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[00:00:00] **Ove Hoegh-Guldberg:** We're seeing an increase in the death rates of corals through extreme events. Used to be like five to seven years between bleaching events, but what we saw over the last decade was massive escalation in the damage that was occurring. At the same time as also seeing back to back bleaching. No time to recover Corals dying faster than they can be replaced.

[00:00:20] If these things continue to poke through that threshold, they'll get too warm for reefs to survive.

[00:00:33] **Nate Hagens:** Today I am joined by marine biologists and climate scientists, Ove Hoegh-Guldberg to discuss the current state and future risks of earth's coral reefs. Ove Hoegh-Guldberg is Professor of Marine Studies at the University of Queensland in Brisbane, Australia, where his research focuses on existential risks to earth's marine ecosystems.

[00:00:58] Ove was one of the first scientists to identify the serious threat posed by global heating to coral reefs in a landmark paper published in 1999, which predicted the total loss of coral reefs by 2050. In this episode, Ove provides an overview of the fundamentals. Of coral reefs, the most recent data on ocean acidification and coral bleaching trends and the risks that we all face if we lose these vital reef ecosystems.

[00:01:29] These small but mighty ecosystems play an outsized role in upholding biodiversity and ocean systems as we know them today. A topic which is very important to me personally. A reminder, if you'd like to learn more about the information presented in this episode or any episode, I encourage you to take a look at the show notes, which you combined on our website, The Great

Simplification dot com, and at the link at the bottom of the description of this episode, the show notes include valuable resources and references, and are available for every episode in our catalog since episode one.

[00:02:06] Lastly, before we begin, if you enjoyed this podcast, one of the biggest ways you can support us is by subscribing to it on your favorite platform and sharing this episode with someone who might also enjoy it. We believe in making this content free and accessible to as many people as possible, so we appreciate your support.

[00:02:25] With that, please welcome Ove Goldberg to discuss Coral Reefs. Ove, welcome to the show. Great to see you. Good to see you too, Nate. So, the status and importance of coral reefs in our world is a topic that in the three and a half years of this podcast, we have not yet covered. but many people I know, in my inner circle feel that this topic is incredibly important for understanding the state of our biosphere.

[00:02:55] And as Johan Strom recently said, the health of the coral reefs are a canary in the coal mine. And so I've invited you here today because you have decades of experience communicating and researching this topic. In fact, you, in prepping for this, I discovered you were one of the first scientists to identify the serious threat po posed by global heating for coral reefs in a paper published over 25 years ago in 1999, which predicted the loss of coral reefs by 2050.

[00:03:27] So let's begin this interview there with an update. It was, as we are now halfway to that point, how is this prediction held up until now? What sort of signs and guideposts and symptoms are we seeing from reefs about their overall health and stability?

[00:03:45] **Ove Hoegh-Guldberg:** Well, it's really interesting because, when I was writing that paper in 1999, I.

[00:03:51] Sort of came to a point where it was sort of very gloomy to the point where it'd be unbelievable. And in fact, many scientists wouldn't really support the conclusions at first because it just seemed incredible. You know, this is 25% of the biodiversity of the oceans lives in and around coral reefs.

[00:04:10] They're hugely important to people. Ecosystems, you know, almost everything in the, you know, tropical world and to the idea that this would disappear was sort of, you know, incredible really. It, couldn't be possible. And of course, I sort of concluded in the end that it will just have to get this out there and follow the, you know, the process of science, debate this, really important issue.

[00:04:37] And if at the end of the day I walked away with egg on my face 'cause I was wrong, that would be the sweetest egg I'd ever had.

[00:04:44] **Nate Hagens:** Right. I know, the feeling.

[00:04:47] **Ove Hoegh-Guldberg:** That's right. And so put it out there and, yeah, and I was a young lecturer at University of Sydney and, you know, suddenly there was this sort of immense spotlight on, on everything.

[00:04:58] And I remember some of the, you know, press the, press releases and so on, got quite spirited and, you know, felt really quite strange, you know, sort of going through this as a young lecturer. But in the end, you know, it's just really shows that science is really important to resolving these questions like, you know, global heating and acidification the oceans and so on.

[00:05:22] And so at the end it's like, well, yeah, this is happening now. That was sort of, you know, I, in fact, I, was working on. coral bleaching form my PhD at UCLA, you know, in the early eighties. and so, you know, I was sort of building up this sort of understanding of what was going on, and so it eventually came to a point where it was sort of, you know, this paper had to be written, it was written,

and then sort of second part of my career sort of started to unfold, which was, you know, a defending this, but also then trying to drive the research to understand what was happening and, what we must do to sort of avoid it.

[00:06:04] As part of that, I also made some predictions, you know, that by. Mid-century, we would see the loss of coral reefs, in great numbers. And when I was doing this stuff with my PhD, it was very much a sort of a localized phenomenon. And people were saying, you know, what's this thing going on? You know, it's a disease or is it, some physical variable?

[00:06:27] Or is it, you know, what is it? And it turned out that temperature was the, you know, the predictor and it was temperature is so good that you can actually project where coral bleaching is going to occur just on the anomaly in, temperature above the long-term sum maximum for a region. And so when you looked at those sort of issues, you start to build it, this picture, well, are we on track?

[00:06:51] Unfortunately, yes. When we look at, you know, just the last decade, you know, remembering this is not seen in the scientific record prior. To the 1980s, and then you look at where we are today. So it was sort of, you know, the occasional bleaching event that occurred in, that, early phase. But what we've just experienced over the last decade is sort of, you know, six massive coral bleaching events that are sort of off the scales, killing large amounts of coral and causing, you know, the, you know, so, yeah, I, I got it.

[00:07:26] Right. Unfortunately,

[00:07:28] **Nate Hagens:** by getting it right, you mean we're on the trend that you predicted and so you still believe that by mid-century, which is only 25 years from now, yeah. We might, like a human who is alive in 2050 will outlive coral reefs.

[00:07:46] **Ove Hoegh-Guldberg:** Yeah. And that's where, if you look at things like the intergovernmental panel on climate change reports, you know, a couple of years ago, they.

[00:07:57] You know, the, consensus I was part of the, you know, the experts reviewing the evidence, was that if we restrained sea temperature to, you know, or to global warming, sorry, to 1.5 degrees Celsius, which still lose sort of between 70 and 90% of the corals we have on reefs today. So that overall abundance would drop.

[00:08:24] Missed that opportunity and, restrained, ocean temperature to two degrees above, you know, the, pre-industrial period, we would see sort of, you know, 99%. And of course if you go to three degrees, it's really questionable, as to weather reefs in any way, shape or form, are going to be there.

[00:08:48] And of course, that has implications for enormous numbers of, you know,

[00:08:54] **Nate Hagens:** is issues. So, so I've had probably a dozen podcasts on this platform about ocean issues, but I've not had someone talk about corals and I, know very little about them. how old are, how long has the planet had coral reefs and how do we know that?

[00:09:13] **Ove Hoegh-Guldberg:** Well, corals. Create perfect fossils in a way, right? Because part of their biology and signature, I guess, in, in the fossil record is, you know, large amounts of, of, calcium carbonate being precipitated principally as orite, to build these skeletons and so on. So when you look at that, you can go back several hundred million years and you've had this persistent, structures, which, form coral reefs and of course that structure.

[00:09:47] Explains the biodiversity. So, you know, if you look at a coral reef, and you, know, just blur your eyes and just look at, you know, the calcium carbonate, it's full of nooks and crannies for life to, create the little, you know, the driver of biodiversity. And so you look at that and you say, well, actually, okay, so we've, got very similar things over hundreds of millions of years and, that type of structure in today's oceans.

[00:10:16] And in fact, you know, with the other fossils that are found that you find this plethora of, life and, you know, that's, pretty hard to argue against. But what's really amazing is that. This hairless ape from Africa, has they been able to sort of organize the collapse of this enormous ecosystem?

[00:10:37] You know, it's just incredible.

[00:10:39] **Nate Hagens:** Yeah. we'll get to that later in the program. So is there, are there evidence in the five previous mass extinctions and my ecology nerd friends, tell me there's been over 10, prior mass extinctions, depending on, the definition. But how did those, events, especially the ones caused by, Laval basalts and volcanic outgassing that raise the temperature and the acidity of the oceans, how did the, did were there die-offs of coral reefs then, or do we know anything about that?

[00:11:13] **Ove Hoegh-Guldberg:** Yeah, well, I mean, we know. That there were things like the Cretaceous boundary event, which, from what I understand is sort of, explained by a huge crater near the Yucatan in Mexico. And during that period you had the, you know, loss of 90% or more of, you know, coral types and, of course of the life associated with, coral reefs.

[00:11:38] So you're really looking at, you know, major changes. Now they're in a different class really, to, I suppose what we're seeing today. I mean, I, think what, you know, if I'm just to predict if, humans no longer have an influence or suddenly

get their act together in terms of, you know, the stewardship of coral reefs and, of life in general, then you're likely to see the recovery of reefs over long periods of time.

[00:12:06] But, you know, this gets the question about, you know, the sort of, discussion of, what's important, you know, and for. You know, the 500 million plus people that depend on coral reefs today, you know, a Cretaceous boundary event would wipe things out. And of course, but also you, could see things come back over time, but it's the disruption to people's lives, which is most important, you know?

[00:12:34] Now.

[00:12:34] **Nate Hagens:** So I have, you're probably not too familiar with this podcast, but now, I have a lot of questions to ask you here. So, 500 million people in a, let's just say 99% of the reefs are killed. and we're gonna get into the mechanisms why, but 500 million people, their livelihoods would be displaced.

[00:12:56] Why is that?

[00:12:57] **Ove Hoegh-Guldberg:** Well, when you look at those people, and these are people throughout the tropics, there's a large number of people that depend on coastlines to provide food, livelihood, resources, cultural significance and so on. So it's that immediate need that humans have that, you know, to fill out the basic essentials.

[00:13:20] But of course, if you take away the reef, which people go out on a daily basis to collect their food, to then go back and, you know. Provide some income to take the kids to school, or if that's possible, you're looking at a whole range of, it's a vulnerability.

[00:13:38] **Nate Hagens:** Well, it's, interesting that, and horrifying that we hear about climate refugees and the expectations are in coming decades.

[00:13:47] That could be in the billions. But when we talk about climate refugees, we're talking about, unable to live in a wet bulb, temperature above, yeah. You know, a certain threshold. But we're not talking about necessarily the 400, 500 million people that depend on the reefs for food under those similar warm conditions.

[00:14:10] So this is a subset of climate refugees, you might argue.

[00:14:14] **Ove Hoegh-Guldberg:** Yeah, no, definitely. and it's just horrifying when you think of that number of people being dislocated just in the issue of coral reefs, you know, into large cities and to urban centers because it's the sad dislocation of their lives.

[00:14:29] **Nate Hagens:** I want to get into, what is coral bleaching, and how does that actually happen?

[00:14:36] But there's been a lot of data and headlines in the last few years about the declining health in coral reefs. Before I get into that science, how are you and your colleagues and scientists around the world, how do we actually measure the stability and abundance of coral reefs and how far back does this data reliably go?

[00:14:59] **Ove Hoegh-Guldberg:** Well, I suppose, one of the, Challenges, I guess, is to get a regular update on corals in terms of abundance, you know, because that sort of, you know, is at the nub of, the issue. To get that, of course, requires coordination between nations. So, as the coral reef crisis developed, there are a number of initiatives that were designed to sort of, get a handle on, on, on that.

[00:15:29] And one of those was the United Nations, coral Reef Monitoring Network, which was designed to sort of, its 30 nations coming together, in its initial stages to sort of understand how biodiversity was, you know, how the quality and abundance of coral reefs was varying. And so it was a bit spotty and not the best data in the beginning.

[00:15:52] But when you look at that particular group, and then you look at the efforts that countries like Australia and the United States have, made, to, you know. Under underpin that sort of measurement you, you're dealing with probably a very good, you know, it's a very good understanding of what's going on.

[00:16:09] And what we're seeing is that, for example, over the last decade, you know, something like 14% of the world's coral reefs in terms of abundance, has have dis. And so, you know, that has implications. And of course there's been responses of international agencies and so on that have increasingly focused on it.

[00:16:33] But there are really, I, think there are very, good things. I mean, just this. Week we've seen the release of the latest long-term monitoring project from, the Australian Institute of Marine Sciences, where they look at the Great Barrier Reef and other reefs like Ningaloo in Australia. And they have provided a very, good understanding.

[00:16:55] Of course, there is, you know, some years there's a, there's an increase and other years there's a decrease. But what, we're seeing is that it's becoming much more violent in the swings and that it's really starting to sort of, disappear. So, for example, reefs that I work on in the Southern Great Barrier Reef for a long time weren't being affected.

[00:17:16] And that was sort of very interesting to understand why it was sort of more a phenomenon of the lower latitudes and so on. But we suddenly see high

latitude briefs like this one at Heron Island on the Southern Great Barrier Reef, just in, you know, what happened over the last sort of know 24 months.

[00:17:33] It's been well, it's been heartbreaking. It's been truly, you know, transformative. Those coral reefs we're claiming were doing well, fell over and this gets to these issues like tipping points and, we're, starting to, you know, investigate things that are pretty interesting

[00:17:52] **Nate Hagens:** in,

[00:17:52] that

[00:17:52] **Ove Hoegh-Guldberg:** respect.

[00:17:53] **Nate Hagens:** So let's, get right into the science of it. So one of the main risks and not the only risks to coral reefs is through coral bleaching. So what is coral bleaching? How does it happen and how does it affect the health of corals? this is a generally scientifically literate, audience, but just assume I'm like a teenager that, that's curious about this as you explain it.

[00:18:18] **Ove Hoegh-Guldberg:** Well, I think the first thing to know about corals is that they're not just corals and in fact, they're underpinned by a. Wonderful mutualistic symbiosis between tiny brown, single cell dyna flagellates that live inside the gastric tissues of corals and a range of other organisms. And that association, associ explains the, tremendous productivity and diversity and so on, of coral reefs because you are, you know, you're essentially with this very efficient symbiosis where the algae capture sunlight and provide the food, you know, from, that to the coral host.

[00:19:11] And in return, the coral host, you know, there's an oversimplification, you know, it's very, you know, but, essentially the, Coral host provides nutrients to the

algae. So there's, you know, alga, produ producing the, photosynthetic products and, you know, the nutrients, the phosphates and, ammonia and so on are then nourishing the algae.

[00:19:35] And that turns out to be the ultimate, you know, Get out of jail free card, for corals as tropical organisms, because one of the problems about the tropics, which is why we go to the tropics, to see the beautiful clear water, is that there are very low on nutrients. So if you can keep those nutrients within this sort of, animal, dyna, flagellate coral, a host, association, you can, thrive in a nutrient desert like a coral reef.

[00:20:09] **Nate Hagens:** And then the dino flagellates and the corals themselves create the ecosystem for many more creatures and shelter and its own productivity's and everything's,

[00:20:19] **Ove Hoegh-Guldberg:** and, you know, this, goes right back to Darwin 'cause it's just, it was extraordinary to see. The greatest biodiversity in the ocean occurring in essentially nutrient

[00:20:30] **Nate Hagens:** deserts.

[00:20:32] How is a, coral born or how does it start and how does it grow? Does it start with just a tiny, well, I don't know how it starts, please. Yeah, no, it's really interesting. Yeah,

[00:20:42] **Ove Hoegh-Guldberg:** and it's a fascinating story. corals are Nigerians, which are sort of simple animals that, you know, have, you know, create these things.

[00:20:53] And so, yeah, I, mean, for a long time people didn't really quite understand, you know, the, biology of corals until a, group of students at, James

Cook University in Australia realize that one of the most spectacular events in nature occur on the reef. And that is that over a couple of nights, you know, all of, you know, practically all, of you know, all of the corals and many, other organisms spawn together.

[00:21:21] Essentially to overwhelm the, you know, the predator net, you know, the, these are things that are gonna pick off the larvae. And so they produce millions of eggs and millions of sperm and bundles and all sorts of, you know, biology there. But the bottom line is that this thing happens over a couple of nights and you just have this tremendous sort of explosion of the next generation of corals and so on.

[00:21:45] **Nate Hagens:** And then the ocean currents take them to other areas.

[00:21:48] **Ove Hoegh-Guldberg:** Absolutely. And so they swirl around and you know, you have, I mean you go down to the beaches after the spawning has occurred, and it's just piles of sperm and egg and, this sort of, the smell of, washed up, you know, not so successful sort of coral, babies.

[00:22:06] **Nate Hagens:** The smell of coral sex in the morning. Yes, exactly. so, so then if they find the right conditions in a nutrient, sparse environment, then eventually some algae will find them and it'll grow and it'll be the size of a mushroom, and then a hundred years later, it's this huge reef because it's growing and taking nutrients and expanding.

[00:22:30] **Ove Hoegh-Guldberg:** That's right. You've got corals being among the most long lived organisms on the planet. How long do they live? You know, generation times can be between sort of three to five years to as much as sort of a hundred years. And, so you have corals, which, scientists now sort of drill cores of and, you know, the, those things are five, 600, you know, years old.

[00:22:58] So you can really get weekly temperatures, for example, of corals going back, you know, hundreds of years. And so that's been really important, understanding, whether these temperatures we are seeing on reefs are actually normal or not.

[00:23:15] **Nate Hagens:** So even in normal, temperatures, normal, cool ocean temperatures of, the last, few dozen millennia, corals die from old age or something.

[00:23:29] **Ove Hoegh-Guldberg:** Yeah.

[00:23:30] **Nate Hagens:** But then they're recreated elsewhere, maybe close by and yeah, it's just this, constant cycling and the, it we're concerned about the net amount of coral right now on the planet, yeah. Of, of living coral. What happens when they, they bleach.

[00:23:48] **Ove Hoegh-Guldberg:** So you've got this symbiosis and you've got the alga.

[00:23:51] And so in many ways, it's a knife hedge existence. It's sort of finely tuned so that you've got a one or one organism living inside another. And you just think of the evolutionary steps, the co-evolution that needs to happen for that to be, you know, viable. I think means that, they're the first organisms to start to show stress when you push the boundaries.

[00:24:20] And so what you see there is that, the dyna flags. Don't work as well. They start to produce antioxidants and, sorry, active oxygen and, things like that. And so the response of the host is with this sort of, mutualistic relationship starting to break down, is to lose the elli. And so early in, in the understanding of this phenomenon, it was sort of, you know, people were saying, well, that's a really tiny amount of temperature change.

[00:24:52] Surely not. I mean, one or two degrees above the summer maxima over a month is enough to cause bleaching to occur. And in some cases, if it's returns to normality quickly, corals will then regain their algae from algae inside the tissues, not from necessarily from the out outside, and then go on as they had before.

[00:25:15] But increasingly, as we've seen these escalating amounts of thermal stress, we're starting to see corals are just outright die. They just get too hot and die. And so it's not so much bleaching, it's just coral death.

[00:25:30] **Nate Hagens:** But if corals are bleached death, they're more susceptible to death in the near future, correct?

[00:25:36] **Ove Hoegh-Guldberg:** Yeah, that's right. Yeah. I mean, there's interactions between those,

[00:25:40] **Nate Hagens:** variables. So here's something that I didn't think about till just now. So it's not an absolute temperature limit, like, I'm sorry. I still am in the States and thinking Fahrenheit and the, water temperature, once it gets to 88 degrees corals die.

[00:25:59] It's, the relative to what they're used to. Is that correct? Because I believe that's right, that there are thriving corals in the Red Sea and the temperature there is quite a bit warmer than in Florida or in Australia.

[00:26:13] **Ove Hoegh-Guldberg:** Yeah. So we explored this, you know, phenomenon, years ago where, and some of the scientists in, sort of network, translocated corals from the.

[00:26:28] Top of the reef, you know, to, to the bottom. So it went from, where corals were at two degrees higher than those at the bottom. And when you mix

those up and then had a bleaching event, you saw those corals that had been translocated from the, you know, the warmer sections of the reef survived the bleaching events on the, Southern Great Barrier Reef, because they were genetically, it would seem adapted to the local temperatures at some scale.

[00:26:56] So there's, for the Great Barrier Reef, if you go from that warm north to the, you know, the, cooler southern part, you have a two degree, temperature difference. And that's reflected in the sort of, you know, the genetic tolerance.

[00:27:10] **Nate Hagens:** When you say two degree, you would say the average temperature of the water there during the year.

[00:27:15] Yep, that's right. So two degrees Celsius is actually probably quite a lot.

[00:27:19] **Ove Hoegh-Guldberg:** Yeah, absolutely. And, and. so what you're seeing then is you're seeing this sort of, you know, there, there's that aspect and then you've got, probably a little bit of acclimation that goes on as things change. The bottom line seems to be that if you push them beyond that sort of temperature that they're normally experiencing, you get that bleaching.

[00:27:42] And of course, the, the situation in the Red Sea, was really interesting. In fact, the Israeli and Jordanian scientists that have been looking at it, we've, been in, you know, collaboration with them. And at first I was like, you know, 'cause one of them was, one of the principals was a postdoc in my lab for a while at the University of Queensland.

[00:28:06] at first I was like, oh, you know, this, can't be so, you know, it, they always bleach, you know, when they get one to two degrees above the, summer maxima and for a region and, so, so be it. It turns out in the Red Sea though, there's a very unusual, situation with this, you know, a thousand Mile Red Sea where you've got a tiny little, you know, in the most warm, parts of that, that, that

reef down to Yemen and other, you know, pa parts of that, that, that system, you are seeing waters being sort of 32 to 33 degrees Celsius, yet up the top you've got, you know, temperatures that are more like, you know, 27, 28.

[00:28:52] And so coral larvae coming through the bottom of the Red Sea go through a. A selection for warm genotypes only. They flood into the Red Sea, they mix up through the Red Sea, but by the time they get to the Gulf of Aaba in the, north, you've only got warm genotypes.

[00:29:12] **Nate Hagens:** Is it possible that under a one and a half degree Celsius, which it's my opinion, that is, in the rear view mirror and two degrees Celsius, and beyond that, there may be a selection for the warm water genotypes.

[00:29:28] **Ove Hoegh-Guldberg:** Yep. That's exactly what we think is happening. And it does stand to reason. I mean, what's really interesting about that is that, clearly adaptation to local conditions takes time. So you'd think that over time they get up into and, get exposed to those COVID temperatures, they should be selecting for, you know, more normal behavior in, in, in this sort of, you know.

[00:29:57] **Nate Hagens:** Brown, even if we do select for a warm water genotype coral, your prediction for mid-century, that 99% ish of coral reefs will have disappeared. Still holds.

[00:30:13] **Ove Hoegh-Guldberg:** Yeah. Because this is a very tiny part of the overall distribution.

[00:30:18] **Nate Hagens:** Okay.

[00:30:18] **Ove Hoegh-Guldberg:** It does though, start to address the issues of scale because there's a lot of science being done with all respect to the people doing it that sort of say, okay, well if we can find a super coral and we can breed

the super coral and then we can sort of put it on a reef and you know, off we go, problem

[00:30:37] **Nate Hagens:** solved.

[00:30:37] or in some places in the world they're making artificial coral reefs and dropping them in.

[00:30:42] **Ove Hoegh-Guldberg:** Yep, that's right. And so, you know, will that solve the problem of the loss of coral reefs? Probably not. Because the scale, you know, to replant corals onto the Great Barrier Reef, for example, which is 40,000 square kilometers of, coral habitat that you'd have to replace.

[00:31:07] And you have, you know, doing this at scale, you know, you start to look at trillions of dollars.

[00:31:15] **Nate Hagens:** Well, even if we were able to do it at scale, the environmental conditions, if we are at a two degree Celsius average warmer water, they have no incubation. Yeah. They have no, rookery for baby corals to survive.

[00:31:28] **Ove Hoegh-Guldberg:** Yep. No, that's right. As I said, I don't want to do. The science being done and we have to do some science to get idea this, but to claim that this is going to solve the problem is inaccurate.

[00:31:42] **Nate Hagens:** So every time that I, mention coral, reefs and that a child, a human child today, born today, will outlive.

[00:31:52] Coral reefs on this planet. I invariably get emails or comments in YouTube that say, no, according to the United Coral Global Watchdog, the extent of coral in the world's oceans is actually at a all time high, or the Great Barrier Reef has a higher, net or, gross area of coral than ever before.

[00:32:16] And yet, when I talk to scientists like you, there's massive bleaching events and, the corals are not doing well and expect to be virtually gone in 25 years. How, do you justify those statements? Is there some different quality, that's going on in the coral, or please help me understand that.

[00:32:37] **Ove Hoegh-Guldberg:** As we've said before, you know, corals go up and down in, in terms of, you know, no, no year is consistently in one direction or not. There's a bit of variability around that signal. And so if you. Look at it during a phase when it, for example, we talked about those reefs on the Southern Great Barrier Reef.

[00:32:57] They were doing well. There was a less stress, and in fact the warming may have benefited the coral reefs. And so you've seen this in that region. You'd see this massive explosion of corals and so on and say, well, what's the problem? But of course, you've only gotta look a couple of years later to see.

[00:33:15] You know, that we've now swung back down and this latest report from the Australians to Marine Sciences, which is their long-term monitoring project, on, corals since 1983. They've been measuring the abundance. It's only when you do it at that sort of scale and intensity and timeframe that you're able to see the, big trends going through the system.

[00:33:39] I mean, that's informed also by lots of laboratory work that show that there are limits to the amount of, you know, differences in sea temperature that corals can survive and so on. So, all that, all these elements come together to take just a snapshot look and say, look, see, it's all okay. It's just naive from a science point of view because this is a large scale ecosystem that's sort of lumbering along through many parts of the world.

[00:34:08] And so, you know, bringing together the great, you know, the United Nations GCR, the Global Coral Reef Monitoring Network, and those types of, of

information sources provide a much more sophisticated look at that issue. It isn't as simple as yep, they're going up, problem solved.

[00:34:28] **Nate Hagens:** But is it true that the extent of coral reefs globally is at an all time high?

[00:34:33] **Ove Hoegh-Guldberg:** I dunno that what the information source is, but I've seen similar things being said about the Great Barrier Reef.

[00:34:38] **Nate Hagens:** Yeah. And is it true about the Great Barrier Reef?

[00:34:41] **Ove Hoegh-Guldberg:** Yeah. In some pa places, coral, abundance has, gone up from one year to the next. But in many places it's gone down. And I think what we are seeing is we're seeing an increase in the death rates of corals through massive event, you know, extreme events.

[00:34:57] Like, you know, not only is it temperature, but it's also, you know, big storms for example, that are also having a big impact on reefs. And so you take all of those things together, we're getting more of the, extreme events and less of the sort of positive bits where it's growing for a sustained period of time in an upward direction.

[00:35:18] **Nate Hagens:** What about the quality of the, corals? like we could say that the country of Spain has increased its forest cover, but it's mostly monocrop, plantations. It's not real forest. Yeah. So is there an analog with coral reefs and the diversity and types of coral?

[00:35:37] **Ove Hoegh-Guldberg:** Yeah. So you know, if you go to a coral reef in the Indo-Pacific, you are looking at probably.

[00:35:46] 500, 600, species of coral that go to form those mature reefs. And so it's a bit like, and so, these pro projects have re replenishing. We've been sort of

doing our hardest to sort of get that diversity out there and so on and so forth. But you're probably planting something like five to six different species to create that structure.

[00:36:12] And, yes, that's got some value, but it's a bit like planting pinus radiata in the place of a. A mature rainforest, you know, with the Pinus radiator is, you know, a very low diversity system. It's probably got a couple of beetles and a couple of worms and you know, a bird or two. And there you have that's, the ecosystem.

[00:36:34] Whereas, rainforest, of course, would have hundreds of species and, a completely different scale of biodiversity and interaction, and you can't replace that. Obviously with a radio out of pine Forest.

[00:36:49] **Nate Hagens:** So, f forgive me, but you're a very mild mannered, and careful scientist. Sure. But how you led this off by saying 25 years ago you wrote a paper saying within 50 years there would be no coral left.

[00:37:06] And now you just kind of said, well, it's growing some years, it looks like it's growing some years it's not. and I get it and I appreciate that you're a scientist and want to be careful. Yeah. But that doesn't jive with, in 25 years all the corals are gonna be gone. or does it?

[00:37:26] **Ove Hoegh-Guldberg:** Oh, it does.

[00:37:27] I mean, one, one is a variability around a signal.

[00:37:30] **Nate Hagens:** Okay.

[00:37:30] **Ove Hoegh-Guldberg:** Right. So you've got, that ups and downs, you know, good years, bad years, and so on and so forth. But the trend is

unmistakable. the trend is unmistakable. But what I said before was, you've gotta be careful about, you know, how you measure those things.

[00:37:43] Because if you just have a spot check and go, yep, the corals era have survive, that means everything else is gonna be

[00:37:50] **Nate Hagens:** okay. And this is the problem with communicating, incredibly existential science to the average person. 'cause they want a binary yes. This or no. And it's so nuanced in so many ways.

[00:38:03] **Ove Hoegh-Guldberg:** Yeah, Absolutely. Yeah. So I agree. I mean, I, yes, I am being mild mannered, but I'm being truthful to it as well. It's like, yes, it takes time to get a good fix on what's actually happening. So with these global networks and, all of the other information coming in that informs this space is heavily in the.

[00:38:24] It, is changing and it's changing very rapidly. And we will see reef systems that have very low, you know, abundances of coral now then you say, okay, well will that destroy it? Yes, it'll destroy it for the 500 million people that are depending on it. 'cause they need the food today, not tomorrow, may tomorrow.

[00:38:43] But over time this will probably recover and it'll be like the Cretaceous boundary event in which we lose a lot of species. But then, you know, over time, well

[00:38:52] **Nate Hagens:** over time, meaning hundreds of thousands or millions of years once we Exactly, yeah, exactly. But in any human timescale, they won't recover. Yeah, that's right.

[00:39:02] Or, you know, because they won't have the conditions. now how much of the conditions is heat and how much of it is acidity? We haven't talked about acidity much. Does acidity affect coral reefs?

[00:39:15] **Ove Hoegh-Guldberg:** Well, ocean acidification is this phenomenon where, CO2, has a, an, it's not just a warming potential.

[00:39:23] It's got this interaction with water that's so important. So CO2 enters the ocean, interacts with water, creating a dilute acid, the, you know, the protons that are released, then like to bind into, calcium, to, cal, to carbonate, turning it into bicarbonate, which takes it away from its role in building the skeletons of corals.

[00:39:49] **Nate Hagens:** So it, everything else being equal, a more acidic ocean, and they're the baby corals. after the, they're gonna grow much slower and be limited.

[00:40:02] **Ove Hoegh-Guldberg:** That's right. And so you're gonna see, yep. Impacts on coral larvae, but you also see the ability to lay down the calcium carbonate skeletons, which create the infrastructure that, you know, that the 3D structure of reef, which is really important to, you know, the species living among the branches of corals and all of that sort of thing.

[00:40:23] That stuff disappears and you start to see also the impacts on humans through. Reduce calcium, coastal, protection and pain.

[00:40:32] **Nate Hagens:** Let's talk about that for a second. you've mentioned the 500 million humans might be climate refugees if, the coral reefs go away, but let's talk about the broader, biodiversity and ecosystem services that coral reefs provide.

[00:40:48] How much of the web of life in the ocean would depend on this and what would happen to the broader web of life, maybe even dolphins and, cean and the fishes all the way up? what would happen if corals, disappeared? Even if everything else in the biosphere remain the same

[00:41:08] **Ove Hoegh-Guldberg:** at one scale, you know, the immediate effects may be delayed, for example.

[00:41:14] So, you coral the corals die. but, studies have shown that the fish populations. Don't immediately respond, you know, that takes time for these things to, to plow through. And so over 10, 20 years now, we're starting to see the loss of coral reef fishers. Now those fish populations are really important for supporting humans along coastlines.

[00:41:44] At first, you, might see a couple of disgruntled divers and just say, oh, wonder there's no, you know, some of the fish are disappearing. But to the, non-expert eye, you might. Not expect to see much thing. And so I've had a lot of situations where I've taken people who were just regular tourists out to see where I work and places like, and one of them was in Cook Islands where I worried while we went in to look at the reefs, that they were all eaten by crown of Thorn Starfish and killed off by bleaching and so on.

[00:42:16] And, you know, the tourists would be upset, but they came up going. That was one of the most fantastic dives I've done. Did you see the turtle shifting baselines? Maybe? Yeah, it is. That's it. Yeah. it's a perfect example. And in fact, I think Jeremy Jackson and others, you use coral reefs as this sort of, you know.

[00:42:37] **Nate Hagens:** You know, the, model, but you wouldn't be guilty of shifting baselines because I bet you've had hundreds or even thousands of dives in your lifetime. So when you were in 1990s, your doctoral studies on this versus today, what are you noticing? And maybe just for a moment, bring the viewer into

the land of, under the ocean surface and how magical and colorful and, sacred that is.

[00:43:05] Maybe tell us a story about that.

[00:43:07] **Ove Hoegh-Guldberg:** I, mean, when you do go below the surface and, you know, you go to a beautiful tropical reef and so on, and you go below the surface and you start to look at what's going on in front of you, it's a bit like going into New York, you know what I mean? Because there is just busyness everywhere.

[00:43:24] There's fishes that are, you know, protecting a little piece of territory. There's, predators that are working together to capture prey, you know, two different species working together to, to, create, opportunities in terms of, you know, just like in New York, right? It's just it lures you in and it's fantastic, but you know.

[00:43:50] At the scale of that, that, that, city, if you take New York for example, there's good and bad bits. There's beautiful art galleries going on over here. And then there's neighborhoods that are under threat over here. And that's just the same as on a coral reef. You know, you'll find areas where it's, under construction and other areas where it's under destruction, and it's a balance between those two forces, which explains whether you are getting the outcomes we've been talking about or not.

[00:44:21] You know, if you have much more destruction than you have in terms of construction, you know, you're gonna start to see those reefs sort of disappear and so on. And it could be very slow, but it's very

[00:44:32] **Nate Hagens:** fine if you have a, let's just use, Rough numbers if you have a mile of coastline. And on that coastline, there's a couple of areas that have large coral reefs and the rest of the coastline doesn't have coral.

[00:44:47] Well, most of the, small, medium and large fishes kind of congregate, surrounding the areas with coral because that's the base of the food chain.

[00:44:58] **Ove Hoegh-Guldberg:** Yes, it's fascinating when you go and see these things. I mean, one of the, there are places on the Great Barrier Reef where you've got, algae, Seaweed's essentially growing across the bottom. And so what you're seeing is the normal fish you see in those types of habitats where it's, fishers that are blending into the background. So they're brown, seaweed colored looking things. But then suddenly you'll come across a place where there might've been little bit more sea urchin, gr grazing and so on.

[00:45:30] And so you've reduced the seaweeds. And out of that we'll see beautiful, you know, coral and it might just be a couple of meters of coral. But above that, coral is this sort of all the fishes you see around corals normally, accumulating.

[00:45:48] **Nate Hagens:** So, Your reference to New York City might actually be appropriate.

[00:45:55] Corals are like cities in the ocean, with all the people and the busyness. I mean, not the people, the fish and all the things going on, and they attract, travelers and all the things.

[00:46:07] **Ove Hoegh-Guldberg:** No. Absolutely. And of course that was picked up, you know, in, the various movies out of Hollywood with, Nemo.

[00:46:15] You know, that's actually, I remember seeing that film and then, I had to look at the, you know, the, leads 'cause it was so accurate. It was, you know, they'd created this sort of mythical cartoon universe, but it was so, precise from

[00:46:30] **Nate Hagens:** the biological point of view. So back to your work and the alarming, trends that, our mutual friend John, alerted me to.

[00:46:42] I understand there have been several mass bleaching events in the past 10 years, including this year in 2025. Can you explain of, what a mass bleaching event is, in comparison to typical bleaching and what is so important about these events happening more frequently?

[00:47:02] **Ove Hoegh-Guldberg:** So the. You have the disintegration of the relationship between the dyna flag and the coral host.

[00:47:11] And so, just to pick up where we were on that, you know, tho those corals can, in, in the days gone by when I was doing my PhD, for example, we saw corals recover. They just get their algae back. They wouldn't have died. So that's bleaching. But then more and more have been dying, outright. So it now gets just too warm.

[00:47:32] They don't lose their algae, or they lose very few at first. And then, you know, they, die. Now the, you know, what we've seen is, so if you can imagine there is a threshold for each of those regions we talked about, which is the summer sea surface temperature. And what you see is that as you go above that, you, you, have, you know, a bleaching event and so on.

[00:47:59] And so in the past we've recovered, you know, used to be like seven, five to seven years between bleaching events. They only occurred in the El Nino years. But what we saw over the last decade was, you know, two things was

massive, you know, escalation in the damage that was occurring at the same time as also seeing, you know, back to back bleaching.

[00:48:25] So, you know, you had a bleaching head one year, and then the next year you had one straight afterwards. No time to recover. Corals dying faster than they can be replaced, and that then brings you into the sort of conclusion bit, which is if these things continue to poke through that threshold, they'll get too warm for reefs to survive.

[00:48:51] That's where we start to look at this. So when you know, that number of 14% of corals, having died over the last decade as being one of the things that the Global Coral Reef Monitoring Network, the United Nations Agency, that's looking at the sort of abundance of coral that is, is a, shocking thing because in that city, that New York, it's like suddenly you decide you're not gonna do any construction and you're just gonna sort of mow down and, you know, just let everything fall into disrepair.

[00:49:25] And of course becomes a dangerous place. you know, the wrong people, the wrong fishes are in the wrong spots and it's, you know,

[00:49:33] **Nate Hagens:** so it's not. Precisely that 14% of corals have died. It might be that 18% of corals have died and 4% have been born and grew, but the net is a 14% decline. Is that correct?

[00:49:47] **Ove Hoegh-Guldberg:** That's right. That's right.

[00:49:47] **Nate Hagens:** Yeah. And so what is the current status of the mass bleaching event that's happening right now in 2025? and which reefs is it mainly affecting?

[00:49:57] **Ove Hoegh-Guldberg:** Well, it's been working its way through the coral reef resources since, so we've seen another, you know, period. I mean, earlier this year on, I went to various places on the Great Barrier Reef for, you know, look at how Coral was doing.

[00:50:12] And you saw, you know, up and down that, that, that region you saw, unsustainable amounts of coral bleaching be, occurring, and mortality, I should say,

[00:50:22] **Nate Hagens:** for someone that's devoted their life to this and has predicted it. Emotionally, I can imagine that's gotta be difficult for you to go visit reefs that you knew 30 years ago and see what's happening.

[00:50:38] **Ove Hoegh-Guldberg:** Yeah, no, it's, it is really tricky. And it's also heartbreaking when your children who are also very keen on the ocean, are going to live into the predictions of their father and my, my, my kids. Right. I mean, if you think about it, they're gonna be, was dad, right? And I shouldn't say me. I mean, I'm talking about a whole group of science and so on, but, you know, dad said this would happen.

[00:51:03] Has it happened? And I really hope, just like I did all those years ago as a young, you know, as a, you know, young scientist, and I just hope it's egg on my face that no, there was a whole bunch of stuff that went on, which, you know, meant that priests were not gonna disappear.

[00:51:21] **Nate Hagens:** Sometimes I, I marvel and I wonder, which is more amazing, the fact that we evolved from simpler organisms or the fact that humans figured it out.

[00:51:35] And in the same way, I wonder, which is more extreme of a scenario, the fact that a human born today will outlive coral reefs, or the fact that no one is

talking about this or seems to care about it, it's really a profound, disconnect. Or maybe it's cognitive dissonance that a lot of people are aware of it and they don't wanna talk about it.

[00:52:00] So, Johan Strom, who was recently on this. Program discussing planetary boundaries. Recently warned at a climate conference that tropical coral reefs may have crossed their tipping point and are experiencing unprecedented dieback. So ove, for someone who's worked on this their entire career, have we reached a point of no return?

[00:52:21] Or is there still time to alleviate, coral stressors in a significant way for them to, recover on a human timescale sort of, thing.

[00:52:31] **Ove Hoegh-Guldberg:** So here, it's one of the hard truths, I guess, and that is that even if we put into play all of the pledges about emission reductions and so on, so we've got those that are sort of planned and those that actually have been put into play, we're still headed towards three degrees above the pre-industrial period that, that sink in.

[00:53:00] And then you say, what do we know about? The tolerance of corals. And that is sort of, you know, as I said before, it's, you know, 1.5 above the pre-industrial, it's 70 to, to 90% of corals today, or the abundance disappearing by three degrees. We just, you know, it's just, it, will be very, that we know be no benefits coming from reefs that come close to what we've been seeing over this generations of, experience.

[00:53:32] **Nate Hagens:** There'll be underground museums to, underwater museums to use the city analogy.

[00:53:38] **Ove Hoegh-Guldberg:** Yeah, that's right. And that will be it. It'll be lots of, remade to David Attenborough movies, you know, about the wonder of these systems, but they will be in past tense. So what would that

[00:53:53] **Nate Hagens:** like, just to be emotionally graphic?

[00:54:00] Under a three degrees Celsius, world. And I still hold hope that it won't get to that level, because I don't think we have that amount of fossil fuels. But I think two degrees is pretty locked in. I, you know, I don't know. But under a three degrees Celsius world a hundred years from now, what would today's coral reefs look like?

[00:54:21] Would the coral still be there, would just be like beginning to fossilize or, I mean, what would it look like?

[00:54:28] **Ove Hoegh-Guldberg:** Well, I think in terms of, you know, the structure of reefs, there's been, quite a bit of work now done where, for example, colleague. Who I'm married to, another marine scientist in the family, Sophie Dove, put together Mesocosms of the Future.

[00:54:49] So it's basically these fairly large tanks connected to the Reef Crested Heron Island that changed the temperature and the acidity of the water surrounding these things, and ran it for many years to see what would happen. And what she found was that, you know, yes there's corals dying and so on, but the, shift in the carbonate balance was some of the most, you know, concerning the sediments was starting to break down at much greater rates than, you, you, would expect, based on the literature.

[00:55:26] and, that overall, you know, flattening of reefs was profound and very, final. Once you've lost that structure, you just have essentially a parking lot in the

Jani Mitchell context. So you look at that, you go like, well, we are looking at a, at a world, which we are hurtling towards. And yes, the only.

[00:55:52] Humans didn't do corals in because probable corals will survive beyond, you know, humans. Because corals are, I mean, after that Cretaceous boundary event, a lot of them, you know, probably, because one, one thing I didn't mention, we talked about the sexual reproduction of corals, but, they're also asexual reproduction, where they break apart, they, little pieces of coral then can grow into other coral colonies.

[00:56:20] And that allows you to keep, you don't have to have sex, you don't have to meet another partner to have sex, to create babies to, to go into that thing. You can just literally break bits off yourself or storms, break bits off you. And so, so, yeah, you know. Corals will out survive this, which will be maybe some sort of penance.

[00:56:42] **Nate Hagens:** How would that happen? Let's assume that we get to two and a half degrees and we lose most corals. yeah. And then there, with or without humans, the 500,000 years from now, there's, bio geochemical weathering, and eventually the temperatures and CO2 levels come down and all that happens.

[00:57:05] But there weren't corals alive during this time. So how does a new baby coral come about, at that future date?

[00:57:13] **Ove Hoegh-Guldberg:** That's where the, I think this a four reproduction comes in. It just. The species persists until they go back to the density of the reefs like today. And then you start to have the input of, you know, that sexual component of reproduction.

[00:57:29] **Nate Hagens:** So what is the fate of coral reefs, which you have predicted, will mostly be gone by mid-century. What does the fate of coral reefs tell us about the health of the world's oceans and planetary boundaries more, more generally?

[00:57:44] **Ove Hoegh-Guldberg:** Well, well, I think it's a great worked example, in terms of, johan's, you know, limits.

[00:57:54] We don't have an endless ability to keep going here. As we get further and further away from the sort of norms of what we've evolved towards as the sort of, you know, ecosystems and people, you know, you get to a certain point where, you know, basically things. A little bit of a push, a little bit of a push, and then suddenly the whole thing collapses.

[00:58:16] it's a tipping point that, that is probably of great, you know, and the late will Stefan, who really promoted this and, so on, I think was, correct in that we are going to see an increased freak, you know, things like coral reefs and the Amazon, and places like this, going to be okay.

[00:58:36] Okay. Okay. And then suddenly bang, that's it. And goodnight and thanks for all the fish.

[00:58:42] **Nate Hagens:** So a lot of these things, like I've had many recent guests on, now adding you to the list where you're focused on a specific issue. In this case, coral reefs. I had Anastasia Mari Keeva talking about, forest and biotic pumps, and I had a couple people, Carlos Nore talking about the Amazon.

[00:59:03] And in each case you're talking about let's protect this incredibly important piece of the natural world of our home earth. And there are strategies to help these local things. Like for instance, in the Amazon. Eat less beef and therefore there's less demand for clear cutting to plant soybeans. But the

unspoken grim reaper in all three of these examples I chose is the global CO2, emissions rising, which no matter what you do to protect the, I think you mentioned the NLU or something like that, reef in Niloo Pro, reef locally to protect it in the best way you can, you still have this global phenomenon that is a human metabolism sort of impact that dwarfs those, micro local effects, at resilience.

[01:00:03] Is that correct?

[01:00:04] **Ove Hoegh-Guldberg:** That's correct. But I think it does push you in a certain direction, which I think clarifies. And so what we're edging towards here is sort of, you know, what do we. What are the responses? And for me, you know, taking coral reefs as a signature ecosystem, we have to do really, I guess two things.

[01:00:28] And, that is that we have to reduce emissions of greenhouse gases and CO2 as quickly as possible, right? There's every piece of that. CO2, going to the atmosphere has a huge impact on the wellbeing of ecosystems and people. But once you've done that, we should be seeking out those reefs that are least exposed to climate change and protect them as if there were no tomorrow.

[01:00:59] **Nate Hagens:** Are there reefs that are le less exposed to climate change? And why would that be? I mean, the climate is a global phenomenon.

[01:01:06] **Ove Hoegh-Guldberg:** Absolutely. But it's the local scale oceanographic things like, for example, in Indonesia. There seems to be a lot of these sort of locations and it's in an area, you know, Indonesia is the archipelago stretching between the Indian and the Pacific oceans, where there's upwelling and there's all sorts of phenomenon that are bringing cool water to the surface and thereby helping protect those, you know, those populations.

[01:01:36] And so we're seeing, you know, when you look at the stress overall, those regions are, and so they're the best places to put your dollars because they are limited relative to the scale of the problem. Put, those dollars to, to, have the reefs of the future to reap. Len,

[01:01:54] **Nate Hagens:** those risks. So just in, you know, hypothetically in a, perfect world, let's say we do head for two degrees Celsius world, but in these locations that you're discussing, that the upwelling gives them a little bit more of a buffer than the Great Barrier Reef for the Red Sea or somewhere that doesn't have such a phenomenon.

[01:02:14] And so they're able to survive longer, especially if we protect them. Is it possible then, if those are the last, stands of healthy coral in the world that the, the coral sex in the morning populates and goes all around the oceans with the, baby corals? I mean, does it do Yeah. Do It can go really far in the ocean currents.

[01:02:41] **Ove Hoegh-Guldberg:** Yeah. So, it still takes time. I mean, estimates of, you know, the, I guess the influence of a spawning. Coral here on other reefs nearby is on the scale of sort of tens of kilometers. So you have this, you know, one season coral releases eggs. Those eggs then drift away. And then depending on the, you know, the length of the generation times of those corals and so on, you, might have, you know, faster or slower rates, but it's at that scale.

[01:03:16] So the, reason for reducing greenhouse gases, you know, to zero as quickly as possible is, very much about stabilizing the ocean. If we stabilize the ocean, then those adaptations that are developing, and over time we'll have the opportunity to sort of move into a stable en environment. If we continue, if we don't deal with that CO2 problem and we get to the point where it goes two degrees, three degrees and four degrees, then we have no option.

[01:03:46] So that has to happen. And so in talking to our political leadership in Australia, for example, I'm seeing, you know, the, you know, the pollies are getting it, and so they're starting to, you know, log on.

[01:04:02] **Nate Hagens:** But it's a global, problem, right? Yep. I mean, the Australia's barrier reefs depend on the coal being burned in China and India.

[01:04:11] **Ove Hoegh-Guldberg:** Yep. Yep. So it's gotta be a vastly, we can no longer, we, can't imagine, you know. Country X make country X greater. I mean, that's a lunacy in today's world.

[01:04:26] **Nate Hagens:** This is a rite of passage for our species. and yeah, right now we're, gonna fail. as I'm sure you would agree, but let me ask you this of, as one of the first scientists to advocate, on this topic, 30 years ago, what, have you learned about communicating science to policymakers and, the public during that time?

[01:04:48] **Ove Hoegh-Guldberg:** Well, I think science has a very special role to play in making the blunt points. You know, I mean, it's really interesting. I mean, we, that's what we are designed to do. We are constantly trying to be, promote ourselves on the bodies of the other scientists. It's like this competitive world we live in, you know?

[01:05:09] And so I, you know, it's, one of those things where, that being able to. Come into and talk to ministers of different parties and say, this is what's going on. You know, and of course you're depending on this reservoir of science through the IPCC and other international bodies that just allows you to bring sense to the table.

[01:05:36] 'cause you know, politicians of course have to balance all sorts of other things going on and, you know, can't often be as honest as they'd want to be. We

have the ability to be blunt, and I think that's really important right now. And now once that's said, I think we also have to be nuanced in our behavior.

[01:05:55] We have to also realize that not everyone's going to understand what ocean acidification is when they first come across it. That makes the world a bit more perilous, but it also means we've got a job to do in terms of communicating. you know, the science to the policy makers that will

[01:06:11] **Nate Hagens:** helping make the decisions.

[01:06:13] Well, let me ask you this. I mean, I live in Minnesota and there's no coral here, although there are a lot of fossils that I find when I look for agates and satellites. I did a sabbatical in Indiana. I know exactly what you mean. Yeah. But, where you live in Australia, there are coral reefs all around your entire country.

[01:06:30] So are people, are the general population aware and concerned about this in Australia or is it like in the United States, you know, the people that don't live by the coast don't think about the oceans much?

[01:06:43] **Ove Hoegh-Guldberg:** No, I think people in Australia do, and the difference is we don't have the same population.

[01:06:51] In the center of our continent. 'cause we're the reverse of the United States. So everyone lives on the coast. We're all living on the coast. So we're living with the, you know, the, properties and outcomes of things. You know, we bleaching events are serious people going, you don't see them and the tourists don't turn up and it's becoming an issue.

[01:07:07] I

[01:07:07] **Nate Hagens:** is there a, like a, coral reef trauma anxiety groups that people have seen these bleaching events and they get together and grieve yeah. And, help each other cope. I, imagine that's a thing.

[01:07:21] **Ove Hoegh-Guldberg:** Yeah,

[01:07:21] No, absolutely. I mean, you know, during the, you know, the, well, the beginning of the last 10 years when it started to really hook up and, you know, started to really become an in your face, you know, issue, you know, leading scientists remaining nameless, you know, were crying because their.

[01:07:45] The, you know, the ecosystem they had sort of become one with was now being stripped away

[01:07:51] and, disappearing. And so yeah, it's, an emotional issue. I, I often wonder why I haven't felt like crying. and I wonder what that is, whether I'm insensitive or whether I really do believe in the, you know, the fact is that the game is not over.

[01:08:18] And, that we, you know, through that. Reduce emissions and protect thing. I mean, if we could get that to scale, we'll have a world in which we can live in, which will have some coral reefs left, but not many with the, you know, the wonderful, phenomenon of an expanding coral reef. As we get to stability over this century, I mean, I, see that as the big project we're on.

[01:08:45] We've gotta get beyond the political cycle of three to four years. We've gotta now start to look at and plan on a century basis. Now, if we do that, I think we lift ourselves up and go, yep, things were bad. And we didn't do the best things in the beginning. But look at what we're doing now, and we're starting to see the changes.

[01:09:03] We've stabilized, the ocean. We're starting to see, you know, that, Find those reefs that, that have the best chances of, surviving the overall climate issue. And I think that, you know, that is reason for hope and, ke keeps me going.

[01:09:21] **Nate Hagens:** So not to personalize this, ove, but I, I. I actually recommend, crying.

[01:09:28] I'm in my late fifties and I, the only times I've cried as an adult is when my dogs died, but I've cried a half a dozen times in the last nine months as I've become more and more aware and open to this, and I feel much better and actually much more creative and, with a sense of meaning and purpose.

[01:09:46] afterwards, and I've had a couple guests talk about grief, and the like. and I think it's a real thing. Let me just, not to put you on the spot, but the fact that you shared that you're married to a science colleague working on these issues, that's gotta be both a blessing and a curse, right?

[01:10:05] because if it was a gardener or a kindergarten teacher, you just have different worlds, but you both understand. The implications of the topic you're studying that must be difficult, to tune out. Do you guys just ever just watch Netflix shows and, do things totally unrelated to the severity of this topic?

[01:10:30] Crime shows. Crime shows, yeah. I like those too.

[01:10:33] I like crime shows. And Sophie's

[01:10:34] **Ove Hoegh-Guldberg:** a genius at that. I mean, she's become a genius.

[01:10:37] **Nate Hagens:** Yeah. Okay. So you do laugh and she

[01:10:40] **Ove Hoegh-Guldberg:** can watch like the first few, lines of a film go, well, yeah, okay. That's the bad guy. This, person isn't, you're gonna, just Yeah.

[01:10:47] No, but, you know, to be serious, I mean, we do, and it's, there is a lot of tension. I mean, you know, we, and especially, you know, in the fast paced world of this, you know, of these changes, it's, you know, we, often argue about things, you know? Yeah. About the reality of, one possibility versus another.

[01:11:06] And she's. Trained in math and philosophy. So she's deadly in terms of, you know, dinner, table, you know, debates. And I have to watch my step. 'cause for example, for a long while I was talking about it being about bleaching. And she said, no, it's not about bleaching, it's about death. And she was right on the money.

[01:11:26] **Nate Hagens:** Whoa. And

[01:11:27] **Ove Hoegh-Guldberg:** so it's a, you know, it's a simple sort of, you know, a nuance there, but it, you know, when we talk about bleaching almost, it's, it's like a, an

[01:11:36] **Nate Hagens:** excuse. It's, like global warming. It's like this soft euphemism coral bleaching. Well, we put bleach in to make our clothes cleaner.

[01:11:46] Coral death would get a lot more attention.

[01:11:49] **Ove Hoegh-Guldberg:** Yeah. And, it has as a result and so on. So, yeah, we, yeah. we've enjoyed lots of science. I mean. Taking the kids on our, expeditions when we used to do them every year. So they spent, you know, on this island called Heron Island, which I've talked about before.

[01:12:07] And on the Southern Great Barrier Reef, it's, you know, a couple of, football fields in size. it's an eight square kilometer coral reef. It's mostly protected. and they would go up there every summer and run wild for two months

where you didn't have to know where they were. 'cause the island was very safe and just had to tell them not to go into the, where the sharks were.

[01:12:31] But overall, it was just a sort of a wonderful experience to have that family where we were. Sophie and I were doing the science by day, and the kids were looking at the turtles, laying eggs or, you know, seeing the bat rays come in or, you know.

[01:12:48] **Nate Hagens:** I, can't imagine. I've snorkeled a few times. I've never scuba dived.

[01:12:54] And I know my colleague, who we wrote a few books together, DJ White, one of the early green Peaces, and he runs Earth Trust. He's told me stories about the magical world of, having some fins on and just spending a lot of time in these reefs, and it's a different world, and they're going away, unless we change the, trajectory.

[01:13:17] So, before I get to closing questions of what, what can individuals who care about this topic, the world's coral reefs, and want to do something about it, what can they do to most effectively support coral reefs? Or is, the answer to that all the same answers as, global heating?

[01:13:38] **Ove Hoegh-Guldberg:** Look, I think, I mean, for me, we need advocates.

[01:13:44] For the very reason you said before, which was that you look at the, you know, people in Iowa or Minnesota or wherever in the center of America, there isn't that connection and we're all connected to the reefs. Ultimately, this is part of what we bought into as participants. You know, this is a, this 25% of the biodiversity of the, of, the ocean living in and around this place that's no bigger than about 1% or less of the

[01:14:15] **Nate Hagens:** earth.

[01:14:15] Whoa. So 25% of the biodiversity in the ocean lives in 1% of the space. Yep. Little

[01:14:23] **Ove Hoegh-Guldberg:** bit. So,

[01:14:24] **Nate Hagens:** okay.

[01:14:25] **Ove Hoegh-Guldberg:** You look at that, I know, it's just, it's breathtaking. You know, things like the euphoric zone, which it didn't talk about the lower light areas of the reef, where every time you go there, you run into new species.

[01:14:37] So it's like Darwin gets to the Amazon, you know, first, and it's like one of those things. So, I mean, I, so I think, you know, people that care about these types of issues, I mean, we should do our best to, you know, to find, to educate themselves on the issues, to, take on board that issue that we have to reduce greenhouse gases urgently.

[01:15:03] You know, this is gonna be really important because unless people that make the decisions understand that this is an important issue, they won't. respond very little. So I think that's one thing. And I think also, you know, it's just like, you know, get to, you know, use what the tools you have. If you're a filmmaker, go and make great films about this.

[01:15:28] If you are a writer, write great books about it. If you're a school teacher, bring this into the classroom. And not just coral reefs, I mean, they're just the narrative of a story which is being repeated across the planet where it's about ecosystems falling over, you know, tipping points, people and so on.

[01:15:49] So, I mean, if we can get to that point where we start to, to develop a, movement, and then we start to change things at the scale that they need to be

changed at, we can no longer open up, you know, gas fields, coal mines, and so on. That day is over. The sooner we get off that. And it sounds radical, but it's, doable, right?

[01:16:13] The technology's there. I mean, that's the, you know, the amazing thing is that we've, we're still hugging onto the coal and so on if these magnates, but it's now a dangerous product. So you, know, the best sequestration for CO2 is to leave it in the ground, leave the methane, leave the CO2.

[01:16:36] **Nate Hagens:** So do you have, for the listeners of the program, beyond coral reefs, do you have any personal advice, to the viewers of this show at this time, of, global upheaval and anxiety and worries about the ecosphere and the economy and polarization and all the things, what some might call the meta crisis?

[01:16:56] Do you have any general advice, of

[01:16:59] **Ove Hoegh-Guldberg:** Yeah, look, I think the last thing we wanna do is to lose hope, right? So we've gotta. Look at the things that have been impacting us, and we've gotta be careful about how we frame it. Because, you know, while we don't wanna have false hope, there's plenty of reasons to be hopeful.

[01:17:22] For example, you know, just the explosion in different technologies that we are seeing. And not to be a technology apologist, but we are rapidly expanding our ability to respond to global issues. It's like, we didn't get it. We didn't get it, and now we're on a, you know, this. Escalation of activity. And so, you know, I often talk to undergraduate audiences and people say, well, you know, it's all gonna be dead by the time I get out of university.

[01:17:50] So, you know, why would I want to go and study a coral reef or, do something? And you go, like, you are the generation that will fix things. You have

it in your hands. And you have one of the, probably something that many humans that have existed have never really experienced, which was you've been able to save a planet, and it's a planet that is out there.

[01:18:12] There's only one in every 5,000. It's probably a planet that has life on it. So just

[01:18:18] **Nate Hagens:** join the, fight. Do you still teach or are you primarily doing research on this?

[01:18:23] **Ove Hoegh-Guldberg:** Yeah, look, I, still teaching to, I used to run a co, a, a course called, global Climate Change and, you know, bringing in different, People to talk to undergraduate audiences and so on, and also give lectures myself. So I love teaching, but of course it's, the other is a

[01:18:44] **Nate Hagens:** full-time job as well, so I love teaching too. So, so what, although I'm not doing it now, what advice do you have for teenage and early 20 humans who are becoming aware of all this stuff?

[01:18:56] How would you change your advice for young humans?

[01:18:59] **Ove Hoegh-Guldberg:** Look, I, think, some people think that, you know, the generation coming through should be a little bit more angry. I wouldn't blame them if they were exactly, they, you know, they, they have born into the world more or less on the assumption that there would be reasonable like-minded individuals that would make sure that the resource wasn't destroyed, when that's quite the opposite.

[01:19:24] And so now we're seeing that, and now, you know, I, think it's, not so much get. Angry, but it's get real on this and to really start to become active. Because to me, we talk a lot about this issue and then, you know, our ability to

translate that talk into action, dissipates just because of, you know, the other things that people have to worry about.

[01:19:48] But, really, I, think it's really important that we get to the point where we say, right, okay, here's what we need to do. Here's how we solve the problem. And it's a generational, it's a long-term process, but we can get there. Just have to start doing it. And of course, that's where I think, you know, that can be uplifting when you know, think it through.

[01:20:14] **Nate Hagens:** What do you care most about in the world of

[01:20:18] **Ove Hoegh-Guldberg:** my family, my planet?

[01:20:22] **Nate Hagens:** Good. Good answer. I don't know how familiar you are with, my program, but I always ask this question near the end. If you could wave a magic wand and there was no personal risk or recourse to your decision, what is one thing you would do to improve human and planetary futures?

[01:20:43] **Ove Hoegh-Guldberg:** Yeah, no, I think it, comes down to, the dance we have with politicians is we could have some sort of sprinkle dust, you know, that you could suddenly have everyone speaking the truth. Then I think we could sort of go, okay, that's where we're at, so now let's take those pieces and put it in together into a clever plan forward.

[01:21:09] But I think, you know, that would be the ultimate.

[01:21:13] **Nate Hagens:** Fairy dust, then they wouldn't be politicians, they would be implementers or some different skillset than being a politician. But I agree with the sentiment.

[01:21:26] **Ove Hoegh-Guldberg:** that's right. Might even make them cry.

[01:21:29] **Nate Hagens:** Yeah. So what are you working on? What is your main research and professional thrust right now on, on these issues?

[01:21:36] **Ove Hoegh-Guldberg:** Well, at the moment I'm really interested in the sort of communication side of things. And so, I've got a, a group that's working, in, my, team that are creating online learning, experiences for people in countries where it's hard to get that information normally, or, you know, people have not had the pleasure of going to university and so on.

[01:22:02] And the idea is that there's lots of people, for example, in Indonesia who haven't. To have a degree and do the regular sort of, you know, through to then looking out, you know, running a department, you know, on the environment who, you know, have had to sort of put it together as they go. And the idea is that these courses would be like to take blue carbon, for example, which is an important concept.

[01:22:26] What is blue carbon? Well, blue carbon is, if you, it's basically recognizing the value of the ocean within the sort of global cycles. And so a big part of that is carbon that's associated with the ocean and that has lots of opportunity for the future. But it's a hard concept to explain to a lot of people who have not been exposed to it.

[01:22:52] So the idea is that if you have a course on that or you have, you know, sim simple course on, on who lives on a coral reef, and you do it in Bahaa and it's, it gives you a certificate, at the end of the day. Then there's this opportunity to sort of develop and help, build an understanding and capability in, in this region, in, in that, area.

[01:23:18] So it's, a work in progress. I mean, we've had a thousand students sort of enroll in our first series of courses. you can, I can give you the website if you'd like

[01:23:29] **Nate Hagens:** and so on. Yeah. Yeah. We'll put that all in the show notes. So, so, is there a research question that you don't know the answer to with respect to the oceans and, coral reefs that you're really curious about that's relevant to, to the future?

[01:23:46] What, is something that you'd really like to research, given time and resources that you'd like to understand?

[01:23:52] **Ove Hoegh-Guldberg:** For me, it would be. Trying to understand where the, you know, opportunities lie in, in harnessing the value of oceans in the climate question. And so, I also did some years ago, a, project with the World Resources Institute, on, you know, the fact is that we often see oceans as the victim, when in fact they could also be the solution.

[01:24:28] And so this project, which was funded by the World Resources Institute, allowed us to bring together to, you know, to together with a colleague, you know, 20 world experts on shipping, on blue carbon, on, you know, all those different elements. And, you know, to, To essentially look for the opportunities.

[01:24:54] And the opportunities were really interesting. I mean, the top number one intervention was shipping. You know, when we wait for our things from Google and Amazon and so on, they're all powered by this sort of fleet, which of boats, which is somewhere near 15 to 20% of the total emission budget.

[01:25:16] And so, you know, what could you do with that? Well, you know, replace the engines with, you know, renewable energy, renewable sort of stored power

[01:25:26] **Nate Hagens:** and so on. Or replace the demand for the things with less.

[01:25:30] **Ove Hoegh-Guldberg:** Yeah. And, you know, the combination. But, this could be a real win for the, for those, you know, things.

[01:25:38] And so, you know, and the second of this was, renewables at sea. So the idea of not only new technologies, but simply taking, floating, windmills and make them part of the ocean that turns out to be a really sort of, you know, it's an area which, could have a lot of promise in terms of reducing emissions.

[01:25:58] And so when you do that and then look at how much of the emissions that you need to shave off, you know, the emissions that, that, that are pushing us towards three degrees instead of 1.5 degrees, that between 25 and 30% of those emissions could be taken care of by off the shelf technology that can be, you know, employed today.

[01:26:20] So those types of issues to me are really issues. I mean, they're not the science ones that I used to go after and, I'm really interested in still doing some science along the way

[01:26:30] **Nate Hagens:** because the primary question about Coral, and the prognostications of people like you are pretty clear. So now your research questions are more on communication than science and implementing, the importance of the oceans with humans.

[01:26:47] Yep.

[01:26:48] **Ove Hoegh-Guldberg:** And spending a lot of time talking to politicians. I mean, I, you know, I'm fascinated by that. And, you know, at the moment, I think we've got a rare, situation in a, in Australia where we've got a strong labor party, a liberal party that's studied, reform itself, and, earn a greens that's very, you know, pro action on climate change.

[01:27:08] And so you look at those elements and you start to think, well, here is a moment when we need to make hay. The sun is shining. We've got some alignment. The Americans don't. Of course we understand that. And, but yeah,

[01:27:22] **Nate Hagens:** I apologize for that.

[01:27:24] **Ove Hoegh-Guldberg:** Look, I know how wonderful America is, and I think this is the sad thing about it, is that you're now being tainted by a brush, which not everyone owns.

[01:27:35] In fact, very few people from what I understand. So, I mean it, but it, but for us. We've got this alignment and I think this is the opportunity.

[01:27:44] **Nate Hagens:** Thank you, so much for your time today and your work over decades. And I hope that, one day you do have happy egg on your face and that there are coral reefs, by mid-century, yeah, to be determined.

[01:27:58] Do you have any closing comments, for people watching and listening who understand and agree with what you've laid out here today?

[01:28:05] **Ove Hoegh-Guldberg:** Well, I think it is keep the faith and get active and let's solve this problem together. And, yeah, it's been really a really fun to be here, Nate. And, it's interesting 'cause it's not smooth, you know, you're, it, when you're asking those questions, it's sort of, these are hard things to talk about.

[01:28:27] Yeah. In, one sense because we've been talking about 'em for, so long and we still have to have hope. And for me, you know, you know, it's great to have people like yourself, guiding the discussion. It's really important.

[01:28:42] **Nate Hagens:** O Ho Goldberg, thank you very much and to be continued, my friend. Oh, thanks Nate.

[01:28:48] Bye. If you enjoyed or learned from this episode of The Great Simplification, please follow us on your favorite podcast platform. You can also visit The Great Simplification dot com for references and show notes from today's conversation. And to connect with fellow listeners of this podcast, check out our Discord channel.

[01:29:11] This show is hosted by me, Nate Hagens, edited by No Troublemakers Media, and produced by Misty Stint, Leslie Balu, Brady Hayan, and Lizzie Sir.