Think Deep!

Episode 1: Marine Carbon Dioxide Removal

Transcript:

Eesha: Hello and welcome to Think Deep: Ocean Policy with the Experts. This is a new podcast series from the Deep Ocean Stewardship Initiative, also known as DOSI. It is meant to provide a helpful look into the pressing ocean policy topics of our time. I am Eesha Rangani, a deep-sea biologist, and I am happy to be your host for this episode. In today's episode, we are diving into how efforts to tackle climate change could affect the deep sea. According to the IPCC (The Intergovernmental Panel on Climate Change) one proposed tool to meet global goals on climate change is CDR, or carbon dioxide removal. CDR involves taking carbon dioxide out of the atmosphere and storing it underground, on land, or in the ocean. For simplicity, we will refer to ocean-based approaches as marine carbon dioxide removal, or mCDR. As climate change effects become more severe, many stakeholders are looking toward the ocean for mCDR solutions. But there is a concern: We haven't fully considered what mCDR technologies might do to deep-sea environments, which are crucial for the health of our planet. That is why we've invited our speakers today to discuss what this means for the future of our ocean.

Our first guest is Dr. Lisa Levin, distinguished Professor Emerita at Scripps Institution of Oceanography, University of California, San Diego. She is passionate about the deep sea and researches the ecology of different ecosystems in the deep ocean, their vulnerability to climate change and human resource extraction. Welcome, Lisa. Thanks so much for making time for this today. How are you?

Lisa: Thank you, I'm just fine, thanks for asking.

Eesha: Our second guest is Dr. Sarah Seabrook, a marine biogeochemist at the National Institute of Water and Atmospheric Research in New Zealand. Her research integrates techniques in microbiology, geochemistry and ecology to investigate the connections between physical environments, ecosystems and climate change. Welcome, Sarah. How are you today?

Sarah: I'm doing very well. Thank you for having us on here.

Eesha: Thank you both for being here. So, the concept of marine carbon dioxide removal or mCDR is about using the ocean to keep planet heating carbon out of the atmosphere. To get us started, could you tell us a few examples of how that might be done?

Lisa: Well, it's not one thing, obviously, mCDR. Well, not obviously. Many people may not know there is about seven or eight different technologies involved. At a minimum... there's probably more than that, but there are a number of primary ones, and quite a few of them work to enhance natural processes. For example, there's a set of technologies that are aimed at stimulating the growth of phytoplankton in the surface ocean. Phytoplankton remove carbon dioxide from seawater as part of photosynthesis. And when that happens, more carbon is drawn out of the atmosphere into the ocean. The idea is that the phytoplankton ultimately will aggregate and sink or be eaten and taken down into deep water. So the technologies that do this are called ocean fertilization, or iron fertilization, because iron is the limiting nutrient. So when you add it, it stimulates phytoplankton growth.

And another technology is called artificial upwelling, where deep nutrient rich water is artificially brought to the surface and providing phytoplankton with nutrients to stimulate their growth. So those two more or less fall in the same category. There's another group of technologies that involves sinking organic matter into the deep ocean. One of them is called macroalgal culture and sinking, and basically it involves establishing massive seaweed farms and then sinking that algae into the deep sea and other related... but different technologies involve taking crops, waste from land, and sinking it into the deep ocean or taking wood waste from land or woodchips and compressing them and baling them and sinking them into the deep ocean. And then there's a whole nother set of technologies that involve changing the alkalinity of the ocean so that more CO_2 is drawn, uh, drawn in. There's several forms of that as well.

What else did I forget? Oh, the subsurface carbon dioxide injection. Do you want to talk about that one, Sarah?

Sarah: No, you're on a roll. You finish it up.

Lisa: Ok. There is an interest in taking carbon dioxide in liquid form and injecting it into the deep sea, and in many cases, underground in the deep sea, into geologic formations that could then sequester it for many hundreds of years. So that's another technology. And the reason that everybody wants to put these forms of carbon into the deep sea is that they stay out of the atmosphere and out of circulation for a long time if they go below a thousand meters. At least that's what the models tell us, although, you know, there's some uncertainty there. And it's fair to say that all of these technologies would affect the ocean ecosystems and deep ocean ecosystem systems in some way.

Sarah: Yeah. And I will add to that that marine carbon dioxide removal is… it's not really a new topic either in the research field. When I first heard about some of these techniques, I was in graduate school and they were taught to us as these experiments that had happened previously, particularly iron fertilization. There was this researcher who really started doing a lot of work around iron fertilization with the famous saying: “you give me a tankard of iron and I'll give you an ice age” around this this idea that by putting iron into the ocean, you could create phytoplankton blooms and draw down carbon. And a lot of the experiments that happened earlier around this were not very promising and showed negative implications. And so the work sort of stopped around that. And that's how it was taught to me in graduate school. And so it's really just this resurgence of this, this idea that has existed for a while and an idea that previous research wasn't necessarily finding exactly promising results around earlier on.

Eesha: So if that's the case, why are we seeing renewed interest in mCDR now? Lisa and Sarah, both of you were at the most recent United Nations climate change conference in December, which is their major annual meeting to make decisions and climate policy. It was called COP 28 for short, which stands for the 28th Conference of the Parties. Did attending the conference give you any insights into why people are talking so much about mCDR as a possibility?

Lisa: We really began to see strong advocacy, I guess you would call it, from many different sectors now, not just the businesses starting to do… to develop these technologies, but also from academic institutions and even some governments. And they seem to be entering some kind of crisis mode where people feel we absolutely have to do something, whether it makes sense or not, whether carbon removal has been verified for these techniques or whether they're safe for the environment.

People were doing what we call reversing the precautionary principle and telling their audiences that it was precautionary to act under extreme uncertainty. Even if people didn't know these technologies, whether these technologies would work or not.

Sarah: In relation to what we are talking about here today, both Lisa and I continued to be surprised at how common marine carbon dioxide removal was as a topic at various events at COP 28 and the different forums that we saw it brought up at. And this is something that has continued to be impressed upon people following COP 28, including various researchers that I think we have both spoken with who are really seeing an urgency in elevating research around this topic in response to public interest in it.

Lisa: There was a lot of discussion about marine carbon dioxide removal, but very little mention of the environmental risks or safety of these proposed practices. So that was very surprising that that just wasn't part of the conversation.

Eesha: Thank you. Bringing back the focus into the deep sea, what are those impacts and why should they matter?

Sarah: The impacts are very dependent on the method and there's still a lot of uncertainties, I would say, in the feedbacks between these methods and how things will actually play out in the real environment if some of these were deployed at scale. A lot of the research that has been done to date and a lot of sort of experiments we can have from natural analogs that exist in the environment show potential for deoxygenation and acidification. And there is potential for, for example, if you think of macroalgal and crop waste, you have potential for smothering the seafloor and causing direct biological harm as well as releasing hydrogen sulfide, nitrous oxide or methane from the sediment. I think a lot about the impacts that could be had for the biological pump. So this is a process in the ocean where microorganisms, plankton, zooplankton in process sinking organic matter as it sinks through the water column before it gets to the sediments. And this is a major source of the carbon sequestration that happens in the ocean. But it's a delicate process. And if you are adding, for example, alkaline minerals, there could be trace metals that come off of this, which could cause toxicity and that could harm the organisms that are involved in this process and restrict the ability of that process to to continue.

Eesha: So Sarah, I have a question: You mentioned deoxygenation. Do you mind explaining that?

Sarah: Yeah. So deoxygenation is a process where in the ocean loses oxygen and oxygen is an important and important molecule for life in the ocean, just as it is for us. And so it’s the same as if a human goes up to Mt. Everest where there's less oxygen in the atmosphere and they have to wear an oxygen mask in order to be able to survive. When there is less oxygen in the ocean, It causes stress to animals and it also can cause mortality. And that leads to very different life living in those areas. It restricts the ability for some organisms to live in that area of the ocean where oxygen is lower. And as those oxygen minimum zones expand, we see many animals having to migrate to new locations and other such impacts.

Eesha: Thank you, Sara. Lisa, did you want to add to that?

Lisa: Sure. I mean, just to build on what Sara just said, oxygen loss was predicted to be one of the major consequences of iron fertilization. And it was one of the reasons that people dismissed the idea ten years ago. And I'm not sure that much has changed. But to talk about a few of the other kinds of impacts are... actually not so much different than what Sara said, but just to point out that all the changes that she spoke about will totally alter ecosystems in the ocean and change the way they work. And I think people haven't really been paying attention to that as they propose these technologies. I mean, some of them change... there will be changes in light in the water and the reflection of sunlight. If you cover massive parts of the ocean with macroalgae, it'll change the albedo of the ocean. The algae, ah, will rob... basically do what's called nutrient robbing and take nutrients away from phytoplankton and put them into algae. And we know that algae support completely different food chains and food webs than phytoplankton. And so we run the risk of damaging, you know, fisheries or production or some other aspects and ecosystem services that we care about like carbon cycling, as, as Sara said. So I think, you know, it doesn't take that much to alter an ecosystem and change the species that can survive and how well they do and so on.

Eesha: I guess I just want to follow up and ask how are these impacts going to trickle down to the deep ocean? Sarah mentioned the biological pump, but I think people think that the deep ocean is barren and almost it's okay to, you know, have things go down there. Could you any of you talk a little bit more about the impacts, particularly on deep-sea fauna and why we should care about the deep ocean?

Lisa: I can start. It is full of a host of different environments and each one has its own biodiversity. So we have canyons and seamounts, oxygen minimum zones and abyssal plains, hydrothermal vents, chemosynthetic ecosystems like vents and seeps. So we have all different systems in the ocean and they are, in some ways they are interconnected with each other and the seafloor ecosystems are connected with the water column.

Sarah: One of the things that is really unique about deep sea habitats is that they exist in this environment that changes very slowly. Many of the organisms function with processes that occur on a thousand year timescales, right? In many areas of the deep sea, you have very low rates of carbon or other material falling down to deep sea sediments. It can occur, you know, millimeters per hundreds to thousands of years in some cases. And so if you have this environment that's used to, to really stable conditions and then you're injecting high volumes of some material into that environment, that is going to completely change that, the dynamics of how that ecosystem can function. And it may be that there's not the organisms and the capacity for that ecosystem to respond to such a change.

Lisa: I think it's fair to say that we don't even know all the consequences of blanketing the bottom with massive amounts of phytoplankton or algae or wood chips or crop waste. I mean, we can imagine that it will damage a lot of organisms. But I think because most so much of deep-sea biodiversity is yet to be described and we still don't know very much about how organisms function, it would be really hard to accurately predict what all the consequences are. We do know the ocean's really connected. And one study by Alessandro Tagliabue, a modeling study, suggested that fertilizing the Southern Ocean would draw away nutrients that otherwise would have made it to the tropics, that fuel fish production and biomass, and that the predictions are that massive Southern Ocean iron fertilization will have really negative consequences for fisheries in the tropical countries. So that's just an example of the really high connectivity of the ocean. But we're still learning about deep water circulation. I was at a conference a week, a couple of weeks ago that made it very clear how little the oceanographers know about where *water* goes in deep water, and the nutrients in that water.

Eesha: I guess my next question is more policy related. You both have attended and been closely following both the scientific and the policy developments on mCDR. As we know you were both at the climate conference held in Dubai last year and you have participated in other events discussing the same since then. Where do you see the policy conversation going with managing the environmental consequences of mCDR? Is it is it being spoken about at all?

Lisa: A little bit. There's definitely conversations within countries, especially the Northern Hemisphere countries that are developing these technologies, about the need to bend or rewrite some of the existing legislation to enable testing and deployment of mCDR. So there's those kinds of conversations about the Clean Water Act and things like that. In international waters, the organizations that would possibly govern some of these technologies would be the London Convention and London Protocol, and they are basically a UN instrument that governs dumping into the ocean. So if you put iron in to stimulate phytoplankton growth or you put crop waste or wood waste in, that's organic dumping, they would regulate it. And they've already produced evaluations and press statements that said they have a lot of concerns about the environmental risks of these practices. And they weighed in on iron fertilization long ago and developed an annex that basically said it could only occur as research, not as full on deployment to address climate. But that annex hasn't been ratified by enough countries yet. So it hasn't entered into force. And I would see the new Biodiversity Treaty, the BBNJ agreement, as potentially being able to weigh in through the institution of Environmental Impact Assessment. So presumably any deployments of these technologies in international waters, once that treaty is in force, which it's not, not been ratified by 60 countries yet. But yeah, that would also be another vehicle for at least considering impacts. I don't know how much governing capacity that treaty would have to actually stop an activity.

Sarah: Yeah, and I think it is a really tricky thing to consider across national, international policy mechanisms because it just as we were talking about earlier, for example, with the Tagliabue paper, where you can have iron fertilization in the Southern Ocean that impacts fisheries in the tropics. If you had regulatory approval in one nation's exclusive economic zone, the area of the ocean that they govern, to do an activity but that would have impacts for the high seas, so the part of the ocean that all nations are invested in and have regulatory interactions with, or to have feedbacks with another nation's exclusive economic zone. How can you regulate that and integrate that into policy development? I think it's one of the really tricky things about marine carbon dioxide removal is how… just as the ocean is very connected, how do you develop policies that can account for that interconnectedness?

Eesha: So, recognizing those challenges, how can policymakers effectively account for deep ocean science and potential environmental impacts when making decisions on them?

Lisa: That that's a hard question. I mean, first, they have to learn about it and know about it, but people have to understand why the deep ocean is important. And we don't have very many valuation studies of it to understand how people value it and whether they would be willing to trade it for something else. I think in making decisions about mCDR, we also have to look at efficacy and how much carbon in a net sense would be actually removed and whether it's worth damaging ecosystems to do that. Because my sense is that for most of these technologies there is very little evidence of efficacy, of significant carbon removal or understanding of how long it would stay out of the atmosphere. And, you know, I think we won't ever know everything that's in the deep sea or what all the effects of this are. And so people have to have some understanding of the value of that unknown biodiversity and why we might want to keep it around for future generations.

Sarah: Yeah, and I would add to that that at a base level, policymakers in considering these technologies, just as they consider any sort of activity in the ocean, it's really important that they are aware of and keeping in mind that it is one ocean and it is a very connected place and that the majority of that ocean is deep sea. And so in doing anything in any of these waters, you are interacting with the deep ocean environment. You are reliant upon processes that are happening in the deep ocean environment, and that what you do in one area will have feedbacks and consequences for some other area. And many of those are unknown and so it's not just making a decision about one thing in one area, it is making it a decision that's very holistic in nature.

Eesha: Thank you. I think I would like to end it on that note. Thank you both for your time. I really appreciate both of you being here. This was a great conversation and I hope people benefit from hearing this and learn more about why the deep ocean matters and how important it is. Thanks, Lisa and Sarah.

Lisa: Thank you.

Sarah: Thanks, Eesha.

Eesha: Thanks, everyone, for joining us today. I really hope you enjoyed this episode. At DOSI, we are proud to connect a diverse network of experts from around the globe, all united by a common passion making deep ocean science influential at the policy level. Stay tuned and dive deeper into these conversations with us as we explore the vast potential of our deep ocean. Thank you.