FY19 Annual Report

International Ocean Discovery Program

JOIDES Resolution Science Operator

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National Science Foundation

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Brad Clement

Director,
International Ocean Discovery Program,
Texas A&M University

Brad Clement was appointed Director of the International Ocean Discovery Program at Texas A&M University in August 2009. Clement previously chaired the U.S. Science Advisory Committee and has a long history of involvement with the Program, having sailed on four expeditions, worked as an Ocean Drilling Program Staff Scientist, and served on the JOIDES Ocean History Panel. Clement earned his B.S. in Geology from the University of Georgia (1979) and his M.A. (1981) and Ph.D. (1985) in Geology from Columbia University. He previously served as Associate Program Director for the Ocean Drilling Program in the National Science Foundation's Ocean Sciences Division from 2001 to 2003, as a Professor in the Department of Earth and Environmental Science at Florida International University from 1988 to 2009, and as Adjunct Associate Professor of Geophysics at Texas A&M University from 1984 to 1988. Clement was Associate Editor of the *Journal of Geophysical Research* and has served on several American Geophysical Union committees.

Mitch Malone

Assistant Director and Manager of Science Support,
International Ocean Discovery Program,
Texas A&M University

Mitch Malone was appointed Assistant Director of the International Ocean Discovery Program at Texas A&M University and Manager of Science Operations in 2011. Malone began working for the Ocean Drilling Program as a Staff Scientist in 1995, and after transitioning into the Integrated Ocean Drilling Program as a Staff Scientist in 2003, he held the positions of Supervisor of Science Support (2004–2006), Manager of Science Operations (2006–2011), and Acting Director (2008). During Malone's tenure, he has sailed on 10 Ocean Drilling Program and Integrated Ocean Drilling Program expeditions. Malone earned his B.A. in Geography from the University of Texas at Austin (1986) and his M.S. (1989) and Ph.D. (1995) in Geology from Duke University. He has also been an adjunct faculty member in the Texas A&M University Departments of Geology and Geophysics since 1996 and Oceanography since 2005. Malone was an Associate Editor of the *Journal of Sedimentary Research* from 1999 to 2004.

Historical perspective

From October 2018 through September 2019, the international marine research collaboration called the International Ocean Discovery Program (IODP) monitored subseafloor environments and explored Earth's history and dynamics as recorded in seafloor sediments and rocks. IODP built on the earlier successes of the Deep Sea Drilling Project (DSDP), Ocean Drilling Program (ODP), and Integrated Ocean Drilling Program, which revolutionized our view of Earth's history and global processes through ocean basin exploration.

The Integrated Ocean Drilling Program and IODP expanded on the predecessor programs through the use of multiple drilling platforms operated by three implementing organizations (IOs) to achieve the Program's goals. The riserless research vessel *JOIDES Resolution*, a research facility managed for IODP by Texas A&M University (TAMU) as the *JOIDES Resolution* Science Operator (JRSO), continues to expand the global sampling coverage and disciplinary breadth that were characteristic of DSDP and ODP. The riser drilling vessel *Chikyu*, operated by Japan's Center for Deep Earth Exploration (CDEX), allows extended drilling for several months at a single location. Mission-specific platforms operated by the European Consortium for Ocean Research Drilling (ECORD) Science Operator (ESO) allow drilling in environments unsuitable for either the *JOIDES Resolution* or the *Chikyu*, such as locations near the shoreline in shallow-water areas and in climatically sensitive or ice-covered regions. Consistency from one expedition to the next is ensured through provision of an Expedition Project Manager/Staff Scientist from the IO responsible for operating the expedition's platform.

Each IODP platform provider utilizes a Facility Board to make decisions on the effective use of its drilling facility in fulfilling the objectives of the IODP Science Plan, "Illuminating Earth's Past, Present, and Future," and each of the IOs provides liaisons with appropriate expertise to interact with the Facility Boards and other Program working groups and task forces. The *JOIDES Resolution* Facility Board (JRFB) is informed by advisory panels—the *JOIDES Resolution* Facility (JRF) Science Evaluation Panel (SEP) and the JRF Environmental Protection and Safety Panel (EPSP)—to evaluate the science, sites, environmental protection, and safety of hypothesis-driven science expedition proposals aligned with principal research themes outlined in the IODP science plan.

IODP facilities are funded by three platform providers (the US National Science Foundation [NSF], Japan's Ministry of Education, Culture, Sports, Science and Technology [MEXT], and ECORD) with financial contributions from the People's Republic of China Ministry of Science and Technology (MOST); the Coordination for Improvement of Higher Education, Brazil (CAPES); the Interim Asian Consortium, represented by the Korea Institute of Geoscience and Mineral Resources (KIGAM); the Australian and New Zealand IODP Consortium (ANZIC) funded by the Australian Research Council (ARC) and GNS Science (New Zealand); and the Ministry of Earth Sciences (MoES), India. Together, these agencies represent 26 participating nations whose scientists are selected to staff IODP research expeditions conducted throughout the world's oceans.

The *JOIDES Resolution* at port.

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1. Executive summary

Texas A&M University (TAMU) acts as manager and science operator of the research vessel *JOIDES Resolution* as a research facility for the International Ocean Discovery Program (IODP). Administrative services in support of *JOIDES Resolution* Science Operator (JRSO) activities are provided by the Texas A&M Research Foundation (TAMRF) through TAMU Sponsored Research Services (SRS).

JRSO scope of work

As the science operator of the *JOIDES Resolution* research facility, the JRSO provides wireline coring and logging services along with technical, science, operations, engineering, and IT support; curates core materials; develops data applications and manages digital databases; and publishes pre-expedition and postexpedition reports and results. All of these Program activities are conducted in accordance with direction provided by the Program's advisory panels and the JRFB and as outlined in approved Annual Program Plans.

The scope of activities associated with initial planning and preparation of IODP expeditions is similar to early Integrated Ocean Drilling Program activities in terms of deliverables, challenges, and risks. In addition, the JRSO carries out postexpedition activities related to IODP expeditions and ongoing operational tasks (e.g., completing reports and technical documentation), completing legacy work (e.g., producing scientific publications), conducting long-lead planning work in preparation for expeditions scheduled for future fiscal years, and providing all necessary clearances and environmental assessments for IODP expeditions conducted by the JRSO.

On behalf of the JRSO and as outlined in this Annual Report, TAMRF contracted with ODL AS for the services of the *JOIDES Resolution* and with Schlumberger Technology Corporation (Schlumberger) for the provision of downhole logging equipment and engineering support.

FY19 overview

During fiscal year 2019, the JRSO completed three full-length expeditions and two shorter expeditions to advance global understanding of Earth systems and processes. Postexpedition research on the collected sediments and materials from these expeditions will improve our understanding of the breakup of the

IODP JRSO FY19 expedition summary.

Expedition	Operations time (days)	Distance traveled (nmi)	Sites (number)	Holes (number)	Meters cored	Cores recovered (number)	Core recovery (%)	Holes logged (number)
368X: Return to Hole U1503A (South China Sea)	18.58	567	1	1	715.0	87	25	1
379: Amundsen Sea West Antarctic Ice Sheet History	35.45	3,670	2	11	1,276.0	151	85	0
382: Iceberg Alley and Subantarctic Ice and Ocean Dynamics	41.99	2,430	5	18	3,228.4	415	87	1
383: Dynamics of the Pacific Antarctic Circumpolar Current	36.13	5,416	6	19	2,648.7	310	100	0
385T: Panama Basin Crustal Architecture and Deep Biosphere: Revisiting Holes 504B and 896A	11.24	4,503	2	2	0.0	0	0	0
Totals	**143.39**	**16,587**	**16**	**51**	**7,868.1**	**963**	**85**	**2**

Note: Operations time = time on site (does not include transits, waiting on weather, or breakdown time).

northern South China Sea (SCS) margin; the relationship between climate and ocean change and the evolution of the West Antarctic Ice Sheet (WAIS); the cyclicity of ice sheet advance and retreat processes, bottom water circulation, and water mass changes; and the links between Antarctic Ice Sheet (AIS) variability and global sea level.

The Co-Chief Scientist review and the National Science Foundation (NSF) review panel again culminated in positive feedback that congratulated the JRSO for its excellent management of an aging facility that continues to successfully address the diverse science questions of the IODP Science Plan. Activities in response to the previous year's facility review included facilitating an effective outreach program on board the *JOIDES Resolution* and simplifying the process for reporting expedition-related publications by expedition science party members.

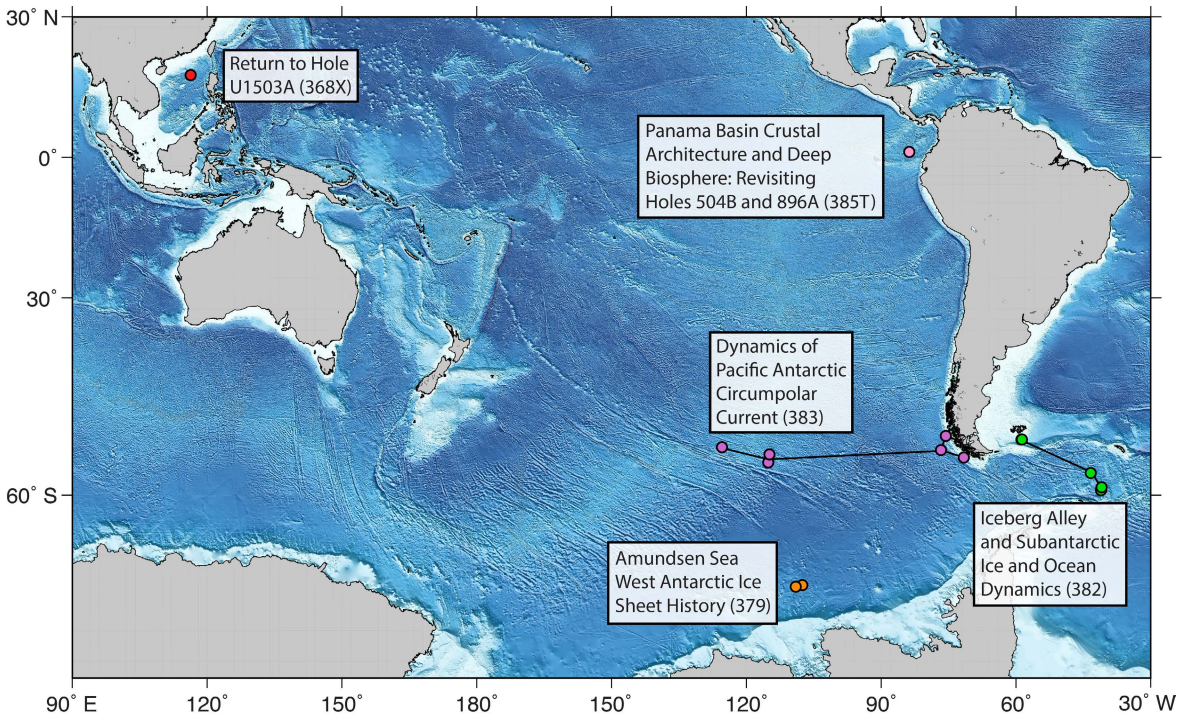
This IODP JRSO FY19 Annual Report details these accomplishments and other activities undertaken in support of NSF Cooperative Agreement OCE-1326927 during the period from 1 October 2018 to 30 September 2019.

2. Expedition operations

Expedition 368X: Return to Hole U1503A (South China Sea)

Expedition 368X, South China Sea Rifted Margin (15 November–8 December 2018), is the third of three expeditions that form the South China Sea Rifted Margin program. Expeditions 367, 368, and 368X shared the common key objectives of testing scientific hypotheses of breakup of the northern SCS margin and comparing its rifting style and history to other nonvolcanic or magma-poor rifted margins. The four primary sites for the overall program are located in the continent–ocean transition (COT) zone and range from the outer margin high to the interpreted steady-state oceanic crust of the SCS.

FY19 expedition sites.



The main scientific objectives for the South China Sea Rifted Margin program include (1) determining the nature of the basement in crustal units across the COT of the SCS that are critical to constrain style of rifting, (2) constraining the time interval from initial crustal extension and plate rupture to the initial generation of igneous ocean crust, (3) constraining vertical crustal movements during breakup, and (4) examining the nature of igneous activity from rifting to seafloor spreading. In addition, sediment cores from the drill sites targeting primarily tectonic and basement objectives will provide information on the Cenozoic regional environmental development of the Southeast Asia margin.

The drilling strategy for Expedition 368X was to finish the operational objectives of Expedition 368 in Hole U1503A, including coring the lowermost sediments and basement and logging the hole. Postexpedition research on the recovered sediments and basalt will enable determination of emplacement age and geochemical analyses of rock composition and assessment of melting processes and age of crystallization. The combination of such analyses will contribute to geochemical or thermomechanical modeling that will constrain mantle origin and melting processes leading to the formation of these basalts.

Expedition 379: Amundsen Sea West Antarctic Ice Sheet History

The Amundsen Sea sector of Antarctica has long been considered the most vulnerable part of the WAIS because of the great water depth at the grounding line and the absence of substantial ice shelves. Glaciers in this configuration are thought to be susceptible to rapid or runaway retreat. Ice flowing into the Amundsen Sea Embayment is undergoing the most rapid changes of any sector of the Antarctic Ice Sheet outside the Antarctic Peninsula, including changes caused by substantial grounding-line retreat over recent decades, as observed from satellite data. Warm Circumpolar Deep Water (CDW) is impinging onto the Amundsen Sea shelf and causing melting of the underside of the WAIS in most places. Reconstructions of past CDW intrusions can assess the ties between warm water upwelling and large-scale changes in past grounding-line positions.

Expedition 379, Amundsen Sea West Antarctic Ice Sheet History (18 January–20 March 2019), conducted operations in the Amundsen Sea with the following main objectives: (1) to test the hypothesis that WAIS collapses occurred during the Neogene and Quaternary and, if so, when and under which environmental conditions; (2) to obtain ice-proximal records of ice sheet dynamics in the Amundsen Sea that correlate

From left: Chilean fjords at the ship's bow. Filtering pore water for geochemical analyses. Looking through a Munsell color chart.

with global records of ice-volume changes and proxy records for atmospheric and ocean temperatures; (3) to study the stability of a marine-based WAIS margin and how warm deep-water incursions control its position on the shelf; (4) to find evidence for earliest major grounded WAIS advances onto the middle and outer shelf; and (5) to test the hypothesis that the first major WAIS growth was related to the uplift of the Marie Byrd Land dome.

Sites U1532 and U1533 on the continental rise provided unique records that will enable study of the cyclicity of ice sheet advance and retreat processes as well as bottom water circulation and water mass changes. In addition, a dominant feature of the recovered cores is lithofacies cyclicity. Initial comparison of these cycles to published records from the region suggests that the units interpreted as records of warmer time intervals in the core tie to interglacial periods and the units interpreted as deposits of colder periods tie to glacial periods. Records from the continental rise reveal the timing of glacial advances across the shelf and thus the existence of a continent-wide ice sheet in West Antarctica at least during longer time periods since the late Miocene. Cores from both sites contain abundant coarse-grained sediments and clasts of plutonic origin transported either by downslope processes or by ice rafting. If detailed provenance studies confirm our preliminary assessment that the origin of these samples is from the plutonic bedrock of Marie Byrd Land, their thermochronological record will potentially reveal timing and rates of denudation and erosion linked to crustal uplift. The chronostratigraphy of both sites enables generation of a seismic sequence stratigraphy not only for the Amundsen Sea continental rise but also for the western Amundsen Sea along the Marie Byrd Land margin through a connecting network of seismic lines. Sea ice conditions prevented accessing any of the primary or alternate sites on the shelf.

Expedition 382: Iceberg Alley and Subantarctic Ice and Ocean Dynamics

The Subantarctic Front contourite drift, deposited on the northern flank of an east-west–trending trough off the Chilean continental shelf, is ideally situated to monitor millennial- to orbital-scale variability in the export of Antarctic Intermediate Water beneath the Subantarctic Front. Expedition 382, Iceberg Alley and Subantarctic Ice and Ocean Dynamics (20 March–20 May 2019), recovered continuously deposited late Neogene sediment from five sites drilled east of the Drake Passage: two sites at the northern edge of the Scotia Sea and three sites in the southern Scotia Sea.

Sites U1534 and U1535 are expected to yield a wide array of paleoceanographic records that can be used to interpret millennial- to orbital-scale variability in Antarctic Intermediate Water beneath the Subantarctic Front in the Atlantic sector of the Southern Ocean, giving insights into the role and evolution of the Pacific-to-Atlantic cold-water route over climate episodes like the most recent warm interglacials of the late Pleistocene and the intensification of Northern Hemisphere glaciation.

“Iceberg Alley” is the main pathway along which icebergs calved from the margin of the AIS travel as they move equatorward into the warmer waters of the Antarctic Circumpolar Current (ACC). Ice-rafted detritus in sediments collected at Sites U1536–U1538 in Iceberg Alley will allow assessment of the magnitude and location of iceberg discharge from the AIS during key times of ice sheet evolution, in particular past glacial terminations during the Neogene. These sites will also enable study of interhemispheric phasing of ice sheet growth and decay, the distribution and history of land-based versus marine-based ice sheets around the continent over time, and the links between AIS variability and global sea level.

By comparing north–south variations across the Scotia Sea between the Pirie Basin (Site U1538), the Dove Basin (Sites U1536 and U1537), and the Subantarctic Front (Sites U1534 and U1535), Expedition 382 will also deliver critical information on how climate changes in the Southern Ocean affect ocean circulation through the Drake Passage, meridional overturning in the region, water mass production,

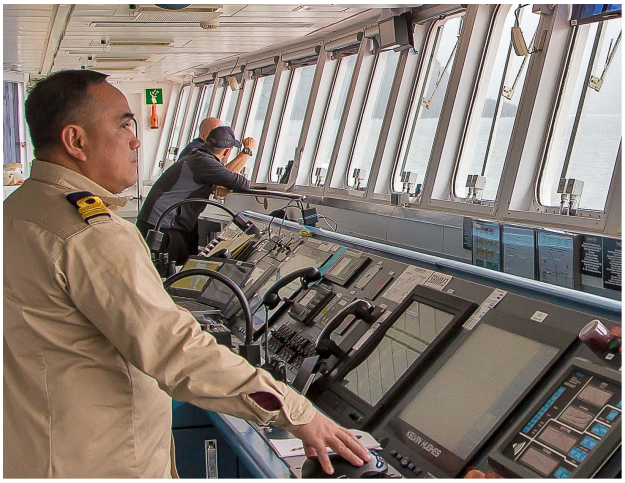
ocean-atmosphere CO_2 transfer by wind-induced upwelling, sea ice variability, bottom water outflow from the Weddell Sea, Antarctic weathering inputs, and changes in oceanic and atmospheric fronts in the vicinity of the ACC. Comparing changes in dust proxy records between the Scotia Sea and Antarctic ice cores will also provide a detailed reconstruction of changes in the Southern Hemisphere westerlies on millennial and orbital timescales for the last 800 ky. Extending the ocean dust record beyond the last 800 ky will help to evaluate dust-climate couplings since the Pliocene, the potential role of dust in iron fertilization and atmospheric CO_2 drawdown during glacials, and whether dust input to Antarctica played a role in the mid-Pleistocene transition.

Expedition 383: Dynamics of the Pacific Antarctic Circumpolar Current

The ACC is the world's strongest zonal current system. It connects all three major ocean basins of the global ocean and integrates and responds to global climate variability. Its flow is largely driven by strong westerly winds and is constricted to its narrowest extent in the Drake Passage. Transport of fresh and cold surface and intermediate water masses through the Drake Passage (cold-water route) strongly affects the Atlantic Meridional Overturning Circulation and the inflow of Indian Ocean water masses (warm-water route). Both oceanographic corridors are critical for the South Atlantic contribution to Meridional Overturning Circulation changes.

In contrast to the Atlantic and Indian sectors of the ACC and with the exception of drill cores from the Antarctic continental margin and off New Zealand, deep-sea drilling records of the Pacific sector of the ACC lack information on its Cenozoic paleoceanography. To advance knowledge and understanding of Miocene to Holocene atmosphere-ocean-cryosphere dynamics in the Pacific and their implications for regional and global climate and atmospheric CO_2, Expedition 383, Dynamics of the Pacific Antarctic Circumpolar Current (DYNAPACC) (20 May–20 July 2019), recovered sedimentary sequences at (1) three sites located in the central South Pacific (U1539–U1541), (2) two sites at the Chilean margin (U1542 and U1544), and (3) one site from the pelagic eastern South Pacific close to the entrance to the Drake Passage (U1543). Sea state prevented occupation of the southernmost site in the central South Pacific.

Sediments from Sites U1541 and U1543 reach back to the late Miocene, and those at Site U1540 reach back to the early Pliocene. High-sedimentation-rate Pleistocene sedimentary sequences were drilled both in the central South Pacific and along the Chilean margin. Taken together, the sites represent a



From left: *JOIDES Resolution* 2nd officer navigating the Chilean fjords. One of many icebergs encountered in Iceberg Alley.

depth transect from ~1100 m at Site U1542 in the Chilean margin to ~4070 m at Site U1539 in the central South Pacific and enable investigation of changes in the vertical structure of the ACC, a key issue for understanding the role of the Southern Ocean in the global carbon cycle. The sites are located at latitudes and water depths where sediments will allow the application of a wide range of siliciclastic-, carbonate-, and opal-based proxies to address expedition objectives of reconstructing with unprecedented stratigraphic detail surface to deep-ocean variations and their relation to atmosphere and cryosphere changes through stadial to interstadial, glacial to interglacial, and warmer than present time intervals.

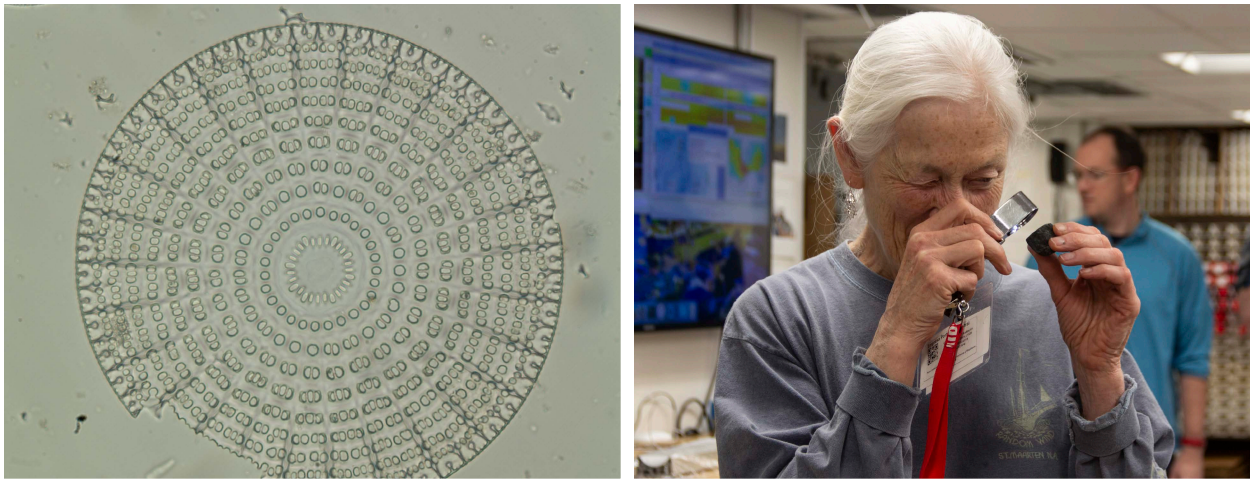
Expedition 385T: Panama Basin Crustal Architecture and Deep Biosphere (Revisiting Holes 504B and 896A)

Expedition 385T, Panama Basin Crustal Architecture and Deep Biosphere (Revisiting Holes 504B and 896A) (18 August–16 September 2019), took advantage of a transit of the *JOIDES Resolution* from Antofagasta, Chile, to San Diego, California (USA), to accomplish new sampling and data collection from legacy borehole observatories in Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP) Holes 504B and 896A on the southern flank of the Costa Rica Rift. Scientific objectives were to collect (1) new Formation MicroScanner logs from Hole 504B for improving lithologic interpretations of crustal architecture at this archetype deep oceanic crust hole and (2) fluid samples from both holes for evaluating the crustal deep biosphere in deep and warm oceanic crust.

Accomplishing both of these scientific objectives required the removal of old wireline CORK observatories, including associated inflatable packers that were installed in the cased boreholes in 2001. Despite successfully removing the CORK wellhead platforms from both holes, we were unable to remove the packers stuck in casing at both, thus precluding accomplishing any of the expedition scientific objectives.

3. Management and Administration

The JRSO's organizational structure directly reflects the responsibilities specified by NSF for technical and scientific management, administration, and operation of the *JOIDES Resolution*, including planning, coordinating, overseeing, reviewing, and reporting activities. The TAMU portion of the organization consists of four departments: Science Operations (SciOps); Technical and Analytical Services (TAS); Development,



From left: *Arachnodiscus* sp. (diatom). Examining a dropstone under a hand lens.

Information Technology, and Databases (DITD); and Publication Services (Pubs). Managers of these departments report to the JRSO Director, who is responsible for the Program's overall management and performance. The Human Resources and Curation groups are part of the Director's Office.

On-site administrative staff members dedicated to JRSO support are overseen by a General Manager who reports to the Executive Director of TAMU SRS. This separate reporting chain ensures that the administrative unit retains the independence to ensure regulatory compliance while working directly with JRSO staff to efficiently implement the Program. The Director's Office and the Administrative Services group combined serve as the Management and Administration group.

Reporting and liaison activities

The JRSO reports to and liaises with funding agencies and IODP-related agencies (e.g., *JOIDES Resolution* Facility Board [JRFB], JRFB advisory panels, Program Member Offices [PMOs], and other national organizations and facility boards) and participates in facility board, advisory panel, and IODP Forum meetings. Minutes from the facility board meetings are available online (http://iodp.org/facility-boards).

The JRFB includes liaisons from the European Consortium for Ocean Research Drilling (ECORD) and the Institute for Marine-Earth Exploration and Engineering (MarE3), and the *Chikyu* and ECORD Facility Boards each include a JRSO liaison. This year, JRSO representatives participated in the Science Evaluation Panel (SEP) meetings in January and June, the ECORD Facility Board meeting in March, the JRFB meeting in May, the NEXT: Scientific Ocean Drilling Beyond 2023 workshop in May, the US Advisory Committee (USAC) meetings in January and July, and the IODP Forum meeting and IODP PMO meeting in September. Senior JRSO staff attended the United States Science Support Program (USSSP) leadership meeting on 12 December.

The JRSO hosted the following postexpedition meetings in College Station, Texas:

- JRSO Expedition 372/375 editorial meeting, 5–9 November
- JRSO Expedition 376 editorial meeting, 3–7 December
- JRSO Expedition 368X editorial meeting/sampling party, 15–25 April
- JRSO Expedition 379 editorial meeting/sampling party, 15–22 August

Project portfolio management

M&A managed large cross-departmental tasks and projects through teams using a formal project portfolio management (PPM) approach to identify, categorize, review, evaluate, select, and prioritize proposed projects. Projects closed, continued, or planned during FY19 are listed below.

The JRSO completed the West Campus Data Center Move project and put the Data Publishing project on hold.

The JRSO continued work on the following projects:

- GEODESC
- DESClogik Replacement
- SampleMaster Replacement
- JR Communications Update

Facility assessment

The JRSO hosted a facility review on 25 and 26 February during which eight of the ten FY18 expedition Co-Chief Scientists assessed the JRSO's performance in implementing FY18 Expeditions 369 and 372–376. Their findings were compiled in a report that was presented at the NSF Review Panel for Ocean Sciences site visit held 7 and 8 August to assess the JRSO's performance as a facility in meeting the needs of IODP in fulfilling its Science Plan. The site visit panel concluded that "the JRSO provides a facility that meets and often exceeds the needs of the IODP Science Plan" and "is well positioned to effectively support the IODP Science Plan through its final years and support the science drilling community through FY24."

4. Subcontractors

The Administrative Services department managed subcontracts with ODL AS for ship services and Schlumberger for wireline logging services. Administrative Services staff reviewed subcontractor invoices prior to payment and ensured financial compliance with cost allowability and other contractual requirements.

The JRSO continued to interact with ODL AS to ensure efficient and compliant operations of the *JOIDES Resolution*. The JRSO and ODL AS executed a restatement of the TAMRF/ODL contract that simplified the document by removing irrelevant material and condensing amendments into cohesive text.

The JRSO continued to interact with Schlumberger Technology Corporation (Schlumberger) to ensure that wireline logging operations aboard the *JOIDES Resolution* continue in an efficient and compliant manner and to streamline travel and shipping activities. The JRSO recompeted the wireline logging subcontract by issuing a call for proposals. Schlumberger was the sole respondent, and a fully executed contract is in place.

5. Science Operations

The Science Operations (SciOps) department provides scientific and operational planning and implementation for *JOIDES Resolution* drilling expeditions by leading the scoping, planning, and implementation of science expeditions; interacting with and providing technical oversight to the drilling and logging

From left: Paleomagnetic cube sample. Using the rock saw to cut a paleomagnetic cube sample from mudstone. Sunrise from the *JOIDES Resolution*.

subcontractors; conducting long-range operational planning for out-year JRSO expeditions; and utilizing IODP resources to oversee engineering development projects.

Expedition planning, implementation, and scientific leadership

The JRSO hosted the following pre-expedition meetings in College Station:

- JRSO FY20 Expedition 387 (Amazon Margin), 28 and 29 March
- JRSO FY20 Expedition 388 (Equatorial Atlantic Gateway), 6 and 7 February

Routine planning activities occurred for FY19 and FY20 expeditions throughout the year. The Expedition 382 and 383 Expedition Project Managers (EPMs) met with some members of their science parties at the American Geophysical Union (AGU) Fall Meeting in December. Videoconferencing and conference calls were held for EPMs to discuss laboratory methods and operations with the Expedition 385T and FY20 Expedition 385 (Guaymas Basin Tectonics and Biosphere) science parties, to address questions regarding third-party tools (e.g., water-sampling tool, incubators, hybridization ovens), and for initial Co-Chief Scientist presentations to the FY20 Expedition 387 and 388 science parties.

The Expedition 385T title was changed to better reflect addition of the second Ancillary Project Letter (APL), and the JRSO also worked on addressing essential engineering issues associated with removing the wireline-deployed observatories from DSDP Hole 504B and ODP Hole 896A.

An addendum to the Expedition 378 (South Pacific Paleogene Climate) *Scientific Prospectus* was published to document the change in starting port and revised operational plan that resulted from the revision of the schedule due to the replacement of the propellers.

The JRSO ordered new bits (tricone tungsten-carbide bits, a hybrid roller cone/polycrystalline diamond [PDC] bit, and a PDC bit), one new underreamer, and related support equipment that will be tested during FY20 Expedition 384 (Engineering Testing).

Expedition staffing

Science staffing was initiated or completed this year for Expeditions 378, 382, 383, 379T, 385T, 385, 387, and 388.

IODP JRSO FY19 expedition science staffing breakdown.

	Expedition					
Member country/consortium	**368X**	**379**	**382**	**383**	**385T**	**Total**
United States Science Support Program (USSSP)	1	11*†	13*†	11*†	8**†	44
Japan Drilling Earth Science Consortium (J-DESC)	0	3	3	2	0	8
European Consortium for Ocean Research Drilling (ECORD) Science Support and Advisory Committee (ESSAC)	3	11*†	9*	9*	0	32
Korea Integrated Ocean Drilling Program (K-IODP)	0	1	1	1	0	3
IODP-China	4	2	2	2	0	10
Australia/New Zealand IODP Consortium (ANZIC)	0	1	1	2	0	4
India Ministry of Earth Science (MoES)	0	1	1	1	0	3
Coordination for Improvement of Higher Education (IODP-Brazil)	0	1	1	2	0	4
Total Science Party Participants	**8**	**31**	**31**	**30**	**8**	**108**

Notes: * = includes one Co-Chief Scientist. ** = includes two Co-Chief Scientists. † = includes Onboard Education/Outreach Officer(s) (EOOs). Expedition 385T science staffing was limited to the number of scientists required to complete the Ancillary Project Letter (APL) proposals. Numbers do not include observers that become part of the Science Party.

Logistics support

Operational ship supplies were acquired and shipped preceding all FY19 expedition port calls.

Clearance/Environmental permitting/Risk management

The Environmental Protection and Safety Panel (EPSP) and the TAMU Safety Panel (SP) met twice (12 February and 4–6 September) to review and make recommendations on scheduled expeditions, proposals at the JRFB, and preview selected proposals at SEP.

The JRSO submitted the tentative Expedition 368X Science Party and crew list on 2 October, and clearance authorizations were received from Taiwan and China on 13 and 14 November, respectively.

A modification to the Antarctic waste permit for Expeditions 379, 382, and 383 was approved on 21 December. The environmental evaluation for these expeditions was completed for sites in Antarctic waters on 21 December, and the Antarctic radioisotope use request form was approved on 21 December. The JRSO submitted the Annual Antarctica Waste Report on 27 March. Authorization from the United Kingdom for Expedition 382 to conduct research in the Falkland Island Exclusive Economic Zone (EEZ) was obtained on 16 January, and authorization from Argentina to conduct research in the Islas Malvinas EEZ was obtained on 19 March.

The JRSO was notified 4 weeks prior to Expedition 383 that Chile required submission of an internal environmental assessment and later learned through investigation that the submission into the environmental review must be done by a Chilean national. A contact in Chile submitted the environmental assessment on the JRSO's behalf, which was reviewed positively before the expedition. Chile authorized the expedition on 31 May, 6 days after the ship left port. Because of the late authorization from Chile, the planned order of sites was changed to start in international waters and end in Chilean waters.

Chile also required an internal environmental assessment for Expedition 379T (JR100) in addition to permitting from the department of fisheries because of the biological sampling associated with the originally planned plankton tows. The proponents removed the biological sampling, and the JRSO worked with two different Chilean agencies to remove fisheries permitting from the requirements. On 11 June, Chile denied any scientific work in their territorial seas (<12 nmi) and in their inland waters, which was a

From left: The *JOIDES Resolution* searchlights highlighting icebergs, bergy bits, and growlers at night. Paleomagnetic cube samples ready for analysis in the superconducting rock magnetometer.

secondary objective of the expedition. A contact in Chile was engaged to submit the environmental assessment on the JRSO's behalf, and authorization from Chile to conduct research in the Chilean EEZ was obtained on 17 July, 3 days before the start of the expedition.

The JRSO submitted the marine scientific research (MSR) application for Expedition 385 to the US State Department on 19 January, and the US State Department submitted the application and diplomatic note to the Mexican government on 15 February. The JRSO submitted a list of all scientific participants and their corresponding primary and secondary Mexican embassies/consulates to Mexican authorities as a preparation step for obtaining the required Mexican Research Visa (Visa de Cooperante). The visa access code was not received until 11 September, which caused scientists and technical staff to have to scramble to obtain required visas before leaving home or at the San Diego, California, consulate. Despite the challenges, all participants who made it to port call obtained a Mexican visa. However, one participant could not obtain a US visa and was unable to join the ship at port call. In addition, it was determined that a brief port stop in Ensenada, Mexico, was required to comply with a US immigration regulation for non-US crew members to clear in a foreign port before returning to San Diego.

The Expedition 384 MSR application was submitted to the US State Department on 4 September, and required hard copies of the documentation were overnighted to the US Embassy in San Jose, Costa Rica.

Final documentation to meet Brazil MSR requirements was assembled, and the MSR application forms in English and Portuguese for FY20 Expeditions 387 and 388 were completed and submitted to the US State Department on 15 July and 12 August, respectively. The US State Department submitted the MSR application and diplomatic note for Expedition 387 to the Brazilian government on 12 August. In addition, cooperation agreements between TAMU and the Brazilian Co-Chief Scientist's institutions will be submitted to comply with clearance requirements. NSF approved the environmental evaluation required for acoustic activity scheduled for Expeditions 387 and 388.

The New Zealand government issued authorization to conduct research in New Zealand waters for FY20 Expedition 378 in August. In accordance with the New Zealand EEZ Act, an MSR notification to key Māori groups was issued on 27 June. ODL AS began investigating the best options for hull biofouling requirements for the lesser standard of a short-stay vessel for the site in New Zealand waters.

From left: Working in the core description laboratory. Exotic pebbles found at the top of a core.

Engineering support

The engineering section concluded efforts on a project to replace the obsolescent hydraulic power unit for the vibration-isolated television (VIT) camera winch. The VIT winch system was successfully tested during the transit from Subic Bay, Philippines, to Hong Kong.

Education/Outreach support

Shipboard berths were made available to accommodate Onboard Education and Outreach Officers (EOOs). JRSO staff participated in EOO training for Expeditions 382, 383, and 385; provided technical support for EOOs' live ship-to-shore broadcasting; and helped plan and execute public relations and outreach activities during port calls for FY19 Expeditions 383 and 385. A press conference and ship tours on 22 May were conducted in Punta Arenas, Chile, for members of the regional and national press, students and teachers of local high schools, and researchers from the Universidad de Magallanes. The press conference resulted in local articles and news spots on local and national television. As the first port call in the US lower 48 states since 2005, the Expedition 385 port call provided an opportunity for a wide range of outreach activities, including a symposium and reception at Scripps Institute of Oceanography and ship tours for 160 visitors from various universities in California and Mexico, staff friends and family, TAMU and NSF officials, and local media, which resulted in several news stories.

JRSO scientists mentored 15 college students this year through Staff Scientist science engagement activities, which culminated in presentations of students' work at the TAMU Geology & Geophysics research symposium, the TAMU student research week, and the Geological Society of America South-Central Joint Section Meeting in March. JRSO scientists also mentored high school students for TAMU's Mentor-Up College of Education program, served on the committees of seven Ph.D. students at TAMU and TAMU Galveston, taught GEOS 105 (Introduction to Environmental Geoscience), co-taught OCNG 251 (Oceanography), and started teaching the First Year Experience course in the TAMU College of Geosciences.

JRSO scientists contributed to IODP outreach efforts by organizing and co-teaching the IODP Past Antarctic Ice Sheet Dynamics (PAIS) Antarctic School in College Station in June, participating in the TAMU College of Geosciences Aggieland Saturday Open House and the Children's Museum of the Brazos Valley Ocean Camp, hosting training for the NSF-funded *JOIDES Resolution* Pop-Up/Drill Down Exhibit, and hosting core activities for Austin Community College students as part of another NSF-funded grant.

Legacy documentation

Copies of documents and reports produced by the JRSO on behalf of IODP, including expedition science and operations reports were archived electronically.

6. Technical and Analytical Services

The Technical and Analytical Services (TAS) department facilitates core flow and oversees laboratories. TAS stocks the shipboard laboratories; operates scientific measurement equipment and provides support to shipboard scientists; provides a supervisory and reporting structure for seagoing JRSO personnel; educates customers regarding laboratory and general shipboard safety; maintains, repairs, and develops scientific equipment at sea; provides support for downhole tools and measurements; works to ensure quality assurance/quality control (QA/QC) of measurements made in the shipboard laboratories; and supports shore-based laboratories.

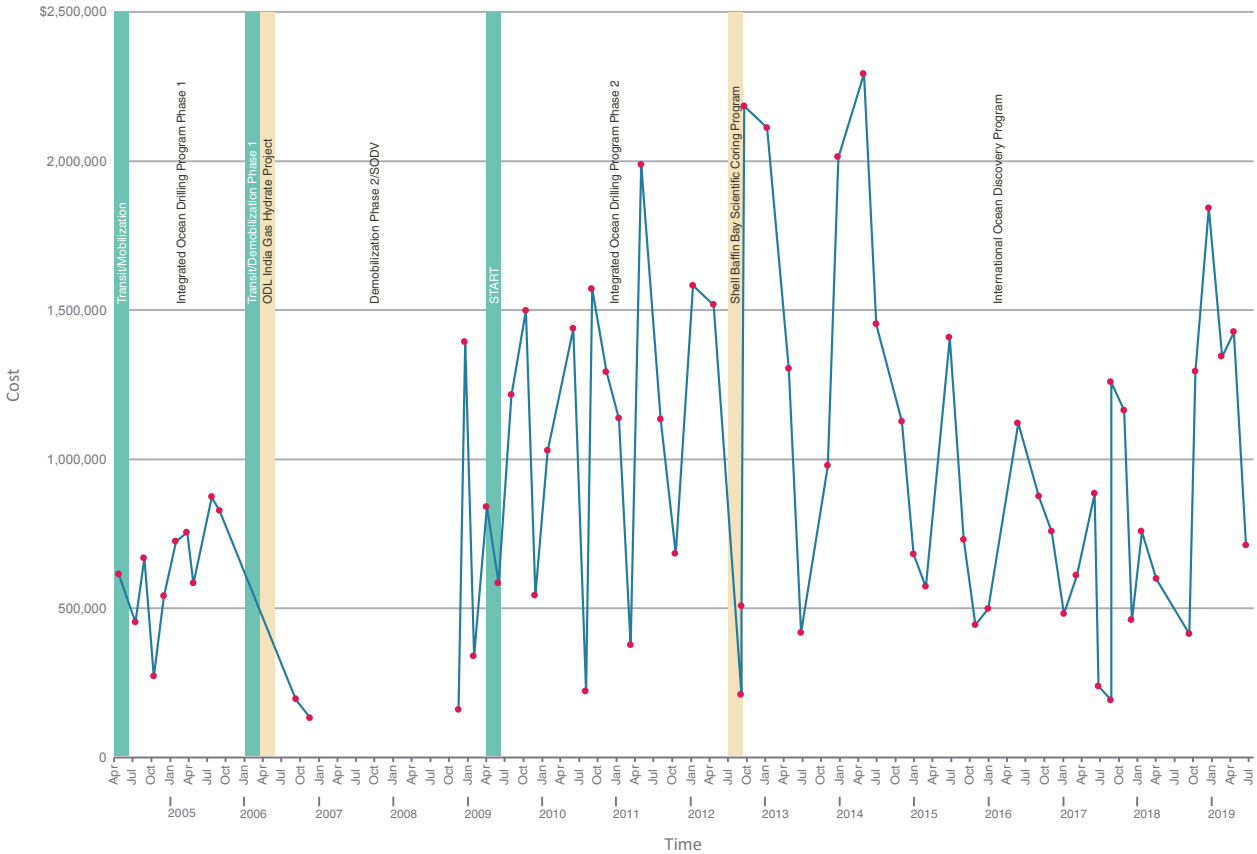
Analytical systems

The new X-Ray Imager (XRI) was installed on the Whole-Round Multisensor Logger (WRMSL) in the core track area. The system uses a continuous source (120 kV, 1 mA max power) and a high-resolution digital detector to provide the science party with X-ray images of whole- or half-round core sections. JRSO-developed software runs the instrument and reduces the raw image data to adjust brightness and contrast and to compensate for the geometric distortion of analyzing round samples.

The software and hardware for the track of the Natural Gamma Radiation (NGR) logger were upgraded to make the automated track compatible with all other shipboard track systems, and changes were made in the software to improve the calibration process and enhance quality control. Additional upgrades this year included replacement of the compressor on the superconducting rock magnetometer (SRM) and replacement of a faulty power supply on the X-ray diffractometer (XRD).

New equipment installed in the shipboard laboratories included a digital computer numeric control (CNC) mill to facilitate machining of replacement parts; a vacuum impregnation system to produce better quality thin sections; a Malvern Panalytical AERIS XRD to replace the aging Brüker AXS D4 ENDEAVOR; a spare X-ray source for the X-ray Imager; a Zeiss Axioscope A1 to replace the oldest upright microscope; a new color linescan camera for the Section Half Imaging Logger (SHIL); and high-pressure stainless steel air lines for the seismic G-Guns, which are used for vertical seismic profiling studies.

Actual ship fuel costs FY04–FY19.



Laboratory working groups

The Geochemistry and Microbiology, Geology, Geophysics, and Curation and Core Handling laboratory working groups (LWGs) include technical and science staff members and external participants who review cruise evaluations, expedition technical reports, and issues management communications to develop advice on corrective actions and potential developments on the *JOIDES Resolution* and on shore. The LWG technical and science leads attend Issues Management Team meetings to help management better prioritize the LWG efforts. The four LWGs provided advice on equipment acquisition and upgrades, improvements to methodologies and measurements, maintenance period activities, and ongoing quality assurance work during FY19.

Shipboard laboratory support

More than 5,800 core sections were processed through the shipboard laboratories during the five FY19 expeditions, and more than 25,000 samples were taken. Shipboard technical staff and expedition scientists made well over 2.5 million shipboard measurements on FY19 samples and placed more than 12,900 images (sections, close-ups, and microimages) in the database archive.

During the tie-up period, transit, and dry dock, TAS removed the old deck crane from the fantail; painted most of the laboratory floors, the gym floor, and the pallet stores floor; installed built-in bookshelves in the Science Lounge; and replaced older laboratory chairs with new ergonomic chairs.

7. Development, IT, and Databases

The Development, IT, and Databases (DITD) department oversees JRSO data collection/storage, management, and archiving; maintains information technology (IT) infrastructure on ship and shore; develops and maintains instrument-specific software for data acquisition; and manages the Programs' extensive databases.

Expedition data services and program-wide data query services

During expeditions, laboratory work aboard the *JOIDES Resolution* produces a vast amount of data that are stored in the Laboratory Information Management System (LIMS). LIMS data collected during JRSO

From left: Preparing solid samples for geochemical analyses. Learning how to draw three-dimensional objects during the JR Academy 2019.

Expeditions 368X, 379, 382, and 383 and non-IODP Expedition JR100 were successfully transferred to shore, merged with the cumulative LIMS database, and made available online to participating scientists. More than 76,250 downloads were made from the LIMS database during FY19.

Operation and maintenance

In response to a Texas A&M University System mandate to consolidate all "significant IT equipment" to an approved member or commercial data center by 1 September 2019, the JRSO migrated nearly all of its IT equipment to the TAMU West Campus Data Center in June.

8. Curation

Core Curation provides services in support of IODP core sampling and curation of the core collection archived at the Gulf Core Repository (GCR) and also supports the XRF core scanning facility at the GCR to provide scanning as Program measurements.

Sampling at the Gulf Core Repository

In FY19, the GCR processed a total of 10,084 sample requests and hosted sampling parties for Expeditions 368X and 379, during which an additional 1,800 and 11,000 samples, respectively, were taken.

Use of core collection and education and outreach activities

The GCR core collection was used for Program outreach through materials provided for display at meetings and museums, tours of the repository, and educational programs. This year, the GCR hosted TAMU classes for undergraduate and graduate students, a workshop for students from Austin Community College, and Summer Safari science camp middle school groups. JRSO staff gave tours of the GCR to more than 300 visitors, including representatives from the University of Svalbard in Norway, which is in the process of building a core repository.

Onshore XRF scanning

More than 1,300 core sections were scanned by XRF at the GCR this year, 231 cores were processed through the shore-based SHIL, and 35 were processed through the WRMSL.

9. Publication Services

The Publication Services (Pubs) department provides publications support services for JRSO drilling expeditions and editing, production, and graphics services for all required reports and scientific publications as defined in the JRSO cooperative agreement with NSF. IODP publications for FY19 included quarterly and annual reports for the JRSO; a *Scientific Prospectus*, *Preliminary Report*, and *Proceedings of the International Ocean Discovery Program* volume for each JRSO, Center for Deep Earth Exploration (CDEX), and ECORD Science Operator (ESO) expedition; and Data Reports for USIO and CDEX expeditions that concluded by the end of FY14.

Shipboard publications support and postexpedition editorial meetings

Publications Specialists sailed during all JRSO expeditions to coordinate shipboard reports. During postexpedition editorial meetings, Publications staff coordinate science reviews of all expedition reports

content and assist meeting participants with editing prior to publication. In FY19, JRSO staff in College Station, Texas, hosted postexpedition meetings for four JRSO expeditions.

IODP scientific publishing and publication coordination

IODP Publication Services produced and published seven *Scientific Prospectuses*, three *Preliminary Reports*, and eight Expedition Reports volumes for JRSO, CDEX, and ESO expeditions. During FY19, IODP Publication Services also coordinated postexpedition publications and published Expedition Research Results content for 15 expeditions, including 13 data reports.

Web services

The JRSO hosts web services for expeditions, publications, and legacy programs. In addition to internal JRSO web page updates and additions, new content is regularly added to IODP expedition web pages at http://iodp.tamu.edu/scienceops/expeditions.html.

All DSDP, ODP, Integrated Ocean Drilling Program, and IODP scientific publications are accessible online at the IODP Publications and legacy websites. Volumes are available as disk image or zip files so users can download the expedition reports portion of any IODP *Proceedings* volume. There were more than 92,000 visits to the IODP Publications website during FY19.

Bibliography and citation management

The Scientific Ocean Drilling Bibliographic Database is a subset of the American Geosciences Institute's (AGI's) GeoRef database and includes more than 36,000 entries related to IODP and the preceding scientific ocean drilling programs, representing a half century of scientific ocean drilling research. In FY19, more than 6,000 queries were run on the Scientific Ocean Drilling Bibliographic Database, and additional records for more than 7,800 citations were viewed.

Outreach support

Program scientific publications are accessible through CrossRef, an official digital object identifier (DOI) registration agency for scholarly and professional publications. Program publications accessed through CrossRef numbered more than 110,000 DOI resolutions for Integrated Ocean Drilling Program and IODP

From left: The *JOIDES Resolution* at sunset in San Diego. IODP JRSO Director Brad Clement conducting a ship tour for TAMU Vice President for Research Mark Barteau and TAMU President Michael Young.

publications and more than 149,000 DOI resolutions for DSDP and ODP publications. The JRSO also participates in CrossRef's "Cited-by Linking" and CrossMark validation services.

The JRSO deposited 99 chapters from Integrated Ocean Drilling Program and IODP Expeditions 302, 313, 339, 342, 344, 346, 352–355, 362, 366, 370, 380, and 381 into ScienceOpen, a professional networking research platform for scholars and publishers. The IODP collection can be viewed at https://www.scienceopen.com/collection/IODP_Publications. In addition, the JRSO deposited 1,495 records from expedition-related research published in outside literature into the expedition research results collection, which can be viewed at https://www.scienceopen.com/collection/8b0582f6-47bf-4988-b90a-8533135e6fcc.

This year, the JRSO began contributing publications metadata to TAMU's Symplectic Elements database, which feeds data to Altmetric.com, a platform that enables monitoring of the online activity surrounding academic research. The JRSO deposited DOIs of Integrated Ocean Drilling Program and IODP *Proceedings* volumes and data reports for Expeditions 301–357, 359–368, 370, and 380.

Legacy and archiving

The JRSO uses Archive-It to save publications to the Internet Archive, a long-term archive specializing in full website backups. The IODP publications website is now available at the Internet Archive, including full content from all Integrated Ocean Drilling Program and IODP volumes, and quarterly crawls incrementally update the archive with new files. In addition, the archive houses legacy publication sites for DSDP and ODP. At the end of FY19, the JRSO archive collection contained 1.2 TB of data and more than 6.7 million documents. The archive can be viewed at https://archive-it.org/collections/9148.

Progress reporting

JRSO operations and management reports were submitted to NSF for the following quarters:

- Fourth quarter of FY18 (July–September 2018) on 13 November 2018
- First quarter of FY18 (October–December 2018) on 6 February 2019
- Second quarter of FY18 (January–March 2019) on 22 April 2019
- Third quarter of FY18 (April–June 2019) on 12 August 2019

All reports are available at http://iodp.tamu.edu/publications/reports.html.

A chinstrap penguin contemplates a leap from a growler iceberg into the icy Scotia Sea.

URL list

Illuminating Earth's Past, Present and Future: The Science Plan for the International Ocean Discovery Program 2013–2023: http://iodp.org/about-iodp/iodp-science-plan-2013-2023

IODP Program Member Offices: http://www.iodp.org/about-iodp/program-member-offices

IODP Science Support Office: http://www.iodp.org/program-organization/science-support-office

JOIDES Resolution Facility Board and Panels: http://www.iodp.org/facility-boards

IODP JRSO website: http://iodp.tamu.edu

IODP JRSO FY19 Annual Program Plan: http://iodp.tamu.edu/publications/PP/IODP_JRSO_FY19_APP.pdf

IODP JRSO FY19 Quarterly Reports: http://iodp.tamu.edu/publications/reports.html

IODP expedition schedule: http://iodp.tamu.edu/scienceops/index.html

IODP expedition information: http://iodp.tamu.edu/scienceops/expeditions.html

Gulf Coast Repository: http://iodp.tamu.edu/curation/gcr/index.html

Core database: http://web.iodp.tamu.edu/OVERVIEW/

LIMS Reports: http://web.iodp.tamu.edu/LORE

Sample requests: http:/iodp.tamu.edu/curation/samples.html

IODP scientific publications: http://publications.iodp.org

Proceedings of the International Ocean Discovery Program: http://iodp.tamu.edu/publications/proceedings.html

Expedition-related citation lists: http://iodp.tamu.edu/publications/citations.html

Scientific Ocean Drilling Bibliographic Database: http://iodp.americangeosciences.org/

2019 Scientific Ocean Drilling Bibliographic Database and Publication Impact Report: http://iodp.tamu.edu/publications/AGI_studies/2019_Pub_Impact.pdf

HathiTrust DSDP digital collection: https://babel.hathitrust.org/cgi/mb?a=listis&c=1930557976

HathiTrust ODP digital collection: https://babel.hathitrust.org/cgi/mb?a=listis&c=1868324439

IODP Publications Archive-It collection: https://archive-it.org/collections/9148

IODP Publications ScienceOpen page: https://www.scienceopen.com/collection/IODP_Publications

IODP expedition-related outside literature ScienceOpen page: https://www.scienceopen.com/collection/8b0582f6-47bf-4988-b90a-8533135e6fcc

Acronyms

ACC	Antarctic Circumpolar Current
AGU	American Geophysical Union
AIS	Antarctic Ice Sheet
CDEX	Center for Deep Earth Exploration
CDW	Circumpolar Deep Water
CNC	computer numeric control
COT	continent–ocean transition
DOI	digital object identifier
DSDP	Deep Sea Drilling Project
ECORD	European Consortium for Ocean Research Drilling
EEZ	exclusive economic zone
EOO	Education and Outreach Officer
EPM	Expedition Project Manager
EPSP	Environmental Protection and Safety Panel
ESO	ECORD Science Operator
GCR	Gulf Coast Repository
IODP	International Ocean Discovery Program
JRFB	*JOIDES Resolution* Facility Board
JRSO	*JOIDES Resolution* Science Operator
LIMS	Laboratory Information Management System
LWG	laboratory working group
MarE3	Institute for Marine-Earth Exploration and Engineering
MSR	marine scientific research
NGR	natural gamma radiation
NSF	National Science Foundation
ODP	Ocean Drilling Program
PAIS	Past Antarctic Ice Sheet Dynamics
PDC	polycrystalline diamond
PMO	Program Member Office
PPM	project portfolio management
SCS	South China Sea
SEP	Science Evaluation Panel
SHIL	Section Half Imaging Logger
SRM	superconducting rock magnetometer
TAMU	Texas A&M University
USAC	US Advisory Committee
USSSP	US Science Support Program
VIT	vibration-isolated television
WAIS	West Antarctic Ice Sheet
WRMSL	Whole-Round Multisensor Logger
XRD	X-ray diffraction
XRI	X-Ray Imager