Fall 2018

Ocean Discovery

The U.S. Scientific Ocean Drilling Community Newsletter

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The International Ocean Discovery Program (IODP) is an international research collaboration among roughly two dozen countries to advance scientific understanding of the Earth through drilling, coring, and monitoring the subseafloor. The U.S. Science Support Program (USSSP) supports the involvement of the U.S. scientific community in IODP and is funded by the U.S. National Science Foundation (NSF). IODP utilizes multiple drilling platforms to carry out its missions: the riserless *JOIDES Resolution*, managed by Texas A&M University; the riser-equipped *Chikyu*, operated by the Center for Deep Earth Research (CDEX), a subdivision of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC); and various mission-specific platforms operated by the British Geological Survey on behalf of the European Consortium for Ocean Research Drilling (ECORD). For more information, visit: www.iodp.org.

To contact the editor of Ocean Discovery, email: jspencer@LDEO.columbia.edu; or call 845-365-8785

For more information about USSSP, visit: usoceandiscovery.org/what-is-usssp

CALENDAR

December

10-14 — **American Geophysical Union Fall Meeting (Town Hall, 12 December)**
Washington, DC

January

8-10 — **Science Evaluation Panel**
La Jolla, CA

23-25 — **U.S. Advisory Committee for Scientific Ocean Drilling**
La Jolla, CA

February

12 — **Environmental Protection and Safety Panel**
College Station, TX

March

21-22 — **ECORD Facility Board**
Bremen, Germany

TBD — **ECORD Training Course: Virtual Drillship Experience**
Bremen, Germany

April

7-12 — **European Geosciences Union General Assembly**
Vienna, Austria

May

8-9 — ***JOIDES Resolution* Facility Board**
Denver, CO

June

11-12 — ***Chikyu* IODP Board**
Kobe, Japan

25-27 — **Science Evaluation Panel**
Edinburgh, Scotland

Letter from the JRFB Chair

Dear Scientific Ocean Drilling Friends,

I am writing to introduce myself as the new Chair of the *JOIDES Resolution* Facility Board (JRFB), having taken over from Anthony Koppers on 1 October 2018. We as a community owe Anthony a huge "thank you" for guiding and growing our program so diligently over the last three years. We also owe Brad Clement and his *JOIDES Resolution* Science Operator (JRSO) team at Texas A&M similar kudos because the combination of the JRSO and JRFB management has made the U.S. part of the International Ocean Discovery Program much more efficient and hugely successful.

Anthony will be a tough act to follow! Therefore, it is with some trepidation that I have accepted the position of JRFB Chair and I plan to continue the excellent working relationship among the JRFB, JRSO, NSF, and the science support structure—the Science Evaluation Panel (SEP), the Environmental Protection and Safety Panel (EPSP), and the Science Support Office (SSO). Above all, my position is one of service to the community, so please feel free to contact me with any questions/concerns you may have about the JRFB and IODP and I will do my best to find answers for you.

We should hear early next year from the National Science Board about the renewal of the JR facility. We are all hoping for a positive response, especially given the efficient management of the facility and the science return on the NSF investment. You may also have heard that the JR experienced some mechanical difficulties this year that resulted in the curtailment of one expedition and the postponement of others. These events clearly demonstrate that the JR is aging. Please note that as chair of the JRFB, I am acutely aware of the situation and have been in close contact with the JRSO to keep up to date with the latest developments, but also to discuss options for the future of the U.S. IODP drilling vessel.

Finally, you will note from the schedule shown at iodp.org, the JR is now scheduled until 6 June 2021 and at the next JRFB we will schedule the ship into 2022. The International Ocean Discovery Program will end in 2023, so now is the time when we also need to start preparing for the next phase of scientific ocean drilling. It is vital that we maintain good proposal pressure at the SEP to demonstrate to national agencies and decision makers that the program is vibrant. I believe that our community should be optimistically looking to the future, and I urge you to think positively about getting new proposal ideas that follow or even dictate the ship track (shown on page 11 of this issue of Ocean Discovery). Therefore, I ask you to think about two very important questions:

- For IODP beyond 2023, do we need a new science plan?
- Why do we need more core/data from our oceans?

The IODP Town Hall at the AGU meeting will be held on Wednesday night, December 12, at the Washington Plaza Hotel and I strongly urge you to attend that event. I believe we are on the cusp of something special for the drilling program, but it will require hard work, cooperation, and your participation.

I am sincerely yours,

Clive R. Neal
Chair, *JOIDES Resolution* Facility Board

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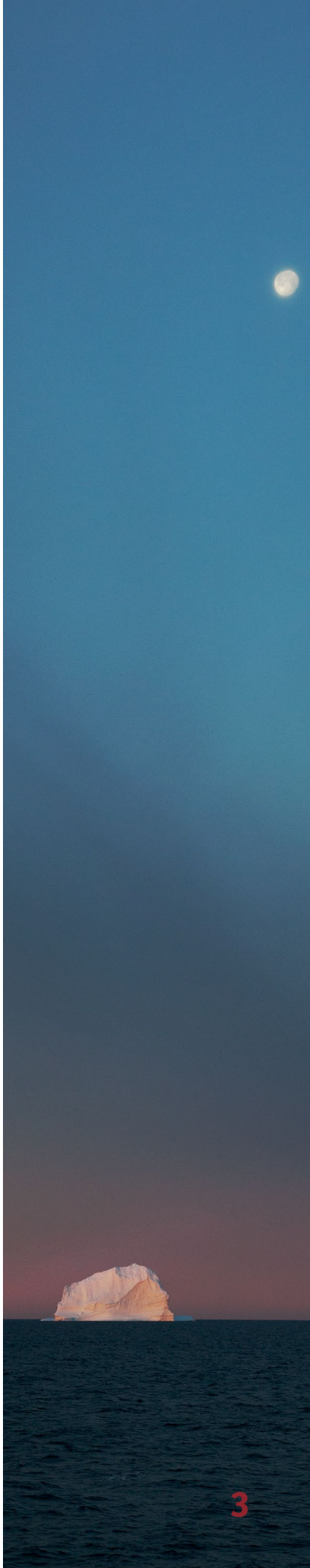

Expedition 379 to Explore the History of the West Antarctic Ice Sheet in the Amundsen Sea

Karsten Gohl and Julia Wellner

The West Antarctic Ice Sheet (WAIS), and in particular the region that feeds ice to the Amundsen Sea, has long been considered to be vulnerable to sudden ice retreat. Models suggest that much of the ice sheet could be lost even under relatively moderate greenhouse gas emission scenarios (DeConto and Pollard, 2016). However, projections are limited by lack of constraints in several areas, most notably a lack of detailed reconstructions about glacial history.

Expedition 379 to the Amundsen Sea (Figure 1) will test several key questions about controls on ice sheet stability. First, it will offer a direct record of glacial history in a drainage basin that receives ice just from the WAIS, allowing clear comparisons between WAIS history and low-latitude proxy records. Today, Circumpolar Deep Water (CDW) is impinging onto the Amundsen Sea shelf, causing melting of the underside of the ice; reconstructions of past CDW intrusions (Hillenbrand et al., 2017; Minzoni et al., 2017) will assess the ties between warm water and large-scale changes in past grounding line positions. Finally, this expedition will take place as part of a suite of Antarctic IODP expeditions, allowing large-scale reconstructions and comparisons between different drainage basins.

The scientific goals for this expedition are built on five hypotheses about WAIS dynamics and related paleoenvironmental conditions:

Hypothesis 1: The WAIS responded to atmospheric and/or oceanic warming by major retreat from the shelf or by even partial to full collapse. Ice sheet models hypothesize that past climate warming caused major deglaciation of the WAIS (e.g., DeConto and Pollard, 2016). For example, results from the Antarctic Drilling Project (ANDRILL) suggest repeated WAIS retreats during warm early middle Pliocene and Pleistocene interglacials (e.g., Naish et al., 2009). The ANDRILL sites, though, record a combined WAIS and East Antarctic signal and this hypothesis needs to be tested in a region solely fed by West Antarctic ice. Thus, the Expedition 379 drill cores will help to answer the crucial question: did the WAIS collapse during the Neogene and Quaternary as previously suggested, and if so, when and under which environmental conditions?

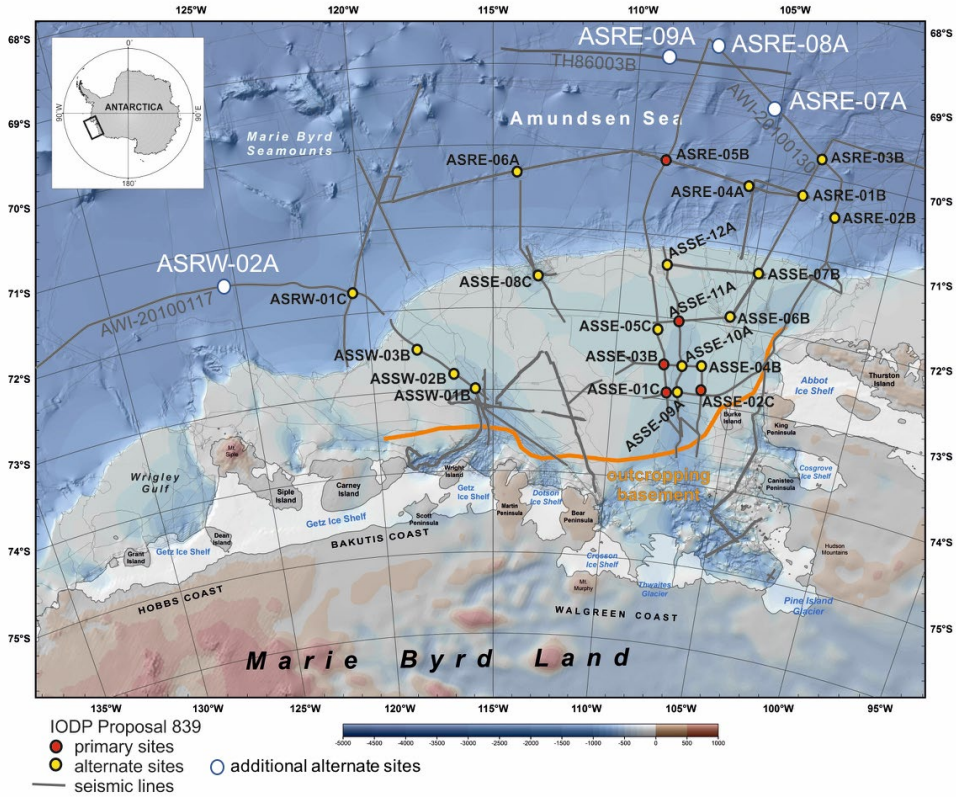

Figure 1. Bathymetric map of the Amundsen Sea region (adopted from Nitsche et al., 2007) with Expedition 379 primary (red), alternate (yellow), and newly added alternate (white) drill sites. Thick gray lines mark marine seismic profiles. Orange line marks the boundary between the outcropping basement of the inner shelf and the sedimentary basin of the middle shelf (Gohl et al., 2013).

Hypothesis 2: Ice-proximal records of ice sheet dynamics in the Amundsen Sea correlate with global records of ice-volume changes and proxy records for atmospheric and ocean temperatures. Throughout the Cenozoic era, unexplained discrepancies are observed between Earth's temperature and global ice volume reconstructed from proxies in deep-sea sediments, climate models, sea-level estimates, and, for the last 800 ky, ice cores. Results of ANDRILL (Naish et al., 2009) and Integrated Ocean Drilling Program Expedition 318 to the Wilkes Land margin (Cook et al., 2013) reignited the debate as to whether the Antarctic ice sheets underwent major collapses during Pliocene interglacials. Such collapses are not directly recognizable from oxygen isotope proxies at far-field sites. In fact, results from Shallow Drilling (SHALDRIL) cores and other data from the eastern Antarctic Peninsula shelf indicate progressive cooling and associated decline in vegetation over the past 37 My, culminating in early Pliocene ice sheet expansion onto the continen-

tal shelf (Anderson et al., 2011); however, results from Leg 178 cores from the western Antarctic Peninsula margin are consistent with repeated ice sheet advances throughout the Pliocene (Eyles et al., 2001). To date, the record from the Amundsen Sea is missing from the range of ice sheet histories hinted at from the various other records. The drill cores from the Amundsen Sea will decipher whether the WAIS responded directly to the orbitally paced climatic cycles of the Pliocene and Quaternary or if it varied at periods determined by its internal dynamics.

Hypothesis 3: The stability of marine-based WAIS margins is and has been controlled by warm deep-water incursions onto the shelf. Incursions of relatively warm CDW onto the West Antarctic continental shelf have been implicated in regulating WAIS behavior in the Holocene (Hillenbrand et al., 2017; Minzoni et al., 2017). Longer paleorecords of CDW upwelling are urgently needed to understand the relationship between WAIS dynamics and ocean circulation. With recent observations of present CDW advection through the bathymetric troughs of the Amundsen shelf (e.g., Arneborg et al., 2012), drilling on the Amundsen Sea shelf has a good chance to recover sample material suitable for applying benthic foraminifer–based proxies to reconstruct past CDW upwelling onto the shelf and its effect on WAIS dynamics.

Hypothesis 4: Major WAIS advances onto the middle and outer shelf occurred since the middle Miocene. Seismic data reveal progradational and aggradational deposition on the outer shelf and slope of the Antarctic Sea Embayment has likely occurred since the mid-Miocene (e.g., Gohl et al., 2013). The preservation of buried grounding-zone wedges in the Pliocene/Pleistocene sequence on the outer Amundsen Sea shelf is consistent with prolonged continuous accumulation of marine sediments, probably during a long interglacial period with a significantly reduced WAIS, as observed on the Ross Sea shelf during the early Pliocene. However, the models of grounded ice advance and retreat across the Amundsen Sea shelf are based on long-distance correlations of seismic facies and characteristics. Drilling in the Amundsen Sea will allow development of a chronology of WAIS advance and retreat in the area, which can be tied to seismic data and compared to other sectors of the Antarctic Ice Sheet.

Hypothesis 5: The first WAIS advance onto the inner ASE shelf occurred during the Oligocene and was related to the uplift of Marie Byrd Land. The onset of major glaciation in West Antarctica is still undated because of sparse drill cores. Ice sheet models (e.g., DeConto and Pollard, 2003) suggest an early WAIS nucleus in the mountain chain extending from elevated Marie Byrd Land over the Ellsworth Mountains to the southern Antarctic Peninsula. The exhumation and erosion history of Marie Byrd Land, and especially the Marie Byrd Land dome (Spiegel et al., 2016), is important for the interrelations between ice sheet and lithosphere dynamics because exhumation and erosion change topography, which in turn influences glacier movements by slope steepness. In addition, exhumation is often associated with surface uplift, which will favor formation of glaciers, and, at the same time, glaciation changes erosion rates and, due to isostatic adjustment, exhumation rates. This relationship can be investigated by detailed provenance and thermochronological analyses of Neogene drill samples from the Amundsen Sea.

As part of a suite of Antarctic expeditions, IODP Expedition 379 will depart Punta Arenas, Chile, in January 2019 and return in March. Expedition 374 to the Ross Sea took place in early 2018 and initial results are imminent. Immediately following Expedition 379, Expedition 382 will drill in the Scotia Sea, north of the Antarctic Peninsula and sub-Antarctic islands. Together these expeditions represent the chance for a step function increase in our understanding of the evolution of the Antarctic Ice Sheets. Drilling from the *JOIDES Resolution* in glacial areas has formidable difficulties due to the potential presence of sea ice that will limit operations and due to poor recovery typical from glacial sediments. Expedition 379 has a wide-range of alternate sites (Figure 1) so that sea ice can be avoided. In addition, at least one site will be cored in deep-sea drifts where a continuous record of paleoenvironmental changes can be expected.

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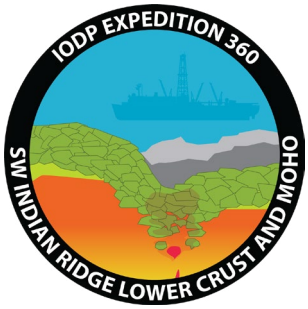
School of Rock 2018+ Follow Up Report

Dieuwertje Kast and Sharon Katz Cooper

For 9 days this July, 19 educators from the U.S., New Zealand and Australia had the amazing opportunity to visit and learn more about the geology of New Zealand (NZ) and the research efforts that go on there and aboard the *JOIDES Resolution*. We began our journey by spending 2 days on the JR, which had just returned to port in Auckland, NZ from Expedition 376 investigating the hydrothermal activity at the underwater Brothers volcano. While onboard we were given a tour and learned about the history of IODP, the ship and other ocean drilling projects that have been operating over the last half-century. The cores taken by the JR are used by geoscientists to learn about the ocean and climate conditions of Earth's past. Instructor Dr. Lisa White (Director of Education, UC Museum of Paleontology at UC Berkeley) taught us the basics of one of the techniques used by scientists studying these cores -- micropaleontology, including how to make a smear slide from core samples! During our time on the ship we had the opportunity to take some samples of our own and look at microfossils under the microscopes.

After two amazing days aboard the JR, our School of Rock adventure turned to the amazing geology surrounding New Zealand. With our guides Dr. Bruce Hayward (University of Auckland) and Dr. Chris Hollis (GNS Science), we were able to explore a huge variety of sites of



geologic and ecologic importance and learn more about the geosciences work done there. We began on Rangitoto Island, which sits in Auckland's Hauraki Gulf and is the youngest and largest of the 50 or so volcanoes that make up the Auckland Volcanic Field. We hiked to the top of this shield volcano's 850 ft (260 m) tall peak and saw structures called lava tubes, which are formed when the surface of a pahoehoe (low-viscosity) lava flow solidifies but molten lava is still moving beneath. Rangitoto is important ecologically, as it is a wonderful place to study how volcanic landscapes shift over time to become hospitable to many forms of life—for now, it's mostly left to the lichens! This was just the first of many volcanic sites we visited—others included Māngere Mountain, where we were able to see one of Auckland volcanic field's best preserved volcanic cones as well as lava bombs; Maori Bay/Muriwai Beach, where we saw cliffs with preserved lava tubes and a beach made out of black sand from eroded volcanic structures; and more!

One of the other amazing opportunities we had was taking samples along a transect of three sites in Weymouth—the Mangrove swamps, the mudflats and the Ihumatao fossil fields. We were then able to visit the University of Auckland, where we cleaned and sieved our samples to look for foraminifera. We learned that foram fossils are often used by researchers both at the University and onboard the JR to study Earth's past and decipher what the environment was like when they were alive. After we removed the forams from our samples, we put them onto slides and used a microscope to identify which species of forams were present!

School of Rock 2018 was an amazing and diverse experience. It was lava-ly and it rocked (all the geology puns). I cannot wait to translate this experience into curricula for the programs that I manage!

In June 2018, a group of School of Rock 2017 and 2016 alumni and faculty, along with several former Onboard Outreach Officers gathered with USSSP Education/Outreach staff in Victoria, British Columbia to report on progress to date and brainstorm next steps. In particular, they aimed to generate new ideas for broadening participation from groups traditionally underrepresented in the geosciences across the U.S. and build on action plans and experiences put into place since their School of Rock or JR stints.

Participants reported on a variety of initiatives that arose out of these experiences, including Science Club field trips with School of Rock faculty (Mark Leckie, University of Massachusetts, Amherst), partnerships between local universities to work with minority-serving institutions in the Eastern Shore area in Maryland, community college efforts to involve the community and their diverse student bodies, broader impacts projects involving middle school field trips to Port Aransas with faculty from Expedition 360 (Jason Sylvan, Texas A&M University), and more.

A range of new ideas were generated to build on these projects and grow their impacts. They included having a presence at some new and different kinds of conferences from the ones IODP traditionally attends, writing articles and opinion pieces for science and education journals, writing several new proposals for grants to fund extensions of these projects, creating a podcast series, taking advantage of the upcoming U.S. port calls in San Diego, extending the reach of the Earth's Secrets traveling exhibit to additional sites around the country, and developing a science communication workshop specifically for IODP scientists who will be sailing. Efforts will be made to engage all sailing scientists in broader impacts and post-cruise outreach in a more consistent manner going forward.

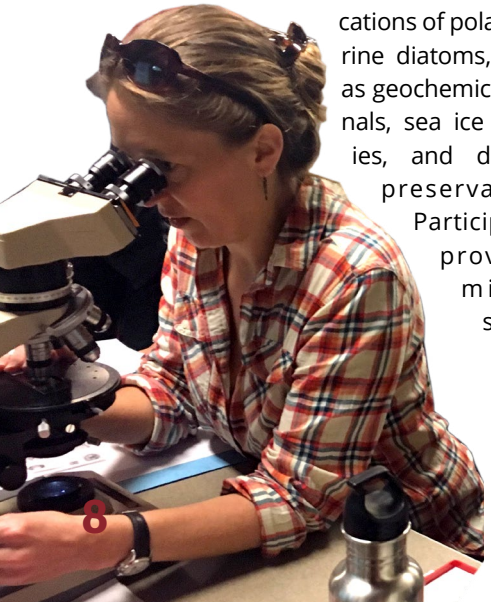
More information the School of Rock Program can be found online at www.joidesresolution.org in the Fall.

Dozens of Diatomists Share Taxonomy and Applications in Northwest Iowa

Beth Caissie and Jonathan Warnock

The 6th Polar Marine Diatom Workshop, held August 6-10 at the Iowa Lakeside Lab, was a successful week filled with engaging taxonomic discussions, inspiring talks, and a bit of summer fun. We met our goal of creating an atmosphere where researchers new to diatoms could learn from and interact with more senior diatomists. We also saw younger members of the group stepping into leadership roles for the first time. We worked hard to create a participant group that was diverse and hosted 40 participants representing 12 countries. Sixty percent of participants were women and 46% were graduate or undergraduate students.

Historically, the Polar Marine Diatom Workshop has been primarily a taxonomic workshop, and the majority of our time was spent in microscope sessions that focused on individual genera such as *Actinocyclus*, *Thalassiosira*, and *Corethron* and applications of polar marine diatoms, such as geochemical signals, sea ice proxies, and diatom preservation. Participants provided microscope slides for each other, to act as reference sets for both taxonomy and biostratigraphy.



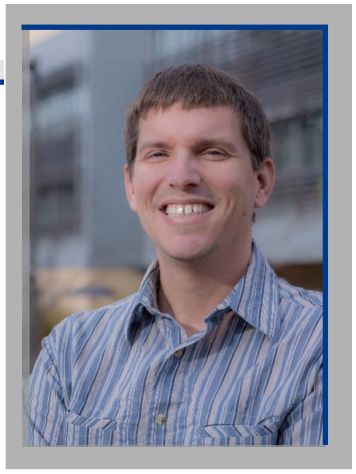
We paid particularly close attention to Antarctic biostratigraphy during this meeting because of IODP's upcoming expedition schedule focused on the Southern Ocean. Having just served as a diatomist on Expedition 374 (Ross Sea West Antarctic Ice Sheet History), Dr. David Harwood, University of Nebraska Lincoln, presented a revised Southern Ocean biostratigraphy to the group, complete with slides representative of the various time periods. We spent an entire morning working through these slides. Everyone interested, but especially those who have applied for or been accepted to sail on upcoming IODP Antarctic expeditions, was encouraged to come to the lab in the evening to continue working through this slide set. Many participants took advantage of evening microscope biostratigraphy sessions. The goal of these sessions was to ensure that all upcoming IODP expeditions will use the same diatom biostratigraphy and that diatomists on these expeditions will all start on the same page when they sail.

In addition to the microscope sessions, we had ten research talks and thirteen posters. Talks highlighted new research, such as tintinnid and diatom associations, modern Arctic and Antarctic diatoms, and several new Antarctic records. The talks also inspired us to try out new methodologies for prepping samples for isotopic analysis and identifying reworking in our own samples.

Finally, we balanced out our week by spending time out in the prairie and on the beautiful Lake Okoboji. An ecologist from Iowa State, Lori Biederman, led prairie walks; a graduate limnology student from the University of Minnesota, David Burge, led modern diatom collecting trips; and our resident artist, Claudia Stevens, led two evening art workshops. We also hosted a well-received evening outreach event where participants could look at polar marine diatoms through the microscope and learn about how we collect our samples and why polar marine diatoms matter. The participants, local community members, were enthusiastic and thankful for the opportunity to learn.

A special issue in Marine Micropaleontology is planned. If you would like to contribute articles related to the theme of "Applications and Innovations in Polar Marine Diatom Analysis," please contact Reed Scherer (reed@niu.edu), Beth Caissie (bethc@iastate.edu), or Amy Leventer (aleventer@colgate.edu). We especially welcome contributions from diatomists who were not able to attend the workshop. We anticipate a May 2019 deadline for manuscript submission.

More information on this workshop can be in the final workshop report which will be published online at http://usoceandiscovery.org/workshop-polar-marine-diatoms-2018/



Dr. Brandon Dugan, 2018 AGU Taira Prize Winner

Dr. Brandon Dugan, associate professor and Baker Hughes Chair in Petrophysics & Borehole Geophysics at Colorado School of Mines, has been named the winner of the 2018 Asahiko Taira International Scientific Ocean Drilling Research Prize.

Established in 2014, the Asahiko Taira International Scientific Ocean Drilling Research Prize (The Taira Prize) is given annually to one honoree in recognition of "outstanding transdisciplinary research accomplishment in ocean drilling." A partnership between the American Geophysical Union and the Japan Geoscience Union, the prize is given in honor of Dr. Asahiko Taira of the Japan Agency for Marine-Earth Science and Technology, who has more than 40 years of experience studying tectonics, paleoceanography and ocean drilling science.

Winners receive $18,000 as well as an invitation to present a lecture at either the AGU Fall Meeting or JpGU Annual Meeting.

Dugan's research interests include how fluids flow through shallow sediments in the deep ocean. This has led to projects studying how large landslides occur in oceans on slopes less than two degrees, how the composition of sediments entering subduction zones influences the earthquake location and size, and how natural gas hydrates accumulate in oceanic sediments. While studying these problems, he has spent nearly a year at sea aboard scientific ocean drilling research vessels, participating in ODP Leg 194 as well as IODP Expeditions 308, 322, 338, 362, and 372. Dugan led two of those expeditions, sailing as a co-chief scientist.

As part of his research, Dugan has helped develop and test new downhole tools for measuring in-situ formation pressure, which is integral to addressing fluid flow and geo-mechanical problems. He has also developed process-based models that explain how abnormal pressures are generated in shallow sediments and how this facilitates submarine landslides.

The 2018 AGU Fall Meeting (Washington D.C.) will include a special Union session lecture for the Asahiko Taira International Scientific Ocean Drilling Research Prize, *Understanding Shallow Subsurface Fluid Flow in Marine Sediments through Coring, Logging, Experiments, and Models*, Wednesday, 12 December, 14:40 – 15:25 PM, Marriott Marquis 6.

2019-20 Ocean Discovery Lecture Series

For over twenty years, the Ocean Discovery Lecture Series (formerly the Distinguished Lecture Series) has brought the exciting results and discoveries of scientific ocean drilling to academic research institutions and informal learning centers. The roster of 2019-20 Ocean Discovery Lecturers will focus on topics such as climate change, monsoon history, sediment diogenesis, and more.

Beth Christensen
Rowan University
How plate tectonics drove continental climate change in Australia

Ginny Edgcomb
Woods Hole Oceanographic Institution
Life at the edge of what is possible: microbial biosignatures in the lower oceanic crust

Matt Hornbach
Southern Methodist University
New Insights into slope failure and slide-generated tsunami from IODP drilling

Chris Lowery
University of Texas, Austin
The Chicxulub impact and the resilience of life

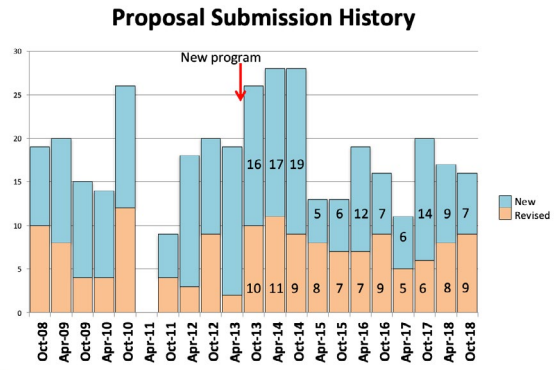
Brandi Reese
Texas A&M University, Corpus Christi
Wanted dead or alive: on the hunt for microbes bellow the ocean floor

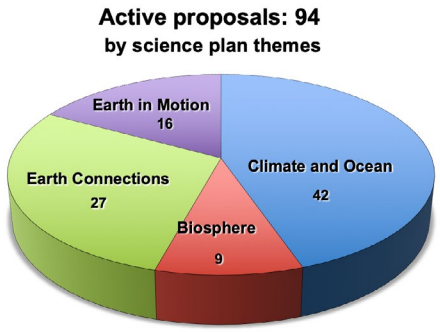
Lindsay Worthington
University of New Mexico
Buried alive: how sediments shut down faults in the Gulf of Alaska

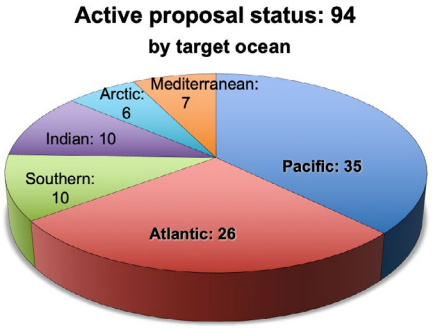
IODP Drilling Proposal Statistics

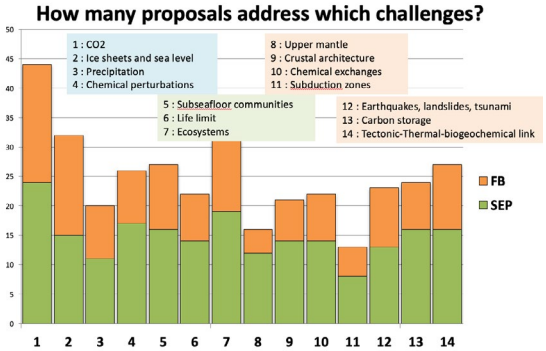
The IODP Science Support Office (SSO), located at Scripps Institution of Oceanography, typically accepts drilling proposals on a semiannual schedule, with cycles in April and October. Most proposals have multiple proponents, often with expertise in different geological subdisciplines.

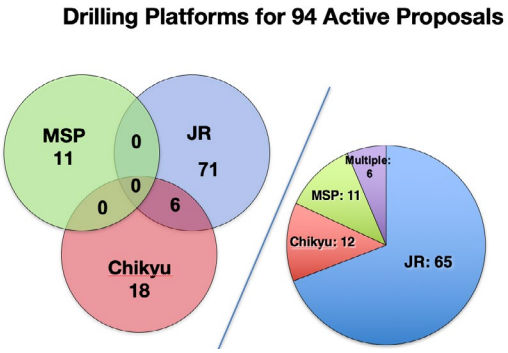
After each submission cycle the SSO compiles statistics and graphics that display various characteristics of the active proposals in the IODP system. Below are several figures that provide information about the current proposals, as of November 2018. (Figures are courtesy of Michiko Yamamoto and Holly Given, IODP SSO.)

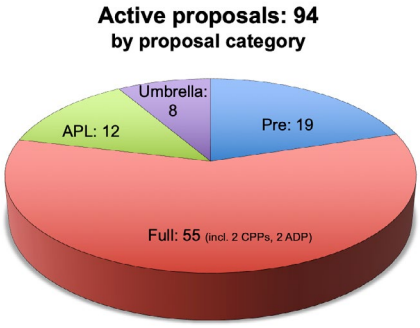








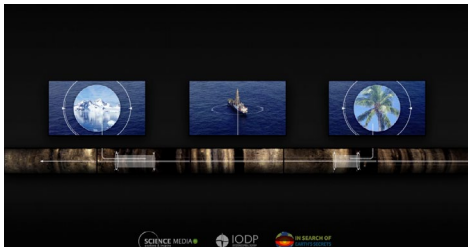




IODP Community Video Resources

In an effort to provide informative and instructive resources for the IODP community, a series of videos was recently developed and released on the *JOIDES Resolution* YouTube channel (https://www.youtube.com/user/theJOIDESResolution). The subjects of the three videos are varied, but the goal of all three was to address specific needs and frequently asked questions from IODP community members.

Antarctic Scientific Deep Sea Drilling: A Long History. Follow the journey into Antarctica's past to better understand it's future. How much sea level rise can we expect from Antarctica, and when? Take a look at the past 50 years of Antarctic scientific drilling in this video. From the Deep Sea Drilling Project's expeditions on the *Glomar Challenger*, to ANDRILL and other projects based on the ice itself, to the International Ocean Discovery Program's most recent adventure to the Ross Sea. The scientific community has come a long way in understanding Antarctica through scientific drilling. And there is still so much more to discover.



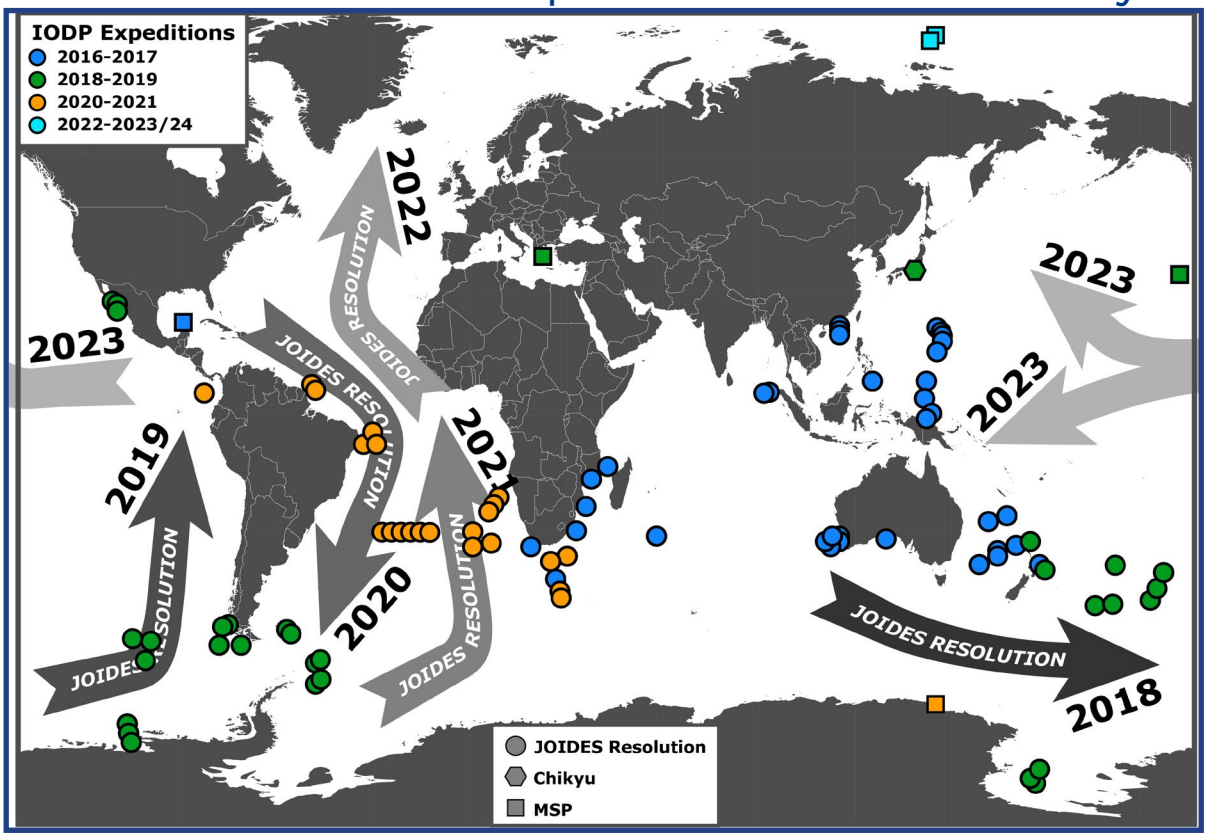
In Search of Earth's Secrets. Ever wonder how we know so much about Earth's history? Scientists travel back in time using cores of rock or sediment from the seafloor. Fossils of animal or plant remains tell us detailed stories of what the earth looked and felt like hundreds or even millions of years ago. Evidence found in these cores helps us understand why the dinosaurs went extinct or how the climate shifted between warm and cold periods. Scientists can even better predict earthquakes or discover new life forms.

Winner of the 2018 NSF Vizzies Challenge

Exploring Zealandia Video Series. This video series, developed during IODP Expedition 371 (Tasman Frontier Subduction Initiation and Paleogene Climate) documents the unique challenges of exploring a newly discovered continent: Zealandia. Beautiful drone shots paired with laboratory footage and meetings highlight the scientific process of testing hypotheses and developing new theories and paradigms.

What resources would you like to see in the future? Email usssp@ldeo.columbia.edu and let us know!
https://www.youtube.com/user/theJOIDESResolution

The *JOIDES Resolution* Ship Track: From Summer 2016 and Beyond



Map modified with permission from the IODP-JRFB

2018 - 2021 IODP EXPEDITION SCHEDULE

Platform	#	Expedition	Dates	Ports
	358	NanTroSEIZE: Plate Boundary Deep Riser 4	Through 3/19	
	368X	Return to Hole U1503A (South China Sea)	11/15/18 - 12/8/18	Hong Kong Hong Kong
	379	Amundsen Sea West Antarctic Ice Sheet History	1/18/19 - 3/20/19	Punta Arenas, Chile - Punta Arenas, Chile
	382	Iceberg Alley and Subantarctic Ice and Ocean Dynamics	3/20-18 - 5/20/19	Punta Arenas, Chile - Punta Arenas, Chile
	383	Dynamics of Pacific Antarctic Circumpolar Current	5/20/19 - 7/20/19	Punta Arenas, Chile - Punta Arenas, Chile
	385T	Panama Basin Crustal Architecture (504B) and Restoring Hole 896A	8/18/19 - 9/16/19	Antofagasta, Chile - San Diego, California
	389	Hawaii Drowned Reefs	09/19 - 10/19	
	385	Guaymas Basin Tectonics and Biosphere	9/16/19 - 11/16/19	San Diego, California - San Diego, California
	378	South Pacific Paleogene Climate	1/3/20 - 3/4/20	Fiji - Papeete, Tahiti
	384	Engineering Testing	3/4/20 - 4/26/20	Papeete, Tahiti - Barbados
	387	Amazon Margin	4/26/20 - 6/26/20	Barbados - Recife, Brazil
	388	Equatorial Atlantic Gateway	6/26/20 - 8/26/20	Recife, Brazil - Recife, Brazil
	390	South Atlantic Transect 1	10/5/20 - 12/5/20	Rio de Janeiro, Brazil - Cape Town, South Africa
	391	Walvis Ridge Hotspot	12/5/20 - 2/4/21	Cape Town, South Africa - Cape Town, South Africa
	392	Agulhas Plateau Cretaceous Climate	2/4/21 - 4/6/21	Cape Town, South Africa - Cape Town, South Africa
	393	South Atlantic Transect 2	4/6/21 - 6/6/21	Cape Town, South Africa - Rio de Janeiro, Brazil

JOIDES Resolution
Chikyu
Mission Specific Platform