

**WRITTEN TESTIMONY OF
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**HEARING ON
"CLIMATE CHANGE AND IMPACTS ON THE MOST VULNERABLE SOCIETIES"**

**BEFORE THE
SUBCOMMITTEE ON ASIA, THE PACIFIC, AND THE GLOBAL ENVIRONMENT
COMMITTEE ON FOREIGN AFFAIRS
U.S. HOUSE OF REPRESENTATIVES**

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INTRODUCTION

Chairman Faleomavaega, Ranking Member Manzullo, and other members of the Committee, thank you for inviting me to speak with you today regarding the global impacts of climate change. I am honored to be here as the lead for climate services in the National Oceanic and Atmospheric Administration (NOAA) and as Director of NOAA's National Climatic Data Center.

Over the last 50 years, researchers at NOAA's Mauna Loa Observatory in Hawaii have been measuring the increasing concentrations of carbon dioxide and other greenhouse gases in the Earth's atmosphere. This long-term carbon dioxide record has been instrumental in improving our understanding of global atmospheric change, as well as acting as a catalyst for international policies. It is now well-documented in scientific literature and publicized in the media that our changing climate will have impacts on a global scale. Today, we must now begin to understand and address the impacts of climate change in highly vulnerable locations such as Asia, the Pacific Islands, and small island nations.

A landmark interagency report entitled *Global Climate Change Impacts in the United States* was released in June. NOAA led the development of this report, which is a synthesis of 21 assessments prepared by the 13 agencies that make up the U.S. Global Change Research Program. I have submitted the report for the record as part of my written testimony. This report provides concrete scientific evidence that demonstrates unequivocally that climate is changing and we are seeing its impacts in our own backyards and in every region in our country. While this report is largely focused on observed and anticipated impacts in the U.S., it also provides a summary of global climate impacts. Some of the critical global impacts already observed include: rising global temperatures; changing precipitation patterns, such as decreases in the Mediterranean, most of Africa, and in southern Asia, and widespread increases in heavy precipitation events; increasing impacts of changing ocean chemistry (e.g. ocean acidification) affecting corals and other marine organisms important for preserving ocean food chains; retreat

of mountain glaciers on every continent, including those glaciers essential for local water resources; and rising sea levels, which are of particular concern for low-lying regions and nations, many of which are densely populated, developing, and more vulnerable to natural hazards such as storm-related coastal inundation.

Under a broad range of scenarios that allow greenhouse gas emissions to continue unchecked, warming over this century is projected by the Intergovernmental Panel on Climate Change (IPCC) to be substantially larger than over the past century. Changes in many other components of the climate system (warming patterns being only one example) are also very likely to be larger than those observed in the present century. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC-AR4) and other climate assessment reports identify coastal and small island communities like those in Asia and the Pacific as particularly vulnerable to climate variability and change. Some consistent themes that run through such reports include:

- Climate change is projected to increase demand for water resources;
- Sea level rise is expected to amplify the effects of other coastal hazards, such as hurricanes (including storm surge), flooding, and erosion;
- Invasion of non-native species is expected to occur with rising temperatures; and
- Climate change is expected to exacerbate other existing human influences on fisheries and marine ecosystems, such as over-fishing, habitat destruction, pollution, and excess nutrients.

I will now turn to a more detailed summary of a few selected observed and projected impacts most relevant to Asia and the Pacific based on several of the most recent and rigorous studies to date.

WATER

The quality and abundance of water is a theme that runs through many observed and projected impacts of global climate change including impacts on energy, agriculture, health and others. A recent technical report of the IPCC, attached as part of my written testimony, details regional impacts on water resources across the globe. Of interest to this Subcommittee, Asia is a region where water distribution is uneven and large areas are under water stress. Even in humid and sub-humid areas of Asia, water scarcity is one of the constraints limiting sustainable development. Ability to respond to water stress in this region is exacerbated by additional factors, such as high population growth and low development levels. In the Pacific, climate change is projected to reduce water resources in many small islands to the point where, by mid-century, resources may be insufficient to meet demand during low rainfall periods. Specific examples of challenges associated with climate-related water scarcity include:

- In parts of China, temperature increases and decreases in precipitation, along with increasing water use, have caused water shortages that have led to drying up of lakes and rivers.
- In India, Pakistan, Nepal and Bangladesh, water shortages have been attributed to issues such as rapid urbanization and industrialization, population growth and inefficient water

use, which are all aggravated by changing climate and its adverse impacts on demand, supply and water quality.

- In arid and semi-arid central and west Asia, changes in climate and its variability continue to challenge the ability of countries to meet growing demands for water.

Climate change is expected to further stress water resources in Asia and the Pacific, together with multiple socio-economic stresses.

OCEAN ACIDIFICATION, SEA SURFACE TEMPERATURES, AND CORAL REEFS

The oceans have absorbed approximately one third of the human-produced carbon dioxide and are an important 'sink' for carbon dioxide. However, this process of absorbing carbon from the atmosphere into the ocean has measurable effects on ocean chemistry by increasing acidification, which has an effect on critical and sensitive resources. For example:

- Valuable coral reefs worldwide are among the ecosystems at high risk of extreme degradation due to climate change. According to one estimate, Hawaii's coral reefs, when combining recreational, amenity, fishery, and biodiversity values, were estimated to have direct economic benefits of \$360 million/year.¹
- Cold-water corals are particularly vulnerable to climate change because they are long-lived, slow-growing, and fragile species. They are also economically important because they provide habitat and nursery grounds for a variety of fish species,² thereby contributing to commercial, recreational, and community-based subsistence fisheries. It is estimated that 70 percent of cold-water corals, globally, could be living in unsustainable conditions by the century's end³.
- In addition to the food resources and biodiversity that coral reefs provide, deterioration in coral reef condition is expected to impact the value of these areas as tourist destinations — a critical income source for many island and coastal nations.
- As baseline sea surface temperatures increase, corals are more susceptible to extreme heating events such those often occurring in El Niño conditions. It is apparent in the summer of 2009 that we are embarking on just such an episode with globally-averaged sea surface temperatures emerging as the warmest June on record.

SEA LEVEL RISE

Sea level rise is expected to amplify the effects of other coastal hazards such as inundation, storm surge, tsunami and erosion, as well as the loss of fish and wildlife habitat and the reduction of freshwater availability due to saltwater intrusion, especially in low-lying islands. Even under the most conservative IPCC estimates of sea level rise, by the end of current century sea level

¹ Cesar, H., P. van Beukering, S. Pintz, and J. Dierking, 2002: Economic valuation of Hawaiian reefs. Cesar Environment Economics Consulting, Arnham, The Netherlands, 123 pp.

² Raven, J., K. Caldeira, H. Elderfield, O. Hoegh-Guldberg, P.S. Liss, U. Riebesell, J. Shepard, C. Turley and A.J. Watson. 2005. Ocean acidification due to increasing atmospheric carbon dioxide. Policy Document. The Royal Society, London.

³ Guinotte, J.M. and V.J. Fabry. 2008. Ocean acidification and its potential effects on marine ecosystems. *Annals of the New York Academy of Sciences*. 1134: 320-342.

rise is projected to increase the annual number of people who experience flooding in coastal populations from 13 million to 94 million. Almost 60 percent of this increase will occur in South Asia (along coasts from Pakistan, through India, Sri Lanka and Bangladesh to Burma), while about 20 percent will occur in South-East Asia, specifically from Thailand to Vietnam including Indonesia and the Philippines⁴. Island nations such as the Maldives in the Indian Ocean, and islands in the South Pacific such as parts of Vanuatu, Tuvalu, Kiribati, the Marshall Islands and Fiji, are at risk of permanent inundation from sea level rise. In some cases national governments that are extremely vulnerable to future rises in sea level, such as the Maldives, are exploring options to purchase land in other countries, such as in Australia, so that their people will continue to have a place to live if the island is inundated as is projected. Recent research and reports such as *Global Climate Change Impacts in the United States* suggest that estimates at the higher end of the ranges projected for sea level rise in the IPCC-AR4 might be conservative.

HEAT WAVES AND EXTREME PRECIPITATION

According to the IPCC, over recent decades there has been a general increase in the duration of heat waves and intensity of extreme rainfall in many parts of Asia, with the latter causing more severe floods, landslides, and debris and mud flows. While we have observed an increase in rainfall intensity, at the same time the number of rainy days and the total annual amount of precipitation has decreased in the region overall. This indicates a more variable rainfall pattern has developed across Asia. An increase in occurrence of extreme weather events including heat waves and intense precipitation events is projected to continue in South Asia, East Asia, and South-East Asia along with an increase in the year-to-year variability of daily precipitation in the Asian summer monsoon. One impact of this rainfall variability and increase in temperature is increased water stress and lower production of rice, maize and wheat in many parts of Asia. Freshwater and marine ecosystems will also be affected by warming waters, sedimentation and erosion from floods, and habitat loss and saltwater intrusion from droughts.

It is also virtually certain that Australia will see an increase in heat waves (and wildfires), while floods, landslides, drought and storm surges are also very likely to increase. These events are projected to threaten more infrastructure, as well as crop and forestry production, especially in the South and East parts of Australia. The climate change impacts (described in the previous sections, above) will be further amplified by existing climate variability phenomenon, such as El Nino/La Nina. In both southern Asia and in the South Pacific, the variability of El Nino/La Nina cycles are superimposed on climate change trends. These cycles already stress the capacity of regions and townships to cope with the resulting impacts. Under further climate change, the stress will increase. We may soon have first-hand experience of this increased stress, as in the summer of 2009 we are embarking on just such an episode with globally-averaged sea surface temperature emerging as the warmest June on record. NOAA is predicting a moderate El Nino to develop.

INCREASING RESILIENCE

⁴ Cruz, R.V., H. Harasawa, M. Lal, S. Wu, Y. Anokhin, B. Punsalmaa, Y. Honda, M. Jafari, C. Li and N. Huu Ninh, 2007: Asia. *Climate Change 2007: Impacts, Adaptation and Vulnerability Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 469-506

In recognition of the climate challenges already facing many parts of the globe, NOAA has supported, through partnerships and within its own offices, efforts to understand and predict environmental change and provide the tools that will allow more effective management of resources impacted by climate change. For example:

- A NOAA-supported project at the International Research Institute for Climate and Society is assessing climate information necessary to better balance reservoir management to meet water needs for drinking, energy (electricity production) and agriculture in the metro Manila area of the Philippines.
- A network of partners and stakeholders across the Pacific region, known as the Pacific Risk Management 'Ohana, is coordinating development and delivery of risk management-related information, products and services to improve decision-making
- NOAA is also developing forecast tools to better predict coral-bleaching events allowing local communities to prepare for and limit adverse effects on these ecosystems and the resources they provide
- NOAA researchers are working with academic partners to understand how climate change is altering global ocean conditions (e.g., water temperature, currents, upwelling, and plankton blooms), and how the changing ocean conditions will affect changes in habitat range and abundance of economically important fish and protected species.

CONCLUDING REMARKS

In brief summary, climate change impacts across the globe are emerging as serious challenges for virtually all nations, including our own. However, the vulnerability of populations located in coastal, impoverished, or resource-poor nations across the globe is even greater. NOAA is taking action to assist in improving understanding and prediction of climate change. NOAA is also providing information and tools to improve the management of critical resources across the globe to increase resilience and opportunity in the face of climate change impacts.

Thank you very much for the opportunity to testify today. I look forward to answering your questions

ATTACHMENTS

Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds. Climate and Water. IPCC Secretariat, Geneva, 210 pp. June 2008

GCRP, 2009: Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.