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INTOSAI
Working Group
on Environmental
Auditing

Auditing Government Efforts to Adapt to the Potential Effects of Climate Change and Ocean Acidification on the Marine Environment



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Foreword and Acknowledgements

The health and prosperity of much of the world's population is closely tied to the marine environment, which for the purposes of this report encompasses both marine ecosystems and coastal communities. Climate change and ocean acidification—which refers to chemical changes that increase the acidity of ocean waters—could affect the status of the marine environment by altering conditions in both potentially harmful and beneficial ways. The marine environment has long been an area of concern for the International Organization of Supreme Audit Institutions' (INTOSAI) Working Group on Environmental Auditing (WGEA). However, auditing climate change and ocean acidification issues in the marine environment remains a relatively new area for many WGEA members. The WGEA initiated this research project as part of its 2014-2016 Work Plan in recognition of Supreme Audit Institutions' (SAIs) interest in these issues and in the hope of supporting expanded auditing efforts in this area.

The SAI of the United States (the United States Government Accountability Office) led the implementation of this project, and I am pleased to present the results. The report provides WGEA members with an overview of issues to consider as they examine their governments' actions related to climate change and ocean acidification in the marine environment and highlights the previous audit experiences of SAIs in this area, including identifying challenges SAIs have faced and potential approaches to overcome them. In doing so, this report aims to provide SAIs with additional information and resources to bolster their capabilities to audit these issues in the future.

Significant thanks go to the authors of this report from the SAI of the United States and to the SAIs that volunteered to serve on the project subcommittee, including the SAIs of Bulgaria, Indonesia, Kenya, Kuwait, Morocco, Netherlands, Norway, Philippines, Senegal, and Yemen. Similarly, I would like to acknowledge the contributions made by other SAIs worldwide who generously shared information on their experiences auditing climate change and ocean acidification issues in the marine environment, as well as the members of the WGEA Steering Committee for their guidance and support. This report would not have been possible without the hard work and contributions of the SAIs mentioned above.

{Note: The Chair of WGEA will sign at the conclusion of this section.}

Table of Contents

Foreword and Acknowledgements.....2

Acronyms and Abbreviations.....5

Executive Summary.....6

Introduction.....9

Chapter One: Key Potential Effects of Climate Change and Ocean Acidification on the Marine Environment and Examples of Government Efforts to Adapt.....11

 Overview.....11

 Potential Effects of Climate Change and Ocean Acidification on Marine Ecosystems.....11

 Potential Effects of Climate Change and Ocean Acidification on Coastal Communities.....14

 Examples of Government Efforts to Adapt to the Potential Effects of Climate Change and Ocean Acidification on the Marine Environment.....18

Chapter Two: SAIs’ Experiences in Auditing Issues Related to Climate Change and Ocean Acidification in the Marine Environment.....26

 Overview.....26

 Government Assessments of Marine Environment Risks and Vulnerabilities.....27

 Government Efforts to Adapt to the Effects of Climate Change and Ocean Acidification on the Marine Environment.....33

 Coordination among Government Agencies and between Governments and Other Entities.....38

Chapter Three: Challenges SAIs Face in Auditing Climate Change and Ocean Acidification Issues in the Marine Environment and Approaches to Help Overcome Them.....42

 Overview.....42

 Limited Audit Criteria and Government Action.....42

 Fragmented Government Response.....46

 Limited Experience and Training.....47

 Competing Audit Priorities.....48

 Limitations in the Scope of SAI Audit Mandates.....49

Appendix I: Objectives, Scope, and Methodology.....51

Appendix II: List of Audits Analyzed for this Report.....53

Appendix III: Additional Resources that Can Assist SAs in Auditing Climate Change and Ocean Acidification Issues in the Marine Environment.....56

Appendix IV: Bibliography.....59

Acronyms and Abbreviations

AUD — Australian Dollars

DR&D — Department of Resources and Development (Federated States of Micronesia)

EUROSAI — European Organization of Supreme Audit Institutions

FOARAM — Federal Ocean Acidification Research and Monitoring Act of 2009 (United States)

FSM — Federated States of Micronesia

INTOSAI — International Organization of Supreme Audit Institutions

IPCC — Intergovernmental Panel on Climate Change

OEEM — Office of Environmental and Emergency Management (FSM)

OLACEFS — Organization of Latin American and Caribbean Supreme Audit Institutions

PASAI — Pacific Association of Supreme Audit Institutions

SAI — Supreme Audit Institution

SERNA — Secretary of Natural Resources and Environment (Honduras)

UNFCCC — United Nations Framework Convention on Climate Change

USD — United States Dollars

WGEA — INTOSAI Working Group on Environmental Auditing

Executive Summary

According to projections from the Intergovernmental Panel on Climate Change (IPCC), the marine environment of the future may look considerably different than the marine environment of the present as a result of climate change and ocean acidification.¹ In particular, the IPCC has reported that changes in ocean conditions due to climate change and ocean acidification—such as warmer temperatures, increasing acidity, and rising sea levels—could affect the marine environment in potentially significant but not fully understood ways.² Any changes that occur in the marine environment could subsequently have a profound impact on people, as marine ecosystems support important habitats and species that generate food, jobs, and economic activity, and large numbers of people worldwide live in coastal areas.

This report addresses the role of SAIs in supporting government efforts to respond to these issues in the marine environment.³ Specifically, this report describes (1) the potential effects of climate change and ocean acidification on the marine environment and examples of government efforts to adapt to these effects; (2) previous SAI audit work related to climate change and ocean acidification issues in the marine environment; and (3) the challenges SAIs have experienced in auditing these issues and approaches SAIs can take to help overcome them.⁴

¹The United Nations Environment Programme and the World Meteorological Organization established the IPCC in 1988. Since that time, the IPCC has served as the leading international body for the assessment of climate change and has periodically produced comprehensive assessment reports of the current state of scientific knowledge on climate change and its potential environmental and socio-economic consequences. The fifth and most recent IPCC assessment report, published in 2014, formed the scientific basis for the information presented in this report on the potential effects of climate change and ocean acidification. As discussed in the IPCC report, climate change refers to changes that could occur in various natural and human systems due to increased greenhouse gas concentrations in the atmosphere, whereas ocean acidification refers to chemical changes in the oceans due, primarily, to the oceans' absorption of carbon dioxide from the atmosphere. For more information on the IPCC and to download copies of its reports, see its website at <http://www.ipcc.ch/index.htm>.

²IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Summary for Policymakers)*, Christopher B. Field et al. (Eds.), (Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014).

³Societal responses to climate change and ocean acidification include adaptation and mitigation efforts. Adaptation refers to actions taken to prepare for and adjust to new conditions, thereby reducing harm or taking advantage of new opportunities. Mitigation refers to actions, such as reducing carbon dioxide emissions, taken to reduce the amount or speed of change. This report does not cover mitigation actions. For information on mitigation, please refer to the WGEA 2010 guidance document, *Auditing the Government Response to Climate Change: Guidance for Supreme Audit Institutions*.

⁴Appendix I presents information on the scope and methodology used to address each objective.

Key findings on the potential effects of climate change and ocean acidification on the marine environment and government efforts to adapt to them include:

- According to the IPCC, the potential effects on marine ecosystems may vary by location and could involve a mix of positive and negative impacts to marine species, food webs—which represent the feeding interactions of organisms—and habitats.⁵ These effects could include shifts in fish stock distribution and abundance, and threats to coral reef habitats, among other things.
- The IPCC has reported that climate change and ocean acidification may affect coastal communities by causing increased coastal flooding and erosion, among other things.⁶ In addition, climate change and ocean acidification could have socioeconomic implications for coastal communities that depend on marine resources for commerce.
- Approaches governments have taken to adapt to these potential changes in the marine environment, include (1) implementing structural projects (such as building seawalls) to help protect against rising sea levels and coastal flooding; (2) using ecosystem-based adaptation approaches, such as reinforcing natural defenses like mangroves (a type of tree often found in estuaries where freshwater meets saltwater), to help protect their coasts; and (3) using policy instruments to support adaptation efforts, such as policies to restrict development in vulnerable coastal areas.⁷

Previous SAI audit work related to climate change and ocean acidification issues in the marine environment has generally focused on examining:

- government assessments of marine environment risks and vulnerabilities, such as by auditing the approaches governments took to perform these assessments, the quality of the results the assessments produced, and how governments subsequently used them.

⁵IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 30: The Ocean)*, (Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014).

⁶IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 5: Coastal Systems and Low-Lying Areas)*, (Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014).

⁷IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 14: Adaptation Needs and Options)*, (Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014).

- government efforts to adapt to the effects of climate change and ocean acidification on the marine environment. In some cases, SAIs have covered marine environment issues within the scope of audits that looked broadly at climate change adaptation activities or the implementation of international agreements on climate change.
- coordination among government agencies and between governments and other entities on activities to address the effects of climate change and ocean acidification on the marine environment.

Key challenges SAIs have identified in auditing climate change and ocean acidification issues in the marine environment include (1) the limited extent of audit criteria and government action in some nations; (2) the fragmentation of government response in some nations; (3) limited experience and training among some SAIs; (4) competing audit priorities; and (5) limitations in the scope of some SAIs' audit mandates. Potential approaches SAIs can take to address some of these challenges include:

- using international agreements, good governance criteria, and good management criteria as the basis for audits;
- contracting with independent experts (e.g., from academia) to obtain expertise not available within the SAI;
- conducting cooperative audits to benefit from the experience and skills provided by other participating SAIs;
- expanding the scope of already-planned audits on related topics, such as fisheries or coastal flooding, to include the effects of climate change and ocean acidification; and
- cooperating with regional and local auditors in cases where an SAI's authority is limited to auditing the central government.

Introduction

According to the IPCC, elevated concentrations of greenhouse gases in the atmosphere could alter the climate and lead to significant changes in a variety of natural and human systems, including changing surface temperatures and precipitation patterns, and affecting human health and food production.⁸ In addition, climate change could lead to changes in various physical properties of the oceans. For example, the IPCC has reported that the oceans have absorbed more than 90 percent of the excess heat resulting from the enhanced greenhouse effect, which has contributed to increases in global average sea surface temperatures since the beginning of the 20th century.⁹ Rates of increase in temperature are highest near the surface of the ocean, and the IPCC projects that most, if not all, of the oceans will continue to warm in the future, although the rates of warming will vary by region. In addition, the IPCC has reported that climate change may cause sea levels to rise as a result of the thermal expansion of ocean waters as they warm, and the melting of glaciers and ice sheets. The IPCC projects that global mean sea levels could rise between approximately one-half and three-quarters of a meter by 2100 depending on future global greenhouse gas emissions, with potential variations among locations.¹⁰ For a more detailed description of the scientific understanding of climate change, including its potential effects outside of the marine environment, SAIs may refer to the IPCC's assessment reports and the WGEA's 2010 report *Auditing the Government Response to Climate Change: Guidance for Supreme Audit Institutions*.

In addition to physical changes that may occur in the oceans due to climate change, ocean acidification causes chemical changes that may further affect marine species and habitats important to humans.¹¹ Although climate change and ocean acidification stem largely from the same source—carbon dioxide emissions—this report treats them as distinct, albeit related, issues. According to the IPCC, the oceans have absorbed approximately 30 percent of the

⁸IPCC, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Summary for Policymakers)*, Core Writing Team, R.K. Pachauri, and L.A. Meyer (Eds.), (Geneva, Switzerland: 2014).

⁹IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Chapter 30: The Ocean)*, 2014.

¹⁰IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014.

¹¹IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Chapter 30: The Ocean)*, 2014.

carbon dioxide emitted by human activities since 1750, which has increased the acidity of ocean waters and decreased the availability of minerals (such as aragonite and calcite) needed by many marine organisms to build shells and skeletons.¹² Projections for future ocean acidity levels vary by location and by different carbon dioxide emissions scenarios. SAIs may refer to the IPCC's assessment reports for additional information on the scientific background of ocean acidification.

In 1992, nations worldwide negotiated the United Nations Framework Convention on Climate Change (UNFCCC) to stabilize atmospheric concentrations of carbon dioxide and five other greenhouse gases.¹³ The UNFCCC represents the primary international response to climate change and has served as the framework for subsequent agreements, such as the 1997 Kyoto Protocol.¹⁴ Outside of these international agreements, individual governments have also taken a variety of actions to respond to climate change and ocean acidification, including the potential effects they may have on the marine environment. Such actions have produced uneven results and it remains unclear what additional actions governments may take in the future to respond to the changing conditions they face. In such an environment, SAIs may have a unique opportunity to promote good governance and accountability by informing government efforts to understand and adapt to the potential changes facing the marine environment through their audits of relevant programs and activities.

¹²IPCC, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Summary for Policymakers)*, 2014. Also, IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Chapter 30: The Ocean)*, 2014.

¹³The five other gases are methane, nitrous oxide, and three synthetic gases—hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

¹⁴The Kyoto Protocol set binding emission targets for 37 industrialized nations and the European Community. For more information on the Kyoto Protocol and other climate change agreements, see the UNFCCC website at <https://unfccc.int/2860.php>.

Chapter One

Key Potential Effects of Climate Change and Ocean Acidification on the Marine Environment and Examples of Government Efforts to Adapt

Overview

The IPCC has reported that climate change and ocean acidification could produce profound changes in the marine environment, with the effects felt broadly across marine ecosystems and coastal communities.¹⁵ Considerable uncertainty exists, however, about the exact nature, severity, and timing of the effects. This chapter describes these potential effects and the actions governments and multinational institutions have taken to adapt to them. In addition to covering these issues from a global perspective, this chapter presents some regional and country-specific information. This information can help SAIs better understand the evolving nature of the marine environment in their countries. This understanding, in turn, could help SAIs determine how to focus future audits related to these issues. Specific topics covered in this chapter include:

- the potential effects of climate change and ocean acidification on marine ecosystems, including effects on marine species, food webs, and habitats;
- the potential effects of climate change and ocean acidification on coastal communities, including coastal flooding and erosion, saltwater intrusion, and socioeconomic effects; and
- examples of government efforts to adapt to these potential effects, including structural adaptation efforts, ecosystem-based adaptation efforts, and the use of various policy instruments.

Potential Effects of Climate Change and Ocean Acidification on Marine Ecosystems

Potential Effects on Individual Marine Species

According to the IPCC, climate change and ocean acidification could produce a wide range of effects on marine species, with some species considered vulnerable to harm and other species

¹⁵IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Summary for Policymakers)*, 2014.

potentially benefitting. For example, warming ocean temperatures have already begun to affect the distribution and abundance of various fish and invertebrate species, with many species shifting toward the poles or to other deeper and cooler waters.¹⁶ Such spatial shifts of marine species could cause species richness to increase at mid and high latitudes and to decrease at tropical latitudes. In addition, ocean acidification could negatively affect the survival and growth of some marine species—such as oysters and some coral species that produce shells and skeletons composed of calcium carbonate minerals—by making calcification more difficult.¹⁷ Ocean acidification could also cause behavioral changes in some fish species by interfering with the functioning of sensory systems, such as the ability to smell.¹⁸ Nonetheless, some marine plant species, such as certain seagrasses, may benefit from ocean acidification as elevated carbon dioxide concentrations in the ocean enhance their growth.¹⁹

Potential Effects on Marine Food Webs

The IPCC has reported that the effects of climate change and ocean acidification on marine species could reverberate throughout marine food webs, but the nature and extent of these potential effects remains uncertain.²⁰ In addition, uncertainty exists about the potential for other anthropogenic stressors in the marine environment, such as overfishing and pollution, to amplify the effects of climate change and ocean acidification on marine food webs.

¹⁶IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 6: Ocean Systems)*, (Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014).

¹⁷IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 6: Ocean Systems)*, 2014.

¹⁸Munday et al., “Replenishment of Fish Populations Is Threatened By Ocean Acidification,” *Proceedings of the National Academy of Sciences of the United States of America*, vol. 107, no. 29 (2010) and Munday et al., “Behavioural Impairment in Reef Fishes Caused By Ocean Acidification at CO₂ Seeps,” *Nature Climate Change*, vol. 4, no. 6 (2014).

¹⁹IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 6: Ocean Systems)*, 2014.

²⁰IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 6: Ocean Systems)*, 2014.

According to the IPCC, predicted changes in the distribution, abundance, and function of marine organisms could lead to the reorganization of marine ecosystems and food webs.²¹ For example, pteropods—a type of small calcifying sea snail—represent an important component of some marine food webs and serve as a key food source for salmon and other animals. Research has found that some pteropod species could experience increased shell dissolution and reduced growth and calcification rates under acidified conditions.²² If pteropod populations decline as a result of ocean acidification, this could harm other species that rely on pteropods for food.

Climate change and ocean acidification could also affect other critical elements of marine food webs, such as phytoplankton, in unclear ways. The IPCC has described phytoplankton as dominant primary producers at the base of the marine food chain and reported that any changes to phytoplankton could subsequently resonate through marine food webs and potentially affect fishery yields.²³ According to the IPCC, existing projections suggest an increase in phytoplankton production at high latitudes, such as the Arctic and Southern Oceans, and a decrease in phytoplankton production in the tropics and at mid-latitudes.²⁴

Potential Effects on Marine Habitat

The IPCC has also reported that climate change and ocean acidification could have significant impacts on certain types of marine and coastal habitats. For example, warmer ocean temperatures increase the susceptibility of some coral species to coral bleaching, which places corals under increased stress and can lead to greater mortality and decreased abundance of coral reef habitat.²⁵ Ocean acidification may further amplify the risks to coral reef habitat by making it more difficult for some coral species to grow their skeletons and potentially affecting

²¹IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Chapter 30: The Ocean)*, 2014.

²²IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 6: Ocean Systems)*, 2014. Also, Arctic Monitoring and Assessment Programme, *AMAP Assessment 2013: Arctic Ocean Acidification* (Oslo, Norway: 2013).

²³IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Chapter 30: The Ocean)*, 2014.

²⁴IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 6: Ocean Systems)*, 2014.

²⁵IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Chapter 30: The Ocean)*, 2014.

coral reproduction, which could lead to declines in the size or structural complexity of some coral reefs.²⁶ In contrast, the effects of climate change and ocean acidification might counteract each other for some types of marine habitat, such as seagrass beds, which could suffer under warming ocean temperatures while benefiting from the effects of ocean acidification.²⁷ In addition, sea level rise and the potential for increased damage from storm surges pose risks to some coastal habitats, such as sandy beaches that provide habitat for marine turtles.²⁸

Potential Effects of Climate Change and Ocean Acidification on Coastal Communities

Increased Coastal Flooding and Erosion

The IPCC has reported that rising sea levels and more severe coastal storms due to climate change could increase coastal flooding and erosion globally.²⁹ These effects could displace people residing in low-lying areas and threaten critical infrastructure, such as transportation networks (e.g., roads and railways), ports, power and water plants, homes, business, and industrial facilities. However, the severity of these impacts will vary by location, with some locations, such as certain island nations, potentially threatened more than others. For example, the Asian Development Bank reported in 2013 that Palau could lose a significant portion of its land area to rising seas and strong storms over the next 100 years.³⁰ Also, the extent to which a nation's population and infrastructure are located in coastal areas plays a key role in determining its vulnerability to climate change. The IPCC has cited studies projecting that nations in Asia are expected to continue to have the largest total number of people exposed to

²⁶National Research Council, *Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean*, (Washington, D.C., United States: 2010).

²⁷IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014.

²⁸IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014. Also, Steffen, Will, Hunter, John, and Hughes, Lesley, *Counting the Costs: Climate Change and Coastal Flooding* (Australia: Climate Council of Australia, 2014)

²⁹IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014.

³⁰Asian Development Bank, *The Economics of Climate Change in the Pacific* (Mandaluyong City, Philippines: 2013).

coastal flooding risks, and nations in Sub-Saharan Africa could experience the greatest growth in populations vulnerable to coastal flooding in the future.³¹

In some cases, flooding due to rising sea levels could result in the permanent inundation of coastal areas. For example, a United States government report found that an increase in sea level of approximately 0.6 meters would place over \$1 trillion (United States Dollars (USD)) worth of property and structures at risk of inundation.³² Similarly, an Australian report estimated that a sea level rise of 1.1 meters would potentially expose at least \$226 billion (Australian Dollars (AUD)) of the nation's commercial, industrial, road and rail, and residential assets to flooding and erosion hazards.³³ According to the report, Australian coastal assets at risk from the combined impact of inundation and shoreline recession include more than 5,800 commercial buildings, more than 3,700 light industrial buildings, and over 27,000 kilometers of roads and rail.

According to the IPCC, the effects of climate change could also result in significant impacts to low-lying Arctic coastal communities that could force some communities to relocate.³⁴ In the state of Alaska in the United States for example, studies have identified more than 30 Native villages (including coastal villages such as Shishmaref) that may need to relocate, or have already begun to do so, due to the loss of permafrost (permanently frozen soil), sea level rise, and coastal erosion.³⁵

³¹IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014.

³²The IPCC projects that a 0.6 meter rise in global mean sea levels could occur by 2100 under some of its emissions scenarios. IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014. Also, Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe (Eds.), *Climate Change Impacts in the United States: The Third National Climate Assessment*, 2014.

³³The IPCC projects that a 1.1 meter rise in global mean sea levels could occur by 2200 under some of its emissions scenarios. IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014. Also, Steffen, Hunter, and Hughes, *Counting the Costs: Climate Change and Coastal Flooding*, 2014.

³⁴IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 28: Polar Regions)*, (Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014).

³⁵Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe (Eds.), *Climate Change Impacts in the United States: The Third National Climate Assessment*. United States Global Change Research Program (Washington, D.C., United States: 2014).

Saltwater Intrusion

According to the IPCC, rising sea levels may also exacerbate the risk that saltwater intrusion could harm coastal freshwater supplies.³⁶ The IPCC has defined saltwater intrusion as the displacement of fresh surface water or groundwater by saltwater, which can occur due to a variety of factors, including rising sea levels.³⁷ For instance, as sea levels rise, the boundary along which saltwater meets freshwater above and below the surface will change, which could lead to the contamination of some freshwater supplies. Such impacts to freshwater could also have implications for coastal agriculture, as saltwater displaces the freshwater previously used to support crops. For example, a 2013 World Bank report cited estimates that projected increases in sea levels by 2040 could lead to saltwater intrusion resulting in the loss of about 7 percent of the area used for crop production in the Mekong Delta, a critical agricultural area in Vietnam.³⁸ According to a 2013 Asian Development Bank report, small islands may experience the most severe effects of saltwater intrusion due to the low elevation of much of their land.³⁹ For example, the SAI of the Federated States of Micronesia (FSM) reported that certain low lying atolls in the country have already begun to experience food security issues as a result of saltwater intrusion from sea level rise.⁴⁰ The SAI reported that rising sea levels have raised the underground water tables and brought saltwater beneath more inland areas, where it has subsequently harmed plant roots. Taro gardens in particular have suffered extensive damage, thus reducing the supply of one of the country's staple food items. Taro plants' leaves and roots can be consumed as a nutritious vegetable and have traditionally served as an important food source for Pacific Islanders. Saltwater intrusion can also pose a risk to coastal aquifers, but the

³⁶IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014.

³⁷IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Annex II: Glossary)*, (Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014).

³⁸World Bank, *Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience*. A Report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics (Washington, D.C., United States: 2013).

³⁹Asian Development Bank, *The Economics of Climate Change in the Pacific*, 2013.

⁴⁰Office of the National Public Auditor of the Federated States of Micronesia, *Audit on the Management of the Impacts of Climate Change on Food Security in the FSM (Fiscal Year 2010-2012)*, (Palikir, Pohnpei, FSM: 2013).

IPCC has reported that the extent to which sea level rise may exacerbate the risk to drinking water supplies remains unclear.⁴¹

Socioeconomic Effects

The effects of climate change and ocean acidification also have potential socioeconomic implications for coastal communities and industries that depend on marine resources for commerce. According to the IPCC, changes in fish stock abundance or distribution will vary by region, with fishery yields expected to increase in some high-latitude regions and decrease in tropical regions.⁴² Given the potential for such varied responses, the IPCC has reported that shifts in fish stock abundance and distribution could produce both “winners” and “losers” among different nations.⁴³ The Food and Agriculture Organization of the United Nations estimated in 2014 that fisheries and aquaculture support the livelihoods of 10 to 12 percent of the world’s population and that billions of people rely on fish as an important source of animal protein.⁴⁴ Consequently, climate change and ocean acidification could impact large numbers of people if they affect marine species in ways that harm fishing or aquaculture industries or reduce food security. For example, between 2005 and 2009, ocean acidification in the Pacific Northwest region of the United States contributed to the deaths of billions of oyster larvae and caused significant harm to the local oyster aquaculture industry, an important economic driver in some parts of the region.⁴⁵

According to the IPCC, climate change and ocean acidification could also affect the tourism industry in some coastal locations.⁴⁶ The IPCC reported that coastal tourism represents the

⁴¹IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014.

⁴²IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 6: Ocean Systems)*, 2014.

⁴³IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Chapter 30: The Ocean)*, 2014.

⁴⁴Food and Agriculture Organization of the United Nations, *The State of World Fisheries and Aquaculture: Opportunities and Challenges* (Rome, Italy: 2014).

⁴⁵Washington State Blue Ribbon Panel on Ocean Acidification, *Ocean Acidification: From Knowledge to Action, Washington State’s Strategic Response*, H. Adelman and L. Whitely Binder (Eds.), Publication no. 12-01-015 (Olympia, United States: Washington Department of Ecology, 2012).

⁴⁶IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014.

largest component of the global tourism industry and more than 100 countries benefit from the recreational value provided by their coral reefs. Consequently, potential threats to coastal tourism could result in significant socioeconomic effects. For example, if warming ocean temperatures and ocean acidification harm coral reef ecosystems, this could harm the economies of coastal communities that rely on marine tourism and recreation activities dependent on reefs (such as snorkeling and scuba diving). Furthermore, sea level rise and extreme weather events that exacerbate coastal flooding and erosion pose a risk to the infrastructure that supports coastal tourism, such as beaches and resorts.⁴⁷ On Australia's Gold Coast, for example, projected sea level rise threatens popular tourist beaches and no opportunity exists for these beaches to move inland due to adjacent developments, according to a 2014 report.⁴⁸ As a result, maintenance of the beaches in the future may require the addition of sand from external sources, which the report estimated could cost more than \$10 million to more than \$50 million (AUD) per year over the next century for the sand alone, without any additional infrastructure, depending on sea level scenarios.

Examples of Government Efforts to Adapt to the Potential Effects of Climate Change and Ocean Acidification on the Marine Environment

Structural Adaptation Efforts

One common climate change adaptation approach has involved structural projects—such as building seawalls and elevating buildings—to help protect people, property, and infrastructure against sea level rise, coastal flooding, and storm surges. Some governments may struggle, however, with the costs and complexity of these projects, and uncertain projections about future weather conditions, population growth, and human behavior can affect the projects' feasibility and utility.⁴⁹ The following examples illustrate the structural adaptation efforts that some governments have implemented:

- **Indonesia.** The Indonesian government has proposed building a 20-mile sea wall along the coast as part of a land reclamation project designed to help protect the city of

⁴⁷IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014.

⁴⁸Steffen, Hunter, and Hughes, *Counting the Costs: Climate Change and Coastal Flooding*, 2014.

⁴⁹IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 14: Adaptation Needs and Options)*, 2014.

Jakarta from flooding and rising sea levels. Parts of Jakarta already sit below sea level, and the city is considered one of the world's most vulnerable big cities to the impacts of climate change. If implemented, this project could cost tens of billions of dollars (USD) to complete, with much of the funding expected to come from the private sector.⁵⁰

- **Italy.** The city of Venice has begun installing mobile barriers at the entrance to its lagoon to better protect the city from flooding due to high water levels and projected sea level rise. The mobile barriers consist of a row of flap-gates that lay flat on the bottom of the inlet entrance during normal conditions, but when water levels rise, compressed air will fill the gates to bring them to the surface. The city expects to complete the project in 2016.⁵¹
- **Liberia.** The national government has proposed spending \$60 million (USD) to build structural adaptation measures to strengthen coastal protection in the cities of Buchanan and Monrovia. Specifically, this proposed project calls for the construction of sea walls in Monrovia and for a breakwater system in Buchanan. According to a 2013 United Nations Environment Programme report, the construction of this infrastructure will help to protect these areas from coastal erosion and the potential repercussions that erosion could have on coastal economic activity.⁵²
- **Solomon Islands.** Communities in Choiseul Bay, with a combined population of about 5,000 people, have begun the process of relocating in response to expected sea level rise and their current vulnerability to storm surges and tsunamis. The villages plan to move in stages to a less vulnerable area nearby and have already acquired the land to do so. As a next step, the villages plan to construct essential infrastructure in the new

⁵⁰Ho, Yudith and Rahadiana, Rieka, *Sinking Jakarta Starts Building Giant Wall as Sea Rises*, (Bloomberg Business: November 11, 2014), accessed April 28, 2015, <http://www.bloomberg.com/news/articles/2014-11-11/sinking-jakarta-starts-building-giant-wall-as-sea-rises-cities>.

⁵¹*Integrated System for the Safeguard of Venice and Its Lagoon Against Flooding (MOSE)*, in the European Climate Adaptation Platform, accessed June 10, 2015, http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=3334.

⁵²United Nations Environment Programme, African Ministerial Conference on the Environment, and Climate Analytics, *Africa's Adaptation Gap Technical Report: Climate-Change Impacts, Adaptation Challenges and Costs for Africa*, 2013.

location, a process that could take several years to complete and cost hundreds of millions of dollars (AUD).⁵³

As noted in several of the examples above, structural adaptation efforts to address climate change impacts often require large upfront costs. According to the IPCC, however, small island nations may find it difficult to downscale these costs in proportion to the size of their population or territory.⁵⁴ Consequently, island nations with small populations will likely face higher unit costs per capita to build shoreline protection structures compared to nations with larger territories and populations. Many small island nations face this socioeconomic reality, notwithstanding the benefits that could accrue to island communities through adaptation.

Ecosystem-Based Adaptation Efforts

Governments have also begun to look at ways to preserve and enhance the resiliency of natural systems to help address the effects of climate change on coastal communities. According to the IPCC, ecosystem-based adaptation efforts increasingly attract attention and include actions such as protecting and reinforcing natural coastal defenses like oyster reefs, mangroves, and salt marshes.⁵⁵ In particular, research has shown that wetlands and other natural features like sand dunes and aquatic vegetation can reduce storm surge and the subsequent inundation of coastal infrastructure from extreme weather events.⁵⁶ In addition to helping protect people and infrastructure from the effects of sea level rise and coastal flooding and erosion, these natural systems provide other beneficial services as well. The IPCC has reported that mangroves, for example, serve as nurseries for some fish species and thus can help to support healthy local fisheries.⁵⁷ Additionally, the very high carbon sequestration potential of the soils in mangroves

⁵³Rowling, Megan, *Solomons Town First in Pacific to Relocate Due to Climate Change* (London, United Kingdom: Thomson Reuters Foundation, August 15, 2014), accessed October 22, 2014, <http://www.reuters.com/article/2014/08/15/us-foundation-climatechange-solomons-idUSKBN0GF1AB20140815>.

⁵⁴IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 29: Small Islands)*, (Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014).

⁵⁵IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014.

⁵⁶United States Army Corps of Engineers, *North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk* (United States: 2015).

⁵⁷IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 14: Adaptation Needs and Options)*, 2014.

and peat swamp forests provides opportunities for combining adaptation with mitigation through restoration of degraded areas.⁵⁸

In contrast, the IPCC found that the use of hard defenses (e.g., sea walls and levees) to help protect agriculture and human settlements from flooding may have negative consequences for both natural ecosystems and carbon sequestration by preventing natural adjustments to changing conditions.⁵⁹ Specific examples of governments implementing ecosystem-based adaptation approaches in the marine environment include:

- **England.** In southeast England, the government and environmental groups initiated an effort to transition a plot of coastal agricultural land protected by a sea wall to a natural saltwater marsh that could better respond to future sea level rise. Using a cost-benefit analysis that did not support further expensive maintenance of the sea wall, the environmental groups purchased the property and breached the sea wall to allow for tidal flooding of the land. In addition to improving coastal defenses in the area, the newly created habitat contributed to the government's biodiversity targets for saltwater marsh creation and benefitted fisheries by supporting fish nurseries.⁶⁰
- **Fiji.** Recent efforts in the coastal town of Lami illustrate how, in some cases, using ecosystem-based adaptation approaches in conjunction with structural approaches can help protect coastal populations from the effects of climate change. Lami includes low-lying areas vulnerable to sea level rise and faces a greater risk of coastal flooding and erosion due to climate change. To help adapt to these threats, the government has begun implementing a plan that focuses on the restoration and rehabilitation of

⁵⁸IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 24: Asia)*, (Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014).

⁵⁹IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Chapter 24: Asia)*, 2014.

⁶⁰European Commission, *A Sustainable Coastal Defence Re-Creating Wildlife Habitats Alongside Economic Farming Methods, Abbott's Hall Farm - UK*, in the European Commission OURCOAST Integrated Coastal Zone Management Database, accessed March 17, 2015, <http://ec.europa.eu/ourcoast/index.cfm?menuID=6&articleID=5>.

mangrove ecosystems in strategic locations and the implementation of targeted structural options to bolster local resilience.⁶¹

- **Gambia.** Gambia's coastal zone represents the most heavily populated part of the country, with approximately one-third of Gambia's land area, including the capitol of Banjul, located 10 meters or less above sea level. According to Gambia's National Adaptation Programme of Action, the country has planned several climate change adaptation projects, including one focused on the restoration and protection of coastal environments. Specific objectives proposed for this project included improving coastal defenses and conserving biological diversity of ecological assets. To achieve these objectives, the plan for the project called for a variety of activities, such as beach stabilization and the rehabilitation of wetlands, as well as reducing destructive activities such as sand mining and cutting of mangroves.⁶²
- **United States.** The state of Washington issued a report in 2012 that identified a variety of strategies to adapt to the impacts of ocean acidification on shellfish, including planting certain types of vegetation in or near shellfish hatcheries.⁶³ According to the report, using vegetation in cultivated shellfish beds to remove carbon dioxide from seawater can help protect young shellfish from ocean acidification. The report identified the development of this type of vegetation-based activity as an essential next step for reducing the risks associated with ocean acidification.

Policy Instruments

The IPCC has reported that governments could use a variety of policy instruments to support adaptation efforts in the marine environment, including:

- adopting building codes and zoning policies to improve the safety of coastal communities threatened by rising sea levels, coastal flooding, and erosion. For instance, some governments have adopted policies to restrict development in vulnerable coastal

⁶¹United Nations Department of Economic and Social Affairs, *How Oceans- and Seas-Related Measures Contribute to the Economic, Social and Environmental Dimensions of Sustainable Development: Local and Regional Experiences*, 2014.

⁶²Gambia Department of State for Forestry and the Environment, *Gambia National Adaptation Programme of Action on Climate Change* (Banjul, Gambia: 2007).

⁶³Washington State Blue Ribbon Panel on Ocean Acidification, *Ocean Acidification: From Knowledge to Action*, 2012.

areas, thereby reducing potential damage from future coastal storms and flooding in those locations.⁶⁴

- integrating coastal climate change adaptation into their broader planning efforts for disaster risk reduction,⁶⁵
- designing financial incentives, tax policies, and insurance requirements to advance broader adaptation goals, such as by providing incentives for coastal inhabitants to elevate structures in vulnerable areas;⁶⁶ and
- establishing protected areas to help increase the overall resilience of marine ecosystems threatened by climate change and other stressors.⁶⁷

At the international level, the conference of the parties to the UNFCCC established an adaptation fund to finance adaptation projects in developing countries vulnerable to the effects of climate change. More specific examples of governments using some of the policy instruments listed above to support climate change adaptation efforts in the marine environment include:

- **Australia and New Zealand.** According to the IPCC, responsibility for adapting to sea level rise in Australia and New Zealand rests primarily with local governments through the use of various planning instruments.⁶⁸ For example, some local areas in Australia and New Zealand have adopted policies to establish coastal setback requirements to limit further development in areas at risk. In addition, the New Zealand Coastal Policy Statement, which guides local authorities in their management of the coastal environment, mandates a minimum 100-year planning horizon for assessing hazard risks and recommends avoidance of new development in vulnerable areas. The IPCC

⁶⁴IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 25: Australasia)*, (Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014).

⁶⁵IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014.

⁶⁶IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 14: Adaptation Needs and Options)*, 2014.

⁶⁷IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 27: Central and South America)*, (Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014).

⁶⁸IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Chapter 25: Australasia)*, 2014.

noted, however, that opposition to adaptation approaches that place restrictions on development has occurred in some cases, which subsequently placed pressure on state and local government authorities to modify their adaptation policies.⁶⁹

- **Japan.** As part of Japan's disaster risk reduction efforts, the government has incorporated climate change adaptation into its coastal disaster management framework. This action will help ensure that the country considers the effects of future sea level rise as it upgrades its coastal defenses following the devastating 2011 tsunami.⁷⁰
- **United States.** The United States government has initiated an effort to incorporate climate change considerations, such as rising sea levels, into its hazard mitigation assistance programs. According to the United States Federal Emergency Management Agency, hazard mitigation includes any sustained action taken to reduce or eliminate long-term risk to people and property from natural hazards (i.e., disasters) and their effects.⁷¹ The agency's hazard mitigation assistance programs support a variety of activities in coastal and non-coastal areas, such as elevating structures vulnerable to flooding or acquiring and demolishing flood-prone structures to convert the land to open space. In February 2015, the agency revised the guidance for its hazard mitigation assistance programs to better integrate climate change and resilience considerations by, for example, incorporating sea level rise estimates into the benefit-cost analysis tool used to assess the cost-effectiveness of proposed hazard mitigation measures.⁷²
- **Various Nations in Central and South America.** According to the IPCC, Central and South American nations' coastal climate change adaptation efforts have predominantly involved the establishment of marine protected areas.⁷³ Generally speaking, a marine protected area provides greater protection to marine resources (e.g., fish) in a defined

⁶⁹IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Chapter 25: Australasia)*, 2014.

⁷⁰IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (Chapter 5: Coastal Systems and Low-Lying Areas)*, 2014.

⁷¹United States Federal Emergency Management Agency, *Hazard Mitigation Assistance Guidance: Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, and Flood Mitigation Assistance Program* (Washington, D.C., United States: 2015)

⁷²United States Federal Emergency Management Agency, *Hazard Mitigation Assistance Guidance*, 2015.

⁷³IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Chapter 27: Central and South America)*, 2014.

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area of the ocean relative to the surrounding areas.⁷⁴ For example, marine protected areas may include restrictions on the types of activities that may occur within them, such as limits on fishing, to help achieve conservation objectives. By helping to increase the overall resilience of marine ecosystems, marine protected areas have the potential to improve the ability of marine habitats and species to adapt to the impacts of climate change.

⁷⁴Food and Agriculture Organization of the United Nations, *Marine Protected Areas: Country Case Studies on Policy, Governance and Institutional Issues*. FAO Fisheries and Aquaculture Technical Paper. No. 556/1 (Rome, Italy: 2011).

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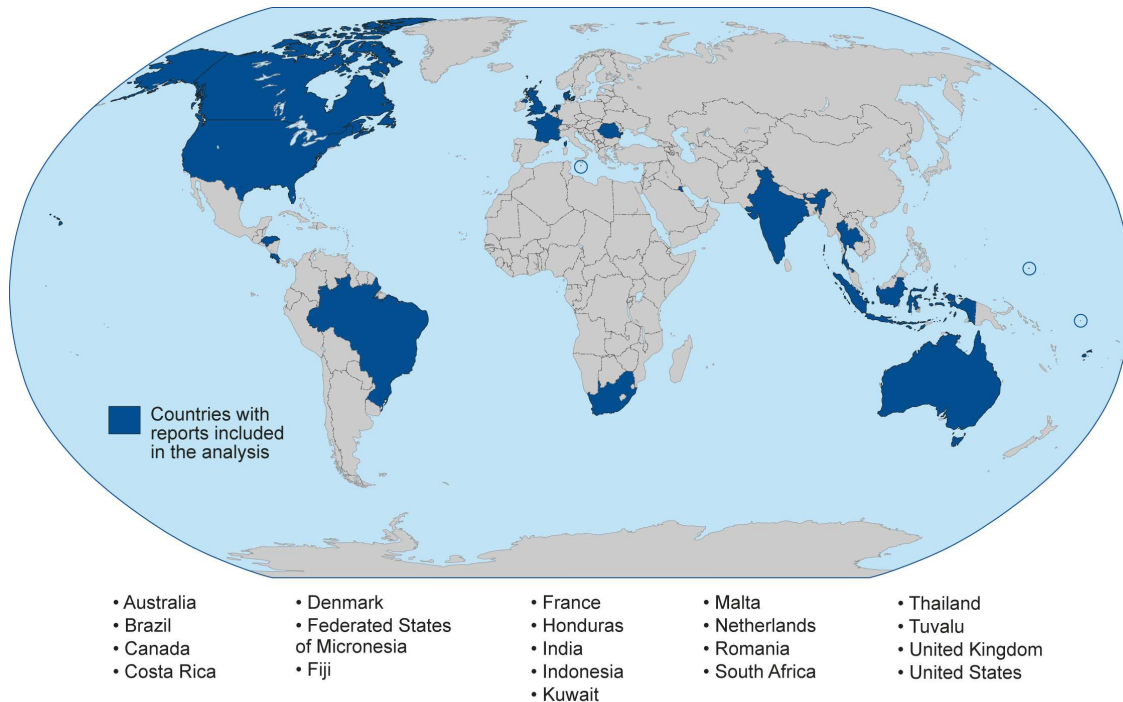
Chapter Two

SAIs' Experiences in Auditing Issues Related to Climate Change and Ocean Acidification in the Marine Environment

Overview

SAIs have conducted a variety of audits that addressed, at least in part, issues related to climate change and ocean acidification in the marine environment. Nonetheless, many SAIs have little or no experience conducting such audits, and some topics, such as ocean acidification, have received minimal attention from SAIs. To examine SAIs' experiences in auditing climate change and ocean acidification issues in the marine environment, the project team contacted SAI officials, reviewed SAI websites, and searched the WGEA audit database to identify audits that addressed these topics. Through these steps, the project team identified 37 audits for analysis, published between 2002 and 2015.⁷⁵ The following map illustrates the geographic diversity of SAIs with audits included in the project team's analysis.

Map of Countries with Audits Included in the Analysis



Sources: GAO and Map Resources.

⁷⁵Appendix II presents the full list of 37 audits analyzed by the project team. 34 of the audits were national reports published by individual SAIs from 20 different countries, and the other 3 audits were collaborative reports produced by multiple SAIs.

The remainder of this chapter presents an overview of SAIs' experiences auditing climate change and ocean acidification issues in the marine environment and uses audit matrices to highlight certain audits in-depth. Common areas of focus for SAIs conducting audits of these issues include examining:

- government assessments of marine environment risks and vulnerabilities;
- government efforts to adapt to the effects of climate change and ocean acidification on the marine environment; and
- coordination among government agencies and between governments and other entities.

Government Assessments of Marine Environment Risks and Vulnerabilities

Many of the SAIs included in this analysis focused on auditing their governments' efforts to assess their country's risks and vulnerabilities resulting from climate change. In general, SAIs audited these activities by examining the approaches governments used to perform such assessments, the quality of the results the assessments produced, and how governments subsequently used them. For example, in 2012 the SAI of Malta published an audit that examined whether Malta's groundwater was adequately protected from various challenges, including climate change.⁷⁶ As part of this audit, the SAI evaluated the adequacy of risk and vulnerability assessments that the government had commissioned for different groundwater bodies to help determine the extent to which they identified climate change threats. Among other things, the SAI reported that these assessments showed sea level rise could exacerbate the threat posed by saltwater intrusion to several groundwater bodies.

In another example highlighted below, the SAI of Brazil evaluated its government's efforts to assess the climate change vulnerabilities of coastal zones as part of a broader audit focused on coastal adaptation (see Feature Audit #1).

⁷⁶National Audit Office of Malta, *Safeguarding Malta's Groundwater*, (Malta: 2012).

Feature Audit #1: SAI of Brazil's Adaptation Measures for Climate Change Scenarios in the Brazilian Coastal Zones

As part of its participation in the WGEA's 2007-2010 Coordinated International Audit on Climate Change, the SAI of Brazil conducted three simultaneous audits on climate change adaptation issues in different sectors. Figure 1 presents information on one of these audits from 2009, which focused on climate change adaptation measures in coastal zones. The SAI selected coastal zones as an area of focus on the basis of consultations with scientific experts and a review of documentation, which identified coastal zones as likely to be severely affected by climate change. More than one-quarter of Brazil's population and some of the country's most important economic markets are located in coastal zones and potentially at risk. In response to concerns about these threats, the SAI audited the status of government efforts to adapt to the potential impacts of climate change in Brazilian coastal zones. According to an SAI official, this audit helped to build knowledge and capacity within the SAI on climate change and coastal issues and served as an important starting point for future auditing work in these areas.

Figure 1: Audit Matrix for the SAI of Brazil's *Adaptation Measures for Climate Change Scenarios in the Brazilian Coastal Zones*^a

Objectives / Researchable Question(s)	Audit Criteria, Required Information, Sources of Information	Scope and Methodology	Challenges Encountered in Conducting the Audit	Audit Results and Key Findings
<p>The audit's overall objective was to examine the Brazilian government's efforts to adapt to the impacts of climate change in Brazil's coastal zones. Specifically, the SAI evaluated:</p> <ol style="list-style-type: none"> 1) the extent to which vulnerability and risk assessments had been performed for coastal zones; 2) the adequacy of information produced by such assessments; and 3) the extent to which the government was prepared to face the identified risks in coastal zones and had begun to take action to adapt to these vulnerabilities. 	<p><u>Criteria</u></p> <ul style="list-style-type: none"> • Brazil's National Plan on Climate Change • UNFCCC—Article 4(e) and (f) <p><u>Required Information and Its Sources</u></p> <ul style="list-style-type: none"> • Information on potential climate change impacts on coastal zones, obtained from studies and interviews with scientific experts. • Information on government activities to respond to potential climate change impacts, obtained through document reviews and interviews with agency officials. • Perspectives of program managers and officials from agencies potentially affected by climate change impacts in coastal areas. 	<p>The SAI examined the activities of a variety of national and state entities that could be affected by the impacts of climate change on coastal zones. The SAI was unfamiliar with the subject matter, so the audit team worked with experts from the Ministry of Science, Technology, and Innovation, as well as academics, to develop a knowledge base and learn more about the technical issues surrounding climate change risks and vulnerabilities in Brazil's coastal areas. According to a SAI official, these consultations were essential and helped determine the scope of the work.</p> <p>In addition to consulting with experts, the SAI employed the following methods to conduct this evaluation:</p> <ul style="list-style-type: none"> • Reviewed published studies on coastal zone vulnerabilities and other documentation, such as Brazil's National Plan on Climate Change; • Interviewed managers responsible for relevant research and monitoring programs; and • Interviewed officials and representatives from government agencies and other entities (e.g., port authorities) that could be affected by climate change. 	<p>According to a SAI official familiar with the audit, the broad scope of the audit (i.e., looking at climate change impacts on coastal zones as a whole) and the general nature of the available criteria were conducive to a more descriptive report. Consequently, the official said it may be more difficult to measure the impact of an audit like this than for audits that focus on specific adaptation projects. Nonetheless, the official said that performing this type of "big picture" review can serve as a starting point for SAIs and can help lay the foundation for future in-depth evaluations.</p>	<p>The SAI identified a number of challenges to adapting to the impacts of climate change in Brazil's coastal zones, including:</p> <ul style="list-style-type: none"> • Existing studies on coastal zone vulnerabilities did not adequately assess climate change risks and potential impacts. • The absence of a centralized system to coordinate and store oceanic monitoring data hampered efforts to better understand and predict potential climate change impacts on coastal zones. As a result, monitoring efforts were decentralized, and some important variables were not sufficiently monitored. • The Brazilian government had not set guidelines for adaptation actions for coastal zones in its National Plan on Climate Change or elsewhere, which made it difficult for agencies and other entities to determine how to move forward on this matter. <p>As a result of these findings, the SAI recommended, among other things, that the responsible government agencies take steps to implement a permanent system and database to monitor oceanic variables.</p>

^aThe WGEA [website](#) contains an English summary of this audit.

The effects of climate change and ocean acidification in the marine environment may also present unique, and potentially substantial, financial risks to national governments that have drawn the attention of some SAIs. SAIs could pursue a variety of lines of inquiry related to this subject, such as examining the greater financial liabilities governments may face associated with threats to public infrastructure and government insurance programs due to the effects of sea level rise and more frequent and severe storms in coastal areas.

For example, in 2014 the SAI of the United States conducted an audit to examine the effects of climate change on public and private insurers.⁷⁷ Through its analysis of agency and private sector data and reviews of scientific studies and other literature on climate change, the SAI found that government and private sector exposure to insured losses had grown since it last audited this topic in 2007, and that climate change may increase insured and uninsured losses in the future. In particular, the SAI identified the potential for climate change to affect the severity of extreme storms such as hurricanes—which impact coastal areas—as a primary driver behind the projected increases in future losses. As the fiscal exposure of the government’s insurance programs has grown over time, so too has the potential financial risk to the government if climate change leads to greater losses from extreme weather events. To help address this concern, the SAI recommended that the government’s flood and crop insurance programs take additional steps to encourage policyholders to adopt building and agricultural practices that reduce long-term risk and the government’s exposure to losses.⁷⁸

In some instances, SAIs included marine environmental issues as part of broader examinations of their governments’ efforts to assess and respond to climate change risks, vulnerabilities, and impacts, as illustrated below in Feature Audit #2.

⁷⁷United States Government Accountability Office, *Climate Change: Better Management of Exposure to Potential Future Losses Is Needed for Federal Flood and Crop Insurance*, GAO-15-28, (Washington, D.C., United States: 2014). In 2013, the SAI of the United States added “Limiting the Federal Government’s Fiscal Exposure by Better Managing Climate Change Risks” to its list of high risk areas vulnerable to fraud, waste, abuse, and mismanagement or most in need of transformation. For more information, see United States Government Accountability Office, *High-Risk Series: An Update*, GAO-15-290, (Washington, D.C., United States: 2015).

⁷⁸The SAI reported that the agency responsible for implementing the government’s flood insurance program agreed with the SAI’s recommendation, and that the agency responsible for implementing the government’s crop insurance program neither agreed nor disagreed with the recommendation.

Feature Audit #2: SAI of Canada's *Adapting to Climate Impacts*

A 2010 audit by the SAI of Canada, shown in fig. 2, focused on the government's efforts to adapt to potential climate change impacts. A central feature of this audit involved the SAI assessing the risk management processes and related activities of five federal departments with mandates that climate change could affect, including departments with responsibilities in the marine environment. SAI officials credited this audit with raising awareness about the importance of climate change issues to various sectors and regions of the country, in part due to the considerable media attention the audit received. In particular, the officials highlighted the regional case studies featured in the audit as key to generating media and public interest, such as a case study focused on assessing the potential impacts of sea-level rise in New Brunswick. In addition, they said that using concrete regional case studies can make it easier for people to understand complex and potentially abstract issues like climate change.

Figure 2: Audit Matrix for the SAI of Canada’s *Adapting to Climate Impacts*^a

Objectives / Researchable Question(s)	Audit Criteria, Required Information, Sources of Information	Scope and Methodology	Challenges Encountered in Conducting the Audit	Audit Results and Key Findings
<p>The audit had two objectives with respect to evaluating the Canadian government’s efforts to support climate change adaptation. Specifically, the SAI assessed whether selected federal departments had:</p> <p>1) Established adequate risk management processes and measures to address climate impacts in their areas of responsibility; and</p> <p>2) Shared information on climate impacts and adaptation in a manner that responded to their users’ needs.</p>	<p><u>Criteria</u></p> <ul style="list-style-type: none"> • The SAI used a risk management policy and framework developed by a central government agency to assess climate change-related risk management processes and measures. • For the objective on information sharing, the SAI derived audit criteria from government communication policies, the UNFCCC (Article 4(1)(h)), and applicable legislative mandates for the audited departments. <p><u>Required Information and Its Sources</u></p> <ul style="list-style-type: none"> • Documentation maintained by the audited departments. • Perspectives of departmental officials obtained through interviews and questionnaires. • Perspectives on users’ needs for information on climate change, obtained from interviews with third-party entities. • Information on case study examples, obtained through interviews, documentation reviews, and site visits. 	<p>Through a planning process involving numerous interviews with government officials, consultations with outside experts, and reviews of documentation, the SAI narrowed the scope of the audit to focus on five departments (such as Fisheries and Oceans Canada) with mandates expected to be significantly affected by climate change.</p> <p>To audit these departments, the SAI:</p> <ul style="list-style-type: none"> • Analyzed departmental documentation, such as corporate risk management and planning documents, to determine if they identified and assessed potential climate risks. • Obtained information from departmental officials through interviews and questionnaires. • Interviewed potential users of climate change information from outside the federal government, such as officials from regional and local governments, Aboriginal organizations, and industry associations. • Obtained expert opinions on various climate change matters from academics and other researchers. • Conducted site visits to obtain information for regional case studies. 	<p>The government had not established any statutory requirements that the SAI could use as criteria to assess the government’s climate change risk management activities. To overcome this challenge, the SAI consulted with a central government agency to confirm that it could use its risk management policies and framework as criteria to evaluate the selected departments’ efforts to identify and manage climate change risks.</p>	<p>The SAI concluded that the five departments it examined had not taken concrete actions to adapt to the impacts of a changing climate. In part, the SAI attributed this to the absence of a federal adaptation policy, strategy, or action plan to help prioritize and coordinate the departments’ efforts.</p> <p>Nonetheless, the SAI found that some of the departments (including Fisheries and Oceans Canada) had taken the first steps of risk management by completing assessments of their climate change risks and by prioritizing those risks. The SAI also found limited instances where Fisheries and Oceans Canada had addressed climate change risks in its policies and plans.</p> <p>In addition, the SAI’s examination of four climate-related programs within the five departments found that the programs had responded to their users’ needs regarding sharing information on climate change impacts and adaptation, but that the programs struggled to meet the increasing demands for such information.</p>

^aThis audit can be obtained from the SAI’s [website](#).

Government Efforts to Adapt to the Effects of Climate Change and Ocean Acidification on the Marine Environment

The 37 audits analyzed for this report featured many that evaluated adaptation efforts in the marine environment.⁷⁹ SAIs have conducted adaptation-related audits for a variety of climate change effects, including efforts to adapt to effects on fisheries and marine ecosystems and to help coastal communities and infrastructure adapt to rising sea levels and extreme weather events. For example, in 2012, the SAI of Indonesia performed an audit to assess the management of certain coral reef ecosystems and the effectiveness of actions taken to adapt to the threats facing coral reefs, including those related to climate change.⁸⁰ The audit identified problems in the government's management of the coral reef ecosystems and found that the percentage of live coral cover had declined, as reported by the Ministry of Marine Affairs and Fisheries' Coral Reef Rehabilitation and Management Program. However, the SAI found it difficult to determine the extent to which climate change contributed to this decline and reported that the Coral Reef Rehabilitation and Management Program had not properly measured the environmental impacts caused by increasing ocean temperatures.

The Pacific Islands include some of the most vulnerable nations to climate change impacts, particularly those related to sea level rise. Consequently, SAIs from several Pacific Island nations have begun to audit their governments' efforts to adapt to these threats, as highlighted below in Feature Audit #3 from the SAI of Tuvalu.

Feature Audit #3: SAI of Tuvalu's Performance Audit on Coastal Protection Management in Tuvalu

Flooding and inundation due to rising sea levels and coastal storm surges pose potentially significant threats to Tuvalu, which has a highest point of approximately 4 meters above sea level. In recognition of these threats, the SAI of Tuvalu focused on efforts to protect Tuvalu's coast as the subject for its contribution to the Pacific Association of Supreme Audit Institutions' (PASAI) coordinated performance audit on climate change adaptation and disaster risk reduction. The SAI of Tuvalu had minimal experience conducting performance audits, so the SAI worked with facilitators from the Pacific Regional Audit Initiative to help determine the scope and the approach taken for this audit, which was published in 2014. Figure 3 presents additional information about this audit and the recommendations made by the SAI to help strengthen Tuvalu's coastal protection efforts.

⁷⁹For additional information on performing climate change adaptation audits, see the WGEA's 2010 report titled, *Auditing the Government Response to Climate Change: Guidance for Supreme Audit Institutions*.

⁸⁰The Audit Board of the Republic of Indonesia, *Performance Audit on Indonesia Coral Reef Ecosystem Protection*, (Indonesia: 2012).

Figure 3: Audit Matrix for the SAI of Tuvalu’s *Performance Audit on Coastal Protection Management in Tuvalu*

Objectives / Researchable Question(s)	Audit Criteria, Required Information, Sources of Information	Scope and Methodology	Challenges Encountered in Conducting the Audit	Audit Results and Key Findings
<p>The audit’s overall objective was to assess the effectiveness and efficiency of the government’s plans and projects to protect Tuvalu’s coast from sea level rise and storm surges. Specifically, the SAI examined:</p> <p>1) whether an effective framework was in place to manage coastal protection; and</p> <p>2) whether coastal protection projects and programs had been implemented effectively, efficiently, and economically.</p>	<p><u>Criteria</u></p> <ul style="list-style-type: none"> National legislation, such as Tuvalu’s Environment Protection Act International agreements and conventions, such as the UNFCCC <p><u>Required Information and Its Sources</u></p> <ul style="list-style-type: none"> Applicable national legislation and planning documents Perspectives of agency officials, obtained through interviews. Information on completed, ongoing, and planned adaptation projects in coastal areas, including projects funded and managed by the government as well as projects funded and managed directly by international development partners. 	<p>The SAI collaborated with facilitators from the Pacific Regional Audit Initiative to determine the scope of the audit, eventually deciding to focus on coastal adaptation and protection due to Tuvalu’s high vulnerability to sea level rise and coastal storm surges. Specifically, the SAI audited two government agencies with significant roles in coastal protection management—Tuvalu’s Department of Environment and its National Fisheries Department. In addition, the SAI examined the implementation of coastal adaptation projects funded by international partners, such as the Global Environment Facility.</p> <p>To conduct this audit, the SAI:</p> <ul style="list-style-type: none"> Reviewed applicable legislation (e.g., Tuvalu’s Environment Protection Act) and international agreements (e.g., UNFCCC) that guide Tuvalu’s environmental and climate change-related activities. Analyzed national policy and strategic documents, such as the Tuvalu Climate Change Policy and the National Strategy for Sustainable Development. Interviewed key agency officials, including the Acting Director of Tuvalu’s Department of Environment and the Coordinator of the National Adaptation Program of Action. 	<p>The SAI identified determining an appropriate and manageable scope as the greatest challenge it faced in participating in the PASAI coordinated audit. In particular, the SAI determined that looking broadly at climate change and disaster risk reduction issues would be too large of a task. Instead, the SAI worked with facilitators from the Pacific Regional Audit Initiative to narrow the scope of the audit to focus on the area of climate change adaptation most relevant to Tuvalu—coastal protection management.</p>	<p>The SAI determined that coastal protection management measures in Tuvalu could be jeopardized because the government’s policies and plans did not align well with the legislation in place to address environmental issues. For example, the SAI found that no policy specifically focused on coastal protection management in Tuvalu and that the National Strategy for Sustainable Development did not adequately address coastal erosion and protection issues. Consequently, the SAI concluded that coastal protection strategies could receive less support from the government than other priorities.</p> <p>In addition, the SAI’s review of coastal protection projects found that the government had only completed some of the planned projects and had not used a significant amount of the funds allocated for climate change adaptation measures. The audit concluded that better program governance arrangements, particularly with regard to sound management and project monitoring, would help support coastal protection programs and projects.</p> <p>The SAI made a number of recommendations based on these findings, including recommending that Tuvalu develop a coastal zone management policy that reflects the risks of climate change.</p>

In many cases, SAIs included marine environment issues as a part of audits they performed looking broadly at their government's climate change adaptation efforts. For example, the SAI of Fiji's 2013 audit on climate change adaptation and disaster risk reduction included coastal flooding as one area of focus within its scope.⁸¹ Climate change may increase coastal flooding risks in Fiji due to sea level rise and more frequent and intense severe weather events, so the SAI audited the effectiveness of actions taken by different agencies in implementing flood risk reduction strategies. Among other things, the SAI found that the agencies had not established an adequate process or criteria for prioritizing investments in adaptation actions, such as building sea walls or relocating coastal villages to higher ground. Consequently, the audit raised the concern that the agencies or other stakeholders could misuse the funds targeted for such activities or use them on projects that may not yield as great of an impact as others.

In some instances, collaborative audits involving several SAIs also focused broadly on adaptation issues, such as the 2012 European Organization of Supreme Audit Institutions (EUROSAI) cooperative audit on climate change adaptation.⁸² As part of this coordinated effort, the SAI of the Netherlands published an audit that presents a comprehensive look at the implementation of climate change adaptation policies in the Netherlands, including actions taken in response to the threats posed by sea level rise and coastal flooding.⁸³ The audit found that the Dutch government had not effectively implemented the country's national climate change adaptation strategy overall, but it had taken some actions in response to flood safety and water security risks.

Some audits that do not explicitly focus on climate change issues may still address topics relevant to understanding potential government responses to climate change impacts in the marine environment. For example, the SAI of Canada published an audit in 2012 that examined its government's efforts to plan, establish, and manage marine protected areas, a potential tool governments can use to adapt to the effects of climate change on marine species and

⁸¹Office of the Auditor General of the Republic of Fiji, *Climate Change Adaptation and Disaster Risk Reduction Strategies*, (Fiji: 2013).

⁸²EUROSAI, *Adaptation to Climate Change – Are Governments Prepared?*, (Oslo, Norway: 2012).

⁸³Netherlands Court of Audit, *Adaptation to Climate Change: National Strategy and Policy*, (The Hague, Netherlands: 2012).

ecosystems.⁸⁴ Even though this audit did not focus on climate change specifically, the SAI's work on marine protected areas still represents a valuable contribution to the larger body of auditing work that feeds into and supports more direct climate change efforts.

As another approach, some SAIs have audited their governments' general implementation of actions called for in international agreements, such as the UNFCCC. In doing so, some SAIs have addressed adaptation activities—including those in coastal areas and in the marine environment—within the scope of their audits on UNFCCC implementation. For example, from 2009-2011, SAIs from nine nations in Central and South America participated in a coordinated audit to assess each country's implementation of the UNFCCC.⁸⁵ The participating SAIs used a common audit framework to evaluate these issues in their respective countries and published individual national audits to communicate the results of their evaluations. The common objectives of this coordinated audit included, among other things, determining whether governments had developed climate change adaptation strategies or implemented any policy instruments in response to identified climate risks, such as potential risks to coastal zones. Feature Audit #4 presents the individual national audit performed by the SAI of Honduras as part of this collaborative effort.

Feature Audit #4: SAI of Honduras' *Implementation of Commitments Under the UNFCCC*

The SAI of Honduras focused on climate change as the subject for its first coordinated audit, presented in fig. 4, which it performed in conjunction with eight other SAIs from Central and South America. As agreed upon with the other SAIs, this audit examined the actions taken by the Honduran government to fulfill its commitments under the UNFCCC in the areas of climate change mitigation and adaptation. This audit included coastal zones as one of several areas of focus and emphasized the importance of vulnerability studies to help determine appropriate adaptation measures. The SAI of Honduras has followed up on the results of this audit since its publication in 2010 and found that the government has taken some actions to address the challenges identified in the audit. For example, the government has elevated the Climate Change Unit in the Secretary of Natural Resources and Environment to become the National Climate Change Office and has created a new Climate Change Economic and Financial Management Unit.

⁸⁴Office of the Auditor General of Canada, "Marine Protected Areas," *Report of the Commissioner of the Environment and Sustainable Development*, (Ottawa, Canada: 2012).

⁸⁵The nine participating SAIs were Argentina, Brazil, Colombia, Costa Rica, El Salvador, Honduras, Panama, Paraguay, and Peru. In addition to the national audit reports produced by each SAI, a report summarizing the overall results of this coordinated effort was also released. For more information on this summary report, see Organization of Latin American and Caribbean Supreme Audit Institutions Special Technical Commission on Environment, *Coordinated Performance Audit on the Implementation of the United Nations Framework Convention on Climate Change*, 2011.

Figure 4: Audit Matrix for the SAI of Honduras' *Implementation of Commitments Under the United Nations Framework Convention on Climate Change*^a

Objectives / Researchable Question(s)	Audit Criteria, Required Information, Sources of Information	Scope and Methodology	Challenges Encountered in Conducting the Audit	Audit Results and Key Findings
<p>The audit's overall objective was to evaluate the extent to which the Honduran government had fulfilled its commitments under the UNFCCC. Specifically, the SAI sought to:</p> <ol style="list-style-type: none"> 1) determine if the government had developed appropriate UNFCCC-related strategies and mitigation plans; 2) evaluate the implementation of UNFCCC-related policies, plans, and programs; and 3) determine the extent to which the government had developed and implemented strategies and adaptation plans to protect areas vulnerable to climate change, such as coastal zones. 	<p><u>Criteria</u></p> <p>National strategies and laws, including Honduras':</p> <ul style="list-style-type: none"> • National Climate Change Strategy • Forestry, Protected Areas, and Wildlife Law <p>International agreements, including:</p> <ul style="list-style-type: none"> • UNFCCC • Kyoto Protocol • Marrakech Accords <p><u>Required Information and Its Sources</u></p> <ul style="list-style-type: none"> • Information on the Honduran government's climate change strategies, policies, and plans, obtained from documentation and interviews. • Information on expected climate change impacts on coastal zones, obtained from vulnerability analyses and interviews with officials. • Perspectives of government officials on climate change activities, obtained through interviews and questionnaires. 	<p>The audit primarily evaluated actions taken by the Climate Change Unit of the Secretary of Natural Resources and Environment (SERNA), the main government entity in charge of fulfilling Honduras' commitments assumed under the UNFCCC. The broad overall scope of the audit covered, among other things, SERNA's efforts to adapt to climate change impacts on coastal zones.</p> <p>To evaluate the actions taken by SERNA to implement climate change adaptation and mitigation commitments assumed under the UNFCCC, the SAI:</p> <ul style="list-style-type: none"> • Analyzed documentation from official government sources, such as vulnerability analyses of coastal zones, as well as the Honduran National Climate Change Strategy, among others. • Interviewed officials from SERNA and other relevant governmental authorities. • Developed questionnaires to obtain additional information from officials. 	<p>The audit team did not play a significant role in determining the agenda and structure for the coordinated audit because it could not attend the planning meetings with the other participating SAIs. As a result, the audit team had to implement a general audit plan and guidelines that it had not helped to develop.</p> <p>To help ensure the audit team understood and could adhere to the decisions reached in these meetings, the team consulted with the SAI coordinator and the other participating SAIs outside of the formal meetings for guidance and support.</p>	<p>According to an SAI official, this audit provided a valuable overview of the government's management of climate change issues. Key findings related to marine environment issues included:</p> <ul style="list-style-type: none"> • The government had conducted climate change vulnerability analyses, including for coastal zones, but had not taken action to help adapt or protect the affected vulnerable areas. • The government had not effectively implemented the Honduran National Climate Change Strategy and had not established a national policy or plan for climate change adaptation in vulnerable areas, such as coastal zones. • In the absence of a national policy or plan for climate change adaptation, the government also had not developed monitoring or performance evaluation mechanisms for costs and revenues related to adaptation efforts, including those in coastal zones.

^aThis audit (in Spanish) can be obtained from the WGEA [website](#).

Coordination among Government Agencies and between Governments and Other Entities

SAI audits related to climate change and ocean acidification in the marine environment also commonly examined issues related to the coordination of government activities in this area. As noted in the 2010 WGEA coordinated audit on climate change, climate change responses often involve many actors across different levels of government and from the private sector, which can present coordination challenges.⁸⁶ The success of climate change-related risk assessment and adaptation activities depends, in part, on effective coordination, and many SAIs have experience assessing coordination effectiveness in audits on other topics.

Coordination issues supported findings and recommendations in several of the audits analyzed for this report, including in Feature Audit #1. In that 2009 audit, the SAI of Brazil identified shortcomings in the coordination and storage of monitoring data on oceanic variables, which was being performed in a decentralized way by several different entities. Consequently, some oceanic variables important for modeling climate change scenarios were not monitored, which made it more difficult to predict potential climate change impacts on coastal zones and to forecast extreme events. More recently, the SAI of the United States developed a finding on the need for improved coordination as part of its audit on the government's response to ocean acidification, highlighted below in Feature Audit #5.

Feature Audit #5: SAI of the United States' Ocean Acidification: Federal Response Under Way, but Actions Needed to Understand and Address Potential Impacts

Ocean acidification has not yet received much attention from SAIs despite its potentially serious consequences. Notably, only 1 of the audits analyzed for this report examined ocean acidification issues in depth (see fig. 5). In its 2014 audit, the SAI of the United States evaluated its government's response to ocean acidification and the implementation of a 2009 law requiring the creation of an interagency working group on ocean acidification and the establishment of an ocean acidification program. Eleven United States government agencies have joined the working group, and their efforts to address ocean acidification have primarily focused on supporting various research and monitoring activities. As part of this audit, the SAI made several recommendations to improve the government's response to ocean acidification, including recommending steps to strengthen coordination, such as clearly defining the roles and responsibilities of the agencies involved and designating the entity responsible for coordinating the next steps in the government's response.

⁸⁶INTOSAI WGEA, *Coordinated International Audit on Climate Change: Key Implications for Governments and their Auditors*, 2010.

Figure 5: Audit Matrix for the SAI of the United States' *Ocean Acidification: Federal Response Under Way, but Actions Needed to Understand and Address Potential Impacts*^a

Objectives / Researchable Question(s)	Audit Criteria, Required Information, Sources of Information	Scope and Methodology	Challenges Encountered in Conducting the Audit	Audit Results and Key Findings
<p>The audit's overall objective was to review the federal government's efforts to address ocean acidification. Specifically, the SAI examined:</p> <p>1) the scientific understanding of the effects of ocean acidification;</p> <p>2) the extent to which federal agencies had implemented the Federal Ocean Acidification Research and Monitoring Act of 2009 (FOARAM); and</p> <p>3) additional actions, if any, that could be taken to advance the federal response to ocean acidification.</p>	<p><u>Criteria</u></p> <ul style="list-style-type: none"> • Law: FOARAM • Best practices for interagency collaboration. <p><u>Required Information and Its Sources</u></p> <ul style="list-style-type: none"> • Summary reports on ocean acidification published by federal agencies and others (e.g., international intergovernmental groups and state agencies). • Peer-reviewed scientific articles. • Agency documents related to actions taken to address ocean acidification. • Testimonial evidence from agency officials, scientists, and nonfederal stakeholders regarding the response of the federal government to ocean acidification. 	<p>To examine the scientific understanding of ocean acidification, the SAI reviewed six summary reports on ocean acidification—which were based on extensive reviews of the scientific literature—developed by federal agencies and others. The SAI identified common themes and summarized the reports' findings in four broad areas of scientific inquiry: (1) changes to ocean chemistry, (2) effects on individual species, (3) effects on ecosystems, and (4) socioeconomic effects on coastal communities. The SAI also examined peer-reviewed scientific articles and interviewed scientists.</p> <p>To identify the extent to which federal agencies have implemented FOARAM, the SAI reviewed agency documents and interviewed agency officials.</p> <p>To identify additional actions that could advance the federal response to ocean acidification, the SAI reviewed agency documents and previous audits that identified key practices for interagency collaboration. The SAI also interviewed nonfederal stakeholders involved with or interested in ocean acidification issues, including state agencies, conservation groups, and fishing industry groups.</p>	<p>The SAI faced challenges in determining how best to examine the scientific understanding of the potential effects of ocean acidification, in part due to the rapidly-evolving state of the science. To help address this challenge, the team worked with agency officials and scientists to identify summary reports that would provide an overview of the scientific knowledge. In addition, the team supplemented its review of the summary reports with a review of selected peer-reviewed scientific articles and with interviews with ocean acidification experts.</p> <p>To help ensure the accuracy of the scientific information included in the audit report, the team had scientific experts review its description of the effects of ocean acidification prior to the audit's publication.</p>	<p>The SAI found that United States government agencies had taken steps to address ocean acidification, such as developing a national ocean acidification research and monitoring plan, but federal efforts to implement FOARAM were incomplete. Among other things, the SAI found that:</p> <ul style="list-style-type: none"> • Ocean acidification could have a variety of potentially significant effects on marine species, ecosystems, and coastal communities. For example, acidification could reduce the ability of some species to form shells and could disrupt marine food webs. • Federal agencies had taken steps to implement FOARAM but had not completed certain requirements, such as clarifying each agency's role in implementing the ocean acidification research and monitoring plan. • Designating an entity responsible for coordinating the implementation of the research and monitoring plan could help advance the federal response. One possible approach would be to establish an independent national ocean acidification program office.

^aThis audit can be obtained from the SAI's [website](#).

Some of the multinational collaborative audits conducted by regional WGEA groups in recent years have also raised concerns about ineffective coordination on climate change activities. For example, the 2012 EUROSAI cooperative audit on climate change adaptation found that the extent and quality of coordination varied among countries, with most of the participating SAIs reporting weaknesses in their countries' coordination of adaptation policies.⁸⁷ Similarly, the PASAI coordinated audit on climate change adaptation and disaster risk reduction identified weaknesses in coordination across the government agencies responsible for climate change adaptation in the participating Pacific Island nations.⁸⁸ For instance, as part of this coordinated effort the SAI of FSM found that poor coordination on actions to address climate change impacts on food security had led to duplication of efforts among national, state, and non-governmental entities (see Feature Audit #6).

Feature Audit #6: SAI of the Federated States of Micronesia's (FSM) Audit on the Management of the Impacts of Climate Change on Food Security in the FSM (Fiscal Year 2010 – 2012)

For its contribution to the PASAI coordinated audit, the SAI of FSM audited its government's efforts to address the impacts of climate change on food security, as shown in fig. 6. According to the audit, FSM is particularly vulnerable to the impacts of climate change as a small island developing country, and research has shown that climate change represents the greatest threat to the country's food security. For example, as discussed in the previous chapter, saltwater intrusion due to rising sea levels has already begun to damage crops in certain low-lying areas of FSM, and sea level rise could pose a significant threat to supplies of taro, one of the country's traditional and staple food items. Climate change impacts affect multiple agencies in FSM, and the SAI's 2013 audit found that the actions taken to address the impacts of climate change on food security had been uncoordinated and inefficient. Nonetheless, the SAI reported that, in response to the audit, the audited agencies had begun to take steps to eliminate overlapping activities by improving collaboration with each other and with state agencies and non-governmental organizations.

⁸⁷EUROSAI, *Adaptation to Climate Change – Are Governments Prepared?*, 2012.

⁸⁸PASAI, *Report of the Coordinated Pacific Region Performance Audit: Climate Change Adaptation and Disaster Risk Reduction Strategies and Management*, 2015.

Figure 6: Audit Matrix for the SAI of FSM’s *Audit on the Management of the Impacts of Climate Change on Food Security in the FSM (Fiscal Year 2010 – 2012)*^a

Objectives / Researchable Question(s)	Audit Criteria, Required Information, Sources of Information	Scope and Methodology	Challenges Encountered in Conducting the Audit	Audit Results and Key Findings
<p>The audit’s overall objective was to determine whether the responsible government entities had effectively developed and implemented strategic action plans to address the impacts of climate change on food security in the FSM.</p>	<p><u>Criteria</u></p> <ul style="list-style-type: none"> • International agreements (e.g., UNFCCC) • Best practices (e.g., related to conducting vulnerability assessments) <p><u>Required Information and Its Sources</u></p> <ul style="list-style-type: none"> • Perspectives of agency officials involved in food security and climate change activities, obtained through interviews. • Applicable international agreements and related national legislation. • Data and information on projects and activities administered at the state level, obtained through document reviews, interviews with state officials, and site visits. 	<p>To audit the FSM government’s efforts to address the impacts of climate change on food security, the SAI examined the activities of two agencies—the Office of Environmental and Emergency Management (OEEM) and the Department of Resources and Development (DR&D). The scope of the audit covered 2010 to 2012.</p> <p>To perform this evaluation, the SAI:</p> <ul style="list-style-type: none"> • Interviewed officials from OEEM, DR&D, and other relevant national agencies involved in implementing and monitoring food security activities or climate change issues. • Reviewed international agreements and national legislation and policies related to climate change. • Interviewed officials from applicable state agencies about their coordination with the national government on projects related to food security and climate change. • Analyzed data and documents on relevant projects administered at the state level in coordination with the national government. • Conducted site visits (e.g., to farms) to verify the accuracy of the data on the projects. 	<p>The SAI faced challenges conducting site visits due to resource and budget constraints. As a result, the SAI could not visit all of the desired sites. Nonetheless, the SAI credited the site visits it made as being a crucial part of the audit’s methodology. Specifically, directly observing the status of project implementation helped to make up for missing or poor quality data on some projects.</p> <p>In addition, the complex nature of climate change issues presented a challenge for the SAI. To help overcome this challenge, the SAI received technical assistance from its regional auditing association (PASAI).</p>	<p>The SAI found no assurance that the FSM could successfully respond to the impacts of climate change on food security. In particular, the SAI found that poor policy and planning by OEEM and DR&D had resulted in minimal actions to improve food security. Among other things, the agencies had not developed a comprehensive action plan to address climate change impacts on food security, and DR&D’s 2010 food security vulnerability assessment was inadequate.</p> <p>In addition, the SAI found that the limited actions taken were uncoordinated and inefficient. For example, OEEM and DR&D were unaware of ongoing efforts related to food security administered by other national and state agencies, as well as by non-governmental organizations. Consequently, the SAI observed that overlapping activities occurred among these various agencies and organizations, which, in turn, resulted in the inappropriate expenditure of some funds.</p> <p>The SAI made a number of recommendations to address shortcomings identified in this audit, including recommending steps to improve coordination.</p>

^aThis audit can be obtained from the SAI’s [website](#).

Chapter Three

Challenges SAIs Face in Auditing Climate Change and Ocean Acidification Issues in the Marine Environment and Approaches to Help Overcome Them

Overview

SAIs face a variety of challenges in auditing issues related to climate change and ocean acidification in the marine environment. In some instances, these challenges present barriers that can prevent SAIs from attempting to audit these issues, while in other cases these challenges may make the process of conducting such audits more difficult. This chapter explores the challenges SAIs reported facing in this area in their responses to a 2014 survey conducted by the WGEA Secretariat. In addition, the chapter presents approaches SAIs can use to help overcome these challenges, identified by SAIs in their survey responses or independently by the project team.⁸⁹ Specific challenges covered in this chapter include:

- limited audit criteria and government action;
- fragmented government response;
- limited experience and training;
- competing audit priorities; and
- limitations in the scope of SAI audit mandates.

Limited Audit Criteria and Government Action

SAIs identified two fundamental challenges that hinder their abilities to audit their governments' efforts to understand and adapt to climate change and ocean acidification in the marine environment. First, SAIs noted a widespread absence of specific criteria at the national level because few laws and regulations exist to direct government action related to these issues. Second, SAIs noted that many governments had taken few actions to address climate change and ocean acidification in the marine environment, which provides little for SAIs to evaluate. In some cases, SAIs noted, governments may not collect basic data that would allow them to describe physical and chemical changes in the ocean environment (e.g., temperature, oxygen levels, and acidity) and the effect of any such changes on species and ecosystems.

⁸⁹Appendix III lists additional resources that SAIs may find useful in auditing climate change and ocean acidification issues in the marine environment.

Several SAIs also noted that the scientific understanding of the causes and likely effects of climate change and ocean acidification in the marine environment continues to emerge and, in some cases, is changing quickly. For example, a decade ago, few scientists or government officials had much knowledge about ocean acidification and how it might affect marine ecosystems. In more recent years, however, new scientific findings that refine, and even substantially change, earlier understandings of the issue have been frequently published. The emerging nature of the understanding of these issues led some SAIs to note that these issues may be more appropriate for scientific inquiry than environmental auditing.

A number of approaches could help SAIs overcome the limited extent of applicable national criteria and government action. For example:

- *Use international criteria.* International agreements—in particular, the UNFCCC and the Kyoto Protocol—establish general commitments related to both mitigation and adaptation for the parties that have ratified the agreements. The WGEA, in its 2010 climate change guidance document, highlighted two UNFCCC provisions that may be relevant to SAIs looking to audit adaptation issues.⁹⁰ For example, the UNFCCC states “all parties [shall] facilitate adequate adaptation to climate change [and] cooperate in preparing for adaptation to the impacts of climate change.” In addition, under the UNFCCC, least-developed countries are offered assistance to prepare and implement national adaptation programs. However, although the presence of international agreements may help some SAIs, their utility as criteria often depends on a country adopting laws and regulations or taking other actions to implement the agreements. For examples of how SAIs have used these types of criteria, please see the audit matrices included in feature audits 1, 3, 4, and 6 in chapter 2.
- *Use good governance and good management criteria.* INTOSAI has issued guidance for good governance, which include Guidelines for Internal Control Standards for the Public Sector.⁹¹ The WGEA climate change guidance document also highlighted the utility of using good governance and good management criteria in auditing the government

⁹⁰INTOSAI WGEA, *Auditing the Government Response to Climate Change*, 2010. Chapter 3 of this report includes a detailed explanation of UNFCCC and Kyoto Protocol provisions.

⁹¹For more information on INTOSAI’s Internal Control Standards, including guidance documents that include examples of how SAIs have implemented and evaluated internal controls, see <http://www.issai.org/intosai-guidance-for-good-governance-%28intosai-gov%29/>.

response to climate change. In many cases, SAIs can use these types of criteria even if their governments have not adopted national legislation establishing specific criteria related to climate change and ocean acidification in the marine environment. For example, according to the WGEA climate change guidance document, principles of good governance suggest governments need to (1) define objectives and expected results, (2) develop implementation strategies, (3) provide the information needed to assess efficiency and goal achievement, and (4) use appropriate risk-based management.

Similarly, principles of good management suggest that governments should establish internal control systems, a key component of which is to identify, assess, and respond to risks that may affect their ability to meet their objectives. Although the exact scope and severity of effects resulting from climate change and ocean acidification in the marine environment may not be fully known, enough is known about these issues for governments to determine that the effects pose risks to some government programs. Therefore, even without specific legislation directing government action, SAIs may consider using risk-based management or an internal controls framework to evaluate the extent to which their governments are responding to known risks.⁹² For example, by enhancing resilience and reducing vulnerabilities, adaptation efforts effectively serve as a type of risk management strategy, and SAIs could use a risk-based management framework to examine their government's efforts in this area.

Furthermore, if governments need to identify, analyze, and respond to risks, sufficient data are a necessary component to analyzing the risks and likely outcomes of different actions. If agencies do not have such data, SAIs could report on their importance and recommend that their governments collect it. For examples of how SAIs have used these types of criteria, please see the audit matrices included in feature audits 2, 5, and 6 in chapter 2.

- *International benchmarking.* International benchmarking is a process for comparing a country's programs, methods, processes, or procedures against those of other countries that consistently distinguish themselves in the same areas. SAIs have used

⁹²For more information on risk-based management, see International Organization for Standardization, *Risk Management - Principles and Guidelines (Standard 31000:2009)*, 2009; and National Research Council, *Science and Decisions: Advancing Risk Assessment*, (Washington, D.C., United States: 2009). For more information on internal control systems, see United States Government Accountability Office, *Standards for Internal Control in the Federal Government*, GAO-14-704G, (Washington, D.C., United States: 2014).

benchmarking to (1) prompt an objective review of processes, practices, and systems; (2) develop criteria and identify potentially better ways of operating; and (3) lend more credibility to audit recommendations. The 2013 WGEA report on auditing water issues examined how SAIs had used this approach to audit a variety of water-related issues.⁹³ For example, it described an audit where the SAI of the United Kingdom conducted a literature review of initiatives implemented in certain countries selected for comparison. The literature review helped identify best practices and provided information on whether the United Kingdom's Environment Agency had the correct balance in its use of regulation, education, and incentives. According to the United Kingdom audit team, the benchmarking exercise was particularly useful in identifying alternative approaches that the Environment Agency could take, and to determine whether the Environment Agency had actively looked externally for best practices. In the context of this report, SAIs auditing climate change and ocean acidification in the marine environment could examine other countries' efforts to adapt to these issues to identify best practices and assess their own country's actions against those practices.

- *Consider opportunities to inform lawmakers.* Audits can include descriptive, rather than evaluative, objectives that provide information to lawmakers, agency officials, and the public about the importance of an issue. For example, in its 2014 audit on ocean acidification, the SAI of the United States included an objective that summarized the scientific understanding of the known and predicted effects of ocean acidification on marine species, ecosystems, and coastal communities.⁹⁴ This objective did not evaluate the government's performance, but it provided information that demonstrated the importance of addressing this issue. Similarly, in 2011, the SAI of Canada published a study on fisheries management that identified the key properties of sustainable fisheries, the practices and principles involved in managing fisheries sustainably, and the challenges of operating fisheries in a sustainable way.⁹⁵ This study—which identified climate change as a major challenge facing fisheries managers—did not assess the government's fisheries management practices, but rather provided information to help

⁹³INTOSAI WGEA, *Auditing Water Issues: An Examination of SAIs' Experiences and the Methodological Tools They Have Successfully Used*, 2013.

⁹⁴United States Government Accountability Office, *Ocean Acidification: Federal Response Under Way, but Actions Needed to Understand and Address Potential Impacts*, GAO-14-736, (Washington, D.C., United States: 2014).

⁹⁵Office of the Auditor General of Canada, "A Study of Managing Fisheries for Sustainability," *Report of the Commissioner of the Environment and Sustainable Development*, (Ottawa, Canada: 2011).

legislators better understand the issues associated with sustainable fisheries management, including the effects of climate change, and to lay the foundation for future SAI audits on this topic.⁹⁶ Including descriptive information in audit reports might not have the immediate impact of an evaluative finding and recommendation, but may provide information that can inform new laws or programs that might be beneficial and help spur future action.

Fragmented Government Response

Even in countries where governments have taken action to understand and adapt to climate change and ocean acidification in the marine environment, SAIs reported audit challenges associated with the fragmentation of the response among multiple government agencies and levels of government. Climate change and ocean acidification are complex issues and involve many different government programs, such as those related to energy policy, air and water pollution control, infrastructure development, fisheries, land and ocean protected areas, economic development, and insurance. In any single country, many different government agencies likely oversee and implement these programs. Moreover, the laws, policies, and programs for each of these areas have often evolved around specific industry sectors (e.g., agriculture, electricity generation, fisheries, and motor vehicles) and may not recognize, let alone address, the interconnectedness of the sectors and how each may contribute to climate change and ocean acidification.

From an auditing perspective, such fragmentation can create difficulties. Audits often look at individual laws or programs. However, an audit examining fisheries management decisions in light of climate change could be limited if it did not consider, for example, the impact of infrastructure development in coastal areas on important fish habitat or of water pollution on the health of valuable fisheries. Evaluating multiple programs simultaneously poses its own challenges to the auditor, particularly if the government (or the relevant agencies) have not established an overall framework laying out the key components of the government's response, how they relate, and responsibilities for implementing which actions.

Some of the same approaches discussed above can also help SAIs overcome the challenges associated with fragmentation. For example, SAIs could consider using a risk-based approach

⁹⁶For additional information on the role of SAIs in auditing the management of sustainable fisheries, please refer to the WGEA's 2010 report titled, *Auditing Sustainable Fisheries Management: Guidance for Supreme Audit Institutions*.

to identify the various programs and sectors that affect climate change and ocean acidification in the marine environment and then assess the extent to which the agencies responsible for those programs and sectors have coordinated their actions. The fragmented nature of some governments' responses to climate change can present coordination challenges to government agencies. Consequently, SAIs may have an opportunity to help overcome the challenges posed by such fragmentation by focusing audits on coordination issues in this type of situation. The SAI of the United States has examined numerous programmatic areas involving multiple government agencies and has published a series of reports identifying best practices for interagency collaboration.⁹⁷ These best practices could serve as criteria for coordination-related audit findings and recommendations, and include things such as establishing mutually reinforcing or joint strategies; agreeing on each agency's roles and responsibilities; developing mechanisms to monitor, evaluate, and report on results; and reinforcing agency accountability for collaborative efforts through agency plans and reports. In addition, in situations where government actions are fragmented among numerous agencies, another potentially helpful approach is for SAIs to narrow the focus of their audits to the agencies with the most important roles and responsibilities.

Limited Experience and Training

Many SAIs reported that their staffs' limited experience and training on climate change and ocean acidification—and, in some cases, environmental issues more broadly—hinders their ability to audit these issues. Among other things, auditing staff may not have familiarity with the science that supports these complex and technical issues or with the actions taken by the international community to deal with them.

SAIs also identified a variety of approaches that can help mitigate shortcomings in experience and training. These approaches ranged from providing additional training to their staffs, to contracting with independent experts (e.g., from academia), to conducting joint or cooperative audits with other countries. In addition, some regional SAI organizations have initiated multi-national audits of issues related to climate change in the marine environment that involved providing technical and other assistance to the participating SAIs. For example:

⁹⁷See, for example, United States Government Accountability Office, *Managing for Results: Key Considerations for Implementing Interagency Collaborative Mechanisms*, GAO-12-1022, (Washington, D.C., United States: 2012), and *Results-Oriented Government: Practices That Can Help Enhance and Sustain Collaboration among Federal Agencies*, GAO-06-15, (Washington, D.C., United States: 2005).

- PASAI conducted a coordinated audit on climate change adaptation and disaster risk reduction in 2013. SAIs from several Pacific Island nations participated in this coordinated effort by concurrently auditing climate change adaptation and disaster risk reduction issues in their respective areas of jurisdiction.⁹⁸ PASAI chose this topic because Pacific Island countries are among those most vulnerable to the effects of climate change, including from rising sea levels, cyclones, coastal erosion, and food security. PASAI conducts cooperative audits to help raise the auditing capacity of individual SAIs and to support the production of individual national audit reports. The participating SAIs received support in conducting their individual audits from the INTOSAI Development Initiative, the Asian Development Bank, and others. For example, PASAI's Regional Working Group on Environmental Auditing was instrumental in planning and defining the scope of the coordinated audit, and the Secretariat of the Pacific Regional Environment Program provided technical expertise on climate change adaptation and disaster risk reduction measures in the Pacific. SAIs have reported that this type of assistance has helped them audit complex issues such as climate change and ocean acidification in the marine environment.
- The Organization of Latin American and Caribbean Supreme Audit Institutions (OLACEFS) also conducted a cooperative audit in 2009-2011, in which the SAIs from 9 countries participated, that examined compliance with commitments related to the UNFCCC.⁹⁹ Participating SAIs benefited from using a common audit framework, which was similar to the one developed for a previous WGEA coordinated audit on this topic.¹⁰⁰

Competing Audit Priorities

Many SAIs reported that they had not audited issues related to climate change and ocean acidification in the marine environment because they had scarce audit resources and other issues were a higher priority. Some SAIs noted that these issues are a relatively low priority for

⁹⁸PASAI published an overview report summarizing the results of the coordinated audit. See PASAI, *Report of the Coordinated Pacific Region Performance Audit: Climate Change Adaptation and Disaster Risk Reduction Strategies and Management*, 2015. In addition to the PASAI overview report, the following eight SAIs that participated in the coordinated audit published national or state reports about their audits: the Cook Islands, the FSM National Office, the FSM State of Kosrae, the FSM State of Pohnpei, Fiji, Palau, Samoa, and Tuvalu.

⁹⁹OLACEFS Special Technical Commission on Environment, *Coordinated Performance Audit on the Implementation of the United Nations Framework Convention on Climate Change*, 2011. The participating SAIs were from Argentina, Brazil, Colombia, Costa Rica, El Salvador, Honduras, Panama, Paraguay, and Peru.

¹⁰⁰See INTOSAI WGEA, *Coordinated International Audit on Climate Change: Key Implications for Governments and their Auditors*, 2010.

auditing because their governments have not taken many actions to address them or because their countries have not yet experienced visible effects from these issues.

A number of SAIs, however—including both SAIs who reported auditing these issues and those who did not—recognized that SAIs already audit other government activities that will be, or are likely to be, affected by climate change and ocean acidification. In such cases, conducting audits focused solely on climate change or ocean acidification may not be necessary. Rather, SAIs could expand the scope of an already-planned audit so that it examines the effects that climate change and ocean acidification in the marine environment could have on the audit topic at hand. For example:

- *Fisheries.* SAIs have long focused on the health and management of fisheries as an environmental auditing subject. In general, however, SAI audits focused on fisheries management have not considered the potential effects of climate change and ocean acidification. Future audits, therefore, could examine the extent to which fisheries management considers the impact of these factors on the health of fish stocks, which could help governments reduce any future disruption to fisheries.
- *Coastal Flooding.* By raising sea levels and increasing severe storm activity, climate change could increase the frequency and severity of coastal flooding, however SAIs have often not included these impacts in the scope of their flooding-related audits. Future audits, therefore, could examine the extent to which government programs take into account the predicted effects of climate change on future coastal flooding.
- *Infrastructure.* Governments often finance infrastructure projects such as roads, bridges, and power plants, making such projects a potential area of interest for SAIs. Climate change could pose a threat to infrastructure located in coastal areas, however, due to the potential for damage from rising sea levels and more severe coastal storms. Future infrastructure-related audits could, therefore, also examine the extent to which governments consider potential climate change impacts in the planning and implementation of key infrastructure projects.

Limitations in the Scope of SAI Audit Mandates

A few SAIs also reported that limitations in the scope of their audit mandates have hindered their ability to audit climate change and ocean acidification issues in the marine environment (e.g., an SAI's mandate may not specifically include environmental auditing or may limit the

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scope of the SAI's authority to auditing the central government). For example, the SAI of the Netherlands reported that its mandate is limited to auditing the central government but that some important government actions—notably, those related to coastal flooding defense projects—are also undertaken by lower levels of government. To help mitigate this limitation, the SAI said that it could audit national entities that supervise regional and local governments and could also cooperate with regional and local auditors.

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Appendix I

Objectives, Scope, and Methodology

Objectives

- 1) Identify and describe potential effects of climate change and ocean acidification on the marine environment and examples of government efforts to adapt to these effects;
- 2) Provide information on previous SAI audit work on issues related to climate change and ocean acidification in the marine environment; and
- 3) Describe the challenges SAIs face in auditing these issues and identify approaches that can help SAIs overcome these challenges.

Scope and Methodology

Objective One – To address this objective, the project team:

- Reviewed literature published by prominent international institutions (such as the IPCC and the World Bank) and consulted with officials from the 10 SAIs serving on the project Subcommittee. In doing so, the project team sought to include effects germane to various regions of the world and to both developed and developing countries; it did not attempt to include the full universe of potential effects.
- Reviewed SAI audits and information published by various countries' national institutions (such as environmental ministries), regional sources (such as the European Climate Adaptation Platform), and international bodies (such as the United Nations), to obtain examples of adaptation efforts.

Objective Two – To address this objective, the project team:

- Identified and examined 37 audits published between 2002 and 2015 that addressed, at least in part, government efforts to understand and adapt to the effects of climate change and ocean acidification on the marine environment.¹⁰¹ 34 of these audits were national reports published by individual SAIs from 20 countries, including both developed and developing countries from various geographic regions. In addition, 3 of the audits were collaborative reports that involved SAIs from multiple countries. The team identified

¹⁰¹The 37 audits examined by the project team are not intended to represent the entire universe of relevant audits published between 2002 and 2015, as, for example, the project team limited its analysis to audits that had at least some information available in English or Spanish.

the 37 audits by contacting SAI officials from the 10 Subcommittee members and other SAI partners, as well as by researching SAIs' websites and the WGEA website.¹⁰² Appendix II presents a list of the 37 audits examined for this project.

- Developed audit matrices for selected audits to highlight examples of SAIs auditing climate change and ocean acidification issues in the marine environment. As part of this effort, the project team contacted officials from the SAIs that had performed the highlighted audits. These officials provided written responses with additional information and important insights on the SAIs' experiences conducting these audits, the challenges they faced, and the impact that the audits had in their home countries.

Objective Three – To address this objective, the project team:

- Used the WGEA Secretariat's 2014 survey of INTOSAI members to obtain information from dozens of SAIs on the challenges they face in auditing climate change and ocean acidification issues in the marine environment. The survey asked SAIs to identify (1) any audits they had completed that addressed, at least in part, issues related to the effects of climate change and ocean acidification in the marine environment; (2) any challenges the SAIs faced in auditing these issues; and (3) any approaches SAIs found useful in overcoming these challenges. The project team analyzed the survey results to identify common challenges shared by multiple SAIs to focus on in this report.
- Analyzed the collection of 37 audits discussed above to identify challenges presented in those reports.
- Contacted officials from several SAIs to obtain information on the specific challenges they experienced conducting the audits highlighted in chapter 2 and the steps they took to overcome these challenges.
- Reviewed performance auditing literature and WGEA guidance documents to help identify additional approaches that can help SAIs overcome the challenges they face in auditing these issues.

¹⁰²See <http://www.environmental-auditing.org/> to access the WGEA's website, which includes a searchable database of environmental audits from around the world.

Appendix II

List of Audits Analyzed for this Report

The following table lists the 37 audits analyzed for this report, organized by SAI. In some cases, the audit titles presented in the table are approximate English translations from the original publication language.

Table 1: List of Analyzed Audits

SAI(s)	Audit Title	Year of Publication	Link to Report (Active as of July 16, 2015)
Australia	The Conservation and Protection of National Threatened Species and Ecological Communities	2007	Report (English)
Brazil	Adaptation Measures for Climate Change Scenarios in the Brazilian Coastal Zones	2009	Report (Portuguese) Summary (English)
	Marine Protected Areas	2012	Report (English)
	A Study of Managing Fisheries for Sustainability	2011	Report (English)
Canada	Adapting to Climate Impacts	2010	Report (English)
	Managing Severe Weather Warnings— Environment Canada	2008	Report (English)
	Adapting to the Impacts of Climate Change	2006	Report (English)
Costa Rica	Management of the Environmental Authorities in the Implementation of the Commitments of the United Nations Framework Convention on Climate Change	2010	Report (Spanish)
Denmark	Report to the Public Accounts Committee on Denmark's Performance in the Arctic	2013	Report (English)
Federated States of Micronesia	Audit on the Management of the Impacts of Climate Change on Food Security in the FSM (Fiscal Year 2010 – 2012)	2013	Report (English)
Fiji	Climate Change Adaptation and Disaster Risk Reduction Strategies	2013	Report (English)

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SAI(s)	Audit Title	Year of Publication	Link to Report (Active as of July 16, 2015)
France	Lessons from the 2010 Floods on the Atlantic Coast (Xynthia) and in the Var	2012	Report (French) Summary (English)
Honduras	Implementation of Commitments Under the United Nations Framework Convention on Climate Change	2010	Report (Spanish)
India	Salinity Ingress Prevention Programme	2010	Report (English)
Indonesia	Performance Audit on Indonesia Coral Reef Ecosystem Protection	2012	N/A
Kuwait	Evaluating the Potential Impacts on the Marine Environment	2002	Summary (English)
Malta	Safeguarding Malta's Groundwater	2012	Report (English)
Netherlands	Adaptation to Climate Change: National Strategy and Policy	2012	Report (English)
	Weak Links in Coastal Defences Programme	2009	Summary (English)
Romania	Protection of the Black Sea Against Pollution	2010	N/A
South Africa	Report of the Auditor-General to Parliament on the Status of Climate Change Initiatives in South Africa	2010	Report (English)
Thailand	Audit of Coastal Erosion Management and Protection	2008	N/A
Tuvalu	Performance Audit on Coastal Protection Management in Tuvalu	2014	N/A
United Kingdom	Strategic Flood Risk Management	2014	Report (English)
	Flood Risk Management in England	2011	Report (English)
	Adapting to Climate Change	2009	Report (English)
	Building and Maintaining River and Coastal Flood Defences in England	2007	Report (English)

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SAI(s)	Audit Title	Year of Publication	Link to Report (Active as of July 16, 2015)
United States	Ocean Acidification: Federal Response Under Way, but Actions Needed to Understand and Address Potential Impacts	2014	Report (English)
	Climate Change: Energy Infrastructure Risks and Adaptation Efforts	2014	Report (English)
	Climate Change: Future Federal Adaptation Efforts Could Better Support Local Infrastructure Decision Makers	2013	Report (English)
	Climate Change Adaptation: Strategic Federal Planning Could Help Government Officials Make More Informed Decisions	2009	Report (English)
	Climate Change: Agencies Should Develop Guidance for Addressing the Effects on Federal Land and Water Resources	2007	Report (English)
	Climate Change: Financial Risks to Federal and Private Insurers in Coming Decades Are Potentially Significant	2007	Report (English)
	Alaska Native Villages: Most Are Affected by Flooding and Erosion, but Few Qualify for Federal Assistance	2003	Report (English)
Collaborative Audits Involving Multiple SAIs	Report of the Coordinated Pacific Region Performance Audit: Climate Change Adaptation and Disaster Risk Reduction Strategies and Management (SAIs participating under PASAI – Cook Islands, Federated States of Micronesia (the national audit office and state audit offices from Kosrae and Pohnpei), Fiji, Palau, Samoa, and Tuvalu)	2015	Report (English)
	Adaptation to Climate Change – Are Governments Prepared? (SAIs participating under EUROSAI – Austria, Bulgaria, Cyprus, European Court of Auditors, Malta, Netherlands, Norway, Russia, and Ukraine)	2012	Report (English)
	Coordinated Performance Audit on the Implementation of the United Nations Framework Convention on Climate Change (SAIs participating under OLACEFS – Argentina, Brazil, Colombia, Costa Rica, El Salvador, Honduras, Panama, Paraguay, and Peru)	2011	Report (English)

Appendix III

Additional Resources that Can Assist SAIs in Auditing Climate Change and Ocean Acidification Issues in the Marine Environment

In addition to the approaches discussed in chapter 3, the project team identified additional resources that can assist SAIs in auditing climate change and ocean acidification issues in the marine environment.

WGEA Guidance Documents and Other Audit-Related Training Materials

WGEA has issued several guidance documents that contain information about audit approaches that SAIs may find useful in auditing climate change and ocean acidification issues in the marine environment, including:

- *Auditing Water Issues: An Examination of SAIs' Experiences and the Methodological Tools They Have Successfully Used* (June 2013).
- *Auditing the Government Response to Climate Change: Guidance for Supreme Audit Institutions* (June 2010).
- *Auditing Sustainable Fisheries Management: Guidance for Supreme Audit Institutions* (June 2010).
- *Auditing Biodiversity: Guidance for Supreme Audit Institutions* (November 2007).

WGEA, as well as individual SAIs, have also developed audit-related training materials that SAIs may find helpful in auditing climate change and ocean acidification issues in the marine environment. For example:

- WGEA, Climate Change Audit E-Learning Course: <http://www.environmental-auditing.org/Home/FocusonClimateChange/ELearningCourse/tabid/244/Default.aspx>
- Comptroller and Auditor General of India, *Environment and Climate Change: Auditing Guidelines*, 2010.

List of Selected International and National Websites

Numerous international and national organizations maintain websites that include information—including links to data, scientific summaries, and assessments—that SAIs may find useful in auditing climate change and ocean acidification issues in the marine environment. The following list highlights some of these online resources.

- Arctic Monitoring and Assessment Programme: <http://www.amap.no/>
- European Climate Adaptation Platform: <http://climate-adapt.eea.europa.eu/home>
- European Commission Climate Action: <http://ec.europa.eu/clima/>
- European Environment Agency: <http://www.eea.europa.eu/themes/climate> and http://www.eea.europa.eu/themes/coast_sea
- Food and Agriculture Organization of the United Nations: <http://www.fao.org/fisheries/en/>
- Global Climate Observing System: <http://www.wmo.int/pages/prog/gcos/index.php?name=AboutGCOS>
- Global Ocean Acidification Observing Network: <http://www.goa-on.org/>
- Global Ocean Observing System: <http://www.ioc-goos.org/>
- Intergovernmental Panel on Climate Change: <http://www.ipcc.ch/>
- Kyoto Protocol: http://unfccc.int/kyoto_protocol/items/2830.php
- Ocean Acidification International Coordination Centre: <http://www.iaea.org/ocean-acidification/page.php?page=2181>
- United Kingdom (Ocean Acidification Research Programme): <http://www.oceanacidification.org.uk/>
- United Nations Atlas of the Oceans: <http://www.oceansatlas.org/>
- United Nations Environment Programme: <http://www.unep.org/climatechange/>
- United Nations Framework Convention on Climate Change: <http://unfccc.int/2860.php>
- United States (Global Change Research Program): <http://www.globalchange.gov/>
- United States (Interagency Working Group on Ocean Acidification): <http://oceanacidification.noaa.gov/IWGOA.aspx>

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- United States (Ocean Acidification Program, National Oceanic and Atmospheric Administration): <http://oceanacidification.noaa.gov/>
- World Bank: <http://www.worldbank.org/en/topic/climatechange>

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Appendix IV

Bibliography

Arctic Monitoring and Assessment Programme. *AMAP Assessment 2013: Arctic Ocean Acidification*. Oslo, Norway: 2013.

Asian Development Bank. *The Economics of Climate Change in the Pacific*. Mandaluyong City, Philippines: 2013.

European Commission. *A Sustainable Coastal Defence Re-Creating Wildlife Habitats Alongside Economic Farming Methods, Abbott's Hall Farm – UK*. European Commission OURCOAST Integrated Coastal Zone Management Database. Accessed March 17, 2015. <http://ec.europa.eu/ourcoast/index.cfm?menuID=6&articleID=5>.

EUROSAI. *Adaptation to Climate Change – Are Governments Prepared?* Oslo, Norway: 2012.

Federal Court of Accounts of Brazil. *Adaptation Measures for Climate Change Scenarios in the Brazilian Coastal Zones* (report is in Portuguese). Brazil: 2009.

Food and Agriculture Organization of the United Nations. *Marine Protected Areas: Country Case Studies on Policy, Governance and Institutional Issues*. FAO Fisheries and Aquaculture Technical Paper No. 556/1. Rome, Italy: 2011.

Food and Agriculture Organization of the United Nations. *The State of World Fisheries and Aquaculture: Opportunities and Challenges*. Rome, Italy: 2014.

Gambia Department of State for Forestry and the Environment. *Gambia National Adaptation Programme of Action on Climate Change*. Banjul, Gambia: 2007.

Ho, Yudith and Rieka Rahadiana. *Sinking Jakarta Starts Building Giant Wall as Sea Rises*. Bloomberg Business: November 11, 2014. Accessed April 28, 2015. <http://www.bloomberg.com/news/articles/2014-11-11/sinking-jakarta-starts-building-giant-wall-as-sea-rises-cities>.

Honduras Superior Court of Auditors. *Implementation of Commitments Under the United Nations Framework Convention on Climate Change* (report is in Spanish). Tegucigalpa, Honduras: 2010.

Integrated System for the Safeguard of Venice and Its Lagoon Against Flooding (MOSE). European Climate Adaptation Platform. Accessed June 10, 2015. http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=3334.

International Organization for Standardization. *Risk Management - Principles and Guidelines (Standard 31000:2009)*. 2009.

INTOSAI WGEA. *Auditing the Government Response to Climate Change: Guidance for Supreme Audit Institutions*. 2010.

INTOSAI WGEA. *Auditing Sustainable Fisheries Management: Guidance for Supreme Audit Institutions*. 2010.

INTOSAI WGEA. *Coordinated International Audit on Climate Change: Key Implications for Governments and their Auditors*. 2010.

INTOSAI WGEA. *Auditing Water Issues: An Examination of SAIs' Experiences and the Methodological Tools They Have Successfully Used*. 2013.

IPCC. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Summary for Policymakers)*. Christopher B. Field et al., Eds. Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014.

IPCC. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 5: Coastal Systems and Low-Lying Areas)*. Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014.

IPCC. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 6: Ocean Systems)*. Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014.

IPCC. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 14: Adaptation Needs and Options)*. Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014.

IPCC. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 24: Asia)*. Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014.

IPCC. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 25: Australasia)*. Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014.

IPCC. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 27: Central and South America)*. Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014.

IPCC. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 28: Polar Regions)*. Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014.

IPCC. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 29: Small Islands)*. Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014.

IPCC. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 30: The Ocean)*. Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014.

IPCC. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Annex II: Glossary)*. Cambridge, United Kingdom and New York, United States: Cambridge University Press, 2014.

IPCC. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Summary for Policymakers)*. Core Writing Team, R.K. Pachauri, and L.A. Meyer, Eds. Geneva, Switzerland: 2014.

Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds. *Climate Change Impacts in the United States: The Third National Climate Assessment*. United States Global Change Research Program. Washington, D.C., United States: 2014.

Munday, Philip L., Danielle L. Dixson, Mark I. McCormick, Mark Meekan, Maud C.O. Ferrari, and Douglas P. Chivers. "Replenishment of Fish Populations Is Threatened By Ocean Acidification." *Proceedings of the National Academy of Sciences of the United States of America*, vol. 107, no. 29 (2010).

Munday, Philip L., Alistair J. Cheal, Danielle L. Dixson, Jodie L. Rummer, and Katharina E. Fabricius. "Behavioural Impairment in Reef Fishes Caused By Ocean Acidification at CO₂ Seeps." *Nature Climate Change*, vol. 4, no. 6 (2014).

National Audit Office of Malta. *Safeguarding Malta's Groundwater*. Malta: 2012.

National Research Council. *Science and Decisions: Advancing Risk Assessment*. Washington, D.C., United States: 2009.

National Research Council. *Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean*. Washington, D.C., United States: 2010.

Netherlands Court of Audit. *Weak Links in Coastal Defences Programme*. The Hague, Netherlands: 2009.

Netherlands Court of Audit. *Adaptation to Climate Change: National Strategy and Policy*. The Hague, Netherlands: 2012.

Office of the Auditor General of Canada. "Adapting to Climate Impacts," *Report of the Commissioner of the Environment and Sustainable Development to the House of Commons*. Ottawa, Canada: 2010.

Office of the Auditor General of Canada. "A Study of Managing Fisheries for Sustainability," *Report of the Commissioner of the Environment and Sustainable Development*. Ottawa, Canada: 2011.

Office of the Auditor General of Canada. "Marine Protected Areas," *Report of the Commissioner of the Environment and Sustainable Development*. Ottawa, Canada: 2012.

Office of the Auditor General of the Republic of Fiji. *Climate Change Adaptation and Disaster Risk Reduction Strategies*. Fiji: 2013.

Office of the Auditor-General of Tuvalu. *Performance Audit on Coastal Protection Management in Tuvalu*. Vaiaku, Funafuti, Tuvalu: 2014.

Office of the National Public Auditor of the Federated States of Micronesia. *Audit on the Management of the Impacts of Climate Change on Food Security in the FSM (Fiscal Year 2010-2012)*. Palikir, Pohnpei, FSM: 2013.

Organization of Latin American and Caribbean Supreme Audit Institutions Special Technical Commission on Environment. *Coordinated Performance Audit on the Implementation of the United Nations Framework Convention on Climate Change*. 2011.

PASAI. *Report of the Coordinated Pacific Region Performance Audit: Climate Change Adaptation and Disaster Risk Reduction Strategies and Management*. 2015.

Steffen, Will, John Hunter, and Lesley Hughes. *Counting the Costs: Climate Change and Coastal Flooding*. Australia: Climate Council of Australia, 2014.

The Audit Board of the Republic of Indonesia. *Performance Audit on Indonesia Coral Reef Ecosystem Protection*. Indonesia: 2012.

Rowling, Megan. *Solomons Town First in Pacific to Relocate Due to Climate Change*. London, United Kingdom: Thomson Reuters Foundation, August 15, 2014. Accessed October 22, 2014. <http://www.reuters.com/article/2014/08/15/us-foundation-climatechange-solomons-idUSKBN0GF1AB20140815>.

United Nations Department of Economic and Social Affairs. *How Oceans- and Seas-Related Measures Contribute to the Economic, Social and Environmental Dimensions of Sustainable Development: Local and Regional Experiences*. 2014.

United Nations Environment Programme, African Ministerial Conference on the Environment, and Climate Analytics. *Africa's Adaptation Gap Technical Report: Climate-Change Impacts, Adaptation Challenges and Costs for Africa*. 2013.

United States Army Corps of Engineers. *North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk*. United States: 2015.

United States Federal Emergency Management Agency. *Hazard Mitigation Assistance Guidance: Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, and Flood Mitigation Assistance Program*. Washington, D.C., United States: 2015.

United States Government Accountability Office. *Results-Oriented Government: Practices That Can Help Enhance and Sustain Collaboration among Federal Agencies*. GAO-06-15. Washington, D.C., United States: 2005.

United States Government Accountability Office. *Managing for Results: Key Considerations for Implementing Interagency Collaborative Mechanisms*. GAO-12-1022. Washington, D.C., United States: 2012.

United States Government Accountability Office. *Standards for Internal Control in the Federal Government*. GAO-14-704G. Washington, D.C., United States: 2014.

United States Government Accountability Office. *Ocean Acidification: Federal Response Under Way, but Actions Needed to Understand and Address Potential Impacts*. GAO-14-736. Washington, D.C., United States: 2014.

United States Government Accountability Office. *Climate Change: Better Management of Exposure to Potential Future Losses Is Needed for Federal Flood and Crop Insurance*. GAO-15-28. Washington, D.C., United States: 2014.

United States Government Accountability Office. *High-Risk Series: An Update*. GAO-15-290. Washington, D.C., United States: 2015.

Washington State Blue Ribbon Panel on Ocean Acidification. *Ocean Acidification: From Knowledge to Action, Washington State's Strategic Response*. H. Adelman and L. Whitely Binder, Eds. Publication no. 12-01-015. Olympia, United States: Washington Department of Ecology, 2012.

World Bank. *Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience*. A Report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics. Washington, D.C., United States: 2013.