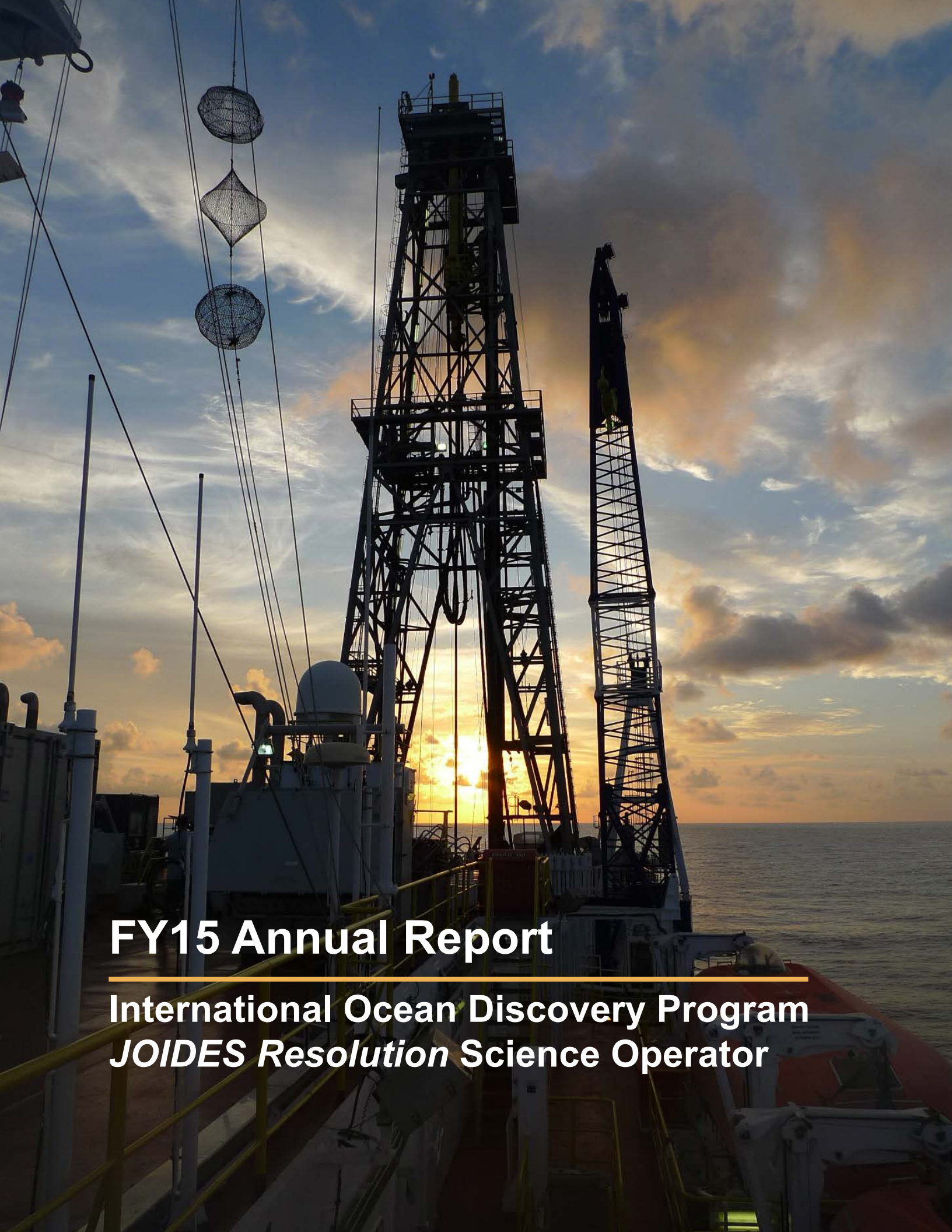

FY15 Annual Report

International Ocean Discovery Program
JOIDES Resolution Science Operator

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JOIDES Resolution Science Operator

National Science Foundation

Cooperative Agreement OCE-1326927

1 October 2014–30 September 2015

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, 2015. ***FY15 Annual Report***. http://iodp.tamu.edu/publications/reports.html

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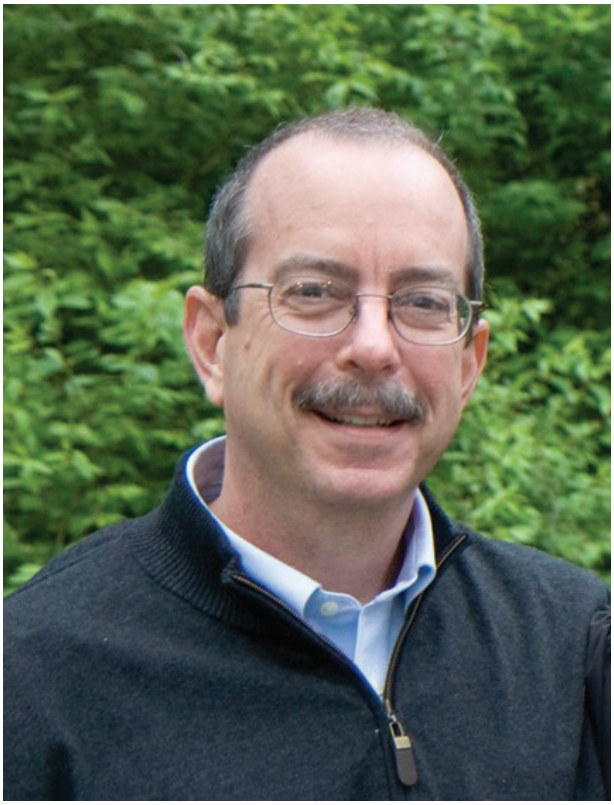


Brad Clement

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

Brad Clement was appointed Director of the Integrated Ocean Drilling Program at TAMU in August 2009. Clement previously chaired the U.S. Science 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 Support 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.

Contents

Historical perspective

From October 2014 through September 2015, 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; 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.

JOIDES Resolution helipad at dusk.

1. Executive summary

The *JOIDES Resolution* Science Operator (JRSO) successfully completed four full-length expeditions this fiscal year that will advance the global understanding of Earth systems and processes. These expeditions comprise the first ever investigation of the core region of summer monsoon precipitation in the Bay of Bengal (Expedition 353); a study of the early stages of Himalayan erosion in the Bengal Fan and the Neogene development of the Asian monsoon and its impact on sediment supply and flux (Expedition 354); an investigation of the relative role of climate–tectonic interactions and the net impact on weathering and erosion of the western Himalaya (Expedition 355); and the collection of a 5 My record of Indonesian Throughflow (ITF), Indo-Pacific Warm Pool, and climate evolution (Expedition 356). Tie-up periods during the year were used to improve the R/V *JOIDES Resolution* facilities and laboratory infrastructure in support of future International Ocean Discovery Program (IODP) expeditions.

Expedition 353 (Indian Monsoon Rainfall) drilled into the Bay of Bengal to reconstruct post-Miocene changes in Indian monsoon circulation. Sediment sections collected from key regions where changes in rainfall and surface ocean salinity were best preserved show salinity changes from direct precipitation, runoff from river basins, and changes in monsoonal circulation over orbital to tectonic timescales. Expedition 354 (Bengal Fan) drilled into the Bengal Fan to document the erosional record of the Himalaya and development of the Asian monsoon over Cenozoic time. The collected sediments document terrestrial changes of Himalayan erosion and weathering and have mineralogical and geochemical signatures relevant for reconstructing time series of erosion, weathering, and changes in source regions, as well as impacts on the global carbon cycle. Expedition 355 (Arabian Sea Monsoon) recovered sediment largely derived from the Indus River that will document the weathering and erosional responses of the western Himalaya to changes in monsoon strength during the latter parts of the Neogene, including the 8 Ma climatic transition, when monsoon intensity is believed to have changed strongly; sediment from a large mass transport deposit; and basalt and associated volcaniclastic sediment that should address key questions related to rifting and volcanism associated with formation of the Laxmi Basin. Expedition 356 (Indonesian

Scientist Lisa Tauxe, recent inductee to the US National Academy of Sciences, giving a science talk on board the *JOIDES Resolution*.

Throughflow) drilled into the northwest Australian shelf and obtained a shallow-water history of ITF variability and its relationship to climate that should allow us to understand the history of the Australian monsoon and the timing and development of aridity on the Australian continent. Postexpedition research on the collected sediments from these four expeditions will improve our understanding of mechanisms that play critical roles in current and future climate change in monsoonal regions and deep-Earth dynamics and their impact on surficial processes.

The JRSO produced and published IODP scientific publications online to disseminate IODP research to the scientific community and the public, delivered a redesigned *Proceedings* format guided by feedback from the international scientific community, and documented the impact of IODP science through publications in the 2015 Ocean Drilling Citation report. Use of the *JOIDES Resolution* as a platform for education continued this year with the JRSO providing technical support to Onboard Education Officers as they promoted JRSO expeditions and IODP science through the http://joidesresolution.org website, other social media tools, and live ship-to-shore broadcasting. JRSO staff also assisted with planning and conducting port call outreach and made the IODP core collection available for Program outreach.

This IODP JRSO FY15 Annual Report details these accomplishments and other activities undertaken in support of National Science Foundation (NSF) Cooperative Agreement OCE-1326927 during the period from 1 October 2014 to 30 September 2015.

2. IODP JRSO expeditions

Expedition 353: Indian Monsoon Rainfall

IODP Expedition 353 (29 November 2014–29 January 2015) drilled six sites in the Bay of Bengal, recovering 4,280 m of sediments (average = 97%) during 32.9 days of on-site drilling. The primary objective of the expedition was to reconstruct changes in Indian monsoon circulation since the Miocene at tectonic to centennial timescales. Analysis of the sediment sections recovered will improve our understanding of how monsoonal climates respond to changes in forcing external to the Earth's climate system (i.e., insolation) and changes in forcing internal to the Earth's climate system, including changes in continental ice volume, greenhouse gases, sea level, and the ocean-atmosphere exchange of energy and

IODP JRSO FY15 expedition summary.

Expedition	Operations time (days)	Distance traveled (nmi)	Sites (number)	Holes (number)	Meters cored	Cores recovered (number)	Core recovery (%)	Holes logged (number)
353: Indian Monsoon	39.38	4,024	6	18	4,431.8	557	96.6	1
354: Bengal Fan	48.8	1,906	7	17	2,889.7	462	59.8	7
355: Arabian Sea Monsoon	50.27	1,318	2	8	2,642.8	333	65.1	1
356: Indonesian Throughflow	50.07	1,927	7	18	7,781.5	1,148	66.6	6
Totals:	188.52	9,175	22	61	17,745.8	2,500	72.8	15

Scientists carrying the last Expedition 353 core on deck.

moisture. All of these mechanisms play critical roles in current and future climate change in monsoonal regions.

The primary signal targeted is the exceptionally low salinity surface waters that result, in roughly equal measure, from both direct summer monsoon precipitation and runoff from the numerous large river basins that drain into the Bay of Bengal. Changes in rainfall and surface ocean salinity are captured and preserved in a number of chemical, physical, isotopic, and biological components of sediments. Expedition 353 sites are strategically located in key regions where these signals are the strongest and best preserved. Salinity changes at Sites U1445 and U1446 (northeast Indian margin) result from direct precipitation as well as runoff from the Ganges-Brahmaputra river complex and the many river basins of peninsular India. Salinity changes at Sites U1447 and U1448 (Andaman Sea) result from direct precipitation and runoff from the Irrawaddy and Salween river basins. Site U1443 (Ninetyeast Ridge) is an open-ocean site with a modern surface water salinity very near the global mean but is documented to have recorded changes in monsoonal circulation over orbital to tectonic timescales. This site serves as an anchor for establishing the extent to which the north to south (19°N to 5°N) salinity gradient changes over time.

Expedition 354: Bengal Fan

IODP Expedition 354 (30 January–31 March 2015) to 8°N in the Bay of Bengal drilled a seven-site, 320 km long transect across the Bengal Fan. Three deep-penetration and four shallow holes give a spatial overview of the primarily turbiditic depositional system that comprises the Bengal deep-sea fan. The expedition was proposed to obtain data that can not only test hypothetical links between climate and tectonics but also provide new data not easily acquired but relevant for understanding a number of Earth processes. This expedition focuses on the erosional record of the Himalaya and on the development of the Asian monsoon over Cenozoic time. Because geology lacks the tools for determining paleoelevations except in unusual and ideal circumstances, the sedimentary record of material eroded from a mountain belt holds the least ambiguous record of its paleotopography. Approximately 80% of the material eroded from the Himalaya was deposited in the Bay of Bengal, which therefore hosts the most complete record.

Sediments recovered during Expedition 354 originate from Himalayan rivers, documenting terrestrial changes of Himalayan erosion and weathering, and are transported through a delta and shelf canyon, supplying turbidity currents loaded with a full spectrum of grain sizes. Mostly following transport channels, sediments deposit on and between levees while depocenters laterally shift over hundreds of kilometers on millennial timescales. During Expedition 354, these deposits were documented in space and time, and the recovered sediments have Himalayan mineralogical and geochemical signatures relevant for reconstructing time series of erosion, weathering, and changes in source regions, as well as impacts on the global carbon cycle. Miocene shifts in terrestrial vegetation, sediment budget, and style of sediment transport were tracked. Expedition 354 has extended the record of early fan deposition by 10 My into the late Oligocene.

Expedition 354 scientists working in the microbiology cold room.

Expedition 355: Arabian Sea Monsoon

IODP Expedition 355 (31 March–31 May 2015) drilled Sites U1456 and U1457 in Laxmi Basin in the eastern Arabian Sea to document the coevolution of mountain building, weathering, erosion, and climate over a range of timescales. The Indian (southwest) summer monsoon is one of the most intense climatic phenomena on Earth. Its long-term development has been linked to the growth of high topography in South and Central Asia. The Indian continental margin, adjoining the Arabian Sea, offers a unique opportunity to investigate tectonic–climatic interactions and the net impact of these processes on weathering and erosion of the western Himalaya. In addition, recovering basement from the eastern Arabian Sea provides constraints on the early rifting history of the western continental margin of India with special emphasis on continental breakup between India and the Seychelles and its relationship to the plume-related volcanism of the Deccan Plateau.

Both sites recovered a Neogene–Quaternary section dating back to ~11 Ma that is punctuated by three hiatuses of varying lengths, with part of the upper Miocene, the lower Pliocene, and the lower Pleistocene missing. Both sites recovered an interval spanning the 7–8 Ma climatic transition, which is characterized by the expansion of C4 plants and is thought to be a time when monsoon intensity

Trimming the end of an Expedition 355 core section on the catwalk.

changed significantly, and cored through a large mass transport deposit emplaced in the late Miocene. Identification of similar facies on regional seismic lines in Laxmi Basin suggests that the recovered material is part of one of the world's largest mass transport deposits. Site U1457 cored 16 m into igneous basement, which is overlain by ~30 m of mudstone and interbedded volcaniclastics dated to the early Paleocene. The basalt and associated volcaniclastic sediment at this site should address key questions related to rifting and volcanism associated with formation of Laxmi Basin. The initial findings preclude opening of the basin in the presence of a major mantle thermal anomaly, such as that associated with the Deccan large igneous province. Postexpedition analyses of the more than ~1,722 m of core will provide further information about the nature of tectonic–climatic interactions in this global type area for such studies.

Expedition 356: Indonesian Throughflow

IODP Expedition 356 (31 July–30 September 2015) cored seven sites covering a latitudinal range of 29°S–18°S off the northwest coast of Australia to obtain a 5 My record of ITF, Indo-Pacific Warm Pool, and climate evolution that has the potential to match orbital-scale deep-sea records in its resolution. The ITF is a critical part of the global thermohaline conveyor. It plays a key role in transporting heat from the equatorial Pacific (the Indo-Pacific Warm Pool) to the Indian Ocean and exerts a major control on global climate. The complex tectonic history of the Indonesian archipelago, a result of continued northward motion and impingement of the Australasian plate into the southeast Asian part of the Eurasian plate, makes it difficult to reconstruct long-term (i.e., million year) ITF history from sites within the archipelago. The best areas to investigate ITF history are downstream in the Indian Ocean, either in the deep ocean away from strong tectonic deformation or along proximal passive margins that are directly under the influence of the ITF. Although previous Ocean Drilling Program and Deep Sea Drilling Project deepwater cores recovered in the Indian Ocean have been used to chart Indo-Pacific Warm Pool influence and, by proxy, ITF variability, these sections lack direct biogeographic and sedimentological evidence of the ITF.

The coring strategy for the expedition was designed to reveal a detailed shallow-water history of ITF variability and its relationship to climate. This should allow us to understand the history of the Australian monsoon and its variability, a system whose genesis is thought to be related to the initiation of the East Asian monsoon and is hypothesized to have been in place since the Pliocene or earlier. It also will lead to a better understanding of the nature and timing of the development of aridity on the Australian continent. In addition, detailed paleobathymetric and stratigraphic data from the transect will allow the construction of subsidence curves to constrain the spatial and temporal patterns of vertical motions caused by the interaction between plate motion and convection within the Earth's mantle, known as dynamic topography. The northwest shelf is an ideal location to study this phenomenon because it is positioned on the fastest moving continent since the Eocene, on the edge of the degree 2 geoid anomaly. Accurate subsidence analyses over 10° of latitude can resolve whether northern Australia is moving with/over a time-transient or long-term stationary downwelling within the mantle, thereby vastly improving our understanding of deep-Earth dynamics and their impact on surficial processes.

A specimen tray holding foraminifers from Expedition 356.

3. Operational and technical support

The JRSO provided operational and technical support for four complete *JOIDES Resolution* expeditions during FY15 and improved shipboard laboratory infrastructure during maintenance periods in Keelung, Taiwan, and Fremantle, Australia.

Expedition planning

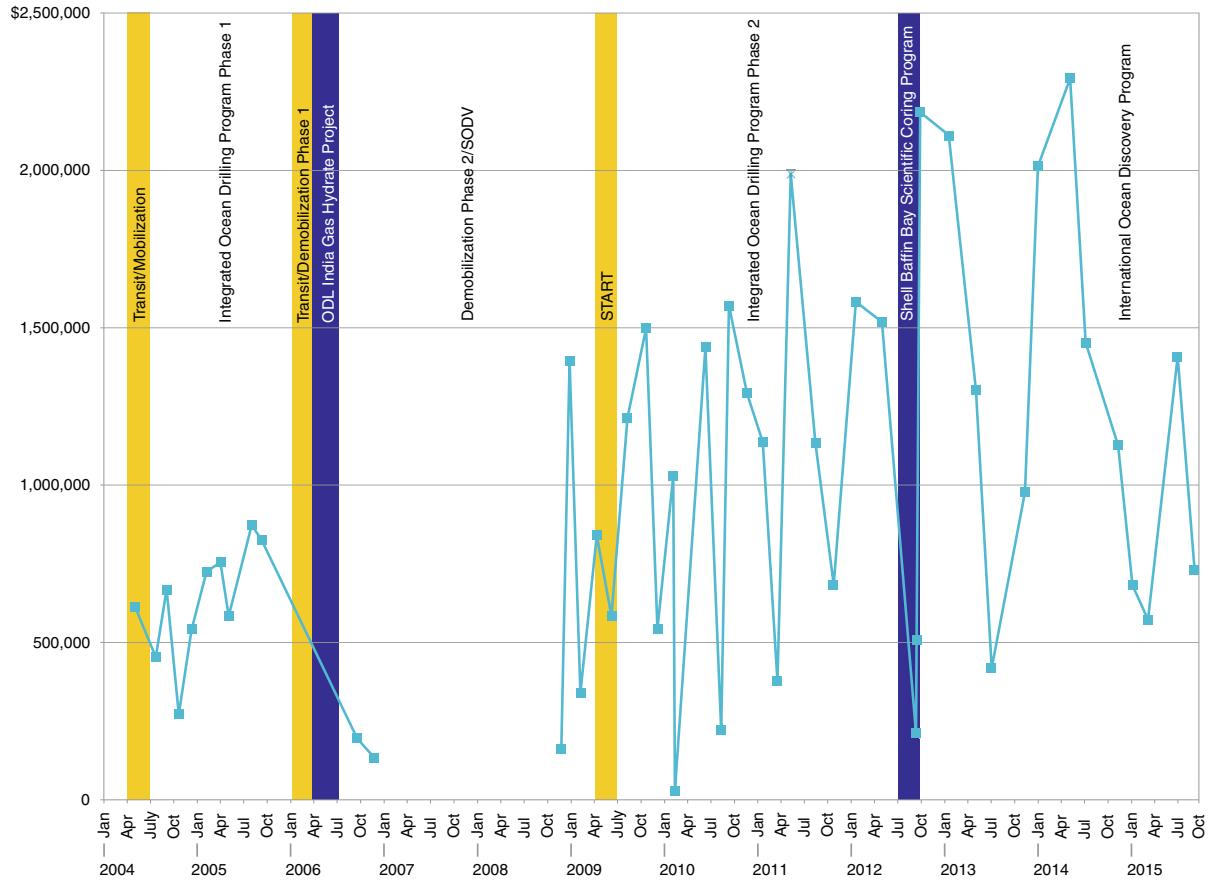
The JRSO coordinated science staffing to fulfill specialized needs, made shipboard berths available to accommodate education and outreach efforts, and acquired and shipped operational and laboratory supplies for restocking during all FY15 expedition port calls.

Science staffing was completed this year for FY15 Expeditions 355 and 356 and FY16 Expeditions 359 (Maldives Monsoon and Sea Level), 360 (Southwest Indian Ridge Lower Crust and Moho), 361 (Southern African Climates), and 362 (Sumatra Seismogenic Zone). Pre-expedition planning meetings were held in

College Station, TX (USA), for FY16 Expeditions 359, 360, 361, 362, and 363 (Western Pacific Warm Pool), along with a CORK engineering design meeting for the Hikurangi Subduction Margin expedition.

The JRSO worked closely with staff at the US embassy in New Delhi, India, to obtain clearance, permitting, licenses, and certificates from the Ministry of Home Affairs, Ministry of Defense, Department of Telecommunication, Ministry of Shipping, and Ministry of Earth Science; naval security clearance and inspection in the Port of Visakhapatnam; and a diplomatic note on 30 December 2014 granting authorization from the Ministry of External Affairs for Expedition 353 operations in Indian waters. The Australian Department of Foreign Affairs and Trade approved Expedition 356 operations in the Australian exclusive economic zone (EEZ). The Maldives Ministry of Fisheries and Agriculture approved Expedition 359 operations in the Maldives territorial waters following a series of meetings with a representative from the JRSO and an Expedition 359 Co-Chief Scientist. In consultation with NSF, the JRSO decided not to implement Ancillary Project Letter (APL) 849 as part of Expedition 359, thereby eliminating two sites in the Indian EEZ. The JRSO also submitted a clearance application to the US State Department for Expedition 361 to conduct operations in South Africa and Mozambique waters. Several serious hurdles

Actual fuel costs FY04–FY15.



ODL = Overseas Drilling Limited, SODV = U.S. Scientific Ocean Drilling Vessel, START = Expedition 320T: Sea Trials and Assessment of Readiness Transit.

were identified that could prevent obtaining clearance to work in Indonesian waters during Expedition 362. If the issues cannot be resolved in time to submit the clearance application, then the expedition will focus instead on alternate sites in international waters.

NSF reviewed environmental evaluations and approved the use of acoustic sources to conduct zero-offset vertical seismic profiles (VSPs) during Expeditions 354, 355, and 356. The Environmental Protection and Safety Panel (EPSP) and the Texas A&M University (TAMU) Safety Panel recommended approval of two new Expedition 355 sites, approval of new alternate sites and a depth extension of a previously approved site for Expedition 359, and several new alternate sites for Expedition 362. Finally, the EPSP and TAMU Safety Panel recommended approval of Expeditions 361, 366 (Mariana Convergent Margin), and 369 (Australia Cretaceous Climate and Tectonics) sites. Recommendations for Expeditions 367 and 368 (South China Sea Rifted Margin) sites were deferred to the 2016 EPSP meeting.

Engineering and tool development and support

Vibration-isolated television cable

The new replacement vibration-isolated television (VIT) cable was shipped to a third-party vendor and tested before and after being spooled onto the winch drum. The cable was delivered to the *JOIDES Resolution* in July in Fremantle, Australia, where the umbilical was installed during the tie-up period and then successfully tested during Expedition 356.

Shipboard and laboratory improvements

Laboratory working groups

The Geochemistry, Geology, Geophysics, and Curation and Core Handling laboratory working groups (LWGs) comprise technical and science staff members 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 allow management to better prioritize the LWG efforts.

Hardhats at the ready.

The four LWGs advised equipment acquisition and upgrades, process improvements, maintenance period activities, and ongoing quality assurance work during FY15. The JRSO broadened the membership of the LWG teams this year to include external members—scientists who will sail on JRSO expeditions in the near future—to provide a broader spectrum of community input into the laboratory development and improvement process. These new team members began reviewing action items and recommendations from previous LWG meetings and contributing to ongoing and anticipated laboratory developments.

View of the *JOIDES Resolution* crane from below.

Shipboard systems and laboratories

JRSO staff replaced equipment and installed a new furnace and water treatment system in the shipboard laboratories during the first-quarter maintenance period. New power outlets, cables, and supply units were installed to bring laboratories up to new regulation standards, and the conference room presentation system was revamped. New preventative maintenance protocols during downtime allowed the JRSO to use a smaller team of technicians to restart all analytical systems.

During transits, JRSO staff conducted extensive core-splitting maintenance (deep cleaning), inventory control, computer systems upgrades, preventative maintenance activities, cross training, and assigned projects (see “Development projects”). Old laboratory equipment was repaired or replaced (Agico KLY KappaBridge, OI Analytical TOC Analyzer, and UIC Model 5015 coulometer), and new equipment was installed in the shipboard laboratories (Icefield MI-5 multishot magnetic inclinometer borehole survey tools, FLIR E8 infrared cameras, and DTECH alternating field demagnetizer). JRSO staff investigated and reduced the correction factor for the frequency-adjusted MS2C 90 mm magnetic susceptibility (MS) loops and developed a variable integration time method for the Ocean Optics color reflectance measurements done on the Section Half Multisensor Logger (SHMSL).

More than 12,000 core sections were processed through the shipboard laboratories during the four FY15 expeditions, and nearly 44,500 samples were taken, more than 6,000 of which were catwalk samples. Shipboard technical staff and expedition scientists made well over 3,000,000 shipboard measurements

on FY15 samples and placed more than 23,900 images (sections, close-ups, and micro-images) in the database archive.

Shore-based geosciences laboratory

The TAMU Geosciences X-ray fluorescence (XRF) Core Scanner facility housed at the Gulf Core Repository (GCR) hosted scientists for XRF scanning projects throughout the fiscal year, using the facility an average of 64% of available days. IODP expedition scientists have begun requesting XRF scanning to enhance the shipboard splice; the Expedition 355 and Expedition 356 Science Parties plan to do extensive scanning while the cores are in College Station.

Core-receiving platform on the catwalk awaiting core.

Core curation

Gulf Coast Repository

The JRSO provides services in support of IODP core sampling and curation of the core collection archived at the GCR. In FY15, the GCR processed a total of 14,421 sample requests and hosted the Expedition 355 sampling party, during which more than 17,000 samples were taken.

In September, the GCR embarked on a refurbishment project with the demolition and removal of existing furniture and cabinetry. A temporary space in the chemistry laboratory was made available for sampling activities until the project's anticipated completion in December 2015.

Kochi Core Center

The Kochi Core Center (KCC) curates Program legacy cores (DSDP, ODP, and Integrated Ocean Drilling Program) and IODP cores collected by the *JOIDES Resolution* under a long-term contract with the Texas A&M Research Foundation (TAMRF). In FY15, the KCC delivered more than 11,000 samples and hosted the Expedition 354 sampling party, during which 7,736 samples were taken. Some of the Expedition 354 samples were taken in red-light condition so the researchers could analyze samples for light-sensitive parameters.

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 information technology (IT) services. Upgrades for IT infrastructure and science system services were implemented this year, along with planning and work toward several high-priority development projects.

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 352–355 were successfully transferred to shore, merged with the cumulative LIMS database, and made available online to participating scientists. More than 24,000 downloads were made from the LIMS database during FY15.

System updates, inventory, and security

The JRSO installed new workstations on the *JOIDES Resolution* at the beginning of FY15 and installed versions of the Schlumberger software package, Petrel, both on the vessel and on shore. Shipboard software was updated during the maintenance period to meet TAMU password complexity requirements, and appropriate security profiles were assigned. LabVIEW (one of the JRSO's primary software products) was upgraded, and all associated code changes for shipboard systems were implemented. Java and Tomcat on the shipboard Linux servers were upgraded to the same versions used on shore.

Development projects

Teams were assigned through JRSO's project portfolio management process, and planning began for projects to replace the 20-year-old shipboard liquid helium cryogenic magnetometer with a new liquid helium–free magnetometer and upgraded software; improve functionality and maintainability of web services for data input and output to LIMS; and improve

Welding two joints of casing together on the *JOIDES Resolution* rig floor.

support for capture, retrieval, and management of Whole-Round Line Scan (WRLS) images and their composites.

Major projects assigned in FY14 or FY15 that were completed in FY15 include the LIMS On-line Report Environment (LORE), scanning electron microscope (SEM) uploader, and Extending IMS to WRMSL and STMSL.

LIMS On-line Report Environment

The LORE project implemented a reporting framework that eased the discovery and sharing of IODP content by incrementally handling very large data sets (such as RGB) without crashing end-users' browsers or intermediate systems participating in the transfer process. LORE provides a framework for the distribution of all kinds of reports going forward and is viewed as the replacement for both Web Tabular Reports and LIMS Reports.

Scanning electron microscope uploader

The SEM project provided online access to all images taken with the SEM, along with equipment configuration (e.g., magnification, methods of sample preparation, and sample type and ID) and other metadata that were collected aboard the *JOIDES Resolution*. The SEM data is accessed within the LORE interface, which provides access to numerous reports of instrumental data.

Extending IMS to WRMSL and STMSL

This project replaced applications used on the Whole-Round Multisensor Logger (WRMSL) and Special Task Multisensor Logger (STMSL) with the current versions of integrated measurement system (IMS) framework applications. From the user's perspective, this application should look and feel like the other IMS-supported logging systems. From the developer's perspective, a large percentage of the code will be reused from the other IMS-supported logger libraries and new code will be developed in the IMS framework. All work on this project was completed during FY14, but deployment was delayed at the Expedition Project Manager's request from the Expedition 359 sail date to the beginning of Expedition 361 in March 2016.

Program integration and planning for the future

The JRSO produced Integrated Ocean Drilling Program *Proceedings* volumes for expeditions that concluded by the end of FY14, including European Consortium for Ocean Research Drilling (ECORD) Science Operator (ESO) and Center for Deep Earth Exploration (CDEX) expeditions. In addition, the *Chikyu* and ECORD Facility Boards each include a JRSO liaison, and the *JOIDES Resolution* Facility Board (JRFB) includes liaisons from ECORD and CDEX. This year, JRSO representatives participated in the ECORD

Council Meeting and opening ceremony for the new core repository at the KCC in October, JRFB meeting in May, Science Evaluation Panels (SEPs) in January and June, ECORD Facility Board meeting in March, EPSP meeting in September, and US Advisory Committee (USAC) meeting in August.

4. Broader impacts

The JRSO conducts ongoing IODP Publication Services efforts 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.

Publication Services

IODP Publication Services provides publication support services for Integrated Ocean Drilling Program and IODP riserless and riser drilling expeditions and editing, production, and graphics services for required Program reports, technical documentation, and scientific publications as defined in the JRSO cooperative agreement with NSF.

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 three *Scientific Prospectuses* for JRSO and ESO expeditions, four *Preliminary Reports* for Integrated Ocean Drilling Program US Implementing Organization (USIO) FY14 and JRSO expeditions, and seven *Proceedings* volumes for JRSO expeditions and USIO, ESO, and CDEX expeditions that concluded by the end of FY14. The *Proceedings* volumes include expedition reports and postexpedition research data reports and synthesis contributions. During FY15, IODP Publication Services coordinated postexpedition publications and worked on *Proceedings* content for 21 expeditions, including 22 data reports and shipboard reports from 7 expeditions.

JOIDES Resolution in silhouette during Expedition 353.

The JRSO facilitates production of IODP *Proceedings* volumes by sailing Publications Specialists on JRSO expeditions to coordinate shipboard reports and hosting

IODP JRSO homepage.

postexpedition editorial meetings during which Publications staff coordinate science reviews of all expedition reports content and assist meeting participants with editing prior to publication. In FY15, Publications Specialists sailed during all JRSO expeditions, and JRSO staff in College Station hosted postexpedition meetings for three USIO expeditions and two JRSO expeditions.

The redesigned *Proceedings of the International Ocean Discovery Program* format debuted this year with publication of the shipboard reports from Expedition 349 (South China Sea Tectonics). The new PDF product features a two-column layout with figures laid out in-line in journal fashion. Data tables in the site chapters are provided as .csv files that can be downloaded on demand, and there are multiple ways to access figures in the HTML version, including from thumbnails in text. IODP Publication Services staff led and implemented the publication redesign, which was guided by important feedback about desired publication features and functionality from more than 300 members of the international scientific community.

IODP Publications also rolled out a new JRSO logo this year and a responsive Program website design (http://iodp.tamu.edu) that functions well on a wide range of electronic devices.

Making IODP publications accessible

All Deep Sea Drilling Project (DSDP), Ocean Drilling Program (ODP), Integrated Ocean Drilling Program, and IODP scientific publications are accessible online through the IODP Publications website (http://publications.iodp.org), and ISO disc images are available so users can download and burn a replica of the Expedition Reports portion of any IODP Proceedings volume. Program scientific publications are also easily accessible through the Ocean Drilling Citation Database subset of the American Geosciences Institute (AGI) GeoRef database (http://odp.georef.org/dbtw-wpd/qbeodp.htm) and through CrossRef, an official digital object identifier (DOI) registration agency for scholarly and professional publications.

This year, IODP Publication Services implemented CrossRef's update system, CrossMark, by including the CrossMark logo/link and linked metadata on HTML and PDF versions of IODP science publications. The CrossMark logo on a PDF or HTML document indicates that the publisher is stewarding the document through any updates, corrections, retractions, or other changes.

In October 2014, a physical archive of three full sets of legacy Program publications, including *Initial Reports of the Deep Sea Drilling Project* (321 volumes), *Proceedings of the Ocean Drilling Program* (648 volumes), and *Proceedings of the Integrated Ocean Drilling Program* (81 DVDs), was relocated from the TAMU warehouse used as a Publication Services distribution center to the JRSO office. The remaining inventory was offered to the scientific ocean drilling community at no cost other than shipping before the unclaimed inventory was recycled and the warehouse vacated and made available to the TAMU College of Geosciences in July. IODP Publication Services staff continued to explore options for a permanent electronic archive solution for legacy Program expedition publications.

Measuring Program publication impact

The JRSO makes Program scientific publications accessible to the public and documents how postexpedition Program-related research is disseminated into the scientific community through publications. The number of times Program publications were accessed through available online resources gives an indication of the level of interest in IODP scientific publications. There were more than 87,000 visits to the IODP Publications website during FY15. Program publications accessed through CrossRef numbered more than 52,000 DOI resolutions for Integrated Ocean Drilling Program and IODP publications and more than 156,000 DOI resolutions for DSDP and ODP publications. More than 19,700 queries were run on the Ocean Drilling Citation Database, and additional records for more than 6,000 citations were viewed.

JRSO Director B. Clement, Expedition 356 Co-Chief Scientists, and Australian officials during port call in Darwin, Australia.

The impact of IODP science through publications was documented through publication of the 2015 Ocean Drilling Citation Database Report, which summarized contents of the ~31,200-citation database and also charted nearly 2,800 articles in high-impact scientific publications based on primary Integrated Ocean Drilling Program and IODP expedition research. IODP Publication Services also 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.

Supporting education and outreach

Promoting IODP science from the *JOIDES Resolution*

JRSO staff provided technical support for Onboard Education Officers' live ship-to-shore broadcasting during Expeditions 353, 354, and 356 and assisted with the planning and execution of extensive public relations and outreach activities during the maintenance period in Fremantle, Australia, and the Expedition 359 port call in Darwin, Australia. The Expedition Project Manager coordinated education and outreach activities during Expedition 355, including 41 ship-to-shore events led by scientist volunteers and a 2-hour Reddit "Ask Me Anything" web chat during which the Co-Chief Scientists answered questions from people from all over the world.

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. The GCR hosted the biannual meeting of the Curators of Marine and Lacustrine Geological Samples group (21–23 April) and the Minority-Serving Institution–Reconstructing Earth's Climate History (MSI-REaCH) School of Rock program (21–26 June) and gave repository tours to nearly 600 visitors, including conference participants, university faculty and students, the NSF Director, the NASA Strategic Alliance, US Representative Lamar Smith (R-Texas), and congressional staffers. The KCC hosted more than 180 visitors to the repository in FY15, including government dignitaries, university faculty and students, and media representatives who are writing articles about IODP cores for *Blue Earth* magazine and the local newspaper, *Kochi Shimbun*.

Live broadcasting from the *JOIDES Resolution* bridge to a class of 7-year-olds at Klosterfeld School in Ellwangen, Germany.

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 FY15 Annual Program Plan: http://iodp.tamu.edu/publications/PP/IODP_JRSO_FY15_APP.pdf

IODP JRSO FY15 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

Ocean Drilling Citation Database: http://iodp.tamu.edu/publications/citations/database.html

2015 Ocean Drilling Citation Report: http://iodp.tamu.edu/publications/AGI_studies/AGI_study_2015.pdf

Acronyms

AGI	American Geosciences Institute
APL	Ancillary Project Letter
CDEX	Center for Deep Earth Exploration
DOI	digital object identifier
DSDP	Deep Sea Drilling Project
ECORD	European Consortium for Ocean Research Drilling
EEZ	exclusive economic zone
EPSP	Environmental Protection and Safety Panel
ESO	ECORD Science Operator
GCR	Gulf Coast Repository
IMS	integrated measurement system
IODP	International Ocean Discovery Program
ITF	Indonesian Throughflow
JRFB	*JOIDES Resolution* Facility Board
JRSO	*JOIDES Resolution* Science Operator
KCC	Kochi Core Center
LIMS	laboratory information management system
LORE	LIMS On-line Report Environment
LWG	laboratory working group
NSF	National Science Foundation
ODP	Ocean Drilling Program
SEM	scanning electron microscope
SEP	Science Evaluation Panel
SHMSL	Section Half Multisensor Logger
STMSL	Special Task Multisensor Logger
TAMRF	Texas A&M Research Foundation
TAMU	Texas A&M University
USAC	US Advisory Committee
USIO	US Implementing Organization (predecessor Program)
VIT	vibration-isolated television
VSP	vertical seismic profile
WRLS	Whole-Round Line Scan
WRMSL	Whole-Round Multisensor Logger
XRF	X-ray fluorescence
MEXT	Ministry of Education, Culture, Sports, Science and Technology (Japan)
MOST	Ministry of Science and Technology (People's Republic of China)
KIGAM	Korea Institute of Geoscience and Mineral Resources
ANZIC	Australia-New Zealand IODP Consortium
ARC	Australian Research Council
MoES	Ministry of Earth Sciences, India