FY17 Annual Report

International Ocean Discovery Program
JOIDES Resolution Science Operator

FY17 Annual Report

International Ocean Discovery Program

JOIDES Resolution Science Operator

National Science Foundation

Cooperative Agreement OCE-1326927

1 October 2016–30 September 2017

PUBLISHER'S NOTES

This publication was prepared by the International Ocean Discovery Program *JOIDES Resolution* Science Operator (JRSO) as an account of work performed under the International Ocean Discovery Program. Funding for the program is provided by the following agencies:

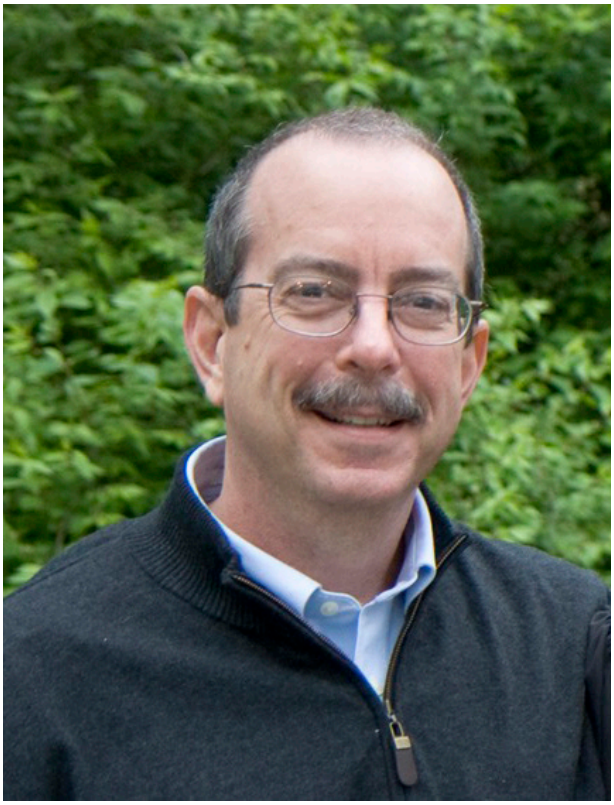
- National Science Foundation (NSF), United States
- Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan
- European Consortium for Ocean Research Drilling (ECORD)
- Ministry of Science and Technology (MOST), People's Republic of China
- Korea Institute of Geoscience and Mineral Resources (KIGAM), South Korea
- Australian Research Council (ARC) and GNS Science (New Zealand), Australian/New Zealand IODP Consortium (ANZIC)
- Ministry of Earth Sciences (MoES), India
- Coordination for Improvement of Higher Education (CAPES), Brazil

Citation:

International Ocean Discovery Program *JOIDES Resolution* Science Operator, 2017. *FY17 Annual Report*. http://iodp.tamu.edu/publications/reports.html

DISCLAIMER

http://iodp.tamu.edu
Texas A&M University
1000 Discovery Drive
College Station TX 77845 USA
Tel: 979.845.2673
Fax: 979.845.1026



Brad Clement

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

Brad Clement was appointed Director of the Integrated Ocean Drilling Program at Texas A&M University (TAMU) in August 2009. Clement previously chaired the US Advisory Committee (USAC) and has a long history of involvement with the Program, having sailed on four expeditions, worked as an Ocean Drilling Program (ODP) 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 TAMU 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 Integrated Ocean Drilling Program at TAMU and Manager of Science Operations in 2011. Malone began working for ODP 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 ODP 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 TAMU 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 2016 through September 2017, 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* docked in Guam at sunset.

Contents

1. Executive summary

This fiscal year, the *JOIDES Resolution* Science Operator (JRSO) successfully completed five full-length expeditions that will advance the global understanding of Earth systems and processes. Postexpedition research on the collected sediments from these expeditions will improve our understanding of geologic processes at convergent plate margins, mechanisms that play critical roles in current and future climate change in monsoonal regions, and deep Earth dynamics and their impact on surficial processes.

Expedition 363 drilled nine sites off the coasts of Australia, Papua New Guinea, and the Federated States of Micronesia to document the regional expression and driving mechanisms of climate variability (e.g., temperature, precipitation, and productivity) in the Western Pacific Warm Pool (WPWP). Excellent recovery from these sites will allow us to trace the evolution of the WPWP through the Neogene at different temporal resolutions, reconstruct density profiles of the western equatorial Pacific deep water during the Last Glacial Maximum, and investigate volcanogenic mineral and carbonate weathering and their possible implications for the evolution of Neogene climate.

Expedition 366 drilled into active sites of eruption in three serpentinite mud volcanoes near the Mariana Trench. Recovered cores show the effects of dynamic processes that have likely been bringing materials from subducted seamounts and from the lithosphere of the Pacific plate to these sites for tens of millions of years. Deployment of borehole casings for future observatories set the framework for in situ experimentation at Expedition 366 sites.

Expeditions 367 and 368, implemented as a single science program, completed operations at six sites in a transect across the South China Sea (SCS) rifted margin in an effort to discriminate between possible models for rifting and plate rupture. Data from these expeditions provided solid evidence for a process of breakup that included vigorous synrift magmatism.

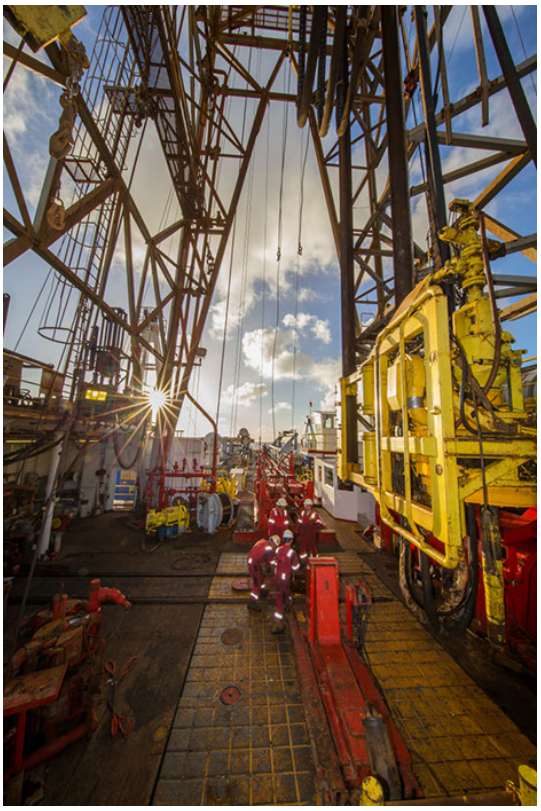
Expedition 371 drilled six sites in the Tasman Sea and obtained significant new records of southwest Pacific climate. Observations from this expedition, which can be directly related to the timing of plate failure, the magnitude and timing of vertical motions, and the timing and type

Reentry cone with mud skirt attached splashing into the moonpool.

of volcanism, represent a substantial gain in fundamental knowledge about the northern part of the continent of Zealandia.

During port calls, the JRSO installed and tested new equipment and made improvements to laboratory infrastructure. A fourth-quarter ship transit/maintenance period allowed time for the completion of extensive information technology (IT) infrastructure changes, testing to ensure the laboratory systems would be ready for Expedition 371, and updates of instrument user guides and other documents for use during future expeditions.

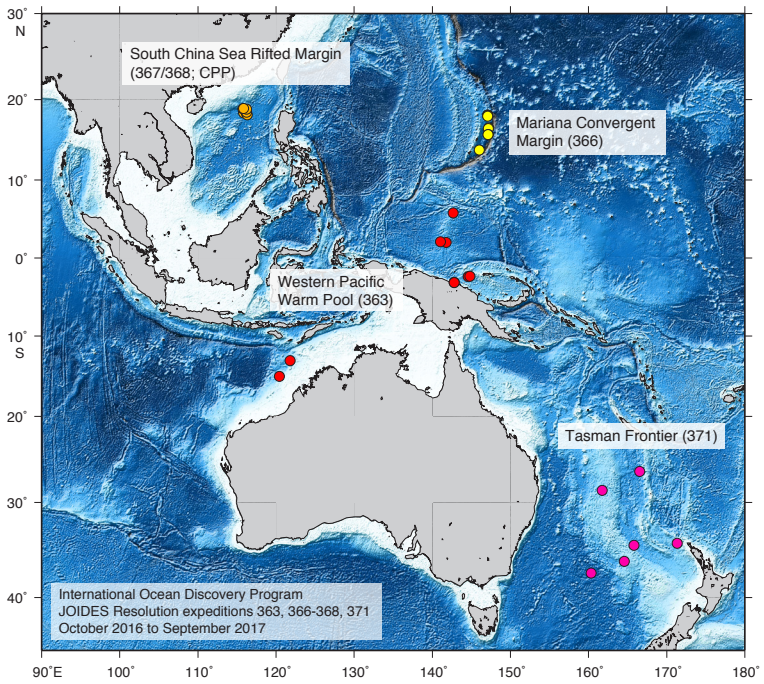
The JRSO produced and published International Ocean Discovery Program (IODP) scientific publications including *Scientific Prospectuses*, *Preliminary Reports*, and expedition *Proceedings* volumes containing expedition site reports, expedition research results data reports, and synthesis papers online to disseminate IODP research to the scientific community and the public; tracked IODP expedition science publications in the outside literature and maintained bibliographies of expedition-related publications; and illustrated the impact of IODP science through program and external publications in the 2017 Scientific Ocean Drilling Bibliographic Database Report. JRSO Staff Scientists mentored Texas A&M University (TAMU) students this year through science engagement activities, presented IODP talks, and led IODP field trips for visiting students from other universities. JRSO staff members provided technical support to Onboard Education Officers who used the *JOIDES Resolution* as a platform for education and promoted JRSO expeditions and IODP science through social media tools and live ship-to-shore broadcasts. JRSO staff also assisted with planning and conducting port call outreach, hosted workshops at the Gulf Core Repository (GCR), and made the IODP core collection available for Program outreach.



Siem Offshore workers on the *JOIDES Resolution* rig floor.

The Co-Chief Scientist review and the National Science Foundation (NSF) review panel and site visit early in the second quarter again culminated in positive feedback, which concluded that the JRSO is managing the *JOIDES Resolution* facility exceptionally well and receiving effective oversight by the JRFB and NSF. In response to panel recommendations and NSF guidance, the JRSO made plans to work with NSF and the JRFB toward more effective communication during operational planning of risks, limitations, and contingencies for all aspects of expeditions; holding regular Program Member Office

(PMO) meetings to address ongoing concerns related to Science Party staffing; scheduling at-sea testing of engineering tools to assess readiness with minimal impact on science; publicizing recent engineering advances and the significant impacts of regional planning on addressing key science plan questions; and facilitating an effective Education and Outreach (E&O) program.



Activities in response to the previous year's facility review included renovating the X-ray fluorescence (XRF) scanning facility, hiring an XRF Laboratory Manager, and installing and testing a second Avaatech XRF Core Scanner, thereby tripling the number of XRF-scanned core sections per quarter. The JRSO also initiated the search for a new clearance and permitting specialist to be hired in FY18 to provide assistance in the Science Operations department with the requirements of research clearance and environmental assessments.

The JRSO set up long-term archiving of legacy Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP) print *Proceedings* volume digital scans and the complete contents of the main IODP publications website; deposited Expeditions 301–360 *Proceedings* chapters into a professional "search and discovery" networking platform for scholars and publishers; and initiated a project for long-term digital archiving of expedition information and data files.

This IODP JRSO FY17 Annual Report details these accomplishments and other activities undertaken in support of NSF Cooperative Agreement OCE-1326927 during the period from 1 October 2016 to 30 September 2017.

2. JRSO expeditions

Expedition 363

Expedition 363 (Western Pacific Warm Pool; 6 October–8 December 2016) was designed to document the regional expression and driving mechanisms of climate variability (e.g., temperature, precipitation, and productivity) in the WPWP as it relates to the evolution of Neogene climate on millennial, orbital,

IODP JRSO FY17 expedition summary

Expedition	Operations time (days)	Distance traveled (nmi)	Sites (number)	Holes (number)	Meters cored	Cores recovered (number)	Core recovery (%)	Holes logged (number)
363: Western Pacific Warm Pool	38.89	4,991	9	30	6,865.8	801	99	1
366: Mariana Convergent Margin	43.30	2,603	9	22	1,049.7	185	46	1
367: South China Sea Rifted Margin	50.51	569	2	4	2,098.8	230	45	2
368: South China Sea Rifted Margin	45.70	1,339	5	13	2,213.3	292	72	3
371: Tasman Frontier Subduction Initiation and Paleogene Climate	34.60	4,210	6	11	3,729.1	373	64	2
Totals	**213.00**	**13,712**	**31**	**80**	**15,956.7**	**1,881**	**74**	**9**

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

and geological timescales. Sites with wide geographical distribution and variable oceanographic and depositional settings were selected, and nine sites were cored, recovering a total of 6,956 m of sediment in 875–3,421 m water depth with an average recovery of 99%.

The wide spatial distribution of the cores, variable accumulation rates, exceptional biostratigraphic and paleomagnetic age constraints, and mostly excellent foraminifer preservation will allow us to trace the evolution of the WPWP through the Neogene at different temporal resolutions, meeting the primary objectives of the expedition. Specifically, the high–sedimentation rate cores off Papua New Guinea will better constrain mechanisms influencing millennial-scale variability in the WPWP, investigate relationships between equatorial and high-latitude climate variability, and document implications for temperature and precipitation variations in this region under variable climate conditions. Furthermore, these high accumulation rates offer the opportunity to study climate variability during previous warm periods at a resolution similar to existing studies of the Holocene.

Collecting interstitial water measurements in the geochemistry laboratory.

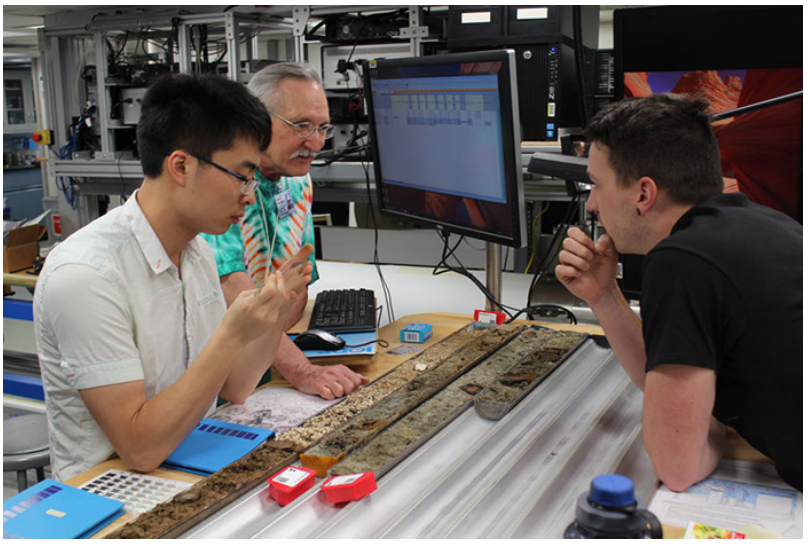
With excellent recovery, Expedition 363 sites are suitable for detailed paleoceanographic reconstructions at orbital and suborbital resolution from the middle Miocene to Pleistocene and thus will be used to refine

the astronomical tuning, magnetostratigraphy, isotope stratigraphy, and biostratigraphy of hitherto poorly constrained intervals within the Neogene timescale (e.g., the late Miocene) and to reconstruct the history of the East Asian and Australian monsoon and the Indonesian Throughflow on orbital and tectonic timescales. Results from high-resolution interstitial water sampling at selected sites will be used to reconstruct density profiles of the western equatorial Pacific deep water during the Last Glacial Maximum. Additional geochemical analyses of interstitial water samples in this tectonically active region will be used to investigate volcanogenic mineral and carbonate weathering and their possible implications for the evolution of Neogene climate.

Expedition 366

Geologic processes at convergent plate margins control geochemical cycling, seismicity, and deep biosphere activity in subduction zones and suprasubduction zone lithosphere. Expedition 366 (Mariana Convergent Margin & South Chamorro Seamount; 8 December 2016–7 February 2017) was designed to address the nature of these processes in the shallow to intermediate depth of the Mariana subduction channel. Although no technology is available to permit direct sampling of the subduction channel of an intraoceanic convergent margin at depths up to 18 km, the Mariana forearc region (between the trench and the active volcanic arc) provides a means to access this zone.

Active conduits, resulting from fractures in the forearc, are prompted by along- and across-strike extension that allows slab-derived fluids and materials to ascend to the seafloor along associated faults, resulting in the formation of the largest serpentinite mud volcanoes on Earth. Their positions adjacent to or atop fault scarps on the forearc are likely related to the regional extension and vertical tectonic deformation in the forearc. Serpentinite mudflows at these volcanoes include serpentinized forearc mantle clasts, crustal and subducted Pacific plate materials, a matrix of serpentinite muds, and deep-sourced formation fluid. Mud volcanism on the Mariana forearc occurs within 100 km of the trench, representing a range of depths and temperatures to the downgoing plate and the subduction channel. These processes have likely been active for tens of millions of years at this site and for billions of years on Earth.



Working at the core description table.

Expedition 366 collected data from cores recovered from three serpentinite mud volcanoes that define a continuum of subduction-channel processes defined by the two previously cored serpentinite mud volcanoes and the trench. Three serpentinite mud volcanoes (Yinazao, Fantangisña, and Asùt Tesoro) were chosen at distances 55 to 72 km from the Mariana Trench. Cores were recovered from active sites of eruption on their summit regions and on the flanks where ancient flows are overlain by more recent ones. Recovered materials show the effects of dynamic processes that are active at these sites, bringing a range of materials to the seafloor, including materials from the lithosphere of the Pacific plate and from subducted seamounts (including corals). Most of the recovered material consists of serpentinite mud containing lithic clasts derived from the underlying forearc crust and mantle and the subducting Pacific plate. Cores from each of the three seamounts drilled during Expedition 366, as well as those drilled during Ocean Drilling Program Legs 125 and 195 (Conical and South Chamorro), include material from the underlying Pacific plate. A thin cover of pelagic sediment was recovered at many Expedition 366 sites, and at Site U1498 we cored through serpentinite flows to the underlying pelagic sediment and volcanic ash deposits.

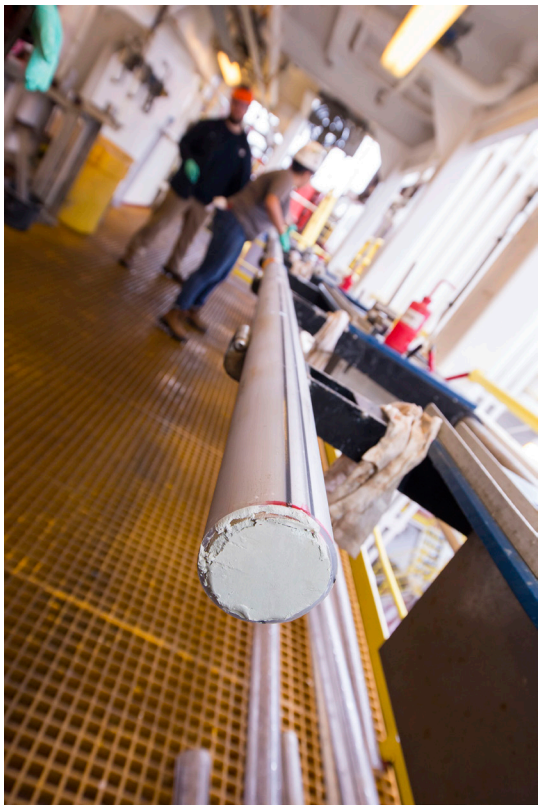
In addition to coring operations, Expedition 366 focused on deployment and remediation of borehole casings for future observatories and set the framework for in situ experimentation. Water samples collected from two of the three boreholes revealed significant inputs of formation fluids, which suggests that each of the boreholes tapped a hydrologic zone, making them suitable for experimentation with the future deployment of a CORK-lite.

Expeditions 367 and 368

Expeditions 367 and 368 (South China Sea Rifted Margin; 7 February–11 June 2017) were implemented as a single science program with 114 days of drilling operations spread across two IODP expeditions to drill four high-priority, deep-penetration sites in a transect across the SCS rifted margin. Of these, three sites targeted acoustic basement in the continent–ocean transition (COT) and one site targeted prerift through synrift to postrift sequences on the landward side of the transect. Although

Sliding basalt from the core liner.

the primary focus of this drilling expedition was to discriminate between possible models for rifting and plate rupture, the drilling, along with results from ODP Leg 184 and IODP Expedition 349, will also improve our understanding of the Cenozoic environmental development of the southeast Asian area as recorded within the sediments of the SCS basin. The drilling strategy for Expeditions 367 and 368, however, primarily targeted the deep basement coring and logging objectives.


Freshly delivered core on the catwalk.

The SCS margin is an accessible and seismically well-imaged location where drilling of synrift sediment and underlying basement will provide key constraints on the processes of rifting and eventual rupturing of the continental lithosphere during breakup at a highly extended rifted margin. Four primary sites were selected for the overall program: one in the outer margin high (OMH) and three seaward of the OMH on distinct margin-parallel basement ridges. These three ridges are informally labeled A, B, and C. They are located within the COT zone ranging from the OMH to the interpreted steady-state oceanic crust (Ridge C) of the SCS.

As a result of the limited length of drill string that could be deployed during the latter part of Expedition 368, the secondary expedition objectives addressing the environmental history of the SCS and Southeast Asia received more focus than originally planned, allowing the inclusion of Site U1505 (alternate to Site U1501). Despite this change in focus, Expeditions 367 and 368 provided solid evidence for a process of breakup that included vigorous synrift magmatism as opposed to the often-favored interpretation of the SCS margin as a magma-starved margin or a margin possibly overprinted at a much later stage by plume-related magmatism. In this broader perspective, Expeditions 367 and 368 accomplished a fundamental objective of the two-expedition science program.

Expedition 371

The primary goal of Expedition 371 (Tasman Frontier Subduction Initiation and Paleogene Climate; 27 July–26 September 2017) was to understand Tonga-Kermadec subduction initiation through recovery of Paleogene sediment records in the Tasman Sea of the southwest Pacific. Secondary goals were to understand climate history and climate dynamics since the Paleogene. Six sites were drilled, recovering

Sediment in the core catcher.

2,506 m of cored sediment and volcanic rock in 34.6 days of on-site drilling. Wireline logs were collected at two sites. The observations made represent a substantial gain in fundamental knowledge about the northern part of the continent of Zealandia because the only previous boreholes to have penetrated strata beneath the upper Eocene were at DSDP Sites 206, 207, and 208, which were drilled in 1971.

The cored intervals at Sites U1506–U1510 sampled nannofossil and foraminiferal ooze or chalk that contained volcanic or volcaniclastic intervals with variable clay content. At Site U1511, a sequence of abyssal clay and diatomite was recovered with only minor carbonate. The ages of strata at the base of each borehole were between middle Eocene and Cretaceous, and the new results provide the first substantial basis for defining formal lithostratigraphic units that can be mapped across a substantial part of northern Zealandia and related to onshore regions of New Caledonia and New Zealand.

The primary science objectives of Expedition 371 were successfully completed. All six sites provided new stratigraphic and paleogeographic information that can be put into context through regional seismic-stratigraphic interpretation and hence provide strong constraints on geodynamic models of subduction zone initiation. The new observations can be directly related to the timing of plate failure, the magnitude and timing of vertical motions, and the timing and type of volcanism. Significant new records of southwest Pacific climate were obtained and are the subject of postexpedition research.

3. Program review

2017 facility performance assessment

The JRSO hosted two meetings during the second quarter of FY17 to assess the JRSO's performance. The first meeting, held 27 and 28 February 2017, was a Co-Chief Scientist review chaired by Lisa McNeill (University of Southampton, United Kingdom), during which seven of the eight FY16 expedition Co-Chief Scientists assessed the JRSO's performance in implementing FY16 Expeditions 359–362. Their findings were compiled in a report that was presented at the second meeting, an NSF Proposal Review Panel for Ocean Sciences site visit held 1–3 March to assess the JRSO's performance as a facility in meeting

IODP's needs in fulfilling its Science Plan. The panel's primary finding was that the facility is well run with exceptional management and effective oversight, showing exemplary financial performance and reflecting the dedication, hard work, and competence of the JRSO, JRFB, Science Evaluation Panel (SEP), and Environmental Protection and Safety Panel (EPSP).

Panel recommendations and NSF guidance

The JRSO received panel recommendations from NSF on 3 April 2017 with guidance for implementation, and the JRFB met in May and fully supported NSF's conclusions and recommendations. Some of the recommendations were addressed during FY17, and others were addressed in the JRSO FY18 Annual Program Plan.

Engineering advancements and regional planning

The panel recommended that the JRSO take steps to capitalize on engineering advances and the regional emphasis of operations to publicize globally the ambition and scale of *JOIDES Resolution* activities and the scientific missions they underpin. In the FY18 Annual Program Plan, the JRSO proposed working with NSF and the JRFB to determine the best mechanisms to better publicize recent engineering advances and the significant impacts of regional planning on addressing key science plan questions.

Critical information for key stakeholders

The panel recommended that the JRSO implement additional steps during expedition planning to ensure that key stakeholders (e.g., proposal proponents and Co-Chief Scientists) are made aware of the limitations, risks, and contingencies that impact all aspects of the facility, including logging and specialty tools. The JRSO proposed in the FY18 Annual Program to re-examine how key information is provided

The *JOIDES Resolution* departing Townsville, Australia, for Expedition 371.

and communicate more effectively the risks, limitations, and contingencies in the operational planning for all aspects of the expedition.

Testing tools and engineering innovations

The panel recommended that the JRSO implement, in conjunction with the JRFB, mechanisms for assessing the readiness of tools and other engineering innovations and, when proven ready, schedule their testing at sea with minimal impact on science. The JRSO proposed working with the JRFB to schedule at-sea testing of tools under development to determine their readiness for routine deployment. The JRFB supported the scheduling of engineering testing during transits on an as-needed basis and requested regular updates from the JRSO on engineering developments and testing.

Long-term archiving and research platform tools

The panel recommended that the JRSO continue to pursue long-term archiving to include digital documents and other types of relevant products for the geosciences community, ensuring that figures and illustrations are preserved in the highest definition possible; advertise Publication Services efforts widely; and inform researchers of the new tools available and their capabilities to facilitate research and increase its impact.

IODP Publication Services explored long-term archiving options for digital program materials and decided on HathiTrust, which now serves as the long-term digital archive of the best digital scans of the legacy DSDP and ODP print *Proceedings* volumes, and Archive-It, where the main IODP publications website, with full content from all Integrated Ocean Drilling Program and IODP volumes, is now archived. In addition, 593 chapters from these volumes (Expeditions 301–360) were initially deposited into ScienceOpen, a professional "search and discovery" networking platform for scholars and publishers, where they can be viewed in context with citations, alternative metrics, and comments. The JRSO published a series of tweets on the IODP @Texas A&M twitter feed directing readers to blog entries containing instructions on the

The ship's chart table on the Bridge aboard the *JOIDES Resolution*.

IODP JRSO FY17 expedition science staffing breakdown

	Expedition					
Member country/consortium	**363**	**366**	**367**	**368**	**371**	**Total**
United States Science Support Program (USSSP)	11*	12**	9	8	11*	60
Japan Drilling Earth Science Consortium (J-DESC)	3	4	2	1	3	17
European Consortium for Ocean Research Drilling (ECORD)	9*	9	5	7*	9	49
Korea Integrated Ocean Drilling Program (K-IODP)	1	1	0	1	1	5
IODP-China	3	3	13*	13*	2	37
Australia/New Zealand IODP Consortium (ANZIC)	2	1	1	1	3*	10
India Ministry of Earth Science (MoES)	0	0	1	1	0	3
Coordination for Improvement of Higher Education (IODP-Brazil)	1	1	0	1	1	5
Total Science Party Participants	**30**	**31**	**31**	**33**	**30**	**155**

* = includes one Co-Chief Scientist. ** = two Co-Chief Scientists. Numbers do not include observers that become part of the Science Party. USSSP numbers include one Onboard Education Officer for all expeditions except Expedition 367.

use and potential of ScienceOpen and will continue to work to publicize our new tools for authors and researchers.

The JRSO also initiated a project to build a framework, tools, and processes capable of publishing expedition information for long-term digital archiving, including data files that are not currently available online.

GCR collection accommodation

The panel recommended that the JRSO develop a long-term plan to continue accommodating core in the GCR within the existing building footprint. The plan should include adequate space in the GCR for use during sampling parties and effective mechanisms for consistent training and supervision of student workers. The JRSO committed to making the most efficient use of the GCR storage space and will work to use the available space in the most efficient way possible. Plans were made for the JRSO to provide a written report to the JRFB two months before the annual meeting delineating options, cost estimates, and/or solutions for the expansion plans of the GCR and the addition of new onshore analytical capabilities supported through the GCR.

GCR laboratory core instrumentation

The panel proposed that the JRSO assess the need for additional laboratory core instrumentation in the GCR to limit potential damage to cores shipped for whole-core analyses. The JRSO had already initiated the XRF scanning facility as an effort to minimize risks associated with core shipment and proposed examining other possible instrumentation as feasible.

Science Party staffing concerns

The panel recommended that regular meetings of the PMOs be held to address ongoing concerns related to *JOIDES Resolution* Science Party staffing. The JRSO proposed assisting with this effort, and the Director and the Supervisor of Science Support (who oversees the staffing process) attended the annual IODP PMO meeting held in Shanghai, China, on 13 September.

Education and outreach

The panel recommended that IODP establish a structure that allows the JRSO to effectively facilitate an E&O program. The JRSO proposed to work with the "appropriate body" (as referred to by NSF) to facilitate an effective E&O program for IODP. The JRFB found that closer coordination between the expedition science objectives and the E&O programs is warranted and supported the plan to discuss the role of shipboard Education/Outreach Officers during the IODP Forum and PMO meetings in September 2017.

4. Operational and technical support

The JRSO provided operational and technical support for five complete *JOIDES Resolution* expeditions during FY17 and improved shipboard laboratory infrastructure, updated instrument documentation, and completed programmatic projects.

Expedition planning

The JRSO coordinated science staffing to fulfill specialized needs, made shipboard berths available to accommodate education and outreach efforts, and acquired and shipped operational and laboratory supplies for restocking during all FY17 expedition port calls.

Science staffing was completed this year for FY18 Expeditions 369 (Australia Cretaceous Climate and Tectonics), 372 (Creeping Gas Hydrate Slides and Hikurangi LWD), 374 (Ross Sea West Antarctic Ice Sheet History), and 375 (Hikurangi Subduction Margin), and staffing webinars were conducted for FY19 Expeditions 378 (South Pacific Paleogene) and 379 (Amundsen Sea West Antarctic Ice Sheet History). Pre-expedition planning meetings were held in College Station, Texas (USA), for FY17 Expedition 371 and FY18 Expeditions 372, 374, 375, and 376 (Brothers Arc Flux), along with CORK engineering design review meetings for Expedition 375 and an initial planning meeting on pressure core degassing for Expedition 372. Plans were made for routine meetings to track issues and progress for FY20 Expedition 386 (Gulf of Mexico Methane Hydrate).

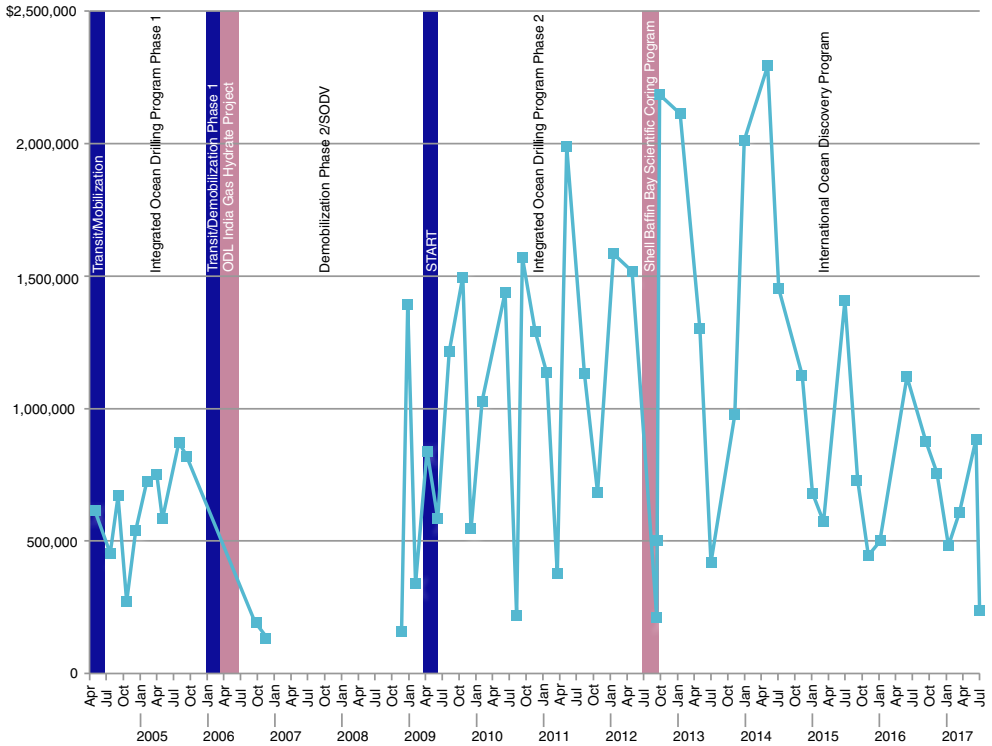
The JRSO received Expedition 363 authorization from the Philippines on 20 October, after the start of the expedition, but did not occupy the remaining alternate site in Philippine waters. Taiwan and the State

Oceanic Administration of China issued permits in January for Expeditions 367 and 368 operations, and the Australian and New Zealand governments issued authorization in September for Expedition 371 to conduct research in Australian and New Zealand waters. The JRSO submitted the Expedition 375 marine scientific research (MSR) application through the US embassy to the New Zealand government on 19 July.

The New Zealand Expedition 371 authorization included a requirement to submit a pre-activity notice to their Environmental Protection Authority (EPA). In addition, other EPA requirements included notifications to parties of interest (e.g., Māori groups) and an initial environmental assessment prior to the expedition, reporting during the expedition, and a postactivity report. The EPA reporting will be required on all IODP expeditions in New Zealand waters. The Australian Department of Environment and Energy reviewed the Expedition 369 referral package and determined that Expedition 369 is not a controlled action. Final authorization for Expedition 369 was issued on 20 September. NSF reviewed and approved environmental evaluations for use of an acoustic source during Expeditions 369 and 371 check shot surveys.

The EPSP and the TAMU Safety Panel approved additional alternate site and modification requests for Expeditions 367 and 368 and depth extensions for Expeditions 363, 366, 369, and 371 sites.

Actual fuel costs FY04–FY17.



Shipboard and laboratory improvements

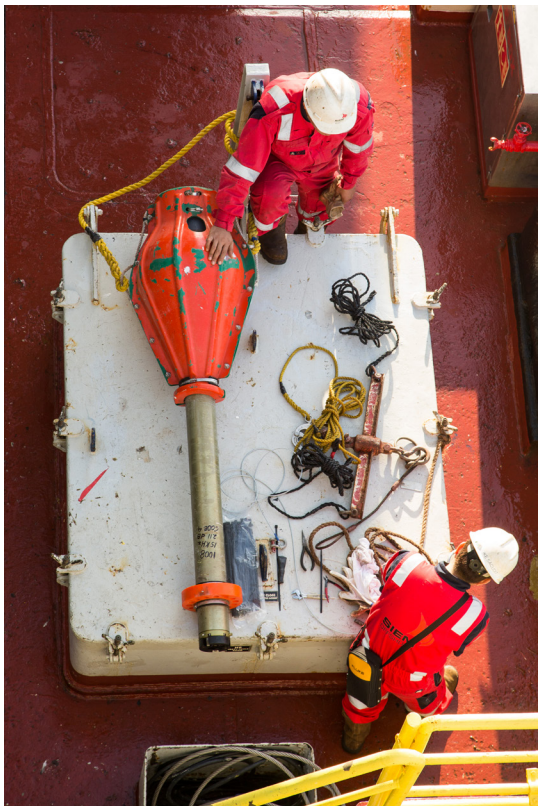
Laboratory working groups

The Geochemistry, 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 advised equipment acquisition and upgrades, process improvements, maintenance period activities, and ongoing quality assurance work during FY17.

Shipboard systems and laboratories

The scope of IT infrastructure changes planned for the Expedition 371T transit required additional staffing to ensure the laboratory systems would be ready for the next expedition. The majority of the systems were fully functional at the start of Expedition 371, with only a few remaining issues that were resolved during the expedition. JRSO staff also updated 77 instrument user guides and other documents during the Expedition 371T transit and made plans for remaining updates to be completed during the next few expeditions.

The JRSO hosted a Color Reflectance Measurement Workshop during the first quarter that resulted in the installation of new Ocean Optics QE Pro Peltier-cooled spectrometers on the Section Half Multisensor Logger (SHMSL) to improve color reflectance measurements. The paleomagnetics laboratory was rebuilt in a more efficient layout during the Guam port call, and a new 2G Enterprises liquid helium-free superconducting rock magnetometer (SRM) was installed. The SRM and its software were tested during the Shanghai port call by four experienced paleomagnetists, who found the system to be functioning properly. Other new equipment installed in the shipboard laboratories included an Olympus DELTA Premium portable energy-dispersive X-ray fluorescence (pXRF) spectrometer and an Agilent 5110 inductively coupled plasma–atomic emission spectroscope (ICP-AES). The JRSO also developed a new *P*-wave logger (PWL) system for the Special Task



Preparing the seafloor sonar beacon.

Multisensor Logger (STMSL) and acquired another Zeiss DISCOVERY V8 stereomicroscope to replace the aging SV-8 and SV-11 microscopes and a KOACH clean bench system to provide an ultralow particulate–count area for microbiology work.

Taking a core section for digital imaging.

More than 11,000 core sections were processed through the shipboard laboratories during the five FY17 expeditions, and more than 136,000 samples were taken. Shipboard technical staff and expedition scientists made well over 3,750,000 shipboard measurements on FY17 samples and placed more than 20,000 images (sections, close-ups, and microimages) in the database archive.

Core curation

The JRSO provides services in support of IODP core sampling and curation of the core collection archived at the GCR. In FY17, the GCR processed a total of 32,172 sample requests and hosted sampling parties for Expeditions 361, 363, and 367/368, during which an additional 36,540, >48,000, and 28,158 samples, respectively, were taken.

XRF core scanning facility

The TAMU Geosciences XRF Core Scanner facility housed at the GCR was transitioned into JRSO management and control this year. The JRSO renovated the facility, hired an XRF Laboratory Manager, and acquired a second Avaatech XRF Core Scanner to support scanning services as an IODP programmatic measurement. The XRF Laboratory Manager wrote new documentation relating to operation, advanced configurations, maintenance, and troubleshooting. More than 2,300 core sections were scanned this year, and nearly 40% of those sections were scanned after the addition of the second scanner.

Data management

The JRSO manages data in support of IODP activities, including expedition and postexpedition data; provides long-term archival access to data; and supports JRSO IT services. The JRSO GroupWise email

system was migrated to the TAMU Exchange email system this year, both on shore and on the ship. Shipboard tie-up activities included upgrading the Oracle Database system, configuring the new Oracle Enterprise Manager (OEM) server, replacing general-use Windows and Macintosh workstations, and replacing instrument hosts. Planning and work toward several high-priority development projects continued throughout the year.

Laboratory Information Management System

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 Expeditions 362, 363, and 366–368 were successfully transferred to shore, merged with the cumulative LIMS database, and made available online to participating scientists. More than 29,700 downloads were made from the LIMS database during FY17.

Development projects

Teams were assigned through the JRSO's project portfolio management process, and planning began for projects to review and revise XRF operations and devise new procedures for the JRSO shore-based XRF laboratory; design, build, and deliver a new and improved geological description (GEODESC) tool set to replace DESClogik; design, build, and deliver an application with a simple, intuitive user interface that will make it easier for technicians and scientists to operate the coulometer and correctly record the results of measurements; create an uploader to transfer the KappaBridge magnetic susceptibility data to the LIMS database and build LIMS Online Report Environment (LORE) reports for viewing and downloading the data; and build a framework, tools, and processes capable of publishing expedition information for long-term repository storage and discovery of referenceable information.

Ongoing efforts completed during the year include projects to install a new liquid helium–free magnetometer aboard the *JOIDES Resolution* and test the new Integrated Measurement System (IMS)-based SRM software running the system; replace the current LIMSpeak application with a set of applications that will improve the user interface and experience and adopt some user-requested improvements; and implement installation, data handling processes, quality assurance guidelines, and staff training for a second Avaatech XRF core scanner to be used on shore along with an existing Avaatech scanner to facilitate postexpedition XRF scanning.

Program integration and planning for the future

The JRFB includes liaisons from ECORD and CDEX, and the *Chikyu* and ECORD Facility Boards each include a JRSO liaison. This year, JRSO representatives participated in the SEP meetings in January and June, the *Chikyu* IODP Board (CIB) and ECORD Facility Board meetings in March, the JRFB meeting and an informal

meeting of US members/chairs of JRFB panels in May, the US Advisory Committee (USAC) meeting in August, 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 14 December 2016 at the American Geophysical Union (AGU) Fall Meeting in conjunction with the IODP Town Hall meeting and a planning meeting and facility tour of a Siem Offshore drilling vessel in Rotterdam, The Netherlands, in July.

The JRSO produced Integrated Ocean Drilling Program *Proceedings* volumes for expeditions that concluded by the end of FY14, including CDEX and ECORD science operator (ESO) expeditions. The JRSO also made arrangements this year for long-term digital archiving of both the legacy print volumes and the full content of the main IODP publications website.

5. Broader impacts

The JRSO publishes IODP science on an ongoing basis and provides technical support for shipboard and port call education and outreach efforts to expand the visibility of IODP as a societally relevant, cutting-edge international Earth science research program.

Publications

IODP Publication Services produces publications from Integrated Ocean Drilling Program and IODP riserless, mission-specific, and riser drilling expeditions and provides editing, production, and graphics services for required Program reports, technical documentation, and scientific publications as defined in the JRSO cooperative agreement with NSF. Publications from IODP mission-specific expeditions are produced under contract with the British Geological Survey on behalf of ECORD and ESO.

The gangway framed by Hong Kong's harbor and skyline.

Publishing IODP science

IODP scientific publications are the primary method of disseminating Program research to the scientific community and the public. This year, IODP Publication Services produced and published 10 *Scientific Prospectuses*, 6 *Preliminary Reports*, and 8 *Proceedings* volumes for JRSO, CDEX, and ESO expeditions. *Proceedings* volumes include

expedition reports and postexpedition research data reports and synthesis contributions. During FY17, IODP Publication Services coordinated postexpedition publications and worked on *Proceedings* content for 21 expeditions, including 26 data reports, and shipboard reports from 7 expeditions.

The JRSO facilitates production of IODP *Proceedings* volumes by sailing Publications Specialists on JRSO expeditions to coordinate shipboard reports and hosting postexpedition editorial meetings. During these meetings, Publications staff coordinate science reviews of all expedition reports content and assist meeting participants with editing prior to publication. In FY17, Publications Specialists sailed during all JRSO expeditions, and JRSO staff in College Station, TX, hosted postexpedition meetings for one JRSO expedition, two CDEX expeditions, and one ESO expedition. The JRSO also assisted the International Continental Drilling Project (ICDP) Oman Ophiolite Drilling Project Phase I core processing effort aboard the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) riser drilling vessel *Chikyu* by providing curatorial hard rock expertise and support and editorial and graphics publications support for the 2 month description party during Summer 2017.

Making IODP publications accessible

All DSDP, ODP, Integrated Ocean Drilling Program, and IODP scientific publications are accessible online at the IODP Publications website (http://publications.iodp.org). Volumes are available as zip files so users can download the expedition reports portion of any IODP *Proceedings* volume. Program scientific publications are also easily accessible through CrossRef, an official digital object identifier (DOI) registration agency for scholarly and professional publications; the Scientific Ocean Drilling Bibliographic Database; and beginning this year, HathiTrust, Archive-It, and ScienceOpen.

The Scientific Ocean Drilling Bibliographic Database is a subset of the American Geosciences Institute's (AGI's) GeoRef database and includes more than 33,500 entries related to IODP and the preceding scientific ocean drilling programs, representing nearly a half century of scientific ocean drilling research. Users can set up accounts to customize their experience by making publication lists, adding notes to records, and saving favorite searches. Interface search and support is offered in multiple languages, and users will find expanded search fields; suggested keywords and categories based on search; and options for filtering results, browsing, conducting geographic searches, and exporting bibliographic records in multiple formats.

IODP Publication Services worked with HathiTrust this year to provide a long-term digital archive of DSDP and ODP print volumes. HathiTrust's archive already contained almost all of the volumes, made ready through an agreement with Google Scholar, and the ODP volumes were already publicly available. JRSO staff provided the necessary permissions to make DSDP volumes available as well and created a collection for each Program—a HathiTrust feature that provides specific items on a single webpage—by including links to the best scan of each volume.

IODP Publication Services also began a subscription this year with Archive-It, a long-term archive specializing in full website backups. The main IODP publications website is now archived, with full content from all Integrated Ocean Drilling Program and IODP volumes included, and quarterly crawls will incrementally update the archive with new files. The initial backup on 15 September totaled 182.3 GB of data and 165,544 total documents.

Ship tour in Shanghai.

Measuring Program publication impact

IODP Publication Services tracks the number of times Program publications are accessed through available online resources to derive an indication of the level of interest in IODP scientific publications. There were more than 80,000 visits to the IODP Publications website during FY17. Program publications accessed through CrossRef numbered more than 63,000 DOI resolutions for Integrated Ocean Drilling Program and IODP publications and more than 113,000 DOI resolutions for DSDP and ODP publications. More than 9,000 queries were run on the Scientific Ocean Drilling Bibliographic Database, and additional records for more than 13,000 citations were viewed.

The annual Scientific Ocean Drilling Bibliographic Database Report documents how postexpedition Program-related research is disseminated into the scientific community through publications (http://iodp.tamu.edu/publications/AGI_studies/AGI_study_2017.pdf). The 2017 report looks at publications from highly ranked peer-reviewed journals, publications by authors from current IODP member countries, and publications by IODP expedition and Science Plan theme. The report also illustrates through “cited-by” data from Google Scholar how often peer-reviewed science articles cite publications containing research results from Integrated Ocean Drilling Program and IODP expeditions.

IODP Publication Services uses CrossRef’s free “Cited-by Linking” service, which utilizes publisher-provided metadata to provide links from all Integrated Ocean Drilling Program and IODP publications table of contents pages to scientific articles or books that cite the Program publication.

The JRSO made an initial deposit of 593 chapters from Integrated Ocean Drilling Program and IODP Expeditions 301–360 into ScienceOpen, a professional networking research platform for scholars and

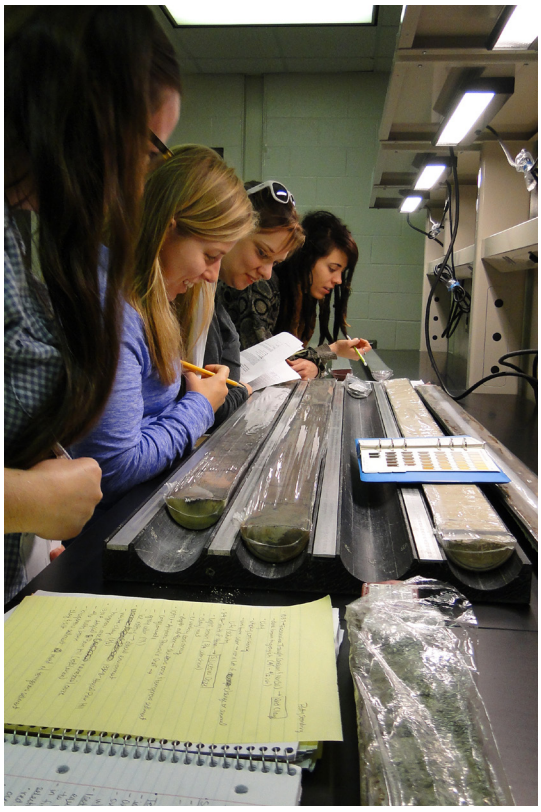
publishers (https://www.scienceopen.com/collection/IODP_Publications). Research in ScienceOpen can be viewed in context with citations, Altmetric scores, usage numbers, shares, and more. Researchers can set up a personal profile in ScienceOpen based on their ORCID and then network with other scientists, create topical collections, or share their expertise on any article on the platform, either by commenting, recommending, or through Public Post-Publication Peer Review.

Supporting education and outreach

Promoting IODP science

JRSO staff provided technical support for Onboard Education Officers' live ship-to-shore broadcasting and helped plan and execute public relations and outreach activities during port calls for FY17 Expeditions 367, 368, and 371 and FY18 Expedition 369. More than 200 media representatives, scientists, high-school teachers, VIPs from government agencies, and others toured the *JOIDES Resolution* during port calls. Pre-expedition coverage for Expedition 371 was televised in 38 Australian cities and appeared in 4 print newspapers and 25 online news sites, and a related interview with Neville Exon (The Australian National University, Canberra) aired on 12 Australian radio stations. Expedition 371 postexpedition coverage appeared in nearly 50 media outlets worldwide, including two BBC radio interviews with Co-Chief Scientist Rupert Sutherland.

JRSO scientists mentored TAMU students this year through Staff Scientist science engagement activities, which culminated in presentations of the students' work at the TAMU Student Research Week, the North American Micropaleontology Section (NAMS) Microfossils IV conference, and the Expedition 355 scientific postexpedition meeting in July. JRSO scientists also presented a TAMU seminar on how scientific ocean drilling has advanced geosciences, presented an IODP talk to a TAMU climatology class and helped students develop ideas for drilling proposals, led IODP field trips for University of South Florida and Austin Community College students, and helped to prepare an NSF-funded ocean drilling traveling exhibit.



Austin Community College tour of the Gulf Coast Repository.

Using IODP core collections for education

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 a Hard Rock workshop designed and taught by IODP staff, a Consortium for Ocean Leadership Shipboard Sedimentology Short Course attended by 16 scientists planning to sail on future IODP expeditions, and TAMU classes for 160 undergraduate and graduate students. A film crew funded by the Center for Dark Energy Biosphere Investigations (C-DEBI) visited the GCR with the aim to produce multimedia educational materials relating to microbiology, and JRSO staff gave tours of the GCR to more than 600 visitors, including a group of VIP delegates from the Ocean University of China and the annual GeoX tour designed to attract new students to the TAMU Geology program.

Conducting a core laboratory tour for the Hong Kong Sea Cadet Corps.

URL list

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

IODP funding agencies: http://www.iodp.org/funding-agencies

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

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

IODP JRSO FY17 Annual Program Plan: http://iodp.tamu.edu/publications/PP/IODP_JRSO_FY17_APP.pdf

IODP JRSO FY17 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://iodp.tamu.edu/tasapps

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/vufind

2016 Scientific Ocean Drilling Bibliographic Database Report: http://iodp.tamu.edu/publications/AGI_studies/AGI_study_2017.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 ScienceOpen page: https://www.scienceopen.com/collection/IODP_Publications

Acronyms

AGI	American Geosciences Institute
AGU	American Geophysical Union
C-DEBI	Center for Dark Earth Biosphere Investigations
CDEX	Center for Deep Earth Exploration
CIB	*Chikyu* IODP Board
COT	continent–ocean transition
DOI	digital object identifier
DSDP	Deep Sea Drilling Project
ECORD	European Consortium for Ocean Research Drilling
E&O	Education and Outreach
EPA	Environmental Protection Authority
EPSP	Environmental Protection and Safety Panel
ESO	ECORD Science Operator
GCR	Gulf Coast Repository
GEODESC	geological description
ICDP	International Continental Drilling Project
ICP-AES	inductively coupled plasma–atomic emission spectroscope
IMS	Integrated Measurement System
IODP	International Ocean Discovery Program
IT	information technology
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JRFB	*JOIDES Resolution* Facility Board
JRSO	*JOIDES Resolution* Science Operator
LIMS	Laboratory Information Management System
LORE	LIMS Online Report Environment
LWG	laboratory working group
MSR	marine scientific research
NAMS	North American Micropaleontology Section
NSF	National Science Foundation
ODP	Ocean Drilling Program
OMH	outer margin high
PMO	Program Member Office
PWL	*P*-wave logger
pXRF	portable energy-dispersive X-Ray fluorescence spectrometer
SCS	South China Sea
SEP	Science Evaluation Panel
SHMSL	Section Half Multisensor Logger
SRM	superconducting rock magnetometer
STMSL	Special Task Multisensor Logger
TAMU	Texas A&M University
USAC	US Advisory Committee
WPWP	Western Pacific Warm Pool
XRF	X-ray fluorescence