The Great Simplification

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[00:00:00] **Malin Pinsky:** What we're seeing is probably the largest mass movement of marine life in the last 10,000 years as waters are warming, as prey are shifting towards the poles, as oxygen levels in the ocean are going down, all of these things are making conditions in hospitable for many of the species, especially fish and the ocean.

[00:00:22] And then this has ripple effects that go through to coastal economies and fisheries, even international relations. It's sparking conflict in some cases between countries. So it says wide reaching consequences.

[00:00:39] **Nate Hagens:** Today I'm joined by Marine biologist Malin Pinsky to discuss what he describes as possibly one of the largest animal migrations in our planet's history occurring right now in earth's oceans. Malin is an associate professor in the Department of Ecology and Evolutionary Biology at the University of California Santa Cruz, where he has been using decades of data to research the changes in adaptations in ocean life due to climate change.

[00:01:09] He is also a fellow of the American Association for the Advancement of Science, science, an Earth Leadership Fellow, and an early career fellow of the Ecological Society of America. Most notably, Melin and his team have been studying the polar word shift in animal populations due to both rising temperatures and insufficient oxygen levels, which is the subject of today's episode.

[00:01:32] We have dedicated quite a few episodes of this podcast to Ocean Systems, and I am excited to continue our exploration on this important topic as it is my belief that oceans are one of the most impactful, but often overlooked aspects of the enormous planetary changes currently underway. Today's conversation with Malin expands on just one piece of this complex and unfolding situation.

[00:01:57] If you're interested in learning more about Oceans, we will link a few of the team's favorite episodes in the description. Before we begin, if you enjoy this

podcast, one of the biggest ways you can support us is by subscribing to it on your favorite platform, as well as sharing this episode. Who might also enjoy it?

[00:02:15] Or learn from it. We believe in making this content free and accessible to as many people as possible, and we appreciate your support With that, please welcome Professor Malin Pinsky. Professor Pinsky, welcome to the program. Thanks so much for having me. Great to be here. You are an ocean expert. And what better place to study the oceans than the University of California Santa Cruz.

[00:02:39] What a lovely town and a lovely setting. It's a fantastic place to be. I'm actually

[00:02:44] **Malin Pinsky:** looking out at the ocean right now. So,

[00:02:46] **Nate Hagens:** you know, historically humans co-evolved, near water and, well we evolved outta the ocean. If, you go way back, historically, but it seems like a lot of populations today are like where I live near Minneapolis.

[00:03:00] The ocean is almost an abstraction because it's so far away and we don't get the emotional, we don't look out the window like you are and, seeing it, but the oceans are so vital to how the world works and food and climate stability and everything. So, it must be good to have a daily reminder of what you're studying and how important it's

[00:03:24] **Malin Pinsky:** Yeah, it definitely is.

[00:03:25] I mean, I look out right here and the edge of the horizon is the ocean. And it's at least a small reminder that this, isn't really planet earth, this is planted ocean. and so much of our, trade, a lot of the food for people around the world comes from, fish. even if we don't necessarily see the ocean in our backyard daily, it is such an important part of our economy and our life.

[00:03:54] Our society is supported by the ocean.

[00:03:56] **Nate Hagens:** Do you ever like just sit on the beach and look out into the ocean and imagine someone on the coast of China is doing the same thing, looking at you?

[00:04:06] **Malin Pinsky:** Yeah. No, it's a, good point. You know, they're so, you know, most people actually live. Near the ocean as well.

[00:04:13] You know, we, even in today's world, so many of us in today's world especially, most, a large fraction of, humanity lives within, you know, say a hundred kilometers or so of the ocean. There's a big attraction both for trade, you know, that's where our ports are. That's where, goods get moved between, cities and it's also, you know, property prices are high near the water as well.

[00:04:39] Clear evidence that lots of people wanna live near the water, live near the ocean.

[00:04:43] **Nate Hagens:** Well, I'm, I mean, we're gonna, your team, researches marine organisms that are non-human, which is gonna be the focus of this conversation. But yeah, we could spend a whole, hour and a half talking about the implications for people on the coast, in the coming century with sea level rise, et cetera.

[00:05:02] But you and your team are, world class, experts in marine animal response to ecosystem changes that are happening in the world's oceans due to warmer temperature, and more CO2. so to start with, can you just unpack the broad patterns that you and your team are seeing, observing with animal migration in the ocean and why this topic is important?

[00:05:30] **Malin Pinsky:** Yeah, so I, I run the. Global Change research group, as you said at the University of California Santa Cruz. And we collaborate with, scientists all over the world to collate data on where marine species have been historically and where they are now and where they're going. And what we're seeing is the, it was probably the largest mass movement of marine life, at least in the last 10,000 years, towards the poles primarily.

[00:06:03] as waters are warming, as prey are shifting towards the poles, as oxygen levels in the ocean are going down, all of these things are contributing to making conditions at low latitudes inhospitable for many of the species, especially fish in the ocean. And then this has ripple, effects that go from ecosystems and species interactions and the productivity of, the ocean through to, coastal economies and fisheries.

[00:06:38] The food on our plates and even international relations, it's starting to affect, trade and, Even sparking conflict in some cases between countries. so it says wide reaching consequences.

[00:06:58] **Nate Hagens:** We just met and had an introductory conversation, and I reached out to you because Daniel Polly is a friend of mine, and he was on our podcast, a few years ago talking about, Gil Oxygen Limit Theory.

[00:07:09] Saying much of the same things. And so this is something that I don't think is in the public's, imagination or awareness, and I have so many questions for you. and some of them will be on the naive side. For example, this, you just said, this may be the greatest migration of animals, at least in the last 10,000 years.

[00:07:32] How would we begin to know that? How do you know it's a greater migration than even 300 years ago? Scientifically?

[00:07:38] **Malin Pinsky:** So, yeah. I mean, that's a guess. but an informed one, based on a lot of the research we've been doing, tying movements over the last primarily 50 years where we do have strong observations of where, many marine fishes have been and where they've moved to.

[00:07:59] And one of the key things that we've found is that they, follow their preferred temperatures quite well, so quite closely. And, as those preferred temperatures are moving towards the poles, also to some extent moving towards deeper waters and further from the coast, it's not always just a clear march towards the, polls.

[00:08:23] It's definitely more, more complicated and nuanced than that. But that's the broad brush strokes. And because of that close link between. Temperature in many marine species distributions. Geographic distributions. We can then sort of do that hind cast. Think about what would've happened in the past.

[00:08:42] And we're seeing right now one of the largest changes in temperature in, sort of since we came out of the, last glacial maximum, the last ice age. And when was that? About 12, 20,000 years ago. It's also, I mean, even beyond that, you have to go back more like 120,000 years until you find a time in earth's history when it's as warm as it is right now.

[00:09:10] And I think that's for me at least one of the scariest things when we think about, what does that mean for marine ecosystems, but also ecosystems

[00:09:21] **Nate Hagens:** around, around the world. I'll tell you something that's even scarier. It's one of the warmest times, but I. and I'd like to tee you up to, to explain what I'm about to ask you.

[00:09:33] but the oceans have not warmed nearly as much as on land, and they are acting as a buffer. And so some warming is yet to come just because the oceans are this really slow feedback mechanism. Can you explain that?

[00:09:48] **Malin Pinsky:** So, so you're right. The oceans have not warmed as much. It's the oceans are effectively the heat sink for the earth.

[00:09:56] more than 90% of the excess heat from anthropogenic climate change has ended up in the oceans. If we didn't have the oceans, we would already be very crispy toast. It would just be ridiculously hot on, on the earth's surface already. And the surface of the ocean has warmed about 0.9 degrees Celsius so far.

[00:10:18] That's quite a bit less than the land surface, which is about 1.6 degrees Celsius. And yet one of the things that's interesting is that because the ocean buffers heat buffers temperature so much, it absorbs heat, but it doesn't actually change temperature all that much. species that live in the ocean actually are not adapted to changes in temperature all that much either.

[00:10:42] So even a relatively small change in temperature of the ocean, has had very large consequences for ocean life. Actually, species in the ocean are shifting towards the poles about five times faster than we are seeing, on land.

[00:10:58] **Nate Hagens:** And this isn't a, It's a little bit cooler over there. I think I'm gonna swim in that direction.

[00:11:04] It's just like a internal biological like, oh, this is uncomfortable and I can't get enough oxygen or food, so I'm swimming in that direction.

[00:11:13] **Malin Pinsky:** Well, it's a whole range of mechanisms and it depends on the species. So, you know, for example, surf clams on the east coast of the us, they've been dying off.

[00:11:26] Yeah. 'cause they can't swim. They can't swim. Exactly. So that's been more of a die off. And then population growth further towards the poles. They have larvae, they disperse with ocean currents. They have an ability to move towards other locations. But it's largely undirected. It's not fish with fins deciding they're gonna use them.

[00:11:47] **Nate Hagens:** Their populations have the ability to move to different locations. Correct. Not their individual bodies.

[00:11:52] **Malin Pinsky:** Exactly.

[00:11:53] **Nate Hagens:** Yeah.

[00:11:54] **Malin Pinsky:** Yeah, So it depends on the species. For some it's, oh yeah, it's uncomfortable. I need a lot. My metabolism's going up, my body's hot. I need a lot of oxygen. I need a lot of food.

[00:12:08] Let me go somewhere else that's more comfortable. But for other species it's just survival.

[00:12:12] **Nate Hagens:** So you said that the ocean surface, has warmed 0.9 sea. do we measure at lower levels? 'cause the ocean goes down a long ways. Do we have any, evidence or, metrics on deeper or mid-level ocean temps?

[00:12:30] **Malin Pinsky:** Yeah.

[00:12:30] So, the, surface is warming the fastest and then rates of warming decline as you Okay. As you go deeper

[00:12:38] **Nate Hagens:** and, You said that many, not just a few fish, but many different marine organisms are swimming or moving their populations northward, but are they also moving deeper because deeper might also be cooler and have more oxygen?

[00:12:54] Yes.

[00:12:54] **Malin Pinsky:** Yes. That, is correct. though there are limits to how far that goes,

[00:13:00] **Nate Hagens:** because then there's not enough, photosynthetic productivity that leads to food, you know, algae and phytoplankton and things like that when you're at a half mile down. Right,

[00:13:12] **Malin Pinsky:** right. we have the photic zone where lots of light, penetrates.

[00:13:17] We have lots of, phytoplankton, basically the plants of the ocean that are growing. And also, you know, a lot of fish are visual predators, so they need that light to find their prey so they, you know, going deeper to find cooler, cooler water, it helps to some extent. But only to some extent.

[00:13:38] **Nate Hagens:** So you've studied, horizontally and vertically the entire gamut of ocean creatures and their responses, but what sort of breadth and variety and diversity of ocean creatures do you study and are you observing this phenomenon?

[00:13:55] In the majority of them, they're, swimming poleward or deeper.

[00:13:59] **Malin Pinsky:** My research group in particular has focused in particular on, fishes and crustaceans that are observed on continental shelves. So these are the relatively shallow parts of the ocean, close to land. here on the west coast, it's a relatively narrow continental shelf, but on the east coast, you know, it's a couple hundred miles and these are the most productive parts of the ocean.

[00:14:22] They're also the parts of the ocean that interact the most with human society. It's where most of our fisheries. Operate. It's also the parts of the ocean that are best observed. So there are surveys that, governments all over the world conduct on continental shelves. So it provides an opportunity for us to test our hypotheses and better understand how ocean life is responding.

[00:14:44] On the other hand, you know, other scientists are working on marine mammals and invertebrates and many other, species across the ocean. And this consistent picture has emerged of the. Vast majority of marine species that we have observed well enough to know where they're going, are shifting towards the poles.

[00:15:07] **Nate Hagens:** So let's get into, the core of your science a bit. I think it's intuitive, to most listeners, but can you give a specific explanation of why temperature is an important factor for determining what sorts of organisms can live in a given ecosystem, either on land or in the ocean?

[00:15:27] **Malin Pinsky:** Yeah.

[00:15:27] Temperatures is the metronome for life, you know, especially for what we call ectoderm. So this is fish in the ocean, but also crabs, crustaceans, pretty much everything in the ocean except for marine mammals. their ecto, herms, their body temperature is set by the temperature of the water around them.

[00:15:44] When water temperature goes up, their metabolism goes up as well. So they need more food. They also need more oxygen. It also affects protein. if my

[00:15:55] **Nate Hagens:** body temperature goes up, do I need more food and more oxygen?

[00:15:58] **Malin Pinsky:** You get a fever, so do I. Oh, right. You know, just a degree or so. Right. And you'll feel feverish.

[00:16:07] You know, you're, the homeostasis of your, the equilibrium of your body is thrown off metabolism and demand for oxygen relative to how much is available in the water around them. Similarly for food. And then temperature also affects protein structures. They basically get wobbly and fall apart when it gets too hot.

[00:16:28] So for some species, that's an issue. And actually it also affects the permeability of cell membranes. So temperature is really this fundamental biological, factor that affects a whole organism. So you mentioned thermal safety margin. One of the things that my group has been very interested in is trying to

understand, how sensitive marine species are to rising temperatures compared to rising temperatures on land and species on land.

[00:16:58] And one way you we can make that comparison and we've, made this comparison is, to basically measure what's the temperature, that fish are living in and how close are they to the highest temperature that they can tolerate. And those are, high temperature tolerances that are measured in the laboratory, sort of in, in experiments.

[00:17:22] And then we can compare that, difference, that buffer is what we call a thermal safety margin. And we compare that safety margin to then safety margins for amphibians and reptiles and insects on land. And one of the things we found that was really surprising for us and for many of our colleagues is that marine species actually live closer to their upper thermal limit in general than do species on land.

[00:17:46] So they're more sensitive to rising temperatures. And actually we've seen. Twice the fraction of marine populations disappearing at low latitudes and presumably moving towards higher latitudes, as we've seen disappear on in the on land as well. So not only are they more sensitive, but they're also disappearing at higher rates.

[00:18:09] **Nate Hagens:** Let me ask you a question. So, as temperatures in the water warm, two things are happening. One is they're getting less oxygen staying in the same place and their food might be moving, northward or not be available. Do you see any evidence where, In order to feel better and to not have a fever, metaphorically, marine organisms hold out in cooler temperature, maybe deep water or something like that, but there's no food there.

[00:18:44] So then they have to go to where the food is and when they're done eating, they go back to where it's cooler instead of maybe back in the day. Those were the same location. is there any examples of such a thing?

[00:18:58] **Malin Pinsky:** Yeah, no, that's a really good question. There's a very interesting study done in, Norwegian fjords a few years ago where they had, trackers on Atlantic cod, you know, very, favorite species for the fish, for people to

eat all over the world, basis of many economies across Europe too, and especially in the.

[00:19:19] A couple hundred years ago. But the cod, when it wasn't too hot, the cod were feeding in very productive shallow parts of the fjord. When it got too hot, they would move deeper where it was cooler, but where there wasn't as much food. So they would sort of avoid the high temperature areas when they had to.

[00:19:37] But as soon as they, as soon as they cooled off, they'd come back to the, surface, the shallower areas where they could feed.

[00:19:44] **Nate Hagens:** I know you're an ocean expert, but is there analogs in freshwater lakes, where obviously the temperature must be also be warmer because it's warmer on land and warmer in the air?

[00:19:55] So are there, do fish in the Great Lakes or in the lakes in Minnesota, the land of 10,000 lakes where I live, are they hanging out at a deeper level because it's, it feels better.

[00:20:07] **Malin Pinsky:** Yeah. It's common in freshwater lakes and rivers as well. You can often find, Trout, for example, hanging out near cold water, seeps in a, river, and then moving into warmer waters to grab some prey, but then retreating to the colder locations.

[00:20:23] **Nate Hagens:** What I meant is there evidence in the last 50 years that, that, where fish are hanging out is, deeper than it used to be.

[00:20:31] **Malin Pinsky:** I am not aware of that though. There has been evidence that many freshwater species are also, populations are growing at the northern or high latitude parts of the range and shrinking in the low latitude parts.

[00:20:47] So we're seeing similar patterns in freshwater as well, similar to what we're seeing in the ocean, though I will say. Moving and swimming is trickier in freshwater, right? You don't, necessarily have a river going north, south. Sometimes they go east, west,

[00:21:01] **Nate Hagens:** well, or you might be in a lake and you

[00:21:02] **Malin Pinsky:** can't go north beyond where the lake is.

[00:21:05] And we have dams and yeah, a lot of barriers in freshwater.

[00:21:08] **Nate Hagens:** So, you're not studying, endotherms, though you have a lot of 'em right outside your door. The last time I was there, there were sea lines, like on the, promenade there, in Santa Cruz. How is this impacting whales, dolphins, sea lines, other ocean, megafauna?

[00:21:28] **Malin Pinsky:** Yeah, it's a great question. Yeah, I feel pretty lucky actually sometimes. Monterey Bay called the Serengeti of the, of the ocean, so Really? Oh yeah, last time I was there it was amazing. Highest diversity of marine mammals, in the world as far as I'm aware. Watch. Really? Yeah. Wow. Yeah, it's cool.

[00:21:44] and why is that? It's very productive. So lots of food to feed on. So we've got, very deep ocean, ocean water, very close to shore, and a lot of upwelling. So upwelling is a particular oceanographic phenomenon that brings very nutrient rich water up to the surface, where then it sparks, phytoplankton growth, and then you have zooplankton feeding on them and fish feeding on them, and then whales coming in and seals and sea lion coming in as well.

[00:22:11] **Nate Hagens:** So, so what's the evidence? I mean, is this impacting ocean? I mean, they're at the top of the food chain, right? So they have to be impacted somehow.

[00:22:20] **Malin Pinsky:** Well, and that's exactly how they're impacted. Largely it's through, their prey and through their food. So we also, here on the west coast, we see dolphins, showing up more in Oregon and Washington.

[00:22:32] Historically, they were found around California. One of the. One of the key cases actually has been, north Atlantic, right whale, so a critically endangered species on the, in the Atlantic, on the east coast of the us There are only about 370 individuals left and they, showed up, have been showing up in much larger numbers up in Canada, in the Gulf of St.

[00:22:59] Lawrence. And presumably they're, well, actually, we, know pretty well that they're following their prey. You know, they're not as directly impacted by, temperature and warming, but their prey definitely are. They feed primarily on Copa pods, basically the protein bars of the ocean. and with their prey more productive further north, the whales are following them as well.

[00:23:25] That's led to a number of other complications because they've also then been entangled in fishing gear. And that's one of the main threats to, right whales, but also an issue here on the West coast.

[00:23:39] **Nate Hagens:** So as the oceans warm, the delta of current temperatures versus future temperatures would be highest in the northern latitudes as we approach the poles.

[00:23:52] But maybe the absolute temperature, high temperature would be near the equators. what are the implications for your, work? There will still be fish depending on eventually how this all unfolds, but there will still be fish at the warmest ocean layers, and levels around the equator that will just be fewer, less diverse, more simple species or what can you say about that?

[00:24:19] **Malin Pinsky:** Yeah, so it's actually already been an observation that there are fewer. Species at the equator than there have been historically, and that the number of species is already declining. and the normally we, you know, we talk about, the greatest number of species being present at low latitudes. Often we think about that at the equator and the ocean.

[00:24:42] It's actually at slightly higher latitudes, both north and south. And there's a bit of a dip when you get to the equator, which is really surprising. there, I think one of the biggest concerns in the tropics is coral reefs. You know, we know that corals as a species, many corals as a species can tolerate higher temperatures.

[00:25:05] But the, species that are most important for building the massive reefs that we can see from space that, you know, people go scuba diving and snorkeling on. And they're also so important for supporting fisheries and tropical countries, those reefs. Do not, you know, they're very sensitive to high temperatures and we see global coral bleaching happening in recent years, and that leads to mortality of the corals and eventually degradation of the reef as well.

[00:25:34] So the big concern in the tropics is loss of coral reefs especially,

[00:25:39] **Nate Hagens:** and what's downstream from that? 'cause the food, chain has a ripple effect. Or is it just the loss of, coral in which itself would be a tragedy. But,

[00:25:50] **Malin Pinsky:** you know, you, we think of corals in some ways, like the rainforest of, the ocean.

[00:25:53] You know, they, so they provide the structure and the habitat for an incredible diversity of shrimp and fish and crabs and everything else. Yeah.

[00:26:07] **Nate Hagens:** How many different organisms? Roughly? I can't say I, I've counted, but thousands. Thousands of different Thousands of species. Yeah. Thousands of species. Yeah. And how are you actually measuring and researching these changes as you as, the director of this effort?

[00:26:21] **Malin Pinsky:** Yeah. So we, work with, scientists all over the world who are conducting these surveys.

[00:26:30] we, at the moment, I'm helping coordinate a group, an effort called Fish Globe to pull together data on, fish, marine fish near the coast, all around the world. And to understand observations of where these fishermen observed, how has that changed through time? And then how is that linked to ch to changes in their environment?

[00:26:51] So we, we build lots of statistical models and other more mechanistic mathematical models. To understand what's been happening and what's likely to happen going forward, but with

[00:27:03] **Nate Hagens:** thousands of species and, funding now with, NOAA and NASA and other scientific orgs, under threat, like how do we have the actual manpower and science power to keep tabs of all these species?

[00:27:19] Is that, an increasing

[00:27:20] **Malin Pinsky:** challenge? That's what part of what's been so concerning in the, last couple months, right? I mean, the, these changes are happening in the ocean. These changes are happening in the, climate, whether we see them and understand them or not. And by cutting out the scientific infrastructure, and that's both observations, but also the experts to take those observations, you know, in government agencies like the National Oceanic and Atmospheric Administration.

[00:27:55] We don't, you know, we won't have the ability to know what's happening. it's kind of like driving quickly at night without our headlights on. we just don't know it's coming. and increasingly our fisheries really rely on understanding what's happening in the ocean right now and what's likely to happen next year or over the next couple of years.

[00:28:20] You know, you think about a fishing business that's going to invest in a billion dollar permit for scallops. Scallops better be around for a decade or more for that to pay off. So if you're gonna make a big business investment in fisheries, you wanna know that they're gonna be around and that requires the ability to forecast.

[00:28:45] What the ocean conditions will be and where the fish will be. And there's actually been, and where the scallops will be. Well, yeah, sorry. Yes. The scallops will be totally agree

[00:28:55] **Nate Hagens:** if they'll be anywhere. I mean, so beyond migrating, are you seeing any trends in declining species populations or even the beginnings of what might be extinction, for some species?

[00:29:05] **Malin Pinsky:** So when we've looked across, marine species at their low latitude range edge, so sort of as far south as they're found, half of those species have already disappeared from low latitudes and have contracted towards higher latitudes. So those are what we call local extra patients, local extinctions, there has been.

[00:29:33] A species of coral reef fish that's presumably gone extinct as a result of high temperatures in the ocean. It's the Galapagos Damsel hasn't been observed for the last few decades, and the projections going forward is that if the ocean

continues to warm as much as it could with runaway, greenhouse gas emissions, we could look at extinctions on the order of what's been seen.

[00:30:00] You know, at the end, per the, end Permian extinctions are the largest loss of. Life on earth that we know of in the geological record like 250 million years ago.

[00:30:10] **Nate Hagens:** So Cory Bradshaw, is a population biologist from Australia. He was on the show and he said, and others have said that at three degrees Celsius, warming on land, we would lose half the species on earth.

[00:30:26] And I would have to think that it would be the same in the oceans or similar magnitude. The

[00:30:31] **Malin Pinsky:** latest projections for. End of century, sort of average across or middle of the road. greenhouse gas emission scenario actually is about 10% in the ocean. 10% of species? Yeah. Okay. Yep. So, you know, you can think about many marine species can move towards higher latitudes.

[00:30:53] They have some ability, so its species at the poles that are most at risk. This is not, you know, it's not universal by any means. 'cause they have nowhere to

[00:31:00] **Nate Hagens:** swim. Polar

[00:31:01] **Malin Pinsky:** nowhere, left to go. So, yeah, it's kinda like they're walking a plank towards, but there's a

[00:31:04] **Nate Hagens:** difference between extinction and, viable population.

[00:31:10] And, the, how many organisms comprise a population entirely. Yeah.

[00:31:16] **Malin Pinsky:** No, that's right. you don't need to go to zero before you're, bound for extinction. That's something we call actually the extinction debt. So a population or a species has declined enough or lost enough habitat that they're headed towards extinction, but it's gonna take some time till they actually get there.

[00:31:33] **Nate Hagens:** So the, slowdown of the, the current in the Atlantic Ocean, we've had some people talk about that and if that continues, the conveyor belt Europe might be, and the waters around Europe might be super cold. and I've been thinking about that from a climate impact on land, but that would also have impacts on, fish and marine organisms who would actually want to go to that cold area.

[00:32:04] **Malin Pinsky:** Yeah, no, you, would see many marine species shifting back south. So, you know, north Sea Atlantic cod populations, for example, have not been doing well at all. Part, of that's over fishing, but it's also warm. Ocean waters, Atlantic cod, up in northern Norway are booming, doing really well.

[00:32:23] **Nate Hagens:** So, as I mentioned earlier, a couple years ago, Daniel Polly was on the show talking about Gill oxygen limitation theory, which says that what is driving the polar word movement of fish is that there isn't enough oxygen for them at the location that they currently are in the ocean.

[00:32:40] So how does this factor fit into your work?

[00:32:44] **Malin Pinsky:** That combination of higher temperatures and not enough oxygen to meet demand is one of the key mechanisms that's likely driving the poll word movement that we're seeing. One of the real scientific needs at the moment is actually to make that link more directly.

[00:33:02] Because. We have good observations of temperature, but it's only in recent years that we're starting to get actually reconstructions of what oxygen availability in the ocean, especially down deep where, fish are actually found. How much oxygen is down there. And how has that changed through time?

[00:33:20] How do we know how it changes through time? Most? So we have some observations, but they're quite sparse and that's what's made it difficult. So they get reconstructed actually by oceanographic models, so mathematical models of how, the ocean circulates and how oxygen and other, and nutrients, transform as well.

[00:33:41] **Nate Hagens:** And, at all the take, take, the Mariana's trench, the deepest place in the ocean, there's the surface water and then like how many mile

five miles down, what does the oxygen look like from zero all the way down to 30,000 feet or whatever it is.

[00:33:59] **Malin Pinsky:** So oxygen tends to decline as you go. Somewhat deeper in the ocean than we have actually a Xi.

[00:34:06] **Nate Hagens:** But it's much, much colder though down there.

[00:34:08] **Malin Pinsky:** So the demand for oxygen for species that live down there is also lower. So you have these sort of two counteracting factors. as you go deep, deeper in the ocean though, you, raise an interesting question. 'cause especially offshore, this isn't right, close to shore, but we have something called an xim oxygen minimum zone where there's basically enough, life that a lot of the oxygen gets used up, but it's not easily replenished from the surface because the very surface mixes with, air, we have relatively large amount of oxygen right at the surface of the ocean.

[00:34:50] But then, you know, the oxygen minimum zone and as the ocean has been warming has two effects. one is it. It tends to stratify ocean waters more. It's kinda like putting a lid on the ocean to some extent. So there's less mixing of oxygen into the ocean. And these oxygen minimum zones have been getting, getting larger area wise, but also getting, thicker in the ocean.

[00:35:15] And it's been pushing species, many species of fish like tunas and swordfish into just a narrower, range of depths in the ocean. It's made them actually more accessible to fisheries.

[00:35:29] **Nate Hagens:** They're just kind of corralling 'em into the, only sliver of ocean that actually has sufficient oxygen because this other stuff has, is below the minimum oxygen threshold.

[00:35:39] Exactly, yep. Because the oceans are stratifying because of all the changes we've been discussing, which leads to, Peter Ward is a good friend of mine. He wrote a book called Under a Green Sky, which is about historical canfield oceans, where the oceans become fully stratified and there's hydrogen sulfide gas, and other nasty things.

[00:35:58] Let's hope we're not headed in that direction. Yeah, exactly. Yeah. So getting back to Daniel Polly and Gill Oxygen limitation, theory ha, has your research yet produced strong evidence for this theory, or are there, strong inclinations that it will?

[00:36:15] **Malin Pinsky:** So we've, done some work on, black Sea Bass, and I should say actually more broadly, there's the Gill Oxygen Limitation Theory.

[00:36:22] There's also related theory called the oxygen and Capacity limited Thermal Tolerance. and these broad ideas that it's this balance between metabolic demand for oxygen and then the supply of oxygen is part of what's setting distribution limits for, fish and other marine life. So we've done some work on Black Sea bass, one of the fastest, moving species on the east coast of the us.

[00:36:56] So about 190 miles further north than they were in the 19 1970s

[00:37:02] **Nate Hagens:** when you order sea bass at a fancy restaurant. Is that what we're talking about?

[00:37:06] **Malin Pinsky:** A bunch of things get called CBAs. So whether it's black CBAs, you'd have to ask. Okay. Yeah. It's also Chilean CBAs, and when we compared where the black CBAs were and where they moved to that was best explained by changes in not just temperature, but also oxygen.

[00:37:21] So, interesting evidence that oxygen is a very important part of the changes we're seeing.

[00:37:27] **Nate Hagens:** So what, questions under this umbrella, still need to be researched further? and, are there plans to do that?

[00:37:36] **Malin Pinsky:** Yeah. Ray, one of the big questions actually is how important, These different ocean changes are, you know, there's temperature, there's oxygen, there's prey.

[00:37:46] It's also ocean currents. How important are these different factors so that we can start to forecast where these species will be? And there's been very few and just very initial efforts to start to forecast where these fish will be, which is

important for, guiding fisheries and also fisheries management, so we can start to adapt to these changes as well.

[00:38:08] One of the, one of the things we've been observing is that these species are moving quickly. They move across political boundaries. So they cause problems for fisheries. they cause problems for politics, they cause problems for humans. But, you know, the, fish are just adapting to the ocean changes.

[00:38:27] So we need a better understanding and better ability to forecast what these changes are going to be going forward.

[00:38:32] **Nate Hagens:** Are there any examples of major fisheries for human protein that have been demonstrably changed in the last 30 years that have caused fishermen and, cities and people that live in, those areas have to adapt their diets and purchasing,

[00:38:53] **Malin Pinsky:** patterns?

[00:38:54] Oh, very much so. I mean, these are very real changes that are happening now. you know, just to give you a, couple examples, North Carolina, used to have quite a large local fishery for summer flounder. Summer flounder now declined quite a bit off North Carolina. It become quite abundant off New Jersey, New York, Rhode Island.

[00:39:13] Huh. Some of those boats, the boats that are bigger, big enough are now fishing 600 miles further north means they burned a lot more diesel to get there. whereas a lot of the small, fisher fishermen, small boat fishermen, just have had to leave the business. There was a, I mentioned surf clams earlier.

[00:39:34] There was a processing plant in Virginia that closed down. A new processing plant moved, opened in Massachusetts, close to where the population is more productive and where the fishery has moved in, in Europe. northeast Atlantic mackerel expanded north and west into Icelandic waters. Had historically been a fishery shared by the European Union and Norway and a couple other countries.

[00:40:02] Iceland then became involved 'cause there were mackerel in Icelandic waters. Iceland European Union, and the other parties couldn't agree. It became a

trade war. Trade war is now resolved, but they still haven't agreed actually on how to share that fishery.

[00:40:15] **Nate Hagens:** So in addition to climate migration, in addition to, energy resource, sort of wars, the mid latitude countries, if you look forward 20, 30, 40, 50 years, it's the northern and the maybe south southern, like South America areas that the fish are gonna move towards.

[00:40:38] And this has a international trade and fishery implication for the future, as you've alluded to.

[00:40:44] **Malin Pinsky:** Yeah, it does. And you know, one of the really interesting cases with the mackerel example that I told you earlier is the, so the countries haven't been able to agree how to share this fishery. So actually it's been overfished, being meaning it.

[00:41:00] Too many fish are being removed, more fish are being removed from the population than they can replenish each year. And so actually they lost a sustainability certification from the Marine Stewardship Council. And so a number of companies are actually now pushing them, pushing the countries to, to agree, so that they can fish sustainably and get this certification back, which is important for business.

[00:41:21] **Nate Hagens:** Are there any types of fish that are, popular for human consumption that aren't as, sensitive to increases in temperature or reduction in oxygen, maybe a, slower metabolism fish, for instance? Yeah,

[00:41:37] **Malin Pinsky:** I, can't say I can really think of one. Okay. Necessarily. Yeah. I'm just

[00:41:43] **Nate Hagens:** thinking of a barracuda.

[00:41:44] They're just so thin and wiry and fast, and probably they would be really sensitive and then maybe a grouper would be less so, but I'm not a fish scientist, so

[00:41:53] **Malin Pinsky:** Yeah. You know, they're all, there are many different ways to make a living as a fish. They're all sensitive to temperature. Yeah. And oxygen. And

[00:42:02] **Nate Hagens:** oxygen.

[00:42:03] Yeah. Yeah. So what are the implications, the broader implications of, your findings, and your colleagues on these trends for overall biodiversity and integrity of the physical, planetary systems?

[00:42:17] **Malin Pinsky:** Yeah, massive. you know, part of what we, one of the things we recently found is that in parts of the ocean though, actually on, on land and in freshwater as well, in places where temperature is changing, the fastest up to half of the species are getting replaced every decade.

[00:42:36] It's a massive

[00:42:39] **Nate Hagens:** scrambling. So if you have a hundred species, total species where you are, and on some coastline in the earth, that in a decade the 50 of those

[00:42:50] **Malin Pinsky:** will have moved on, potentially replaced by, you know, if you're, especially if you're at mid-latitudes, potentially replaced by 50 new species.

[00:42:56] Right? And that affects how productive these ecosystems are. it affects what we can catch in fisheries. it affects the food webs. And we don't, the problem is we don't know necessarily. I mean, there's so much we don't understand about how these ecosystems now function.

[00:43:13] **Nate Hagens:** There's a reductionist way to catalog the census of these different organisms.

[00:43:18] But, I had a recent podcast on, with Thomas Crower, who's an ecologist, who talks about biocomplexity, which is the interactions in symbiosis between other species within an ecosystem. And how do you measure that when half of the species are, displaced?

[00:43:35] **Malin Pinsky:** Right? I mean, it's, sort of like taking.

[00:43:38] It's like the ocean's a snow globe and we're just shaking it really hard.

[00:43:41] **Nate Hagens:** Obviously you love and care about the oceans and you know, in our previous conversation I can tell how, you know, solid a scientist you are, but also as a human how you deeply care about these things. Do you ever just take a step back at, the, arc of the trajectory that we're on and just get incredibly sad?

[00:44:02] **Malin Pinsky:** There are moments. yes, though, you know, it's also. Nature is incredibly resilient. We don't necessarily know in what ways, we don't know which species are going to survive. We don't know what these ecosystems will do and whether they'll continue to sustain our way of life in the same way going forward.

[00:44:26] and I think that's, those are some of the really big scientific questions. You know, what are these ecosystems going to look like going forward?

[00:44:33] **Nate Hagens:** I could make a case that we could regenerate local ecosystems on land, by planting a lot of trees. And there's a lot of things going on in Africa right now with crescent farming and capturing moisture and building, ground table waters up and things like that.

[00:44:52] I just can't imagine a way that oceans cool and have more oxygen in the coming century or so. Is there a plausible way for that to happen

[00:45:03] **Malin Pinsky:** if we can stop emitting so many greenhouse gases? I mean, that's the, biggest thing when it comes to ocean, ocean climate. But it will still

[00:45:12] **Nate Hagens:** warm and still have less oxygen just at a slower pace than the default.

[00:45:18] I mean, I'm talking about actually like going the other direction. Is, there any possibility of that?

[00:45:24] **Malin Pinsky:** So the climate projections that involve, I mean, a really massive societal effort to halt emissions and even go towards negative emissions don't involve a lot of ocean warming, you know? Okay. Yeah.

[00:45:42] Yeah. No. and does, you know. Ocean can stay below, 1.5 degrees Celsius of surface warming. We're pretty much at that limit. But, that's, the worrying part. When people talk about the specific

[00:45:58] **Nate Hagens:** heat, what does that mean?

[00:45:59] **Malin Pinsky:** So it's how much does the temperature go up, for a, either for water or for air, or any other substance when a certain amount of heat is absorbed?

[00:46:13] So specific heat of water, for example, is substantially higher than air. So water can absorb a lot of heat, but not actually warm up very much. I mean, you, can see that just in your, daily life. How long does it take? A kettle of water to boil on your stovetop? Takes a while? Yeah. Yeah. Or how much energy goes into, your hot water heater rather than, You know, a, furnace or something in a, home. So,

[00:46:46] **Nate Hagens:** do you teach? Yeah. Yeah, I do. what classes do you teach? I teach primarily ecology. Ah, that must be fun. It is ecology and evolution. in tandem?

[00:46:57] **Malin Pinsky:** No, I teach, an upper level ecology course. Some, one of my other colleagues teaches an evolution course, and they're, a pair.

[00:47:04] **Nate Hagens:** And, how does all this land with your students, learning about ecology and living on the ocean? And, presumably you, share some of your research on these things. How are these 19, 20, 21 year olds reacting to this stuff?

[00:47:18] **Malin Pinsky:** They are, they care so much about the future of this earth. and the.

[00:47:24] The environment that they're moving into. You know, they, often come and think about taking a course in ecology and or evolutionary biology because

they care about nature. and they care about the future of the earth. So, you know, they, they see these changes as really important.

[00:47:40] And they wanna know why are they happening and what can we do

[00:47:43] **Nate Hagens:** and what can we do? What do you, tell them? What, can average people do who want to get involved in supporting marine life? And this goes beyond your wearing your science hat. But how do people watching this podcast who care about this go, in support of marine life and ocean ecosystem integrity at large?

[00:48:04] **Malin Pinsky:** I see two, two big things. One, you know, don't underestimate, The power of your voice and your skills, whatever that may be, whether that's science or art, or literature or organizing, you know, express, your opinion and, you know, make it, clear that continued climate change is not a good direction for the earth to go.

[00:48:32] and we really need action politically, you know, pushing our political leaders to act faster. I think the other thing is that, you know, climate change is not. That's one. The second thing is climate change is not the only stressor on the ocean. So we as individuals can also make choices and choose sustainable seafood.

[00:48:56] **Nate Hagens:** Given, everything is going forward or deeper. Is sustainable seafood and oxymoron? Not at all. No. It's

[00:49:05] **Malin Pinsky:** actually more important than ever.

[00:49:06] **Nate Hagens:** What is

[00:49:06] **Malin Pinsky:** sustainable seafood? Sustainable seafood are fisheries that are not depleting populations too far. Okay. And we know that more abundant populations, they have more genetic diversity, they have more geographic diversity, they're better able to cope with changing temperatures.

[00:49:27] **Nate Hagens:** Can you give an example of, a such a fishery?

[00:49:29] **Malin Pinsky:** Yeah. I mentioned summer flounder earlier. Okay. it's one of the species that's shifting north. It's actually very interesting. It was heavily over fished, right around, sorry, through the eighties, around 1990. It's actually a species that as a country we have recovered.

[00:49:43] Largely

[00:49:44] **Nate Hagens:** so, so I, do remember seeing at some fancy restaurants, which I rarely go to here, are sustainable fishery options and they change over time depending. so I've seen that, but of course my buzz kill systems ecologist question is if everyone starts to choose sustainable seafood, won't there be too much demand for it to remain sustainable,

[00:50:08] **Malin Pinsky:** certified sustainable?

[00:50:10] Not just because they're abundant, but also because they have an effective management system in place. And, you know, we actually have some of the best fisheries regulations in the US and they mandate rebuilding if populations become small. And for that reason, many fisheries around in the US have recovered.

[00:50:29] So buying US sourced seafood actually is. Almost always a sustainable choice. If you wanna get more nuanced, there are Monterey based seafood watch cards, Monterey Aquarium, seafood, watch cards. That can be useful guides. There are labels like Marine Stewardship Council that can also be, useful.

[00:50:47] **Nate Hagens:** Let me ask you a question that I asked Daniel Polly, not to put you on the spot.

[00:50:51] What's the deal with, farmed versus, wild salmon? what's the consumer supposed to do there? Or no salmon at all?

[00:50:58] **Malin Pinsky:** Yeah, I'd prefer to eat frozen wild caught salmon. I farmed salmon. They're predators. They eat a lot of fish in order to grow. Aquaculture industry is, trying to change quite a bit.

[00:51:12] They're substituting soybeans and other things still. I mean, soybeans have their own environmental impacts. Eating low on the food chain is also a good choice. You know, you're basically eating fish that are closer to sunlight. like, like sobe, soybeans, and anchovies. but also filter feeders.

[00:51:33] Things like, blue mussels or oysters. yeah. But farmed, shrimp, farmed salmon. Not great choices. There are some exceptions, but they're harder to find. So,

[00:51:50] **Nate Hagens:** Wearing your science hat, but tilting it a little bit. given all the data that you've looked at and the fish and marine organism movements over the last 50 years, can you, before I turn to, my closing questions, can you give us a best case, base case and worst case, scenario for the, your work and the species you observe in the coming decades?

[00:52:21] if you might.

[00:52:22] **Malin Pinsky:** Yeah. I think best case if, climate change is kept mostly under control. We're talking about species moving a couple hundred miles further north, but not a thousand miles further north. That's when things get, start to get really disastrous. There will be surprises, to maintain sustainable seafood.

[00:52:46] It's going to require. Our managers, but also supply chains, being nimble and knowing what's happening and better understanding what's coming, being able to forecast not just when marine, marine heatwaves are happening, but what are the impact, what are the impacts going to be on fish and other marine life.

[00:53:06] That's the piece we don't understand well yet.

[00:53:08] **Nate Hagens:** I'm gonna let you get to base case and worst case, but here's a question I forgot to ask. What about like kelp and the plants, on the coastlines that are home and part of the ecosystem? is there a, change in, movement of them as well due to, lower oxygen and higher temp waters?

[00:53:27] **Malin Pinsky:** Yeah, I was actually just talking to a student, last week who does a bunch, of field research up in Alaska and he was talking about giant kelp appearing further north and also further west. If you think of Gulf of Alaska,

then they historically have been observed. Similarly at the other end, giant kelp goes all the way down into Baja, California and some of the farthest south populations, largely disappeared in, marine heatwave around 2014 through 2016.

[00:54:00] And they haven't come back. They have come back in some other locations. So actually there's a lot we still don't understand about where are those ugia, what exactly creates a refugium for giant kelp. And as you probably know, kelp is really important as nursery for, small fish, rock fish that then feed our fisheries.

[00:54:19] Also really important for abalone, You know, a very, prized invertebrate on the coast of California and on the west coast of North America.

[00:54:31] **Nate Hagens:** So getting back to your, you talked about the base, the best case, which is we're gonna end up having a 200 mile on northward migration. What's the base case in worst case?

[00:54:40] **Malin Pinsky:** Yeah, so that's, you know, sort of base case if we can keep things under control. Worst case we're talking about species, at least here in North America, in some cases a thousand kilometers further north. I mean, that is really scrambling, our fisheries really changing. and what

[00:54:56] **Nate Hagens:** happens

[00:54:57] **Malin Pinsky:** to the ones that are within a thousand kilometers of the North Pole?

[00:55:00] Well, exactly, that means some of them losing their available habitat. I mean, species going extinct. It also means large scale loss of coral reefs in the tropics. That makes me really worry about, food supply and Coastal communities throughout the tropics. Coral reefs are often the source of food of last resort, if you, can't do anything else, do a lot of field work in the Philippines.

[00:55:34] it is scary to think about what would happen if coral reefs were not available as a source of food. And, those and other parts of the. Parts of the tropics.

[00:55:43] **Nate Hagens:** Yeah. Not to mention all the other, ripple effects, yeah, exactly. In the world. if that comes to pass, I wanna ask you some personal questions that I ask all my guests, but, just outta curiosity, I'm, you know, you run a lab and you have students and you're very busy, man.

[00:56:00] What, can you name one or two, like specific research projects you're working on right now that you're kind of passionate about? or just give me the crazy titles that I wouldn't understand.

[00:56:11] **Malin Pinsky:** Hopefully I can make it, not too crazy and somewhat understandable. So, one, we're trying to forecast where marine fish will be in the coming years and decades.

[00:56:20] So we're not talking about long-term end of century, where will they be in 2100, but where will they be in 2027 or 2030? And then how can we best provide that information to fisheries managers, but also fishing businesses and other. Ocean activities that need to adapt to these changes. So you're

[00:56:42] **Nate Hagens:** almost building a model and then by 2027, if they are where you expected, then that becomes, something of predictive capability.

[00:56:52] **Malin Pinsky:** Exactly. I mean, that's, that is the danger of making forecasts. We, might very much be wrong, but it also means it's how we learn. Right. And actually what we do is we, you know, to test ourselves, we rewind the clock, you know, we pre pretend it's 2020. Yeah. Would we have been able to forecast what happened in 2025?

[00:57:09] And that's how we, tune things. But there's this disconnect right now. You know, so much of what we talk about when it comes to climate change is really long term. And yet fisheries and fishery managers are making decisions about next year or a few years out. And so we need the science that provides that information at the same timescale.

[00:57:29] Any other projects? The second one I was going to mention, is, if you'll permit me, I'm, I'll mention two, but they're related. please. One is effectively genomic time travel. We're trying to figure out if evolution is an important part of how some marine species are coping with climate change and other ocean changes.

[00:57:51] So one of the projects is a collaboration with the Smithsonian National Museum of Natural History. They have one of the largest collections of fish in the world, and for a fluke of scientific history, they were collected in sugar cane alcohol from the Philippines in the early 19 hundreds. They've effectively been fish in vats of rum for a hundred years.

[00:58:17] What it means is that their DNA has been quite well preserved and is an incredible archive of the evolutionary history of these populations just a hundred years ago. So we're working with Philippi, amazing set of Filipino collaborators to redo these collections and understand to what extent evolution.

[00:58:37] these coastal fishes have evolved over the last a hundred years. We've already found some evidence that they have, and we're doing similar things now here on the coast of California, but with giant kelp. and trying to help the state of California and other conservation groups and, managers better understand how to help kelp be more resilient to further increases in temperature.

[00:59:00] **Nate Hagens:** If you don't mind, I'm gonna ask you some closing questions, that I ask all my guests. now taking your scientist hat off and just putting your human hat on, what, recommendations do you have for general people, being alive today, being aware of climate and polarization and, geopolitics and economic problems and all the things?

[00:59:28] Do you have,

[00:59:29] **Malin Pinsky:** advice? I think the biggest advice is I. Find, find your passion and how you want to contribute. Right? it's, we all have incredible skills, whether that's art or organizing or science, and bring that, passion to making the world a better, place. we know, it can be.

[00:59:53] And, you know, don't ever underestimate the power of one person inspiring others around them. You know, and a lot of this, I think, really can start locally and build up from there.

[01:00:04] **Nate Hagens:** And how would you change that advice for 19, 20, 21 year olds who, are your students? That, largely is the advice I give to

[01:00:12] **Malin Pinsky:** the 19, 20, 20 1-year-old students that I advise.

[01:00:18] also older, you know, the older grad students, even the, you know, they've picked, you know, marine biology, marine, climate science as their career, but still it's. What's so important, and you know, to have that motivation to continue when things are hard, you really have to be passionate about what you're doing.

[01:00:39] yeah. And that's a balance between what you're doing, but also take care of yourself. You know, make sure that you're, if you get, joy by being outside on the water or in the mountains like I do, make sure you take time for that too. Don't burn out. What do you care most about in the world?

[01:00:55] Malin? I, my kids, you know, I've got two boys. love being outside with them. They, love it too. And just seeing them light up. I hope we can, I hope to help, find a way to pass on a world, as relatively intact to them so that they can continue to enjoy it the way. I was able to,

[01:01:22] **Nate Hagens:** how old are they?

[01:01:24] nine and 12 when I was a little boy. I grew up in Seattle, which is quite different than Santa Cruz, but I know there's one thing in common, those banana slugs. you have slugs in Santa Cruz, so I'm sure your boys have had much experience with those slugs.

[01:01:38] **Malin Pinsky:** Banana slugs are amazing. amazing animals.

[01:01:43] Yeah. Yeah, they're very cool. Does anything

[01:01:45] **Nate Hagens:** eat them?

[01:01:45] **Malin Pinsky:** You know, if you wanna listen to, the uc, Santa Cruz athletic department, they'll tell you there's no known predator. Right. So that's the slogan for our, many of our sports teams. Yeah, you know, raccoons and yeah, things do eat them.

[01:01:59] But,

[01:02:00] **Nate Hagens:** so if you could wave a magic wand and there was no personal recourse to you or your status or reputation, what is one thing you would do to improve human planetary and ocean futures?

[01:02:13] **Malin Pinsky:** Capture the past and future greenhouse gas emissions that we admit, store them away. Okay. That would require a magic wand that really would require a magic wand, you know?

[01:02:23] Yeah. The, I was keying off the bit you said on, on magic, huh?

[01:02:26] **Nate Hagens:** Yeah. Yeah. but I hear you. I hear you. So, if you were to come back in a year, back on this show, is there any specific thing about the ocean that you are particularly passionate and interested about that is relevant to the future of our oceans, that you would be willing to take a deep dive on that one nerdy scientific topic?

[01:02:53] **Malin Pinsky:** It'd be really interesting to go in one of two directions, start thinking about the. The role of evolution in coping with global change right now and whether that really can play an important role to helping, natural systems adapt. The other direction would be how dig in more on those ripple effects.

[01:03:14] You know, it's not just shifts in where fish are, but then how does that ripple through fisheries, supply chains, politics? International businesses.

[01:03:27] **Nate Hagens:** Thank you, so much for your continued work and your time today. do you have any closing thoughts? for our viewers and listeners,

[01:03:36] **Malin Pinsky:** we're all connected to the ocean, whether we realize it or not.

[01:03:39] It's a place of. Wonder, an astounding beauty, but it's also on the front lines of climate change right now. Professor Malin Pinsky, thank you so much. Thank you. It's great talking to

[01:03:49] **Nate Hagens:** you. If you enjoyed or learned from this episode of The Great Simplification, please follow us on your favorite podcast platform.

[01:03:58] You can also visit the great simplification.com for references and show notes from today's conversation. And to connect with fellow listeners of this podcast, check out our Discord channel. This show is hosted by me, Nate Hagens, edited by No Troublemakers Media, and produced by Misty Stinnett, Leslie Balu, Brady Hyen, and Lizzie Siri.