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Destruction of mangrove forests spews millions of tons of carbon into the air.

Scientific leaders explore pathways to climate solutions

Ecologist Jane Lubchenco and nuclear physicist Ernest Moniz offer ways forward from land and sea

By **Anne Q. Hoy**

Climate change is altering ocean ecosystems and impacting Earth's land surfaces. Yet strategies to address such challenges largely focus on land activities when broader responses offer more powerful solutions, said marine ecologist Jane Lubchenco during a lecture at the American Association for the Advancement of Science's 44th Science & Technology Policy Forum.

"We can't really think about climate solutions without including the ocean, and that's true on both the mitigation and the adaptation front," Lubchenco said in her Gilbert S. Omenn Grand Challenges Address. "The opportunity here is not to only address climate change—pretty big deal in and of itself—but to also simultaneously be able to focus on food security, resilience of coastal communities, and abundance of wildlife."

Lubchenco recited the extensive benefits Earth's oceans deliver and walked through threats now facing the oceans that cover 71% of the planet's surface during her 3 May lecture at AAAS's headquarters in Washington, D.C.

The speech served as a bookend to one given by Ernest J. Moniz at the AAAS Science & Technology Policy Forum on 2 May that called for energy technology innovation, coalition building, and implementation of his plan to curb climate change. Moniz, chief executive officer of the Energy Futures Initiative, former Energy Department secretary, and professor emeritus at Massachusetts Institute of Technology, presented the 2019 William D. Carey Lecture in recognition of significant contributions to science and the articulation of public policy issues.

Drawing from an array of scientific disciplines, Lubchenco and Moniz each pointed to the effectiveness of multidisciplinary scientific approaches and collaborative responses to climate change, including those that reach into business and policy arenas, perspectives that displayed core elements of the Science & Technology Policy Forum's "Strengthening Science and Its Benefits to Society" theme.

In building a verbal bridge between transformations facing the world's land surfaces and those confronting the oceans, Lubchenco said that success dealing with climate change can only be accomplished by taking on the risks to land and the oceans.

"The problems in the oceans are actually really important and

more important than most people understand for their own health, prosperity, and well-being," she said. "Such degradation threatens the most vulnerable people on the globe, economic prosperity, quality of life, opportunities for everyone, to say nothing of the well-being of the oceans and its life-forms."

Already, the oceans are warming, growing more acidic, holding less oxygen, rising due to higher water temperatures, generating more storms, producing fewer fish stocks, and becoming more polluted from plastics—factors depleting and disrupting the oceans, she said.

At risk are the beneficial powers of the oceans: the production of more than half the planet's oxygen, absorption of more than 90% of excess heat entrapped by greenhouse gas emissions, and absorption of almost half the carbon dioxide emitted by human activities. Such repercussions, she said, endanger coastal habitats and ocean creatures from wetlands to whales.

Restoring rapidly disappearing mangrove forests, tidal marshes, and seagrass meadows and protecting coastal areas—which touch 78% of the world's countries—can play an active role in eliminating greenhouse gas emissions, said Lubchenco. Over a decade and a half beginning in 2000, for instance, the deforestation of mangrove ecosystems, among the best carbon sequestration systems, resulted in the release of 122 million tons of carbon into the atmosphere.

The effectiveness of ocean "biological pumps" that move carbon around and store it on the ocean floor, due to such things as the submersion of whale carcasses, is weakening. Restoring whale populations could rebuild the ability of oceans to absorb some 160,000 tons of carbon each year, said Lubchenco.

More scientific research is needed to understand "significant unknowns" and reveal the full potential of the oceans to contribute to climate adaptations and mitigation approaches, said Lubchenco, even as some activities are already under way.

Revamping global fisheries responsible for releasing 170 million tons of carbon dioxide into the atmosphere in 2011 and overhauling the shipping industry responsible for 2.6% of the world's carbon emissions in 2016 would deliver significant benefits. Adapting fisheries would expand seafood yields by 40%, increase ocean fish stocks by 5%, and boost industry economic gains by 30%, benefits that would contribute to climate change responses, said Lubchenco.

"I would suggest to you that it's time for all of us to, pardon the pun,

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seas the day and embrace the potential for co-benefits of tackling climate change and ocean health together," she said.

With a focus on energy innovations, Moniz called for adoption of low-carbon electricity generation systems, including advanced nuclear technologies, implementation of energy efficiency practices across economic sectors, and transformative carbon capture and storage techniques. Such approaches, he said, need to be part of a viable climate change response plan.

Moniz proposes solutions that recognize the diversity of regional energy systems and implement energy efficiency across sectors of transportation, industry, electricity, buildings, and agriculture. Regional differences in how power is generated, he said, ticking off natural gas, coal, nuclear, solar, hydroelectric, and wind power systems, and the infrastructures built around such systems require "tailored solutions that account for unique challenges and opportunities in each subsector."

Moniz summarized what he calls the "Green Real Deal" that he first proposed in a March opinion piece co-written with Andy Karsner, a former George W. Bush energy official, calling for a "wise and just transition to a low-carbon economy, moving as fast as it is technically and socially possible."

The approach would require increased energy efficiency across sectors, a low-carbon electricity system, and forging of coalitions that include energy companies, industry disruptors, military representatives, and other players who remain pragmatic and avoid either end of the political spectrum. Moniz noted that the proposal echoes President Barack Obama's energy policies, which emphasized practical solutions and innovation.

Drawing a link between the earlier climate proposal backed by U.S. House Rep. Alexandria Ocasio-Cortez (D-NY) and U.S. Sen. Ed Markey (D-MA) and his own approach, Moniz said in his lecture that the lawmakers' proposal "is fundamentally the statement of one important fact... And that is that in pursuing low carbon, we pursue social equity at the same time."

At one point, Moniz returned to an introductory comment by AAAS Chief Executive Officer Rush Holt in which he noted that President Donald Trump had withdrawn the United States from the landmark 2015 Paris Agreement on climate change, a decision announced on 1 June 2017.

"We're still in Paris," Moniz said. "Technically, we are not out until the day after the next presidential election. So we will see what happens there."

The withdrawal decision, Moniz said, elicited "striking reactions" from governors, mayors, and "well over a thousand businesspeople who said, 'Look, we're staying the course, possibly even upping the ante in terms of going to low carbon.'"

While expressing confidence that the Paris goals can be met, Moniz acknowledged that it will be expensive and require "a home run" by each economic sector.

He also pointed to the power of other factors outlined in a recent opinion piece he co-wrote with John Kerry, former secretary of state and Massachusetts senator, in recognition of Earth Day. The piece looked back at the first Earth Day in 1970, a demonstration that marshaled a dismayed public demanding legislative action to clean up the nation's then-battered air, water, and environmental resources. The event contributed to the enactment of landmark environmental laws.

"Americans in a certain sense mobilized and got the message... to the political sphere that there was going to be accountability," Moniz said. "There was political accountability, the people were fed up, it was time to address these issues."