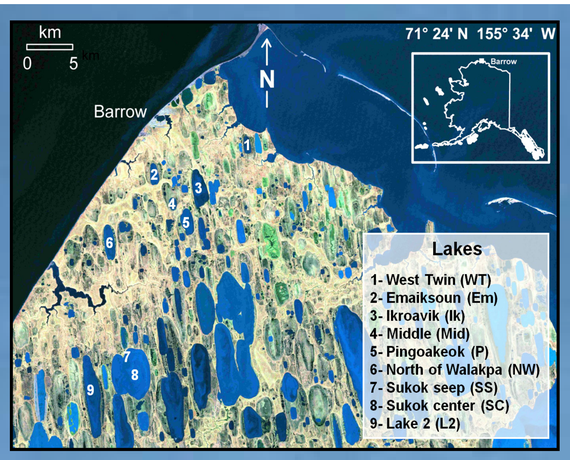
Bacterial activity in methane-rich, icy habitats

Heather E. Adams[1] and John Priscu
Montana State University, Department of Land Resources and Environmental Sciences
[1] hea@montana.edu

Background Information

Thermokarst lakes near Barrow, Alaska were sampled during late season ice cover (April) to assess the role of geogenic methane on microbial metabolism. Ten sites in nine lakes were selected which varied in physical and chemical characteristics. Controls on aquatic microbial activity such as carbon, nutrients, and temperature were examined along with methane oxidation and leucine incorporation. This work will be linked to lake ice and sediment microbial activity and biomarkers as one component of the NASA Astrobiology Institute's Icy Worlds project which aims to identify potential biological activity on the icy moons of our solar system.



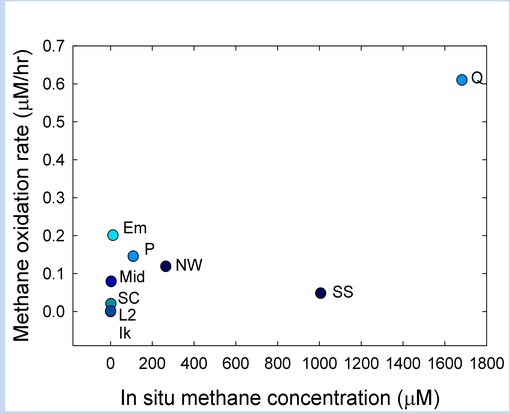
Sampling locations near Barrow, Alaska. Lake Qalluuraq (Q) is located south of this map at N 70° 22.674' W 157° 20.930' .

Top left: Collecting water samples, top right: gas bubbles forming under ice in sampling hole at Lake Qalluuraq, bottom left: different colors of water samples from several lakes, bottom right: examining gas bubbles in lake ice.

Methods

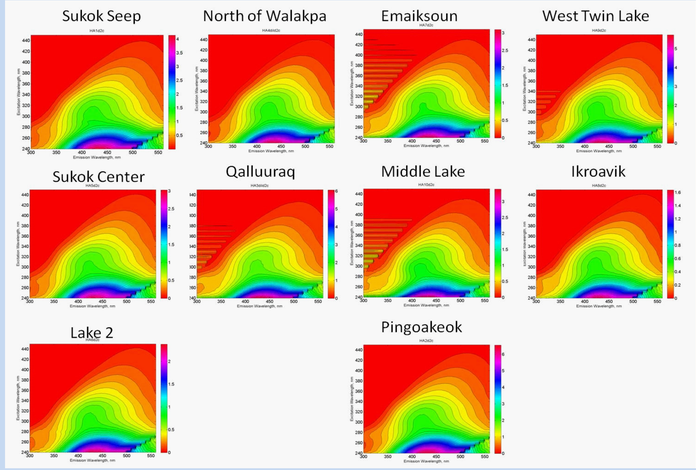
Water samples were collected below ice cover. The sites had an average ice thickness of 1.3 m and liquid water column of 0.7 m. Methane oxidation was measured by bulk changes in methane concentrations of bubble-free 30 mL serum vials incubated at 4 °C. Methane concentrations were measured by headspace equilibration in vials preserved with $HgCl_2$ and gas samples were run on a GC. DOC and TDN concentrations were measured on GF/F filtered and acidified samples run on a Shimadzu TOC analyzer. DOM fluorescence emission-excitation matrices were detected following Cory and McKnight 2005. Q10 values were determined for leucine uptake during incubation at 1, 12, and 25 °C.

Methane oxidation



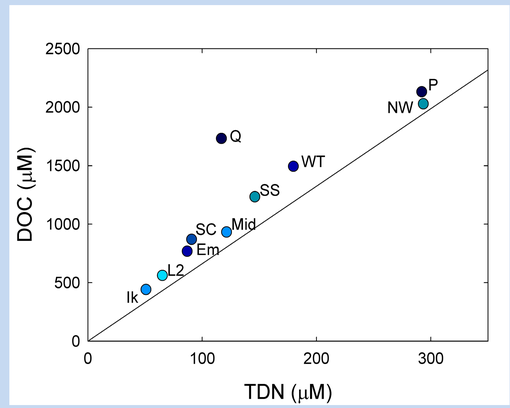
Dissolved methane in the liquid water column versus net methane oxidation rates. Rates of methane oxidation at different sites were not correlated with methane concentration, suggesting that dissolved methane was at saturation levels. Without resupply of methane to the water column, depletion would occur in 1.4 days at Middle Lake up to 866 days at Sukok seep at these rates.

DOM characterization



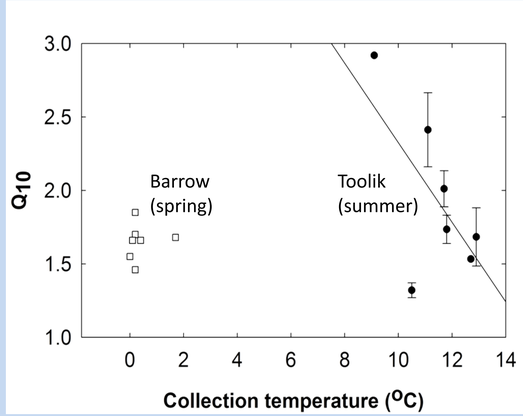
DOM fluorescence excitation-emission matrices indicate that organic matter is of similar chemical structure. FI values ranged from 1.441 to 1.522 in between standard end points of 1.1 for allochthonous and 1.9 for autochthonous DOM inputs. SUVA ranged from 0.005 to 0.032 also indicating that the DOM sources at these sites have similar proportions of aromatic compounds.

DOC and TDN concentrations



TDN and DOC concentrations with a line representing the Redfield ratio of 106:16 C:N. Highest ratios occured in the lakes with the highest methane concentrations. SRP concentrations were all less than 0.3 uM, indicating likely nutrient limitation.

Q10 of leucine incorporation



Q_{10} values for leucine uptake between 1 and 25 °C ranged from 1.5 to 1.9, generally less than those reported in the summer for other lakes on the North Slope of Alaska. Low Q_{10} values may indicate a microbial community that is optimized to low temperatures and can not readily respond to short term increases in temperature.

Summary

- Our results indicate that geogenic methane in the Barrow lakes can be rapidly oxidized beneath the seasonal ice cover by bacteria that are adapted to cold temperatures.

- These lakes were similar in DOM quality although they differed in quantity of both carbon and nitrogen.

- Low concentrations of phosphate and high Redfield ratios of DOC to TDN indicate possible nutrient limitation of the lakes.

- Q10 values did not indicate strong temperature limitation of the bacterial communities, suggesting cold adapted communities are still dominant during the spring season.

Our next steps include measuring the Q10 of methane oxidation in both fall and spring microbial communities as well as a comparison of fall and spring chemistry at a subset of these lakes. Bacterial community composition is also being examined as a potential control of activity in these methane and DOC rich lakes.

Citations

Adams, H.E., B.C. Crump, and G.W. Kling. 2010. Environ. Microb. 12(5): 1319-1333.
Cory, R.M. and D.M. McKnight. 2005. Environ. Sci. Tech. 39: 8142-8149.

Barrow map modified from: **http://www.geography.uc.edu/~kenhinke/dtlb/**

Photos from Icy Worlds team members.

Acknowledgements

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