Press Releases

May 23, 2018
JAMSTEC
Atmosphere and Ocean Research Institute,
The University of Tokyo

- Nitrogen Fixation is an Important Nutrient Source in the Arctic Ocean -

Overview
A research team led by Dr. Takuhei Shiozaki at the Japan Agency for Marine-Earth Science and Technology (JAMSTEC: president, Asahiko Taira) has determined that extensive nitrogen fixation occurs in the western Arctic Ocean (Figure 1) without a clear correlation to depth (light intensity) or nitrate concentration. Such light-independent nitrogen fixation seems to be caused by non-photosynthetic bacteria, suggesting that nitrogen fixation occurs even below the observed depth (100 m) and during the winter dark period. This research project was carried out in collaboration with the Atmosphere and Ocean Research Institute at The University of Tokyo.

Nitrogen is essential for all organisms to live and grow, but in order for living organisms to use atmospheric nitrogen, it must be converted into ammonium or other molecules. This reductive process (nitrogen fixation) requires a large amount of energy, so marine nitrogen fixation has traditionally been assumed to occur mainly in oligotrophic tropical and subtropical regions. Although recent studies have documented the occurrence of nitrogen fixation in colder marine regions, little is known about the distribution of diazotrophs (nitrogen-fixing organisms) and how nitrogen fixation contributes to the nitrogen cycle in the Arctic Ocean.

To examine the diazotroph community structure in the region, scientists obtained samples and environmental data in the shelf and off-shelf regions of the Chukchi Sea during a cruise by the research vessel R/V *Mirai* from September 6 to October 3, 2015 (MR15-03). Their analysis found widespread nitrogen fixation across the western Arctic Ocean (Figure 2), which significantly contributes to the nitrogen supply in oligotrophic water masses. In addition, nitrogen fixation was found not only in oligotrophic water masses but also in waters with sufficient nitrogenous nutrients (Figure 3). Furthermore, diazotrophs in the western Arctic Ocean were mainly affiliated with anaerobic bacteria, not cyanobacteria as seen in tropical and subtropical oligotrophic regions (Figure 4). This means that nitrogen fixation in the Arctic Ocean is not light-dependent, suggesting the occurrence of nitrogen fixation in the mesopelagic zone of the ocean and during the polar night.

Recently, some parts of the Arctic Ocean have tended to become more oligotrophic due to ice melt, particularly in the Canada Basin where nitrate supply is decreasing. In such regions, nitrogen fixation is likely to play a more important role in the growth and development of organisms. Moreover, nitrogen fixation in the Arctic Ocean could be a key to better understanding biogeochemical cycles on a global scale. Biological nitrogen fixation is a major source of oceanic-fixed nitrogen (Figure 5), while marine

nitrogen loss is facilitated by denitrification, the process by which nitrogen is removed from water. Although previous research has shown that nitrogen gain by fixation and loss by denitrification are roughly in balance on a global scale, recent measurements have shown that marine denitrification rates are much higher than fixation rates. This may be due to underestimated nitrogen fixation rates resulting from neglected observation areas including the Arctic Ocean. Dr. Shiozaki says, "To understand nitrogen fixation in the Arctic Ocean more accurately, we need to carry out observations in wider areas throughout the year."

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The above study results were published in *Limnology and Oceanography* by the Association for the Sciences of Limnology and Oceanography on May 21, 2018 (JST).

Title: Diazotroph community structure and the role of nitrogen fixation in the nitrogen cycle in the Chukchi Sea (western Arctic Ocean)

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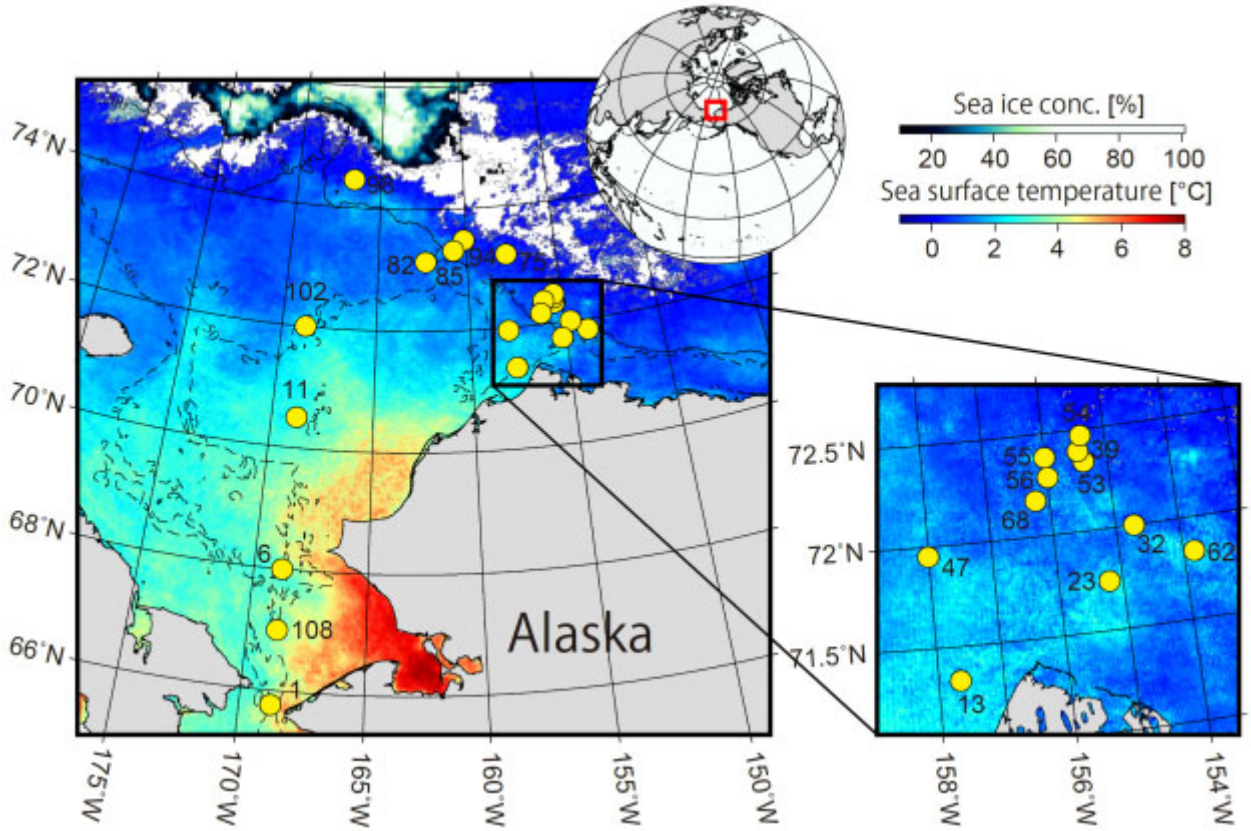

Figure 1. Sampling locations in the Chukchi Sea during the MR15-03 cruise of the R/V *Mirai*. Background contours indicate sea ice concentration (SIC) observed by the Advanced Microwave Scanning Radiometer 2 (AMSR2) and sea surface temperature

(SST) observed by Moderate Resolution Imaging Spectroradiometer (MODIS) during the cruise periods.

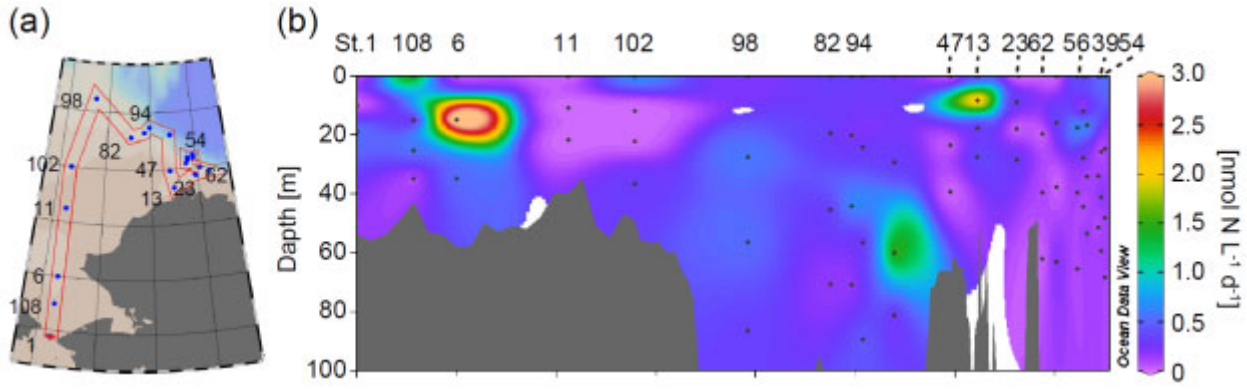

Figure 2. Nitrogen fixation in the Arctic Ocean: (a) Map view and (b) Cross-section of nitrogen fixation observations. Fixation is clearly not dependent on water depth, unlike tropical and subtropical regions where it is most active in surface waters with active photosynthesis.

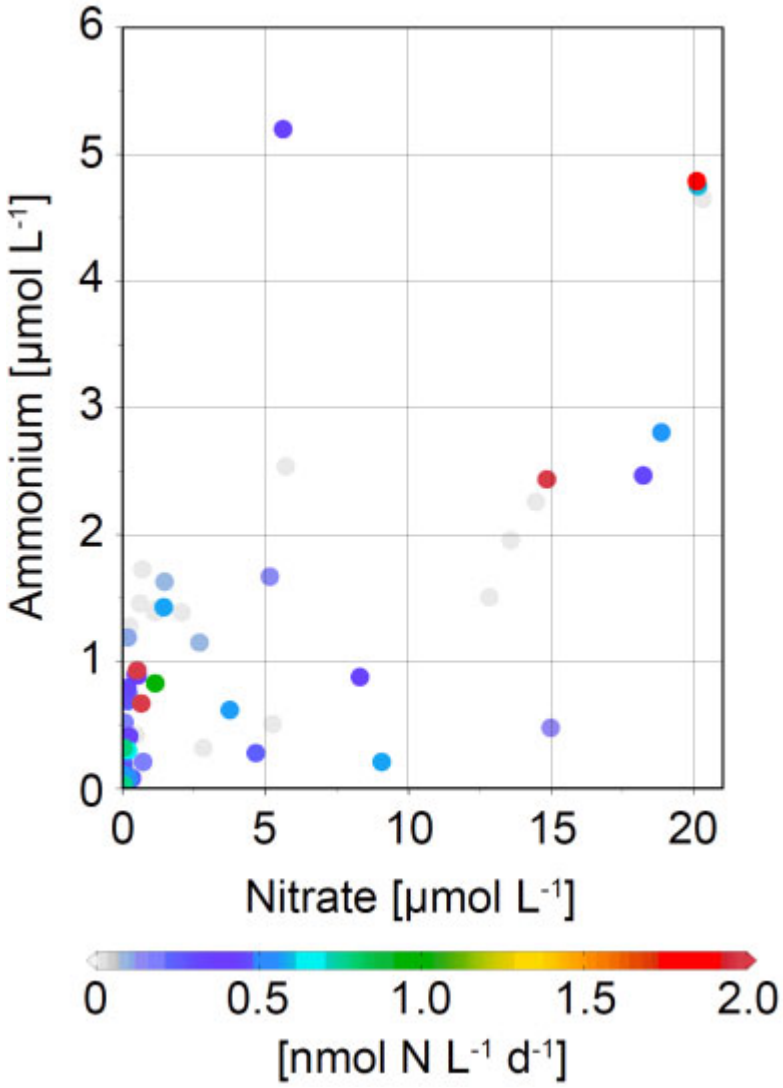

Figure 3. Relationship of nitrogen fixation (colored dots) to nitrate and ammonium concentrations in the Arctic Ocean.

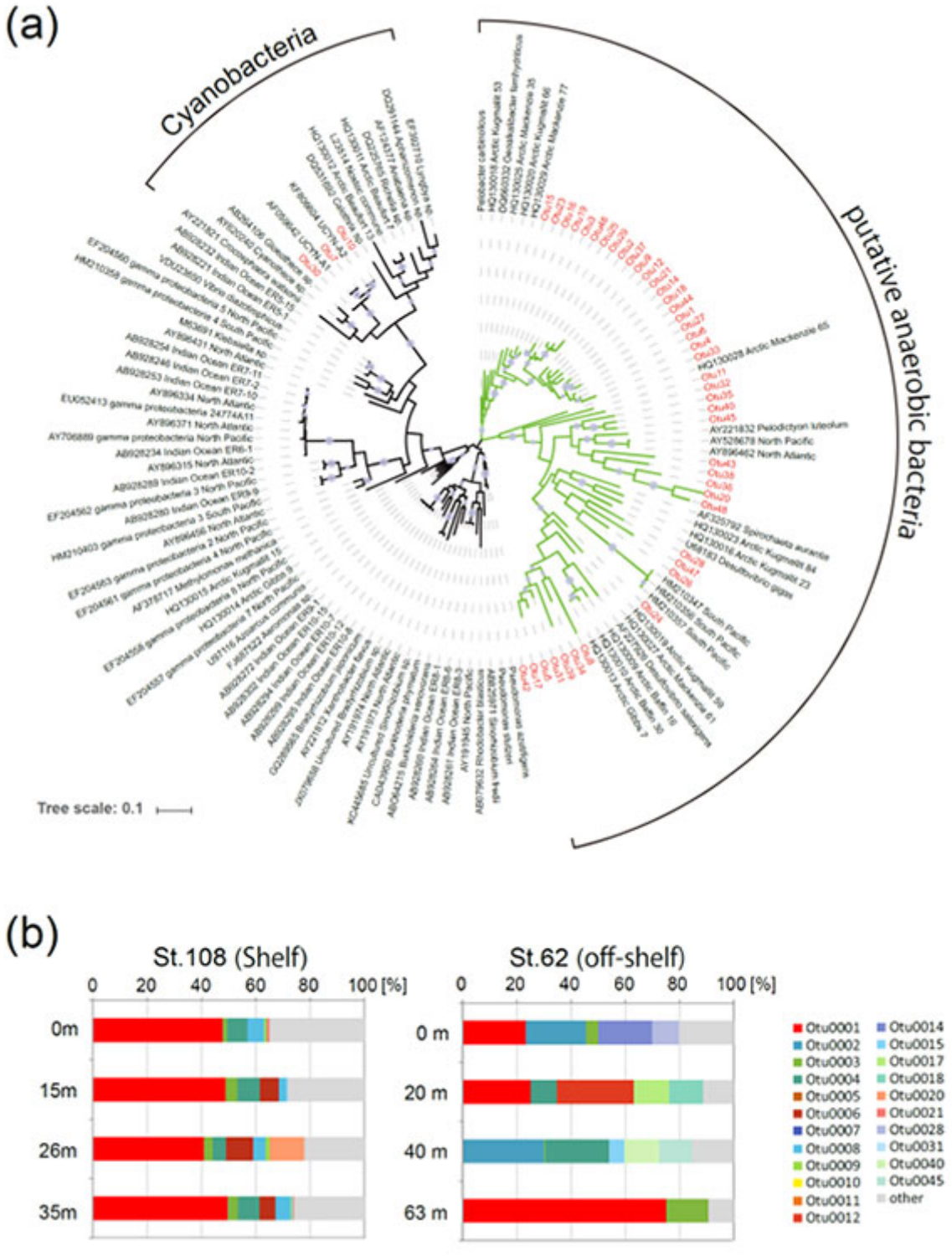

Figure 4. (a) Maximum likelihood phylogenetic tree of *nifH* gene sequences. The *nif* genes encode nitrogenase that fix nitrogen. The 45 representative operational taxonomic units (putative species) that account for >90% of all sequences in this study are shown in red. The green lines indicate sequencing of putative anaerobic bacteria. (b) Diazotroph community composition in the shelf and off-shelf regions of the Arctic Ocean.

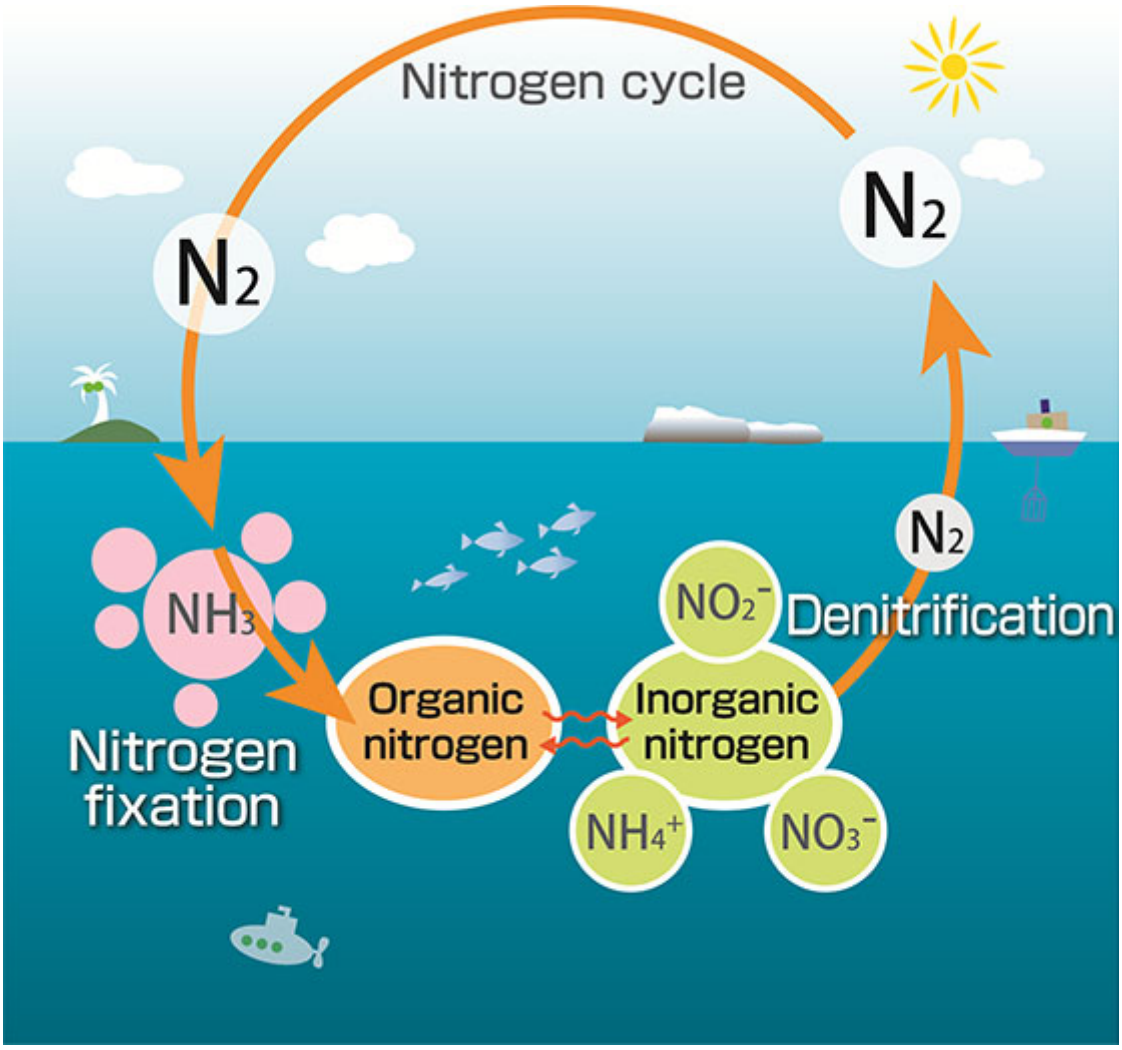

Figure 5. Schematic diagram of the marine nitrogen cycle.

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