Jennifer Stock: You're listening to Ocean Currents, a podcast brought to you by NOAA's Cordell Bank National Marine Sanctuary. This radio program was originally broadcast on KWMR in Point Reyes Station, California. Thanks for listening!

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Jennifer Stock: Hello, everyone and welcome. This is Jennifer Stock. I'm your host for Ocean Currents. This show is the first Monday of every month where we dive into our blue planet and highlight different ocean-related topics. We talk with scientists, educators, explorers, policy folks, ocean enthusiasts, ocean adventurers, and more all trying to uncover and learn about the mysterious and vital part of our planet.

So, I bring this how to you from the Cordell Bank National Marine Sanctuary. Cordell Bank is one of four special areas in California waters that are part of the national marine sanctuary system and is located just offshore of the KWMR listening radius off the Marin-Sonoma coast. So, today we're going to be talking a little bit about corals, a little bit about climate change and monitoring a fairly interesting way to monitor our environment. The term, coral, evokes images of shallow, sunlit reefs with a wide diversity of organisms including an abundance of colorful fishes and most people are aware of the role that coral reefs play in supporting the local economies of tourist destinations like the Florida Keys and the Hawaiian Islands and the ecological that these reefs play, but further, most of us are probably aware of the dangers that increasing water temperatures, overfishing, and disease on the ecological health of these reef ecosystems.

However, most people, except for fishermen and some scientists, are unaware that corals also occur in cold water and deep sea regions around the earth including right off here off the Marin-Sonoma coast. So, although the existence of these deep sea corals was first documented probably about two and a half centuries ago, most of what we know about them has come from exploration and research within the past few decades. With the development of simple, underwater imaging technologies like camera sleds and submersibles and remotely operated vehicles, scientists are beginning to study these corals and the associated organisms within their natural environments, but also, to utilize them for studying large-scale environmental research, such as our guest, Tessa Hill, does today.

In recent years, climate change has dominated our conversation in our everyday lives, everything from our jobs, our food, our transportation, our health, and we can't help but wonder what's around the corner in terms of how these ecological habitats and plants and wildlife will adapt, or maybe not. So, climate periods have varied with the long history of this planet and today, we're going to learn about how we can learn a little bit about the past.

So, today, we're talking with Dr. Tessa Hill from UC Davis Bodega Marine Lab, who uses deep sea corals and microfossils to study and understand environmental change in the marine environment, particularly in the last 50,000 years and she is an assistant professor at Bodega Marine Lab, UC Davis and she oversees graduate students in teaching and continues her own research. So, I'd like to welcome Tessa to the KWMR studio. Thanks for joining me.

Tessa Hill: Thank you so much for having me.

Jennifer Stock: So, we're going to talk about a couple of different things. Let's just start, first, how did you first get interested in studying environmental change or deep-sea corals because I assume one of those areas of interest drew you to the other?

Tessa Hill: That's true. I think I've been studying environmental change for longer than I've been studying deep sea corals, per se, but I became interested in particularly ocean environmental change as an undergraduate and so, for that I credit a particularly great undergraduate mentor. I was at a small liberal arts college in Florida called Eckhart College and I got involved in research with the professor that really opened up my eyes to what we can learn by using marine sediments to track environmental change over time and I continued to utilize marine sediments through my graduate career and I still do that and we can talk about that as we go along, but then, sort of, more recently I became interested in similarly using bamboo corals, or deep-sea corals as a sort of underwater archives of what the ocean has experienced, particularly in the last couple of hundred years.

Jennifer Stock: It's amazing because we just kind of recently just started seeing them with this new technology that we have and I still find it fascinating that we're finding new areas right now where these deep-sea corals are. So, where are deep-sea corals? Let's talk specifically about bamboo coral. Where does this animal live? What is a little bit about its natural history, its depth, and what does it eat? That's what I want to know. They live so deep. What do they eat?

Tessa Hill: Sure. All very good questions. So, I should mention that all of this work has been done in collaboration with the Monterey Bay Aquarium Research Institute. So, all of my research on this has been facilitated by their remotely operated submersibles. So, my students and I go out on ships and use their submarines to actually explore the depths where we find these deep sea corals and bamboo corals are found around the world from about, probably, 1,000 feet to much deeper than that, probably about 6,000 feet and the reason why they're called bamboo corals is that they look like pieces of bamboo or maybe even a better way to describe them are as pieces of bone with, sort of, joints connecting the bones.

You can imagine that bamboo also has that sort of joints that connect each segment of the bone and those pieces of bone are coral-skeletal material, essentially and the polyps of the coral, which is actually the living organisms, the colonial organisms that make up the coral, sort of, cover the outside of that skeletal, that bone-like structure. So, they live quite deep. They live below any penetration of light. So, they're entirely in the dark.

The deep sea is a very interesting place because it's sort of lower in density of organisms than what you just described in terms of coral reefs, but it's actually quite high in diversity. So, the number of species that we see in the deep sea is remarkable and every time you go on one of these submersible expeditions, people tend to discover something new or something they've never seen in that particular color or things like that.

So, it's…we haven't really explored the deep sea well enough to understand all of those things, but..So, you asked what bamboo corals eat and they basically exist on material that is floating down from the surface ocean and so, you can imagine that the surface ocean is very productive. There's a lot of plant and animal life including small animals, things we call zooplankton. So, you can imagine that to be larval fish or larval invertebrates or very small crustaceans and over time, those things sink out of the surface ocean into the deep sea and we also get, sort of, just detritus, organic matter that sinks out from the surface ocean into the deep sea and it looks like, this is actually based on some work that a graduate student of mine is doing, it looks like the bamboo corals are just sort of sitting at the bottom, waiting for something interesting to come along and actually capture it in their polyps and consume it.

Jennifer Stock: Tell me a little bit more about…this is something I've always had a hard time understanding, the colonial nature of corals? You mentioned that they're colonial organisms and there's colonial polyps. So, does that mean some of these polyps have different roles to play in terms of the life functioning of that specific animal?

Tessa Hill: Sure. I mean, what we know about corals in general is that sometimes polyps have different roles in keeping the organism going. You can kind of imagine that those polyps would be similar to sort of a group of very small anemones. So, you can imagine an organism made up of many, many anemone-like creatures living together on one structure and certainly, you know, the polyps at the very top of the organism might be responsible for collecting, sort of, more food or something like that, but I don't know that we actually know those things very well about deep sea corals. So, that's a very good question, one that I probably can't completely answer.

Jennifer Stock: I just always find it fascinating hearing about colonial animals, same thing with velella velellas, they're colonial. It's just one animal and I've always wondered about that.

Tessa Hill: Well, in the case of velella velella, the different parts of the colony actually definitely do play different roles. So, that's a particularly good example, but I'm not sure that we know that for sure about bamboo corals. We're still trying to understand their biology and that's made difficult by the fact that when we sample them at depth and we bring them up, they don't stay alive. So, we've never been able to keep them alive in the lab. So, essentially, we're studying, sort of, the material that is left over after we bring this organism up from thousands of feet deep.

Jennifer Stock: Now, when you're talking about what the structure of a bamboo coral looks like and there's these growth spurts and it almost looks like cartilage in between or something. Are each of those, like, chunks a growth year or a series of years that you are looking at or how are those little breaks in the coral, how are those different? Is it kind of like a tree or a twig, you know, there's that growth period.

Tessa Hill: Yeah, so they grow much like you would imagine a tree to grow. So, for each year that they grow, they add an annual band on that skeletal structure and they also grow in height. They look much like you would imagine a tree to look. So, they have a branching structure like a tree and so, the very, very upper part of those branches would be the newest part of the growth, but also you could go all the way down to the bottom of the coral where it's attached to a rock and the outermost layer of the skeleton is also the most recent growth.

So, what we do in my laboratory is we take advantage of the fact that they're growing like that. They grow with annual bands, like I said, just like a tree ring does and so, we can take a cross-section, sort of a slice across the bottom of that coral and see every year that it's grown for the entire time it's lived and they live, we think, for up to about 300 years, maybe 400 years. So, this is a very long-lived, slow-growing organism that records each year of its life in its skeleton.

Jennifer Stock: That's amazing. I've just read too that deep sea corals may be some of the oldest living marine organisms around. Is that true?

Tessa Hill: Well, they're certainly very slow-growing environments in general. That's one of the things that concerns us quite a bit about protecting these environments because if deep sea ecosystems are impacted by a variety of different human impacts including deep sea trawling, fishing, when these organisms die, it may take hundreds of years before you would actually build up that environment again.

So, they're quite fragile in that it's probably taken, like I said, hundreds of years to sort of develop any density of corals and I should mention that all of the work, so bamboo corals are found around the world, but all the work that I do has basically been limited to the California coast. So, I'm talking about bamboo corals and their associated fauna, the other organisms that you find around them all along the California Coast and so, we see things like sponges and other types of corals.

We see fish, we see sea stars, sea urchins, a lot of different organisms that all live together on these seamounts. So, they're basically hard-bottom substrate that organisms can actually attach to. It's not sediment that's washing around in the currents. It's actually a hard structure that corals can grow on.

Jennifer Stock: That's a good point, you brought that up, because one of the things when I was looking on your website of your work, it seems like it's all on sea mounts, but I guess that's where corals are going to be. So...

Tessa Hill: Yeah, they're not..we have found some, for example, in Monterey Canyon, sort of, not in a place that you would expect. So, you know, in areas that are covered with sediment, but as it turns out, the corals themselves are attaching to something firm underneath that sediment. So, if they can find any sort of rocky substrate, even if it's not very large, they seem to be able to make a home there.

Jennifer Stock: Yeah. So, let's talk a little bit about the work with the rings and I get a good picture of this cross section. How do you then study that for understanding climate periods and environmental change? Some of these animals, you say, could be a couple hundred years old. So, can we learn anything prior to that potential life history of the animal? How exactly does this work with this studying the environmental change?

Tessa Hill: Yeah, so, there's sort of two different approaches. One is the ones that we've samples recently that were alive when we sampled them and were very careful about doing that and that's because we don't want to sample very many of these long-lived organisms.

We want to preserve their environment as much as possible, but we do have a few of them that have been sampled alive that we think have been alive for 350 or so years and we then can basically sample with a very small drill and get maybe one sample for each ring of their life or every other year of their life or something like that and we're basically looking at the chemical fingerprints in that skeletal material and that skeletal material is made of calcium carbonate, which we can talk about as we go on, but so, we're taking a sample of each year of their life, or maybe every other year of their life and we're attempting to reconstruct things like temperature or nutrients or surface ocean productivity by using things like isotopes and particular elements that are captured in the skeleton of the coral and so, two particularly interesting examples of this is that the first thing we have to do is prove that those relationships between, for example, temperature and the chemistry of the skeleton exists and so, we do a lot of work of just selecting different corals that might tell us something about temperature change and we prove that there's a relationship between temperature change and the chemistry of the coral skeleton.

So, we've been working very hard on that and we do think we've shown that relationship and so, now we can go back to some of these longer-lived ones and actually reconstruct temperature over hundreds of years and then another particularly interesting example is that it appears as though these corals respond to and record things like El Nino episodes or Pacific Decadal Oscillation, which is a longer-term shift in the Pacific and so, we could potentially use these corals to actually reconstruct how those episodes have occurred in the past.

So, we have very good instrumental records of things like El Nino or Pacific Decadal Oscillation over the last 100 years, but if we wanted to say what has happened to those kind of processes over three hundred years, the corals might actually shed some light on that.

Jennifer Stock: Interesting. For those just tuning in, I'm talking with Dr. Tessa Hill from the UC Davis Bodega Marine Lab. We're talking, right now, about her use of deep sea corals in studying environmental change. So, you've gotten this nice link now between proving the chemical composition of the coral and linking it to specific data periods.

What are some of the findings from historical time periods that you've found? This is amazing and can you correlate it with other animals that do this type of correlation with environmental change? I mean, these are older animals, but are there other things you can somewhat triangulate...

Tessa Hill: Sure, so, of course, all of this work is ongoing. So, I may not have a perfect answer to that question yet, but one thing we do have is we managed to get some corals from the Atlantic that were sort of fossil corals. They appear to be about 20,000 years old and they're bamboo corals and so, we may be able to use some of these relationships that I just told you about with temperature and El Nino and things like that and actually look at that with these very old fossil corals since that's something that's ongoing in my lab and then, your question about what else can we sort of correlate this to is a great one.

So, we definitely like to compare these coral records to things like tree ring records on land or lake records on land so we can compare side by side what's happening in the ocean in the nearby California terrestrial environment and then the other thing is that we like to use these as sort of a bridge between what's happening in the very near past, so, the last couple hundred years to some of the other work that I do that really looks at records over thousands of years using sediment cores and so, you can imagine how we might ask some similar questions about how temperature has changed over time or how nutrients in the ocean have changed over time and we would use the corals to look at very recent time periods and then we might use a sediment record to look at the last

10,000 years and ask a similar question. So, they certainly can be sort of a bridge to other climate archives.

Jennifer Stock: Interesting. So, what does this look like? It seems like you must be finding that there's some rapid change happening. Do the corals show that in the last 100 years or so?

Tessa Hill: We don't see evidence of rapid temperature change using these corals, but I'm not certain that we would expect to. You have to remember what depth they're living at…is very isolated from what we experience in the surface waters of the ocean and in the atmosphere. We know from instrumental records that the deep sea is responding to global warming, to modern climate change, but it's responding on a very small scale, like, maybe a tenth of a degree or something like that and so, we would have to have a very good deep sea thermometer in order to reconstruct that over three hundred years.

So, I'm not sure we're going to see, necessarily, evidence of anthropogenic climate change at those depths using bamboo corals, but we do see things, for example, one of my students is very interested in whether we can reconstruct changes in the productivity of the surface ocean along California over hundreds of years because the corals are dependent upon a food source from the surface ocean, if they're getting more or less food, you would expect to see that in the chemistry of their skeleton and so, one of the things we're very interested in is can we look at things that Californians really care about like surface productivity and how it impacts the salmon fishery and can we then sort of connect that to how it's impacting the deep sea and what we see over time.

So, again, all of that work is sort of ongoing. So, I'm going to have to check back with you in a year or two and I can tell you all the flashy results, but those are the kinds of things that we think about in terms of connecting these records to other things.

Jennifer Stock: That's really cool. So, you've also been looking a bit at ocean acidification and that kind of is projecting somewhat into the future, but you were telling me earlier about some studies that are happening locally here that relate to this and I'd love you to talk a little bit about this because in my mind in the last few years, it's been like, "Oh, it's coming. It's coming!" But it's really, truly here. Can you talk a little bit about that?

Tessa Hill: Sure. Would you like me to tell you a little bit about what I mean by ocean acidification?

Jennifer Stock: Yeah. Let's back up with that. Thanks for the good point. What is ocean acidification? You know, about five years ago I remember people asking me about it and I was like, "I don't know what that is," you know? It was a new term and now we're throwing it around pretty regularly, but let's back up and define that a little bit for folks.

Tessa Hill: Yeah, sure. So, it turns out that carbon dioxide or CO2 is very soluble in seawater and so, you can think of the ocean as a big sponge for atmospheric carbon dioxide. So, it's soaking up a lot of the carbon dioxide that we are putting into the atmosphere through human activities and so, basically about half of the CO2 that we've put into the atmosphere through those human activities has probably been absorbed into the ocean and when that happens, when that CO2 becomes soluble in sea water, it binds with a water molecule and actually produces a weak acid and that's called carbonic acid and so, that, basically, the addition of that CO2 into sea water makes sea water more acidic. For people familiar with the pH scale, that would mean that we dropped pH.

So, right now…or decrease pH. So, right now the ocean has an average pH of about 8.1 and it's expected that that pH will drop to about 7.5 within the next 100 years and that's all due to this sort of…this addition of anthropogenic CO2 into the atmosphere that then gets soaked up by the ocean and the interesting thing about that is as we add that carbon dioxide to the ocean and we produce that acid, that weak acid, carbonic acid, we see a corresponding decrease in another compound in calcium carbonate ion and so, at this point, everybody is probably wondering, "Why does this all matter?"

And the point is that that calcium carbonate ion is basically the building block for most hard parts and skeletal structures of organisms including the corals we were just talking about. So, when you think about clams or mussels or abalone, oysters, urchins, corals, any of those invertebrates with hard parts are producing their hard part out of that carbonate ion and so, when there's less carbonate ion in sea water, which is what's happening over time, we expect, we're not certain what will happen, but we expect that it will become more difficult for organisms to precipitate those hard parts of those shell materials.

Jennifer Stock: It goes back to when I was in elementary school, I remember doing a science experiment where we were testing different acids and bases and what not and I clearly remember the acid reacting with the calcium and it bubbled away.

Tessa Hill: That's right.

Jennifer Stock: And that always is the image in my mind when thinking about ocean acidification of things that have the hard shell in the ocean and reacting with this acidic water and not being able to survive. So, I think it's pretty scary. So, you also were doing some local studies of some potential larval invertebrates and predicted conditions in the future. Can you tell us a little bit about that?

Tessa Hill: Yeah, sure. So, I'm part of a group of faculty at Davis and Bodega Marine Lab who are approaching this problem and we have sort of made the decision to approach it in three different ways. So, I can kind of describe those three ways to you, but one of those ways is that we are raising larval invertebrates.

So, you can think of these as baby clams or baby oysters, at the marine lab, and we're raising them in conditions expected over the next 100 years in terms of the CO2 concentrations that we'll see and so, for example, we started with larval oysters and we raised them at both current CO2 concentrations in the atmosphere as well as concentrations that we would not expect to see for another 100 years and what we see in those larval oysters and as they transition into juvenile oysters is a significant decrease in how fast they grow when they're raised in the higher CO2 concentrations.

So, that's fitting, sort of, this hypothesis that they're going to have a harder time growing shell material in higher CO2 concentrations. That is actually bearing out in the lab.

Jennifer Stock: Wow. So, a huge economic impact just from that study alone.

Tessa Hill: Yeah, I mean, it's interesting because we, so far, have been working with native oysters collected here in Tomales Bay, but obviously this would have an impact on commercial non-native oyster hatcheries as well and so, we have definitely been in a dialogue with the oyster farms in order to, sort of…how to get our information to them and help them understand what might happen in the future and then also have them help us with, sort of, what kinds of questions would be relevant for us to test in the lab for them.

Jennifer Stock: So, this is fairly new research because we didn't really have a lot of information about this prior, but it's kind of precipitated a need to learn more pretty quickly with climate change. So...

Tessa Hill: That's right.

Jennifer Stock: It just boggles my mind because the economic ramifications in addition to, of course, the habitat and the ecology of, just, ecosystems and what's going to unravel in the ocean is going to be pretty terrifying. So, you know, we're just about at 1:30 here. I can't believe we've already gotten to 1:30 talking about corals and acidification, but you're listening to Ocean Currents. This is Jennifer Stock and my guest today is Dr. Tessa Hill from UC Davis Bodega Marine Lab and we're talking about the use of corals, deep sea corals, to learn about ocean warming periods and different environmental periods and we've just been talking about ocean acidification. We'll be taking a short break right now. So, please stay with us and we'll be back in a little bit.

(Music)

Jennifer Stock: And welcome back. You're listening to Ocean Currents and this is Jennifer Stock. I have Tessa Hill here in the studio with me from UC Davis Bodega Marine Lab and right before we took our break we were talking about ocean acidification and some of the studies on the invertebrate larvae in future ocean acidification conditions, but you also mentioned, Tessa, you were doing some other work with sediments in Tomales Bay. So, I was wondering if you could talk a little bit about some of the sediments and some of the historical periods you're learning about, potentially, with some of the work you're doing.

Tessa Hill: Sure. So, I mentioned that my colleagues and I had sort of decided to approach acidification in three different ways and one of them is raising these larval invertebrates in the lab and so, we've…my colleagues have constructed this set up for us to be able to raise a variety of different invertebrates in the lab under controlled CO2 and pH conditions.

The, sort of, second prong to that effort is to actually monitor what's going on today and so, we do that using boat surveys, both offshore Bodega as well as within Tomales Bay on a monthly basis to actually monitor things like temperature and nutrients and acidification indicators so we can see, sort of, what the natural month-to-month variability is within our ocean climate right in our backyard and also understand if it's possible that there's any anthroporgenic impact already, again, right in our backyard and then, sort of, the third way that we go about that is to use…or go about these questions is to use sediment cores, which I had kind of gotten at earlier and so, a student of mine and I are pursuing sediment coring in Tomales Bay and basically, we go out and take ten to twenty feet of sediment at a time. We do this off of a boat and we use what's called the vibra-core.

So, it's essentially, sort of, a cement vibrator that's attached to an aluminum irrigation pipe and the cement vibrator acts to, sort of, encourage that irrigation pipe to go as far into the sediments as possible and so, we get, hopefully, between ten and twenty feet, that's what we've been getting and using those sediments, we actually look at microfossils within the sediment. So, these are very small organisms that have left behind a shell in the sediments and we can actually use the shells of those organisms, just like I told you with the corals, we can use them to reconstruct things like how the chemistry of the environment has changed, how the temperature has changed, things like that and then we also use the shells themselves.

So, one of the things we're interested in is how has the environment of Tomales Bay changed over time and how is that reflected in the actual organisms that are found in Tomales Bay. So, we're interested in both, sort of, the chemical indicators, but also the biological indicators of change and when I say change, I mean of a wide variety of things, but we're interested in looking at temperature change or salinity change, perhaps changes in runoff from land as well as acidification and Tomales is a particularly excellent place to study these things because it's small and it's pretty enclosed.

So, for someone like me, I go out in the ocean and I look for places that are going to trap a good record of sediments that I can then use to reconstruct what's happened over a time and so, the sediments that flow into Tomales tend to stay in Tomales. It's a good sediment trap and then, the other reason why Tomales is particularly good for this is that we actually have a very well documented historical record of the kind of impacts that humans have had on this system over time.

So, things like cattle ranching, changes in land use, human settlements, things like that, and more recently, land that has been in the parks administration as well as restoration efforts and so, we have a pretty good idea of, sort of, what has been happening on the terrestrial side due to human impacts and what we're trying to understand is how do we see that imprint in the marine environment?

Jennifer Stock: Is it too early to tell many of these results at this point?

Tessa Hill: Well, we do have, I mean, what I can tell you is that we see…so, we have sediment cores that go back the past couple hundred years and we do see some periods of time where, in particular, the microfossil species themselves actually change over the course of these cores.

For example, there's two periods at the surface of the cores where the different species that occur seem to change fairly dramatically and so, what my student and I are trying to figure out at this point is what can we attribute to natural processes versus anthropogenic processes and maybe that we see some of both in Tomales, so, it may be that natural things, like what I was getting at earlier with El Nino and Pacific Decadal Oscillation have an impact on what of these microorganisms live in Tomales, but we think that at least one of those two shifts is probably related to a more anthropogenic change in the bay and so, you know, what we're excited about now is looking for that elsewhere within Tomales Bay and really trying to understand what has occurred to precipitate those biological changes.

Jennifer Stock: With the dating of different oceanographic periods using the microfossils and the corals, have you found that El Ninos came at a regular interval historically and did that interval change at all in more recent times?

Tessa Hill: So, this is not based on work that I have done in particular, but other colleagues in my general field have reconstructed El Nino over thousands of years and it does appear to have occurred on a fairly similar frequency over, I think, probably the last five to six thousand years. When you get further back than that, there do appear to be some changes in how El Nino occurred both in how often it occurred and also the magnitude of the El Nino events, but I think we do know that El Nino is a fairly constant part of the modern climate system, certainly over the last couple thousand years.

Jennifer Stock: Interesting. Now, also with the Tomales Bay stuff…earlier when you were talking about this, I was thinking about the different sea level changes and that we had a lower sea level and Tomales Bay was probably a dry drainage ditch pretty much and the edge of the sea level was just past the continental shelf, Cordell Bank, Farallon

Islands area. So, do you think you're going to be able to get that deep to find out what it was like then as far as that lower sea level?

Tessa Hill: So, that's a very good question. I mean, we probably couldn't using the coring technology that I just told you about. We would have to core in a different way. For example, in sort of, ten or fifteen feet of sediment, we're only getting back maybe a thousand years or so and so, you can imagine in order to get all the way back to that sea level low-stand, which would have been 18,000 years ago, or maybe even if we could get back 12,000 years ago, you would need many, many, many feet of sediment in order to get back that far. So, it certainly would be possible if we could core that deep. My guess is that you would find evidence of freshwater environments in Tomales and not a lot of seawater until probably 9 or 10,000 years ago.

Jennifer Stock: Interesting. I've had a lot of interest in finding out what the conditions were like out at the shelf near Cordell Bank historically, just because we consider it such a benthic habitat, but it really at one time, was its different type of habitat? It really would be interesting to find out…need someone to do some cores out there. How do you determined the background state or baseline state of the climate system with all of this information?

Tessa Hill: Sure. So, this really gets at why we use sediment cores as long-term climate archives. So, I've done a lot of sediment coring along the California coast, quite a bit in southern California, actually, and one of the things we've done is been able to get sediment cores that go back 50 or 100 years in time, or maybe, sometimes even longer than that and so, what that tells us, then we use the same tools that I told you about for bamboo corals and for Tomales, we look at the geochemistry of those sediments and the microfossils present in the sediments and we can actually reconstruct pretty well, over time, we can reconstruct things like temperature change, salinity change, nutrients in seawater, things like that and so, what that tells us is what did the, sort of, background state of the climate system look like long before humans ever were involved?

And that's actually the other half of my research is my interest in, sort of, the fundamental parts of the climate system. So, things like how ocean circulation impacts the earth's climate and how greenhouse gasses impact the earth's climate. These are fundamental questions that we're still learning about the earth's climate system, meanwhile, also trying to understand human impacts on that very climate system that we're still learning about.

Jennifer Stock: Right. So, is it hard to tell at this point, then, what type of environmental conditions humans civilization has brought on in terms of the historic record prior to that?

Tessa Hill: In some ways, no, I don't think so. I mean, I think that the…if you were only to look at temperature records, for example, the human imprint of global warming is stand out compared to the historical records and those sediment core records or ice core records, which are very similar. So, we really can see particularly, since about 1925 or 1950 if you look at historical measured temperature records, you can really see, sort of, this inflection of the temperatures increasing well outside of what we know the background state was for hundreds of thousands of years.

Jennifer Stock: Amazing. So, one of the other areas that you've done some work on is a broader time scale and that was with methane and one thing I learned with your website and a link from some of the work you've been doing there is about how climate change is speeding up, how methane gasses are released, and what does that effect have on the atmosphere? Can you first talk a little bit about where is methane on our earth? Is it in the earth itself, trapped in the ocean and the atmosphere and a little bit about how it's tied with the climate, global warming, and how that's impacting methane as well?

Tessa Hill: Yeah, sure. So, methane is found both in terrestrial and marine environments. It's produced by bacteria that are breaking down organic matter. So, you can find it in a variety of different places. You can find it in swampland and in the ocean as well and in ocean sediments and I've been interested in methane for a couple of reasons. One is that it's not as well-studied as CO2. So, it's intriguing.

It's a very powerful greenhouse gas. So, it can be 40 to 50 times more powerful as a greenhouse gas than CO2, but it's found in our atmosphere in much lower concentrations. So, we tend to pay it less attention and then the other reason is what you were just getting at, which is that there are large ocean stores of methane and that comes in the form of methane hydrate, which is basically a frozen form of methane that we find along continental margins of the oceans and then also, we find methane in oil and gas deposits.

So, scientifically, we would call that thermogenic methane, but that's basically methane that has been produced in the same way that our oil and gas deposits are produced and so, the work that I've done using sediment cores has attempted to reconstruct the natural seepage rates of that methane from the ocean into the atmosphere and so, we've basically developed geochemical fingerprints of what methane looks like as it bubbles through the ocean and into the atmosphere and we've been able to show that over long periods of time, the amount of methane released from the ocean goes up during time periods of climatic warming and we've done this in a couple of different places around the globe including on the California Coast, and again, this is one of those questions that we're really getting at the fundamentals of the climate system, how the climate system works, but it's interesting because that would provide what we would call a positive feedback to warming.

So, if warming starts for some other reason in the climate system, these reservoirs of methane can respond and actually release additional gas and that promotes warming even further. So, it becomes this positive loop and that's what we see in these sediment records as the earth moves from the glacial period into the modern warm period, you know, the earth as we know it. So, at about 18,000 years ago, we see these changes where temperature is warming at the earth's surface quite a bit from the glacial into the modern system and over that warming interval, those methane hydrates appear to have responded and actually released additional gas.

Jennifer Stock: So, do we have evidence that that's happening as well since we have a period of warming going on?

Tessa Hill: Well, actually, just recently there's been a lot of evidence coming out of the arctic of increased methane coming out of these frozen, basically, these sort of hydrate and permafrost environments and so, people are still trying to understand what's driving that and whether or not it's this modern anthropogenic warming that is driving it, but there's a lot of concern that that process of methane release during warm intervals is now playing out.

Jennifer Stock: This is fascinating. There's so much science going on right now, just, everything you've talked about has been really interesting in terms of putting together a climate record and studying the future for acidification and the impacts it might have on the ecosystem as well as humans, since we're so tied to the ocean. What are some of your biggest concerns from all of this that you're finding out with your research as far as the next thousand years on this planet?

Tessa Hill: Well, it's a really good question. I think we're part of a great experiment that's going on, our own experiment on the earth's surface and with the ocean and, I mean, I think that some of the results coming out of this acidification work can be quite concerning, but as I was saying to you before the show started, I think, it's studies like these that are essential.

What we need are some hard facts to deal with in terms of what we might anticipate coming in the future and then we cane make different decisions as we go along. So, I tried to try and…I try to sort of focus on that aspect of it as, sort of, how can we use this information and move forward and make good policy decisions as we move forward.

Jennifer Stock: Based on hard science instead of hypothesizing. That's good. As far as a broader picture here, I have listeners, I know, in West Marin, but also elsewhere listening on the web and is there anything that you would like to let listeners know about what their role is in protecting the ocean no matter where they live, near the coast, or near the middle of the United States, or even beyond that?

Tessa Hill: Sure. I mean, I guess probably the most important thing is it's great that people listen to this show. I think we should all try and make ourselves as educated as possible about the ocean and the natural environment and then take that knowledge with us in our daily activities when we vote, when we interact with other people…that's certainly the message I try to send.

I teach oceanography classes at UC Davis and that's certainly…I hope my students walk away with a little bit more knowledge about how the ocean works and that they carry that with them into their careers, whatever their future career may be. So, I think we could…anything that we can do to just learn a little bit more about the ocean will help our decision-making in the future.

Jennifer Stock: That's great. Thank you so much. Is there any online resources that you could direct listeners to to learn more about some of this work that you're talking about?

Tessa Hill: Sure. The Bodega Marine Lab has an excellent website and that would be www.bml.ucdavis.edu and my web page is on there. It has more information about all of these projects that we've talked about today.

Jennifer Stock: Excellent. When I was Googling to get a little bit more information, there's a lot on the MBARE website from the cruises that you did there, which is always interesting because what they do out there with their exploratory work is fascinating and one thing I just want to ask you, real quick, you mentioned that we're always learning new things about deep sea life and what not, but what's it like to be on the ship and people are discovering something brand new they've never seen before?

Tessa Hill: It's amazing. It's, I mean, I think it's life-changing as a scientist to be a part of an expedition like that where people are discovering brand new things and you also are very aware of the fact that you are seeing things that very few people on this planet have the pleasure of seeing and the honor of seeing. So...

Jennifer Stock: That's exciting.

Tessa Hill: …I should mention that in addition to acknowledging MBARE that everything we've talked about today has been supported by the National Science Foundation as well as the NOAA undersea research program and so, without federal funding like that, science like this would be very hard to do.

Jennifer Stock: Excellent, well, it's nice to hear there's funding going towards ocean research. So, much of it goes to outer space. So, it's great. Well, I just wanted…we're going to take a quick break here. We'll have a couple announcements when we come back, but thank you again for joining us in the studio

Tessa Hill: Thank you so much.

Jennifer Stock: And I will be back in just a minute here with a couple announcements. Hang on. Stay with us for a little bit.

(Music)

Jennifer Stock: And I want to just thank Tessa again for joining us here in the studio. What an incredible diversity of science going on and it's so fascinating for me to learn about how we use animals that are living today to tell us about the past. I think it's just so interesting. So, I just want to share a couple announcements. First I want to thank everyone who came out to celebrate the Cordell Bank Sanctuary 20th anniversary event with us last Saturday, October 24th.

It was a really great evening and we celebrated the early explorers of Cordell Bank before anyone even knew why Cordell Bank was so special and we have some corals on Cordell Bank, but I don't think they're as old as the ones that Tessa was describing. There's another event coming up to celebrate the work of the Sea Turtle Restoration Project.

The 20th anniversary of the Sea Turtle Restoration Project is November 14th and it's being held at a brand new lead platinum certified building center in Berkeley, the David Brauer Center, that is housing an incredible group of different nonprofits doing incredible environmental work. So, it might be interesting to enjoy learning about Sea Turtle Restoration Project and celebrating them at this beautiful facility. They have a couple different pricing options and all the proceeds go to help continue the important conservation work they're doing. So, go to seaturtles.org to learn more and get your tickets.

(Music)

Jennifer Stock: And it's just a couple months away, but I want to put the bug in your ear that the San Francisco Ocean Film Festival is coming again, February 3rd through the 7th and this is a great weekend of films from all around the world , having full focus on the ocean and it's just a wonderful event and if you're interested in volunteering, it's a great way to meet ocean-minded folks and also to see the films for free and help out the event. They really depend on a lot of volunteers for helping.

So, if you're interested of putting this on your calendar and getting involved, you can email the film festival at volunteer@oceanfilmfest.org. You can also just Google San Francisco San Francisco Ocean Film Festival, but February 3rd through the 7th, 2010 and that will be an incredible event coming up. Also, I've mentioned this place before, but I just happened to browse upon it the other day and way re-inspired to share this, but there's a wonderful resource through the Blue Ocean Institute called SeaStories.org and it's different art and writing about the ocean and they unfortunately have stopped publishing simply because of funding, but all of the work from the last few years is there and hopefully, again, they be able to just publish more recent work, but seastories.org, wonderful place to go and see what other people are writing about in terms of the ocean and it's a wonderful way to culturally reflect and share stories about the ocean.

So, today you've been listening to Ocean Currents here. We've been talking with Tessa Hill from Bodega Marine Lab, UC Davis and learning a little bit about how we're using the ocean for studying the science and environmental change and climate change for a huge period. It's pretty exciting to hear of the different types of work that's happening here locally in Tomales Bay and out on the Continental shelf along the Pacific Rim, but we will be back next month. Ocean Currents is part of a monthly, well, actually weekly series, the West Marin Matters Series.

Every Monday at 1 you can hear a locally produced program that relaters to the environment and I'm not sure what we're going to do next Monday, next month, but we will have something back live, I'm sure and if you're interested, I have all the past shows from Ocean Currents on our podcast and you can go to CordellBank.NOAA.gov to download all the past shows and you can subscribe to a podcast to hear those as well.

So, don't forget about those if you want to turn in to the past few years and see what we've had on the show here. You'll get quite a broad overview of different ocean topics. So, I'd like to say thank you for tuning in. Enjoy this beautiful weather. You're listening to KWMR, Point Reyes Station and Bolinas. Thanks for tuning in.

(Music)

Jennifer Stock: Thank you 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 of 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.