Statement of

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Good morning, Mr. Chairman, and members of the committee. Thank you for the opportunity to speak with you today. My name is Tom Frazer. I am a Professor and Dean of the College of Marine Science at the University of South Florida and Executive Director of the Florida Flood Hub for Applied Research and Innovation.

In 2019, I had the honor to testify about how climate change affects oceans before the Environment Subcommittee of the U.S. House of Representatives Committee on Science, Space, and Technology, and my position has not changed. To be clear, I will preface my comments today with a brief statement regarding my position on climate change:

> *Climate change and its associated detrimental effects are real, emissions from human activities are largely responsible, and managing our collective, global behavior is the most effective and practical way to address the fundamental cause.*

Today's hearing focuses on one key facet of climate change – ocean warming. Oceanic temperatures increase because atmospheric temperatures rise due to heat that is trapped by carbon dioxide and other greenhouse gas emissions. These relationships are well established. What may not be fully appreciated, however, is that no matter what we do today to reduce emissions and stabilize mean global air temperatures, the ocean will continue to warm well into the next century and beyond, which will generate numerous challenges.

Given this outlook and my professional background, I want to focus on how science can help us deal with challenges to two sectors: fisheries as a representative of natural environments and flooding as an example for the built environment.

Among the challenges facing fisheries, I will focus on two: altered ranges and altered habitats. As the ocean warms, some warm-water species can expand their ranges northward, but some cold-water species will be forced to contract their ranges. Thus, the location and size of catches for commercial and recreational fishers will change. As the ocean warms, we also will see changes in habitats. For example, warmer water stresses inshore, structural habitats that provide food and shelter for many fishery species, such as seagrass meadows and corals.

What should our responses be? Our management of fisheries needs to broaden from single species management to ecosystem management. Ecosystem management considers changing temperature, along with other physical, chemical, and biological components of the environment and their interactions. Our management of habitats needs to include increased protection from pollution, freshwater runoff, and other stressors under our control so that habitats have the best chance of coping with warming water. We also should be prepared to restore habitats if needed, which includes developing new techniques for culturing and transplanting replacement organisms, exploring genetics to identify more tolerant strains, and organizing supply chains that operate at the necessary scale.

In terms of flooding, I will focus on compound flooding. Compound flooding results from intense precipitation putting water on the land and higher sea levels inhibiting drainage. Warming oceans contribute to both components because warmer water expands leading to higher sea level, and warmer water fuels wetter storms.

What should we do here? We have access to a variety of actions that allow us to mitigate or adapt to flooding, such as sea walls, flood gates, raised structures, and improved drainage. All these solutions have costs, so determining how much investment is needed becomes a key issue. An accurate assessment of risk, in other words the magnitude and likelihood of various levels of flooding, promotes optimal investment in adaptation and mitigation. Currently, our projections of future conditions rely heavily on global climate models that are driven, in large part, by changes in atmospheric temperature. These global climate models are complex, and they function best at larger temporal and spatial scales. Considerable uncertainty surrounds our efforts to downscale longer-term, global changes in sea level and precipitation to projections of risk at the temporal and spatial scales needed for optimal planning. National and state agencies and organizations have key roles to play because they have the charters and expertise to successfully translate global insights into useful and useable local insights. Improved projections will help us employ existing solutions optimally and highlight the need for innovative approaches moving forward.

Is anything currently happening? Yes, and I will provide just two examples. The National Oceanic and Atmospheric Administration and regional fisheries management councils are expanding their efforts to apply ecosystem management that recognizes the changing climate. In terms of flooding, the State of Florida is funding the Florida Flood Hub for Applied Research and Innovation, which is coordinating experts from multiple organizations to tailor sea level rise and precipitation projections for Florida to guide planning and actions that increase resilience.