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Research

Large Deposits of Potentially Producible Gas Hydrate Found in Indian Ocean

By Alex Demas and Tim Collett

[reprinted from USGS News Release, July 25, 2016]

The USGS has assisted the Government of India in the discovery of large, highly enriched accumulations of natural gas hydrate (**http://energy.usgs.gov/GeneralInfo/EnergyNewsroomAll/TabId/770/ArtMID/3941/ArticleID/1230/Results-of-the-India-National-Gas-Hydrate-Program-Expedition-02.aspx**) in the Bay of Bengal. This is the first discovery of its kind in the Indian Ocean that has the potential to be producible.

Natural gas hydrates are a naturally occurring, ice-like combination of natural gas and water found in the world's oceans and polar regions. The amount of gas within the world's gas hydrate accumulations is estimated to greatly exceed the volume of all known conventional gas resources.

"Advances like the Bay of Bengal discovery will help unlock the global energy resource potential of gas hydrates as well help define the technology needed to safely produce them," said **Walter Guidroz**, USGS Energy Resources Program coordinator. "The USGS is proud to have played a key role on this project in collaboration with our international partner, the Indian Government."

This discovery is the result of the most comprehensive gas hydrate field venture in the world to date, made up of scientists from India, Japan, and the United States. The scientists conducted ocean drilling, conventional sediment coring, pressure coring, downhole logging, and analytical activities to assess the geologic occurrence, regional context, and characteristics of gas hydrate deposits in the offshore of India.

The deepwater vessel Chikyu *as deployed during the National Gas Hydrate Program Expedition 02. The vessel was designed by the Japanese government for international scientific drilling operations. Photo credit: Japan Agency for Marine-Earth Science and Technology.*

This research expedition, called the Indian National Gas Hydrate Program Expedition 02, is the second joint exploration for gas hydrate potential in the Indian Ocean. The first expedition, also a partnership between scientists from India and the United States, discovered gas hydrate accumulations, but in formations that are currently unlikely to be producible.

Although it is possible to produce natural gas from gas hydrates, there are significant technical challenges, depending on the location and type of formation. Previous studies have shown that gas hydrate at high concentrations in sand reservoirs is the type of occurrence that can be most easily produced with existing technologies.

As such, the second expedition focused on the exploration and discovery of highly concentrated gas hydrate occurrences in sand reservoirs. The gas hydrate discovered during the second expedition is located in coarse-grained sand-rich depositional systems in the Krishna-Godavari Basin and is made up of a sand-rich, gas-hydrate-bearing fan and channel-levee gas hydrate prospects. The next steps for research will involve production testing in these sand reservoirs to determine if natural gas production is practical and economic.

(Gas Hydrate continued on page 2)

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Submission Guidelines

Deadline: The deadline for news items and publication lists for the 165th issue of *Sound Waves* is Wednesday, October 19, 2016.

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).

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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

Research, continued

(Coastal Erosion continued from page 1)

*USGS Scientists **William Waite** (right) and **Pamela Swarzenski** making measurements on sediment cores recovered from Indian Ocean during the National Gas Hydrate Program Expedition 02.*

"The results from this expedition mark a critical step forward to understanding the energy resource potential of gas hydrates," said USGS Senior Scientist **Tim Collett**, who participated in the expedition. "The discovery of what we believe to be several of the largest and most concentrated gas hydrate accumulations yet found in the world will yield the geologic and engineering data needed to better understand the geologic controls on the occurrence of gas hydrate in nature and to assess the technologies needed to safely produce gas hydrates."

The international team of scientists was led by the Oil and Natural Gas Corporation Limited of India on behalf of the Ministry of Petroleum and Natural Gas India, in cooperation with the USGS, the Japanese Drilling Company, and the Japan Agency for Marine-Earth Science and Technology. In addition, the USGS is working closely with the National Institute of Advanced Industrial Science and Technology Japan on the analysis of pressure core samples collected from sand reservoirs with high gas hydrate concentrations.

The USGS has a globally recognized research program (**http://woodshole.er.usgs.gov/project-pages/hydrates/**) studying natural gas hydrates in deepwater and permafrost settings worldwide. USGS researchers focus on the potential of gas hydrates as an energy resource, the impact of climate change on gas hydrates, and seafloor stability issues. More information can be found about the study and other USGS energy research at **http://energy.usgs.gov/OilGas/UnconventionalOilGas/GasHydrates.aspx**. ❁

Photograph showing burning gas hydrate.

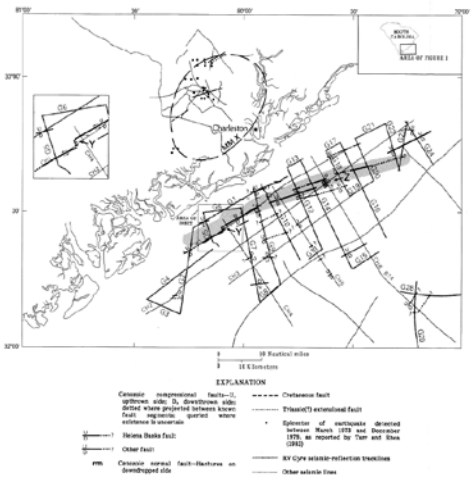
Re-Evaluating the Causes and Hazards of South Carolina Earthquakes

By Fran Lightsom

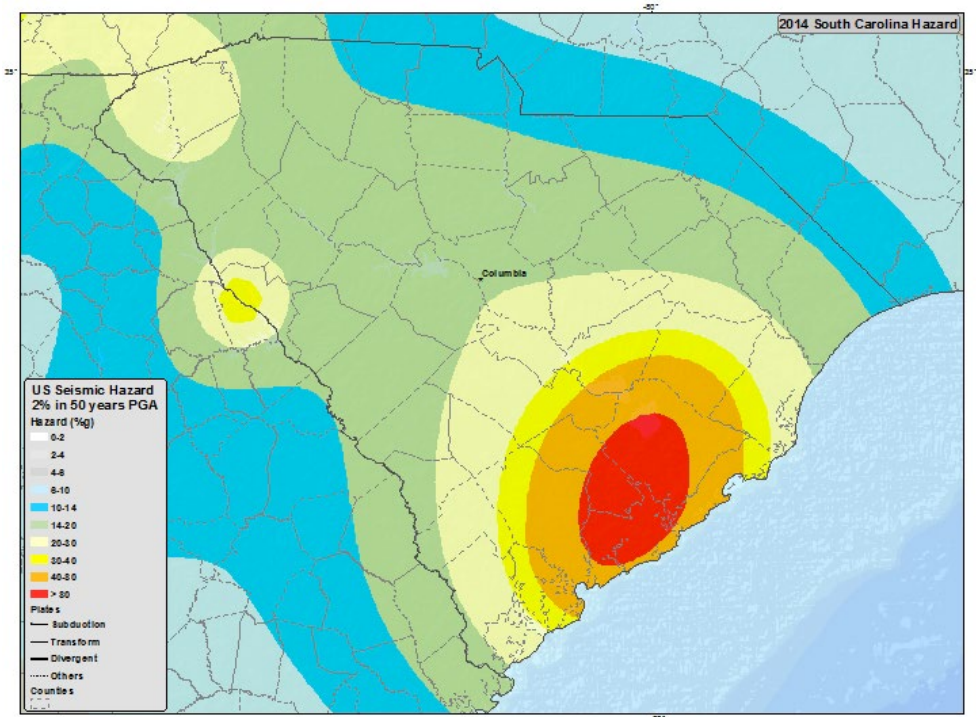
South Carolina has earthquakes and the hazards that go with them, like seismic shaking and ground failure. The 1886 Charleston earthquake (**http://earthquake.usgs.gov/earthquakes/states/events/1886_09_01.php**) caused extensive damage in the city and throughout the Southeast, and was felt as far away as Ontario, Bermuda, and Cuba. But unlike many other parts of the world where earthquakes occur along boundaries between tectonic plates—the Pacific "Ring of Fire" (**http://pubs.usgs.gov/gip/dynamic/fire.html**) for example—South Carolina earthquakes result from the reactivation of ancient geologic structures associated with much older tectonic events, such as the building of the Appalachian Mountains (**http://pubs.usgs.gov/gip/birth/**) and the rifting that opened the Atlantic Ocean (**http://pubs.usgs.gov/gip/dynamic/historical.html**).

In the 1980s, USGS geologist **John Behrendt** published important work on South Carolina earthquakes, based in part on offshore seismic reflection data (**http://woodshole.er.usgs.gov/operations/sfmapping/seismic.htm**) collected by the USGS Woods Hole office in 1979 and 1981. Today, in light of additional information, University of South Carolina professor **James Knapp** is revisiting Behrendt's interpretation, especially the nature of the offshore Helena Banks fault zone, and he wanted to examine the original data.

Knapp consulted his colleague **Daniel Lizarralde** at Woods Hole Oceanographic Institution, who had downloaded the digital data for the 1981 field activities from the USGS Woods Hole Data Library website (**http://woodshole.er.usgs.gov/operations/ia/**), and knew about additional data at the Data Library that had not been posted online. Knapp then contacted Woods Hole Data Librarian **Linda McCarthy** in February 2016 and requested high-quality digital images of the 1979 data and the associated navigation data that was not available at the Data Library website. McCarthy digitized 11 seismic reflection data records from the 1979 expedition and sent them, with metadata ("data about data"), to Knapp in March.



*The lines of data collection during **John Behrendt's** USGS research cruise in 1981, with his geologic interpretations in the Helena Banks fault zone. The map is available online at **https://pubs.er.usgs.gov/publication/mf2056**.*



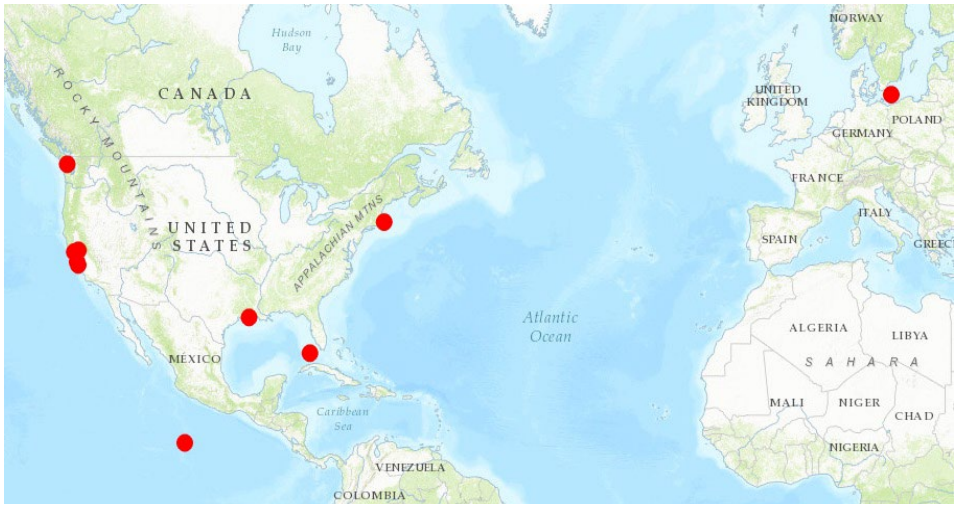
*The South Carolina seismic hazard map has a bullseye at the coast near Charleston, illustrating the importance of undersea geology for understanding earthquake causes and seismic hazards. No tectonic plate boundaries are shown because South Carolina is in the interior of the North American Plate. The map is available online at **http://earthquake.usgs.gov/earthquakes/byregion/southcarolina-haz.php**.*

The data library's contribution will assist Knapp's project to create an improved understanding of the geometry and origin of offshore faults, which may help guide seismic building codes in 21st century South Carolina, in addition to informing decisions about offshore resource extraction and other planning issues. The new interpretation will also be a model for understanding other "passive" continental margins that are more seismically active than you might expect. As Knapp said later, "Preservation of these legacy marine geophysical data provides scientists a tremendous opportunity to re-evaluate the geology of the subsurface." ❁

Future Fieldwork, October-November 2016

Rex Sanders

USGS scientists plan to visit more than 11 locations in October and November 2016, studying delta sediment, deep sea minerals, greenhouse gases, and much more. Here's a quick a preview of some coastal and offshore fieldwork scheduled by our researchers. Plans could change at any time.



Approximate locations of some planned USGS coastal and offshore fieldwork in October and November 2016. Image from ***http://coastalmap.marine.usgs.gov/****.*

- **Carmel River, California:** Measure river channel topography and turbidity, and take photos following dam removal, January 1–December 31, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-638-FA**

- **Cape Cod, Massachusetts:** Collect water samples, marsh cores, and time series water quality and flow data from Sage Lot Pond, April 8–November 30, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-015-FA**

- **Cape Cod, Massachusetts:** Examine the environmental geochemistry and health of 11 estuaries, April 11–November 30, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-016-FA**

- **Sacramento-San Joaquin Delta, California:** Time series measurements of suspended sediment, tides, and waves for habitat restoration, August 8–October 14, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-662-FA**

- **Dry Tortugas National Park, Florida:** Collect biogeochemical data on habitats surrounding the Ocean Carbon System, September 26–October 7, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-346-FA**

- **Elwha River, Washington:** Monitor changes in the river, estuary, and offshore after dam removal, September 27–October 3, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-664-FA**

- **Monterey Bay, California:** Retrieve and replace moorings for the Coordinated Canyon Experiment, October 3–7, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-670-FA**

- **East Pacific Rise:** Collect metal sulfide minerals, and metal sulfide particles in high temperature fluids, October 6–28, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-672-FA**

- **Louisiana and Texas coastline:** Collect bathymetry and sub-bottom profiles from Marsh Island to Sabine Pass, October 11–25. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-339-FA**

- **Sacramento-San Joaquin Delta, California:** Time series measurements of suspended sediment, tides, and waves for habitat restoration, October 12–December 9, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-669-FA**

- **Baltic Sea:** Participate in greenhouse gas calibration, October 15–22, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-042-FA**

- **San Pablo Bay, California:** Collect sediment cores to investigate the Hayward-Rodgers Creek fault, October 17–21, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-671-FA**

- **Stellwagen Bank National Marine Sanctuary, Massachusetts:** Collect seabed sediment samples for geological mapping, October 21–28, November 4–18, and November 25–December 9, 2016. Details at:t **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-039-FA**

  http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-040-FA

  http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-041-FA

For a complete list of past, present, and future USGS Coastal and Marine Geology program fieldwork, see: **http://cmgds.marine.usgs.gov/data_search.php**. ☸

Duke TIP Summer Programs Visit USGS

By Kira Barrera

The USGS St. Petersburg Coastal and Marine Science Center hosted groups of students participating in Duke Talent Identification Program (TIP, **https://tip.duke.edu/**) summer programs for middle and high school students.

Research oceanographers **Hilary Stockdon** and **Nathaniel Plant** presented to students from the Duke TIP CRISIS (Creative Resolutions of Impending Situations with Intelligent Solutions) program at Eckerd College. The Duke TIP CRISIS is a one-week summer residential program for fifth and sixth graders who are members of the Duke TIP 4th–6th Grade program. Through problem-based learning, CRISIS builds leadership and teamwork skills by asking students to assume the role of a professional on a research team—collaborating with team members to solve a community crisis. This year the program's focus was "Hurricanes: impacts, research, and response." Stockdon and Plant shared their research on nearshore processes, coastal geomorphology, and large-scale coastal behavior that informs predictions of coastal response to storm events. A demonstration of the USGS Coastal Change Hazards Portal (**http://marine.usgs.gov/coastalchangehazardsportal/**) allowed students to explore the probability of storm-induced coastal change impacts along the U.S. coastline.

Geologist **Ginger Tiling-Range** gave a presentation about the effects of hurricanes on mangrove ecosystems. The presentation focused on comparing the effects of Hurricane Andrew and Hurricane Wilma on Everglades National Park, specifically addressing wind effects and the resulting defoliation, storm surge, and erosion, as well as sediment deposition.

Students from the Duke TIP CRISIS (Creative Resolutions of Impending Situations with Intelligent Solutions) Summer Program examine the impacts to the barrier island they constructed in the coastal erosion model at the St. Petersburg Coastal and Marine Science Center.

Physical scientist and outreach and education coordinator **Kira Barrera** gave tours of the center and showed the students a coastal erosion model that simulates hurricane impacts to a barrier island.

Research microbiologist **Dale Griffin** presented to high school students participating in the Duke TIP Blue Gold: Science, Engineering, and the Future of Water program, a two-week residential field study program that focused on water management, policy, and global water issues. Griffin highlighted the importance of water quality research and shared several of his past and present projects including African dust studies and the impacts of pollution on coral reefs. ❁

Hilary Stockdon *demonstrates the USGS Coastal Change Hazards Portal.*

Nathaniel Plant *gives a presentation about hurricane prediction and coastal impacts.*

Advanced Model Training for Predicting Coastal Storm Impacts

by John Warner

To better understand storm impacts and their effects on our coastlines, there is an international need to better predict storm paths and intensity. The USGS has been leading the development of a Coupled Ocean-Atmosphere-Waves-Sediment-Transport (COAWST) Modeling system **http://woodshole.er.usgs.gov/operations/modeling/COAWST/index.html**.

This open-source and publically developed modeling system pulls together many sophisticated components to provide a collective system that can be used to simulate earth system processes. Some of the components include the atmosphere Weather Research and Forecast Model (WRF), the ocean Regional Ocean Modeling System (ROMS), the wave Simulating WAves Nearshore (SWAN), and the USGS Community Sediment models. The USGS has provided and developed varying aspects of all these individual systems, and provided enhanced capabilities to allow all of these components to feedback to one another. For example, a typical hurricane modeling simulation may include great details for the atmosphere component, but with limited connectivity to the ocean. However, with the COAWST system, these simulations will allow the ocean to dynamically evolve and provide a feedback to the atmosphere simulation. This will modify the storm development and provide a more realistic suite of physical storm processes.

Group photo for the COAWST 2016 training. Photo credit: ***Kanoksri Sarinnapakorn****.*

To advance the user community of the modeling system, the USGS has held several COAWST Modeling System Trainings. The first training took place in 2012, the second in 2014, and the third training was held from August 15-19, 2016. All the trainings were viewed and recorded via WebEx online. More than 70 scientists from around the world attended the most recent training. It provided both a hands-on tutorial of the system, as well as fundamental information about the modeling components. The training was performed by many of the model developers, and users shared their own experiences to gain feedback from other attendees. The COAWST modeling system currently has over 700 registered users. ❁

USGS scientists Elected as AGU Fellows

The American Geophysical Union (AGU) has chosen the 2016 class of AGU Fellows and will honor them at the upcoming 2016 Fall Meeting in San Francisco, California.

USGS scientists **James E. Cloern**, **Judson W. Harvey**, **Thomas W. Sisson**, and **Uri S. ten Brink** have been selected as AGU Fellows.

This special honor recognizes scientific eminence in the Earth and space sciences. It acknowledges Fellows for their remarkable contributions to their research fields, exceptional knowledge, and visionary leadership. Only 0.1% of AGU membership receives this recognition in any given year.

The full list of the 2016 Class of AGU Fellows is available in an AGU news release (**http://www.agu.org/news/press/pr_archives/2012/2012-04.shtml**). ❁

James E. Cloern

Judson W. Harvey

Thomas W. Sisson

Uri S. ten Brink

USGS Research Oceanographer Hosts Visiting Scholars to Collaborate on CFD Modeling of Sand and Oil Agglomerates

by Soupy Dalyander

USGS oceanographer **Soupy Dalyander** hosted **Niels Jacobsen** of Deltares (Netherlands, **https://www.deltares.nl/en/**) the week of September 11–17 at the USGS St. Petersburg Coastal and Marine Science Center. Jacobsen is advising the Master's research of **Melanie Schippers**, who is also being hosted from August 14 to October 28. In collaboration with the USGS and Deltares, Schippers is developing a computational fluid dynamics (CFD) model of the incipient motion behavior of sand and oil agglomerates (tar balls) which will be used to improve prediction of their behavior and fate following an oil spill.

For more information about sand and oil agglomerates, see "Assessing mobility and redistribution patterns of sand and oil agglomerates in the surf zone" (**http://dx.doi.org/10.1016/j.marpolbul.2014.01.004**).

Soupy Dalyander *(USGS, right) with Deltares researchers* ***Niels Jacobsen*** *(left), and* ***Melanie Schippers*** *(center).*

Cape Cod Susceptible to Potential Effects of Sea-Level Rise

By Donald Walter, Jeff Barbaro, Peter Weiskel, and Hannah Hamilton

[reprinted from USGS News Release, July 12, 2016]

Cape Cod is vulnerable to rising water tables and, in some areas, groundwater inundation as a result of rising sea levels, according to a new USGS study.

Groundwater inundation occurs when the water table reaches or exceeds land surface. The challenges associated with the issue are likely to become more prevalent as seas rise. In some communities, groundwater inundation may result in saltwater intrusion of aquifers, problems with underground utilities and pipes, flooded basements and septic system failures, among other challenges. Depending on the severity, it may make areas unsuitable for residential and commercial development.

The USGS study, done in cooperation with the Association to Preserve Cape Cod, the Cape Cod Commission, the Massachusetts Environmental Trust, and the Nature Conservancy, found that the water table on Cape Cod could rise by about two feet, on average, in response to a six-foot sea-level rise, the level some models predict will occur by 2100. The potential rise in the water table is less than the potential rise in sea level because the Cape's streams and wetlands are expected to dampen the water-table response, which likely would mitigate some of the effects of sea level rise in inland areas.

USGS Scientists ***Carol Johnson***, ***Eric White***, *and* ***Tim McCobb*** *prepare to deploy geophysical equipment in a coastal embayment April 9, 2015, in Falmouth, Massachusetts. This equipment will outline the geological conditions under the water, which will give the scientists a better understanding of the geology and hydrology of the sandy glacial deposits underlying this portion of Cape Cod's coast.*

"Near the coast, however, we believe the rise in the water table would probably be larger, suggesting a substantial likelihood for groundwater inundation in some low-lying coastal areas," says **Donald Walter**, a USGS hydrologist and lead author of the study. "Although sea level rise is a global issue, the impacts can be local. Cape Cod is a coastal area with a large population and some areas that will be susceptible to sea-level rise."

"The potential for saltwater intrusion into aquifers, which can affect drinking water wells, is an additional concern in coastal areas," Walter added. "But our

(Cape Cod continued on page 8)

(Cape Cod continued from page 7)

study found that extensive saltwater intrusion is unlikely on Cape Cod."

The USGS looked at projected changes to the water table and groundwater inundation in response to sea level rises of two, four, and six feet. The information from the study is expected to help local officials as they address how to mitigate expected sea level rise on the island.

"This study points the way to several next steps. In areas where the water table is predicted to rise, communities should plan for impacts on water quality, management of stormwater and wastewater, and infrastructure," said Jo Ann Muramoto, the Association to Preserve Cape Cod's director of science programs. "Long-term monitoring of groundwater, streams, and sea level rise will be needed to confirm the model over time and alert us to rising groundwater. The Cape's natural drainage system of streams and connected ponds is important for offsetting the effects of rising groundwater. Protecting and restoring our natural surface drainage system could be an important coastal resilience measure."

The full citation for the report is:

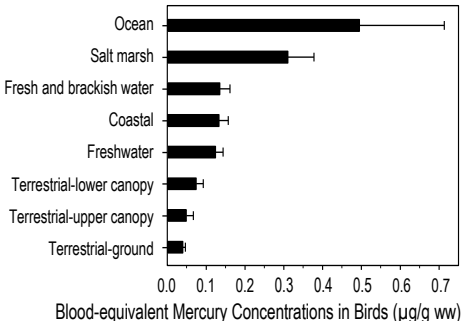
- Walter, D.A., McCobb, T.D., Masterson, J.P., and Fienen, M.N., 2016, Potential effects of sea-level rise on the depth to saturated sediments of the Sagamore and Monomoy flow lenses on Cape Cod, Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5058, 55 p., **http://dx.doi.org/10.3133/sir20165058**. ❁

Mercury found in birds across western North America

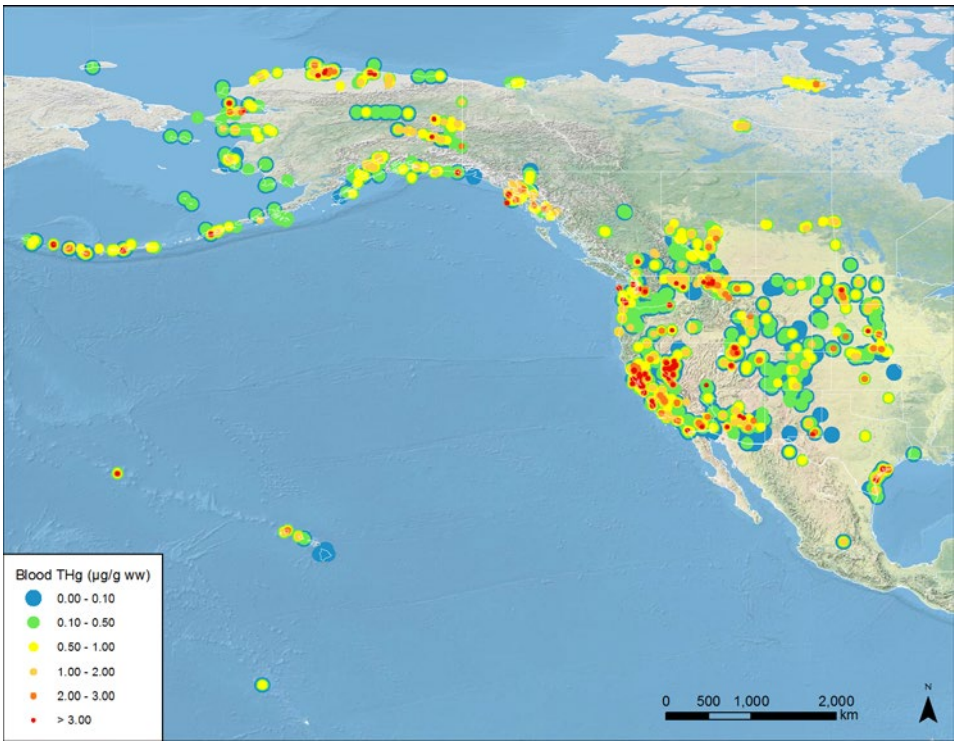
Josh T. Ackerman

A recent landscape-scale study by USGS and U.S. and Canadian collaborators has documented mercury in birds throughout western North America, identifying hotspots and large-scale ecological attributes that influence mercury exposure and accumulation in birds. This is the first study to combine toxicity benchmarks developed for different bird tissues into an overall assessment of mercury's risk to birds.

Mercury concentrations differed among species, foraging guilds, habitat types, locations, and ecoregions and were greatest in ocean and salt marsh habitats, followed by freshwater habitats, and lowest in terrestrial habitats (see chart below). Birds that ate fish or other animals had the greatest mercury concentrations, whereas birds that ate plants and seeds exhibited the lowest mercury concentrations.



Blood-equivalent total mercury concentrations in birds among habitats in western North America (n=27,629 individual samples; data shows least squares means ± standard errors).



Blood-equivalent total mercury (THg) concentrations in birds across Western North America using original data (n=27,629 individual samples). All individual data points are shown, with lower THg concentrations in the background as larger symbols and higher THg concentrations as smaller symbols on top.

This study used a new model to translate published mercury toxicity benchmarks across bird tissues into a common blood-equivalent mercury concentration. Scientists identified four general toxicity benchmarks for mercury contamination in birds. The analysis included 30,000 samples from 225 species and, using data from 200 scientific publications, incorporated an additional 2,000 mean mercury concentrations, representing 20,000 individuals and 176 species.

Overall, using blood-equivalent mercury concentrations, 66% of birds sampled in western North American exceeded the lowest-observed effect level (0.2 µg/g wet weight), 28% exceeded moderate risk (1.0 µg/g wet weight), 8% exceeded high risk (3.0 µg/g wet weight), and 4% exceeded severe risk (4.0 µg/g wet weight). The

(Mercury Found continued on page 9)

(Mercury Found continued from page 8)

map below shows the distribution of mercury concentrations in birds throughout western North America.

Methylmercury contamination of the environment is an important issue globally and birds are useful bioindicators for environmental contamination. Landscape-scale assessments of environmental pollution can be helpful for understanding the major drivers and distributions of contaminants in animals, prioritizing contaminant monitoring and remediation programs, focusing policy-making decisions, and evaluating the health of species of concern.

This work was conducted as a part of the Western North American Mercury Synthesis Working Group supported by the John Wesley Powell Center for Analysis and Synthesis, funded by the USGS with additional support from the USGS Ecosystems Mission Area and Contaminant Biology Program.

The full citation for the publication is:

- Ackerman, J.T., Eagles-Smith, C.A., Herzog, M.P., Hartman, C.A., Peterson, S.H., Evers, D.C., Jackson, A.K., Elliott, J.E., Vander Pol, S.S., and Bryan, C.E., 2016, Avian mercury exposure and toxicological risk across western North America: A synthesis, *Science of The Total Environment*: **http://dx.doi.org/10.1016/j.scitotenv.2016.03.071**. ❁

Recent Publications

Alexeev, V., Arp, C.D., Jones, B.M., and Cai, L., 2016, Arctic sea ice decline contributes to thinning lake ice trend in northern Alaska: Environmental Research Letters, v. 11. [**http://dx.doi.org/10.1088/1748-9326/11/7/074022**]

Baldwin, W.E., Foster, D.S., Pendleton, E.A., Barnhardt, W.A., Schwab, W.C., Andrews, B.D., and Ackerman, S.D., 2016, Shallow geology, sea-floor texture, and physiographic zones of Vineyard and western Nantucket Sounds, Massachusetts: Open-File Report Report 2016–1119. [**http://dx.doi.org/10.3133/ofr20161119**]

DeWitt, N.T., Fredericks, J.J., Flocks, J.G., Miselis, J.L., Locker, S.D., Kindinger, J.G., Bernier, J.C., Kelso, K.W., Reynolds, B.J., Wiese, D.S., and Browning, T., 2016, Archive of bathymetry and backscatter data collected in 2014 nearshore Breton and Gosier Islands, Breton National Wildlife Refuge, Louisiana: Data Series Report 1005. [**http://dx.doi.org/10.3133/ds1005**]

Felis, J.J., Kissling, M.L., Kaler, R.S.A., Kenney, L.A., and Lawonn, M.J., 2016, Identifying Kittlitz's Murrelet nesting habitat in North America at the landscape scale: Journal of Fish and Wildlife Management. [**http://dx.doi.org/10.3996/112015-JFWM-116**]

Fischbach, A.S., Kochnev, A.A., Garlich-Miller, J.L., and Jay, C.V., 2016, Pacific walrus coastal haulout database, 1852–2016— Background report: Open-File Report Report 2016-1108, 36 p. [**http://dx.doi.org/10.3133/ofr20161108**]

Flocks, J.G., and Terrano, J.F., 2016, Analysis of seafloor change at Breton Island, Gosier Shoals, and surrounding waters, 1869–2014, Breton National Wildlife Refuge, Louisiana: Open-File Report Report 2016–1069, 34 p. [**http://dx.doi.org/10.3133/ofr20161069**]

Hartman, C., Ackerman, J., and Herzog, M., 2016, Island characteristics within wetlands influence waterbird nest success and abundance: Journal of Wildlife Management, v. 80, p. 1177–1188. [**http://dx.doi.org/10.1002/jwmg.21120**]

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