SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY

Press Release

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Complex ocean behavior studied with 'artificial upwelling'

Honolulu, HI – A team of scientists is studying the complex ocean upwelling process by mimicking nature – pumping cold, nutrient-rich water from deep within the Pacific Ocean and releasing it into surface waters near Hawaii that lack the nitrogen and phosphorus necessary to support high biological production.

The researchers are harnessing the power of the ocean to conduct their experiments, using the up-and-down motion of waves to pump deep water to the surface. Their next step is to create a pump that can withstand the rigors of the rugged Pacific and then see if the biology follows the physics.

The design of this experiment is based on the results of an ongoing 20-year study at Station Aloha, which looks at the variability of the biology, chemistry and physics of the ocean. The theory behind the experiment has just been published in the journal, Marine Ecology Progress Series. The initial test of the pumps and their effect in the open ocean is the focus of a documentary that is scheduled to be broadcast September 5th on the Discovery Channel.

This experiment was funded in part by the National Science Foundation and the Gordon and Betty Moore Foundation. Angelicque "Angel" White, a post-doctoral researcher at Oregon State University (OSU) and a member of the scientific team, and lead investigators Ricardo Letelier of OSU and David Karl of the University of Hawaii are part of the NSF-funded Center for Microbial Oceanography: Research and Education (C-MORE) based in Hawaii, which Karl directs.

Deployment of the single pump off the back deck of the R/V Kilo Moana.
Photo: Karin Bjorkman, SOEST

“Microbially based ocean ecosystems, like those in the central gyre off Hawaii, are dynamic and unpredictable”, says Karl. “They are the key to Earth’s habitability, yet we still don’t understand how they are structured or maintained.” The scientists stress that the goal of creating artificially induced upwelling is to understand how marine microbial ecosystems respond to large-scale perturbations, "a critical step if we want to understand the risks of manipulating these large ecosystems in order to solve global greenhouse buildup," said Letelier, a professor in OSU's College of Oceanic and Atmospheric Sciences.

"This is not a new concept," Letelier said. But Karl adds, “It has never been tested in the open ocean.” Letelier continues. "It was proposed in 1976 that scientists could use wave energy to pump water from the depths to the surface and fuel plankton growth. But there are many nuances; simply bringing nutrients to the surface can result in the wrong kinds of biological growth. It also can bring water enriched with carbon dioxide, which can de-gas into the atmosphere.
"If you're adding more CO_2 than subtracting by fertilizing the ocean," Letelier added, "you're running the wheel in the wrong direction."

“The key to understanding ocean carbon sequestration goes beyond carbon dioxide and must include the inorganic nutrients that also sustain life”, Karl said. “It is the ratio of carbon to nitrogen to phosphorus in the environment of interest that will ultimately determine whether carbon dioxide from seawater is released to the atmosphere or incorporated into organic matter. Some of the incorporated carbon dioxide has the ability to sink to the deep portions of the world’s oceans for long periods of time before it reenters the atmosphere. This is called long term carbon sequestration.”

David Karl and Eric Grabowski, standing in front of the R/V Kilo Moana. Photo:Robert Chinn

Their studies at Station Aloha have shown, however, that water at a depth of 300 to 700 meters has the proper ratio of nitrogen and phosphorus to trigger a two-stage phytoplankton bloom. The researchers believe that upwelling with water from that depth will first cause a bloom of diatoms, which are a common type of plankton – often single-celled. The diatoms will consume the nitrogen, leaving some amount of phosphorus in the water, which will stimulate a second-stage bloom of nitrogen-fixing cyanobacteria. These blooms are often observed during summer months at Station Aloha in open ocean waters, Letelier said. Karl adds that the “formation of open ocean blooms has become a major focus of the Hawaii Ocean Timeseries (HOT) program and C-MORE, which is why this artificial upwelling experiment has become so fundamental to our understanding of open ocean dynamics.”

In previous field experiments, conducted by graduate students of the University of Hawaii at Manoa, the researchers were able to create stage-one diatom blooms by mixing deep and surface water in large incubation bottles, but they need to conduct additional studies in the ocean to see if the second stage of blooms actually occurs following additions of deep water. The dynamics of stage one and stage two blooms was the major focus of the artificial upwelling experiment, coined OPPEX-1 for the Ocean Productivity Perturbation Experiment.

"We were able to pump about 50 cubic meters of water per hour using the wave energy," White said, "which is a small amount compared to the vastness of the ocean. If we want to generate a bloom in an area of one-square kilometer, we would need to replace about 10 percent of the surface waters with upwelled water, which would take about a month at the rate we pumped."

The scientists used undersea gliders in their Hawaii study to monitor the water from the pump so they have an idea how widely and quickly it disperses, and how much of an impact it can have on surface waters. “These gliders have the ability to survey the ocean remotely and broadcast their information back to the home base laboratories in Hawaii and Oregon”, says Karl.

"We know a lot about how upwelling works and the physics of the ocean," Letelier said, "but there also are things we don't know, which is why this study is so important. In this open ocean area near Hawaii, for example, phytoplankton blooms occur in the summer when there are almost no nutrients at the surface and the winds generally are calm. What triggers the blooms and where are the nutrients coming from? We need to know.”

"These vast, seemingly barren regions comprise more than two-thirds of our oceans and nearly 40 percent of the entire Earth," he added. "It is a large area of exchange between the atmosphere and the ocean and understanding large-scale interactions is critical to understanding climate change."

The researchers believe they can control plankton growth by determining which species respond to specific nutrients, and then adjusting the rate of nutrient feeding by the frequency and duration of water pumping.
"These vast regions of the open ocean may be perfect for sequestering carbon," Letelier said, "but before we can begin to seriously consider a large-scale intervention, we must better understand how the biology responds by using perturbations on a small scale. We're getting there."

“In promoting natural seascape engineering projects, like artificial upwelling, to enhance the efficiency for the ocean’s biological carbon pump, one must always be vigilant of unintended consequences, such as harmful algae blooms, or the production of nitrous oxide and toxins,” says Karl.”However, human induced climate change is already having measurable climate consequences that need to be addressed by the scientific community. Sitting idle, or criticizing those who do take a position on geo-engineering are not good options in my opinion. For this reason, understanding ecosystem response to artificial upwelling is important for our general understanding of marine ecosystems and their protection.”

Press release written by Mark Floyd (Oregon State University), with additional information by Tara Hicks Johnson.
For more information on this cruise, see the OPPEX-1 web site http://hahana.soest.hawaii.edu/oppex/index.html

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