Deep Ocean Exploration Institute
2009 Funded Project
Final Report

Exploring the Microbial Imprint on Deep-ocean Dissolved Organic Matter

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What were the primary questions you were trying to address with this research? (Or, if more appropriate, was there a hypothesis or theory that you were trying to prove or disprove?)

The primary purpose of this research was to describe the molecular-level composition of low-molecular weight dissolved organic matter in the deep ocean (>200 m) and to assess possible roles for shifts in this composition with depth and latitude. We hypothesized that the composition of this complex mixture would change during deep-water transport and during dissolution of particles raining down from the surface.

What have you discovered or learned that you didn't know before you started this work?

This project was the first molecular-level assessment of the composition of dissolved organic matter in the deep Atlantic Ocean. We identified organic compounds that are characteristic of North Atlantic Deep Water, the primary deep-water mass in the Atlantic Ocean, and we observed that these compounds contained unexpectedly high sulfur content and contained building blocks of biological origin. These compounds will provide interesting targets for us to analyze in our future work in the deep ocean.

What is the significance of your findings for others working in this field of inquiry and for the broader scientific community?

The deep ocean's reservoir of reduced carbon is comparable in size to atmospheric carbon dioxide and thus merits intense scrutiny. Through this project, we developed new computational tools that will allow us and others to mine these complex mixtures for novel trends. Our data suggests that organic sulfur is an unexpectedly important component of deep dissolved organic matter and further work with genomics and proteomics may highlight new genes and proteins capable of degrading these compounds.

What is the significance of this research for society?

The deep ocean is a large reservoir of reduced carbon and its conversion into carbon dioxide is governed by its molecular-level composition. Our research has provided new insights into the composition of this climatically-important pool of compounds and is the basis of new hypotheses on the formation and degradation of dissolved organic matter in the deep ocean. For example, our data provides a foundation for molecular-level studies of the reactions of this complex mixture under different climate change scenarios.

What were the most unusual or unexpected results and opportunities in this investigation?

Conventional wisdom in this field suggests that deep dissolved organic matter is an increasing unreactive mixture of compounds that look less and less like the cell matter from which they originated. Thus, we were quite surprised to find that many of the building blocks of deep dissolved organic matter were indeed similar to biological building blocks such as amino acids. This finding occurred through the use of new computational tools developed during this project and is being tested in ongoing work.

What were the greatest challenges and difficulties?

The greatest challenge associated with this project was sample acquisition. Deep ocean samples require dedicated wire-time (~6h / sample) with appropriate sampling gear and this can be difficult to arrange on cruises of opportunity. In our case, the time allocated to obtain the deep water samples was dramatically curtailed after the primary science of our cruise encountered trouble. The extended length of CTD casts descending below 4500 meters and the volume of water we required only allowed us to obtain samples from a limited number of stations.

When and where was this investigation conducted? (For instance, did you conduct new field research, or was this a new analysis of existing data?)

Samples for this project were collected in July 2010 during a cruise off the northeastern coast of South America. This was a cruise of opportunity led by Prof. Rainer Lohmann (University of Rhode Island) and our participation in the cruise was made possible by funding from DOEI.

What were the key tools or instruments you used to conduct this research?

The primary instrument used to analyze these samples was the 7-T ESI FT-ICR mass spectrometer located in the FT-MS facility here at WHOI.

Is this research part of a larger project or program?

No.

What are your next steps?

Preliminary data from this project was the basis of a successful NSF proposal to examine the composition of dissolved organic matter in both North Atlantic Deep Water and Antarctic Bottom Water. This cruise went from Uruguay to Barbados and re-occupied the stations from this DOEI project. We obtained sufficient samples to undertake detailed characterizations of compounds that appear unique to NADW and to focus on compounds that are changing along the deep portion of the global conveyor belt.

Have you published findings or web pages related to this research? Please provide a citation, reprint, and web link (when available).

We have submitted a paper from this project and have presented 3 talks at national meetings.

Longnecker, K. and E. B. Kujawinski. Submitted (July 2013). Network analysis highlights building blocks of deep sea organic molecules. *Geochimica et Cosmochimica Acta.*

K. Longnecker, E. B. Kujawinski. 2013. Assembling complex organic molecules in the deep sea. 2013 ASLO meeting, New Orleans, LA.

K. Longnecker, E. B. Kujawinski. 2012. New analysis tools for ultrahigh resolution mass spectrometry data. Summer 2012 ASLO meeting. Lake Biwa, Japan.

E. B. Kujawinski, K. Longnecker. 2011. Molecular-level characterization of deep-ocean DOM. Spring 2011 ASLO meeting, Puerto Rico, USA.

Please provide photographs, illustrations, tables/charts, and web links that can help illustrate your research.