

Jennifer Stock: 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, authors 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 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. Just off shore of the KWMR listening area on the West Marin coast are the Greater Farallones and Cordell Bank National Marine Sanctuaries, which together protect 4,881 square miles of ocean waters.

The theme of today's show is neurotoxins. A neurotoxin by definition is a substance that inhibits, damages, or destroys tissues of the nervous system, and they seem to be all around us in the ocean and the air. It's February 1st, and while we've enjoyed some tremendous rains on the coast, I've been wondering what's happening with the large-scale, harmful algal bloom that has had quite a tremendous impact on the coastal communities up and down the coast from Southern California all the way up to Canada. So in a few minutes, Vera Trainer, an oceanographer from NOAA, will join us to talk about the current state of this large-scale harmful algal bloom. And unfortunately this has prevented the opening of the Dungeness crab fishery in California, still to this day. Later on in the show, Bodega Bay community member and fisherman, Dick Ogg, will call us to talk a little bit about how the Bodega Bay community is coping with that closure. Then later on the second half of our show, we'll focus more on the coast and new findings about what's in the fog. Dr. Weiss-Penzias from UC Santa Cruz will join us to share a little bit more of the research he's been finding in his fog studies. So stay tuned for a full show here on Ocean Currents. Stay with us.

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You're listening to Ocean Currents here on KWMR, and today on this first half of the show we're going to get an update from Vera Trainer, an oceanographer with NOAA. Welcome, thanks for joining us. You're live on KWMR, and I'm really happy to bring you on Vera, specifically because you were on KWMR last year talking about this at the beginning of this algal bloom, and from my understanding, it's still going on, and I'm wondering if you could give us an update after all the research you've been doing about where are we at with this harmful algal bloom along the West Coast?

February 2, 2016, oc020116.mp3

Nasty Neurotoxins

Jennifer Stock, Vera Trainer, Dick Ogg, Dr. Peter Weiss-Penzias

Vera Trainer: Yeah, thanks a lot for the invitation to talk to folks. When you say the algal bloom is going on, its effects are still being felt, but live, toxic cells large bloom is not present offshore right now. We have folks on a research vessel, the research vessel Shimada, as part of a winter hake survey, who are sampling some of the phytoplankton offshore, and looking to see what is present. They've seen very low numbers of the cells that caused the big algal bloom last spring, but such low numbers that we're really not concerned. However, what has happened is this big bloom that was present in the spring and summer last year, it has sunk into the bottom waters, into the sediment. You have organisms like crabs, sand crabs, Dungeness crabs, even rock crabs that are potentially feeding on organisms that are found in the sediments, and they are basically continuing to accumulate these toxins or some organisms like Dungeness crab that have high levels of toxin in their viscera, they just haven't gotten rid of these toxins from this bloom that occurred last year.

Jennifer Stock: How long does it take for a system to somewhat flush of this toxin produced by the plankton? I understand it's not live or necessarily abundant in the surface waters, but it continues on the sea floor. How long does it take for a system to flush it out? Or does it?

Vera Trainer: Well, let me talk about the organisms. So, razor clams, and Dungeness crab, and I believe some rock crabs in California are still containing in some places high enough level of toxin to keep those fisheries closed. Twin Harbors off the Washington coast is just lurking right around the regulatory level. Razor clams are going above and below, so the fisheries—the razor clam harvest—are closed at Twin Harbors right now. And it's the only location in the coast. I believe Trinidad, that area at the border of California and Oregon, is still closed for some of the crab fisheries. So those organisms are retaining these toxins for what is it now, at least 6 months to 8 months, from a bloom that occurred last spring. As far as how long these toxins reside in sediment, they are there but they are I would say concentrated right after the bloom happens. So the major effects are going to happen right after the bloom starts decaying. After that time you are going to get some mixing, you're going to get some stirring up of the sediments, winter waves, and winds are going to start really mixing things up. So our hope is that some of these effects are going to dissipate pretty quickly. So unless we have a new bloom, which we have El Niño coming, we anticipate we're going to see something. We don't know how big it's going to be, but if we don't have a new bloom, we think that these effects are going to continue to decrease, toxin level are going to continue to decrease, and all of these fisheries are going to be able to open soon.

February 2, 2016, oc020116.mp3
Nasty Neurotoxins
Jennifer Stock, Vera Trainer, Dick Ogg, Dr. Peter Weiss-Penzias

Jennifer Stock: Well, that's really good news to hear. I wanted to ask: You know, it sounds like some monitoring is done by shipboard opportunities like the Shimada that is out at sea. Are there other ways to monitor plankton blooms like this? Or at least toxic blooms?

Vera Trainer: Yes. As far as what happens well off shore, really ships are the best way to identify what is there. Sometimes we can use satellite images, but as you know, we sometimes have fog or cloud, and that really hinders what we can see by satellite. We have a number of programs that look for these toxic cells in waters up against the beach, every single week. I know the California Department of Public Health has a monitoring program like that. We have a couple of programs in Washington, one called the ORHAB (Olympic Region Harmful Algal Bloom) Program, and the other Sound Toxins, which is localized and Puget Sound, and we have folks looking in their microscopes every single week. And there are also some rapid methods for assessing whether the plankton that are seen are highly toxic or not, and some of these monitoring programs are starting to incorporate those.

Jennifer Stock: I'm anticipating we're going to be seeing more of these monitoring programs continue year-round as one of the predictions with warming ocean is to have potentially more harmful algal blooms.

Vera Trainer: Yeah, I have to say they are really fantastic. Some of the programs have paid participants, but others, for example the Sound Toxins program in Puget Sound, it's folks who are really interested in being better in touch with their coastal waters, understanding what is there. So we have private citizens, we have environmental learning centers, we have shellfish growers and tribes, all participating in this program. A microscope has provided folks learn how to do the analysis, to do the microscopy, to identify these organisms. And for us scientists, you can't be at all the places all the time. This is an invaluable way for us to have eyes on the shorelines to see what is there. And it really enhances our research capabilities as well.

Jennifer Stock: That's fantastic. More data is better. As long as you have the ability to handle it all. In terms of adaptation, I know one of NOAA's big missions is to help coastal communities adapt with the changing conditions we're having. What are some different types of mitigation ideas in regards to dealing with these harmful algal blooms? They obviously have really large consequences for specifically coastal communities, but economically as well. What are some different ideas that are being thought about in

February 2, 2016, oc020116.mp3
Nasty Neurotoxins
Jennifer Stock, Vera Trainer, Dick Ogg, Dr. Peter Weiss-Penzias

terms of how to continue to live and earn money, when we have these large blooms that shut down fisheries?

Vera Trainer: I can't give all the answers, but I can give one example. And I think more knowledge means greater security. So, I mentioned this ORHAB project in coastal Washington, back when domoic acid became a problem in 1991 to our coast. The state managers would just close the beaches if there was any sign and any increase in toxicity in shellfish. Now, because we have this plankton monitoring, they have greater security. They know what is happening at many of the beaches along the coast. So, they are able to selectively close those beaches that have a problem while opening others. So when you make a plan to go razor clamming, there's a pretty good likelihood that you're going to be able to go clamming at at least one of the beaches, whereas in the past, there would be these emergency closures coast wide. It's our hope that that can be a model for how we live and adapt with these increasing harmful algal bloom events. The more we know, the greater the potential for these selective closures of only certain fisheries that are affected.

Jennifer Stock: Now, I can understand with clams and other shellfish, they don't move, so they're in the ground, but what about for crab that are moving around? And I know that's affected how they've considered opening the fishery along the state of California. How do you think that might affect that?

Vera Trainer: Well, we know for example this year that there were several hotspots in California: Santa Barbara area, Santa Cruz, and then up at the California Oregon border. I think by understanding what's happening at these hotspots, there's greater confidence in opening the crab fishery in those areas. You're right, the crab do move, but they're somewhat of a limited range in which they move in a certain period of time. So, I think that you can manage your state with confidence that crabs in this particular area are going to be okay. And the greater warning that they can give to the fishers, the greater the potential that the fishers will go to those areas, where they are safe.

Jennifer Stock: Excellent. So hopefully there will be some new adaptations of how we can open fisheries in the future. Now, back to the species that we were talking about, this is one specific species of phytoplankton, I understand: *Pseudonitzschia*. Correct?

Vera Trainer: Well that's a genus, and there are over 20 species of *Pseudonitzschia*, some of which are very highly toxic, and some much less toxic. And unfortunately, the bloom in 2015 was

February 2, 2016, oc020116.mp3
Nasty Neurotoxins
Jennifer Stock, Vera Trainer, Dick Ogg, Dr. Peter Weiss-Penzias

primarily composed of very healthy cells of *Pseudonitzschia australis*, which is one of our most toxic species.

Jennifer Stock: Okay. Now, one thing I've read with warming conditions—one thing we've seen up here—is tropical species of plankton showing up here. Is this a widely dispersed species, up and down, all around the ocean? Is it one that could potentially be displaced? How does that happen?

Vera Trainer: That's a really good question. We're actually looking at that very carefully. *Pseudonitzschia australis*, especially in the spring, we think is more of a southern species. But because we had enhanced northward transport, including some unusual zooplankton species and fish species going in far north as far as Alaska, we think that those conditions as well as the anomalously warm water brought sort of these invasive species further north. *Pseudonitzschia australis* is not typically seen in high numbers off our coastline, let's say Washington, British Columbia, early in the spring. And we think that it was an anomaly last year. Whether we'll see more of this, we just don't know. I think the potential is there. We're almost considering that this cell was an invasive species last spring.

Jennifer Stock: Wow. It's amazing, the microscopic has so much punch for really affecting everybody in the west coast here, so that's really interesting. In just a minute or two I'm going to bring on Dick Ogg, a fisherman out in Bodega Bay, to talk a little bit about what's been happening in Bodega. But could you just share, are there any online resources that folks could go to learn more about harmful algal blooms and how NOAA is studying them?

Vera Trainer: Well, we have a webpage. We're at the Northwest Fisheries Science Center, so <https://www.nwfsc.noaa.gov>, also the Woods Hole Oceanographic Institution has a really fantastic website on harmful algal blooms. And then California, there are various programs in California, so if you would Google California and harmful algal bloom I'm sure you'd find a lot.

Jennifer Stock: Great. Well, thank you so much Vera, for the update, and I really appreciate the continued monitoring that you've been doing up there throughout the three states here, and hopefully we'll see some changes in the next few weeks with the fisheries.

Vera Trainer: You're very welcome.

Jennifer Stock: All right, take care, Vera.
That was Vera Trainer with Northwest Fisheries Science Center, and she just gave us a little update about the harmful algal bloom that we've been experiencing on the west coast here. I

February 2, 2016, oc020116.mp3
Nasty Neurotoxins
Jennifer Stock, Vera Trainer, Dick Ogg, Dr. Peter Weiss-Penzias

want to bring on Dick Ogg, who is a fisherman in Bodega Bay. His boat, the Karen Jeanne, is at Spud Point Marina, and he has been a fishing community representative on the Cordell Bank National Marine Sanctuary Advisory Council. So Dick, thank you for coming on Ocean Currents. You are live on the air.

Dick Ogg: Thank you Jennifer, I really appreciate the opportunity.

Jennifer Stock: Thank you so much for calling, and being so involved in communicating between the Bodega Bay community and everybody else about the impact of this closure. Dungeness crab is a huge, important economic piece of the pie here in California, but I know specifically for small fishing communities like Bodega Bay. How is the Bodega Bay community coping with the lack of a season this year?

Dick Ogg: Well, quite honestly, with the less and stellar salmon season and no crab to speak of at this point, the fishing community in general has been in a desperate situation. Our bills continue to add up, and we haven't any income for quite a few months. It's put us in a very, very awkward spot. Fortunately, right at the moment, there's been an opportunity for us to get a little bit of money from another fishery, which is black cod, and a number of us are trying to utilize that to hold ourselves together here for a while. Right now we're trying to utilize a fish called sable fish or black cod, it's known on the common market as butterfish, and that's not a large amount that we can get. We're limited by quotas, but the guys are trying their best to make it work with the little amount that they are allowed.

So, that's part of what is happening, but the captains, we tend to be able to weather this a little bit better; the people I was most concerned about were the crew members, the guys that really keep us afloat, the guys that do all the work. These guys have no source of income. They rely on us every year for providing them with a source of income. And with the lack of salmon and all, crab season we were hoping was going to be fairly good, and unfortunately, as it's turned out, there's been no income for the guys at all. Many of them quit their jobs to be able to come over and put a couple of months in to gear together and get ready to work, while like I said, now they have no income at all.

Jennifer Stock: Have there been any local relief efforts set up to help folks in terms of fundraising drives, or food drives? Are there ways that listeners could potentially help relief some of the effects that have been felt by folks that are not making any money?

Dick Ogg: Absolutely, and thank you for asking. There's a food bank that Lori Cavanaugh put together between her and the Chamber of

February 2, 2016, oc020116.mp3
Nasty Neurotoxins
Jennifer Stock, Vera Trainer, Dick Ogg, Dr. Peter Weiss-Penzias

Commerce out here, the President, Patty Ginochio, put together at the Marina, that anyone can bring by food and leave it at the Spud Point Marina. They can leave the food there, it's distributed to the deacons. We also have a freezer for frozen products, and we're trying to get donations for the frozen products too, so that we can give the guys some extra food and so on and so forth. And it's been absolutely fantastic. The community's support has been just incredible, absolutely incredible. I can't say enough about the community support that we've had. In addition to that, the county stepped up, and Carol Heart, Jim Intel, Shane Lewis, have all put together a foundation that is a vital one through T3 that you can donate directly, and that is a one-to-one. If you give a dollar, a dollar gets to the deacons. And Carol Hart came up with the idea of offering \$100 gift cards to the deacons and we've done that now 2 times, and we're looking at doing it again. That's another way to support the crews and the people out here too.

Jennifer Stock: Is that through the Sonoma County Regional Parks Foundation?

Dick Ogg: Yes, ma'am. Do you want the website?

Jennifer Stock: Well. I think if people Google "Sonoma County Regional Parks Foundation", they could probably get to it, where they could get information. Is that correct?

Dick Ogg: That's correct.

Jennifer Stock: Okay, good to know.

Dick Ogg: They can also call Pam McBride at 565-1355 and she can also help with credit cards, and so on and so forth.

Jennifer Stock: Is that area code 707?

Dick Ogg: Yes, ma'am.

Jennifer Stock: (707) 565-1355, and that's to take credit card donations, you're saying.

Dick Ogg: Yes, it is.

Jennifer Stock: So I understand that a bipartisan group of legislators actually requested California governor Jerry Brown to declare a fishery disaster due to the impact of the closure last year. What does this do for communities for Bodega Bay that are really impacted by this?

February 2, 2016, oc020116.mp3
Nasty Neurotoxins
Jennifer Stock, Vera Trainer, Dick Ogg, Dr. Peter Weiss-Penzias

Dick Ogg: Well, right now we're just hoping that this moves up and Governor Brown signs the declaration. From that point on, I'm not exactly sure how the funds are distributed or if where they're going to get them from, and so on and so forth. But we do need to have that done. That's very important. I don't know there's any way we can recover what we've already lost financially. Even if they do open the season now, it's just going to be very, very difficult for everybody, so I'm hoping that Governor Brown follows through on this, and there's a lot of hope from all of us that everything is going to work out.

Jennifer Stock: Crab season usually goes until June, for commercial. Do I have that right?

Dick Ogg: Yes.

Jennifer Stock: So if it did open now, there'd still be a couple months to maybe recoup some funds?

Dick Ogg: That's true, there would be. One of the problems is, the crabs go into their mating season, and when they do that they don't eat. And number two, shortly after that they begin to molt: when crabs turn soft, their meat goes away, and it would become basically water, and their shells harden up and there'd be meat again and everything kind of cycles through. It usually takes 3~6 weeks, and that puts you sometime in the latter part of April, until you can actually start to fish again. This could be very, very detrimental. The other thing is that the product is not necessarily sought after, after some time around April, because most of the crab season's gone—no Christmas, no New Years, no Super Bowl. People start to look into salmon. So it's a very difficult thing for us right now. We're still doing the testing; I'm included in that. I help testing for the state, and we still have crabs that are above the action level. We're continuing to test and hope for the best, and we're just going to hope it's going to clear up, and hope we're going to be able to fish.

Jennifer Stock: Great. Dick, thank you so much for the update. We're just about the half hour here. Are there any last things you want to share with the audience about what's happening out there?

Dick Ogg: Well, one thing I would like the audience to know is that the fishermen are opening a community fishing association. We offer fresh products from the boat, at Masons Marina. We are in the process of putting this all together, and we're hoping that we can provide the community with sustainable, fresh products from the local fishermen here directly across the Bodega Bay at the Masons Marina, so that's a new and upcoming opportunity for the community in this area.

February 2, 2016, oc020116.mp3
Nasty Neurotoxins
Jennifer Stock, Vera Trainer, Dick Ogg, Dr. Peter Weiss-Penzias

Jennifer Stock: Wonderful. Well, thanks for sharing that. Community fishing association at Masons Marina, and you'll keep me posted so I could share that. I hope it comes along.

Dick Ogg: Yes, thank you so much.

Jennifer Stock: Fantastic. Well, Dick, good luck, and thank you so much for sharing what's happening out there. And we'll keep our fingers crossed that there can be some relief for the group out there as well as up and down the entire California west coast for a lot of folks impacted. So thank you again for calling in today, on Ocean Currents.

Dick Ogg: Jennifer, have a wonderful day. Thank you.

Jennifer Stock: You too. Take care.

Dick Ogg: Bye bye.

Jennifer Stock: Bye bye.
That was Dick Ogg, a fisherman out in Bodega Bay, talking a little bit about the impacts that the closure of Dungeness crab fishery has had for the community. And this is all caused by the harmful algal bloom, that has toxic plankton that's making it very unsafe for consuming Dungeness crab. And he mentioned a couple different ways if folks want to help communities that really relies on its income. Sonoma County Regional Parks Foundation has an account to help deacons and whatnot, and they have gift cards, and are accepting cash donations, and it goes 1 to 1 to the fishermen. You can look at Sonoma County Regional Parks Foundation online. You can also call directly (707) 565-1355, and they'll accept credit card donations to help. And there's also a food bank at Spud Point Marina, all the way down there out of Bodega Bay. So if you happen to be going out there, bring some food to help share. It's pretty tough. This is an important fishery for the community, and it's been a real tough thing for everybody. So let's hope for the best that things turn around really quickly.

We're going to take a break here. It's KWMR Point Reyes Station, and in a few minutes we'll come back and talk about fog, and what is in fog. We are about to learn a little bit more than I knew about until recently, about what's in fog. You're tuned to Ocean Currents. Stay with us.

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February 2, 2016, oc020116.mp3
Nasty Neurotoxins
Jennifer Stock, Vera Trainer, Dick Ogg, Dr. Peter Weiss-Penzias

This is Ocean Currents. My name is Jennifer Stock. We're going to switch gears to another topic, but still related to neurotoxins. On the west coast, the coastal Pacific ocean waters mean warm, air masses, and make fog. Fog rolls off the ocean, and it brings cooling air across the Bay area and other coastal communities up and down the higher west coast. A huge percentage of our country's food comes from this region, I'll also add wine as well, because of this fog. But do we know what's in the fog, besides water moisture? Well, today my guest, Doctor Peter Weiss-Penzias, an environmental toxicologist from UC Santa Cruz, is going to help enlighten us based on some studies he's been doing. So I'd like to welcome Peter, you're live on KWMR.

Peter Weiss-Penzias: Hi, it's nice to be with you.

Jennifer Stock: Thanks for calling in today.

Peter Weiss-Penzias: Sure.

Jennifer Stock: Fog. This is such a big part of our lives here, and I don't know if many people have thought too much about what's in fog besides moisture, but certainly you have been. Why did you initiate studying fog?

Peter Weiss-Penzias: You're right. It's something that's all around us if we live on the coast, and a lot of people have personal experiences with it, and if you look in literature there hasn't been a lot of chemical characterizations of actually what's in the fog. But my reason for studying it was pretty specific, and that was in the complicated cycling of mercury, which is a neurotoxin that we'll talk about. There was this hypothesis that this mercury in the ocean, which is just floating around as inorganic mercury, can become methylated by these bacteria that live deeper in the ocean or in the sediment where there is any oxygen. And this methylmercury can incorporate into the food web of the ocean. That's well known, and can be built up into the higher trophic-level fish, so on and so forth.

But a certain form of this methylated mercury, which is called dimethylmercury, is produced, and it is actually volatile. There's not a lot of information on dimethylmercury because it's incredibly toxic, and it is volatile. There's maybe only 2 or 3 laboratories in the whole world that even work with dimethylmercury, because it's just super toxic, and you need to have a fume hood within a fume hood, within a ventilator room even to work with it. So a lot of basic chemical information is not really well known about it, and it's also produced in very low concentrations in the ocean. But it was thought that along the coast, especially in California and other places where you have

February 2, 2016, oc020116.mp3

Nasty Neurotoxins

Jennifer Stock, Vera Trainer, Dick Ogg, Dr. Peter Weiss-Penzias

upwelling, it brings the deeper water to the surface, and even bring sediments to the surface, that there could be dimethylmercury brought along with that deeper water, up to the surface, where it would then evade to the atmosphere. If that were occurring, this dimethylmercury would be rapidly taken up by a cloud droplet, and it could accumulate into the fog. That was idea that I wanted to test, and it turned out that nobody had every really measured methylated mercury in fog water before.

Jennifer Stock: Interesting. So, did you find dimethylmercury?

Peter Weiss-Penzias: Well, we don't actually test for dimethylmercury, but we test for its breakdown product, which is monomethylmercury. So the two methyls on mercury is one methyl too much, apparently, and it rapidly degrades, especially at the acidic pH of cloud water. And then monomethylmercury can be stable for an order of a couple days, but it is also pretty reactive. But it dose find its way into cloud water.

Jennifer Stock: I'm assuming any sort of mercury getting into the food web is not a good thing. We know that mercury is toxic, specifically for pregnant women, they're really warned to be careful of mercury ingestion through seafood. Are we talking about the same type of mercury here that is potentially in the fog?

Peter Weiss-Penzias: Yeah, absolutely. The reason that it was of primary concern to learn about this is because in rainwater, which there has been lots of measurements of mercury in rainwater, in fact there is the mercury deposition network, which is almost 100 sites across the US and Canada where they collect weekly measurements of rainwater and they test the amount of mercury in it, they're looking for total mercury, which is dominated by inorganic forms. And these forms are important, they get into the ecosystem and they find their way in fish in so forth. But what we were suspecting in the fog was actually the methyl mercury. Methyl mercury needs to be formed in anoxic environments, so there isn't typically very much methyl mercury in plants or soil or on the surface of things, because we live in an oxygenated environment, and we wouldn't have these bacteria that form methyl mercury. So the possibility that it could be raining out of the sky in enhanced concentrations—relative to what we've seen in rain, which is very low and practically negligible— was seriously interesting to us.

Jennifer Stock: And with the presence of fog, it's almost like a constant effect it seems along the coast. There's fog a good portion of the year, even if it's in low concentrations, it still has moisture there.

Peter Weiss-Penzias: Yeah, it's true, and that's the study as well: it's to try to quantify the amount of water that the fog delivered to the terrestrial ecosystem, because there's scant data on that as well.

Jennifer Stock: I want to ask two questions. I want to come back to the plants in the second, but I wanted to go back to where is the mercury coming from? You talked about upwelling of the ocean, mercury is a naturally occurring element, but is the source really the ocean? Or, I was assuming this was from pollution from burning of fossil fuels.

Peter Weiss-Penzias: Well, it's a multi-hop mechanism. Mercury indeed is a naturally occurring element, and all of the mercury that was on planet Earth when it was formed is still here with us, so we haven't made mercury—like alchemists— or anything like that, but what we're doing is we're increasing the rate of its cycling. We're digging up the sequestered mercury, just like we do with carbon, and putting it into the atmosphere. So you're right that we can trace back the source of this mercury, likely to atmosphere commissions, but there are other sources, so we can't say for certain. Mercury was used extensively in gold mining, especially in California, but a lot of that mercury is bound in sediments: it's not really going anywhere. Once it makes it out of the San Francisco Bay, it's pretty firmly attached in a mineralized state, so it's getting buried with ocean sediments.

The likely source of the mercury that's sending up in the fog comes from emissions to the atmosphere. Right now it's estimated that about 3/4 of atmosphere commissions are from anthropogenic sources, and about 1/4 is just purely natural. But our activities can influence the natural sources as well, like those coming from soils, or maybe biomass burning due to our natural processes, but when we have land disturbances or we cause climate change and more biomass burning, then that releases more mercury into the atmosphere. As far as the industrial sources go, the two main sources are combustion of coal and coal fire power plants, and in small-scale gold mining operations which are primarily located in the tropical countries, like Peru, Indonesia, and Central Africa. But they still use a lot of mercury for their gold extraction processes. So it makes it in the atmosphere, it's fairly inert in the atmosphere, fully oxidizes and rains out, and gets into the ocean in a molecule-by-molecule sort of way. Once in the ocean, undergoes another cycle involving the bacteria that methylate it, and some of that evades back to the atmosphere, some of it gets incorporated into the biota and it's hopefully eventually going to attach to a thinking particle and go down to the sediments and become buried until it leaves the system.

February 2, 2016, oc020116.mp3
Nasty Neurotoxins
Jennifer Stock, Vera Trainer, Dick Ogg, Dr. Peter Weiss-Penzias

Jennifer Stock: That's fascinating to talk about that whole cycle of mercury, we typically are thinking about carbon cycling through that. I didn't really know about the mercury and the whole.

Peter Weiss-Penzias: Yes, it's a lot less concentrated, but every element cycles, and mercury is very analogous to carbon because it has a presence in the atmosphere and a fairly long lifetime, it oxidizes, and it's also taken up by plants, directly.

Jennifer Stock: That's what I wanted to ask. We have fog along the coast, we've got a lot of plants, fog deposits on the plants, and you were talking about anoxic environments. Is anoxic without oxygen?

Peter Weiss-Penzias: Yup.

Jennifer Stock: So if it's landing on the plants, there's obviously oxygen, but you're saying when it sinks into the soil it becomes anoxic. But can the plants take it up?

Peter Weiss-Penzias: Yup. We don't know that much about it. We know redwood needles take up fog water. Some other plants do take up fog water through their leaves, and if there's methyl mercury in the fog water, that would go directly into the plant. The water can drip off the needles and go into the soil, and also, that can be taken up by the plants as well. Plants also take up mercury that's on the gas phase just straight out of the air, but then they'll sometimes release it back. So that's sort of a two-way flux.

Jennifer Stock: Interesting. So all of it's very low-level but is there concern about bioaccumulation overtime and addition to all the other things that were bioaccumulating, it's like "one more little stressor!"

Peter Weiss-Penzias: Yes, there is some concern. We're working with some wildlife biologists right now, and quantifying the amounts of mercury in the tissue of terrestrial species. We've been looking at plants, redwoods, other plant species along the coast and inland from some Sierra Nevada sites, and we're looking at deer fur, and puma fur and whiskers.

Jennifer Stock: Interesting.

Peter Weiss-Penzias: And the fur is a convenient sample to measure for mercury because mercury binds tightly to proteins and to sulfur-containing proteins, and we have an abundance of those in our hair. So that is one way in which mammals get rid of mercury in their bodies, is just through the hair. If you want to get your mercury levels checked, you can just give a hair sample. And that tends to show you accumulation of mercury over a long

period of time. If you want to look at acute poisoning, then you would test one's blood, but for an animal like a puma, the fur is a very good way to see their accumulation over time. And what we've found so far—and this research is ongoing—but we presented a poster on this at the American Geophysical Union Conference in San Francisco just last month in December, and we found higher concentrations of mercury in coastal pumas and coastal deer, compared to their inland counterparts.

Jennifer Stock: That would probably translate to people that live here on the coast and if they have a food locally grown here as well, they may have higher levels of mercury, too?

Peter Weiss-Penzias: It's possible. I don't know if I can go that far. I think with humans that would be really, really hard to show because we eat food from all over.

Jennifer Stock: Right. There's so many other sources.

Peter Weiss-Penzias: Yeah. And pumas are really specific: 95% of their diet is deer, so they're like "what's for dinner tonight?" "deer" "again?"

Jennifer Stock: Some people rely on tuna as their food, and tuna's got a lot of mercury.

Peter Weiss-Penzias: That's true.

Jennifer Stock: "What's for dinner? Tuna!"
What are you thinking for the next steps of this study? What do you want to know more about?

Peter Weiss-Penzias: Well, there's a lot of gaps in our understanding, just the basic chemistry and transport of this methylated mercury from the ocean to the fog and deposition on to land. There's a lot of details: Is it happening in particles? What are the reaction rates? And we've been collecting fog at different locations and looking at the amount of methyl mercury. What we found—and this will be in a paper that should be coming out next month in the journal *Elementa*—is that among all of our sites, there was highest levels of methyl mercury right along the coast, and then it decreased as one goes inland. Our most inland site was 40km from the coast, but still received a lot of fog, near Santa Rosa.

Jennifer Stock: Wow.

Peter Weiss-Penzias: And so this kind of behavior—plus we also collected fog over the ocean 40km offshore, and that had very low concentrations of methyl mercury. So we're seeing highest right along the coast, decreasing inland, and decreasing offshore. So

February 2, 2016, oc020116.mp3
Nasty Neurotoxins
Jennifer Stock, Vera Trainer, Dick Ogg, Dr. Peter Weiss-Penzias

we're trying to come up with a mechanism that can explain all that. We were thinking it could have something to do with the near-shore environment, like wave breaking, but we need more measurements, and we might try to collect fog droplets in a different platform, possibly a drone: put a little fog collector on a drone and fly it through a cloud right above the ocean surface and collect the droplets.

Jennifer Stock: Neat. Is there a website where people can learn more about this study and the fog collection sites that you have?

Peter Weiss-Penzias: Yeah. Our website is fognet.ucsc.edu.

Jennifer Stock: fognet.ucsc.edu. I know people were really interested in fog nets earlier in the year when we were talking about drought and I used to work on Catalina Island and they experimented with fog nets out there to collect water. They were playing with the idea of it. But it's interesting. It's also a tool for collecting fog to study, so fognet.ucsc.edu.

Peter Weiss-Penzias: Yes, and it's a blog, so anyone can sign up on the site, and they can post if they have information about fog, whether it's scientific or observational, because we live in the coastal environment. One thing that we've learned is that fog is fickle. Very difficult to collect it, sometimes it's foggy 100ft up and not at the surface. Sometimes it's foggy at the surface and not up. It's very hard to predict fog events, and the chemistry of it seems hard to explain at this point. Right now we're also interested in other talks in the fog that could be moving from let's say Ag field or industrial areas.

Jennifer Stock: Wow.

Peter Weiss-Penzias: Right now I'm collecting fog in Merced, so we're trying to get some tule fog samples. That is a control for the non-marine environment to see what the methylmercury levels are. We expect them to be very low because it's the non-marine environment, but we'll find out.

Jennifer Stock: Well thank you, Peter. It's really interesting to hear about the study of fog and a great place for people to learn more about these too. fognet.ucsc.edu. And has human health implications, so I appreciate that. Thank you.
I wanted to go out with a song that you wrote and sang. You have a whole other persona as the singing scientist.

Peter Weiss-Penzias: That's right.

February 2, 2016, oc020116.mp3
Nasty Neurotoxins
Jennifer Stock, Vera Trainer, Dick Ogg, Dr. Peter Weiss-Penzias

Jennifer Stock: Tell us a little bit about how you got into these great songs, by the way. Listening to them and my son is going to love them. I can't wait to play them with him. How'd you get into the music?

Peter Weiss-Penzias: Well, just as a kid, I played a lot, and at school was in bands. When I was in graduate school I sort of led this dual life: I was in a rock band in Seattle where I was in graduate school at the University of Washington, and we'd play in clubs at night. I'd be in the lab in the day and the two worlds never seemed to come together. Then I started raising kids and writing kids songs, and just wanted to have more of a message just to educate people about the environment and inspire them, and I just thought through music was a great way to do it. I just started becoming the singing scientist and playing shows, and made a CD. I'll be playing on March 6th at the UC Santa Cruz arboretum for their Hummingbird Days. My website there is singingscientist.com and you can check it out, listen to my music and I really appreciate you spreading the word.

Jennifer Stock: Excellent. Well, we're going to go out with *Do As You Otter*. Thanks again, Peter, for coming out on Ocean Currents today.

Peter Weiss-Penzias: Okay, my pleasure.

Jennifer Stock: Take care.

Peter Weiss-Penzias: Bye.

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