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The oceans are the hub of the climate system on the planet and they've been warming up over the last 40 years. All of the oceans have been warming up and you ask yourself, where did that heat come from? And a lot of people have looked at that. It did not come from the sun. It did not come from geothermal sources. It came from a radiational imbalance in the atmosphere. That means more heat coming from the sun than we're radiating into space. So the whole system warms up, and that's what the oceans have been doing for at least the last 40 years.

When you warm the ocean a number of things can happen. First of all, the warm water is at the top and it tends to cap off the oceans, if it gets warm enough. So you don't have vertical mixing; you can't bring nutrients up from deep in the ocean into the euphotic zone – the area where the phytoplankton live. And you say, "well, so what?" Well, phytoplankton are the basic building block of life in the ocean and they rely on those nutrients to live. Without the nutrients, no phytoplankton, without the phytoplankton, no zooplankton, without the zooplankton, you don't have fish. And right on down the line. So the whole food web in the ocean is gone.

[The state of the planet's oceans] is a huge subject. I think from the physical point of view we certainly are warming up the oceans and putting that warm cap over them. It's no secret that glaciers all over the planet are melting as well as a lot of ice in the Arctic. That's putting fresh water into the system and [fresh water] is lighter and it tends to cap the ocean. What people worry about is that the great thermohaline circulation that redistributes heat through the ocean all over the planet would shut down. And if that happened, I don't think anybody's really got a good idea what would go on, but I can pretty well guarantee it wouldn't be nice.

The oceans are also becoming more acidic. Who cares? Well, again, the little phytoplankton – the building block of life in the ocean – care because they have a calcium shell, a lot of them. And [their shells] tend to dissolve if [the water] gets too acidic. They're thinking by the year 2100 it will be acidic enough at the rate we're going that it will have a major impact on planktonic life forms.

Glaciers are in retreat almost everywhere in the world. Not quite everywhere, but almost everywhere, and that has some very scary repercussions. Let's take for instance, China. The third biggest hunk of ice on the planet outside the two poles sits on top of the Himalayas – and it's melting. People use that melt water now during the summer, during the dry season, for irrigation and drinking and all sorts of things. But as the glaciers continue to melt the day will come – perhaps thirty, forty, fifty years into the future – when there won't be any glaciers. What will those people do for water? I mean this is "fossil water." It was laid down thousands of years ago in the glaciers. And when it's gone, it's gone. There's no replacement for it. Even worse is the Andes, Bolivia, and Peru. Their glaciers are melting too, but they'll be gone sooner than those in China. What does this mean in terms of people? Twenty-five million people in the South American region

impacted by this? Three hundred million people in China impacted by this. It's hard to imagine those people are going to just sit there and go thirsty or that their government will allow them to do it. So you want a cause for World War III? How about water?

And the glaciers supply water not only for humans, but also for wildlife.

[I was once skeptical] about the whole [climate change] issue. I probably did the first statistical detection project back in the 1980s to try to take the signals predicted by the greenhouse models and go into the real world and say, "Gee, does this signal exist there?" And in those days the answer was a very resounding "No!" It wasn't. In the early 1990s, I helped form a group of people around the world who were interested in detecting signals of global warming, and for the first five or six years of that group's existence, I think I was the lead [person saying], "No, we haven't really seen it yet." A skeptic, if you want. But you know, as year after year went by the models got better, the data got stronger, the signal got stronger until it became so obvious that there was something going on and that I could not be a skeptic any more.

The oceans by and large are in failing health. Not fatal at the moment, but failing. You know, you've heard about the great reductions in large-scale fish populations. We're just simply over-fishing them. We pollute our coastlines, where most of the people live, with ever-increasing amounts of pollutants because there's simply more people. We talked a little bit about the coming acidification of the ocean. The changes in the physical properties of [the ocean] like temperature and creatures. Well, we have a good example off [the coast of] California. Take El Nino. During an El Nino, the water off the coast here is quite warm. And we get a lot of tropical species that we never see up here normally. In the future world, that might be all we see here is the tropical species. So the whole ecosystem of the ocean will undergo – will have to undergo – some kind of major adjustment. Such an adjustment is happening right now in the Arctic. The ecosystem there is basically disintegrating as that part of the world warms up more and more.

[The melting of Arctic sea ice means] a couple of things. If you're an Eskimo, it means a [heck] of a lot to you because [you've] already lost some cities. There's talk about polar bears and walrus and things like that becoming extinct in a warming world. But I think the bigger message here is that computer models suggest to us – or tell us – that the first impacts are going to be in the high latitudes of the Northern Hemisphere. And we're seeing those first impacts right now. Do you want to sit around and wait until you see them in your back yard? Or do you want to get busy and do something about it? So I think as a bellwether for the climate system, the Arctic is really important. The other thing, as I mentioned earlier, is that if you get a fresh water melt from the Arctic, it can form a cap in the North Atlantic and stop deepwater formation and really upset the thermal balance of the planet.

There are tons of things that we can do [to help mitigate the problem]. I mean, it's just an incredible list, starting with individuals who can become more energy-conscious. Each person does his part. What we really need now, though, is leadership at the highest levels of our government. Unfortunately, we do not have it. All sorts of programs could be started

for alternative fuel sources. I saw in the energy bill where the energy industry is getting billions of dollars in subsidies from the U.S. Government. The last time I looked, Exxon/Mobil for instance, had billions of dollars of profit in their last quarterly statement. Why do they need billions of dollars of support? That money could go to developing alternative fuel sources. We're blessed here in California with lots of sun. Why don't we have a bigger solar effort here? Dollars and cents.

On a couple of different scales, [there are some success stories.] From a scientific point of view, El Nino was sort of a big mystery ten years ago. But we can do a pretty good job of predicting it now. As you know, it has tremendous impacts on the United States and our weather. And I think we've been able to save some people and probably lots and lots of money by letting folks know that an El Nino is coming and what kind of impacts to expect. On another level, I believe it was Newsweek or Business Week some time back had an article on global warming. And they went through all the major corporations. A surprising number of them, and they were taking actions to cut down their emissions. And what do you know? They all found that it was a profitable thing for them to do. So I think there are success stories. But they are a fraction of what they could be.

[We should care about what happens to the glaciers on Kilimanjaro or in Peru because we] get a picture there of what the future world will be like. And that's one of increased strife, increased problems. Those people are not going to sit quietly and just get thirstier and thirstier and watch their crops die. They're going to take some kind of action, and that's not going to necessarily be a good kind of action. Certainly if they move, they're going to have to move in where somebody else already exists. So I think what you're seeing there are just little pieces of civilization that are going to be heavily impacted, and you take enough of those pieces and wiggle them around you've impacted the entire planet.

[When I think about the state of the world in 2050,] it's pretty clear that fresh water availability is going to be a major factor. It's also clear that extreme weather events like, for instance, the really, really hot days like we've had in San Diego here recently, are going to become more common. That means people are going to want to turn their air conditioners on more, so you see a big energy crunch coming. And how do you solve that? By building more fossil fuel plants to make the problem worse? I don't think so. There are better ways to do it. On the longer-time scale, we need to worry about things such as sea level rise. Most of the sea level rise will not come from the warming of the oceans and then expansion, but it will come when the large ice masses on the planet melt, like Greenland, like the glaciers that we've been talking about. In that case, if you melt Greenland, for instance, you're going to increase the sea level by seven meters. That is twenty-one feet, roughly. That takes out most of the seaports in the world as well as some low-lying countries. That's on the longer-time scale. Don't ask my how long, maybe 2100, maybe 2200, but that's the direction we're going. The problem we've got is that CO2 lives in the atmosphere for more than a hundred years. And so it will stay up there and continue to do its warming just as happily as can be. And that's what we're wishing on our kids. We're making their planet now, the planet they're going to live in. If they don't like it, tough! They're going to be stuck with it.

[When I think about the world we leaving for our children and grandchildren,] I have a hard time keeping my scientific hat on alone, because I have six grandkids. And I tend to get a little carried away on this one. We're going to leave, in the near future, a world with serious freshwater problems. We looked at the snowmelt-dominated water regions of the world. It covers virtually all the industrialized world and affects one-sixth of the population. Based on studies we've done here in California and other places, it is clear that without sufficient dam capabilities it's just going to get drier. We're just not going to have the water that we do now.

And carbon dioxide lives in the atmosphere for roughly 100 years. That means it's warming the atmosphere as long as it's up there. If we were to level off our concentrations of CO2 today, the planet would continue to warm for the next three or four decades. There's that much warming built into the system already. So you can see why it's urgent to get a handle on it now because it will be to the point eventually where we decide we want to do something that would frankly be too late. This is a real challenge for humanity, not just the politicians. Carbon fuels are the basis of our socio-economic system. So we're going to have to find something else and do it quick. Do we have time? I don't think so, frankly, because I don't think we'll kick our carbon habit as easily as we might hope. But we can at least start to do something about it. So, in the near term – a few decades – I see water as a problem. Energy is a problem because the occurrence of hot days, for instance, will become more common. More air-conditioning, so on and so forth with more electricity needed. How do you satisfy that? Today's answer would be build some more fossil fuel power generating plants, which of course just makes it worse. [That's] sort of dumb thing to do.

On the longer-time scale there are some very scary things out there to think about. One has to do with sea level rise. As the oceans warm, sea levels will rise a little bit. Not a whole lot. The real problem comes when you start melting the glaciers and particularly the big ice sheets like Greenland. Melt Greenland and you raise sea level about 21 feet. That takes out most of the harbors of the world — Los Angeles, New York, and so on, as well as some low-lying countries. Also on the longer-time scales, it's known that there is frozen methane beneath the tundra and in some of the shallow seas. When it gets warm enough, that methane will be released into the atmosphere. And methane's a really bad greenhouse gas. It will give us a spike in the global warming. Some people think that's one of the factors that caused the great Permian Extinction of 250 million years ago. Controversial, but physically it sounds reasonable. So I think the longer we let it go, the scarier it gets. And the less likely and less able we will be to do anything about it.

[The impact of global warming on the fish populations in the ocean may be moot because] we may catch all the fish before it becomes a factor. I'm not sure. At the rate we're going… But in the North Sea, I've been reading where they already see a shift in the population of plankton and small food fishes further north. It's gotten warm there and a lot of the basic productivity is gone north. So I think you'll see major disruptions in the fish populations. Major translocations to start with. And then eventually in the long term some of the populations probably will not make it.