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HEALTHY OCEANS AND HEALTHY ECONOMIES: THE STATE OF OUR OCEANS IN THE 21st CENTURY

OVERSIGHT HEARING

BEFORE THE

SUBCOMMITTEE ON WATER, OCEANS, AND WILDLIFE

OF THE

COMMITTEE ON NATURAL RESOURCES
U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED SIXTEENTH CONGRESS

FIRST SESSION

Thursday, February 7, 2019

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OVERSIGHT HEARING ON HEALTHY OCEANS AND HEALTHY ECONOMIES: THE STATE OF OUR OCEANS IN THE 21st CENTURY

Thursday, February 7, 2019

U.S. House of Representatives

Subcommittee on Water, Oceans, and Wildlife

Committee on Natural Resources

Washington, DC

The Subcommittee met, pursuant to notice, at 3:20 p.m., in room 1324, Longworth House Office Building, Hon. Jared Huffman [Chairman of the Subcommittee] presiding.

Present: Representatives Huffman, Costa, Van Drew, Velázquez, Case, Lowenthal, Levin, Cox, Cunningham, Grijalva (ex officio), McClintock, Lamborn, Graves, and Bishop (ex officio).

Mr. HUFFMAN. Good afternoon, everyone. The Subcommittee on Water, Oceans, and Wildlife will come to order.

The Subcommittee is meeting today to hear testimony on "Healthy Oceans and Healthy Economies: The State of Our Oceans in the 21st Century."

Under Committee Rule 4(f), any oral opening statements at this hearing will be limited to the Chairman, the Ranking Member, the Vice Chair, and the Vice Ranking Member. This allows us to hear from our witnesses sooner and helps keep Members on schedule.

Therefore, I ask unanimous consent that all Members' opening statements be made part of the hearing record if they are submitted to the Clerk by 5 p.m. today or the close of hearing, whichever comes first.

Hearing no objection, it is so ordered.

STATEMENT OF THE HON. JARED HUFFMAN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. HUFFMAN. Good afternoon. I want to take this opportunity to welcome everyone to the Water, Oceans, and Wildlife Subcommittee hearing, our first hearing of the year.

And, yes, the acronym for this Subcommittee is "WOW." I think that is appropriate when you consider the broad jurisdiction we have and the makeup of this Subcommittee, which includes several returning Members and quite a few new Members. I look forward to working with every one of you.

I am excited to chair this Subcommittee because our jurisdiction encompasses so many issues that I care deeply about, many of which I have spent most of my career working on. That includes water supply, protecting habitats and wildlife, managing coastal and marine environments and fisheries, and sportsmen's issues, just to name a few. These are critically important things.

And I am looking forward to working with our new Ranking Member, Mr. McClintock—congratulations, Tom—to find a fresh start at finding common-sense, scientifically-based solutions to the challenges and opportunities we will confront.

I have thought a lot over the past 6 years in Congress about things that I would try to do differently if I ever got a chance to hold one of these. And I know that I am just one person in a big institution that is somewhat ossified, but I want to try some new things here at the WOW in this Congress.

First, as complex and challenging as these resource issues can be, I want to challenge the assumption that our job is simply to fight about them. Frankly, it is one of the things that has frustrated me the most over the past 6 years, not that we have differences—we obviously have differences—but, somewhere along the line, people stopped trying to find consensus on tough issues. They stopped even trying to develop a common understanding of the baseline facts and science before jumping right into the partisan fights. And, for the most part, they even stopped trying to make policy in an open, deliberative, and inclusive way that should follow from that work to develop a common baseline of facts and science.

I know that this place has been hardwired for partisan combat for a long time. We may not always succeed, but I am going to at least try to do all those things as the Chair of this Subcommittee.

And toward that end, I have already begun reaching out to every member of this Subcommittee of both parties. I want to sit down and get to know each other and think about things that we might be able to collaborate on.

I consider myself Chair of the whole Subcommittee, not just Members from my party. And that means that if any Member has a good idea, I want to encourage it. If any Member proposes something I don't support, I am not just going to say "no." I will try to work with you and see if there are creative ways to get to "yes." I would love to see every member of this Subcommittee move at least something forward with bipartisan support. And I hope you will consider my staff and I to be resources if you want to do that kind of work.

Another change I am hoping to implement involves the witnesses we invite to hearings. I have spoken to Ranking Member McClintock about this and directed my staff to take suggestions from all Members, reach across the aisle, so that instead of always having only Democratic and Republican witnesses, we can include at least one joint witness whenever that is possible.

We are going to be busy in this Subcommittee. In addition to resetting the factual and scientific baseline on big issues, we need to bring a lot of new Members up to speed. And that is why we are holding a series of informational and oversight hearings that I informally refer to as WOW 101. Today is the first of these, and we are focusing on the health of our oceans.

By the way, another change I am promising involves the titles of our hearings. I have seen too many hearings with inflammatory titles that read like angry, partisan ransom notes. When the very title of your hearing tees up a partisan fight, it is hard to work together. So, we are going to be a little less inflammatory and substantive and accurate in our hearings for these titles.

Today, we are focused on oceans and coastal communities that depend on them, which is a big deal no matter where you live. If you are part of the 40 percent of the United States living in coastal shoreline counties, you probably already get it. These communities depend on ocean-related industries like fisheries, tourism, and shipping. Businesses and jobs directly dependent on oceans and Great Lakes resources contribute $352 billion to our GDP in this country. They employ over 3 million Americans. But even if you live far from the coast, the health of oceans should matter to you. It affects the air we breathe, it affects the food we eat, and the livability of our climate.

As we will hear today, things are not going so well for our oceans and coastal communities. Major threats include ocean acidification, increased frequency and intensity of storms, vanishing polar ice caps, melting permafrost, pollution, overfishing, sea-level rise, harmful algal blooms. The list goes on.

This hearing isn't specifically to tee up a fight about climate change—I do want to underscore that—but you can't have a serious conversation about the health of our oceans and coastal communities without acknowledging the growing impacts of climate change. And we will hear more about that from experts today.

Of the 23 members on this Subcommittee, well over half represent districts that are at least close to the shore. Those of us representing those type of districts are seeing the impacts already firsthand. But it is important to note that every district in this country benefits from oceans and every district is impacted by their failing health.

[The prepared statement of Mr. Huffman follows:]

PREPARED STATEMENT OF THE HON. JARED HUFFMAN, CHAIR, SUBCOMMITTEE ON WATER, OCEANS, AND WILDLIFE

Good afternoon. First, I would like to take this opportunity to welcome everyone to the first Water, Oceans, and Wildlife Subcommittee hearing this year. We have several returning members and quite a few new members on the Subcommittee. I look forward to working with each one of you.

The jurisdiction of this Subcommittee is broad, and includes managing, developing, and protecting America's water supply, protecting habitats and wildlife, managing coastal and marine environments and fisheries, and sportsmen's issues, to name a few. These issues are critically important, and I welcome the ability of this Subcommittee in this new Congress to identify challenges and work to build common-sense, scientifically-based solutions. That means this Subcommittee is going to be very busy.

While many of these issues are complicated, I'm asking all of you to roll up your sleeves and work together to develop **real** solutions, so that Americans can continue to sustainably use and enjoy our water, oceans, and wildlife for years to come. As Chairman, my goal is to start with the facts and address these challenges head on.

In that vein, the focus of today's hearing is the health of our oceans and the coastal communities that depend on them. More than 40 percent of the U.S. population lives in coastal shoreline counties. These communities depend on ocean-related industries like fisheries, tourism, and shipping. Businesses and jobs directly dependent on ocean and Great Lakes resources contribute $352 billion to the United States Gross Domestic Product annually and employ over 3.1 million Americans. And no matter where you live in this country, we all depend on the ocean for the air we breathe and for regulating our climate. We need to keep our oceans healthy to ensure our economies, communities, and planet stay healthy too.

But, our oceans and coasts are facing an increasing number of threats, including ocean acidification, increased frequency and intensity of storms, vanishing polar ice caps, melting permafrost, pollution, overfishing, sea level rise, harmful algal blooms, shifting water temperatures, coral reef die offs, and massive flooding. These threats are only exacerbated by climate change. Of the 23 members on this Subcommittee,

well over half of us represent coastal districts or districts close to the shore. Those of us representing coastal districts are seeing the impacts firsthand, but it's important to note that every district in the country benefits from America's oceans—and every district is impacted by their failing health.

In my district, commercial and tribal salmon fisheries are suffering due to severe drought and warming waters, dealing a multi-million dollar blow to our salmon fishermen and harming tribal communities, year after year. And because of massive algal blooms caused by warming ocean temperatures, the dungeness crab fishery lost $110 million in revenue during the 2015–2016 season. Although NOAA later declared that season a fishery disaster and Congress has appropriated disaster funds, our fishermen have yet to see a single dollar in Federal assistance because of holdups at the Department of Commerce as well as the impacts of the government shutdown.

Warmer oceans have also led to a quietly escalating crisis in the kelp forests along California's coast. Explosions of purple sea urchin populations, starving abalone, melting sea stars, and barren underwater seascapes where there was once a lush kelp forest—all of this is upending a critical coastal ecosystem and having ripple effects on fisheries, wildlife, and communities along the North Coast.

These are just a few examples of climate change impacts that are happening now, in my district. I don't have time to mention the other ocean impacts, from acidification to sea level rise, but the point is that now is the time to do something. Our constituents deserve action.

It is important to note that while our oceans are at increasing risk from the impacts of climate change, oceans can also be part of the solution. By comprehensively protecting ocean ecosystems, we will also strengthen a key tool to mitigate carbon emissions, naturally protect vulnerable coastlines, and keep fisheries sustainable in the face of a changing environment.

I am looking forward to hearing from an esteemed panel of experts and community leaders on these topics. We have a lot to learn from them. We will be hearing from a former EPA administrator, a leading scientist in her field, a representative from the fishing community, a leader fighting for the public health of her community, and a Chieftess of a historic coastal African-American community that is already facing the effects of climate change.

This Subcommittee is going to hit the ground running. Ocean health is critical for people and the planet, and it's time to prepare and adapt our coasts for the future that has already arrived. I look forward to all the important legislation that will pass through this Subcommittee this Congress, and I'm excited to hear from this incredible panel of witnesses.

Mr. HUFFMAN. So, with that, I want to invite my Ranking Member to say a few remarks, and then we will welcome and introduce the witnesses.

STATEMENT OF THE HON. TOM MCCLINTOCK, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. MCCLINTOCK. Thank you, Mr. Chairman. And we, too, look forward to searching for common ground. In fact, I have a number of proposals I will share in a few moments to explore that search.

Abraham Lincoln told the story of once boarding with the family of a Presbyterian minister on the night of the greatest meteor shower ever recorded in North America. He was awakened by the minister, who shouted, "Arise, Abraham, for the heavens are falling and the day of judgment has arrived." But Lincoln noticed that, despite all the hysteria around him and the chaos above him, he could still see the familiar constellations fixed in the sky, and he knew the world was not about to end.

No one denies that our planet is warming, carbon dioxide levels are increasing, and ocean levels are rising. But before we run screaming into the night, let's also do a quick reality check: the sky isn't falling.

Warming is nothing new. Our planet has been warming on and off since the last Ice Age. There have been periods within both human history and throughout paleo history when scientists tell us temperatures were much warmer than they are today.

Science tells us that carbon dioxide levels have varied widely throughout the planet's history, when they have been many times higher than they are today.

Science tells us that at the end of the last Ice Age ocean levels were 400 feet lower than they are today. And, as we will hear, the current rise has been steady, small, and doesn't correlate to increases in carbon dioxide levels.

Hurricane activity is much lower than that recorded in the 18th century.

And despite what we are told, there is a vigorous debate within the scientific community over how human activity compares with the vastly more powerful natural influencers that have driven dramatic climate change for 4½ billion years.

As Chicken Little belatedly discovered, there is a big difference between an acorn and the sky.

So, we welcome a civil and open debate on these issues. And for that reason, we are pleased to have with us Professor David Legates from the University of Delaware, a pre-eminent climatologist who has served as its Director of the Center for Climatic Research and as Delaware's State Climatologist.

Science thrives on civil and dispassionate debate. When someone tells you the debate is over, that dissent should be forbidden, and dissenters should be personally attacked, that is not a scientist talking; that is a politician.

We also need to consider the enormous cost that the left would impose on each of our families in pursuit of its Green New Deal. We already have a taste of these policies in California, where carbon taxes have produced among the highest electricity and gasoline prices in the United States.

We are also pleased to have on the panel Dr. Kevin Dayaratna to discuss these issues. He is the Senior Statistician for The Heritage Foundation's Center for Data Analysis and holds a Ph.D. in mathematical statistics and two master's degrees, in business and management and mathematical statistics.

This discussion also offers us the opportunity to find common ground. Now, there are many ways to reduce carbon dioxide emissions without destroying the lives of working families and producing the kind of reaction that we now see on the streets of Paris. We have discussed these opportunities at great length over the last 8 years.

For example, if we need to generate power without carbon, doesn't it make sense to build new nuclear power plants and hydroelectric dams that produce electricity with no air emissions at far lower costs and with far smaller footprints than wind and solar?

If temperatures are rising and we can store less winter moisture in the mountains of snow, doesn't it make more sense to build more reservoirs to save that water rather than lose it to the ocean?

If oceans are rising, doesn't it make sense to phase out flood insurance subsidies that encourage people to build in flood plains by hiding their risk?

Last year's wildfires pumped 290 million metric tons of carbon dioxide into the atmosphere, making a mockery of our carbon dioxide restrictions. Doesn't it make sense to harvest excess timber before it can choke off the forest and burn? Doesn't it make sense to manage our forests, to match the tree density to the ability of the land to support it? Doesn't it make sense to space trees so that snow isn't trapped in dense canopies to evaporate before it can reach the ground?

These are desirable policies in their own right, and they serve the Democrats' desire to reduce carbon emissions. I would offer them as a way forward and one that should have bipartisan support.

With that, I yield back.

[The prepared statement of Mr. McClintock follows:]

PREPARED STATEMENT OF THE HON. TOM MCCLINTOCK, RANKING MEMBER, SUBCOMMITTEE ON WATER, OCEANS, AND WILDLIFE

Abraham Lincoln told the story of once boarding with the family of a Presbyterian minister on the night of the greatest meteor shower ever recorded in North America. He was awakened by the minister who shouted, "Arise Abraham, for the heavens are falling and the day of judgment has arrived." But Lincoln noticed that despite the hysteria around him and the chaos above him, that he could still see the familiar constellations fixed in the sky, and he knew the world was not about to end.

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Warming is nothing new: our planet has been warming on and off since the last ice age. There have been periods within both recorded history and throughout paleo history when scientists tell us temperatures were much higher than they are today. Science tells us that carbon dioxide levels have varied widely throughout the planet's history, when they have been many times higher than today. Science tells us that at the end of the last ice age, ocean levels were 400 feet LOWER than they are today, and as we will hear, the current rise has been steady, small, and doesn't correlate to increases in carbon dioxide levels. Hurricane activity is much lower than recorded in the 18th century.

And despite what we are told, there is a vigorous debate within the scientific community over how human activity compares with vastly more powerful natural influencers that have driven climate change for 4½ billion years. As Chicken Little belatedly discovered, there is a big difference between an acorn and the sky.

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These are desirable policies in their own right and they serve the Democrats' desire to reduce carbon emissions. I offer them as a way forward that should have bipartisan support.

Mr. HUFFMAN. Thank you very much.

Let's move on to the witnesses. Let me remind the witnesses that, under our Committee Rules, they should limit their oral statements to 5 minutes, that the entire statement will appear in the hearing record.

When you begin, the lights on the witness table are going to turn green for you. After 4 minutes, there will be a yellow light that comes on. And your time will have expired when the red light comes on, and I will ask you at that point to please complete your statement.

I will also allow the entire panel to testify before we begin questioning the witnesses.

I will now introduce the witnesses, and I would like to—oh, perfect timing. I want to invite my colleague from South Carolina to introduce our first witness, if Congressman Cunningham is ready.

Mr. CUNNINGHAM. Thank you, Mr. Chairman.

It is my pleasure to introduce my constituent, Queen Quet Marquetta Goodwine, Chieftess of the Gullah/Geechee Nation, a culturally distinctive African American group from the low-country region of Georgia and South Carolina. She founded the Gullah/Geechee Sea Island Coalition, the premier advocacy organization for the continuation of her nation's culture.

In 1999, she became the first Gullah to speak before the United Nations. Very impressive. That is where she testified at a hearing of the Commission of Human Rights.

Queen Quet is a published author and environmental justice advocate. And I am honored to call her a constituent of South Carolina's 1st District. Please give a warm welcome.

Mr. HUFFMAN. Queen Quet, welcome to the Committee.

STATEMENT OF QUEEN QUET MARQUETTA L. GOODWINE, CHIEFTESS AND HEAD-OF-STATE OF THE GULLAH/GEECHEE NATION, ST. HELENA ISLAND, SOUTH CAROLINA

Ms. GOODWINE. [Speaking native language.]

So, as I just said to you, thank you so much for having me here today. And I said it to you in my native tongue, which is the Gullah language, so many people who have said, "Well, I never heard that language before" obviously have never been to this land where I am from.

We literally live in the Atlantic Ocean, on islands called the Sea Islands, from Jacksonville, North Carolina, to Jacksonville, Florida. And you will often hear native Gullah/Geechees say, "The water that bring we, the water gonna take we back." And many of you have even sung our songs, the spirituals that are my South Carolina State music now, where we say that "God gonna trouble the water. Wade in the water."

I am very happy to be able to bring this flow from the Sea Islands up the Hill this time so that we can sit together and talk about our love of the oceans. Because, of course, for us, as Gullah/Geechees, the land is our family and the waterways are our bloodline.

So, it is of great concern and grave concern to us when we find that pollutants, poisons, overbuilding, acidification, erosion, and all of these things are now compounding as elements within the water that is changing the ecology of the water.

So, as someone [speaking native language] out the creek. We love to eat seafood, and I am sure all of you who come down where we are would love to eat some too. We have seen those seafoods changing. We have seen less in certain stocks. We have seen where the catfish no longer flow around St. Helena Island.

So, as a founding member of the Gullah/Geechee Fishing Association, these are the things that made us form as a group to make sure that our voice is heard in the national discussions about what can we do to go ahead and have these tides that are rising lift all of our boats together. We make the battle boat. You might have a yacht. But trust me, if that tide is moving and we are all out there, we are going to flow with it or we are going to fight against it.

And I agree with the Chairman, it shouldn't be about the fight. It should be about us being able to sit together, the same way we do on our beautiful Sea Islands beneath those oak trees, even with a little sweet tea—I know up here you all don't put the sugar in until later; we put it in in the beginning—so we can have some sweet discussions about this powerful element that we as human beings are all made of: water.

So, when we talk about healthy oceans and healthy economies, I wanted to make sure that you also realize we have to talk about healthy communities. And as I prepared to come here, 2 weeks ago, all of a sudden the Creator put the words into my mind of an acronym for the ocean. I was to come here to ask you to be a part of opening culturally enriched avenues of navigation, so that when we talk about the ocean and the sea, we are not just talking about the fish, we are not just talking about the shrimp, but we are talking about the cultural communities that live from these fisheries, that have lived in harmony and balance with them for all these generations.

A Gullah/Geechee proverb says: The big fish [speaking native language]. Often we think that the people that are higher up in the hierarchy of government are the big fish and all the rest of us are little. But I always tell people: a school of piranha can definitely fight back together against that big old whale.

So, we know this is a whale of a number of issues, but I am sure we can navigate this together in such a way that those whales will

follow our boat the way our dolphins and porpoises do on a beautiful Sea Island day.

I thank you for the opportunity to be here to engage in dialogue with you and to be a part of something that I know is definitely a "wow," to have all these women here today to say, as mothers of the Earth, that we are here to help nurture our oceans.

Thank you, Honored Chairman, for having me this day right here during Black History Month. Yes, thank you all.

[The prepared statement of Ms. Goodwine follows:]

PREPARED STATEMENT OF QUEEN QUET, CHIEFTESS OF THE GULLAH/GEECHEE NATION

Peace Chairman Huffman and members of the U.S. Congressional Subcommittee on Water, Oceans, and Wildlife!

On behalf of the citizens of the Gullah/Geechee Nation that exist from Jacksonville, NC to Jacksonville, FL and encompasses all of the Sea Islands and 30 miles inland to the St. John's River, I say to you in my native language—Gullah, "Tenki Tenki fa disya." Thank you very much for this opportunity! We greatly appreciate your work on behalf of America's great outdoors which we treasure due to the fact that since the 1600s our people have lived from the land and the sea in the southeast along the Intercoastal Waterway. I personally reside in the Atlantic Ocean on a historic Gullah/Geechee island called "St. Helena."

My families roots not only stem from St. Helena Island, but also Polowana and Dataw Islands. I am a native Gullah/Geechee that grew up on and has dedicated my life to the Sea Islands where my mother, father, grandparents on both sides, and great grandparents on both sides all passed down our cultural traditions. Amongst these traditions are not only agriculture, musical and spiritual practices, but also sea work traditions. We find the latter in jeopardy due to the state of the global environment and this is of great concern to us because there is a Gullah/Geechee proverb that we truly believe in—"De wata bring we and de wata gwine tek we bak." We got here via the water and the water taking us back has numerous spiritual and cultural context for us because our cultural heritage and continued existence is inextricably tied to Sea Island land and the waters that surround and nurture us.

For Gullah/Geechees, water is sacred. It is not only the place to which we are taken to literally learn how to feed our families by harvesting the fish, shrimps, clams, oysters, and crabs that so many visitors come to eat when they vacation in our area by the hundreds of thousands of people per year. It is also the place where we baptize as a spiritual ritual and the place upon whose shorelines we bury those that pass away into the ancestral realm. We gather sweetgrass for our traditional baskets here and used to gather the rush or as we call it "sedge" of the marsh to bring back to higher ground to nourish our fields once again.

Over time, we have felt the pain of the waters as pilings have been driven into the shoreline to proliferate private docks and buildings that then get damaged and brought down into the water when the hurricanes arrive during their season. We have watched the closures of oyster beds, the loss of some fish species in certain areas, the changes in the types and quantities of shrimp all taking place as pollutants ended up in our waterways and flow into the ocean due to overbuilding, changes in the climate, and what our scientists now call the "acidification" of our oceans. We have also stood up to stop this pain and prevent its increase by also opposing seismic gun use and offshore drilling in our oceans.

The Gullah/Geechee Sea Island Coalition, the Gullah/Geechee Fishing Association, and the Gullah/Geechee Sustainability Think Tank have been consistently working together to combat these issues and do what we can to mitigate any further harm to this body which has done so much to nurture and feed us and our family members for generations. We have replanted oyster shells in an effort to increase our viable oyster beds. We educate native Gullah/Geechees on how to keep alive our traditions and pass them on the future generations given that our traditional fishing methods have minimal impacts on the environment. We take what is necessary and not more in order to allow the natural balance to take place so that there will be more sustenance for the next generation. As established in "Da Land da We: Gullah/Geechee Sustainability Report," we believe sustainability is "meeting the needs of the present generation without compromising the ability of future generations to meet their needs."

I work with youths as we look toward methods to combat climate change by looking back to the work that my ancestors and elders did in order to sustain themselves, our culture, and a healthy environment. I reflect on these things whenever I go to the ocean to do environmental work or to simply pay homage to my ancestors, many of whose bones rest at the bottom of the ocean since they did not make it across during the Middle Passage journey that many took to get to North America from Africa. I am rejuvenated by the power and beauty of the waters which I can still see clearly from shorelines around my beloved St. Helena and Hunting Islands in South Carolina. As I stand along the Atlantic shore with the salty Sea Island breeze embracing me, I see an

Organism that feeds into other bodies of water including human bodies.

Climate and

Environment are acclimating to what is ultimately ending up in this water and

Affecting the economy and the continuation of coastal cultural heritage and traditions.

Neutralizing the acidification of the oceans so that these bodies will continue to nurture us physical and spiritually needs to be a national priority.

The flow of the ocean is energizing and the flow of work that it takes for us to get to where we need to be in regard to healing the waters has to be done by

Opening

Culturally

Enriched

Avenues of

Navigation

So, I appreciate the opportunity to not only provide you with my testimony as a person that was raised on an island in the ocean and to provide background on my native Gullah/Geechee culture, but to also work directly with you to open these new avenues of navigation so that we can travel together via open channels of communication and along pristine waters from the oceans to our rivers and streams. As we do so, we will have the opportunity to celebrate the rich cultural heritage and the wonderful environment that we have been able to sustain along the shore together.

I thank you for taking the time to not only hear and read my testimony, but for including it in the record of the work that your Committee is doing on behalf of us, our waters and wildlife. I look forward to hearing more from you and to engaging in work with you.

Mr. HUFFMAN. I think a lot of us want to get down to Mr. Cunningham's district now after hearing your testimony.

Ms. GOODWINE. Come on down. We will fry you some fish.

Mr. HUFFMAN. Our next witness is the Honorable Carol Browner, who previously served as the Administrator of the Environmental Protection Agency from 1993 to 2001, making her the longest-serving EPA Administrator to date.

She served in the Obama administration as the Director of the White House Office of Energy and Climate Change Policy. She also served as the U.S. Representative of the Global Ocean Commission and is currently Senior Counselor at Albright Stoneridge Group.

The Chair now welcomes and recognizes the Honorable Carol Browner.

STATEMENT OF CAROL BROWNER, FORMER ADMINISTRATOR OF THE ENVIRONMENTAL PROTECTION AGENCY, WASHINGTON, DC

Ms. BROWNER. Thank you, Mr. Chairman, and thank you, Ranking Member McClintock.

That was awesome. Thank you.

Ms. GOODWINE. Thank you.

Ms. BROWNER. I really do appreciate the opportunity to appear before you today to discuss climate pollution.

As you heard, I spent 8 years running the Environmental Protection Agency. I have spent the better part of my professional life working to reduce pollution—I am from Florida, the Florida Everglades—to the soot and the smog that plague our cities and cause asthma attacks in our children, to the dangers of toxic chemicals in our communities.

Throughout, I have relied on science to understand the threats, and I have worked with industry to find common-sense, cost-effective solutions to these public health challenges, including agreements for cleaner, more efficient cars; redeveloped brownfields and Superfund sites; and investments in clean sources of energy.

Despite the good work of so many to address the real and vexing pollution problems that threaten all Americans, today we face the greatest pollution challenge ever: climate change.

We are already beginning to see the impacts of climate change. We are living with more powerful hurricanes, worsening drought, melting glaciers, devastating wildfires, and rising sea levels.

And it is not just environmental impacts. Climate change is wreaking economic calamity too. Natural disasters cost the world $155 billion last year. From 2011 to 2017, extreme weather caused $675 billion in economic damages. Hurricane Michael and the destruction of Tyndall Air Force Base will cost the Air Force over $5 billion to rebuild. Damage from Hurricane Florence will cost the Marine Corps roughly $3.7 billion to rebuild Camp Lejeune.

We are not saying that these hurricanes are climate-change-caused, but hurricanes are certainly being made worse by climate change as our seas warm and the temperature of the water changes.

Climate change is also having a measurable negative impact on the lifeblood of our planet, our oceans. Our oceans are in decline. Why should we care about oceans and climate change? Because failing to do so threatens every life on the planet. Oceans cover nearly three-quarters of the Earth's surface. They produce almost half of all the oxygen we breathe and absorb more than a quarter of the carbon dioxide we emit.

As you heard, I served on the Global Oceans Commission. Our final report noted: all life on Earth, including our own survival, depends on healthy, vibrant oceans. Billions of us rely on it for food, transportation, energy, recreation, and livelihoods.

The science shows us that the oceans have the mechanisms and opportunity to heal. That is the good news: that through the regenerative role of the high seas, it is possible to restore the whole ocean health.

The Commission called for a regeneration zone, an area free from industrial fishing in the high seas; tougher offshore oil and gas

safety standards; and closing down illegal, unreported, and unregulated fishing.

Here at home, Congress should maintain marine-protected areas already designated and support efforts to identify additional areas for protection. Through the Antiquities Act and the National Marine Sanctuaries, these areas protect vulnerable ecosystems and benefit sustainable fisheries.

Congress should support more funding for coastal and marine habitat restoration programs. And Congress should encourage monitoring programs that provide essential information to coastal communities and ocean-dependent businesses, including the Federal Ocean Acidification Research and Monitoring Act, the National Estuarine Research Reserves, and the Sea Grant Program.

When it comes to climate change, we have more science than we have ever had on any environmental or economic crisis, more science than was behind any decision made by EPA to protect our air and our water. Waiting will only make it worse.

In my work, I have known some of the best environmental engineers in the country, in the world. There is not a one among them that can actually reverse sea-level rise.

With the new Congress comes a new opportunity to lead and a responsibility to act. The scientists are issuing the warnings; we are running out of time. You could be our greatest hope to reverse the curve of inaction and instead find the solutions that will determine our economic and environmental future.

Now is the time for action that addresses climate change, quickens the inevitable transition to clean energy sources, protects our oceans and environment for future generations.

Again, thank you for the opportunity to be with you today.

[The prepared statement of Ms. Browner follows:]

PREPARED STATEMENT OF CAROL M BROWNER, FORMER ADMINISTRATOR OF THE ENVIRONMENTAL PROTECTION AGENCY

Thank you Mr. Chairman and Ranking Member.

I appreciate the opportunity to appear before you today to discuss climate pollution. I have spent the better part of my professional life working to reduce pollution—from the Florida Everglades to the soot and smog that plague our cities and cause asthma attacks in our children, to the dangers of toxic chemicals in our communities. Throughout, I have relied on science to understand the threats and I have worked with industry to find common-sense cost-effective solutions to these public health challenges, including agreements for cleaner more efficient cars, redeveloped brownfields and superfund sites, and investments in cleaner sources of energy.

Despite the good work of so many to address the real and vexing pollution problems that threaten all Americans, today we face the greatest pollution challenge ever and its impacts—climate change.

Scientists have been warning for decades that climate change was going to have far, wide and expensive economic and health impacts on our communities, our country and our world. While we debated the problem here in the United States, two things happened: First, our international competitors like China outpaced us in innovation that is driving a clean energy economy globally. Second: climate change grew worse and the impacts on our lives grow more real.

Yes, we are already beginning to see the impacts of climate change. We are living with more powerful hurricanes, worsening drought, melting glaciers, devastating wildfires and rising sea levels around the world.

And it is not just environmental impacts—climate change is wreaking economic calamity too.

Natural disasters cost the world $155 billion last year. From 2011–2017 extreme weather caused $675 billion in economic damages.

Forty percent of Americans live in coastal counties. Hurricanes are very expensive. As Senator Jack Reed of Rhode Island noted: Hurricane Michael and the destruction of Tyndall Air Force Base will cost the Air Force over $5 billion to rebuild. Damage from Hurricane Florence will cost the Marine Corps roughly $3.7 billion to rebuild Camp Lejeune. These superstorms may not have been caused by climate change, but the science proves they were made far more intense and more destructive due to the elements of climate change, such as warmer water temperatures.

Climate change is also having a measurable negative impact on the lifeblood of our planet—our oceans. Our oceans are in decline. Habitat destruction, biodiversity loss, overfishing, pollution, climate change are all interconnected and damaging our oceans.

A recent *Science Journal* reported a new study that found that 2018 was the warmest year on record for the global ocean. The U.S. government's own National Climate Assessment demonstrates the major impacts that warming is having and will have on our oceans and marine fisheries.

Why should we care about oceans and climate change? Because failing to do so threatens every life on the planet. Oceans cover nearly three-quarters of the Earth's surface. Oceans produce almost half of all oxygen we breathe and absorb more than a quarter of the carbon dioxide we emit. Again, oceans provide nearly 50 percent of the oxygen we need to breathe. That alone merits action. As we consider the threats to oceans we should also be mindful of the opportunity that oceans present to help address the climate challenge.

I had the opportunity to serve on the Global Ocean Commission—an international group of business and political leaders that worked to raise awareness and promote action to address the degradation of the ocean and help restore it to full health and productivity. As our final report noted: All life on Earth, including our own survival, depends on healthy, vibrant oceans. Billions of us rely on it for food, transportation and energy, recreation and livelihoods.

The ocean is basically the kidney of our plant—keeping systems health and productive.

We must adopt "ocean smart policies."

The science shows that the oceans have the mechanisms and opportunity to heal—that through the regenerative role of the high seas—it is possible to restore whole ocean health. To do so will require a series of actions—some can begin here at home, others will require international cooperation. But all will benefit.

Specific actions called for by the Commission included the creation of a high seas regeneration zone—an area free from industrial fishing; tougher offshore oil and gas safety standards; keeping plastics out of the ocean and closing down illegal, unreported and unregulated fishing.

Science shows that marine reserves like those created through the Antiquities Act and the National Marine Sanctuaries protect vulnerable ecosystems, benefit sustainable fisheries, and provide important buffers. Marine reserves can build greater ecological resilience to climate by maintaining biodiversity and protecting populations for faster recovery after disturbances. Congress should maintain marine protected areas already designated and support efforts to identify additional areas for protection.

Coastal ecosystems—particularly marshes, mangroves and sea grasses—are important tools in the fight against climate change. They serve as carbon sinks and provide protection for coastal communities during severe weather events as well as provide food for coastal communities. Congress should support more funding for coastal and marine habitat restoration programs.

The Coastal Zone Management Act provides a number of avenues through which states and local communities can ensure that access to key coastal areas are protected in the face of rising seas.

Ocean and coastal monitoring programs provide essential information to coastal communities and ocean dependent businesses. Congress should support implementation of the Federal Ocean Acidification Research and Monitoring Act. Congress should also support monitoring of harmful algal blooms. And to ensure that this data and information can be used to develop actions Congress should continue to support programs such as the National Estuarine Research Reserves and the Sea Grant program.

When it comes to climate change we have more science that we have ever had on any environmental and economic crisis. It is time to focus on solutions. Waiting will only make the task that much harder. In my work I have known some of the best environmental engineers but there is not a one among them that can actually reverse sea level rise.

With a new Congress comes a new opportunity to lead and a new opportunity to act. The eyes of the world are on the United States. For the past 2 years, this

country has abdicated is leadership in the global community, especially with regard to solving climate change, the most serious environmental and economic challenge of our time. The scientists are issuing the warnings. We are running out of time. You could be our greatest hope to reverse the curve of inaction and instead find the solutions that will determine our economic and environmental future. Now is the time for action that addresses climate change, quickens the inevitable transition to clean energy sources, and protects our oceans and environment for future generations who deserve to live in a safe and clean world.

Thank you.

Mr. HUFFMAN. Thank you very much.

The Chair now recognizes Ms. Casoni, who has served as the Executive Director of the Massachusetts Lobstermen's Association, the MLA, since 2014 and has worked for the Association since 2008.

The MLA is a member-driven organization that supports the interdependence of species conservation and the members' collective economic interests.

Welcome, Ms. Casoni.

STATEMENT OF BETH CASONI, EXECUTIVE DIRECTOR, MASSACHUSETTS LOBSTERMAN'S ASSOCIATION, SCITUATE, MASSACHUSETTS

Ms. CASONI. Thank you, Mr. Chairman.

I grew up in a village section called Brantrock in Marshfield, Massachusetts, and I have commercial lobstermen in my family. I have been working with the Massachusetts Lobstermen's Association since 2008 and have been the Executive Director for 5 years now. I have extensive experience on committees and boards that involve fishermen. Specifically, I am on the Atlantic Large Whale Take Reduction Team and the Massachusetts Ocean Commission. As the Executive Director, I am actively engaged in the Northeast Regional Ocean Council stakeholder processes, the Massachusetts Coastal Zone Management, and the Bureau of Ocean and Energy Management processes to advocate for commercial fishermen's needs and concerns.

I am here today to give you the perspective of those fishermen and outline how climate change is just one of the many issues we are facing as we try to operate our businesses.

Climate change is of concern to the commercial fishing industry as a whole. Without a healthy ocean, the many species our members harvest to earn a living would cease and many coastal communities would fail. For many coastal communities, commercial fishing has been a way of life for centuries, and impacts to our fishery mean lasting impacts to our communities.

There are two fundamental ways climate change is impacting the lobster industry: warming waters and ocean acidification. Warming-water trends are causing lobster stocks to shift, impacting fishermen and confounding regulators.

The Gulf of Maine, for example, is one of the fastest-warming bodies of water on the planet. In the last century, it has warmed faster than 99 percent of the oceans. It has been estimated that by 2050 that warming could cut lobster population stocks by 62 percent in the Gulf of Maine.

Lobster stocks are also moving further offshore to deeper waters. That makes them more difficult and expensive to reach. This added difficulty means that fishermen have to often travel further offshore, increasing fuel costs that impact our business, as we pursue stocks that were bountiful near shore.

Lobster is also shifting to the north, with more and more of it now in Canadian waters than U.S. waters. This means less lobsters are available for our U.S. fishermen. The lack of access due to this shift is yet another impact to our businesses and coastal communities.

To make matters even more complicated, fish that eat lobster are also moving north. This means more overlap between predators in the once-abundant lobster habitat in Massachusetts. We are seeing a compounded effect, and all of this disrupts the ecosystem and makes it more difficult for our lobstermen to earn a living.

Ocean acidification happens as the ocean absorbs carbon from the atmosphere, adds even more harmful impacts and an increasing threat for our industry. Juvenile lobsters have a harder time growing the shells they need to protect themselves from predators due to ocean acidification.

These threats from climate change are intensified by other challenges lobstermen are facing. We do not have the luxury of looking for any one of these impacts on its own. All of them collectively together are causing declines in the resource, hurting our bottom line and our communities.

Offshore wind is increasing exponentially on the East Coast, impacting habitat and ecosystems. We are concerned about offshore oil and gas development in the Northeast region. An oil spill would be devastating to our resources.

Ocean acidification and other climate changes are magnified by land uses that increase local pollution and runoff, including lawn fertilizers. Our fishermen are also removing bags of trash every day. They remove balloons, bottles, bags, and even fishing gear. And we are committed to helping clean up the ocean through our own marine debris beach cleanups.

In closing, the commercial lobstermen are stewards of the sea. We are the first to see the impacts of the environment and currently are experiencing the impacts of climate change. The concept of climate change is not something abstract to us. Not only are we balancing the challenges created by shifting stocks but also a myriad of other challenges and impacts facing our industry.

Without a healthy ocean, there would be no commercial lobster industry. We no longer have the luxury of ignoring this threat to our livelihoods. We are here today asking for action from Congress to help the thousands of commercial lobstermen and women to mitigate climate change. We are asking that you find effective ways to help commercial lobstermen in the industry adapt to the changes that are already here and the ones that are coming if we do not stop them.

Thank you for your time today.

[The prepared statement of Ms. Casoni follows:]

PREPARED STATEMENT OF BETH CASONI, EXECUTIVE DIRECTOR, MASSACHUSETTS LOBSTERMEN'S ASSOCIATION

I grew up in the village of Brantrock in Marshfield, Massachusetts, with commercial lobstermen in my family and have been working at the Massachusetts Lobstermen's Association (MLA) since 2008. I have been the Executive Director for 5 years now.

I have extensive experience in committees and boards that involve fishermen. Specifically, I am on the Atlantic Large Whale Take Reduction Team, the Massachusetts Ocean Commission, the New England Fisheries Management Council Herring Advisory Panel, and the Atlantic States Marine Fisheries Commission Herring Advisory Panel. As the Executive Director, I am actively engaged in the Northeast Regional Ocean Council stakeholder processes, Massachusetts Coastal Zone Management, the Bureau of Ocean and Energy Management, the Massachusetts Fishermen's Advisory Board for offshore wind development, and the Massachusetts State Ocean Planning processes to advocate for commercial fishermen's needs and concerns. I am here today to give you the perspective of those fishermen's concerns and outline how climate change is just one of many issues we are facing as we try to operate our businesses. Climate change complicates our lives and increases the uncertainty in an already complex ocean.

The Massachusetts Lobstermen's Association is one of the leading, self-funded, commercial fishing organizations in New England and is member-driven, accepting and supporting the interdependence of species conservation and our members' collective economic interests. We were established in 1963 by commercial lobstermen and the 1,800 MLA members hail from ports in Canada down to Maryland, commercially fishing for a multitude of species. We strive to be proactive on the many issues affecting the commercial lobster industry and, as I outlined above, are actively engaged in fisheries management processes at both the state and Federal levels.

The MLA communicates with its members through a monthly newspaper, a weekly e-mail, Facebook, Twitter and attendance at meetings. For the past 56 years, the MLA has become a trustworthy voice for the commercial lobster industry on important issues, and is looked to by both the commercial lobster industry and the management community alike for guidance on the needs and challenges of our industry.

Climate change is of concern to the commercial fishing industry as a whole. Without a healthy ocean, the many species our members harvest to earn a living would cease and many coastal communities would fail. For many coastal communities, commercial fishing has been a way of life for centuries and impacts to our fishery mean lasting impacts in our communities.

There are two fundamental ways climate change is impacting the lobster industry—warming waters and ocean acidification. Warming water trends are causing lobster stocks to shift, impacting fishermen and confounding regulators. The Gulf of Maine, for example, is one of the fastest warming bodies of water on the planet. In the last century, it has warmed faster than 99 percent of the oceans. It has been estimated that by 2050, that warming could cut lobster populations by 62 percent in the Gulf of Maine. Lobster stocks are also moving further offshore to deeper waters that make them more difficult and expensive to reach. This added difficulty means that fishermen have to often travel further offshore, increasing fuel cost that impact our business as we pursue stocks that were bountiful near shore.

Lobster is also shifting to the north with more and more of it now in Canadian waters instead of our U.S. waters. This shift means less lobster are available for our U.S. fishermen. The lack of access due to this shift is yet another impact to our businesses and coastal communities. To make matters even more complicated, fish that eat lobster are also moving north. This means more overlap between predators and once abundant lobster habitat off of Massachusetts. We are seeing a compounding effect, lobster are moving further offshore and loss of access as lobster as they move into Canadian waters, and the increase in those fish that are moving north from warm waters to the south that prey on lobster. All this disrupts the ecosystem and makes it more difficult for our lobstermen to make a living.

Ocean acidification happens as the ocean absorbs carbon from the atmosphere, adds even more harmful impacts and is an increasing threat for our industry. Juvenile lobsters have a harder time growing the shells they need to protect themselves from predators due to ocean acidification and the risk of disease in lobster also increases, compounding the already bad situation that I have outlined here today. It's a lot for our industry to deal with and these challenges will only increase.

These threats from climate change are intensified by the other challenges lobstermen are facing. We do not have the luxury of looking at any one of these

impacts on its own—all of them collectively are causing declines in the resource, hurting our bottom line, and our communities.

Offshore wind is increasing exponentially on the East Coast. While this emerging use has the potential to mitigate climate impacts by creating more access to renewable energy, we must be mindful of selecting areas that do not put undue burden on important habitats for our fisheries. This means selecting turbine and cable areas without eel grass or hard bottoms, because these are important habitats for different life stages of lobster. MLA has engaged extensively in the Northeast Ocean planning process over the years. In doing so, we outline for decision makers the complexities of fisheries and their interactions with proposed projects. Our hope is that as offshore wind proposals advance that state and Federal agencies will engage with fishermen early to drive better decisions moving forward. Fisheries data must be accurate, complete, transparent, and readily available for decision makers, and an important part of this process is talking to lobstermen early to ensure conflicts to our industry can be mitigated.

There is increasing concern about the impact on the future of fishing in offshore wind farms and many fishermen are concerned about navigating around the turbines. Depending on turbine placements, fishermen may not be able to set their gear as they typically do. Therefore, mitigation measures must be taken into consideration.

Additionally, as talks of offshore oil and gas development increase in the Northeast region, we worry about the environmental and economic risks associated with offshore drilling. An oil spill could decimate stocks and local economies reliant on lobster. Yet another concern that we have to balance as we consider future impacts to fishing and local communities.

We are also engaged in the difficult challenge of right whale conservation, but this issue will only become more complicated as offshore wind farms spring up in the feeding grounds of right whales. Climate change impacts on right whales, such as water temperature and food availability, could alter their distribution patterns and eventually call for revised conservation measures. Lobstermen will need to adapt accordingly, especially if different areas become closed off. This is yet another challenge for lobstermen.

It is not simply what is occurring in the ocean that is affecting lobster. Ocean acidification and other climate change impacts are magnified by land use changes that increase local pollution and runoff. Land use changes and the increasing use of lawn fertilizers present challenges for fisheries. For example, lawn fertilizer contributes to polluted and nutrient-rich runoff. Runoff with high nitrogen levels often contributes to harmful algal blooms, resulting in low oxygen areas where lobster and fish struggle to survive and reproduce.

On top of all of our climate change concerns and the obstacles to fishing I've already described, our fishermen are also removing bags of trash every day from balloons, bottles, bags, and even fishing gear. The MLA supports many marine debris clean-up initiatives, as lobster pots are lost due to storms or vessel traffic creating more marine debris. We are committed to help cleaning up the ocean through our own beach and island clean-up initiatives.

In closing, commercial lobstermen are stewards of the sea. We are the first to see impacts to our environment and are currently experiencing the impacts of climate change. The concept of climate change is not something abstract to us. Not only are we balancing the challenges created by shifting stocks, but also the myriad of other challenges and impacts facing our industry. Without a healthy ocean there would be no commercial lobster industry, we no longer have the luxury of ignoring this threat to our livelihoods. We are here today asking for action from Congress to help the thousands of commercial lobstermen and women by mitigating climate change. We ask that you find effective ways to help the commercial lobster industry adapt to the changes that are already here and the ones that are coming if we do not stop them. As you discuss climate change and look for policies to support the communities affected, we ask that you consider that these impacts are one of many facing our industry and consider the multiplying affect that climate change has to the men and women fishing our seas.

Thank you for your time today. I look forward to answering your questions and I hope that you will use me as a resource as you develop funding and mitigation measures to address the climate change and multiplier impacts to our industry.

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Mr. HUFFMAN. Thank you very much.

All of our witnesses have been right on time, so this is very good time management we are seeing.

The Chair next recognizes Ms. Chalk.

Ms. Chalk is a community organizer from the Seventh Ward of New Orleans, where she has participated in the Louisiana Strategic Adaptation for Future Environments, which encourages residents to be actively engaged in any decision-making process that impacts coastal southern Louisiana.

Welcome, Ms. Chalk.

STATEMENT OF ANGELA CHALK, EXECUTIVE DIRECTOR, HEALTHY COMMUNITY SERVICES, NEW ORLEANS, LOUISIANA

Ms. CHALK. Thank you, Mr. Chairman, Honorable Committee members. Thank you for this opportunity to come before this distinguished body.

As the Chairman has said, I am Angela Chalk, Executive Director of Healthy Community Services, a non-profit organization based in the Seventh Ward of New Orleans.

It is my testimony today to discuss our collective connectivity. In my opinion, the most significant waterway in our Nation is the Mississippi River. The testimony I share with each of you today are my personal experiences. While we live in a data-driven, metrics society, you will not hear that from me. My emphasis is personal, tangible, and has dire consequences to real people who call Louisiana home.

As I was preparing for this testimony, I thought of my first encounter with the river. It began with my maternal aunt teaching me how to spell "Mississippi." Later, I would learn of the river's importance. It is the source of our drinking water. The river provided high-paying jobs for African American longshoremen, who received cargo for import and export. But, most importantly, it is the river pilots who navigate these waters daily that provide goods and services for our Nation.

The safety and natural environment are so very vital to our economy that if for any reason river traffic will stop, our economy stops. In essence, I was taught the river was and remains today the source of life. Life is defined by one's culture and heritage, economics and connectivity.

Each day, I welcome thousands of visitors into the home by way of the Mississippi River. We are connected. Surely as the snow that falls in the Midwest, Northeast, and Mid-Atlantic, the snow will melt and find its way via the contributing watersheds that will flow to the Mississippi River.

All of the sediment collected on this journey will settle in the Gulf of Mexico. I invite each of you to experience the point at which the mighty river connects to the Gulf of Mexico. The experience is the freshwater of the river never mixes with the saltwaters of the Gulf. You will clearly see the connectivity, either by sea, air, or by standing on the many barrier islands home to natural rare birds and sanctuaries.

In order to help foster a healthier economy, it is vital to remember that the community organizations engage our residents and educate residents about the effects of climate change, sea-level rise, and restoration efforts. We are our front line of defense to these environmental changes, not because of the theoretical signs but because of generational life expectancies and reality. You can't come to Louisiana to teach me how to make a gumbo if you have never made a gumbo before. But certainly you can listen to the people who are experiencing the things that are current as a result of our environmental changes.

For as climate change is now, we are adapting now. We have been for years. So, as this body makes decisions, remember the people. We are real. Remember that we are already fighting these battles in our backyards, not just for ourselves but for everyone

upstream too. And just as our efforts in Louisiana matters, your decisions matter too.

What you are looking at is "An Island in Crisis," entitled by Ted Jackson. That is the burial place of the ancestors of people who live in southeast Louisiana. That was taken in 2016. We are in 2019, and that area has vanished by the Gulf of Mexico. Sea-level rise is real.

This is the science that helps protect our coastal communities, which is the barrier that surrounds southeast Louisiana and, namely, protects New Orleans from the storm surge of intense hurricanes.

But, together, we must marry the science and the green infrastructure that is in place and the restoration efforts that protect us from storm surge and repetitive flooding and more frequent and more severe storms. We must be proactive rather than reactive.

I thank this Committee for the opportunity to come before you and to have my testimony. Thank you, and God bless you all.

[The prepared statement of Ms. Chalk follows:]

PREPARED STATEMENT OF ANGELA M. CHALK, EXECUTIVE DIRECTOR, HEALTHY COMMUNITY SERVICES

INTRODUCTION

As I begin this written testimony, I wish to state that I am honored and privileged to come before this body of the U.S. House of Representatives. My testimony before the Subcommittee on Water, Oceans, and Wildlife is truthful.

I come before this Subcommittee, proud to represent the people of the Great State of Louisiana and provide testimony to our waterways. I will speak to the effects of land loss; the work being done by community organizations; support and resources as well as current restoration efforts.

My work in the community of engaging vulnerable populations for the past 14 years has been both educational and enlightening. The passion to understand in detail, the consequences, of climate change, sea level rise, urban water management and food insecurity drives my commitment to help be that, change agent of people's behavior. I contend that only through, true, community engagement, education and outreach that residents are better able to understand the environmental factors that causes climate change, sea level rise and the actions that can be taken to adapt to those changes.

In the past year, I've participated with the LA SAFE (LA Strategic Adaptation for Future Environments (1). As a 'table facilitator' to explain the participatory process to residents, it became evident, that while people may not have been able to explain the science of these environmental changes, those changes had been gradually occurring for the past 50 years. Residents of both the rural and urban communities had been living this reality. Residents now had the opportunity to be actively engaged and make decisions about the future of coastal southeast Louisiana. The common thread was the "collective connectiveness" of faith, family, food, culture and heritage. These changes were and remain real. Residents of Louisiana live these environmental changes daily.

Finally, my participation in this process of understanding the effects of climate change is not abstract. I am a fourth generation New Orleanian. I am the beneficiary of the vast natural resources this state offers. Therefore, it is incumbent upon me to help protect and preserve the waterways of Louisiana. This is not solely for my benefit but, for the benefit the residents of 31 states that share the Mississippi River water shed [1] (2),(3).

EFFECTS OF LAND LOSS

Vanishing Communities/Lost of Cultural Norms

The science demonstrates that coastal Louisiana has had significant land lost, in the past 50 years (1). However, the science doesn't demonstrate the value of the

[1] https://www.epa.gov/ms-htf/mississippiatchafalaya-river-basin-marb.

communities that have literally been swallowed by the Gulf of Mexico. As I write this testimony, I know that the residents of Isle de Jean Charles, LA, despite restoration efforts, will have to relocate to higher ground, more inland. The cause sea level rise (4). This is not an isolated event.

St. James Church, originally known as St. Jacques de Cabahanoce Church dates to 1764 and is the "First Acadian Coast." This is the first church of the first Acadian exiles. Cabahanoce is its Indigenous name, meaning "where the wild ducks roost" (5).

The ancestral burial space at St. James Cemetary is completely submerged in the Mississippi River. If one thinks, that is awful, visualize an oil/gas line that is directly above this sacred space (6). Can anyone begin to imagine not being able to visit the final resting place of relatives?

The question then becomes what happens to the history of these communities, their social and spiritual "collective connectiveness" to their homes. How should one prepare to lose their cultural significance and heritage to the effects of land loss?

THE WORK OF COMMUNITY ORGANIZATIONS

Experiences

I have enjoyed many experiences but. I salute the ordinary people doing extraordinary tasks and who advocate for more resilient communities. We each organize around common goals and objectives. We know that time is crucial to the work we've committed ourselves. I consider myself to be in great company:

Name	Organization	Parish
Collette Pichon Battle	Gulf Coast Center for Law & Policy	St. Tammany Parish, LA
Bette Billiot	Houma Nation	Terrebonne Parish, LA
Sharon Foret	Bayou Interfaith Shared Community Organizing	Lafourche Parish, LA
Jonathan Foret	South LA Center for the Arts	Lafourche Parish, LA
Bri Foster	Greater New Orleans Housing Alliance	Orleans Parish, LA
Ivy Mathieu	Community Advocate	St. John the Baptist Parish, LA
Corey Miller	Coalition to Restore Coastal Louisiana	Jefferson Parish, LA
Darilyn Demolle Turner	Zion Travelers Coop Center	Plaquemines Parish, LA
Katrina Williams	Coastal Communities Consulting	Jefferson Parish, LA

In urban communities increased rainfall in shorter amounts of time overwhelms the current drainage capacity of New Orleans. However increased education through community engagement and outreach efforts, have changed the behaviors of residents. For example, Healthy Community Services have provided workshops and trainings for residents to learn how to implement green infrastructure interventions. The projects in the 7th collectively harvest, detain or retain approximately 2,000 gallons of water.

This work would not have tangible results without "collective connectiveness." Our organizations work to be inclusive of all residents regardless of race, gender, ethnicity or social-economic status and to be a voice for vulnerable populations.

Youth Involvement

Again, time is crucial. That is why, it is imperative for our youth to understand the cost to be paid, if this work is left undone. Just as recently as Super Bowl LIII, the youth of coastal Louisiana brought national attention to land loss and the urgency at which a resolution must be achieved (7). Young people spoke out using primetime and social media platforms. #Restore the Coast[2]

[2] http://mississippiriverdelta.org/restore-the-coast-old/?utm_source=twitter&utm_campaign=mrd_none_upd_mrd&utm_medium=social-media&utm_id=1548714284.

SUPPORT AND RESOURCES

Philanthropic Resources

In this testimony, I must acknowledge the many philanthropic organizations, government agencies, public private partnerships that provide the resources and technical support that help community organizations, put forth this work.

Because of this support, I've been able to experience the marshes of southeast Louisiana by boat to see firsthand, the diversion of the Mississippi River which helps to rebuild land; by air, to view the point at which the river meets the Gulf of Mexico or to view the protection levee which helps safeguards the city of New Orleans from storm surge and; by land, to hear the voices of residents that now feel empowered to make informed decisions about the effects of climate change.

RESTORATION EFFORTS

Reclaiming Land/Projects

Hope is defined by Webster as a "desire accompanied by expectation of or belief in fulfillment." Therefore, it is my hope for humanity to understand that there is no amount of money, technology or engineering that can compete with the forces of nature.

As a society, we can however, integrate technology, science and the experiences of local residents to help reduce the effects of climate change, sea level rise. In New Orleans the Bayou Bienvenu wetlands are being revitalized by the planting cypress tree seedlings (8). The cost of a cypress tree seedling is approximately $1.59. "Coastal wetlands can provide critical protection against incoming hurricane storm surges. The traditional rule of thumb: each 2.7 miles of marsh knocks down the storm surge by 1 foot" (9).

To further the restoration of land loss, organizations such as Coalition to Restore Coastal Louisiana are recycling oyster shells to reclaim the land (10). "CRCL's Oyster Shell Recycling Program collects shell from New Orleans-area restaurants and uses that shell to restore oyster reefs that help protect Louisiana's eroding coast line. Launched in June 2014, this is the first program of its kind in Louisiana, and it has collected thousands of tons of oyster shell" (11).

When I speak of "collective connectiveness," each year, "The New Orleans Christmas Tree Recycling Program (12), collects those old Christmas trees and strategically drops bundles of them into the wetlands in Bayou Sauvage National Wildlife Refuge. These trees create wave breaks and trap sediment, producing new marsh habitat that supports growth of native grasses. Over the years, the program has replenished approximately 175 acres of wetlands in Bayou Sauvage." The power of the people in a regain has incrementally created a massive change in coastal restoration efforts.

CONCLUSION

I hope that I've demonstrated to this Committee the value of "collective connectiveness." As each of you move forward with the decision-making process, remember that whether you reside to the west or east of the Mississippi River; Colorado or Pennsylvania, we share the precious space of this waterway, "the Great River." The Mississippi River and its contributaries drains 41 percent of the contiguous United States and 15 percent of North America (3).

In closing, I'd like to thank my family, friends and neighbors, for providing support, love and encouragement on this journey. Most importantly, the people who support me to express my voice, Liz Williams Russell, Rachel Sanderson, Caressa Chester and Klie Kliebert of the Foundation for Louisiana.

Again, thank you for this opportunity to come before this body and speak the truth of this Nation's greatest waterway.

APPENDIX

Sources

1. (LA Coastal Protection Restoration Authority, 2019)
2. (U.S. Department of the Interior, 2018)
3. (Environmental Protection Agency, 2019)
4. (LA Coastal Protection Restoration Authority, 2019)
5. (DeLuca, 2019)
6. (Historic Churches of Acadiana, 2018)
7. (Restore the Delta, 2019)
8. (Global Green New Orleans, 2017)
9. (Jeffrey Masters, 2012)

10. (Coalition to Restore Coastal Louisiana, 2019)
11. (Coalition to Restore Coastal Louisiana, 2019)
12. (Restore the Mississippi River Delta, 2016)

Mr. HUFFMAN. Thank you very much, Ms. Chalk.

The Chair now recognizes Dr. Bronk, the President and CEO of Bigelow Laboratory for Ocean Sciences. She has a Ph.D. in marine, estuarine, and environmental sciences and has more than two decades of experience as a professor and an oceanographer.

Welcome, Dr. Bronk.

STATEMENT OF DEBORAH BRONK, PRESIDENT AND CEO, BIGELOW LABORATORY FOR OCEAN SCIENCES, EAST BOOTHBAY, MAINE

Dr. BRONK. Thank you for the opportunity to talk with you today.

I will start by saying that I love this country, I love the ocean, and I have spent my life in service to both. I am an oceanographer who has spent the last 30 years, but thank you for the 20, studying the growth of microbes at the base of the ocean food web all around the world. I was elected president and chair of two different scientific societies, one that represents over a million scientists in the United States across many different disciplines. I served as director of the Division of Ocean Sciences at the National Science Foundation. And last year, I became the president and CEO of one of the world's most innovative oceanographic institutions, the Bigelow Laboratory for Ocean Sciences in East Boothbay, Maine.

In the spirit of transparency, I will say that I am a middle child, so I am about as middle-ground in terms of politics as you are likely to find. I am not as liberal as many of my scientific colleagues, and I am not nearly as conservative as my much-loved father wished I was.

Like the vast majority of environmental scientists around the world, I have watched data from many disciplines accumulate for years, and there is no doubt in my mind that the Earth's climate is changing and that human beings are responsible.

Every year, humanity releases billions of tons of carbon into our atmosphere, and, as a result, our oceans are warming. Historically, the oceans have absorbed about a quarter of this carbon, and, as a result, they have become more acidic. And both of these changes have far-reaching implications.

Ocean warming leads to a melting sea ice. I have seen the massive changes in ice coverage during the last decade in my own work in the Arctic, based largely out of Barrow, or now called Utqiagvik, Alaska. The reduction in protective sea ice is destroying their coast and changing their traditional way of life.

Ocean warming leads to sea-level rise and coastal flooding. Sea level, as a result of thermal expansion as well as the melting of land ice, like glaciers and ice sheets—since the 1900s, average sea level has risen by about 7 to 8 inches. And this is nothing compared to what we will see if current trends of glacial movement in Greenland continues.

Roughly 40 percent of people in the United States live in coastal areas at risk of flooding, shoreline erosion, enhanced-risk storms. And all will worsen as sea-level rise continues.

Ocean warming leads to changes in the migration and distribution of marine organisms, from the smallest bacteria to the largest fish, because it affects ocean and atmospheric circulation, precipitation, and the delivery of nutrients. The economic consequences of these changes could be severe. In the United States, the fishing sector alone contributes over $200 billion to our economy each year and contributes 1.6 million jobs.

Ocean warming also leads to reductions in ocean oxygen. At the most fundamental level, warm water holds less oxygen than colder water. In coastal regions, low oxygen is a particularly devastating problem. And low- or no-oxygen dead zones have been reported for more than 500 ecosystems.

Then there is ocean acidification. When carbon dioxide in the atmosphere dissolves into seawater, it changes several aspects of ocean chemistry, which threatens many organisms, including those important to fisheries and aquaculture.

Coral reefs are perhaps the hardest hit because they are impacted by both global warming and ocean acidification. In addition to forming the foundation of ecosystems, corals provide storm protection to coastal communities and can form the basis of local or regional economies. By the end of this century, the loss of recreation from coral reefs in the United States is expected to reach $140 billion.

So, here we are. Vast numbers of scientists around the world, people that basically argue over data for a living, have come together to speak with one voice through the IPCC, the National Climate Assessments, and other reports. If this were a medical epidemic and the medical community spoke with this sense of unity and urgency, every single one of us in this room would have taken the treatment prescribed by now.

But I have almost lost hope in our political process on this issue. The economic pressure to keep the status quo is too intense. And I do not believe we, as a country or as a global community, will make the societal changes in time to ward off the extreme climate disruptions—disruptions that will most harm those that are least able to respond to it.

But I believe that in science there is always hope. Climate change is a problem that, ironically, science, through our own success, has created. And I believe it is through science that we will solve it.

But U.S. investment in the study of our ocean and our planet is grossly inadequate considering the challenges we are facing. The U.S. investment in social science is grossly inadequate considering human behavior and economics are so important in charting a sustainable way forward. U.S. investment in science education is grossly inadequate considering the brainpower we will need to power our global recovery. And people in this building can change that.

We need to reduce greenhouse gas emissions and to capture the carbon we have already emitted. And to do this, we need to empower scientists and engineers and to fund innovation, from

discovery all the way to getting it from solutions to the market—a notoriously difficult process to fund. I believe we can do this, but we need to start now because we are out of time.

Thank you.

[The prepared statement of Dr. Bronk follows:]

PREPARED STATEMENT OF DEBORAH A. BRONK, PHD, PRESIDENT AND CEO, BIGELOW LABORATORY FOR OCEAN SCIENCES

MY BACKGROUND

For the last 30 years I have devoted my life to the study of the oceans. For 26 of those years I was a college professor who ran my own laboratory focused on the study of nutrients and how they control the growth of phytoplankton and bacteria at the base of the ocean food web. I have participated in over 50 research expeditions from the Arctic to the Antarctic. Over the last decade, I have also taken what I learned in the ocean, and applied it to help water reclamation facilities.

Throughout my career I have been committed to service—to science and this country. I was a member of the Ocean Carbon and Biogeochemistry Scientific Steering Committee and the U.S. Carbon Cycle Science Plan Working Group, and have served on numerous review committees for tenure and promotion, research funding, and programs, including as chair of the institutional review of the Woods Hole Oceanographic Institution. I was elected member-at-large and then president of the Association for the Sciences of Limnology and Oceanography, the largest international scientific society dedicated to the aquatic sciences. I have also served as member-at-large, treasurer and chair of the Council of Scientific Society Presidents, an organization that represents over a million scientists in the United States across all scientific disciplines. From 2012 to 2015, I served at the National Science Foundation as section head and then director of the Division of Ocean Sciences where I was responsible for programs across all ocean disciplines as well as major oceanographic facilities including NSF use of the U.S. research fleet, ocean observing, and the ocean drilling program. It is an honor to continue that service by providing testimony to this Committee. I offer these thoughts as a citizen based on my experience as a scientist, an educator, and a mother.

I also note that I am a middle child; we tend to be the peacekeepers. I was raised by very conservative parents that I respected and adored and I have spent my life working with many very liberal individuals who are like a second family. This means I have spent my entire life trying to look at both sides of what can be very contentious issues. When it comes to the ocean there are many.

Earth's climate is changing and human activities are responsible. As a scientist, I have been trained to be skeptical, to dig deep and to look for holes in every argument. I admit it took me longer than most of my colleagues to fully acknowledge the truth our changing climate and then only after mounting evidence across many scientific disciplines was irrefutable.

My work has taken me to the world's most remote areas and humanity's fingerprints are everywhere—on land and in the ocean. One need only look at the nighttime composite photos of the Earth from space to see how dramatically we have changed the face of this planet. From this vantage point, that we have altered our climate should come as no surprise.

There is an abundance of scientific literature documenting changes to our climate and oceans and I will not do it justice here. In the time and space allowed I have tried to provide a brief tutorial of the basics that I would want all of our elected officials to know. I direct interested readers to the many excellent summary documents prepared through the National Climate Assessments, the State of the Carbon Cycle Reports, and the many products developed through the Intergovernmental Panel on Climate Change (IPCC).

WHY THE CLIMATE IS CHANGING

Life exists on Earth because the planet has a blanket of atmospheric gases, including water vapor, carbon dioxide, and methane, that acts like the glass of a greenhouse and retains some of the energy from incoming solar radiation. Over the past 100 years, mankind has taken carbon buried deep within the ground as fossil fuels, and burned it to power the incredible technological advances started during the Industrial Revolution. The result raised the standard of living for billions of people around the globe. It also increased the concentration of these greenhouse gases in our atmosphere resulting in an average increase in global temperature from 1901 to 2016 of ~1.0°C (1.8°F; Hayhoe et al. 2018).

This massive alteration of Earth's atmosphere has had a profound impact on our oceans, which have absorbed more than a quarter of the carbon dioxide released. Here I highlight two direct effects this increase in greenhouse gas concentrations have had on our oceans—they are now warmer and the pH of the water has declined, making the ocean more acidic.

A. Ocean Warming

Every year, humans release about 10 gigatons (36 billion tons) of carbon into the atmosphere from burning fossil fuels and other activities (Le Quéré et al. 2018). In 2016, atmospheric levels of carbon dioxide passed 400 ppm, a striking milestone and a dramatic increase from pre-Industrial levels of 280 ppm. This huge surge in the levels of carbon and other greenhouse gases blanketing the atmosphere traps excess heat in the Earth's climate system.

The oceans have absorbed 93 percent of this excess heat and store it for two main reasons. First, water has the highest specific heat capacity of any common material, meaning that it can absorb a great deal of heat before its temperature actually increases. Second, the global ocean is vast, covering 71 percent of the Earth's surface with an average depth of 4 kilometers (12,123 feet). This incredible volume makes it a huge reservoir for heat that is continuously distributed by currents and other circulation processes.

The highest degree of warming has taken place in the upper 75 meters (246 feet), as this upper layer lies closest to the warming atmosphere. Average global temperatures in the surface ocean have increased by 0.7 ± 0.08°C (1.3° ± 0.1°F) per century between 1900 and 2016 (Jewett and Romanou 2017). The upper ocean also mixes vigorously, distributing the heat it absorbs. As more energy enters Earth's climate system, heat penetrates deeper into the ocean. Warming at the poles is especially impactful because these are the sites of deep ocean water formation. The combination of ice formation and extreme cold makes the waters in the North Atlantic dense relative to surrounding waters. These dense waters sink carrying heat to the ocean's interior.

Most of the remaining 7 percent of this heat goes into melting sea ice, glaciers, ice caps, and warming the continent's land mass. Only a tiny fraction goes into warming the atmosphere, but even that is felt in rising global temperatures. The six warmest years on record have all occurred since 2010 (NOAA State of the Climate Report 2019). While there is much debate over the record of increasing air temperatures, the ocean does not have parking lots or heat island effects and yet still we see significant increases in temperature.

The complex interactions between continued greenhouse gas emissions, the resulting energy imbalance, and changes in ocean heat storage and transport will largely control the impacts of anthropogenic climate change. I focus on five critical impacts here—melting of sea ice, sea level rise and coastal flooding, changes in the distribution and migration of marine organisms, the decline of coral reefs and deoxygenation of the ocean.

1. Melting of Sea Ice

The Arctic Ocean is important to the world's ecology, climate, and economy. Due to the shape of the planet, more incoming solar radiation concentrates at the equator than at the poles. The atmosphere and ocean currents address this energy imbalance by transporting heat away from the equator. This process has driven annual average temperatures in the Arctic to increase more than twice as fast as the global average, resulting in substantial loss of sea ice and glacial mass. Climate models using the IPCC "business as usual" scenario predict average Arctic temperatures will increase 7°C (45°F) by the year 2100.

Since 1979,the annual average extent of Arctic sea ice has decreased 3.5 to 4.1 percent per decade, including an 80 percent loss in summer sea ice volume (Comiso and Hall 2014; Vaughan et al. 2013). The melting of sea ice now starts 15 days earlier than it did in the past, and it is predicted that the Arctic will be nearly free of late-summer sea ice by the middle of this century (Taylor et al. 2017). Diminishing sea ice also further amplifies Arctic warming, because blue water will absorb more energy than white ice, thus creating a positive feedback loop between warming and continued ice loss.

The lack of summer Arctic sea ice is increasing seaside erosion, undercutting villages, and washing away infrastructure. Alaskans are being forced to change their hunting strategies and even the locations of whole communities. From 2010 to 2017, I made seven trips to Barrow, Alaska, the northern most village in the United States. In that short time, the changes to the region and community have been profound including the impending destruction of the main road from Barrow to Point Barrow due to erosion from the sea.

The effect of sea ice loss is profound because it is a key part of polar ecosystems. Large blooms of algae occur at the ice edge and form the base of the Arctic Ocean food web (Arrigo 2014). As ice coverage declines, the timing and location of the ice edge blooms change, as does critical habitat for more than a thousand species, including polar bears, seabirds, and seals. Many organisms hunt, give birth, migrate and shelter on ice, and the loss of ice is causing declines in a number of species (Laidre et al. 2015). As one example, walruses are moving farther from shore as the sea ice extent shrinks, and hunters from native Arctic communities that rely on them must now travel further across open water, threatening both people's safety and traditional ways of life.

Shrinking ice cover is also making the Arctic more accessible to shipping, with access by various countries and commercial entities. This brings both new opportunities and risks. The challenges that accompany greater access include protecting the border from new threats to national security, a heightened threat of oil spills and illegal fishing, and the need to update severely outdated nautical charts and put search and rescue plans in place.

2. Sea Level Rise and Coastal Flooding

Sea level is rising as a result of warming ocean temperatures and the melting of ice on land, such as glaciers and ice sheets. Warming water temperatures contribute to sea level rise because of thermal expansion—warm water takes up more volume than cooler water. Since 1900, average sea level has risen by about 16 to 21 cm (7 to 8 inches) globally with about a third of the increase due to thermal expansion. Even more alarming than the amount is that nearly half of this increase has occurred since 1993. Sea level continues to rise at a rate of about one-eighth of an inch per year (Hayhoe et al. 2018).

The ultimate magnitude of sea level rise will vary based on how land ice responds to continued warming. Predictions for the century between 2000 and 2100 vary from 1 to 4 feet of sea level increase, with extreme increases of over 8 feet if the Antarctic ice sheets collapse. If the ice sheet on Greenland were to melt, sea level could increase by an incredible 21 feet. These scenarios are unlikely, but I note that past increases have been larger and occurred more rapidly than expected. As a Nation, we need to prepare for the worst.

There will be many consequences of higher sea levels. Destructive and deadly storm surges will reach farther inland, bringing more frequent flooding with high tides. These floods are disruptive and expensive. Today, nuisance flooding is estimated to be from 300 percent to 900 percent more frequent within U.S. coastal communities than 50 years ago (Sweet et al. 2014).

As ocean and atmospheric warming trends persist, sea level rise over the next centuries will ramp up to rates significantly higher than what we see today. Nearly 40 percent of people in the United States live in high-population-density coastal areas, where they will be subject to the flooding, shoreline erosion, and hazardous storms that come with rising sea levels. These impacts will also be felt globally—8 of the 10 largest cities in the world are near a coast as are 4 of the 10 largest cities in the United States.

Specific locations will experience sea level rise differently based on local factors, such as subsidence and rebounding from natural geological processes, changes in regional ocean currents, and withdrawal of groundwater and fossil fuels. Sea level rise has already increased the frequency of flooding at high tide by a factor of 5 to 10 since the 1960s for several U.S. coastal communities. The frequency and extent of tidal flooding are expected to continue to increase in the future and it's anticipated that there will be more severe flooding associated with coastal storms, hurricanes and nor'easters (Sweet et al. 2014). The infrastructure essential for local and regional industries in urban environments will be threatened, including roads, bridges, oil and gas wells, and power plants.

3. Changes in the Migration and Distribution of Marine Organisms

Increases in water temperatures and its associated effects have caused alterations to global patterns of ocean and atmospheric circulation, precipitation, and nutrients. Collectively, these effects are having a drastic impact on the abundance, diversity, and distribution of marine organisms—from the smallest bacteria to the largest fish.

Most of the life in the ocean is microscopic. While we cannot see these microorganisms without a microscopic, they produce half of the oxygen we breathe and form the base of ocean food webs. As most are single-celled organisms that can only drift in the water column, these vital plankton are highly vulnerable to ocean changes.

Broadly speaking, the ocean has two parts—a warmer, less dense layer at the surface that receives sunlight but has low nutrients (because the microorganisms have taken them all up) and a deep layer that is denser and colder, with no light but

lots of nutrients (because decomposing organisms sink and release nutrients as they decompose). Rapid warming of surface water is increasing the temperature difference between these layers, increasing the stratification of the ocean and preventing the surface and deep water from mixing efficiently. As a result, most phytoplankton have a harder time staying near the sunlight that they need to grow, and the greater stratification restricts the delivery of nutrients phytoplankton need from the deep ocean.

These changes to the base of the ocean food web reverberate through other marine species including the fishing sector, which contributes over $200 billion in economic activity each year and supports 1.6 million jobs (NOAA Fisheries 2017). The species this industry relies upon are changing as a result of warming waters. These shifts in species distributions are complicating fishery management by changing the nature of traditional fisheries and efforts to protect endangered species.

These shifts are especially prominent of the U.S. East Coast. For example, surveys conducted by state and Federal agencies have documented a number of shifts in distribution in fish, shellfish and other species along the mid-Atlantic with a trend toward poleward movement and/or movement to deeper cooler water (Lucey and Nye 2010). Recent research at Bigelow Laboratory shows that copepods (tiny crustacean that eat phytoplankton and are then eaten by higher organisms) are less viable if grown in warmer waters. Shrinking copepod populations will threaten numerous marine species that rely on them for nutrition, including the endangered North Atlantic right whale. As another example, surf clams, an important fishery in the mid-Atlantic region, have migrated to deeper waters at the southern edge of their range, causing regulatory issues for this industry (Weinberg 2005).

I have provided a few examples of shifts in the distribution of organisms but I note that detecting and quantifying these changes are a challenge because each species within a community may response differently due to differences in their life history, where they live, and what they eat.

Organisms also vary with respect to the outside forces that affect them such as fishing, destruction of their habitat or pollution. Due to this complexity, detecting and understanding shifts in species and populations requires a commitment to long-term monitoring programs, which have historically been very difficult to maintain.

4. Coral Reef Decline

Coral reefs are the foundations of many tropical ecosystems. Temperature is a powerful controlling variable for the health and location of coral reefs, and many exist at or near their upper temperature limit (Schoepf et al. 2015). As a result, ocean warming has had a devastating effect on coral reefs around the world. When corals are exposed to waters even slightly above their temperature maximum, they can release the symbiotic algae, called zooxanthellae, that live within their tissues. This process is known as bleaching because of the stark white color it turns corals. The symbiotic algae provide vital nutrients to the coral, and so bleaching often kills them.

During the last 30 years, there have been several global-scale coral bleaching events (in 1987, 1998, 2005, and 2015–2016) that have resulted in a dramatic reduction of live coral. This puts the entire community of plants and animals that rely on the reefs in jeopardy. In the United States, mass bleaching events and outbreaks of coral diseases have occurred in the waters off Florida, Hawaii, Puerto Rico, the U.S. Virgin Islands, and the U.S.-Affiliated Pacific Islands (Miller et al. 2009; Rogers and Muller 2012).

In addition to the direct physiological stress of elevated temperatures, ocean warming also increases the incidence of coral disease, and ocean acidification affects the ability of corals to produce their calcium carbonate structures (discussed further in Section B below). When these effects compromise reef-building corals, the entire reef ecosystem becomes threatened (Jones et al. 2004). This includes a vast number of invertebrates and fish, organisms that many coastal communities depend on for subsistence. Corals also provide storm protection to coastal ecosystems and can form the basis of local or regional tourism economies (Pratchett et al. 2008).

5. Low Oxygen

Oxygen makes up 21 percent of the air we breathe and supports life on Earth, and half of this oxygen was produced by phytoplankton in the ocean. In water, oxygen exists in a dissolved form and acts as a limiting resource that controls the growth of many marine species. One consequence of climate change is the loss of oxygen from the oceans, known as ocean deoxygenation.

Levels of oxygen in the ocean depend on a balance between oxygen production through phytoplankton photosynthesis, depletion through respiration by animals, and physical mixing processes. Climate change is shifting this balance in several

ways. At the most fundamental level, warmer water holds less oxygen than cold. As the oceans warm, they lose their ability to physically hold oxygen.

In addition, the surface ocean is warming fastest due to its proximity to the atmosphere. This makes the surface water less dense and less able to mix with the colder, denser water below, limiting the distribution of oxygen. At the same time, global ocean circulation patterns are shifting with climate change. Slower circulation and more upwelling of oxygen-poor deep water are further decreasing oxygen levels in the ocean.

Long-term monitoring efforts reveal that oxygen concentrations have declined during the 20th century, and the IPCC 5th Assessment Report predicts that they will decrease 3–6 percent during the 21st century due to ocean surface warming. In coastal regions, low oxygen is a particularly devastating problem and dead zones where most organisms cannot live because of insufficient oxygen have been reported for more than 479 systems and their numbers have doubled every decade since the 1960s (Diaz and Rosenberg 2008).

This decline will be particularly impactful in hypoxic and suboxic areas of the ocean where oxygen is already in low concentrations. In hypoxic areas, oxygen is so low that it is detrimental to most organisms. In suboxic areas, oxygen levels are so low that most life cannot be sustained and water chemistry is severely altered. Oxygen minimum zones are severely oxygen-depleted waters that underlie productive surface waters and comprise 8 percent of the global ocean (Paulmier and Ruiz-Pino 2009). These zones are expanding through the globe's tropical ocean basins and the subarctic Pacific Ocean, compressing the habitat available to marine species around the globe. A mere 1°C warming in the upper ocean, less than predicted by even optimistic warming scenarios, will increase hypoxic areas by 10 percent and triple suboxic areas (Deutsch et al. 2011).

Changes to biological processes are also contributing to this issue. Warmer water temperatures increase oxygen demand from organisms, leading to the faster depletion of available oxygen and threats to a vast range of species, including those that comprise valuable fisheries. For example, off the coast of California, waters between 200 and 300 meters have lost 20–30 percent of their oxygen in the last 25 years (Bograd et al. 2008), threatening important fisheries. In the tropical Atlantic Ocean, the vertical habitat of tuna and blue marlin reduced by 15 percent between 1960 and 2010 due to expanding oxygen minimum zones (Stramma et al. 2012; Schmidtko et al. 2017).

B. Ocean Acidification

In addition to warming, excess carbon dioxide in the atmosphere has a direct and independent effect on the chemistry of the ocean. Ocean acidification is the process of carbon dioxide being absorbed by the oceans and causing significant changes to seawater chemistry. Global chemical processes keep gasses in the ocean and the atmosphere in equilibrium. While humans have drastically increased the amount of carbon dioxide in the atmosphere, the ocean has been working to keep up. About a quarter of the carbon dioxide we generate through industrial activity ends up in the ocean, and the resulting change in chemistry has caused the surface ocean to become 30 percent more acidic. This has occurred at a rate at least 10 times faster than any natural acidification event in the past, and affects everything from chemical processes to sea life.

When carbon dioxide in the atmosphere dissolves in seawater, it changes three aspects of ocean chemistry. First, it increases levels of dissolved carbon dioxide and bicarbonate ions, which are the fuel for photosynthesis in phytoplankton and plants. Second, it increases the concentration of free hydrogen ions, which makes the water more acidic. Third, it reduces the concentration of carbonate ions. Carbonate is critical to many marine organisms, which use the mineral calcium carbonate to form their shells or skeletons. For some species, rising temperatures and decreasing oxygen levels in the ocean may exacerbate the effects of ocean acidification.

The cold temperature of high latitude ecosystems results in great carbon dioxide solubility making polar regions highly vulnerable to ocean acidification. Sea ice loss is causing Arctic waters to acidify faster than expected. Further, acidification along the U.S. coast is greater than the global average for a number of reasons, including the natural upwelling of acidic waters off the Pacific Northwest and California coasts, changes to freshwater inputs in the Gulf of Maine, and anthropogenic nutrient input into urban estuaries. Here I'll focus on two major consequences of ocean acidification—changes to the ocean carbon cycle and the impact on organisms and the industries built around them including fisheries and aquaculture.

1. Changes to the Ocean Carbon Cycle

Carbon is recycled and reused through biological and physical ocean processes including photosynthesis, respiration by animals, and mixing. The carbon cycle drives important biogeochemical processes that shape the character of the global ocean and planet as a whole. When organisms die, they sink, bringing the carbon that composes their bodies into the deep ocean. This is referred to as the biological pump because it pumps carbon from the surface to the deep ocean and can sequester carbon away for hundreds of years. The oceans are by far the largest carbon sink, or storage reservoir, in the world.

The combined effect of ocean warming and acidification lowers the ability of the ocean to take up additional carbon dioxide in three general ways. First, as noted above, warmer water can simply hold less gas than colder water. Second, the warmer water in the surface ocean becomes, the more stratified the water column will be. Greater stratification reduces mixing and so reduces the ability for carbon dioxide dissolved in surface water to be mixed into deeper waters. Third, it is generally harder for organisms to build shells out of calcium carbonate in more acidic waters. This means that phytoplankton that build shells (such as coccolithophores), and are therefore heavier and so sink faster, are at a disadvantage. As the ocean continues to acidify, any selection away from organisms that build shells and toward organisms that do not, will likely weaken the biological pump and decrease the transport of carbon into the deep ocean as phytoplankton die. These effects are already being seen and the oceans are becoming less able to absorb carbon dioxide (e.g. Khatiwala et al. 2016).

2. Threats to Organisms, including Fisheries and Aquaculture

The impacts of ocean acidification are diverse. Although certain species are favored by more acidic waters, ocean acidification appears to negatively impact more marine species than it helps. Organisms that use carbonate minerals to build skeletons or shells struggle with this basic function in more acidic waters. Organisms like clams, mussels, and phytoplankton that use calcium carbonate to build shells and other structures are important in environments and economies around the globe. Under the IPCC low emissions scenario, 7 to 12 percent of calcifying species would be significantly affected by lowering pH, and 21 to 32 percent of calcifying species would be impacted under the high emissions scenario (Azevedo et al. 2015).

Ocean acidification also appears to favor some toxic phytoplankton species that form harmful algal blooms, allowing them to become more abundant in changing ecosystems. Including freshwater and marine ecosystems, harmful algal blooms are a significant environmental problem in all 50 states (EPA).

Entire coral reef ecosystems are also severely threatened by ocean acidification. Corals depend on calcium carbonate to build their exoskeletons, and acidification impedes this process. The acidic water also literally dissolves coral structures, and the bulk of a coral reef itself. Many reefs around the world are dissolving faster than they can build themselves back up. In addition to forming the foundations of ecosystems, corals also provide storm protection to coastal ecosystems and can form the basis of local or regional tourism economies. By the end of this century, the loss in recreation from coral reefs in the United States is expected to reach $140 billion (Pershing et al. 2018).

Some of the animals at risk from acidification also comprise lucrative fisheries in the United States, like lobsters in the Northeast and squid in California. These animals are physically compromised by acidification, and they may find it harder to get the food they need in acidifying oceans. Acidification impairs the senses of some fish and invertebrates, causing them to misinterpret cues from predators and engage in risky behaviors, like swimming far from home. Damage to key phytoplankton and zooplankton species can reverberate through entire food webs, affecting the fisheries that they support.

The U.S. aquaculture industry is already shifting in response to ocean acidification. Larval shellfish cannot build shells under high acidity, and high mortality rates have afflicted the Pacific Northwest's $270 million shellfish industry since 2005. The poor conditions have prompted some shellfish aquaculture facilities to relocate. In Maine, some shellfish farmers are also growing kelp in an effort to improve local water quality and the health of their stocks.

CONCLUDING THOUGHTS

Climate change is bringing societal disruption on a global scale. As with any disruption, there will be winners and losers. Our challenge as a nation moving forward is to reduce the risks of climate change while capitalizing on its benefits, and I believe there will be plenty of both. The nation who will own the future will be the

one that *invests* in the science of climate change so that decisions are based on sound data, that educates its citizen on ways to *mitigate* its effects, and that *adapts* to the new reality we all face. Here I will focus on the investments needed in the science.

The ultimate cause of climate change is the burning of fossil fuels and the resulting release of greenhouse gases. There has been much talk about reducing greenhouse gas emissions and as a nation we need to make this a priority. At Bigelow we occupy a Platinum LEED certified laboratory building that is cost effective to run and have a residence powered by a solar array. Supporting programs to advance the science and reduce the cost of green technology is critical to our country's future. I believe it is too late, however, to rely solely on this approach to mitigate severe climate disruption. The carbon ship has left the dock and humanity has shown little commitment to taking it back into port.

There is no doubt in my mind that to limit the effects of climate change, humanity will geoengineer the planet. This could take many forms including seeding the atmosphere with reflective particles, ocean fertilization, or large-scale industrial carbon sequestration. I do not advocate for this approach but fear that we will quickly reach a point where it will seem inevitable. When that time comes, and I fear it will come soon, we need the scientific data to maximize the chance of success and limit the many risk. We will also need an international regulatory and ethical framework to protect the humanity it seeks to serve.

With respect to the science, we need to dramatically increase our investments in understanding our own planet if we are to succeed. The National Science Foundation (NSF) is the Federal agency that supports basic research across all science and engineering disciplines. I believe NSF is our secret sauce and the reason the United States has been a leader in science and technology on this planet. This foundational research supports the many other mission agencies that address ocean issues, the National Oceanographic and Atmospheric Administration and National Aeronautics and Space Administration being two of the most important. As director of the Division of Ocean Science at NSF, I managed a budget of $356M and was responsible for basic research across all scientific disciplines. This is a lot of money until one considers that it is only about a dollar per person in this country. Considering the importance of understanding how the ocean works and the rapid changes we see in the world, it is not nearly enough. This country must increase its investments in basic and applied research at the Federal, state, and local level if it is to efficiently understand and mitigate the problems we are facing and it needs to do it now.

Climate change is a global issue and its root causes will only be addressed through international cooperation. Just as it took an international effort to synthesize and build scientific consensus around climate change through the IPCC, so will it take an international effort to regulate and control geoengineering with all of its many risks. Any regulations will need to be built on a foundation of an ethical framework. As the recent birth of two babies born with edited genomes has shown, there are real dangers when scientific capabilities get ahead of established standards for its ethical use.

In conclusion, despite the doom and gloom of the proceeding pages, I am optimistic about our future. We live in a time of rapid scientific advancement where each of us is able to access much of the collective knowledge of humanity on our cell phone. That so many scientists around the world, a group of people trained to be skeptical, hypercritical, and, dare I say, argumentative, have found a way to reach consensus and to speak with one voice on climate change is another reason to hope. Through my work at the Bigelow Laboratory for Ocean Sciences, I interact daily with brilliant scientists that are thinking outside of the box, students committed to changing the world, people of wealth who are stepping in to support innovation, and my fellow citizens who care enough to show up for talks, beach cleanups, and recycling events. The will is there and we will find the solutions we need but the time to act is now. As I have said many times—I believe in science, I believe in this country and I believe in good old-fashioned American ingenuity.

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Mr. HUFFMAN. Thank you, Dr. Bronk.

Next, we recognize Dr. Legates, a Professor of Climatology at the Department of Geography at the University of Delaware.

Welcome, Dr. Legates.

STATEMENT OF DAVID R. LEGATES, PROFESSOR OF CLIMATOLOGY, UNIVERSITY OF DELAWARE, NEWARK, DELAWARE

Dr. LEGATES. Thank you, Chairman Huffman.

Coasts are naturally hazardous areas due to the impact of rising seas, coastal storms, shifting barrier islands, and flooding caused by rainfall draining into low-lying areas.

Globally, sea level has naturally risen at a rate of about 8 inches per century for at least several hundred years. This rate may be higher in some places due to local land subsidence caused by glacial isostasy, such as along the Mid-Atlantic region, and/or sediment compaction through river channelization, such as in southern Louisiana. Shifting sands on barrier islands through strong storms change the local landscape and can affect life along the coast.

The question we wish to answer is whether anthropogenic increases in greenhouse gas concentrations exacerbate these coastal impacts.

The data I present in my written testimony, sea-level rise has been consistently linear at nearly all stations for which more than 70 years of data are available. As greenhouse gas concentrations have increased—about 45 percent from before the Industrial Age—the lack of a significant change in the rate of increase implies that sea levels are not significantly affected by changes in carbon dioxide.

Moreover, extreme climate events are becoming neither more intense nor more frequent. When Hurricane Harvey made landfall near Houston in 2017, it ended a record of nearly 12 years without a major hurricane landfall in the United States. Tools that chart the frequency and intensity of tropical cyclones, such as their number and the energy associated with them, show a cyclical pattern to hurricane activity but no long-term trend over the last 50 years.

In the United States, 14 Category 4 or 5 hurricanes made landfall in the 44-year period between 1926 and 1969, but only 4 have occurred in the 49 years since. Historically, hurricane landfalls are

more frequent during colder periods and become less frequent as the temperature rises.

Consequently, we can agree with the IPCC that low confidence exists in the attribution of changes in tropical cyclone activity to human influence owing to insufficient observational evidence, a lack of physical understanding of the links between anthropogenic drivers of climate and tropical cyclone activity, and the low level of agreement between studies as to the relative importance of internal variability, anthropogenic, and natural forcing.

Seawater is naturally alkaline, but the addition of dissolved carbon dioxide leads to acidification or a lowered pH, so the addition of carbonic acid. Rather than causing the dissolution of calcium-carbonate-based shells of various animals in the oceans, many species such as lobsters and blue crabs actually will thrive on the additional carbonate and bicarbonate ions and a slightly lowered pH content. Studies which have attempted to demonstrate that calcium-carbonate-based shells dissolve in lower-pH conditions often use hydrochloric acid rather than carbonic acid, which has a considerably different chemistry and a deadlier impact.

My main concern here today is that we are focusing on an expensive solution that will have virtually no impact on the Earth's climate. Climate has always changed, and weather is always variable due to complex, powerful natural forces. No efforts to stabilize the climate can possibly be successful.

Current climate observations indicate that the events which kill or injure the most people and have the biggest economic impact are not affected significantly by changing greenhouse gas concentrations. Insistence that these events must be caused or exacerbated by human activity reflects a denial of basic climate science. Decades of failed forecasts of climate doom underscore the problem.

The current emphasis on climate change abatement will do far more harm than good. So-called clean energy sources, wind and solar, require environmentally degrading strip-mining practices to extract rare-earth elements from the ground. Wind turbines, hybrid cars, and solar panels require large quantities of these rare metals. Mine workers are exposed to highly toxic and dangerous working conditions, usually for low pay and often with child-labor exploitation. Water from the mines contaminates soil and groundwater and the required process of strip-mining involves significant environmental degradation. These clean energy sources are anything but clean.

The long-term impact of eschewing fossil fuels will unintentionally make energy expensive. Anything that uses energy will therefore cost more. Transportation costs will skyrocket, making it expensive to travel to work and to transport goods to market. Heating and cooling costs will become so expensive that many will have to choose between food or heat. Energy is necessary to produce almost everything we have. To make energy expensive is to make living difficult for all but the richest citizens.

We certainly wish to be good stewards of our environment, and we should strive for energy conservation and to search out alternative forms of inexpensive energy. But the notion that we should fast-transition from fossils fuels to so-called clean energy to protect us from climate change and to save the planet is a recipe for

personal and economic disaster that will have virtually no impact on the Earth's climate.

I urge you to investigate the true science behind climate change and not be influenced by climate exaggerations, so you can better understand the role inexpensive energy can have in lifting the poorest among us.

Thank you.

[The prepared statement of Dr. Legates follows:]

PREPARED STATEMENT OF DAVID R. LEGATES, UNIVERSITY OF DELAWARE

I am David R. Legates, professor and climatologist, at the University of Delaware. I also hold a joint appointment in the Department of Applied Economics and Statistics as well as in the Physical Ocean Science and Engineering program. I served as the Delaware State Climatologist from 2005 to 2011 and was a founder of the Delaware Environmental Observing System, a statewide network for environmental monitoring and analysis. I was part of the U.S. delegation that negotiated a protocol for the first climate data exchange program with the Soviet Union in 1990. I am recognized as a Certified Consulting Meteorologist by the American Meteorological Society and was the recipient of the 2002 Boeing Autometric Award in Image Analysis and Interpretation by the American Society of Photogrammetry and Remote Sensing. I would like to thank both the Chairman and the Committee for the opportunity to provide my perspective of 40 years of experience on climate change and coastal communities.

It is a privilege for me to offer my views on the science involving sea level rise and coastal impacts due to weather and climate variability. I might best be described as a statistical hydroclimatologist—someone who researches the interactions between water and climate from an observational setting. I have investigated biases in our evaluation of precipitation owing to errors in precipitation gage measurement and how they influence satellite and radar estimates. I also have been involved with the analysis of hydrological data to assess the impact of climate variability and change.

INTRODUCTION

Living along the coasts and in low-lying areas can be hazardous. Coastal storms, such as hurricanes, tropical storms, and nor'easters, often batter the coast, producing high winds and waves. Heavy rainfall pools into low-lying areas, turning flood plains and the mouths of streams and rivers into flooded regions with possibly fast-moving water. Sea levels are rising, as they have been for the past 20,000 years, which encroaches upon the land. In addition, the land subsides in places due to channelization of the river system or the response of the Earth's mantle to glacial isostatic adjustment.

In Louisiana, for example, the land is subsiding at a considerable rate due to sediment compaction. The Mississippi River flood plain is naturally replenished by the sediment that is deposited during flood events. However, the Mississippi River has been channelized by the levee system such that it is like a "freeway with no on-ramp." Rivers such as the Amite and Comite no longer empty into the Mississippi. Thus, local flooding occurs in Baton Rouge and throughout much of southern Louisiana east of the Mississippi River because of the changed drainage patterns. Moreover, the flood waters of the Mississippi River, which used to bring sediments to replenish the land, are efficiently transported to the Gulf of Mexico. The land, therefore, subsides as the existing sediments compact, leaving areas such as New Orleans below sea level and resulting in an increased loss of wetland areas.

In the Mid-Atlantic region (i.e., Delaware and New Jersey), the land also is subsiding at a rapid rate. At the maximum spatial extent of the Laurentide ice sheet (~21,500 years ago) that extended as far south as central Pennsylvania, the weight of the ice pressed down on the land surface causing it to subside, particularly over much of New England and eastern Canada. Consequently, the land along the peripheral forebulge of the Laurentide ice sheet (i.e., in the Mid-Atlantic region) was forced upward due to the pressure placed on the land to the north. As the deglaciation of the Laurentide ice sheet occurred during the late Holocene, the regions under the ice sheet, much of New England has seen relatively rapid uplift, while regions just to the south have experienced (and continue to experience) subsidence.

Barrier islands often block the effect of landfalling storms and mitigate the effect of these storms on inland areas. Storms often reshape the coastline by moving the

sand that comprises barrier islands. Problems often arise when humans build upon these shifting sands and expect them to remain immobile. The fact is that barrier islands are constantly dynamic, and their shape and presence make living in coastal regions potentially hazardous.

SEA LEVEL RISE AND CLIMATE CHANGE

Globally, sea level began to rise after the demise of the last major glaciation approximately 20,000 years ago (Figure 1), rising nearly 400 feet (~120 m). As the glaciers covering much of the Northern Hemisphere land areas melted, sea level rose quite rapidly. Over the last 8,000 years or so, the rise has been much slower, and has occurred due to melting of land ice as well as the thermal expansion of sea water. The rate over the last century has been about 7 to 8 inches (~2 mm yr^{-1}). However, the North Polar region has not yet reached equilibrium such that melting continues to occur. Locally, trends in sea levels may vary substantially from the global trend because of both tectonic activity and coastal subsidence or coastal isostatic rebound.

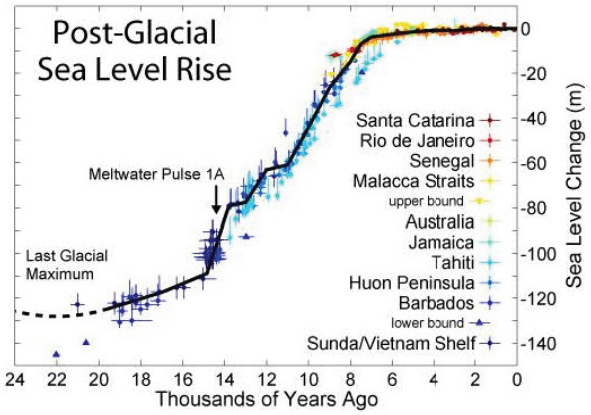


Figure 1. Sea level rise since the last glacial maximum (Wikipedia).

Consider a cube of ice placed into a room at 72°F. The ice will continue to melt, even though the room remains at a constant temperature. This is because the ice cube has not reached equilibrium with the temperature of the room and melt of the ice cube will continue to occur.

Our question today is whether rising concentrations of greenhouse gases are causing sea levels to rise dramatically. Specifically, are we seeing an increase in the rate of sea level rise? To address this question, we can examine historical observations of sea level as well as satellite-derived estimates.

The National Oceanographic and Atmospheric Administration (NOAA) regularly updates its coastal sea level tide gauge data which includes measurements at coastal locations along the East Coast, the Gulf Coast, the West Coast, the Pacific Ocean, the Atlantic Ocean, and the Gulf of Mexico. Their record covers more than 200 measurement stations.

The longest NOAA tide gauge record in the United States is located at the Battery in New York City. Its 160-year record (Figure 2, top) shows a steady rate of sea level rise of 11 inches per century, slightly higher than the current global average of about 7 to 8 inches per century (or about 0.075 inches per year) due to the coastal subsidence discussed earlier. Atlantic City NJ (Figure 2, bottom) illustrates a steady rise at a higher level—about 16 inches per century—due to its location near the peripheral forebulge of the Laurentide ice sheet.

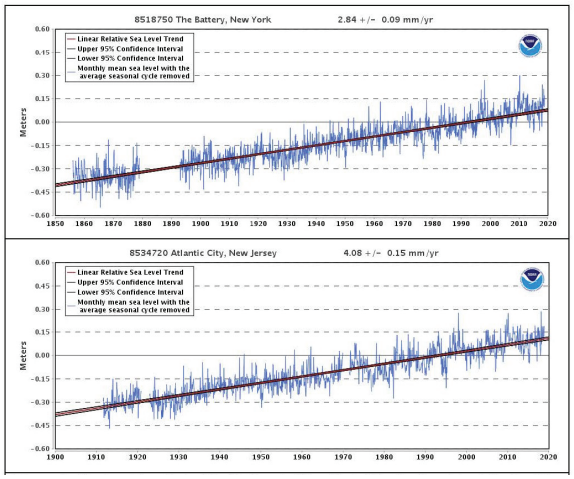


Figure 2. Sea level trends for The Battery in New York City (top) and for Atlantic City, New Jersey (bottom). Data retrieved on February 4, 2019.

Although the data from Kings Point is a much shorter record, both stations show that sea level rise over the past century (and since 1855 for The Battery) has been steadily increasing despite periods of relatively rapid air temperature increase and cooling that have occurred over the past century. Moreover, no correlation exists between atmospheric carbon dioxide concentrations and sea level rise—CO_2 has exhibited no apparent impact on the rate of sea level rise despite the rise in atmospheric CO_2 concentrations from 280 parts per million to 400 parts per million.

Consider now the West Coast of the United States. The 100+ year record in Seattle, WA (Figure 3, top) shows a steady rate of sea level rise of about 8 inches per century, near the long-term global average. Although a shorter record at Los Angeles CA (Figure 3, bottom), Los Angeles has experienced a steady rate of sea level rise of about 4 inches per century, below the long-term global average.

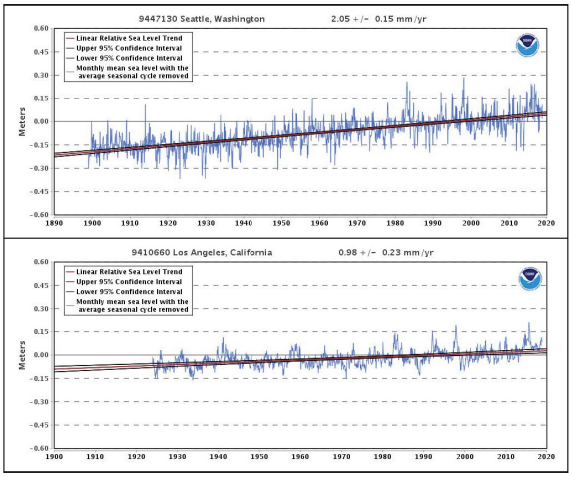


Figure 3. Sea level trends for Seattle, Washington (top) and for Los Angeles, California (bottom). Data retrieved on February 4, 2019.

Along the United States Gulf Coast, the 100+ year record at Grand Isle, LA (Figure 4) also shows a steady rise in sea level of about 35.7 inches. Although the curve shows a very high rate of sea level rise, the increase is linear with little hint of an accelerating trend due to the possible impact of increases in anthropogenic greenhouse gases. Again, the culprit for this high rate of sea level rise is the compaction of sediments and the channelization of the Mississippi River.

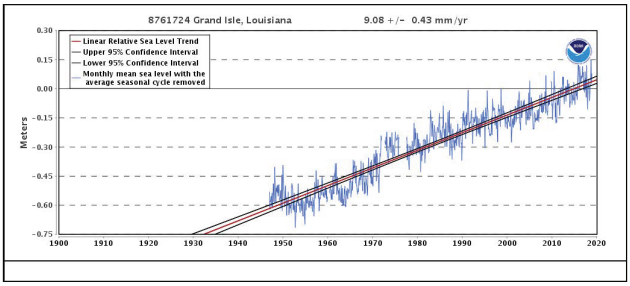


Figure 4. Sea level trends for Grand Isle, Louisiana. Data retrieved on February 4, 2019.

Honolulu, HI (Figure 5), like many island stations, exhibits significant yearly fluctuations in sea level due to the impact of global ocean currents. However, sea level rise in Honolulu has been only about 5.8 inches per century, with virtually no correlation with global CO_2 levels.

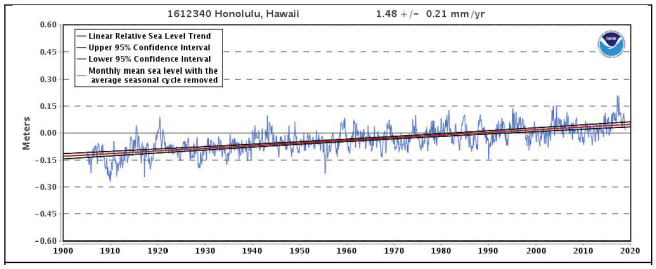


Figure 5. Sea level trends for Honolulu, Hawaii. Data were retrieved on February 4, 2019.

By contrast, sea level trends for Sitka, AK (Figure 6) shows a *decrease* in sea level of about 9.2 inches per year. This illustrates the effect from both local tectonic activity as well as isostatic rebound effect of the unloading of the ice sheet during the last ice age.

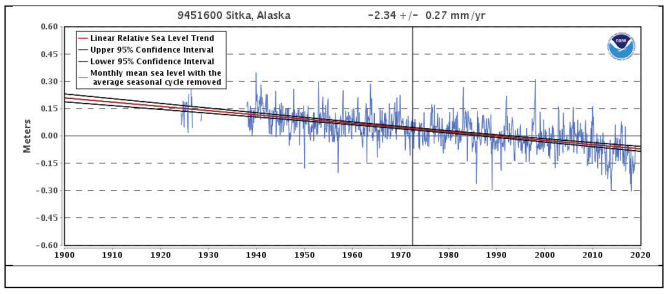


Figure 6. Sea level trends for Sitka, Alaska. Data were retrieved on February 4, 2019.

The message of these and many other stations around the United States is that while sea level rise is not constant, its rate of change over time is *not* changing because of increasing concentrations of greenhouse gases. If CO_2 was an agent

causing sea level rise to increase, the patterns should show an increasing trend in the rate of sea level rise over time. The records shown here (and at many other stations around the globe) do not exhibit a substantial increase in sea level over time. Local and regional changes in sea levels exhibit typical natural variability, relatively unrelated to changes in the global averaged sea level. Thus, atmospheric trace gas concentrations have no measurable impact on sea levels.

TROPICAL CYCLONES AND CLIMATE CHANGE

The impact of more frequent and intense hurricanes is important owing to the damage that may occur to coastal areas. However, much of the potential damage due to tropical cyclones along the coast is likely due to human settlement of low-lying and coastal areas.

In 2013, the Fifth Assessment report of the IPCC proclaimed "there is *low confidence* in long-term (centennial) changes in tropical cyclone activity, after accounting for past changes in observing capabilities . . . and there is *low* confidence in attribution of changes in tropical cyclone activity to human influence owing to insufficient observational evidence, lack of physical understanding of the links between anthropogenic drivers of climate and tropical cyclone activity and the low level of agreement between studies as to the relative importance of internal variability, and anthropogenic and natural forcings."

Investigation of the trend in hurricanes making landfall in the continental United States since 1990 shows no significant trend in either landfalling hurricanes, major hurricanes (Category 3 or higher), or normalized damage (Figures 7 and 8). Although the data exhibit considerable variability, the long-term trend is fewer landfalling hurricanes and major hurricanes while the normalized damage (constant dollars) has remained unchanged.

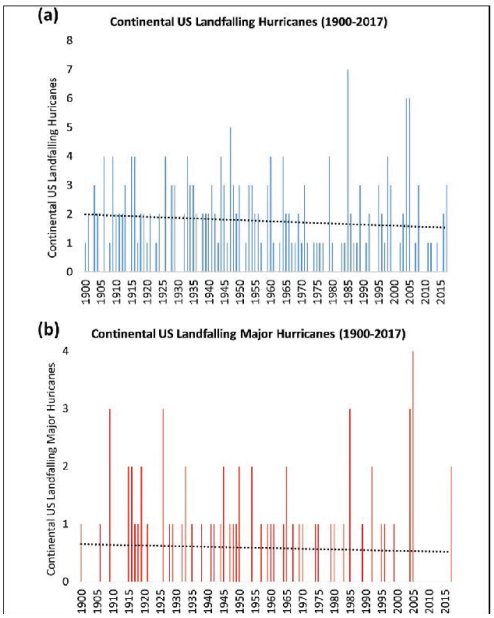


Figure 7. Landfalling hurricanes and major hurricanes for the continental United States since 1900. Figure from Klotzbach, P.J., S.G. Bowen, et al. (2018). "Continental U.S. hurricane landfall frequency and associated damage." Bull. Amer. Meteorol. Soc. 99(7):1359–1377.

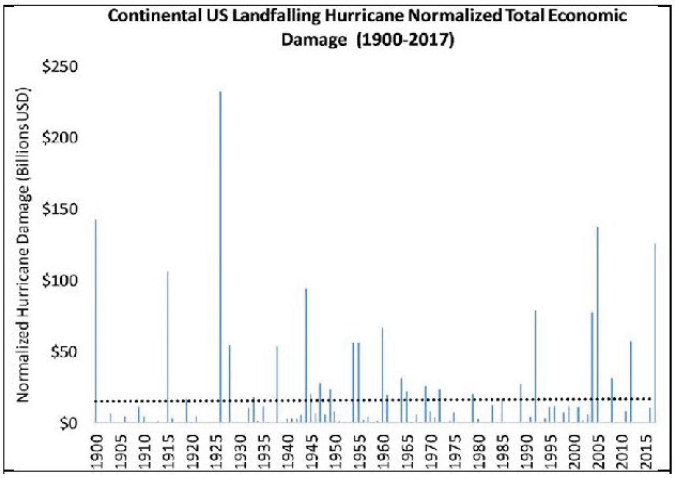


Figure 8. Normalized landfalling hurricane damage for the continental United States since 1900 in constant 2017 dollars. Figure from Klotzbach, P.J., S.G. Bowen, et al. (2018). "Continental U.S. hurricane landfall frequency and associated damage." Bull. Amer. Meteorol. Soc. 99(7):1359–1377.

In the 1990s, Dr. William Gray (Colorado State University) found that natural cycles in the Atlantic basin (sea surface temperatures) and air temperature variability drove variability in hurricane activity. Variability in the Atlantic Multidecadal Oscillation (fluctuations of sea surface temperature) may be related to changes in the thermohaline circulation. In its positive (warm) phase, hurricane formation is more likely while the converse is also true (Figure 9, blue line).

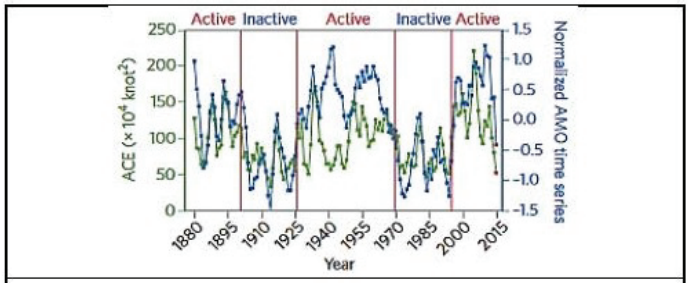


Figure 9. Accumulated cyclone energy (green) and the normalized Atlantic Multidecadal Oscillation (blue). Figure from Klotzbach, P.J., W.M. Gray, et al. (2015). "Active Atlantic hurricane era at its end?" Nature Geoscience 8(10):737–738.

Accumulated Cyclone Energy (ACE) is the summation (every 6 hours) of the apparent wind energy produced by a tropical system over its lifetime. The 3-year averaged ACE for the Atlantic Basin is shown (Figure 9, green line) and for the Northern Hemisphere and the globe (Figure 10). As with the Atlantic Multidecadal Oscillation, ACE shows much temporal variability but little by way of a trend.

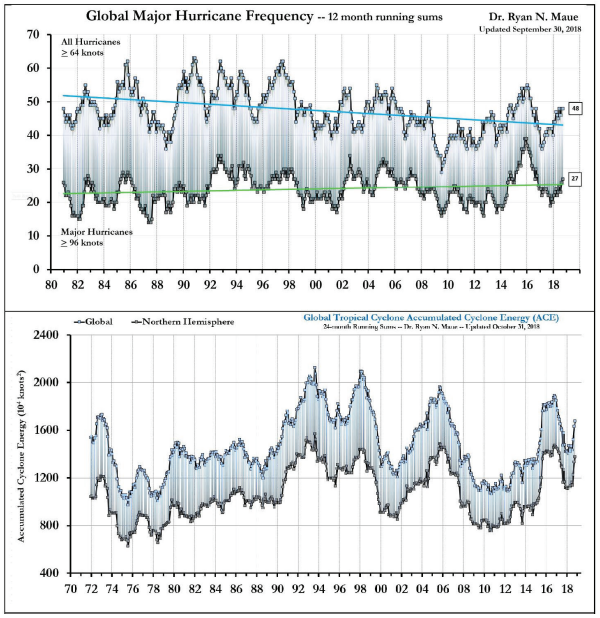


Figure 10. Major (Category 3 to 5) hurricane frequency (top) and the accumulated cyclone energy (bottom) for both the globe and the Northern Hemisphere. Figure from http://policlimate.com/tropical/, downloaded on February 5, 2019.

Little-to-no observational evidence exists that tropical cyclone activity has worsened over the last 50+ years, let alone address the question of whether changes in hurricane activity could be affected by anthropogenic activities. None of these data demonstrate any obvious long-term trends, but they do exhibit large variability on yearly/decadal time scales.

While devastating, Hurricanes Katrina and Sandy were neither unusual nor unexpected. In the 1990s while at the University of Oklahoma, I taught that eventually a hurricane would pass New Orleans and the cyclonic winds would put stress on the levee system holding Lake Pontchartrain back. The pressure upon the levees may be enough to cause them to fail and water to flood portions of New Orleans. The normal FEMA response is to wait for the storm surge to recede and bring in mobile houses if the homes are uninhabitable. But since sediment compaction has caused portions of New Orleans to be below sea level. Thus, the water would not recede, and the normal FEMA response would be inappropriate. I was not a prophet; but rather, what I imparted to the students was simply a fact that climatologists knew was likely to occur.

Similarly, Hurricane Sandy was rare in that it turned west while in mid-latitudes. It is not surprising that weak storms (Hurricane Sandy was extratropical by the time it made landfall) would be affected by mid-latitude weather patterns. Hurricane Sandy, therefore, was not unexpected but the results were devastating because it made landfall at a highly populated location.

OCEAN ACIDIFICATION

Due to dissolved salts (primarily Na^+ and Cl^-), the pH of ocean seawater is primarily basic. With the inclusion of dissolved CO_2, the pH of ocean seawater is decreasing (i.e., becoming more acidic), which is termed "ocean acidification." The question is whether this acidification is significant and whether it matters.

The addition of CO_2 to seawater increases carbonic acid which lowers the pH. However, the chemistry is more complex as chemical buffering by dissolved salts greatly affects the resulting pH. IPCC AR5 suggests that a doubling of atmospheric CO_2 might lower the pH by up to 0.2—well within the normal seasonal/diurnal variation in seawater pH. Globally, ocean surface pH varies considerably. Many factors affect local pH, including components of the ecosystem, underlying ocean depth, and dissolved parent material.

An argument has been made that lowering the oceanic pH due to the absorption of more CO_2 would likely destroy the $CaCO_3$ shells of various animals. Indeed, Dr. Jane Lubchenco testified on December 2, 2009 to a U.S. House subcommittee: "Who in the ocean is affected by this ['Osteoporosis of the Sea']? Any plant or animal that has a shell or skeleton made of calcium carbonate. The hard parts of many familiar animals such as oysters, clams, corals, lobsters, crabs, . . . are made of calcium carbonate" and showed pictures from the National Geographic Society of the shell of a *Limacina helicina Antarctica*, a Pteropod, that had largely dissolved after about 45 days when subjected to decreased pH. But a study in 2008 (Iglesias-Rodriguez, M.D., P.R. Halloran, et al. 2008. "Phytoplankton calcification in a high-CO2 world." *Science* 320:336–340) concluded that "Increased atmospheric CO_2 also enhances marine life, in contradiction to previous claims where lower pH in the ocean was said to be dissolving calcium material (i.e., $CaCO_3$) and therefore causing harm to marine life." They go on to note that "most of these experiments [with lowered pH] used semi-continuous cultures, in which the carbonate system was modified by the addition of acid and/or base to control pH." Indeed, some of these lab studies used hydrochloric acid, not carbon dioxide (i.e., carbonic acid) to lower the pH of the seawater. While the change in pH may be similar, the chemistry involved with the chlorine ion is far different than that with the carbonate and bicarbonate ions.

Dr. Justin Ries of the University of North Carolina at Chapel Hill raised both lobsters and blue crabs in a CO_2-enriched environment (Figure 11) and demonstrated that under elevated CO_2 levels, both species grew faster. He has raised the concern that such rapid growth could disrupt the food chain but to simply assert that ocean acidification will necessarily diminish all life in the oceans is an extreme claim.



Figure 11. Lobster (top) and blue crab (bottom) grown under different levels of atmospheric CO_2. On the left are crustaceans grown under current (i.e., 400 ppm) atmospheric CO_2 concentrations and under elevated CO_2 on the right (i.e., ~2800 ppm). Figure from Dr. Justin Ries, marine researcher at the University of North Carolina-Chapel Hill.

SUMMARY

Coasts are naturally hazardous areas due to the impact of rising seas, coastal storms, shifting barrier islands, and flooding caused by rainfall into low-lying areas. Global sea levels have risen naturally at a rate of about 7 to 8 inches per century for at least several hundred years. Locally, this rate may be higher due to local land subsidence and/or compaction of sediments or lower due to isostatic rebound.

Shifting sands on barrier islands change the local landscape and can affect life along coastal areas.

The question we wish to answer is whether anthropogenic increases in CO_2 concentrations exacerbate these coastal impacts. From the data shown above, sea level rise has been consistent linear at nearly all stations for which long-term measurements are made. This indicates that increasing CO_2 concentrations are not significantly affecting the rate of sea level rise. As these concentrations have increased from before the industrial age when atmospheric CO_2 levels were about 280 ppm to current conditions where they exceed 400 ppm, the lack of a significant change in the rate of increase implies that sea level rise is not responding to changes in greenhouse gas concentrations.

Severe weather events—most notably tropical cyclones/hurricanes—have not increased significantly over the last 60 or more years. No significant trend exists with either landfalling hurricanes in the United States, landfalling significant hurricanes (Category 3 or higher), or with the accumulated cyclone energy; a measure of the energy associated with tropical cyclones integrated over all storms in the basin for a given season or month. In all cases, short-term trends exist but those reflect natural variability and do not contribute to the longer-term trend. Damage for the continental United States from landfalling tropical cyclones since 1900 also shows no increasing trend in constant dollars despite the increased development along our coastlines. Consequently, we can agree with the IPCC that low confidence exists in the attribution of changes in tropical cyclone activity to human influence.

Seawater is naturally alkaline, but the addition of dissolved CO_2 leads to acidification (i.e., lowered pH) through the addition of carbonic acid. Rather than leading to the dissolution of $CaCO_3$-based shells of various animals in the oceans, many species will thrive on the addition of carbonate and bicarbonate ions and the slightly lowered pH content. Studies which have attempted to demonstrate that $CaCO_3$-based shells dissolve in lowered pH conditions often have used hydrochloric acid, rather than carbonic acid, which has a considerably different chemistry.

Coastal living is accompanied by additional hazards, although it is unlikely that these hazards will increase in the future due to increases in atmospheric concentrations of CO_2, in large part because concentrations have increased nearly 45 percent over pre-industrial levels and no significant impact on these hazards has been observed.

Mr. HUFFMAN. Thank you, Dr. Legates.

Finally, the Committee welcomes and the Chair recognizes Dr. Dayaratna, Senior Statistician and Research Programmer at the Institute for Economic Freedom, a program of The Heritage Foundation in Washington, DC.

Welcome, Doctor.

STATEMENT OF KEVIN DAYARATNA, SENIOR STATISTICIAN AND RESEARCH PROGRAMMER, INSTITUTE FOR ECONOMIC FREEDOM, THE HERITAGE FOUNDATION, WASHINGTON, DC

Dr. DAYARATNA. Thank you. Chairman Huffman, Ranking Member McClintock, and other members of the Subcommittee, thank you for the opportunity to testify about healthy oceans and healthy economies.

My name is Kevin Dayaratna. I am the Senior Statistician and Research Programmer at The Heritage Foundation. The views I express in this testimony are my own and should not be construed as representing any official position of The Heritage Foundation.

Energy is literally the basis of anything and everything we do, from flipping on the light switch, to starting up your car, to enabling this very hearing to operate. And, unfortunately, many people take energy for granted.

Over the course of the past decade, it has been the fundamental goal of policy makers in Washington to expand regulations across the energy sector of the economy. During my work at Heritage, my

colleagues and I have used various academic models to examine the impact of proposed regulations. In our work published with The Heritage Foundation, we have found that the policies aimed at decarbonization will result in devastating economic impacts, with negligible impacts on the climate.

The primary metric used by policy makers to justify carbon-based regulations is the social cost of carbon, which is defined as the economic damages associated with a metric ton of carbon dioxide emissions summed across a particular time horizon.

Our work is based on the same models that the Federal Government used to estimate the social cost of carbon. This work, published at Heritage as well as in the peer-reviewed literature, has repeatedly demonstrated, while these models might be interesting for academic exercises, their assumptions can be readily manipulated by regulators and bureaucrats.

These models make fundamental assumptions regarding climate sensitivity. The idea is that these models attempt to forecast temperatures centuries into the future to quantify the associated cost of carbon dioxide emissions. A very reasonable question is how accurate these forecasts actually are.

Equilibrium climate sensitivity distributions are used to quantify the Earth's temperature response to a doubling of carbon dioxide concentration. A vast amount of recently published research has shown lower-than-expected sensitivity to carbon dioxide. Indeed, recent sensitivity assumptions have lowered the social cost of carbon by as much as 80 percent or more.

A more fundamental question not discussed by the Federal Government is: Are there actually any benefits associated with carbon dioxide emissions? Well, a model often employed by the EPA actually quantifies these benefits. In fact, under some very reasonable assumptions, there are substantial probabilities of negative social cost of carbon, or, in layman's terms, actual benefits, in some cases as high as two-thirds, resulting from greater CO_2 prevalence allowing increased agriculture and forestry yields. This negative social-cost-of-carbon estimate would signify that carbon dioxide emissions are not a cost but a benefit to society.

So, the bottom line is, these regulations are predicated on models that have been manipulated to justify a particular regulatory agenda. At Heritage, we have an exact clone of the Department of Energy's National Energy Modeling System to quantify the economic impact of this agenda.

In particular, we modeled the regulations suggested by the previous administration's interagency working group and found that the economic impacts would be quite devastating. In particular, by 2035, the country would see an average employment shortfall of nearly 400,000 lost jobs and up to a 20-percent increase in household electricity expenditures and an aggregate $2.5 trillion loss in GDP.

Last, I will talk about the climate impact of these policies. The primary goal of any of these carbon-capture/carbon-reduction policies is to reduce global climate change. At Heritage, we have used one of the EPA's models, the Model for the Assessment of Greenhouse Gas Induced Climate Change, to quantify the climate impact associated with the policies that I have described.

In one series of simulations, we assumed the United States reduced carbon dioxide emissions from fossil fuels by 80 percent and assumed a climate that is more sensitive than what was even assumed by the interagency working group. We found that by 2100 there would be a temperature reduction of one-seventh degree Celsius and a minuscule 1.35 centimeters of sea-level-rise reduction.

In conclusion, regulatory policies regarding carbon dioxide emissions are predicated on faulty models, will have devastating economic impacts, and will only have negligible impact on the climate.

Thank you for your attention, and I look forward to your questions.

[The prepared statement of Dr. Dayaratna follows:]

PREPARED STATEMENT OF KEVIN D. DAYARATNA, PHD, SENIOR STATISTICIAN AND RESEARCH PROGRAMMER, THE HERITAGE FOUNDATION

Chairman Huffman, Ranking Member McClintock, and other members of the Subcommittee, thank you for the opportunity to testify about healthy oceans and healthy economies. My name is Kevin Dayaratna. I am the Senior Statistician and Research Programmer at The Heritage Foundation. The views I express in this testimony are my own and should not be construed as representing any official position of The Heritage Foundation.

Energy is the fundamental building block of civilization from flipping on a light switch, to starting up our cars, to enabling this very hearing to operate. Unfortunately, however, many people take energy for granted. Over the course of the past decade, it has been a fundamental goal of policy makers in Washington to expand regulations across the energy sector of the economy. As a result, it is important to quantify the impacts of this fundamental building block both in terms of the economy as well as in terms of the climate. Over the course of my work at The Heritage Foundation, my colleagues and I have used the same models that the Federal Government has used to quantify these impacts ourselves. We have found in our work published both at Heritage and in the peer-reviewed literature that these policies aimed at decarbonization are predicated on user-manipulated models. Moreover, we have found that these policies will result in devastating economic impacts along with negligible impacts on the climate. Policies aimed at taking advantage of our vast oil and gas supply, on the other hand, will grow the economy for years to come.

THE JUSTIFICATION BEHIND THESE REGULATIONS

For much of the past decade, the Federal Government has sought to expand regulations across the energy sector of the economy. One of the primary justifications for doing so has been the social cost of carbon (SCC), which is defined as the economic damages associated with a metric ton of carbon dioxide (CO_2) emissions summed across a particular time horizon.[1]

There are three primary statistical models that the Interagency Working Group (IWG) has used to estimate the SCC—the DICE Model, the FUND model, and the PAGE model.[2] Over the past several years at The Heritage Foundation, my

[1] The official definition of the social cost of carbon is the economic damages per metric ton of CO_2 emissions, and is discussed further in U.S. Environmental Protection Agency, "The Social Cost of Carbon," http://www.epa.gov/climatechange/EPAactivities/economics/scc.html (accessed September 14, 2013).

[2] For the DICE model, see William D. Nordhaus, "RICE and DICE Models of Economics of Climate Change," Yale University, November 2006, http://www.econ.yale.edu/~nordhaus/homepage/dicemodels.htm (accessed November 6, 2013).

For the FUND model, see "FUND—Climate Framework for Uncertainty, Negotiation and Distribution," http://www.fund-model.org/ (accessed November 6, 2013).

For the PAGE model, see Climate CoLab, "PAGE," http://climatecolab.org/resources/-/wiki/Main/PAGE (accessed November 6, 2013).

See also U.S. Interagency Working Group on Social Cost of Greenhouse Gases, "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866," May 2013, revised November 2013, https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf (accessed February 6, 2019); U.S. Interagency Working Group on Social Cost of Greenhouse Gases,

Continued

colleagues and I have used the DICE and FUND models, testing their sensitivity to a variety of important assumptions. Our research, published as Heritage Foundation publications, in the peer-reviewed literature, and discussed in my prior congressional testimony, has repeatedly illustrated that although these models might be interesting academic exercises, they are extremely sensitive to very reasonable changes to assumptions.[3] These models can be manipulated by user-selected assumptions and are thus not legitimate for guiding regulatory policy.

These models are estimated by Monte Carlo simulation. The general idea behind Monte Carlo simulation is that since some aspects of the models are random, the models are repeatedly estimated to generate a spectrum of probable outcomes. As a result of principles in probability theory, repeated estimation for a sufficient amount of time provides a reasonable characterization of the SCC's distributional properties.

As with any statistical model, however, these models are grounded by assumptions. In our work, my colleagues and I have rigorously examined three important assumptions: the choice of a discount rate, a time horizon, and the specification of an equilibrium climate sensitivity distribution.

DISCOUNT RATE

The concept of discount rates is best viewed by considering an expenditure today as a benefit in the future via an investment. Discounting future benefits of averting climate damage compares the rate of return from CO_2 reduction to the rate of return that could be expected from other investments. In principle, discounting runs the compound rate of return exercise backward, calculating how much would need to be invested at a reasonably expected interest rate today to result in the value of the averted future climate damage.[4]

The Environmental Protection Agency has run these models using 2.5 percent, 3.0 percent, and 5.0 percent discount rates despite the fact that the Office of Management and Budget guidance in Circular A–4 has specifically stipulated that a 7.0 percent discount rate be used as well.[5] In my research, we re-estimated these models using a 7.0 percent discount rate in a variety of publications. Below are our results published in the peer-reviewed journal *Climate Change Economics*:

"Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analyses under Executive Order 12866: Application of Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide," August 2016, https://www.epa.gov/sites/production/files/2016-12/documents/addendum_to_sc-ghg_tsd_august_2016.pdf (accessed February 6, 2019); and U.S. Interagency Working Group on Social Cost of Greenhouse Gases, "2010 Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866," February 2010, https://www.epa.gov/sites/production/files/2016-12/documents/scc_tsd_2010.pdf (accessed February 6, 2019).

[3] Kevin D. Dayaratna and David W. Kreutzer, "Unfounded FUND: Yet Another EPA Model Not Ready for the Big Game," Heritage Foundation *Backgrounder* No. 2897, April 29, 2014, http://www.heritage.org/research/reports/2014/04/unfounded-fund-yet-another-epa-model-not-ready-for-the-big-game; Kevin D. Dayaratna and David W. Kreutzer, "Loaded DICE: An EPA Model Not Ready for the Big Game," Heritage Foundation *Backgrounder* No. 2860, November 21, 2013, http://www.heritage.org/research/reports/2013/11/loaded-dice-an-epa-model-not-ready-for-the-big-game; and Kevin D. Dayaratna, and David Kreutzer, "Environment: Social Cost of Carbon Statistical Modeling Is Smoke and Mirrors," *Natural Gas & Electricity*, Vol. 30, No. 12 (2014), pp. 7–11; K. Dayaratna, R. McKitrick, and D. Kreutzer, "Empirically Constrained Climate Sensitivity and the Social Cost of Carbon," *Climate Change Economics*, Vol. 8, No. 2 (2017), p. 1750006; Kevin D. Dayaratna, "An Analysis of the Obama Administration's Social Cost of Carbon," testimony before the Committee on Natural Resources, U.S. House of Representatives, July 23, 2015; and Kevin D. Dayaratna, "At What Cost? Examining the Social Cost of Carbon," testimony before the Committee on House, Sciences, and Technology, U.S. House of Representatives, February 28, 2017.

[4] D. W. Kreutzer, "Discounting Climate Costs," Heritage Foundation *Issue Brief* No. 4575, June 16, 2016, https://www.heritage.org/environment/report/discounting-climate-costs.

[5] Office of Management and Budget, "Circular A–4," Obama White House, February 22, 2017, https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4/ (accessed February 6, 2019), and Paul C. "Chip" Knappenberger, "An Example of the Abuse of the Social Cost of Carbon," Cato-at-Liberty, August 23, 2013, http://www.cato.org/blog/example-abuse-social-cost-carbon (accessed February 6, 2019).

DICE Model Average SCC—Baseline, End Year 2300

Year	Discount Rate—2.50%	Discount Rate—3.0%	Discount Rate—5.0%	Discount Rate—7.0%
2010	$46.58	$30.04	$8.81	$4.02
2020	$56.92	$37.79	$12.10	$5.87
2030	$66.53	$45.15	$15.33	$7.70
2040	$76.96	$53.26	$19.02	$9.85
2050	$87.70	$61.72	$23.06	$12.25

FUND Model Average SCC—Baseline, End Year 2300

Year	Discount Rate—2.50%	Discount Rate—3.0%	Discount Rate—5.0%	Discount Rate—7.0%
2010	$29.69	$16.98	$1.87	−$0.53
2020	$32.90	$19.33	$2.54	−$0.37
2030	$36.16	$21.78	$3.31	−$0.13
2040	$39.53	$24.36	$4.21	$0.19
2050	$42.98	$27.06	$5.25	$0.63

As the above tables illustrate, the SCC estimates are drastically reduced under the use of a 7.0 percent discount rate. In fact, under the FUND model, the estimates are negative, suggesting that there are actually benefits to CO_2 emissions. These changes in the discount rate can cause the SCC to drop by as much as 80 percent or more.

TIME HORIZON

It is essentially impossible to forecast technological change decades, let alone centuries, into the future. Regardless, however, these SCC models are based on projections 300 years into the future. In my work at Heritage, I have changed this time horizon to the significantly less, albeit still unrealistic, time horizon of 150 years into the future, and we obtained the following results for the DICE model in our work published in 2013:[6]

DICE Model Average SCC—End Year 2150

Year	Discount Rate—2.50%	Discount Rate—3.0%	Discount Rate—5.0%	Discount Rate—7.0%
2010	$36.78	$26.01	$8.66	$4.01
2020	$44.41	$32.38	$11.85	$5.85
2030	$50.82	$38.00	$14.92	$7.67
2040	$57.17	$43.79	$18.36	$9.79
2050	$62.81	$49.20	$22.00	$12.13

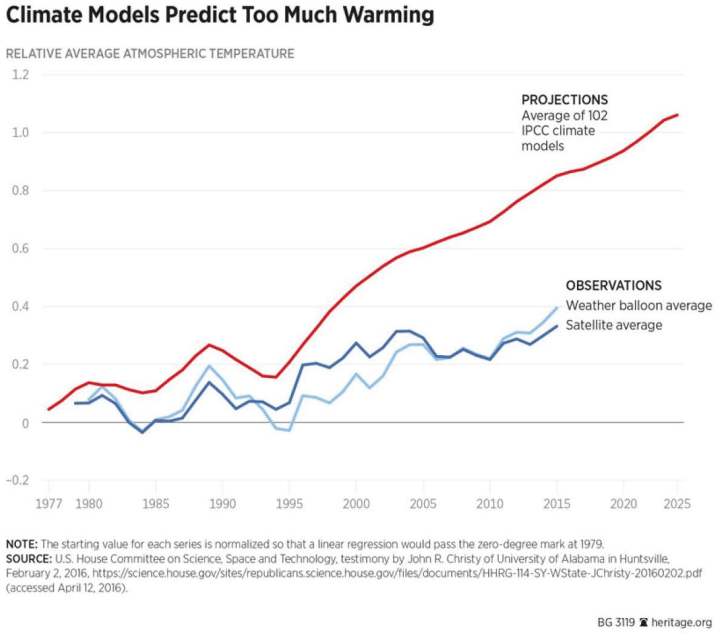
Clearly, the SCC estimates drop substantially as a result of changing the end year (in some cases by over 25 percent).

EQUILIBRIUM CLIMATE SENSITIVITY (ECS) DISTRIBUTION

These models, of course, take into account assumptions regarding the planet's climate sensitivity. The real question, however, is the degree of accuracy statistical models have at doing so. Professor John Christy testified in both 2013 and 2016

[6] Dayaratna and Kreutzer, "Loaded DICE: An EPA Model Not Ready for the Big Game."

regarding the efficacy of climate change projections and juxtaposed them against actual weather balloon and satellite data.[7] Christy has exposed the sheer inadequacy of the Intergovernmental Panel on Climate Change's (IPCC) models in forecasting global temperatures:



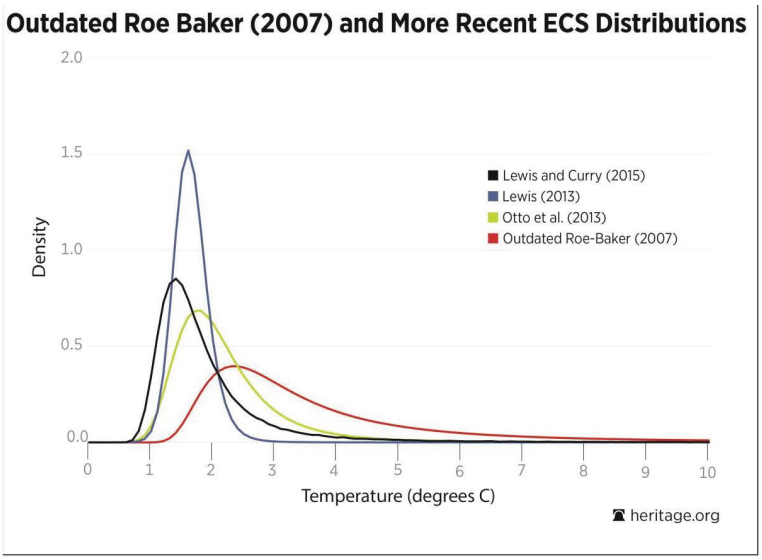
The climate specification used in estimating the SCC is that of an ECS distribution. These distributions probabilistically quantify the earth's temperature response to a doubling of CO_2 concentrations. The ECS distribution used by the IWG is based on a paper published in the journal *Science* 12 years ago by Gerard Roe and Marcia Baker. This non-empirical distribution, calibrated by the IWG based on assumptions that the group decided on climate change in conjunction with IPCC recommendations, has been deemed to be "no longer scientifically defensible."[8] Since then, a variety of newer and more up-to-date distributions have been suggested in the peer-reviewed literature. Many of these distributions, in fact, suggest lower probabilities of extreme global warming in response to CO_2 concentrations. Below are a few such distributions:[9]

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[7] John R. Christy, testimony before the Committee on Science, Space & Technology, U.S. House of Representatives, February 2, 2016, and John R. Christy, "A Factual Look at the Relationship Between Climate and Weather," testimony before the Subcommittee on Environment, Committee on Natural Resources, U.S. House of Representatives, December 11, 2013.

[8] Patrick J. Michaels, "An Analysis of the Obama Administration's Social Cost of Carbon," testimony before the Committee on Natural Resources, U.S. House of Representatives, July 22, 2015, https://www.cato.org/publications/testimony/analysis-obama-administrations-social-cost-carbon (accessed February 6, 2019).

[9] Gerard H. Roe and Marcia B. Baker, "Why Is Climate Sensitivity So Unpredictable?" *Science*, Vol. 318, No. 5850 (October 26, 2007), pp. 629–632; Nicholas Lewis, "An Objective Bayesian Improved Approach for Applying Optimal Fingerprint Techniques to Estimate Climate Sensitivity," *Journal of Climate*, Vol. 26, No. 19 (October 2013), pp. 7414–7429; Alexander Otto et al., "Energy Budget Constraints on Climate Response," *Nature Geoscience*, Vol. 6, No. 6 (June 2013), pp. 415–416; Nicholas Lewis and Judith A. Curry, "The Implications for Climate Sensitivity of AR5 Forcing and Heat Uptake Estimates," *Climate Dynamics*, Vol. 45, No. 3, pp. 1009–1923, http://link.springer.com/article/10.1007/s00382-014-2342-y (accessed February 6, 2019); and U.S. Interagency Working Group on Social Cost of Greenhouse Gases, "2010 Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866," February 2010, https://www.epa.gov/sites/production/files/2016–12/documents/scc_tsd_2010.pdf (accessed February 6, 2019).



The area under the curve between two temperature points depicts the probability that the earth's temperature will increase between those amounts in response to a doubling of CO_2 concentrations. Thus, the area under the curve from 4 degrees C onwards (known as a "tail probability") provides the probability that the earth's temperature will warm by more than 4 degrees Celsius in response to a doubling of CO_2 concentrations. Note that the more up-to-date ECS distributions (Otto et al., 2013; Lewis, 2013; Lewis and Curry, 2015) have significantly lower tail probabilities than the outdated Roe-Baker (2007) distribution used by the IWG. In our research published in *Climate Change Economics*, we re-estimated the SCC having used these more up-to-date ECS distributions and obtained the following results: [10]

DICE Model Average SCC—ECS Distribution Updated in Accordance with Lewis and Curry (2015), End Year 2300

Year	Discount Rate—2.50%	Discount Rate—3.0%	Discount Rate—5.0%	Discount Rate—7.0%
2010	$23.62	$15.62	$5.03	$2.48
2020	$28.92	$19.66	$6.86	$3.57
2030	$33.95	$23.56	$8.67	$4.65
2040	$39.47	$27.88	$10.74	$5.91
2050	$45.34	$32.51	$13.03	$7.32

[10] Dayaratna, McKitrick, and Kreutzer, "Empirically Constrained Climate Sensitivity and the Social Cost of Carbon."

FUND Model Average SCC—ECS Distribution Updated in Accordance with Lewis and Curry (2015), End Year 2300

Year	Discount Rate—2.50%	Discount Rate—3.0%	Discount Rate—5.0%	Discount Rate—7.0%
2010	$5.25	$2.78	−$0.65	−$1.12
2020	$5.86	$3.33	−$0.47	−$1.10
2030	$6.45	$3.90	−$0.19	−$1.01
2040	$7.02	$4.49	−$0.18	−$0.82
2050	$7.53	$5.09	$0.64	−$0.53

Again, we notice drastically lower estimates of the SCC using these more up-to-date ECS distributions. These results are not surprising—the IWG's estimates of the SCC were based on outdated assumptions that overstated the probabilities of extreme global warming, which artificially inflated their estimates of the SCC.

NEGATIVITY

When people talk about the social cost of carbon, they tend to think of damages. Not all of these models, however, suggest that there are always damages associated with CO_2 emissions. The FUND model, in fact, allows for the SCC to be negative based on feedback mechanisms due to CO_2 emissions. In my research at The Heritage Foundation, we computed the probability of a negative SCC under a variety of assumptions. Below are some of our results published both at Heritage as well as in the peer-reviewed journal *Climate Change Economics*: [11]

FUND Model Probability of Negative SCC—ECS Distribution Based on Outdated Roe-Baker (2007) Distribution, End Year 2300

Year	Discount Rate—2.50%	Discount Rate—3.0%	Discount Rate—5.0%	Discount Rate—7.0%
2010	0.087	0.121	0.372	0.642
2020	0.084	0.115	0.344	0.601
2030	0.080	0.108	0.312	0.555
2040	0.075	0.101	0.282	0.507
2050	0.071	0.093	0.251	0.455

FUND Model Probability of Negative SCC—ECS Distribution Updated in Accordance with Otto et al. (2013), End Year 2300

Year	Discount Rate—2.50%	Discount Rate—3.0%	Discount Rate—5.0%	Discount Rate—7.0%
2010	0.278	0.321	0.529	0.701
2020	0.268	0.306	0.496	0.661
2030	0.255	0.291	0.461	0.619
2040	0.244	0.274	0.425	0.571
2050	0.228	0.256	0.386	0.517

[11] Dayaratna and Kreutzer, "Unfounded FUND: Yet Another EPA Model Not Ready for the Big Game," and Dayaratna, McKitrick, and Kreutzer, "Empirically Constrained Climate Sensitivity and the Social Cost of Carbon."

FUND Model Probability of Negative SCC—ECS Distribution Updated in Accordance with Lewis (2013), End Year 2300

Year	Discount Rate—2.50%	Discount Rate—3.0%	Discount Rate—5.0%	Discount Rate—7.0%
2010	0.390	0.431	0.598	0.722
2020	0.375	0.411	0.565	0.685
2030	0.361	0.392	0.530	0.645
2040	0.344	0.371	0.491	0.598
2050	0.326	0.349	0.449	0.545

FUND Model Probability of Negative SCC—ECS Distribution Updated in Accordance with Lewis and Curry (2015), End Year 2300

Year	Discount Rate—2.50%	Discount Rate—3.0%	Discount Rate—5.0%	Discount Rate—7.0%
2010	0.416	0.450	0.601	0.730
2020	0.402	0.432	0.570	0.690
2030	0.388	0.414	0.536	0.646
2040	0.371	0.394	0.496	0.597
2050	0.354	0.372	0.456	0.542

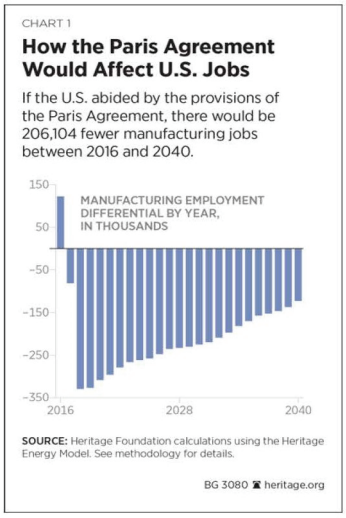
As the above statistics illustrate, under a very reasonable set of assumptions, the SCC is overwhelmingly likely to be negative, which would suggest the government should, in fact, subsidize (not limit) CO_2 emissions. Of course, we by no means use these results to suggest that the government should actually subsidize CO_2 emissions, but rather to illustrate the extreme sensitivity of these models to reasonable changes to assumptions and can thus be quite easily fixed by policy makers.

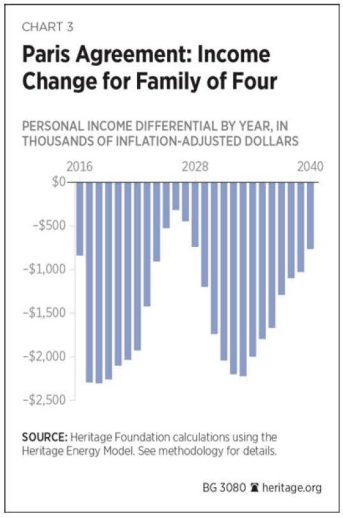
ECONOMIC IMPACT

In our research at The Heritage Foundation, we used the Heritage Energy Model, a clone of the Department of Energy's National Energy Modeling System to quantify the economic impact of both implementing further carbon-based regulations as well as repealing existing ones. One policy we analyzed was the Clean Power Plan, a policy initiated by the Obama administration to regulate carbon-based emissions. We found that by 2035, the policy would result in an average employment shortfall of over 70,000 lost jobs, a loss of income of more than $10,000 for a family of four, an up to 5 percent increase in household electricity expenditures, and an aggregate $1 trillion loss in gross domestic product (GDP). I discussed these facts during congressional testimony for the House, Sciences, and Technology Committee in June 2016.[12]

In addition, we also used the Heritage Energy Model to quantify the economic impact of the Paris Agreement on the American economy. In our research published in 2016, we found that the economic impacts would be quite devastating—in particular by 2035, the country would see an average employment shortfall of nearly 400,000 lost jobs, a loss of income of more than $20,000 for a family of four, an up to 20 percent increase in household electricity expenditures, and an aggregate $2.5 trillion loss in GDP.

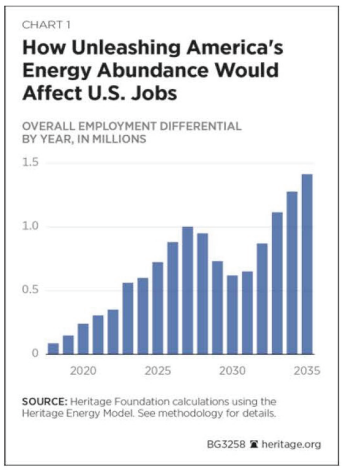
[12] Kevin D. Dayaratna, "The Economic Impact of the Clean Power Plan," testimony before the Committee on House, Science, and Technology, U.S. House of Representatives, June 24, 2015, https://www.heritage.org/testimony/the-economic-impact-the-clean-power-plan.

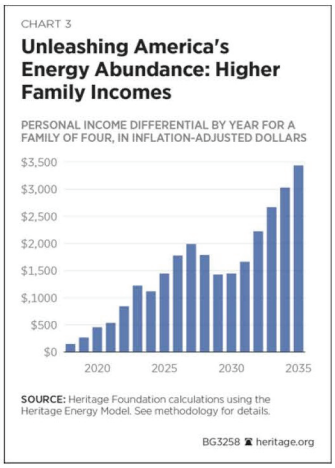




In other research at The Heritage Foundation, we considered the impact of taking advantage of the significant shale oil and gas supply available here in the United States. The Institute for Energy Research has noted that North America alone has over 1.4 trillion barrels of oil and 2.2 quadrillion cubic feet of natural gas. My colleagues and I have used the Heritage Energy Model to look into the impact of actually taking advantage of these resources. Our research found that if this vast supply were actually utilized that by 2035, the country would see an average employment gain of nearly 700,000 jobs, an increase in over $27,000 for a family of four, a marked reduction in household electricity expenditures, and an aggregate $2.4 trillion increase in GDP.[13]

[13] Kevin D. Dayaratna, Nicolas D. Loris, and David W. Kreutzer, "The Obama Administration's Climate Agenda: Will Hit Manufacturing Hard," Heritage Foundation *Backgrounder* No. 2990, November 13, 2014, http://www.heritage.org/research/reports/2014/11/the-obama-administrations-climate-agenda-underestimated-costs-and-exaggerated-benefits;
Kevin D. Dayaratna, Nicolas D. Loris, and David W. Kreutzer, "The Obama Administration's Climate Agenda: Underestimated Costs and Exaggerated Benefits," Heritage Foundation *Backgrounder* No. 2975, November 13, 2014, http://www.heritage.org/research/reports/2014/11/the-obama-administrations-climate-agenda-underestimated-costs-and-exaggerated-benefits;
Nicholas D. Loris, Kevin Dayaratna, and David W. Kreutzer, "EPA Power Plant Regulations: A Backdoor Energy Tax," Heritage Foundation *Backgrounder* No. 2863, December 5, 2013, http://www.heritage.org/research/reports/2013/12/epa-power-plant-regulations-a-backdoor-energy-tax; David W. Kreutzer, Nicholas D. Loris, and Kevin Dayaratna, "Cost of a Climate Policy: The Economic Impact of Obama's Climate Action Plan," Heritage Foundation *Issue Brief* No. 3978, June 27, 2013, http://www.heritage.org/research/reports/2013/06/climate-policy-economic-impact-and-cost-of-obama-s-climate-action-plan; David W. Kreutzer and Kevin Dayaratna, "Boxer-Sanders Carbon Tax: Economic Impact," Heritage Foundation *Issue Brief* No. 3905, April 11, 2013, http://www.heritage.org/research/reports/2013/04/boxer-sanders-carbon-tax-economic-impact; "Consequences of Paris Protocol: Devastating Economic Costs, Essentially Zero Environmental Benefits," Heritage Foundation *Report*, April 13, 2016, http://www.heritage.org/environment/report/consequences-paris-protocol-devastating-economic-costs-essentially-zero;
Institute for Energy Research, *North American Energy Inventory*, December 2011, https://www.instituteforenergyresearch.org/wp-content/uploads/2013/01/Energy-Inventory.pdf (accessed February 6, 2019); and Kevin Dayaratna and Nicholas Loris, "Turning America's Energy Abundance into Energy Dominance," Heritage Foundation *Report*, November 3, 2017, https://www.heritage.org/energy-economics/report/turning-americas-energy-abundance-energy-dominance.





NEGLIGIBLE ENVIRONMENTAL BENEFITS

In our research at The Heritage Foundation, we have also estimated the environmental impact of a number of pertinent policies using the Model for the Assessment of Greenhouse Gas Induced Climate Change. In one exercise, we simulated the impact of reducing CO_2 emissions in the United States by 80 percent. Assuming a climate sensitivity of 4.5 degrees Celsius, we found that by 2100, the earth would incur a temperature reduction of 0.135 degrees Celsius and 1.35 cm sea level rise reduction. In a second exercise, we simulated the impact of eliminating all CO_2 emissions from the United States completely. We found a similarly trifling change of 0.2-degree Celsius temperature reduction and 2 cm of sea level rise reduction. In a third exercise, we modeled the climate impact of taking advantage of the oil/gas resources discussed in Dayaratna et al. (2017). We again found a negligible impact of less than 0.003-degree Celsius change in temperature and 0.02 cm of sea level rise increase.[14]

CONCLUSIONS

Policies aimed at "decarbonizing" the American economy are predicated on faulty models that are prone to user-selected manipulation. These policies will raise the cost of energy, thus resulting in devastating economic impacts. On the other hand, policies that are aimed at taking advantage of fossil-based fuels have tremendous potential to grow the economy. And moreover, either policy—regulatory or deregulatory—will have negligible impact on the climate.

Mr. HUFFMAN. Thank you very much.

We will begin our questions now.

And I am reminded that here in the U.S. Congress we often hear lots of different perspectives and different interests put forward—folks to advance their perspectives, sometimes their agendas. And years ago, of course, we had scientists and doctors telling us that smoking was completely beneficial and maybe even good for you. Years later, I don't know where those doctors and scientists are or how they feel about what they said, but I think history has

[14] Kevin Dayaratna and Nicholas Loris, "Turning America's Energy Abundance into Energy Dominance," Heritage Foundation *Report*, November 3, 2017, https://www.heritage.org/energy-economics/report/turning-americas-energy-abundance-energy-dominance, and University Corporation for Atmospheric Research, "MAGICC/SCENGEN," http://www.cgd.ucar.edu/cas/wigley/magicc/ (accessed January 9, 2017).

rendered judgment on what they said. And I have to wonder if we haven't heard some similar testimony here today.

I want to ask several of the other witnesses about a couple of the claims that were just made, one being Dr. Legates saying that ocean acidification should cause lobsters to thrive. And that all sounds benign and great. We just heard, in fact, from Dr. Dayaratna that there could be all kinds of beneficial effects of increasing CO_2 levels in the atmosphere and that, in fact, there may even be an EPA model that points to all of this. And I am so glad we have a former administrator of the EPA to tell us about that.

So, why don't I start with you, Ms. Browner. Tell us about this model.

Ms. BROWNER. Well, thank you for the question, and thank you for your comments.

The model that I think the gentleman is referring to would have been developed after my tenure at EPA. But I think it is important to note that cost-benefit analyses are a tool that are frequently used in evaluating the impacts of regulations. And when I was at EPA in the 1990s, a long time ago, we did a lookback under the Clean Air Act of all of the regulations and what the costs had been with those regulations and what the benefits had been. And across the board, what we found is, the costs were lower than anticipated—industry, even EPA, got it wrong; they were lower, and the benefits were greater.

So, why is that? Because you cannot factor in American ingenuity and innovation. When you set a standard, when you adopt a regulation requiring CFCs to be replaced, you create a market opportunity, and the investments flow, and suddenly you have a replacement—faster, cheaper, more efficient than you had originally anticipated.

Similarly, the benefits, they are hard to measure at the starting point, but what you find is that putting scrubbers on coal-fired power plants will reduce the pollutant you were targeting but it will reduce other pollutants as well. So, the benefits grow.

So, across the board, what we saw is that regulations, properly done, that the cost-benefits done at the moment were not completely informed, because you couldn't be, but, in retrospect, the costs were lower and the benefits were greater of reducing pollution.

Mr. HUFFMAN. Ms. Casoni, how about from the perspective of the lobster industry? Surely, you have seen things happening with respect to acidification that maybe suggested lobster are not going to thrive, but I am sure you have also reached out to the best scientists on this subject because this is kind of an existential thing for you.

Ms. CASONI. Correct. Thank you, Mr. Chairman.

With all due respect, I am not a scientist, and I have been following ocean acidification for about 5 years. Congressman Keating held a panel at Woods Hole Oceanographic Institute in Falmouth. The highest level of scientists there studied ocean acidification for their careers. And they were focused primarily on scallops, and the scallops cannot reproduce their shells.

So, I asked a question of the panel. I said, what about the lobsters? And they kind of shrugged their shoulders and said, we

really haven't done a lot of research on lobsters, but they seemed OK. Big lobsters. It is the small lobsters, it is the larval, the sediment; that is the future stocks of the lobster industry.

It takes 8 years for a lobster to become harvestable, so we are talking about the eggs, the larval stages, the near-shore acidification where the waters are warming the fastest. The runoffs are having a severe impact on that. And through the state of Massachusetts and the region, they have what is called the Lobster Settlement Index. They are seeing less and less of the lobsters settling near shore.

So, that is the concern where we are seeing it. And without the future stocks, we don't know where the lobster industry will be in 8 years. I can come back and let you know.

Mr. HUFFMAN. Yes. Thank you.

Dr. Bronk, as an oceanographer and a scientist, do you see any beneficial effects of ocean acidification, CO_2 concentrations, and other impacts of climate change?

Dr. BRONK. Definitely not of ocean acidification.

And to comment on some of Dr. Legates' testimony, it is true that some of the early studies were done using acids that added more of an artifact into some of the findings. And it was the scientists themselves that in peer review got hammered by other scientists that said, this is not the way to do it. There was a whole community that got together to do best practices. And now we run experiments very differently, by doubling the atmosphere, which is much more realistic to what is happening.

And, in that case, Ms. Casoni is correct, it is the larval stages that are impacted. And it is definitely not good for shellfish, lobsters, corals.

Mr. HUFFMAN. Excellent. Thank you all very much.

By the way, I forgot to mention, as I thank the panel for their testimony, I need to remind you, the Members, that Committee Rule 3(d) imposes a 5-minute limit on questions.

The Chairman will now recognize the Ranking Member of the Full Committee, Mr. Bishop, I believe. Or are we going to go—we will go to Ranking Member McClintock.

Mr. MCCLINTOCK. Thank you, Mr. Chairman.

Dr. Legates, you are the only climatologist on the panel, and you are a pre-eminent one at that.

Let me first ask you to comment on the critiques of the studies that you have cited.

Dr. LEGATES. Some of this was work done by the University of North Carolina at Chapel Hill. And one of the things they did is they put blue crabs and lobsters into water with 400 parts per million of carbon dioxide, the others into 2,800 parts per million of carbon dioxide——

Mr. MCCLINTOCK. Is this the study where they actually doubled the——

Dr. LEGATES. They actually did, yes, and they found that they grew faster.

As I mentioned, it doesn't hold for every species. But the issue is that, in general, some species looked better, some species looked worse, and it is——

Mr. MCCLINTOCK. So, the lobsters actually looked better when they did the science correctly, used the atmospheric gases that Dr. Bronk mentioned, and discovered that lobsters grow faster, healthier, and stronger with higher concentrations. Is that what you are saying?

Dr. LEGATES. Yes.

Mr. MCCLINTOCK. OK. And with respect to the dissolving of the clam shells?

Dr. LEGATES. Well, yes, calcium-carbonated shells. That was the original argument that was made, that, essentially, if you increased acidification, it would cause them all to disintegrate.

Mr. MCCLINTOCK. And they simply got the chemistry wrong.

Dr. LEGATES. And they found that that is not necessarily the case. Yes.

Mr. MCCLINTOCK. You know, the thing we hear all the time is, "Oh, all the scientists agree," and yet here you are, a former climatologist with the state of Delaware. We heard from Judith Curry yesterday in the Full Committee, a former chair of the School of Earth & Atmospheric Sciences at Georgia Institute of Technology. I read the work of Roy Spencer and John Christy, who pioneered satellite sensing global climate; Fred Singer, former Director of the U.S. National Weather Satellite Service; Freeman Dyson, often referred to as Einstein's successor at Princeton.

They are all telling us what you are telling us, and that is that this is not unusual and that there is still a great debate going on over the extent of human contributions to the climate issues, to the powerful natural forces that have driven it for millennia. Can you shed some light on this?

Dr. LEGATES. Yes. I mean, I don't have enough time to do it, but the argument is that carbon dioxide is not this magic knob that decides the temperature of the planet. In particular, there are an awful lot of other things that happen. The planet does not warm like a greenhouse. That is simply pure radiation balance. But essentially the atmosphere moves, and we have vertical convection, we have horizontal convection.

There are a lot of other processes that go on that I talk about in my Intro to Physical Climatology class that are more complicated than just simply the——

Mr. MCCLINTOCK. Let me ask you the same question I asked Dr. Curry yesterday. Are we experiencing the highest temperatures in the planet's history?

Dr. LEGATES. The planet's history? No. Probably over the last 150 years, yes. But that has little to do with carbon dioxide. It has to do with the demise of the Little Ice Age and warming conditions we have had due to an increasing sun.

Mr. MCCLINTOCK. Are we experiencing the highest levels of atmospheric carbon dioxide in the planet's history?

Dr. LEGATES. No, not in the planet's history.

Mr. MCCLINTOCK. Are we experiencing the worst droughts in recorded history?

Dr. LEGATES. No, we are not.

Mr. MCCLINTOCK. Are we experiencing the most ferocious hurricanes in recorded history?

Dr. LEGATES. No, we are not.

Mr. MCCLINTOCK. Over the last 30 years have our actual climate observations tracked with the predictions that were made by the IPCC and folks like James Hansen?

Dr. LEGATES. This generally gets into a discussion of climate sensitivity, and most models are tuned to have a sensitivity of somewhere between 2½ and maybe 3½ degrees Celsius warming for doubling of carbon dioxide.

Generally what we found and what a lot of other people have found more recently is that number is very high, probably on the order of about 1 degree Celsius per doubling. That is why the models have tended to show warming that is much greater than we have actually seen in the observations.

Mr. MCCLINTOCK. Dr. Dayaratna, you have studied the economics of the situation. I am sure you have looked at the Green New Deal. Again, just in layman's terms, what is that going to cost an average working family in America and what is it going to get us?

Dr. DAYARATNA. We haven't specifically modeled the Green New Deal yet, but we have modeled very similar carbon capture/carbon reduction policies. For example, the economic impact of the Paris Agreement—I think we are running out of time, so I won't show the slide—but we noticed that over the next 20 years there would be, using the heterogeneity model, an average employment shortfall of over 400,000 lost jobs, a loss of income of over $20,000 for a family of four, an up to 20 percent increase in household electricity expenditures, and an overall $2.5 trillion loss in GDP—all, again, for negligible changes in the climate.

Mr. MCCLINTOCK. And what do we get for all of that according to the climate models?

Dr. DAYARATNA. Less than 0.2 Celsius degrees temperature reduction, and about less than 2 centimeters of sea level rise reduction.

Mr. MCCLINTOCK. Over what period?

Dr. LEGATES. In 2100.

Mr. HUFFMAN. All right. Thank you.

Mr. Levin is recognized.

Mr. LEVIN. Thank you, Chair Huffman. I appreciate you holding this hearing.

Thank you to our witnesses for taking the time to join our Subcommittee today.

Yesterday, I was very pleased to participate in our Full Committee hearing highlighting the urgent challenge climate change presents. And I think Chair Grijalva, it was the first committee on climate change we have had in about 6 or 8 years. Long overdue.

I think the testimony from our witnesses yesterday and today was overwhelmingly conclusive that climate change is driven by human activity and that Congress cannot waste any more time with inaction. Otherwise, the consequences for our communities and planet will be devastating.

Today's focus on the state of our oceans is critical, particularly critical to me because my district in southern California, in northern San Diego County and South Orange County, has more than 50 miles of coastline. And my constituents are dealing with

the impacts of climate change every day. It is not some theoretical concept for them.

Already cliff erosion driven by sea level rise and wave energy is posing a public safety hazard to my constituents. In fact, the U.S. Geological Survey last year projected even higher levels of climate change-driven coastal erosion in San Diego and Orange Counties over the next century. And just a couple days ago there was an article in the Orange County Register, a historically very conservative paper, about coastal erosion in our beach communities in Orange County.

And in South Orange county towns, like San Clemente and Dana Point, stronger storms influenced by climate change are literally washing away our beaches. We have seen a sea wall crumble, coastal trees topple over. In many cases they have been there for decades or even close to a century. Orange County now even plans to demolish public basketball courts and restrooms on the beach that are no longer safe to use.

It is clear something is not normal about all of this. And I think it is important that our Subcommittee continue to explore these climate challenges that directly impact our coastal communities.

I would like to turn to a couple of questions.

Specifically to Dr. Dayaratna, did I get your name correct?

Dr. DAYARATNA. Yes.

Mr. LEVIN. In your testimony, which I read, you discuss the social costs of carbon at length. I believe you refer to it as the negative social cost of carbon. And you say that at the Heritage Foundation you used the same data that the Obama administration used for its social cost of carbon calculation, presumably that the EPA uses and other agencies use. Obviously, you came to a very different conclusion.

You also claim that the Federal Government manipulated the data to support, as you say, a regulatory agenda, implying an obvious bias, at least in your opinion.

I will remind you that the Environmental Protection Agency was created under President Richard Nixon and that the Clean Air Act and Clean Water Act enjoyed broad bipartisan support, near unanimous support.

The agenda, and I have known people from the EPA in past administrations, both Republican and Democratic—their agenda, at least their original agenda as intended from President Nixon and both the Democrats and Republicans who supported the Clean Air Act and the Clean Water Act at the time, was simply to protect human health and the environment.

On the other hand, Dr. Dayaratna, I find your agenda perhaps a bit more suspect. So, please answer yes or no, just yes or no. Do studies funded by fossil fuel money have an agenda?

Dr. DAYARATNA. I am sorry, Congressman. I cannot answer that question because that has nothing to do with my research, so——

Mr. LEVIN. I think it is clear your organization has an agenda.

Dr. DAYARATNA. Congressman, our financial records are available online. You can go to www.heritage.org and look them up.

Mr. LEVIN. I have researched them. I have researched them extensively, as a matter of fact.

Dr. DAYARATNA. You can look at them all you want. I encourage you to get to the meat at hand, which is what these policies——

Mr. LEVIN. I encourage you to answer my question, sir. Does your organization have an agenda?

Dr. DAYARATNA. Does my organization have an agenda?

Mr. LEVIN. Yes, and specifically your conclusions, are they based on objective evidence or perhaps an agenda funded by fossil fuel money.

Dr. DAYARATNA. Congressman, I am an independent scholar within the Heritage Foundation, and my work can be scrutinized. It has been published both in Heritage, as well as——

Mr. LEVIN. If you follow the money it is clear, Doctor, that you have an obvious, blatant agenda.

Dr. DAYARATNA. I have no agenda besides doing high quality research.

Mr. LEVIN. And yet the decades of experienced people before you at the EPA who used that very same data to calculate a true social cost of carbon reached an entirely different conclusion, including one of our past administrators of the EPA, who I beg will differ with you, sir, and your false conclusion. Thank you.

Dr. DAYARATNA. Congressman, if you look at the assumptions that they make——

Mr. LEVIN. I yield my time.

Mr. HUFFMAN. Thank you.

Mr. Lamborn is recognized.

Mr. LAMBORN. Thank you. Thank you for having this hearing.

I am going to try to stick to the issues and policies and facts, not personalities. And I would like to stick to the solutions that are being proposed. And one solution that is being proposed we heard about today, we heard about today at 12:30, there was a big press release. And we all got our first chance to see what Speaker Nancy Pelosi calls the Green Dream. But instead of a dream the Green New Deal looks more like a nightmare.

This non-binding resolution makes grandiose and socialistic promises of jobs for everyone, free college, and prosperity, but at the same time it calls for policies that will actually bankrupt our economy and destroy jobs.

The Green New Deal includes a proposal to move 100 percent of U.S. electricity production to renewable resources by 2030, 11 years from now. The numbers are being worked on, but it seems that it will require at least $5 trillion of investments in renewable energy and storage and will have a transition cost of $13 trillion over a 10-year period. It will eliminate 88 percent of our current energy sources and about 6 million jobs.

So, here are some facts on transportation and electricity, and I am going to leave aside heating, winter heating and manufacturing and other uses of energy.

For transportation, Americans own roughly 250 million cars and trucks, and they drive 11 billion miles a day—a day. The vast majority of these cars and trucks are powered by gasoline and diesel. How will we replace that in 11 years?

There are 30,000 commercial aviation flights a day in the United States, and these are all powered by jet fuel. How will we replace that in 11 years?

With electricity, 82 percent of U.S. electricity is generated by coal, natural gas, and nuclear energy. The remainder is hydropower, about 7 percent, wind 8 percent, and solar 2 percent.

So, to meet the need for electricity that is currently provided by hydrocarbons and nuclear would require, if you want to go to wind turbines—I will leave aside solar panels for a moment—but the wind turbines you would need because you can't put them right next to each other, they have to have some space between each other, you would need an area twice the size the state of California. OK, where are we going to put those?

So, Dr. Dayaratna, if we go to 100 percent renewable there is a cost involved. Electricity is going to go up, just electricity. And I know this is a big range. I hope people keep working on these numbers and we will refine this. But right now the range is, with an average electrical bill in the country of $111 per household nationwide, of between $576 and $3,882 per family per year.

What kind of impact will that have, maybe not on the middle class or upper class, but on working class and poor Americans, elderly people on a fixed income?

Dr. DAYARATNA. OK. I am sorry, Congressman, that statistic you cited was regarding electricity?

Mr. LAMBORN. Electricity alone.

Dr. DAYARATNA. Yes, well, that is a great question, Congressman. The fundamental issue is, yes, obviously household electricity expenditures are going to go up, and that is another thing that families are going to have to deal with, but when you think about it, like I said, energy is the most fundamental building block of society. So, costs regarding everything will go up, costs of hiring are going to go up, costs of transportation are going to go up. It is going to be more expensive for businesses to hire. Jobs will decline. The economy will suffer overall. And hundreds upon thousands of jobs will be lost as a result of these policies at this moment.

Mr. LAMBORN. Are there other social or economic impacts of a proposal such as the Green New Deal?

Dr. DAYARATNA. The biggest issue is that these policies are going to kill jobs, destroy the economy in many regards, and they will only have a negligible impact on the climate. These policies will not meaningfully impact the climate. So, when you really think about the cost-benefit analysis there are significant costs, and the benefits are basically minuscule.

Mr. LAMBORN. OK. Thank you very much, Mr. Chairman. I yield back.

Mr. HUFFMAN. Thanks. I do want to remind Members that this hearing is about the health of our oceans.

And with that, I recognize Mr. Lowenthal.

Mr. LOWENTHAL. Thank you. And thank you, Chair Huffman, for this important hearing.

And thank you to all the panelists.

This hearing, getting back to the oceans and to water, comes on the heels of new and unprecedented melting in Antarctica and in the Himalayas that we have just heard, I mean staggering.

I had the good fortune of being on a Congressional Delegation to Tibet and the Himalayas and to see the potential impacts on the

rivers. This is going to create chaos in all of Asia in terms of drinking water in Asia. This is unbelievable magnitude.

I was also recently on a National Graphic exploratory to Antarctica and visited with naturalists, and was shocked by what I learned was happening in Antarctica.

So, we are experiencing this crisis that I am going ask some questions, and we are not doing anything about this impact really on oceans.

In the State of the Union address, the President did not mention climate change at all, it was just completely ignored, which is totally unacceptable. If we are having any kind of national emergency, it is climate change. It is not our Southern border.

We are all accountable. I am not blaming the President at all. We are all accountable and we are all responsible for what is happening to the planet and what impacts it is having on our oceans and our water supply. And that is the reason why I mentioned the Himalayas and also Antarctica.

Dr. Bronk, in your written testimony you mention that the magnitude of sea level rise, as I have it, depends upon the amounts of ice sheets and glacier melts in Greenland and in Antarctica. As I just pointed out, just last month a new study came out that is showing that there is a huge cavity now under a glacier, under the glaciers in the west Antarctica that is of major concern to scientists studying the rate at which Antarctica glaciers are melting.

And it was shocking listening to the people, the percentage of the world, the planet's water that is in Antarctica, that some of the glaciers are 800 million years of age, and they are melting at a much faster rate than we thought before.

Can you explain why scientists are so alarmed by the rapid melting of these glaciers in Antarctica now, what that means to sea level rise that is going to happen, and how it will impact the already existing that we have talked about from Arctic and other causes of sea level rise?

Dr. BRONK. All right. So, both the ice that is on the land in Antarctica and on the land in Greenland, when that melts that will flow into the ocean and it will increase sea level rise. I am not an expert on glaciers, but my understanding is that there is a grounding area where the glacier is actually held back from going into the ocean. And what has been discovered over the last decade is that ocean water will erode underneath it, and it basically creates a skid that makes the glaciers move faster. And this is what seems to be happening especially in Greenland, and now we are discovering it also in Antarctica. And the idea behind it is just going to move things up. And the question is, are we going to reach a tipping point where we are not going to be able to stop it?

Mr. LOWENTHAL. The same thing with the Himalayas, which are going to have a tremendous impact on the water supply of all of Asia.

Dr. BRONK. Of all of Asia, correct.

And, yes, so that is basically my understanding of the glaciers. Once you start eroding underneath and kind of greasing the glacier from the bottom, and we have known it has been happening for about a decade in Greenland, and now we are seeing it in Antarctica.

Mr. LOWENTHAL. And I was told in Antarctica that almost 80 percent of the world's water supply is there in Antarctica. So, this is of a magnitude that we did not understand before and now see, because we thought more of it was happening in Greenland and the Arctic, now we are seeing the great vast amounts of water.

Dr. BRONK. And I believe that if the ice sheets that people are most worried about in Antarctica, if they were to flow into the ocean and melt, we are talking about a 21-feet increase.

Mr. LOWENTHAL. That is what they were talking about.

Dr. BRONK. Yes.

Mr. LOWENTHAL. If anybody else wants to comment on an event.

Recently in my district we had a meeting of homeowners, because I am a coastal district, where the executive director of our aquarium talked to everybody and said all along the coastal region, which is very expensive homes, sometimes we think the most impact will be on less expensive, but this is along the peninsula and Venice and Belmont Shore, those that know Southern California, these are beautiful, that they all better have an exit strategy because it is coming, flooding is coming, and the ability to live in those areas is coming down the road.

And they had never—they kept asking, well, isn't climate change, can't we stop it? And there are things we can do, which we must do. But economically the impacts of climate change will totally overwhelm the impacts of what else we are doing.

So, thank you.

Mr. HUFFMAN. Thank you, Mr. Lowenthal.

Mr. Bishop is recognized for 5 minutes.

Mr. BISHOP. That is 5 minutes, wasn't it? OK. Good.

I appreciate the opportunity to be here and listening to all the good science that we have heard from all over the place. And having experienced that now, I want you to know that never in my life have I been so grateful that I was a liberal arts major. I don't know what the hell you all are talking about, but it sounds really nice.

And for Mr. Grijalva, I have been practicing. As I have walked around today I have been chewing gum hopefully to get ready for this so I can illustrate the solutions you are going to be presenting. So far I have just wasted of a pack of gum, but I am still trying. I will still work with you. As soon as we come up with that it is going to be exciting.

Mr. Dayaratna, I am really happy to see you here again. You have been a witness before in this Committee on those meetings apparently we never had, but for some reason you were here testifying, so thank you for that, in the last couple of years.

I am interested that both of you were talking in some respect about, as we do all the modeling that we come up with, obviously the important criteria is the assumptions that are made.

Dr. DAYARATNA. Oh, absolutely.

Mr. BISHOP. So, you change the assumptions, then you change the outcome. So, that becomes the significant one.

Dr. DAYARATNA. Exactly.

Mr. BISHOP. I am interested in the idea that energy which is a cost, and energy which is a concept we don't actually quantify very well. If the cost of that energy increases, is it the lowest income people that are hurt the most in our society?

Dr. DAYARATNA. Absolutely. Yes, these policies are going to impoverish lower income people and hurt them the most.

Mr. BISHOP. Like yesterday, when I was forced to leave because I had work to do, Democrats suggested that innovation is not the answer.

So, I want to know from both of you, if you would, if you have any thoughts about pragmatic solutions that are within the jurisdiction of this Committee that we can do. We have proposed in the past that active forest management actually has a positive impact on the environment, that grazing and sequestration can have a positive impact on the environment, that hydropower, water storage, could have a positive impact.

Have you seen any of these concepts that really are the purview of this Committee being integrated in the proposals that have been set forth by the other party yet?

Dr. DAYARATNA. I have not, but those policies would not have the economic impacts that these other things that I have heard about today such as the Green New Deal and other policies would have on the economy, and they do have the capacity to reduce carbon dioxide emissions. Yes.

Mr. BISHOP. So, it could still be one of those things that pragmatically we could actually do if we were to further those efforts we have started in the past?

Dr. DAYARATNA. Quite possibly, yes.

Mr. BISHOP. Dr. Legates, if I could just yield to you. Look, I have 2 minutes, do only a minute in the answer. But it was brought up about the melting of Antarctica, for which I do not know much. Can you just tell me very briefly about what is causing that, if there is something that can be actually——

Dr. LEGATES. Well, part of the discussion that comes with the east Antarctica ice sheet is that the east Antarctica sheet is actually growing in mass. The west Antarctic ice sheet is losing mass. And part of the concern is whether or not there is tectonic activity underneath that is leading to a heating from below, which is causing it to move.

I will point out that essentially we are not at equilibrium anyway. That is, if I were to take an ice cube and place it here in the room during the time period of this hearing that ice cube would continue to melt even though the room's temperature didn't change. I mean, that is why we have seen sea level rising essentially since the demise of the last ice age and it has been rather continuous over the last several hundred years. So, it is because we haven't reached equilibrium, which is why we are seeing sea level rise.

Mr. BISHOP. I appreciate that. I appreciate you doing it within the 1 minute.

Let me actually make up for some others and yield back faster than I could. I do have one unanimous consent request. And also I am going to be looking forward to the "so what" phase when we get there on what solutions actually will be proposed in here which will be a much more meaningful discussion at that point in the game.

But, Mr. Chairman, Mr. Chair, I am going to ask unanimous consent to enter into the record a study from the Journal of

Agricultural Economics, from the journal, Agriculture, Ecosystems, and Environment, titled "Grazing management impacts on vegetation, soil biota and soil chemical, physical and hydrological properties in tall grass prairie."

And if that doesn't put you all to sleep, nothing else will. It is a wonderful title. It is a long article. But actually it has some data that is useful.

Mr. HUFFMAN. Without objection.

Thank you, Mr. Bishop. And I am going take your testimony as an invitation to co-sponsor the bills that I have on all the issues you walked through in this Congress. So, we are off to a great collaborative start.

Mr. BISHOP. And if they are good bills then I will be happy to do that. Otherwise I will save the ink.

Mr. HUFFMAN. Mr. Van Drew, you are recognized.

Mr. VAN DREW. Thank you, Chairman.

First of all, let me congratulate the Chairman on holding these hearings and also ensuring that there is a Minority and a Majority viewpoint. I think that helps a lot in the future as we all deal with each other. We really are all in this together. I know many of us think we are not, but we are, so I think that is a good thing.

I am from New Jersey, coastal New Jersey, Cape May County, which is considered the fifth most vulnerable place during an evacuation literally in the East Coast and maybe the United States of America. This is an issue between the Delaware Bay and the Atlantic Ocean and the whole area that concerns me a great deal.

And the second thing I wanted to say that I really appreciated on everybody's part, I deal with a lot of fishermen, always did. I was a State Senator before. I really appreciate that people generally understand that the majority of fishermen are not individuals who want to hurt the ocean, that they really do realize in order for their lives to go forward there has to be fish. So, they are really concerned.

And I will say, third, that I have spoken to a lot of them, I do all the time, and they have noticed that there are different fish that are coming in different areas of the ocean as we speak.

The part that has always been complicated for me with this is, whether it is RGGI or whether it is many of the other programs or policies that we can have, how is the United States going to be able on its own to be able to make a tangible impact for those that do believe in global warming when so much of the world doesn't care? For those that believe it, how are you going to do it? China doesn't care, Russia doesn't care, a lot of Asia doesn't care.

So, I wonder how are we really going to be able to effect real change even if you do believe it? Anybody have thoughts, any of you, on that? We are such a small part of the globe relatively.

Ms. BROWNER. Right, but we have a long history, and so I think many of us would believe that we have a responsibility that we have to provide global leadership. And under the prior administration, which I was honored to be part of, we were doing just that. We were working with other countries around the world, working in global forums to craft solutions, while also doing the work we needed to do here at home, whether it was working with the car industry to agree on a program to bring cleaner, more efficient

cars, which means a tank of gas would go further, saving people money at the tank, our children would breathe easier. So, it is a combination.

Mr. VAN DREW. And it is, and those things are good and I agree with you, and we certainly did the right thing. The problem now is that, for example, China is burning coal. I mean, we are talking about many steps beyond that.

So, I would just like to express my one concern—I am concerned of how we even get it done, period. I know we can help, I know we can make things a little better, but this is going to be a very huge challenge.

The second issue I have—and I know these are kind of tough questions and I don't mean to put anybody on the spot, and I really do respect all of you a lot for being here—why is it now being scientists or some of you being scientists that you do disagree? Why do you disagree?

I mean, this is a major difference. I am a dentist, which is kind of a little bit like being a scientist, and a cavity is a cavity. It is just there. And there are only so many ways to fill it.

Dr. BRONK. I think the degree of disagreement is vastly overstated here. To put it bluntly, you can find a scientist that will say just about anything you want them to say.

I would look at the consensus documents. For a scientist to agree on anything, you can get six of them to agree to go to the restaurant, one of them needs to pick one. We argue by nature. The fact that there are thousands of scientists that have reached consensus on documents around the world, that is what we should be paying attention to. Of course you are going to find people that are going to have other agendas.

Mr. VAN DREW. Would you say that literally it is 90 percent?

Dr. BRONK. It is more than that.

Mr. VAN DREW. Ninety-nine percent?

Dr. BRONK. It is more than that. And I would also—for all of you, when you are looking at the kind of written statements that people had to submit here, what are they referencing, what are they citing? Are they citing themselves? Are they citing their own testimony? Are they citing peer-reviewed literature, and not journals that didn't exist 5 years ago? Where are they publishing in the journals that were here 100 years ago?

Mr. VAN DREW. Last real quick question, and I don't mean to rush you, it was a good answer, it is just that I am out of time.

Do you think—and it alludes to the other question I had—even if we do these things—two things: Do you think we can do it without really hurting the economy and making sure that people of lower socioeconomics aren't hurt? And second, do you think we can really make a major difference, a major difference worldwide, globally?

Mr. HUFFMAN. A little question, in 30 seconds.

Ms. CHALK. Congressman, I am sorry. I would like to add that it is the real people in south Louisiana that are starting to make the change. And once we begin to educate residents around this issue people can make informed decisions based on the best science, based on the reality that we are living, because we are living this every day.

So, no matter what the scientists may say, I beg to differ, because we are living and we are seeing it. We are seeing our vanishing coastline and communities moving. We are seeing the population shift. So, I would say visit us.

Mr. VAN DREW. Oh, believe me, I see it in New Jersey. I live 2 miles from the beach, so I know.

Thank you all very much.

Mr. HUFFMAN. Thank you, Mr. Van Drew.

Mr. Graves is next.

And Mr. Graves, I am sorry, when I introduced Ms. Chalk earlier I looked over to see if—I thought there might be some southern Louisiana greeting you might want to offer. But it is your turn now, so you are recognized for 5 minutes.

Mr. GRAVES. Ayeee, there we go.

Ms. CHALK. Ayeee.

Mr. GRAVES. We are done.

Hey, thank you all very much for being here, and I enjoyed your testimony.

Queen Quet and Ms. Chalk, I enjoyed the fact that each of you put a lot of emphasis on community and culture. And being from south Louisiana, which I share with Ms. Chalk, I think that Louisiana has—south Louisiana has amazing people, amazing culture, amazing food, amazing music.

And I can't tell you how much I appreciate somebody else walking into this Committee to talk about south Louisiana because every single one of those people are so sick of hearing me talk about it and talking about the land loss. So, I was telling the truth. We have other people that believe it.

But also you put a face on it. And I do appreciate that. South Louisiana has lost 2,000 square miles, and it is really extraordinary, and it is losing communities, it is losing people. Isle de Jean Charles, one of our native communities down there, is effectively having to leave, and they have been around there for 300 years.

So, yes, this is something that is today, that is now, that your community is facing, that our community is facing, and it is awful. It is. It is awful.

One thing that I think we can agree upon, Mr. Chairman, is that I do believe that the climate is changing, and I think I have said that at virtually every hearing we have had where climate has been discussed.

Number 2, I believe that we need to be focusing, right now, on adaptation measures and figure out how to protect Queen Quet's community, how to protect the community where Ms. Chalk lives, where my family lives, where 2-plus million people in south Louisiana live.

And I know, Mr. Cunningham, I have been to your district and have seen some of the challenges with sustainability you have over there as well, and I think that is an area where we need to all be focusing.

Ms. Browner, you noted that you think we need more funds invested in ecological restoration. I agree with you. And it is something we have been battling to try to address now for many years, including in this Committee, and I have expressed much frustra-

tion whenever this very Committee has tried to cut ecological restoration for south Louisiana or the various administrations have, because here we have wetlands laws protecting our wetlands at the same time we have lost 2,000 square miles in south Louisiana, and I think it is wrong.

There was a dialogue that I watched from the anteroom that I will tell you I was disturbed by. There was a line brought up—and I am not going to try to pronounce your name because you are not going to even know I am even talking to you. Help me out pronouncing your name.

Dr. DAYARATNA. Dayaratna.

Mr. GRAVES. Dayaratna. If I would have tried, you wouldn't have known I was talking to you.

Dr. Dayaratna, I want to ask you a question, yes or no. Is every member on this panel right now, did we receive contributions? Every member on this panel.

Dr. DAYARATNA. I am sorry, receive contributions?

Mr. GRAVES. Did we receive campaign contributions, every Member on this panel?

Dr. DAYARATNA. Can you receive campaign contributions?

Mr. GRAVES. Did we, have we, do you think we received campaign contributions to be elected?

Dr. DAYARATNA. I would assume so.

Mr. GRAVES. That would be a yes. That would be a yes. And I will tell you, I was a little offended by the suggestion that anybody who has received a contribution suddenly has been bought in regard to an agenda. That offended me. That is not how I do business, and I don't think that is how people on this panel do business. And I want to apologize to you because I didn't think that was fair to you to make that suggestion.

Dr. DAYARATNA. Thank you.

Mr. GRAVES. Look, let's all be clear, there are people that do, but I don't think it is fair to have a default position that everyone who has accepted a contribution has been bought or then takes that agenda and moves forward, and I want to make note that the questioner in that case has received I think it is over $6.5 million in contributions, and I hope we have an opportunity to be a little more fair with that in the future.

Last, Dr. Legates, could you very quickly, there were questions brought up earlier about the relationship between ocean warming and hurricanes and tropical activities. I am from south Louisiana where we experience more than our share of those. IPCC, as I believe, has assigned low confidence. Could you expand on that, please?

Dr. LEGATES. Yes. Warmer waters do provide the energy. I mean, hurricanes are latent heat engines. They run off the fact that you have evaporating water, then the energy condenses, and you get the energy back into the atmosphere.

But the issue happens to be that there is an awful lot more to hurricane formation than simply water temperature underneath. Particularly, one of the important components is wind shear. What you need for that is the hurricane to develop vertically.

So, if you have a lot of wind shear, which simply means winds moving at different speeds at different levels, then as the air starts

to rise it literally gets shifted and moved over or shorn apart, and so the storm doesn't develop.

So, a lot of cases we see where we have very warm water, we have no hurricane development, simply because the wind shear keeps that from happening. There are a lot more ingredients in the hurricane formation.

Mr. GRAVES. Thank you.

If you can just very quickly, Ms. Quet, Queen Quet, I did an amendment in this Committee a few months ago trying to designate Cajuns as endangered species. I am trying to get endangered species protection. Perhaps we can do your folks, as well, and Congressman Cunningham and I can work on that.

But seriously, I appreciate you all being here, and I am looking forward to working with all of you.

Ms. GOODWINE. And I would appreciate you doing that today. Thank you.

Mr. HUFFMAN. Thank you.

Mr. Cunningham is recognized.

Mr. CUNNINGHAM. Thank you, Mr. Chairman.

As you may know, protecting the coast of South Carolina from offshore drilling has been——

Mr. HUFFMAN. Mr. Cunningham, would you indulge me? I will restore your time. I forgot I was supposed to tell the witnesses that if anybody has to catch a flight, because I know we are running late, we won't hold that against you and we will understand.

Otherwise, let's give Mr. Cunningham a full 5 minutes, and I apologize for the interruption.

Mr. CUNNINGHAM. I appreciate it, Mr. Chairman.

As you may know, protecting South Carolina's coast has been my Number 1 priority, especially protecting the coastline from offshore drilling. It is one of the reasons my constituents in the 1st Congressional District sent me here, and it is a commitment that I intend to honor. It is why on the very first full week of being on the job, I introduced the Coastal Economy Protection Act, which would put into effect a 10-year moratorium on oil and gas preleasing, leasing, and related activities on the Outer Continental Shelf, and that includes the North Atlantic, Mid Atlantic, South Atlantic, and the Straits of Florida planning areas, and in the Eastern Gulf of Mexico.

Our oceans are at an increasing risk from the impacts of climate change. We have heard the testimony here today from warming waters, and we see those impacts in South Carolina. We see hurricanes intensifying and presenting a more clear and present danger. Climate change is an immediate threat. It is the greatest nonmilitary threat to our world, and we have to take it seriously. And I appreciate each and every one of you all taking the time to provide testimony here today, because we realize what is at stake, and not just the beautiful beaches, but also our culture.

And I appreciate Queen Quet coming up here and to testify as to that and the Gullah Geechee corridor and making sure that corridor is preserved beyond 2021, 2022, which we will talk about at a later date. But, Queen Quet, I wanted to give you an opportunity to educate the rest of the Committee as to the Gullah Geechee culture, why it has such an impact on South Carolina and our

region and why it is of the utmost importance that that culture be preserved and how intertwined culture and the oceans are and the impact of climate change and what you would suggest that this Committee do to take its first step in addressing that.

Ms. GOODWINE. Thank you. Thank you greatly for all the work you have done in a short period of time that you have been seated here up the Hill from the low country, all right, because we come from the flat area, you know that. One of the things that is so powerful in what you asked about is how to deal with climate change and deal with culture, and I think it is important for this Committee and all of the policy setters, not just in the United States, but around the world to calculate cultural heritage. You can't.

I am a mathematician and computer scientist by degree. You cannot actually calculate the cost of the loss of all the cultures that are the communities that are along these coasts. We have heard all the different percentages of how many communities of the world, how much coastline of the world is part of what feeds the rest of the world. Eighty percent of the country is being fed from these coastal communities. So, if we don't listen to the people who live on the land, live from the water, live in the water about how they sustain themselves, we won't be able to form the right policies, whether we are dealing with resilience, sustainability, climate change, sea level rise or any of these things.

We formed the Gullah Geechee Sustainability Think Tank 8 years ago to start to look at a lot of these issues before there were even some of the scientific data that we have been talking about today, because we knew Gullah Geechee culture would not continue to thrive or survive if we get displaced from the sea islands.

So, it is critical to us that this Committee start to look at, where is the money? I have heard that term in this room today, follow the money. Well, follow the money because it proves what you truly are vested in and investing in. And I believe that if we put the money back directly in the hands and the pockets of the people literally living on the shorelines, it can make all the difference in the world because when you take the leelee children like Alicia, and you teach them about the water from that age, they will be just like me when they get older. They will realize the value of the coast and what they need to do as individuals and what they shouldn't do as individuals, so that collective consciousness will continue to move this whole process forward and be able to reverse a lot of what we did when we didn't know any better.

I think that we need to invest more in citizen science. We need to invest directly in the cultural communities and the people there instead of consultants that fly in from elsewhere and parachute in, then parachute out and just write a paper and make a PowerPoint about us, while we are still there trying to yet hold on. I think it is critical that we work together, and that is why I said what I said earlier, that we need to make this a culturally relevant discussion, because there are things that we know from over 400 years on the sea islands that nobody else knows, and now everyone in the scientific world is looking at us saying, hey, maybe they had something that we all need to know because they are still there, and they don't leave when they say evacuate, and we the Beenyas and

we still ain't going nowhere until we told. And I'm going to be there when you get home.

Mr. CUNNINGHAM. I appreciate Queen Quet and educating people both in the Beenyas and the Comeyas on the different types of cultures that make the low country a special place to live. And I want to thank the rest of the panel as well and everyone who put the time and effort to get here to educate me.

I yield back the remainder of my time.

Mr. HUFFMAN. Thank, you Mr. Cunningham.

Ms. Velázquez, you are recognized. Thanks for your patience.

Ms. VELÁZQUEZ. Thank you very much, Mr. Chairman. And thank you so much both Mr. Grijalva, our Chairman, and you for holding this important hearing. It is important to me because I am a Member of Congress who happens to be Puerto Rican American, and we all know what happened in Puerto Rico.

I would like to ask whether or not you see a correlation between Hurricane Maria, Harvey, Irma, all of them happening in 1 year? And it is not only that there were three, but the force, Category 4 and 5. Do you think there is a correlation between the fact that Earth experienced one of the warmest years ever recorded and the number of hurricanes Category 4 and 5?

Dr. BRONK. I will take this. The hurricanes are difficult in terms of getting—because they are so sporadic, so in terms of the IPCC, there is not solid evidence, strong evidence to suggest that there is a link with climate warming in terms of the force of the hurricanes. What we are finding is evidence that because the ocean is warming, evaporation is greater, there is more moisture in the air, there is more precipitation coming from the hurricanes. But right now, we can't say necessarily that global warming is dramatically increasing the strength of hurricanes, but they are making it more devastating in terms of the precipitation they bring. And it may be quite a while before we will see anything like that because they are so sporadic to begin with, but warmer ocean water is what powers hurricanes.

Ms. VELÁZQUEZ. I would like to borrow something from the Republican playbook today, and that is quite weird for me, but they always say that localities, local communities, they know better. And when you look at how public sentiment is changing among people in this country regarding climate change, there is this collective awareness from Florida to New York, Louisiana, everywhere in our country, farming, agriculture, all those communities that think that there is something that must be done. And today, the polls are telling us that close to 70 percent of the American people believe that there is climate change.

Mr. Dayaratna, you mentioned the cost-benefit analysis.

Dr. DAYARATNA. Correct.

Ms. VELÁZQUEZ. For many people, particularly low-income communities, communities of color, indigenous communities, they care less about cost analysis when they know that they have been victims of climate change and environmental degradation.

If you go to New York and talk to communities of color, particularly Latinos who come from the Caribbean, they feel strongly that climate change is here and that we need to confront it. So, inaction on this is not a choice, it is not an option. And what is the best

way to proceed? Well, this is why we are bringing all the experts here. But to reject it based on studies that maybe, yes, are funded by fossil fuels or not—this is an issue that is not going away. Even the majority of Republicans, 64 percent, believe in climate change, so I welcome that.

We say that low-income communities will be the victims of the cost of energy because of the impact of regulations on their lives. Well, the fact of the matter is that they are the victims, not about paying more for electricity, but by the inaction that is happening in our agencies or our government in terms of addressing the issue of global warming and climate change.

Dr. DAYARATNA. OK. Can I respond? She addressed me.

Mr. HUFFMAN. Take 10 seconds, if you would.

Dr. DAYARATNA. Ten seconds. OK. Well, like I said, first, I am not denying that the climate is actually changing. I believe that the climate has been changing, the planet is warming, but it is warming at a much, much lower pace than a lot of people would have you believe. I would say that it is luke-warming.

And second, these policies are not going to do anything to impact it, even if it is accelerating at a significantly high pace.

Mr. HUFFMAN. Thank you, Dr. Dayaratna.

Dr. DAYARATNA. And these people are going to suffer from these types of policies that I have talked about, including low-income communities.

Mr. HUFFMAN. Thank you.

Last, but certainly not least, the illustrious Chairman of this Full Committee, Mr. Grijalva, is recognized for 5 minutes.

Mr. GRIJALVA. Thank you very much, Mr. Chairman, and thank you for the hearing. Excellent witnesses and excellent work you and the staff do to put this together, and I appreciate it very much, and that you made a priority of the fact that oceans and the jurisdiction of your Subcommittee had to be part of the solution. I appreciate that, and I think everybody appreciates that.

Queen Quet, I was going to ask you a question, but my colleague, Mr. Cunningham, asked you almost the same question. I think he was looking at my notes, but I am not going to mention that—regarding culture, the importance, what that glue means to people and what that means to regions, and thank you very much for that answer.

Ms. Chalk, I was going to ask you, what is your response to people who say that climate change isn't real?

Ms. CHALK. Thank you, Mr. Chairman. I would say that they have not experienced the things that we have experienced in southeast Louisiana or coastal Louisiana. I had 6 feet of water in my home due to Hurricane Katrina, 6 feet, and my house is raised 4 feet. So, until or unless you have water in your home or you can no longer get to a community because of rising sea levels, there is nothing that you can say that is more impactful than having experienced that. If you are familiar with the canopy at the Lowe's store, the water in my neighborhood was as high as the canopy on that store.

And I had the privilege of participating with the Louisiana Strategic Adaptation for Future Environments, and no matter where I participated in that process, everyone across the six

parishes that participated in that program had the same sentiment: family, faith, and food in our culture. And as the climate changes and those communities disappear, we lose that. So, I want this Committee to remember my face when you are making these decisions.

Mr. GRIJALVA. Thank you.

Ms. CHALK. This is real impact to real people.

Mr. GRIJALVA. Thank you very much, and I appreciate that very much. Before we start shedding a lot of crocodile tears about the poor, the people that are being displaced, the ones that are suffering the most, let's put some substance behind those crocodile tears, and not make it worse, but factor and bring to the table the impacted communities so they can be part of the solution. I appreciate very much your comments.

Ms. CHALK. Absolutely.

Mr. GRIJALVA. Before I ask Ms. Browner—and thank you, good to see you again—any questions, the Green New Deal, you already hear the rumblings of creeping socialism. Planes are going to fall from the sky. Cars and trucks will be abandoned in highways and then blow away in the dust. The economy as we know it will be destroyed. Nothing will be left of this civilization. And you will hear more and more on that because that is going to be the new set of talking points—because there has been some progress made.

We are not dealing with full throated denial of climate change; we are dealing with climate change avoidance. Let's talk about forests, let's talk about this, let's talk about, well, maybe the science isn't what it should be, and excuses not to act. And regardless of the talking points against the Green New Deal, it is simply this: it is aspirational. It puts the climate change at the top of the legislative agenda and the specificity on committees, like Mr. Huffman that will put together the legislative language and packages to begin to deal with resiliency and adaptation. That is the work of Congress and that is the work we should be doing.

But I support the aspirational statement, the resolution that is non-binding, people don't have to sign it, but the fact remains that it is setting—it is bringing to light something that has not been discussed around here for a good 8 years. So, I think that is good.

Ms. Browner, have you ever seen the discussion around environmental stewardship and the topic today this partisan?

Ms. BROWNER. I think the partisanship has grown significantly over the last——

Mr. GRIJALVA. Take the snapshot here—and why?

Ms. BROWNER. Well, I think that there are more and more interests that are separated. And the polluters want certain things, and other people, the communities, want other things. But when I was confirmed to my job at EPA, in 1992 was my hearing in the Senate, and John Chafee, a Republican, chaired that hearing, and he said to me at the end of the hearing, "Ms. Browner, I hope I never hear you say the word 'balance,' because your job is not to balance. You are running the EPA. Your job is to protect." And I think we need to remember that we have these institutions of the government that are there to protect our citizens, whether it is these women from these local communities or the children who are experiencing asthma and it is getting worse, that we have a responsibility in the

government, and it is unfortunate that we do not focus on that responsibility and on that problem solving.

I want to say one thing about the Green New Deal. I totally agree with everything you said. We put a man on the moon because we committed ourselves to it. There is nothing this country can't do with innovation and ingenuity. I have absolute faith in our ability.

Mr. GRIJALVA. Thank you. I yield back, Mr. Chairman. Thank you.

Mr. HUFFMAN. Terrific. Thank you, Mr. Chair.

I do want to thank all of the witnesses for your time and your expertise and coming to Washington and sharing your testimony. I do hope this hearing serves as a baseline on what we hope to address in this Subcommittee. We will prioritize ocean-related climate adaptation and mitigation measures as we go forward. And Ranking Member Bishop has sometimes asked where is this heading, where is it going? I know at least in this Subcommittee, there is going to be a strong emphasis on those things, and that is squarely within this Subcommittee's jurisdiction.

Especially I want to thank you, Dr. Bronk, because the Committee Rules are very limiting. If I were to provide a panel of witnesses that truly reflected the scientific consensus on climate change, I would have needed over 90 more witnesses, and this room just can't accommodate that many, and the Committee Rules would never let me get away with that. But you were carrying the water, so to speak, for the overwhelming global scientific consensus on these issues, and I thank you and all the other witnesses.

Going forward, again, just by way of preview of this Committee's work, we will have opportunities for coastal and marine habitat restoration programs to be considered, to reauthorize and strengthen the Coral Reef Conservation Act, to bolster programs addressing ocean acidification, uphold and strengthen the Coastal Zone Management Act, to improve data and monitoring efforts. And there are many of those that seem, I think, to be bipartisan, the Digital Coast and Integrated Ocean Observing System, National Estuarine Research Reserves, Sea Grant Program, and Harmful Algal Bloom Monitoring system.

We will have a chance to address shifting fish stocks and management of our fisheries, to strengthen the National Coastal Zone Management Program, which works with coastal states and territories to address some of today's most pressing coastal issues, to conserve and restore blue carbon, particularly marshes, mangroves, and sea grasses. We will have an opportunity to pursue policies that support living shorelines that will certainly be talking about offshore drilling in this Committee. And I know Mr. Cunningham and many others are looking forward to that.

We will have an opportunity to consider marine protected areas and possible expansion of those and to expand the Coastal Barrier Resources Act to cover more areas in order to protect our coasts from wind and tidal forces caused by coastal storms, and, of course, that is critical habitat for aquatic species.

Finally, we will include the issue in this Subcommittee of marine plastics. Not only is that hurting our oceans—we didn't have enough time to talk about that today—but the greenhouse gas

emissions associated with plastic production are part of this bigger problem we are talking about. And I hope we will be able to reauthorize and bolster the North American Wetlands Conservation Act and many, many more things.

So, again, thanks everyone for participating in a terrific first hearing of this Subcommittee. The members of the Committee may have some additional questions for the witnesses, and I will ask, if you would, to respond to those in writing under Committee Rule 3(o). Members of the Committee must submit written questions within 3 business days following the hearing, and the hearing record will be held open for 10 business days for responses.

If there is no further business, without objection, this Committee stands adjourned.

[Whereupon, at 5:18 p.m., the Subcommittee was adjourned.]

[ADDITIONAL MATERIALS SUBMITTED FOR THE RECORD]

PREPARED STATEMENT OF THE HON. RAÚL M. GRIJALVA, CHAIR, COMMITTEE ON NATURAL RESOURCES

Thank you to my friend from California, and thanks to all of the witnesses for being here today. Thank you for sharing your stories of how climate change is affecting your work and your neighborhoods. In holding hearings on climate change at both the Full Committee and Subcommittee levels, we were hoping to turn over a new leaf in the important work of addressing climate change and its impacts in this Committee. However, the Minority is sticking to its old, big oil-funded playbook, continuing to be out of step with the scientific consensus on climate change. That may have worked for the past 8 years, but unfortunately we are running out time to address climate pollution before the impacts devastate our economy. One need not look any further than our oceans and coasts, and the communities that depend upon them, to see just how quickly the costs of climate pollution are adding up.

For example, over the past 8 years, as Republicans were in control of the House of Representatives but did nothing about climate change, our country experienced:

- 96 storm events with over a billion dollars in damages, totaling $674 billion
- 26 fishery disasters declared or pending
- Loss of a football field of coastal wetlands every 100 minutes in Louisiana
- Spent $1.9 billion to nourish 130 beaches across the country

Needless to say, it's time to roll up our sleeves and get to work on climate change.

CONSERVATION INTERNATIONAL,
ARLINGTON, VIRGINIA

February 19, 2019

Hon. JARED HUFFMAN, *Chairman*,
Hon. TOM MCCLINTOCK, *Ranking Member*,
House Subcommittee on Water, Oceans, and Wildlife,
1324 Longworth House Office Building,
Washington, DC 20515.

Re: Subcommittee Hearing on Healthy Oceans and Healthy Economies: The State of Our Oceans In the 21st Century

Dear Chairman Huffman and Ranking Member McClintock:

Thank you for the opportunity to provide input to the Committee's hearing: Healthy Oceans and Healthy Economies: The State of Our Oceans In the 21st Century.

Our ocean is a 21st century wild west; its resources are in peril and its governance is weak—and yet it is also a major economic frontier, ripe for exploitation.

Policy needs to be forward-looking and agile in responding to these opportunities and challenges.

Overfishing, pollution, habitat loss and climate change have resulted in coastal and ocean ecosystems that are often unrecognizable from their pre-industrial state. These changes are accelerating—including the dramatic projections of climate change impacts on our oceans, coastlines, and low-lying areas. This leads to lost economic opportunities and threats to the safety, livelihoods and culture of coastal communities in places like Florida, Puerto Rico, Hawai'i, Texas, Rhode Island, and every other coastal state.

At the same time, there are clear opportunities to derive more economic value from the phenomenal size and productivity of the ocean, to deliver new sources of energy, and to build resilience to growing climate impacts.

Emerging technologies now enable us to reach parts of the oceans that have been inaccessible until now, with parallels to the 'wild west' era—opening up a region of untapped potential but limited governance.

Smartly designed policy, including leveraging new technologies such as satellite monitoring and unmanaged submersibles, and partnering with coastguard and military interests, can help the ocean to support a thriving US economy while respecting its ecological and cultural significance. Sticking to the status quo would fail to maximize this opportunity; leave economic assets and communities exposed to unacceptable levels of risk; and drive overexploitation, wholesale conversion of territory into poorly regulated productive systems, and loss of species akin to the fate of the American Bison in the 19th century.

Conservation International believes that a positive vision for the ocean's future is achievable, and that government, academia, civil society, and the private sector all have important roles to play.

For example, in Hawai'i our work with the local fishing communities is supporting a vibrant culture and economy around seafood. Hawai'i's fisheries are valued at $539 million and provide over 45 million lbs. of seafood annually. Working with traditional and local fishers we are creating markets for sustainable seafood, implementing seafood traceability, and working with businesses to reducing seafood waste.

Similarly, strong conservation in the Papahānaumokuākea Marine National Monument led to over $100 million of investment in research, vessel operations, and education in the first ten years of its establishment. Lessons learned from research and management in this remote part of the archipelago have also helped to transform management practices and science in the populated islands. Such momentum has helped to inspire the state government, all four counties, the University of Hawai'i, and the Office of Hawaiian Affairs to commit to the Hawai'i Green Growth initiative and goals of the Aloha+ Challenge.

The private sector

It is particularly notable that looking out to the ocean will provide rich opportunities for businesses to innovate and develop new product lines in fields such as aquaculture, algae production, maritime technology, insurance, and renewable energy—alongside the ongoing revitalization and recovery of wild-capture fisheries and the growth of ocean-facing industries including shipping, ports, marine engineering and coastal tourism. Businesses (and municipal governments) would also benefit greatly from increasing their awareness of the many risks they face from accelerating ocean change—an awareness which is often lacking at present.

Conservation International is partnering with universities, governmental and non-governmental organizations to develop the Natural Capital Protocol for the Ocean—a framework, case studies and guidance to help business leaders to assess these opportunities and the options available to them, by considering their dependencies and impacts on ocean natural capital.

National Security

On a global scale, the human importance of the ocean becomes clear: The asset value of the global ocean has been estimated at $24 trillion;[1] 2.4 billion people live within 100 kilometers of the coast;[2] 90% of global trade is shipped;[2] more than 3 billion people depend on fish for at least 20% of their total animal protein intake;[3]

[1] WWF, Reviving the Ocean Economy—The Case for Action. 2015.
[2] United Nations, The Ocean Conference Factsheet: People and Oceans, 2017.
[3] FAO, Fish and human nutrition factsheet.

93% of the heat released by climate change has been absorbed by our ocean;[4] and the ocean provides 99% of the living space on planet 'Earth'.

Many of the most vulnerable communities—and the highest unemployment rates—are found in coastal and port communities, across a range of countries from Colombia to China. Sea-level rise and increasing impacts from hurricanes, storms and flooding is already exacerbating the situation, and this will only intensify in future. These social conditions often contribute to increased social unrest, illegal activity, and migration, which impacts on US national security interests. By investing to maintain healthy forests, wetlands, aquifers, and rivers, we can help blunt the impacts of natural disasters when they strike and make communities more resilient to extreme weather events.

Targeted U.S. investment in international conservation efforts contributes to America's long-term foreign policy objectives and enhances U.S. economic and national security interests around the globe.

Science and data

Conservation International employs economic analysis, innovative financing, and ocean science to support coastal communities, businesses, and policymakers in securing a positive, sustainable future.

The Ocean Health Index has scientifically measured the state of the ocean for the past seven years. It is the first and only ocean assessment tool to scientifically assess key elements from all dimensions of the ocean's health—biological, physical, economic, and social—equipping managers and policymakers with meaningful information to help manage oceans sustainably. While the global average score has remained fairly stable at 70/100, the United States' ranking has dropped from 53rd in the world in 2014 to 91st in 2018; its score is now 68, below the global average. Significant declines have been seen in the US scores for fisheries, natural products, coastal protection, and biodiversity. The large decline in the coastal protection score, from 94 to 75, is in part due to a substantial loss in coastal sea ice in Alaska, as climate change impacts accelerate.

More detailed regional Ocean Health Index assessments have been completed for the US west coast and for Hawai'i, providing insights to inform management decisions in those regions. Declines in coastal and ocean habitats in these regions are having negative consequences to ocean economies and livelihoods. For example, tourism in Hawai'i is directly linked to Hawai'i's unique natural environment, generating $24 billion annually. But Hawai'i's alluring habitats are literally eroding—72% of Hawaii's beaches are shrinking, and up to 50% of coral cover has already been lost in some areas over the last five years, with greater losses projected to follow as oceans warm further.

The ocean, once considered inexhaustible and unknowable, is now open for business. Understanding and respecting the resulting opportunities, dependencies and risks; encouraging innovation and new technologies; nurturing sustainable businesses; and ensuring that regulatory frameworks are agile and ready for the changes ahead will ensure that our ocean frontier will positively influence economies, communities and ecosystems for decades to come.

Sincerely,

DAWSON J. HUNTER,
Senior Director, U.S. Government Policy.

OCEAN CONSERVANCY,
WASHINGTON, DC

February 7, 2019

Hon. JARED HUFFMAN, *Chairman*,
Hon. TOM MCCLINTOCK, *Ranking Member*,
House Subcommittee on Water, Oceans, and Wildlife,
1324 Longworth House Office Building,
Washington, DC 20515.

Re: Subcommittee Hearing on Healthy Oceans and Healthy Economies: The State of Our Oceans In the 21st Century

[4] IUCN, Explaining ocean warming: causes, scale, effects and consequences, 2016.

Dear Chairman Huffman and Ranking Member McClintock:

Thank you for the opportunity to provide input in regards to today's hearing. We commend the Subcommittee's leadership in addressing oceans and climate change, and urge continued focus and action on this critical issue as we move further into the 116th Congress.

Ocean Conservancy creates science-based solutions for a healthy ocean and the wildlife and communities that depend on it. Climate change is one of the most pressing challenges for our ocean, and Ocean Conservancy has been deeply engaged in supporting solutions at the local, national, and global levels. Our work ranges from supporting ocean acidification funding and research, to fisheries management adaptation and modelling, to addressing ocean policy in venues like the International Maritime Organization and Arctic Council. The ocean is a system at risk, struggling to keep pace with rising temperatures, pollution, and the absorption of greenhouse gases. It is increasingly clear that urgent action is required to preserve the essential functioning of both the ocean and climate systems, and that saving one can't happen without saving the other. Congress must act on climate change. The science is clear, solutions are available here and now, and the ocean must be at the heart of climate action.

Why climate change matters to ocean and coastal communities

The ocean and America's coastal communities are on the frontlines of climate change impacts. Thirty-nine million people live near the coast in the United States. They, and the ocean they depend on, are experiencing major risk from extreme weather events, sea level rise, high water temperatures, low dissolved oxygen levels, and ocean and coastal acidification. Extreme events associated with the ocean are projected to become more common and severe as these conditions intensify and intersect. All of this is putting jobs and resources at risk, including America's multi-billion dollar seafood and ocean and coastal recreation industries, and trillion dollar coastal property market. In addition, the recent Fourth National Climate Assessment (NCA4) report found that the impacts of climate change along our coasts are actively worsening social inequality (NCA4, Chapter 1). American lives, livelihoods, and culture are at risk.

Below are just a few examples of how climate change is dramatically affecting ocean and coastal communities and economies:

Sea level rise

Repeated tidal flooding, coupled with sea level rise and heavy precipitation events, are already significantly harming America's public infrastructure and trillion-dollar coastal property market. Global average sea level has risen by about 7–8 inches since 1900, with almost half this rise occurring since 1993 as oceans have warmed and land-based ice has melted. Sea level rise, driven by expansion of warming seawater and melting of glaciers, now causes regular flooding in coastal communities around our country—euphemistically called "sunny day flooding" or "king tides." 50 million housing units are within 1/8 of a mile of the coast, and projections suggest that between $66 and $106 billion of real estate value may be underwater by 2050 (NCA4, Chapter 8). Moreover, 60,000 miles of roads and bridges are located along the coast (NCA4, Chapter 12), and many if not most of these will need to be repaired or relocated. These costs will become an increasing economic liability for municipalities and programs like the National Flood Insurance Program, which may become insolvent when properties become unsellable (NCA4, Chapter 8).

Around the country, costs of forced adaptation are already mounting. In Florida, there are already 120,000 properties at risk from frequent tidal flooding (NCA4, Chapter 19). Sea level around Florida is 8 inches higher than it was in 1950, and the state is planning over $4 billion in sea level rise solutions (SeaLevelRise.org). Cities like Miami are installing pumps to remove floodwaters from coastal streets. Some communities are considering leaving the coastal zone altogether: the Biloxi-Choctaw tribe in Louisiana has a $48 million grant from the Federal Government to develop a relocation plan (NCA4, Chapter 15). In California alone, the cost to elevate ports to withstand 6 feet of sea level rise could be $12 billion (NCA4, Chapter 8). The nation's largest naval base, in Norfolk Virginia, is at major risk from sea level rise, a fact acknowledged by the Department of Defense (January 2019 Report of Effects of a Changing Climate to the Department of Defense).

Fisheries

U.S. commercial and recreational fisheries generate $212 billion in sales impacts each year (Fisheries Economics of the United States Report, 2016) and are a critical economic driver for thousands of coastal communities. But ocean warming, acidification, and oxygen loss are rapidly altering the abundance, productivity, and distribu-

tion of fish stocks. These impacts on fish are resulting in a cascade of management and sustainability challenges, which impact fishermen and fishing communities.

In ocean waters, species distributions are shifting at an estimated 70 kilometers per decade (Poloczanska et al., 2013), with most species moving poleward or to deeper waters as the oceans warm (NCA4, Chapter 9). Scientists expect 10–50 percent decline in fish from warmer regions by 2085 (NCA4, Chapter 9), while catch could increase elsewhere. Warm water has already contributed to overfishing of the iconic Atlantic cod in the Gulf of Maine, and negatively affected the allowable catch of Pacific cod in the Gulf of Alaska and the Bering Sea. American lobster has experienced a major range shift, with its center of abundance having moved 3 degrees north in latitude from Long Island to Maine. The Gulf of Maine has warmed faster than 99 percent of the rest of the global ocean in the last century; by 2050 lobster populations could be cut by more than half with continued warming (La Bris et al., 2018). As stocks move, research suggests fisheries have only been able to shift 10–30 percent as much as their target species, likely due to economic and regulatory constraints (Pinsky and Fogarty, 2012). Changing ocean conditions will also affect the productivity of fish stocks by influencing habitat suitability, interactions between predators and prey, and the life history parameters of fish such as growth and recruitment (Karp et al. 2018). These changes in productivity make it more difficult to define and achieve management targets (Karp et al. 2018).

With changing abundance and distribution of fish stocks, changes in fishing patterns follow, and commercial, recreational, and subsistence fishermen are on the front lines. A survey of commercial fishermen in the Northeast found that the majority attributed changes they saw to climate change and 65 percent believed that climate change would ultimately force them out of their fishery (Center for American Progress, 2014). Climate change is also already affecting U.S. fishery management as species shift their distributions and productivity is altered. Among the pressing issues are jurisdictional and boundary conflicts for managing stocks, coordination and allocation issues among and across states and regions, the need to manage new and emerging fisheries, and increased costs for fishermen to pursue fisheries over longer distances. Taken together, these issues make fisheries harvests less secure and complicate management of both fisheries and protected species. Recognizing the urgency of these issues, the National Oceanic and Atmospheric Administration (NOAA), the Regional Fishery Management Councils, and others are working to refine the science, assess fish and community vulnerabilities, incorporate insights into planning and decision-making, and develop a more climate-ready fishery management system (for example, see Link et al. NOAA Fisheries, 2015).

Arctic

The potential impacts from climate change and acidification in the U.S. Arctic warrant particular attention. The Arctic region is warming at twice the rate of the rest of the planet. This warming is already causing significant effects in Alaska, America's only Arctic state, some of which ripple through the rest of the United States. Alaska marine ecosystems and coastal communities are inextricably linked and, together, they are threatened by climate change. Coastal communities are being forced to relocate as homes and other infrastructure erode into the ocean. Warming is also disrupting subsistence that has existed in coastal communities for millennia, including making hunting more dangerous and less predictable, which contributes to the loss of food security and cultural continuity.

Warming is causing the loss of sea ice. The 2018 sea ice minimum was tied for the sixth lowest on record, and NASA scientists estimate that approximately 21,000 square miles of ice—an area the size of Maryland and New Jersey—has been lost for each year since the late 1970s (Earth Observatory 2018). The loss of sea ice is disrupting marine ecosystems and contributing to erosion and other impacts. It is also opening the region to other industrial activities—like oil and gas exploration and development and commercial fishing—in addition to increasing vessel traffic. These changes, in turn, are having profound impacts on maritime transportation in the Arctic. Vessel traffic in the Arctic has already grown significantly, and is poised to increase rapidly in coming years as the ice-free season lengthens. As vessel traffic increases, so too does the potential for significant impacts to residents of the region and to the marine ecosystem.

Warming ocean conditions are also affecting commercial, recreational, and subsistence fisheries in Alaska. Pacific cod populations in the Gulf of Alaska have diminished by more than 80 percent, and that loss has been attributed to a "warm blob" of ocean water in the Pacific. Pacific cod has also seen a significant decline in the Bering Sea. The reduction in cod had dramatic impacts of the Pacific cod fishery, which has been worth as much as $50 million per year in the past. The warm blob has also been linked to sea bird die-offs, whale strandings, and algal blooms (Seattle

Times, 2017). Arctic waters are particularly susceptible to ocean acidification because they are colder and because freshwater inputs from melting glaciers make them less saline. Acidification will have dramatic effects on Arctic marine ecosystems by disrupting the base of a fragile food web.

Why climate change matters to ocean ecosystems

The ocean is our largest single buffer against climate change. It is the Earth's largest heat and carbon sink: it has absorbed 93 percent of the excess heat generated by industrial-era carbon dioxide emissions, and it captures nearly 30 percent of the carbon dioxide released into the atmosphere every year. Recent headlines have highlighted new research that suggests the ocean is storing even more heat than previously estimated (Cheng et al. 2019). Ocean surface waters have warmed 0.7 degrees Celsius since 1990. Dissolved oxygen in the ocean is falling because warmer water holds less oxygen and decreased circulation is causing oceans to become increasingly stratified; these impacts have already been detected as far as 1000 feet below the surface. By 2050, 86 percent of the ocean will see temperature and ocean acidification conditions that modern ecosystems and species have never experienced (NCA4, Chapter 9). Each new scientific assessment confirms that the pace and scale of change is greater than scientists previously thought.

Below are just a few examples of how these changes are dramatically affecting the functioning of ocean ecosystems:

Mass disruption of ocean ecosystems and food webs

The NCA4 report found that changing ocean conditions and increasing temperatures are already causing the loss of important habitats and changing food webs and species distributions, an effect that will only increase as warming, acidification, and oxygen loss continue.

In one dramatic example, just last week a new study from Cornell University documented that sea star wasting syndrome, a climate-change driven disease, has virtually extirpated *Pycnopodia helianthoides* (colloquially called the sunflower star) along a 3,000 mile stretch of the West coast (Harvell et al. 2019). This loss is threatening the survival of kelp forest ecosystems. A classic example of a "keystone species", sunflower stars keep purple sea urchin populations in check, which in turn allows giant kelp to grow prolifically, creating the physical structure that harbors all the other species that collectively comprise the kelp forest. Science warns that without *Pycnopodia*—and the other sea stars killed by the wasting disease—there could be no kelp forests. And that is what is happening. As sea star abundances have tumbled across the west coast, the abundance of kelp has likewise fallen and these once vibrant habitats have increasingly become barren zones dominated by sea urchins. This is just one example of the types of major trophic cascades ocean scientists are anticipating as a result of climate change.

Ocean Acidification

One of the major drivers of atmospheric climate change, carbon dioxide, is also responsible for driving ocean climate change by causing ocean acidification. Carbon dioxide dissolved in water creates carbonic acid, which changes not only the pH of oceans but also other chemical balances important for marine life. Thirty-year ocean time-series datasets provide direct evidence of this process worldwide (2018 2nd State of the Carbon Cycle Report: Chapter 17).

In the mid-2000s, mass mortality at shellfish hatcheries in the Pacific Northwest alerted the shellfish aquaculture industry to a major systemic problem. Partnering with federal and university researchers, they identified the problem as ocean acidification, caused by fossil fuel emissions absorbed by the Pacific Ocean over the last several decades, upwelled to coastal waters decades earlier than previously predicted (Feely et al., 2008, Science). To protect multi-generational businesses that support an industry employing thousands of people and sustaining the entire Pacific oyster industry, hatchery owners invested in "future proofing" steps such as monitoring seawater intakes, modifying the water chemistry of intake water, and researching the prospects for selective breeding to help safeguard the industry. At the same time, research on other impacts of ocean acidification took off. Since ocean acidification was identified as a threat to marine life, laboratory studies have shown it can alter fish and marine invertebrate reproductive success (e.g., Kroeker et al. 2013), fish and shark behavior (Dixson et al. 2010), and predator-prey relationships. Modeling studies suggest that these effects together have the power to decrease fishery yields of lucrative fisheries such as sea scallops (Cooley et al. 2018), red king and Tanner crabs (Punt et al. 2016), and Puget Sound fisheries (Busch et al. 2013). Surprisingly, preliminary studies suggest that OA worsens the toxicity of harmful algal blooms by increasing domoic acid toxin production (Sun et al. 2011), and it can

decrease the flavor and food appeal of northern shrimp (Dupont et al. 2014). It is clear that the full effects of ocean acidification on marine life are still being determined, but we know that it can interact in subtle and difficult to predict ways with other marine drivers like warming, oxygen loss, and nitrogen loading.

Loss of Coral Reefs

Coral reef survival, along with the ecosystem and storm buffering services they provide, are at significant risk from warming and acidifying oceans. In the United States, coral reefs fringe the warm-water coastlines around Florida and Hawaii and territories of Puerto Rico, Guam, American Samoa, and the U.S. Virgin Islands. The past several summers in Hawaii, Guam, and the Commonwealth of the Northern Mariana Islands, widespread coral bleaching occurred. The 2015 event killed approximately half of the coral cover in Western Hawaii (NCA4, Ch. 27). Cold-water-loving coral species also ring the entire coast, from Alaska to Hawaii. Both warm and cold-water reefs provide vital habitat for a wide variety of marine life, many of which are species that sustain economically important fisheries. In addition, reefs in shallow waters also help protect coasts from waves, acting like "speed bumps" that help dissipate wave energy. Erosion of reefs in Florida, U.S. Virgin Islands, and Hawaii from the combined effects of wave action, storms, and acidification is changing the seafloor topography enough that changes in wave runup on land can be expected. Losses of $140 billion in recreational revenue alone are projected from loss of coral reefs by 2100 (4th US Climate Assessment, Ch. 9). With forecasts calling for increased flooding threats from hurricanes that carry extra precipitation because of anthropogenic climate change (Patricola and Wehner, 2018), it is essential to maintain these invisible coastal protections that help defend against wave-based flooding.

Solutions: Ocean-based mitigation and adaptation

The ocean, and the coastal communities and economies that depend on it, are an important part of the solutions to climate change. The fundamental solution to ocean warming and acidification is decreasing atmospheric greenhouse gas levels, particularly carbon dioxide, and the ocean can help us to do that. In addition, even if we stopped emitting greenhouse gases today, there would still be years of "momentum" in the system, as existing atmospheric greenhouse gases continue to warm and acidify the ocean. As we work toward reducing our carbon footprint, there are concurrent steps that should be taken to decrease other ocean stressors and to support adaptation to ocean climate change.

The ocean can help us reduce our carbon footprint.

The ocean is more than a victim of climate change. It is a potential solution to the mitigation targets we must achieve to keep global temperatures below 2 degrees Celsius. The ocean provides critical carbon sinks, such as "blue carbon" ecosystems (mangroves, seagrasses, and tidal marshes, which have the added benefit of insulating communities from the effects of sea level rise and storm surges) and other elements of a living ocean. The ocean also provides important opportunities for decarbonization, such as clean energy via offshore renewables like wind and wave power, and reduction in emissions from offshore activities such as shipping and drilling. For example, shipping accounts for about 90 percent of global trade, and emission of greenhouse gases from shipping represent 2–3 percent of total global emissions. It is possible to reduce or eliminate these emissions using short-term measures such as design and technology solutions for new ships, adoption of low-carbon fuels, reduction of black carbon emissions, and mandatory speed reductions. These solutions should be addressed with industry in the dialogue as we work to develop a holistic approach to carbon reduction. Regardless of the mitigation mechanisms employed, any mitigation targets should include a specific focus on CO2, since CO2 has a significantly greater impact on the ocean by causing ocean acidification.

Ocean communities, industries and ecosystems need resources and support to secure long-term adaptation & resilience.

As noted above, the ocean impacts of climate change present significant and growing risks to coastal communities, economies, and ecosystems. We must invest in making them resilient to the climate change impacts we can't avoid. Functioning fisheries are needed to support populations, and healthy ecosystems are needed to protect coastlines. Protecting coastal and marine ecosystems against the adverse effects of climate change is vital for human and ecosystem adaptation and, in many cases, also contributes to reduction of emissions. Reducing anthropogenic stressors on the oceans, such as overfishing and other unsustainable exploitation of marine resources, habitat degradation, pollution and nutrient runoff, may also enhance the

ocean's capacity to absorb the impacts of climate change and reduce the acidifying impact of CO2 emissions. We need to ensure the actions we take are designed with a changing climate and the goal of building resilience in mind.

In particular, we recommend focusing on two key approaches to adaptation and resilience:

Work to decrease ocean stressors: Studies show that multiple layered drivers on ocean ecosystems have a greater chance of acting synergistically—that is, exerting more stress on ocean life together than they would singly, or simply added together—than to counteract each other (Harley et al. 2006). This implies that reducing as many ocean drivers as possible, to reduce overall stress on ocean life, is warranted. Actions to reduce ocean stressors should include activities to combat things like oxygen loss, nitrogen pollution, sedimentation, disease, and other types of chemical pollution (Kelly & Caldwell, 2013). Marine resource management has sought to reduce these problems as part of general water quality improvement for decades, with progressive success in doing so (Côté et al. 2017), but the need is even more pressing in the face of climate change. Preventing the expansion of offshore oil and gas activities, especially in sensitive or remote places where the risks of these activities far outweigh any potential benefits, is also an important way to decrease additional ocean stressors. Decreasing marine pollution and other stressors to ecosystems is a "no-regrets" policy approach because of the multiple benefits that accrue—both the immediate value of reducing single stressors, and the likely synergistic effect of the stressors acting together (Côté et al. 2017).

In the Arctic in particular, we can put in place measures and best practices that will both decrease unnecessary ocean stressors and increase safety and protect communities. We can take common-sense steps to prevent maritime accidents from happening, such as implementing targeted vessel routing measures, tightening limitations on discharges into the water, supporting advancements in vessel tracking and communication, and improving nautical charts. We can also improve our ability to respond effectively if an accident does occur by increasing spill response equipment and training in local communities, continuing to fund design and construction of new ice-breaking polar security cutters and supporting seasonal Arctic Shield operations and additional Coast Guard outreach activities in Arctic communities.

Support community adaptation planning: To date, ocean climate change has driven piecemeal adaptation. As more adaptation efforts begin, there is an increasing risk that overlapping, uncoordinated efforts could be at best inefficient and at worst interfere with each other. Around the world, nations are currently planning both mitigation and adaptation actions to address climate change as part of their Nationally Determined Contributions under the Paris Agreement, but little guidance exists to ensure coordination and inclusion of the ocean in these activities. A similar dynamic exists within the U.S., where state and local governments nationwide are at widely different stages and levels of coordination in adopting ocean-smart climate policies.

Resources and support for long-term resilience and adaptation planning are desperately needed. At a minimum, this should include support for regional ocean planning through tools that support coordinated data and management like regional ocean data portals. Comprehensive planning approaches underpin community and ecosystem resilience and ecosystem-based management. States and regional ocean partnerships across the country have found value in comprehensive planning, and resources should support the priorities outlined by states. It should also include support for policies and programs, particularly those within NOAA, that support ocean and coastal resilience. This includes priorities such as ocean acidification monitoring and funding, ocean and coastal habitat and coral reef restoration, and fisheries management adaptation. In addition, there is a particular need to increase resilience and adaptation planning in the Arctic. Funding and support is needed for communities that must relocate, and there are opportunities to plan for coming changes and ensure that Alaskan communities, ecosystems, and economies will be resilient in a changing future.

Growing Global Momentum for Ocean-Climate Action

We are seeing energy for coordinated, ocean-focused action on climate change occurring at the local and regional levels, and we are also seeing it at the international level. There is excellent interagency work happening on climate change through the U.S. federal agencies. All of this action has not been matched by action at the federal legislative or executive level. This must change.

Ocean acidification, until recently an issue unknown outside the science community, has been the cause of much regional organizing. In the United States, scientists are joining largely self-organized groups such as the Global OA Observing Network (GOA-ON), the regional Coastal Acidification Networks (CANs) associated

with the OOS network. These groups are also engaging regional industry and resource management experts, as well as educators and science communicators. As a result, lessons learned in one region are being transferred to other regions, accelerating the application of adaptive solutions and technology to monitor ocean climate change. This bottom-up energy has recently contributed to the creation of the International OA Alliance, a non-binding network of governments and non-governmental members dedicated to enhancing ambitions to reduce CO2 emissions, sharing knowledge about ocean acidification, increasing actions to address it, and international capacity building efforts, through programs like the International Ocean Acidification Coordination Centre (OA-ICC), funded by the International Atomic Energy Agency.

Regions across the U.S. are also focusing on oceans and climate change more broadly. The recent Global Climate Action Summit, led by the state of California, is one prominent example where oceans were at the fore of the discussion. Other examples include the work of the Arctic Council and Pacific Coast Collaborative. In the international sphere, there is growing energy to address ocean issues in international climate policy, evidenced by the push to include ocean-focused actions in Nationally Determined Contributions as well as large number of ocean-focused meetings and panels at U.N. climate meetings over the past year.

Conclusion: U.S. Action is Needed Now

The time is right for the United States to consider how it can safeguard ocean resources and ecosystems for now and into the future. Heightening ambitions to cut carbon dioxide is a necessary first step to genuinely address ocean warming and acidification. Considering how climate-focused action, or inaction, impacts the ocean is also a necessary step. Plans for climate adaptation must be coordinated. States and regions are taking steps to do so, which can be learned from, exported, and applied to other areas to accelerate action.

Congress must debate and move aggressive climate legislation that will ensure communities and ecosystems are spared the most devastating potential impacts from climate change, and are able to successfully adapt to those they can't avoid. That work must start now. But in addition, Congress can and must take action immediately using the tools we already have. This spring Congress will take up appropriations legislation for the next fiscal year. Those bills must prioritize critical funding for the climate research, coastal resilience, and adaptation programs that are already working to tackle our climate challenges.

Ocean climate change is happening now. It will get worse before it gets better. Congress must act now to curb climate change and plan to protect coastal communities as pro-actively as we can from the changes that are coming.

Sincerely,

JANIS SEARLES JONES,
CEO.

[LIST OF DOCUMENTS SUBMITTED FOR THE RECORD RETAINED IN THE COMMITTEE'S OFFICIAL FILES]

Submission for the Record by Rep. Bishop

—"Grazing management impacts on vegetation, soil biota and soil chemical, physical and hydrological properties in tall grass prairie," by W.R. Teaguea, S.L. Dowhowera, S.A. Baker, N. Haile, P.B. DeLaune, D.M. Conovera, *Agriculture, Ecosystems and Environment,* 141(2011)310–322.

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