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Select Committee on the Climate Crisis
U.S. House of Representatives

Hearing on
"Building Climate-Resilient Coastal Communities: Perspectives from Oregon's State, Local and Tribal Partners"

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Thank you Chair Castor, Ranking Member Graves, and Representative Bonamici for this opportunity to speak to you today to discuss the important issue of building climate-resilient communities.

I am Francis Chan. I am an associate professor at Oregon State University where I conduct research on ocean chemistry and ecology. I am also the Director of the Joint NOAA-OSU Cooperative Institute for Marine Ecosystem Studies (CIMERS). This Cooperative Institute, like 14 others around the country, was established to ensure that NOAA can draw on the full breadth of the Nation's scientific expertise and capacity in managing the ocean.

I have spent two decades studying changes in Oregon's coastal ocean. This field hearing could not be more timely. Oregon's coastal communities and industries are on the frontlines of climate change. If we drive down the coast, we can talk with Sue Cudd and Mark Weigardt, owners of the Whiskey Creek Shellfish Hatchery about how an acidifying ocean almost put them out of business. They were put in that situation because carbon dioxide levels in seawater had passed the chemical threshold that's safe for growing seed oysters (Barton et al. 2012). This is important because oyster farms up and down the coast depend on their seed oysters to support a $100 million per year oyster industry.

Climate change is also giving rise to increasing frequency and severity of marine heatwaves (Oliver et al. 2018). Marine heatwaves are periods of abnormally high ocean temperature. One of the largest marine heatwaves on record landed on our shores in 2014. Marine heatwaves are an important concern because they turn the normally productive ocean food web that allows salmon to thrive into one where juvenile salmon have trouble finding enough food to survive (Daly et al. 2015).

Further, we also now know that a warming ocean also gives rise to oxygen-poor (or hypoxic) zones. This is because warmer waters hold less dissolved oxygen and warmer waters on the surface of the ocean act to slow the replenishment of oxygen from the atmosphere to the deep ocean (Keeling et al. 2010). Along the Oregon coast, ocean conditions are also affected by changes in winds that drive upwelling ocean currents that pull deep, oxygen-poor but nutrient-rich waters to a productive, shallow continental shelf. Stronger winds from climate change accentuate the risk and severity of low oxygen events (Bakun et al 2015).

Along the Oregon coast, oxygen levels can drop, as it is right now, to levels so low that Dungeness crabs, the most valuable fishery on the west coast, can suffocate in the pots of fishermen before they can be brought to market (Grantham et al. 2004). Just as we have wildfire seasons that start earlier and spread farther on land because of climate change, we now have a low oxygen (or hypoxia) season that returns to our coastal waters each year. The low oxygen zones that we experience today are more severe and closer to shore than what can be seen in historical records that go back seven decades (Chan et al. 2008, Figure 1). Just last year, a hypoxic zone developed off Oregon's central coast in April and persisted for six months. But unlike wildfires, hypoxia is not something that can be seen. A fisherman cannot tell from the surface if he or she is about to drop crab pots into a hypoxic zone. In addition, because observations of dissolved oxygen values near the sea floor are limited, a fisherman can't tell how far she or he should move to get away from a hypoxic zone. The climate crisis is not a far horizon event, it is an everyday challenge for people working our coastal waters.

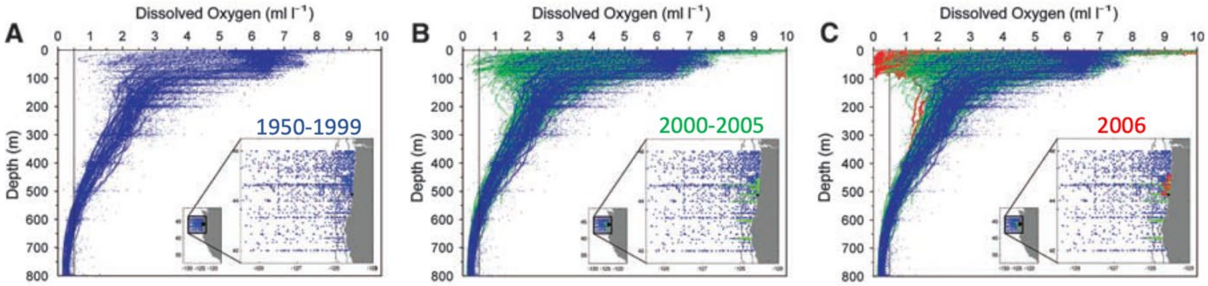

Figure 1. Dissolved oxygen measurements along the Oregon coast, A) from the first five decades of oceanographic observations, B) increasing severity of hypoxia (vertical dash line denotes 0.5 ml l-1, C) first documented observation of nearshore anoxia (zero oxygen). Figure from Chan et al. 2006)

Along the Oregon coast, you will also find local residents, scientists, fishermen, and resource managers rolling up their sleeves to find solutions to this crisis. They are doing this by taking advantage of the best available science and by working together. At Whiskey Creek, OSU researchers supplied hatchery managers with state-of-the-art seawater carbon dioxide sensors that have allowed them to stay in business. In Oregon's marine reserves, coastal residents are a working part of citizen scientist teams that are using research-grade pH sensors to identify hotspots and refuges from ocean acidification (Figure 2). Down the coast in Newport, you'll find scientists from OSU and NOAA's Northwest Fishery Science Center working side by side with commercial fishermen to track ocean conditions and the health of juvenile salmon (https://www.fisheries.noaa.gov/west-coast/science-data/ocean-ecosystem-indicators-pacific-salmon-marine-survival-northern). This information requires sustained, long-term support but gives fishermen and fishery managers an invaluable look ahead into what the salmon fishery can expect to see in adult returns up to 4 years out.

Figure 2. Examples of citizen scientists using Oregon's Marine Reserves as sentinel sites for ocean acidification monitoring. From Chan et al. 2019.

In my own work, with support from NOAA's National Centers for Coastal Ocean Science, I've been able to collaborate with the blue high-tech industry to develop a cheaper, smarter, and tougher oxygen sensor that crab fishermen put onto their pots (Stoltz et al. 2021, Figure 3). The sensors plot oxygen levels every time the pot comes on deck so fishermen can now see if they are working inside a hypoxic zone. For researchers, this partnership has meant an order of magnitude increase in the number of critical measures that we have for detecting and tracking the progression of hypoxic zones in Oregon. The technology that we've developed is now in the hands of lobstermen in New England who are dealing with the rise of hypoxia in their traditional fishing grounds (Figure 4).

The examples that I've shared came about from wise federal investments in innovations and partnerships. We have an opportunity to go much farther. In CIMERS, OSU and NOAA scientists are working on the intersection between new ocean acoustic technologies and artificial intelligence. The sounds captured by NOAA's Ocean Noise Reference Network (https://www.pmel.noaa.gov/acoustics/noaanps-ocean-noise-reference-station-network) have varied uses including tracking climate change impacts on sea ice, monitoring the impacts of renewable energy projects, and delineating crucial habitats for marine mammals. By developing new acoustic technologies, including the use of autonomous underwater vehicles and new ways to automate analyses through artificial intelligence, ocean sound monitoring has the potential to cost-effectively provide the information needed to guide the management of multiple ocean priorities such as fishing, marine renewable energy, and protection of marine life.

Figure 3. Commercial crabber bringing on deck a crab pot equipped with a smart dissolved oxygen sensor (red arrow) developed with support from NOAA NCCOS' Coastal Hypoxia Research Program. (Photo credit: Pat Kemmish, *F/V Richard H*.)

Working at a public university, I also see firsthand the value proposition of a blue high-tech economy. Investing in innovations is investing in workforce development. A student that is inspired to blend artificial intelligence with sensors that survive the bottom of the ocean or the inside of a commercial crab pot will have the kinds of creative, technical problem-solving skills that are vital to our economy. There is much work to do and we need to make sure that inquisitive and creative students from economically challenged communities, be it the coast, the inner-city of Portland, or the high desert are not left behind. We need to make sure that they have access to opportunities that give them an on-ramp to the growing blue economy.

Innovations also take the form of new ideas. At OSU, researchers are working to stimulate a new marine climate insurance industry that would help seafood growers and harvesters be more climate-resilient. On land, farmers have access to insurance products to safeguard their livelihoods against drought and weather events. For fishermen dealing with increasing marine heatwaves or hypoxia, that's not an option. This is due in part to a lack of access to scientific information, such as the frequency and severity of events that would allow insurers to adequately price risk. Some of this information is already in hand and some will require further research, but this is the kind of blue economy opportunity that NOAA's vision for climate products and services can catalyze. Importantly, a marine climate insurance industry would give seafood growers and harvesters a tool to adapt to the uncertainties that continued climate change will bring.

Figure 4. Dissolved oxygen sensor (lower red arrow) and deck display (upper red arrow) being used by New England lobstermen to track the onset of hypoxia on the East Coast (Photo credit: Lowell Instruments)

Partnerships are key to our success and help us point science in the right direction. I am working with NOAA colleagues to develop tools that can make the Dungeness crab fishery a more climate resilient fishery. This effort draws on expertise from researchers in NOAA's Pacific Marine Environmental Laboratory, Northwest Fishery Science Center and NCCOS and public universities to link together our best knowledge and tools in ocean climate and fishery observations and modeling. Importantly, we are honored to have representatives from Tribal nations and the commercial fishing industry serve on our advisory board to make sure that we go after the most actionable options.

Further, connecting the dots between climate, ecosystems, and wise management is fundamental and crucial. A good example of a collaborative and multi-disciplinary initiative is NOAA's Climate, Ecosystem and Fisheries Initiative that allows federal and university scientists to build an operational ocean modeling and decision support system that is needed to reduce impacts, increase resilience, and help marine resources and resource users adapt to changing ocean conditions (https://www.fisheries.noaa.gov/resource/document/noaa-climate-ecosystems-and-fisheries-initiative-fact-sheet).

Finally, I've seen firsthand the potential for sound science to guide how we prepare for a changing ocean. I previously co-chaired the West Coast Ocean Acidification and Hypoxia Science Panel (https://westcoastoah.org/westcoastpanel/). On this panel, 20 leading scientists from across the west coast lent their expert advice to provide science-informed recommendations to inform state actions including new legislation in Oregon (SB 1039, https://olis.oregonlegislature.gov/liz/2017R1/Measures/Overview/SB1039; HB 3114, https://olis.oregonlegislature.gov/liz/2021R1/Measures/Overview/HB3114) and California (SB 3163, http://www.leginfo.ca.gov/pub/15-16/bill/sen/sb_1351-1400/sb_1363_cfa_20160818_010548_asm_floor.html; AB 2139, http://www.leginfo.ca.gov/pub/15-16/bill/asm/ab_2101-2150/ab_2139_bill_20160914_chaptered.htm).

I am buoyed by federal attention to the challenges that coastal communities face from a changing ocean climate. And Oregon's Representative Bonamici is at the forefront of these efforts. The Congresswoman's recently enacted Coastal and Ocean Acidification Research and Innovation Act gives us a blueprint for targeted investments in ocean research, innovations, and engaging people most impacted by the ocean climate crisis to build solutions. There is a way forward.

Thank you Chair Castor, Representative Bonamici, Ranking Member Graves and this panel for your attention to preparing our coastal communities for the challenges ahead.

Citations

Bakun, A., Black, B.A., Bograd, S.J., Garcia-Reyes, M., Miller, A.J., Rykaczewski, R.R. and Sydeman, W.J., 2015. Anticipated effects of climate change on coastal upwelling ecosystems. *Current Climate Change Reports*, *1*(2), pp.85-93.

Barton, A., Hales, B., Waldbusser, G.G., Langdon, C. and Feely, R.A., 2012. The Pacific oyster, Crassostrea gigas, shows negative correlation to naturally elevated carbon dioxide levels: Implications for near-term ocean acidification effects. *Limnology and oceanography*, *57*(3), pp.698-710.

Chan, F., Barth, J.A., Kroeker, K.J., Lubchenco, J. and Menge, B.A., 2019. The dynamics and impact of ocean acidification and hypoxia. *Oceanography*, *32*(3), pp.62-71.

Chan, F., Barth, J.A., Lubchenco, J., Kirincich, A., Weeks, H., Peterson, W.T. and Menge, B.A., 2008. Emergence of anoxia in the California current large marine ecosystem. *Science*, *319*(5865), pp.920-920.

Daly, E.A., Brodeur, R.D. and Auth, T.D., 2017. Anomalous ocean conditions in 2015: impacts on spring Chinook salmon and their prey field. *Marine Ecology Progress Series*, *566*, pp.169-182.

Grantham, B.A., Chan, F., Nielsen, K.J., Fox, D.S., Barth, J.A., Huyer, A., Lubchenco, J. and Menge, B.A., 2004. Upwelling-driven nearshore hypoxia signals ecosystem and oceanographic changes in the northeast Pacific. *Nature*, *429*(6993), pp.749-754.

Keeling, R.F., Körtzinger, A. and Gruber, N., 2010. Ocean deoxygenation in a warming world. *Annu. Rev. Mar. Sci*, *2*(1), pp.199-229.

Oliver, E.C., Donat, M.G., Burrows, M.T., Moore, P.J., Smale, D.A., Alexander, L.V., Benthuysen, J.A., Feng, M., Sen Gupta, A., Hobday, A.J. and Holbrook, N.J., 2018. Longer and more frequent marine heatwaves over the past century. *Nature communications*, *9*(1), pp.1-12.

Stoltz, L., Chan, F., & Childress, J. Fishing for Oceanographic Data: New tools energize a partnership of fishing communities and scientists. *Sea Technology* Feb 2021: 14-16.