USGS
Sound Waves
Coastal and Marine Research News from Across the USGS
http://soundwaves.usgs.gov/

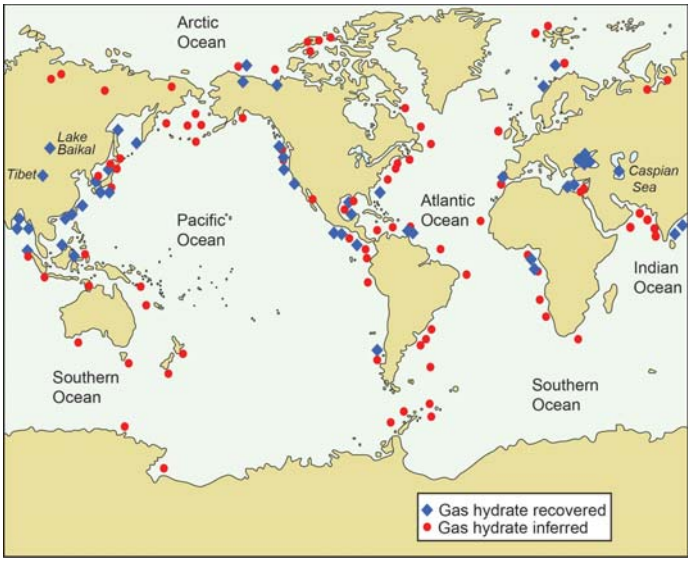
Research

Gas Hydrates and Climate Warming—Why a Methane Catastrophe Is Unlikely

By Carolyn Ruppel and Diane Noserale

*[Modified from USGS Science Pick at **http://www.usgs.gov/blogs/features/usgs_science_pick/gas-hydrates-and-climate-warming/**.]*

News stories and Web postings have raised concerns that climate warming will release large volumes of methane from gas hydrates, kicking off a chain reaction of warming and methane releases. But recent research indicates that most of the world's gas hydrate deposits should remain stable for the next few thousand years. Of the gas hydrates likely to become unstable, few are likely to release methane that could reach the atmosphere and intensify climate warming.



Gas hydrates have been discovered worldwide, and scientists predict that they may occur in many areas that have not yet been surveyed. Blue diamonds show areas where gas hydrates have been recovered in seafloor samples; red dots, areas where gas hydrates are inferred to be present from geophysical data.

Methane hydrate is sometimes called "the ice that burns" because the warming hydrates release enough methane to sustain a flame.

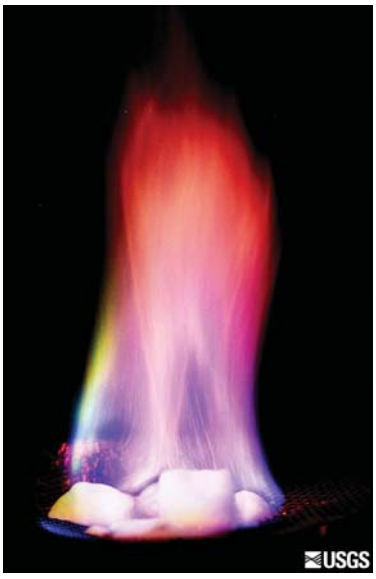
Gas Hydrates Primer

Gas hydrates are an ice-like combination of natural gas and water that can form in deep-water ocean sediments near the continents and within or beneath continuous permafrost. Specific temperatures and pressures and an ample supply of natural gas are required for gas hydrates to form and remain stable.

An estimated 99 percent of gas hydrates are in ocean sediment and the remaining 1 percent in permafrost areas (see map). Methane hydrate or "methane ice," which is the most common type of gas hydrate, represents a highly concentrated form of methane: one cubic foot of methane hydrate traps about 164 cubic feet of methane gas.

The amount of methane trapped in the Earth's gas hydrate deposits is uncertain, but even the most conservative estimates conclude that about 1,000 times more methane is trapped in hydrates than is consumed annually worldwide to meet energy needs. The most active area of gas-hydrate research focuses on gas hydrates' potential as an alternative source of natural gas (for example, visit **http://web.mit.edu/mitei/research/studies/natural-gas-2011.shtml** and scroll down to the link "Supplemental Paper 2.4"); the U.S. Geological Survey (USGS) Gas Hydrates Project has several programs addressing this topic (see **http://energy.usgs.gov/OilGas/UnconventionalOilGas/GasHydrates.aspx**).

Solid gas hydrate recovered from sediment about 20 ft (6 meters) below the seafloor near Canada's Vancouver Island during Integrated Ocean Drilling Program Expedition 311.



Gas Hydrates and Climate Change

Gas hydrate researchers are examining the link between climate change and the stability of methane-hydrate deposits. Warming climate could cause gas hydrates to break down (dissociate), releasing the

(Gas Hydrates continued on page 2)

Sound Waves

Editor
Helen Gibbons
Santa Cruz, California
Telephone: (831) 460-7418
E-mail: hgibbons@usgs.gov
Fax: (831) 427-4709

Print Layout Editors
Susan Mayfield, Sara Boore
Menlo Park, California
Telephone: (650) 329-5066
E-mail: smayfiel@usgs.gov; sboore@yahoo.com
Fax: (650) 329-5051

Web Layout Editor
Jolene Gittens
St. Petersburg, Florida
Telephone: (727) 803-8747 Ext. 3038
E-mail: jgittens@usgs.gov
Fax: (727) 803-2032

SOUND WAVES (WITH ADDITIONAL LINKS) IS AVAILABLE ONLINE AT URL
http://soundwaves.usgs.gov/

Contents

Submission Guidelines

Deadline: The deadline for news items and publication lists for the August issue of *Sound Waves* is Tuesday, June 12.
Publications: When new publications or products are released, please notify the editor with a full reference and a bulleted summary or description.
Images: Please submit all images at publication size (column, 2-column, or page width). Resolution of 200 to 300 dpi (dots per inch) is best. Adobe Illustrator© files or EPS files work well with vector files (such as graphs or diagrams). TIFF and JPEG files work well with raster files (photographs or rasterized vector files).

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

U.S. Geological Survey
Earth Science Information Sources:

Need to find natural-science data or information? Visit the USGS Frequently Asked Questions (FAQ's) at URL **http://www.usgs.gov/faq/**

Can't find the answer to your question on the Web? Call 1-888-ASK-USGS

Want to e-mail your question to the USGS? Send it to this address: ask@usgs.gov

(Gas Hydrates continued from page 1)

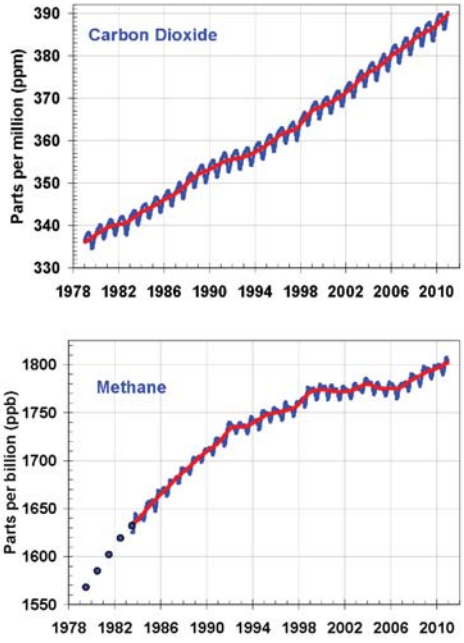
methane that they now trap.

Methane is a potent greenhouse gas. For a given volume, methane causes 15 to 20 times more greenhouse-gas warming than carbon dioxide, and so the release of large volumes of methane to the atmosphere could, in theory, exacerbate climate warming and cause more gas hydrates to destabilize.

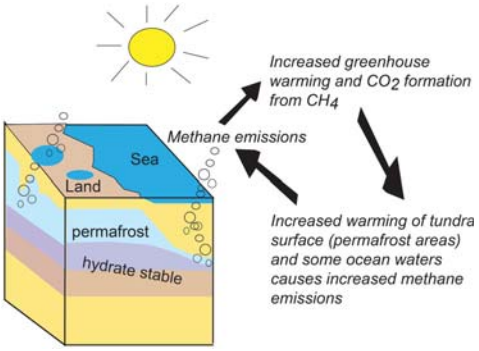
Some research suggests that such large-scale, climate-driven dissociation events have occurred in the past. For example, extreme warming during the Paleocene-Eocene Thermal Maximum about 55 million years ago may have been related to a large-scale release of methane from global methane hydrates. Some scientists have also advanced the clathrate-gun hypothesis to explain observations that may be consistent with repeated, catastrophic dissociation of gas hydrates and triggering of submarine landslides during the late Quaternary (400,000 to 10,000 years ago).

Methane As a Greenhouse Gas

The atmospheric concentration of methane, like that of carbon dioxide, has increased since the onset of the Industrial Revolution. Methane in the atmosphere comes from many sources, including wetlands, rice cultivation, termites, cows and other rumi-



Atmospheric concentrations of carbon dioxide (in parts per million) and methane (in parts per billion). Source: NOAA.



Schematic of a theoretical scenario in which Arctic methane emissions from dissociating gas hydrates lead to increased climate warming, which in turn exacerbates gas hydrate dissociation.

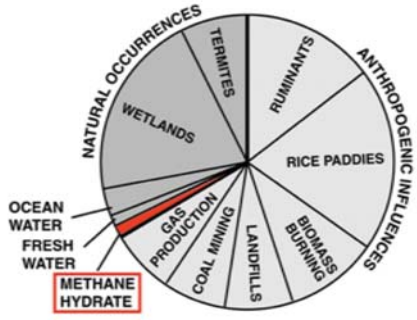
nants, forest fires, and fossil-fuel production. Some researchers have estimated that as much as 2 percent of atmospheric methane may originate with dissociation of global gas hydrates. Currently, scientists do not have a tool to say with certainty how much, if any, atmospheric methane comes from hydrates.

Although methane is a potent greenhouse gas, it does not remain in the atmosphere for long; within about 10 years, it reacts with other compounds in the atmosphere to form carbon dioxide and water. Thus, methane that is released to the atmosphere ultimately adds to the amount of carbon dioxide, the main greenhouse gas.

Climate-Driven Gas Hydrate Dissociation

For the most part, warming at rates documented by the Intergovernmental Panel on Climate Change for the 20th century should not lead to catastrophic breakdown of methane hydrates or major leakage of methane to the ocean-atmosphere system

(Gas Hydrates continued on page 3)



Possible sources of atmospheric methane. Currently, no proof exists that gas hydrates are contributing to total atmospheric methane budgets. Source: U.S. Department of Energy's Methane Hydrates R&D Program.

(Gas Hydrates continued from page 2)

from gas hydrates that dissociate. Although most methane hydrates would have to experience sustained warming over thousands of years before dissociation was triggered, gas hydrates in some places are dissociating now in response to short- and long-term climatic processes.

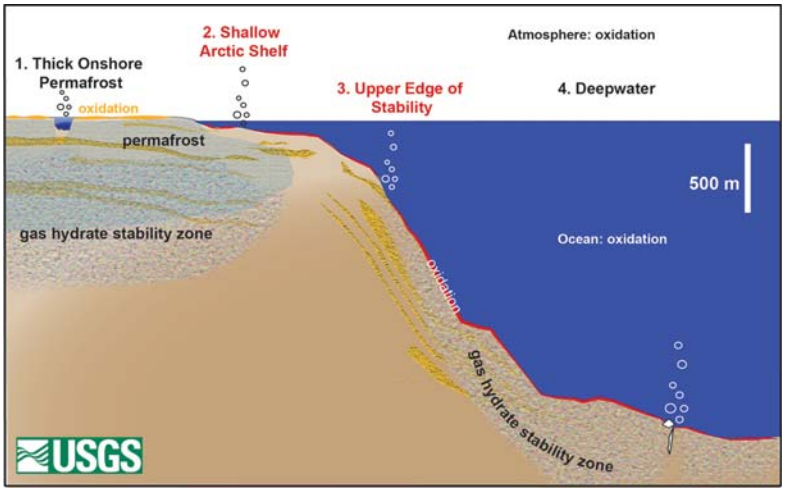
The following discussion refers to the numbered type locales or sectors shown in the diagram of gas-hydrate deposits at right.

Sector 1, Thick Onshore Permafrost: Gas hydrates that occur within or beneath thick terrestrial permafrost will remain largely stable even if climate warming lasts hundreds of years. Over thousands of years, warming could cause gas hydrates at the top of the stability zone, about 625 feet (190 meters) below the Earth's surface, to begin to dissociate.

Sector 2, Shallow Arctic Shelf: The shallow-water continental shelves that circle parts of the Arctic Ocean were formed when sea-level rise during the past 10,000 years inundated permafrost that was at the coastline. Subsea permafrost is thawing beneath these continental shelves, and associated methane hydrates are likely dissociating now. (For example, see related *Sound Waves* article at **http://soundwaves.usgs.gov/2010/11/**.) If methane from these gas hydrates reaches the seafloor, much of it will likely be emitted to the atmosphere. Less than 1 percent of the world's gas hydrates probably occur in this setting, but this estimate could be revised as scientists learn more.

Sector 3, Upper Edge of Stability: Gas hydrates on upper continental slopes, beneath 1,000 to 1,600 feet (300 to 500 meters) of water, lie at the shallowest water depth for which methane hydrates are stable. The upper continental slopes, which ring all of the world's continents, could host gas hydrate in zones that are roughly 30 feet (10 meters) thick. Warming ocean waters could completely dissociate these gas hydrates in less than 100 years. Methane emitted at these water depths will probably dissolve or be oxidized in the water column and is unlikely to reach the atmosphere. About 3.5 percent of the Earth's gas hydrates occur in this climate-sensitive setting.

Sector 4, Deepwater: Most of the Earth's gas hydrates, about 95 percent, occur in water depths greater than 3,000 feet (1,000 meters). They are likely to remain stable even with a sustained increase in bottom temperatures over thousands of years. Most of the gas hydrates in these settings occur deep within the sediments. If the gas hydrates do dissociate, the released methane should remain trapped in the sediments, migrate upward to form new gas hydrates, or be consumed by oxidation in near-seafloor sediments. Most methane released at the seafloor would likely dissolve or be oxidized in the water column. A recent article, "Methane Hydrates and Contemporary Climate Change," provides more detail (see **http://www.nature.com/scitable/knowledge/library/methane-hydrates-and-contemporary-climate-change-24314790**).



Gas-hydrate deposits by sector. Currently, gas hydrates are most likely dissociating in sectors 2 and 3. Only sector 2 is likely to release methane that could reach the atmosphere. Modified from "Methane Hydrates and Contemporary Climate Change," by ***Carolyn Ruppel (http://www.nature.com/scitable/knowledge/library/methane-hydrates-and-contemporary-climate-change-24314790)****.*

USGS Research Activities

The USGS Gas Hydrates Project is studying Arctic methane hydrates, methane emissions, and their relation to short- and long-term climate change. Since 2009, the USGS Gas Hydrates Project has been conducting field research to determine whether gas hydrates are currently dissociating in response to climate warming and, if so, how much methane emitted from these gas hydrates might reach the atmosphere. Study areas include the U.S. Beaufort Sea (for example, see **http://soundwaves.usgs.gov/2010/11/**) and Alaska's North Slope (see **http://soundwaves.usgs.gov/2009/10/**). The USGS has also organized workshops to identify priorities in climate-hydrates research (see *Fire in the Ice*, **http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/newsletter/newsletter.htm**, v. 11, no. 1, p. 18) and to plan ocean-drilling projects related to these issues (see **http://iodp-usssp.org/workshop/catching-climate-change/**).

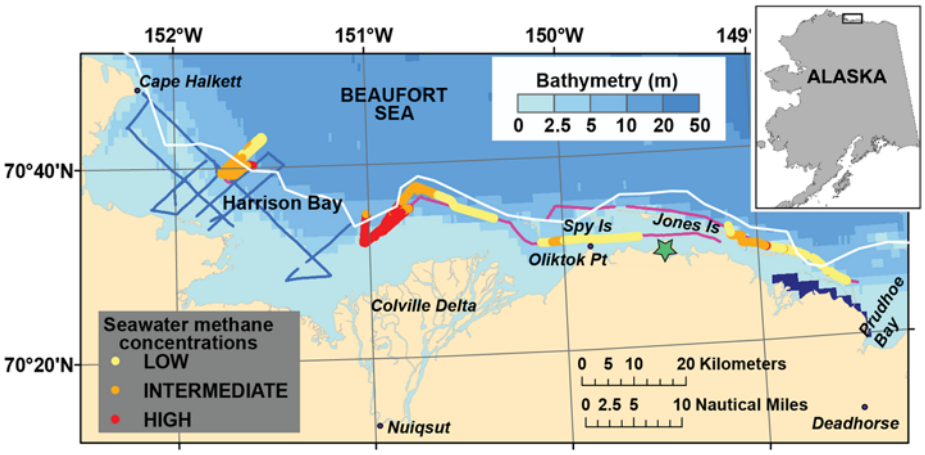
USGS researchers deploy a mini-sparker sound source to image seafloor sediments in the shallow Beaufort Sea near Prudhoe Bay, Alaska, August 2011. The USGS and the U.S. Department of Energy are cooperating in this work.

Real-Time Mapping of Seawater and Atmospheric Methane Concentrations Offshore of Alaska's North Slope

By John Pohlman, Carolyn Ruppel, Casey Maue (Woods Hole Oceanographic Institution Summer Student Fellowship Program and Stanford University), Laura Brothers, John Kessler (Texas A&M University), and Charles Worley

The continental shelf offshore of the Alaskan North Slope has been flooded by rising seawaters since at least the beginning of the Holocene Epoch, about 11,700 years ago. Like the well-studied East Siberian Arctic Shelf, the U.S. Beaufort Shelf (named for the overlying Beaufort Sea) may be underlain by thawing permafrost and dissociating methane hydrate, an ice-like crystalline solid in which methane molecules are trapped. (For a primer on gas hydrates and their relation to climate warming, see "Gas Hydrates and Climate Warming…," this issue, **http://soundwaves.usgs.gov/2012/06/**.)

Methane is a powerful greenhouse gas, and the methane hydrates on circum-Arctic Ocean continental shelves are some of the most climate-susceptible gas hydrates on Earth. Methane released on these shallow-water shelves—whether from dissociating gas hydrates or other sources—is likely to reach the atmosphere without dissolving or being converted to carbon dioxide by microbial processes in seawater.



Study area on the central U.S. Beaufort Shelf. Lines are vessel tracklines for geophysical surveys in 2010 (blue) and 2011 (magenta). Dots show relative seawater methane concentrations, from low (yellow) to high (red). Star shows approximate location of British Petroleum Exploration Alaska (BPXA)-U.S. Department of Energy (DOE)-USGS Mount Elbert Gas Hydrate Stratigraphic Test Well. White curve denotes minimal seaward extent of subsea permafrost.

Geophysical and Geochemical Survey

In August 2011, the U.S. Geological Survey (USGS) Gas Hydrates Project conducted a combined geophysical and geochemical survey on the central part of the U.S. Beaufort Shelf in an area largely underlain by subsea permafrost (see map). USGS research geologist **Tim Collett** and his collaborators have established the existence of gas hydrates onshore in the eastern part of our study area; the British Petroleum Exploration Alaska (BPXA)-U.S. Department of Energy (DOE)-USGS Mount Elbert Gas Hydrate Stratigraphic Test Well was also drilled in this area. The 2011 offshore research was carried out aboard the research vessel (R/V) *Ukpik*, a 48.5-foot vessel operated by Southern Cross LLC. The surveys focused on parts of Harrison Bay and on the area landward and seaward of the barrier islands that protect the coast between the Colville River Delta and Prudhoe Bay. USGS analyses of seismic data that were collected by the oil industry 20 to 35 years ago (see **http://walrus.wr.usgs.gov/NAMSS/**) indicate that both areas should have transitions from nearshore subsea permafrost to an absence of permafrost farther offshore.

During the first phase of the 2011 cruise, we collected simultaneous bathymetric (seafloor depth) data with the SEA SWATHPlus-M sonar system, high-resolution subbottom imagery (down to several meters below the seafloor) with the EdgeTech SB-424 (Chirp) subbottom profiler, and profiles of the sediments down to approximately 150 m below the seafloor with a SIG 2Mille mini-sparker and receiver system. This work built on an August 2010 cruise that was the first non-industry survey to obtain high-resolution geophysical data along this coastline in more than 3 decades. (See "Degradation of Subsea Permafrost and Associated Gas Hydrates Offshore of Alaska in Response to Climate Change," *Sound Waves*, October/November 2010, **http://soundwaves.usgs.gov/2010/11/**.) The geophysical data from the two cruises constrain the distribution of shallow gas and ice scours and provide images of reflectors that correspond to high-velocity layers mapped as permafrost in the legacy seismic data.

The second phase of the August 2011 cruise acquired real-time measurements of seawater and atmospheric methane and carbon dioxide concentrations by using a Picarro G2301-f "cavity ring-down spectrometer" (CRDS; described below) connected to a gas-extraction system that was constructed from a design by **Shari Yvon-Lewis** of Texas A&M University. Other Texas A&M University scientists were supported by the National Science Foundation to participate in the cruise. The 2011 survey marked the first use of a CRDS by the USGS Coastal and Marine Geology Program for this purpose and provided an outstanding demonstration of the potential of CRDS technology for a variety of greenhouse-gas studies.

Cavity Ring-Down Spectroscopy for Measuring Dissolved Gases

For many years, measurement of dissolved gases has relied on gas-chromatographic analyses of gases extracted from the headspace (the space above the sample in a sealed container) of seawater samples. Although this process can be automated to op-

(Methane Concentrations continued on page 5)

(Methane Concentrations continued from page 4)

erate on continuously pumped seawater, the measurements are more routinely carried out on water samples obtained during discrete "casts," when instruments are lowered from a vessel to measure such seawater properties as temperature and salinity and to collect water samples. Cavity ring-down spectroscopy, in contrast, measures dissolved gases every few seconds from continuously pumped seawater while the vessel is underway.

Cavity ring-down spectroscopy relies on a non-destructive laser to analyze gas concentrations. The laser light bounces between highly reflective mirrors within a pressure- and temperature-regulated cavity until the laser-light energy dissipates to a level below the sensitivity of the cavity's optic sensors. The instrument measures the duration of this dissipation process, which is known as ring-down time. Because the dissipation is partly caused by the collisions between laser light and gas molecules, the ring-down time correlates to gas concentration, with shorter ring-down times associated with higher gas concentrations. Recording ring-down times instead of changes in absolute intensity of the laser light provides increased accuracy. In comparison with other spectroscopic methods, which transmit laser light along a fixed-path length, the laser light in the CRDS cavity can travel tens of kilometers, providing increased sensitivity. The laser can be "tuned" to different light wavelengths to measure different gases.

During the 2011 Beaufort Sea cruise, the CRDS produced discrete measurements of methane and carbon dioxide concentrations in seawater every few seconds. The intake was periodically switched to sample air, which was dried before measurement, or to measure calibration gases. The ship was operated at 3 to 4 knots during the 2011 cruise, but a key advantage of CRDS-based methane mapping is the ability to acquire measurements in real time regardless of the ship's speed.

Gas Fluxes Across the Ocean-Air Interface

One of the most important uses of the continuous CRDS measurements in marine settings is the determination of gas fluxes across the ocean-air interface. These calculations provide the most direct evidence that methane released at the seafloor may be contributing to methane concentrations in the atmosphere. Calculating gas fluxes from the measured gas concentrations requires water-quality parameters, such as temperature and salinity, and meteorological data. We continuously recorded seawater salinity and temperature by using a YSI sonde, and we measured wind speed and other parameters by using an Airmar PB200 WeatherStation integrated with the CRDS. The CRDS was linked to real-time kinematic Global Positioning System (GPS) navigation, and information from all systems was recorded simultaneously with Hypack software.

The map shows relative seawater methane concentrations measured in the Beaufort Shelf study area. At most sites, the seawater is supersaturated in methane, meaning that methane is expected to flux from the ocean to the atmosphere. This observation is consistent with the results reported by chemical oceanographer **Natalia Shakhova** (International Arctic Research Center, University of Alaska, Fairbanks) and coworkers for methane measured in discrete water samples on the East Siberian Arctic Shelf. Our data reveal a possible methane hotspot in eastern Harrison Bay, above an area of seafloor that the geophysical imagery shows to be charged with shallow gas. Neither the CRDS data nor our geophysical results yield evidence for massive ebullition (bubbling) of methane as the primary means of methane emissions at the seafloor. This observation contrasts with those on the East Siberian Arctic Shelf and in the Mackenzie Delta area of the Canadian Beaufort Shelf. Numerical models predict that the most dramatic dissociation of methane hydrate should be just beyond the present-day seaward extent of subsea permafrost; however, the CRDS data do not detect systematic changes in methane concentrations when crossing from nearshore sediments underlain by seismically detected permafrost to sediments lacking such permafrost.

Future Plans for Cavity Ring-Down Spectroscopy

The successful first deployment of the CRDS and seawater equilibrator system for real-time mapping of greenhouse-gas concentrations and fluxes on the U.S. Beaufort Shelf was an important step for the USGS Gas Hydrates Project. On the basis of lessons from the initial deployment, USGS engineer **Emile Bergeron** has constructed a smaller, more portable version of some system components, which will simplify operations in remote areas or from small open boats in lakes. Using multiple CRDSes or a switching system among several pumps, we may eventually measure methane at several depths within the water column nearly simultaneously, providing higher quality data than can be obtained from numerous discrete casts that commonly occur over periods of hours or longer. We are also collaborating with USGS marine geochemist **Kevin Kroeger** to measure lateral fluxes of dissolved greenhouse gases from salt marshes and plan to incorporate a CRDS that simultaneously measures the concentrations and carbon-isotopic compositions of methane and carbon dioxide. This instrument will be deployed in summer 2012 when we conduct a multidisciplinary survey across the Beaufort Shelf with support from the U.S. Department of Energy's Methane Hydrate R&D Program (**http://fossil.energy.gov/programs/oilgas/hydrates**). The potential applications of CRDS technology reach far beyond the USGS Gas Hydrates Project—collaborations are already developing within the USGS and with outside partners to deploy the instrument to support greenhouse-gas studies in terrestrial settings, wetlands, estuaries, and deepwater marine environments.

***John Kessler** (top; Texas A&M University) and **John Pohlman** (USGS) on the research vessel* Ukpik *with one of the cavity ring-down spectrometers used during the 2011 surveys.*

Coastal and Marine Geoscience Data System—Single Point of Access for Digital Geophysical and Lidar Data of the USGS Coastal and Marine Geology Program

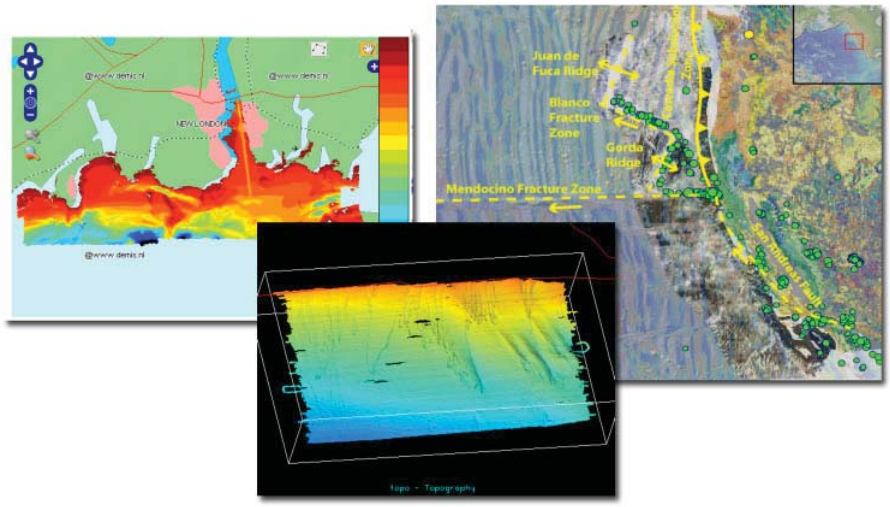
By Greg Miller and Shawn Dadisman

The Coastal and Marine Geoscience Data System (CMGDS, **http://cmgds.marine.usgs.gov/**) is now online and will eventually provide a single point of access to geophysical and lidar (light detection and ranging) data collected by the U.S. Geological Survey (USGS) Coastal and Marine Geology Program (CMGP). The CMGDS uses a "technology stack" or suite of open-source Web services and protocols to help users easily discover and access CMGP data. Initial efforts are focused on adding the most recent seismic-reflection, bathymetric, and lidar data to the system, which will eventually also include sidescan-sonar mosaics and gravity and magnetic data.

Users are helped to find data by various search methods, including interactive global map displays for data type or field activity; publication listings that can be sorted by data type, geographic area, data-access method, or date of acquisition; and a catalog of published metadata. (Metadata is information about the data, such as how, when, where, and by whom they were collected.) These methods can be accessed through tabs at the top of each Web page or from the body of the homepage, which provides more detail about each data-discovery or data-access method.

Where appropriate, access to data types will be provided via several methodologies: file download; the Open Geospatial Consortium (OGC)'s standard Web Map Service (WMS), Web Coverage Service (WCS), and Web Feature Service (WFS) (learn more at **http://www.opengeospatial.org/standards/**); THREDDS (Thematic Realtime Environmental Distributed Data Services, **http://www.unidata.ucar.edu/projects/THREDDS/**); and GeoMapApp (**http://www.geomapapp.org/**) and Virtual Ocean (**http://www.virtualocean.org/**) (see related article on GeoMapApp and Virtual Ocean, this issue, **http://soundwaves.usgs.gov/2012/06/research4.html**).

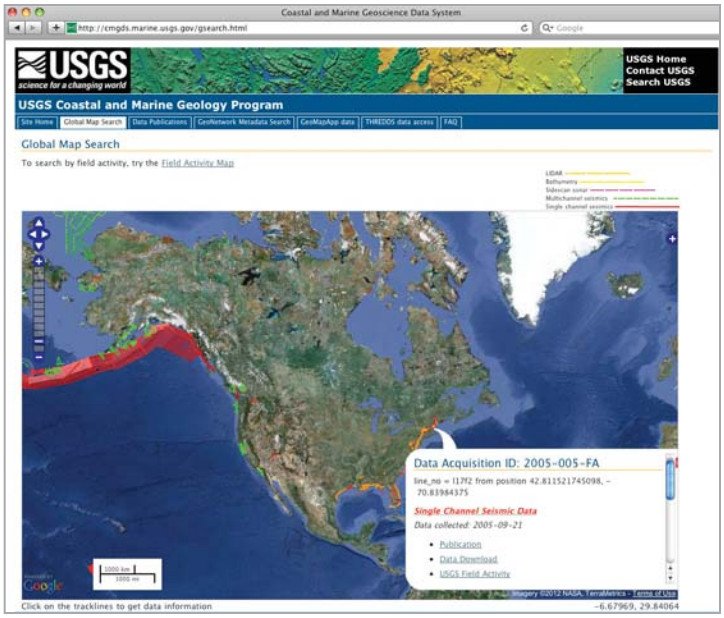
If the data are already posted online, the CMGDS will point to that source. Otherwise, the CMGDS provides data storage for direct data download. OGC Web services are provided via an open-source-software server called GeoServer (**http://geoserver.org/**), which allows users to view and integrate geospatial data via a wide variety of geographic-information-system (GIS) software. In addition, a THREDDS service is provided for NetCDF (Network Common Data Form, **http://www.unidata.ucar.edu/software/netcdf/**) access to some bathymetric datasets. Links are also provided for some NetCDF viewers, such as Integrated Data Viewer (IDV), NetCDP-Java Tools UI, and Godiva2.



*Images from homepage of the USGS Coastal and Marine Geoscience Data System (**http://cmgds.marine.usgs.gov/**), showing access to USGS Coastal and Marine Geology Program (CMGP) data via various data-visualization tools. Left to right: bathymetry from offshore New London, Connecticut, using Godiva2 software; bathymetry south of Martha's Vineyard, Massachusetts, using Integrated Data Viewer (IDV); and CMGP GLORIA sidescan-sonar data integrated with other data from GeoMapApp.*

What else is under the Web site's hood? For the Global Map Search function, shapefiles are created and displayed for each data type collected for each field activity and are served up using OpenLayers

(Data Systems continued on page 7)



*CMGDS Global Map Search Web page (**http://cmgds.marine.usgs.gov/gsearch.html**), showing distribution of geophysical and lidar data collected by the CMGP. Popup window provides information about data collected during the field activity, as well as links to data publication, data-download locations, and fieldwork information.*

(Data Systems continued from page 6)

interactive Web mapping software. Each shapefile is linked by a popup window to more information about the dataset, such as field-activity ID, data type, date collected, online publication, data-download location, and a link to more general information about the field activity. A similar display, called "Field Activity Map Search," uses Google Maps to show the location of each field activity by CMGP Center, with field activity ID and data coverage revealed when the cursor is positioned over the marker. Clicking on the marker displays a popup window with information similar to that provided in the Global Map Search display. These easy-to-use GIS displays allow the user to search geospatially for CMGP data by data type.

*CMGDS GeoNetwork Metadata Search feature (**http://cmgds.marine.usgs.gov/geonetwork/srv/en/main.home**). GeoNetwork metadata catalog provides searchable access to Federal Geographic Data Committee (FGDC) metadata for all published CMGDS data holdings. The catalog is also harvestable by other metadata catalogs.*

The same shapefiles are also served via a WMS to allow use in other GIS software. The Data Publications function is controlled by a mySQL database, which generates the publication listings sorted by geographic location, data type, acquisition date, or data-delivery method. The GeoNetwork Metadata Search function uses the GeoNetwork (**http://geonetwork-opensource.org/**) open-source metadata-cataloging software to search and retrieve Federal Geographic Data Committee (FGDC) metadata previously uploaded from the publications. CMGDS OGC Web services are also harvested into this metadata catalog. (Web "harvesting" is the use of Web-crawling software to automatically copy and collect Internet content, such as Web-site pages, to create a more focused set of information.) GeoNetwork allows local searches of the metadata and also facilitates metadata harvesting by other metadata-cataloging systems, such as the new prototype Geoportal used by the Interagency Working Group for Ocean and Coastal Mapping (IWG-OCM) inventory project and, in the future, Data.gov.

Population of the CMGDS is an ongoing task. Initial efforts are focusing on seismic-reflection (single-channel and multichannel), bathymetric, sidescan-sonar, and lidar datasets.

Recent single-channel seismic and lidar datasets are nearly complete. Many older datasets will need to be published before inclusion. Frequently-asked-question (FAQ) pages and video demonstrations of services are being developed to aid in the use of this site. The site currently contains 148 single-channel seismic datasets, 20 multichannel seismic datasets, 67 lidar datasets, 70 bathymetric datasets, 42 sidescan-sonar datasets, 59 magnetic datasets, and 45 gravity datasets. More data will be added over time.

Exploring USGS Coastal and Marine Geophysical Data Using GeoMapApp and Virtual Ocean: Tools for Integrating Earth-Science Data

By Shawn Dadisman and Greg Miller

A new National Ocean Policy has raised awareness about the need to find new and improved ways to share information about the coastal and marine environment with a wide-ranging public audience (**http://www.whitehouse.gov/administration/eop/oceans/policy**). The U.S. Geological Survey (USGS) Coastal and Marine Geology Program (CMGP) has begun a large-scale effort to incorporate the program's publicly available, digital geophysical data into two widely used Earth-science tools, GeoMapApp (**http://www.geomapapp.org/**) and Virtual Ocean (**http://www.virtualocean.org/**). This task of the CMGP Integrated Data Management System project will help support information exchange with partners, regional planning groups, and the public, as well as facilitate integrated spatial-data analysis. Sharing USGS-CMGP geophysical data via GeoMapApp and Virtual Ocean will aid data discovery and enable the data to support new purposes beyond those for which the data were originally intended.

Although few open-source tools currently exist for visualizing or analyzing marine geophysical data, GeoMapApp and Virtual Ocean are freely available and well known among the Earth-science community. These applications, which work on multiple platforms (Mac OS X, Windows, and Unix), were specifically developed for exploring Earth-science data collected in the marine environment. The applications are widely used by federal, state, academic, and international Earth-science organizations to view, integrate and explore data in a wide variety of ways in both

(Data Tools continued on page 8)

(Data Tools continued from page 7)

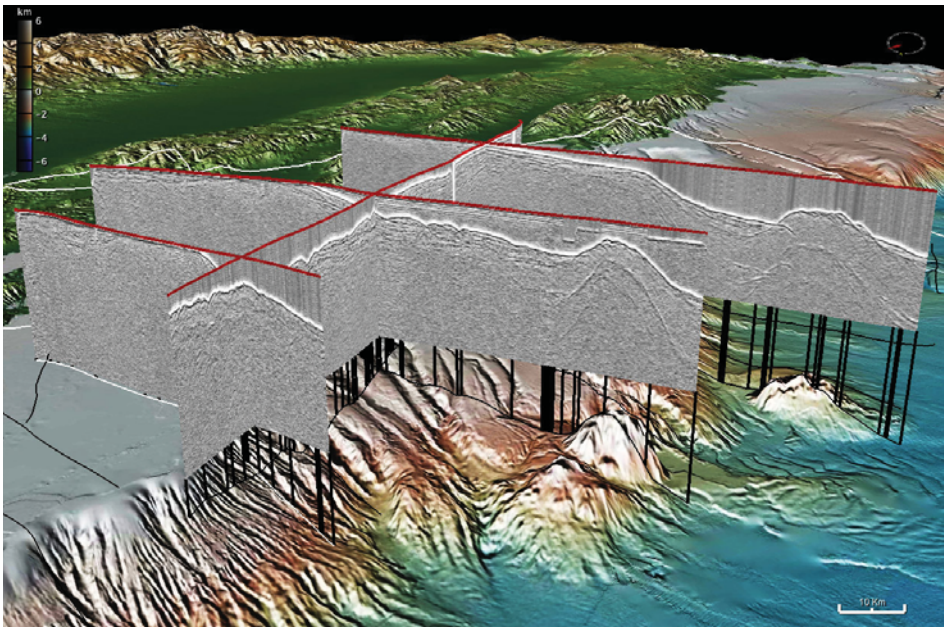
two-dimensional (GeoMapApp) and three-dimensional (Virtual Ocean) space.

GeoMapApp and Virtual Ocean were developed as part of the Marine Geoscience Data System (MGDS) funded by the National Science Foundation (NSF), with additional support from the Lamont-Doherty Earth Observatory (LDEO) at Columbia University. Virtual Ocean also uses the World Wind 3D engine developed by the National Aeronautics and Space Administration (NASA). LDEO Adjunct Professor Emeritus **William Ryan** and the rest of the LDEO team have been instrumental in redesigning software to accommodate USGS geophysical resources. In addition to providing access to data holdings within GeoMapApp and Virtual Ocean, both applications allow data to be integrated with information from local or published sources via Open Geospatial Consortium (OGC) standards (**http://www.opengeospatial.org/standards/**), including Web Map Service (WMS) and Web Feature Service (WFS). Tables, spreadsheets, and various other data import formats are supported, depending on which tool is used. Inclusion of CMGP data in these popular applications will make CMGP geophysical data more accessible and allow integration with many other types of information from both national and international sources.

Incorporating USGS data into GeoMapApp and Virtual Ocean has led to the development of the USGS Coastal and Marine Geoscience Data System (CMGDS) (**http://cmgds.marine.usgs.gov/**), a task headed by USGS scientist **Greg Miller**. The CMGDS is a single point of access to the data (see related article, "Coastal and Marine Geoscience Data System…," this issue, **http://soundwaves.usgs.gov/2012/06/research3.html**). Datasets must be published before they can be included in any of these public resources. Analyzing the geophysical data holdings for review and reprocessing has provided valuable opportunities for quality control and has helped resolve previously undetected data-management issues.

All three CMGP science centers (in Woods Hole, Massachusetts; St. Petersburg, Florida; and Santa Cruz and Menlo Park, California) have initially focused on importing the vast holdings of single-channel and multichannel seismic-reflection data into GeoMapApp and Virtual Ocean. Currently, data from 161 single-channel and 36 multichannel expeditions have been imported. Project Task Leader **Shawn Dadisman** has overseen processing performed by **Arnell Forde** and **Karynna Calderon** on data collected by the St. Petersburg Coastal and Marine Science Center (SPCMSC), and **Dave Foster** has led similar work being completed by **Jeff Obelcz** on data collected by the Woods Hole Coastal and Marine Science Center (WHCMSC). **Ray Sliter**, **Dave Foster**, and **Shawn Dadisman** have coordinated work by **Jeff Obelcz** and **Karynna Calderon** on data holdings of

(Data Tools continued on page 9)



*Three-dimensional (3D) viewing is one of Virtual Ocean's unique capabilities. Here, Virtual Ocean shows a 3D fence diagram created with four USGS multichannel seismic-reflection profiles collected across the continental margin off the Golden Gate (the entrance to San Francisco Bay, California). The fence-diagram mode superimposes the sections onto the Marine Geoscience Data System's Global Multi-Resolution Topography (GMRT) database from LDEO (**http://www.marine-geo.org/portals/gmrt/**). The user can manipulate the vertical exaggeration, the viewing direction, or the perspective of the data with simple mouse movements. View is south-southeastward, with a topographic vertical exaggeration of 5x. Black lines draped on seafloor show locations of other seismic profiles. Vertical black lines represent course changes, red lines indicate top of profile, and white boundary lines display extent of multichannel surveys. Virtual Ocean's display is highly interactive and allows the user to rotate the image in all directions and turn profiles on or off.*

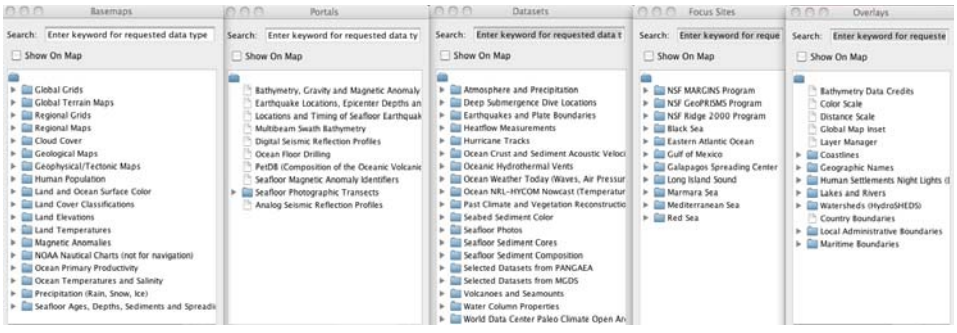


Table of dropdown menu items from GeoMapApp, showing the wide spectrum of data holdings from national and international sources that are accessible for use in data integration and visualization. For example, to view USGS single-channel and multichannel seismic-reflection datasets, select Digital Seismic Reflection Profiles in the Portals dropdown menu; and to view USGS GLORIA (Geological LOng-Range Inclined Asdic) imagery, select Regional Grids > Backscatter > U.S. Continental Margin in the Basemaps dropdown menu. Additional USGS data types will be available in the future. Virtual Ocean has similar but more limited dropdown menus.

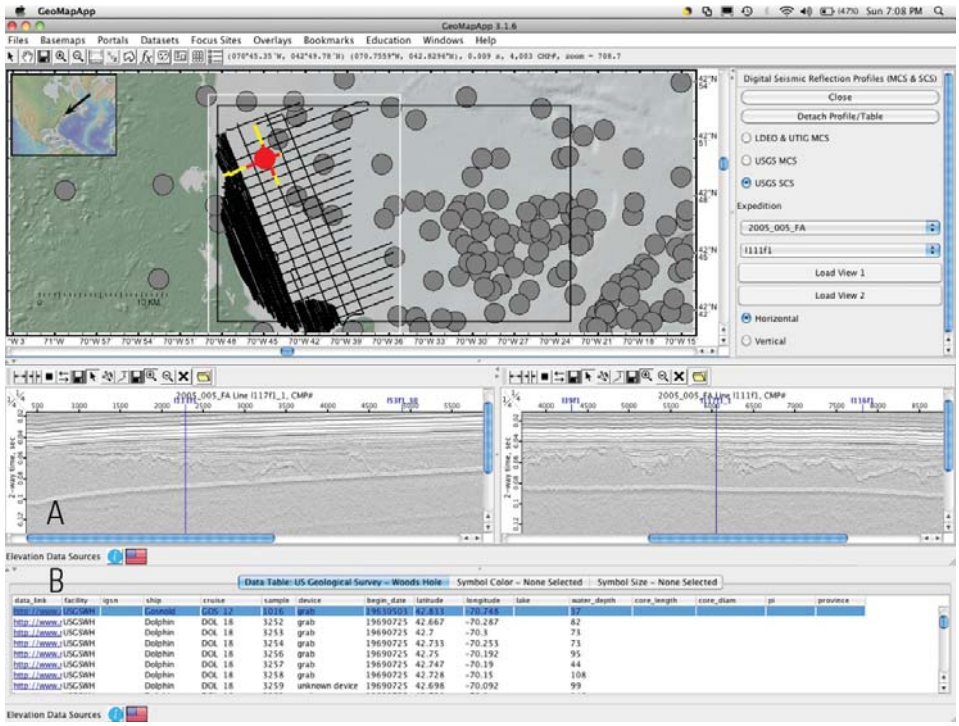
(Data Tools continued from page 8)

the Pacific Coastal and Marine Science Center (PCMSC). The CMGP has one of the nation's largest collections of publicly available marine seismic-reflection data; once the data are incorporated into GeoMapApp and Virtual Ocean, the number of datasets previously available via these tools will triple. The initial focus has been on data collected by the USGS, but the effort will also include older two-dimensional multichannel datasets that were collected by the petroleum industry and rescued by the USGS (**http://walrus.wr.usgs.gov/NAMSS/**).

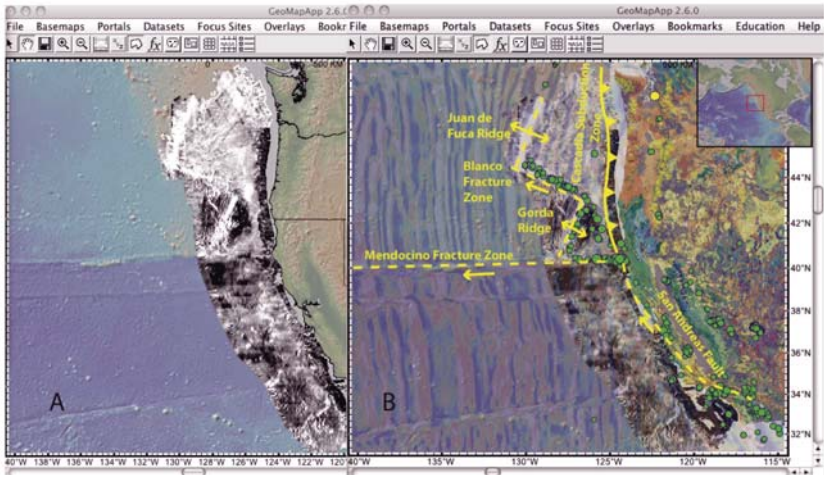
Heather Schreppel (SPCMSC), **Carolyn Degnan** (PCMSC), and **Dan Metzer** (National Oceanic and Atmospheric Administration [NOAA]) are working together to address reformatting and publishing of the large holdings of CMGP gravity, magnetic, and single-beam bathymetric data so that these data also can be imported into GeoMap-App and Virtual Ocean, as well as into the National Geophysical Data Center (NGDC) Web site (**http://www.ngdc.noaa.gov/**). **John O'Malley** (WHCMSC) has made GLORIA (Geological LOng-Range Inclined Asdic) sidescan-sonar imagery from all 46 USGS GLORIA cruises available in GeoMapApp via WMS. Plans are also in place to provide access to CMGP swath bathymetry, additional sidescan-sonar mosaics, and lidar (light detection and ranging) data through GeoMapApp and, possibly, Virtual Ocean.

The CMGP Integrated Data Management System project is working to provide these valuable holdings to a broad range of users, including other government agencies and academic institutions involved in planning offshore activities, managing natural resources, and identifying gaps in data and knowledge when planning future data collection. Access to USGS information through these systems will also facilitate new research and discoveries as the data are used in new and different ways.

The GeoMapApp and Virtual Ocean software can be downloaded from **http://www.geomapapp.org/** and **http://www.virtualocean.org/**, respectively. USGS data loaded into GeoMapApp and Virtual Ocean are available for download via the Coastal and Marine Geoscience Data System (CMGDS; **http://cmgds.marine.usgs.gov/**).



GeoMapApp images integrating seismic-reflection data and core information. A, GeoMapApp allows the user to interactively view seismic-reflection data in both map and profile views. Map view (top) shows locations of USGS single-channel chirp seismic-reflection tracklines (black, red, and yellow lines) and USGS core or sample locations (gray dots) off northern Massachusetts. Profile view (below map) shows images of two seismic profiles highlighted on the map view by yellow and red lines. The red segments of the lines show the visible extents of the profiles, and the yellow segments represent portions of the profiles not displayed in the images. The user can manipulate the direction, size, and extent of profiles, as well as add interpretations, export results, and see where profiles intersect (blue vertical lines in profiles). The white box outlines the extent of the selected seismic survey, and the black box indicates the extent of another seismic survey. B, Alternative GeoMapApp table display for the same map view above, but here displaying the USGS core data. Core location highlighted in red on the map corresponds to the table entry highlighted in blue. The data link (first column in table) leads to an online core description.



GeoMapApp images demonstrating the ease and value of integrating various data types. A, GeoMapApp presentation of USGS GLORIA sidescan-sonar data collected off the U.S. west coast. The GLORIA data are superimposed on the Marine Geoscience Data System's GMRT. B, GLORIA imagery integrated with NOAA magnetic anomalies (blue, green, and purple stripes at 50-percent opacity), USGS earthquake data (green and yellow dots), and onshore geologic-map information. Interpretations of major tectonic-plate boundaries along the U.S. west coast are shown in yellow.

Weather Conditions Prevent 2011 Survey of California Sea Otter Population

By Ben Young Landis

Scientists were unable to complete their 2011 survey of the California sea otter (*Enhydra lutris nereis*; also known as the southern sea otter) population because of heavy fog, poor visibility, and strong winds throughout the spring and summer.

The population survey has been conducted annually since the 1980s to track the recovery trend of this threatened species. The U.S. Geological Survey (USGS) leads this effort with a team of dedicated scientists and volunteers.

The population index calculated from the survey data is used by the U.S. Fish and Wildlife Service to assess the sea otter's progress toward population recovery and determine whether the species is ready for delisting under the Endangered Species Act.

"We use two standardized methods for our visual surveys, which are telescope observations from shore and aerial observations from a small twin-engine plane," said **Tim Tinker** of the USGS Western Ecological Research Center and chief scientist for the annual survey. "Although our shore-based surveys were successful, unusually heavy marine fog or high winds throughout the spring and summer repeatedly hindered our attempts to conduct aerial surveys. Both measurements are crucial, and so without the aerial observation data, we were unable to provide a reliable, standardized total count for California sea otters in 2011."

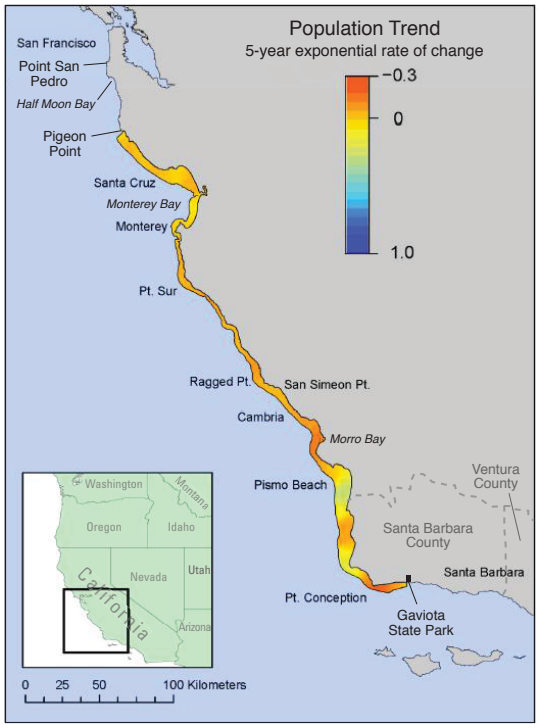
This was the first incomplete result in more than two decades of continuous monitoring. Data from portions of the survey that were successfully completed in 2011 will still be useful in computing a population index after 2012.

Typically, the research crew conducts the annual survey in May and June, covering the entire coast from Point San Pedro in San Mateo County in the north to the Santa Barbara-Ventura County line in the south. About half of this coastline can be surveyed by using ground-based observations, but the remaining half must be counted by air because of limited coastal access.

Otters sighted by shore-based crews and aerial crews are added up to provide the "raw count" for that year. The official population index is calculated by averaging the raw count from that year and the two previous years. This precaution reduces the influence of random variation in raw counts caused by year-to-year differences in viewing conditions.

"The inability to complete the survey in 2011 introduces an unfortunate but unavoidable gap in our understanding of the population's trajectory, with respect to recovery thresholds," said **Lilian Carswell**, Southern Sea Otter Recovery Coordinator for the U.S. Fish and Wildlife Service. "But we're grateful for the detailed survey effort by the USGS in the past three decades and in the years to come. We'll work together with the USGS if the need arises to adjust the annual survey methods."

In 2010, the California sea otter population index was 2,711—a decline for the second year in a row (see "California Sea Otter Numbers Drop Again," *Sound Waves*, December 2010, **http://soundwaves.usgs.gov/2010/12/**). For California sea otters to be considered for removal from the Federal List of Endangered and Threatened Wildlife, the population index has to exceed 3,090 for three consecutive years, according to the threshold established under the Southern Sea Otter Recovery Plan by the U.S. Fish and Wildlife Service.



Distribution of sea otters in California in 2010, showing spatial variation in the rate of population change over the previous 5 years. Values greater than zero (yellow, green, and blue colors) indicate increasing numbers; values less than zero (orange and red colors) indicate declining numbers. Slightly modified from figure 4 at ***http://www.werc.usgs.gov/ProjectSubWebPage.aspx?SubWebPageID=16&ProjectID=91****.*

The annual California sea otter survey is a cooperative effort of the USGS Western Ecological Research Center; the California Department of Fish and Game's Marine Wildlife Veterinary Care and Research Center; the Monterey Bay Aquarium; the University of California, Santa Cruz; and many experienced and dedicated volunteers. Assistance also comes from staff of the U.S. Fish and Wildlife Service and the U.S. Bureau of Ocean Energy Management. The 2012 survey is currently underway.

Past survey numbers are available online at **http://www.werc.usgs.gov/seaottercount**.

*A California sea otter (*Enhydra lutris nereis*) swims in Monterey Bay, California. The USGS leads annual surveys of sea otters along the California coast, but heavy fog, poor visibility, and strong winds prevented completion of the 2011 survey. Photograph taken August 9, 2008, by* ***Tania Larson****, USGS.*

Upcoming!
Exhibit at Gallery in Santa Cruz, California, Will Celebrate Collaboration Between Artists and USGS Scientists

Newly created artworks and informational displays about the scientific research on which they are based will be exhibited June 1–July 7, 2012, at the R. Blitzer Gallery in Santa Cruz, California (**http://rblitzergallery.com/**).

Titled "earth • science • art / sixteen collaborative explorations," the exhibit pairs artists from California's central coast and San Francisco Bay Area with scientists from the U.S. Geological Survey (USGS) Pacific Coastal and Marine Science Center in Santa Cruz (**http://walrus.wr.usgs.gov/**). After an introductory gathering in January, the artists have been meeting with the scientists and creating new artworks inspired by the scientific research.

"This project is an opportunity to showcase the talents of our area's artists, as well as the exciting scientific work being done in Santa Cruz by the USGS," said **Lisa Hochstein**, artist and curator of the exhibit. "Through these collaborations, we hope to invite people to reflect on the vastness of geological time, the impact of humans on the planet, and the creative ways that, as scientists and artists, we study and represent the world around us."

The exhibit will feature the artists' new works alongside informational displays by the participating scientists. Two panel discussions during the month of June will give the public an opportunity to speak with the artists and scientists about their collaborations. The gallery is located at 410 Natural Bridges Drive, Santa Cruz.

For more information more about the exhibit, including artists' reflections on their collaborations, please visit **http://www.earthscienceartsc.com/**.

Antarctic Science and Arts: Trio Performs in Russia as Part of Workshop

By Alan Cooper

Three U.S. Geological Survey (USGS) volunteer geoscientists—**Alan Cooper** (emeritus scientist, USGS Pacific Coastal and Marine Science Center), **Julianne Stafford** (Volunteer for Science, USGS Pacific Coastal and Marine Science Center), and **Larry Schemel** (emeritus scientist, USGS National Research Program in Water)—traveled to St. Petersburg, Russia, in May 2012 to participate in a workshop on the Antarctic Seismic Data Library System for Cooperative Research (SDLS; **http://sdls.ogs.trieste.it/**). The SDLS is an international collaborative project initiated and led by USGS Pacific Coastal and Marine Science Center scientists, now in its 21st year as part of the Antarctic Treaty system. The workshop focused on legacy Russian multichannel seismic data and their use in stratigraphic paleoclimate studies of the Antarctic continental margin and the Southern Ocean, which encircles Antarctica.

As part of the workshop, the USGS scientists participated in a collaborative science and arts project by performing their trio's (**http://www.leftbanktrio.com/**) multimedia presentation "Music of the Antarctic Expeditions from Captain Cook (1770's) to the Antarctic Treaty (1959): Its Roles in Exploration, Science and Collaborations" (with text in Russian) at the Russian Geographical Society in St. Petersburg. They first performed this presentation in 2009 at the Antarctic Treaty Summit in Washington, D.C., recognizing 50 years of science (and arts) collaborations under the treaty (**http://soundwaves.usgs.gov/2010/02/meetings3.html**). The presentation was later performed at the USGS campus in Menlo Park, California, and is planned for Antarctic science-arts events in conjunction with the Scientific Committee on Antarctic Research (SCAR) Open Science Conference in July 2012 in Portland, Oregon (see **http://soundwaves.usgs.gov/2010/12/outreach.html**).

USGS volunteer geoscientists and members of the Left Bank trio (left to right) ***Julianne Stafford****,* ***Alan Cooper****, and* ***Larry Schemel*** *before performing for an Explorers Club meeting at the California Academy of Sciences in San Francisco, May 20, 2011.*

Two USGS Scientists Selected as Fellows of the American Geophysical Union

U.S. Geological Survey (USGS) scientists **Daniel R. Cayan** and **Thomas E. Parsons** have been selected as Fellows of the American Geophysical Union (AGU) in the class of 2012.

Dan Cayan

Tom Parsons

Dan Cayan (San Diego, CA) was selected as a Fellow in AGU's Hydrology section for his pioneering, cross-disciplinary contributions and leadership advancing understanding of hydroclimatic variation and change in western North America. A scientist with the USGS and the Scripps Institution of Oceanography, University of California, San Diego, **Cayan** conducts research that has led to major shifts in the way that the climate and hydrology of western North America are studied and understood by most scientists and decision makers in the region. Early in his career, he collaborated with others to illuminate recurring, long-distance (or "teleconnected") centers of action in global patterns of atmospheric circulation and ocean conditions that strongly influence the climate of the Pacific-North American sector. His studies of global-scale, quasi-periodic climate modes—such as the El Niño-Southern Oscillation—provided important foundations for understanding and predicting key patterns in the North American climate. A focus on western rivers and snowpacks led **Cayan** to recognize and demonstrate important trends over the past 50 years toward more rain and less snow, earlier snowmelt, earlier vegetation greenup, and earlier streamflow from snow-fed rivers across western North America. While bringing the global-warming debates home to the West in clear and visceral ways, **Cayan** has also been the voice for calm science-based approaches as agencies have begun to swing into action to plan their potential responses. In addition to his own careful research, **Cayan** has inspired many students and scientists to explore the roles of climate in diverse water and environmental applications.

Tom Parsons (Menlo Park, CA) was selected as a Fellow in the Tectonophysics section for his fundamental insights into earthquake triggering, earthquake interaction, and fault mechanics. A geophysicist at the USGS Pacific Coastal and Marine Science Center, **Parsons** studies earthquake triggering and fault interaction, probabilistic methods to forecast earthquakes and tsunamis, statistical seismology, and crustal deformation/fault mechanics. He is equally at home with finite element analysis, elastic dislocation theory, crustal and mantle rheology, waveform seismology, and plate tectonics. He has employed these tools to probe how earthquakes are triggered, to understand how tectonic forces drive the interplay of faulting and volcanism, and to improve seismic-hazard assessments destined for the public and for engineers in our nation and beyond. "What we most admire about Tom's research agenda is his utter lack of fealty to any hypothesis, idea, or conviction," wrote his nominators. "This agility and fierce objectivity are what propels science forward, but are exceedingly rare because most of us defend and burnish our past work rather than tear it down to reveal the next or deeper insights."

Parsons, **Cayan**, and 59 other 2012 Fellows were selected by the AGU Fellows Selection Committee (the full list is available in an AGU news release at **http://www.agu.org/news/press/pr_archives/2012/2012-04.shtml**). AGU members who are selected as Fellows have attained an acknowledged eminence in a branch of the geophysical sciences. The number of Fellows selected annually is limited to no more than 0.1 percent of the AGU membership. Congratulations to these distinguished scientists!

Chinese Scientist Visiting USGS Pacific Coastal and Marine Science Center

By Jingping Xu

Dr. Jianru (Jerome) Li, assistant professor from the State Key Laboratory of Marine Geology, Tongji University, China, is visiting the U.S. Geological Survey (USGS) Pacific Coastal and Marine Science Center for 9½ months, from March 15 to December 31, 2012.

Jerome is a marine geologist by training. Both his M.S. and Ph.D. theses addressed the effect of variations in the Earth's orbit (or "orbital forcing") on the ocean carbon cycle. In recent years, he has been in charge of overseeing all of his laboratory's seagoing research cruises—from planning to instrument acquisitions to logistic details.

During his USGS visit, **Jerome** will be working with **Jingping Xu**, **George Tate**, and our Marine Facility staff to develop a free-ascending tripod (FAT), a bottom-

(Jerome Li continued on page 13)

(Jerome Li continued from page 12)

mount platform for the deep-sea environment, to be deployed in the South China Sea in early 2013. The tripod is one critical component of the project In-Situ Observation of Bottom Currents and Sediment Transport in the Northeastern South China Sea, a collaboration between the USGS and Tongji University. The near-term objective of this project is to collect oceanographic and sediment-dynamics data along the 2,500-meter bathymetric contour in the northeastern South China Sea where such data do not exist. The long-term scientific objectives are to understand (1) the bottom-boundary-layer processes and (2) the circulation of the near-bed current in the deep basin of the region. These factors are thought to control the source, transport, and deposition of the region's deep-sea sediment and the evolution of the basin-scale sedimentary deposits. The project is part of an 8-year research program, the South China Sea Deep (**http://www.scs-deep.org/**), funded by the National Natural Science Foundation of China. ❁

***Jerome Li** on board the research vessel* Marion Dufresne*, departing Singapore for the joint Chinese-French Marco Polo/IMAGES (International Marine Past Global Changes Study) cruise in the South China Sea, May 2005.*

International Volunteer from Belgium Assists USGS Southeast Ecological Science Center Staff in Everglades National Park

By Thomas J. Smith

Ms. Zoë Verlaak arrived at Everglades National Park, Florida, in early February 2012 to assist with research by U.S. Geological Survey (USGS) scientists and their collaborators. **Zoë** came to us from her home in Ghent, Belgium, as a part of the National Park Service's International Volunteers-in-Parks Program (**http://www.nps.gov/oia/topics/ivip/ivip.htm**). She holds both B.S. and M.S. degrees in geology from Ghent University. Her research interests are in paleoecology and paleoclimatology. Her M.S. thesis is titled "A Detailed Analysis of Laminations in the Late Pleistocene Sedimentary Record of Laguna Parrillar, Southern Patagonia, Chile."

During **Zoë's** stay, she assisted hydrologic technicians **Gordon Anderson** and **Karen Balentine** of the USGS Southeast Ecological Science Center (**http://fl.biology.usgs.gov/**) with their work in the mangroves of Everglades National Park. Additionally, she worked with our academic colleagues involved in the Florida Coastal Everglades Long Term Ecological Research project (**http://fce.lternet.edu/**) based at Florida International University—specifically, with **Laurel Collins** and **Evelyn Gaiser**, associate professors in the Department of Biological Sciences. This project, on which USGS research ecologist **Tom Smith** (**https://profile.usgs.gov/tom_j_smith**) is an associate investigator, is a National Science Foundation (NSF)-funded, university-based research project in Everglades National Park. **Zoë** conducted field sampling for the presence of foraminifera (single-celled shelled organisms) and copepods (tiny crustaceans, typically 1–2 millimeters long) in the estuary, shallow groundwater, and sediment at USGS study sites in the southwestern coastal Everglades from February through early May. Both groups of organisms provide information about the salinity of the water in which they occur; variations in species composition indicate variations in salinity.

***Zoë Verlaak**, volunteer from Ghent, Belgium, who assisted USGS Southeast Ecological Science Center staff in Everglades National Park from early February through early May 2012.*

Thanks, **Zoë**, for your valuable help! ❁

Recently Published Articles

Armstrong, B.N., Warner, J.C., Voulgaris, G., List, J.H., Thieler, E.R., Martini, M.M., and Montgomery, E.T., 2011, Carolinas Coastal Change Processes Project data report for observations near Diamond Shoals, North Carolina, January-May 2009: U.S. Geological Survey Open-File Report 2011–1156 [**http://pubs.usgs.gov/of/2011/1156/**].

Barr, J.G., Engel, V., Fuentes, J.D., Zieman, J.C., O'Halloran, T.L., Smith, T.J., III, and Anderson, G.H., 2010, Controls on mangrove forest-atmosphere carbon dioxide exchanges in western Everglades National Park: Journal of Geophysical Research, v. 115, G02020, 14 p., doi:10.1029/2009JG001186 [**http://dx.doi.org/10.1029/2009JG001186**].

Bernier, J.C., Morton, R.A., and Kelso, K.W., 2011, Trends and causes of historical wetland loss, Sabine National Wildlife Refuge, southwest Louisiana: U.S. Geological Survey Open-File Report 2011–1169, 36 p. [**http://pubs.usgs.gov/of/2011/1169/**].

Bonisteel-Cormier, J.M., Nayegandhi, A., Fredericks, X., Jones, J.W., Wright, C.W., Brock, J.C., and Nagle, D.B., 2011, EAARL topography—Potato Creek watershed, Georgia, 2010: U.S. Geological Survey Data Series 617, DVD [**http://pubs.usgs.gov/ds/617/**].

Bonisteel-Cormier, J.M., Nayegandhi, A., Fredericks, X., Klipp, E.S., Nagle, D.B., Vivekanandan, S., Wright, C.W., Sallenger, A.H., and Brock, J.C., 2011, EAARL coastal topography—Virginia, post-Nor'Ida, 2009: U.S. Geological Survey Data Series 638, DVD [**http://pubs.usgs.gov/ds/638/**].

Bonisteel-Cormier, J.M., Nayegandhi, A., Wright, C.W., Brock, J.C., Nagle, D.B., Vivekanandan, S., Klipp, E.S., Fredericks, X., and Stevens, S., 2011, EAARL coastal topography—Assateague Island National Seashore, Maryland and Virginia, 2010: U.S. Geological Survey Data Series 628, DVD [**http://pubs.usgs.gov/ds/628/**].

Bonisteel-Cormier, J.M., Nayegandhi, A., Wright, C.W., Sallenger, A.H., Brock, J.C., Nagle, D.B., Vivekanandan, S., Klipp, E.S., and Fredericks, X., 2011, EAARL coastal topography—northern Outer Banks, North Carolina, post-Nor'Ida, 2009: U.S. Geological Survey Data Series 616, DVD [**http://pubs.usgs.gov/ds/616/**].

Casazza, M.L., Coates, P.S., Miller, M.R., Overton, C.T., and Yparraguirre, D.R., 2012, Hunting influences the diel patterns in habitat selection by northern pintails *Anas acuta*: Wildlife Biology, v. 18, no. 1, p. 1–13, doi:10.2981/09-099 [**http://dx.doi.org/10.2981/09-099**].

DeWitt, N.T., Flocks, J.G., Pendleton, E.A., Hansen, M.E., Reynolds, B.J., Kelso, K.W., Wiese, D.S., and Worley, C.R., 2012, Archive of single beam and swath bathymetry data collected nearshore of the Gulf Islands National Seashore, Mississippi, from West Ship Island, Mississippi, to Dauphin Island, Alabama—methods and data report for USGS cruises 08CCT01 and 08CCT02, July 2008 and 09CCT03 and 09CCT04, June 2009: U.S. Geological Survey Data Series 675, CD-ROM [**http://pubs.usgs.gov/ds/675/**].

DeWitt, N.T., Flocks, J.G., Pfeiffer, W.R., Gibson, J.N., and Wiese, D.S., 2012, Archive of side scan sonar and swath bathymetry data collected during USGS cruise 10CCT03 offshore of the Gulf Islands National Seashore, Mississippi, from East Ship Island, Mississippi, to Dauphin Island, Alabama, April 2010: U.S. Geological Survey Data Series 671, DVD [**http://pubs.usgs.gov/ds/671/**].

Fisher, R.N., and Ineich, I., 2012, Cryptic extinction of a common Pacific lizard *Emoia impar* (Squamata, Scincidae) from the Hawaiian Islands: Oryx, v. 46, no. 2, p. 187-195, doi:10.1017/S0030605310001778 [**http://dx.doi.org/10.1017/S0030605310001778**].

Forde, A.S., Dadisman, S.V., Flocks, J.G., Wiese, D.S., DeWitt, N.T., Pfeiffer, W.R., Kelso, K.W., and Thompson, P.R., 2011, Archive of digital Chirp subbottom profile data collected during USGS cruises 10CCT01, 10CCT02, and 10CCT03, Mississippi and Alabama Gulf Islands, March and April 2010: U.S. Geological Survey Data Series 611, 11 DVDs [**http://pubs.usgs.gov/ds/611/**].

Fredericks, X., Nayegandhi, A., Bonisteel-Cormier, J.M., Wright, C.W., Sallenger, A.H., Brock, J.C., Klipp, E.S., and Nagle, D.B., 2011, EAARL coastal topography—eastern Florida, post-Hurricane Jeanne, 2004—bare earth: U.S. Geological Survey Data Series 627, DVD [**http://pubs.usgs.gov/ds/627/**].

Halstead, B.J., Wylie, G.D., Coates, P.S., Valcarcel, P., and Casazza, M.L., 2012, Bayesian shared frailty models for regional inference about wildlife survival: Animal Conservation, v. 15, no. 2, p. 117–124, doi:10.1111/j.1469-1795.2011.00495.x [**http://dx.doi.org/10.1111/j.1469-1795.2011.00495.x**].

Halstead, B.J., Wylie, G.D., Coates, P.S., Valcarcel, P., and Casazza, M.L., 2012, 'Exciting statistics'—the rapid development and promising future of hierarchical models for population ecology: Animal Conservation, v. 15, no. 2, p. 133–135, doi:10.1111/j.1469-1795.2012.00540.x [**http://dx.doi.org/10.1111/j.1469-1795.2012.00540.x**].

Jiang, J., DeAngelis, D.L., Smith, T.J., III, Teh, S.Y., and Koh, H-L., 2012, Spatial pattern formation of coastal vegetation in response to external gradients and positive feedbacks affecting soil porewater salinity—a model study: Landscape Ecology, v. 27, p. 109–119, doi:10.1007/s10980-011-9689-9 [**http://dx.doi.org/10.1007/s10980-011-9689-9**].

Kuehl, S.A., Ketterer, M.E., and Miselis, J.L., 2012, Extension of $^{239+240}$Pu sediment geochronology to coarse-grained marine sediments: Continental Shelf Research, v. 36, p. 83–88, doi: 10.1016/j.csr.2012.01.016 [**http://dx.doi.org/10.1016/j.csr.2012.01.016**].

Larson, S., Jameson, R., Etnier, M., Jones, T., and Hall, R., 2012, Genetic diversity and population parameters of sea otters, *Enhydra lutris*, before fur trade extirpation from 1741-1911: PLoS ONE, v. 7, no. 3, e32205, doi:10.1371/journal.pone.0032205 [**http://dx.doi.org/10.1371/journal.pone.0032205**].

Mignone, A., Stockdon, H., Willis, M., Cannon, J., and Thompson, R., 2012, On the use of wave parameterizations and a storm impact scaling model in National Weather Service coastal flood

(Recently Published continued on page 15)

(Recently Published continued from page 14)

and decision support operations [abs.]: American Meteorological Society Annual Meeting, 92nd, New Orleans, La., January 22–26, 2012 [**http://ams.confex.com/ams/92Annual/webprogram/Paper196615.html**].

Miselis, J.L., McNinch, J.E., and List, J.H., 2012, Interannual and storm-related evolution of nearshore morphology and its relationship to shoreline behavior [abs.]: Ocean Sciences Meeting, Salt Lake City, Utah, February 20–24, 2012 [**http://www.sgmeet.com/osm2012/viewabstract2.asp?AbstractID=11373**].

Misra, V., Moeller, M., Stefanova, L., Chan, S., O'Brien, J.J., Smith, T.J., III, and Plant, N., 2011, The influence of the Atlantic Warm Pool on the Florida panhandle sea breeze: Journal of Geophysical Research, v. 116, D00Q06, 14 p., doi:10.1029/2010JD015367 [**http://dx.doi.org/10.1029/2010JD015367**].

Nayegandhi, A., Bonisteel-Cormier, J.M., Clark, A.P., Wright, C.W., Brock, J.C., Nagle, D.B., Vivekanandan, S., and Fredericks, X., 2011, EAARL topography—Three Mile Creek and Mobile-Tensaw Delta, Alabama, 2010: U.S. Geological Survey Data Series 618, DVD [**http://pubs.usgs.gov/ds/618/**].

Nayegandhi, A., Bonisteel-Cormier, J.M., Wright, C.W., Brock, J.C., Nagle, D.B., Vivekanandan, S., Fredericks, X., and Barras, J.A., 2012, EAARL coastal topography—Alligator Point, Louisiana, 2010: U.S. Geological Survey Data Series 665, DVD [**http://pubs.usgs.gov/ds/665/**].

Nayegandhi, A., Fredericks, X., Bonisteel-Cormier, J.M., Wright, C.W., Brock, J.C., Nagle, D.B., Vivekanandan, S., and Barras, J.A., 2012, EAARL coastal topography—Central Wetlands, Louisiana, 2010: U.S. Geological Survey Data Series 673 [**http://pubs.usgs.gov/ds/673/**].

Pendleton, E.A., Twichell, D.C., Foster, D.S., Worley, C.R., Irwin, B.J., and Danforth, W.W., 2011, High-resolution geophysical data from the sea floor surrounding the western Elizabeth Islands, Massachusetts: U.S. Geological Survey Open-File Report 2011-1184, DVD, [**http://pubs.usgs.gov/of/2011/1184/**].

Raabe, E.A., Stonehouse, D., Ebersol, K., Holland, K., and Robbins, L., 2011, Detection of coastal and submarine seeps on the Florida Gulf coast with an airborne thermal infrared mapping system: Professional Geologist, v. 48, no. 5, p. 42–46.

Rivera-Monroy, V.H., Twilley, R.R., Davis, S.E., III, Childers, D.L., Simard, M., Chambers, R., Jaffe, R., Boyer, J.N., Rudnick, D.T., Zhang, K., Castañeda-Moya, E., Ewe, S.M.L., Price, R.M., Coronado-Molina, C., Ross, M., Smith, T.J., III, Michot, B., Meselhe, E., Nuttle, W., Troxler, T.G., and Noe, G.B., 2011, The role of the Everglades Mangrove Ecotone Region (EMER) in regulating nutrient cycling and wetland productivity in South Florida: Critical Reviews in Environmental Science and Technology, v. 41, supp. 1, p. 633–669, doi:10.1080/10643389.2010.530907 [**http://dx.doi.org/10.1080/10643389.2010.530907**].

Rogers, C.S., and Muller, E.M., 2012, Bleaching, disease and recovery in the threatened scleractinian coral *Acropora palmata* in St. John, US Virgin Islands—2003–2010: Coral Reefs, doi:10.1007/s00338-012-0898-8 [**http://dx.doi.org/10.1007/s00338-012-0898-8**].

Rose, K.V., Nayegandhi, A., Moses, C.S., Beavers, R., Lavoie, D., and Brock, J.C., 2012, Gap analysis of benthic mapping at three national parks—Assateague Island National Seashore, Channel Islands National Park, and Sleeping Bear Dunes National Lakeshore: U.S. Geological Survey Open-File Report 2011–1291, 60 p. [**http://pubs.usgs.gov/of/2011/1291/**].

Ross, S.W., Demopoulos, A.W.J., Kellogg, C.A., Morrison, C.L., Nizinski, M.S., Ames, C.L., Casazza, T.L., Gualtieri, D., Kovacs, K., McClain, J.P., Quattrini, A.M., Roa-Varón, A.Y., and Thaler, A.D., 2012, Deepwater Program—studies of Gulf of Mexico lower continental slope communities related to chemosynthetic and hard substrate habitats: U.S. Geological Survey Open-File Report 2012–1032, 301 p. [**http://pubs.usgs.gov/of/2012/1032/**].

Saha, A.K., Moses, C., Price, R.M., Engel, V., Smith, T.J., III, and Anderson, G.H., 2012, A hydrological budget (2002–2008) for a large subtropical wetland ecosystem indicates marine groundwater discharge accompanies diminished freshwater flow: Estuaries and Coasts, v. 35, p. 459–474, doi:10.1007/s12237-011-9454-y [**http://dx.doi.org/10.1007/s12237-011-9454-y**].

Sallenger, A., Doran, K., and Howd, P., 2012, Sea-level-rise acceleration and storm surges along the U.S. northeast coast [abs.]: Association of American Geographers Annual Meeting, New York, N.Y., February 24–28, 2012 [**http://meridian.aag.org/callforpapers/program/AbstractDetail.cfm?AbstractID=42369**].

Smith, C.G., Marot, M.E., and Osterman, L.E., 2012, Influence of anthropogenic activities and natural processes on historic depositional patterns and environmental change in the Mobile Bay estuarine system, Alabama (USA) [abs.]: Ocean Sciences Meeting, Salt Lake City, Utah, February 20–24, 2012 [**http://www.sgmeet.com/osm2012/viewabstract2.asp?AbstractID=10370**].

Smith, C.G., and Swarzenski, P.W., 2012, An investigation of submarine-groundwater-borne nutrient fluxes to the west Florida shelf and recurrent harmful algal blooms: Limnology and Oceanography, v. 57, no. 2, p. 471–485, doi:10.4319/lo.2012.57.2.0471 [**http://dx.doi.org/10.4319/lo.2012.57.2.0471**].

Smith, T.J., III, Tiling-Range, G., Jones, J., Nelson, P., Foster, A., and Balentine, K., 2010, The use of historical charts and photographs in ecosystem restoration—examples from the Everglades Historical Air Photo Project, *in* Cowley, D.C., Standring, R.A., and Abicht, M.J., eds., Landscapes through the lens—aerial photographs and the historic environment [Occasional Publication of the Aerial Archaeology Research Group, no. 2]: Oxford, U.K., Oxbow Books, p. 179–191 [**http://sofia.usgs.gov/publications/papers/hischartsphotos/**].

Spear, J.W., Reynolds, C.E., and Poore, R.Z., 2011, Seasonal flux and assemblage composition of planktic foraminifera from the northern Gulf of Mexico, 2008–2010: U.S. Geological Survey Open-File Report

(Recently Published continued on page 16)

(Recently Published continued from page 15)

2011–1215, 19 p. [**http://pubs.usgs.gov/of/2011/1215/**].

Stefanova, L., Misra, V., Chan, S., O'Brien, J.J., Griffin, M., and Smith, T.J., III, 2011, A proxy for high-resolution regional reanalysis for the Southeast United States—assessment of precipitation variability: Climate Dynamics, doi:10.1007/s00382-011-1230-y [**http://dx.doi.org/10.1007/s00382-011-1230-y**].

Stockdon, H.F., and Holman, R.A., 2011, Observations of wave runup, setup, and swash on natural beaches: U.S. Geological Survey Data Series 602 [**http://pubs.usgs.gov/ds/602/**].

Subino, J.A., Morgan, K.L., Krohn, M.D., Forde, A.S., and Dadisman, S.V., 2012, Archive of post-Hurricane Charley coastal oblique aerial photographs collected during USGS field activity 04CCH01 from Marco Island to Fort Desoto, Florida, August 15, 2004: U.S. Geological Survey Data Series 651, 2 DVDs [**http://pubs.usgs.gov/ds/651/**].

Tinker, M.T., Guimarães, P.R., Jr., Novak, M., Marquitti, F.M.D., Bodkin, J.L., Staedler, M., Bentall, G., and Estes, J.A., 2012, Structure and mechanism of diet specialization; testing models of individual variation in resource use with sea otters: Ecology Letters, v. 15, no. 5, p. 475–483, doi:10.1111/j.1461-0248.2012.01760.x [**http://dx.doi.org/10.1111/j.1461-0248.2012.01760.x**].

van Mantgem, P.J., and Stuart, J.D., 2012, Structure and dynamics of an upland old-growth forest at Redwood National Park, California, *in* Standiford, R.B., Weller, T.J., Piirto, D.D., and Stuart, J.D., eds., Proceedings of Coast Redwood Forests in a Changing California—a symposium for scientists and managers (USDA Forest Service General Technical Report PSW-GTR-238): Albany, Calif., Pacific Southwest Research Station, p. 323–333 [**http://www.fs.fed.us/psw/publications/documents/psw_gtr238/**].

Xue, Z., He, R., Liu, J.P., and Warner, J.C., 2012, Modeling transport and deposition of the Mekong River sediment: Continental Shelf Research, v. 37, p. 66–78, doi:10.1016/j.csr.2012.02.010 [**http://dx.doi.org/10.1016/j.csr.2012.02.010**].

Zug, G.R., and Fisher, R.N., 2012, A preliminary assessment of the *Nactus pelagicus* species group (Squamata: Gekkonidae) in New Guinea and a new species from the Admiralty Islands: Zootaxa, no. 3257, p. 22–37 [**http://www.mapress.com/zootaxa/list/2012/3257.html**].

Publications Submitted for Bureau Approval

Brock, J.C., Barras, J.A., and Morton, R.A., Historical hurricane impacts on coastal wetlands—contributions of extreme storms to the development of the coastal Louisiana landscape over the past century [abs.]: State of the Coast 2012, New Orleans, La., June 25–27, 2012.

Brock, J.C., Barras, J.A., and Wolcott, M., USGS-USACE-CPRA-NLCLDD collaboration on coastal Louisiana airborne and terrestrial lidar levee acquisition pilot project [abs.]: State of the Coast 2012, New Orleans, La., June 25–27, 2012.

Cochrane, G.R., Dethier, M., Pacunski, R., and Moegling, C., Benthic habitat mapping in the southern Salish Sea [abs.] GeoHab 2012 (Marine Geological and Biological Habitat Mapping), Eastsound, Wash., May 1–4, 2012.

Cooper, A.K., and Stafford, J.S., Effective communication of science; incorporating the arts into our science culture [abs.]: Scientific Committee on Antarctic Research Open Science Conference, Portland, Oreg., July 15–19, 2012.

Cross, V.A., Twichell, D.C., Foster, D.S., and O'Brien, T.F., Apalachicola Bay interpreted seismic horizons and updated IRIS chirp seismic-reflection data: U.S. Geological Survey Open-File Report 2012-1003.

Dartnell, P., and Finlayson, D., Seafloor mapping and video ground-truth of tar mounds and gas seeps in the Santa Barbara Channel, southern California [abs.]: Southern California Academy of Sciences Annual Meeting, Los Angeles, Calif., May 4–5, 2012.

Flocks, J., Miselis, J., Plant, N., and Sallenger, A., The Chandeleur Islands oil spill mitigation sand berm—1 year later [abs.]: State of the Coast 2012, New Orleans, La., June 25–27, 2012.

Griffin, D.W., Nichols, T., Yoder, C., Young, S., and Allen, R., Pathogenic bacteria in North American soils—a joint USGS-USEPA survey [abs.]: National Environmental Monitoring Conference, Washington, D.C., August 6–10, 2012.

Hapke, C.J., Coastal dynamics at Fire Island—connecting inner shelf geology, processes, and trends of shoreline change [abs.]: Fire Island National Seashore Biennial Science Meeting, Patchogue, N.Y., April 27, 2012.

Hickey, T.D., Holocene core logs and site methods for modern reef and head-coral cores; Dry Tortugas National Park, Florida: U.S. Geological Survey Open-File Report.

Kayen, R.E., Ishihara, K., Stewart, J.P., Tokimatsu, K., Cox, B.R., Tanaka, Y., Kokusho, T., Mason, H.B., Moss, R.E.S., Zekkos, D., Wood, C.M., Katsumata, K., Estevez, I.A., Cullenward, S.S., Tanaka, H., Harder, L.F., Kelson, K.I., and Kishida, T., Geotechnical deformations at ground failure sites from the March 11, 2011 great Tohoku earthquake, Japan; field mapping, LIDAR modeling, and surface wave investigation: International Conference on Urban Earthquake Engineering, 9th, Tokyo, Japan, March 6–8, 2012, proceedings.

Kranenburg, C., Nayegandhi, A., Palaseanu-Lovejoy, M., Brock, J.C., and Woodman, R., Unsupervised classification of lidar-based vegetation structure metrics at Jean Lafitte National Historical Park and Preserve: U.S. Geological Survey Open-File Report.

Palaseanu-Lovejoy, M., Brock, J., Cormier, J., and Kranenburg, C., Defining levee geometric metrics from high resolution airborne lidar topography in south Louisiana [abs.]: State of the Coast 2012, New Orleans, La., June 25–27, 2012.

Palaseanu-Lovejoy, M., Kranenburg, C., and Brock, J.C., Land area change analysis

(Publications Submitted continued on page 17)

(Publications Submitted continued from page 16)

following hurricane impacts in Delacroix, Louisiana, 2004–2009: U.S. Geological Survey Scientific Investigations Map.

Rex, M.A., Chaytor, J.D., and Stuart, C.T., Late Pleistocene *Colus stimpsoni* (Mørch, 1868) from a seabed core (2520 m) in the western North Atlantic: Nautilus.

Robbins, L.L., Yates, K.K., Wynn, J., Knorr, P.O., Lisle, J., Buczkowski, B., Byrne, R., Liu, X., and Holland-Bartels, L., Ocean acidification in the Arctic Ocean—new data shows large areas of carbonate undersaturation in Canada Basin [abs.]: American Geophysical Union Science Policy Conference, Washington, D.C., April 30–May 3, 2012.

Ryan, H.F., von Huene, R., Scholl, D.W., and Kirby, S., Potential hazards to U.S. coasts from Alaskan-Aleutian tsunami earthquakes: Eos (American Geophysical Union Transactions).

Ryan, H.F., von Huene, R., Wells, R.E., Scholl, D.W., Kirby, S., and Draut, A.E., Multi-hazard demonstration project tsunami scenario; geologic controls on an earthquake rupture beneath the Fox, Shumagin and Semidi islands, eastern Aleutian megathrust: U.S. Geological Survey Open-File Report.

Sigurðsson, O., Williams, R.S., and Víkingsson, S., Map of the glaciers of Iceland/Jöklar á Íslandi, *in* Satellite image atlas of glaciers of the world: Reykjavik, Iceland, Icelandic Meteorological Office.

Stafford, J.S., Cooper A.K., Lüdecke, C., and Schemel, L., Cultural arts return to Antarctic science; scientists engaging the public [abs.]: Scientific Committee on Antarctic Research Open Science Conference, Portland, Oreg., July 15–19, 2012.

Stockdon, H., Doran, K., Thompson, D., and Sopkin, K., National assessment of vulnerability of U.S. beaches to coastal change during hurricane landfall [abs.]: American Geophysical Union Science Policy Conference, Washington, D.C., April 30–May 3, 2012.

Storlazzi, C.D., Fregoso, T.A., Finlayson, D.P., Figurski, J.D., Freiwald, J., and Lonhart, S.I., Burial and exhumation of temperate bedrock reefs as elucidated by repetitive high-resolution seabed sonar surveys; biological ramifications and guidance for future studies: Continental Shelf Research.

Swarzenski, P.W., Storlazzi, C.D., Presto, M.K., Gibbs, A.E., Smith, C.G., Dimova, N.T., Dailer, M.L., and Logan, J.B., Nearshore morphology, benthic structure, hydrodynamics, and coastal groundwater discharge near Kahekili Beach Park, Maui, Hawaii: U.S. Geological Survey Open-File Report.

ten Brink, U.S., and Lopez-Venegas, A.M., Plate interaction in the NE Caribbean subduction zone from GPS observations: Geophysical Research Letters.

Wong, F.L., Phillips, E.L., Johnson, S.L., and Sliter, R.W., Modeling of depth to base of Last Glacial Maximum and seafloor sediment thickness for the California State Waters Map Series, eastern Santa Barbara Channel, California: U.S. Geological Survey Open-File Report.