

APPENDIX A— OVERVIEW OF THE NATIONAL ASSESSMENT

Rationale and Institutional History

The influence of climate permeates life and lifestyles in the United States. Year-to-year variations are reflected in such things as the number and intensity of storms, the amount of water flowing in our rivers, the extent and duration of snow cover, and the intensity of waves that strike our coastal regions. Science now suggests that human activities are causing our climate to change. Although details are still hazy about the extent of changes to come in each region of the country, changes are starting to become evident. Temperatures have increased in many areas, snow cover is not lasting as long in the spring, and total precipitation is increasing, with more rainfall occurring in intense down-pours. These changes appear to be affecting plants and wildlife. There is evidence of a longer growing season in northern areas and changing ranges for butterflies and other species. The international assessments of the Intergovernmental Panel on Climate Change (<http://www.ipcc.ch>) project that these changes will increase over the next 100 years.

The Global Change Research Act of 1990 (Public Law 101-606) gave voice to early scientific findings that human activities were starting to change the global climate, reporting that “(1) Industrial, agricultural, and other human activities, coupled with an expanding world population, are contributing to processes of global change that may significantly alter the Earth’s habitat within a few generations; (2) Such human-induced changes, in conjunction with natural fluctuations, may lead to significant global warming and thus alter world climate patterns and increase global sea levels. Over the next century, these consequences could adversely affect world agricultural and marine production, coastal habitability, biological diversity, human health, and global economic and social well-being.”

To address these issues, Congress established the U.S. Global Change Research Program (USGCRP) and instructed federal research agencies to cooperate in developing and coordinating “a comprehensive and integrated U.S. research program that will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.” Furthermore, Congress mandated that the USGCRP “shall prepare and submit to the President and the Congress an assessment which:

- integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings;
- analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and,
- analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.”

Objectives of the Assessment

The USGCRP’s National Assessment of the Potential Consequences of Climate Variability and Change is being conducted under the provisions of this Act, and seeks to answer questions about why we should care about, and how we might effectively prepare for, climate variability and change.

The overall goal of the National Assessment is to analyze and evaluate what is known about the potential consequences of climate variability and change for the nation, in the context of other pressures on the public, the environment, and the nation’s resources. The National Assessment process has been broadly inclusive, soliciting and accepting public and private input from academia, government, and interested citizens. Starting with broad public concerns about the environment, the Assessment is exploring the degree to which existing and future variation and change in climate might affect issues that people care about. The Assessment has focused on regional concerns around the U.S. and national concerns for particular sectors, relying upon a short list of questions to guide the process; these questions are:

- What are the current environmental stresses and issues that form the backdrop for potential additional impacts of climate change?
- How might climate variability and change exacerbate or ameliorate existing problems? What new problems and issues might arise?
- What are the priority needs for research and information that can better prepare the public and policymakers to reach informed decisions about climate variability and change? What research is most important to complete over the short term, and over the long term?

- What coping options exist that can build resilience to current environmental stresses, and possibly also lessen the impacts of climate change?

Structure of the Assessment

The National Assessment has three major components:

- **Regional analyses**— these consist of workshops and assessments conducted to identify and define the potential consequences of climate variability and change in regions spanning the U.S. Twenty workshops were held around the country, with the Native Peoples/ Native Homelands Workshop being national in scope rather than regional. To date, sixteen workshop groups have prepared assessment reports that address the particular interests of people in their regions by focusing on regional patterns and textures of changes where people live. Most workshop reports are already available at <http://www.nacc.usgcrp.gov>, with the final reports becoming available in late 1999.
- **Sectoral analyses**— these consist of workshops and assessments carried out to characterize the potential consequences of climate variability and change for broad sectors that encompass environmental, economic, and societal concerns. The sectoral reports analyze how the consequences in each region affect the nation, making the reports widely interesting and national in scope. The sectors studied in the first phase of the ongoing National Assessment include agriculture, forests, human health, water, and coastal areas and marine resources. Publications and assessment reports became available starting in late 1999.
- **The National Overview**— which consists of a summary and integration of findings from the regional and sectoral studies, and conclusions about the importance of climate variability and change for the United States. The National Assessment Synthesis Team was responsible for this report, which became available in the spring of 2000.

Each of the regional, sectoral, and synthesis activities was led by a team of experts from the public and private sectors, including university and government personnel and a wide spectrum of stakeholders from our communities. Their reports went through an extensive review process involving experts and other interested stakeholders. The assessment process is supported cooperatively by USGCRP agencies including the Departments of Agriculture, Energy, Health and Human Services, Interior, and Commerce (National Oceanic and Atmospheric Administration), as well as the Environmental Protection Agency, the National Aeronautics and Space Administration, and the National Science Foundation. Through this collaboration, the

USGCRP hopes to cultivate broad understanding of climate-related issues and their importance for the nation, and a full range of perspectives about how best to respond.

Extensive information about the Assessment, about members of assessment teams, and about links to activities in various regions and sectors, is available over the Web at <http://www.nacc.usgcrp.gov>, or by inquiry to the Global Change Research Information Office / P.O. Box 1000 / 61 Route 9W / Palisades, New York 10964.

*Prepared by Michael MacCracken
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Revised October 5, 1999*

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National Marine Fisheries Service
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¹ Mr. Mark resigned from the Steering Committee upon leaving Outrigger in the summer of 2000.

² In Mr. Karnella's absence, the Pacific Islands Area Office was represented by Mr. Kelvin Char.

APPENDIX D— WORKSHOP ON CLIMATE AND ISLAND COASTAL COMMUNITIES— NOVEMBER 2000

Workshop Summary

November 6-8, 2000

East-West Center, Honolulu, Hawai'i

In November 2000, the East-West Center hosted an exciting, three-day Workshop on Climate and Island Coastal Communities that provided a unique forum for business leaders, scientists, government representatives, public interest groups and community leaders to jointly explore opportunities to address the significant challenges that climate variability and change present to Hawai'i and other island jurisdictions throughout the Pacific and the Caribbean. The Workshop was organized as part of a Pacific Islands Regional Assessment project funded by the National Science Foundation (NSF), on behalf of NSF, the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration and the U.S. Department of the Interior. The results of this project will provide a Pacific regional contribution to the first U.S. National Assessment of the Consequences of Climate Variability and Change; the National Assessment was organized under the auspices of the U.S. Global Change Research Program and the White House Office of Science and Technology Policy.

The November 2000 Workshop was designed to achieve two mutually-supportive objectives:

- To develop a more complete understanding of the regional consequences of climate variability and change for Pacific Island jurisdictions in the context of other economic, social and environmental stresses; and
- To initiate and sustain a dialogue among scientists, governments, businesses and communities in the Pacific region that promotes use of climate information to support practical decision-making.

As EWC President Charles Morrison noted in his letter of welcome to Workshop participants, “climate variability and change, like so many critical issues facing the Asia-Pacific Region, require creative approaches that bring governments, businesses, communities and scientists together in innovative, new partnerships.” The theme of sustaining critical partnerships was reflected throughout the Workshop and provided the focus for an inspirational closing keynote address by Puanani Burgess.

Rather than the traditional approach of identifying and quantifying impacts, the Workshop was organized around

the concept of climate vulnerability. This conceptual framework enabled participants to explore not only issues of climate sensitivity and exposure but also the ability of communities, ecosystems, and businesses to respond (adapt) to climate impacts. Reflecting this focus on identifying and promoting appropriate action, most of the Workshop deliberations took place in highly-interactive working-group discussions of the implications of climate variability and change for key aspects of island life; these include:

- providing access to fresh water;
- protecting public health;
- ensuring public safety and protecting community infrastructure;
- sustaining tourism and agriculture as key economic sectors; and,
- promoting wise use of coastal and marine resources.

In each of these areas, Workshop participants provided valuable insights into how Pacific Island jurisdictions can reduce climate sensitivity and exposure and enhance their adaptive capacity — build resilience - to the significant challenges presented by climate variability and change. Detailed findings and recommendations in each of these critical areas are being incorporated into the Pacific Islands Regional Assessment report scheduled to be completed in spring 2001.

EWC Climate Project Coordinator Eileen Shea has summarized a number of important general findings that emerged from the Workshop. First is the strong endorsement of a commitment to continuing a Pacific Islands climate dialogue that engages experts from all knowledge groups— each bringing its own unique insights and experience to the table in a joint effort to understand and respond to a shared challenge. Establishing and sustaining these critical partnerships in research, dialogue and education emerged throughout the Workshop as the fundamental key to effectively responding to the challenges of climate variability and change. Embedded within this commitment should be the meaningful integration of traditional knowledge and practices into the paradigm of western science and technology. Kumu Hula John Ka'imikaua set the stage for this important concept in his keynote presentation of story, chant and dance, which provided exciting examples of the insights that can be drawn from traditional knowledge of weather and climate

in the Native Hawaiian community. Other key findings included recommendations related to:

- Enhancing efforts to interpret and communicate climate information;
- Pursuing proactive (rather than reactive) policy options with a sustained commitment to adaptation and integration of climate information into planning, decision-making and policies at all levels of government;
- Using climate information to address today's problems today— e.g., responding to the dramatic year-to-year climate fluctuations like the 1997–1998 El Niño;
- Recognizing the special characteristics of island communities, including their unique natural and cultural assets, the limitations imposed by their geographic size and isolation, and their dependence on critical natural resources (e.g., coral reefs) and climate-sensitive economic sectors (e.g., agriculture and tourism);
- Addressing the consequences of extreme events (e.g., changes in patterns of droughts and tropical storms) as well as long-term trends (e.g., rising sea level); and,
- Filling critical information gaps, including the development of regional and local-scale information on climate processes and consequences.

The November 2000 Workshop on Climate and Island Coastal Communities reflected an emerging paradigm of climate (and other environmental) assessments as a sustained process that combines scientific exploration with an effective science<>policy dialogue. This paradigm suggests that, in a practical sense, a commitment to a climate assessment mission means a commitment to supporting the emergence of a climate information system designed to meet the needs of decision-makers. As EWC President Charles Morrison noted in his letter of welcome, “The Workshop’s approach of combining research, dialogue and education mirrors the mission of the East-West Center itself, supporting the emergence of such new partnerships in progress toward an Asia-Pacific community committed to shared learning and joint problem-solving.”

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Workshop Agenda

*Workshop on Climate and Island Coastal Communities
November 6-8, 2000*

MONDAY, NOVEMBER 6 (PLENARY)

- | | |
|------------|--|
| 8:00 a.m. | Workshop Registration
Continental Breakfast |
| 9:00 a.m. | Opening Plenary
Oli Aloha
Welcome
Opening Remarks

Opening Keynote:
Huli Ka Lani Kanu Pono Ka Honua
“When the Heavens Change, the Earth
is Planted Accordingly”
<i>Kumu John Ka'imikaua and
Halau Kukunaokala</i> |
| 10:30 a.m. | Break |
| 11:00 a.m. | Overview of Workshop Objectives and
Organization
<i>Eileen L. Shea – East West Center</i> |
| 11:15 a.m. | The Concept of Vulnerability
<i>Ricardo Alvarez – International
Hurricane Center</i> |
| 12:15 p.m. | Lunch (Imin Center Garden Level)
Video Presentation:
A Mau A Mau: To Continue Forever |
| 1:30 p.m. | <i>The Honorable Neil Abercrombie:
U.S. House of Representatives</i> |
| 1:45 p.m. | Discussion of Working Group Structure
and Goals
<i>Mike Hamnett— Social Science Research
Institute
Eileen Shea
Ricardo Alvarez</i> |
- Anticipated Goals and Products -Why are we here?
 - Introduction of Working Group Topics/Key Issues
 - Access to Fresh Water
 - Protecting Public Health

- Ensuring Public Safety in Extreme Events and Protecting the Built Environment/Community Infrastructure
- Sustaining Tourism and Agriculture
- Promoting Wise Use of Coastal and Marine Resource

5:30 p.m. Working Groups Adjourn

5:30-6:30 p.m. OPTIONAL—Working Group Chairs, Rapporteurs and Workshop Chairs meet briefly]

7:00 p.m. Workshop Banquet (Hawaiian Regent Hotel)

Overview of Key Working Group Questions

- What systems, activities, communities (and populations) are particularly sensitive to climate and how?
- How might we respond to enhance the adaptive capacity of these systems, activities communities (and populations)?
- What information/research is needed to reduce sensitivity or enhance adaptive capacity (build resilience)?
- How can information about climate be used to enhance planning, policy formulation and decision-making?
- What cooperative partnerships could be pursued to enhance adaptive capacity?

WEDNESDAY, NOVEMBER 8 (PLENARY)

8:30–10 a.m. Continental Breakfast Available

Working Group Chairs and Rapporteurs complete reports individually

10:30 a.m. Workshop Convenes in Plenary Summary of Working Group Findings & Recommendations (approx. 15 minute presentations followed by 15 minutes general discussion; complete three before lunch)

2:45 p.m. Break

3:15 p.m. Overview of Climate Change Scenarios for Workshop Deliberations
Tony Barnston:
International Research Institute for Climate Prediction

12:00 noon Lunch Presentation:
Islands Hanging in the Balance:
Testimonials from Yap
(Eric Metzgar, Triton Films)

4:00–5:30 p.m. Convene in Working Groups (Introductions, summary of key issues, work plan)

1:30 p.m. Complete Working Group Reports

3:00 p.m. Afternoon Tea

6:15–8:30 p.m. Opening Reception (Waikiki Aquarium)

3:30 p.m. Summary Remarks and Plenary Discussion
Ricardo Alvarez
Mike Hammett
Eileen L. Shea

TUESDAY, NOVEMBER 7 (WORKING GROUPS)

8:00 a.m. Continental Breakfast

4:30 p.m. Closing Keynote: Sustaining Critical Partnerships
Puanani Burgess

9:00 a.m. Working Groups Reconvene

12:00 (noon) Convene in Plenary for Quick Updates and Identification of Issues/Problems (Boxed Lunches Provided)

5:15 p.m. Closing Ceremonies

5:30–7:30 p.m. Closing Reception (Imin Garden Level)

1:30 p.m. Working Groups Reconvene

Workshop Steering Committee

Workshop on Climate and Island Coastal Communities

Cheryl L. Anderson
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International Hurricane Center
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Workshop on Climate and Island Coastal Communities

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³ These individuals were responsible for leading discussions of vulnerability in each of the six key activity areas addressed during the November Workshop; the reports of their deliberations provided a foundation for the final Pacific Islands Regional Assessment Report.

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APPENDIX E— WORKSHOP ON THE CONSEQUENCES OF CLIMATE VARIABILITY AND CHANGE FOR HAWAI‘I AND THE PACIFIC: CHALLENGES AND OPPORTUNITIES— MARCH 1998

Workshop Summary

March 3–6, 1998

East-West Center in Honolulu, Hawai‘i

This document provides a brief summary of the Workshop on the Consequences of Climate Variability and Change for the Hawai‘i-Pacific Region: Challenges and Opportunities. The Workshop was organized under the auspices of the White House Office of Science and Technology Policy and the U.S. Global Change Research Program as part of the initial phase of the first U.S. National Assessment of the Consequences of Climate Variability and Change. Additional details on the history, rationale, objectives and organization of the Workshop can be found in the Workshop Background Paper generated as a supplement to this summary. Following is a brief summary of the Workshop deliberations.

Objectives and Organization

The March 1998 Workshop was designed to provide representatives of business, government, public interest groups and the scientific community with an opportunity to:

- Initiate a long-term, interactive dialogue on the sensitivity of communities, businesses and ecosystems to climate change; and
- Explore opportunities for use of new scientific information to adapt to or mitigate the consequences of those changes.

During the opening plenary session on March 3, Workshop participants were provided with a number of individual and panel presentations designed to address what climate variability and change means for the Pacific Region from three points of view:

- A climate system perspective;
- A community planning and economic development perspective; and,
- A habitat and natural resource perspective.

On the second day of the Workshop, participants met in small working groups to discuss climate-related vulnerabilities in six areas: fisheries; agriculture; community planning, infrastructure and economic development; water resources; biodiversity and endangered species; and public health and safety. On the third day of the Workshop, working-group

participants reconvened to discuss response strategies and develop recommendations for future action. Key findings and recommendations from each working group were presented in plenary during the final day of the Workshop, after which the Chair closed the Workshop with a discussion of common themes and next steps.

Plenary Presentations

Opening ceremonies on Monday, March 3 included video presentations from Vice President Al Gore and Senator Daniel K. Inouye (D-HI) and written statements from Senator Daniel K. Akaka (D-HI), Representative Neil Abercrombie (D-HI) and Representative Patsy T. Mink (D-HI). Their comments highlighted the vulnerability of the Pacific Region to the consequences of climate variability and change, took note of the important role that research about the Region plays in understanding local, regional and global climate processes and impacts, and commended the Workshop organizers, sponsors and participants for their commitment and leadership.

During the opening plenary, the Honorable Maizie Hirono, Lieutenant Governor of the State of Hawai‘i, welcomed Workshop participants and highlighted the importance of establishing an effective connection between the private sector and scientists to help address issues related to climate variability and change. The Lieutenant Governor noted that climate variability and change was a topic of great urgency for the Pacific and noted that there were “few scientific efforts of greater moment” than emerging regional assessment programs like the one the Workshop represented. The Lieutenant Governor highlighted some of the significant contributions that scientists and institutions in Hawai‘i have made to the understanding of climate variability and change, including sustained observations of increasing concentrations of CO₂ on Mauna Loa; leadership in national and international scientific programs (e.g. the Tropical Ocean Global Atmosphere program investigating El Niño; the Hawai‘i Ocean Time Series program designed to enhance understanding of the global carbon cycle; and the continuing efforts of the Intergovernmental Panel on Climate Change). The Lieutenant Governor then delivered a formal Proclamation from Hawai‘i Governor Benjamin Cayetano proclaiming the week of March 2–7, 1998 to be “Climate Awareness Week,” and encouraging the people of Hawai‘i and the Pacific Region to learn more about climate variability and its impact on our lives.

Dr. John A. (Jack) Gibbons, Assistant to the President for Science and Technology (and Director of the White House Office of Science and Technology Policy) presented the Keynote Address. Referring to global climate change as “perhaps the most pervasive and challenging long-term environmental issue that we face as we enter the 21st century,” Dr. Gibbons talked about the importance of understanding local consequences for ecosystems and human communities— translating a global problem into what matters on regional and local scales where “most of the significant consequences will be witnessed.” Dr. Gibbons then provided Workshop participants with an overview of climate that included:

- A historical perspective on “disruptions” in the climate system, including a look at evidence of large-scale changes such as glacial/interglacial periods and shorter-term variations such as the El Niño Southern Oscillation (ENSO) cycle in the tropical Pacific;
- Documentation of the approximately 1.0°F temperature increase observed over the past century and the concomitant rise in global sea level of approximately 4–10 inches during the same period;
- Evidence of the role of human activities in enhancing the global greenhouse effect by adding CO₂ and other greenhouse gases to the atmosphere through the burning of fossil fuels and other industrial activities;
- The consequences of year-to-year variability in the climate system, such as El Niño and the potential benefits of using emerging forecasting capabilities to support decision-making;
- Some of the potential consequences of climate change associated with increasing concentrations of greenhouse gases in the atmosphere (based on model simulations), including accelerated sea-level rise; intensification of the water cycle; and possible changes in the frequency and/or intensity of tropical storms and other extreme events; and,
- Some of the potential actions that he believes should be taken to address the challenges and opportunities presented by climate variability and change, including an increase in scientific understanding of climate change and its relationship to other stresses, particularly at regional scales; continued engagement in international policy discussions; and development and deployment of clean technologies for cost-effective reductions in greenhouse gas emissions, including identifying opportunities for U.S. leadership.

In closing, Dr. Gibbons commended Workshop participants for accepting the challenge of creating a framework for regional assessment of climate issues, and noted that the Workshop was an early step in a sustained effort to understand and cope with the consequences of climate variability and change.

A Climate System Perspective

Following Dr. Gibbons’ remarks, the Workshop heard presentations from four representatives of the scientific community:

- Fred MacKenzie (University of Hawai‘i), who provided some additional comments on the enhanced greenhouse effect and global warming;
- Gerald Meehl (National Center for Atmospheric Research), who highlighted some important patterns of climate variability and change and their consequences for the Pacific, and discussed what the future may hold based upon studies using global climate models;
- Roger Lukas (University of Hawai‘i), who addressed issues related to El Niño and other aspects of seasonal-to-interannual climate variability, and the development of an end-to-end climate prediction program for the Pacific; and,
- Charles (Chip) Guard (Water and Environment Research Institute, University of Guam), who provided examples of the practical applications of seasonal-to-interannual climate predictions based on the experiences of the Pacific ENSO Applications Center (PEAC) during the 1997–1998 El Niño.

Presentations by these panelists were designed to provide Workshop participants with a scientific overview of the climate system, including the nature of processes that determine climate variability and change on a global scale; the regional manifestations of those climate processes; emerging capabilities to forecast climate variability on seasonal and year-to-year time scales, and the potential use of this information to address practical problems; and prospects for assessing the regional consequences of longer-term climate change.

Key points raised during Dr. MacKenzie’s presentation included:

- The possible role of sulfate, soot, and other aerosol particles in producing a regional cooling effect in the Pacific, with particular attention to an anticipated increase in aerosol concentrations associated with fossil fuel emissions (SO₂), biomass burning and volcanic eruptions. In this context, Dr. MacKenzie highlighted the importance of addressing regional cooling associated with aerosols in model-based projections of climate change in the Western Pacific;
- Projections of sea level changes that would have significant consequences for Pacific Islands, including increased shoreline erosion, saltwater intrusion and a reduction in the volume of groundwater (the freshwater lens) in many islands; and

- The importance of anticipating potential “surprises” in the way the Earth’s climate system responds to global warming associated with greenhouse gases—with particular attention to potentially significant changes in ocean circulation and biological feedbacks, neither of which are adequately represented in current global climate models.

Dr. Meehl described the results of a number of studies using global climate models to highlight potentially important patterns of climate change in the Pacific, including possible changes in El Niño or the persistence of El Niño-like conditions. Using the 1997–1998 El Niño as an example, Dr. Meehl highlighted what such conditions might mean for rainfall, temperature and tropical storms throughout the Pacific. He also informed the Workshop that climate change might also affect longer-term (decadal) patterns of variability in the climate system, such as the Pacific Decadal Oscillation characterized by periods of warmer and cooler sea-surface temperatures that appear to oscillate on timescales of around twenty years, with impacts similar to those associated with the ENSO cycle.

Dr. Meehl used some of his own research on prolonged droughts in Kapingamirangi, and periods of increased tropical storm activity in American Samoa, to highlight the potentially devastating human consequences of projected climate change. Citing the effects of sea-level rise as well, Dr. Meehl suggested we may face creation of “ecological refugees”— individuals and communities forced to leave their homes as a result of changes in climate. Dr. Meehl closed by suggesting steps that could be taken in the near term, including capitalizing on emerging capabilities and early successes in the use of El Niño forecasts to support decision making; enhancing research on decadal patterns of climate variability; and conducting additional research and model-based studies to understand how and in what ways climate change might change El Niño patterns or El Niño-like conditions in the Pacific.

Dr. Roger Lukas introduced Workshop participants to the concept of “end-to-end prediction” of seasonal-to-interannual (year-to-year) climate variability, highlighting three critical elements:

- Large-scale prediction of important climate system processes and properties, such as sea-surface temperature, surface winds, rainfall, sea level, ocean currents and air temperatures;
- Assessment efforts designed to identify the impacts of climate variability, and determine the extent to which those impacts are reflected as regional stresses on resources and sectors such as water resources, fisheries, coral reefs, and public health and safety, particularly

impacts associated with tropical storms and other extreme events; and,

- The practical application of climate predictions in supporting decision-making in the public and private sectors, particularly in the Pacific Region.

In this context, Dr. Lukas provided participants with a useful primer on the ENSO cycle in the tropical Pacific, and associated changes in rainfall, winds and tropical storms; waterborne disease vectors, and ocean temperature and circulation patterns (with implications for coral reefs, fisheries and other coastal and marine resources). Dr. Lukas described the intricate interactions between the ocean and atmosphere that give rise to the ENSO cycle, and reviewed the historical record of ENSO events. He then summarized current capabilities in ENSO prediction and provided a comparison of forecasts and observations of the 1997–1998 El Niño by way of example.

Mr. Chip Guard then shared a story about forecasting drought conditions associated with the 1997–1998 El Niño, in order to provide an overview of the challenges and opportunities of using forecasts of year-to-year climate variability in the Pacific. He began with an overview of the PEAC, a joint effort involving the National Oceanic and Atmospheric Administration (through its Office of Global Programs, and the National Weather Service’s Pacific Region Office), the University of Hawai‘i (through its Social Science Research Institute, and School of Ocean and Earth Sciences and Technology), and the University of Guam’s Water and Environment Research Institute. Since 1994, PEAC has provided forecasts of El Niño for U.S.-affiliated Pacific Island jurisdictions and supported a complementary program of education and outreach designed to promote practical use of those forecasts in activities like emergency preparedness and water resource management. In describing the PEAC experience, Mr. Guard emphasized the importance of combining observations with model-based forecasts and local insights, i.e., a team effort that capitalizes on the special expertise and unique capabilities of individuals and institutions working toward a common goal— the development, provision and application of climate forecasts for the benefit of Pacific Island jurisdictions.

During his presentation, Mr. Guard highlighted a number of valuable lessons learned from the PEAC experience, including:

- The importance of forecasting not only the onset, duration and intensity of ENSO events, but also, to the extent possible, the specific impacts that might be anticipated, particularly changes in rainfall and tropical storms;

- The value of using historical analogs (i.e., comparisons with similar ENSO events in the past) to help scientists and users understand what to expect;
- The challenge and importance of making scientific information understandable, useful and usable;
- The need to develop a clear understanding of both impacts and available response options, with an eye toward understanding (and addressing) the scientific, technical, institutional and policy constraints (and opportunities) on the use of climate forecasts; and,
- The importance of sustained face-to-face interaction between scientists, forecasters and users of climate forecast information in governments, businesses and communities—a sustained dialogue that promotes shared learning and joint problem-solving.

A Community Planning and Economic Development Perspective

A second panel provided Workshop participants with a view of climate variability and change from the perspective of people who represented what the panel Chair called “users of scientific information,” noting that their livelihoods and that of their employees and customers are affected by climate variability and change. This perspective was presented by:

- Robin Campaniano (AIG Insurance Hawai‘i);
- Robert Fraser Ripp (GST Telecom Hawai‘i);
- Richard Cox, Hawai‘i State Water Commission; and,
- Richard Ha, President of Kea‘au Banana Farms.

This second panel was organized to provide an overview of some critical regional issues in community planning and economic development; particular attention was given to sectors and communities that are sensitive to climate variability and change, and the goal was to identify opportunities to improve decision-making through the use of new scientific information.

Mr. Robin Campaniano provided insights into how and why climate matters to individuals and businesses concerned with insurance. He specifically highlighted the challenges of providing property and casualty insurance in areas subject to natural hazards such as hurricanes and tropical storms. Referring specifically to wind damage from storms, Mr. Campaniano described the importance of current efforts to reduce damages— through better building codes, for example— but also noted the potential benefits associated with improving emergency planning and preparedness through incorporation of information on climate variability (particularly El Niño) and change. In this context, he suggested that the insurance industry’s interests in climate change would most likely involve issues such as:

- Hurricanes and storm surge;
- Flooding;
- Agricultural losses;
- Health effects; and,
- Economic losses from business interruptions (such as those suffered on the island of Kaua‘i following Hurricane Iniki).

Mr. Campaniano specifically mentioned the emergence of catastrophic-loss-modeling as an important new tool in the insurance sector, and suggested that incorporation of climate information and projections in those models might offer important improvements (e.g., more equitable premium prices that reflect areas of greater or lower risk, to avoid discounting or inflating the true cost of coverage). While acknowledging these opportunities, Mr. Campaniano cautioned that there are significant scientific, institutional, economic and ethical challenges associated with changes to the way in which the insurance industry does business. He noted specifically the need to address the timeliness and accuracy of climate predictions, as well as the evaluation of response options. In conclusion, he noted that it was “economically essential that we develop a more complete understanding of climate events.”

Mr. Robert Ripp provided some insights into the importance of climate information for the telecommunications industry, noting the dual role of telecommunications in both collecting data and communicating information. Mr. Ripp pointed out that telecommunications businesses are primarily concerned with avoiding service interruptions associated with disturbances such as winds. He added that understanding weather and atmospheric conditions is vital to planning decisions regarding what type of systems to install (e.g., choosing fiber optics or satellite options vs. microwave systems, which are more vulnerable to wind disturbances). Mr. Ripp noted that these could be “life or death decisions” for both companies and communities, particularly in isolated island settings. In addition to system design and planning decisions, Mr. Ripp also discussed Hurricane Iniki to highlight the potential benefit of improved weather and climate information in supporting decisions about positioning fall-back systems. In summary, he said that information about climate variability and change would be important for both strategic planning and disaster preparedness in the telecommunications sector.

Mr. Richard Cox spoke from the perspective of someone who has been involved in water resource management, providing interesting insights into how and why climate matters in that sector. He began his comments by noting that current climate conditions (including issues related to

natural variability like ENSO) are already concerns for communities and businesses, and highlighted the importance of understanding what changes are likely to occur, and what steps would be appropriate to build systems that can adjust to those changing conditions. Mr. Cox noted that weather and climate information and research are already important to the water sector (e.g., hurricane and drought forecasting and preparedness). He noted that changes in rainfall, tropical storms and other extreme events, sea-level rise, and increasing temperatures, were important issues from a water resources perspective. He also identified some related issues that could benefit from enhanced information on climate variability and change, including:

- Incorporation of information about climate-related natural hazards into planning for major new facilities and developments (e.g., information on changing patterns of tropical storms, or changes in rainfall patterns that could affect flooding and slope stability); and,
- Improved information on rainfall and water resources for agriculture, which he noted is the largest consumer of water on all Hawaiian islands except O‘ahu.

Mr. Cox noted that most decisions about water resources are based on historical rainfall data and long-term averages, and suggested that some consideration be given to incorporating emerging forecasting capabilities (like El Niño forecasts) and new insights about the possible consequences of climate change; he said information on climate variability and change might, for example, be useful in reassessing aquifer capacities. In addition, he said that exploring the direct and indirect consequences of climate variability and change could help resolve possible response conflicts by providing an opportunity to conduct “what if” scenarios to identify problem areas and review response options (such as water reuse and conservation measures). Noting that he is naturally somewhat conservative or skeptical about new ideas and projections of future conditions, he emphasized the importance of conducting more research on climate variability and change, and sustaining a dialogue among government agencies, businesses, scientists and communities in order both to anticipate what might happen and to develop effective response strategies.

Richard Ha provided Workshop participants with insights into climate and weather from the perspective of a commercial farmer in Hawai‘i. He started his presentation by highlighting the importance of agriculture’s contribution to Hawai‘i’s economy: an annual contribution of \$.5 billion in direct crop value, and a value-added contribution of \$1 billion. Mr. Ha provided a brief description of his banana farming enterprise, noting the critical importance of the

abundant rainfall that “irrigates” his Big Island farm (130 inches/year, compared to Hawai‘i’s average of 32 inches/year); this translates into 3.5 billion gallons/acre/year of “free water” for his farm. He added that when he considered expanding his activities on either the Big Island or O‘ahu (which is closer to markets), his decision “turned on water” and led him to expand his Big Island site.

Mr. Ha acknowledged that anticipation of drought is a persistent factor in farm operations, and said he recently installed an irrigation system (in-ground pipes and drip tape). This irrigation system allows him to prepare for droughts and reduce losses and, in fact, helped him minimize the effects of the dry conditions associated with the 1997–1998 El Niño. This same irrigation system can also provide him with the flexibility to diversify by growing other crops when rains are abundant. He expressed a specific interest in having access to climate forecast information (such as El Niño forecasts) to further enhance his ability to prepare for and deal with droughts and other extreme events. He went on to say that hurricanes are also an important factor in a farmer’s decisions— noting that “we expect drought and we expect to get flattened” periodically. As a result, better information about what climate variability and change might mean for hurricanes would also be useful to the agricultural sector.

A Habitat and Natural Resources Perspective

A third panel looked at the implications of climate variability and change for critical habitats and unique natural resources in Pacific Island settings. This perspective was presented by:

- Oliver Chadwick, University of California at Santa Barbara;
- Peter Vitousek, Stanford University; and,
- Ray Carter, CASAMAR, Guam.

This final panel of the opening day was organized to provide an overview of key issues related to the unique ecosystems and resources of the region, including how climate variability and change interacts with human activities such as land use to affect biodiversity; what can be learned from islands as models of climate change; and what the implications are for climate variability and change for critical resources such as water and fisheries.

Dr. Chadwick cited his work on the Big Island to offer some insights into the importance of island settings in helping to understand ecosystem processes and climate/ ecosystem interactions. He noted that climate is one of the systems that can be analyzed when studying ecosystems (along with specific organisms, topical relief, parent

material and time). He said the 'ohi'a tree is the dominant plant species in his study area, which simplifies his choice of an organism to study. And because the parent material (a lava base) is pretty much the same everywhere in the area, and as a result, time can be calculated pretty accurately by determining distance (time) from the geologic hotspot that gave rise to the Hawaiian islands, he has the opportunity to focus on determining and understanding how changes in climatic conditions might account for historic and current variations in 'ohi'a in different parts of the island; he noted in particular the value of marked changes in rainfall conditions at different elevations along the Big Island's mountain slopes.

Focusing specifically on rainfall as a key climate factor, Dr. Chadwick noted that the Big Island is characterized by diverse environmental conditions above and below the inversion layer, which lies at about 7,000 feet and marks a transition to a relative "polar desert" at the top of Mauna Kea. He also noted that there are two principal sources of rainfall that affect vegetation on the Big Island— storms carried by tradewinds that do not get over the mountains, and cyclonic storms (Kona storms) that bring rain to all parts of the island. Understanding (and comparing) the vegetation regimes that result from these two different sources of rainfall can help clarify how vegetation and ecosystems might vary in response to climate-induced changes in rainfall patterns. He cautioned, however, that his research has revealed a high variability in rainfall at some sites, and suggested that this variability might justify reconsidering concepts like "median rainfall," which is commonly used in climate-vegetation studies. Dr. Chadwick closed his remarks by suggesting that Hawai'i and Pacific Islands in general could be called a "microcosm of nature" with very few external factors to complicate studies of how and why climate matters to island ecosystems.

Dr. Peter Vitousek offered some thoughts on what his research on certain bird species in Hawai'i suggests about the consequences of climate variability and change. He began his discussion by noting that climate change is only one of a number of important factors affecting ecosystem and species change, including land-use change, biological invasions/exotic species, and biodiversity. He noted, for example, how changes in land cover associated with agricultural activity have been a factor throughout Hawai'i's history. Dr. Vitousek also emphasized the importance of understanding the interplay among these various factors as well as understanding individual factors like climate change.

He offered a specific example from his own research, which has clarified how the range of certain native bird species is now determined in part by temperature constraints on an

introduced species of mosquito that serves as a vector for a particularly virulent form of avian malaria. Populations of these birds now tend to be concentrated at higher elevations where temperatures aren't warm enough to sustain the mosquito populations. Dr. Vitousek noted that increasing temperatures associated with climate change might allow the mosquito populations to move upslope, exposing native birds to additional malaria risk with potentially devastating effects; these effects are particularly likely if the birds are forced so far upslope that they encounter a loss of habitat beyond the "hard boundary" where forested areas give way to pasture lands toward the top of Mauna Kea. He added that on the island of Kaua'i, the situation is a bit worse because there is no area that would fall above the survivability threshold for the mosquitoes that carry avian malaria. In contrast, the island of Maui contains sufficient upslope forest to provide habitat for birds as temperature increases and populations move higher.

Dr. Vitousek noted that his research reinforces the importance of considering the impacts of and responses to climate change in the context of other stresses such as land-use change. While variations in climate have occurred in the past— with species and ecosystems adapting and changing in response— many species may find the combination of climate change with other stresses (like biological invasions and land transformations) impossible to accommodate. Recalling Dr. Chadwick's comments, Dr. Vitousek reminded Workshop participants that understanding and responding to the consequences of climate change in islands could provide valuable models for scientists and decision-makers in other regions.

Mr. Ray Carter used the results of some recent work on the impacts of the 1997–1998 El Niño on Pacific tuna fisheries to provide insights into the relationship of climate to this important component of Pacific Island economies; his work has been conducted in collaboration with Dr. Michael Hamnett and Ms. Cheryl Anderson at the University of Hawai'i. As Mr. Carter noted, commercially important stocks of yellowfin and skipjack tuna are highly migratory species whose behavior responds, in part, to climate variations such as El Niño. Confirming previous work by others, Mr. Carter's catch statistics indicate that El Niño-related increases in ocean temperature in the Eastern Pacific were associated with an eastward shift in the catch of tuna; he cited specific examples drawn from areas around the Federated States of Micronesia. In explanation, he said the temperature of the water affects the availability of food organisms, which, in turn, affects the tuna stocks.

This eastward shift in stock distribution can have significant economic implications. A shift out of a country's

Exclusive Economic Zone, for example, means less income from license fees for Distant Water Fishing Nations. Similarly, changes in stock distribution can affect the level of effort (and income) that must be expended by canneries or transshipment facilities; conversely, knowledge of stock distribution can help those facilities prepare for either enhanced opportunities or reductions in business. In addition, information about the effect of climate change on tuna stocks would be important for island businesses and governments planning to install new transshipment facilities or canneries, or anticipating the emergence of tuna fisheries as an important source of income. Mr. Carter noted that his data also showed a change in species composition — an increase in more valuable stocks of yellowfin with a decrease in skipjack stocks. Thus, while overall catch in the region was down, the economic value for an individual vessel might have been even.

Mr. Carter emphasized that while his research, and that of others, clearly shows a link between climate and tuna, there is a need for considerably more data and research. Enhanced information about how climate variability like El Niño affects commercially important tuna stocks from one year to the next could be extremely valuable to businesses and governments throughout the Pacific. Similarly, a better understanding of how climate change might affect stock distribution could help inform important decisions about the role tuna fisheries can play in the future Pacific Island economies.

Working Group Discussions of Vulnerability and Response Strategies

On the second and third days of the Workshop, participants convened in small working groups for an in-depth exploration of regional vulnerabilities to climate variability and change, and discussions of near- and long-term strategies for response to climate variability and change for different sectors and communities. On the second day of the Workshop, participants considered climate-related vulnerabilities in six areas:

- Fisheries— including issues for commercial and recreational fisheries, coastal and marine habitats, and the concerns and rights of indigenous peoples;
- Agriculture— including issues for commercial agriculture, ranching and subsistence farming;
- Community Planning, Infrastructure and Economic Development— including issues for tourism and recreation, energy, transportation, housing, communications, and industry;
- Water Resources— including issues of fresh water availability, access and management;

- Biodiversity and Endangered Species— including issues of species protection, ecosystem conservation and management, resource development, tourism, and the cultural concerns and rights of indigenous peoples; and,
- Public Health and Safety— including issues of climate-related changes in water- and vector-borne diseases, air and water quality, and health and safety as it relates to natural hazards like hurricanes and tropical storms.

Following guidelines provided to all regional workshops within the U.S. National Assessment, participants were asked to address the following:

- What issues concern you (your sector) today?
- In what way are these issues (your sector) sensitive to climate variability and change? and,
- What challenges do affected businesses, communities and ecosystems face in reducing risks or capitalizing on opportunities associated with climate variability and change?

On the third day of the Workshop, participants discussed response strategies that provide an opportunity to:

- Identify critical information needs;
- Explore ways to overcome obstacles that inhibit the use of climate information to support decision-making in various sectors; and
- Recommend near- and long-term actions that could remove those obstacles.

These working groups were asked to evaluate scientific and technical gaps in understanding (What should we know that we don't?); institutional and policy barriers to effective use of climate information (Are changes required in policies or in public and private institutions to enhance decision-making); and limitations on our ability to convey and apply new scientific insights and research results (How can we improve the dialogue between scientists and key decision-makers?).

Key Findings and Recommendations

Following a review of the findings and recommendations contained in the final working group reports, the Chair summarized key findings and recommendations under three categories:

- Vulnerability issues common to all working groups and jurisdictions in the Pacific region;
- Shared principles that could guide the development of effective response strategies; and,
- Critical information needs that should help shape future research.

Common Vulnerability Issues

- Climate variability and change are superimposed on many other stresses, but information on interactions and feedbacks is often lacking;
- In all sectors, year-to-year climate variability such as that associated with ENSO and extreme events already poses significant challenges to communities, businesses, governments and resource managers throughout the region— and it is essential to understand how this variability might change;
- The geographic size and isolation of island communities creates special circumstances (e.g., limited land and water) and may constrain response options, while conversely, island communities can be “models” for understanding and responding to the consequences of climate variability and change;
- The absence of a long-term, strategic planning structure or management vision enhances vulnerabilities in most sectors;
- Required data sets are often missing or inaccessible, including biological and socioeconomic data and information on the physical environment;
- Monitoring, research and modeling programs are essential;
- Localized research is critical but difficult to support;
- There is an absence of research on the consequences and costs of mitigation options.
- Infrastructure and community support services are already stressed in most areas, and there is a need for additional vulnerability assessments;
- Integration of climate information in decision-making is limited and often based on historical data, creating a demonstrable need to anticipate conditions and incorporate emerging predictive capabilities and new scientific insights; and
- Scientific, institutional and communication barriers are creating an information gap between scientists studying climate variability and change and the intended users/potential beneficiaries in governments, businesses and communities.

Shared Principles for the Design of Response Strategies

- Take advantage of and build on previous and ongoing efforts to identify and address the consequences of climate variability and change for island states and communities and start by linking existing institutions and programs;
- Start by enhancing access to currently available data while new information is being developed; there is value in what we have now so get it out there (e.g., integrating ENSO forecasts into decision making now);
- Appropriate response strategies should recognize and respect differences among political, cultural, economic

and natural systems in the region as well as the unique circumstances of island communities and the special insights of local (indigenous) peoples;

- Management and policy options should be flexible in order to adapt to year-to-year natural variability in the climate system and accommodate potential surprises;
- Effective responses require strengthened and new partnerships involving scientists/scientific institutions, businesses, governments and communities;
- Proactive (precautionary) rather than reactive approaches are preferred—integrate climate information into decisions on a regular and continuing basis;
- Look for future opportunities while addressing today’s problems;
- Enhance education activities – formal and informal education programs; address all ages; including information on both anticipated changes and response options;
- Identify, secure and sustain the necessary human and financial resources;
- Involve information users in the development of new climate information products; users and providers should regularly (and jointly) evaluate the usefulness and usability of climate information products and assess progress; and, finally,
- A continuing, interactive dialogue among scientists and decision makers in the public and private sectors is essential; this requires a sustained commitment to the translation and communication of research results and an effective program of outreach and education... this may require the creation of new institutional arrangements.

Critical Information Needs

- Regular and reliable access to emerging forecasting capabilities on year-to-year time scales;
- Improved understanding of the physical, social and economic implications of climate variability and change for key sectors to support near-term decision making and long-term planning;
- Improved understanding of regional trends in demographics and economic development to support local/regional planning and assess the consequences of climate variability and change;
- Improved understanding of the effects of climate variability and change on unique (Pacific) island ecosystems, critical habitats and key species in the region;
- Improved understanding of the health-related consequences of climate variability and change in the region; and
- Maintenance of a continuing dialogue among scientists and public and private sector interests to identify changing information needs, support decision-making and take advantage of new scientific insights and emerging technologies.

Next Steps

The March 1998 Workshop participants identified a number of next steps which have subsequently been pursued by the Workshop organizers and sponsors in the context of a Pacific Islands regional contribution to the first National Assessment of the Consequences of Climate Variability and Change for the United States. The key findings and recommendations from the March 1998 Workshop were provided to the National Assessment Synthesis Team and used to design an 18-month initial Pacific Islands Regional Assessment Project. Funding for this initial assessment project was provided to the East-West Center (Honolulu, HI) through a grant from the National Science Foundation (NSF) on behalf of NSF, NOAA, NASA and the Department of the Interior. The project is scheduled to be completed at the end of calendar year 2000.

Building on the findings and recommendations of the March 1998 Workshop, the initial Pacific Islands Regional Assessment has been organized to achieve the overarching goal of nurturing the critical partnerships necessary to develop and use climate information to enhance the ability of scientists and decision makers throughout the Pacific to understand and respond to the challenges and opportunities presented by climate variability and change.

Based on the findings of the March 1998 Workshop, highest priority in the Pacific Islands Regional Assessment is being given to: water resources; public health and safety (with an emphasis on extreme events); and the special challenges of climate variability and change for island coastal communities and ecosystems.

Like the March 1998 Workshop and the National Assessment, the Pacific Islands Regional Assessment is pursuing dual, mutually reinforcing objectives:

- Conducting research and analysis to develop a more complete understanding of regional consequences; and
- Initiating and sustaining an interactive dialogue to support decision-making.

This latter objective responds to the March 1998 Workshop's call to maintain the momentum initiated by that gathering and establish a regional network of individuals and institutions who will: further explore the consequences of climate variability and change for communities, businesses, governments and natural systems; identify and pursue opportunities for long-term partnerships to support the development and use of climate information; and identify and pursue opportunities for near- and long-term support for ongoing and new programs and the develop-

ment of new institutional capabilities. In this context, the initial Pacific Islands Regional Assessment is supporting a series of workshops and small-group meetings ("roundtable discussions") designed to provide opportunities for in-depth exploration of how and why climate variability and change matter for key sectors (e.g., tourism), resources (e.g., coastal resources, water resources) and communities (e.g., the Native Hawaiian community). The process of shared learning and joint problem solving characterized by this program of outreach and education is the programmatic backbone of the emerging Pacific Islands Regional Assessment. The Assessment process is providing the central support structure around which a new, regional climate information service is taking shape—a service that responds to the findings and recommendations of the March 1998 Workshop.

Workshop Steering Committee

Workshop on the Consequences of Climate Variability and Change for Hawai'i and the Pacific: Challenges and Opportunities

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¹ In Mr. Blanco's absence, the Governor's Office was represented by Mr. Kelvin Char, of the National Oceanic and Atmospheric Administration, who was on an Intergovernmental Personnel Act assignment to the Governor's Office.

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⁴These individuals were responsible for leading discussions of regional climate vulnerability during the March 1998 Workshop; the reports of their deliberations provided a foundation for the final Pacific Islands Regional Assessment Report.

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APPENDIX F— PROCLAMATION BY THE GOVERNOR OF HAWAII



Proclamation

WHEREAS, the people of Hawaii and the peoples of the Pacific region are endowed with a very natural beauty — including the benefits of water, sea, and volcanic splendor; and

WHEREAS, these conditions are essential to the health of our visitor industry, the economy will bring of our citizens, the vitality of our economic environment, and water-based quality of life; and

WHEREAS, the communities, businesses and governments in our region have experienced the impacts of pronounced climate variability that affect water patterns and create conditions that spare life-threatening storms; and

WHEREAS, although our climate system is producing year-to-year climate variability, our ability to adapt and

WHEREAS, this inherent capability, coupled with increased awareness and understanding of the consequences of climate variability, can help to improve decisions in both public and private sectors; and

WHEREAS, a *Handbook on the Consequences of Climate Variability and Change for the Hawaiian Islands* will be available from March 1 through 8, 2011; and

WHEREAS, this workshop presents an opportunity to educate our participants, improve resource management planning, and protect life and property;

NOW, THEREFORE, I, BENJAMIN J. HONOLULU, GOVERNOR OF THE STATE OF HAWAII, do hereby proclaim March 1 to 8, 2011, to be

CLIMATE AWARENESS WEEK IN HAWAII

and encourage the people of Hawaii and the Pacific region to learn more about climate variability and its impact on our lives.

DONE in the State Capitol, in the Executive Chambers, Honolulu, State of Hawaii, this twenty-fifth day of February, 1998.

Benjamin J. Honolua