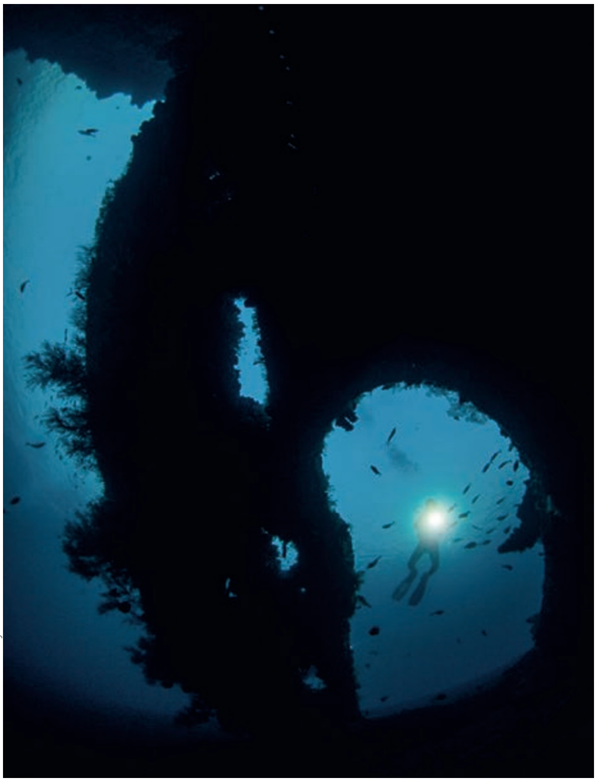
Nature Reviews Microbiology | Published online 11 Dec 2017; doi:10.1038/nrmicro.2017.165

MARINE MICROBIOLOGY

Illuminating the importance of nitrite oxidation

Most of the ocean is too dark to support photosynthesis and, instead, is populated by chemoautotrophic microorganisms. Ammonium-oxidizing members of the Thaumarchaeota phylum and sulfur-oxidizing bacteria have been implicated in the fixation of inorganic carbon; however, the main primary producers and their metabolic functions in the dark ocean remain unknown. Pachiadaki *et al.* now show that members of the Nitrospinae phylum use the energy provided by nitrite oxidation to assimilate bicarbonate and that this function is vital for dark-ocean carbon fixation.



Shahar Shabtai/Alamy Stock Photo

So far, most of the information about marine nitrite-oxidizing bacteria has come from a few cultured isolates. To get a comprehensive picture of the ecology and function of nitrite-oxidizing bacteria, the authors screened 3,463 single amplified genomes (SAGs) from dark-ocean samples based on their 16S rRNA genes. They identified 98 SAGs that belonged to the Nitrospinae phylum and all these SAGs diverged from the single available isolate of this phylum. Phylogenetically, the Nitrospinae were grouped into two clades and their abundance varied in publicly available metagenome data sets. Open-ocean Nitrospinae were abundant at depths below 200 m around the globe, which indicates that they are well adapted to the dark-ocean environment.

The Nitrospinae SAGs contained genes encoding nitrite oxidoreductases and enzymes for the reductive tricarboxylic acid cycle. There was no evidence for any other energy-generating pathways such as ammonium or sulfur oxidation, which suggests that these chemoautotrophic bacteria rely on nitrite oxidation. Furthermore, nitrite oxidoreductase subunits are some of the most highly expressed genes in dark-ocean metatranscriptome data sets. Interestingly, the Nitrospinae also encoded urea transporters and ureases, which can be used for the generation of ammonium from urea. The authors suggest that this function might support cross-feeding to Thaumarchaeota, which then produce nitrite.

To confirm the capacity for carbon fixation, the authors incubated dark-ocean samples with radiolabeled dissolved inorganic carbon and then combined microradioautography with catalysed reporter deposition–fluorescence *in situ* hybridization. Depending on the depth at which the ocean water samples were collected, the Nitrospinae were the most abundant carbon-fixing microorganisms and they contributed up to 43% of carbon assimilation. Furthermore, the volume of individual Nitrospinae cells was 50 times greater than the volume of Thaumarchaeota cells in dark-ocean samples.

Taken together, these results suggest that carbon fixation based on nitrite oxidation is a so far underappreciated component of the global carbon cycle. By using this pathway, Nitrospinae substantially contribute to the chemoautotrophy in the dark ocean. In fact, the authors estimate that marine Nitrospinae fix ten times more carbon per cell than organisms that depend on ammonium oxidation.

Ursula Hofer

ORIGINAL ARTICLE Pachiadaki, M. G. *et al.* Major role of nitrite-oxidizing bacteria in dark ocean carbon fixation. *Science* **358**, 1046–1051 (2017)

© 2017 Macmillan Publishers Limited, part of Springer Nature. All rights reserved.