Fe-Mn) crusts and phosphorite marine mineral deposits, which were the primary target for research during the expedition. Phosphorite on the seafloor has the potential to be a source of phosphorus for agricultural fertilizer, and both Fe-Mn crusts and phosphorites are enriched with rare metals that are used in electronics, green energy, and other technologies.

As nations prepare to develop and allow extractive practices of deep sea minerals, baseline biological data and a better understanding of life in these regions are needed to further assess life in such mineral-rich environments.

In addition to characterizing biodiversity in the SCB, the team also explored and sampled a historic DDT waste production barrel dumping site. The site is located off the coast of Los Angeles in



Discovery of a new, actively precipitating (non-bubbling) methane seep site at Lasuen Bank.

Dive 450



Discovery of a new small whale fall in San Pedro Basin.

Dive 450



12
days at sea



5
CTD casts



13
ROV dives



350
ROV samples collected

the San Pedro Basin. The team collected samples around the barrels to begin to better understand how the DDT and DDT derivatives may be affecting the marine environment.

Specific goals of the expedition included sampling water, rocks, fauna, and sediments, recovery of colonization experiments, conducting biodiversity video transects, and 3D imaging. The exploration of biodiversity in the SCB should inform spatial planning by state and federal agencies and potentially reveal conservation and blue economy resource trade offs within deep waters. The study of the DDT dump sites may inform regional and federal decision-making regarding contaminant hazard and reveal whether there is a need for further deep sea remediation.

Over the 10-day expedition, 13 dives at nine locations took place, collecting a total of 350 samples of water, rock, sediment, and fauna. Seventy video transects were recorded for biodiversity assessment and select flyovers were executed to collect 3D imagery. Samples of Fe-Mn crusts were collected at offshore

sites and phosphorites were collected at more inshore sites, which will allow for the characterization of associated fauna and microbes. The rocks collected will be analyzed for mineral and biogeochemical composition by the USGS. Biological samples will be assessed by researchers at Scripps Institution of Oceanography for faunal and microbial biodiversity and microbes will be assayed for biopharmaceutical potential.

Additionally, some substrate colonization experiments that had been deployed in 2020 at San Juan Seamount and 40-mile Bank were recovered to determine if microbes and other organisms prefer to colonize different substrates when given the choice, and new experiments were deployed in the region. Visits to DDT barrel dumpsites revealed a solid sedimentary feature surrounding some barrels (precipitated or lithified), with a microbial mat halo at the edge. Sponges were one of the few abundant animals in the nearly anoxic DDT barrel setting.



Observation of high concentration of pyrosomes in the water column and in some cases the seafloor.

Photo by Brady Lawrence



Observation of high diversity of sponges with evidence of strong tolerance to hypoxia.

Glass Sponge] Dive 455



DESIGNING THE FUTURE 2



#DesigningTheFuture2

08/12/2021 – 08/21/2021

San Diego, California, USA

Chief Scientist: Dr. Brennan Phillips

Co-Chief Scientist: Dr. Kakani Katija

University of Rhode Island, Monterey Bay Aquarium Research Institute (MBARI), Harvard University, City University of New York (CUNY)/Baruch College, Bigelow Marine Laboratory

Expedition Objectives

- Test a refined version of a next-generation robotic encapsulation device, the Rotary Actuated Dodecahedron Sampler (RAD2)
- Deploy the deep particle image velocimetry (DeepPIV) instrument, to measure fine-scale movements of water in and around animals and create 3D scans of soft gelatinous animals and mucous structures
- Integrate a new, real-time 3D imaging system called EyeRIS onto ROV SuBastian

It is estimated that up to a million species remain undescribed in the midwater zone, owing largely to a lack of sampling effort and limited tools available for the direct collection of single specimens. A significant amount of midwater species also remain undescribed and poorly understood because it is difficult to capture and bring them to the surface intact for further taxonomic inspection. The goals of the expedition involved testing three new sampling technologies developed for addressing these current shortcomings in midwater sampling. The three new pieces of equipment included a robotic encapsulation device outfitted with a tissue sampling system with in situ preservation capabilities, a plenoptic light-field imaging system, and a laser-sheet particle imaging velocimetry (PIV) system. These three systems combined enable the rapid characterization of deep sea specimens.

The physical tissue samples that were collected and preserved in situ will allow for full-genome sequencing, including gene expression,



The project involved three complex pieces of technology working in concert with each other to achieve rapid advancement in midwater biology exploration.

Photo by Jovelle Tamayo



10
days at sea



8
ROV dives



65
ROV samples collected

which has only been achievable in a handful of previous efforts. Advances in the tools available for deep sea, midwater science will create new windows into pelagic ecology. Ultimately the team developed a new technical approach to exploration, which will set a new benchmark for future midwater expeditions, in both imaging and sampling capabilities.

During the expedition, the research team demonstrated what is possible by combining new technologies for biological exploration in the deep sea. The technologies included the RAD2 Sampler with tissue voucher collection and preservation capability; the DeepPIV imaging system, which uses a laser sheet and camera to image sections of midwater animals and is capable of flow visualization and 3D reconstruction; and EyeRIS plenoptic imaging system capable of quantitative imagery of midwater animals. The

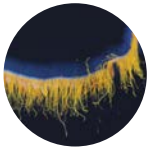
research team and ROV pilots successfully integrated and demonstrated the capabilities of these three technologies working together in concert. Collecting samples took a very short amount of dive time per organism (15-20 minutes) and the team was able to quantitatively image midwater targets of interest in 3D and collect and preserve tissue vouchers in situ. Select samples will be sequenced for full genome and gene expression, with the sequence data archived in publicly accessible repositories onshore in the coming months.

The results from the expedition offer an example of the rich amount of data that can be collected on a single ROV dive, leading to more efficient and productive operations, and advancing the overall ability to explore the deep ocean biosphere.



Connected with over 300 students and members of the public during a livestream tech demonstration in partnership with the MATE competition.

Photo by Jovelle Tamayo



Imaged and sampled many interesting (and perhaps new) midwater siphonophores, ctenophores, polychaetes, and other delicate invertebrates.

Galaxy Siphonophore



INTERDISCIPLINARY INVESTIGATION OF THE PESCADERO BASIN



#PescaderoVentDiving2

10/7/2021 – 11/10/2021


La Paz, Mexico


Chief Scientist: Dr. David Caress


Co-Chief Scientists: Dr. Ronald Spelz-Madero
(Leg 1), Dr. Raquel Negrete-Aranda (Leg 2),
Dr. Victoria Orphan (Leg 3)

Monterey Bay Aquarium Research Institute (MBARI),
Universidad Autónoma de Baja California (UABC),
Centro de Investigación Científica y de Educación Superior
de Ensenada (CICESE), California Institute of Technology,
University of California Davis, Occidental College, Scripps
Institution of Oceanography, Oregon State University

Expedition Objectives

 Systematically map the Carmen, Farallon, and Pescadero pull-apart basins for exploring shallower seafloor shape and structure in order to better characterize tectonic activity in the region

 Collect heat flow measurements around the vent fields and sample vent fluids from as many significant vents as possible to understand what is going on beneath the earth's surface

 Further document the variability in microbial and macro-invertebrate communities and understand their relation to temperature and fluid chemistry and the potential origin of life on earth

The three-part expedition investigated basin-scale tectonics and hydrothermal venting in the southern basins of the Gulf of California. The first leg focused on collecting high-resolution multibeam mapping data of the Carmen, Farallon, and North Pescadero Basins. Legs two and three utilized ROV SuBastian for investigating the Auka and JaichMaa 'ja'ag hydrothermal vent fields in the South Pescadero Basin.

Scientists on Leg 2 focused on using heat flow measurements to understand the nature of fluids flowing beneath the earth's surface and how they feed the vents. Scientists on Leg 3 focused on conducting biological and ecological studies of the chemosynthetic communities living on and near the vent sites.



The mound between Auka and JaichMaa 'ja'ag will be named Maijia awi, after the divine serpent of water in the creation myth of the Kumiai people, one of the Yuman indigenous groups of Baja California.

Dive 464

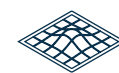


The scientists observed 10 known species not previously found before in the Pescadero Basin.

Photo by Monika Naranjo



33
days at sea



21,269
km² mapped



21
ROV dives
(210 dive
hours)



13
rock samples
collected



5
vent fluid
samples



9
gas-tight
samples

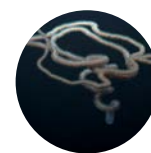


6+
suspected
new species

The science team collected Bathymetric data in largely unexplored parts of the Gulf of California basins, including the Carmen, Farallon, and northern Pescadero pull-apart basins. The data added to mapping data *Falkor* previously collected in 2018. The combined area mapped between 2018 and 2021 is one eighth the total surface area of the Gulf of California, adding a significant contribution to global mapping efforts. The mapping data additionally aids in our understanding of tectonic activity in the Gulf of California and could lead to better prediction of earthquakes in the future.

New high-temperature vents discovered at the northern and southern extreme of the JaichMaa 'ja'ag vent field greatly extend the area of known hydrothermal venting in the Pescadero Basin. The two newly discovered vent

areas remain unsampled, making these locations essential targets for future exploration. Additionally, heat flow measurements were combined with vent fluid samples to better understand what is happening beneath the seafloor that is creating the vent systems. The hydrothermal vents in Pescadero Basin are unlike other known vents around the world, as they emit clear, shimmering liquid instead of opaque liquid. The science team is working to understand if the liquids all come from the same source or from separate cracks in the earth's crust. Lastly, the scientists collected biological specimens and sediment cores to examine the ecology, animals, and microbes present in the southern Pescadero Basin in order to understand symbiotic relationships between animals and bacteria and how they survive in such extreme conditions.



The southern mound is to be named 'melsuu', after the word for "blue" in the Kiliwa language, referring to the dense population of iridescent blue scale worms found at the site.

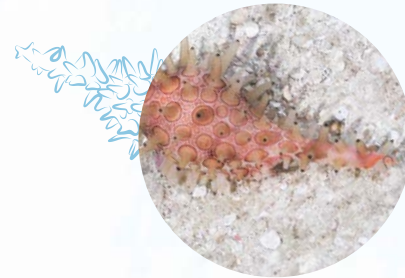
Dive 463



Six or more possible new species were discovered, including polychaetes, arrow worms, crustaceans, mollusks, and roundworms.

Photo by Monika Naranjo

PEERING INTO THE DEEP

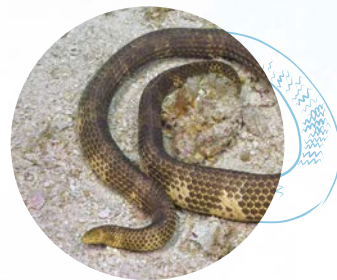


SPINDLE COWRIE

50 meters

April 15th - Ashmore Reef Marine Park - Dive 410

This observation extended the species range and was an anomaly, as the animal was found crawling along the sand. Spindle Cowries are typically found living on soft corals.

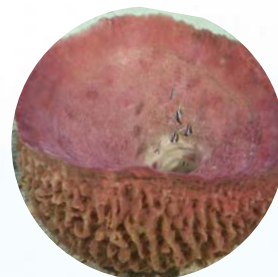


SHORT-NOSE SEA SNAKE

67 meters

April 12th - Ashmore Reef Marine Park - Dive 406

A critically endangered species thought to be locally extinct at Ashmore Reef until ROV SuBastian captured imagery of it.



LARGE SPONGE COLONIES

104 meters

April 22nd - Ashmore Reef Marine Park - Dive 417

Sponges are ecosystem engineers that can create, modify, maintain, or even destroy habitats for other organisms.

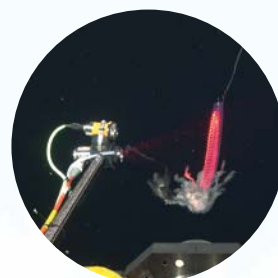


METHANE SEEP

381 meters

August 2nd - San Pedro Basin - Dive 449

Hundreds of crabs were observed dwelling on a newly discovered methane seep at Lasuen Knoll in the Southern California Borderland.



FIRST TEST OF THREE NOVEL ROV TECHNOLOGIES

418 meters

August 12th - San Pedro Basin - Dive 453

Three newly developed pieces of ROV technology, the DeepPIV, EyeRIS, and RAD2, were tested in tandem, successfully creating a new workflow for rapid collection of data on midwater species.

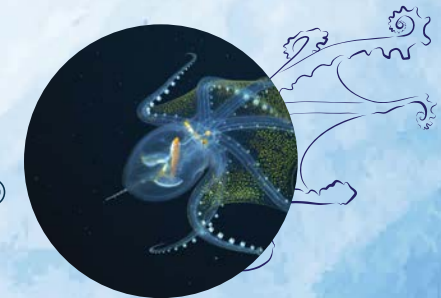


TUBESHOULDER FISH RELEASING LUMINOUS FLUID

626 meters

August 20th - San Pedro Basin - Dive 460

The footage of a tubeshoulder fish is suspected to be the first-ever recording of one releasing luminous fluid in its natural habitat.



GLASS OCTOPUS

661 meters

June 26th - Phoenix Islands - Dive 433

Two individual glass octopuses were observed, resulting in the first-ever high-quality recordings of the species.



WHALE SHARK

670 meters

June 15th - Phoenix Islands - Dive 422

The first sighting of a female whale shark and the deepest ever recorded imagery of a whale shark.



DDT BARREL FIELD

885 meters

August 3rd - San Pedro Basin - Dive 450 & 451

ROV SuBastian captured footage of the DDT dump site off Los Angeles, which is estimated to contain thousands of barrels of discarded DDT waste.



WHALE FALL

885 meters

August 3rd - San Pedro Basin - Dive 450

While exploring the DDT Dump Site, scientists discovered a new whale fall in the San Pedro Basin.



FEATHER DUSTER SIPHONOPHORE

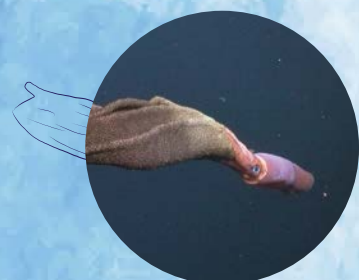
1170 meters
August 20th - Offshore San Diego, California - Dive 460

A stunning siphonophore was the last species characterized during Designing the Future 2 expedition.

CORAL WOUND-HEALING

1602 meters
June 21st - Phoenix Islands - Dive 428

Footage of a new polyp forming on a wounded area of a deep-sea coral provides first physical evidence that these corals heal after predation.



SQUID BROODING EGGS

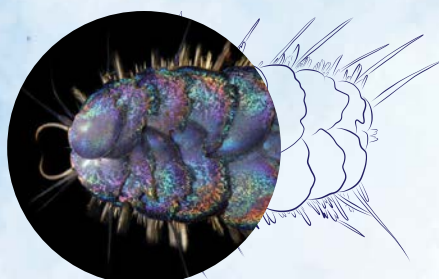
2106 meters
October 30th - Gulf of California - Dive 471

Rare footage of a *Gonatus onyx* brooding her eggs in the water column. These squids are the first cephalopod known to incubate their eggs on their tentacles instead of on the seafloor.

BLUE SCALE WORMS

3634 meters
November 7th - Gulf of California - Dive 479

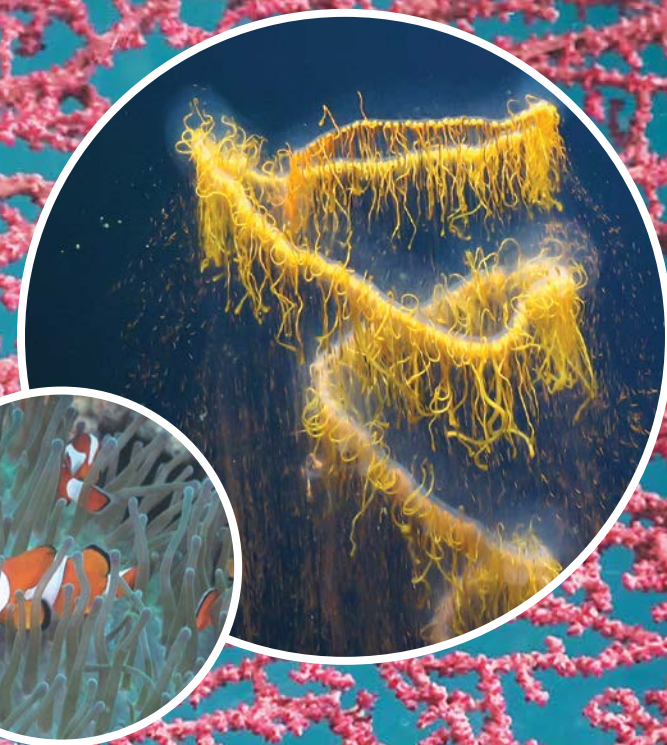
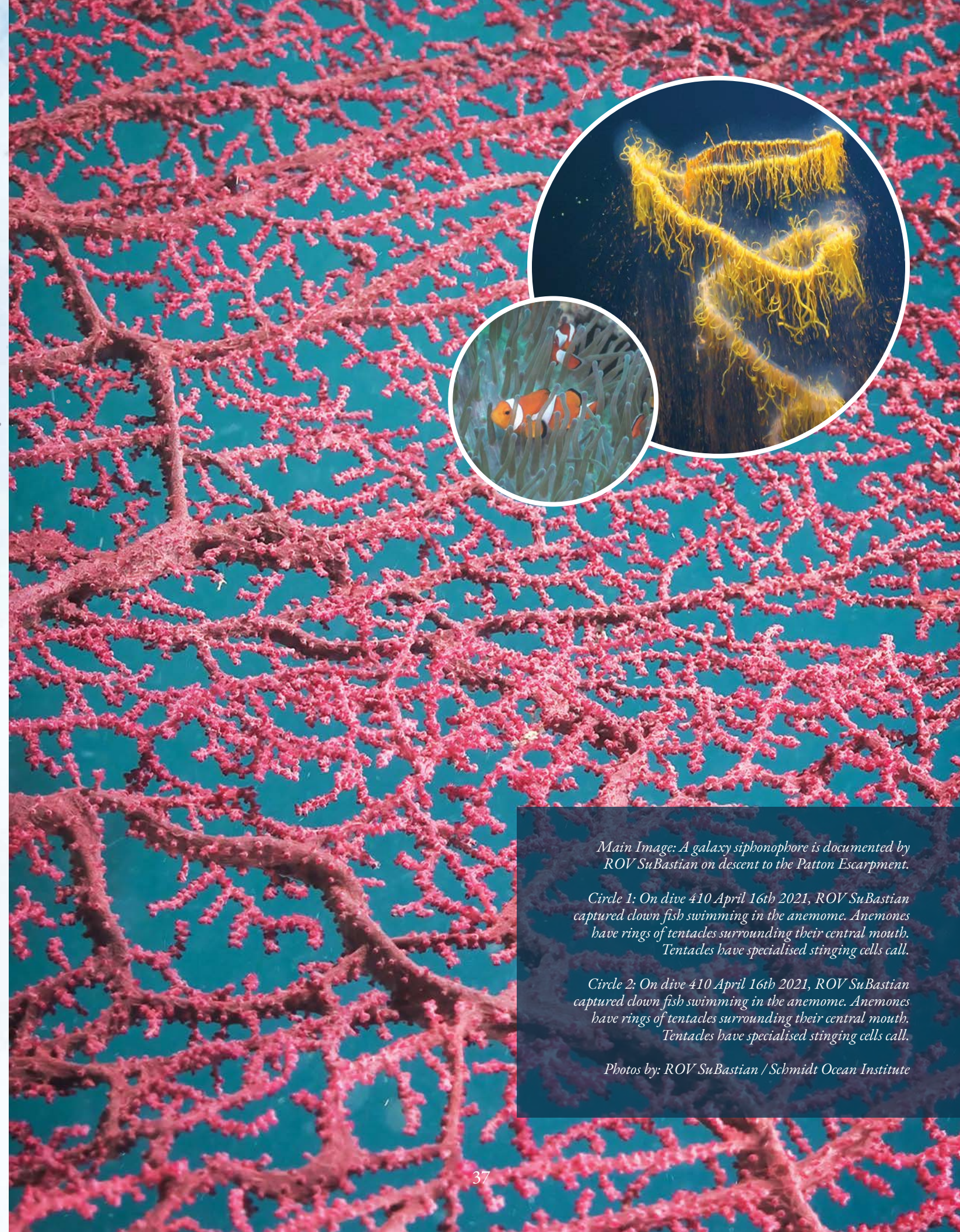
Peinaleopolynoe orphanae was discovered during SOI's 2018 expedition to the Pescadero Basin and officially announced as a new species in 2020; a large quantity of the species were found to be living on the newly discovered 'Melsuu vent.



NEW HYDROTHERMAL VENTS

3661 meters
November 2nd - Gulf of California - Dive 473

Two new hydrothermal features, named Maija Awi and 'Melsuu, were documented during the Interdisciplinary Investigation of the Pescadero Basin expedition, providing further insight into the hydrothermal vent communities in the area.



Main Image: A galaxy siphonophore is documented by ROV SuBastian on descent to the Patton Escarpment.

Circle 1: On dive 410 April 16th 2021, ROV SuBastian captured clown fish swimming in the anemone. Anemones have rings of tentacles surrounding their central mouth. Tentacles have specialised stinging cells call.

Circle 2: On dive 410 April 16th 2021, ROV SuBastian captured clown fish swimming in the anemone. Anemones have rings of tentacles surrounding their central mouth. Tentacles have specialised stinging cells call.

Photos by: ROV SuBastian / Schmidt Ocean Institute



Main Image: A beautiful hard coral is seen at depth on Dive 409 during the Mesophotic Coral Examination Expedition.

Photo by: ROV SuBastian / Schmidt Ocean Institute

Circle 1: The Matterhorn, a hydrothermal vent of Pescadero basin displaying an abundance of red tube worms and white microbial mats. | Dive 467

Photo by: ROV SuBastian / Schmidt Ocean Institute

Circle 2: Swimming Rattail (Grenadier) during Dive 465

Photo by: ROV SuBastian / Schmidt Ocean Institute

Circle 3: Michelle Guraieb (Scripps Institution of Oceanography), Johanna Gutleben (Scripps Institution of Oceanography), and Kira Mizell (U.S. Geological Survey) work in the wet lab to prepare a rock sample retrieved by ROV SuBastian.

Photo by: Brady Lawrence



BUILDING CONNECTIONS

Collaboration and community are essential to our mission. Schmidt Ocean Institute is excited to build relationships and formalize new partnerships, many with the vision of broadening access to and participation in the marine sciences. R/V *Falkor* is not just a vessel for science but also a bridge from the deep sea to the communities living in regions where we operate.



STRATEGIC
PARTNERSHIPS



COLLABORATIONS



GRANTS



BROADENING ACCESS
AND PARTICIPATION



PUBLIC SERVICE AND
ENGAGEMENT



ARTIST-AT-SEA

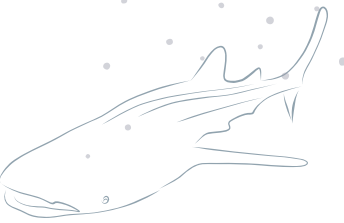


SHIP-TO-SHORES
AND PRESENTATIONS



STRATEGIC PARTNERSHIPS

Schmidt Ocean Institute is especially proud of the following projects that we helped bring to fruition in 2021, thanks to the hard work and dedication of our amazing partners.



Ocean Rising and Nekton

Schmidt Ocean Institute formed a partnership with Nekton in 2021 to boldly envision new avenues for connecting the public with the ocean. Our two organizations co-authored a paper entitled “Ocean Rising: The Quest to Inspire the Public,” exploring ocean advocacy in mainstream platforms like fashion, food, music, gaming, and sports. The paper accompanied a workshop where industry and ocean experts came together to participate in inspiring talks and breakout discussions on how to stimulate the public by engaging popular culture in ocean sciences and storytelling. The results of the workshop and paper were later discussed in a report and fireside chat podcast.



Supporting Students in Marine Technology with MTS/IEEE-OES

Marine Technology Society (MTS), the Institute of Electrical and Electronics Engineers (IEEE) Oceanic Engineering Society (OES), and Schmidt Ocean Institute partnered in 2021 to focus on our common goals of the effective development and application of marine science and technology for purposes of exploration, understanding, and sustainable use of the

ocean and its resources. The collaboration includes supporting student and early career marine technology professionals, women in marine science and technology, and other joint activities. The partnership was announced at OCEANS 2021 San Diego - Porto and includes a commitment to supporting the international Student Poster Competition awards.



Guy Harvey Ocean Foundation

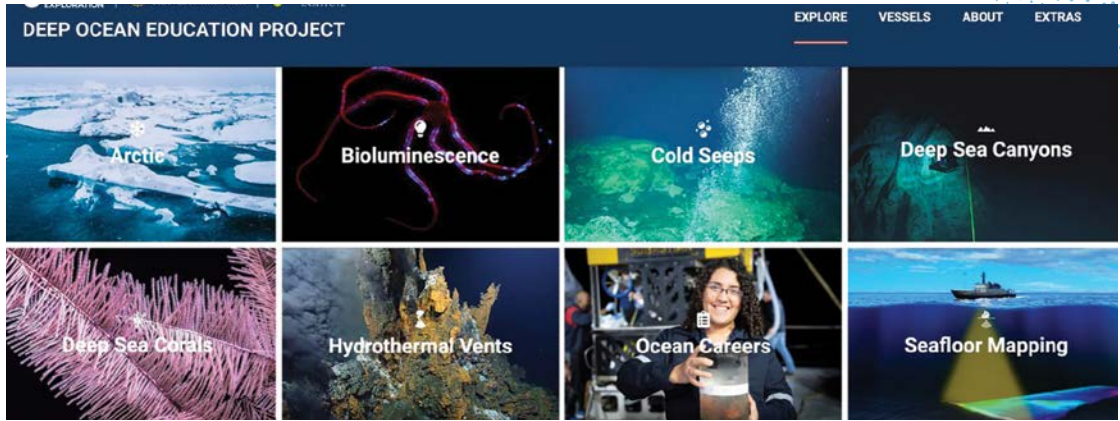
Guy Harvey Ocean Foundation and Schmidt Ocean Institute partnered in 2021 to collaborate on public outreach initiatives, which included live events on Earth Day and World Ocean Day. Students around the globe engaged with scientists and artists aboard R/V *Falkor*, and renowned artist

Guy Harvey. SOI also contributed science content and imagery for the Discovery Education Guy Harvey Channel. The partnership will continue into 2022 with the goal of advancing public understanding of deep sea science through the arts.



COLLABORATIONS

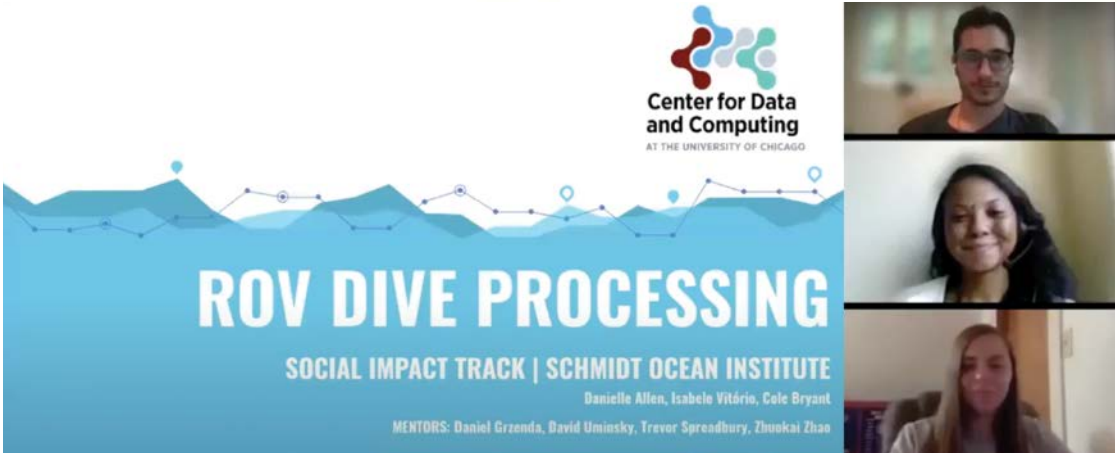
Schmidt Ocean Institute is excited to build collaborations that help achieve mutual goals of training the next generation of marine scientists and broadening access to and participation in the marine sciences.



Deep Ocean Education Project

The Deep Ocean Education project merges the work of Schmidt Ocean Institute, Ocean Exploration Trust, and the NOAA Office of Ocean Exploration and Research to concentrate our most engaging resources for educators in one space. Combining standards-aligned student activities, high-resolution images and videos, stories from

the field, and information needed to stay up-to-date on ocean expeditions, the website aims to make deep sea education accessible to all. The website was formally launched in 2021, offering resources in English and Spanish, and has resulted in 312 educator accounts since going live.



University of Chicago Data and Computing Summer Lab

The University of Chicago’s Center for Data and Computing, which teaches students to become the next generation of data scientists, worked with Schmidt Ocean Institute for the first time as part of their Data Science Institute (DSI) Summer Lab program to create machine learning models that produced valuable analysis on our ROV video library. Two Master’s Students, Danielle Allen and Cole Bryant, and one undergraduate student, Isabele Vitorio,

developed models that tag ROV SuBastian video images with valuable classification information. They also developed a separate model which identifies interesting images from the videos and auto generates a highlight reel from longer dive videos. SOI plans to continue working with DSI’s incoming students to develop this project further.



GRANTS

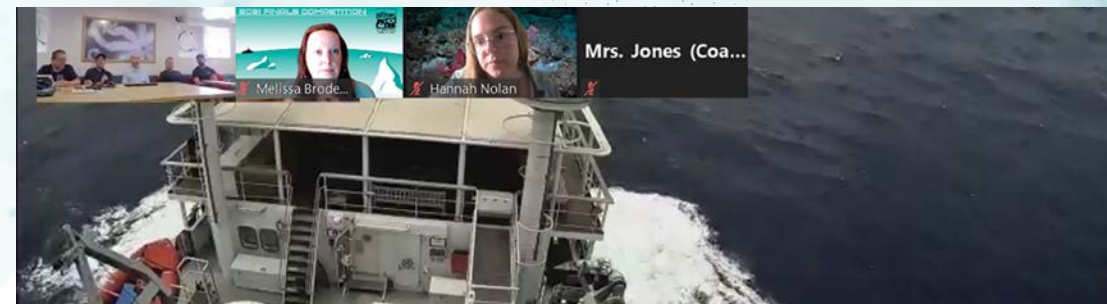
In its second year of grant-making, Schmidt Ocean Institute supported a range of marine science monitoring projects and activities many of which focus on bringing the ocean to the public.



Australian National Maritime Museum
- *One Ocean Our Future Exhibit*

Schmidt Ocean Institute provided funds and assets to the Australian National Maritime Museum for its new exhibit, One Ocean Our Future. The immersive exhibition allows visitors to marvel at the wonders of the deep ocean and the diversity of Australia's marine life revealed during our 2020 circumnavigation of Australia. In conjunction with our support, MIT Media Lab developed five 3D visualizations of deep sea specimens that were collected on R/V *Falkor* expeditions.

We also produced a 10-minute video featuring the scientists' research and discoveries aboard R/V *Falkor*. In addition to the indoor display, Ocean Wonders, a free public photography exhibition in the adjacent Darling Harbour walkway, showcases 30 poles featuring images of species found with ROV SuBastian's high-resolution 4k camera system. "One Ocean Our Future" will remain open until the fall of 2022, and will then rotate to another Australian museum.



Consortium for Ocean Leadership
- *National Ocean Science Bowl*

The National Ocean Sciences Bowl (NOSB), established in 1998, provides a forum for high school students to excel in ocean and climate science. Schmidt Ocean Institute became a supporter of NOSB in 2020, and in 2021 completed the second of a three-year commitment to this long-standing quiz-bowl competition. More than 1,000 students on 210 teams from 30 states participated in the virtual regional competitions, where the 2021 theme was

"Plunging into our Polar Seas". Dougherty Valley High School (San Ramon, CA) won the 2021 champions and their prize included a special conversation with an expert - our executive director, Dr. Virmani. Other Schmidt Ocean Institute staff volunteered in NOSB's career fair and led a Ship-to-Shore video connection with R/V *Falkor* attended by 40 NOSB students and classrooms.



MATE ROV Competition
- *VR World*

Schmidt Ocean Institute supported the international MATE ROV Competition, as the program moved to a semi-virtual format in light of the COVID-19 pandemic. As a result, a new "VR World" was created for competitors to access the competition venue remotely, so students could create their own avatars and interact with each other. The 19th World Championship, 2021 Excite, Educate, Empower: Students Engineering Solutions to Global Problems, included

28 in-person teams from the United States, Mexico, and Egypt. An additional 25 teams from eight countries (Russia, Hong Kong, China, Macau, Turkey, Italy, Scotland, and England) participated via the Telepresence category. Schmidt Ocean Institute will continue to support MATE ROV in 2022, with the theme focusing on the UN Decade of Ocean Science for Sustainable Development.



Nautilus Magazine

- *Ocean Channel*

In 2021, Nautilus Magazine leveraged its audience to create a new website, the Nautilus Oceans Channel. Schmidt Ocean Institute was a patron of its inaugural publication devoted to ocean research, exploration, and conservation stories. Primarily an online publication, Nautilus distributed a special edition print issue on Oceans in June. The print issue was distributed at the Alta Sea Blue Hour, and Nautilus Magazine planted 300 trees in American forests for every magazine that was shared.

The Ocean channel produced 61 articles over the year leading to 317,339 views, some of which featured stories from our expeditions and an exclusive interview with Schmidt Ocean Institute co-founder, Wendy Schmidt. Content from the channel was also shared on medium.com and getpocket.com, reaching another 100+ million monthly users. Schmidt Ocean Institute will continue to support Nautilus' work in 2022 as the magazine spins off Nautilus Oceans into an independent online publication with special print editions. Nautilus Oceans and Schmidt Ocean Institute will also co-host an artist-at-sea exhibition in New York, in conjunction with the UN Decade of Ocean Science in 2022.



University of California San Diego

- *Ocean Keeling Curve*

Schmidt Ocean Institute continued to support, for the second year, Scripps Institution of Oceanography's recording of the time series data for inorganic carbon chemistry from seawater samples. The Ocean Keeling Curve is the longest continuous recording of ocean carbon chemistry measurements. These data are critical for assessing changes in the ocean global carbon cycle, which may play a role in ocean acidification, carbonate dissolution rates, and shifting biological production. Measurements are based on seawater samples collected by ships at two ocean time-series stations near Bermuda and one ocean time series station near Hawaii. The bottles are returned to Scripps once per year for analysis, and the results are publicly published. The funding from Schmidt Ocean Institute is aiding the dedicated team in their analysis of seawater samples from 2017 to 2021. This work complements the Schmidt Futures grant for atmospheric Keeling Curve observations, which first alerted the world to rising carbon dioxide levels.



University of California Santa Cruz

- *Antarctic Whale Monitoring*

Schmidt Ocean Institute provided a research and conservation grant for Dr. Ari Friedlander and the Bio-telemetry and Behavioral Ecology Lab at the University of California, Santa Cruz, to measure the underwater acoustic disturbance of a pier construction at Palmer Station, Antarctica. The project's goal is to determine if noise disturbance from construction impacts the behavior and stress physiology of baleen whales in the region. In 2021, the university's research team deployed passive acoustic recorders while construction occurred, and will

redeploy the recorders the following year with no construction. Comparing the vocalization rates of whales from the same time of year will allow the team to measure whether whales show a physiological stress response to the construction noise. The team will also compare stress hormone levels in skin/blubber biopsy samples collected during construction periods with samples collected at similar times from previous years. Data from the first two months are currently being analyzed.



TBA21

- *Taloi Havini Ocean Space Exhibit*

Taloi Havini was born in the Autonomous Region of Bougainville, in the Southwest Pacific Ocean. In November 2020, she sailed on the Ice Age Geology of the Great Barrier Reef expedition and assisted with the mapping of the Great Barrier Reef. The experience inspired her to create art using sounds that incorporate an ancient compositional technique, producing 22 different sounds through a call and response method. The track includes archival sources, such as hydrophone recordings of sonar mapping taken on R/V *Falkor*, ocean traveling chants, and an instrumental piece composed by renowned Bougainville musician Ben Hakalitz.

Schmidt Ocean Institute has a goal to develop a more inclusive space for the marine science community. This year, Schmidt Ocean Institute supported previous Artist-at-Sea, Taloi Havini in her first international exhibit, The Soul Expanding Ocean #1 - Answer the Call, inspired in part by her time aboard R/V *Falkor*.

The exhibition was shown at TBA 21 Academy's Ocean Space in the Church of San Lorenzo in Venice, Italy, from February through October, 2021.



University of Hawai'i

- Students in Marine Science Technology

In summer of 2021, the University of Hawai'i provided eight graduate students from across Hawai'i with the opportunity to apply innovative technologies in marine science. The marine science technologies course funded by Schmidt Ocean Institute was hosted at the Hawai'i Institute of Marine Biology (HIMB) and provided an intensive program utilizing technology to help the students better understand and advance ocean health and marine conservation. Additional support was provided for native Hawaiian student Hanalei Ho'opai-Sylva in the Marine Biology

Department at the University of Hawai'i to conduct research with the HIMB Coral Resilience Laboratory on an emerging photogrammetry technology called structure-from-motion. The technology is gaining popularity in coral reef science, reconstructing the topography of shallow underwater environments to assist in research and management.

R/V *Falkor* has conducted 12 expeditions in Hawai'i since 2014 and, during the global pandemic, offered financial support to the students in this marine science community.



World Ocean Observatory

- Virtual Aquarium

In 2021, World Ocean Observatory, in conjunction with Schmidt Ocean Institute designed and developed the Virtual Aquarium, which will launch in 2022. The Virtual Aquarium is an educational, interactive online platform for ocean exploration that features R/V *Falkor* expeditions and new species discoveries. Visitors to the virtual space will experience two interactive exhibits on a hydrothermal vent system and whale fall, enabling them to "walk through" these unique ecosystems. Users will

also be able to interact with searchable species tanks using scrollable images, videos, and 3D models, and learn about deep sea species anatomy, habitat, range, migration, and diet. Once launched, the next step will be to align the Virtual Aquarium to the United States K-12 Next Generation Science Standard (NGSS)-aligned Ocean Literacy curriculum, and create teaching modules, educational resources, and lesson plans.



Marine technician Deborah Smith radios a team member as they lower a CTD to pressure test MBARI's DeepPIV instrument aboard R/V *Falkor* on Tuesday, Aug. 17, 2021, during the "Designing the Future 2" cruise.

Photo by: Jovelle Tamayo



BROADENING ACCESS AND PARTICIPATION

Schmidt Ocean Institute is committed to broadening access and participation, especially for people historically underrepresented in oceanographic research, to facilitate inclusivity and grow diverse leadership within ocean exploration. In 2021, Schmidt Ocean Institute developed a number of inclusion, diversity, equity, and access initiatives. Following feedback from a survey to approximately 500 of our alumni and our Advisory Board, the new activities are listed below.



Community Conversations - Participation

Schmidt Ocean Institute provided support through the Ocean Coalition for two virtual conferences in 2021, that focused on inclusion and diversity in the ocean sciences. The first was Capitol Hill Ocean Week’s (CHOW) “Justice, Equity, Diversity and Inclusion - Sustaining Our Ocean and Great Lakes,” followed by the Metcalf Institute’s Advancing Inclusive Science Communication Symposium. Schmidt Ocean

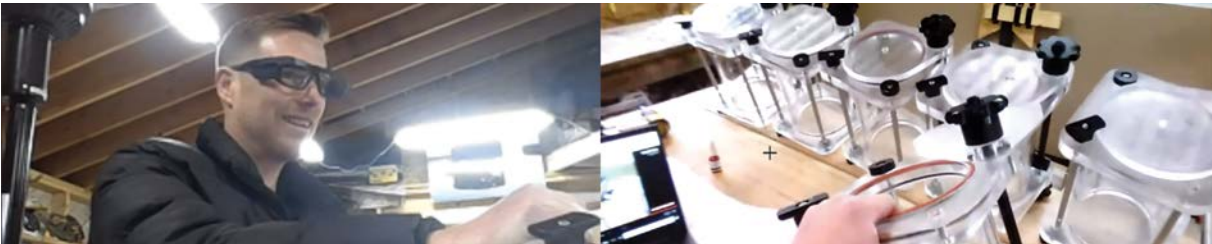
Institute helped to organize panel discussions at each of these events including “Building Resilience with Community-Led Ocean Science and Conservation” at CHOW and a panel at Metcalf titled “How do we make ocean science more accessible?” Both panels addressed structural challenges for inclusive science communication and community engagement in ocean science and engineering.



Berths of Opportunity - Expansion

With the new vessel, R/V *Falkor (too)*, Schmidt Ocean Institute will convert its Student Opportunities program to a more inclusive Berths of Opportunity program by dedicating

a certain number of berths on expeditions for Indigenous leaders, students, resource managers, and traditional knowledge holders.



Access for Scientists At Sea - Enhancement

Schmidt Ocean Institute is expanding opportunities for scientists who are physically unable to sail aboard expeditions by providing meaningful opportunities to participate via telepresence and trialing Augmented Reality as a mechanism for participation. Another barrier to field activities exists for scientists who have to

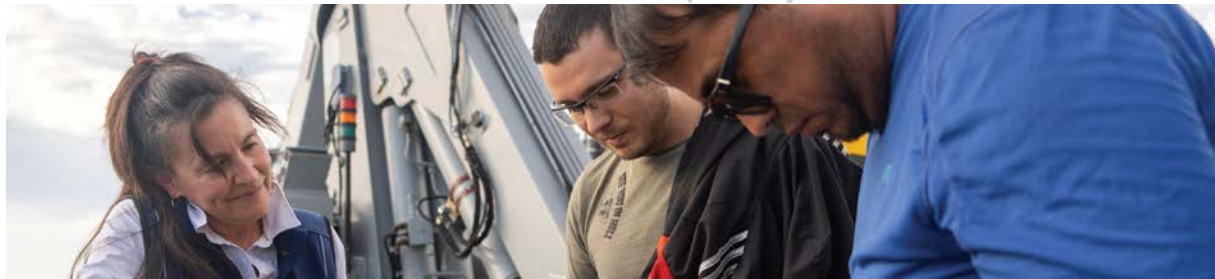
bridge family responsibilities while conducting research away from home. To ease this burden, in 2021 Schmidt Ocean Institute began to offer financial support to at-sea scientists leaving dependents at home. To spotlight the role of scientists working at sea with dependents, we released a Father’s Day Video.



Multilingual Participation -Engagement

Schmidt Ocean Institute began integrating Wordly language translation for our Ship-to-Shore connections in 2021. The Wordly platform captures a speaker’s audio, processes it

via a secure cloud infrastructure, and translates it in real time into 22 different languages. We also offered bilingual weekly expedition videos in Spanish during our work in Mexico.



Regional Inclusion

- Support

In 2021, Schmidt Ocean Institute began piloting a small grants program to local groups (such as schools) in regions where R/V *Falkor* was operating to provide them with the technical capabilities they needed to connect with our expeditions and participate in live streamed events. The intent is two-fold: first, local groups have the opportunity to explore and learn about their own offshore environment; and, second, the groups permanently have the technical

ability to maintain their access to any high-bandwidth needs into the future.

This past year Schmidt Ocean Institute also recognized the importance of regionally represented artists in our Artist-at-Sea program, recruiting six local artists from the areas of R/V *Falkor*'s operations to participate in the research and conduct outreach with the communities where they work.



Broadening Diversity

- Collaboration

2021 also marked the start of grants from the Ocean Coalition, a collaboration between three organizations funded by Eric and Wendy Schmidt: Schmidt Ocean Institute, The Schmidt Family Foundation (Schmidt Marine Technology Partners), and 11th Hour Racing, with the goal of supporting diversity in ocean science.

Funds were provided to support the Black Women in Ecology, Evolution, and Marine Science, a network that embraces Black women and equitable collaboration in marine science. With the Ocean Coalition's support they will develop a website, an ambassador program,

a fellowship, job and training workshops, and a conference. A grant was also provided to Washington Maritime Blue, a nonprofit focused on early career training for high school students and young adults, with heavy emphasis on supporting Black, Indigenous, People of Color (BIPOC) youth, offering paid internships, and anti-racism and diversity and equity training for participating maritime employers. The 2021 funding will help support the year-long training programs and stipend support for a cohort of 25 to 30 students, including six-week on-the-water courses to develop maritime skills, environmental stewardship, and leadership.



Dr Ronald Spelz examines a volcanic rock sample, deciding the best way to break it into smaller pieces for further examination.

Photo by: Monika Naranjo



PUBLIC SERVICE AND ENGAGEMENT

Support for the UN Decade of Ocean Sciences for Sustainable Development

In December 2020, Schmidt Ocean Institute entered into a formal partnership with the Intergovernmental Oceanographic Commission (IOC) to support the UN Decade of Ocean Sciences for Sustainable Development. In 2021, Schmidt Ocean Institute was involved in the formation and execution of two informal working groups. Our executive director, Dr. Jyotika Virmani, co-chairs the Ocean Decade Technology and Innovation group, and Dr. Carlie Wiener, our director of communications and engagement strategy, co-chairs the Decade Communications Advisory Group. Both working groups will continue to be co-chaired by Schmidt Ocean Institute staff in 2022. Our involvement has led to the support of several UN Decade Activities. For example, we hosted an event, “Inspiring and Engaged

Ocean,” with our partner, Nekton, for the first Decade Laboratory in July 2021. Additionally, our co-founder Wendy Schmidt is a Founding Patron of the Ocean Decade Alliance, and Schmidt Ocean Institute is a Founding Member of the Alliance. Wendy is joined by six others including: H.E. Hon. Uhuru Kenyatta, President of the Republic of Kenya; H.E. Marcelo Rebelo de Sousa, President of the Republic of Portugal; His Serene Highness Prince Albert II, Sovereign Prince of Monaco; Her Royal Highness Princess Lalla Hasnaa, President, Mohammed VI Foundation for Environmental Protection; Ms. Inger Andersen, Executive Director, United Nations Environment Programme; and Dr. John Schubert AO, Chair, Great Barrier Reef Foundation.

PUBLIC SERVICE AND ENGAGEMENT

SOI additionally supports the following UN-endorsed Decade Actions:



Challenger 150

A global cooperative devoted to improving our understanding of the diversity, distribution, function, and services provided by deep ocean biota; and devoted to using this new knowledge to educate, inspire, and promote better management and sustainable use of the deep ocean.



Marine Life 2030

A globally coordinated system to deliver actionable, transdisciplinary knowledge of ocean life to those who need it, promoting human well-being, sustainable development, and ocean conservation.



Ocean Biomolecular Observing Network

A global system that will utilize biomolecular technologies to monitor, research and understand life in the sea at every trophic level and scale, how life varies in response to climate and anthropogenic impacts, including fisheries, and how these changes impact society.



Ocean Practices for the Decade

A program that supports all ocean stakeholders in securing, equitably sharing, and collectively advancing methodological heritage. It works to engage diverse communities of practice and aims to transform how science and other stakeholders align their interests/capacities by creating and using practices to promote sustainable human and ocean well-being.



Seabed 2030 Project

A collaborative project that aims to bring together all available bathymetric data to produce the definitive map of the world ocean floor by 2030, and make it available to all. The project is led by the Nippon Foundation of Japan and the General Bathymetric Chart of the Oceans (GEBCO); Schmidt Ocean Institute has a pre-existing partnership with Seabed 2030.



Pink Flamingo Society

The Pink Flamingo Society promotes the safe, efficient, and environmentally responsible operation of research vessels primarily funded through philanthropy in support of the global oceanographic scientific research community. Schmidt Ocean Institute first convened the group in 2019, and we have continued to engage with the 13 participating organizations and provide leadership to the group. In 2021, our senior director of operations, Eric King, chaired the group, and the communications working group was led by director of communications, Dr. Carlie Wiener.

The Pink Flamingo Society met virtually in 2021 to discuss shared challenges and opportunities for collaboration. The group was highlighted in the UN Decade of Ocean Science for Sustainable Development's report on The Transformative Role of Foundations in the Ocean Decade as a forum that will be an "excellent platform for philanthropic research vessels to engage in a collective way with the Decade."



Scientific Ocean Vehicle Alliance (SOVA)

Officially started by Jason Williams, Schmidt Ocean Institute's lead mechanical engineer, in May 2020, the Scientific Ocean Vehicle Alliance (SOVA) is a community of operators, managers, engineers, and technicians involved in the development and operations of scientific ocean vehicles. Collectively, the members of this community have decades of experience, and by sharing knowledge, they will optimize overall operations of marine science vehicles, increase efficiencies, and standardize operational procedures for conducting ocean science across all their organizations and beyond.

Schmidt Ocean Institute hosted two virtual SOVA meetings in 2021. Highlights from the meetings included presentations on virtual and augmented reality, offshore telepresence, internship strategies, Monterey Bay Aquarium Research Institute's AUV program, Woods Hole Oceanographic Institution's Alvin upgrades, and organizational updates from all groups. Plans for 2022 include several focused workshops and expanding to the international community.



Schmidt Ocean Institute in Film

In an effort to bring the deep sea to new audiences, Schmidt Ocean Institute produced a 10-minute film, "The Depths of Ningaloo," which was submitted to several film festivals. The film features footage captured during a 2020 expedition in Western Australia and brings

viewers along as ROV SuBastian discovers new species in this unexplored area of the deep ocean. The film was an official selection for the 2021 Silicon Beach Film Festival and 2021 Sherman Oaks Film Festival, and won Outstanding Short Film at the Sherman Oaks Film Festival.



Schmidt Ocean Institute at COP26

Schmidt Ocean Institute was invited to participate in the UN Climate Change Conference (COP26) where approximately 30,000 heads of state, government representatives, business leaders, scientists, journalists, and environmental activists from around the world convened in Glasgow, Scotland, to discuss tackling climate change as a global priority. Schmidt Ocean Institute was honored to host the first public session in the green zone entitled "Climate and the Deep Sea World." The event was moderated by Dr. Carlie Wiener, SOI's director of communications, and included a panel with SOI's executive director, Dr. Jyotika Virmani, Seabed 2030 director Jamie McMicheal Phillips, and Alex David Rogers, RevOcean science director. Schmidt Ocean Institute produced a new film, "Climate Under Pressure," which premiered at the event and examines deep sea exploration and climate, with

compelling footage from several R/V *Falkor* expeditions.

By invitation from the U.N. Decade of Ocean Science, Dr. Virmani also participated in a panel discussion at the Moroccan Pavilion in the Blue Zone to discuss the Transformative Role of Philanthropy in the Decade.

Several Artist-at-Sea works were exhibited at a side-event exploring the role of arts, creativity and brands in uniting the ocean movement.

Schmidt Ocean Institute and Schmidt Marine Technology Partners also participated on two panels in the Sustainable Innovation Forum - a three-day parallel event at COP26 where the business community discussed climate and sustainability.



SCIENCE SYMPOSIUM BEYOND THE CRUISE

#SOISYMPOSIUM

Schmidt Ocean Institute First Virtual Symposium

On February 17th – 18th, 2021, Schmidt Ocean Institute held its first virtual Symposium showcasing the ongoing impacts of past expeditions across the globe and highlighting future initiatives on technology, ocean research, and exploration. The Symposium was a chance for our team to engage with its community of supported scientists, partners, advisory board members, and those interested in the organization. The virtual event was held for four hours each day and welcomed more than 529 participants in a mix of moderated panels, keynote addresses, lightning interviews, and fireside chats.



On Dive 412 Artist-at-Sea Ellie Hannon works on one of her paintings on the Aft Deck during sunset on the Timor Sea around Ashmore Reef. Ellie Hannon is an Australian artist who works out of her studio in Newcastle NSW.

Photo by: Conor Ashleigh



ARTIST-AT-SEA

“The horizon is not far away at the height of our sight. It is right here; close to us, we are floating on it. The sea is our borderline, between the question and a hint for the answer.”

*Ale de la Puente,
Interdisciplinary Investigation of the Pescadero Basin
(2021)*

Collection

In 2021, Schmidt Ocean Institute welcomed nine artists from the United States, Mexico, and Australia. Their work ranged from marine rope sculpture, interpretive film, and life-sized paintings. We now have 156 pieces in our collection, representing 42 artists; some of these pieces were showcased at COP26 in Glasgow, Scotland, and at the Alta Sea Blue Hour event in Los Angeles, California, U.S. Plans for dedicated Artist-at-Sea shows and artist participants on R/V *Falkor* (too) will resume in 2022.

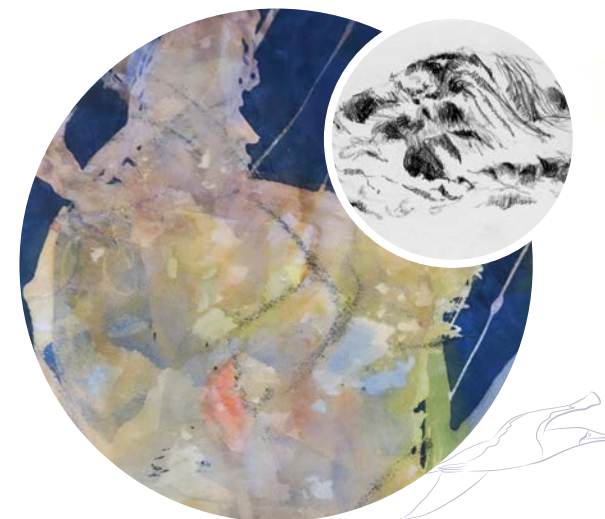
Photos by Justin Nunnink / AltaSea;



Jessica Leitmanis
(Australia)

Jessica Leitmanis examined 3D underwater landscapes to inspire depth and texture that comes through naturally in her weaving. She looked at the issue of manmade, inorganic material in the ocean during the Pinging in the New Year: Mapping the Tasman and Coral Seas expedition.

Photos by Smith



Lea Kannar-Lichtenberger
(Australia)

Lea Kannar-Lichtenberger is a multi-disciplinary artist who examines macro and microscopic worlds to further investigate the dynamics of evolution and the Anthropocene. Lea sailed on the Seafloor to Seabirds in the Coral Sea expedition. She created mechanical drawings as R/V *Falkor* moved through the water and captured the seafloor in her daily multibeam drawings.



Ellie Hannon
(Australia)

Ellie Hannon uses a visual narrative that explores the themes of values and relationship with our natural environments. She sailed on the Australian Mesophotic Coral Examination expedition, collecting images of the biodiversity at seven different Ashmore Reef locations to create a series of collage-style paintings. Using the technology onboard R/V *Falkor*, she created a ceramic vessel mold using digital imaging of certain coral formations on these reefs.

Photos by Conor Ashleigh



Constance Sartor (Guam)

Constance Sartor is a biology student at the University of Guam and an artist who uses collage and up-cycling to showcase the diverse ocean organisms and inspire re-use of manmade materials. Constance sailed on the Discovering Deep-Sea Corals of the Phoenix Islands 2 expedition, creating a series of collages featuring species collected with ROV SuBastian, including a glass octopus, deep sea coral, and crab.

Photo by Erik Olsen



Tanya Young (United States)

Tanya Young, a painter and science illustrator, joined R/V *Falkor* for the Biodiverse Borderlands: Mineral-rich Depths of Southern California expedition, where she observed deep sea species and completed three painted pieces, including a bathymetry map of an underwater ridge, a ctenophore, and deep sea jellyfish.

Photo by Brady Lawrence



Shona Kitchen (United States)

Shona Kitchen heads Rhode Island School of Design's Digital + Media graduate program. Shona joined the Designing The Future 2 voyage, as a follow up to the first expedition with her collaborator Alyson Ogasian. For their project, they considered R/V *Falkor* a species, along with the animals Shona spotted during the expedition. Shona was interested in exploring the similarities between R/V *Falkor*, ROV SuBastian, and the organisms that inhabit the Twilight Zone. From these observations, Shona and Alyson designed a collection of small artifacts, their version of a miniature "cabinet of curiosities" entitled "Another Twilight Zone."

Photo by Jovelle Tamayo



Ale de la Puente (México)

Ale de la Puente, is an award-winning artist with a diverse background, including design, boatbuilding, navigation, astronomy, physics, and philosophy. She is known for her poetic and conceptual explorations of time and space across a wide field of mediums ranging from installations and sculptures to drawings, photography, and video. Ale sailed on R/V *Falkor*'s last science expedition, the Interdisciplinary Investigation of the Pescadero Basin, obtaining multiple data such as dive videos, maps, etc. In the months to follow, she will work with images, videos, and memories to tell another story through video.

Photo by Monika Naranjo



Carol Mickett and Robert Stackhouse (United States)

Carol Mickett and Robert Stackhouse are a collaborative artist team whose art focuses on water and all things connected with water. They have had numerous international exhibits and were on R/V *Falkor* for its final transit from Mexico to Spain. Carol and Robert continue to work on a commemorative painting that they started on their journey, celebrating R/V *Falkor* and its crew. The gold image of the Luck Dragon *Falkor* superimposed over a depiction of the ship R/V *Falkor* will be hung on SOI's new vessel R/V *Falkor* (too). The couple also executed a performative art project from their "ice cube and ice cube tray" series. Every day at 2 p.m. ship time, they tossed an ice cube into the ocean to raise awareness of the warming seas, and then made an ice cube painting where they listed the latitude, longitude, and water temperature of the day.

Photo by Monika Naranjo

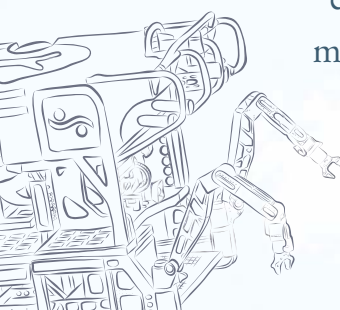




SHIP-TO-SHORES AND PRESENTATIONS

Schmidt Ocean Institute's Ship-to-Shore program facilitates conversations between scientists and members of the public, as researchers connect and engage with students, nonprofits, and other community members through live question-and-answer sessions. Our ship to shore program allows the public to explore R/V *Falkor* and learn more about life at sea. In 2021, the program shifted significantly to broaden and target its reach—44 Ship-to-Shores that engaged with over 10,000 people. Many of the events were with community groups living near locations where R/V *Falkor* was operating at the time. Dual language connections successfully facilitated cross-cultural exchange.

Alongside Ship-to-Shores, members of our staff participated in presentations and panel discussions on various aspects of deep sea exploration. A total of 60 presentations and podcasts reached 52,000 members of the public, government organizations, non profits, and the oceanographic community.



INCREASING RECOGNITION



Schmidt Ocean Institute was honored to receive the following awards acknowledging our dedication to deep sea exploration and sharing our findings with the public.



*Alta Sea Blue Hour
Explorer Award*



*MarComm Platinum
2020 Impact Report*



*MarComm Gold
Deep Ocean Education Project*



*MarComm Gold
Wonders Australian National
Maritime Museum Exhibit Video*



SCIENTIFIC PUBLICATIONS

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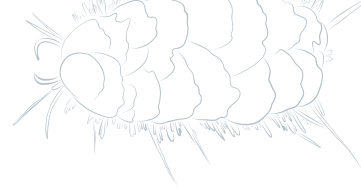
Walker, J., Prugel-Bennett, A., and Thornton, B. (2021). Towards Observation Condition Agnostic Fauna Detection and Segmentation in Seafloor Imagery for Biomass Estimation. *Conference Technical Paper*, OCEANS 2021, San Diego, CA, USA.

Watanbe, H., Chen, C., Chan, B., (2021). A new deep-sea hot vent stalked barnacle from the Mariana Trough with notes on the feeding ecology of Vulcanolepas. *Marine Biodiversity*, 51(9), doi: 10.1007/s12526-020-01144-x. [This article has been published as OPEN ACCESS with support from SOI].

Weber, S., Loick-Wilde, N., Montoya, J., Bach, M., Doan-Nhu, H., Subramaniam, A., et al. (2021). Environmental Regulation of the Nitrogen Supply, Mean Trophic Position, and Trophic Enrichment of Mesozooplankton in the Mekong River Plume and Southern South China Sea. *Journal of Geophysical Research: Oceans*, 126, doi: 10.1029/2020JC017110. [This article has been published as OPEN ACCESS].

Zhang, Y., Ryan, J., Hobson, B., Kieft, B., Romano, A., Barone, B., et. al. (2021). A system of coordinated autonomous robots for Lagrangian studies of microbes in the oceanic deep chlorophyll maximum. *Science Robotics*, 6(50), doi: 10.1126/scirobotics.abb9138.





2021 Presentations

Beaman, R. (2021). Schmidt Ocean Institute R/V *Falkor* Australia Campaign 2020-2021. *Oral Presentation and Conference Paper*, Sub-Committee on Regional Undersea Mapping, General Bathymetric Chart of the Oceans, Virtual from Paris, France.

Beaman, R. (2021). Schmidt Ocean Institute R/V *Falkor* Australia Campaign 2020-2021. *Oral Presentation*. Queensland-Smithsonian Fellowship Speaker Series, Queensland Department of Environment and Science - Smithsonian Institution Conference, virtual.

Beinart, R., (2021). Population Genomics Provide Insights into Symbiont Transmission and Local Adaptation in Hydrothermal Vent Snails, *Invited Speaker*, Interridge 2021 Webinar Series, virtual.

Beinart, R. (2021). The Impact of Microbial Symbionts on the Ecology and Evolution of Hydrothermal Vent Snails. *Plenary Speaker*, Annual Meeting of the American Malacological Society, virtual.

Beinart, R. (2021). Using Population Structure and Host-symbiont Specificity to Inform Knowledge of Transmission Dynamics in two Obligate Marine Microbial Symbioses. *Invited Distinguished Lecture*, University of Wisconsin-Madison, Department of Bacteriology, virtual.

Beinart, R. (2021). Using Population Structure and Host-symbiont Specificity to Inform Knowledge of Transmission Dynamics in two Obligate Marine Microbial Symbioses. *Invited Seminar*, Portland State University, Department of Biology, virtual.

Beinart, R. (2021). Using Population Structure and Host-symbiont Specificity to Inform Knowledge of Transmission Dynamics in two Obligate Marine Microbial Symbioses. *Invited Keynote*, Pioneer Valley Microbiology Symposium, virtual.

Borges de Sousa, J. (2021). Robotic Vehicle Systems for Novel Ocean Observation. *Oral Presentation*, National Science Foundation BLUE-UCI202 workshop, virtual.

Borges de Sousa, J. (2021). Sustainable Presence in the Atlantic? Yes, We Can. *Oral Presentation*, Atlantic International Research Centre, Faial, Portugal.

Borges de Sousa, J. (2021). Ocean Observation with Multi-Domain Robotic Vehicles: Current Trends and Future Developments. *Oral Presentation*, 9th International Workshop on Marine Technology, virtual.

Borges de Sousa, J. (2021). Networked Vehicle Systems for Ocean Observation. *Keynote Speaker*, Marine Autonomy and Technology Showcase, virtual.

Bradshaw, R. (2021). The Controls on the Life Cycle and Evolution of the Kenn Seamount, Coral Sea. *Oral Presentation*, The Geographical Society of New South Wales Annual Honours/Masters Conference, Wollongong, NSW, Australia.

Brooke, B., and Nichol, S. (2021). Coral Sea Marine Survey, *Oral Presentation*, Geoscience Australia, Canberra, Australia

DeAnda, V., Gong, Z., Langwig, M., Rambo, I., Shah, S., Teske, A., et al. (2021). A Map Carbon Flow of Carbon and Energy Through Deep Sea Sediment Microbial Communities. *GRC Marine Microbes Conference*, XXX.

Hanson, N., Dufour, S., and Bates, A. (2021). Effects of Hydrothermal Vent Chemistry on Somatic and Reproductive Allocation in Symbiotic *Alviniconcha hessleri*. *Poster Presentation*, Deep-sea Biology Symposium, virtual.

Hanson, N., Dufour, S., and Bates, A. (2021). Effects of Hydrothermal Vent Chemistry on Reproductive Allocation in Punk-Rock Snails. *Poster Presentation*, Annual Meeting of the American Malacological Society, virtual.

Horowitz, J. (2021). Recent Explorations of the depths of the Northern Great Barrier Reef, *Guest Lecturer*, Environment Institute of Australia and New Zealand Inc., virtual.

Huber, J. (2021). Microbial Life in Venting Fluids from Deep-sea Hydrothermal Systems. *Guest Lecturer*, University of Maryland, Institute of Marine and Environmental Technology, virtual.

Huber, J. (2021). Rocks, Fluids, and Life: Microbial Life in the Deep Sea. *Guest Lecturer*, Stockton University, Biology Department, virtual.

Huber, J. (2021). Ridges and Life. *Oral Presentation*, National Science Foundation GeoPRISMS Workshop: Extensional Processes Across Tectonic Settings and Time Scales - Planning for the Next Decade, virtual.

Huber, J. (2021). Life in Earth's Ocean and the Worlds Beyond. *Oral Presentation*, New England Ocean Science Education Collaborative's 2021 Ocean Literacy Summit, virtual.

Jamieson, J., Sanchez Mora, D., Peterkin, B., Barreyre, T., Escartin, J., and Cannat, M. (2021). Chemical Mass Balance, Depositional Efficiency, and Rates of Formation of Seafloor Massive Sulfide Deposits, *Keynote speaker*, Goldschmidt Geochemistry Conference, Honolulu, HI, USA.

Johnson, A., et al. (2021). Preliminary Interpretation of Multibeam Bathymetry R/V *Falkor* The Tasman and Coral Seas, *Oral Presentation*, GeoHab Conference, Canberra, Australia.

Johnson, A. (2021). Voyaging Aboard the R/V *Falkor*: Guyots and Reefs in the Tasmanid Seamount Chain. *Oral Presentation*, University of Queensland Centre for Marine Science Seminar Series, Brisbane, Australia.

Joye, S. (2021). Regulation and Dynamics of the Anaerobic Oxidation in Hydrothermally-impacted Sediments in the Guaymas Basin (Gulf of California). *Invited Seminar Speaker*, Boston University, Boston, MA, USA.

Joye, S. (2021). From the Deepbiopshere to Hydrothermal Plumes - Microbial Activity and Diversity in Gulf of California Extreme Environments. *Invited Seminar Speaker*, University of Georgia, Athens, GA, USA.

Loranger, S. (2021). Comparison of Measured and Modeled Speed of Sound in the Challenger Deep. *Oral Presentation*, The Journal of the Acoustical Society of America Annual Meeting, Seattle, WA, USA.



McNeil, M., Nothdurft, Lk, Webster, J., Brooke, B., and Beaman, R. (2021). Preliminary Exploration of the Southern Great Barrier Reef: Ice Age Submerged Paleoshorelines and Drowned Coral Reefs, *Oral Presentation*, Submerged Paleo Landscapes of the Southern Hemispheres SHINE 2021 Workshop, virtual.

Mizell, K., and Levin, L. (2021). Key Components of Marine Mineral-related Characterization Studies Learned from Collaborative Research on Mineral Systems in the Southern California Borderland. *Oral Presentation*, AGU Fall Meeting, virtual.

Perez, R., Crémière, A., Wu, F., Speth, D., Schubotz, F., Magyar, J., et al. (2021). Characterization of the Archaeal Communities Involved in Methane and Hydrocarbon Oxidation within Hydrothermal Environments of the S. Pescadero Basin (Gulf of California). *Oral Presentation*, Goldschmidt Conference, virtual.

Thoram, S., Sager, W., and Nakanishi, M. (2021). Improved Bathymetry Map of Southern Shatsky Rise, Northwest Pacific: Implications for Ocean Plateau Formation and Evolution. *Poster Presentation*, AGU Fall Meeting, New Orleans, LA, USA.

Thornton, B. (2021). Remote Awareness of the Deep. *Oral Presentation*, Satellite Applications for the Future of our Seas Workshop, virtual.

Thornton, B. (2021). Re-imagining Seafloor Imaging. *Keynote Address*, Underwater Technology Symposium, virtual.

Tunncliffe, V. and Giguère, T. (2021). Beta-diversity Metrics Assess Biodiversity Distribution in Hydrothermal Vent (and other) Deep-sea Ecosystems. *Oral Presentation*, Deep-sea Biology Symposium, Brest, France.

Walker, J., Prugel-Bennett, A., and Thornton, B. (2021). Towards Observation Condition Agnostic Fauna Detection and Segmentation in Seafloor Imagery for Biomass Estimation. *Oral Presentation*, Global Oceans 2021, San Diego, California, USA.

Student Theses/Dissertations

Carmignani, A. (2021). An Investigation into the Biodiversity and Ecophysiology of Mesophotic Corals (Ashmore Reef). *Honours Thesis*, Curtin University.

Montgomery, A. (2021). Novel Perspectives on Carbon Cycling in Extreme Environments. *PhD Dissertation*, University of Georgia.

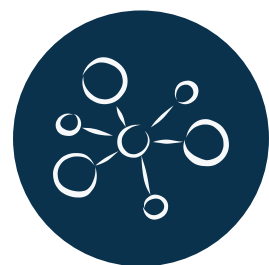
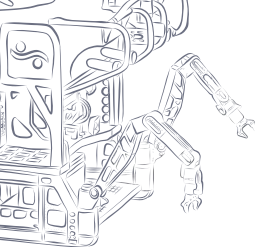
Pruitt, J. (2021). Phylogeny of Ophryotrocha (Annelida: Dorvilleidae) Revisited, with Description of Six New Species from Eastern Pacific Seeps and Whalefalls. *Master's Thesis*, University of California San Diego.

Yamada, T. (2021). Leveraging Domain Knowledge in Machine Learning for Seafloor Image Interpretation. *PhD Dissertation*, University of Southampton.



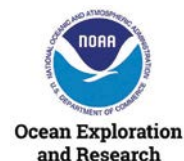
A photo of the Leg 2 science team and crew from Interdisciplinary Investigation of the Pescadero Basin.

Photo by: Monika Naranjo

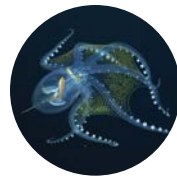


COLLABORATORS

2021



CAPTIONS AND CREDITS



Cover | P.4
ROV SuBastian / Schmidt Ocean Institute;
Two individual glass octopuses were observed, resulting in the first-ever high-quality recordings of the species.



P.2
Brady Lawrence
Researchers process sediment push cores on the aft deck of Research Vessel Falkor.



P. 5
Ben Gibbs
Schmidt Ocean Institute Co-Founders, Wendy and Eric Schmidt.



P.9
ROV SuBastian / Schmidt Ocean Institute
This chimney structure was formed by minerals precipitating from the hydrothermal fluids as they come in contact with the ocean's cold water. Documented between Auka and the JaichMaa 'ja'ag Vent Fields, Dive 473.



Cover
Erik Olsen
Deep-sea biologist Timothy Shank holds a sample jar containing a primnoid coral, a species that hosts many other associate species such as brittle stars, crabs, sea lilies and barnacles.



P.2
Conor Ashleigh
Third engineer Ewan Flatman inspects the motor of a rescue boat after it performed a short rescue mission of Atreyu a small work.



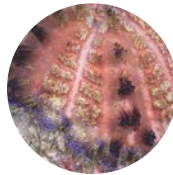
P.6
ROV SuBastian / Schmidt Ocean Institute
Larvacean and "house" seen while descending on Dive 467 to the JaichMaa 'ja'ag Hydrothermal Vent Field.



P.11
Monika Naranjo
R/V Falkor passing the baton to Falkor (too)



Cover
Conor Ashleigh
Research assistant and honours student Amy Carmignani from Curtin University tests a hard coral specimen in the the wet lab from ROV SuBastian after dive 411 on April 16th 2021.



P.2
Sea Urchin
On Dive 408 (Tuesday April 13 2021) ROV SuBastian transfered a a toxic sea urchin to a container. As if there spines weren't already a strong warning, some species are also toxic.



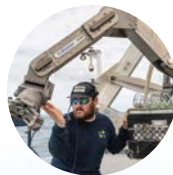
P.7
Jyotika Virmani
Jyotika Virmani in front of Falkor.



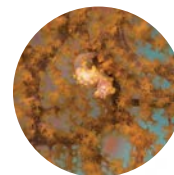
P.12 / 49
Monika Naranjo
Falkor (too)



Cover
Monika Naranjo
ROV SuBastian launched in the morning in the Gulf of California during "Interdisciplinary Investigation of the Pescadero Basin" expedition.



P.2
Conor Ashleigh
On the morning of April 9th 2020, R/V Falkor began a two-day steam to Ashmore Reef off North-Western Australia. ROV pilot technician Corey checks fastidiously over ROV Subastian.



P.7
ROV SuBastian / Schmidt Ocean Institute
A gorgonian coral hosting a pigmy sea horse, seen Sunday April 11th 2021.



P.12
Alex Ingle
Some of the 140 km of cables which run throughout the ship.



P.2
ROV SuBastian / Schmidt Ocean Institute
This chimney structure was formed by minerals precipitating from the hydrothermal fluids as they come in contact with the ocean's cold water. Depth approximately 3680 meters



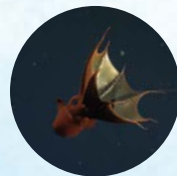
P.3
Alex Ingle
On the day of spooling (the process by which 6000 m of ROV umbilical cable is wrapped at tension onto the ship's winch), a safety briefing takes place in Falkor (too)'s hangar.



P.8
AltaSea
Dr. Jyotika Virmani, Executive Director of Schmidt Ocean Institue, accepts the "Explorer Award" for SOI at the AltaSea "Blue Hour: Ocean of Inclusion" event in San Pedro, CA.



P.12
Alex Ingle
Outside the hanger on the aft deck, an open hatch offers a glimpse into the engine room store and the umbilical room.



P.1
ROV SuBastian / Schmidt Ocean Institute
This vampire squid was imaged during the "Designing the Future 2" expedition at 630 meters on ROV



P.3
Alex Ingle
Falkor crossing



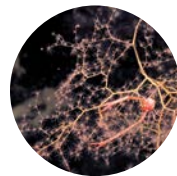
P.8
ROV SuBastian / Schmidt Ocean Institute
This midwater octopus Japatella was spotted before the livestream began on Dive 470 as ROV SuBastian descended toward the seafloor of the Gulf of California.



P.12
Alex Ingle
As the sun sets over Vigo, Spain, R/V Falkor (too) sits in Freire Shipyard where she is undergoing an ambitious refit to transform her into a truly unique scientific research platform.



P. 14
Erik Olsen
Aerial image of Falkor sailing in US EEZ waters while working on unexplored and unnamed seamounts on the Tokelau Ridge in the Phoenix Islands Archipelago.



P. 14
ROV SuBastian / Schmidt Ocean Institute
A small Squat lobster sits on a golden coral in the deep ocean on a previously unexplored seamount. | Dive 419



P. 15
ROV SuBastian / Schmidt Ocean Institute
A squat lobster perches atop a Bubblegum Coral on the San Juan Seamount in the Southern California Borderland. | Dive 419



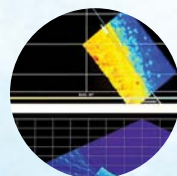
P. 15
ROV SuBastian / Schmidt Ocean Institute
A siphonophore being scanned by MBARI's DeepPIV instrument, as observed from ROV SuBastian during the "Designing the Future 2" cruise, aboard R/V Falkor. | Dive 460



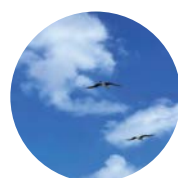
P. 16-17
Brady Lawrence
Researchers process sediment push cores on the aft deck of Research Vessel Falkor. The science team is conducting research on the DDT Dumpsite off the coast of Los Angeles.



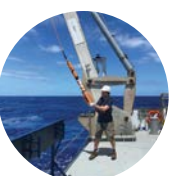
P. 20-21
Schmidt Ocean Institute
Fraser seamount



P.21
Schmidt Ocean Institute
The seafloor is revealed through data seen on the multibeam sonar screen.



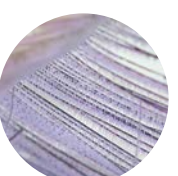
P. 22-23
Francisco Gelves
Boobys flying



P. 23
Francisco Gelves
Lead Marine Technician, John Fulmer, launches a magnetometer.



P. 24-25
ROV SuBastian / Schmidt Ocean Institute
LargeSponge | Dive409



P.25 & Back Cover
ROV SuBastian / Schmidt Ocean Institute
A close up of black coral pinnuls is filmed the ROV SuBastian on April 12th 2021 at Ashmore Reef.



P.26-27
ROV SuBastian / Schmidt Ocean Institute
Chirostyliid Crab | Dive420



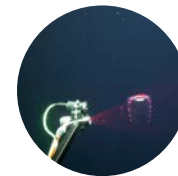
P.27
ROV SuBastian / Schmidt Ocean Institute
Observed and collected the first-ever high-quality footage of 2 glass octopuses, both recorded outside of marine protected areas.



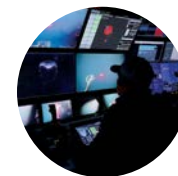
P.28-29
ROV SuBastian / Schmidt Ocean Institute
Helmet Jelly | Dive443



P.29
ROV SuBastian / Schmidt Ocean Institute
A sponge and the rock substrate it's attached to is examined by the ROV Subastian.



P. 30-31
ROV SuBastian / Schmidt Ocean Institute
MBARI's DeepPIV instrument scans a solmissus jellyfish,



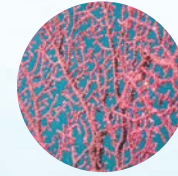
P.31
Jovelle Tamayo
Co-Principal investigator and bioengineer Dr. Kakani Katija, right, watches as the DeepPIV instrument scans a Solmissus, a type of jellyfish, during the first ROV SuBastian dive.



P. 32-33
ROV SuBastian / Schmidt Ocean Institute
Dive 464, exploring the JaichaMaa'ja' ag vent field.



P. 30-31
ROV SuBastian / Schmidt Ocean Institute
Striking Hydrothermal vents, chimneys, and mirror pools, with large population of tubeworms during Dive 464.



P.37
ROV SuBastian / Schmidt Ocean Institute
A close up detail of a gorgonian fans captured by ROV SuBastian on dive 410, April 16th 2021 on the sea floor of Ashmore Reef. Like other corals, gorgonians have polyps. The polyps have tentacles arra



P.37
ROV SuBastian / Schmidt Ocean Institute
A galaxy siphonophore is documented by ROV SuBastian on descent to the Patton Escarpment.



P.37
ROV SuBastian / Schmidt Ocean Institute
On dive 410 April 16th 2021, ROV SuBastian captured clown fish swimming in the anemome. Anemones have rings of tentacles surrounding their central mouth. Tentacles have specialised stinging cells call.



P.38
ROV SuBastian / Schmidt Ocean Institute
A beautiful hard coral is seen at depth on Dive 409 during the Mesophotic Coral Examination Expedition.



P.38
ROV SuBastian / Schmidt Ocean Institute
The Matterhorn, a hydrothermal vent of Pescadero basin displaying an abundance of red tube worms and white microbial mats. | Dive 467



P.38
Brady Lawrence
Michelle Guraieb (Scripps Institution of Oceanography), Johanna Gutleben (Scripps Institution of Oceanography), and Kira Mizell (U.S. Geological Survey) work in the wet lab to prepare a rock sample retrieved by ROV SuBastian.



P.38
ROV SuBastian / Schmidt Ocean Institute
Swimming Rattail (Grenadier) during Dive 465



P.39
Constance Sartor
Constance Sartor uses shredded magazines to create upcycled collage art. This piece depicts a glass octopus seen while on expedition in the Phoenix Islands.



P.39
Conor Ashleigh
On (dive 416) 22nd April 2021, Artist-at-Sea Ellie Hannon holds an art work created for ROV SuBastian.



P.40
Monika Naranjo
The scientific party and crew from leg 01 of the Interdisciplinary Investigation of the Pescadero Basin expedition.



P.41
Jovelle Tamayo
Scientists John Burns, left, and Kaitlyn Becker, process animal samples after recovering them from ROV SuBastian after its final dive of the "Designing the Future 2" cruise.



P.43
Monika Naranjo
John Magyard takes samples of very oily water for hydrothermal vents, right after ROV SuBastian is recovered from Dive 473 in the Gulf of California.



P.43 & Back Cover
Conor Ashleigh
Principal Investigator Dr Karen Miller from the Australian Institute of Marine Science (AIMS) is interviewed by German Television on the final day docked in Darwin Port, Northern Territory, Australia.



P.44
Marinco Kojdanovski
Pepper's Ghost models of deep sea creatures found during SOI's 2020 Australia campaign displayed in the "One Ocean, Our Future" exhibition at the Australian National Maritime Museum



P.49
Jovelle Tamayo
Marine technician Deborah Smith radios a team member as they lower a CTD to pressure test MBARI's DeepPIV instrument aboard R/V Falkor on Tuesday, Aug. 17, 2021, during the "Designing the Future 2" cruise.



P.50
Monika Naranjo
Manet Peña Salinas - a Ph.D student at the Universidad Autónoma de Baja California (UABC) - processes a push core sample retrieved by ROV SuBastian.



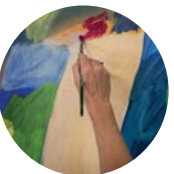
P.53
Monika Naranjo
Dr Ronald Spelz examines a volcanic rock sample, deciding the best way to break it into smaller pieces for further examination.



P.54
Alex Ingle
Schmidt Ocean Institute hosts "Climate and the Deep Sea World: Schmidt Ocean Institute's Global Efforts - A Visual Journey and Panel" in the Green Zone at COP26.



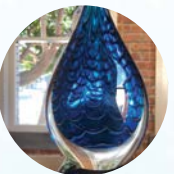
P.59
Conor Ashleigh
On Dive 412 Artist-at-Sea Ellie Hannon works on one of her paintings on the Aft Deck during sunset on the Timor Sea around Ashmore Reef. Ellie Hannon is an Australian artist who works out of her studio in Newcastle NSW.



P.60
Conor Ashleigh
Artist at Sea Ellie Hannon works on one of her paintings inside the wet lab on R/V Falkor. Schmidt Ocean Institute invites artists of broad disciplines to work together with scientists and crew to take



P.64
Conor Ashleigh
Research assistant and honours student Chloe Anderson, Artist at Sea Ellie Hannon and Principal Investigator Dr Karen Miller present a Ship to Shore to two classes of students from Mayfield Public



P.65
Jyotika Virmani
The Explorer Trophy AltaSea awarded to SOI during the Blue Hour.



P.65 & Back Cover
Conor Ashleigh
Inside the wet lab on R/V Falkor, Dr Nerida Wilson inspects a gorgonian fan that was collected on Tuesday 20th April 2021. | Dive 414



P.65
Conor Ashleigh
Marine Technician James Gillard prepares for Atreyu a small work boat they're using to be winched up onto the deck of R/V Falkor.



P.67
Conor Ashleigh
Scientists listen intently while R/V Falkor crew deliver an introductory session to the science party and artist at sea Ellie Hannon. The science party joined R/V Falkor while docked at Darwin Port.



P.67
Jovelle Tamayo
Artist-at-sea Shona Kitchen's notebook on Thursday, Aug. 19, 2021, aboard R/V Falkor, during the "Designing the Future 2" cruise.



P.72
Conor Ashleigh
Setting over Ashmore Reef at the end of ROV SuBastian's second dive on Monday 12th April 2021.



P.73
Monika Naranjo
A photo of the Leg 2 science team and crew from Interdisciplinary Investigation of the Pescadero Basin.



P.81
Conor Ashleigh
At dusk on Wednesday 14th April at the end of dive 408, the lights of ROV SuBastian can be seen underwater as it is winched back on deck of R/V Falkor.



P.83-84
Jovelle Tamayo
Scientists Brennan Phillips, center, and Kaitlyn Becker, with the support of Dave Casagrande, left, assemble the RAD2 (Rotary Actuated Dodecahedron) Sampler, which is integrated on one of ROV SuBastian's manipulator arms.



Back Cover
ROV SuBastian / Schmidt Ocean Institute
A species of the deepwater big eye (pristigenys meyeri) seen during dive 405.



Back Cover
Conor Ashleigh
Research assistant and honours student Amy Carmignani from Curtin University tests a hard coral specimen in the wet lab from ROV SuBastian after dive 411.

Scientists Brennan Phillips, center, and Kaitlyn Becker, with the support of Dave Casagrande, left, assemble the RAD2 (Rotary Actuated Dodecahedron) Sampler, which is integrated on one of ROV SuBastian's manipulator arms.

Photo by: Jovelle Tamayo





IMPACT REPORT 2021

