



FY11 Annual Report

*Integrated Ocean Drilling Program
U.S. Implementing Organization*



Sunset aboard the JOIDES Resolution

Integrated Ocean Drilling Program

A historical perspective

The Integrated Ocean Drilling Program (IODP) is an international marine research program that monitors seafloor environments and explores Earth's history and structure as recorded in seafloor sediments and rocks. IODP builds upon the earlier successes of the Deep Sea Drilling Project (DSDP) and the Ocean Drilling Program (ODP), which revolutionized our view of Earth's history and global processes through ocean basin exploration. IODP represents the latest generation of these highly successful scientific ocean drilling initiatives, with principal research themes outlined in the Initial Science Plan: "Earth, Oceans and Life: Scientific Investigations of the Earth System Using Multiple Drilling Platforms and New Technologies."

IODP greatly expands on the previous programs through the use of multiple drilling platforms—a riserless drilling vessel, a riser drilling vessel, and mission-specific platforms—operated by three implementing organizations (IOs) to achieve its scientific goals. The riserless drilling vessel *JOIDES Resolution*, operated by the U.S. Implementing Organization (USIO), allows IODP to drill more deeply than is possible with the other platforms while continuing 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 IODP to drill for months to a year or more 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 IODP 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.

IODP Management International, Inc. (IODP-MI), a nonprofit corporation with an international membership of academic institutions, serves as the central management organization for IODP and is responsible for Program-wide science planning and oversight, as well as provision of continuous performance evaluation and assessment of all elements of IODP. Science planning is provided by the Science Advisory Structure (SAS), which involves many scientists and engineers on numerous standing committees and panels. Each of the IOs provides liaisons with appropriate expertise to interact with SAS panels and other IODP-MI working groups and task forces.

The USIO comprises the Consortium for Ocean Leadership, Inc. (Ocean Leadership), and its partners, Lamont-Doherty Earth Observatory (LDEO) of Columbia University and Texas A&M University (TAMU). Ocean Leadership is the prime contractor, with ultimate responsibility for all contractual obligations entered into by the USIO. LDEO and TAMU serve as subcontractors that contribute distinct but complementary capabilities that collectively support the full range of activities necessary for implementing scientific drilling programs on the *JOIDES Resolution*. Administrative services in support of TAMU activities are provided by the Texas A&M Research Foundation (TAMRF). In this document, references to TAMU include TAMRF.



The JOIDES Resolution in Papeete, Tahiti, French Polynesia

FY11 Annual Report

Integrated Ocean Drilling Program

United States Implementing Organization

Consortium for Ocean Leadership, Inc.

Lamont-Doherty Earth Observatory of Columbia University

Texas A&M University

National Science Foundation
Contract OCE-0352500

IODP Management International, Inc.
Contract IODP-MI-05-03

1 October 2010–30 September 2011



Aerial view of the JOIDES Resolution

Table of Contents

Executive Summary	1
IODP-USIO Expeditions	7
• <i>Expedition 329: South Pacific Gyre Subseafloor Life</i>	
• <i>Expedition 330: Louisville Seamount Trail</i>	
• <i>Expedition 334: Costa Rica Seismogenesis Project</i>	
• <i>Expedition 335: Superfast Spreading Rate Crust 4</i>	
• <i>Expedition 336: Mid-Atlantic Ridge Microbiology</i>	
Operational and Technical Support	17
• <i>Expedition planning</i>	
• <i>Shipboard and laboratory improvements</i>	
• <i>Engineering and tool development and support</i>	
• <i>Data management</i>	
• <i>Curatorial support</i>	
• <i>Program integration and support for others</i>	
• <i>Planning for the future</i>	
Broader Impacts	27
• <i>Publication Services</i>	
• <i>Education</i>	
• <i>Outreach</i>	
Contractual and Financial Overview	41
• <i>USIO contractual relationships</i>	
• <i>USIO FY11 Annual Program Plans to IODP-MI and NSF</i>	
• <i>Financial tables</i>	
Acronym List	61

Cover photo: The JOIDES Resolution in Auckland, New Zealand

Back cover photo: Rotary core barrel bit



David Divins

*Director of Ocean Drilling Programs
Consortium for Ocean Leadership, Inc.*

David Divins joined the Consortium for Ocean Leadership (formerly Joint Oceanographic Institutions) in January 2006 as the Associate Director, Ocean Drilling Programs, and became Director, Ocean Drilling Programs, in August 2006. Divins came to Ocean Leadership from the National Oceanic and Atmospheric Agency's National Geophysical Data Center (NGDC) in Boulder, Colorado, where he was a member of the Marine Geology and Geophysics Division from 2000 to 2005. Before joining NGDC, Divins was a Research Scientist at the University of Colorado Cooperative Institute for Research in Environmental Science from 1991 to 2000. Divins received his B.A. from Boston University (1981) and his Ph.D. in Oceanography from Texas A&M University (TAMU) (1991). While at TAMU he was involved in many Ocean Drilling Program (ODP) activities, including sailing on an ODP expedition and working in the data management group.



David Goldberg

*Director, Borehole Research Group
Lamont-Doherty Earth Observatory of Columbia University*

Dave Goldberg joined the Lamont-Doherty Earth Observatory (LDEO) of Columbia University as a Research Scientist in 1987 and has served as Director of the LDEO Borehole Research Group since 1992. Goldberg earned his S.B. in Geophysics (1981) and S.M. in Marine Geophysics (1981) from Massachusetts Institute of Technology and his Ph.D. in Geophysics (1985) and M.B.A. (1989) from Columbia University. He has sailed on nine Deep Sea Drilling Project and ODP expeditions and is involved in many synergistic activities, including the Department of Energy's Methane Hydrate Advisory Committee; LDEO and Columbia University's Earth Microbiology Initiative; the LDEO Laboratory for Ocean Drilling, Observation, and Sampling; and the Integrated Ocean Drilling Program's (IODP's) International Scientific Logging Consortium.



Brad Clement

*Director, Integrated Ocean Drilling Program
Texas A&M University*

Brad Clement was appointed Director of IODP at TAMU in August 2009. Clement chaired the U.S. Science Advisory Committee (USAC) and has a long history of involvement with IODP, having sailed on four expeditions, worked as an 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 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.

Executive Summary



Logging tool demonstration for NSF visitors D. Conover and R. Batiza

The Integrated Ocean Drilling Program (IODP) U.S. Implementing Organization (USIO) accomplished its Fiscal Year 2011 (FY11) objectives, including the successful completion of four cutting-edge expeditions and the beginning of a fifth, each of which will advance global understanding of Earth systems. Over the course of these expeditions, the USIO visited one of the least explored areas of the world's oceans, set scientific ocean drilling records, revisited one of the deepest hard rock penetration sites in Program history, and recovered the largest collection of basement rock ever collected for microbiology research during 40 years of scientific ocean drilling.

During Expedition 329, the *JOIDES Resolution* traveled 6,655 nautical miles in the South Pacific Gyre, one of

the largest, most remote, and least explored areas of the world's oceans, where the surface water is the clearest salt water in the world and the sedimentary cover spans more than 100 million years of seafloor age. This area of the South Pacific is remarkably organic poor, with organic carbon content, which is critical for sustaining life, dropping below detectable levels just a few meters below the seafloor. Scientists believe the harsh and remote conditions of the South Pacific Gyre—sometimes called Earth's largest oceanic desert—may have driven the evolution of unique life forms that can live and thrive in extreme environments. Samples recovered during Expedition 329 will lead to key advances in the understanding of fundamental aspects of subseafloor life, metabolic activities, and biomass in this very low activity sedimentary ecosystem.

Expedition 330 traveled to the Louisville Seamount Trail, an extinct 4,300 km long volcanic chain built over the past 80 million years as the Pacific plate moved over a hotspot. Scientists have long regarded hotspots as being fixed in relation to moving tectonic plates and have used submarine volcanic trails to indicate the direction and speed at which tectonic plates move. However, recent ocean drilling of the Hawaiian-Emperor Seamounts indicated that hotspots are not stationary, as once thought. Expedition 330 drilled into the summits of the five guyots that form the Louisville Seamount Trail, which, because of its age and size, is regarded as the South Pacific counterpart of the Hawaiian-Emperor Seamount Chain. A comparison of results from the Louisville Seamount Trail and the Hawaiian-Emperor Seamount Chain may help address this fundamental question of geodynamics: whether hotspots are fixed relative to one another and can truly provide a global reference frame for geodynamic reconstructions.

During Expedition 334, IODP scientists traveled to the eastern Pacific Ocean offshore Osa Peninsula, Costa Rica, where the Cocos Ridge is subducting beneath the Caribbean plate, and collected nearly 1,500 meters (almost 1 mile) of sediment cores that revealed detailed records of some 2 million years of tectonic activity along a seismic plate boundary. Complementing other deep-fault drilling (San Andreas Fault Observatory at Depth [SAFOD] and Nankai Trough Seismogenic Zone Experiment), Expedition 334 investigated the seismogenic processes common to most faults and those unique to erosional margins and explored the only known erosional end-member of convergent margins within reach of scientific drilling.

Expedition 335 returned to Ocean Drilling Program (ODP) Hole 1256D to advance the hole several hundred meters through the dike-gabbro transition into the cumulate gabbros that compose the lower crust. Cores



Just before sunrise on the JOIDES Resolution helideck

from in situ cumulate gabbros may be used to test hypotheses about magmatic accretion of the lower ocean crust, resulting in major advancement in the understanding of how a significant proportion of the Earth's crust formed. Although operations involved drilling into metamorphic rock as hard as any formation ever encountered during ocean drilling, the expedition recovered a remarkable suite of heat-tempered basalts, providing a detailed picture of the rarely seen boundary between magma and seawater, and left the hole stabilized for further deepening during the next return.

Spanning two fiscal years, Expedition 336 will examine the microbiology of a sediment pond and the underlying young, cold, and hydrologically active flank of the Mid-Atlantic Ridge. In September 2011, the USIO returned to Deep Sea Drilling Project (DSDP) Hole 395A and extracted the circulation obviation retrofit kit (CORK) observatory that was installed there during ODP Leg 174B in 1997, retrieving nearly 14 years of data in the process.

In support of FY11 expeditions and the effort to remain responsive to unforeseen issues as they arise, the USIO implemented the Project Portfolio Management (PPM) initiative to prioritize projects and help balance the specific demands of each expedition with longer term Program priorities and focus limited resources on highest priority activities. Laboratory working groups reviewed expedition technical reports and input from participants, applying the PPM assessment tool to

develop advice on corrective actions and potential developments both on board the *JOIDES Resolution* and on shore. More than 20 projects arising from the PPM process were completed during the fiscal year, including equipment acquisitions and upgrades recommended by the laboratory working groups. Shipboard laboratory facilities were improved during a tie-up period and transits between expeditions, and new capabilities were introduced through analytical systems upgrades, engineering tool development, and major information technology (IT) software development.

The USIO continued working to preserve the Program's legacy and to expand the visibility of IODP's contributions to the global understanding of Earth's structure, microbiology, and history as understood through scientific ocean drilling. Publication services provided to international IODP implementing organization (IO) partners culminated in new IODP scientific publications that were made available online to the general public and directly distributed to more than 800 program member offices, universities, and geological organizations worldwide. The USIO also explored methods for documenting the impact of postexpedition Program-related research on the scientific community and options for developing a

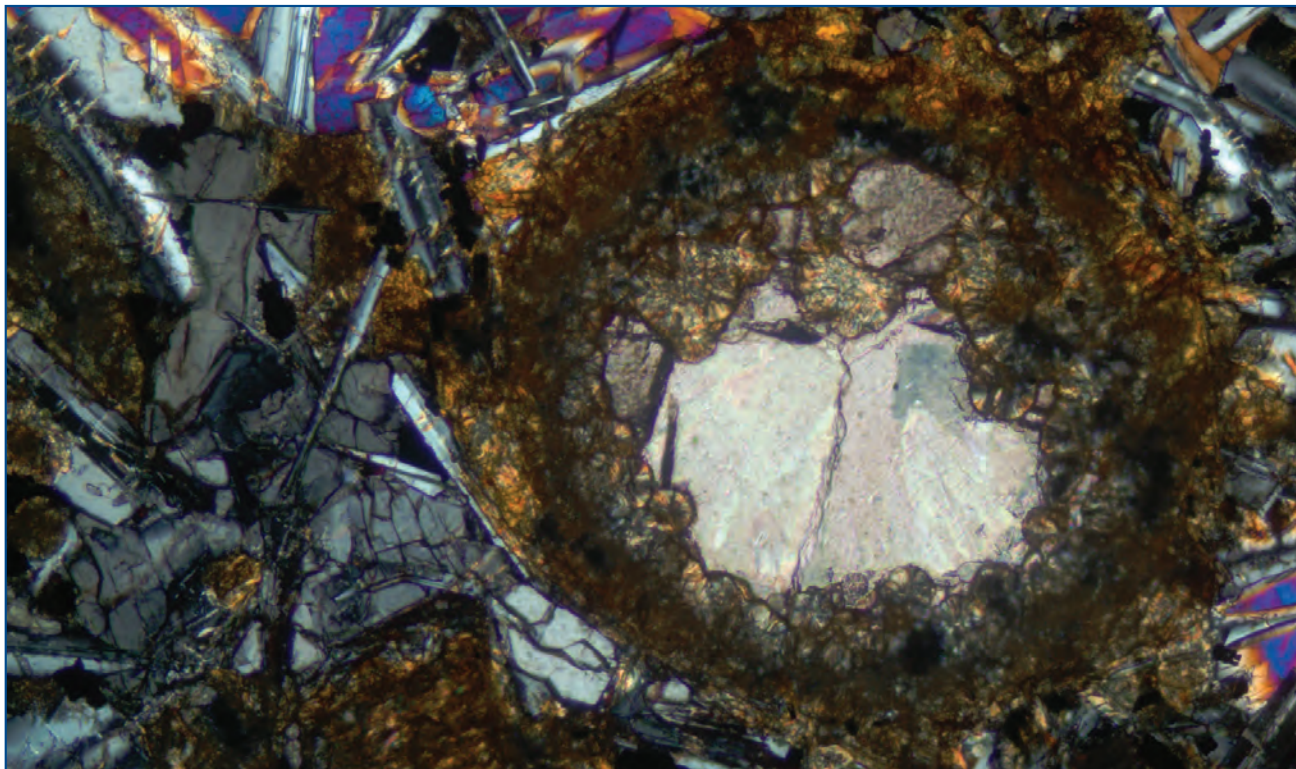
More from the numbers

FY11 expedition operations

<i>Operations time (days)</i>	223.85
<i>Time on site (days)</i>	152.78
<i>Time coring/drilling (days)</i>	121.90
<i>Time logging (days)</i>	13.38
<i>Distance traveled (nmi)</i>	12,436
<i>Sites</i>	19
<i>Holes</i>	60
<i>Cores</i>	581



The JOIDES Resolution bell



Photomicrograph of a vesicle from Expedition 329

long-term archive and preservation strategy for IODP publications. The public visibility of IODP-related science was increased through media and social networking in conjunction with exhibits at national and international museums and live and near-real-time programs that used the *JOIDES Resolution* as a platform for education. Diversity outreach initiatives were introduced to encourage minority students to pursue advanced studies in Earth system sciences or careers in scientific ocean drilling, and a workshop drawing more than three dozen national and international young scientists

introduced all aspects of IODP to a new generation of potential participants.

This IODP-USIO Fiscal Year 2011 Annual Report details these accomplishments and other activities undertaken in support of National Science Foundation (NSF) Contract OCE-0352500 and IODP Management International, Inc. (IODP-MI), Contract IODP-MI-05-03 during the period from 1 October 2010 to 30 September 2011.

More from the leadership

"You could think of [the JOIDES Resolution] as the oceanographic equivalent of the International Space Station. Through recovery and analysis of deep ocean sediments and rocks, the JR has made possible fundamental discoveries in plate tectonics, Earth's climate history, the deep biosphere (did you know organisms live in rock miles below the ocean floor?), earthquake hazards, mineral resources, etc."

—M. Raymo, Chair of the Science Advisory Structure Executive Committee



Examining hard rock in the core splitting room

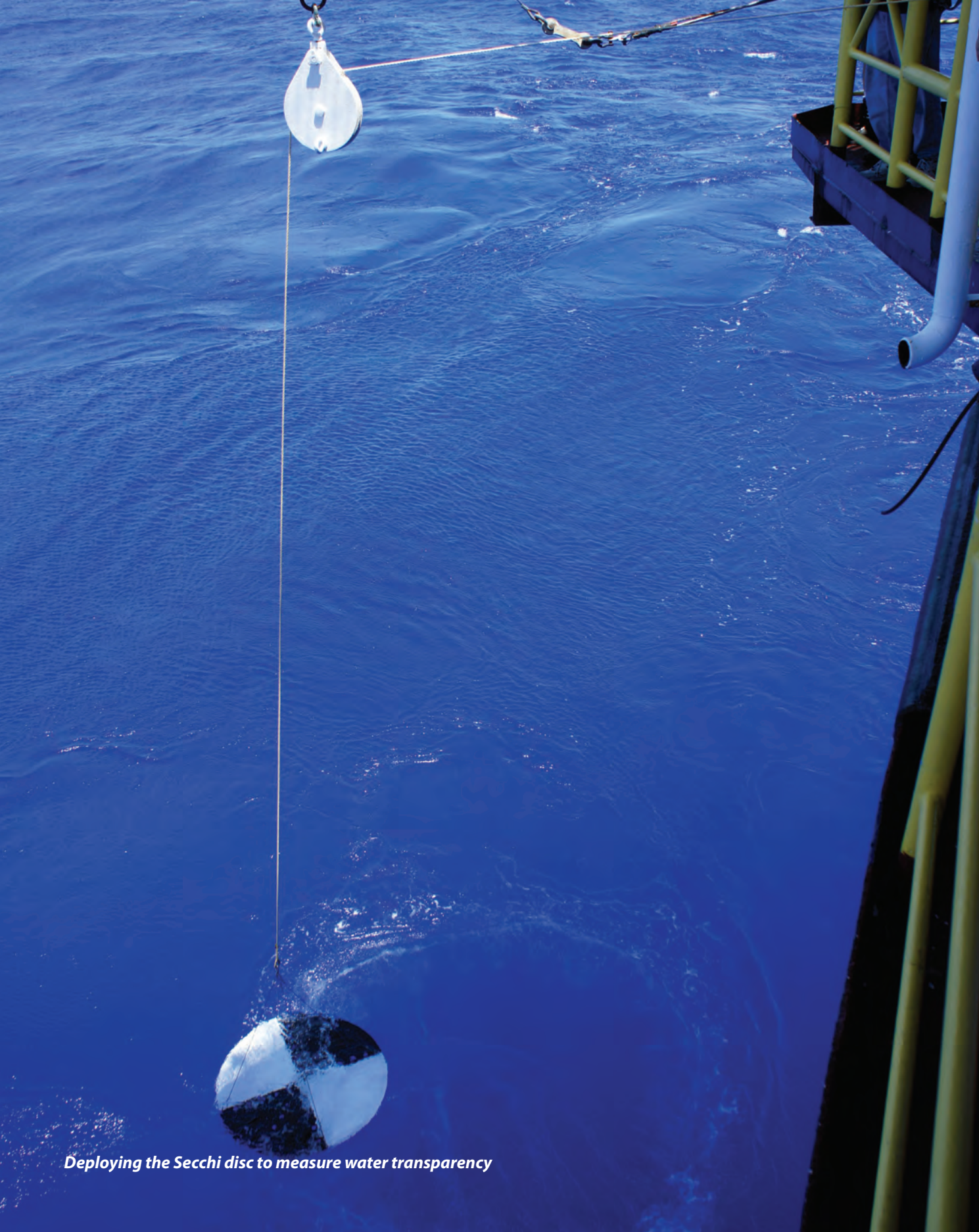
More online

IODP-USIO web page: iodp-usio.org/

IODP Science Plan: iodp.org/isp/

IODP-USIO FY11 Annual Program Plan: iodp.tamu.edu/publications/PP.html

IODP-USIO FY11 Quarterly Reports: iodp.tamu.edu/publications/AR.html



Deploying the Secchi disc to measure water transparency

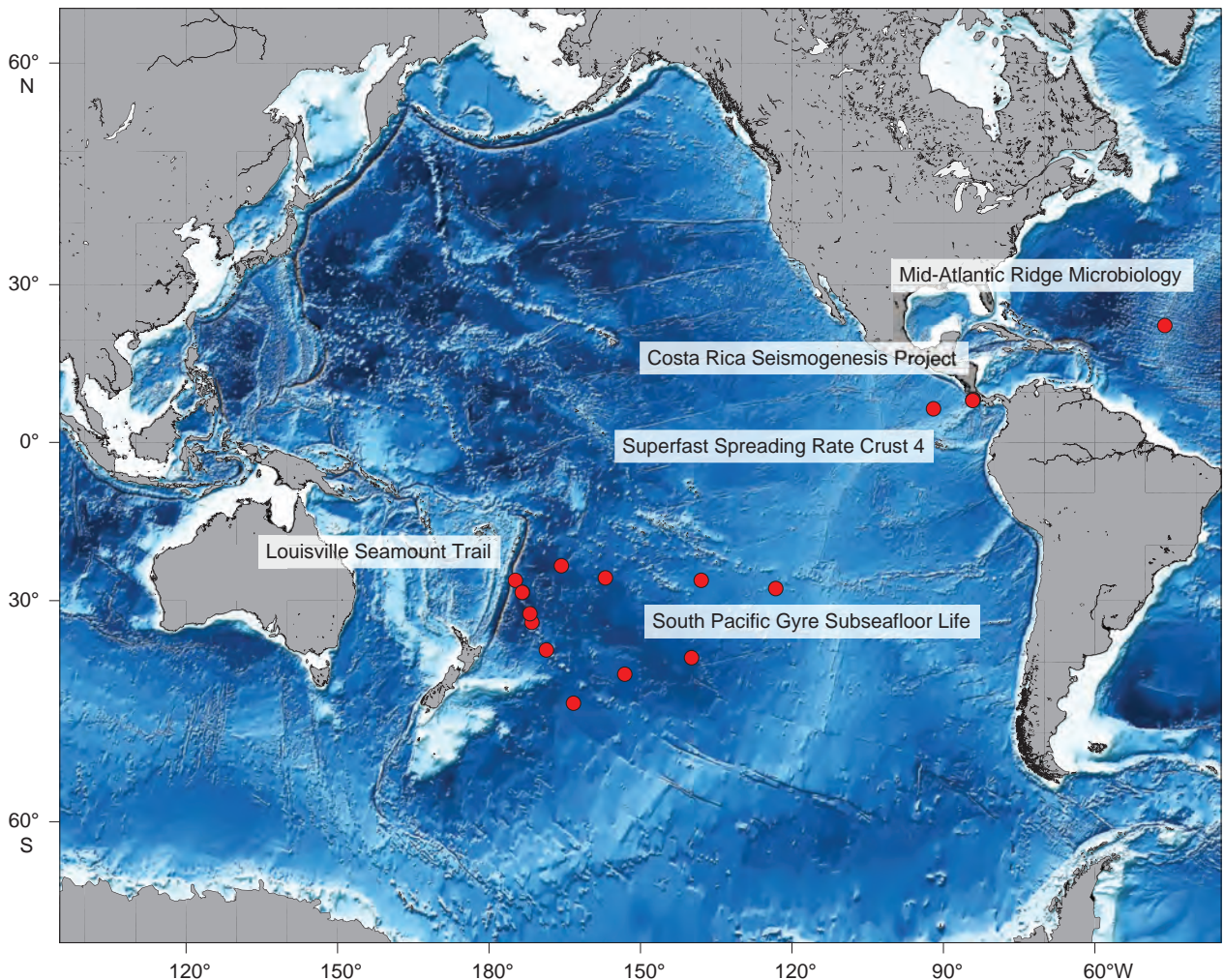
IODP-USIO Expeditions

The USIO completed four full expeditions and began a fifth expedition during FY11. Over the course of these expeditions, the USIO transited one of the farthest distances ever traveled for a scientific ocean drilling expedition, drilled in metamorphic rock as hard as any formation ever encountered, collected sediments and basalts from the only known erosional end-member of convergent margins within reach of

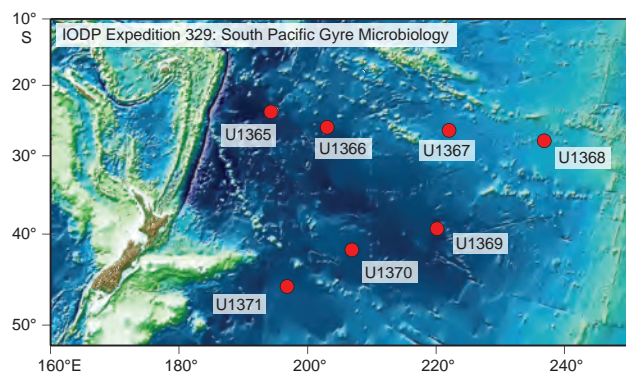
scientific drilling, and recovered a significant collection of basement rock for microbiology research.

Expedition 329: South Pacific Gyre Subseafloor Life

From 9 October to 13 December 2010, an international team of IODP scientists explored one of the largest, most remote, and least explored areas of the world's



FY11 expedition sites



Expedition 329 site map

oceans, gathering data that offer a glimpse into one of the most fascinating ocean phenomenon yet to be studied.

The South Pacific Gyre covers 10% of the Earth's total surface area and has been called Earth's largest oceanic desert because of the harsh and remote conditions. Energy production of tiny plants and microbes is lower here than in any other region of the world's ocean. Samples taken from the seafloor in this gyre have the lowest cell concentrations ever found in the seafloor, and organic oxidation occurs at rates thousands of times below the net respiration rates seen at other sites in the Pacific Ocean. Organic carbon content—critical for sustaining life—decreases so rapidly with depth in this area that it drops below detectable levels just a few meters below the seafloor, yet those few meters host microbial processes that are estimated to be tens of millions of years old. Scientists believe the harsh environment of this region may have driven the evolution of "extremophiles"—tiny, unique life forms that are able to live in areas without sunlight or

More from the IODP scientists

"We were exploring a place [the South Pacific Gyre] that's twice the size of North America, and has scarcely been explored before. So instead of Lewis & Clark setting out in search of the long-extinct American Elephant, we were looking for the microbes beneath the sea."

—S. D'Hondt, Expedition 329 Co-Chief Scientist



Taking samples in the microbiology laboratory

organic matter and at extremely slow metabolic rates, possibly even living on hydrogen generated by natural radioactivity.

The center of the South Pacific Gyre is farther away from any continental landmass than the center of any other oceanic gyre, and the 6,655 nmi covered during Expedition 329 represents one of the farthest distances traveled for an expedition in scientific ocean drilling history. The surface water is the clearest salt water in the world, and the sedimentary cover in the gyre spans more than 100 million years of seafloor age. A range of instruments that are seldom used during IODP expeditions were employed during Expedition 329, including oxygen microelectrodes and optodes, flow cytometric cell counting, radiotracer facilities, and hydrogen analysis. Samples recovered during the expedition will lead to key advances in the understanding of fundamental aspects of subseafloor life, metabolic activities, and biomass in this very



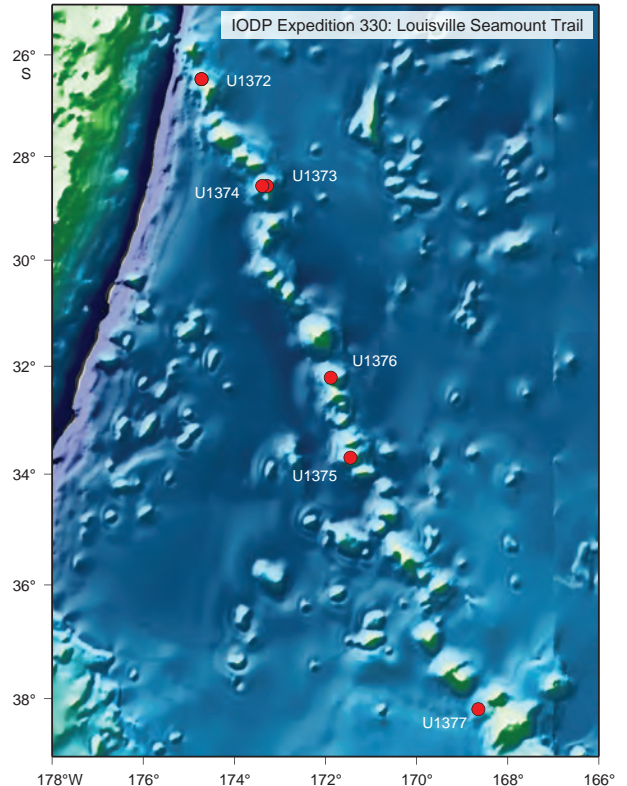
Working in the core reefer “cold” laboratory

low activity sedimentary ecosystem, and also of geological processes, including the factors that control hydrothermal circulation and chemical alteration in the ocean crust, models of regional tectonic history, geodynamo models, and models of glacial–interglacial ocean-climate change.

Expedition 330: Louisville Seamount Trail

In December 2010, the Expedition 330 research team embarked on an expedition to drill into the summits of five guyots in the extinct volcanic chain called the Louisville Seamount Trail. Because scientists have long regarded hotspots as being fixed in relation to moving tectonic plates, submarine volcanic trails have been used to indicate the direction and speed at which tectonic plates move. However, recent ocean drilling of the Hawaiian-Emperor Seamounts has indicated that hotspots are not as stationary as once thought. Comparing results from the Louisville Seamount Trail and the Hawaiian-Emperor Seamount Chain may give clues as to whether the Louisville hotspot moved at the same time and in the same direction as the Hawaiian hotspot, or in a different direction, or not at all. Scientists anticipate the results from Expedition 330 data will help to address this fundamental question of geodynamics—whether hotspots are fixed relative to one another and can truly provide a global reference frame for geodynamic reconstructions.

The Louisville Seamount Trail is a 4,300 km long volcanic chain built over the past 80 million years as the Pacific plate moved over a hotspot; it was once an archipelago



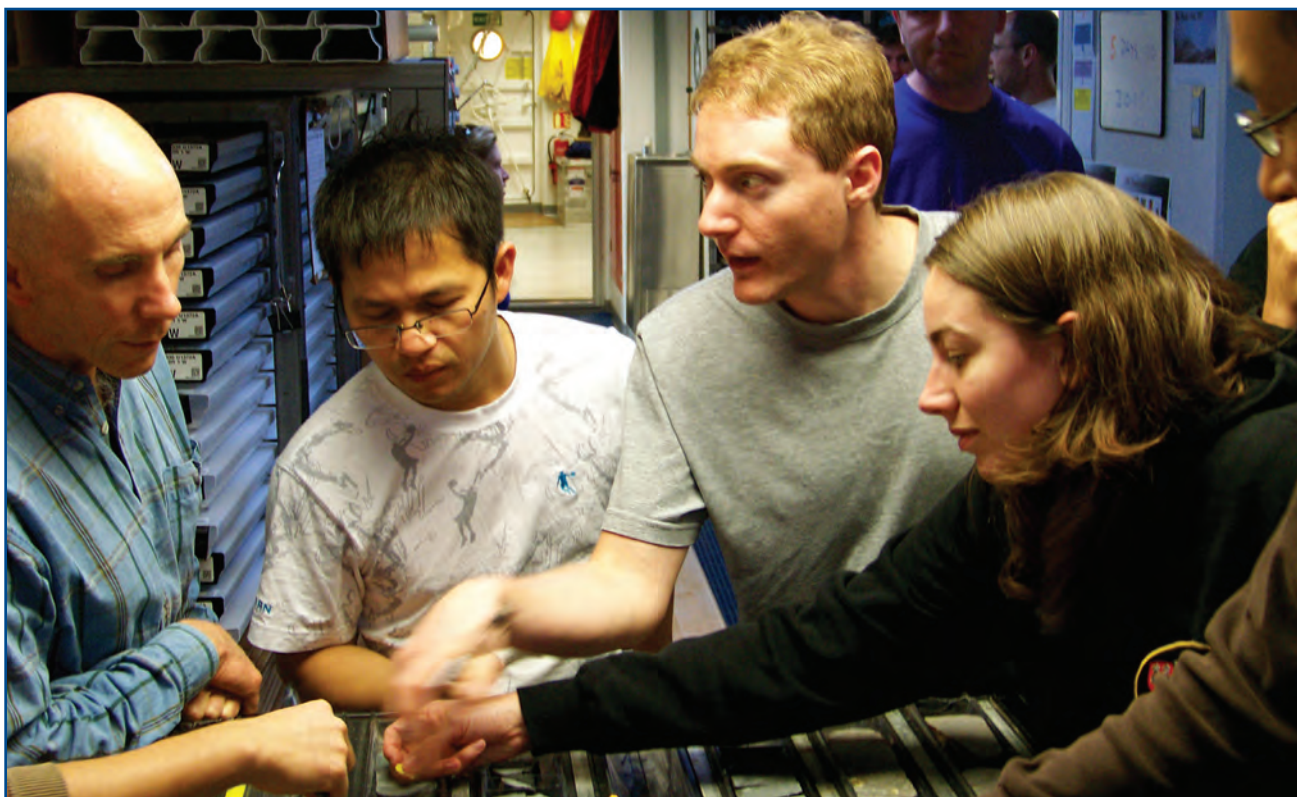
Expedition 330 site map

of volcanic islands, but Expedition 330 drilling revealed evidence that it was at or above the surface of the ocean for only a short time. Because of its age and size, the Louisville Seamount Chain is regarded as the South Pacific counterpart of the Hawaiian-Emperor Seamount Chain. Drilling during ODP Leg 197 in the Emperor

More from the IODP scientists

“Submarine volcanic trails like the Louisville Seamount Trail are unique because they record the direction and speed at which tectonic plates move.... The challenge is that no one knows if hotspots are truly stationary—or if they somehow wander over time. If they wander, then our calculations of plate direction and speed need to be re-evaluated. But even more importantly, the results of this expedition will give us a more accurate picture of the dynamic nature of the interior of the Earth on a planetary scale.”

—A. Koppers, Expedition 330 Co-Chief Scientist



Discussing core descriptions at the shift change

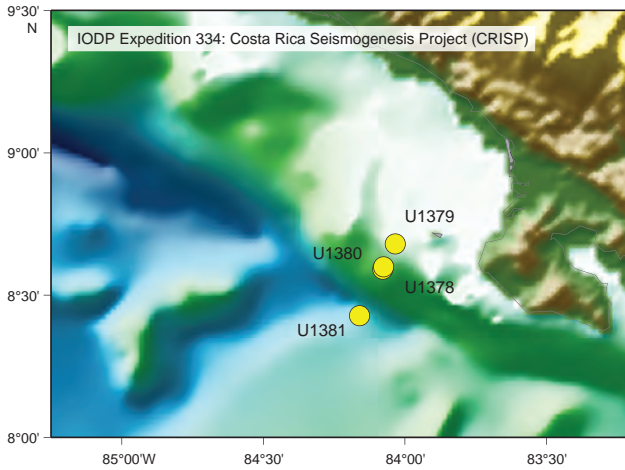
Seamounts confirmed $\sim 15^\circ$ southward motion of the Hawaiian hotspot prior to 47 Ma, calling into question whether the Pacific hotspots constitute a fixed frame of reference. If the Hawaii and Louisville hotspots moved in concert, they might constitute a slowly moving reference frame in the Pacific. Alternatively, these hotspots may have moved independently, as suggested by geodynamic models of mantle flow patterns that reproduce the observed latitudinal motion for the Hawaiian hotspot but predict essentially no latitudinal shift for the Louisville hotspot. These end-member models can be only distinguished through drilling of the Louisville Seamount Trail.

Core recovery during Expedition 330 was outstanding, with an average of 72.4%. At Site U1374 on Rigil Guyot, a total of 522 meters was drilled, with a record-breaking 88% of basement recovery. Nearly all Expedition 330 core material is characterized by low alteration, providing samples of mostly well-preserved basalt containing, for example, pristine olivine crystals with

melt inclusions, fresh volcanic glass, various micro- and macrofossils, and, in one case, mantle xenoliths and xenocrysts. The volcanic rocks collected are well suited for all planned postexpedition geochemical studies, including a range of isotope measurements, high-precision age determination, and detailed paleomagnetic investigations. In addition, the combined Expedition 329 and 330 recovered sample material comprises the largest collection of basement rock ever collected for microbiology research during 40 years of scientific ocean drilling.

Expedition 334: Costa Rica Seismogenesis Project

Expedition 334, the Costa Rica Seismogenesis Project (CRISP), was a 4-week expedition to the eastern Pacific Ocean offshore Osa Peninsula, Costa Rica, where the Cocos Ridge is subducting beneath the Caribbean plate. This expedition was designed to explore the processes that control nucleation and seismic rupture of large earthquakes at erosional subduction zones, where



Expedition 334 site map

nearly 80% of earthquakes greater than magnitude 8 occur across the globe. CRISP involved the only known erosional end-member of convergent margins within reach of scientific drilling. Complementing other deep-fault drilling (SAFOD and Nankai Trough Seismogenic Zone Experiment), Expedition 334 investigated the seismogenic processes common to most faults and those unique to erosional margins. With a relatively thin sediment cover, fast convergence rate, abundant seismicity, subduction erosion, and change in subducting plate relief along strike, CRISP sites offered excellent opportunities to learn more about the causes of earthquake nucleation and rupture propagation. CRISP was also the first research endeavor to drill into the sediments and basalts of Cocos Ridge, which is the trace of the Galapagos hotspot on the Cocos plate. Nearly 1,500 meters (almost 1 mile) of sediment cores were collected during the expedition, revealing detailed records of some 2 million years of tectonic activity along a seismic plate boundary.

The basement was successfully drilled at one (upslope) of the three slope sites, where both cores and logging-while-drilling (LWD) logs penetrated below the slope sediment and upper plate basement interface. It remains unclear if drilling entered a transition zone with clasts of basement (e.g., an erosional surface) or the basement itself; however, further analysis should answer this question. Preliminary results of biostratigraphic ages obtained from the slope sites indicate high sediment accumulation rates in the terrestrially sourced slope sequence. Detailed research of sedimentary facies



Preparing microbiology samples in a nitrogen gas-filled bag

and benthic foraminifer fauna in slope sediments are keys to estimate the mass removal associated with basal erosion and the thickness of the subduction channel.

Present-day in situ stress orientation was estimated from borehole breakouts at sites in the middle and

More from the leadership

"It's critical to understand how subduction zone earthquakes and tsunamis originate—especially in light of recent events in Japan. The results of [Expedition 334] will also help us learn more about our own such zone off the Pacific Northwest."

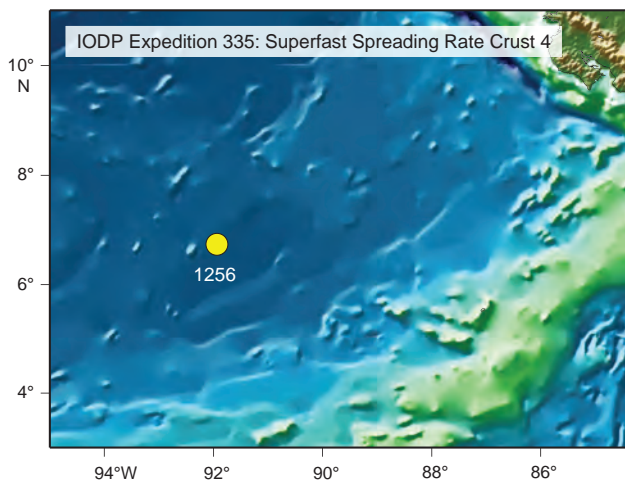
—R. Batiza, Section Head, Marine Geoscience Section, Ocean Sciences Division, National Science Foundation

upper slopes. Borehole breakouts, which form when there are differences in the principal horizontal stresses, were identified from LWD images of borehole radius and density. In addition, types, orientations, and kinematics of faults were determined from cores. Stress at the middle slope site is compressional, whereas that at the upper slope site is extensional. This marked change in stress state occurs within ~12 km along the CRISP transect in the northwestern flank of the Cocos Ridge and may correspond to a change from compression (middle slope) to extension (upper slope), marking the onset of subduction erosion.

Approximately 170 tephra layers with ages ranging from middle Miocene to the present were retrieved from all cored holes at the four different sites. Postexpedition analyses of the tephra will answer questions about the evolution of the magmatic arc, including the deactivation of the volcanoes located on the present-day location of the Talamanca Cordillera.

Expedition 335: Superfast Spreading Rate Crust 4

The *JOIDES Resolution* returned to ODP Hole 1256D in April 2011 for the fourth drilling expedition of the Superfast Spreading Rate campaign. Crust formed at fast-spreading ridges accounts for 50% of the ocean floor and about 30% of the Earth's surface. Superfast spreading crust is thinner than elsewhere, making it possible to reach the lower portions of the ocean crust without having to drill as deep.



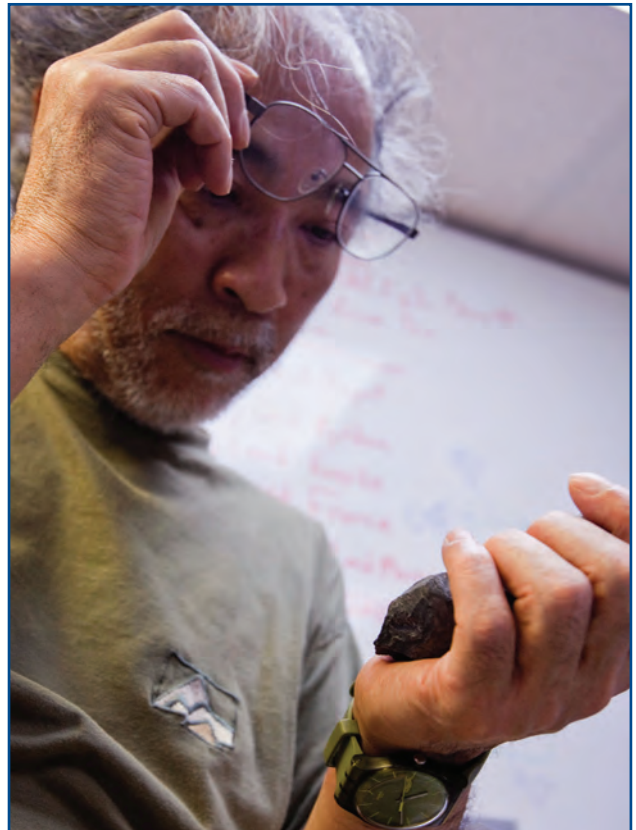
Expedition 335 site map

More from the IODP scientists

"The formation of new crust is the first step in Earth's plate tectonic cycle. This is the principal mechanism by which heat and material rise from within the Earth to the surface of the planet. And it's the motion and interactions of Earth's tectonic plates that drive the formation of mountains and volcanoes, the initiation of earthquakes, and the exchange of elements (such as carbon) between the Earth's interior, oceans, and atmosphere."

—D. Teagle, Expedition 335 Co-Chief Scientist

The objective of Expedition 335 was to advance Hole 1256D several hundred meters through the dike–gabbro transition into the cumulate gabbros that comprise the lower crust. Cores from in situ cumulate gabbros would allow major advancement in our understanding of how a significant proportion of the



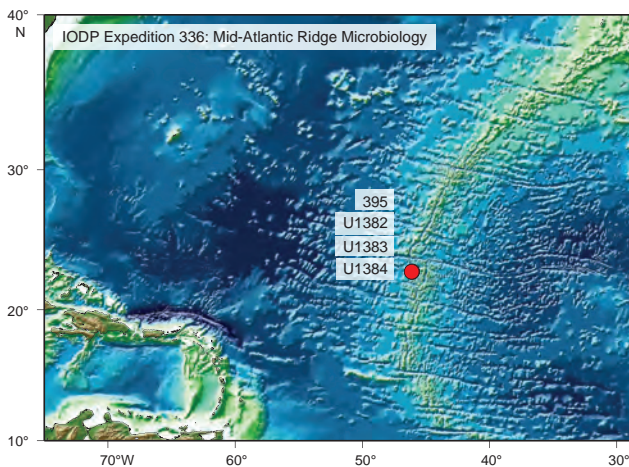
Examining a hard rock sample

Earth's crust formed, by testing hypotheses about magmatic accretion of the lower ocean crust.

Operations in Hole 1256D were challenging, requiring eight reentries before coring could resume, and a total of 24 reentries made with a record of more than 150 miles of pipe trip during the expedition. The granoblastic basalt zone drilled during Expedition 335 contained metamorphic rock as hard as any formation ever encountered during ocean drilling, sometimes tougher than the most resilient of hard-formation drilling and coring bits. A remarkable suite of heat-tempered basalts was recovered that provide a detailed picture of the rarely seen boundary between magma and seawater. In addition, hole-cleaning operations recovered granoblastic and minor gabbroic rocks as large as 3.5 kg that preserve a complex history of recrystallization, hydrothermal alteration, and small-scale intrusions that could not have been observed on a core scale. Hole 1256D, one of the deepest hard rock penetration sites of scientific ocean drilling, was left stabilized, cleared to its full depth, and primed for further deepening during the next return.

Expedition 336: Mid-Atlantic Ridge Microbiology

Expedition 336, which began in September 2011, will examine the microbiology of a sediment pond and the underlying young, cold, and hydrologically active flank of the Mid-Atlantic Ridge. Planned drilling operations at three sites include sediment/basalt coring, basement



Expedition 336 site map



Scraping microbiological samples from the recovered Hole 395A CORK

logging, and installation of three long-term subseafloor observatories, with the objectives of investigating the nature of microbial communities in young ridge flanks and their role in crustal weathering, as well as the origin of deep-seated microbial communities.

During the first 2 weeks of the expedition, the *JOIDES Resolution* returned to DSDP Hole 395A and retrieved the CORK observatory that was installed in 1997 during ODP Leg 174B. Once the CORK was on board, the internal string was pulled out, pressure and temperature data were downloaded, thermistors were cut out of the string, and sections of the string were sampled for microbiologic analyses. Hole 395A was then logged to 600 mbsf with a new in situ tool for detecting microbial life in ocean floor boreholes—the Deep Exploration Biosphere Investigative tool (DEBI-t) (see “[Multifunction telemetry module](#)” in “Operational and Technical Support”).



Pulling the Hole 395A CORK through the JOIDES Resolution moonpool

The new Hole 395A lateral CORK (L-CORK), a modified design to fit DSDP reentry hardware, failed during installation at the seafloor. The CORK head broke off from the rest of the CORK, which remained in the hole. The CORK head and running tool were retrieved and inspected to determine the cause of the failure, and

video evidence and instrumentation data were collected for further review to determine what alterations can be made to increase chances of success in subsequent installations and to identify potential future actions in Hole 395A.

More online

IODP Expedition web pages: iodp.tamu.edu/scienceops/expeditions.html

Proceedings of the Integrated Ocean Drilling Program: iodp.org/scientific-publications/

IODP-USIO FY11 expedition coring and logging summary

Expedition	Meters cored	Cores recovered (number)	Core recovered (m)	Core recovery (%)	Meters logged	Sites logged (%)
Expedition 329: South Pacific Gyre	1,321.8	194	1,168.80	88.0	115.1	14.3
Expedition 330: Louisville Seamount Trail	1,134.2	193	797.08	70.3	704.8	33.3
Expedition 334: Costa Rica Seismogenesis Project	1,761.9	224	1,492.88	84.7	1,419.7	50.0
Expedition 335: Superfast Spreading Rate Crust 4	14.5	5	1.64	11.3	1,520.0	100.0
Totals	4,232.4	616	3,460.40	81.8	3,759.6	33.3



Inspecting severed drill pipe



Recovering core on deck

Operational and Technical Support

The USIO provided operational and technical support for four complete expeditions during FY11 and the beginning of a fifth expedition that will straddle two fiscal years. Significant improvements were made to shipboard facilities, laboratory infrastructure, and database systems during transits between expeditions and during a tie-up period. New capabilities were introduced through analytical system and engineering tool development and acquisitions, as well as major IT software development projects. The USIO also continued to coordinate with and provide support for the Center for Deep Earth Exploration (CDEX) and the European Consortium for Ocean Research Drilling (ECORD) Science Operator (ESO) and participated in ongoing planning efforts for the future of scientific ocean drilling.

Expedition planning

Pre-expedition planning meetings were held in College Station, Texas, for FY12 Expeditions 339 (Mediterranean Outflow), 340 (Lesser Antilles Volcanism and Landslides), and 342 (Newfoundland Sediment Drifts) and FY13 Expedition 341 (Southern Alaska Margin Tectonics, Climate, and Sedimentation). After a series of planning and engineering design meetings, the Cascadia Margin

expedition was removed from the FY12 schedule in response to budgetary and timeline issues. Expedition 340 was approved to replace the Cascadia Margin expedition, and Ancillary Project Letter (APL) 779 was added as stand-alone operation Expedition 340T (Atlantis Massif Oceanic Core Complex). The pre-expedition meeting for Expedition 340T was conducted via conference call. Expedition 342 was added to the FY12 USIO expedition schedule in June 2011, and planning efforts at the end of the year focused on refining schedule details and tentative port selections.

Science staffing was completed this year for FY11 Expeditions 334 (CRISP), 335 (Superfast Spreading Rate Crust 4), and 336 (Mid-Atlantic Ridge Microbiology) and FY12 Expeditions 339, 340T, 340, and 341. The USIO coordinated science staffing to fulfill specialized needs and made shipboard berths available to accommodate education and outreach efforts (see “Education” in “Broader Impacts” for more information). Clearance applications were submitted to the U.S. State Department for operations in the Exclusive Economic Zone (EEZ) waters of Spain and Portugal during Expedition 339 and for operations in the EEZ of Montserrat, Guadeloupe, Dominica, and Martinique

FY11 USIO expedition science staffing breakdown

Member country/consortium	Expedition					Total
	329	330	334	335	336	
United States Science Support Program (USSSP)	8	8	8	8	8	40
Japan Drilling Earth Science Consortium (J-DESC)	8	8	8	8	4	36
European Consortium for Ocean Research Drilling (ECORD)	9	8	8	9	7	41
Korean IODP (K-IODP)	2	0	1	1	1	5
IODP-China	2	1	1	0	1	5
Australia-New Zealand IODP Consortium (ANZIC)	1	2	1	1	0	5
India	0	0	1	1	0	2
Total Science Party participants	30	27	28	28	21	113

during Expedition 340. Environmental evaluations for use of air guns during Expedition 339 check shot surveys and seismic sources to conduct a check shot survey during Expedition 334 were submitted to the National Science Foundation, and development of the environmental evaluation reports for Expeditions 340 and 340T was initiated.

A communications model for future engineering work was established through biweekly teleconferences between the USIO project team, proponents, and engineers who worked together to finalize design requirements for the L-CORKs that would be deployed during Expedition 336. The USIO also managed logistically challenging shipping requirements and specialized outfitting in port to accommodate microbiological and chemical requirements for Expedition 329 (South Pacific Gyre Subseafloor Life), to deploy logging-while-drilling tools for Expedition 334 (CRISP), and to transfer 45 shipments of hardware and equipment to Curaçao in preparation for Expedition 336.

Shipboard and laboratory improvements **Laboratory working groups**

The USIO initiated four laboratory working groups this year that focused on curation and core handling, geochemistry, geology, and geophysics. The groups comprised technical and science staff members who reviewed 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. These groups advised new equipment acquisitions and replacements during FY11, including

- A newly developed system comprising a whole-round core section sample holder, adapters to the split-core imaging system, and modifications to the Section Half Imaging Logger (SHIL) software to allow capture of images of the external surface of hard rocks before splitting;
- CoolLED light sources and filters for epifluorescence microscopy that will generate significantly less heat and stray light on the sample and improve the performance of the stained cell count method;

- A high-capacity ASC Scientific Model TD-48-SC thermal demagnetizer that loads and unloads from the same side, making the system easier to use;
- Two Zeiss Stereo Discovery V8 microscopes, including LED ring lights that can be set to illuminate only specific quadrants for sharper contrasts and better imaging; and
- An Agilent Cary 100 Bio spectrophotometer to act as an effective backup and supplement to the OI Analytical Discrete Analyzer.

Shipboard systems and laboratories

During the tie-up period and transit times between expeditions, the USIO enhanced shipboard laboratory facilities considerably with increased work space; rerouted electrical, plumbing, and gas lines; new refrigeration and freezer space; more easily accessible storage space; and several IT infrastructure and software upgrades. A new towed magnetometer was also deployed and tested, and the high-temperature wireline logging cable was installed.

The Common Logger Graphical User Interface project was also initiated during the tie-up period when a group of USIO staff gathered on board the *JOIDES Resolution* to evaluate the core logging systems software and make recommendations for improvements. The “logger summit” participants determined best practices for future logger software development, the feasibility of implementing a common logger software architecture, and requirements for developing consistent user interfaces across core logging systems.



Working in the core laboratory



Working in the core splitting room

Shore-based Geosciences Laboratory

The Texas A&M University (TAMU) Ocean Drilling and Sustainable Earth Science (ODASES) Geosciences Laboratory housed at IODP-TAMU hosted scientists for X-ray fluorescence (XRF) scanning projects throughout the fiscal year, keeping the XRF in use for more than 50% of the available days. Visiting scientists used the shore-based SHIL for imaging cores that are prepared for XRF analysis, and work began on establishing a shore-based Whole-Round Multisensor Logger with magnetic susceptibility, density by gamma ray attenuation, and *P*-wave velocity capabilities. TAMU ODASES faculty also created a subcommittee to provide advice to the USIO on data management for instruments in the ODASES laboratory.

Engineering and tool development and support

Large-diameter pipe handling infrastructure

Contracts were finalized during FY11 for the design and fabrication of infrastructure for safely and efficiently handling large-diameter (6-5/8 inch) pipe on board the *JOIDES Resolution*. Representatives from the USIO and subcontractors met on board the *JOIDES Resolution* to evaluate the rig floor layout and equipment needed for the design of the new system. Several options for new elevator designs including side- and center-latch styles for use with both conventional IODP pipe and 6-5/8 inch pipe will be considered before final selection.

Magnetic susceptibility sonde rebuild

The USIO continued construction of two new magnetic susceptibility sonde (MSS)-B tools to replace the MSS-A. New susceptibility coil configurations were



Programming the Deep Exploration Biosphere Investigative tool

manufactured and tested, low- and high-resolution sensors were completed, and field testing of the MSS-B was scheduled to take place during Expedition 340.

Multifunctional telemetry module

The USIO's Multifunction Telemetry Module (MFTM), which was designed to transmit third-party tool downhole data back to the surface in real time, was deployed successfully with the DEBI-t during Expedition 336 to measure biomass on the borehole wall and borehole temperature. The DEBI-t was developed by scientists and engineers from the University of Southern California, the National Aeronautic and Space Administration Jet Propulsion Laboratory at the California Institute of Technology, and Photon Systems, Inc. Future deployments of the MFTM are planned in combination with other devices, including the Simple Cabled Instrument for Measuring In Situ Parameters (SCIMPI) and the Motion Decoupled Hydraulic Delivery System (MDHDS).



Removing centralizer from a logging tool

The SCIMPI is a collaborative effort between the USIO, University of Rhode Island, Woods Hole Oceanographic Institute, and Transcend Engineering & Technology, LLC, to develop a borehole observatory sensor system to capture in situ physical and hydrogeological properties data over long time periods. The MFTM will be used to communicate between the surface and the downhole SCIMPI system prior to long-term deployment. Testing of the SCIMPI system began in FY11 and will continue through FY12.

The MDHDS project is a collaborative development between the USIO, the University of Texas at Austin, Massachusetts Institute of Technology, and Mohr Engineering, wherein the MFTM will allow real-time monitoring of formation temperatures and pressures while the MDHDS penetrometer is decoupled from the motion of the drill string. At-sea deployment of the MDHDS MFTM is scheduled to take place during Expedition 342.

Drilling sensor sub

A three-phase project began in FY11 to finalize the development of the drilling sensor sub tool designed to measure drilling and coring parameters near the bit

during operations, save the data in onboard memory, and wirelessly transmit the data to the retrievable memory module, which is recovered with the core and downloaded on the surface. Diagnostic tests and tool calibration were scheduled for early FY12.

Multisensor magnetometer module

The USIO continued development of a third-party borehole magnetometer tool that will provide borehole and tool orientation data, continuous downhole records of formation magnetization surrounding the borehole, and measurements of the borehole field on three axes, allowing calculation of the full formation magnetization vector: inclination, declination, and total field intensity. The multisensor magnetometer tool will be capable of working in both strongly magnetized hard rock formations and in sediments with weaker magnetizations. Bench testing and test deployments are scheduled during FY12, with first expedition deployment targeted for early FY13.

Data management

The USIO manages data in support of IODP activities, including expedition and postexpedition data; provides long-term archival access to data; and supports USIO



Cleaning the High-Resolution Laterolog Array Tool

IT services. Upgrades for IT infrastructure and science system services were implemented this year, along with completion of several high-priority development projects.

Databases

Laboratory Information Management System

During expeditions, laboratory work on board the *JOIDES Resolution* produces a vast amount of data that are stored in the Laboratory Information Management System (LIMS). LIMS data collected during Expeditions 329, 330, 334, and 335 were successfully transferred to shore, merged with the cumulative LIMS database, and made available online to participating scientists.

Log database

Log data for USIO Expeditions 329, 330, 334, and 335 were processed and placed online. The scripts that run the shipboard online Log Database were modified this year to eliminate links to shore that would use excess

bandwidth (e.g., links to the logging reports). The Operations Database schema was also aligned with that of the Log Database to allow better organization of the various operations reports, development of a web-based data entry form for Logging Scientists, and search capabilities that navigate better between databases.

Development projects

LIMS Reports

During FY11, the USIO developed LIMS Reports, an application that provides scientists with a simple, intuitive web interface with 32 reports designed to extract LIMS data via the web and quickly generate reports for scientific analysis. Each report displays the primary data relevant for that system and provides a description, definitions, and examples to guide scientists unfamiliar with the data.

DESClogik enhancements

The USIO significantly improved the tabular data capture functionality and interfaces of DESClogik, the USIO's core description software for descriptive data capture, resulting in a more reliable and feature-rich application that is easier to use and support. More than 35 new features were added during FY11 based on workshop and user input collected over a 2-year period.

An Igneous Core Description workshop held in College Station, Texas, prepared Expedition 335 scientists for the first expedition to use the new core description protocol and DESClogik software as applied to deep crustal rocks. Plans were made for similar workshops to be held in conjunction with FY12 expeditions.

Correlator

USIO staff configured a Mac Pro system to work as a continuous integration server for the shipboard Corewall products, including Correlator, a core visualization tool used extensively for stratigraphic correlation on IODP expeditions. The new system hosts all the tools needed to compile the Corelyzer and Correlator source code for IODP.

Regional Test and Integration Facility

Server and network configuration for the Regional Test and Integration Facility were completed in FY11, providing a consolidated facility for testing USIO-developed software.



Carrying the first core from Expedition 330

System backup

The USIO installed, configured, and tested a network attached storage (NAS) unit at Ocean Leadership and initiated nightly synchronization with the NAS at Lamont-Doherty Earth Observatory (LDEO) at Columbia University, providing both onsite and offsite redundant backups of all key LDEO-Borehole Research Group data.

Curatorial support

The USIO provides services in support of IODP core sampling and curation of the core collection archived at the Gulf Coast Repository (GCR). During FY11, the USIO also established a new protocol for working with legacy cores and materials and worked with a third-party programmer to design a new database to replace the Sample Materials Curation System. The new Sample/Data Request System was completed, evaluated, and scheduled for release in early FY12. Several core legacy documentation projects continued throughout the year, including scanning of DSDP and ODP paper sample request files and thin section archive samples for accessibility via the database. The USIO also collected

digital images of all working half sections that were pulled for sampling during the year and posted high-resolution images on the web to show the extent of working half sampling to date.

San Andreas Fault Observatory at Depth workshop

A SAFOD workshop was hosted at the GCR in conjunction with the 2011 EarthScope National Meeting held 17–20 May in Austin, Texas. Representatives from NSF/EarthScope, UNAVCO, and the U.S. Geological Survey, along with scientists from many U.S. and international institutions, visited TAMU; toured the GCR; examined the SAFOD core collection; and discussed sampling protocol, data management, and future research plans for the program.

Program integration and support for others

The USIO continued to collaborate with and support CDEX and ESO during FY11, providing Log Database services, storage, and search capabilities for nonmoratorium data to ESO and working with CDEX to set up a similar service. Postexpedition meetings



Cutting the core liner

were hosted at TAMU in College Station, Texas, for CDEX Expeditions 331–333 and ESO Expedition 325. The USIO also provided IODP Management International, Inc., with input regarding the impact of IODP science on the scientific community through Program-related articles in science publications.

Planning for the future **Progressive project management**

A new process for prioritizing projects was initiated this year to help balance the specific demands of each expedition with longer term Program priorities, enabling the USIO to remain responsive to unforeseen issues as they arise. USIO-TAMU began the PPM initiative during the first quarter of FY11 to fine tune the way different types of USIO projects are organized, managed, and completed. The management team developed an assessment tool to rank proposed projects based on impact on the scientific community, urgency, and a number of other factors. Ranking was completed and project scoping initiated, with the

goal of moving forward with two to three of the major projects on a project team basis. Project teams were formed in early FY11 to manage the LIMS Reports and DESCLogik projects, the first two of a series of projects that expanded to a portfolio list of 55 by year's end. The assessment process was used throughout the year to prioritize newly proposed projects that emerged during USIO expeditions. At the end of FY11, the PPM initiative was reviewed and new project teams were formed to continue this successful approach to internal decision making and to focus limited resources on the highest priority activities.

Expanding the scientific ocean drilling community

In late March 2011, the USIO hosted and cosponsored the "Engaging Early Career Scientists in Future Scientific Ocean Drilling" workshop in College Station, Texas. The workshop was designed to introduce all aspects of IODP to a new generation of potential participants. Through presentations, small group discussions, and a tour of the GCR, more than three dozen national and international



Labeling core

participants explored new and multidisciplinary approaches to studying Earth's systems through scientific ocean drilling, discussed and provided feedback on the themes highlighted in the post-2013 science plan, and began the process of forming research collaborations and learning how to become active new members of the ocean drilling community.

Planning for post-2013 scientific ocean drilling

The USIO continued to support the International Working Group Plus (IWG+) in their efforts to map out a multinational program architecture that promotes delivery of exciting and relevant science to the broad science community and the public through scientific ocean drilling. USIO representatives attended IWG+ meetings held in January 2011 in Miami, Florida, and in June 2011 in Amsterdam, The Netherlands, and participated in discussions regarding membership categories and levels, Science Advisory Structure (SAS) structure and transition plan, and program



Sunset beginning aboard the JOIDES Resolution

management for the next scientific ocean drilling program.

USIO efforts contributed to the post-2013 research plan, *Illuminating Earth's Past, Present, and Future*, which was publicly released in June 2011. This new science plan outlines the International Ocean Discovery Program that will begin in 2013, building on the scientific and technical foundation of DSDP, ODP, and IODP research.

More from the numbers

Repository and sample statistics

	Visitors hosted	Samples taken
Gulf Coast Repository	444	21,003
JOIDES Resolution	0	59,918

Database statistics

	Visitor sessions	Query hits
LIMS database	3,230	2,600
Janus web database	7,106	65,303
Log web database	1,526	15,885



Assembling the free-fall funnel

More online

IODP expedition schedule: iodp.org/expeditions/

Core database: iodp.tamu.edu/database/

Log database: iodp.ldeo.columbia.edu/DATA/index.html

LIMS Reports: web.iodp.tamu.edu/UWQ/

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

IODP-USIO FY11 Quarterly Reports: iodp.tamu.edu/publications/AR.html

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



View from a shipboard window, with LEGO model of the JOIDES Resolution in the foreground

Broader Impacts

The USIO shared IODP contributions to the global understanding of Earth's ocean basins with a wide variety of audiences this year through ongoing publications, education, and outreach efforts, expanding the visibility of IODP as a societally relevant, cutting-edge international Earth science research program.

Publications

IODP scientific publications are the primary method of disseminating IODP research to the scientific community and the public. The USIO is responsible for production of Program-wide scientific publications, reports, and technical documentation and for warehousing and distributing DSDP, ODP, and IODP publications.

Program-wide scientific publications

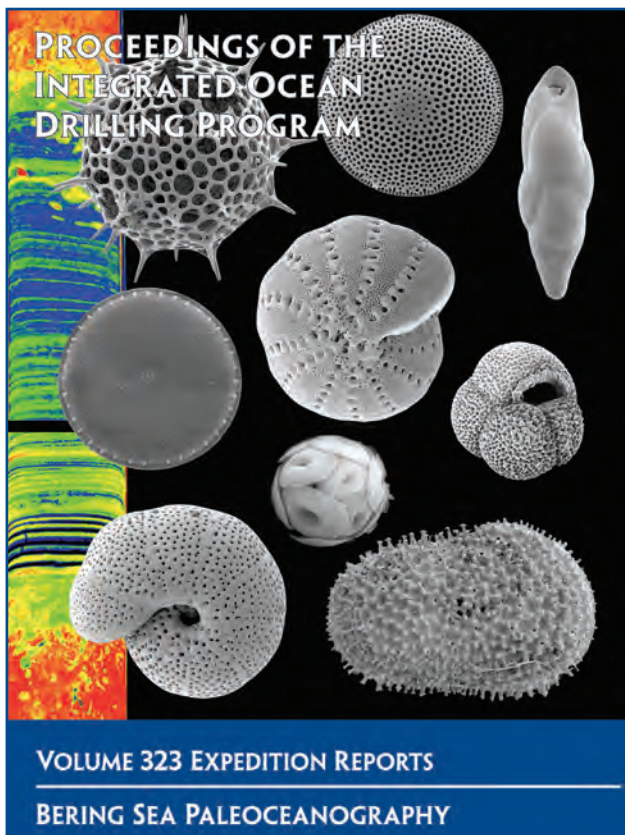
The USIO provides Program-wide scientific publication services, producing and publishing the *Scientific Prospectuses*, *Preliminary Reports*, *Expedition Reports*, and data report contributions to the *Proceedings of the Integrated Ocean Drilling Program* volumes for all three IODP implementing organizations. During FY11, the USIO produced nine *Scientific Prospectuses* and nine *Preliminary Reports*, coordinated postexpedition publications, and published seven postexpedition data reports and expedition reports from nine expeditions in the *Proceedings of the Integrated Ocean Drilling Program*.

Expedition publications support

Publications Specialists sailed during all USIO expeditions to coordinate shipboard reports. A USIO



Distributing materials to the Science Party



Proceedings volume for IODP-USIO expedition

Publications Specialist was scheduled to sail during CDEX Expedition 337 this year, but the D/V *Chikyu* was damaged by the 11 March 2011 tsunami and the expedition was rescheduled for July–September 2012.

Postexpedition publications coordination

Postexpedition meetings for four USIO expeditions, three CDEX expeditions, and one ESO expedition were held at the USIO-TAMU office in College Station, Texas. During the meetings, Publications staff coordinated science reviews of all *Expedition Reports* content and assisted



The new IODP-USIO newsletter, Core Discoveries

meeting participants with editing, formatting, and production of shipboard reports prior to publication.

IODP science publications accessibility and impact

The USIO is responsible for distributing Program scientific publications and documenting how postexpedition Program-related research is disseminated into the scientific community through publications. Initial distribution of IODP scientific publications includes more than 800 program member offices, universities, libraries, and geological organizations worldwide, and

More from the intern

"My time as an intern with IODP-USIO has been an invaluable experience; the opportunity to work with professionals and scientists in so many different fields at such a preeminent international organization has really enriched my thinking about science, and galvanized my interest in scientific ocean drilling!"

–A. Sutton, 2011 IODP-USIO Diversity Intern



Working at an IODP-CDEX postexpedition meeting

the USIO provides additional print or electronic copies of legacy publications upon request.

All DSDP, ODP, and IODP scientific publications are easily accessible online through the IODP Publications website, the Ocean Drilling Citation Database subset of the American Geological Institute (AGI) GeoRef database, and CrossRef, the official digital object identifier registration agency for scholarly and professional publications. The extent of the interest in IODP scientific publications can be inferred from the number of times Program publications were accessed through these resources.

Interest in IODP science publications

There were more than 240,000 visits to the IODP Publications website during FY11, which more than doubled the number of visits during the previous year. The number of times IODP publications were accessed through CrossRef also increased this year to more than

30,000 for IODP publications and nearly 68,000 for DSDP and ODP publications. More than 17,000 queries were run on the Ocean Drilling Citation Database, and additional records for more than 6,000 citations were viewed.

Program science impact

Because it is clear that the science community seeks out Program-related publication information from the Ocean Drilling Citation Database, the USIO collects and provides lists of Program-related citations to AGI to expedite the inclusion of these records. The USIO provided information on more than 500 Program-related citations to during FY11, and more than 1,400 Program-related records were added to the database. The 2011 Ocean Drilling Citation Database Report shows that more than 450 articles based on Program science have been published in the top two high-impact science journals—*Science* and *Nature*—and more than 100 of those articles were published since



Filming a science lecture on board the JOIDES Resolution

the inception of IODP in 2003. The USIO continues to seek ways to more effectively document the impact of Program science through publications.

Technical documentation

The IODP-TAMU technical documentation process continued throughout FY11, with ongoing development of shipboard laboratory instrument guides and manuals. Nineteen technical guides (7 quick start guides, 11 user guides, and 1 advanced user guide) were released, with fourteen additional documents under review.

IODP publications recognition

Three IODP publications were recognized for excellence in the 2011 Society for Technical Communication awards competitions—the IODP Expedition 317 *Preliminary Report* and the IODP-USIO FY09 Annual Report in the category of informational materials and the Ion Chromatograph User Guide in the user support materials category. These awards demonstrate the professionalism of IODP publications as judged against technical publishing industry standards.

Publications digital archive project

In response to an FY10 external review team finding, IODP Publication Services began the process of identifying the requirements of a publications archive. The USIO hired a consultant to develop a long-term archive and publication preservation strategy for Program publications, resulting in a needs assessment



Examining core at the 2011 School of Rock Review

report that covered the inventory of Program publications; access, archive, and digital preservation needs; rights management concerns; metadata standards; digital repository services; and resource requirements.

Exploration of a joint project with the TAMU Libraries to develop a prototype archive of Program publications led to the realization that, although academic and staff representatives of the TAMU Libraries consider the Program publications a prestigious collection, the TAMU Libraries' current infrastructure cannot support the publications in a fully functional digital library. The USIO

More from the numbers

<i>Web sites</i>	<i>Site visits</i>	<i>Page views</i>
<i>U.S. Implementing Organization</i>	319,244	1,250,837
<i>ODP Legacy</i>	1,122,594	4,977,381
<i>DSDP Legacy</i>	142,509	611,691
<i>IODP Publications</i>	240,476	948,529
<i>Deep Earth Academy</i>	57,079	84,318
<i>JOIDES Resolution</i>	52,972	194,143
Total Program-related web sites	1,934,874	8,066,899



Presenting IODP science at the Auckland Museum

continued discussions with IODP-MI regarding various archive options.

Education

A diverse range of initiatives were coordinated this year to educate a broad audience about Earth’s structure, microbiology, and history as understood through scientific ocean drilling. A two-pronged approach provided professional development opportunities for educators via workshops and onboard teacher research experiences and gave IODP scientists the opportunity to participate in both shipboard and onshore educational programming and planning.

The USIO implemented programs using the *JOIDES Resolution* as a platform for education and produced new expedition-specific and thematic video and learning materials throughout the year. USIO representatives also worked to develop and strengthen ongoing relationships with national and international museums and science partners. In addition, new diversity outreach initiatives were introduced that will

expose minority undergraduate and graduate students to careers in scientific ocean drilling.

IODP science online presence and social networking

Information about IODP science is easily accessible online. Expedition science reports are posted daily on the USIO website, along with an array of photos taken by expedition participants depicting life on board the *JOIDES Resolution*. The website “*JOIDES Resolution: Exploring beneath the Ocean Floor*” promotes USIO expeditions and IODP science and provides background information on the ship, its capabilities, and its role in science research. Visitors can engage in a virtual tour of the *JOIDES Resolution*, track the ship’s position during transit, and follow expedition progress through blogs, videos, and interactive features. The website also serves as the hub for Program social networking on Facebook, Twitter, and YouTube sites. Despite the long tie-up period during the fourth quarter, the *JOIDES Resolution* website continued to show strong visitation in comparison to other science and marine sites, reaching thousands of viewers throughout FY11.



Viewing exhibits at the “Engaging Early Career Scientists in Future Scientific Ocean Drilling” workshop

Shipboard educators promoting IODP science

During USIO expeditions, Onboard Education Officers manage *JOIDES Resolution* website content, blog and facilitate blog entries from expedition participants, conduct ship-to-shore video broadcasts, and post entries to *JOIDES Resolution* social networking sites. Separate blogs were initiated on the ship’s website this year, one for educators and one for children, and a series of Program science–related contests were hosted on the Facebook page, resulting in increased participation. Onboard videographers and a scientific illustrator also participated this year in a team approach to education and outreach, culminating in a series of visual art products and short videos featuring expedition science, observatory technology, and life at sea.

IODP videos and video broadcasts

Interest in live video broadcasting from the *JOIDES Resolution* continued to grow this year, with available time slots for broadcasts filling within a few days of the opportunities being posted. During the FY11 USIO expeditions, there were more than 75 ship-

to-shore video broadcasts to museums, teacher workshops, elementary schools, high schools, and colleges worldwide. Broadcasts presented tableaus of life at sea, shipboard safety, the careers of scientists and technicians on board, and science conducted on board the *JOIDES Resolution*. Shipboard videographers integrated video and slide shows to accompany live video segments and interview sessions with expedition scientists. The USIO also coordinated a special broadcast from the *JOIDES Resolution* to the National Science Foundation for winners of the Presidential Awards for Excellence in Mathematics and Science Teaching, during which award recipients virtually toured the *JOIDES Resolution* laboratories and interviewed shipboard scientists.

When Expedition 336 began in September 2011, two videographers were on board to film a general-audience documentary about the expedition and to provide footage for “webisodes” that will be available online during the expedition. In addition to shipboard video work, a new Pacific Equatorial Age Transect

News Network video was produced this year about postexpedition meetings/activities in Paris, France, adding a new dimension to video presentation of IODP science—postexpedition research.

School of Rock Comprehensive Review

A 5-day comprehensive School of Rock review and assessment meeting took place on board the *JOIDES Resolution* during the tie-up period in Curaçao. This summit brought together representatives from every School of Rock professional development program cohort to discuss the impact of the program on their teaching, review their School of Rock-related activities and accomplishments to date, and share ideas for improvements and innovations for the program moving forward. USIO representatives and former School of Rock instructors participated in the summit, along with fifteen School of Rock alumni—three from each of the five workshops—who were selected through a competitive process. Summit activities included a summary of data collected from online surveys completed by nearly 75% of the School of Rock alumni, a review of the impact of the program over time, exploration of elements central to the program's success, future directions for the program, and new science investigations. The success of the School of Rock program is evident from the preliminary survey



Observing a K/T boundary model experiment

More from the School of Rock

"It's difficult to find teacher workshops [like the School of Rock] that deliver mind-bending content. Personally, I find it very useful to be able to explain to people a little about the instruments used to analyze data. That's a weakness for a lot of science teachers since we simply don't have a lot of access to top-of-the-line equipment. When climate naysayers get going with their claims, I [now] feel a lot more equipped to describe a few aspects of what goes into a climate model. It hasn't failed me yet."

"[The primary strength of the School of Rock program is] the ability to transfer science content knowledge about ocean drilling and what it can tell us about our Earth into the hands of educators who can then inform and educate others on the importance of ocean science. The experience on the ship has continued on shore and has created a growing network of educators who understand and can read through science content available for researchers and put it into a format that's digestible by students, other educators, and the general public."

"The primary strength [of the School of Rock] is having the opportunity to work with scientists.... [They] provided realistic activities that allowed us to see how to prepare, analyze, and handle the [core sample] materials. This gave us, the teachers, the chance to have a conversation about how science is actually carried out rather than just another workshop where the presenters are passing on 'second-hand or once-removed' knowledge."

—Anonymous School of Rock alumni (2011 School of Rock Comprehensive Review participants)



Episode 5 of educational outreach comic series *Tales of the Resolution!*

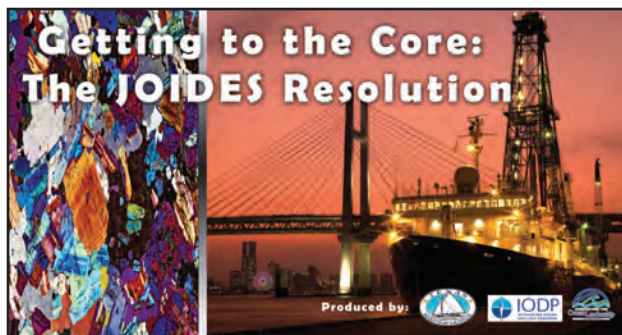
results. Over the past five years, School of Rock alumni have produced 372 program-related activities and have conducted 132 workshops reaching 21,670 people, and workshop and product development efforts continue.

Strategic partnerships and outside funding

The USIO continued working to foster current partnerships and to develop new alliances with national and international museums and science partners with synergistic goals and objectives.

Museum outreach

During FY11, the USIO entered into partnerships with several museums for development and provision of materials for IODP exhibits. Large graphics, live video events, and a core replica were provided for an IODP exhibit mounted in the Oceans Gallery at the Auckland Museum in New Zealand from early January 2011 through the end of Expedition 330. A traveling exhibit called “Getting to the Core: the *JOIDES Resolution*” opened in April 2011 for a 5-month tour at the Texas



Museum exhibit banner

Maritime Museum in Rockport, Texas. The exhibit featured real sediment cores, drilling artifacts, video, activities for children, and a montage of more than 50 spectacular photos and images that tell the story of the scientific ocean drilling expedition. At the end of FY11, the exhibit was set to transfer to The North Museum in Lancaster, Pennsylvania.

Center for Dark Energy Biosphere Investigations

The USIO partnered with the Center for Dark Energy Biosphere Investigations (C-DEBI) during FY11 to support the second *JOIDES Resolution* art (J/aRt) competition and provide microbiology-related projects and activities. C-DEBI also awarded a \$50,000 grant to the Deep Earth Academy for coordination of educational components during the R/V *Atlantis* Expedition AT18-07, which collected samples and data from seafloor observatories installed during IODP Expedition 327. The USIO coordinated a team of five onboard educators that provided updates on the expedition via the *JOIDES Resolution* blog, Facebook, and Twitter and offered live video/audio events. Educational components of the expedition also included a web-based interactive module called “Adopt a Microbe from the Deep Biosphere” that allowed students and educators to follow the mission in real time, virtually “adopt” a microbe from the bottom of the ocean, and receive daily science updates from the vessel.

Ship-to-Shore Science

In the last quarter of FY11, the Deep Earth Academy received a \$250,000 NSF Informal Science Pathways grant to implement its Ship-to-Shore Science program, through which many potential partners will brainstorm ideas for how to connect work done on board the



Broadcasting ship-to-shore from the JOIDES Resolution

JOIDES Resolution with informal audiences. Pilot projects created through this grant may include additional museum exhibits, podcasts, books, interactive web components, and more.

New diversity initiatives

USIO diversity initiatives were expanded in FY11 to include two separate programs for minority undergraduate and graduate students.

IODP-USIO Diversity Internship

The USIO developed a new initiative this year for minority students that are enrolled full-time at (or recently graduated from) a U.S. university or college and have significant interest in the ocean and/or Earth sciences. The IODP-USIO Diversity Internship is designed to expose minority students to careers in scientific ocean drilling by providing them with a 10–12 week educational and career-building experience at one of

More from the IODP scientists

“All of the scientists involved enjoyed the [PAEMST ship-to-shore broadcast] event and found it a rewarding experience. An event like this demonstrates the invaluable contribution that scientific ocean drilling can make to education and outreach efforts—helping the Earth sciences to come alive for audiences of all ages.”

—D. Teagle, Expedition 335 Co-Chief Scientist



Videographer in helmet cam, with Adopt-a-Microbe kit

the institutions that comprise the USIO. The internship will also highlight opportunities within IODP and science program management that may encourage students/interns to pursue advanced studies in Earth system sciences (or complementary fields) and/or careers in scientific ocean drilling.

The first internship, which started in June 2011, focused on science communications. The intern worked with a mentor from the IODP communications group at the Ocean Leadership office to conceive, develop, and disseminate new materials that will help heighten IODP’s national and international visibility. The second internship, scheduled to begin in January 2012 at the Ocean Leadership office, will focus on engineering. Future internship projects may focus on science, engineering, education, or communications.

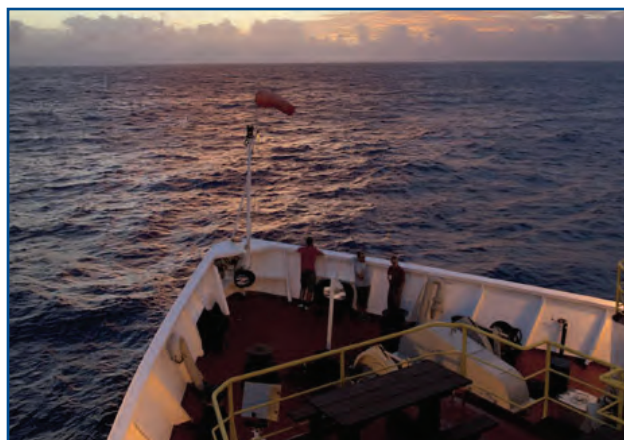
Minorities in Scientific Ocean Drilling Fellowship

The Historically Black Colleges and Universities Fellowship initiative was terminated in July 2011 and replaced by the Minorities in Scientific Ocean Drilling Fellowship, which is designed to broaden and increase



Enjoying high winds on the JOIDES Resolution helideck

the level of participation of ethnic and racial groups currently underrepresented in scientific ocean drilling. Launched in August 2011, the fellowship provides a mechanism for minority graduate students enrolled full-time in a geoscience or engineering program to complete research in topics related to scientific ocean drilling or develop technology that will help advance science or engineering in a scientific ocean drilling research setting. The fellowship will also highlight opportunities in the IODP that may encourage the selected Fellow to pursue a career in scientific ocean drilling and/or participate in IODP. The program will



Bow of the JOIDES Resolution

kick off with an initial 8 month fellowship scheduled to begin in Spring 2012; subsequent fellowships will last 12 months each.

Outreach

USIO Outreach activities are designed to build an easily accessible foundation of knowledge about IODP, to raise the visibility of the connection between the emerging scientific knowledge and its positive contribution to society worldwide, and to encourage interest in the Program. The USIO accomplished these goals in FY11 through key projects that focused on publicizing

More from the students

"I did not expect the video chat to be so interesting! It really helped me understand the overall program better.... Learning about the drilling process made me think [about] how the ocean and marine life is affected. I am actually looking into a career with possibly geoscience or environmental science."

—Isabelle, Grade 11 Geoscience student

"I am not exactly a science buff...but my idea about science was altered today after skyping with you and the rest of the JOIDES [Resolution] crew. It was very fascinating to me to observe science in a whole new and modern way.... I know that what you are doing on the ship is research that will serve many purposes for scientists around the world."

—Meredith, Grade 11–12 Honors Physics student

"The video conference really made me rethink what science is to me. In my experience, most sciences don't seem very applicable in the real world, but I was reminded how many people are employed for the purpose of discovery, and learning about the universe we live in. I also realized how diverse the science community is. There are so many people on the [JOIDES Resolution], and each of them has a different job and purpose on the ship. I have always thought that I wanted to go into science when I get older, and this has reminded me of how many options I have."

—Madeline, Grade 11–12 Honors Physics student

expeditions and developing products designed to highlight the Program's success. Forums including the American Geophysical Union (AGU) Fall Meeting; Geological Society of America Annual Meeting; Oceans '11 MTS/IEEE Kona Conference; Science, Engineering, and Technology Congressional Visits Days; and Coalition for National Science Funding Capitol Hill Exhibition and Reception also provided opportunities for the USIO to engage the science, education, and political communities in IODP research.

Port call outreach

The USIO took advantage of *JOIDES Resolution* port calls to conduct public outreach related to ongoing operations. Outreach activities for Expeditions 329 and 330 were coordinated with the Australia-New Zealand IODP Consortium during port calls in Australia and New Zealand, including a virtual press conference for Australian media, public science lectures at the Auckland Museum featuring expedition Co-Chief Scientists, a VIP lunch event at the Auckland Museum, and tours of the *JOIDES Resolution* for a total of nearly 240 students, teachers, researchers, scientists, and public dignitaries. USIO staff also met with employees of the Oceans Gallery of the Auckland Museum to help strategize the layout of display materials provided for an IODP exhibit and to coordinate expedition promotions for weekly ship-to-shore broadcasts held at the museum during Expedition 330.

During the April 2011 port call in Puntarenas, Costa Rica, the USIO collaborated with leading Costa Rican scientists and the Universidad Nacional de Costa Rica (UNA) to coordinate multiple outreach activities. The UNA Marine Biology Station in Puntarenas hosted a press conference featuring leading scientists from Expeditions 334 and 335, and the USIO hosted *JOIDES Resolution* ship tours for nearly 60 reporters, university and high school students, and members of the Costa Rican scientific community, including the Costa Rica Minister of Science and Technology.

Outreach support and product development

USIO staff provided communications training, collaborated with others conducting IODP outreach worldwide, and developed outreach products that help



The JOIDES Resolution in Puntarenas, Costa Rica

to build an easily accessible foundation of knowledge about scientific ocean drilling.

Communications training

Expedition scientists received training from USIO communications staff to help them prepare for press interviews and public lectures and to instruct them on opportunities and risks of social media and press embargo policies of high-profile science journals.

Global outreach activities

The USIO worked with IODP-MI to coordinate adjacent booth space and complementary content for the AGU Fall 2010 Meeting and provided USIO communications materials to European Consortium for Ocean Research Drilling for distribution at the European Geophysical Union Spring Meeting and the Goldschmidt 2011 Conference. USIO staff also coordinated with IODP-MI before responding to a media query from *Nature*

about the status of the *Chikyu* after the 11 March 2011 tsunami in Japan and supported IODP-MI and the global Outreach Task Force in planning media outreach and preparing speakers for the 16 June 2011 release of the 2013–2023 International Ocean Discovery Program science plan in Amsterdam, The Netherlands.

Outreach products

USIO communications staff developed tools for use in press conference settings, including media advisories and press releases, some of which included links to videos to help readers better understand an expedition's mission, and also contributed to and developed outreach products designed to publicize long-term and recent achievements.

Video footage, images, and computer animation produced during Expedition 327 were provided to Wall to Wall Television for inclusion in a documentary called "Journey to the Earth's Core," which aired on the History Channel on 23 March 2011. Expedition 327

content complemented a section of the documentary addressing the subsurface biosphere.

The USIO also funded and managed participation of an illustrator who sailed during Expedition 335 and developed innovative ways to share the science of the expedition through scientific illustration. Visual art products developed during the expedition will be used for future education projects and by members of the Expedition 335 Science Party as they produce presentations and papers on their work.

Finally, a full-color U.S. IODP Community newsletter—*Core Discoveries*—was introduced this year for triannual distribution to the U.S. scientific community and funding agency representatives. The newsletter is designed to provide readers with timely updates and information on U.S. IODP activities, such as articles on recent and upcoming expeditions, articles on program renewal, a community spotlight, and letters to the community from NSF and the USIO.

More online

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

IODP-USIO FY11 Quarterly Reports: iodp.tamu.edu/publications/AR.html

IODP-USIO FY11 Annual Program Plans: iodp.tamu.edu/publications/PP.html

Ocean Drilling Citation Database: odp.georef.org/dbtw-wpd/qbeodp.htm

2011 Ocean Drilling Citation Report: iodp.tamu.edu/publications/AGI_studies/AGI_study_2011.pdf

Deep Earth Academy website: oceanleadership.org/education/deep-earth-academy/

JOIDES Resolution website: joidesresolution.org/

JOIDES Resolution facebook page: facebook.com/joidesresolution/

JOIDES Resolution twitter page: twitter.com/thejr/

USIO Newsroom website: iodp-usio.org/Newsroom/default.html

USIO videos: youtube.com/user/OceanLeadership/

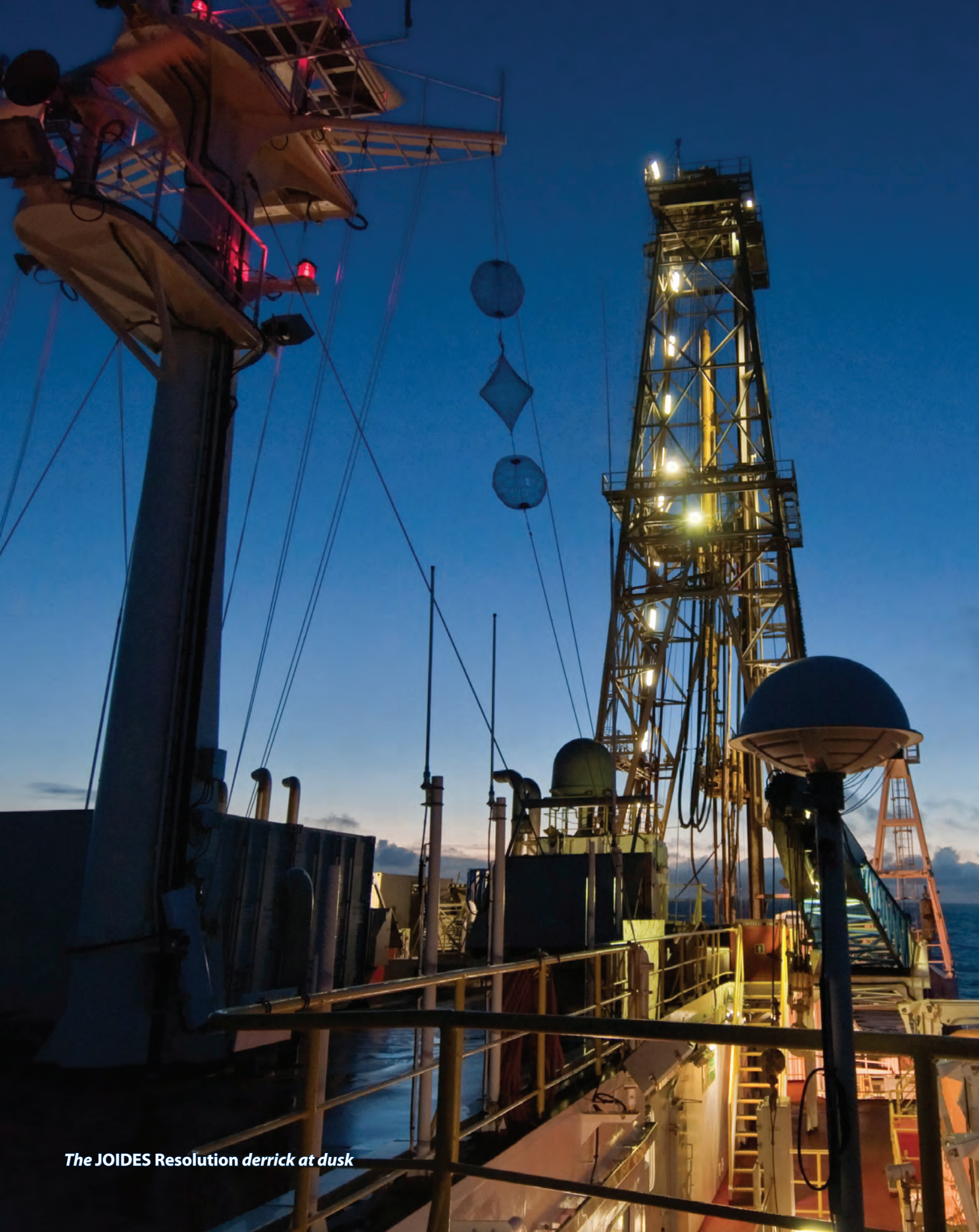
Core Discoveries: oceanleadership.org/programs-and-partnerships/scientific-ocean-drilling/core-discoveries-newsletter/

Tales of the Resolution: ideo.columbia.edu/BRG/outreach/media/tales/index.html

Adopt-a-Microbe Project: am.darkenergybiosphere.org/

Minorities in Scientific Ocean Drilling Fellowship: oceanleadership.org/education/diversity/minorities-in-scientific-ocean-drilling-fellowship/

IODP-USIO Diversity Internship: oceanleadership.org/education/diversity/iodp-usio-diversity-internship/



The JOIDES Resolution derrick at dusk



Checking equipment for drilling operations

Contractual and Financial Overview

IODP is funded by several entities acting as international partners. NSF and Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) are lead agencies, and ECORD is a contributing member. Associate members include the People's Republic of China Ministry of Science and Technology (MOST); Interim Asian Consortium, represented by the Korea Institute of Geoscience and Mineral Resources (KIGAM); Australian/New Zealand Consortium funded by the Australian Research Council (ARC) and GNS Science (New Zealand); and the Ministry of Earth Sciences (MoES), India.

The USIO provides all deliverables through contracts with NSF for platform operating costs (POC) and other program integration costs (OPIC) and with IODP-MI for

science operating costs (SOC). The commingled funds that comprise the SOC budget come from IODP-MI's international partners as part of their membership fees used to fund IODP science. POC funding for each implementing organization are the responsibility of the agency supplying the platform capability.

USIO contractual relationships

The USIO was formally established in 2003 when Ocean Leadership, formerly known as Joint Oceanographic Institutions, established subcontracts with LDEO of Columbia University and the College of Geosciences at TAMU through TAMRF. Each of the three USIO institutions (Ocean Leadership, LDEO, and TAMU) provides fiscal and contractual administration, and the organizational structure employed by the USIO accommodates the work breakdown element



Banner on the JOIDES Resolution helideck



Preparing for magnetometer deployment

accounting structure used by IODP. This structure also aligns the organization to efficiently and economically provide the full array of USIO deliverables.

USIO prime contractor

As the U.S. Systems Integration Contractor, Ocean Leadership is ultimately responsible to NSF and IODP-MI for overall program leadership; technical, operational, and financial management; and delivery of services for the *JOIDES Resolution* and related activities. Ocean Leadership leads long-term planning development for the USIO and represents the USIO and the Program as a whole, when appropriate.

USIO subcontractors

LDEO and TAMU contribute distinct but complementary capabilities that directly support the full range of scientific and technical activities necessary for implementing a riserless scientific drilling program. LDEO is responsible for logging-related shipboard and shore-based science services and technological support and for leading an international logging consortium to participate in scientific ocean drilling operations. LDEO provides downhole logging equipment and engineering support through an ongoing contract with Schlumberger. In FY11, LDEO also contracted with Howard and Associates, Inc., for engineering oversight of the large-diameter pipe-handling infrastructure project and with LGL Limited–Environmental Research Associates for preparation of environmental evaluation



Waiting for core on the catwalk

reports for check shot survey work to be conducted during four USIO expeditions.

TAMU is responsible for providing services directly related to the scientific and engineering activities necessary to support science cruises (vessel and drilling operations, ship- and shore-based science laboratories), as well as managing expedition-related, shore-based functions (data management, core curation, and publications). Administrative services in support of TAMU activities are provided by TAMRF. On behalf of the USIO, TAMRF contracts with Siem Offshore (previously known as Overseas Drilling Limited) for the services of the *JOIDES Resolution*, the riserless drilling vessel for USIO operations.

USIO FY11 Annual Program Plans to IODP-MI and NSF

FY11 USIO contractual requirements for SOC and POC funds are outlined in the IODP-USIO FY11 Annual Program Plan to IODP-MI; POC and OPIC budgets are combined in the systems integration contract (SIC) costs outlined in the IODP-USIO FY11 Annual Program Plan to NSF.

The Annual Program Plans set forth the goals of the USIO, scope of USIO work for IODP deliverables, definitions of projects, and details of required budgets that incorporate funding allocations from NSF or IODP-MI for science operations and from NSF for platform



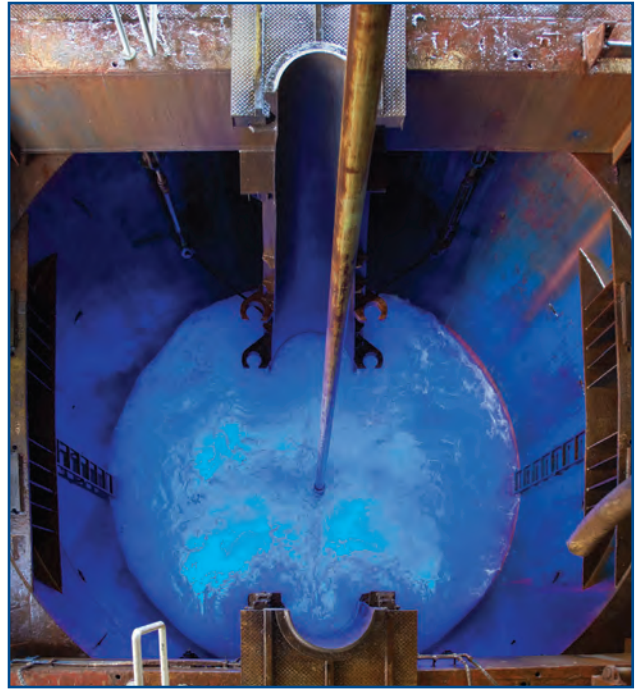
Supervising drilling operations

operations and U.S.-sponsored tasks (education and outreach efforts and associated management and administrative support).

The complex nature of IODP operations requires Annual Program Plans that establish priorities and allow procurement of long-lead time equipment and services for activities that span multiple years. The FY11 Annual Program Plans were based on (1) the mission forecast provided on 12 March 2010 for the USIO by NSF, and (2) the USIO operations schedule that was approved by the Operations Task Force and Science Planning Committee. Budgets outlined in the Annual Program Plans included costs associated with the necessary planning and purchase of long-lead time items and additional items to support expeditions scheduled for FY11 and beyond.

Financial tables

The following financial tables provide a detailed overview of the FY11 IODP-USIO Annual Program Plan budget, including FY10 carryforward of obligated and



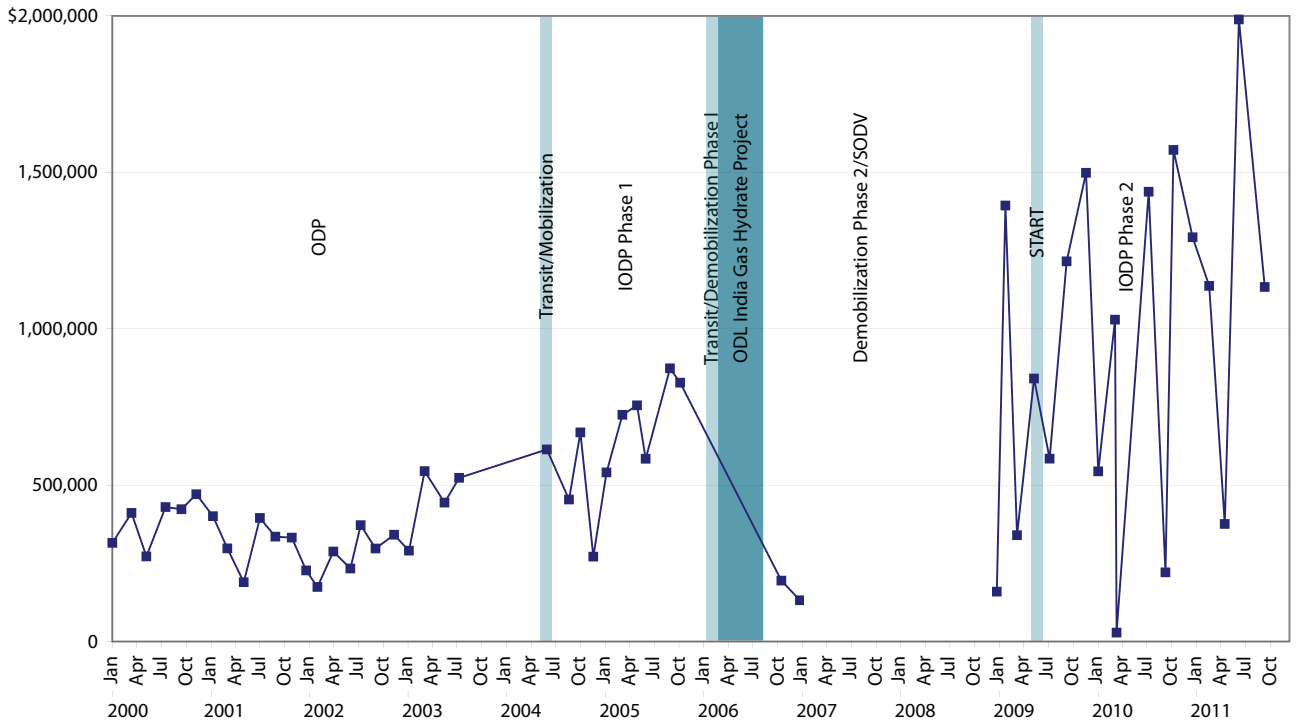
JOIDES Resolution moonpool

unobligated funds, budget modifications that took place throughout the fiscal year, expenditures that were made to execute the Annual Program Plan, and end-of-year totals of obligated and unobligated funds pending approval for transfer to FY12.

These tables individually represent the following:

- USIO FY11 end-of-year financial summary, which encompasses SOC and SIC budgets for the USIO with detail provided for each USIO institution (Ocean Leadership, LDEO, and TAMU);
- USIO FY11 end-of-year summary for the POC (NSF and IODP-MI) budget;
- USIO FY11 end-of-year summary for the SOC (IODP-MI only) budget; and
- USIO FY11 end-of-year summary for the SIC (NSF only) budget.

Actual fuel cost FY00–FY11



More online

IODP-USIO web page: www.iodp-usio.org/

IODP-USIO FY11 Annual Program Plan: iodp.tamu.edu/publications/PP.html

IODP-USIO FY11 Quarterly Reports: iodp.tamu.edu/publications/AR.html

Please contact info@oceanleadership.org for hard copies of the financial pages (pages 45–60).

Acronym List

Acronym	Definition
AGI	American Geological Institute
AGU	American Geophysical Union
APL	Ancillary Project Letter
C-DEBI	Center for Dark Energy Biosphere Investigations
CDEX	Center for Deep Earth Exploration
CORK	circulation obviation retrofit kit
CRISP	Costa Rica Seismogenesis Project
DEBI-t	Dark Energy Biosphere Investigation tool
DSDP	Deep Sea Drilling Project
ECORD	European Consortium for Ocean Research Drilling
EEZ	Exclusive Economic Zone
ESO	ECORD Science Operator
GCR	Gulf Coast Repository
IO	implementing organization
IODP	Integrated Ocean Drilling Program
IODP-MI	IODP Management International, Inc.
IT	information technology
IWG+	International Working Group Plus
L-CORK	lateral CORK
LDEO	Lamont-Doherty Earth Observatory
LIMS	Laboratory Information Management System
LWD	logging while drilling
MDHDS	Motion Decoupled Hydraulic Delivery System
MFTM	Multifunction Telemetry Module
MSS	magnetic susceptibility sonde
NAS	network attached storage
NSF	National Science Foundation
ODASES	Ocean Drilling and Sustainable Earth Science
ODP	Ocean Drilling Program
OPIC	other program integration costs
POC	platform operating costs
SAFOD	San Andreas Fault Observatory at Depth
SAS	Science Advisory Structure
SCIMPI	Simple Cabled Instrument for Measuring In-Site Parameters
SHIL	Section Half Imaging Logger
SIC	systems integration contract (costs)
SOC	science operating costs
SPC	Science Planning Committee
TAMU	Texas A&M University
USIO	U.S. Implementing Organization
XRF	X-ray fluorescence

PUBLISHER'S NOTES

This publication was prepared by the Integrated Ocean Drilling Program U.S. Implementing Organization (IODP-USIO): Consortium for Ocean Leadership (Ocean Leadership), Lamont-Doherty Earth Observatory of Columbia University (LDEO), and Texas A&M University (TAMU), as an account of work performed under the international Integrated Ocean Drilling Program, which is managed by IODP Management International (IODP-MI), Inc. 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 Consortium
- Ministry of Earth Sciences (MoES), India

Citation:

Integrated Ocean Drilling Program United States Implementing Organization, 2012. FY11 Annual Report.
<http://iodp.tamu.edu/publications/AR/FY11AR.PDF>

DISCLAIMER

Any opinions, findings, and conclusions expressed in this publication are those of the author(s) and do not necessarily reflect the views of the participating agencies, IODP-MI, or the Texas A&M Research Foundation.



Anchor in the waves



Integrated Ocean Drilling Program, U.S. Implementing Organization

www.iodp-usio.org

Consortium for Ocean Leadership, Inc.
1201 New York Avenue, NW
Washington DC 20005 USA
Tel: 202.232.3900
Fax: 202.462.8754

**Lamont-Doherty Earth Observatory
of Columbia University**
PO Box 1000, Route 9W
Palisades NY 10964 USA
Tel: 845.365.8341; Fax: 845.365.3182

Texas A&M University
1000 Discovery Drive
College Station TX 77845 USA
Tel: 979.845.2673
Fax: 979.845.1026