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Julie Kuchepatov [00:00:13] Three generations hit the road to explore key seafood producing regions across the U.S. and hear from people working at the intersections of fisheries, aquaculture, seafood, and conservation while grappling with the effects of the global climate crisis. We may represent three generations, but we have a lot in common, namely a love of seafood and a dedication to contribute to a community driven generational effort in movement towards climate justice.

Cameron Moore [00:00:37] The results of these travels? Welcome to In Hot Water, a Climate and seafood podcast series. Join us.

Julie Kuchepatov [00:00:43] Julie Kuchepatov, Gen X.

Crystal Sanders-Alvarado [00:00:45] Crystal Sanders Alvarado, Xennial.

Cameron Moore [00:00:47] And Cameron Moore, Gen Z, as we travel the country and chat with people who share the challenges facing their regions and their personal stories. Along the way, we experience moments that make us ask "What the fish?" as we try to understand why we are in hot water and what we can do about it.

Crystal Sanders-Alvarado [00:01:03] We started the series in the Lone Star State, Texas, with a visit to the Coastal Bend along the Gulf of Mexico. One of the most important offshore petroleum production regions in the world, making up one sixth of the United States total production and a critically important source of seafood, supplying more than 40% of the U.S. domestic seafood. In the second series, we traveled to Maine, where we crisscrossed the state, starting in the bustling hub of Portland, Maine, making our way down east and ending with a visit to Passamaquoddy tribal lands. Fishing in the Gulf of Maine generates nearly $4 billion annually and supports up to 100,000 jobs. And also there's a growing aquaculture sector. Maine's identity is intricately tied to the lobster fishery and with the Gulf of Maine warming faster than 99% of the ocean, this way of life is in jeopardy.

Kyle Foley [00:01:50] My name is Kyle Foley and I'm the sustainable seafood director here at the Gulf of Maine Research Institute. So, our sustainable seafood program here at GMRI works to build demand and awareness of the diversity of seafood that we have here in the Gulf of Maine region. And we do a lot of work with businesses to try to get more regional seafood out into the marketplace. So, we work with retailers and restaurants and institutions and seafood processors and fishermen, everybody up and down the seafood supply chain who is involved in buying and selling, regional or otherwise.

Julie Kuchepatov [00:02:26] What kinds of seafood are found in the Gulf of Maine?

Kyle Foley [00:02:29] So there is a lot of regional seafood available. We have an abundance of regional seafood here in the Gulf of Maine. In New England more broadly, we have a couple parts of our seafood sector that are really high volume, like lobster and scallops. And those two sectors really can compete in the big global marketplace that influences even what we see in local stores and restaurants. Some parts of our seafood industry over time have had a more difficult time competing in that big global marketplace, even at the local level. So that's particularly true for our finfish and our groundfish industry. So our traditional favorites like cod and haddock, but also other groundfish, we have like pollock and hake and redfish and species that even locals are not super familiar with. And

that part of our industry can have a tough time competing against much larger parts of the world, like Norway and Iceland and Alaska that harvest much, much larger volumes of that seafood. And sadly, it is sometimes easier for local restaurants and markets to get that imported seafood from other parts of the world than it is for them to try and access the local product.

Julie Kuchepatov [00:03:49] You support locally caught seafood to get access to local restaurants and retailers?

Kyle Foley [00:03:55] Yeah, definitely. And it's, it's not that we think seafood from overseas or from other parts of the country is necessarily bad or not sustainable. It's really just about trying to level the playing field a bit and to build more space in the local market in particular, but also in the market more generally for the responsibly harvested seafood that we know we have here. And to try and make sure that the harvesters and the seafood supply chain here can continue to be an important part of our coastal economy in this region.

Julie Kuchepatov [00:04:27] So how do you do that?

Kyle Foley [00:04:28] So we do that by really by partnering with businesses and trying to enable them and empower them to buy more regional seafood. A lot of the time what we find is restaurants and local markets and institutions are aware of the traditional favorites that we have here might have trouble accessing some of them from local sources. And so we try to connect the dots along the supply chain. We work through our Gulf of Maine, we have an ecolabel program, a verification program called Gulf of Maine Responsibly Harvested. So, through that program, we license seafood processors in the middle of the supply chain to use our label. The big requirement that they have to fulfill for us is an annual traceability audit of their operations. And we do assessment reports on species from the region to verify that they meet certain criteria around responsible harvest from an environmental perspective. And so that's one way that we can connect local restaurants and markets to the processors that are sourcing and participating in our Gulf of Maine Responsibly Harvested program. So, trying to make it a little bit easier for them to access the seafood they're interested in buying. And part of a lot of what we do also is just trying to build awareness of the range of species that we have here because we have such a broad diversity of species. And as you know very well, Julie, as Americans, we eat a very small number of species and not nearly all the many fish in the sea. And so a lot of what we do is that awareness building of the variety of opportunities that we have here. And we find that especially chefs are really excited to learn that there are more options that they can, put on the, on the menu and sort of introduce to their customers.

Julie Kuchepatov [00:06:20] Tell us about some of the climate challenges happening in the Gulf of Maine.

Kyle Foley [00:06:24] The Gulf of Maine is warming at a rate that is three times faster than the global oceans. So, we are a real hot spot here in the Gulf of Maine, and that's one of the biggest and most obvious climate impacts that's affecting how species move, where species live. We're seeing species coming from southern New England and mid-Atlantic waters that are emerging into the Gulf of Maine and showing up more and more here. We're also dealing with climate impacts like sea level rise and ocean acidification, stronger storms, increased precipitation, which is something you can relate to because it's raining today like it has been today. It has been raining for basically the past month and a half. And so I think the ways that we're seeing impacts in the seafood supply chain are that

there are greater chances of fluctuation in supply and more frequent surprise events. So, we have seen a number of marine heatwaves over the past decade. I think since 2012, we've had the ten warmest years on record in the Gulf of Maine. And so that means that there is, there are surprises that happen. Back in 2012 when we really started seeing the impacts of these warming water temperatures, there was a big glut of lobster landings all at once. Normally, the lobsters molt sort of sequentially and steadily up the coast over time. And that year they all sort of molted and came inshore around the same time. And it had a huge impact on the supply chain not being able to handle that volume that didn't normally come in in such a glut. So those kind of surprise events are happening more regularly. And I think the seafood supply chain has always been really adaptable. They've always dealt with a wild resource that's never perfectly predictable, but I think it is getting a little bit harder to predict. And things are changing more rapidly in terms of supply and availability.

Hannah Baranes [00:08:32] My name is Hannah Baranes and I am a coastal hazards scientist at Gulf of Maine Research Institute. So, the big underlying driver of climate change is humans emitting greenhouse gases, so carbon dioxide and methane. In sort of the world of climate risk, we often think about the hazards so that's the physical process that's driving the change and then about vulnerability. So, for example, coastal flooding isn't a big deal somewhere where no people live, or maybe there's no, maybe where there are no critical ecosystems or no critical fisheries, and so there is the increase in emissions that's driving the hazard of climate change and then on the vulnerability side, despite sort of the increasing threat to coastal environments from climate change, we're seeing an accelerated pace of development along the coast and human migration to the coast. So really those two things in tandem are driving climate risk at the coast, which is mostly where I think about it. But you could say the same for wildfires, for example, too. When I think about climate challenges in the Gulf of Maine, the primary one I often think about is how fast the Gulf of Maine, the ocean water itself is warming, which is changing current patterns, changing weather patterns, driving shifts in the typical ranges that ocean species live in. And then I also often think about having more extreme heat and extreme precipitation days and how those impact particularly vulnerable populations who might not have access to air conditioning or transportation to move somewhere cool. The world that I live in mostly is thinking about coastal flooding that's becoming more severe, driven by sea level rise. Maine is sort of a unique place to work on coastal flooding in that we're actually relatively resilient. Our tide range is really large, so the tide range is about three meters or roughly 10 to 12ft in the southern part of the Gulf of Maine around Portland, where we're having this conversation now. And as you move up towards the Maine-Canada border, gosh, I always do this in meters. The tide range is about six meters and so we have some of the largest tides in the world. And so, the tidal range is actually quite big relative to just the rising water level from a storm or the piece we call storm surge. And so even when we have really severe storms hitting, they happen on top of the tide. So, water comes in and then the water leaves just like a couple hours later. Whereas if you imagine being somewhere like Miami where there's a much smaller tide range, water comes in and it stays.

Julie Kuchepatov [00:11:06] I see, and it stays because it's not, they haven't built the city or built the infrastructure there to support it leaving.

Hannah Baranes [00:11:15] More that there's no, you can sort of think of tides as this natural pump almost that is causing water level to go up and down, up and down, twice per day. And like along the Gulf of Mexico coastline, for example, tides are once a day. So that

pump operates more slowly, and tides are a lot smaller so they don't have water going back down, essentially draining things.

Julie Kuchepatov [00:11:38] Institutions like the Gulf of Maine Research Center are working to address these challenges.

Hannah Baranes [00:11:44] The Gulf of Maine Research Institute, or I'll probably call it GMRI as we chat, I feel like every industry has their acronyms, so there's one of ours. GMRI broadly, we solve collaborative solutions to global ocean challenges, and we have a few different approaches we take to doing it. We have kind of traditional researchers who work on ocean adjacent challenges focused in the Gulf of Maine, but really solving problems that have kind of a global scope of applicability. We have educators and we have folks who work in the community with the fishing industry. And I, kind of over time through GMRI climate change, started cutting across all of our work so just a couple of years ago, GMRI opened a new Climate Center and I sit as a scientist in the Climate Center.

Julie Kuchepatov [00:12:32] In the Climate Center. Okay, so tell us about the Climate Center.

Hannah Baranes [00:12:34] So the Climate Center is aiming to be sort of an end-to-end service provider for communities grappling with climate change in coastal Maine. And so we take a science engagement solutions framework. So, I sit in the science bucket working on more of the physical drivers of climate change in the Gulf of Maine. And then we have folks who specialize in community engagement, who go into communities and work with community members and municipal leaders to try to understand their needs, their processes, and actually work with them on implementing solutions. So then in the solutions bucket, we have somebody who works with businesses. We're working on hiring a climate financing specialist as actually accessing capital to implement climate solutions is often a barrier that communities face. So pretty ambitious. We are a small team of, gosh, I'm going to probably mess up the number something like five right now and looking to build out our capacities pretty quickly over the next couple of years.

Julie Kuchepatov [00:13:39] Yeah, and that's probably kind of mirroring the necessity and the urgency that we need to address some of these problems, right?

Hannah Baranes [00:13:47] Yeah.

Julie Kuchepatov [00:13:48] And how urgent would you say the climate effects are affecting Maine, the Gulf of Maine specifically?

Hannah Baranes [00:13:55] So when I think about urgency and climate change, I kind of think of it as being ever present in that the climate system is nonlinear, which is essentially a fancy word for saying for every 10th a degree of warming there is, it's not like things get 10% worse. There are all kinds of hidden sort of thresholds and tipping points in the system, so we understand where they are. Others we don't. And so, every 10th of a degree matters. And so, in that sense, yes, I view it as extremely urgent.

Julie Kuchepatov [00:14:25] Shell builders like oysters, lobsters, clams, and mussels are important seafoods found in the Gulf of Maine and they face a particular set of challenges in warming waters and there are other organizations like the Gulf of Maine Research Institute working to understand these challenges, like the Island Institute.

Susie Arnold [00:14:41] My name is Susie Arnold and I work at the Island Institute in Rockland, Maine. The Island Institute is a 40-year-old community development organization based in Rockland, Maine. Our mission is to sustain Maine's island and coastal communities, and we exchange ideas with communities here and really globally. So, I am the senior ocean scientist at the Island Institute, and I'm the director of our new Center for Climate and Community. And so, I work really on all things ocean climate change and now also helping communities with energy transitions away from fossil fuel dependencies and helping working waterfronts transition to electrification and electric outboards and solar panels. But specifically, I do a lot of science translation around ocean climate change for fisheries in Maine and fishing communities in Maine.

Julie Kuchepatov [00:15:32] So you translate the science for them so that they can act accordingly.

Susie Arnold [00:15:37] Exactly. Yes, I am on the Maine Climate Council. I'm the appointee for marine science and I'm the co-chair of the Maine Climate Council Scientific and Technical Subcommittee. And so that subcommittee informs the work of the Climate Council and the working groups of the Climate Council. So specifically, we produce science translation pieces and kind of summarize the latest research on ocean climate change and also terrestrial climate change because it's not just the ocean focused council. From an event like the Fishermen's Climate Roundtables, we hear topics of concern from fishers who are on the water every day. And for example, we heard an inquiry about how is ocean acidification going to affect our state. We have all of these shell builders that we know are going to be impacted first by ocean acidification, not just lobsters, but we have a huge bivalve fishery with oysters. Oyster aquaculture is becoming very popular. We've got a mussel fishery. We've got scallops. 75% of our fisheries landings by value are shell building species. So that's concerning when we know the Gulf of Maine is becoming more acidic. So about seven years ago, we were working with fishers to help them diversify away from just a single fishery. Here in Maine, we're very reliant on lobstering. And we know that lobsters are highly impacted by climate change. And there's been this downturn forecasted for quite some time and lots of biological surveys are pointing to a future downturn in the fishery. So, fishers obviously want to have more diversity in their business portfolios. The Gulf of Maine used to be a very diverse place to fish. People could ground fish, they could scallop, they could shrimp in the winter, they could lobster. There was lots of species that were abundant that they could rely on. It's not so much the case anymore either for overharvesting reasons, poor regulations, climate change, lots of lots of reasons have contributed to that lack of diversity. And then the regulatory framework doesn't make it easy to maintain permits. So, if you haven't fished for something in a certain number of years, you'll lose your access to that fishery. So, some fisheries have been able to keep three fisheries going, but it's pretty rare, mostly when you're talking about fisheries in the Gulf of Maine, you're talking about someone who's fishing for lobsters. So, we were working with lobster fishers to help them diversify into something else. And that's something else for us was shellfish and seaweed aquaculture. But at this event, at the Fishermen's Climate roundtables, we heard them say, well, you're telling us about this ocean acidity problem, why would we diversify into another shell building species if the Gulf of Maine is going to be susceptible to ocean acidification?

Julie Kuchepatov [00:18:24] It's a good question.

Susie Arnold [00:18:25] It's a great question. And so that led to years of policy and research on the behalf of the state to really kind of turn the headlights on, to understand how the Gulf of Maine was going to be impacted by ocean acidification.

Julie Kuchepatov [00:18:41] And what have you learned?

Susie Arnold [00:18:43] Unfortunately, the Gulf of Maine is environmentally very susceptible to acidification for a number of reasons. It's been identified as the most susceptible water body on the East Coast, including the Gulf of Mexico. That's for a number of different reasons. Cold water inherently holds more CO2 or carbon dioxide. We have a lot of big rivers emptying more acidic freshwater into the Gulf of Maine. We've got cold freshwater currents or fresher currents coming down like the Labrador current, coming down from Canada, bringing more acidic water into the Gulf of Maine. And then we have this kind of like semi-enclosed shape with Nova Scotia kind of on one end and Cape Cod on another. It's increasing the residence time of that more acidic water, so it doesn't get flushed out much. And for those reasons, we have lower buffering capacity in the Gulf of Maine, which makes us more susceptible to ocean acidification. And then we have that economic dependence on all those shell builders we talked about so the lobsters and bivalves. There is yet to be identified something that will make up the money that is brought into the state of Maine from lobsters when lobsters decline.

Julie Kuchepatov [00:19:56] And you mentioned the decline is anticipated.

Susie Arnold [00:19:59] It is.

Julie Kuchepatov [00:20:00] People working directly on the water or seeing the effects of climate change firsthand.

Libby Davis [00:20:05] My name is Libby Davis and I'm born and raised in Scarborough, Maine. Currently living in Portland, Maine. Mainer born and raised. I'm the founder, owner, operator of Lady Shuckers, Mobile Raw Bar and Event Company. It's a combination food truck and event catering company based here in Maine and the cool thing about the company is that we source from a network of our women-owned sea farms and take them to market for our women-owned oyster farmers. So, the climate change and the oyster thing is is tough and I believe it's, it's imminent. We talk about a lot of the good stuff that happens in oysters and sustainable aquaculture, but the fact of the matter is, is that as oceans warm, acidity increases in our oceans, and when we have a highly acidic ocean environment, oysters are, it's harder for them to grow their shells. And so, yeah, that compromises the future of a highly valuable protein source. It's low in fat. It's sustainable. Sea level change from rising oceans. It can submerge intertidal reefs, which increases oyster mortality. And there's other changes in ecosystem services like reefs provide habitat for fish, and they also decrease like wave energy for erosion control so all shellfish and all mollusks and that goes for mussels and clams they'll have trouble building shells in a highly acidic water. So a lower pH means less carbonate and the shells are based out of calcium carbonate. So that's why we talk about ocean acidification and the important steps we need to take to start remediating that, especially in our tidal zones.

Julie Kuchepatov [00:21:41] Researchers also play an important role in understanding the effects of the climate crisis on the region's fisheries.

Tora Johnson [00:21:48] I am Dr. Tora Johnson. I am currently a professor of environmental studies and geography here at University of Maine at Machias. There's a lot of ways that climate change is impacting both the clam and lobster fishery. Oh my gosh, there's so many that it's hard to even pick one place to start. So, one of the things I do a lot of work on is vulnerability to storms and sea level rise. And also warming waters are

affecting the clam fishery because of increasing instances of red tide, which cause biotoxin closures in the fishery, as well as combined sewer overflows, causing sewage pollution to shut down the fishery. And often that can be for a long period of time. There are some whole sections of bays all over the coast have been closed for years and years because of this problem persisting just.

Julie Kuchepatov [00:22:44] Because of red tide specifically, or like pollution.

Tora Johnson [00:22:48] No, um because of wastewater pollution.

Julie Kuchepatov [00:22:50] I see.

Tora Johnson [00:22:50] Yeah. Yeah. And we have a lot of wastewater infrastructure, treatment infrastructure, that's vulnerable, overcapacity, under-built and it's really vulnerable to sea level rise and storm surges right here where we're sitting. We're just, you know, a quarter mile from the wastewater treatment plant in Machias, Maine. And it is a hugely vulnerable place. And there's you know, it's $1 million, sorry, $10 million of clams come out of this bay every year and it can be closed for ten years if that wastewater treatment plant is destroyed by a storm. And we have had what FEMA calls, quote, hundred-year storms, in other words, happening on average every hundred years. We've had five of those storms in six years.

Julie Kuchepatov [00:23:35] According to the Nature Conservancy. The ocean is now rising at an even faster rate. And the possibility that Maine could see a six-foot increase is more likely than ever. Maine has already lost $70 million in home values due to coastal flooding. Again, here's Hannah Baranes from GMRI.

Hannah Baranes [00:23:52] Yeah. So, another piece of kind of coastal science that I work on is how sediment moves around the coast. And in Maine, the aquaculture industry relies on, well, number one, there being mudflats and then having people having access to those mudflats. And so, there is an organization called Manomet who's working on a project now kind of trying to understand what might the sea level rise impact to the aquaculture industry be in Maine. And I've been had the sort of great fortune of sitting on that project as an advisor. And one thing we've been talking quite a bit about is as sea level rises, what's going to happen to mudflats? Like, do they simply just drown as the water gets higher? Or like, how do you know if there's a local sediment source where the mudflat can accrete to keep pace with sea level rise, so the water gets deeper, but the mudflat builds higher, and the system stays in some kind of a balance. And then is there some kind of threshold where suddenly sea level rise becomes too fast and rates of accretion on mudflats can't keep up as storms, as water gets deeper, do the characteristics of waves change on mudflats and well that take out some of the fine grained sediment that these species need to survive because they can't survive if you just have a sandy bottom left over. So, it's been awesome being a part of this project. It's raised a lot of questions and that's sort of a piece of future research I'm really hoping to get into over the next couple of years.

Julie Kuchepatov [00:25:19] So you don't know any of the answers to any of these things yet?

Hannah Baranes [00:25:21] Well, so I've done.

Hannah Baranes [00:25:23] I've done similar work around salt marshes. I'm trying to understand where the sediment comes from that supplies salt marshes and kind of a really interesting finding of that work. I was working along the Massachusetts coast within the Gulf of Maine was that in some places, sediment comes from the ocean, which is actually a pretty, that finding was sort of counter to what common knowledge had been and a lot of marsh work where people sort of had always assumed that sediment comes from rivers that supplies salt marshes. And we found essentially that like the Gulf of Maine has a really sort of varied coastline with different ocean characteristics, different storm climatologies, and like most importantly, the geology along the coastline varies a lot because it's all sort of a legacy of the last time there were big glaciers around. So that just leads to a really varied landscape. And so circling back to do I know the answer is we found that almost always. It depends. It depends where you are, which is, you know, I think that's an okay answer because that's the nature of my work. I try to focus on what each community needs, not what a whole region needs.

Julie Kuchepatov [00:26:28] Another threat to an already eroding coastline is the invasive green crab, well known as the world's worst invasive species. What do climate change, eroding ecosystems, and green crabs have in common? Here's Susy Arnold.

Susie Arnold [00:26:40] The invasive green crab has become highly abundant across the entire coast of Maine, and you can kind of track it over the decades now all the way up in Canada, and that's been pretty negative for lots of reasons here in Maine. They are voracious predators, even though they're pretty small. And they've done a good job at decimating the soft-shell clam fishery, which was one of our leading fisheries historically in the Gulf of Maine. They're soft-shelled clams, as their name suggests and so those crabs can break that shell pretty easily and have caused that fishery to decline in a major way. They are also kind of burrowing into the coastal ecosystem and causing enhanced erosion with increasing storms and sea level rise, the coast is just getting hammered in a lot of ways and the green crab isn't helping that.

Julie Kuchepatov [00:27:30] So the green crabs are attributing to erosion?

Susie Arnold [00:27:32] Yeah. Well, if you yeah, if you go to a place like Freeport, which has historically had a really robust soft shell clam fishery and I remember going out with Dr. Brian Beal, who's up at the Downeast Institute in Beals, Maine, and he's been studying the green crab Invasion for years. He specializes in soft shell clam biology and works a lot with clammers. And he showed me around a clam flat with the president of the Maine Clammers Association years and years ago, and he showed me where the green crabs live in that marsh and you can pull up a little section of that marsh and they are just scurrying around by the hundreds, eating the roots of those the marshes, the marsh grasses. And that is causing chunks of those marsh pieces to basically fall off.

Julie Kuchepatov [00:28:21] What don't they eat?

Susie Arnold [00:28:23] People.

Julie Kuchepatov [00:28:24] Okay. Let's hope they don't start eating people. So, they're invasive. Were they introduced or did they're just naturally moving north?

Susie Arnold [00:28:32] No, they were introduced. They think they were introduced in ballast water from ships coming over from Europe. So, they were either in the ballast water or their larvae were in the ballast water and they were released.

Julie Kuchepatov [00:28:42] Years ago though.

Susie Arnold [00:28:43] Years ago. Yeah.

Julie Kuchepatov [00:28:45] So far, we've established that climate change is quickly affecting the Gulf of Maine. But how is it affecting Maine's fisheries? Here's Kanae Tokunaga from the Gulf of Maine Research Institute.

Kanae Tokunaga [00:28:56] Yes. So I'm an economist who studies fisheries, aquaculture, seafood, anything related to coastal and marine social ecological system.

Julie Kuchepatov [00:29:07] What problems are you trying to solve?

Kanae Tokunaga [00:29:08] Right. So, fisheries is quite unique in a sense that, you know, we're harvesting wild natural resource. So that's somewhat different from agriculture. The production of the resource really depends on the environment, natural environment. The climate change is clearly impacting the ocean environment. So, in recent years, my research has really focused on how climate change is impacting the fisheries system and also how fisheries are responding to the environmental changes that are already happening in the water.

Julie Kuchepatov [00:29:45] How is climate change affecting fisheries in your findings?

Kanae Tokunaga [00:29:51] Well, there are many ways that the climate change impacts fishery system. When I say fisheries system, I'm also thinking about not just the fish but also the fisheries, the human side of things. The most notable change that we started to see is the changes in abundance and distribution of certain species. So that's one thing. The availability as the resource has changed because most likely because of climate change but also there are other ways that those resources are changing so it's hard to always attribute that change to the climate change. But that's one thing. But climate change also is impacting the human systems as well. So, I think one of the good example is that climate change policies, right, we need to reduce carbon emissions. So now there is offshore wind energy development is happening and fisheries would get impacted from those changes. So, climate change is impacting the natural resource, but also the human systems, the society, policy, economics, and the way we run businesses. All of those are impacted.

Julie Kuchepatov [00:31:06] What are some of the fisheries specific challenges facing the Gulf right now?

Kanae Tokunaga [00:31:11] One of the things is that many of the fisheries are now managed by harvest quotas and in some fisheries, harvest quotas are allocated to either individuals or a group of fish harvesters sometimes allocated to different states. Now, as the resource availability change, the allocation that is currently based on the historical track record may not be aligned with the actual current availability of resources. That would create some inefficiency in terms of economics. If the permit is held by the regions or the individuals who used to have a lot of availability of certain species and stocks, they might now have to go farther north or offshore to chase those resources and that might be more costly to run operations. And that's one of the challenge that you might see in the harvesting sector. And so, the management is really impacted by the climate change and the management, fisheries management is really complex and that's because fisheries

management often try to achieve multiple goals, not just resource sustainability, but also socioeconomic outcomes of fisheries. Now with the climate change impacting the resource, the existing management may not be able to achieve the goals and objectives that they had in mind when those systems are put in place. So that's one of the challenge. And it's really, it takes time to for those systems to kind of change.

Julie Kuchepatov [00:32:51] Kanae, you recently worked on a global case study of how fisheries systems are responding to the challenges created by climate change. What did you discover?

Kanae Tokunaga [00:32:59] What I found was that many fisheries have somewhat of a built-in mechanism to be somewhat flexible by exchanging quotas temporarily, but those solutions are often ad hoc. They're basically being responsive to the changes that they're experiencing to observe right now. So, in this sense, just basically treating the symptoms rather than, right, I mean, you can't cure climate change, but their approach has been to kind of just more coping.

Julie Kuchepatov [00:33:39] I get it. Yeah. Yeah. We've heard a few times in the course of these conversations that specifically in the Gulf here of Maine, that, you know, the lobster fishery is a hugely important fishery, right? It's the important fishery for Maine traditionally and culturally and economically and all of it. All of the above. Yeah. But also because of climate change, they're moving. They may be moving further out or deeper or north. But there's other options. Other species are moving also north. So they're kind of coming into the Gulf like new species, right, that could also now become a source of income, right. So, the lobsters are moving, potentially leaving, and then these new species are coming in. How are people thinking about that? We're hearing it's almost like a solution, right? Like, it's going to be okay because these other species are moving up so we're going to continue to have, it's not going to be lobster, but it might be crab, right. That doesn't sound good to me.

Kanae Tokunaga [00:34:38] Right. So, I think in a fisheries, I think it's a resilient system, so in the long run that can happen. But I think the challenge would be in the short, mid-term kind of like challenge, right? Because the species are moving but until they get settled, there's a lot of uncertainties in terms of where they are or their availability for the harvesters. So how do you deal with that year-to-year fluctuations? That can be a challenge.

Julie Kuchepatov [00:35:11] So new species are moving into the Gulf of Maine, and this represents a challenge and an opportunity.

Kyle Foley [00:35:17] And I think we're going to see more and more of those sort of unpredictable and maybe some of them will be predictable interactions between species that haven't historically lived in the same place or haven't been in the same abundance in the same place. So, there's certainly challenges that these emerging species will present to the fishing industry and to the ecosystem. Yeah. So more research is definitely needed and we need to be taking action to try to address some of the challenges now.

Julie Kuchepatov [00:35:49] In the next episode of the special edition of In Hot Water, a Climate and Seafood podcast featuring the great state of Maine, also known as Vacationland, we will learn more about the state's iconic lobster fishery, dive deeper into the plight of the endangered right whale and understand how the present and future of these critically important species are so intertwined.

Crystal Sanders-Alvarado [00:36:12] Thank you for joining us for In Hot Water, a Climate and Seafood podcast by Seaworthy and SAGE. Let us know what you think by leaving us a review on your favorite podcast platforms. And don't forget to share with your seafaring friends. In Hot Water is a production of Seaworthy and Seafood and Gender Equality or SAGE. Soundtrack generously provided by Mia Pixley. Audio Production, editing, and sound design by Crystal Sanders-Alvarado and the team at Seaworthy.