The Role of Symbiotic Bacteria in Iron Acquisition and Algal Bloom Formation

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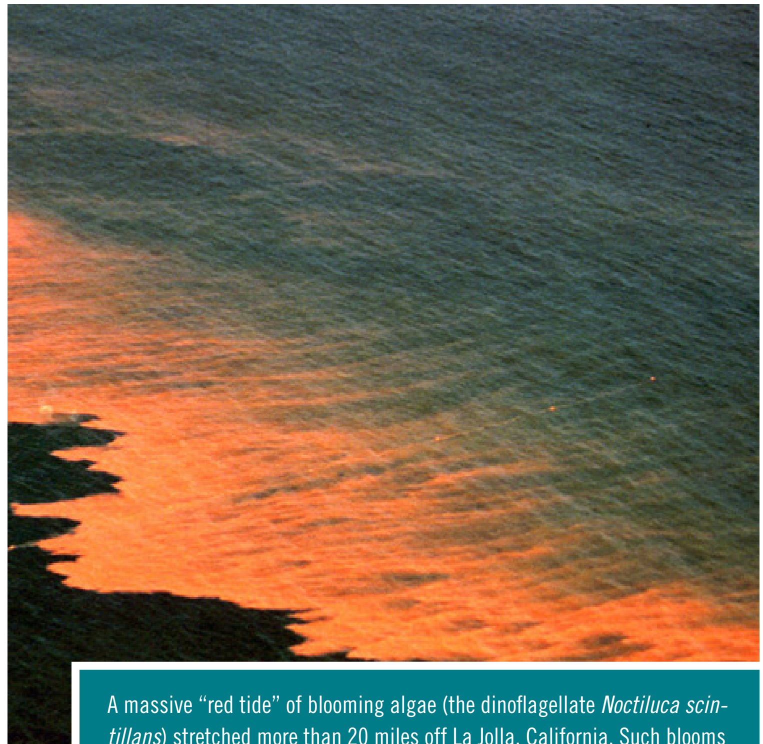
SUMMARY

Certain kinds of bacteria produce iron-binding compounds (siderophores) that may help algae obtain bioavailable forms of iron under conditions when soluble forms of the micronutrient are in low supply and limiting algal growth, scientists leading this project say. In this way, siderophore production may contribute to patterns of primary productivity and, by extension, harmful algal bloom (HAB) formation.

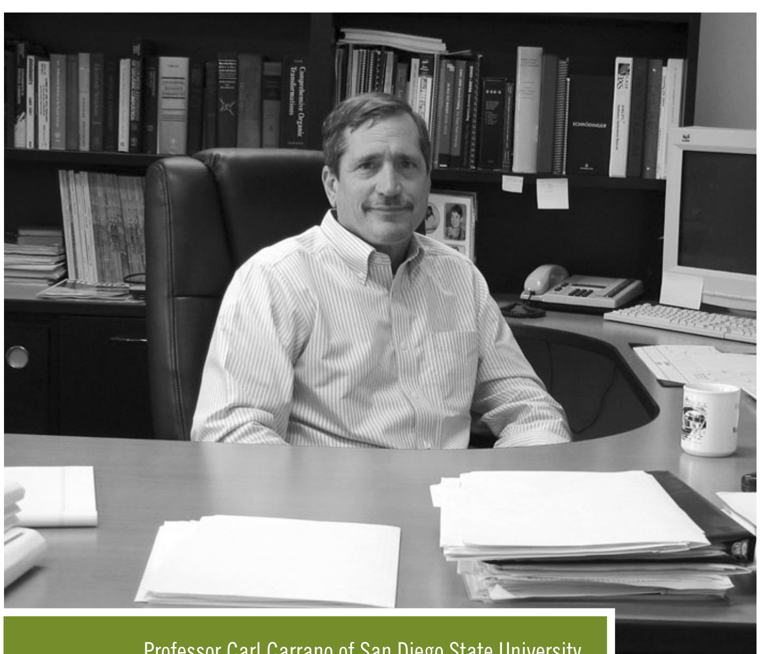
This project seeks to characterize the structure and chemistry of siderophores produced by bacteria associated with bloom-forming dinoflagellates. (Dinoflagellates are a type of algae that swim by whipping tail-like structures known as flagella.) Results illuminate the processes and conditions that may precondition areas for certain kinds of sudden, heavy algal growth and can be used to improve HAB forecasts.



A massive "red tide" of blooming algae (the dinoflagellate *Noctiluca scintillans*) stretched more than 20 miles off La Jolla, California. Such blooms can have devastating effects on human health, coastal economies and marine ecosystems. Algal blooms occur naturally but have become more common in recent years. Image: P. Franks/SIO

PROJECT

There were three parts to this project. In the first, scientists isolated and then characterized siderophores produced by bacteria symbiotic with dinoflagellates (e.g., *Gymnodinium catenatum*) that produce the toxins associated with Paralytic Shellfish Poisoning. The second phase involved testing whether these siderophores supply iron to algae, and whether the algae utilize this iron for growth. In the third, scientists collected water samples from the North Atlantic Ocean and coastal waters off Scotland, where HABs are a problem for the shellfish industry. Bacterial DNA was then extracted from the samples and probed for the genes that code for siderophore production.



Professor Carl Carrano of San Diego State University.
Image: SDSU

RESULTS

All the bacteria studied for this project produced the same siderophore, vibrioferrin (VF), so-named because it was originally isolated from *Vibrio parahaemolyticus*, another shellfish pathogen.

VF was shown to bind weakly to iron and to break down rapidly in the presence of sunlight (10 to 20 times faster than siderophores produced by bacteria not associated with the dinoflagellates).

The byproducts of photolysis include an iron complex that in seawater is oxidized to a transiently soluble iron product, which appears to be rapidly absorbed by both algae and bacteria.

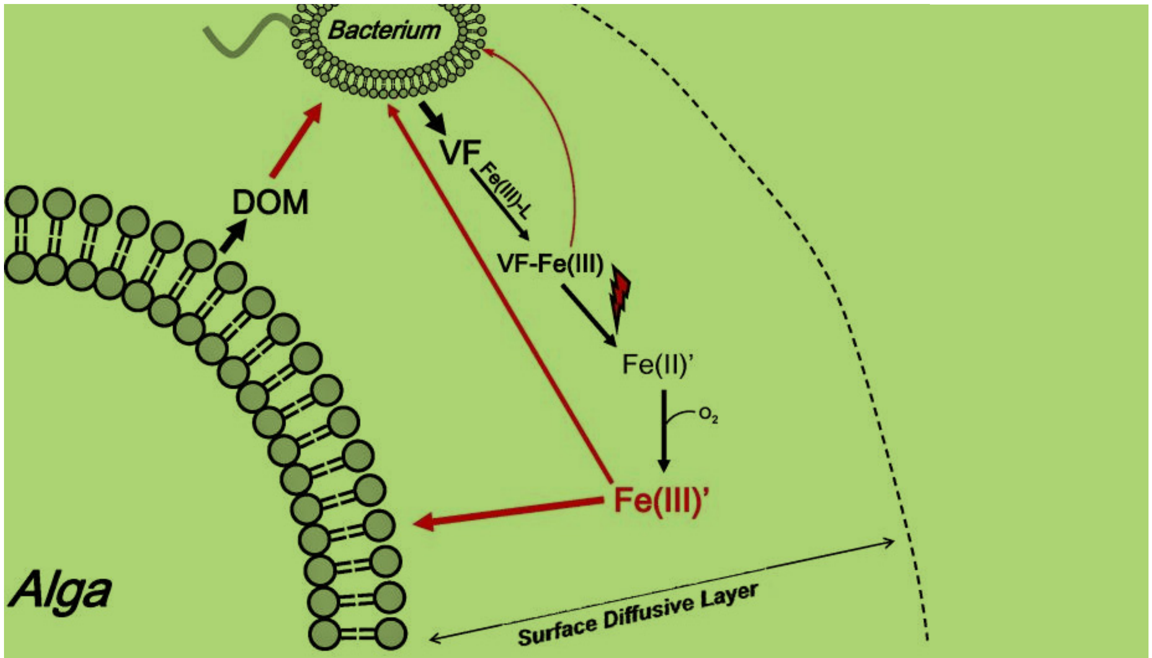
In terms of defining the symbiosis between the bacteria and algae, the theory is that the bacteria provide algae with bioavailable forms of iron, and, in exchange, algae release sugars, amino acids and lipids, upon which bacteria feed.

The fieldwork shows that the genes coding for VF production are common in the North Atlantic Ocean and off Scotland, meaning that the biochemical potential for siderophore production exists in these areas.

In the next phase of the project, scientists will look for the same genes (aka siderophore-producing bacteria) in areas of the world ocean with low productivity and low levels of soluble iron.

APPLICATION

Findings from this project suggest that the presence of siderophore-producing bacteria may provide an early warning of potential algal blooms. Such information is suited for inclusion in HAB forecasting models under development in California. Findings also shed light on the potential and largely overlooked importance of the microbial ocean in driving primary productivity and hence the marine food chain.



A bacterium produces the siderophore vibrioferrin (VF), which binds to iron (Fe). Exposed to light, the iron-VF complex degrades, creating a form of iron usable to the alga. The bacterium is rewarded with food – dissolved organic material (DOM) leaked from the alga. It is believed that natural selection has shaped this carbon-for-iron mutualism. Image: C. Carrano/SDSU

PROCEEDINGS

Amin, Shady A., David H. Green, Mark C. Hart, Frithjof C. Küpper, and Carl J. Carrano. The role of symbiotic bacterial siderophores in promoting marine algal blooms. ASLO Ocean Sciences Meeting, 2008.

Shady A. Amin, Carl J. Carrano, Ariel Romano, Lyndsay Trimble, and David Green. Abundance of a biosynthetic gene of the photoactive siderophore vibrioferrin in the North Atlantic and implications on algal growth. California and the World Ocean, 2010.

PUBLICATIONS

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This publication is based on research project R/CZ-198 and R/CONT-205 and is sponsored by NOAA Sea Grant, U.S. Department of Commerce, under grant NA10OAR4170060, project C/P-1. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its sub-agencies. The U.S. government is authorized to reproduce and distribute for governmental purposes. This document is available in PDF on the California Sea Grant website: csgc.ucsd.edu. California Sea Grant, Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Drive, Dept. 0232, La Jolla, CA 92093-0232 Communications Phone: 858-534-4446