AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

S. HRG. 111–46

# THE BLUE ECONOMY: THE ROLE OF THE OCEANS IN OUR NATION'S ECONOMIC FUTURE

## HEARING

BEFORE THE

SUBCOMMITTEE ON OCEANS, ATMOSPHERE, FISHERIES, AND COAST GUARD

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

JUNE 9, 2009

Printed for the use of the Committee on Commerce, Science, and Transportation

U.S. GOVERNMENT PRINTING OFFICE

50–769 PDF WASHINGTON : 2009

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

## SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

JOHN D. ROCKEFELLER IV, West Virginia, *Chairman*

DANIEL K. INOUYE, Hawaii
JOHN F. KERRY, Massachusetts
BYRON L. DORGAN, North Dakota
BARBARA BOXER, California
BILL NELSON, Florida
MARIA CANTWELL, Washington
FRANK R. LAUTENBERG, New Jersey
MARK PRYOR, Arkansas
CLAIRE McCASKILL, Missouri
AMY KLOBUCHAR, Minnesota
TOM UDALL, New Mexico
MARK WARNER, Virginia
MARK BEGICH, Alaska

KAY BAILEY HUTCHISON, Texas, *Ranking*
OLYMPIA J. SNOWE, Maine
JOHN ENSIGN, Nevada
JIM DeMINT, South Carolina
JOHN THUNE, South Dakota
ROGER F. WICKER, Mississippi
JOHNNY ISAKSON, Georgia
DAVID VITTER, Louisiana
SAM BROWNBACK, Kansas
MEL MARTINEZ, Florida
MIKE JOHANNS, Nebraska

ELLEN L. DONESKI, *Chief of Staff*
JAMES REID, *Deputy Chief of Staff*
BRUCE H. ANDREWS, *General Counsel*
CHRISTINE D. KURTH, *Republican Staff Director and General Counsel*
BRIAN M. HENDRICKS, *Republican Chief Counsel*

---

## SUBCOMMITTEE ON OCEANS, ATMOSPHERE, FISHERIES, AND COAST GUARD

MARIA CANTWELL, Washington, *Chairman*
DANIEL K. INOUYE, Hawaii
JOHN F. KERRY, Massachusetts
BARBARA BOXER, California
FRANK R. LAUTENBERG, New Jersey
MARK BEGICH, Alaska

OLYMPIA J. SNOWE, Maine, *Ranking*
ROGER WICKER, Mississippi
JOHNNY ISAKSON, Georgia
DAVID VITTER, Louisiana
MEL MARTINEZ, Florida

# CONTENTS


| | Page |
|---|---|
| Hearing held on June 9, 2009 | 1 |
| Statement of Senator Cantwell | 1 |
| Statement of Senator Snowe | 2 |
| Prepared statement | 4 |

WITNESSES

| | |
|---|---|
| Judith T. Kildow Ph.D., Director, National Ocean Economics Program | 6 |
| Prepared statement | 8 |
| Alexandra Cousteau, Founder and President, Blue Legacy International | 11 |
| William Fenical, Distinguished Professor of Oceanography and Pharmaceutical Science, Scripps Institution of Oceanography, University of California | 12 |
| Prepared statement | 14 |
| Brad Warren, Sustainable Fisheries Partnership | 16 |
| Prepared statement | 18 |
| Deerin Babb-Brott, Assistant Secretary of Oceans and Coastal Zone Management, Massachusetts Executive Office of Energy and Environmental Affairs, Commonwealth of Massachusetts | 21 |
| Prepared statement | 23 |
| Willett Kempton, Ph.D., Associate Professor, College of Earth, Ocean and Environment, and Director, Center for Carbon-free Power Integration, University of Delaware; Chair, R&D Subcommittee, Offshore Wind Working Group, American Wind Energy Association | 31 |
| Prepared statement | 33 |

APPENDIX

| | |
|---|---|
| John D. Rockefeller IV, U.S. Senator from West Virginia, prepared statement | 51 |

# THE BLUE ECONOMY: THE ROLE OF THE OCEANS IN OUR NATION'S ECONOMIC FUTURE

**TUESDAY, JUNE 9, 2009**

U.S. SENATE,
SUBCOMMITTEE ON OCEANS, ATMOSPHERE, FISHERIES, AND COAST GUARD,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
*Washington, DC.*

The Subcommittee met, pursuant to notice, at 9:30 a.m. in room SR–253, Russell Senate Office Building, Hon. Maria Cantwell, Chairman of the Subcommittee, presiding.

## OPENING STATEMENT OF HON. MARIA CANTWELL, U.S. SENATOR FROM WASHINGTON

Senator CANTWELL. Good morning. The Subcommittee on Oceans, Atmosphere, Fisheries, and Coast Guard will come to order.

Welcome to our panelists this morning. I would like to thank my colleague Senator Snowe, who I am sure is going to join us shortly, for helping to participate in today's hearing.

Today, we are trying to shine a spotlight on the Blue Economy and its contribution to our Nation's economic health and revitalization. The Blue Economy, the jobs and economic opportunities that emerge from our oceans, Great Lakes, and coastal resources, is one of the main tools to rebuilding the U.S. economy.

America, from Fort Lauderdale, Florida, to Seattle, Washington, and as far inland as Topeka, Kansas, rely on our oceans for numerous goods and services—for food to fuel to rain for crops and, obviously, the great work we are going to hear about today, cures for cancer.

Today, the ocean and coastal economies of the U.S. provide over 50 million jobs for Americans and contribute nearly 60 percent of our GDP. We also rely on our oceans for trade in goods vital to our economy. Nearly 80 percent of U.S. imports and export freight is transported through our seaports.

And in my home State of Washington, our history and our economy are based on a rich maritime tradition that contributes as much as $3 billion for commercial fishing alone. For example, there are over 3,000 vessels in Washington's fishing fleet, and it employs over 10,000 fishermen.

There is great untapped wealth in our oceans, and that will lead to new jobs and new business opportunities. Fungus living on seaweed, bacteria growing in deep sea mud, sea fans may all hold the

key to curing cancer and other deadly diseases. And aquaculture is a growing industry along our shorelines and in the deep blue waters.

And concern with climate change is fueling interest in new blue jobs in renewable energy resources. According to a report released yesterday by the National Ocean Economics Program, the strength of the Blue Economy is dependent upon the health of our oceans and our coast, and today, our oceans are in peril.

Climate change, ocean acidification, pollution, overfishing, rising sea levels, and marine debris all have economic, social, and environmental impacts to our coast, to our oceans, and coastal economies. Protecting our oceans is an environmental and economic imperative.

There are steps that we need to take to maintain our Blue Economy. First, we must pass climate change legislation to reduce our carbon emissions, and second, we must strengthen the National Oceanic and Atmospheric Administration by doubling its budget over the next 4 years and creating a strong mission through an organic act that doesn't exist at this point. Third, we must find new approaches to incorporating ecosystem-based management in our oceans.

Our Blue Economy has been the foundation of our economy for centuries in the past, and it holds tremendous potential to growing economic opportunities for future generations. Our challenge is to strike a balance between maintaining the economic and social benefits of our oceans and coastline while protecting the vital marine ecosystem resources.

Before I introduce the panel today, I would like to turn to my colleague, Senator Snowe. Again, thank you for being here and helping us coordinate on the holding of this hearing. And I will turn to you for your opening statement.

## STATEMENT OF HON. OLYMPIA J. SNOWE, U.S. SENATOR FROM MAINE

Senator SNOWE. Thank you, Madam Chair. Thank you very much for calling this hearing today and for helping accommodate schedules.

It is a very difficult and challenging time. There are so many things going on at the same time. But I thought it was most appropriate to hold this hearing this week during Capitol Hill Ocean Week, to delve into some of the issues that are important to the oceans, but also to our Nation's economy.

I am pleased to welcome this esteemed panel of witnesses today to discuss many of the issues that are so important, especially in the developments in your respective spheres.

Today, the world's oceans face numerous threats toward their productivity and viability, including the looming threat of climate change. So, we must take stock of our ocean resources and examine the ways we can continue to utilize the goods and services our ocean provides, while simultaneously redoubling our efforts to ensure that we are using our oceans sustainably and also protecting them from the inevitable damage that will occur as a result of global climate change.

So, I am delighted that all of you could be here today to discuss relevant developments in your fields of expertise and help inform the policies we will develop in this committee in the coming years and months.

The more than 5,500 miles of coastline in my home State of Maine continues to shape our culture and our economy, as they have defined our heritage. The oceans have been truly the lifeblood of Maine's economy.

In 2007, Maine's fishermen landed over 180 million pounds of fish valued at nearly $350 million. Still, this represents a precipitous decline from the industry's peak in the early 1990s, particularly in the groundfish industry of cod, haddock, and flounder.

Until the last few years, Maine's fishermen made their living pursuing a diverse number of species, including groundfish, shrimp, lobsters, scallops, among others. Yet increasingly, our fishermen have been dependent on a single species. In 2007, over 80 percent of the value of Maine's catch came from lobster. This kind of consolidation is extremely perilous for our coastal communities, which rely heavily on the fishing industry and its affiliated businesses to survive.

Meanwhile, additional uses of ocean spaces are emerging that can contribute not just to our economy, but to the future of energy generation and climate policy. And just this last Friday, I joined the Governor of Maine and the Congressional delegation to meet with Secretary Chu about developing an offshore wind energy research development center at the University of Maine.

Today, the average Maine family spends 20 percent of their household budget on energy. That is expected to expand to 40 percent within the next 10 years.

Meanwhile, off the coast of just the Lower 48 States, we have wind resources capable of producing enough energy to exceed our Nation's total energy demand. And just off the coast of Maine lies wind resources that can generate energy equivalent to approximately 40 nuclear power plants.

Technology is currently available to harness the winds in shallow water, but we must push the envelope. Developing deepwater offshore wind technology capable of operating farther from our coasts where the winds are stronger and more consistent can help reform energy generation in Maine, throughout the Nation, and across the globe.

Maine is certainly uniquely positioned to be a leader in this effort. The oceanographic conditions in our State waters have excellent wind resources and water deep enough to deploy floating turbines, and that is going to be critically important. So, hopefully, we can explore the potential of this enormous opportunity for the State, as well as our country. It means thousands of jobs that can be created nationally, and it certainly means a clean energy future for generations.

I want to again thank our panel of witnesses for their efforts to be here today. And I also want to recognize Dr. Kildow and her report. I know she co-authored it with Dr. Charles Colgan, who is a Professor as well as the Chair of the Community Planning Development Center at the University of Southern Maine at the Muskie School of Public Service.

And I thought some of the statistics were truly fascinating, and I think it really does explain the scope of what we are talking about in terms of the use of the oceans and what they contribute to our Nation's economy and the coastal communities. And I am staggered by the fact that when you think about what you mentioned in your report that coastal counties, just 18 percent of the U.S. land area, contribute 42 percent of the U.S. economic output in 2007. The coastal States account for 83 percent of the U.S. economy.

I think that those are the statistics and facts that have to be heralded as to why we have to do everything we can to preserve the way of life in our coastal communities, the oceans, and what they represent, both for our energy purposes or for climate change, for our ecosystems, for our habitats. And people just truly don't understand the dimensions to which it contributes to this Nation and for generations to come.

So I very much appreciate you all being here today and your expertise. And if I have to leave early, please forgive me. I have another meeting on healthcare. What is coming up is we are beginning on healthcare reform. But I want to thank you all very much for being here, and I will certainly submit questions if I can't be here for the question period.

Thank you, Madam Chair.

[The prepared statement of Senator Snowe follows:]

PREPARED STATEMENT OF HON. OLYMPIA J. SNOWE, U.S. SENATOR FROM MAINE

Thank you, Madam Chair, for calling this hearing today to delve into the incredibly vital role the oceans play in our Nation's economy. It is appropriate that we have taken the opportunity presented by Capitol Hill Oceans Week to convene this in-depth discussion.

I am pleased to welcome this esteemed panel of witnesses here today to delve into these issues and update us on developments in their respective fields. Today, the world's oceans face numerous threats to their productivity and viability, including the looming threat of climate change. So, we must take stock of our ocean resources and examine the ways we can continue to utilize the goods and services our oceans provide while simultaneously redoubling our efforts to ensure that we are using our oceans sustainably, and also protecting them from the inevitable damage that will occur as a result of global climate change. Dr. Kildow, Ms. Cousteau, Dr. Fenical, Mr. Warren, Mr. Babb-Brott, and Dr. Kempton, I thank you all for taking the time to be here today to discuss relevant developments in your fields of expertise and help inform the policies we will develop in this Committee in the coming months and years.

Eons ago, the oceans began carving bays, inlets, and islands to form the more than 5,500 miles of shoreline in my home state of Maine, which continue to shape our culture and economy as they have defined our heritage. From the first settlers who hauled their food from the bounty of the Gulf of Maine to the proud ships that have been built at Bath Iron Works since 1888, to today's efforts to develop and deploy offshore renewable energy technology that can help wean our state from dependence on fossil fuels and foreign oil, the oceans have been the lifeblood of Maine's economy.

In 2007, Maine's fishermen landed over 180 million pounds of fish valued at nearly $350 million. Still, this represented a precipitous decline from the industry's peak in the early 1990s, particularly in the groundfish industry—cod, haddock, and flounder. Until the last few years, Maine's fishermen made their living pursuing a diverse number of species including groundfish, shrimp, lobster, scallops, and others. Yet increasingly, our fishermen have been dependent on a single species. In 2007, over 80 percent of the value of Maine's catch came from lobster. This kind of consolidation is extremely perilous for our coastal communities which rely heavily on the fishing industry and its affiliated businesses to survive. Which is why I have worked diligently with the National Marine Fisheries Service to implement a new regu-

latory structure in the groundfish industry that promises to make our fishery more profitable today and more sustainable for future generations.

Meanwhile, additional uses of ocean space are emerging that can contribute not just to our economy, but to the future of our energy generation and climate policy. Just last Friday, I joined Governor Baldacci and my colleague Senator Collins in a meeting with the Secretary of Energy to express our support for establishing a deepwater offshore wind energy research and development center at the University of Maine. Today, the average Maine family spends 20 percent of their household budget on energy costs, a figure projected to grow to 40 percent within 10 years. Meanwhile, off the coasts of just the Lower 48 states, we have wind resources capable of producing enough energy to exceed our Nation's total energy demand. And just off the coast of Maine lies wind resources that can generate energy equivalent to approximately forty nuclear power plants.

Technology is currently available to harness the winds in shallow water, but we must push that envelope. Developing deepwater offshore wind technology, capable of operating further from our coasts where the winds are stronger and more consistent, can help reform energy generation in Maine, throughout the Nation, and across the globe. Maine is uniquely positioned to be a leader in this effort—with the research capabilities already in place at the University of Maine in Orono, oceanographic conditions in our state waters with excellent wind resources and water deep enough to deploy floating turbines near shore in state waters, and legislation now in place—signed into law just last week—facilitating the testing of offshore wind turbines. Here we have an industry with the potential to bring tens of billions of dollars in investments and thousands of jobs to our state and the Nation, the result of which would be a clean energy future for future generations.

Once more, I thank our panel of witnesses for their efforts to be here today, and I look forward to an enlightening discussion. Without stealing too much of Dr. Kildow's thunder, I want to reference one statistic that clearly stood out to me in a 2009 report she co-authored with Dr. Charles Colgan, Chair of the Community Planning and Development Program at the University of Southern Maine's Muskie School of Public Service. Their report focuses on the state of the U.S. Ocean and Coastal Economies, and found that coastal counties—just eighteen percent of the U.S. land area—contributed forty-two percent of the U.S. economic output in 2007. As these findings make clear, our oceans truly hold the key to the future of our Nation's economy.

I regret that prior conflicts dictate that I will not be able to remain with you for the entirety of this vital discussion, but I will have several questions which I hope our witnesses will be able to answer for me in writing to be included in the formal record of these proceedings. Thank you, Madam Chair.

Senator CANTWELL. Thank you, Senator Snowe. And thank you for that passion.

Senator Martinez, would you—Senator Martinez, do you care to make an opening statement?

Senator MARTINEZ. No, thank you very much.

Senator CANTWELL. Well, thank you.

We will now turn to our witnesses. And again, I want to thank them for being here today and for their expertise in this area. Let me just briefly introduce them.

Dr. Judith Kildow, who is a social scientist and Director of the National Ocean Economics Program. Ms. Alexandra Cousteau, Founder and President of the Blue Legacy International. Dr. William Fenical, Director of the Center of Marine Biotechnology and Biomedicine of the Scripps Institute of Oceanography at the University of California. Mr. Brad Warren, Director of Ocean Health and Sustainable Fisheries Partnership, the Sustainable Fisheries Partnership in Seattle, Washington. Welcome. Mr. Deerin Babb-Brott, Assistant Secretary of Oceans and Coastal Zone Management, the Executive Office of Energy and Environmental Affairs, the State of Massachusetts, and Dr. Willett M. Kempton, Associate Professor for Marine Policy at the University of Delaware.

So welcome to all of you. Thank you for participating in this important hearing.

And we will start with you, Dr. Kildow.

**STATEMENT OF JUDITH T. KILDOW PH.D., DIRECTOR, NATIONAL OCEAN ECONOMICS PROGRAM**

Dr. KILDOW. Good morning, Chair Cantwell and Senator Snowe and members of the Committee.

My name is Judith Kildow, and I am Director of the National Ocean Economics Program.

I want to thank you for inviting me to speak today, and I am here to summarize our new report, as you have referred to it, and would like to make three points in my testimony.

First, that jobs and businesses generated by the coastal and ocean economies are the very foundations of the U.S. economy. The ocean and coastal economies are no longer a subset of the U.S. economy. They really are the U.S. economy. Second, coastal and ocean economies will power the Nation's economic recovery. And third, the deleterious effects of climate change will adversely affect the continuing growth of these important economies unless we take action to curb greenhouse gases soon.

So the National Ocean Economics Program began 10 years ago with an idea that a value could be placed on a portion of the national economy that was linked to our coasts and coastal ocean. And you have seen the reports of the compilation of our data in the report that you referred to.

But before beginning, I want to say two things about the report. First, to clarify what I will report on is that the coastal—we measured two economies. First, we measured the coastal economy, meaning all economic activity generated on land near the oceans, and then the ocean economy, meaning the economy generated by activities that depend on using the ocean and its resources. One is geography-based, the coastal economy. The other one is industrial-based, based on those industries that must have and use the ocean.

My report also comes with a caveat. It underreports by a lot what the ocean economy is worth. It does not include a lot of sectors, such as pharmaceuticals that you will hear about today. It doesn't include real estate, which is a huge part of the financial sector. And it does not include research and development.

These are categories that are not easily threaded out of the U.S. accounts from which we drew our data. So this is yet to come. I say this so that you will understand that the numbers that I report today are very underreported.

But we did put together a report based on living marine resources, marine transportation, marine construction, coastal tourism and recreation, ship and boat building and repair, and offshore minerals.

Now, how big is the impact of the coast and ocean economies? Well, Senators Cantwell and Snowe have really reported the numbers from our report. So I won't repeat what they have said. I will just summarize by saying that four out of five people who live in this country live along our coasts and generate more than 80 percent of the U.S. economy.

This speaks volumes, and they also represent about 80 percent of the jobs. The coast is the U.S. economy, and the coastal states are, and we can't deny this. If we look at the small band along the coast, what the impact is, this small band of shore-adjacent counties, which represents only a small portion of our country, we find that it represents more than half of the GDP for this country.

This tiny, little band of coastal shore-adjacent counties represent almost 50 percent or more than 50 percent of our gross domestic product and equal amount of jobs and population. So we really are talking about a mega-economy that has really been either neglected or avoided in discussions about economic recovery.

The other part that I want to report is that our fisheries, which I know are important to you, the value of U.S.-caught fisheries is one-half of the value of imported fisheries into this country, something that would have been inconceivable years ago.

And finally, I would like to say that we looked at nonmarket values. These are extremely important. They go unreported most of the time, but it is the value of our recreational and natural resource assets along the coast—estuaries, watersheds, beaches. These are worth hundreds of billions of dollars. We have studies on our website that describe these values and describe how experts have derived them.

But this is a part of our economy we cannot ignore. It is the very foundation upon which the market economy is based, and it represents a huge savings.

So the next question I want to refer to is what role the oceans and coastal economies have on the economic recovery. While all sectors of the coast and ocean economies are in decline now and will continue to shrink for the next few years, we should not misconstrue this as eliminating pressures on our coastal resources.

In fact, this economy will rebound, and it will rebound stronger, and it will grow essentially across the board. And when this happens, we have to be mindful that we definitely conserve and manage our resources so that we can make sure that we have a healthy economy.

Shipbuilding, marine construction, and other of the sectors will grow. They will actually stabilize the recovery. These are sectors that have fiscal and cyclical characteristics that will make the Nation's economy strong.

Finally, how will climate change impact these economies? This question probably presents the greatest challenge of all, unimaginable in years ahead. The significant environmental changes that we know that are underway that you just mentioned of sea temperature rise and ocean acidification, et cetera, will affect our food supplies, the very air we breathe, and our water supplies at the very least.

The landscape along the coast will definitely shift and change due to inundation and sea level rise. And shoreline communities that host these industries that are the foundation of the U.S. economy are going to have huge challenges in how to sustain their economies.

The offshore industrial expansion and environmental protection efforts from new energy and food demands from water delivery and housing pressures, plus responses to environmental threats, will

require creative management schemes akin to what coastal management strategies were since the early 1970s.

We project on our team that over the next 30 years, the Nation will see the most significant changes in the ocean and coastal economies since the arrival of industrialization and urbanization.

I hope you have found my summary useful and will take the time to read the full report that is found on our website and that we have distributed to your members today.

One final note. Unfortunately, there are no funds to continue this work, so that this may be the only report of its kind. While everyone seems to want this information, no one seems to want to invest in collecting it.

So I suggest that the Federal Government—that it is imperative that the Federal Government keep a set of oceans accounts somehow. Why? Because the oceans are too important to the United States economy to be overlooked.

I thank you for your time and interest.

[The prepared statement of Dr. Kildow follows:]

PREPARED STATEMENT OF JUDITH T. KILDOW PH.D., DIRECTOR, NATIONAL OCEAN ECONOMICS PROGRAM

Good morning Chairman Cantwell and Members of the Committee.

My name is Judith Tegger Kildow and I am Director of the National Ocean Economics Program.

I am here today to summarize a major report: "State of the U.S. Ocean and Coastal Economies" just released by my research team from the National Ocean Economics Program (NOEP) to kick off Capitol Hill Ocean Week. Let me first give you a bit of background about me and this report, and then provide you with the information I know you await.

When I had the idea, 10 years ago, that a value could be placed on that portion of the national economy that was linked to our coasts and coastal oceans, "they" thought I was crazy. This was especially true at the university where I was a professor—MIT. They had good reason to think that. I was in the ocean engineering department, not the economics department. And I wasn't an economist; my Ph.D. is in international Science Policy. But there was good reason to pursue my idea:

*In 1983, the U.S. acquired an exclusive economic zone offshore of more than 4 million square miles that more than doubled U.S. territory; yet its value has barely been estimated until now, and its management is currently under intense discussions.*

I had the notion that I could identify all of the segments of the economy that depend upon a location near or on the ocean. I thought I could parse out what fishing really brings to the American economics menu. And marine transportation. Drilling for oil. Building ships. I thought I could even figure out the value of a day at the beach!

I assembled an advisory board of world-class economists and other experts, including a Nobel laureate. Despite my doubters, I persisted, left MIT, and began a decade-long odyssey that would take the NOEP to the University of Southern California, the University of Vermont, California State University Monterey Bay, and the Monterey Bay Aquarium Research Institute. Basically, what I was doing was carrying a tin cup to any place interested in my ideas that might host me and my program and pony up a bit of money to finance the study.

In the beginning I attracted interest from NOAA, which provided partial funding throughout much of the 10 years, especially the Coastal Services Center. And early on, I hooked up with Dr. Charles Colgan, a professor at the University of Southern Maine, who had the intellectual skills, and the grit and persistence, to fly down to Washington on a regular basis and immerse himself in the arcane national data bases that provide the details of the comprehensive report that we have just concluded.

This was literally grunt work, especially for an academic like Charlie. But he labored in the trenches, gathering information compiled over many years using complex formulas that could separate ocean from non-ocean-related activities in a way that didn't violate disclosure rules, so that we would have a comprehensive database that embraced the entirety of two distinct, but overlapping, economies: the coastal

economy, meaning all economic activity generated on the land near the oceans; and the ocean economy, meaning the economy generated by activities that depend on using the ocean and its resources. It can get confusing because the ocean economy and coastal economy are not the same, yet do overlap, so you cannot add them up to get a single number that represents the size of these two economies.

But size is important here. The coastal economy alone—that is, the counties that border the oceans, Gulf of Mexico, and the Great Lakes—totaled $5.7 trillion in 2007, despite comprising only 18 percent of U.S. land area, and where more than 108 million people reside and hold more than 48 million jobs. More than three-quarters of the growth of the entire U.S. economy has taken place in coastal states. Parenthetically, 83 percent of U.S. GDP is in those coastal states.

The ocean economy—a smaller economy than the coastal economy—in 2004 generated $138 billion, approximately 1.2 percent of the U.S. GDP, and provided 2.3 million jobs. This is equivalent in size to the U.S. insurance industry by employment and the motor vehicle parts industry by GDP.

I would like to make two points here that I think important:

First, the coastal and ocean economies will power the Nation's economic recovery.

Second, the deleterious effects of climate change will adversely affect the continuing growth of these important economies unless we taken action to curb greenhouse gasses soon.

My report comes with a caveat: it under reports the true size and impact of the coastal and ocean economies. This is because throughout the 10 years, we have not been able to fully utilize the data that are gathered by the Federal Government's North American Industrial Classification System, which is our primary source of information for market sectors. The NAICS accounts as established do not fully identify ocean-related activities. For example, data on the pharmaceutical industry does not categorize the significant amount of income generated by the industry from exploiting the riches of the sea to make drugs. Likewise we can only obtain data on coastal real estate by literally gathering it by hand—going to local sources to track transactions. If you've tried buying a house on the coast lately, you'll know that this is a significant omission.

Nevertheless, we put together a report that measures the economies of these sectors with consistency so that they are comparable across geographies and sectors: living marine resources, marine transportation, marine construction, coastal tourism and recreation, ship and boat building and repair, and offshore minerals.

Some off-the-top findings detailed in the report about the ocean economy:

- The largest and fastest growing sector of ocean economy was tourism and recreation with 1.7 million jobs or 75 percent of ocean economy employment and $70 billion—that's more than half of GDP; marine transportation was second largest with $27.6 billion, 20 percent of the ocean economy.
- Total U.S. offshore oil production, 28 percent of all U.S. oil production, was valued at >$27 billion in 2004: $3 billion in state waters, the rest in Federal waters. It is apparent that the balance has shifted over the years and states are not getting nearly the revenues that the Federal Government is from these operations.
- Total landed value of fish caught in U.S. waters was $3.7 billion in 2004—and that totals just half the value of imported fish for that same year. Not so long ago, this would have been unimaginable. Now farmed seafood is expected to make up for this loss.

These two economies, ocean and coastal, will drive the Nation's economic recovery in part just by sheer size, but also because of a rapidly growing non-market economy in these regions—in short, the value of a day at the beach. When Dr. Linwood Pendleton, recently a professor at UCLA and now a Fellow with the Ocean Foundation, joined our team, we were finally able to quantify the non-market economies, such as recreation, the allure of scenery and the wildlife viewing. Professor Jason Scorse from the Monterey Institute for International Studies continued this work, and found that values from this non-market economy exceed $100 billion annually, and will grow. It isn't expensive for families to partake of days at the beach, and they flock there in increasingly greater numbers, spending money that trickles into the local economies. You and I have come to appreciate the valuable services of storm buffering, pollution filtration and fishery nursery grounds provided by estuaries; the enormous recreational revenues generated by beaches and harbors, and the importance of stable shorelines to protect infrastructure ranging from homes to airports. The value of these services is not found in the marketplace, but needs to be accounted for as we plan for the challenges that lie ahead.

While all sectors of the coastal and ocean economies are in decline along with the rest of the economy, changes over past decades have increased their contributions as a share of the national economy. Over the next few years, they will shrink, without doubt, causing some to think that the intense pressures on costal regions have abated so there is less need to protect these resources.

That would be a serious mistake. The economy will recover generally, and historic coastal pressures will resume and intensify. This will result in growth essentially across the board. Ship building, for example, primarily for the U.S. Navy, marine construction, particularly for ports, and the offshore minerals industry will grow in part because of inherent cyclical characteristics, and because of Federal fiscal policy.

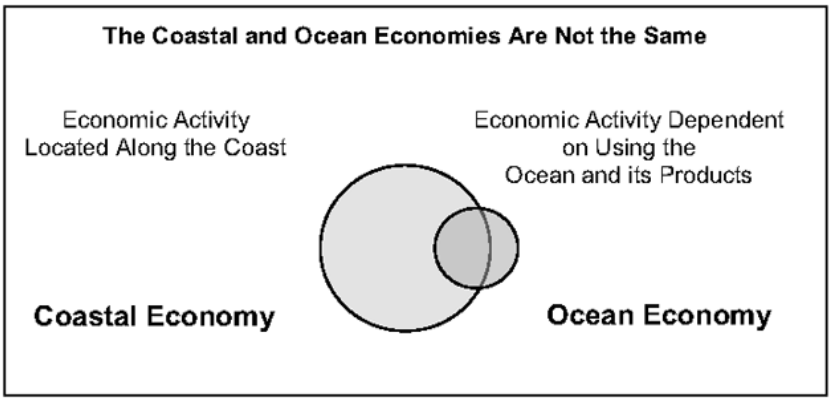
How will climate change alter the future?

First, there will be significant environmental changes, such as sea level and sea temperature rise, oxygen depletion, and ocean acidification. The landscape will change dramatically, restructuring an array of natural and physical assets as well as cultural and economic. In fact, our research team projects that over the next 30 years the Nation will see the most significant changes in the ocean and coastal economies since the arrival of industrialization and urbanization. Shoreline communities that host tourism, recreation, marine transportation, and marine construction will have to adapt to an increasingly hostile environment for both built structures, such as ports and harbors, and natural structures, such as beaches and estuaries.

This is the first report of its kind about the United States—and likely the last. It was prepared by academics at three institutions and reviewed by experts in government, academia, and nongovernmental organizations. NOEP has developed the most detailed ocean valuation methodology available anywhere, and it is in use as a core template by other nations that are publishing ocean accounts, such as the United Kingdom, France, Canada, New Zealand, Australia, and the European Union.

There are no funds to continue this work so this may be the only report of this kind. Everyone seems to want this information, but no one wants to invest in collecting and analyzing it. The NOEP website will remain on the Internet at *www.OceanEconomics.org* until the end of this calendar year, and there will be a special page for this national report, the appendices, and other supplementary materials we have prepared including a full set of coastal state summaries of their ocean and coastal economies. The website for these materials is found on the inside back cover of the report you have here today. Whether the NOEP continues, or not, the government should keep a set of ocean accounts for many reasons, especially in light of the changes that are underway from greenhouse gas impacts and the volatile economy. The oceans are too important to the U.S. economy to be overlooked.

Thank you.




Senator CANTWELL. Thank you, Dr. Kildow.

We really do appreciate the report, and I know that you mentioned these statistics. But I think, in fact, that these economies of shore-adjacent counties will be the third-largest economy in the world after the European Union and the United States based on

GDP is just quite an impressive number. So thank you for your work.

Ms. Cousteau, thank you for being here with us today, and if you would go ahead and make your statement?

Thank you.

Ms. COUSTEAU. Thank you, Chair Cantwell.

Senator CANTWELL. You might have to pull that up close to you so we can——

Ms. COUSTEAU. Is that better? No?

Senator CANTWELL. It will help if you get it a little closer. There we go.

**STATEMENT OF ALEXANDRA COUSTEAU, FOUNDER AND PRESIDENT, BLUE LEGACY INTERNATIONAL**

Ms. COUSTEAU. Before I deliver my formal comments this morning, I want to say a very sincere thank you to Chair Cantwell, Senator Snowe, Senator Martinez, to the Members of this Committee and their respective staff members for inviting me to be here with you today and share my thoughts on this critical issue.

My grandfather spoke strongly of the importance of informed policy and always relished the opportunity to discuss these issues frankly with leaders of this body. It is an honor for me to continue that legacy here today because, for me, water and our oceans are more than a legacy. I have dedicated my life to exploring how these vital issues impact everyday people around the world, and I have created my organization, Blue Legacy, to do just that.

I am convinced that in order to truly make a difference, it is time we stopped viewing ocean and water policy as freestanding issues and realize how interconnected all environmental and economic issues truly are. If this generation is to change things, we must bring ocean policy ashore.

The ocean is the lifeblood of the Earth, covering more than 70 percent of the planet's surface, driving weather, regulating temperature, and ultimately, supporting all living organisms. Throughout history, the ocean has been a vital source of sustenance, transport, commerce, growth, and inspiration.

But the decline of the oceans due to pollution, overfishing, and climate change is now increasingly being felt in the quality of life of people everywhere. It is not just the coastal areas that are affected by these issues.

Louisiana's wetlands, for example, are twice the size of the Everglades National Park, funnel more oil into the U.S. than the Alaskan pipeline, sustain one of the Nation's largest fisheries, and provide vital hurricane protection for New Orleans. And they are disappearing under the Gulf of Mexico at the astonishing rate of 33 football fields a day.

While we were in Louisiana on a recent expedition, we spent time with the Cajun shrimp fishermen who have been fishing the Gulf of Mexico for five generations. The core component of the culture of coastal Louisiana is shrimping and fishing. It is not just the way people have historically made a living. It is life. It is what they do, and it is who they are.

Scott St. Pierre, a shrimp fisherman in his mid-40s told me, "We are not American. We are Cajun. We love food. We love our fami-

lies. We love the church, and we love to fish." They are obviously proud of their unique culture and the fact that they contribute significantly to the 40 percent of U.S. seafood supplied from Louisiana's waters.

But sadly, the Cajun way of life is gradually dying out, due to pressure from a number of factors that are all related to water. The land is rapidly sinking because Louisiana's wetlands have been nearly destroyed. Hurricanes, which are growing increasingly frequent and powerful due to climate change, threaten to wipe their town off the face of the Earth. And local young people are leaving for jobs in big cities, in part because the massive amount of agricultural runoff is creating a dead zone the size of New Jersey that is eradicating the Gulf of Mexico's shrimp supplies.

This story is just a single microcosm. The same story is true of every one of our coastal communities with their myriad of traditions and economies that are at risk. And this underscores the reason why, as a Cousteau, I spend the majority of my time on land, talking with small communities, rather than on a boat or diving underwater. Because while the degradation of the oceans is happening out there, it is being felt right here in the homes of everyday people in this country and around the world.

If we are to take ocean policy seriously, we need to take it onto the land. We must start to realize that there can be no stand-alone policies, especially as they relate to our water resources. Energy, transportation, climate change, infrastructure, agriculture, urban development—this is where our ocean policies must begin because everything is interconnected.

Water is Earth's great storyteller. It is the mark of sustainability in a culture and is where we will feel the effects of climate change first. Unless we begin to work together to build a shared focus on this blue planet as a single hydrosphere, we will never build the kind of momentum it takes to leverage real and long-term change.

Thank you.

Senator CANTWELL. Thank you, Ms. Cousteau.

And thank you for your and your family's dedication to the oceans and the illuminating research that you have done. So we appreciate you continuing in that legacy.

Dr. Fenical, welcome. Thank you very much for being here. We look forward to your testimony.

**STATEMENT OF WILLIAM FENICAL, DISTINGUISHED PROFESSOR OF OCEANOGRAPHY AND PHARMACEUTICAL SCIENCE, SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNIVERSITY OF CALIFORNIA**

Dr. FENICAL. Thank you very much, Senator Cantwell, Senators Snowe and Martinez, and members of the Congressional staff.

I am here to talk about what we haven't done with the ocean, what remains, and the amazing economic impact that exploration of the ocean can have on our economy.

This needs to be preset in the context that the American economy has been and is growingly more dependent upon our ability to discover and to innovate than it is in our ability to produce. And in that context, I want to point out that nature has provided huge numbers of new products of commercial importance.

Four thousand years ago, humankind began to explore nature and to utilize products from plants and animals all throughout the world, and this led, over the ensuing centuries, to the development of products. You can look at any product that you have in your medicine cabinet, in your food supplies, in your cosmetics, and see on the label that natural products are part of these products providing really an incalculable context of economic benefit to our society.

But when you think about that development, that history, what we realize right away is that it has only been very recently that we have recognized the importance of the oceans. And a tremendous benefit remains for us to harvest from that source. As was said, the oceans are a huge component of our planet. They are, in particular, a very diverse environment in the American waters, from the Caribbean to the far South Pacific areas, and we have yet to utilize these products in commercial context.

What is unique about the ocean is that when one considers genetic diversity, 44 of the 46 basic phyla, basic divisions of life, exist in the ocean, whereas, only 17 of these basic divisions occur on land. And so, to be accurate, we should have started to explore the ocean first. Why are we looking at our terrestrial life?

Well, this is natural because we are terrestrial beings, and we are unfamiliar with the ocean. But we are becoming more familiar. And with technology, we are becoming able to develop studies of the oceans, including the deepest parts of the ocean.

What we are talking about are natural compounds. Genetic diversity equates because of coding for the production of natural compounds, and it is these same natural compounds that have been used to generate great economic value.

These compounds consist of cosmetic products, as I said, but go way beyond that to include coloring agents, food products, and so on. And very few of these products have, at this point, been explored in the ocean.

One of the most important areas, and an area that I specialize in, is the development of pharmaceutical products. And this is an area of economic benefit to the United States in excess of $290 billion per year. Forty of the top pharmaceutical products provide income in excess of $1 billion per year.

And so, these are enormous economic benefits. But, of course, not just the economic benefit, but the benefit to society is important. In 1900, the average life span was 47 years. Now, in 2009, the average life span is 76 years. And this is a result of medical research, education in health, but in a major way, the discovery and development of new pharmaceutical products that treat cancer, infectious diseases, diabetes, and the like.

Why haven't we looked at the oceans? The oceans are a great resource, but it has been the last resource because we are conservative on developing such a vast area of resources. The oceans have been explored recently and are beginning to be explored, and this has resulted in the development of two marine-derived drugs—one for intense pain and the other for cancer treatment of soft-tissue sarcoma.

But this is just the beginning of an enormous iceberg of development and discovery that could happen in the future. Twenty-six

drugs derived from marine life are being developed. Currently, they are in human clinical trials. And as time passes, of course, we intend to increase that number significantly.

What are our challenges? Of course, the challenge is global warming, seawater temperature increase, and this is providing extinctions, mass migrations of plants and animals to new environments, and the like.

Last, I think that the oceans and human health legislation that we are looking at now is an opportunity to change the situation in a very positive way to bring a focus on the health benefits of the ocean and develop new products and resources.

Thank you very much.

[The prepared statement of Dr. Fenical follows:]

PREPARED STATEMENT OF WILLIAM FENICAL, DISTINGUISHED PROFESSOR OF OCEANOGRAPHY AND PHARMACEUTICAL SCIENCE, SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNIVERSITY OF CALIFORNIA

**Introduction**

Scientific and technological discovery and development, more than ever before, is perhaps the most important foundation of the economy of the United States of America. As we enter the decades to come, it is crucial that the U.S. lead in *marine biological research* providing for the creation of new industries based upon discoveries made from the ocean.

**The Oceans as Our Great Resource**

The world's oceans occupy more than 70 percent of the surface of the Earth and 90 percent of the volume of its crust. While this is the largest ecosystem of plant Earth, we have only now realized that it is the most important of our biological resources.

Biological diversity is best viewed at the phylum level, with humankind occupying the phylum Chordata. There are 46 phyla of biodiverse life on this planet, but these are unequally distributed between terrestrial and marine environments. On land, it is generally agreed that 17 phyla are represented. In the ocean 44 phyla are present, comprising our most diverse and complex biological community.

*Why has it taken so long to accept this reality?*

As terrestrial beings, humans have classically been unable to comprehend the scope of marine environments and the diverse biota that abound from the ocean surface to depths of greater than 13,000 meters. Humans are not adapted to life in the sea, hence they are less familiar with the oceans and even frightened to explore it.

**Genetic Diversity = Chemical Diversity**

Since genes are the molecular codes for new chemical compounds, it is clear that genetic diversity leads to chemical diversity. Thus, it is easily predicted that the oceans are our most prolific source for new chemical compounds. Sometimes called "natural products", naturally-produced chemical compounds are the foundation of a large diversity of industries and products, including pharmaceuticals (50 percent of all drug are from Nature), cosmetic products (most contain natural chemicals), food flavorings and colorings, food additives (thickeners, vitamins, preservatives), biomaterials (polymers and biomaterials), and a host of others. If one examines the labels of virtually every consumer product we use, natural chemical compounds can be readily seen.

**Values of Natural Products—Pharmaceuticals Top The List**

It is difficult to estimate the overall economic importance of natural chemical compounds, but clearly it is immense. Some of the most significant areas include the discovery and development of new pharmaceuticals and personal care products. As the U.S. population ages, they rely more than ever before on medications that can suppress or cure human diseases. Since the invention of the automobile, human life pan has increased from 47 years to over 75 years; much of this life extension is due to effective medical care which emphasizes drug treatments for cancer, heart disease, diabetes, and many other human maladies. In 2007, the U.S. pharmaceutical

industry documented sales in excess of $286 B USD.[1] Much of this came from sales of "blockbuster drugs" such as the cholesterol-lowering drug Lipitor, which generated $7 B USD in 2007. Overall, there are more than 40 currently prescribed drugs that report sales in excess of $1B USD per year.[2]

**The Impact of Pharmaceuticals on Human Life**

While the economics of pharmaceutical sales is huge, the positive benefits on human health must be underscored. More than ever, difficult diseases are treated with the latest pharmaceutical discoveries. Diseases once considered fatal, are not treatable and often curable. *There is no question that the discovery and development of new drugs is one of our most important societal goals.*

**Pharmaceutical Discovery in the Oceans**

Considering that 50 percent of the current drugs are either of natural origin or fashioned from natural drugs, it is imperative that we carefully consider the sources we have that are undeveloped. The treatment of cancer and infectious diseases, in particular, rely on naturally-occurring chemical compounds (Taxol, Penicillin are prominent examples) for their effective control. Because of the difficulty in treating complex cancers, and the growing epidemic of drug-resistant infectious diseases (MRSA for example), these diseases provide the greatest societal need for new and more effective therapeutics.

*Where will the new drugs in the next decades be derived?*

Drug discovery is a very complex process involving many effective approaches including bioassay-guided synthesis and computer-assisted design. In the areas of cancer and infectious diseases, it is generally agreed that natural drugs provide perhaps the best opportunities.

Because of the enormous biodiversity, marine environments provide the most prolific sources for new, natural drugs. This has been recognized by academic scientists and pharmaceutical researchers, leading to two current drugs (for cancer and pain control) on the market, and more than 25 additional marine-derived drugs currently being evaluated in human clinical trials.[3]

Despite the enormous benefits, the U.S. pharmaceutical industry has been slow to embrace marine drug discovery. This has not been the case with the smaller biopharmaceutical industries ("Biotech"), which are less risk averse and can create and utilize new technologies in more dynamic ways. The linkages between academic scientists familiar with the ocean and its biodiversity, and biotech industries capable of development and sales, is a crucial one allowing the oceans to be explored. It is this aspect of science policy that should be underscored as the resources of the ocean are developed.

**Secondary Benefits of Marine Drug Discovery**

It is important to understand that the process of natural drug discovery has enormous additional benefits to medical research. Often, new drug candidates are discovered that, for numerous reasons, are recognized to be unsuitable for treating human disease. At the same time, these agents possess unique pharmacological properties and affect human biochemical pathways that were previously unknown or poorly understood. Known as "molecular probes", these compounds have enormous utility in medical research. One such probe, known as aqueorin or Green Fluorescent Protein (GFP), is a protein isolated from the jellyfish *Aqueoria victoria*. GFP, which can be linked to drugs and other proteins, has revolutionized the study of human cell biology. This led to the award of the 2008 Nobel Prize to Chalfie, Shimomura and Tsien, for their discovery and development.[4]

**How Will Climate Change Impact Natural Drug Discovery?**

The biodiversity we currently enjoy is not guaranteed as we recognize the impact of global climate change. Populations of marine organisms are already beginning to decline or to migrate to new environments. While we can measure the impact on macroscopic marine life, and have done so in many areas, the impact on microbial communities, because of their more limited temperature adaptation, is likely to be greater.

---

[1] *http://www.usatoday.com/money/industries/health/2008–03–12-drug-sales__N.htm.*

[2] *http://www.drugs.com/top200.html.*

[3] D. Newman and G. Cragg, Chap. 12 in *Bioactive Natural Products, Detection, Isolation and Structure Determination,* Steven M. Colegate, Russell J. Molyneux, eds., CRC Press, 2007.

[4] *http://www.conncoll.edu/cca.cad/zimmer/GFP-ww/GFP–1.htm.*

*Why do we care?*

Microorganisms are historically the most prolific sources for new drugs. The discovery of penicillin in 1929 heralded the great "antibiotic era", which produced virtually all of the antibiotics we use today. Microbial antibiotics are produced by cultivation of bacteria and fungi in large-scale fermentors. The oceans are a major, untapped resource for bacteria and other microorganisms. Seawater is composed of 28 million microscopic cells per ounce. The bottom sediments, which mimic the soil, contain more than 1 billion cells in the volume of an ordinary cube of sugar. This is an amazingly unique community that is distinct from its terrestrial counterparts. Currently, at least 2 anti-cancer drugs, produced by marine microbes, are in clinical trials for the treatment of various forms of cancer.[5] When one considers the medical emergency we face with drug-resistant infectious diseases, and the fact that microorganisms are the best source for new antibiotics, it is clear that marine bacteria and fungi represent the next great source for the discovery of new antibiotics to control human infectious diseases.

Recognizing the important role marine microorganism will play in the future, it is disconcerting to consider the impact of global climate change on their survival and distribution. As the temperature of seawater increases, temperature adapted microorganisms typically illustrate stress responses. Thus, in several ways, the diversity of the ocean and our ability to use this amazing resource are linked to our future success in controlling global change.

Senator CANTWELL. Thank you, Dr. Fenical.

And we look forward to asking you some questions more about that and potential products for the future.

Mr. Warren, welcome. Thank you for being here.

Obviously, part of today's discussion is the impacts that climate change have on our oceans and on our environment. We should note that this week, everybody has been complaining about Seattle weather being in Washington, D.C. And I note that we have been having wonderful 85-degree weather in Seattle, sunny.

So, anyway, welcome to Washington, D.C.

## STATEMENT OF BRAD WARREN, SUSTAINABLE FISHERIES PARTNERSHIP

Mr. WARREN. Thank you, and thank you for having this hearing. I am really pleased that people here in D.C. are paying attention to the ocean. We need that.

My name is Brad Warren. I run a program at the Sustainable Fisheries Partnership dealing with ocean health. I got started doing this because after 20, 25 years working in essentially trade publishing in the fishing industry, I saw things coming in climate change that we really had to deal with.

Can you hear me? OK.

An industry like this that totally depends on ocean health is going to have a lot to say about this, and I thought we have got to get these guys up to speed, and we have got to get their influence at the table where they can help contribute to solutions. So that is what I am doing.

I am going to tell you a nutshell story that relates to what Dr. Fenical is doing. I have a very dear friend that I have spent a lot of time with in the hospital in the last 2, 3 months. He is fighting a form of soft-tissue sarcoma for which one of the treatments that people have a lot of hope for is a compound derived from sea urchins.

[5] *http://www.nereuspharm.com/.*

Sea urchins are among the species most vulnerable, most likely to dissolve because of ocean acidification. We have an enormous resource here in terms of its medical value, and we may well be throwing it away. Having said that, I will go into the rest of my testimony.

What we are dealing with in terms of the dangerous rise in world emissions of carbon dioxide is something that has the potential to undercut every aspiration that we have for fisheries and ocean ecosystems. This isn't just one more problem for the ocean. It is the one that sets the terms for all the others.

There are lots of efforts underway to conserve fisheries and protect marine habitats, but there is a good chance that none of them will amount to much if we don't get this one right, if we don't get a grip on our rising emissions of carbon.

I want to thank this committee again for recognizing that the ocean belongs in this discussion, that the kind of integration of issues that Ms. Cousteau was talking about is exactly what we need. To be clear, SFP, for which I work, is not a lobby group. We instead help leaders in the seafood industry to understand the issues well enough to be part of the solution to the problems they really care about. They do the advocacy work. We are more of a technical adviser.

What is at stake in getting a grip on carbon for the ocean is pretty big. Not even getting into the economic value of the pharmaceuticals that are likely to come out of this ocean, we are still at the infant stages of that, just the fish products. In the U.S. alone, seafood generated $68.4 billion in retail sales in 2007, according to NMFS. When you add wholesale and processing value to that, you see 67,000 jobs there. Add food service, and the numbers soar. There were, in 1999, the latest study I have seen from New York on this, 70,000 full-time jobs supported by sales of seafood in restaurants.

Worldwide, marine fisheries provide the primary source of income and food for hundreds of millions of people. FAO and other international resource agencies estimated this year that 3 billion people rely on the ocean for essential nutrition. About 400 million people in poor countries get half or more of their annual protein and minerals from seafood. About half a billion people worldwide in developing countries earn a living from fisheries and aquaculture.

How much of this will be lost if we don't reduce emissions? We don't know. There aren't good answers for that, but we do know that it doesn't look good. And if we make a mistake here, the losses will be permanent.

At a minimum, we expect ocean acidification and hypoxia alone will reduce productivity of fish stocks that generate food and livelihood for many millions of people. In the worst case, we could see the extinguishment of many fisheries. Large parts of the world's surface ocean, the top few hundred meters where virtually all of our seafood comes from, are already becoming corrosive to many of the plankton species that form the foundation of marine food webs. If the fish lose their dinner table, we will lose ours.

The consequences of warming also take a toll. I will cut to the chase here and mention that there is some hypoxia occurring in the

North Pacific that is particularly severe. We are looking at very deep loss of habitat for groundfish, some of the most valuable and productive fisheries we have.

Adaptation has limits. When it comes to chemical change in the ocean, unlike thermal change, it is not clear that you can—well, once the ocean becomes corrosive for calcifying species, they dissolve. An ocean that is unfit for fish and the things they eat is not an ocean that fisheries can adapt to.

There are some things we can do in terms of adaptive management. We can do some good research. We should do more. We have a profound need to dig in deeper in terms of how productivity in the ocean is changing so that we have a chance of managing fisheries sustainably as the ocean changes.

If we invest in understanding these changes, we have a chance of adapting in a responsible way. So I would say there are a couple of take-home points here. We need a strong carbon policy. One can argue about where the thresholds should be. We are going to get a pretty good glimpse of that in a paper that is pending in press now by Feely and Turley that says here are the biological and chemical bases for setting thresholds for $CO_2$ based on ocean health. We think that is going to be a good place to look for figuring out how to set those thresholds.

We urge you—and we are urging the industry to do the same, to urge you—to do everything you can to do the kind of thing you are already talking about. You are talking about doubling the budget for NOAA. We salute that. We are going to need a lot of that research, or we are not going to know enough to handle this problem.

And then remember the nature of the risk. Overfishing and things like that are classic old-school risks that we manage in a way that bears in mind that you can usually get it back. You blow it—well, you just fish less. The fish generally come back. It is a marvelous kind of risk to face. This is not that kind of risk.

This is one where, as far as we human beings are concerned, the geologic record suggests it is basically forever. We lose it. It is gone.

Thank you.

[The prepared statement of Mr. Warren follows:]

PREPARED STATEMENT OF BRAD WARREN, SUSTAINABLE FISHERIES PARTNERSHIP

Thank you for the opportunity to testify today. It's especially gratifying to be here today because the theme of this hearing, the Blue Economy, shows that many of our elected leaders today—including leaders from both parties—"get it" about the ocean. We are all here today because you understand that the ocean, which has been so generous to human beings for so long, now needs our help.

My name is Brad Warren, and I run a program on ocean acidification and global ocean health at the Sustainable Fisheries Partnership (known as SFP). SFP is a nonprofit group that works with the seafood industry to conserve fisheries and marine ecosystems around the world.

I came to this work after more than two decades in the fishing industry, where I mainly ran industry trade journals. I left the publishing business to focus on preparing the industry to confront $CO_2$-driven ocean acidification and climate impacts. I made this change because it was the most important work I could think of to do. The dangerous rise in world emissions of carbon dioxide has the potential to undercut every aspiration we have for fisheries and ocean ecosystems.

This isn't just one more problem for the ocean. It's the one that sets the terms for all the others. There are lots of efforts underway to conserve fisheries and protect marine habitats. But there is a very good chance that none of them will amount

to much if we don't get a grip on the world's carbon dioxide emissions. It will be hard to save the fish if the ocean stops making them.

I want to thank this committee for recognizing that the ocean belongs in this discussion. If we want the ocean to keep producing the benefits we enjoy—things like fish, whales, seafood jobs for millions of people, and (thanks to photosynthesizing plankton) about half of the oxygen we breathe—then we're going to need carbon policies that preserve its capacity to deliver the goods.

To be clear, SFP is not a lobby group. Instead, we help leaders in the seafood industry to take on fundamental challenges to their future ability to produce and market fish products. Ultimately it will be up to them to speak for themselves on this issue. But I can tell you that they're listening, they're seriously concerned, and they are sorting out how they can be part of the solution. Some of the companies and fishing groups we work with are keen to learn more about carbon policy, where it's going, how it might affect them, and how it might help protect the ocean they depend on.

What's at stake? Well, In the U.S., seafood generated $68.4 billion in retail sales in 2007, according to the National Marine Fisheries Service. Processing and wholesaling alone accounted for 67,000 jobs. Add foodservice to that, and the numbers soar. Seafood sales in New York State restaurants were estimated to support the equivalent of 70,000 full-time jobs in 1999, according to New York Sea Grant.

Worldwide, marine fisheries provide the primary source of income and food for hundreds of millions of people. FAO and other international resource agencies estimated this year that 3 billion people rely on the ocean for essential nutrition. About 400 million people in poor countries get half or more of their animal protein and minerals from seafood. Another 500 million people in developing counties earn a living from fisheries and aquaculture.

How much of this will be lost if we don't reduce emissions? There are no good answers yet. But we do know this: If we delay acting until we know exactly what is at risk, we will make more of those losses unavoidable. Future generations will remember us for this. Whether they will forgive us is another question.

We at SFP, and some of our colleagues in other organizations, have done a lot of work to make sure leaders of the U.S. fishing industry understand what the science is telling us about ocean acidification.

The chemistry is pretty clear. The changes have been measured, not just modeled. We know that billions of tons of $CO_2$ from smokestacks and tailpipes are mixing into the ocean every year. The resulting carbonic acid depletes the rich soup of calcium carbonate in seawater. Many of the fish we eat depend on food species that literally build themselves out of that soup. One example: Pteropods, an important food source for salmon and many other fish, have been shown to dissolve quickly in calcium carbonate-depleted conditions resulting from elevated $CO_2$ concentration. Those conditions already occur in some near-surface waters along the West Coast and Alaska.

If you want to see the key scientific papers that document acidification impacts, I would be happy to provide them.

At a minimum, we expect ocean acidification and hypoxia alone will reduce productivity of fish stocks that generate food and livelihood for many millions of people. In the worst case, acidification could extinguish many fisheries. Large parts of the world's surface ocean—the top few hundred meters, where virtually all our seafood comes from—are already becoming corrosive to many of the plankton species that form the foundation of marine food webs. This is what fish eat. If fish lose their dinner table, we'll lose ours.

The consequences of thermal change—global warming—are mixed for fisheries: Small amounts of warming can and do increase the productivity of fish stocks, at least temporarily. One could make a case that some of our major fisheries have benefited from warming in the last few decades. As temperatures rise further, though, that benefit will vanish. Like Goldilocks, fish want temperatures that are "just right."

The consequences of warming also take a toll on the oxygen content of seawater, especially in deeper waters. Several studies suggest that we're rapidly losing deep habitat for many marine fish because warming has triggered processes that deplete the oxygen they need to survive. Some of the most compelling work on this problem comes from Canada's Department of Fisheries and Oceans.

Some fisheries, such as Washington State's oyster industry, may already be suffering grave harm from ocean acidification. Oyster growers have suffered 4 years of reproductive failure. There is preliminary evidence that this may be due to ocean acidification, or possibly to a disease that thrives in acidified, oxygen-depleted seawater. Larval forms of many marine species are especially vulnerable, and lab experiments show very high mortality; in a preliminary study by NOAA scientists, 67

percent of larval blue king crab died when exposed to levels of acidification similar to those already measured in some waters—including parts of the West Coast during summer upwelling.

Based on peer-reviewed NOAA research findings, it appears that the West Coast and the North Pacific off Alaska are especially vulnerable in the near term, because $CO_2$ tends to collect there. In the near-surface waters where most fish and shellfish live, $CO_2$ concentrations are unusually high in the North Pacific region. Alaska produces about two-thirds of the U.S. fish harvest. So a lot of food is at stake.

If we lose marine fisheries, some people hope that aquaculture will take up the slack. I wouldn't count on that. The popular farmed seafood products we consume in America—shrimp, salmon, tuna, etc.—are raised on feeds that include millions of tons of wild caught marine fish. Indeed, aquaculture consumes 57 percent of the world's annual production of fishmeal and 90 percent of all fish oil, according to a recent report by my colleagues at SFP.

Although we work closely with them, we don't represent the fisheries industry. There isn't yet agreement on every point or every step toward solutions. But I can say that many leaders of the industry are seriously concerned about acidification. We think they should be.

It's fair to say that seafood producers have two interests at stake in controlling $CO_2$ emissions.

First, they depend on the ocean to make fish. Some fishers and fishing communities are pressing for strong carbon policy in order to protect ocean productivity. We encourage that. They also want to know how $CO_2$ emissions are affecting fish and shellfish. Fishing and processing groups have advocated successfully for two important government research programs, one national, one regional, that will help to clarify how $CO_2$-driven acidification affects marine ecosystems and commercially harvested species

The second point of concern is the same one every other industry faces: fishing takes fuel. Fishers and processors want to protect the resource, and they also want to stay in business. They want emission reductions targets that are achievable. They also want emissions regulations to be fair and affordable.

Their experience is unusually relevant as the Nation prepares to adopt a cap and trade system for carbon. Probably more than any other industry, fishers understand the use of transferable "rights" or "allowances" to address environmental problems. The lessons learned apply directly to carbon regulation. Dozens of transferable fishery quota systems have evolved over the last for 25 years around the world. Fishers and seafood processors have learned how these systems can solve difficult problems such as reducing bycatch; they have also learned how these cap-and-trade systems create competitive advantages and disadvantages. If a new regulatory system for carbon dioxide is going to create tools and incentives that help companies reduce emissions, improve energy efficiency, and reduce fuel costs, people in the fish business will want access to those benefits.

The fishing industry is a tiny emitter. Based on data from the U.N. Food and Agriculture Organization and U.S. Department of Energy, we've estimated that fishing fleets worldwide account for about 0.2 percent of global $CO_2$ emissions. Probably no U.S. seafood company (and certainly no single facility) emits 10,000-ton $CO_2$e, the threshold for regulation envisioned by many carbon policy proposals. But again, if a new system creates special benefits, they will want the benefits to be allocated in a fair and inclusive way—not reserved for a few big emitters, while everybody else just pays more at the pump.

There can be legitimate disagreements about how, and how much, to reduce emissions. But there is one goal everyone should hold in common: We want controls that allow the ocean to keep giving us fish to eat .

An excellent documentary film on ocean acidification has just come out. It's called *A Sea Change* (information online at *www.aseachange.net*). I recommend this film to everyone here.

Thank you again for holding this hearing. Good luck!

Senator CANTWELL. Thank you, Mr. Warren.

Mr. Babb-Brott, thank you for being here and for your work in Massachusetts. We look forward to hearing about your efforts in planning.

**STATEMENT OF DEERIN BABB-BROTT, ASSISTANT SECRETARY OF OCEANS AND COASTAL ZONE MANAGEMENT, MASSACHUSETTS EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS, COMMONWEALTH OF MASSACHUSETTS**

Mr. BABB-BROTT. Thank you, and good morning, Madam Chair and Senator Snowe.

Thank you for the opportunity to share with you our firsthand experiences in the initial applications of marine spatial planning and ecosystem-based management through the development of the Commonwealth's first comprehensive ocean management plan.

In my testimony this morning, I will describe the concept of marine spatial planning and ecosystem-based management and explain our current efforts in Massachusetts to improve our stewardship and the management of the ocean environment in and beyond Massachusetts ocean waters.

Nationally and internationally, variations on the discipline of marine spatial planning are emerging as a basis for stewardship of the ocean ecosystem. While there are many technical definitions, marine spatial planning can be simply described as the adaptive process of collecting, analyzing, and managing the spatial distribution of marine resources and habitats and human activities to achieve the goals defined by society.

Not unlike what we regularly do on land in terms of land use planning to site development while protecting such features as open space habitat and drinking water supplies, marine spatial planning seeks to do the same in the ocean environment. Marine spatial planning thus supports decisions related to the allocation of ocean services.

A related discipline, ecosystem-based management, provides the tools for understanding, maintaining, and enhancing the ecosystem's ability to provide those services humans need and desire. In brief, ecosystem-based management focuses on the system; acknowledges interconnectedness within and among systems, such as between air, land, and sea; and integrates ecological, social, economic, and institutional perspectives, recognizing their strong interdependencies.

In 2003, the Massachusetts Ocean Management Task Force was appointed to examine evolving ocean issues and develop a comprehensive approach to managing ocean resources. In March 2004, the Task Force presented as its top priority the enactment of legislation establishing comprehensive ocean resource management in Massachusetts ocean waters.

This recommendation led to the passage of the Oceans Act of 2008, signed by Governor Patrick last May. The Oceans Act has 15 core requirements whose elements include requirements to identify and protect special, sensitive, or unique marine life and habitat; value biodiversity and respect the interdependence of ecosystems; identify appropriate locations for development; foster sustainable uses that capitalize on economic opportunity; respect the importance of commercial and recreational fishing; and address climate change and sea level rise.

Two key features of the Act include the fact that the ocean plan is not a regulatory, but all approvals by any political subdivision

of the State must be consistent with the plan. And fisheries management plans and fisheries regulations are not subject to the ocean plan. Commercial and recreational fishing are allowed uses, subject to the exclusive jurisdiction of the State fisheries agency.

The Oceans Act requires a draft for public review 12 months from its enactment, and the final plan must be promulgated 6 months thereafter. To develop the plan, EEA invested in 6 months of listening to and learning from the public and stakeholders, gathering and synthesizing existing data, and identifying key data gaps that could be addressed within the schedule; 3 months developing and reviewing management options and incorporating new data; and 2 months refining and revising the ocean plan.

As the basis for the plan, we adopted four goals—integrated management, so that individual actions will be considered in the context of a plan that integrates natural, social, and economic information; effective stewardship through management of human uses; the effective stewardship through the protection of resources; and the development of an adaptive planning framework. Specific planning strategies were developed to address the 15 requirements of the Oceans Act, such as to meet the condition of the Oceans Act that the ocean plan reflect the importance of commercial fishing, we established as a strategy that we would locate incompatible uses outside areas of high commercial fishing effort and value.

Overall management options were then developed and reviewed with the Ocean Advisory Commission. Options ranged from using the new data and information to support existing management and regulatory processes to fully zone the ocean for allowable and prohibited uses. We are now working with a hybrid approach that designates some specific areas that allow or prohibit uses, but that also leaves the majority of the planning area unallocated where new uses will be subject to siting and performance standards that direct development away from high-value resource areas and concentrations of existing water-dependent uses.

In our work to date, we have learned that marine spatial planning is extremely time and labor intensive. Sufficient staff and agency resources are required to address data, public participation, and planning needs. A minimum requirement is sufficient data to accurately characterize baseline environmental and human conditions, but importantly, this baseline data can be derived from multiple sources of varying temporal and spatial scale and resolution. Acquiring, analyzing, presenting, and based on feedback, revising information in an iterative process with the public is critical.

And last, the need for the coordinated and supportive participation of the Federal agencies cannot be overstated. To successfully support local and regional marine spatial planning initiatives, we strongly believe that the National Oceanic and Atmospheric Administration should have a centralized coordinating Federal role in working with the States and regions to advance Federal, regional, and State marine spatial planning policy initiatives.

Thank you for the opportunity to testify this morning.

[The prepared statement of Mr. Babb-Brott follows:]

PREPARED STATEMENT OF DEERIN BABB-BROTT, ASSISTANT SECRETARY OF OCEANS AND COASTAL ZONE MANAGEMENT, MASSACHUSETTS EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS, COMMONWEALTH OF MASSACHUSETTS

**Introduction**

Good morning, Mr. Chairman and Members of the Committee. My name is Deerin Babb-Brott, and I am Assistant Secretary of Oceans and Coastal Zone Management of the Executive Office of Energy and Environmental Affairs for the Commonwealth of Massachusetts. I am pleased to be here today to share with you our first-hand experiences in the initial applications of marine spatial planning and ecosystem-based management through the development the Commonwealth's first comprehensive ocean management plan. In my testimony today, I will describe the concept of marine spatial planning and explain our current efforts in Massachusetts to use spatially-explicit information on ecosystem components and human uses, activities, and facilities to improve our stewardship and management of the ocean environment in and beyond Massachusetts marine waters.

**The Context for Marine Spatial Planning**

Our Nation's oceans provide the foundation for uses, goods, and services that collectively represent a significant component of the United States economy. The oceans support an impressive list of renewable and non-renewable goods and services including: commercial and recreational fishing; marine transportation and navigation; energy, communications, and waste/process-water infrastructure; sand and gravel extraction; recreational boating, diving, wildlife watching; science and education; and historical and cultural sites. "Ecosystem services" has emerged as a term capturing the array of uses, goods, and benefits that humans derive from natural systems. Estimates of the value of the services derived from marine ecosystems can be generated but they are generally very conservative as numerous services are very difficult to quantify.

Human society benefits greatly from the uses, goods, and services provided by estuarine and marine ecosystems, but our activities—both in the ocean, along its coasts, and on adjacent land and watersheds—are also having detrimental effects on these same systems, their components and processes. Rapid climate change, habitat loss and changes, pollution, and spread of invasive species are just some of the threats and stressors which are jeopardizing these ecosystems and the human services they provide.

At the same time, the marine waters are increasingly eyed for new uses and development, including traditional energy facilities such as liquefied natural gas terminals and associated pipelines, offshore aquaculture, and the extraction of sand or gravel resources for beach and shoreline stabilization. Another significant use of the ocean going forward is the development of renewable energy facilities. While tide, current, and wave resources represent potential as renewable energy sources, wind energy in the Northeast is the resource with the greatest promise on the basis of currently available technology. Here, offshore wind is superior to remote onshore wind in terms of resource size, distribution, capacity factor, reliability, minimization of environmental impact, and proximity to population centers. It is a potentially inexhaustible resource that, in many cases, is available in close proximity to regions with the highest electricity demand, minimizing the need for costly new transmission lines.

Concurrent with these new demands comes an increasing awareness of the tremendous importance of maintaining a healthy and resilient marine ecosystem to both support the uses and services that society values and benefits from and also to support its resilience to the increasing threats of global climate change. Time is long overdue to be more active stewards of these public resources and to take a more pro-active stance in planning for marine ecosystem protection and the responsible and sustainable uses that stem from it.

**Marine Spatial Planning and Ecosystem-based Management**

Aspects of two formal methods for developing and organizing information and making management decisions about human uses in the marine environment are being used in the development of the Massachusetts Ocean Management Plan: marine spatial planning and ecosystem-based management. The United Nations Educational, Scientific, and Cultural Organization web page on marine spatial planning (*http://www.unesco-ioc-marinesp.be/*) explains that:

> Marine spatial planning is a *public process* of *analyzing and allocating the spatial and temporal distribution of human activities* in marine areas *to achieve ecological, economic, and social objectives that usually have been specified through*

> *a political process.* Characteristics of marine spatial planning include ecosystem-based, area-based, integrated, adaptive, strategic and participatory.
>
> Marine spatial planning is not an end in itself, but a practical way to create and establish a more rational use of marine space and the interactions between its uses, to balance demands for development with the need to protect the environment, and to achieve social and economic objectives in an open and planned way.

More than 220 academic scientists and policy experts with relevant expertise signed the *Scientific Consensus Statement on Marine Ecosystem-Based Management,* which was published in 2005 by Communication Partnership for Science and the Sea and written by K. L. McLeod, J. Lubchenco, S. R. Palumbi, and A. A. Rosenberg. This statement defines ecosystem-based management as:

> . . . an integrated approach to management that considers the entire ecosystem, including humans. The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. Ecosystem-based management differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the cumulative impacts of different sectors.

Specifically, ecosystem-based management:

- emphasizes the protection of ecosystem structure, functioning, and key processes;
- is place-based in focusing on a specific ecosystem and the range of activities affecting it;
- explicitly accounts for the interconnectedness within systems, recognizing the importance of interactions between many target species or key services and other non-target species;
- acknowledges interconnectedness among systems, such as between air, land and sea; and
- integrates ecological, social, economic, and institutional perspectives, recognizing their strong interdependencies.

While these definitions exemplify the many interpretations of marine spatial planning, we have adopted one from the United Nations' Educational, Scientific, and Cultural Organization that has particular appeal for us by virtue of its intuitive simplicity.

> *Marine spatial planning is the adaptive process of collecting, analyzing and managing the spatial distribution marine resources and habitats and human activities to achieve the goals defined by society. Not unlike what we regularly do on land in terms of zoning and land-use planning to site development while protecting such features as open space, habitat, and drinking water supplies, marine spatial planning seeks to do the same in the ocean environment.*

**The Massachusetts Oceans Act**

In Massachusetts, rich ocean waters and a spectacular coastline have shaped our history, economy, and way of life. Today, these ecologically and economically vital public resources face unprecedented development pressure and represent potential solutions for new challenges, such as climate change. In addition to traditional ocean uses—recreation and tourism, fishing and shellfishing, and shipping and trade—new proposals for energy, aquaculture, off-shore sand mining, and other projects highlight the need for a comprehensive ocean management strategy.

In 2003, the Massachusetts Ocean Management Task Force was appointed to examine evolving ocean uses and develop a comprehensive approach to managing ocean resources. In March 2004, the Task Force released its final recommendations in the *Waves of Change* report. These recommendations focused on: strengthening state agencies to address environmental, planning, and public trust issues in both state and Federal waters; establishing an ecosystem-based protocol to improve management of Federal waters; and initiating ocean education and stewardship initiatives. The Task Force's top recommendation was that legislation be enacted to require the development of comprehensive ocean resource management plans for Massachusetts ocean waters. This recommendation and the cooperative efforts that followed led to the passage of the Oceans Act of 2008.

The Oceans Act of 2008 requires the Secretary of the Executive Office of Energy and Environmental Affairs (EEA) to develop an integrated ocean management plan. Specifically, the Oceans Act requires that the plan shall:

1. Set forth the Commonwealth's goals, siting priorities, and standards for ensuring effective stewardship of its ocean waters held in trust for the benefit of the public.
2. Adhere to sound management practices, taking into account the existing natural, social, cultural, historic, and economic characteristics of the planning areas.
3. Preserve and protect the public trust.
4. Reflect the importance of the waters of the Commonwealth to its citizens who derive livelihoods and recreational benefits from fishing.
5. Value biodiversity and ecosystem health.
6. Identify and protect special, sensitive, or unique estuarine and marine life and habitats.
7. Address climate change and sea-level rise.
8. Respect the interdependence of ecosystems.
9. Coordinate uses that include international, Federal, state, and local jurisdictions.
10. Foster sustainable uses that capitalize on economic opportunity without significant detriment to the ecology or natural beauty of the ocean.
11. Preserve and enhance public access.
12. Support the infrastructure necessary to sustain the economy and quality of life for the citizens of the Commonwealth.
13. Encourage public participation in decision-making.
14. Adapt to evolving knowledge and understanding of the ocean environment.
15. Identify appropriate locations and performance standards for activities, uses, and facilities allowed under the Oceans Sanctuaries Act.

The Oceans Act does not create a new layer of regulation, but rather provides that all state certificates, licenses, permits and approvals for any proposed structures, uses, or activities be consistent with the plan to the maximum extent practicable. Additionally, the ocean management plan must be incorporated into the Massachusetts Coastal Zone Management Plan. Therefore, in addressing the requirements of the Oceans Act, the ocean management plan must take an integrated approach across levels of government, both in its development as well as its implementation.

The Act stipulates that the Division of Marine Fisheries (DMF) shall have sole responsibility for developing and implementing any fisheries management plans or fisheries regulations, and, further, that commercial and recreational fishing shall be allowable uses subject to the exclusive jurisdiction of DMF. Additionally, DMF is directed to assess the potential economic impacts of planning decisions to commercial and recreational fishing and make recommendations to minimize those impacts. To ensure that the ocean management plan and fisheries management are complementary, the Ocean Act requires that fisheries management shall be integrated, to the maximum extent practicable, with the plan.

In addition, the Oceans Act makes a new allowance for the development of "appropriate scale" renewable energy development, including wind, wave and tidal energy, in state waters; establishes an Ocean Resources and Waterways Trust Fund to restore or enhance marine habitat and resources or compensate for navigational impacts that is to be funded by mitigation fees assessed to ocean development; establishes an Ocean Advisory Commission and Ocean Science Advisory Committee to assist the Secretary in developing the ocean management plan; and requires that the ocean plan be revised and reviewed by the public and the legislature at least every 5 years.

Finally, the Oceans Act established an aggressive eighteen-month timeline for developing the ocean plan, challenging us to respond quickly. While the schedule is ambitious, we will meet it, with an ocean plan that both advances the marine spatial planning state-of-the-art in Massachusetts and beyond, and sets out a framework for ongoing, adaptive planning and ocean management.

**Marine Spatial Planning in Massachusetts**

Principles and practices of marine spatial planning and ecosystem-based management, whether derived from academic expression, conceptual models, or specific application in other ocean management plans, provided one aspect of the basic foundation for the Massachusetts Ocean Management Plan. The plan considered marine spatial planning and ecosystem-based management principles through the prism of other elements of the planning context, including:

- The Oceans Act as a source for siting priorities and standards.
- Existing state law, particularly the Massachusetts Environmental Policy Act, for siting thresholds and standards.

- Performance standards in Massachusetts agencies' resource and regulatory programs.

Importantly, as planning and management disciplines, marine spatial planning and ecosystem-based management have been advanced in alternative configurations that share the common elements of a formalized and iterative process that applies specified deliberative methodologies and information requirements. The structure and content of the ocean plan will be consistent with, and has been framed carefully to allow for, ongoing incorporation of new knowledge and refined methods relevant to marine spatial planning and ecosystem-based management.

As the basis for developing the ocean plan, a planning team at the Executive Office of Energy and Environmental Affairs (EEA), supported by EEA's Office of Coastal Zone Management, conducted an ambitious public information and participation campaign that included the following:

- *Websites and Electronic Updates*—To provide the public with the necessary information to effectively participate in plan development, EEA launched the Massachusetts Ocean Plan website. In addition, EEA developed the Public Input Portal for Massachusetts Ocean Planning to provide direct access to video/transcripts of public meetings, an online commenting form, and a log of the public comments submitted. EEA also distributed periodic Ocean Planning Alert e-mails, available both electronically and in print.
- *Public Listening Sessions*—In September and October of 2008, EEA held 18 public Listening Sessions in Boston, Eastham, Fall River, Gloucester, Lowell, Nantucket, New Bedford, Norwell, Oak Bluffs, Pittsfield, Plymouth, Salem, Salisbury, Springfield, West Barnstable, Weymouth, Woods Hole, and Worcester. More than 300 people turned out to give their input on the goals for the ocean management plan. Videos and transcripts of these Listening Sessions were posted on the Public Input Portal to support further public participation, and summaries of the comments provided at the meetings were posted to the EEA Ocean Plan website.
- *Ocean Management Planning Principles Workshop*—In November 2008, the OAC and SAC held a joint workshop to discuss various aspects of the general practice of marine spatial planning. In addition to OAC and SAC members, 30 individuals participated.
- *Data Workshops*—In February 2009, twin workshops were held by EEA in Sandwich and Boston to for the public to review draft work group (see below for a description of the work groups) maps and products. More than 40 people participated in the Sandwich workshop and almost 60 participated in Boston.
- *Stakeholder Meetings*—During the development of the draft plan, EEA held more than 80 meetings with individual interest groups, advocates, industry representatives, and others to answer their questions and solicit their direct input. More than 110 people were interviewed through these meeting and summary reports of their comments were posted on the EEA Ocean Plan website.
- *OAC Workshop on Preliminary Plan Components*—In May 2009, the OAC held twin workshops in Woods Hole and Boston to discuss preliminary spatial analysis of existing ocean management data, compatibility and impact analysis of ocean uses, and conceptual management measures to be used in the Massachusetts Ocean Management Plan. More than 130 stakeholder representatives attended these workshops.

To collect and analyze information needed for plan development, EEA worked with state agency staff and the Massachusetts Ocean Partnership. Reports stemming from these efforts and detailing their results are available electronically at *www.mass.gov/czm/oceanplan/index.htm.*

- *Technical Work Group Reports*—Work groups made up of state agency staff and members from Federal agencies, academia, the renewable energy industry, and non-governmental organizations were charged with assembling available natural resource and human use data to be used in plan development. These work groups were organized topically and covered: habitat; fisheries; transportation, navigation, and infrastructure; sediment; recreation and cultural services; and renewable energy. Much of the data used in the ocean management plan stemmed from these work group reports, and members of the habitat and fisheries work groups formed the core staff that worked on the Ecological Valuation Index (described more fully in Chapter 3.
- *Qualitative Commercial Fishing Information*—EEA staff met with commercial fishermen in meetings coastwide to discuss the development of the ocean man-

agement plan and concerns of fishermen. At several of these meetings, fishermen used maps and National Oceanic and Atmospheric Administration charts to provide information regarding the locations of particular fisheries in the planning area, type of gear used, and seasonal restrictions.

- *Qualitative Recreational Fishing Information*—The Division of Marine Fisheries performed a coast-wide survey of recreational fishing interests to identify areas of concentrated recreational fishing activity. While this survey was not designed to be statistically accurate, it provided useful information for planning purposes.
- *Qualitative Recreational Use Information*—The Massachusetts Marine Trades Association developed a series of maps indicating areas of concentrated recreational activity throughout the planning area.
- *Automated Information System (AIS)*—The Stellwagen Bank National Marine Sanctuary provided AIS information for the planning area and adjacent Federal waters. This data captures the tracks of commercial vessels greater than 299 tons. This information was digitized with the assistance of the Massachusetts Ocean Partnership and used to identify areas of the planning area used by commercial vessel traffic.
- *Vessel Monitoring System (VMS)*—The Gloucester office of the National Marine Fisheries Service provided VMS information for the planning area and adjacent Federal waters, which indicates the tracks of commercial fishing vessels that are fishing in Federal waters. This information was digitized with the assistance of the Massachusetts Ocean Partnership and used to identify areas of the planning area traversed by commercial fishing vessels fishing in Federal waters.
- *Assessment of Human Activities in the Planning Area*—Through funding provided by the Massachusetts Ocean Partnership, scientists from the National Center for Ecological Analysis and Synthesis at the University of California/Santa Barbara mapped the footprint and preliminarily assessed the impact of certain human activities in the planning area.
- *Science Tools to Implement Ecosystem-Based Management in Massachusetts*—Through funding provided by the Massachusetts Ocean Partnership, the consulting firm MRAG Americas, Inc. provided an overview and recommendations regarding the application of ecosystem-based management principles to the Massachusetts Ocean Management Plan. This report also provided an overview of decision support tools and ecosystem models.
- *Planning Framework Review*—The Massachusetts Ocean Partnership funded a team of consultants to review ocean management efforts outside of Massachusetts to identify applicable aspects for the approach to the ocean management plan. This team provided recommendations for the overall framework for the ocean management plan.
- *Development of Mitigation Framework Options*—Through funding provided by the Massachusetts Ocean Partnership, the firm IEc reviewed previous ocean development projects in Massachusetts and interviewed involved parties. The purpose of this study was to provide recommendations for developing a framework for how to develop an approach to mitigation for ocean development in the future.

The basic purpose of the ocean management plan is to translate the policy direction and specific requirements of the Oceans Act into a management plan through a logical, sequential process of developing decision-making guidance for use in analyzing existing data.

The plan was developed by a sequential process that entailed: (1) evaluating the Oceans Act and developing goals and strategies to identify key issues to be addressed based on values expressed therein; (2) assessing the compatibility and impacts of uses, activities, and facilities allowed under the Ocean Sanctuaries Act with marine resources and other uses; (3) applying the strategies as initial planning guidance to identify appropriate and inappropriate locations for specific uses, activities, and facilities; (4) correlating the planning guidance with spatial data and generating maps that illustrate impacts associated with uses marine resources; (5) evaluating options for managing uses; and (6) developing an ocean management plan that best accomplishes the management plan goals described above.

The overall approach to developing the ocean management plan was therefore framed by the 15 core requirements and other substantive and procedural elements of the Oceans Act, including the independent status of commercial and recreational fishing, the requirement that the plan be revised no less frequently than every 5

years, and the consultative roles of the Ocean Advisory Commission and Science Advisory Council. Important additional considerations included:

- Vested public interest in the development of the draft plan;
- The amount of data and information either immediately available or able to be acquired within the schedule for the draft plan;
- Principles and practices of marine spatial planning and ecosystem-based management;
- Existing law and policy; and
- The degree of change in current management practices necessary to address current challenges, justifiable by available information, and reasonable as a first response to the Ocean Act's comprehensive expression of the public trust doctrine.

To begin developing the ocean management plan and understanding the requirements of the Oceans Act, the 15 requirements of the Oceans Act were organized in generally common themes as illustrated below.

| *Governance and Management* |
|---|
| Set forth the Commonwealth's goals, siting priorities and standards for ensuring effective stewardship of its ocean waters held in trust for the benefit of the public |
| Coordinate uses that include international, Federal, state, and local jurisdictions |
| Adhere to sound management practices, taking into account the existing natural, social, cultural, historic, and economic characteristics of the planning areas |
| Adapt to evolving knowledge and understanding of the ocean environment |
| Facilitate public participation in decision-making |
| Preserve and protect the public trust |
| *Natural Ecosystems* |
| Value biodiversity and ecosystem health |
| Respect the interdependence of ecosystems |
| Address climate change and sea-level rise |
| Identify and protect special, sensitive, or unique estuarine and marine life and habitats |
| *Human Uses* |
| Identify appropriate locations and performance standards for activities, uses, and facilities allowed in Ocean Sanctuaries |
| Foster sustainable uses that capitalize on economic opportunity without significant detriment to the ecology or natural beauty of the ocean |
| Support the infrastructure necessary to sustain the economy and quality of life for the citizens of the Commonwealth |
| Reflect the importance of the waters of the Commonwealth to its citizens who derive livelihoods and recreational benefits from fishing |
| Preserve and enhance public access |

This organization by general theme was further refined by addressing the questions: What central principles does the Oceans Act establish? What are the most specific, important things that the Act requires the plan to do? How can the plan best accomplish those things in the context of the other important considerations described above? To respond to these questions, the following subjects were reviewed: the Oceans Act requirements, the current state of knowledge of the marine environment and its uses, consideration of the preferred management approach (discussed above), and public and stakeholder comment including input from the Ocean Advisory Commission.

This review led to the development of the following framework for the ocean management plan: specific *goals* describe what the ocean plan should achieve); *findings* summarize conditions, issues, and desired future conditions associated with the

goals; *strategies* describe the information and process needed to achieve the goals; and *outcomes* define the final product that achieves the goals.

The four goals established in the ocean management plan are: (1) integrated ocean management; (2) good stewardship—protection of the marine ecosystem; (3) good stewardship—human use of the marine ecosystem, and (4) an adaptive foundation for ocean management in the future. These goals reflect the highest priority, basic elements needed to be responsive to the Act and provide the basis for ongoing work. For each of the goals, there is an accompanying outcome for the ocean management plan to achieve.

Findings provide summary characterizations of conditions, issues, and desired future conditions associated with each of the goals and also provide a general rationale for the selection of particular strategies. Findings are based on the understanding of the ocean ecosystem, human uses and natural resources in the marine environment, stakeholder comment, and the Ocean Act requirements and other existing laws, policies, and regulations regarding ocean resources and uses.

These goals and their associated strategies and findings provide the foundation for the Massachusetts Ocean Management Plan. The next step in developing the plan was to apply the decision-making guidance supplied by the goals and strategies. This step occurred through the development of compatibility assessment and application of this assessment using existing data, as discussed in the next section.

Uses, activities, and facilities allowed by the Ocean Sanctuaries Act, as described below, were analyzed to determine the degree to which they are incompatible with marine resources and other uses, activities, and facilities based on: (1) functional incompatibility (*e.g.,* two uses that cannot physically occupy the same location); (2) the significance of potential impacts to natural resources that have special status under existing law and policy (*e.g.,* a use that could have significant impacts to a Special Aquatic Site protected by the Clean Water Act); and (3) the significance of potential impact to values expressed in the Oceans Act (*e.g.,* areas of high fishing effort and value).

Once these planning criteria were defined, they were then correlated with data layers to represent the location and extent of human uses and natural resources.

Uses and special status resources were then mapped by category of potential incompatibility or impact. These initial maps served two purposes: first, they provided the basis for screening and identification of areas suitable areas for large-scale wind energy development; and second, they provided the basis for considering management and regulatory options to be implemented by the ocean management plan.

The maps resulting from the compatibility assessment analyses conducted for each category of use, activity, and facility allowed under the Ocean Sanctuaries Act formed the basis for consideration of planning and management options that were reviewed and discussed with the Ocean Advisory Commission. Three general management options were considered:

1. Regulate as now, using ocean data for alternatives analysis and performance standards in permit conditions;
2. Designate specific areas for individual use based on data and compatibility assessment criteria; or
3. Apply a hybrid approach to: (1) designate areas for uses with potentially significant impacts for which EEA has good data; and (2) identify exclusionary areas, defined by resources and uses subject to likely or significant incompatibility or impact, applicable to spatially indeterminate uses or uses for which EEA has poorer data.

The management options were evaluated based on their ability to:

- Advance the interests of the Oceans Act;
- Protect the marine environment;
- Avoid and minimize conflict with existing water-dependent uses;
- Provide flexibility for new uses and future changes to management based on an increasing understanding of the marine environment, new technologies, and evolving social values;
- Apply management and regulatory limits that can be substantiated by current data;
- Use and streamline existing law and regulation to allow regulatory decisions appropriate to the scale of potential impact;
- Employ new data and information within an adaptive framework

As the management options for uses were being developed, in a parallel process, options for identifying and protecting special, sensitive, or unique marine and estua-

rine life and habitats was conducted (as required by the Oceans Act). Members of the Habitat and Fisheries Work Groups convened to develop an approach to address the requirements of the Oceans Act to identify and protect special, sensitive, or unique areas by developing the concept, methodology, and data for an ecological valuation index (EVI). The EVI is an attempt to systematically evaluate the ecology of Massachusetts waters using available data. The EVI was conceived and developed to be responsive to the directives of the Oceans Act, to incorporate existing ecological knowledge and data (qualitative and quantitative, as available and appropriate), and to be scientifically defensible and rigorous in approach. Not all data compiled by the Habitat and Fisheries Work Groups were used in the EVI development. Some data sets were spatially and/or temporarily incomplete and had limitations that precluded their use in this process.

As a brief overview, the EVI begins with a compilation and analysis of existing spatial data regarding species occurring in the ocean planning area. Data for four marine mammal species, five bird species, five crustacean species, eight mollusk species, and 22 fish species were incorporated into the EVI. Individual datasets were then rated according to a standard set of ecological criteria (major contribution to survival/health of population, spatial rarity, and global and regional importance). The planning area was gridded into 250-meter cells and the values for each cell calculated based on the sum of the rankings of the dataset present in each cell.

The intent of the EVI was to develop a scientifically defensible approach for differentiating areas in terms of their ecological value. Such a differentiation would support efforts to identify locations appropriate for particular uses and to designate "special, sensitive, or unique" areas of life and habitat, pursuant to the Oceans Act. Because it was a multi-species approach by design, it was also a step toward incorporating an ecosystem-based perspective into the ocean management plan.

Limitations of the EVI included data availability (data for certain species or guilds are not available) and the spatial resolution of certain data leading to limitations on the conclusions that could be drawn. Additionally, our understanding of ocean habitats and species habitat requirements is continually evolving, as are the related data available to managers. The development of the EVI provided important information for use in ocean management plan specifically regarding how special, sensitive, or unique areas are identified and protected.

**Current Status of Planning**

A public review draft of the ocean plan is due on June 30, 2009. Following public hearings and legislative review, the ocean plan will be promulgated by December 31, 2009.

**Lessons Learned to Date**

- Marine spatial planning cannot occur in the absence of data to characterize the human and natural components of the marine ecosystem. Comprehensive data is not necessary, but a minimum requirement is sufficient data to accurately characterize baseline environmental and human use conditions. Baseline data can be derived from data of varying temporal and spatial scale and resolution.
- Marine spatial planning is extremely time and labor intensive and sufficient staff and agency resources are required to address data, public participation, and planning needs. The Massachusetts planning process was fortunate to be supported by the Massachusetts Ocean Partnership, with funding from the Gordon and Betty Moore Foundation. This support allowed us to benefit from applied planning research, develop significant new data, and greatly facilitated public and stakeholder participation.
- A related point is that for marine spatial planning, process is substance. Acquiring, analyzing, presenting, and, based on feedback, revising information in an iterative process with public, stakeholder and decision-making audiences has been a fundamental component of developing our ocean plan.
- The principles and practices of marine spatial planning must be interpreted within the specific political, legal, social, and environmental context in which it is applied.
- Marine spatial planning and, particularly, ecosystem-based management address complex systems about which much is poorly understood or unknown. We have not let absence of knowledge be an excuse to not take action. However, a key principle has been to continually review our planning material to ensure that management decisions can be substantiated by available information.
- Similarly, we have not let the perfect be the enemy of the good, and have embraced the ambitious schedule established by the Oceans Act as the basis for establishing an adaptive framework for future planning.

- Last, the need for the coordinated and supportive participation of the Federal agencies cannot be overstated. To successfully support local and regional marine spatial planning initiatives, we strongly believe that the National Oceanic and Atmospheric Administration should have a centralized, coordinating Federal role in working with states and regions to advance Federal, regional and state marine spatial planning policy and implementation. NOAA is operationally and administratively well suited for this position by virtue of its expertise and role in providing data, technical services, research and coordination across Federal agencies related to climate and weather, ocean and coastal services, charting and observation, fisheries and marine resources, and regional and state relationships.

Senator CANTWELL. Thank you, Mr. Babb-Brott.

And now, our last witness, Dr. Kempton, thank you very much for being here and for your contributions to the oceans and the environment.

Thank you.

**STATEMENT OF WILLETT KEMPTON, PH.D., ASSOCIATE PROFESSOR, COLLEGE OF EARTH, OCEAN AND ENVIRONMENT, AND DIRECTOR, CENTER FOR CARBON-FREE POWER INTEGRATION, UNIVERSITY OF DELAWARE; CHAIR, R&D SUBCOMMITTEE, OFFSHORE WIND WORKING GROUP, AMERICAN WIND ENERGY ASSOCIATION**

Dr. KEMPTON. Thank you, Madam Chair and Senator Snowe, for the opportunity to testify today.

My topic that I was asked to speak on is offshore renewable energy. To evaluate ocean energy, we need to know the resource size in order to evaluate its significance to the economy and to the environment. Unfortunately, careful resource assessments have not been done for any ocean energy sources other than oil and gas.

Using imprecise EPRI and DOE estimates—in my written testimony I cover this in more detail—but let us compare the U.S. energy use and electricity, 419 gigawatts. That is 419 large nuclear power plants. I am taking Senator Snowe's way of describing a gigawatt.

The offshore wind resource, using the same metric, is 450 gigawatts. That is, it is greater than the entire electric use of the country. That is by a DOE estimate, which, I believe, is low. All other offshore renewable energy is about 50 gigawatts.

Offshore oil extracted over 20 years and converted into electrical units is 185 gigawatts. So the offshore wind resource is twice the offshore oil resource. By this DOE estimate, it is about the same as our country's electrical use.

So we hear lists of offshore renewable energy, and we want to develop research on many of those and develop devices. But if we want to deal with carbon dioxide and have a large offshore renewable energy industry, we have to focus on offshore wind, as I will in my comments that follow.

Current offshore wind technology, developed primarily in Europe, is immediately applicable to areas with shallow water—that is under 100 feet of depth—no hurricanes and no ice. That means the Northeast, shallower waters of the West Coast, and some areas of the Great Lakes. As the industry develops products which overcome these conditions, which I believe will happen in the next 10 to 15 years, all U.S. coastal areas will be potential offshore wind sites.

There are environmental impacts of offshore wind and of all energy forms. Just as an example, I will describe an analysis we did of a 600-megawatt offshore wind farm proposed for Delaware. Six hundred megawatts in comparison to Delaware would provide 17 percent of the State's electricity.

Negative impacts included bird kills. We took worst-case scenarios. Suppose everybody got it wrong, and they put it right in the middle of a flyway. We estimated 240 birds killed per year under that scenario. More likely, it would be 20 to 50.

There is a viewshed impact, which didn't seem to concern people in Delaware as much as it has in another state further to our north. But let us look at the positive impacts because you have to really look at the balance. It is the positive impacts minus the negative impacts.

Overall human health benefit of this project due to reduced emissions of existing power plants was $53 million per year, broken out into 10 to 12 human deaths prevented per year, 203 emergency room visits avoided, 5,000 asthma attacks avoided, and so forth.

Looking at plant cooling water from our current power production facilities—again, they are shut down part of the time when you have a large wind farm added—600,000 fish fry and yearlings saved from death in power plant cooling per year. So comparing that against maybe 20 to 50 bird kills. A 17 percent reduction in power plant $CO_2$ emissions statewide. So those are the overall positive and negative environmental impacts.

I didn't talk much about $CO_2$ reduction, but if you look at offshore wind at a national and regional basis in terms of $CO_2$, it boils down to this. Offshore wind today is the only power source that coastal States have at hand at a scale that can significantly slow $CO_2$ emissions and at moderate cost. That is cost close to today's cost of power in coastal areas in the East at least, and that is with a nascent industry.

I will discuss State and Federal permitting processes briefly, identification of optimal sites. We have observed a process of picking sites and negotiating with state governments and publics in Massachusetts, Rhode Island, New York, New Jersey, and Delaware. The process that has occurred in most of those areas, the State has requested power bids.

Massachusetts is the exception, where the developer came in and just said we want to use this block of water. In all others, it has been driven, first, by the state government. Then applicants—that is, developers—apply, seek information, investigate locations, and then propose two or more site options.

The next step is that State environmental and power planning officials recommend for or against these developer proposed sites in contract terms. Then if the State process is successful, it goes on to the Federal process, and then, thus, allocation of water space. And upon successful completion of environmental permits and reviews, financing, then the project is built.

I describe in more detail in my written testimony the concern that our analysis raises with a competitive process going on at the State level over power, the lowest-cost power and some environmental review by State coastal managers, then getting handed over

to MMS, which is requiring by law a competitive process in bidding for water.

So you could have a developer that has a contract for power that has been approved by one environmental process then going into a second competitive process for water space, where they could have a speculator bidding against them and really couldn't do anything with it, but would make it difficult to continue that process.

So I would ask that that might be something that would be considered as an amendment to the authorizing law for the MMS to site offshore renewables.

I think I will have to have a longer discussion. Maybe at lunch, Mr. Babb-Brott and I could talk about spatial planning. I think it is a useful planning exercise. I think it is very important to do, as he has, leave the majority of planning area unallocated. I think it is very hard to divide up every single bit of space now, as technologies are just being developed and as the environment is changing very rapidly.

In my written comments, I go through a detailed assessment of the resource potential in the Mid-Atlantic, and just to hit the bottom line, using current technology, only shallow water, we find the practical offshore wind resource from North Carolina to Massachusetts is enough to power all electricity for those coastal States, displace all gasoline for their entire light vehicle fleet, and provide all building heating fuels. That uses two-thirds of the shallow water offshore wind resource.

It is very large. And that is why I said in the beginning I think these DOE estimates are quite low, but even they show this is the largest resource.

How would we do that? It could be built in 15 years with 10 manufacturing complexes in the region, each employing perhaps 500 people, a subcomponent supply chain and 10 construction crews with associated installation vessels.

In other words, we have tried to calculate this resource is large, yet it could be developed in 15 years with a plausible set of industrial complexes in the region. And I would like to volunteer two automobile plants in Delaware, which have been shut down in the last 6 months as part of that.

If we did build this out, we would reduce $CO_2$ emissions from the area by 68 percent. So I have specific recommendations as to law, which I will leave to the written version.

Thank you very much.

[The prepared statement of Dr. Kempton follows:]

PREPARED STATEMENT OF WILLETT KEMPTON, PH.D., ASSOCIATE PROFESSOR, COLLEGE OF EARTH, OCEAN AND ENVIRONMENT, AND DIRECTOR, CENTER FOR CARBON-FREE POWER INTEGRATION, UNIVERSITY OF DELAWARE; CHAIR, R&D SUBCOMMITTEE, OFFSHORE WIND WORKING GROUP, AMERICAN WIND ENERGY ASSOCIATION

My name is Willett Kempton. I am Associate Professor at the University of Delaware College of Earth, Ocean and Environment, and Director of the University's Center for Carbon-free Power Integration. I serve as Chair of the R&D Subcommittee of the Offshore Wind Working Group of the American Wind Energy Association. At the University, I direct research on carbon-free energy by about 25 researchers. I have published extensively on energy and the environment.

Today I speak on the basis of my expertise; I am not representing the position of any organizations with which I am affiliated.

**Comparing Ocean Energy Resources**

I start by estimating the size of several ocean energy resources. This is important both to know how much economic activity each could stimulate, and to see which of them could make significant impact on other national goals such as energy independence, reduction $CO_2$ emissions, and reduced external payments.

Unfortunately, careful resource assessments have not been done. In Table 1, I review existing estimates that are imprecise but allow an initial comparison for discussion. The ocean renewables estimates draw on a recent NREL/DOE report (Musial 2008, table 3, in turn based on EPRI and earlier studies). I have added U.S. electricity consumption (top line) and OCS oil (bottom line) for comparison, and I convert TWh/yr to $GW_a$.

A GW is 1,000,000,000 watts, the size of one of the largest nuclear or coal plants, and $GW_a$ ("a" for "average") is a fluctuating amount with an average at one GW. For scale, one watt runs an iPod. One to two thousand watts runs an average house. A little over one $GW_a$ runs Delaware. 419 $GW_a$ runs the United States. By the estimate below, the U.S. offshore wind resource is 450 $GW_a$. I make a more detailed regional estimate below.

Table 1. Sizes of Ocean Energy Sources

| Energy Source | TWh/yr | $GW_a$ |
|---|---|---|
| *U.S. Electricity Use* [1] | *3,670* | *419* |
| Deep Water >30-m Offshore Wind | 3,270 | 373 |
| Shallow Offshore Wind | 678 | 77 |
| Wave Energy | 252 | 29 |
| Tidal Current | 17 | 2 |
| Ocean Current (Florida) | 50 | 6 |
| In-stream River Current | 110 | 13 |
| Thermal gradient (OTEC) | Very large | |
| Offshore oil (64 BBO) [2] | 1,627 | 185 |

The above table illustrates that offshore wind is the United States' largest ocean energy resource, even in comparison to offshore oil resources. Even based on the assumption in Table 1 that we drill very fast and pump oil out at a rate that would exhaust the supplies in 20 years, offshore oil is only ½ the size of the offshore wind resource.[3] Of course, when we are done pumping, the oil is gone along with the associated jobs.

**Offshore Wind Commercial Availability**

Fortunately, offshore wind is not only the largest ocean energy resource, but also the most commercially ready. Like the wind industry on land, it can be roughly divided into four industries: manufacturing, developing sites, installation, and operating. Over the past 4 years, a handful of U.S. developers have emerged, that is, firms that now have expertise in designing, siting, permitting, raising capital, closing the power contract, and preparing to build offshore wind facilities. And our marine construction firms could, with minimal re-tooling (including purpose-built vessels), build offshore wind farms. Our country lacks offshore wind manufacturing, but Denmark has been developing it for the past 15 years, and has had wind turbines operating at sea since 1990. So the industries and equipment are available to construct commercial-scale offshore wind facilities today. To add offshore wind manufacturing will take some policy effort, described subsequently.

In short, the U.S. has offshore wind companies covering developers and operators, but currently not manufacturers. In 2009, for the first time we are beginning to see RFPs for offshore wind R&D. If we want manufacturers, we need an active and expanding set of developments, and DOE support for R&D in this area must continue and expand.

---

[1] U.S. EIA, Table 5.1. "Retail Sales of Electricity to Ultimate Customers" Electric Power Monthly with data for February 2009, Report Released: May 15, 2009. This figure is 2007 retail sales.

[2] Mean Undiscovered Economically Recoverable Resources of the OCS, at $110/BBL, from Table 2, OCS Report MMS 2009–015. If natural gas is included, the resource would approximately double. To compare with electricity, oil energy is equivalenced to its energy content (1 BBL = 1,695 TWh), then to electric power at 30 percent conversion, and assuming a 20 year burn. If gasoline versus electric automobiles are compared, the conversion multiplier for oil should be 20 percent rather than 30 percent.

[3] If we assume instead that it takes 40 years to pump out all the offshore oil, the flow of oil would be roughly ¼ the energy of the offshore wind resource.

Because offshore wind technology was developed in Denmark, it is best suited for offshore areas like Denmark—relatively shallow, and lacking both hurricanes and sheets of ice. This means the Northeast, parts of the west coast under 30 m depth, and some areas of the Great Lakes (Lake Erie). As R&D and private investment advance, the areas appropriate will expand as well.

Table 2. Wind Technology Goals to Expand Offshore Wind's Geographical Application

| Technology Goal | Current State/need | Added Application Regions |
|---|---|---|
| Current technology | In serial production | Northeast plus shallow areas of West Coast and Great Lakes |
| Withstand floating ice impact on tower | A few examples in Europe | Great lakes |
| Withstand Category 5 hurricanes | Requires re-engineering of blades, turbine and controls | Gulf; South of North Carolina |
| Deeper platforms | Prototype in North Sea; U.S. developer has licensed | Expand turbine count in all areas above, especially West Coast |
| Floating platform | Many designs; Statoil floats 2.3 MW prototype this weekend | More for West Coast; expand reach further out OCS elsewhere |
| Overall optimizations | Ongoing | Reduce price and increase reliability in all regions |

That is, with some continued development, offshore wind can be a very large power resource for all coastal areas of the United States, including the Great Lakes.

**Environmental Impacts**

Offshore wind will have both positive and negative environmental impacts. The negative environmental impacts of offshore wind can be projected based on a long-term study of a Danish offshore wind farm (DONG Energy 200x), along with the now-completed Environmental Impact Statement for the Cape Wind proposal.

The primary projected impacts are related to wildlife and aesthetics. To summarize, most birds that encounter offshore wind farms simply fly around. A few birds are displaced or killed. Off Denmark, Nysted was built in a duck flyway (Common Eiders). Despite that poor siting, estimated mortality was only 1.2 birds/year/tower. Since bats rarely fly over the ocean, significant bat effects are unlikely. Some people find the visual intrusion on the ocean negative; in Cape Cod our surveys show 43 percent opposed, whereas in Delaware, we found only 4 percent opposed (Firestone, Kempton & Krueger 2008). Noise during construction could plausibly have an impact on marine mammals; knowing this, European offshore wind construction companies have developed methods for attenuating noise of construction. The towers offer new habitat for smaller organisms, in turn making them attractive to sports fishermen. No other significant impacts have been found in the cited studies. We should continue to study effects, but from thorough studies to date, the only notable negative environmental impact seems to be modest avian mortality.

With offshore wind power, like other renewable energy, impact analysis is misleading without quantifying the positive impacts. For construction of a 600 MW offshore wind farm off Delaware, consisting of 200 turbines, each 3 MW, we did a cursory impact analysis based on literature rather than direct measurement. We used the health impact of Delaware's current power production that would be displaced, along with a report on fish kills from current Delaware power plant cooling water.[4] Offshore wind reduces air pollution and fish kills because the wind power production leads other power plants to throttle back and reduce output, and thus reduce pollution and water intake. We found that this one offshore wind farm would have the following yearly impacts:

Negative impacts (projected)

Up to 240 birds killed (240 is worst case—if mistakenly built in flyway)
View shed impact

[4] The study found that one large Delaware coal plant killed the equivalent of 800,000 year-old winter flounder during 1 year studied, more than 518,000 year-old Atlantic croaker and nearly 2.7 million bay anchovy (Montgomery 2008). If we here estimate by considering the 17 percent reduction in power brought by the offshore wind facility as a rough approximation of fish and fry saved, that would be a reduction in fish kills of 683,000 per year.

Positive impacts (projected)

10–12 human deaths/year prevented
203 emergency room visits (due to respiratory distress) prevented
5,156 asthma attacks prevented
. . . total human health benefit $53 million/year
683,000 fish fry and yearlings saved from death in power plant cooling water
17 percent reduction in power plant $CO_2$ emissions statewide

The above figures are based on literature and approximation rather than measurement after the fact or detailed modeling. However, it appears that the net environmental effect is positive rather than negative, by a substantial margin, even without considering $CO_2$ reduction benefits.

If $CO_2$ reduction is considered an environmental benefit, as I emphatically believe it is, my assessment of the importance of offshore wind is this: Offshore wind is today the only large scale power source that coastal states have at hand, that can significantly slow $CO_2$ emissions at moderate cost. Due to the versatility of electricity, wind power is capable of displacing fossil electric generation, fuel for building heat, and fuel for cars. Because of both the potential for $CO_2$ reductions, and the economic benefit, I recommend some improvements to the permitting process in sections below.

**State and Federal Permitting Process; How to Identify Optimal Sites**

Our research group has observed the process of picking sites and negotiating with state governments and publics in Massachusetts, Rhode Island, New York, New Jersey, and Delaware. There are two aspects, power planning and site selection.

Regarding power planning, unlike offshore oil and gas, the process we have seen for offshore wind has been that a U.S. state initiates a process soliciting electric power. After the state government has established a need for power, and possibly negotiated an agreement to buy power via a power purchase agreement, the offshore wind developer begins the process to permit with Federal MMS. Cape Wind has been the sole exception, with the developer initiating the process, and the Federal permitting initiated prior to any power agreement with the state.

The process is quite different from offshore oil, which in Federal waters has been permitted by the Federal MMS with little state participation. The difference is due to the transportability of the energy sources—oil can be shipped worldwide for little incremental cost, whereas electricity must be transmitted by high voltage cables, which to date have taken a short path from the offshore wind development to shore. For similar reasons, oil is traded on global markets, while electricity (including that from ocean renewables) is sold on state or regional markets.

A processes that we see working well for identifying sites is:

1. The state requests bids, for power or specifically for offshore wind, along with criteria for picking the winning bidder.
2. Developers seek information about existing ocean uses, in order to avoid conflict areas-this is in their interest, to avoid places where coastal managers, residents, fishermen, etc may oppose their proposed development.
3. Developers study locations, including wind speeds, ocean and subfloor conditions, and considering current technology, value of power, their tolerance for delay due to controversy, etc., then propose two or more site options.
4. State environmental and power planning officials recommend for or against sites and power contract characteristics proposed by developer.
5. If any sites are acceptable to the state, developer proceeds to permitting, including environmental review by MMS, and contract for use of ocean space.
6. Upon successfully completion of all permits and reviews, and financing, project is built.

There is one problem in this process, created by the law that authorized MMS to carry out these leases. The developer has already gone through a bidding process and has been awarded a contract or permit to sell power to one or more electric entities ashore. One important criterion in their section would presumably be that the price of power was competitive. But since MMS requires competitive bids for ocean space, the space that the developer has already bid on in the state power process, now must be bid again with MMS, possibly against speculators who have no ability to even sell the power they would generate. In the announcement of rule, MMS tried to address this problem by saying that prior state competition would be considered in the competition for ocean space. However, it would be appropriate to examine whether it is appropriate to change the law, given that electricity is not oil, and that rules for competition are already well established in state and regional electric mar-

kets, and subsequent competition for offshore space may lead to speculation and gaming.

Regarding choice of location, I feel that the optimum process is close to the numbered sequence above—that the state sets parameters, the private developer studies many sites then proposes a site, and the state selects. The developer must go through environmental review including any conflicting use and consistency with the state's coastal zone management plan. I do not include advanced spatial planning in this list, because I believe that no-one today can plan what will be the best location for a variety of technologies several years in the future. Also, I do not believe that spatial planning by state or Federal officials will be as thorough as that by a developer with investment at risk, followed by established EIS or EA processes.

The agreement last week (June 4, 2009) among the Governors of New York, New Jersey, Delaware, Maryland, and Virginia, was that spatial analysis might proceed, but it should not cause any slowdown in project proposal and development. I believe this is the correct approach.

**Economic Potential**

Here I summarize our more detailed resource estimate for the Northeast, then show how that translates into economic opportunity. In 2008 we estimated the total offshore wind resource adjacent to the Mid-Atlantic coastal states from North Carolina through Massachusetts (Kempton et al, 2008; attached). This was an arbitrary area manageable for a low-cost study, but one more detailed than anyone had previously done. We used 20 years of wind speed data from NOAA buoys, bathymetric data and sampled data on ocean uses such as shipping lanes or bird flyways that would exclude wind turbines. We assume only machines and towers that were either available or prototyped at the time of the study. And, we compared the offshore wind resource against energy demand of those Mid-Atlantic coastal states, electricity as well as gasoline for cars and heating fuels.

Table 3. Mid-Atlantic Offshore Wind Resource Compared With Energy Demand
(from Kempton et al 2008)

| Source/demand | $GW_a$ |
|---|---|
| Offshore wind | 330 |
| Electric load | 73 |
| Cars | 29 |
| Heating | 83 |
| Total demand | 185 |

In other words, for the Mid-Atlantic, with a large shallow continental shelf, but with very high levels of population and energy use, our more careful resource assessment shows that the practical offshore wind resource is enough to power all electricity, all gasoline for automobiles, and all fuel oil, natural gas, and other building heating fuels. (My use of average GW is a simplification, as I do not address the match of fluctuating wind power and fluctuating load, which have to be matched.)

To estimate the economic impact, assume we plan to build enough offshore wind to power electricity and cars but not heat, 108 $GW_a$. To produce 108 $GW_a$, assuming a 40 percent capacity factor, would require 54,000 wind turbines each rated at 5 MW. Current wind turbine factories running 5 days and three shifts can produce 350 turbines per year. If we wanted to build 54,000 turbines within 15 years, we would require 10 factories. In addition we would need about 10 factories for blades and 10 for towers. This would be like 10 large automobile manufacturing factories, each employing perhaps 500 people, with approximately a 4x multiplier for indirect jobs among suppliers, a total of 20,000 jobs. This is one of several reasons that coastal states officials have preferred offshore wind to distant onshore wind (Bowles 2009; Svenvold 2008).

I do not give these estimates in order to say that we should produce exactly this much offshore wind, or at this pace, but to show that the resource is very large, yet it could all be developed with a manageable industrial complex in the region. We can build a great deal, and even substitute electricity for end uses that not depend on liquid fuels, and not exhaust the resource. If the entire 185 $GW_a$ were developed, the Mid-Atlantic would reduce its $CO_2$ emissions by 68 percent. And such large reductions in $CO_2$ would have global significance in reducing the impact of ocean acidification and climate change on the oceans.

**Industry Needs for Development**

Below are recommendations that would follow from my experience and from the above.

1. Longer-term extension of the PTC, possibly limited to ocean renewables. An offshore wind project could take 5 or 6 years to complete, much longer than a land-based project. Investment in manufacturing for offshore class turbines, towers and blades would require at least 6–7 years of sales to return investment in plant. The current 3-year PTC extensions insure that manufacturing stays in Europe. Congress should pass a 10-year PTC. This could limited, if necessary specific to offshore renewable energy.
2. Facilitate development of manufacturing of offshore-wind manufacturing in the US.
3. As noted above, R&D is needed to develop offshore wind turbines that work in more U.S. regions, to improve on current designs, to extend the coastal areas for which we have turbines, to understand the resource, and for policy and public opinion studies. The attached R&D Subcommittee document suggests specific needs and rationale. In addition to the attached wind R&D document, the U.S. should invest in long-term research on other ocean energy technologies in Table 1.
4. In particular, we should develop expertise in assessing the offshore wind resource by several independent parties, not only MMS or DOE but also by state governments and/or universities working with state government power planners. My group has produced guidance for others who want to get up to speed and analyze their state offshore wind resource (Dhanju et al 2008). Small grants for partnerships between states and universities would seed this activity and provide local expertise on this resource assessment.
5. With many permit applications already headed to MMS, the agency already needs more people. Need to fund MMS to allow it to hire individuals to oversee the NEPA and licensing process.

**Supplemental material**

1. Kempton, W., C. L. Archer, A. Dhanju, R. W. Garvine, and M. Z. Jacobson, 2007 "Large $CO_2$ reductions via offshore wind power matched to inherent storage in energy end-uses", *Geophys. Res. Lett.,* 34, L02817, doi:10.1029/2006GL028016. (Retained in Committee files and available at *http://www.agu.org/journals/gl/gl0702/2006GL028016/*.)

2. Research and Development Needs for Offshore Wind, R&D Subcommittee, Offshore Wind Working Group, American Wind Energy Association. April 2009 [Retained in Committee files and available at *http://www.newwindagenda.org/pdf/Offshore_R&D_Needs.pdf*]

**References**


Bowles, Ian, Home-Grown Power, *NY Times* Op Ed, March 7, 2009

Amardeep Dhanju, Phillip Whitaker, Willett Kempton (2008), Assessing offshore wind resources: An accessible methodology. *Renewable Energy* 33(1): 55–64. doi:10.1016/j.renene.2007.03.006

DONG Energy *et al,* 2006, *Danish Offshore Wind—Key Environmental Issues,* Published by DONG Energy, Vattenfall, The Danish Energy Authority and The Danish Forest and Nature Agency, November 2006 (Order from the Danish Energy Authority's Internet bookstore *http://ens.netboghandel.dk*)

Firestone, Jeremy, W. Kempton and A. Krueger, 2008, Public Acceptance of Offshore Wind Power Projects in the United States, *Wind Energy 11.* (DOI: 10.1002/we.316)

Montgomery, Jeff , 2008, "Indian River center of fish debate: Power plant's cooling system said to destroy millions of fish each year." *The News Journal,* January 3, 2008

Musial, Walt, 2008, Status of Wave and Tidal Power Technologies for the United States. *Technical Report* NREL/TP–500–43240, August 2008

Report to the Secretary, U.S. Department of the Interior, 2009, Survey of Available Data on OCS Resources and Identification of Data Gaps. OCS Report MMS 2009–015

Mark Svenvold "Wind Power Politics" *New York Times Magazine.*


For further information on offshore wind, including our articles cited above, see *www.ocean.udel.edu/windpower,* and *www.carbonfree.udel.edu*

Senator CANTWELL. Again, I want to thank Dr. Kempton for his testimony and following what has happened in the previous energy bills and things we might do to improve it.

I thank all the witnesses again for their testimony.

I am going to turn to Senator Snowe for her questions.

Senator SNOWE. Thank you, Madam Chair. Thank you very much for allowing me to go first.

I just want to thank all of you for your very powerful testimony. The Chair and I were just discussing it would be nice if all members of the Senate could hear your testimony in terms of the contributions that the ocean makes, and also the impact on the ocean and the severity of many of the consequences that we are facing now and well into the future if we don't reverse course here on many levels. So I really appreciate the dimensions of what you have offered here today in your respective testimony and professions.

I know, Dr. Kildow, you mentioned in your report how Federal investment in ocean and coastal communities has been woefully insufficient. I think it was like $9.5 billion, or 0.3 percent of the Federal budget. Where do you think we could be most useful in making these investments?

And you mentioned also, which I thought was very interesting—I hesitate to ask this as well—but over the next 30 years you said would bring significant changes to the oceans and the coastal communities, the most significant since the industrialization and urbanization of the late 19th century. So why do you expect that to happen?

And I will ask any of you or all of you to respond. Where do you think we should be making our mark, either in investments or on the issue of expertise in climate science, which is obviously an area of our jurisdiction with NOAA? And what is the investment we need to make because, obviously, the impact goes beyond industrial activities, the acidification that you are all talking about, the ecosystems that are under attack, and how are we going to reverse course?

Because what you were saying, Mr. Warren, about the fact that it is irreversible. The fish are gone. Can you rebuild the stock? Well, no. That is disconcerting, and it is breath-taking for those of us who depend on the fisheries, as our country does.

So can you just tell us very quickly what you think we should be focusing on in this committee both from the standpoint of the investments or expertise in climate science or whatever. Dr. Kildow?

Dr. KILDOW. I would suggest that because the Government has jurisdiction over most of the natural resources along the shoreline, whether it is State government or Federal Government, Federal and State governments should work together to preserve, restore, and strengthen the resiliency of estuaries, beaches, the shoreline. Those are our protection against a number of the environmental changes that we face.

Without those and the strength of those, we are just going to receive even worse impacts than we would have anticipated. So I would recommend the investments go where the Federal Government can make them most and where others are less likely to

make them, and that is in restoring and strengthening estuaries, making sure that beaches are secured where they should be secured. Where they are going to naturally erode, we have to let that happen.

But the beaches are worth billions of dollars a year. Our estuaries do so much protection of our shoreline. So I think the natural resources are really where you should be focusing, and the industry can look to others.

I also think that you can help local communities plan for the effects that are coming from climate change impacts. Local communities are really, in some cases, clueless as to what they can do, how they can do it. So they need planning money. They need technical assistance, and they need to be able to figure out how to mobilize their communities so that they can withstand the inundation and all the other kinds of climate change impacts. So that is what I would do.

As far as the shoreline changing over the next 30 years, what we were referring to is the fact that infrastructure is going to be deeply affected. I live in California, and we just put out a report, the Pacific Institute did, that identified inundation areas. And things like San Francisco airport and our ports are ground zero for a lot of the flooding and inundation.

And we have to figure out how we are going to deal with these shoreline infrastructures that support our very economies. So it seems to me that we are going to envision a very different shoreline, configured in very different ways, and we need to start planning now because these are not changes that we can make in 5 years or 10 years. It is going to take a while to either protect or to relocate a lot of our crucial structures.

My understanding also is that people will be much more inclined to move toward the coast for water purposes and weather purposes due to climate changes. And so, we are going to really be looking at even more intense pressure, population pressures on the coast.

We are going to need to figure out how to reconfigure housing, maybe build higher. But we need to think out of the box. We need to think about how we can live sustainably and have a good standard of living with these changes that are underway. And the next 30 years are going to be critical in our doing that.

Senator SNOWE. Thank you.

Ms. Cousteau, any comments?

Your testimony was very powerful as well and eloquent about the impact.

Ms. COUSTEAU. Thank you, Senator Snowe.

Senator SNOWE. In Louisiana, the dead zone and so on has been a major conversation here, and we have made efforts concerning dead zones and hypoxia, and it is true. I mean, we have got to try to retard this expansion of these dead zones.

Ms. COUSTEAU. Thank you, Senator Snowe. I appreciate your comments.

And I feel strongly that we too often overlook the value of ecosystem services as we make our decisions about how to allocate resources. The communities that I have spent time with not only here in the United States, but around the world are the ones who have no alternatives. They have nowhere else to go. They have no

last resort. And the communities of Golden Meadow in Louisiana were no different.

If we are to really take a stand on protecting our oceans, we need to start with concern for the communities that are being impacted by the degradation of the oceans and understanding how that happens and what the consequences of that will be. Which is why I said that ocean policy starts on land. It starts in St. Louis and the decisions that are made on the Mississippi River.

It starts on the Rio Grande. It starts with everyday people. And if we are able to truly integrate ocean policy into policies for climate change, agriculture, urban development, energy, then we will see the kind of change we need to out in the open ocean.

Senator SNOWE. Thank you.

Anyone else care to comment? Dr. Fenical, anything that we should focus on, very quickly?

Dr. FENICAL. Just one comment.

Senator SNOWE. Yes.

Dr. FENICAL. Just one comment that I think it is a very important activity to convince the public that these oceans, and particularly coastal resources, are of great value to them. That without their understanding of what this contributes to their daily lives, you will have some difficulty.

And a case in point is a product that was developed in the Bahamas Islands that was a cosmetic product derived by working with a marine animal from that area. It was of such economic value to the local communities that they literally quit fishing and quit focusing on some of the fishing resources that were dwindling in numbers in that area.

And so, I think developing a number of coastal industries that focus on marine products will help greatly in convincing people to work with their coastal resources.

Senator SNOWE. Thank you.

Mr. WARREN. I will add a couple of points. With respect to fisheries and research investments, I think there are a couple of guides there. One is a study done by the National Academy of Sciences, led by Kleypas in 2006, that articulates a research agenda for ocean acidification. It is a good place to start. Funding the things they call for there would make sense.

To step a little beyond my canon into the territory of Dr. Fenical, if we want to preserve the value the ocean is generating that we haven't even begun to harvest yet in pharmaceutical products, we might want to think about where that value is. If it is like the land, a lot of it is in things that sit still instead of swim—plants, not animals; corals; fixed living organisms that generate compounds that they need in order to survive because they can't run away from predators.

That very complex chemistry they develop is going to be rich, and we are going to lose a lot of it fast if we don't get on it and figure out, one, how to reduce the $CO_2$ input and, two, how to remove some of those organisms from a vulnerable environment and put them in protected aquarium environments where we control the seawater content.

That is a long-term conservation need that will serve the development of a pharmaceutical industry based on ocean products. I regret to say we might need that kind of protection.

And beyond that, I can't say enough—make a strong carbon policy. If we don't do that, everything else that we think matters about the ocean is over.

Thank you.

Senator SNOWE. Thank you.

Mr. BABB-BROTT. Very briefly, Senator Snowe, I would offer three suggestions. Baseline oceanic data, a crucial component of all of the work that is represented by the folks here on the panel. A framework for Federal policy that supports and integrates state initiative, also very important. Each of the States, as you have heard Dr. Kempton talk about, have taken similar, but somewhat different approaches to addressing their issues.

Like the CZMA, there needs to obviously be national consistent policy. But it also needs to support and enhance the initiatives that States and regions have undertaken themselves.

Last, I would reiterate the support for and the recommendation that NOAA's coastal mission be elevated and provided adequate support. All of the panelists have spoken to the importance of the coastal interface, both economically, socially, environmentally, everything about it. NOAA really is uniquely suited to serve that coordinating role, and that coordinating role is very much needed.

Thank you.

Senator SNOWE. Thank you.

Dr. Kempton?

Dr. KEMPTON. Thank you.

On research that might be within NOAA's jurisdiction, I think is the question. I would agree with Mr. Babb-Brott that baseline studies are very useful. For in particular introducing new renewable resources like offshore wind, we would like to know—in our region, we would like to know the Atlantic flyway much better, have a region-wide bird study so we could see how to avoid impacts there.

Also the type of study that I described of resources that is not available, and you mentioned some work in Maine. I believe that was done by your local university. So I think some funding for local universities working with State governments to assess offshore renewable energy resources would be quite valuable and would help get local academics up to speed, as well as informing State decisionmakers.

And a last specific one, NOAA maintains a wonderful set of buoys, mostly near the surface, 10 meters. It would be very valuable to have a string of towers at 100-meter height, which is the turbine hub height. They are expensive, $5 million each. But you can put in a string of them for much less than doing one at a time, and it would give us a much better idea of the resource out there, as well as improving models of marine meteorology.

Senator SNOWE. Again, thank you all very much.

Thank you, Madam Chair.

Senator CANTWELL. Again, thank you, Senator Snowe, for being here. I know you have got a busy schedule this morning, as we all do.

I was mentioning to Senator Snowe, we are also in the middle of an Energy Committee markup in which right now the debate is going on about opening up more offshore drilling, which I find to be very conflicting to the information that is being provided here today. So, hopefully, we can get our questions in and get over to that debate so I can add my voice.

I wanted to start with you, Mr. Warren, furthering the discussion on ocean acidification that you were just having. And I think the thing that people may miss sometimes or don't fully understand is that oceans have already absorbed nearly one-third of the $CO_2$ added in the atmosphere. So we are already seeing this problem.

And for us, in Washington State, I don't know how familiar you are with the shellfish industry—I know you are working with the industry overall—but they are currently reeling from these bacteria and disease-carrying pathogens that are hindering the seed growth for the shellfish industry. So these types of bacteria are already spreading because of temperature changes in the water and because of global warming.

So what else can we do? Do we not have the sufficient or significant scientific data necessary? Because this is, for us, well, it is a $100 million industry in the West in general, and I think we are probably about $97 million of that in the Northwest. So it is a very big impact to us.

So what else do we need to do to prove to people that this is a problem that is here today and real?

Mr. WARREN. Well, I think you hit it on the head. We need a little more research to really prove that this problem is caused by the combination of warming, hypoxia, and acidification. Those are the strongest suspects in the oyster crisis.

We have had a four-year run of reproductive failure in that industry. And if the things you grow don't reproduce, you have got a problem. They are failing either because of an organism that thrives in hypoxic, acidified water or because of the direct effects of acidification and hypoxia. We don't know which one yet.

The work to do that, if people are defining—go ahead.

Senator CANTWELL. Can you explain why would that matter? Or does it?

Mr. WARREN. In order to figure out which nail to hit, it helps to know which one is actually holding the problem in place.

Senator CANTWELL. Well, if the cause is the same, though?

Mr. WARREN. If the problem is $CO_2$ and the underlying assumption behind both analyses is correct, then it is $CO_2$ we need to get at. But until we have strong data showing the economic impacts of essentially a non-$CO_2$ policy, of not doing the job, until we have the economic and scientific basis to make the case that this is jobs, livelihoods, food, lots of things that matter, then we are going to have a hard time defending the policies that are necessary to implement—to deal with that $CO_2$ problem.

Senator CANTWELL. Wouldn't that lead to disastrous results, though? Wouldn't we have to wait—you are saying wait for disastrous results to prove that?

Mr. WARREN. Well, that is one way to do it. Another way would be to do a very rapid investment in research to establish what is causing the problem so that we can stand up and say here it is.

This is what is driving the problem here. It is causing a lot of harm to an industry worth 100 million bucks a year, and it is going cause a lot more.

And that is a good case study to think about funding research in, and there are people working on a research agenda for that, and they are worth talking to. They are asking good questions.

Senator CANTWELL. We are very interested and very supportive of that kind of research because we see the problem coming at us very directly now in the Northwest. And if this is the kind of thing that can happen in other industries—I mean, sorry, other sectors of the seafood industry, it is going to cause huge problems for us.

Dr. Fenical, you are a supporter of more research. You mentioned the Oceans and Human Health Act. What do we need to do, more specifically? I know we have authorized about $60 million, but I don't think much has gotten appropriated in this area.

What do we need to do to change the research and get the right research that both helps us address the adaptation and impact issues as well as the kind of advancements that you are suggesting in medicine?

Dr. FENICAL. Well, I think that is right. I think the problem is that there is authorization, but no research dollars or very small numbers of research dollars coming down to address these problems. I think it is a matter of understanding that the uniqueness of the oceans and human health legislation and the fact that we can address through that resource some of the problems that Mr. Warren has talked about and, in addition, the positive health benefits of the ocean.

So it is quite an overreaching legislation that I would argue is growing in importance each day and that we should support very strongly.

Senator CANTWELL. And how would you direct those research dollars? What is the best way to, if we want to accelerate what we have done so far, both in the amount of money, but obviously because these very species and sources that you are talking about getting data from are also in jeopardy.

Dr. FENICAL. Exactly.

Senator CANTWELL. So what is the best way to pursue that research?

Dr. FENICAL. I think the problem——

Senator CANTWELL. Through our universities and institutions or——

Dr. FENICAL. I think one of the problems with the Oceans and Human Health Act is that it is struggling to know how to effectively allocate those moneys. On one hand, the Oceans and Human Health addresses negative health benefits of the ocean and of inhabitants or organisms within the sea, and on the other hand, addresses the positive health benefits the ocean will provide and has provided.

And so, in fact, the total allocation of funding through NOAA may not address the positive aspects of health. But I think NOAA allocations and previous allocations through the National Institute of Environmental Health Sciences and the National Science Foundation do have the opportunity to address head-on the elements of climate change, ocean acidification, and so on.

But we have to act through that Oceans and Human Health legislation. It has to be strong and directed to create programs to solve these problems.

Senator CANTWELL. Thank you.

Did you have a comment on that, Dr. Kildow?

Dr. KILDOW. Yes. I have two comments. Number one, on the ocean acidification research, I think that several panelists have mentioned that we really don't quite know the impacts of the acidification problem yet on marine creatures. We have a lot of information, but we really don't have a definite predictive capacity.

I think that more money needs to be put into doing the experiments, which are very expensive, to determine the impact of acidification on living resources, including the kinds of problems that we are talking about up in your state. So that would be the first thing that I think is overlooked.

It is assumed that the scientists can do it, but it is very expensive, especially in deep waters, to figure out the impact on the food chain.

The second thing I would suggest is that we are all talking about jobs. We are all talking about the economy of our States, and we are all talking about the survival of certain industries. We do not have good economic data, particularly on the fishing industry.

Fishermen have been exempted from reporting the way other industries do. They are self-employed as far as categories of IRS. And for those of us collecting economic data, we cannot get data on the number of fishermen, on their earnings, and therefore, it is very hard to know what the potential losses are to the industry. They don't come under the unemployment rules.

So this has been a big handicap for all of us collecting data. When buyouts of fishermen are done, this is done by the seat of the pants because we don't really know what they should represent. That is one of the things.

The other thing is that the collection of economic data in general, the kind that my report reports, has just not been a very popular kind of activity. It is research. It is as important research as the scientific research that my colleagues have been discussing on this panel.

And yet it has not been considered research, and it has not been funded. And it has not—there is nothing in the funding for the future that is going to do it either. As I said at the end of my talk, the economic research that we have been doing has come to an end. There is no more money for it.

So if we want the kind of data about "blue" jobs, about sustaining our economy, and how important the kinds of things that all of these people have been talking about, we do not have a facility for doing that. And the Government needs to keep ocean accounts. There is just—we are one of the few governments in the industrialized world that is not doing it now.

Canada, the UK, France, the European Union, Australia, New Zealand, I could go on. Their governments are all supporting ocean accounts. Our Government is not. I think it is really important for us to have the information that you are seeking that we keep ocean accounts and understand the Blue Economy, the jobs that are to be gained or lost from what is happening.

Senator CANTWELL. Well, I couldn't agree with you more. We have talked a little bit about the impact on the fishing industry. We haven't really talked about how climate change can change water levels, and that impact on coastal communities and what that can mean. But for us, the port of Tacoma was responsible for $35 billion in total trade in 2008, with 113,000 jobs; the port of Everett, $17 billion and 2,600 jobs; Seattle, $40 billion and 190,000 direct and indirect jobs.

So I hear you. These kinds of changes to our oceans and waters will have huge impacts on these economies. And I think today's hearing has shone a bright light on that.

And Ms. Cousteau, you talked about this as it directly impacted New Orleans. But how do we get this message across about the adaptation that has to happen? Do you think that we are just missing this information or research, or do you think there is more to it?

Ms. COUSTEAU. I think that, as my colleagues here have mentioned, we do need to invest an enormous amount of money in research and evaluation. I also think that we have underestimated the importance of communication and engaging individuals to understand how they are part of the solution, how we are downstream from one another, and how we all have to play a role in the protection of our water resources.

What astounded me when I was in Louisiana was that the Mississippi River drains 40 percent of this country, from Montana to Pennsylvania. And all the way down to Louisiana, the actions of every individual impact that enormous watershed that tells the story of this country. And being able to engage people in that so that they understand how they impact one another is incredibly important.

I think Government agencies have a big role to play in that, and NOAA has wonderful educational programs. But I think that is incredibly important for all of us to share responsibility for our resources and the stewardship of our resources and the understanding that we are all downstream from one another and the choices that we make impact people downstream.

And I will just end with this. It was very moving to spend time with these Cajun fishermen. I have spent time with fishermen in Panama and in Africa and all over. But these men and women were really living on the edge. They were surrounded by water where there had once been fields. Now it was ocean.

And their levees were the only thing that was separating the Gulf from their homes. And they were talking about farmers upstream and the impact of the agricultural runoff, and why didn't we take action to protect the fisheries from overuse of fertilizer?

And I think that it is incredible when you think that if a cloud of toxic gas were to cover New Jersey and the only things that could survive were ones that could run out of the State, that is what is happening in the Gulf of Mexico. This cloud of hypoxia covers an area the size of New Jersey, and the only things that survive are what can escape that area.

People will go to the beach with their buckets and catch shrimp that are jumping out of the water to breathe because they can't breathe in the water anymore. And as Mr. Warren was saying, when the water is not fit for life, then we have a big problem. And

short-term priorities can no longer get in the way of our long-term priority of protecting life in the oceans.

Thank you.

Senator CANTWELL. Thank you.

I said in my statement, and Dr. Kildow, you mentioned the NOAA budget. And I have said we need to at least double it. Of its $4.48 billion, I know that EPA is getting something like a 37 percent increase right now.

What do we need to do to get the resources? What are we talking about here to adequately get the resources to address this issue? Each of you could comment on that.

Dr. KILDOW. I think that people need to understand, in the inland States as well as the coastal States, the urgency of these problems. I think that if people understood urgency—I think that they understand there are problems. I don't think they get the urgency of what is happening.

And somehow, we have to be able to communicate better that there is urgency because I think if you and your other elected colleagues would understand that we do not have much time and that there will be calamitous effects if we do not act, that NOAA and the climate change programs would and should get the money that they deserve to do the work that is just so wanting.

I don't know what else to suggest. It has been a big frustration. Scientists are stepping up. They are speaking out now. They are testifying.

But I think that people in the Midwest, in the areas that drain into the Mississippi need to understand that the U.S. economy is the coastal economy. We can't look at it any differently now, and they need to understand that the coasts are their lives and their livelihood. So that Kansas City as well as Long Beach are dependent on the same economy.

Senator CANTWELL. So that sounds to me like maybe a little more than doubling of the budget over 4 years. Is that a yes or a no?

[Laughter.]

Dr. KILDOW. You know, I couldn't begin to tell you how much resources, but what I was trying to show is that over the years, as the problems with the ocean have increased, the percentage of the Federal budget that has been dedicated to the oceans has decreased.

Senator CANTWELL. Has decreased, yes. Thank you.

Ms. Cousteau or Dr. Fenical, do you have a number or an idea of how we should look at this?

Dr. FENICAL. Well, one of the concerns I have is the issue of really funneling research funds to those people in a position to examine some of these issues. And it strikes me that the issues are not the same for all of us. In fact, coastal States are obviously not the same. They have different problems. They have different issues.

And I want to refresh your memory about the Department of Commerce Sea Grant program that is a national program, but is dedicated to create research activities around the sea in each of the coastal and Great Lakes States. This program frequently creates new initiatives. It creates activities, both of positive and negative

impacts from the ocean. And I think it could be used very effectively to focus funding for these activities.

Senator CANTWELL. OK. And Mr. Warren or anybody else on the panel?

Mr. WARREN. I will give you two quick thoughts. The numbers I hear about in terms of what people think it will take to fund a really good national ocean acidification research program? About $30 million a year. So probably doable if we pay attention.

One of the concerns that some people have raised, and I think it is a valid one, is if we fund that by robbing Peter to pay Paul, dipping into the funding to support fisheries survey work, we are really not serving the cause. Because that data is how we try to maintain sustainable fisheries. We are going to have to do both.

We are going to need that steady flow of fishery survey data, and we are going to need a whole new raft of data about changing ocean conditions in order to make sure we understand it well enough to manage.

Senator CANTWELL. Thirty million hardly seems like a lot of money if we are the third-largest economy in the world. If you are taking the ocean communities and saying they are the third-largest GDP in the world, $30 million to help deal with ocean acidification seems like next to nothing to protect that huge resource for our economy.

Dr. Kempton or Mr. Babb-Brott, do you have any comments about——

Mr. BABB-BROTT. I would offer briefly that regardless of what the number or what the appropriate number is, we have an obligation, I think, to use the resources that we do have or that we could acquire wisely, and I know I mentioned this in my testimony. But I would reiterate that we can use the Federal budget more efficiently through centralized and coordinated action by the Federal agencies.

From a parochial management interest at the State and regional level, it can be a frustrating thicket to navigate, and it certainly impedes the kind of creative, constructive initiative and response to the issues that we have been discussing here this morning. Again, I think that NOAA is well suited to handle that role.

Thank you.

Senator CANTWELL. Dr. Kempton?

Dr. KEMPTON. I certainly think that increasing the amount of effort on ocean acidification would be very valuable. I am not sure if we need to just prove that it is happening, although that probably helps to get increasing numbers of people buying into it. But as my remarks mentioned, I think it is important to also have researchers working on solution paths.

I see a lot of elected officials who are ready to do something, but they are not sure what to do. So in addition to demonstrating the effects, which can already be seen in fisheries and dead zones and so forth, it is important to work on the how you reduce the amount of $CO_2$ that humans are putting into the atmosphere.

And if you just sort of pour money in the top, that can be—that can all go to sort of traditional activities, whereas prevention of $CO_2$ emissions is not central to the way NOAA may see its mission, although they do have some departments. So I think some direction from the legislative side on working on solution paths because a lot

of the solution paths, at least for coastal States, are also in the ocean.

But coastal managers may not see themselves as those who are supposed to facilitate development of ocean renewable energy resources, for example, but they could play a productive role there.

Senator CANTWELL. And what about adaptation? Is that part of the solution kit? Is that what, when you say "solutions," are you talking specifically about——

Dr. KEMPTON. Well, a person—sorry.

Senator CANTWELL. Or were you talking about the reduction of $CO_2$?

Dr. KEMPTON. I was talking about reducing $CO_2$. A personal reaction to your question is adaptation I find very frightening. We live in a very low-lying State, and talking about adapting to sea-level rise means essentially abandoning Delaware. It will be an archipelago. And I think you could say the same type of things about shellfishing in Washington.

So I don't think there is any adaptation to that. That is why I am focused in my research and our whole group on prevention, which means keeping $CO_2$ from going into the atmosphere, which means changing energy production and agricultural activities.

Senator CANTWELL. Well, I think there are some who believe that if we actually do the work behind adaptation, it would become clear to everyone that that is not a sustainable route. That it is only a temporary issue for dealing with the impacts, but the real issue is to change course. So I appreciate you bringing up that point.

And I want to thank all of the witnesses for your testimony today. We are going to leave the record open so that my colleagues can submit questions, and hopefully, you can get a quick response. But we do plan to move on legislation in this area, and we thank you for helping us build a record to show how incredibly important the Blue Economy really is to our country and what we need to do to protect it.

This hearing is adjourned.

[Whereupon, at 10:55 a.m., the hearing was adjourned.]

# A P P E N D I X

PREPARED STATEMENT OF SENATOR JOHN D. ROCKEFELLER IV,
U.S. SENATOR FROM WEST VIRGINIA

Our oceans and coasts are sources of great economic and environmental wealth for the Nation. Nearly 80 percent of U.S. import and export freight is transported through seaports. Our 3.4 million square mile Exclusive Economic Zone (EEZ), the largest in the world, covers an area greater than the entire United States.

The Blue Economy—jobs and economic opportunities that emerge from our oceans, Great Lakes, and coastal resources—generates more than 50 percent of our Nation's Gross Domestic Product and provides over 70 million jobs to Americans. Simply put, the economic health of America is undeniable linked to the riches of our oceans and coasts.

Today's witnesses have compelling stories to tell us about the Blue Economy and its importance. From food to fuel, we rely on oceans for goods and services that drive the economy. America is on the cusp of major developments that could produce new "blue" jobs in renewable ocean energy development, aquaculture, marine drugs and products, and ocean exploration, and I look forward to hearing from each individual here.

Before we begin, I want to take a moment to highlight what is, in my view the most prominent threat to our Blue Economy and that is climate change. Climate change is acidifying the waters, warming oceans, and creating giant dead zones—jeopardizing the $111 billion commercial seafood industry and the promising development of new products from our oceans. Sea-level rise is threatening coastal communities and the maritime industries that provide millions of jobs.

There are key steps that we must take now to sustain and grow our Nation's blue economy.

We must strengthen the National Oceanic and Atmospheric Administration (NOAA). First, I hope the Administration will commit to doubling the budget of NOAA by 2012. Second, currently, NOAA operates through more than 200 separate authorization creating overlaps and disconnects among different parts of the agency. The U.S. Commission on Ocean Policy recommended that Congress establish an organic act for NOAA to codify its mission. I support this goal and look forward to working with my colleagues and the Administration to enact legislation establishing NOAA.

We also must look for new and innovative ways to plan for uses of our oceans and coasts that supports economic growth, protects ecological services and unique marine areas, and reduces conflicts among users. Balancing use and protection of marine resources for current and future generations requires strong science-based management of our oceans and coasts, interagency coordination, and Federal-state-local partnerships. For this reason, I sent a letter to President Obama urging the Administration working through the Office of Science and Technology Policy, the Council of Environmental Quality, and the National Oceanic and Atmospheric Administration to develop a comprehensive science-based Federal marine planning framework to guide decisions on ocean use and conservation and to promote ecosystem-based management.

In closing I want to state very clearly—for those who live on our coasts and those who do not, like my state—we must all be a part of the effort to improve the health and well-being of our oceans. America's economic growth and the livelihood of so many workers depend on the decisions we make now. What is good for the health of our coastal communities and oceans is good for the Nation.

Thank you.

○