Jennifer Stock: Hello, welcome to another edition of Ocean Currents. I'm your host, Jennifer Stock. On this show, we talk with scientists, educators, explorers, policy makers, ocean enthusiasts, adventurers and more, all uncovering and learning about the mysterious and vital part of our planet, the blue ocean. I bring this show to you monthly on KWMR from NOAA's Cordell Bank National Marine Sanctuary, one of four National Marine Sanctuaries in California, all working to protect unique and biologically diverse ecosystems. Cordell Bank is located just offshore of the KWMR listening radius, off the Marin-Sonoma coast, and is a thriving area with ocean life above and below the surface.

So today, we're diving into some of the most powerful organisms on the planet - phytoplankton. Yes, phytoplankton, the tiny little microscopic ones that float around and photosynthesize. They are extremely powerful. My guest is Dr. Bill Cochlan, and he is a senior research scientist in Marine Microbial Ecology and Oceanography at Romberg Tiburon Center for Environmental Studies at San Francisco State University. His research focuses on what factors control phytoplankton growth, their nutrition and distribution in the ocean. So, in my thoughts, I often, I'm talking about the ocean with my education and outreach work, and I just think it's going to be really interesting to kind of dive into the details of these incredibly interesting creatures which provide for so much life on our planet, but can also turn and be quite harmful. So, welcome Bill! You are live with us in the studio here at KWMR.

Dr. Bill Cochlan: Well thank you Jennifer, It's great to be here.

Jennifer Stock: Bill's also a teacher as part of his work at Romberg Tiburon Center, so I thank you for taking time during your semester to come out here. So, how did you get interested in phytoplankton?

Dr. Bill Cochlan: Well, I was brought up close to the coast, in a small town in British Columbia, so I always saw marine life close at hand, right out our front room window. And I got involved in the actual phytoplankton when I was an undergraduate at the University of British Columbia, and as a freshman project, I did a study on the effect of pulp mill effluent on the ecology of the (unintelligible plankton species). And the dominant effect of the pulp effluent is affecting the phytoplankton. So that's how I first heard about phytoplankton. And then it snowballed, and by the time I finished my undergraduate degree, I was doing an honors dissertation on phytoplankton and the effect of ultraviolet radiation. And then many degrees later, I've been doing phytoplankton research and associated microorganisms that are associated with phytoplankton for the last 30 years or so.

Jennifer Stock: Wow! So you fell in love with these little creatures right away!

Dr. Bill Cochlan: I guess so.

Jennifer Stock: When I was, I was doing a little bit, I used the Ocean Almanac. Have you ever seen this book? It's this funny book that has some incredibly tall tales about the ocean and they call phytoplankton vegetable plankton. Can you…yeah, vegetable plankton. Can you talk a little bit just about the biology of phytoplankton? Sometimes there's confusion about it being a plant or a protist, or another area of level of designation. Can you tell us a little bit about the biology of these organisms?

Dr. Bill Cochlan: Sure, well phytoplankton is sort of a general term, and when you said vegetable plankton, that has a lot of truth to it, in that the vast majority of the phytoplankton get all their energy from the sun. So they photosynthesize just like a regular green plant. But also there's many phytoplankton that actually are heterotrophic, that is they eat other plankton, or there's some that can do both, mixotrophic. So phytoplankton aren't all photosynthetic, in fact some of the ones that you see off the coast here, like *Noctiluca*, which form massive bioluminescent displays, they're 100% heterotrophic, so they don't have the capability of using the sun's energy, they eat other phytoplankton. But overall, when we think of phytoplankton, the most important ones are the ones that do draw their energy from the sun, they photosynthesize and they make carbohydrates, and they essentially are the base of the whole food chain in the oceans today. And in the process of being photosynthetic, they are also producing 40-60% of the oxygen on this planet. So they're pretty important.

Jennifer Stock: That was one of the questions I had. I often hear a statistic of 50-75%, and I'm wondering how do they base that? So you say 40-60? Is that what you said?

Dr. Bill Cochlan: Yeah, well, I haven't done an overall estimate, this is essentially based on how much oxygen they produce through photosynthesis compared to trees, grasslands and such. And so I think the figure is fairly broad. But it's around 50% and maybe in some areas it could be much higher. If you're talking off the desert shores of Africa, essentially all the oxygen is being produced by the phytoplankton, as there is very little plant life in the deserts. Right off the coast of say, Northern California or Oregon, where we have abundant forests that are producing tremendous amounts of oxygen, then the actual percentage in that ecosystem would probably be lower. To round it off, it's probably around 50%.

Jennifer Stock: That is still such an incredible statistic to me as a land-dweller on this planet. We really are indebted to phytoplankton for our survival.

Dr. Bill Cochlan: Oh yeah, without the phytoplankton, we wouldn't have this planet. They produce the oxygen; they get that oxygen in our environment. So, they're pretty important. They're important historically, and they are important today.

Jennifer Stock: So, speaking of the geologic record, how far back, when do phyto… when do plankton appear? Phytoplankton appear?

Dr. Bill Cochlan: I think they mention the Jurassic period. They've been around for an incredibly long period of time. They are evolutionarily very adapted to the oceans. We have all different types of phytoplankton - some that are adapted to the cold, turbid waters. Others do much better in the warmer, stable water masses. Here off California, we have virtually all of them, all of the different types of phytoplankton. Some of them have the capability of producing toxins, which can be harmful to us, but the vast majority, 99.99% of them are totally benign, and they're a fundamental component of marine systems. Without them, the ecosystem would crash.

Jennifer Stock: So the big time for phytoplankton, I know, is the summer, with spring upwelling bringing a lot of nutrients up to help fertilize those waters. How do the plankton populations vary throughout the year? The spring and the summer are big time pea soup, but how does it go the rest of the year, in terms of populations?

Dr. Bill Cochlan: Well there's always phytoplankton out there. For phytoplankton to form blooms, as they really proliferate, they have to have an abundance of nutrients, that's where the upwelling comes in, the upwelling of deep waters to the surface. The deep waters are replete with nutrients. They have to have an abundance of light, so that's why you have more of the phytoplankton blooms in the spring and summer. You have longer daylight, you have more sunlight, you have less clouds, and you have more stable water columns. So you have more potential for the growth of phytoplankton. And if you have the mixing of storms, the phytoplankton get mixed so deep that they just don't have enough light on a per average basis on a day to really grow very, very fast.

Jennifer Stock: So that's when you say stable water column, that has to do with the mixing, like in the winter time when we get these big storms, there's a lot of mixing going on, right?

Dr. Bill Cochlan: Yup.

Jennifer Stock: So in the spring and the summer, they're a bit more stable, meaning they don't flip around so much? There is pretty good water?

Dr. Bill Cochlan: Yes, the water starts to become heterogeneous and it forms layers, and once it forms layers that allows the phytoplankton to stay up at the surface, close to the sun. But at the same time, when those layers develop, that separates them from the abundance of nutrients that are at depth. So here off the Point Reyes, we have episodic upwelling all up and down the California coast. So the upwelling is not continuous because the upwelling will bring the deep waters to the surface and then the upwelling will stop for a while, and that's when the bloom takes off. That's when you get this massive doubling the phytoplankton every day. And so in a matter of days, you have a massive phytoplankton bloom.

Jennifer Stock: Yeah, I read that they reproduce to 2,000 times, up to 2,000 times their winter populations in the spring and summer. Is that about right?

Dr. Bill Cochlan: Um, probably close to that.

Jennifer Stock: Kind of a rough number.

Dr. Bill Cochlan: Yeah, at least, they really, they... I wouldn't say 2,000 but at least a hundred fold to maybe close to a thousand fold, maybe in some areas.

Jennifer Stock: Good to know! Great! So let's talk a little bit about the scientific questions you have been working on, in regards to plankton since obviously did they not only support human life with oxygen, but they support the marine food web, the ocean food web and diverse numbers of species, countless numbers of species. So, can you tell us a little bit about the main research questions that you have in regards to phytoplankton?

Dr. Bill Cochlan: Well, we have three projects right now that we're putting most of my energy into. One of them is looking at how phytoplankton, or how some of the phytoplankton can turn toxic, and what are the environmental factors that will allow these phytoplankton to produce toxin, and find out the role of that toxin. And the toxin isn't meant to go out there and kill us, but that's one of the, that can be one of the side effects of the toxin. That's one of our lines of research.

Our second line is, understanding how environmental factors such as ocean acidification can affect phytoplankton growth, and also the nutritional value to the rest of the phytoplankton, rest of the food chain. So the phytoplankton grow, they may actually grown faster, under a more acidic ocean. That's a possibility in some areas. But their source of nutritional value to the next food chain and further up the food chain, likely will change.

And then finally, our third line of research, we've been looking at phytoplankton as a source of biofuels. And I was working for a number of years, and I was working for a number of years in association with the consortium of universities from all around North America and Canada and Royal Dutch Shell, the oil company, and they were one of the oil companies that were sponsoring the research for us to get a test bed facility to understand the potential of phytoplankton, marine phytoplankton, to be a source of biofuels. So those are three projects we're still working on, and they're all funded by federally competitive grants, and we have a small laboratory, a small active laboratory, the Romberg Tiburon Center, where myself and my research associates and graduate students are pursuing this research.

Jennifer Stock: Fantastic. Thank you. For those just tuning in, this is Ocean Currents, and I'm talking with Bill Cochlan, who is a research scientist at the Romberg Tiburon Center.

So, the first one you're talking about, Bill, is how plankton can turn toxic. And I'm assuming this is when we hear about harmful algal blooms on the coast?

Dr. Bill Cochlan: Um hum

Jennifer Stock: And that's related to plankton blooms that turn toxic. And one of the questions I had around that is, the phytoplankton alone, is it the toxicity, is it a toxic plankton individual on its own, or is it the amount of plankton that might be in the water that together bio-accumulates to become toxic?

Dr. Bill Cochlan: Well, that's a good question, and part of it is terminology. Often you see the term red tide, and red tide is used almost synonymously with harmful algal blooms, and they aren't really the same thing. A red tide is essentially any phytoplankton bloom that's at a high enough concentration that you can actually see it with the naked eye. And a red tide may not have any harmful consequences; it's just a lot of phytoplankton in one area. Now a harmful algal bloom, that's not really a scientific term, it's a societal term, and it's any type of phytoplankton that accumulates to a degree that will cause a negative effect on our national economy. So it doesn't even necessarily need to produce a toxin, but some cells are in such high abundance, they may be close to say, mariculture, and they will affect the fish being cultured there, even though no toxin's involved. Now right now we're working with phytoplankton that actually do produce a biotoxin, it's a naturally produced toxin. Phytoplankton have always had this capability, some of these species, and we're trying to understand what are the factors that trigger the toxin production, and most importantly what is the purpose of the toxin. Because making a toxin requires a lot of energy, so the phytoplankton must have a need for this toxin. So that's our underlying question, is to try to determine what is the toxin for?

Jennifer Stock: That is so interesting! So what are your ideas? What are you thinking in terms of; I mean really, these are tiny little microscopic plants.

Dr. Bill Cochlan: Plant-like

Jennifer Stock: Plant-like animals. Plant-like plants! And why would they need to produce a toxin? I mean I'm thinking on the land-dwelling side to prevent being eaten by other animals...

Dr. Bill Cochlan: Sure, and that is one of the roles of some of the toxins that will decrease their predation. So let's say the zooplankton, which are the little microscopic animal plankton, and they're multi-cellular, they would normally eat the phytoplankton. If the phytoplankton are producing a toxin that will probably deter them from eating them. And they also may produce a toxin to outcompete other phytoplankton for limited resources. And that kind of gets into what our feeling of what the toxin's purpose could be. And we think it actually allows them to acquire nutrients that are in the ocean that are found in very, very small quantities. And the nutrients that are generally found in very small quantity are the micronutrients. Things like iron and copper. And so some of the work that we've done with *Pseudo-nitzschia* which is a diatom found right off the coast here of Northern California and responsible for demolic acid poisoning, and that has had huge impacts on marine mammals here in California. That toxin we've shown can actually help them acquire copper and iron. And the other species we're working with today is *Heterosigma akashiwo* which is a raphidophyte, which is a little flagellated phytoplankton, that means it's a phytoplankton with a tail, and they can swim about the water column and optimize its position in the water column to have lots of light and lots of nutrients. And we feel that this raphidophyte produces toxin that allows it to cause the fish gills to essentially explode. And when the fish gills explode a fish, they release, of course the blood, which has lots of iron and it has nutrients.

Jennifer Stock: Wow. It's incredible! I just, phytoplankton really blows my mind because some of these stories, I'm just like "this is amazing!" because we just don't learn about this stuff unless people like you look under the microscope and really, really dive into it. Very interesting.

Now let's talk a little bit about the environmental factors. This is something I heard you talk about this summer that was so fascinating to me in terms of how ocean acidification may impact, or may affect the nutrient value that they then provide for the food web. So can you talk a little bit about that, and how do they change, how do they change their nutrient value?

Dr. Bill Cochlan: Well, all phytoplankton produce carbohydrates, proteins... they produce more than that... carbohydrates, proteins, and a host of things, but the proteins of course are very valuable. But they also produce lipids. And lipids are composed of amino acids and fatty acids. And depending on their availability, depending on which stage of growth they're in, if they're growing very fast, or they're growing very slow, that's going to have an affect on the type of lipids. When they're growing very fast, they're producing things called polar lipids. And these polar lipids, they form membranes and a number of structural material on the fast-growing phytoplankton; they need to have structure. But when they run out of essential nutrients, then they can no longer grow fast, and they hit a phase called stationary growth, where they're just barely growing. And in that case, they're no longer making the polar lipids, they're making the neutral lipids. And these neutral lipids have a much lower quantity of the polyunsaturated fatty acids called PUFAs. And these PUFAs, we can't make them. Animals can't make PUFAs. So fish can't make them, humans can't make them, but they require them. They have to get them from their diet. So, if we think that ocean acidification would change the way the phytoplankton grow and change how they can acquire nutrients, it will have an affect on their nutritional value, essentially how much of the PUFA they have, and what types of PUFAs. And that's where we think we have this linkage between ocean acidification and potential degradation of the food chain. So we're calling it the rusty acidic food chain.

Now, science is based on developing a hypothesis and then testing it. At this point, some of our European colleagues have shown, yes there is quite a strong link between ocean acidification and the type of, the nutritional value of the phytoplankton, but this is one of the very first studies, and we're expanding on this and working off the California upwelling system to find out, right in this system here, if we have this problem. We'll do it in the laboratory under test organisms, isolated from Northern California, and then we'll actually go to sea in upwelling systems, and see if it's really a problem there as well. Now we hope it's not, but that's what science is all about: testing these hypotheses.

Jennifer Stock: Yeah, fascinating. A lot of stuff happening in the laboratories that I imagine the scale of bringing it to the natural conditions is very difficult…

Dr. Bill Cochlan: Um-hum.

Jennifer Stock: …Scientifically, to test these things. Now are there just specific species that you're working on to analyze the nutrient value of these species?

Dr. Bill Cochlan: We're looking at the species that normally become dominant in these highly productive upwelling systems along the California coast. All the way from essentially Washington, Oregon, California, all part of the California current upwelling system. So we're going to look at the species, isolate them right from the field, the ones that normally do very well here, and see how they're being impacted from the increased ocean acidification, which is occurring today.

Jennifer Stock: Right. Now we have, for those, we've talked about ocean acidification on this show before but basically ocean acidification is the changing pH of the ocean from the excess carbon dioxide in the atmosphere. It's actually altered the pH of the ocean. And from what I'm learning, it sounds like the California current here with the cold water that we get upwelled, that we actually have advanced conditions than other parts of the ocean right now.

Dr. Bill Cochlan: Yes, we do.

Jennifer Stock: But we've always had some variation in the acidity, right, because of this cold-water upwelling system. So are you thinking at all about the natural evolution of these plankton in terms of dealing with these dynamics as it is?

Dr. Bill Cochlan: Um, that may be part of it. When those upwelling waters come to the surface, they're these waters reflect the acidity or the CO2 conditions of when they were first formed at the surface. So they're 30, 40, 50 years ago. And so ocean acidity has increased dramatically since that time, there is much more CO2 in the atmosphere since that time, so the waters that are now coming up have more and more of the dissolved CO2 in it, so they're more acidic. Now when I say acidic, it doesn't mean they're actually corrosive now, they're not low, low pHs like battery acid, it just means that the trend is going towards the acidity part of the pH scale. The pH scale is just a scale like a Fahrenheit scale or Centigrade scale to measure temperature. The pH scale just measures that for acidity. So we are seeing a drop in ocean pH from values of 8.2, 8.1 down a little bit lower to 7.9, 7.8 in these upwelling zones, and sometimes even lower than that. So they're not particularly corrosive, but that's a dramatic increase in the acidity level.

Jennifer Stock: Right. So even these small changes can have a big impact to different areas, different levels of the food web. Very interesting. Very concerning for everybody involved with, anything to do with the ocean. This ocean acidification is kind of changing the ocean conservation conversation quite a bit, on top of all the other stressors that we face.

So how about excess nutrient loads? I'm thinking about this big storm, it's been a huge push of water from the land to the Bay to the ocean and bringing with it tons and tons of nutrients. Can you talk a little bit about excess nutrients in the water, and plankton growth with that?

Dr. Bill Cochlan: Sure. You don't want too many nutrients and you don't want too little nutrients. Here off California, we have an abundance of nutrients already off our coastline, so the extra nutrients that have come down with these massive storms probably aren't going to have a huge effect overall in California. But in other parts of the world, where the ocean water on the coast is devoid of nutrients, when you have these massive rainfall events, you get nutrients from the land, from agriculture, from sewage outfalls, all sorts of different non-point or point sources. And you also get different types of nutrients. Off the California coast here, the nutrients that come from the depth to the surface through upwelling are mostly in the form of nitrates and phosphates and silicates. When you have nutrients coming from shore, you're going to get a reduced form. You're going to get things like urea and ammonium. And these are other forms of nitrogen, and all nitrogen isn’t really treated equal. And these forms of nitrogen may allow certain species to do better than others. So we're trying to determine if the different forms of nitrogen actually will cause a change in the species composition. And there is some evidence, and evidence that has come right from my lab, that shows that some of these nitrogen forms actually make species more toxic. Now we can't generalize, and it's very dangerous to generalize on that, but when we find that say, urea or ammonia will make a certain type of species more toxic, then we really have to understand it in greater detail. We don't want to raise false alarms, but this is what we've been seeing in laboratory work. So now our challenge is find out, is this a problem? If it's not a problem, great! But if it is, we have to understand the problem. We have to understand the mechanisms behind it.

Jennifer Stock: Well hasn't there typically been some human impact too from these outfalls when there's large rains and people surfing in the water, getting different infections?

Dr. Bill Cochlan: Then that’s...

Jennifer Stock: Or is that different?

Dr. Bill Cochlan: Some of that is hearsay, but when you have these large rain events, then of course you have storm run-off and such, so you do have pretty dirty waters on the coast. And so you’ll hear surfers talking about earaches and such. If they've had sewage outfalls, then they've had storm drains going, there are a lot of bacteria and viruses that are not normally found in abundance in the coastal waters. And that's probably the issue. Now as far as phytoplankton changing as a consequence of that, we really don't have a lot of evidence of that. In other parts of the world, again, where they don't have a lot of nutrients in the water, then all of a sudden you get a flush of nutrients, you are going to have an impact, but if you have too many nutrients, you start to get eutrophication That's when you have way too many phytoplankton, and when the phytoplankton start to die, when they run out of nutrients eventually, they settle to the bottom of the ocean, and that decomposition, which is done by bacteria, needs oxygen. It's an oxidation process and they use up the oxygen in the area and that becomes an anoxic zone, or a very low oxygen zone. And we have this off the coast of the Mississippi area, and that whole gulf coast area, because of the excessive amount of nutrients that are coming down from agriculture, these are fertilizers that aren't used by the crops, they fuel a massive phytoplankton bloom, and eventually that bloom falls down to the bottom of the ocean and is decomposed. And so they have these anoxic zones.

Jennifer Stock: And so the other animals that live in that habitat don't have access to that oxygen.

Dr. Bill Cochlan: Correct.

Jennifer Stock: So is this what we call dead zones?

Dr. Bill Cochlan: Dead zones, exactly.

Jennifer Stock: Interesting. So many different fascinating layers of it. I want to actually come back in just a minute here. We're going to take a short break, and I'd love to come back and talk a little bit more about your work in terms of how phytoplankton might be a source of fuel. You were talking about biofuels and we'll take the conversation from there. So those of you tuning in, this is Ocean Currents and my name is Jennifer Stock. I'm talking with Bill Cochlan from Romberg Tiburon Center, and we're talking about phytoplankton. Please stay with us; we'll be back in just a minute.

(Music)

Jennifer Stock: You're tuned to KWMR and this show is Ocean Currents. And today we're talking about phytoplankton. I have Dr. Bill Cochlan, who's been studying phytoplankton and many assets of it, aspects of it for many years and it's just fascinating to really dive into the base of the food web and the very complexities of these organisms and how they respond to changes in the ocean and the changes they provide for other food levels up the food web.

So we're, let's talk a little bit about the biofuel work you were doing. That was another area that your lab is working on. And I've heard a little bit about algae as biofuels and I just haven't heard a whole bunch about it. But can you tell us a little bit about how you organize this work and what are some of the outcomes of it?

Dr. Bill Cochlan: Sure. Well right now, we're funded by the Department of Energy to do some lab scale work on finding the suitable phytoplankton candidates, and the environmental conditions, which allow them to produce the lipids that could be used for biofuel production. And this work all arose, um, I was recruited to lead an effort in Kailua-Kona, Kona Kailua and to help put together a consortium of partners and manage and develop a new facility on the Big Island. And this facility was going to be a pilot project to determine the types of technologies that we need to grow phytoplankton on a large enough scale so we can actually do this commercially, in a commercially viable way. Now, the whole purpose of this project is to try to figure out how to grow phytoplankton, which grow very fast, faster than any other plant, and how to grow them on a large scale so they can be used as a source of for lipids that will make the biofuels. And some of the things we wanted to avoid: we wanted to avoid using fresh water, so that's why we're using marine phytoplankton, not freshwater phytoplankton, we wanted to avoid using agricultural land, which we need for regular food crops, and that's why we were using the lava fields of Hawaii, and we also wanted to avoid using any genetically modified organisms. We felt that Nature, with the abundance of species of phytoplankton, there were some species out there that would be very, very lipid-rich that would be great candidates for biofuels, and we felt that it was ecologically sounder for us to do a survey of the phytoplankton and find those candidate species and grow them to scale.

That's essentially what we did in the first few years of operation, and we were there really to set up the operation, get everything working, train the people, and then I came back here to San Francisco to resume my academic position. So that is what we're doing, we're still part of their consortium, we're still assisting in this whole effort, and right now we're making a lot of headway. One of the things you may have heard may be in the media is a lot of hype about biofuels and biofuels from phytoplankton, and a lot of it really is hype. There were a lot of individuals that were excited about this, and there is good reason to be excited, but they really didn't have the training. They really didn't have the understanding of phytoplankton, and how it all works. So the one big difference in the Shell organization, is they went and they found what they considered experts in the field and brought them all together and we were very successful in doing this work. Now, commercially viable? It's a long ways off, but we have to understand the science behind it before we can ever think of using this new technology to fulfill this need for transportation fuels.

Jennifer Stock: That would be a lot of plankton, I'm thinking for the transportation we need, right?

Dr. Bill Cochlan: Tremendous!

Jennifer Stock: How do they convert the lipids from the phytoplankton to useful energy?

Dr. Bill Cochlan: Well first you have to extract them. We would essentially centrifuge down the phytoplankton and then the lipids are extracted and they're dried, and then they go through a few regular processes where you actually form the right carbon chains that are necessary for either biodiesel, aviation fluid, or whatever fuel you're looking for.

Jennifer Stock: Interesting. So is this something that's a potential for down the line? That we might hear more of it?

Dr. Bill Cochlan: Oh, I think it's definitely a potential, but at this point, none of these technologies have been optimized so they're commercially viable. It's really quite expensive to get that liter of oil or a liter of aviation fuel. So it's not gonna happen overnight. It's going to require a tremendous amount of effort, and we were very fortunate in that the past few years with some of the incentives from the Department of Energy, that some of the techniques and the scientific know-how to understand how phytoplankton produce these lipids and how to optimize them were supported by the administration. So with that sort support, not just here in the United States but also in Europe and in Israel and a few other countries that we are making some pretty significant strides.

Jennifer Stock: That's great, an international effort there. Are there any other countries that are using phytoplankton as biofuel for a smaller scale?

Dr. Bill Cochlan: There are a number of organizations that are using phytoplankton for pharmaceuticals, but as far as a source of biofuel, I don't think there's anyone that's actually producing biofuel from marine phytoplankton in a large enough quantity to really say that they actually sell it as a viable commercial enterprise at this point.

Jennifer Stock: Would there be interest in farming phytoplankton for aquaculture or fisheries?

Dr. Bill Cochlan: Yes, those are two really neat ideas and they have a lot of value. That, you know, rather than feeding your fish farms ground up fish that are from a near shore fishery from Chile or whatever, you actually grow up your phytoplankton, you grow it up under very confined conditions, controlled conditions. You understand the water quality, you understand the kind of phytoplankton, and they can pelletize these dried phytoplankton, and then they can be used as fish feed. And that's one of the goals when we were doing this operation, was to ensure that all aspects, or all components of phytoplankton were being used, so not just the lipids that are becoming a fuel, but also the proteins and also the carbohydrates that are formed as fish feed.

Jennifer Stock: And in a sustainable manner?

Dr. Bill Cochlan: And that's one of the great things about our operation, I think. One of the things I'm most proud about in our operation in Hawaii is that we had zero aquatic waste into the environment. Zero.

Jennifer Stock: That's wonderful. I love models like that that are really taking that into account from the very beginning. Hopefully we'll hear more about that in the future. Now you were just telling me that you were in Korea recently, at an international conference with some students, and a lot of work and ideas being shared. Can you give us some highlights from that?

Dr. Bill Cochlan: Well, it was a great conference in Shandong South Korea. I was in an international conference of harmful algal blooms and we presented our research, my student presented his research and some other collaborative research we've done with NOAA and my colleagues in Canada and also the University of Maine. So the neat thing, the exciting thing about these conferences is you get to see what's hot, what's being, what's going on right now. One to two years before it's actually published. And we saw some great research being done in Europe by some graduate students on the even, how dinoflagellates, which is the type of phytoplankton, how they're using these mucus nets to capture other phytoplankton. And so you're seeing the little phytoplankton act like fish or fishermen themselves, and they're acting more like insects than plants. So you have to remember that they're unicellular, they don’t have a brain, they don't have any of these organs, they have organelles, but they actually have very, very complex behaviors, and that's really exciting work.

Jennifer Stock: That is really cool. And that's just new science, new discoveries.

Dr. Bill Cochlan: Um hum

Jennifer Stock: That's interesting. I think it's really important for scientists to get together like this, to share. I was recently at a conference in Monterey, the ocean acidification conference, and the energy amongst the scientific community of sharing and hearing each other's work was amazing. You could really hear this, everybody lifting up their work and collaborating.

Now, also I know a few years back, this was such an interesting project, you were working on testing iron fertilization and that when we add iron to the ocean that plankton growth increases, and there were some other aspects of that that you were studying. Can you tell us a little bit about this interesting aspect?

Dr. Bill Cochlan: Sure. The last decade or so, I've been involved in all the major American efforts to understand how having minute quantities of iron can change an oceanic desert into an oasis. And what we knew about these areas, we call them high nitrogen, low chlorophyll regions, so that means that they have a lot of macronutrients, like nitrate, just like the nutrients we're talking about in upwelling zones, but they have very, very low quantities of some essential minerals, like iron. And areas include the equatorial Pacific, the southern ocean, the parts of the Northeast of the Pacific. These are all areas that don't have big phytoplankton blooms. And so the idea was, is, we wanted to test, was iron limiting the system. And these experiments showed very, very clearly that yes indeed if you add a small amount of iron, you can cause massive phytoplankton blooms.

So this of course caused a whole deal of excitement and energy, and people getting involved, saying well maybe we can increase fisheries, or maybe we can use it as a way to draw CO2 from the atmosphere. That was not really the design of the experiment. The design of the experiment was to understand if iron was limiting the system. Before we can actually go any further, to find out if we can use this as a way of enhancing fisheries, or maybe enhancing the draw down of CO2, we have to know, or we have to totally understand the effects as we go up the food chain. The easy experiments only explored the chemistry of the ocean and the phytoplankton and their immediate predators, zooplankton. There was no study further up the food chain. So we have no idea how small fish, or how planktivorous fish, or how the fish that feed on the planktivorous fish, how they're being impacted. So you really can't use this as a policy for enhancing fisheries or CO2 mitigation until you understand the effects of the whole system. And that's where virtually all of the scientists involved in these projects cautioned the community; let's figure this out first before we use it as a mechanism of change.

Jennifer Stock: Interesting. Has there been further study since then?

Dr. Bill Cochlan: There's been a number of these studies around the world, not just by American scientists, but by European colleagues and there are Japanese that worked, Japanese colleagues that worked with us on this. But it has, um, commercial groups have been quite interested and there has been a lot of misinformation, and there has been some groups right here in the San Francisco Bay area that have wanted to use this for profit as a system of cap and trade - a way of using your, getting your carbon credits by enhancing phytoplankton bloom. And these seem to have settled down a little because they realize that there is some environmental risk. We have to understand the risk before we even think of doing this.

But just recently, this last summer, back in August, an entrepreneur convinced some of the native people on the Queen Charlotte Islands, the Haida Nation, to invest in a phytoplankton enhancement scheme, by adding iron to increase salmon fisheries. A very misguided effort. Unfortunately I feel the native people of British Columbia were kind of hoodwinked into this kind of idea. I think it's very, very unclear what the results would be. I think the results on actual fish populations would not be dramatic, negative or positive we don't know, but this cost of many millions of dollars from a community that probably could not afford to spend this on very, very fishy science, you might think.

Jennifer Stock: And sort of short-term gains in a way too.

Dr. Bill Cochlan: Could be very short-term gains. Now there could be some potential with this, but you don't do these things in a black box. You do them openly, you do them with the consent and the involvement of scientists in the field, and you do it very, very transparently. And none of this has happened in this experiment.

Jennifer Stock: I can imagine the pressure to the biological community like you when they find out these little gains and successes and the pressure to go further with them, in terms of making them economically feasible.

Dr. Bill Cochlan: Well scientists, we try to figure out how things work. Most of us are not in it for a commercial gain. We like it if it can help the economy, it can help our fisheries, and it can help our coastal economy, that's all great. But a scientist, our level of expertise, our degree of expertise is understanding the mechanisms of the ecological process, or the physiological process. We're not venture capitalists, we're not entrepreneurs per se, we understand the science side, and we like to work with these with these people rather than work against them to ensure that any of these ideas, or these processes that they do receive funding for, that they do it in an ecologically sustainable manner, and they do it transparently, and with our assistance.

Jennifer Stock: With your scientific knowledge applied as the knowledge and not tweaked.

Dr. Bill Cochlan: Well, you know, we're doing this for a reason you know - this is our bread and butter. We like to see our knowledge utilized for society's gain, but not at the expense of the environment.

Jennifer Stock: Yeah, very good point. So, I'm curious from your experience as a scientist with phytoplankton, the many, many questions that you've explored regarding it, are you concerned about the future of phytoplankton?

Dr. Bill Cochlan: Um, phytoplankton are pretty resilient. Our oceans are in trouble. There's a lot of issues that have to be addressed. Our planet is in some pretty serious trouble. I think our number one goal is to ensure that our society knows that things like climate change are real. They're not some theory. They are impacting our oceans and our terrestrial systems today, and we have to do something about it. And I think the science that we're doing may help understand the process. It doesn't provide the solutions yet, but we understand the magnitude of this problem. And as an oceanographer and a phytoplankton expert, I don't think the phytoplankton per se are at risk, but communities could change. The nutritional value could change, and when you're talking about the base of the whole food chain, it's pretty important that we get it right. It's pretty important that we understand the effects that climate change may be having on our whole aquatic food chain. So, we don't have all the answers, but this is not a time to stick your head in the sand, it's a time to put more effort and more resources into understanding our resources.

Jennifer Stock: Do you feel now that, well I know it's been a struggle, the funding for scientific research in the past few years. Now that we've passed this election and we're moving forward, are you hopeful for more funds to come further for scientific research into this important life-sustaining information?

Dr. Bill Cochlan: Well, I'm always very hopeful. It would be great to hear that the White House understood what phytoplankton are. I really don't know how much impact we've had at the highest level of government. NOAA of course has been working very hard on these issues, but NOAA's received massive funding cuts. My colleagues at NOAA are really having their hands tied behind their backs and they're not being permitted to do the research they'd like to do, and some of the best research that our federal colleagues are doing, they do in association with their academic colleagues at universities throughout the country. That has been somewhat curtailed by severe restrictions on their travelling and their collaborative efforts. So, I think NOAA right now has had a funding crutch, crunch, and hopefully that will be rectified with the new administration, and when they do receive the funding, they can start working together with their academic colleagues and we can address these problems.

Jennifer Stock: Excellent. Any last words you'd like to share today with listeners about your work, and science, and phytoplankton or oceans in general?

Dr. Bill Cochlan: Well, I really am quite optimistic that things will get better. I'm very optimistic and pleased to know that our children in school today know what phytoplankton are. When I was a child, I had no idea what a phytoplankton was. Now students receive a curriculum that explains the whole marine ecosystem. They understand the importance of keeping the waters clean, they understand the sustainable fisheries. A lot of issues that were taken for granted in the 60's and 70's, and even the 80's. So I think we've turned the corner. I think that society wants us to look after resources more carefully. And here in California, I think we've taken the lead with excellent schools in both the CSU system and the UC system of studying marine processes, and together I think we actually will make a difference.

Jennifer Stock: Fantastic! I love that view; emphasize education at the end - it's really important. Well thank you so much. This has been a really fascinating conversation. I've learned so much about phytoplankton, and I have a much greater appreciation for them than I did before. I mean I've always appreciated them, but the, it's just a fascinating piece of information in terms of their life histories and their, the way they move and evolve and use nutrients and make nutrients. So, thanks for coming today.

Dr. Bill Cochlan: You're very welcome.

Jennifer Stock: We'll take a short break and I'll come back in just a little bit. You've been listening to Ocean Currents, and my guest has been Bill Cochlan from the Romberg Tiburon Center. Thanks for tuning in. Please stay with us.

(Music)

Jennifer Stock: Well thanks again for tuning in today. You've been listening to Ocean Currents and we've been talking about a very fascinating topic of phytoplankton and the many aspects of science that are being explored with this important level of the food web. And I really enjoyed having Bill Cochlan here to talk about it.

Ocean Currents is the first Monday of every month, and it's part of the West Marin Matters series, where every Monday at 1pm, you can tune into KWMR to learn about a topic of environmental focus. And we have a podcast. You can go to iTunes and search for Ocean Currents or come to cordellbank.noaa.gov to get past episodes as well.

(Music)

Jennifer Stock: Thanks for listening to Ocean Currents. This show is brought to you by NOAA's Cordell Bank National Marine Sanctuary, on West Marin Community Radio, KWMR. Views expressed by guests on this program may or may not be that of the National Oceanic and Atmospheric Administration and are meant to be educational in nature. To learn more about Cordell Bank National Marine Sanctuary, go to cordellbank.noaa.gov.

(Music)

Voice: Thanks for helping to protect our ocean!