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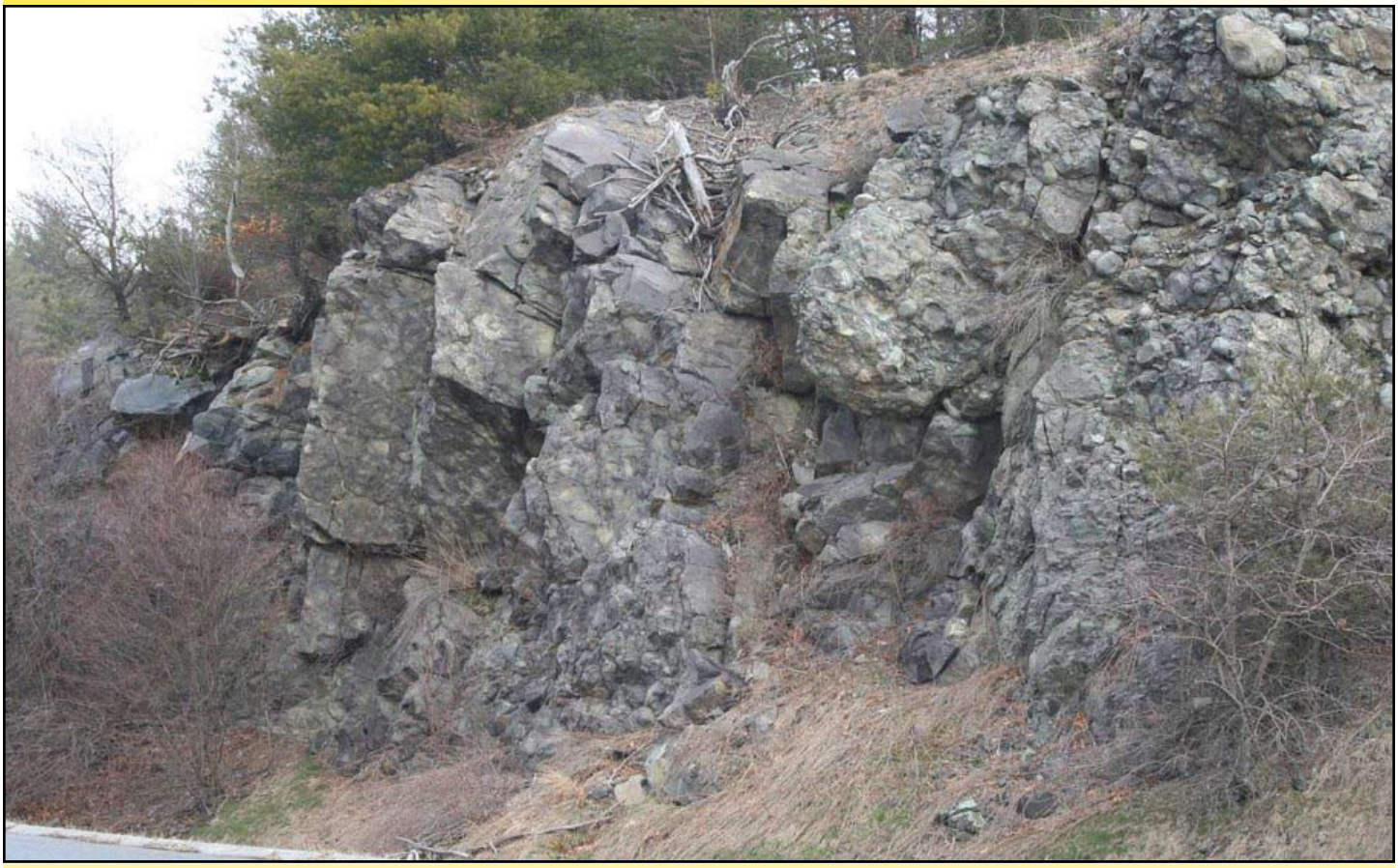

A photo of an outcrop of Roxbury Pudding Stone, taken by Tom Ervin on the NESTA Field Trip at the Boston NSTA. Puddingstone, or Pudding stone, is a conglomerate rock made up of a mixture of different, irregular sized grains and pebbles held together by a finer matrix, usually formed from quartz sand. The sedimentary rock is formed in river channels and may contain various minerals such as chromite, corundum, platinum, diamond, gold, sapphire, and zircon. Its name is said to derive from a resemblance to Christmas pudding. This type-rock is very common in the Boston Basin.

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Professional Development at the Center for Microbial Oceanography: Research and Education (C-MORE)

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Abstract

The *Center for Microbial Oceanography: Research and Education* (C-MORE) is a multi-institution science and technology program that conducts research and education in the field of microbial oceanography. C-MORE offers a variety of resources and programs for teachers, including online resources, participation on research cruises, professional development workshops, and mini-grants to encourage teachers to incorporate microbial oceanography into their curriculum.

Introduction

The *Center for Microbial Oceanography: Research and Education* (C-MORE) was established in 2006 by the National Science Foundation (NSF), which supports innovative, interdisciplinary research in critically important areas through its Science and Technology Center (STC) program. C-MORE is one of seventeen currently funded STCs.

Our overarching goal is captured in the C-MORE motto "From genomes to biomes," meaning that our research explores how microbial diversity at the genomic level influences the structure and function of the world's largest biome, the global ocean. C-MORE researchers seek to understand processes that begin at microscopic scales and ultimately are expressed in vitally significant, global environmental issues such as climate change. Areas of research range from genomic surveys, to studies of the genetic basis of marine microbial biogeochemistry, to ecosystem modeling. C-MORE research emphasizes integrative, interdisciplinary studies that truly range from the microscopic to global in scale.

C-MORE is comprised of six institutions that are leaders in the field of microbial oceanography: Massachusetts Institute of Technology, Monterey Bay Aquarium Research Institute, Oregon State University, University of California at Santa Cruz, Woods Hole Oceanographic Institution, and our headquarters, the University of Hawaii at Manoa. Research and education activities are conducted at all six C-MORE partner institutions.

The C-MORE education and outreach program is focused on increasing scientific literacy in microbial oceanography. Toward this end, C-MORE offers a variety of resources and professional development opportunities for K–12 teachers and informal science educators, including online resources, oceanography research

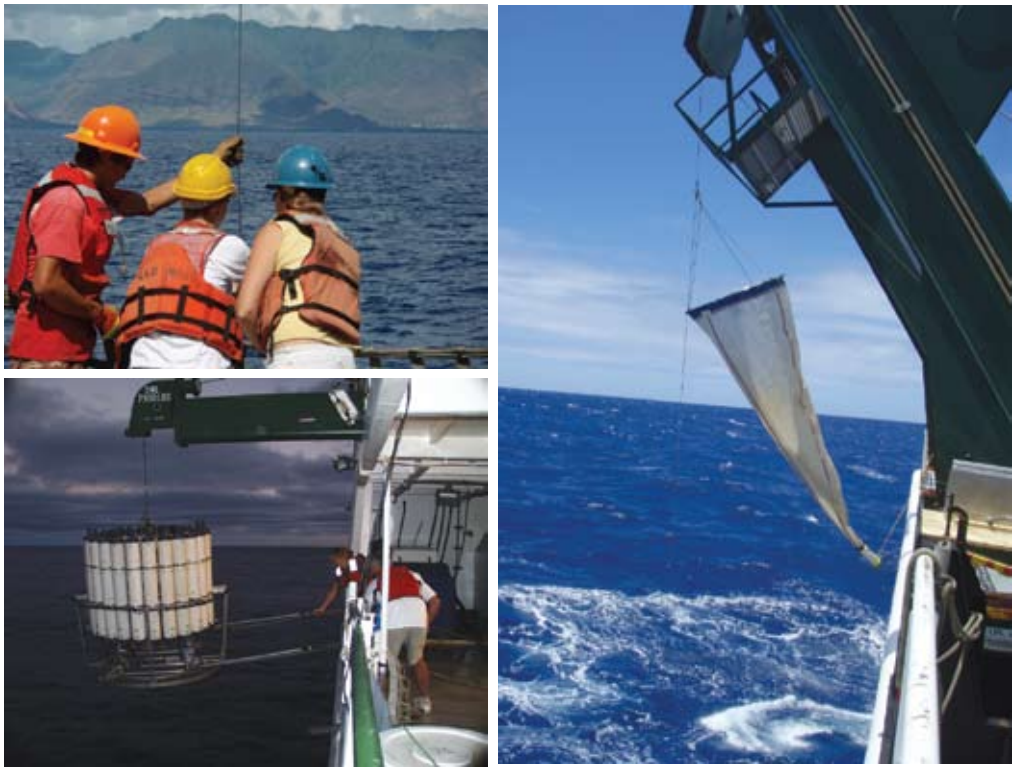

Figure 1: Teachers and scientists conduct research aboard HOT cruises through the C-MORE STARS program. Photos courtesy of S. Curless (top left), L. Sciaroni (bottom left), and HOT team (right).

cruises, teacher-training workshops, and mini-grants to incorporate microbial oceanography-related content and activities into their classroom.

Online Resources

C-MORE is currently updating our website to include a *Kids' Korner* and a *Teachers' Zone* to share online educational resources (cmore.soest.hawaii.edu; click on Education). One of our latest additions is an online Microbe Personality Quiz. In the *Kids' Korner*, students are asked a series of questions about their personality and, based on these answers, they are matched to a microbe. For example, when asked in which bunk bed do they prefer sleeping, students who answer "upper" are matched with marine microbes that are found in the upper water column. At the end of the quiz, kids learn about their microbial match. A complete teachers' guide to how the quiz works is found in the *Teachers' Zone*. The *Teachers' Zone* also includes other resources such as symbiosis cards, an oceanography jeopardy game, and a list of professional development opportunities, which are described below. Our website is actively being updated; please visit it often!

Science Teachers Aboard Research Ships (STARS)

In partnership with the Hawaii Ocean Time-series (HOT) program, C-MORE invites educators to participate in oceanography research aboard a four-day research cruise on the flagship research vessel, the *Kilo Moana*. Approximately once a month, HOT scientists visit a deep-water location in the central North Pacific Ocean called Station Aloha (100 km north of Oahu, Hawaii) to collect a series of physical, chemical, and biological data such as measurements of the ocean's currents, thermohaline structure, primary production, and water column chemistry. Since the program's launch in 1988, over 200 HOT research cruises have visited Station Aloha. By measuring these same variables in the same way, at the same location, for an extended period of time, HOT scientists have developed a comprehensive database that enables the detection of changes in these variables over time. Many important discoveries have been made, including the detection of a significant increase in carbon dioxide and a significant

decrease in pH levels during the past twenty years. These HOT data are publicly available at: hahana.soest.hawaii.edu/hot/hot.html

Teachers are invited to participate on select HOT research cruises (approximately every 3–4 months). Guided by a C-MORE scientist-educator, participating teachers work closely with scientists and actively engage in oceanography research. They conduct experiments, analyze samples, and interpret results. Teachers are also provided with pre-cruise and post-cruise activities for their students based on the HOT dataset. Applications for cruise participation are available on our web site (click on Education; then click on Opportunities for K–12 Teachers). Once on board, all expenses are covered. Teachers are required to cover transport to and from Oahu; see information below on how to obtain a GEMS grant to defray expenses.

Grants for Education in Microbial Science (GEMS)

Grants for Education in Microbial Science (GEMS) are currently being awarded to K–12 public school teachers to foster awareness in microbial science. Funds (up to $1000) may be requested for equipment, consumable supplies, substitute teacher compensation or travel expenses to enable the teacher to participate in shipboard or laboratory experiences, bus transportation for field trips, and other projects related to microbial science. Every grant requires a C-MORE advisor (such as a faculty member, postdoctoral associate or graduate student) from any of the six partner institutions. Advisors can play a variety of roles: for example, they can brainstorm with teachers to develop a project, give feedback on an existing project, or advise teachers on purchasing equipment and supplies.

For more information on GEMS, please visit our website (click on Education; then click on Opportunities for K–12 Teachers). Here, you will be able to read reports of completed GEMS projects to get project ideas, view a video of a GEMS project at one of Hawaii's elementary schools, and download an application form. To find a potential advisor, go to the "C-MORE Team" section of our website and please feel free to contact that person directly.

Professional Development Workshops & Short Courses

C-MORE offers professional development workshops and short courses to introduce K–12 science educators to the latest science concepts, laboratory methods, and technology in the field of microbial oceanography. Formats vary, and often include a laboratory or shipboard component. We intend to offer workshops at all C-MORE partner institutions on a rotating basis. During Spring 2008, C-MORE is offering a six-week short course at the University of Hawaii at Manoa for local Hawaii teachers. This course is a comprehensive training program for teachers to incorporate microbial oceanography into their curricula. Teachers receive classroom and laboratory instruction, classroom-ready materials and activities, and access to C-MORE research equipment for use with their own students following successful course completion.

In Summer 2008, C-MORE and the Monterey Bay Aquarium Research Institute (MBARI) are jointly sponsoring a weeklong national workshop on microbial oceanography to be held at C-MORE partner institution Oregon State University. This workshop is offered through the Education And Research: Testing Hypothesis (EARTH) program, which is coordinated at MBARI. EARTH uses near-real-time data from ocean observatories to design and test outreach with the Internet as an interface to scientists, teachers, students, and the public. During EARTH workshops, educators, scientists, and engineers work together to develop effective educational practices for access and use of near-real-time data. Teachers from across the nation apply to attend EARTH workshops. Once accepted, all of their expenses are covered, including airfare, food

and lodging. Additionally, teachers are paid a stipend of $100/day to compensate them for their time. Please see www.mbari.org/earth for more information on this and future EARTH workshops.

Diversity

C-MORE is committed to broadening participation in the ocean sciences, including establishing educational and career paths for students from under-represented groups. We are actively seeking to engage educators who teach students from under-represented groups in all of our professional development activities.

Online References

Center for Microbial Oceanography: Research and Education (C-MORE), http://cmore.soest.hawaii.edu

Education And Research: Testing Hypothesis (EARTH), http://www.mbari.org/earth/

Hawaii Ocean Time-series, http://hahana.soest.hawaii.edu/hot/hot.html

For more information, please contact Dr. Barbara Bruno, C-MORE Education Coordinator, at barb@hawaii.edu.

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Ancient shallow sea ripples in bed at Dinosaur Ridge (near Morrison), Colorado. This formation is uplifted, and includes impressive dinosaur tracks. Photographed by Roberta Johnson, August 3, 2001.

Modern ripples in the sand near the stream at the Great Sand Dunes, Colorado. Photographed on July 2, 2002 by Roberta Johnson.