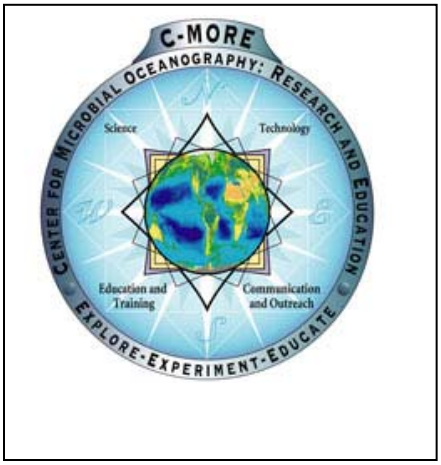
C-MORE Highlights 2007

Award No: CCF-0424599	
Project Title: Center for Microbial Oceanography: Research and Education (C-MORE)	
Investigators: David Karl, Sallie Chisholm, Edward DeLong, Jonathan Zehr	
Institution: University of Hawaii, Lead Partner Massachusetts Institute of Technology Marine Advanced Technology Education (MATE) Center at Monterey Peninsula College Oregon State University University of California at Santa Cruz Woods Hole Oceanographic Institution Monterey Bay Aquarium Research Institute	
Website: http://cmore.soest.hawaii.edu/	**Description of Graphic Image:** The C-MORE logo represents its mission to foster the integration of science discovery, technological advancement, and communication of knowledge through education and outreach.

Project Description and Outcome

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Mincer T. J., Church, M, J., Taylor, L. T., Preston, C. M., Karl, D. M., and DeLong, E. F. 2007. *Quantitative distribution of presumptive archaeal and bacterial nitrifiers in Monterey Bay and the North Pacific Subtropical Gyre*. Environ. Microbiol., In press.

This publication represents a team effort between groups at MIT and Univ. of Hawaii. It is now recognized that a subgroup of Archaea, the Crenarchaea, are major members of planktonic microbial populations from just below the photic zone to the abyss, and that these Crenarchaea may be involved in the oxidation of ammonia to nitrite, a process known as nitrification, and a major flux point in nitrogen cycling in the sea. This collaborative study identified and quantified distributional patterns of crenarchaeal nitrifiers in both coastal and open ocean habitats, and identified likely bacterial participants in the oxidation of nitrite to nitrate. Correlating and quantifying of the proper organisms with specific biogeochemical transformations represents a first step towards a more realistic modeling of ecosystem processes in the sea – one of CMORE's overarching goals.

McCarren, J. and E. F. DeLong. 2007. *Proteorhodopsin photosystem gene clusters exhibit co-evolutionary trends and shared ancestry among diverse marine microbial phyla*. Environ. Microbiol., doi: 10.1111/j.1462-2920.2006.01203.x

A. Martinez A. S. Bradley, J. Waldbauer, R. E. Summons and E. F. DeLong.. 2007. *Proteorhodopsin Photosystem Gene Expression Enables Photophosphorylation In A Heterologous Host*. PNAS, in press.

New photoheterotrophic processes, based on either bacteriochlorophyll or rhodopsin photosystems, have recently been recognized to be more prevalent in marine plankton than was originally supposed. These papers examine the distribution of nitrifiers and elucidate the mechanisms governing the evolution and distribution of proteorhodopsin- based photoheterotrophy. These two publications, again enabled by the CMORE infrastructure and collaborative ties, demonstrate the dynamics of proteorhodopsin lateral gene mobility and function in marine planktonic Archaea and Bacteria. McCarren and DeLong show that the genes for the chromophore retinal are linked to proteorhodopsin in disparate microbial lineages, and the photosystem as a whole exhibits extensive lateral mobility. Martinez et al. show that the whole photosystem, when transferred in a single generic event, confers upon the recipient the ability to generate ATP from light energy. Together, these data strongly suggest it is a small evolutionary step from heterotrophy to proteorhodopsin- based photoheterotrophy.

Recently, a new recognition of the importance of previously overlooked groups of microbes, and previously unknown processes, has transformed our understanding of marine ecosystems. These publications represent significant breakthroughs in the current state of knowledge regarding the distribution and mechanisms controlling nitrification and photoheterotrophy in the oceans.

These publications are both transformative and multidisciplinary. The role of Crenarchaota in nitrification, and the potential role of proteorhodopsin-based photoheterotrophy, are only beginning to be appreciated and understood. These ground-breaking papers will have a major impact on continued research in this field, and will materially enhance our ability to model these processes appropriately.

Managing Program Officer: Matthew D. Kane

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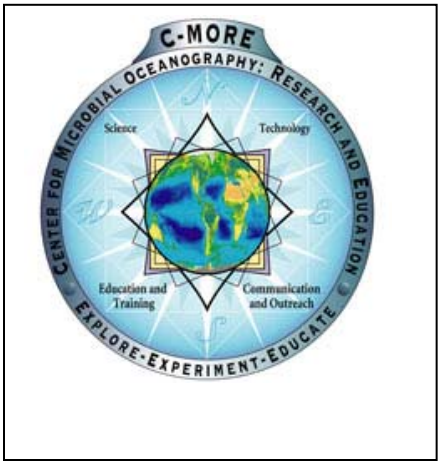
Institution: University of Hawaii, Lead Partner Massachusetts Institute of Technology Marine Advanced Technology Education (MATE) Center at Monterey Peninsula College Oregon State University University of California at Santa Cruz Woods Hole Oceanographic Institution Monterey Bay Aquarium Research Institute	
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CMORE leverages Moore Foundation funded cyberinfrastructure for archiving sequence data and metadata

With encouragement from both NSF and the Moore Foundation, CMORE is teaming with CAMERA (Community Cyberinfrastructure for Advanced Microbial Ecology Research and Analysis), to archive its sequence datasets and their associated metadata. In the beta release (0.7) of CAMERA, CMORE's first prototypical sequence dataset has been released, along with associated environmental metadata and publications. We hope and expect this collaboration to be ongoing as new approaches for serving and analyzing metagenomic datasets evolve. We plan on using CAMERA as the main venue for distributing and communicating CMORE metagenomic data. CMORE's Research Director Edward DeLong serves on the Scientific Advisory Board of CAMERA, facilitating this close interaction.

CAMERA Website: http://cameradev.calit2.net/

C-MORE provides new underway monitoring capability for R/V *Kilo Moana*

Under the direction of C-MORE investigator Z. Kolber, C-MORE has completed construction of a benchtop Fast Repetition Rate fluorometer. The instrument is currently being delivered to the *Kilo Moana*, and will be installed onboard the vessel in March 2007. The FRR fluorometer measures a suite of photosynthetic properties of phytoplankton, such as the efficiency of photosynthetic light utilization, the quantum yield of charge separation, and the kinetics of photosynthetic electron transport. It will be operated continuously, in the flow-through mode, mapping the photosynthetic characteristics of phytoplankton and anoxygenic photosynthetic bacteria along the ship cruise track. The instrument can also process discrete water samples from CTD rosette. We intend to operate this instrument *continuously, over the period of the next 10 years*. In addition to C-MORE activities, the instrument will be available to any scientific party on the *Kilo Moana* under the condition that the acquired data will be shared.

C-MORE is committed to building and supporting new research infrastructure and capabilities. These activities are just two examples of C-MORE efforts to provide new abilities to study and monitor microbially-dominated, globally significant ecosystem processes. CAMERA will dramatically increase the capacity for metagenomic analyses of sequence data within their environmental contexts, and C-MORE will be among the largest contributors to both sequence and contextual. Long-term continuous monitoring of fundamental processes such as photosynthesis will provide the vitally important environmental context for understanding the incoming flood of molecular data.

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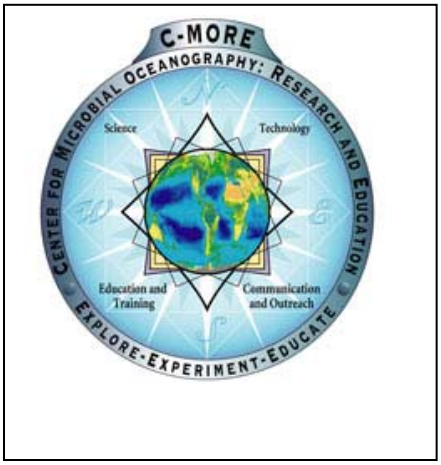
Institution: University of Hawaii, Lead Partner Massachusetts Institute of Technology Marine Advanced Technology Education (MATE) Center at Monterey Peninsula College Oregon State University University of California at Santa Cruz Woods Hole Oceanographic Institution Monterey Bay Aquarium Research Institute	
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CMORE "podcast"

CMORE's Research Director Edward DeLong recently participated in an hour long podcast (a "Futures in Biotechnology" podcast series) detailing the importance of the marine microbial world, microbial diversity, metagenomics, and the general CMORE effort. Podcasts are an increasingly useful outreach medium, and we plan to utilize this format more in the future to highlight CMORE research and education issues.

Podcast Website: http://futuresinbiotech.blogspot.com/2006/11/fib-episode-009-ed-delong-on.html

C-MORE initiates Grants for Education in Microbial Science (GEMS)

GEMS are small, but high-impact grants of up to $1000 per project, awarded to educators at the K-12 level who wish to develop an activity closely related to Microbial Oceanography, with the active help and involvement of a University of Hawaii researcher. These grants are intended both to enable teachers on limited budgets to create such educational activities, and also to entrain (and train) academic researchers in public education and outreach. This program is under the direction of C-MORE Education Coordinator Barbara Bruno.

C-MORE initiates Teachers-at-Sea Program

Under the direction of Education Coordinator Barbara Bruno, C-MORE has initiated a program that will allow in-service K-12 teachers to participate in monthly research cruises. These educators will be encouraged to translate their seagoing experience into educational modules for their classrooms, on the topic of Microbial Oceanography. We intend to develop the capacity for educators to broadcast a classroom lesson from the ship back to their on-shore classroom for a Virtual Classroom-at-Sea experience, with C-MORE researchers actively participating in the broadcast.

C-MORE supports Career-Oriented Education to Address Underrepresentation of Native Hawaiians and Pacific Islanders in Oceanography

C-MORE's education office is working to increase diversity among under-represented groups, particularly Native Hawaiians and Pacific Islanders (NHPI), and has established a strong, working partnership with Ka Imi Ike. Ka Imi Ike, an NSF funded project, seeks to create pathways for NHPI students by linking science with culture and community, providing scholarships and internship opportunities, and linking students with career opportunities in their discipline. C-MORE is working with Ka Imi Ike on providing career resources, overnight culture-science immersions for undergraduates on Coconut Island, laboratory internships and shipboard experiences. This effort is being co-led by C-MORE education coordinator Barbara Bruno and Ka Imi Ike coordinator Noelani Puniwai, both of the University of Hawaii.