GEOTRACES #2 - Nutrients in the Open Ocean - Q & A Transcription

Q. Can one of you just clarify what the difference is between a micronutrient and a macronutrient?

A. Sure. It has to do with how much the plants need. The plants need macronutrients maybe a thousand times more than the micronutrients.

Q. In the areas of the ocean that do get enough iron, are there really high populations of plankton in these areas, or does something else limit them.

A. In general the areas of the ocean that get the highest amount of iron would be areas like the coastal regions where iron is readily supplied by sediments, river runoff, and things like that. So we generally do see elevated concentrations of phytoplankton and plankton in the coastal ocean. The open ocean regions where there is generally low iron, and low phytoplankton in general, there you can get limitations from other macronutrients. In general close to the coast where you do have a lot of iron you have a lot of phytoplankton. Generally things that would be limiting there would be things like light, [?due to self-shading], or around the polar regions of course during the winter time there's not much light, so that's the main limiting factor, and things like that.

Q. What are we seeing in terms of changes in speciation and bioavailability for trace metals in association with climate change or ocean acidification? Are there changes that are taking place that can be seen or that you're looking to investigate?

A. That's a really good question. It's actually unknown really at this time. There's a lot of people including my lab that are starting to look at what the impact is of changing temperatures and CO2 and ocean acidification will have on the speciation of metals like iron. It's expected to have an impact, but the magnitude of that impact and the direction of that is less clear.

Q. Can you explain a little bit more of how organisms may have evolved to steal iron from bacteria that can uptake them?

A. That's what Kristen was talking about, the trap doors. It turns out from what we understand about siderophores that they're produced by bacteria in the oceans, and not by phytoplankton like diatoms. However, as we develop tools to look at the genetics of these organisms, it's been shown that some diatoms for example have the ability in their genes to be able to pick up iron bound siderophores. So back to the example of how a phytoplankton like a diatom might be able to steal an iron that is bound to a siderophore intended for the bacteria that produced that siderophore.

Q. When the first presenter was talking about lead she discussed particle reactivity which seems different from atomic or regular chemical reactivity. Can you explain a little bit what you mean about that particle reactivity?

A. Well, we normally just think about it as being sticky, and sticking to the particles that are sinking in the water. It does have to do with charge. Different charge distributions on the different atoms hang on to the different particles that have different charge distributions as well, and that can lead to a certain sticking on the particle as it sinks in the water.

Q. Has anyone gotten any data about how much of the iron fertilization might take in CO2? So basically have there been measurements of that CO2 absorption during any of these iron fertilization experiments, or has it just been looking at the blooms?

A. No. There definitely have been attempts made to really figure out the sort of the carbon sequestration efficiency that you can expect from iron fertilization experiments. That's been the case almost since the very beginning. This was a big area of focus for these experiments because that was kind of the crux of the iron fertilization hypothesis. In fact over the years our estimates of the efficiency of carbon sequestration as a result of iron fertilization has steadily decreased by orders of magnitude. At this point it's estimated that for large scale iron fertilization like if we really made a big effort to do a massive iron fertilization over a hundred years we can expect to sequester in the range of 25 to 75 gigatons of carbon, which sounds like a lot, but when we compare that to the likely cumulative emissions of carbon from fossil fuel burning over the same time period, which is around 1500 gigatons, that really only accounts for 5% or less of the CO2 emissions over that period. So that's an indicator that large-scale iron fertilization is probably not the most cost-efficient way to counteract atmospheric carbon dioxide increases.

Q. On your Atlantic transect for Kristen's presentation your data showed high ligand concentrations in addition to high iron around the ridge. Do you think they are the same as the ligands in the surface waters, or are they fundamentally different?

A. It's really difficult to say. I would say probably very different, but it's unknown what that is. We're working on that.

Q. So these measurements that are made all the way down on this image, how are those collected? How do you get all the way down to the bottom of the ocean when you guys are collecting these measurements?

A. Sure, so we use what's called a rosette which is a circular device, and it's got bottles on it. So we have lots of bottles, usually 12 bottles or 24 bottles on the frame. The frame is on a cable, which for doing trace metal work has to be non-metallic, so we use a Kevlar line. That rosette is lowered through the water column, and the bottles are closed at the depths you are interested in. The rosette is called a CTD because it has a conductivity C, and temperature T, and depth D, sensor on it. On a ship you can see what is happening in terms of those parameters going through the water column, and knowing where you are, and when you get to the depth you want, you close the bottle, and it closes that water in it, and at the end of your profile you bring that—that's a picture of a rosette with the bottles around it. So as you lower this through the water column you get a picture of what the temperature, salinity look like with depth. Then you close your bottles at the depths you are interested in sampling, and then bring it on board. In the case of GEOTRACES we have to have a steel cable in order to communicate with the ship, but we encompass it in a Kevlar line to make it clean as shown in this figure. We usually did 3 casts to get the resolution that you see. S there were 36 steps in that profile instead of just 12 which would be if we had sent it down one time.

Q. For educators that may have trouble getting their students interested in chemistry, I wanted to know what got you interested in the field? Any tips on making this kind of exciting for their students?

A. I would say try to get them interested in chemistry through biology. Chemistry is the driver of a lot of biological processes. Certainly that was how I became interested in marine chemistry, because like many youngsters I was interested in being a marine biologist. Eventually I decided everyone wants to be a marine biologist, so I moved on and discovered that there's a lot of interesting things to look at the interface between chemistry and biology in marine systems. So that would be my advice to just make the connection to the biology, and then maybe they'll move on and be interested in chemistry.

I agree. I think that is a great method. One of the things that I really found interesting in chemistry was the colors with inorganic chemistry. You can see a little bit of the reaction happening, and it's just not microscopic thing. That's something that I would recommend.

I am kind of similar to both Kathy and Claire's experience where to me chemistry helps explain the world around us and why it works the way it does, and why it looks the way it does. I found that fascinating.

Q. One of you mentioned an iron fertilization experiment that was rogue. It wasn't measured by anybody, it wasn't measured by anyone. Is there anything in place if someone does want to do an experiment of this type that they can do that type of research, or is it just whoever does it does it, and they see what the results are? I guess the question is: Is there a mechanism if you do want to do this type of research?

A. Well actually there hasn't been any of this type of research since 2009. That was the last time that scientists did a kilometer-scale iron fertilization experiment. That took place in the Southern Ocean, and even that experiment was almost cancelled because of protests by environmental groups, even at the point where the ship was sailing. Right now there's actually a moratorium of sorts on any type of iron fertilization experiment activity. The U.N. convention on biological diversity has placed a hold on further ocean iron fertilization activities for any purpose in non-coastal waters until stronger scientific justification is obtained. Supposedly a regulatory framework is being developed for these types of activities via the London Convention and the London Protocol of the U.N., but as I said no new experiments have taken place since 2009. So for all intensive purposes it's illegal to conduct these activities. One exception maybe in the coastal region of certain nations where these nations have sovereign control over their own very close coastal waters. Then again that's probably not the place where you want to do an iron addition experiment because there's probably plenty of iron there at most times. So there isn't a good mechanism, and this is a concern for scientists because these experiments have been fundamental about informing us about the biological role of iron, and how its modified climatic cycles, not just in terms of geoengineering, but over natural cycles, over glacial and interglacial time scales. So it's unclear what the future is for iron fertilization not just in terms of geoengineering, but in terms of purposeful experiments for science.

Q. Under the lab test that you were talking about for iron fertilization, you mentioned the protocol for how to do that. Is this something you think a class could do if they were given the right material just to demonstrate this principle?

A. Maybe if you had cultures of organisms that you had grown to be under iron limitation, and then you could spike one of your cultures—you know some of the cultures with iron. I think that might be easier than trying to do it starting with natural waters. It's difficult to collect iron; it's difficult to collect trace metal sea water cleanly without contaminating and things like that, plus you don't know there might already be enough iron or a lack of macronutrients in that water. So it might be possible with cultures where you can manipulate the profile of the macronutrients and the iron such that those organisms are going to be limited by iron and then you can bang in some iron and you see an effect. That might be possible.