

Microbial Processes at Ocean Station ALOHA

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2015 Balzan Prize for Oceanography

Balzan GPC Advisers: Enric Banda, Charles Godfray

Researchers: Sara Ferrón, Benedetto Barone

Affiliated Institutions: Ocean Station ALOHA (A Long-term Oligotrophic Habitat Assessment)

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Ocean Station ALOHA (A Long-term Oligotrophic Habitat Assessment) is a novel oceanographic research site located approximately 100 km north of Oahu, Hawaii, in the North Pacific Subtropical Gyre, one of Earth's largest habitats. On approximately monthly intervals since October 1988, interdisciplinary teams of scientists from institutions worldwide have studied the biology, physiology and ecology of microorganisms, from genomes to biomes. Research at Ocean Station ALOHA has helped to define the new and exciting discipline of Microbial Oceanography. The numerous scientific discoveries from Ocean Station ALOHA, including novel microorganisms, unprecedented metabolic pathways and complex interactions, have transformed our understanding of microbial life in the sea. The uncertain nature of future climate change and the potential impacts on the structure and function of marine ecosystems demand a comprehensive description and understanding of the sea around us. Sustained research of marine microbes is vital, so continued field observations and experimentation at Ocean Station ALOHA is both timely and important.

Since the start of the Balzan Prize Research Project *Microbial Processes at Ocean Station ALOHA*, significant progress has been made toward the stated project goals. First, in line with the general aims of the field of microbial oceanography, the project

aims to observe and understand microbial life in the sea well enough to make accurate ecological predictions, for example, of the impact of climate variability on microbial processes in the global ocean. At the same time, the project will also provide novel opportunities to move the field forward by using the new observational and analytical techniques, in part developed or refined in David Karl's laboratory over the past two decades. Two early career scientists, Drs. Benedetto Barone and Sara Ferrón, have been collaborating on several aspects of laboratory-based methods development and at-sea observations and experimentation. More importantly, a comprehensive effort in data synthesis and interpretation has led to the publication of several important scientific papers (below) and new knowledge has been created and disseminated. Several additional research papers are in various stages of completion.

Benedetto Barone, the inaugural recipient of the Balzan Research Fellowship at the University of Hawaii, has continued his investigations of the use of autonomous underwater vehicles to measure the variability of microbial processes in the sea. A manuscript on this important topic has been favourably reviewed and is currently being revised for publication in the *Journal of Geophysical Research – Oceans* (see citation below). Barone gave a preliminary presentation at the International Aquatic Sciences meeting in Honolulu, HI, USA in March 2017. Barone was also selected to lead a major research expedition to investigate the ecological and biogeochemical consequences of mesoscale eddies. This international expedition is funded primarily by the Simons Foundation with partial support from the U.S. National Science Foundation and David Karl's Balzan Prize. Barone and Ferrón, funded by the 2015 Balzan Prize in Oceanography, will be among the complement of 23 international scientists and technicians.

Sara Ferrón, a research associate at the University of Hawaii, is partially (50%) supported by the Balzan research award. She has become an invaluable member of the team and has already made major contributions to the project. Last year, she developed a novel approach to measure gross primary production (GPP) using a shipboard membrane inlet mass spectrometer (see citation below, Ferrón et al. 2016). Since that time, she has amassed the largest data set ever on GPP at Station ALOHA, and will soon submit a manuscript describing this novel time-series. She has also been active in several other relevant research projects including, but not limited to, experimental determination of bacterial respiration, measurements of the concentrations of methane and nitrous oxide (two potent greenhouse gases) in seawater, and studies of hydrocarbon gas production during the decomposition of commercial plastics.

Manuscripts published or submitted

- Ferrón, S., del Valle, D. A., Børkman, K. M., Quay, P. D., Church, M. J., Karl, D. M. (2016). Application of membrane inlet mass spectrometry to measure aquatic gross primary production by the ^{18}O in vitro method. *Limnology and Oceanography: Methods* 14: 610-622, doi: 10.1002/lom3.10116.
- Karl, D. M. and Church, M. J. (2017). Ecosystem structure and dynamics in the North Pacific Subtropical Gyre: New views of an old ocean. *Ecosystems* 20: 433-457, doi: 10.1007/s10021-017-0117-0.
- Karl, D. M. and Grabowski, E. (2017). The importance of H in particulate matter stoichiometry, export and energy flow. *Frontiers in Microbiology* 8: article 826, doi: 10.3389/fmicb.2017.00826.
- Letelier, R. M., White, A. E., Bidigare, R. R., Barone, B., Church, M. J. and Karl, D. M. (2017). Light absorption by phytoplankton in the North Pacific subtropical gyre. *Limnology and Oceanography*, doi: 10.1002/lno.10515.
- Wilson, S. T., Aylward, F. O., Ribalet, F., Barone, B., Casey, J. R., Connell, P. E., Eppley, J. A., Ferrón, S., Romano, A. E., Rurk-Kubo, K. A., Vislova, A., Armbrust, V., Caron, D. A., Church, M. J., Zehr, J. P., Karl, D. M., DeLong, E. F. (2017). Coordinated regulation of growth activity and transcription in natural populations of the unicellular nitrogen-fixing cyanobacterium *Crocospaera*. *Nature Microbiology*, 2 (9):171118. DOI: 10.1038/nmicrobiol.2017.118.
- Wilson, S. T., Ferrón, S., Karl, D. M. (2017). Interannual variability of methane and nitrous oxide in the the North Pacific Subtropical Gyre. *Geophysical Research Letters*. 44 (19). September 2017. DOI: 10.1002/2017GL074458.
- Sosa, O. A., Repeta, D. J., Ferrón, S., Bryant, J. A., Mende, D. R., Karl, D. M., DeLong, E. F. (2017). Isolation and characterization of bacteria that degrade phosphonates in marine dissolved organic matter. Submitted to *Frontiers in Microbiology*. 8(2017):1786. DOI: 10.3389/fmicb.2017.01786.
- Barone, B., Nicholson, D. P., Natarov, A., Soares, S. M., Richards, K. J. and Karl, D. M. Mesoscale eddy structure and horizontal biogeochemical variability from autonomous observations in the North Pacific Subtropical Gyre. Submitted to *Journal of Geophysical Research: Oceans*.

Presentations or published abstracts

- Barone, B., Nicholson, D. P., Karl, D. M. Mesoscale eddy structure and horizontal biogeochemical variability from autonomous observations in the North Pacific

- Subtropical Gyre. ASLO Aquatic Sciences Meeting (040), Honolulu, HI, February-March 2017.
- Björkman, K. M., Duhamel, S., Church, M. J., Karl, D. M. Spatial and temporal variability in phosphorus inventories and turnover of inorganic P and adenosine-triphosphate in the North Pacific. ASLO Aquatic Sciences Meeting (040), Honolulu, HI, February-March 2017.
- Curless, S. E., Church, M. J., Segura-Noguera, M., Karl, D. K. Ammonium concentrations at Station ALOHA - Improved methodology allows for full ocean depth analysis. ASLO Aquatic Sciences Meeting (040), Honolulu, HI, February-March 2017.
- Ferrón, S., Barone, B., Church, M. J., Karl, D. M. Biological oxygen production in the North Pacific Subtropical Gyre. ASLO Aquatic Sciences Meeting (040), Honolulu, HI, February-March 2017.
- Foreman, R. K., Karl, D. M. Advancing a new method for the direct determination of dissolved organic nitrogen (DON) in seawater. ASLO Aquatic Sciences Meeting (012), Honolulu, HI, February-March 2017.
- Grabowski, E. M., Karl, D. M. Caloric content of Sinking particulate matter in the North Pacific Subtropical Gyre. ASLO Aquatic Sciences Meeting (040), Honolulu, HI, February-March 2017.
- Karl, D. M. Station ALOHA: A gathering place for discovery, education and scientific collaboration. ASLO Aquatic Sciences Meeting plenary presentation. Honolulu, HI, February-March 2017.
- Royer, S. J., Ferrón, S., Wilson, S. T., del Valle, D. A., Sosa, O., Karl, D. M. Methane production from sinking particulate matter at Station ALOHA. ASLO Aquatic Sciences Meeting (040), Honolulu, HI, February-March 2017.
- Sadler, D. W., Barone, B., Burkitt, J. W., Dore, J. E., Church, M. J., Karl, D. M. High-resolution in-situ pH measurements at Station ALOHA using an ion-sensitive field effect transistor. ASLO Aquatic Sciences Meeting (040), Honolulu, HI, February-March 2017.
- Sosa, O. A., Ferrón, S., DeLong, E. F., Repeta, D. J., Karl, D. M. Degradation of dissolved organic phosphorus by heterotrophic bacteria in the oligotrophic ocean. ASLO Aquatic Sciences Meeting (003), Honolulu, HI, February-March 2017.
- Wilson, S. T., Ferrón, S., Karl, D. M. Seasonal and interannual concentrations of methane and nitrous oxide in the surface waters of the oligotrophic North Pacific Subtropical Gyre from 2008-2016. ASLO Aquatic Sciences Meeting (036), Honolulu, HI, February-March 2017.