FROM THE FIELD - EPISODE 6 - CAROLINE PALMER TRANSCRIPT

Caroline Palmer: it was after a fellowship interview that I had where I'd, given the panel, my cv, which had my publication list in black and white string of first author papers, Phd, cum laude, which is with honors. And they simply did not believe that I had achieved what was on my cv and I was gobsmacked when they kind of presented this to me. I simply didn't know what to say. It had never occurred to me that, that people wouldn't believe that I had achieved what I had achieved. And it was sort of in that moment that I realized that I simply was not the right fit. I was too young to female to something and, and it just struck me that, wow, I could discover the key to immortality and it wouldn't matter because I'm just not the right fit. And Yeah. So I left.

Priya Shelly: Welcome to From the Field, a podcast logging real life scientists and their efforts to improve the world one study at a time. I'm Priya Shelly.

In this episode, I speak with Caroline Palmer, a scientist who earned her Ph.D in Reef Coral Immunity with a focus in coral reef conservation. Caroline co-established the field of coral immunology and she is testing her hypothesis through a project in Costa Rica called Seeking Survivors. She believes that coral immunity is key to keeping coral healthy and alive through events like global warming. Initially, it wasn't all clear tropical waters for Caroline. She pretty much started out with the opposite.

CP: So I first became interested in coral reefs. I mean, I think it stemmed from my fascination with the ocean and the sea. I've always been quite drawn to, to the sea and I learned to dive in the UK when I was about 14. British diving is pretty cold and a lot of it's focused on shipwrecks and finding treasure was a lot more interested in, the sea creatures and, and what was going on with the biology of things. when I went to university, I became really curious about coral and coral reefs, sort of in my spare time if you like, and a lot of dive trips and things with, with surrounding going to tropical coral reefs and how beautiful they were. But there's also talk of this coral bleaching and coral reefs dying.

I just got curious really and started to think, well, what, what is coral bleaching and why are they dying and if they are dying, why is nobody panicking about this? This sounds like a pretty major thing. So I just started reading really in my, in my spare time and, and taught myself myself sort of the basics of, of coral biology, what corals are and how they function and what a reef is. and so that, that curiosity, it's just led me to, well, to, to project in Indonesia where I dove for the first time on coral reefs, but while doing science and I was there to measure coral disease prevalence and that sort of designed this research project from my, you know, student flat in England and suddenly I was immersed in this warm water surrounded by color and an amazing creatures of all shapes and sizes. What I was drawn to the most was the coral and the fact that these things were growing up against each other and interacting with one another some were diseased and some were perfectly healthy. All these questions just popping in my mind, like why.

So I had done my bachelor degree in marine biology and then I carried onto a phd in immunology. And then after that I got a postdoc position, which is typically what follows when you're sort of on the academic pathway,

PS: At this point, Caroline really made a case for Coral Immunology and believed that her work could benefit many other scientists trying to protect and save the coral reef. Unfortunately, the world of academia had other plans for Caroline and her hard earned work.

CP: I chose to leave because I've had a really hard time and both my phd and my postdoc, with things like bullying by, academic staff, sexual harassment and assault being gaslighted,

having ideas stolen. I mean it was just brutal and I got to the point during my postdoc where I just really started to weigh up the costs and the benefits here, um, and it was costing me just far too much personally. So I decided to leave and that was absolutely the best decision because nobody deserves to be treated like I was being treated. Especially when you know, you're trying to, to just get on and do your job and contribute to science and scientific knowledge and to the world.

PS: Caroline took a big step back from the academic ring and while focusing on her family, became a health coach for those suffering with auto-immune diseases. Though still focusing on immune systems, Caroline found herself thinking about the state of coral reefs and decided to re-assert her focus on the bigger picture.

CP: It really was a grieving process for a long time after I decided to leave, and not just grief for sort of my career path and for what I'd invest in it, but also sort of this grief almost if you like for science and actually that there are so many missed opportunities that, you know, because one powerful person doesn't want you to succeed. Then that whole line of research will never get investigated and that's shocking, especially when we're in sort of when the world's in the state that it's in with climate change and things like that.

We need good ideas. But I think, what's more terrifying is not doing anything and sitting by when we have all of this expertise on coral biology and conservation biology and not using it and not trying and that is why I came back to academia because I couldn't sit back and do nothing and I think we need to face the reality of the situation that if, if collectively we don't seriously address climate change and the causes of climate change and our use of fossil fuels, then it's a pretty bleak picture.

PS: So Caroline decided to revisit a nagging question: Why are some corals healthier than others? Co-establishing a new field comes with a little bit of good timing and a lot of pertinent questions that need answering. This time, Caroline had both on her side.

CP: So I think I just just came into sort of the field of Coral biology and coral research at a time when there was a lot of talk about Coral death, Coral disease, coral bleaching, it was just a fresh take and my, my curiosity has sort of led me to that point and I just just saw a different side of it certainly there has been a lot more, a lot of research done on coral immunity since I started my phd But I have been surprised that it hasn't become more mainstream in coral biology.

For me with Coral immunity, it just seemed so logical when I was staring at these diseased corals on a coral reef and looking at the neighboring Coral that was completely healthy and at the time especially, there was a lot of focus on identifying pathogens of coral disease. So what was the particular virus or the particular bacteria that was causing that disease? Um, and for me, it, it didn't, that didn't seem like the pertinent question. It was a very good question and definitely worth exploring. But I was far more interested in understanding why the neighboring coral was healthy and so that's what led me to immunity really.

PS: A lot of the studies surrounding coral restoration involve fragmenting coral, where a piece of coral is taken from a reef, grown in a nursery and placed back into the reef to promote healthy growth. It sounds like a really great idea but it still doesn't touch on the root of the issue.

CP: They're fragmenting Coral that they've taken from a neighboring reef that growing them in a nursery and they're putting them back out in the reef. So those corals are

clones. They're essentially the same as the corals that you've just taken. So that ability to survive a bleaching event is going to be no better than the corals that were originally there. So essentially you may have achieved nothing because the next bleaching event that comes along, I'm may destroy everything. We don't know. Some situations just literally having more Coral may help. There are other restoration projects going on to see if we can genetically engineer coral to be more tolerant. restoration projects going on where corals are exposed and if you like, sort of trained to see if they can , climatize and develop more tolerance to different situations, different environmental conditions. Now in all of this, I don't understand why we're not looking at Coral immunity where we can sample a tiny bit of coral, measure its immunity levels and say, okay, this one's got high immunity, this one's got low immunity, let's fragment the one with higher immunity because we know corals with higher levels of immunity are more likely to survive disease and bleaching events. So let's fragment that one and use that one to restore our reef. And then the same with the genetic engineering, let's focus on genetically engineering, more robust immune systems that seems sensible to me.

If we use coral immunology to inform us about the tolerance of corals that, that we're using to restore coral reef, then we can optimize coral reef restoration, we can make the whole process much more efficient and much more effective. And that means that will cost less. So to me it just seems like the obvious thing to do, um, if you want to, to restore coral reefs, coral reef health.

PS: A healthy coral reef can support multitudes of marine life. To better understand coral health, it's best to understand how coral functions.

CP: carl is an animal. It kind of like a plant and it kind of like a rock, but it's an animal that's related to anemones and jellyfish and they read a taxonomic group Called Nideria. And so what distinguishes Niderians from other organisms? One of the things is that they have stinging cells and these are called new day. So an enemies and jellyfish and Carl have these stinging cells. So coral ancient, they first of all with about 200 million years ago, which is a really long time ago. well I find that kind of mind blowing. I mean, they've been around for that long. I mean obviously the, they've evolved and they've changed and we have different species around today than we did back then.

I just think it's astonishing to think that are really ancient. So most corals are actually colonies, which means that when you think of a coral that may be sort of a branch and coral that's got lots of branches that are shooting off in all different directions. That's a colony. So it's made up of individual polyps, which is essentially, if you think of a Polyp, like an anemone anemone is a polyp. The difference with the coral is that it has hundreds of thousands of these polyps sitting next to one another and joined by a thin layer of tissue and in a refilled and color, for example, which is a hard Carl. It secretes calcium carbonate skeleton. Um, and so the polyps sit in these little skeleton cups and then that joined by, by this thin layer of tissue that lays over the top of the skeleton

This makes them really interesting because they can grow in all sorts of different morphologies shapes and sizes. There's about 800 species of reef building, coral and we're finding new ones all the time. Corals can live in shallow, warm tropical waters and those, the reef building corals typically, um, and soft corals live there too, but we can also have corals in deep water, deep oceans and also cold water. They do different things and they have different biologies.

Tropical Corals, which make coral reefs grow best in, in warm water that you often get in the tropics obviously. And water that's quite shallow because they require light to

grow because they live with this microscopic algae inside their tissues that provide them with energy that they gain themselves from the sunlight.

PS: As soon as the microscopic algae begins to feel threatened by any environmental changes, the coral begins to experience bleaching.

CP: When we hear about coral bleaching and coral reefs dying, that's talking specifically about tropical reef corals. So you have the animal tissue of the coral. And then inside the cells of the Coral actually inside the lining of the guts, which is called the gastrodenjs. You have these tiny algal cells called zooxanthellae which lived there. And they photosynthesize and pass on energy and nutrients to the coral, which the coral uses to grow. And then the coral in turn provides a nice home for the algae. So this is a really classic mutualist relationship and it's vitally important because when that breaks down is when we get coral bleaching, which is when the Algae dies or the coral expels it and we no longer see the brownish coloration to corals.

We just see the translucent tissue and the skeleton underneath which is white. So that's what coral bleaching is. And at that point the coral is still alive. It's just without its nutrient providing algae. So it's essentially starving, but it can recover from that point if the conditions change. Um, so it's this combination of the coral animal, the algae that live inside the coral's cells and also a really diverse community of other microbes like bacteria and viruses that also live in association with the coral. And the algae that make this sort of multi-path type organism is called, or a holobiont. So all of these different organisms that live together enable each other to be healthy and enable tropical reefs to be constructed because without those components and doing what they do in order to maintain the health of that individual coral colony, then the health breaks down and then no longer able to survive, no longer able to build skeleton, which means that the coral reef will die.

PS: The world of a coral reef sounds a little alien, but from an immunological perspective, they have similarities to humans that you wouldn't really expect.

CP: So there's been more, um, information coming to light about, about human guts and the human micro biome or microbiota where we now know that our gut lining on our gut lining, there's a really diverse microbiota which means lots of different types of bacteria or live there. And that's when we're healthy. And actually that diversity of bacteria helps us to stay healthy. And it's the same with corals. Corals have specific microbial communities that they live with and when they, those microbial communities shifts. So when one bacteria becomes really dominant or another sort of disappears, then you get a coral that suddenly unhealthy. And this is something that's, that was with learning about now and it's something that is really sort of shifting the way we think about Coral and Coral health

So somehow they're able to coexist in homeostasis in balance. And when they're in that balance, that's when corals are healthy and that's when they build reefs and it's when that balance has shifted such as when, the water becomes too warm during a bleaching event and the algae become unhealthy.

So this, this is an exploration stage, but, typically we think of corals is having just innate immune systems, which means the most immunity and humans have it too, and it's basically the first immune response that you get to a scratch or something like that, or even an infection. It's when you get that sort of red area on your skin and that becomes inflamed. So it's an inflammation response.

And that type of response type of immunity doesn't learn. So if you get an infection and you just have innate immunity, then if you get infected by the same pathogen again, you won't have defenses ready to go to specifically attack that one pathogen. So thinking about immune systems like that, coral immunity as sort of input in the most simple side of things, um, that they just have simple immune systems, they're not complex and with that means that they're not able to have immune memory. So immune memory is when you have an immune response that is bigger or more effective when you have a second challenge by the same thing. So when you have a reinfection by the same pathogen, the second time you get infected, your immune system's ready to go. So it's assumed that invertebrates, more simplistic organisms don't have this kind of immunity, but more recently this has been argued and insects and other invertebrates you can see that actually when you have a second challenge, they are able to get rid of the infection much more efficiently.

PS - One of the bigger questions of coral immunity is whether or not corals retain immune memory, which could help them become more tolerant of extreme events over time.

CP: it's something that's extremely crucial to understand when we think about climate change and restoration projects now from an immunity perspective, Carl's a tolerant if they have higher levels of immunity. And so we know that coral species, for example, that have high levels of immunity and less likely to get diseased and less likely to suffer from bleaching. Now we also know that these coral's behave differently if you like, when they are exposed to threats. So, a coral that has high levels of immunity under healthy conditions will not become sick as quickly, but it might still have to induce an immune response in order to get through the infection, but it won't die, it will be able to fight it off and we might not even notice that it had the infection in the first place and quickly it returns back to health and everything's fine.

Now, if the same thing happens to a coral that has really low levels of immunity, then you might see a really big and quick immune response. So when you measure that, you might think, wow, this coral has got way more immunity then that coral over there that we thought was tolerant because it's up regulated, this massive immune response. But the trouble with that is that immune responses are really costly. So in order to get that high immune response from that low initial level that coral has had to invest everything into it, and immunity is also costly in terms of damage. So it can actually harm yourself if you induce a really big immune response. So it's this delicate balance. So what we find is the corals that are most susceptible, they have lower levels of immunity to start off with, and then when a perturbation like an infection or a bleaching event happens, they throw everything at their immune response which goes really high, but then actually they can't maintain it because they don't have the energy to maintain it.

And so they'll succumb to the infection or to the bleaching event much more quickly. So that something that's interesting to think about is whether that starting point of immunity known as constituent immunity, that baseline level which determines tolerance, whether that can increase through time, which is what we're getting at when we think about acclimatization and sort of training Carl's to become more tolerant to future climate change. Um, and on the one hand, I think that yes, there is the potential for this to happen, but I think it is very dependent on the species of coral and the specific circumstances.

PS: The biggest culprit of coral reef death is global warming. Faced with three large bleaching events in the last 30 years, scientists like Caroline have their work cut out for

them. Especially because coral reefs provide so many benefits to marine life and to humans.

CP: We've lost 50 percent of coral reefs in the last 30 or 50 years, um, which is shocking and, and we're facing losing, you know, 90 percent of what's left over the next 30 years. Um, if we do nothing and, and it's, I mean, it literally, it renders me speechless to think that these systems that provide so much could essentially be gone. And then the knock on effect of that is devastating. I mean, tropical coral reefs cover about one percent of the ocean, but the habitat that they create this, these complex coral reef habitat support 25 percent of marine life, which is a quarter as an enormous amount for one percent of the ocean to be supporting. So if we lose coral reefs, what's going to happen to that 25 percent of marine life that depends on it.

They feed millions and millions of people. 500 million people depend on food from coral reefs. So if those coral reefs disappear, what are those 500 million people going to eat? These are questions which need to be asked and need to really hit home because now is the time for action because we're at a point now where actually if we do take serious action on climate change, reducing greenhouse gases and personally taking action in our own day to day lives, then we do have a chance of, of reducing the impact and the cost if we don't, it's just astronomical. I mean, reefs are estimated to be worth 10 trillion US dollars, which is an enormous amount. If we just sit back and do nothing, then that's gone, you know, they, they fixed carb and they cycle nutrients, they, you, they protect coastlines from storms and you know, with climate change, storms are going to be getting worse. So all of those coastal communities, of course they're going to be the first to suffer and they're going to suffer really badly.

And even for countries who don't necessarily have reefs or have offshore reefs, then you'll be surprised at the millions of dollars that actually feed back into economies from, for example, the British overseas territories, um, the tourism industry because of the coral reefs, feeds, feeds millions back into the British economy. Um, and this is very easy to overlook it because you think when you're sat in your apartment in London that coral reefs are a millions miles away and they're somebody else's problem. But actually if, if coral ecosystems crash and 25 percent of marine life is no longer supported, then the whole world is going to look a lot different.

What’s so easy for us as humans to forget as we go about our daily lives in towns or cities or even the countryside, we’re on land and if we look out across the ocean or across the sea, we just see the sort of sunlight reflecting off the surface, but actually to jump in and look underneath it, you really realize how much we’re missing and how much there is to be seen and to learn about. And yea, I mean I think everybody needs to stick their head in the ocean and see what’s there because they’re missing out if they don’t.

PS: And that’s just what Caroline’s project, Seeking Survivors, encourages the locals of Costa Rica to do.

CP: I have a project called seeking survivors, which is in Costa Rica or the North Pacific coast and it's in area of Guanacaste. I'm in a conservation area. called, ACG which is also a world heritage site and yeah, we're looking at monitoring the coral reefs the longterm and through seasonal fluctuations and at the same time we're measuring coral immunology and we're doing this to, to inform conservation to get a really good understanding of, um, how Coral immunity varies through time and to be able to identify which corals are the most tolerant, which corals survive the best and then use that information to inform conservation and restoration projects in the area.

A major component of seeking survivors is the local community. So I'm obviously not a local Costa Rican researcher, but I'm working with the locals there. We, with Guanacaste, so dry forest conservation fund were employing local people who have just primary school education. So they left school at about 10, with training them as field biologists and they come out with us out on the boats, they can now sample the corals, I can identify the different coral species, they're running the diving underwater surveys, the coral transects, they're looking at bleached corals and disease Carl's and identifying them and now they're starting to learn the lab work So they're employed, this is their job, this is their, their work and they're learning about the system from a biological perspective.

And this is the system that they, you know, they grew up is that their fathers fished on and now they're taking the information that they learned from being out with us and they're sharing that with their friends and their family. Um, we do other community outreach if you like, and hold public talks and sort of engage as much as we can because there's, there's just no way you can conserve anything, any biological system if you don't involve the local people and don't help them to understand the value in conserving it.

I mean we can't, you of have effective conservation with just science and you can't have it with just community. You need to blend these two together and have informed conservation projects that involve the community and have the community on side. And this is something that's is hugely challenging and it's not something you get taught as an academic, I mean you get taught to do the science and this is where social scientists and really taking the time to engage with the community that you're working with, to understand their culture, to learn their language and be respectful and it's hugely important even more so than the science at times.

One of the two career citizen scientists who work with us at the moment is a, um, an amazing man called Hilbert and he, he is a fisherman's son and he started fishing. I mean, it's a, it's a small fishing village. So the majority of people fish. And after he had worked with us on a few of the trips, he came up to me and he, he was just so grateful and he was so determined that his son would not grow up to be a fisherman. And he told me that he goes home every night and he talks to his son about the importance of the coral reefs are, why we have to look after it. And it was, it was so moving to hear him say that. And that's, that is what this is all about. Essentially. I mean if, if we can educate and bring up the next generation to understand from the age of five to his son, is that actually the reef isn't there just to provide, you know, indefinitely we need to look after it to then that's, that's what has to be done.

PS: If all goes according to plan, Caroline's project could vastly benefit the coral restoration effort in little to no time because of the unique attributes of the reef she currently studies.

CP: the site is really interesting in that it's what we would call a marginal reef site. So tropical coral reefs typically written in shallow, warm, clear tropical waters, and the reefs in this area of Costa Rica, um, are exposed to seasonal upwelling, which means that for about six months of each year, the water gets really cold, it gets down to about 16 degrees Celsius, sometimes 14, um, which is very cold for tropical water. The water becomes more acidic and much more turbid, which means the light doesn't get through. So these are conditions which are not normal for your typical tropical coral.

Now, of course, the corals that live there are used to it. They've lived there all their lives, so it's normal for them. But if you were to take a tropical coral from somewhere else and put it in this system, it wouldn't be able to survive. So there's something interesting about the biology of these corals that enabled them to survive such massive fluctuations in environmental conditions, which is very intriguing in itself. Um, and what we're doing, we've got 14 reef sites across a marine protected area, um, and we are serving up to four times a year for Carl a disease prevalence and bleaching prevalence. And we have tagged corals at each site that we're following through time and we're taking small samples for immunity measures and what this will tell us along with data loggers that we have at each site at two depths, three and five meters.

So this will tell us how the immunity levels of these different corals changes through time with environmental fluctuations. So right now we're at the data gathering stage and this will continue. That's the plan. If we can continue to get funding to do it and we will continue to monitor and this will just just, um, build on our data and provide us much better information as we go through time. And so what we will be able to tell is which corals are more tolerant, which curls are more likely to get diseased or bleached, which corals bleach and then recover. And then we can link all this back to their immunity because we've been measuring that through time. So this will be really informative for conserving the reefs. And then also developing restoration projects as when or if that becomes necessary because we will already know which corals are the most tolerant to environmental change and so we can jump in and use those corals to initiate our restoration projects.

PS: While finding a promising solution depends on collecting years worth of data or dispersing teams of scientists into the ocean. It really comes down to finding money for the project.

CP: As always, it depends on funding. If I can get secure the funding that I would need to do it, then there's a five year plan essentially. And this is something that specific to the local area, yes, this is my study site, but these measures of Carla immunity and this sort of assessment that will give us a range of healthy and unhealthy and more tolerant and less tolerant measures of immunity of different coral species will be able to take that information and apply it to different reef systems. So this is, this has global applications and this is something that I'm working towards now. Given the funding, this is doable within, within five years deployable perhaps within seven.

PS: If we continue to take action and stay mobilized, Caroline believes that despite the large reduction of our reef system, we can still enable and promote coral health to keep it from completely disappearing.

CP: I think it's very easy to be terrified by the prospect of climate change and the rate of coral reef declines and it's very easy to think that anything we do is going to be futile. But we have the capacity to change and we have the capacity to take action and so there is hope. We just need to channel that and make our actions effective.

If we focus on the science and the conservation side of things, we have so much left to learn about the coral biology and yes, coral reefs will look different in the future. There's no getting around that. Some corals will die no matter what we do now, um, we've just left it too late for some of them, but what we can do is try and maintain ecological function of reefs and that means enabling enough corals, of enough different species to survive in a given reef system so that it provides that complexity to provide habitat for that quarter of marine life and that, that quarter of marine life can then feed the millions

of people who need to be fed and that it can support local economies. So yes, coral reefs will look different.

If we work collectively and collaboratively and if we focus on the differences in local reef systems and targets, um, the specific nature of those reefs and focus our conservation efforts on what's going to make that most effective there, then yes, there's hope. Absolutely. We just need to get on and do it and we need the funding to do it, which unfortunately is what it comes down to.

CP: So there are loads of ways to get involved and it depends. It depends on what you want to do and what you're able to do, but the worst thing you can do is to do nothing. So even if your way to conserve coral reefs is to drive a hybrid car or change your light bulbs to leds or to cut out eating red meat, then those are positive change. They may be small in the global scheme of things, but it's something and if we all did that, then that's a big impact in terms of getting involved in conservation and restoration projects. There's a huge potential now for citizen science. I'm seeking survivors is always looking for volunteers either to come down to Costa Rica and actually be involved in the field work to engage with the local community to fundraise to work on the images. There's so many things you can do to actually be involved in coral conservation and restoration. We're looking for enthusiastic people who want to make a difference.