Alaska's Climate Change Strategy: Addressing Impacts in Alaska
Executive Summary

INTRODUCTION

In Alaska, climate change has begun to touch almost every aspect of the natural world and the human systems that have evolved around, and rely on, a set of stable and predictable climatic conditions and seasons. It is a world where a warming environment has already begun to render ground and building foundations unstable, disrupt transportation routes, and trigger phenomena placing coastal communities in imminent danger from flooding and erosion. Impacts have resulted in myriad consequences to residents of the state, to subsistence livelihoods, to the wildlife and vegetation in Alaska's terrestrial and marine environments, and to the many industries that support the Alaskan economy.

While these changes are of critical import to Alaskans, they have also garnered attention of leaders in the United States and around the world. The primary driving force has been the accelerated retreat of Arctic sea ice, which has been a catalyst for multi-disciplinary planning and has underscored the need for increased domestic and international cooperation. A navigable Arctic Ocean presents opportunities for shipping and commerce in the Northwest Passage and has elevated interest in developing fisheries and mineral resources. Consequently, this creates a need for additional and improved weather and navigational tools, research to better understand and manage our strategic assets, and increased efforts to provide national, environmental, and economic security. Widespread interest in the Arctic has also been elevated by the important role that the Earth's polar region plays in influencing climate and oceans on a global scale. What happens in Alaska has far-reaching and long-lasting implications.

Box 1. Sectors Addressed by the AAG Report

Alaska's economy and the health and well-being of its residents will be affected by climate change. Key impacts being addressed include:

Public Infrastructure

Impacts of climate change on public, private, or cooperatively owned infrastructure for the public good including buildings, transportation, shoreline protection, water and sanitation systems, and defense facilities.

Health and Culture

Climatic changes and associated changes in natural systems are increasing the potential for health impacts from vector-, water-, and food-borne diseases and are beginning to cause stress on subsistence communities. Erosion, changes in permafrost, and extreme events are already impacting coastal communities, sanitation infrastructure, and archaeological sites and gravesites. Weather related injuries and detrimental effects on mental health have also been associated with rapidly changing conditions.

Natural Systems

Impacts of changing climate on marine, terrestrial, and freshwater ecosystems will have implications for Alaska's economy and subsistence communities. Changes in fisheries and forest resources, modes of travel, and the diversity and location of different plant and animal species have both beneficial and adverse impacts on natural systems and the services they provide.

Other Economic Activities

Changing climate may affect all sectors of Alaska's economy dependent on weather conditions and/or the natural environment or reliant on engineered infrastructure that is threatened by changes. This sector addresses their adaptation needs and also explores possibilities for new and/or expanding potential economic development created by a warming environment.

The adaptation component of Alaska's climate change strategy contains adaptation options designed to reduce the vulnerability of Alaska's natural and human systems to climatic changes and examine the potential growth of economic opportunities that might arise.

The *Arctic Climate Impact Assessment*, a comprehensive assessment conducted by hundreds of scientists and indigenous peoples, confirms that the Arctic is now experiencing some of the most rapid and severe climate changes on earth and is extremely vulnerable to both observed and projected climate change and its effects. To address the impacts of climate change on Alaska, Governor Sarah Palin signed Administrative

Order 238 on September 14, 2007, which established and charged the Alaska Climate Change Sub-Cabinet to advise the Office of the Governor on the preparation and implementation of a comprehensive Alaska Climate Change Strategy (AO 238). This document represents the recommendations of the Adaptation Advisory Group (AAG), which was charged with evaluating and developing options to adapt to climate change. The report also provides additional background on projected climate and impacts for Alaska.

The types of recommendations contained in this report vary. The options range from new systems approaches and institutional structures to adoption of new or revised policies, initiatives, and other actions. The Sub-Cabinet will consider these, as well as recommendations from the Immediate Action Work Group, the Mitigation Advisory Group, and the Research Needs Work Group in the context of other complementary efforts. A comprehensive Climate Change Strategy for Alaska will then be drafted for consideration by the Governor. While no one report or event can set a definitive course of action in the dynamic and uncertain set of circumstances created by a changing climate, the work of the Adaptation Advisory Group establishes a foundation from which to make progress towards improving our individual and societal ability to adapt.

IMPACTS ON HUMAN AND NATURAL SYSTEMS IN ALASKA

Over the past three decades, Alaska has experienced a sharp reduction in snow-cover extent and duration, shorter river- and lake-ice seasons, melting of mountain glaciers, sea-ice retreat and thinning, permafrost retreat, and increased depth of summer thaw. These changes are in turn affecting human and natural systems. The AAG, with the support of four Technical Working Groups, has developed options to adapt to these changes, i.e., to reduce the adverse impacts or take advantage of the opportunities presented by climate change (see Box 1).

Permafrost Thawing and Sea Ice Melting

Permafrost underlies most of Alaska. Air temperature, snow cover, and vegetation affect the temperature of the frozen ground and the depth of seasonal thawing. Recent decades of warmer temperatures have produced extensive thawing, which has resulted in increased coastal erosion, landslides, and sinking of the ground surface, as well as consequent disruption and damage to forests, buildings, infrastructure, and coastal communities. In addition, many industrial activities depend on frozen ground surfaces, and many northern communities rely on ice roads for transport of groceries and other materials. Continued warming will further impair transport by shortening the seasonal use of ice roads. Thawing is projected to accelerate under future warming, with as much as the top 10 to 30 feet of discontinuous permafrost thawing by 2100.

Sea ice off the Alaskan Coast is retreating and thinning, with widespread effects on marine ecosystems, coastal climate, human settlements, and subsistence activities. Recent studies estimate arctic-wide reductions in annual average sea-ice extent of about 5-10% and a reduction in average thickness of about 10-15% over the past few decades. Retreat of sea ice allows larger storm surges to develop, increasing the risk of inundation and increasing erosion on coasts already made vulnerable by permafrost thawing. Loss of sea ice also causes large scale changes in marine ecosystems, and threatens populations of marine mammals and polar bears that depend on ice. At the same time, the continued reduction of sea ice is very likely to increase the navigation season, and within several decades a seasonal opening of the Northern Sea Route is likely to make trans-arctic shipping feasible during summer months, although increasing ice movement will initially make shipping more difficult in some channels of the Northwest Passage.

Threats to Coastal Communities, Habitats, and Infrastructure

Alaska has more coastline than the other 49 states combined. Increases in the frequency and intensity of storm surges have triggered increased coastal erosion that is threatening a number of coastal villages. A recent report from the Government Accountability Office (GAO) indicated that 31 villages face imminent threats. Storm surges have also reduced the protection that barrier islands and spits provide to coastal habitats. Both coastal and inland infrastructure face threats due to the climate change. Thawing permafrost threatens water and sanitation infrastructure, and roads, buildings, pipelines, power lines and other infrastructure are threatened by coastal erosion and degrading permafrost.

Forest and Vegetation Changes

The Arctic region, particularly Alaska, is already experiencing major ecological impacts as a consequence of warming. Rising temperatures have caused northward expansion of boreal forest in some areas, significant increases in fire frequency and intensity, and unprecedented insect outbreaks. Current projections suggest that, due to increases in burn area per decade, the tundra-dominated landscape on Seward Peninsula will eventually be replaced by deciduous forest. In other areas, forested areas are likely to convert to bogs as permafrost thaws. Growing-degree days have increased by 20%, with benefits for agriculture and forest productivity on some sites, and reduced growth on others.

Sensitivity of Marine Ecosystems and Fisheries

The Gulf of Alaska and Bering Sea support marine ecosystems of great diversity and productivity as well as the nation's largest commercial fishery. Perhaps one of the most daunting threats lies in increasing acidification of the cold Alaskan waters. This would affect all organisms that possess calcifying shells, and these organisms play an integral role in the food web. Recent climate-related impacts observed in the Bering Sea include significant reductions in seabird and marine mammal populations, unusual algal blooms, abnormally high water temperatures, and low harvests of salmon on their return to spawning areas. Future projections for the Bering Sea suggest productivity increases at the base of the food chain, poleward shifts of some cold-water species, and negative effects on ice-dwelling species. Warmer temperatures will also affect commercial fisheries by inducing large northward shifts of fish and shellfish species. This would result in decreased harvesting of cold-water species such as salmon and pollock, and increased harvesting of other species.

Changes In the Diversity, Ranges, and Distributions of Species

The Arctic sub-region that includes Alaska, Chukotka, and the Western Canadian Arctic is home to over 70 percent of the rare plant species that occur only in the Arctic and a number of plant and animal species already classified as "threatened." Species concentrated in small areas, such as Wrangell Island, are particularly vulnerable to the direct effects of climate change combined with competition from migrating non-native species.

Increased Stress on Subsistence Livelihoods and Lifestyles

Subsistence makes an important contribution to livelihood in many isolated rural communities, especially but not exclusively for native peoples. Livelihoods that sustain indigenous communities include hunting, trapping, gathering, and fishing. These activities not only make significant contributions to the diet and health of many indigenous populations, but also play large and important social and cultural roles. Reduced or displaced populations of marine mammals, seabirds, and other wildlife, together with continuing thinning of sea-ice, have affected the safety and the dietary and economic well-being of subsistence communities.

ALASKA'S APPROACH TO ADAPTATION: RECOMMENDED OPTIONS

Climate change presents both potential impacts and opportunities for Alaskans and the Alaska economy. Developing a viable set of policies and actions to adapt to climate change requires recognizing the decentralized nature of government decision making, and the role of all levels of government. Successful adaptation will require engaging not only governments, but also private business, communities and community leaders, and individual households. Developing information on climate and other information needed for adaptation and making this information accessible is key to enabling these public and private entities to take action. Finally, an adaptation strategy must recognize both the need for immediate action to address observed effects of climate change (in some cases) as well as the importance of developing a foundation of data, policies, and knowledge about adaptation strategies that will enable successful adaptation over the long term.

The options recommended by the AAG are summarized below. These are actions that the state of Alaska, sometimes in partnership or cooperation with other agencies or organizations, can take to adapt to climate change. The options include actions such as increased coordination within and outside the state, data collection or assessment, regulatory or programmatic changes, capacity building and education, capital improvements, and financial assistance. In some cases the options may require new institutions or new legislative authority, but in many cases they have been designed to build on existing programs and staff.

Public Infrastructure

These options address the observed and projected impacts of climate change on Alaska's infrastructure, and include priority adaptation actions that the State of Alaska should take to address the impacts and their associated vulnerabilities. Public infrastructure is defined to include essential facilities and utilities under public, cooperative, or private ownership that deliver goods and services to communities. Such infrastructure includes infrastructure related to road, air, water, and other transportation (ranging from highways to landing strips); public buildings; seawalls and river shoreline protection; power, water, communication, and other utilities and their supporting structures; and national defense infrastructure. The goal of these options is to develop a system that increases the likelihood that Alaska has sustainable infrastructure to support communities in an uncertain environment.

The options developed for public infrastructure are designed to address three critical problems. First, the vulnerability of, and risk to, public infrastructure is growing. In some locations, entire Alaskan villages are at immediate risk; in other locations, critical roads and public buildings are at risk. Second, adaptive capacity for existing infrastructure is low, so new construction provides an opportunity for adaptation. Most public infrastructure is hard and fixed (for example, roads and buildings) and cannot easily alter its alignment, elevations, or structural foundation to accommodate coastal erosion or increased flood risk. Third, increased communication and coordination is critical. Increased communication and coordination across agencies, communities, and scientific and applied researchers is needed to adapt Alaska's public infrastructure.

The AAG is recommending a systems approach to reduce the impacts of climate change on Alaska's public infrastructure by accomplishing actions under three policies/programs.

PI-1 Create a Coordinated and Accessible Statewide System for Key Data Collection, Analysis, and Monitoring

Baseline data on the condition of current infrastructure and on regional and local environmental conditions needs to be collected, so that decision makers can identify what the problems are and where they occur, and what approaches are and are not working. Decision making also requires that projections of climate and other

information be based on the best science and collected empirical data. The Environmental Atlas of Alaska should be updated. The resulting information needs to be available to all interested parties.

PI-2 Promote Improvements that Use the Current Best Practice

Managing the risks and/or reducing the uncertainties associated with climate change will take time. Promoting sustainability, reducing operating costs, and protecting/extending the service life of existing infrastructure is always worthwhile. Simultaneously with PI-1, improvements to existing infrastructure that are worth doing regardless of climate change effects should be undertaken.

PI-3 Build to Last; Build Resiliency into Alaska's Public Infrastructure

As PI-1 and PI-2 are enacted and our knowledge base expands, new and upgraded infrastructure needs to be sited, planned, designed, and built to be resilient and sustainable in an uncertain environment. Systematic feedback with a performance review and analysis needs to be integrated into the public infrastructure funding, development, construction, and operations, so that planners and builders use "what works" and codes and standards are assessed and improved as needed to achieve the best results.

Natural Systems

The Natural Systems sector addresses the observed and projected impacts of climate change on Alaska's ecosystems and the services they provide. The AAG recommends priority adaptation actions that the state of Alaska should take to address the impacts and vulnerabilities associated with these impacts. Key impacts for Alaska include:

- those on marine ecosystems in the seas around Alaska and the communities and industries reliant on marine-based fisheries;
- changes in terrestrial ecosystems and in species' diversity, ranges, distribution, and abundance, with consequences for forestry and subsistence harvest of fish and wildlife; and
- changes to freshwater ecosystems, with consequences for freshwater appropriates and for freshwater species and the people who access and harvest the fish and wildlife.

The goal of the options below is to sustain natural ecosystem services in Alaska that meet society's essential needs, through adaptation to changing environmental conditions.

The five adaptation options recommended for this sector are targeted to sustaining the natural ecosystem services that meet Alaska's essential needs for food, water, renewable resource economies, community stability and safety, and cultural well-being. The recommendations build on existing state authorities and programs, and will move Alaska forward substantially in its ability to adapt to climate change impacts. Implementation of these options will require leadership and policy direction, as well as a moderate investment in staffing and funding to complete priority tasks. Through this work, the State will take a major step forward in integrating adaptive management to long-term climate change into the State's resource management programs and practices, so that it becomes a way of doing business and not a suite of separate initiatives.

NS-1 Fisheries Management

This option incorporates climate change into fisheries assessment and management and assists fishing communities and users in adaptation. This option includes several key elements: (1) review of the state's fishing-related statutes; (2) a comprehensive assessment of existing habitat, fish species, and stock

monitoring programs; (3) development of a centralized source of information on climate effects; and (4) development of a long-term strategy to work with fishing-reliant communities and business.

NS-2 Wildland Fire

This option would review and modify as appropriate Alaska's wildland fire policy and programs to address potential climate-induced increases in wildland fire frequency, size, and geographic location. Key elements include: (1) increasing the capacity of communities to initiate, complete, and implement Community Wildfire Protection Plans (CWPP); (2) reviewing selected wildland fire management practices for lands in Alaska; and (3) developing a comprehensive fuels management program to treat high-risk areas.

NS-3 Freshwater Management

This option addresses the effects of climate change on Alaska's freshwater resources through adaptive management, supported by improved hydrologic data. This option includes data collection, coordination, and protection. It also includes a review and adjustment as necessary of water management laws, policies, and practices in order to improve adaptive capacity.

NS-4 Invasive and Eruptive Species

Under this option, the state would expand its efforts to be an active partner with all levels of government and with other entities in addressing the problem of invasive and eruptive species in Alaska. The goal is to reduce introduction and spread of invasive species and eruptive species in the context of climate change.

NS-5 Fish and Wildlife

Under this option, the state would improve its capability to manage fish and wildlife species adaptively in Alaska to assure sustainable management of these important resources. The option includes two specific actions: (1) develop and adopt a more timely regulatory process for the harvest of wildlife; and (2) develop a coordinating framework that documents existing fish and wildlife monitoring efforts, identifies priorities for monitoring, and identifies gaps and potential for collaboration.

NS-6 Sustainable Agriculture

Under this option, the state would support and expand sustainable agriculture production and marketing in Alaska. This option recognizes the importance of local agriculture to Alaska's food security and seeks to develop an Alaska food policy and strategic plan that increases reliance on locally produced agricultural products. The option includes three specific actions: (1) encourage community-based agriculture and practices that optimize the use of the land and resources available; (2) research the magnitude and composition of food consumption in the state; and (3) research the sources of food supply and the risk associated with high reliance on imported foods.

Other Economic Activities

Some of Alaska's major economic activities, such as tourism and shipping, are highly dependent on weather conditions and/or the natural environment, both of which can be significantly affected by climate change. Some activities, such as mining and oil and gas exploration, rely on engineered infrastructure that is also potentially affected by climate, weather, and underlying environmental conditions. At the same time, climate change could create economic development opportunities in existing and new sectors. The options developed for this sector identify adaptive actions and options that contribute to the ability of sectors of the Alaska

economy not directly supported by living systems (e.g., fishing) to adapt to the effects of climate change and ensure the sustainability of a robust Alaska economy.

The recommendations in this sector focus on broad issues relevant to the economy as a whole, rather than actions designed to address the concerns of a particular economic group or industry. Three options are recommended.

EA-1 Evaluate Capability Needs for Potential Expansion of Arctic Economic Activities

This option recommends that the State recognize and address the potential for increased Arctic economic activities and identify gaps in infrastructure and the ability to provide an adequate presence in the Arctic coastal region to protect environmental resources, human health, and safety.

EA-2 Develop and Evaluate Scenarios for the Alaskan Economy

Components of the Alaska economy will experience varying impacts due to potential effects of climate change. An assessment of economic strengths, weaknesses, opportunities, and threats by sector is needed to better understand current and potential future components of the economy. This understanding will aid state agencies and other stakeholders in identifying and acting on optimum adaptive strategies and policies to help address future conditions. This option recommends conducting and managing a project to develop and evaluate possible economic scenarios for the State, based on potential climate change effects.

EA-3 Improve Availability of Mapping, Surveying, Charting and Imagery Data

Accurate, timely information about the distribution and magnitude of changes is needed to better address economic challenges and opportunities. This option recommends improving the availability of data, specifically real-time mapping, digital elevation model, and imagery, to better track and understand the impacts of climate change. This option would build on the work of the Statewide Digital Mapping Initiative and aid in transitioning between locations at the water-land interface.

Health and Culture

Climate change is being linked to increases in the geographic range and incidence of certain infectious and non-infectious diseases, new problems in sanitation and solid waste management, contaminant exposures, and diseases related to diet as well as mental health. Current programs are insufficient to identify and control these changes. To protect the health of humans, domesticated animals, and wildlife from the effects of climate change in Alaska, existing programs and activities need to be augmented to address these emerging concerns by developing new methods for surveillance and reporting of human and animal diseases.

The goal of the options recommended for this sector is to Improve adaptive capacity to maintain human health and healthy ways of life, reduce current and likely future increases in disease due to a changing climate, and prevent the destruction of gravesites, archaeological sites, and historic sites due to accelerated coastal and river erosion. Four options are recommended.

HC-1 Augment Surveillance and Control Programs for Vector-, Water-, and Food-borne Diseases

This option augments surveillance and control programs for vector-, water-, and food-borne diseases likely to become greater threats because of climate change. In addition, it develop educational programs for the public, health care providers, environmental staff, and others on approaches to reduce emerging disease threats.

HC-2 Community Health Impact Evaluations

This option develops a tiered approach to evaluate recommended adaptation and mitigation options to determine whether they could result in adverse health impacts and, if so, recommends approaches to reduce these risks.

HC-3 Assess Sanitation and Infrastructure Risks from Climate Change

This option assesses sanitation infrastructure and practices at risk from flooding, thawing permafrost, and other risks, or that are otherwise subject to changing conditions that significantly reduce performance in environmental health protection. This option would consider modification, rebuilding, or relocation of sanitation infrastructure to protect human and environmental health.

HC-4 Assess, Protect, and Develop Plans for Archaeological Sites and Gravesites

In cooperation with appropriate local, regional, and statewide entities, the state would assess archaeological sites and gravesites at risk from accelerated coastal and river erosion; convene archaeologists, anthropologists, Alaska Native elders, and others to discuss how best to address and prioritize sites at risk; and develop a plan for the protection or recovery of important at-risk sites. This option would also assist in identifying and opening new gravesites; convening a respectful discussion about gravesites while exploring best practices; and providing assistance for the relocation of existing at-risk gravesites.

Common Themes

Across the sectors, a number of common themes emerge for types of actions that will be needed to assist Alaska in adapting to climate change. These themes include needs for improving access to data, for community assistance, for coordination, and for education. Most of these themes are as relevant to mitigation as they are to adaptation. The recommendations fill a variety of needs that will greatly assist Alaskan efforts to address and respond to climate change. Four options that represent common themes across the sectors were developed.

CT-1 Establish an Alaska Climate Change Knowledge Network

This option recommends establishing an Alaska Climate Change Knowledge Network (ACCKN) to provide an effective, collaborative means to manage data and foster its use for adaptation. Where appropriate, the ACCKN would organize, consolidate, integrate, and archive data, information, and knowledge related to climate change. The network would serve as a point of coordination for National Oceanic and Atmospheric Administration's (NOAA's) proposed Regional Climate Center in Alaska.

CT-2 Coordinate Implementation of Alaska's Efforts to Address Climate Change

This option recommends that Alaska's efforts to address climate change continue to be coordinated internally to ensure synergy among State agency efforts, unified and strategic interaction with federal agencies, and effective outreach and education.

CT-3 Community Climate Impact Assistance

An array of state, federal, and regional entities are responsible for delivering services to Alaskan villages, rural communities, and urban centers, but specific policies and regulatory constraints produce conflicting directives that prevent the coordinated delivery of vital services that will enable endangered villages, traditional culture, and vulnerable communities to adapt in the face of climate change. There is a need to establish a coordinating

entity with the ability to navigate these multiple bureaucracies and to leverage their resources to support vulnerable communities in emergency response, relocation, subsistence concerns, and other priorities.

CT-4 Promote Climate Change Science through K-12 Education

This option promotes development of curriculum and training to support climate change education in grades K-12.