

Sea Surge

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Greg Dalton: Welcome to Climate One, a conversation about America's energy, economy, and environment. To understand any of them, you have to understand them all. I'm Greg Dalton.

Today, we're discussing how changing climate and oceans have impacted societies in the past and today. Fierce temperatures have been warming for 15 thousand years, and that has had a profound impact on human civilization. What's new in the industrial era is the introduction of human-caused and rapid change driven by burning fossil fuels. Carbon pollution skewing from tail pipes and smoke stacks is impacting oceans in an increasingly visible way. Sea level rise will put Pacific Island nations underwater this century. Hurricane Sandy poured the Atlantic Ocean into the New York City subway. Less visible to most people is the increasing acidification of oceans that threatens the food web and economies based on it.

Over the next hour, we'll look at the causes and consequences of warming and rising seas. Joining our live audience at the Commonwealth Club in San Francisco, we're pleased to have with us two people who look at oceans and climate change from different perspectives. Meg Caldwell's a lawyer and Director of the Environmental and Natural Resources Program at Stanford Law School. She's also Executive Director of the Center for Ocean Solutions at the Woods Institute for the Environment at Stanford. She's a former chair of the California Coastal Commission. Brian Fagan is an archaeologist and professor, retired from UC Santa Barbara and author of several books on climate change including *The Little Ice Age* and *The Long Summer*. His most recent book is *The Attacking Ocean: The Past, Present and Future of Rising Sea Levels*. Please welcome them to Climate One.

[Applause]

Greg Dalton: Brian Fagan, let's take a brief tour through history and talk a little bit about — you write during the medieval period, there were tremendous storms and sea surges that killed tens of thousands of people. Tell us about some of those.

Brian Fagan: Basically, if you take as your stage the North Sea, what people don't realize is that 12,000 years ago, the North Sea was dry land.

It was marshy and swampy dry land, but it was dry land. The North Sea, as we know it, did not exist, and in there were living probably maybe 10,000 hunters and gatherers, who simply retreated as the sea rose, and it rose so fast that in places probably the shoreline was unrecognizable for what it had been when you were young, by that time you were at the end of your life which would've been in your twenties probably. And by 5500 B.C., it was gone; you had the ocean we know today.

And ever since then, people living in the Low Countries have been defending themselves against the rising ocean. And what really triggered the current sea level defenses of the Netherlands was a series of gigantic North Sea gales, which started in the Atlantic and barreled ashore on the low lying, unprotected shores of the low lands, of the Low Countries, without warning, because there was no forecasting.

And these brought very strong winds and high waves. And if one of these coincided with high tide, you got huge storm surges, which would sweep several meters of water over hundreds of thousands

of acres.

And in 1362, there was one of these storms, which is called the Grote Mandrenke, which is the great killing of people. And this killed what the contemporary records call an infinity of people. And it literally rolled herds of cattle and sheep with the waves far inland and flooded an enormous area. And there were a whole series of these, which really triggered the history of sea defenses.

And it's worth mentioning before I shut up, that there were two defining events like this. Now this will come up later in the 20th Century. One was a sea surge in 1916, which resulted in the damming of Zuiderzee, which became the IJmeer, and the latest one was in 1953, when dikes burst in Southern Holland and killed 1,200 people, as well as about the same number of people in Britain. So, there's a long history of this.

Greg Dalton: And one of the interesting stories you write about is that there was a worm brought in on ships. I believe it was the East India Company that decimated some of the defenses and this is an interesting example of how even well designed defenses can be thwarted by something unexpected from outside the system.

Brian Fagan: Oh yes, because basically, there was no rock in the Netherlands, much of which is basically a series of estuaries and they used timber. But these ships brought in a Teredo worm, which loves timber, and they literally ate the sea defenses. So they had to start bringing in stone, they started using seaweed, which is surprisingly effective when combined with sand, and they devised ways of diverting water from the sea walls. But today of course, these are huge, and it's worth mentioning that if you would live in a village near the ocean in the Netherlands, you won't have an ocean view. All you will see will be a sea wall covered with grass being grazed by sheep who look very well fed.

[Laughter]

Greg Dalton: So, lessons from the Dutch and from history, is that the future for California? What can we learn from history in the Dutch experiment with sort of defending against this onslaught of the seas? And then we'll get to Meg Caldwell here and talk about California today. So Brian Fagan?

Brian Fagan: What lessons have they learned?

Greg Dalton: What lessons can be learned from this history about — applied to today?

Brian Fagan: The options in the face of rising sea levels that one has are well known. One of them is to wall off the ocean, which is what the Dutch have done with great brilliance. They are also looking far, far ahead, and they are planning for 1,000 and even 10,000 year storm events having very, very, very forward looking, extremely conservative, and spending enormous sums of money on this. And they've got one barrage where they put up an inscription, which says, "Here, the ocean is controlled by the moon, the sun, and us."

[Laughter]

Brian Fagan: Which is a very arrogant self assured statement. And in the long run, the question I would ask is do sea walls, with all the consequences of building them, actually master the ocean. Notice I'm deliberately not answering the question. I don't know.

Greg Dalton: Meg Caldwell, former Chair of the California Coastal Commission, what kind of —

what do you think about the future of California in terms of this history? And what are our vulnerabilities here in California thinking about rising sea levels and what's going on?

Meg Caldwell: I think the first thing that we need to keep in mind is that we have some fairly recent examples of what is likely to occur more frequently in the future. So if we just look back to the 1982, 1983 El Niño and then the 1997, '98 El Niño, we saw tremendous damage along our coastal areas. The '82, '83 El Niño, I think, caused something on the order of \$215 million worth of damage, and that's in 2010 dollars.

So where we have the greatest risk and vulnerability is where we have a combination of these very large storms that are generated and increasingly intense as climate change progresses in combination with high tides and creating very large storm surges. And this is where the bulk of the damage is really occurring.

Our memories are short, but it's only within the last few decades that we've had very intimate experience with what we will increasingly experience in the future. So the question is — I know Brian mentioned the first thing that might be done as a form of adaptation, which is to fortify the coast. Well, we have also lessons from having done so. We know that seawalls are of a limited lifetime. They require a maintenance over time. They don't always work. They could have detrimental impact on property values. They certainly limit coastal access, which is a constitutional right in the state of California both getting to the coast and walking along the coast for anyone who's traversed the area on the Ocean Beach that has a whole combination of rock revetments and seawalls. And if you've done so near high tide, you realize that it's really dangerous and in fact impossible to traverse the beach in certain stretches. So we've got some public safety concerns as well.

Not only that, but the construction of seawalls and rock revetments involves a tremendous commitment of capital and greenhouse gas emissions, I might add. We know that our cement plants are among our largest emitters of greenhouse gas in the state, and so what we're basically doing is doubling down on a very bad commitment towards using fossil fuels into the future.

So a second option might be to adjust how we build and develop along the shoreline to not rebuild in areas that had been devastated by or in basically high-risk areas that had been formerly devastated by high tides, big storms. Just don't rebuild in those high hazard areas. We can also adjust how we build. We can change our building codes. We can adjust our development standards and increase our setbacks so that we are building in less and less risky ways.

And a third thing that we can do in the form of adaptation which might be this 10,000 year approach, taking the long view is to pull off the coast where it's simply too risky. And we know that the long-term option is to move off these high-risk areas.

So I think one framework that really helped me think about sort of sensible adaptation is a framework that was suggested by an editorial in Global Climate Change a couple of years ago. And it really sets out a series of questions that give you pause and make you think about whether or not adaptation is constructive adaptation or whether it's maladaptation.

So maladaptation might involve basically choosing options that results in greater greenhouse gas emission than others, perhaps seawalls versus different development standards, for example. Maladaptation would be to choose options that actually put the most vulnerable of society at greater risk.

So thinking about areas along the coast where we have more socially vulnerable, less resilient

communities, the low income communities, communities with lower education, communities who simply don't have the social capital to bounce back.

And then another question is will this course of action actually commit us to a long-term commitment of resources and institutional momentum so that we foreclose our options in the future? And over the medium term, I think of, for example, building desalination plants along the coast or great seawalls along the coast.

And finally, will the option actually cause more social, economic, and ecological damage than alternatives? So these are the kinds of questions that we need to be asking as we think about adaptation.

Greg Dalton: A lot there, and I want to drill into a lot of those. But first give Brian Fagan's response to any of that. That was quite a bit there from your historical lands, the questions of retreating, cultures retreating from the coastline, just any response to that.

Brian Fagan: I would agree with everything Meg said. She's absolutely correct. There are no easy solutions to adaptation. The one that truly — and I'm going to go over slight tangent here, because this is relevant. The one that truly frightens me is Bangladesh. And this raises another issue, which she didn't raise which to me seems very interesting and important and that is in Bangladesh, which is on average 38 feet above sea level, they've got densely populated cities. They have subsistence farmers with rice and shrimp farms on the coast. They've stripped off all the natural or most of the natural mangrove swamps that protects Bangladesh, which is on top of the Bay of Bengal.

So literally, cyclones come up and they say, "Good afternoon. How are you? Let's go ashore." And bang, they go ashore.

And there was a wonderful account to one in 1864 before they started doing mitigation where a ship were drifting in the storm and floated over the top of trees and landed with its bow split over a post office. Or the official who was touring — a government official took shelter when a hut blew away. And this is a lovely account. He wrote of how the water rose suddenly, and it rose to his waist at precisely 1:20 p.m., at which point his watch stopped. It's lovely. But I mean probably a hundred thousand people died in that sea surge.

And today, with the population rise, with their forecasting 21 million people in the city of Dhaka in 2021, that's not far away, and with the coastal population also growing and ground water being contaminated by an increasing amount of seawater once the sea level rises and the moment the sea level rises, the spread very often horizontally is much bigger than the rise, much more extensive.

They are facing the real issue of thousands of environmental refugees who will have nowhere to go because their land is gone. And the same in Egypt, and these people aren't people who are experts in computers, or people with money, or people who have connections on the cities. These are subsistence farmers who are anchored in that land. Where are they going to go? They're not going to go to India. India doesn't like Bangladesh, and there's no space, Myanmar, ditto.

There are no, to my knowledge, and she may know better than I, international policies for environmental refugees which are confronting this problem, which is going to be here, I think, within our great grandchildren's lifetimes if not before. But I'm open to correction as she probably knows more than I do.

Greg Dalton: There's a film called *Climate Refugees*, and in that film — a documentary film that

came out a couple of years ago — they cite a U.N. statistic. There's already 50 million climate refugees in the world, and they attach climate to lots of droughts in Africa, etcetera, even Darfur and other places. And let's touch briefly on the Pacific Islands, and we'll come back to California.

Pacific Island nations — they're already shopping for land in nearby countries to move their populations. Brian Fagan?

Brian Fagan: Oh, yeah. They will be. And there was actually a study done by the British government on environmental refugees, which is well worth reading; it's on the web. And it frightened the hell out of me.

Greg Dalton: Meg Caldwell?

Meg Caldwell: Yeah. We know that the president of Carabas is actually exploring a purchase of significant land in Fiji, for example, for his country, because they will be displaced very soon. Some have already. And we've already seen migration of people from Micronesia into places like New Zealand.

And there's an incredible social and cultural toll here that largely doesn't get accounted for in our kind of structural discussions. And the loss of whole cultures and the degree to which cultures can be or should be assimilated in new societies and what the toll is on the New Zealanders themselves, and I think this is something that we really need — the social scientists to be helping us to understand and how best to facilitate migration where it's absolutely necessary. And as you mentioned and many of the Pacific atolls it will be.

Greg Dalton: Who contributed least to it are suffering first and suffering most. Sure, Brian Fagan?

Brian Fagan: If I may add something to this, I spent an early part of my misspent youth living among subsistence farmers in the Zambezi Valley, some of whom had been forcibly moved.

And the most striking thing about those people was their relationship with the land they cultivated; it was the land of their ancestors. And when they had a village meeting every time, the village spirit medium got up and invoked the ancestors clapping his hands, because the ancestors are the guardians of the land. You move people, say subsistence villagers on barrier islands on the Arctic Sea, and you want to move them to say any city up there. They don't want to go, because that's their land, that's their heritage. They'd rather move five miles at vast expense and build a new village and with good reason, because they're terrified of urban life and of alcohol, because many of these settlements are dry. It's a very, very complex sensitive subject, extremely.

Greg Dalton: Meg Caldwell, that brings to mind some cases in Alaska, Kivolina, and other places, where there are some native cultures and villages that are being — basically, their land is being eroded by sea level rise. They say they contributed very little to it, and there's been some very early court cases. I don't know if you're able to comment at all on those cases in the Ninth Circuit here and others. There are sort of some early cases testing sort of the legal avenue for damages, loss of property and villages that may be forced to move and lose that connection to the land that Brian Fagan just mentioned.

Meg Caldwell: I can't comment on those cases, but I can tell you that there's a very concerted and serious effort underway right now within the U.N., and colleagues of mine from Stanford are traveling to New York right now to present the case on behalf of the small island states, AOSIS, and to explain what climate change is visiting on these cultures and on these societies.

And it's not just sea level rise; it's ocean acidification and ocean warming and really changing the whole relationship between these societies and their coastal and ocean ecosystems, which is primarily what they depend on for livelihoods and for protein.

Greg Dalton: Let's talk about ocean acidification. I believe Jane Lubchenco, former Administrator of the National Oceanic and Atmospheric Administration, called ocean acidification 'the evil twin' of climate change. A lot of people don't know about it, don't see it. So what is ocean acidification and why should we care?

Meg Caldwell: Well, so Brian, feel free to chime in at any point here. But the ocean, the global ocean has actually done us this incredible favor by buffering us from a lot of the effects of climate change and our fossil fuel addiction, if you will. And part of that is that it has simultaneously absorbed a lot of the atmospheric heat, so the ocean is getting warmer, sea surface temperatures are warming, and it has also absorbed a great deal of the atmospheric CO₂ that we are responsible for. So what the scientific community reports to us is that they know from Mauna Loa and other research stations that had — where they have really long-term studies that — and tracking the PH and chemistry of the ocean are really long term as well — that since the industrial revolution, the oceans have become about 30 percent more acidic.

So the combination of warming ocean, warming sea surface temperatures, more acidic ocean, and simultaneously frequently comes with its own evil twin of a lowering of oxygen in the sort of three-dimensional ocean.

We have a squeezing out effect for certain species, and we expect that there are effects going on within the marine food web that we haven't even begun to understand. On ocean acidification, in particular, because I know you really wanted to talk about that. I mean we already know from the species that we've studied so far that about half the species, an increasingly acidic ocean adversely affects them. So oysters and mussels, any species that relies on calcium to create its skeleton, either external skeleton or interior skeleton can be affected by ocean acidification.

We know that some of the base of the food chain in the ocean and here in the Pacific, these fabulous oceanic snails called pteropods form their exterior shell using calcium carbonate. That we've seen both in the lab and in the field that the current conditions are adversely affecting their shell formation.

And these are a particular concern to us, because these pteropods are actually one of the primary prey of our juvenile salmon. And it's — salmon, of course, is a major industry along the West Coast. We have very strong cultural connections with salmon, of course, and to think of how that might be, this relationship between predator and prey may be altered by ocean acidification, is really daunting. Oysters — we've already seen dramatic effects on oysters on the West Coast. We have Taylor shellfish, and Whiskey Creek hatcheries up in Oregon and Washington.

And since about 2009, they've experienced incredible impacts on their ability to convert embryos into juvenile oysters and into spat that then they sell to the California oyster industry. We don't grow any of our own spat here, so we are entirely dependent on Oregon and Washington for our oyster industry. Ours, of course, isn't as large as Oregon's and Washington's, but it's still substantial. So think of this: not being able to go down at the Ferry Building and get your Hog Island oysters anymore.

So the industry, of course, is trying to adapt to this. They're experiencing what we thought would be

like 2050 conditions for ocean acidification now. They're doing things like buffering the water as they bring it in to the tanks, where they're trying to grow these babies. They are going over to Hawaii and trying to establish hatcheries over there that have slightly better conditions, which -

Greg Dalton: That's a low carbon solution.

Meg Caldwell: Yeah. Exactly.

[Laughter]

Meg Caldwell: So this is obviously not sustainable especially when you think about the fact that at some point you have to bring those babies out into the field. You can't grow all the oysters in tanks. So I don't know if any of you had the opportunity to listen to Dick Feely, one of the managers from Taylor Fish Seafood, last Friday on Science Friday, but it was a great 20-minute program that went even deeper on this issue of how ocean acidification is affecting oysters.

Greg Dalton: What can California or anyone do about ocean acidification?

Meg Caldwell: Well, the first thing we can do is stay the course with our current policies of reducing our greenhouse gas emissions. So AB 32 is absolutely critical. We need to be thinking beyond AB 32 now, and, of course, that was a law that insisted that we go back to 1990 levels for greenhouse gas emissions by 2020.

Well, 2020 is fast approaching, so we need to redouble our efforts to reduce our own carbon footprint as a state. We're a major economy, and we are a contributor to this global problem.

The second thing that we can do while really being a leader in that field and trying to bring others along is to kind of pull off some of the other stressors on our coastal and ocean ecosystems and give them a chance during this period, where we are hopefully converting a way from a fossil fuel based economy and society and into renewables. And that would involve things like reducing our urban runoff, our agricultural runoff, checking our air emissions. All of these can affect and do affect our coastal and ocean ecosystems in different ways and in different locations. But this is a strategy that many scientists sort of called buying time and increasing the resiliency of these coastal and ocean ecosystems so that we give them a chance in the face of climate change.

Greg Dalton: Brian Fagan, does your reading of history give you hope, optimism that we will adapt in this way? We've adapted many times before. Would we get it right this time?

Brian Fagan: Which is interesting, because I could jump off what she just said here. To me, the most startling thing, and in archaeology, which is my field, we've had this for years. I am startled how little informed the general public is. And this is a serious deficiency in the way we educate people and create and inform citizenry. It's all very well doing all the research, but one of the primary jobs we have is to talk about ocean acidification in intelligible terms for lay people and say, "Look, you want oysters, this is going to happen."

Greg Dalton: Get out of your SUV or whatever, yeah.

Brian Fagan: Yeah. I really think about this, because one of the lessons of history is — that I can be optimistic— we are Homo sapiens. We're the wise people, obviously. We're not often wise, but we're wise. We innovate, we plan, we think ahead, or we think we do, we're infinitely ingenious.

And time and time again in history, we found solutions, we've solved problems. Today, the problems we face — growing population, pollution, and so on — are unprecedented. But I happen to believe that we're ingenious enough to solve the problem.

Having said that, part of this is being clever enough to rise the importance of defining moments and two that I would mention here from the ocean point of view, Hurricane Katrina, Superstorm Sandy, and the El Niños that hit us a decade ago. Because, believe me, ladies and gentlemen, they're coming back. They love this coast. They want to attack it. And the sooner we start educating people about the realities of this, the better off we are. So I really believe that the future lies, a lot of it, in an informed citizenry.

Greg Dalton: And that's why people are here today. It's why we do this Climate One radio show. If you're just joining us, our guests today at Climate One are Brian Fagan, retired professor from UC Santa Barbara and author of *The Attacking Ocean: The Past, Present and Future of Rising Sea Levels*. Our other guest is Meg Caldwell, Senior Lecturer in Law at Stanford University and Executive Director of the Center for Ocean Solutions at the Woods Institute for the Environment. I'm Greg Dalton. Podcast of this and other Climate One programs are available on iTunes. You can follow us on Twitter at our handle @ClimateOne.

So the citizenry is not informed. How about the state of California? Are the people responsible for policy planning, understanding this is going on? And what's the government doing to sort of prepare? And I want to talk a little bit about time frames and time cycles, which tend to be very short-term focused as business people as a polity, and yet these are very long-term challenges. Meg Caldwell?

Meg Caldwell: First, let me go back to the presumption or the precursor to that question which was the citizenry is not informed. And I want to share with you the results of a recent survey that we conducted at the Woods Institute for the Environment and Center for Ocean Solutions with Jon Krosnick, who's a professor of psychology and political science -

Greg Dalton: And a pollster who does a lot of good polling work on this, yeah.

Meg Caldwell: Right. And we essentially developed a baseline study, if you will, for sort of — well, he's done a lot of studies on the degree to which the public recognizes that climate change is happening.

And what those previous surveys tell us is that the public actually knows. They are well aware that climate change is occurring, that it's having negative effects on communities and on the environment. The study that we connect, we wrote, and developed actually builds on that and ask questions like, "Do you understand whether the degree to which sea level rise is part and parcel of climate change?" and "Will sea level rise be good, bad, or indifferent for coastal communities? Will we experience more damaging storms?" And overwhelmingly, the public responded in California and in the nation as a whole, because this was a national survey where we did an oversample in California said yes.

Over 80 percent said climate change is happening, and over 80 percent said, "Yes, it involves sea level rise, and it will produce more damaging storms." And over 80 percent said that, "We really think the government needs to take a leadership role here. We should be preparing for this in advance of these more damaging storms and sea level rise. And we are looking to local government, state government, and the federal government to take action."

So I think we have kind of a disconnect between sort of the urban legend that the public is not informed, and that the public is not concerned, and that they don't expect action. And what the elected officials are telling us which is, "Well, we're not really seeing our constituencies rallying behind this." And so part of our job as scholars in this area is to share this information and let them know that in fact the public is pretty well informed about this, and they do have an opinion about it. And elected officials do have a very important role and government agencies have a very important role here.

So I forgot the other part of your question, but I kind of went out on a roll about —

Greg Dalton: Yes, fair enough. And tomorrow, we will have former governor of New Jersey. Christine Whitman will be here with us and former governor of Colorado, Bill Ritter, will be here. And Governor Whitman told me on the phone this morning that there's always this disconnect that elected officials follow the people; they don't lead them usually. And then — anyway, there's more about that tomorrow if you'd like to join us at noon.

So the question is what is government doing to sort of plan and the time frames for this, because people think about sea level rise, they think about centuries, it's a slow threat. We'll have time to respond and history and Hurricane Sandy would say, "Well, sea level rise can kind of pack a pretty mighty punch, pretty fast, and it's here now. It's not something for great grandchildren." Let's talk about the time frame and planning.

Meg Caldwell: Okay. So yes, the state of California has actually been a leader to some degree, and so I really want to give it credit where credit is due. We've seen here in the San Francisco Bay Area the BCDC, the Bay Conservation and Development Commission, tackling sea level rise, developing its own sea level rise policy, and really being very transparent about how it's going to make decisions in the face of sea level rise and coastal development around the bay.

We've seen the California Energy Commission putting a lot of money and other resources into research to better understand what the impacts are that we can expect in California. Guido Franco has been a leader in his field there, and I really have to hand it to the staff at the energy commission.

So we've developed a lot of really good information, and we've been delivering that information to the elected officials and agency leaders. And we are starting to see commitment of resources and a sense of some urgency that we do have to engage in planning now to deal with sea level rise. So the California Coastal Commission is developing a sea level rise policy as we speak.

The Ocean Protection Council has been working in combination with the Coastal Conservancy to extend grants to local jurisdictions so that they can adjust their general plans and their local coastal programs to account for sea level rise.

We have a bill in the legislature that would make it very clear that under the California Environmental Quality Act we should be looking at the physical changes that we can expect along the coast in the context of any kind of environmental impact report for a project that is located along the coast.

Those kinds of changes are happening, and we see agencies like Caltrans that had developed a sea level rise policy. Now, that one sets basically for long-term projects — projects longer, I think, five years out. They absolutely have to take sea level rise into account.

So the engine of change is revving up and starting to get in motion. I think what we haven't done is

sort of taking a collective time out and said, "In the meantime, until all of these plans are in place, how can we make sure that we don't further double down on bad decisions, commit resources sort of irretrievably in the wrong direction in the name of adaptation and begin to rethink some of our bigger institutions that really do affect behavior like our flood insurance program and disaster relief?"

So these are the things that we have yet to tackle.

Greg Dalton: Brian Fagan, you live in Santa Barbara. Is there a recognition of this in Santa Barbara? Are people moving back from the coast? I believe there was one case where some people wanted to do a blue line of where sea level rise would be in the future, and there's a lot of pushback from that.

Brian Fagan: Oh, the blue line.

[Laughter]

Brian Fagan: You would bring up the blue line. This was in the ten some years ago by some, I think, activists to paint on the line on the streets of Santa Barbara showing where sea level would go. This was shouted down, (a) by developmenting fists, and (b) by people who thought this was just bloody stupid. And I hate to say it, but they had a point.

But it didn't give us some exposure. And Santa Barbara, I guess, I don't really know. I've been away a lot and really I'm not very much in touch.

But they are obviously concerned. We have, for example, a very vulnerable harbor, which is going to need work, and so on. But an awful lot of what happens in Meg's world is, I think, people aren't aware of it. And I would make one final provocative point. If anyone in this room has any illusions about the cost of all these and any illusion that in the future we can have government on the cheap which seems to be one of the litanies now, forget it. It doesn't matter what your ideology is, reality suggests we've got to spend public money and a lot of it as well as private.

Greg Dalton: Let's explore that, because we're going to have to spend a lot of money just to maintain what we already have today. Roads are going to need to be moved, water treatment plants are needed to be raised or adapted, and we don't like to pay for these things, and we're not going to have some shiny new object at the end of day if we're going to kind of have the status quo, but protect it. There's an effort, I believe, in a couple of years, to have a parcel tax in the nine Bay Area counties to do some wetlands restorations and sort of use this nature sponges to protect the bay from sea. Meg Caldwell, where are we going to get all the money to pay for this? We certainly don't want to increase taxes.

Meg Caldwell: Well, don't speak so soon. The same survey that we conducted looking at attitudes about climate change also looked at what kind of adoptive measures are most appealing to the California public, and who should pay for them.

So here's the rundown. Roughly half of the California public believes that the state government should pay for general preparations. So in terms of all of the planning that I discussed a little earlier, that's a government function that really all of us should pay for.

But when we look at specific adaptation measures, things like building seawalls, reconstructing dunes, beach nourishments, induced retreat-pulling people off the coastline, there the public says

overwhelmingly, and this is amazing. These percentages were amazing that it is the coastal property owners and businesses who should be paying for that. So that speaks directly to this issue of a parcel tax versus income tax. Right? Because right now we all pay. When disaster strikes, we all pay.

Greg Dalton: But that's people who don't own coastal properties saying people who own coastal properties should pay. Right? I mean, there's a little bit of —

Meg Caldwell: We wondered about that, so we asked about that. So we went back. We looked at the data, and we segregated coastal property owners and in-landers and renters. And do you know that over — well, again, overwhelmingly, coastal property owners believed that they should be the ones who should pay for these specific adaptation measures. So -

Greg Dalton: Did you survey in Tiburon? Because they're fighting that in Tiburon. They don't want to pay.

[Laughter]

Meg Caldwell: Yes. The entire California public.

Greg Dalton: Okay.

Meg Caldwell: Everyone had an equal opportunity to participate in the survey.

Greg Dalton: Because in Tiburon, they've notably pushed back on things that sort of paid for that waterfront lifestyle they have. Okay. So people might be willing to pay. Say people were willing to pay, so you telling that taxes may go up? And Brian Fagan's — we were not going to get this on the cheap. This is going to cost a heck of a lot.

Meg Caldwell: So I think there's a difference between what's happening right now is we all pay, and we all pay through basically the income tax system. And -

Greg Dalton: We pay to bail out of New York and New Jersey after Sandy.

Meg Caldwell: —we pay to bail them out. That's right. So it's a hidden cost, and we're not explicit about that.

And so the question is the degree to which we're willing to be explicit about this and basically ask those who would visit upon themselves greater risk by building in high hazard areas to actually bear the cost of that risk.

Greg Dalton: If you're just joining us, we're talking about sea level rise in California and beyond with Meg Caldwell, a law professor at Stanford University and Brian Fagan, a retired archaeologist from UC Santa Barbara and an author.

We're going to invite your participation and audience participation and invite you to come up and ask a one one-part question or a comment. And if you're on this part of the room, we invite you to please go through that door, and the line starts with our producer, Jane Ann right there. And then we'll get you included in this. And this is often one of the most informative engaging parts of the conversation. And who's going to be first. Come on, don't be shy. Someone will be first once it gets going. And then we will include you in this.

Let's go to audience questions. Welcome to Climate One.

Male Participant: Hi. Gary, Malaysian. Your last comment about people that live in-land might be not want to pay, but, however, when people that live in-land want to go on vacation, they go to the coast. So the amount of money that is spent on the coast is for the benefit of the entire populace as my mind sees it. It's not just because you live in Fresno, you will vacation in San Francisco, and Santa Barbara, etcetera, etcetera. So I think everybody should pay.

And the second thing is climate — how are we going to get — I come to a lot of these gatherings. I never see a legislator here. City, state, national — they're always on the platform. How do we get that information to these [inaudible] that are dragging their feet about climate change?

Greg Dalton: Meg Caldwell, local elected officials, there's a - yeah.

Meg Caldwell: So let me share with you that the first hearing for a new select committee in the California legislature on sea level rise and the California economy just occurred. So we do — I think, perhaps the sleeping giant has awoken, and the legislature is aware that it needs to educate itself on what climate change will bring to coastal communities, and how those impacts will affect the California economy, and what the legislature needs to be doing to improve our prospects moving forward and reduce our vulnerabilities and increase our resilience over the long haul.

So the first of four hearings just occurred last month in Sacramento. And the remaining three hearings are going to occur throughout the state. So you can Google it I'm sure and find the select committee on Sea Level Rise and the California Economy to find out where these hearings are going to be held but — and the legislature is paying attention now.

Greg Dalton: And some local officials know about this, but they say we don't have any money or tools to deal with it.

Meg Caldwell: So that's where you go to things like the Ocean Protection Council and Coastal Conservancy Grant Program where these grants are actually being extended to cities and counties along the coast to update their general plans and to build in the best readily available science to their planning.

Greg Dalton: Let's have our next question. Welcome to Climate One.

Male Participant: You didn't address at all the corporate factors in the climate change resistance by oil companies to curb the use of fossil fuels.

And how is the effectiveness of the carbon credits going?

Greg Dalton: Who'd like to tackle that?

[Laughter]

Brian Fagan: I didn't really catch completely the question.

Male Participant: Fossil fuel companies opposing action on climate change?

Brian Fagan: Ah, you should see my emails. Dear Dr. Fagan, I'm very distressed to see in your book, which you say that climate change is being caused by humans. I enclose here with the paper, which I wrote recently and you look at it. I'm grateful to the Exxon Corporation for sponsoring this

paper." I get a lot of this. Almost invariably, the people who write to me about this, who oppose this have agendas.

Greg Dalton: I thought the energy companies were a little more discrete about that these days.

[Laughter]

Brian Fagan: The ones who have written to me have gotten more discreet, but they weren't some years ago.

Greg Dalton: Right. In fact, Steve Coll, who wrote a book *Private Empire* about ExxonMobil talks about how they fund research with the specific purpose of getting it into the peer reviewed literature stream, for the purpose of litigation that they anticipate years down the road. So they're quite savvy on long-term thinking about funding research that'll be beneficial and —

Brian Fagan: Compared with Meg, I am but a child in all this. I'm an archaeologist. I look back.

Greg Dalton: We'll be studying the seawalls that we — your successors will be studying the seawalls that we build in future generations.

Let's have our next question.

Male Participant: That's totally appropriate. My question is to Meg Caldwell, and it has to do with these adopted measures. I happen to be a coastal dweller, very perilously, behind the seawall. How do you justify when you talked about the coastal retreat and the right to universal access to the California beaches with the private property rights that my wife and I have to preserve our home? These are — I mean we're hearing historically from the professor at the — about the people want to have a sense of home and place. Well, that is our home and place. So what is the Coastal Commission and the state of California doing to preserve our constitutional right to live and raise our family on the coast?

Greg Dalton: Meg Caldwell?

Meg Caldwell: So I'll try to parse this a little bit and build up. The first thing is that no matter what the Coastal Commission does or what private property owners do, sometimes it's not enough in the phase of these really damaging storms. So we've seen areas like Pacifica where buildings — despite the fact that they had revetments at the bottom of the bluff — these buildings fall over the cliff.

Greg Dalton: What's a revetment?

Meg Caldwell: A pile of rocks.

Greg Dalton: Okay. That, I can understand.

Meg Caldwell: Well, yes. And usually they're really big rocks, so they're coming from — they're big quarry rocks that are piled up along the coastline. The second thing is that there is a common law doctrine that is alive and well in California and enshrined in both the Coastal Act and in our Constitution called the Public Trust Doctrine. And what that doctrine says is that the state is a trustee of our coastal and marine resources and is responsible for guaranteeing the right of the public to access the shoreline for fishing and navigation and swimming, recreation, and also to protect — in California, we have a very robust Public Trust Doctrine — to protect ecological function. So that Common Law Doctrine exists with or without the Coastal Act. With the Coastal Act, we have

a state statute that was written and adopted in 1976, when folks didn't know what we know now about what climate change would bring to the California coast. And there we have a couple of provisions that are relevant to your question. One is a provision in the Coastal Act that says the Coastal Commission is not allowed to effect the taking of private property to — it doesn't have the power of eminent domain to take property and then pay you for it. So it needs to make its decisions in a manner where it avoids such a situation.

We also have a condition, a provision in the Coastal Act that says that for existing structures, there is a qualified rate to armor and to protect your structure. It's qualified by the fact that your structure needs to be in danger of erosion, and that you need to — any kind of hardening needs to be basically an alternative to other more detrimental environmental alternatives. So it needs to be the least environmentally detrimental alternative for you to be able to pursue that.

And this is — this provision that talks about protecting existing structures. So back when the Coastal Act was written clearly we were thinking, we were definitely grandfathering existing structures that were along the coast. But as that provision has been interpreted over time, the Commission has looked at say your proposal for a seawall and said, "Well, do you have a structure existing along the coast at the time you filed that application?" And your answer would be yes, and we would say, "Oh, it's an existing structure."

So back in the 1980s, the Coastal Commission looked at another provision — well, looked at many, I know.

But at least one other provision in the Coastal Act which says that it does not have the liberty to approve development, new development along the coast that will, at some point in the future, require coastal armoring.

So now, the Commission basically includes conditions of approval that says, "You have a no-future seawall condition attached to your approval, your permit." So regardless of your own particular circumstances, we're at a situation where the Commission has really tried to do honor to the balance of the Coastal Act which says we do not want a hardened California shoreline, and we need to build responsibly in a way that won't ultimately require a hardening of our shoreline but also needs to take into account provisions I've talked about not effecting a taking.

So one of the elements of any kind of legal analysis of coastal property owner situation is to say, "What is the impact and the effect of the Public Trust Doctrine in this case?" And if you are going to build a seawall on public trust lands, the wet sand, for example, perhaps you should pay rent back to the public.

So I think there are a variety options that the Commission has and will continue to consider over time and within the parameters that it must live. And these are never easy, but they make good father for lawyers.

[Laughter]

Greg Dalton: I'll just mention one other book. We had an author here named John Englander. Recently, he wrote a book called *High Tide on Main Street*. It's centered really on Florida, but it also looks at sea level rise, and a lot of people came up to him during the writing of that book and said recognize sea level rise.

These are people who own ocean front condos in Miami and said, "If I sell in ten years, will I be okay?"

[Laughter]

Greg Dalton: People know that coastal property markets will, at some point, be hit by this. The value of coastal property may be changed, and people just don't know. I'm sure it's about the time

frame.

Let's have our next audience question. Welcome to Climate One.

Female Participant: Thank you. Could you talk about the impact of desalination? There's a lot already going on in the Middle East. And what is the overall impact?

Greg Dalton: Desalination.

Female Participant: Desal-

Greg Dalton: Desalination.

Brian Fagan: What about it?

Greg Dalton: What we think? What you think about it?

Brian Fagan: I think it's really more Meg's than mine, but it costs fossil fuel to make it. And then you have the issue of transporting it. It makes sense, maybe, in a place like Abu Dhabi. Have you been to Abu Dhabi?

Female Participant: I had been to Dubai.

Brian Fagan: You have?

Greg Dalton: Dubai, yeah.

Brian Fagan: Oh, Dubai.

Greg Dalton: She's been to Dubai.

Brian Fagan: I've no desire to go back. The water tasted terrible, but they have unlimited fossil fuel, but the ecological consequences are considerable. I'm not violently enthusiastic about it, but it is one of our choices.

Greg Dalton: San Diego is going forward with that expensive desalination project. It's under consideration in Monterey. It's expensive, energy intensive. Meg Caldwell?

Meg Caldwell: Yeah. And there are also environmental impacts that need to be considered quite seriously. So whether you're dealing with wells that are in the beach area, the sand area and don't risk impacts like impingement and entrainments.

So impingement is when individual organisms smash up against the screens of the intake pipe and die as a result. Or entrainment where larvae and other organisms — I mean the ocean is a habitat. I think that's really important to understand.

Our ocean and coastal systems are ecosystems. There are living organisms. There's the base of the food web there. The baby rockfish who develop in our estuaries and later go out off the continental shelf and become important parts of our commercial fisheries, they are part of this whole ecosystem.

So entrainment can actually suck those critters in in their baby stages or larval stages and results in complete mortality. So these are some — plus there's the issue of what to do with the by-product of desalination, which is the brine. And we are learning more and more about how brine behaves when

it's discharged into our coastal system. And from that we've learned that it doesn't just dissolve and disperse evenly, that it can, depending on the local conditions, it can coat the benthic area, where you may have other critters, who are adversely affected.

So these are all some of the other considerations on top of the carbon footprint of desalination that needs to be considered. And then there's the terrestrial side. There are questions about the degree to which desalination may be growth inducing in areas that simply don't have the water resources or other resources to support coastal development. So were kind of changing our dynamics here as we consider desalination.

I don't purport to have the answer, but I do know that we have to be honest with ourselves about what the potential impacts are and what the costs of desal are as compared to things like water conservation and other efficiencies that we can gain in our water supply system.

So I would just commit everybody to looking at the Pacific Institute's reports on desalination, because they're quite good, and they did a really good job of covering many of these issues.

Greg Dalton: If you're just joining us, Meg Caldwell is a professor of law at Stanford University. Let's have our next question.

Female Participant: My question is are we currently, through our taxes and disaster funds, paying for people to relocate from low-lying areas? And if we'd want people to leave these areas, how are we going to get them to do it? Santa Barbara, if you walk along the beach, you see houses upon the cliff with half of their deck off the cliff, and they're evidently in lawsuits with the cities and counties they live in perpetually. They're still there, and their deck hasn't fallen yet, but it will.

Greg Dalton: We want to live in paradise but not pay the price of paradise. Who'd like to tackle that? Brian Fagan or Meg Caldwell?

Meg Caldwell: We do currently —

Greg Dalton: Meg Caldwell.

[Laughter]

Meg Caldwell: There is a FEMA grant program, Federal Emergency Management Administration, or Agency, that — for which the funds have been used to relocate structures and households, businesses off and away from high hazard coastal areas. So there is some money that — for which we all are contributing that it's being used for what many of us call managed retreat.

There are also some really cool land use techniques that can be used, and I'm reminded of Humboldt County, where they're in the pathway of Humboldt Bay, and we know with sea level rise, Humboldt Bay will — should continue to migrate landward.

And so one subdivision that came up with the Coastal Commission actually required — the conditions of approval required that for every shoreline lot that there be a complimentary lot, a sister lot, if you will. And when a certain level of sea level was achieved that the structure, which was built to be moved — it was basically — they needed to be constructed in a way that they could be moved, that those structures would be moved back to the sister lot.

So there — that — for new development, that kind of thing can work. And for existing development,

move up to other techniques like compensating folks for moving off the shoreline.

Greg Dalton: Just a few minutes left, let's try to get one or two more questions. And yes, welcome to Climate One.

Female Participant: Thank you. My name is Maureen Forney. I'm a public school teacher in San Leandro, California. I was particularly attentive when you mentioned an informed citizenry, because my students look nothing like the audience here today, and I knew who our future informed citizenry is supposed to be. They're in my classroom and all around me.

So my question is in regards to school standard reform and in the STEM area, Science, Technology, Engineering, and Math, and new common course standards are being written around these. There's little if any attention paid in the STEM standard, Science, Technology, Energy, I'm sorry, Engineering, and Math that refer to any of these issues that we as an informed citizenry here know are incredibly important. What is being done? What can be done? What will be done to take the considerable knowledge that you have and others have to offer to influence standards to be written for our students' education so we do have an informed citizenry that you obviously made clear is important to our future?

[Applause]

Greg Dalton: Brian? Brian Fagan, there have been some efforts to get this into the state —[crosstalk]

Brian Fagan: Say again? I'm sorry.

Greg Dalton: Your response on the education standards, please.

Brian Fagan: Forgive me. I'm slightly deaf, so I have trouble hearing the questions. So if I haven't got this right, tell me.

To my mind, and a lot of what Meg is saying to me is a revelation to me. I mean a lot of it's wonderful stuff. I think an awful lot of this, and I'm a — thank God — a former professor, not a current one. I think there has to be a very radical, radical thing about what undergraduates are taught, and I think a great deal of what Meg is talking about should be required at the lower division level instead of some of the stuff that's taught now. I think we really need to take a drastic look at undergraduate education in the context of adapting to the future.

As far as communicating with the public is concerned, one of the big problems now is that a great deal of publishing is concerned with entertainment. And I, as an author like serious non-fiction, which hopefully is readable; the sex scene is on page 80, but the people you really want to meet maybe don't read it. And we have an issue there. So really, I can't give you a very good answer.

Greg Dalton: Meg Caldwell, also an educator.

Meg Caldwell: Yes. Let me add a little bit of dimension to this, and that is just in my capacity. I had served on the board of the Monterey Bay Aquarium. And the aquarium is a partner organization within the Center for Ocean Solutions, so I'm aware of the incredible work that institutions like the aquarium have played in the STEM standards and in reaching out to local school districts in the case of the Aquarium to Watsonville area in particular and working with them on bringing ocean literacy directly into the classroom and bringing students and of course all public school students then come

to the Aquarium for free.

So there's a major effort there. I do know that the aquarium education program staff members have been involved in the STEM standards and have done their level best to get ocean literacy into those standards that I admit that I'm sure we're a long way off. Yes, there's a little bit of progress there.

Greg Dalton: We are out of time. We have to end it there. Our thanks to Brian Fagan, author of *The Attacking Ocean: The Past, Present and Future of Rising Sea Levels*; and Meg Caldwell, Senior Lecturer at Stanford University. I'm Greg Dalton.

Thank you for coming to Climate One today. Podcast of this and other Climate One programs are available in the iTunes store. Thanks for coming.

[Applause]

[END]