

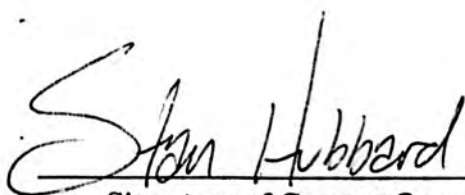
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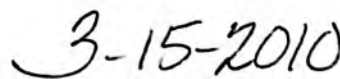
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Established by Legislative Resolve 49 (HCR 30), 2006.

Contents: 39 files. Includes some CD's of audio and video of public hearings.

Alaska Climate Impact Assessment Commission (ACIA) final report, public hearing agendas and presentations, and reading file are currently on 2007-2008 House Majority web page for Representative Samuels under "Committee Memberships, Chairmanships: Alaska Climate Impact Assessment Commission":
<http://www.housemajority.org/coms/index.php?c=38>.

Following is a list of materials. Only the preliminary and final reports have been microfiched. Copies of the reports are also available in Legislative Reference Library LLIB collection.

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March 1, 2007

The Honorable Lyda Green, President
Alaska State Senate
State Capitol #111
Juneau, AK 99801-1182

The Honorable John Harris, Speaker
Alaska State House of Representatives
State Capitol #208
Juneau, AK 99801-1182

Dear President Green and Speaker Harris:

Pursuant to Legislative Resolve 49 / 2006, herewith submitted is the preliminary report of the Alaska Climate Impact Assessment Commission. The Commission will continue with its responsibilities throughout 2007, and make a final report to the legislature January 10, 2008.

Sincerely,

A stylized, handwritten signature of Representative Ralph Samuels.

Representative Ralph Samuels, Chairman

Sincerely,

A handwritten signature of Representative Reggie Joule.

Representative Reggie Joule, Vice Chairman



AK Climate Impact Assessment Commission

Rp. Ralph Samuels, Chairman / Rp. Reggie Joule, V-Chairman

State Capitol #204, Juneau, AK 99801-1182 / (907) 465-3727 / fax - (907) 465-3810

PRELIMINARY REPORT TO THE LEGISLATURE

March 1, 2007

SUMMARY:

HCR 30 (Legislative Resolve 49 / 2006) established the Alaska Climate Impact Assessment Commission and charged it with assessing such effects under climate change in the Arctic, as would affect the citizens, resources, economy, and assets of the State of Alaska. The Commission is composed of two state House members, two state Senators, and seven public members appointed to specifically-defined seats, focusing on climatology/oceanography, communities, tourism, resource development, the economy, engineering/construction/ maintenance, and fish/wildlife/land management issues. Existing legislative staff has been tasked with supporting the work of the Commission. Authorized expenses include travel, per diem, and supplies.

The Commission is to hold at least eight public hearings throughout Alaska, and issue a report of its findings to the Legislature on January 10, 2008. To date, the Commission has held an organizing meeting, and two public hearings. The two public hearings, one each in Fairbanks and Juneau, were composed of invited professional testimony and open public testimony.

The Fairbanks hearing was held on the campus of the University of Alaska, and emphasized a scientific overview of the major climate change issues affecting Alaska. The Juneau public hearing emphasized state agency perceptions of state responsibilities, and in some cases, operational changes which are already underway due to climate warming in the Arctic. An Anchorage public hearing is scheduled for April, and the Commission will soon plan hearings to be held in rural Alaskan communities over the course of the summer and autumn.

The Commission considers existing evidence for Arctic warming trends sufficient to pursue its charge under HCR 30. Current science and climatology indicate that Alaska is a bellwether for climate change in the United States. Commission activities to date have focused on gathering and exchanging information, including anecdotal information, and evaluating it in terms of the Commission's responsibilities. The Commission will necessarily limit the scope of its investigation to provisions in HCR 30; it is not equipped to engage in major academic discourse on many of the unresolved issues within the climate change arena. Along with evaluating public testimony, the Commission has already begun discussing the framework of its final report due next year.

Commission members have participated in other climate change forums, including those organized by the Alaska Federation of Natives, the Alaska Center for Climate Assessment and Policy and the Department of Engineering at the University of Alaska (Anchorage), the Anchorage Business Roundtable and Resource Development Council, the 7th International Conference on Climate Change at the University of Alaska (Fairbanks), and upcoming, the Society of American Military Engineers and the Warming Oceans Forum to be held during the ComFish Alaska exposition in Kodiak. Other opportunities are anticipated throughout 2007.

SCOPE OF RESPONSIBILITIES:

Under HCR 30, the Commission will assess the effects of warming trends on the citizens, natural resources, public health, economy, natural resource development, forest safety, fish and game utilization, transportation, communities, and resource development infrastructures. It is to estimate the costs of adverse climate change to our citizens and the state, recommend policy and regulatory changes, and identify and coordinate efforts of mutual concern with federal, state, and local entities.

In addition, the Commission will more specifically assess problems caused by flooding, erosion, and permafrost melt. To this end, it will identify specific circumstances of flooding and erosion where these affect life, property, economies, and resource development. The Commission is also obliged to examine prevention and mitigation measures for flooding and erosion problems. It may also recommend land use regulations, including standards for the designation of land prone to erosion and flooding.

DRAFT ACTION PLAN:

Over the remainder of 2007, the Commission will continue gathering and prioritizing information, participating in other public climate change forums, and preparing information for its final report. The Commission is already evaluating reporting formats from other governmental bodies and other relevant entities. The Commission's responsibilities will be viewed in the following major interest areas (not prioritized):

- 1) public health and communities (health, municipal impacts)
- 2) fish and game impacts (commercial, sport, subsistence)
- 3) forest impacts (state and federal assets, wildfire suppression, related economic issues)
- 4) economic impacts (tourism, construction, transportation, insurance, federal spending, agriculture, and flooding/erosion/permafrost damage)
- 5) resource development (oil and gas, mining, support industries)
- 6) policy and regulatory aspects (land use, alternative energy, other legislation / regulation changes)
- 7) state assets at risk (harbors, bridges, roadways, airports, parks)

OBSERVATIONS FROM ALASKANS:

A sampling of observations by Alaskans thus far conveys the diversity of impacts being felt by citizens and communities: Unusual, double-crops of blueberries in the Interior; salmon stocks and other species moving northward; waning birch forests in the Interior and declining yellow cedar stocks in the Southeast; increased frequency and intensity of wildfires; negative implications for continued insurance protection for coastal and riverine communities affected by storm surge, flooding, and erosion; a lack of adequate federal, state, or local data for mapping Alaska's areas at risk; emerging impact costs for state infrastructure; and the need for interagency coordination between local, state, and federal officials, including specially chartered entities such as the Denali Commission. These are but a few of the manifestations of climate change which have come forward.

LOOKING AHEAD:

It is expected that the Anchorage public hearing will offer insight from resource extraction industries, construction and engineering interests, research entities, and federal agencies, to name a few.

As the Commission anticipates public hearings in rural areas, particularly in coastal areas, it expects to concentrate in some detail, on flooding and erosion issues, impacts on the subsistence lifestyle, threats to small communities, and fish and game resources.

Ultimately, the biggest challenge facing the Commission will be to focus on and prioritize those issues within the scope of Arctic climate change, which most substantially impact the state, its people, and its economy. Consolidating the panel's findings into useful, relevant information will remain our objective. The potential exists for some measure of positive economic change due to Arctic climate warming. Although speculative, benefits may be seen in Alaska's fisheries, agriculture, and academic research fields, among others.

SCOMM

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FINAL COMMISSION REPORT

Alaska Climate Impact Assessment Commission

**Alaska State Legislature
March 17, 2008**

FINAL COMMISSION REPORT

Alaska Climate Impact Assessment Commission

**Alaska State Legislature
March 17, 2008**

Representative Ralph Samuels, Chairman
Representative Reggie Joule, Vice-Chairman
State Capitol Building
Juneau, Alaska 99801-1182

(907) 465-2095

http://www.housemajority.org/coms/cli/cli_final_report_20080301.pdf

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Attachments:

- (A) Legislative Resolve 49 (2006)**
- (B) Roster of ACIA Commissioners**
- (C) Copy of the Preliminary Report**
- (D) Roster of Invited Presenters**
- (E) List of ACIA Information Sites**
- (F) State Agency Responses**



AK Climate Impact Assessment Commission

Rp. Ralph Samuels, Chairman / Rp. Reggie Joule, V-Chairman

State Capitol #204, Juneau, AK 99801-1182 / (907) 465-3727 / fax - (907) 465-3810

FINAL REPORT TO THE LEGISLATURE

March 17, 2008

COMMISSION OVERVIEW:

AUTHORITY:

Legislative Resolve 49 from 2006, Attachment (A), established the Alaska Climate Impact Assessment Commission and charged it with assessing such effects under climate change, as would affect the citizens, resources, economy, and assets of the State of Alaska. The Commission was composed of two state House members, two state Senators, and seven public members appointed to specifically-defined seats. A roster of the members can be found at Attachment (B). The public seats focused on climatology/oceanography, communities/public health, tourism, resource development, the economy, engineering/construction/ maintenance, and fish/ wildlife/land management issues. The Commission was also charged with holding public hearings around the state. Existing legislative staff provided support work.

SCOPE OF ACTIVITY:

The Commission took both invited professional testimony and extensive public testimony at each of its hearings. In addition, we left our hearing record open to those who chose to write, fax, or email commentary, right up to the preparation of this final report. Beyond its organizing meeting, the Commission held six public hearings throughout Alaska, and one site inspection visit. The public hearings were in Fairbanks, Anchorage (two), Juneau, Kotzebue, and Barrow. The site inspection was to Kivalina. The Commission was weathered out of Shishmaref, another intended site visit. A total of 210 persons appeared and/or presented public testimony at our field hearings. Another 85 responded by email, letter, or email. A preliminary report to the Legislature was submitted on March 1, 2007, Attachment (C). A final report was due to the legislature by January 10, 2008, but because of the loss of time due to special legislative sessions in 2006 and 2007, an extension was granted.

The Fairbanks hearing was held on the campus of the University of Alaska,

and emphasized a scientific overview of the major climate change issues affecting Alaska. The Juneau public hearing emphasized the role of state government in addressing climate change, as well as learning about operational changes already being experienced, such as fire suppression activities. The two Anchorage hearings took testimony from municipal, business, research, federal, and village interests, as well as considerable anecdotal information from the public.

In Kotzebue, the Commission recorded insights into coastal erosion in the region, village relocation issues at Kivalina and Shishmaref, unstable ice conditions, a decrease in subsistence activities, and local success with wind energy generation. During hearings in Barrow, the Commission was made aware of the challenges of an ice-free Arctic Ocean, retreating coastlines, and a loss of some subsistence opportunities due to drying tundra, low river levels, poor snow and ice conditions, and tundra fires. The North Slope Science Initiative, the Barrow Arctic Research Center, and the Ilisagvik College each showed the community to be engaged at the forefront of research, monitoring activities, and education efforts to address the challenges of a warming Arctic.

At each public hearing, the Commission heard from local public officials and tribal leaders, including the mayors of eight different municipalities. The Commission took testimony on local efforts to better identify and respond to potential climate warming impacts, and noted the varying emphases of concern, generally differing between urban and rural communities. The greater concern of many urban communities was related more to greenhouse gas issues, while with rural communities, the prevailing concerns were more terrestrial; erosion, flooding, subsistence, and permafrost issues.

Commission members appeared as speakers upon request, and routinely participated in other climate change forums, including those organized by the Alaska Federation of Natives, the Alaska Center for Climate Assessment and Policy, the Department of Engineering at the University of Alaska (Anchorage), the Anchorage Business Roundtable and Resource Development Council, the 7th International Conference on Climate Change at the University of Alaska (Fairbanks), the Society of American Military Engineers and the Warming Oceans Forum, the federal Climate Change Roundtable, Coastal Erosion Strategies for Alaska (UAF), the Arctic Research Commission, the Kivalina Relocation Group, the Alaska Water Resources Association, and the Administration's Sub-Cabinet for Climate Change. A Commission member was appointed to the Immediate Action Working Group of the Sub-Cabinet.

TASK DESCRIPTION:

As stated in the Arctic Climate Impact Assessment, "The science suggests that responding to this challenge will require two sets of actions: one, *mitigation*, to

slow the speed and amount of future climate change by reducing greenhouse gas emissions; and the other, *adaptation*, to attempt to limit adverse impacts by becoming more resilient to the climate changes that will occur while society pursues the first set of actions," (ACIA, 2004). It is also important to note that mitigation in the context of the Alaska Department of Military & Veterans' Affairs and FEMA, is consistent with adaptation in improving infrastructure to minimize damage from natural disaster events.

The Commission acknowledged these definitions, and in shaping an approach to its charge under Legislative Resolve 49, prioritized its time, energy, and resources more toward adaptation issues. This emphasis on adaptation issues, it was felt, was more responsive to the immediate threats and concerns facing Alaska, and the need to orient state government toward new responsibilities. This emphasis was judged more the purview of the legislative and administrative functions.

Perhaps the most striking impacts in all of Alaska for mitigation and adaptation strategies to be developed and applied are with the village relocation issue in Western Alaska. The convergence of immediate threats, substantial human need, and prohibitive costs presents decision-makers at all levels of government with daunting challenges.

"There is little doubt that Alaskans are feeling the effects of climate change more than anyone else in our nation. Regardless of whether these changes are caused solely by human activity, we must take steps to protect people in the Arctic."
~ Senator Ted Stevens, July 11, 2007

The Commission found that climate change presents unavoidable challenges to the citizens of Alaska. There will be new responsibilities for the State of Alaska and public entities, and there will be responsibilities for private interests which individuals must accept. Certainly the economics are a key factor in these challenges. Successful adaptation strategies that recognize the environmental, cultural, and economic factors will be the keys to reducing the adversity of climate change.

The effects have been clearly stated in the stories and anecdotes of the Native people who have spoken before the Commission. These statements have stressed the need for help in adapting to an environment that has changed within a generation, when the culture and subsistence ways were dependent on traditional knowledge and wisdom built over many generations. Now, the "world" is different as changes are occurring at a more rapid pace.

SUMMARY OF CONCLUSIONS:

As has been often repeated, the State of Alaska is at the leading edge of impacts resulting from a warming climate. The Commission has recognized many

negative and expensive effects of anticipated climate change. There are potential, positive eventualities, as well. The Commission's concern over a reduction in federal spending implies an increased level of state spending may be in demand.

We considered the most potentially impacted state agencies as being the Department of Commerce, Community, and Economic Development, the Departments of Environmental Conservation, Natural Resources, Transportation and Public Facilities, Fish and Game, Health and Social Services, and the Department of Military & Veterans Affairs (Division of Homeland Security and Emergency Management). In other agencies, there may be budgetary and regulatory impacts, as well as contraction and/or expansion of some programs. The Commission concluded that informed decision-making will need objective, reliable data, continued monitoring activities in the field and at sea, and the most up-to-date research we can acquire.

The potential for commercial shipping expansion in the high Arctic and its related support services may be the most significant new economic development activity on the climate change horizon. Access to Northern Europe via the Northern Sea Route, and to the Eastern United States via the Northwest Passage, are vital to commercial shipping interests. Increased state revenues would be tempered by increased state investments and expenses. Expanded federal and international interagency relationships, regulatory activity, public safety, and other state responsibilities will grow in response. Implications exist for new workforce development and education strategies.

The Commission considers that longer and warmer Arctic summers will help increase the number of tourists coming to Alaska, especially by cruise ship. This would include more tourism in the far north, where currently, there is relatively little marine-based tourism. Shore-based businesses may extend their operating seasons in support of a longer tourism window. The perception of industry trends is considerably more favorable for enhanced tourism under a warming scenario.

Other major economic enhancements will draw from research activities. While other states have long-established records of various impacts upon their lands and their people, Alaska, in many cases, is in its infancy in terms of the historical record, data collection, and monitoring programs. Research of all types in Alaska is a \$300 million per year proposition, and a growth sector, in large measure because of climate change research. Half of that activity is directed by the University of Alaska. As one of Alaska's recognized strengths, the research community within the state positions us well to take advantage of expanding initiatives in support of understanding, diversifying, and managing, our economy.

With an economy based primarily on resource extraction and government spending, the Commission also recognized traditional economies as significant forces in sustaining rural life in the Arctic. Impacts on Alaska's fish and game assets are

one of the most disconcerting signs of climate warming. Migratory patterns of birds, terrestrial mammals, and fish stocks are changing, and marine mammals are being greatly impacted, all to the detriment of wildlife viewers, subsistence and sport users. Boreal forests are in a pattern of range diminishment, and a variety of natural vegetative stocks necessary to sustain terrestrial mammals, is in flux. Testimony to the Commission indicated that many subsistence users have to range farther from home now in pursuit of game species, especially in Western, North-western, and Arctic Alaska.

MOVING FORWARD:

In our view, extending the Alaska Climate Impact Assessment Commission with the same approximate objectives and responsibilities will not generate a justifiable, incremental level of basic knowledge beyond that available in the Arctic Climate Impact Assessment and subsequent documents offered by public and private researchers, Non-Governmental Organizations, and contractors to the Alaska Department of Environmental Conservation.

The Commission concluded that continued identification of potential challenges, threats, and planned responses needs to occur within the Administration. It was also felt that this will enhance the development of policy, prioritization of responses, and in turn, lead to development of funding priorities, program management, and inter-agency collaboration, especially with federal agencies. Our primary responsibility was one of assessment. The Commission recognizes and supports the organizational, professional, and tenured capabilities of the Sub-Cabinet for Climate Change as the entity to develop Alaska's overall implementation plan.

ECONOMIC IMPACTS:

Discussion of the Alaska economy and economic development relating to climate change touches all issues from resource development, fisheries, and subsistence, to the health and welfare of the citizens. As a state with an economy fueled by resource development, Alaskans by necessity must adapt to changes in climate. In fact climatic changes have been a part of human adaptation in Alaska going back over 10,000 years.

In any natural system there will be change, whether we are in a warming trend or a cooling trend often depends upon the timeframe (years to decades to centuries). While some studies such as the 2007 UAA-ISER report suggest increased costs to the State of Alaska for public infrastructure, there are also offsetting savings in heating costs, less cold weather degradation of infrastructure, as well as changes such as potential lower transportation costs due to an ice-free Arctic Ocean. In early 2008, the U.S. Coast Guard (USCG) began working with the cities of Nome and Barrow in anticipation of increasing its presence in those areas.

Certainly there are specific issues such as threatened villages which must be addressed. Recent climatic shifts have accentuated erosion problems, however, the problems have always been there, to one degree or another. Thus looking ahead, the state needs to be proactive in strategic planning for impacts to infrastructure, taking into account the dynamic nature of a changing environment.

Fishing, mining, timber, and other resource extraction industry operations are energy-intensive, and therefore, sensitive to fuel cost escalations. This fossil-fuel dependence and a lack of alternatives has the potential of decreasing the market value of our resources. A variety of alternative energy and renewable energy projects have been and are being considered for Alaska. Those with successful development potential include wind and solar power, wave action/stream-flow technology, bio-fuels, hydro, geothermal, methane, and heat recovery/reuse applications. Feasibility, efficiency, cost effectiveness, and sustainability should remain the guiding principles, as location and funding issues are addressed.

Perhaps one of the greatest benefits of the heightened awareness of climate change to economic development is that policymakers and citizens are now fully aware that we live in a dynamic natural environment, and we always have. Thus adaptation will be required, as it always has been, even if not always recognized.

Specific recommendations to help address future economic impacts to the state from climate change, as well as to capitalize on what these changes could bring as opportunities for Alaska, include:

- Support monitoring systems integrated with state and federal agencies and the University of Alaska, to collect or update pertinent baseline data on physical, biological, and cultural factors.
- Support the state Division of Geological & Geophysical Surveys (DGGs), or other appropriate entity, for the identification and mapping of permafrost, landslides, riverine / coastal erosion, and soil type for engineering studies and community planning.
- Support to ensure decisions are based on science and engineering analysis well documented with recent data and future monitoring programs.
- Education and public awareness on the fact that Alaskans live in a dynamic natural environment, and that adaptation is nothing new, despite what is sometimes said.
- Plan for infrastructure development along the Northwest Arctic and Arctic coasts for maritime industries and offshore resource development.

- Support federal funding for two new ice breakers for the U.S. Coast Guard and new UNOLS ARRV to collect offshore physical, chemical, and biological data throughout the seasons.

Based on these conclusions and the breadth of adaptation needs facing Alaska, the state should have a designated liaison to work with industry (oil and gas, minerals, fisheries, transportation) and federal agencies that will be more involved in the Arctic (e.g. the U.S. Coast Guard, Department of Defense, NOAA, U.S. Fish and Wildlife Service, etc.).

FISHING / HUNTING / SUBSISTENCE:

The Commission took testimony describing projected changes in the movement of commercial fish stocks, especially the potential for salmon species intent on migrating north to follow favorable cooler water temperatures. King salmon were reported being caught with greater frequency in Norton Sound, for example. Other observers described catching unrecognizable fish species in Southeast Alaska, species likely on the move from the mid-Pacific Ocean. Several shark species unseen until recent times in Alaskan waters, have also made appearances in such numbers that sport anglers pursue them as new game fish. Marine species migrations also bring parasites, other elements of more southerly food chains, and unknown impacts to our waters.

The North Pacific Fisheries Management Council (NPFMC) has initiated a process to develop a fisheries plan for the Northern Bering Sea and the Arctic Ocean which will require additional research and fish stock monitoring. The Commission supports this effort as part of an expansion of commercial fisheries opportunities in the far north.

The changing migratory patterns of terrestrial mammals in the state, some species more pronounced than others and some areas of the state more affected than others, are being documented. Some of this is due directly to warming, but also indirectly, due changing distributions of wild plants upon which they feed. Caribou appear the most sensitive to changes in their environment. The Commission concluded that impacts on subsistence hunting and fishing activities may be substantial over time. State game management must address the changing migratory patterns of wildlife by providing current resource data with subsistence users in mind. Real time information is important for the successful hunting and gathering of subsistence resources by rural Alaskan residents.

Changes in animal migration patterns and movement of fishery stocks portray that state and federal agencies charged with management, face new regulatory challenges, for example, with seasonal and harvest limits. These new animal and fish dynamics will need continuing research and monitoring activities.

FEDERAL SPENDING:

Generally, the Commission was not encouraged that federal spending in Alaska will increase over time to meet the overall challenges of climate change, particularly in support of mitigation actions. The exceptions may be federal spending for research, homeland security (a predominantly emergency response-type function), and military spending.

INSURANCE INDUSTRY:

According to the National Association of Insurance Commissioners (NAIC), the insurance regulators will begin to review *"all aspects of insurance regulation with a view to making significant changes that will be necessary as a result of this challenge."* The NAIC has established a Climate Change and Global Warming Task Force, charged with assessing climate change insurance-impacts on consumers, insurers, and insurance regulators. Since 2006, their focus has narrowed on impacts to regulators. We have discovered no corresponding task force or other entity at a statewide level in Alaska.

NAIC findings highlight insurer solvency issues of concern to regulators nationally, their investment practices where assets in coastal areas may face greater threats, and differing potential market impacts for the different lines of insurance protection offered to customers.

Of more local concern in Alaska is affordability, and long term availability of coverage for municipalities, the private sector, and other entities in regions threatened with permafrost degradation, flooding, and erosion.

Insurability of Alaskan communities, especially those with recurring disasters, is a challenge that will require improved data and detailed risk assessments. Presently, risk assessments can only build upon recurrence of natural disasters associated with storm surge and erosion, flooding, ice damage, fires, and thawing permafrost. With federal agencies identifying over 160 communities potentially at risk (USACE, 2006 and 2007), the amount of data required to support adaptation for these communities, while providing sustainability and insurability, is significant. The Commission supports federal efforts to interview and prioritize each community as to the level of risk and potential for recurring natural disasters. This information can help to support cost-effective insurance for public and private community assets.

The Commission recognizes the value of access to the National Flood Insurance Program (NFIP). However, insurance under this program requires communities, boroughs, or counties to be incorporated, and may be considerably more expensive than residents of remote communities can afford. The State of Alaska, together with the Alaska Municipal League's insurance arm, should explore cost-effective means of insuring communities against loss due to climate change.

Ultimately, though, the impacts of climate change on insurers will be borne by those insured.

MARINE TRANSPORT:

Assuming current warming trends continue or accelerate, it should be considered fact that the high Arctic will become increasingly more accessible in the next decade. Couple this with projections that the Arctic will continue to grow as a major energy development arena and that it will offer new, long-sought commercial shipping routes. Given these developments, it can be seen that new demands for financing, shore-based infrastructure, new resource extraction, a variety of regulatory regimes, environmental protection, military and homeland security, international cooperation, cultural integrity, research strategies, and more, will all be at hand. New challenges, opportunities, and responsibilities will confront the State of Alaska.

The Arctic Council (www.pame.is) is the official circumpolar agency which manages a strategic plan for the high Arctic. The Council is comprised of the five Arctic Ocean nations (U.S., Canada, Denmark/Greenland, Russia, and Norway), plus Finland, Iceland, Sweden, representatives of several affected indigenous groups, and a corps of observer entities.

The Arctic Marine Shipping Assessment (AMSA) is a project of the Arctic Council. The AMSA has been underway since 2005, and a final report will be issued later this year. The initial task has been to conduct a marine activity data survey with two major components. One is to establish a baseline of current Arctic marine shipping activity and assess its environmental, social, and economic impacts. The second component of this undertaking is to project levels of Arctic shipping activity out to 2050, and assess related environmental, social, and economic impacts for that period. This component will also generate recommendations for the final report.

The U. S. Arctic Research Commission (www.arctic.gov), established in 1984 by Congress, develops and implements national policy priorities for basic and applied scientific research in the Arctic. Among other things, ARC is engaged with the Arctic Council in evaluating the potential for commercial shipping expansion in the Arctic under climate warming conditions. The ARC stressed to the Commission, the need for environmental monitoring, and voiced support for the work of the Global Earth Observing System (GEOS), the Arctic Observing System (AON), and the Alaska Oceans Observing System (AOOS). The ARC also recommended that the State of Alaska support the Arctic shipping regime currently in the President's draft of the White House Policy On The Arctic.

Shipping routes through the Arctic Ocean between the Pacific Ocean / Bering Sea and the North Atlantic are so attractive that the five nations in the core region

are boosting military capacity in order to assert territorial claims. Chinese interest is significant. Their large container ships could reduce the run from Shanghai to Rotterdam by nearly one-thousand miles using the Northern Sea Route (above Russia). Other opportunities are just as appealing via the Northwest Passage (above Canada). The Commission recognized a potential need for a Vessel Traffic System (VTS), such as is now in place in Prince William Sound, but not in the Aleutians nor in the Bering Strait. Alternatively, the U.S. Coast Guard (USCG) may consider vessel routes or designated shipping lanes within which ships would be obliged to confine their movement.

Infrastructure requirements for Alaska's Arctic coastal seas include charting & hydrography, improved sea ice monitoring & forecasting, enhanced search & rescue, ports & harbors of refuge, communications & navigational aids, oil spill & vessel incident response capacity, marine traffic monitoring, and additional icebreakers. The State of Alaska may need to participate financially in these needs.

USCG officials have called for a national dialogue on American security interests in the Arctic. Today, the USCG is developing plans for a greater presence in the Bering Sea and Arctic Ocean, as new commercial shipping activity becomes more apparent. Presently, there is little or no consistent vessel patrolling in these northern waters, and only one Coast Guard patrol aircraft flies, mainly to monitor activity on the commercial fishing ground.

The USCG now possesses a total of three icebreakers for the entire nation, two of which are at the end of their service lives. Without completely overhauling these or acquiring new ships, we will not be ready for the growth of this new frontier. In addition to keeping shipping lanes open, these vessels are designated research ships, and as such, work extensively for the National Science Foundation, which pays a majority of their operating expenses.

American polar icebreakers are key instruments of U.S. maritime policy and security. It is critical that America's polar icebreakers be operated by the USCG, and not be outsourced to foreign powers, so that such responsibilities as search and rescue, law enforcement, icebreaking, and scientific research (including surveying the outer continental shelves), can be effectively conducted off Alaska. The Commission recommends replacement of the two aging icebreakers in the American fleet as soon as feasible.

ECONOMIC VALUE OF RESEARCH:

The research factor throughout the array of climate change issues, has great and positive implications for Alaska. Research activity and the funding it brings into the state are of considerable significance to the University of Alaska (UA) and other entities, and therefore, the economy in general. Total research value in Alaska is worth about \$300 million per year, with about half under the auspices of UA.

Climate change research is a major share of that activity, and growing. UA refers to research as the "silent giant," which provides nearly 2,400 jobs and a \$92 million payroll. Active UA research exceeded \$151 million in value in 2006, nearly all of which is new money into the economy. Other, indirect benefits of research activity appear beyond the academic community, as well.

TOURISM:

Climate change presents both opportunities and challenges for the tourism industry. The vast majority of visitors to Alaska come in the summer time. About one million of the state's 1.8 million or so visitors come by cruise ship and over the last decade, ships have started coming earlier in May and leaving later in September.

Thus, it can be argued that longer and warmer summers help increase the number of tourists and the amount of money they spend. Also, there is some evidence that people visiting Alaska tend to spend more on some activities on warm sunny days than they do on cooler wetter days. Also, some activities such as flight-seeing sometimes are canceled on stormy days, thus decreasing revenue for Alaskan businesses and reducing the visitor experience. The unusually warm summer weather that occurred in Southeast Alaska in 2004 had a definite and positive economic impact from the point of view of the cruise industry.

If winter continues to leave earlier and start later, it is likely that some businesses which close down for the cold months, will stay open longer. Thus, it is possible that both Alaskans (who can be tourists in their home state) and visitors from outside, will provide an increased source of revenue for these businesses. It might even be argued that shorter and less severe winters have a positive effect on wildlife and their ability to survive. If this is so, wildlife viewing, a major activity for tourists, may well be enhanced.

Another potentially positive economic impact of climate change is the opening of the Arctic Ocean to tour ships. Some small tour ships already offer tours as far north as Barrow, but the receding ice pack in the summer may well increase these opportunities and offer some economic benefits to some of our northern communities.

However, the entire picture is not positive. As Alaska seeks to expand its winter tourism appeal, the unpredictable nature of recent winter weather becomes a problem. We have seen dog sled races, skiing events, and other winter activities cancelled or moved to new locations.

Warm hot summers have brought us record-breaking forest fires both in Alaska and in the Yukon Territory. The smoke from these fires has covered Southeast, South Central and interior parts of the state from time to time. This

smoke has definitely reduced the visitor experience and has caused some ground tours to be canceled or rerouted, often at considerable expense to the tour company.

Receding glaciers may be another negative aspect of climate change. Glaciers are another item on most visitors' "to-do list." The change in glaciers can have a major impact on visitor activities. For instance, Portage Glacier used to be the most visited location in Alaska. However, as the glacier has receded from view, the area has become less of a tourist attraction.

In summary, the fact that the Arctic in general and Alaska in particular experience some of the most dramatic effects of climate change, this may in itself attract more visitors. However, those visitors may experience a different Alaska than if they had made their trip a decade ago.

ALASKA'S COMMUNITIES:

LAND USE ISSUES:

The Commission supports the obvious, that many land use regulations, regional codes, ordinances, and professional practices need to be reviewed for potential climate change impacts. The history of construction in known flood plains, erosion-prone areas, vulnerable coastal locations, and permafrost-degraded regions of the state bares the costly lessons we must avoid in the future.

As a step forward, the Commission recommends issuance of an Administrative Order regarding the siting and building of state-owned and financed construction projects. It's in the state's best interest to protect capital investment by reducing potential impacts from erosion and flooding. Construction standards found in federal regulations under 44 CFR Part 60 of the FEMA National Flood Insurance Program (NFIP) should be mandated for all state agencies with construction authority.

TECHNICAL MAPPING UPDATES:

The Commission took testimony regarding the inadequate state of the technical maps inventory available to researchers, planners, engineers, construction firms, emergency preparedness personnel, and others. These maps chart soils, erosion, flood plain features, surface water, stream and river course changes, and permafrost conditions, all referred to as the vertical datum. Some maps have not been updated in decades, especially in Western and Northern Alaska. This deficiency only serves to increase the level of professional guesswork on various projects.

Updating technical maps to address the problems mentioned above will require a comprehensive effort to establish an accurate vertical datum for Alaska, especially the coastal zone of the Bering Sea from Bristol Bay north to the Chukchi and Beaufort Seas. The vertical datum would establish the orthometric heights relative to the ellipsoid height measured by Global Positioning System (GPS). In conjunction with accurate horizontal datum as established by GPS, this would allow for accurate determination of shoreline and determine direction of water flow and potential flood risk.

To complete this, coastal mapping in Alaska needs also to be expanded. A proposal to map the gravity field of Alaska's Littoral Regions (excluding the Aleutians) with airborne gravity sensors and topographic lidar is in draft by NOAA's National Geodetic Survey (NGS). This effort will produce an accurate shoreline that can be monitored automatically with GPS technology. The statewide digital ortho-image program offers a mechanism for developing the technical maps. The Commission recommends that the state, in conjunction with federal agencies, prioritize mapping upgrades especially for coastal erosion-prone areas. We also recommend that the state encourage NOAA to seek funding for this project so that decisions affecting communities are clear as to the orthometric heights, risks of flooding, and rates of coastal erosion.

In addition to pursuing the digital ortho-image mapping of Alaska, specific communities are in need of more detailed geologic and hydrologic mapping, including geophysical hazard mapping, in order to define the adequacy of the local terrain for: adapting to coastal and riverine erosion and permafrost thawing. Specifically, the state should provide adequate resources to the Division of Geologic and Geophysical Surveys (DGGS) in the Department of Natural Resources, to coordinate state-federal engineering surveys of potential evacuation routes, village relocation sites, and material sources, including gravel and armor rock. This coordinated effort will insure that sites will prove sustainable and can optimize local resources in a cost effective manner.

Efforts by NOAA's Center for Ocean Observations and Prediction have enabled National Water Level Observation Network (NWLON) stations (tide stations) to be increased in Western Alaska, with recent stations established at the Red Dog dock (Kotzebue-Kivalina area), Village Cove on St. Paul Island (Pribilof Islands), and Port Moller (Alaska Peninsula), support an understanding of sea levels associated with meteorological and oceanographic conditions in near real time. Such efforts are valuable in understanding changing sea levels and coastal inundation. Additional stations are proposed between Nome and Port Moller for Western Alaska and Bristol Bay, and at the Red Dog dock and Prudhoe Bay for Chukchi and Beaufort Sea measurements. These, though, are not now at a priority that will allow installation consistent with future Arctic

shipping interests or the needs for predictive tools in planning for coastal flooding and erosion.

THREATENED COMMUNITIES:

The Commission took a considerable amount of testimony from residents of small communities, including villages under threat of damage or demise due to storm surge, river flooding, and severe erosion. We also made site visits in Barrow, Kotzebue, and Kivalina. Some communities have been working on village relocation for nearly twenty years.

In the Commission's view, perhaps the largest impediments in all of this appear to be lack of a unified vision toward goal achievement, little confidence that substantial funding will materialize, and concern for the ability to assist all similarly impacted villages to the extent that the first few might be helped. These lead to other problems evident in many relocation circumstances, including inadequate planning, differentiated authorities in decision-making among agencies, uncertain "first step" funding, and an inability to overcome certain regulatory conflicts in support of community relocation actions. These problems are most acute where relocation sites have not been agreed to, and impasses continue between residents and agencies. The Commission also recognized a concern for the use of funds needed to secure present village sites for public safety reasons, versus the lost opportunity of applying those funds to a new community site. Estimates for stabilizing or securing existing village sites ranges from to several to tens of millions of dollars per year without addressing the long term sustainability of each community.

In Kivalina, a community inspected by the Commission, the assessment of safety preparedness and successful adaptive measures in place for residents and village infrastructure, was not encouraging. Both immediate and long term planning are inadequate although improving, but decision-making among the action entities, including residents, are not coalescing adequately for the ultimate protection and relocation of this community.

Presentations by Newtok showed how the community has maximized the community planning process to identify a new village site and work with state and federal agencies to transfer ownership, characterize the site, develop an infrastructure plan, and begin limited relocating of village assets. Funding of the relocation remains a major challenge as the weakening of the permafrost and subsidence of the Newtok village site makes the relocation inevitable.

Presentations by other communities, including Shishmaref and Koyukuk, show progress on providing protection against coastal erosion and flooding while developing evacuation and relocation routes. In the case of Shishmaref, experimental shoreline protection using armor rock is being evaluated by the

U.S. Army Corps of Engineers (COE) while the relocation to Tin Creek, including gravel source and relocation route, is developed.

As many as twenty other Alaskan villages may suffer from similar strategic short-comings. The Commission recommends exploring the large mine decision-making process used in the Department of Natural Resources as a structure for advancing the goals for successful village relocation projects. Another recommended model may be that of the former Alaska Land Use Council under ANILCA.

Given the breadth of impacts and the unique ownership status of Alaska, these are Federal-State-Native cross-cutting issues. Alaska has employed the Alaska Land Use Council in the past. The State of Alaska has the capability, partially established in the Denali Commission, partially with the COE, and partially within the U.S. Departments of Interior and Transportation. The Commission recommends that appropriate Memorandums of Agreement be developed to establish a point of leadership on behalf of village relocation projects in the state.

NATURAL RESOURCES:

RESOURCE DEVELOPMENT IMPACTS:

Natural resource development in the oil & gas and mining sectors remains an important part of Alaska's economy. Oil and gas development in Alaska has already been impacted by climate change. As the Alaska Department of Natural Resources (DNR) presented to the Commission, the number of days exploration can be carried out on the North Slope, the tundra travel season, steadily declined from near 200 days per year in the early 1970's to around 100 days per year in the early 2000's.

DNR's Division of Mining, Land, and Water, in conjunction with the U.S. Department of Energy, initiated the Tundra Travel Modeling Project which, with scientifically valid, peer-reviewed research, found ways to extend the season without compromising the environment. The success of that project, and continued research by the division and private sector explorers, will be crucial to continued oil & gas and mining developments in the Arctic.

In the broader context, changes in climate which impact natural resource development operations could manifest in several different ways:

- Changes in Soils (permafrost, active layer depth, slope stability)
- Changes in Sea Temperature (ice thickness, timing, and distribution)
- Changes in Weather patterns and severity (snow depth)

Changes in these physical parameters have the potential to result in changes, both positive and negative, in existing and proposed natural resource operations:

- Unexpected settlement damage to existing production facilities (-)
- Shorter operating windows for seasonal ice roads (-)
- Lower design ice loads for offshore and shore structures (+)
- Changes in fresh water availability (+ / -)
- Reduced ice gouge risks for offshore pipelines (+)

Private sector companies operating on the North Slope have already begun assessing the potential impacts of climate change on their operations and developing strategies to adapt their operations to a warmer climate. In addition to researching revised design specifications for future facilities, consideration is being given to potential modification of existing facilities to guard against premature settlement or erosion.

On the positive side, increased transportation opportunities in the Arctic, over the long term, may enhance the economics of resource development. Relatively cheaper water borne transportation, available on a more regular basis, could reduce the costs of delivering resources to market.

At this point, no near term changes to statute or regulations have been identified as crucial for adaptation measures in oil & gas and mining development in the state. In the longer term, as the natural resource extraction industries identify trends requiring adaptive measures, state agencies should remain flexible in their approach to regulation of the industry.

Climate changes in Southwestern, South Central, and Southeast Alaska are not outside the long term variability in the climate fluctuation. Each region will need additional research to identify trends and assess opportunities. Consideration for sustaining natural resources while maintaining resource development opportunities will need positive interpretation of existing data, and a strategy for future data collection.

Whether considering offshore development in the north Aleutian Basin, mines in the mineral-rich districts of the state, or pursuing forest resources in South Central and Southeast Alaska, providing the state with access to the best data will benefit resource managers and developers in finding solutions consistent with the approach to balancing the regulation of developers and the sustainability of the communities and resources involved.

FISHERY IMPACTS:

Commercial and recreational fishing are cornerstones of the Alaskan economy and the Alaskan mystique. The stocks are sustainable because of scientific study, and management regimes that insure responsible recruitment to the fishery, and appropriate escapement for replenishing the populations. Access is insured by the Alaska Constitution and includes a regulatory structure that is of the people and for the people.

These factors recognize the value of healthy habitat, variability in fish populations, changes in the efficiency of the harvest, and competition for the resource. Climate change is being documented as a factor in changing distribution patterns and ranges, in periods of the runs, and in the species mix harvested as catch and bycatch. To address these, the State of Alaska should continue on its present course of action with strong interagency and state-federal management, while interjecting a precautionary approach that reflects the current stock assessments and trends. In this precautionary approach, however, data will be essential to:

- Manage boundaries and seasons opened and closed to fisheries to optimize the catch and minimize risks to stocks and fishermen.
- Show that stream flows, water quality, ocean currents, and ice cover are changing the habitats and directly affect the fish and fishery, whether in our marine fisheries or our anadromous fisheries.
- Optimize economics of the fishery over the long term and allow for a flexible management regime to sustain the fishery while yielding revenue to the fishermen and taxes to the state and federal governments.
- Address species and ecosystem shifts where increases in predatory fish may be lowering harvest levels of preferred finfish and shellfish.
- Understand the near term and long term ramifications of ocean acidification on predator/prey relationships and particularly the survival of calcium dependent shellfish and zooplankton.
- Document the distribution and growth of invasive species in Alaskan waters, either as predators in bio-fouling or niche replacement, or as pathogens affecting the lifecycle of the species or the public health aspects of consuming seafood.

In this light, public education and outreach will need to be an integral part of communicating risks and opportunities with climate change in Alaska. Addressing the climate change impacts on our fisheries will take monitoring and assessment programs, and funding as new questions arise.

An excellent example of addressing the changes can be found in the fishery management policy process in the northerly range extension of salmon into the Arctic, and the northerly extension of walleye pollock to the northern Bering Sea. Recognizing the trends in 2004-2005, the North Pacific Fishery Management Council has begun to develop an Arctic Fishery Management Plan that will provide a framework for future commercial fishing in the Chukchi Sea. Presently, the precautionary approach keeps the fishery closed while scientific data can be collected and assessed. Through the fishery management policy process, a rational public process will lead to decisions that will sustain the fishery and the industry, and allow for optimal use of the resource within federal and state mandates.

FORESTRY and WILDFIRE IMPACTS:

The mean annual surface temperatures in Alaska are increasing, most notably on the Alaskan North Slope. With rising temperatures, changes in precipitation and increased evapo-transpiration are to be expected, as well as continuing permafrost degradation. This results in reduced water availability, such as a net decrease in stream discharge, and a dryer environment with long-term drought potential. These conditions have already been observed as impacting the northern birch and spruce forests, and yellow cedar in the Southeast. Under climate warming assumptions, boreal forests may be expected to see decreased tree growth because of warmer temperatures and reduced water consumption. With probable continuation of these conditions, tree mortality would spread, and conversion to non-forest ecosystems would eventuate.

Climate scientists and other professionals have indicated that the increased frequency, intensity, and scope of suppression activity for wildland fires in Alaska is associated with climate warming. In the past five years, Alaska has experienced record-setting fire seasons, with considerable increases in agency expenses. In 2004 and 2005, the total spent was \$95 million, far over budget.

Indirect impacts and expenses occur when smoke from wildfires pervades urban and rural areas alike. Respiratory illnesses increase, and the public health community becomes more involved. Also, a combination of wildfire events in concert with a greater number of homes and infrastructure built in wooded and rural areas, raise costs to citizens and the private sector. These conditions, likely to increase, necessitate a review at the community and borough levels for zoning and land use changes. Consideration must be given to the prospects that eventually, not all structures and properties may be protected by wildfire suppression services.

EROSION, FLOODING, ENGINEERING:

Erosion and flooding are fundamental issues that impact as many as 162 communities in Alaska (USACE, 2007). Technical evaluations have identified nine communities as Coastal Erosion Communities and ten communities identified for Comprehensive Assessment. An additional 143 communities are identified for interviews for Erosion Assessment. This effort will provide a basis upon which additional decisions can be made under the guidelines provided in the Alaska Village Erosion Technical Assistance Study (USACE, 2006).

These interviews are ongoing, with 20 additional communities to be interviewed in 2008. Given the importance of understanding the potential damage to Alaskan communities, the completion of these interviews should remain a priority, with state participation in the review of findings to assess risks and determine the priority of mitigation needs and adaptation options. To accomplish this, the State of Alaska should join in a timetable with a commitment of staff and resources that will allow effective assessment and planning for meeting adaptation and mitigation measures so as to reduce emergency expenditures.

Determining the risks to communities and infrastructure depends on having accurate environmental models that build upon the changes in climate and ocean conditions. A significant data source for determining risks for engineering in flood plains is the *Precipitation Frequency Estimates* (PFE) of the National Weather Service (NWS). In Alaska, the data is no more current than the 1963 and 1965 NWS Technical Papers 47 & 52, and does not reflect present conditions or observations from the last decade. This is a particular shortcoming relative to the seasonal flooding events in South Central and Interior Alaska, and the significant drying of tundra on the North Slope.

It would benefit the State of Alaska and the 162 communities being assessed for potential risk of flooding, to have updated PFE's for assessing the risks to communities and infrastructure. To accomplish this, the state should endorse efforts by the NWS (Alaska Region), in securing funding for a 2008 update for Alaska.

The melting of the Arctic ice cap and late freeze up of coastal ice are two of the most significant indicators of the impact of global warming on Alaska. The trends have been well presented in the Arctic Climate Impact Assessment (2005), State of the Arctic Report (2006) and the Arctic Report Card (2007). With decreased coastal protection from ice, coastal erosion in the Bering, Chukchi, and Beaufort Sea communities has increased, and the loss during specific incidents is well documented. Storm frequency and wave energy models are being developed through the University of Alaska, Fairbanks

to support engineering decisions (Atkinson, 2007). Research efforts by the U.S. Army Corps of Engineers, NOAA's PMEL, the Arctic Research Commission, and the University of Alaska should continue to be supported so that the rate of change can be monitored and included in models, forecasts, and engineering studies. To accomplish this, the State of Alaska should endorse efforts by federal agencies to continue research into changes in the Bering, Chukchi, and Beaufort Seas' oceanographic and sea ice conditions, and to have the information made available for forecasts and risk assessments.

Comparably, establishing an accurate vertical datum for Alaska, particularly the coastal zone of the Bering Sea from Bristol Bay north, and the Chukchi and Beaufort Seas, would provide a coastal datum reference for determining shoreline change. The vertical datum would establish the orthometric heights relative to the ellipsoid height measured by GPS. In conjunction with the accurate horizontal datum as established by GPS, this would allow accurate determination of the shoreline and determine direction of water flow and potential risk of flooding from GPS-controlled topography and bathymetric mapping.

To complete this, coastal mapping in Alaska needs to be expanded. A proposal to map the gravity field of Alaska's Littoral Regions (excluding the Aleutians) with airborne gravity sensors and topographic lidar is in draft by NOAA's National Geodetic Survey. This effort will produce an accurate shoreline that can be monitored with GPS technology.

To accomplish this, the State of Alaska should prioritize mapping in coastal erosion-prone areas and guide the NOAA NGS on project planning for combined gravity measurements and lidar topographic mapping. The State of Alaska should encourage NOAA to direct funding to this project in order that decisions affecting communities can be made with a clear understanding of the orthometric heights and risks of flooding and rates of coastal erosion.

Recent efforts by NOAA's Center for Ocean Observations and Prediction have enabled National Water Level Observation Network (NWLON) Stations, tide stations, to be increased in Western Alaska, with recent stations established at the Red Dog Mine dock (Kivalina area), Village Cove on St. Paul Island (Pribilof Islands), and Port Moller (Alaska Peninsula). These support an understanding of sea levels associated with meteorological and oceanographic conditions in near real time. Such efforts promote safe navigation, understanding storm surge, and coastal inundation. Additional stations are proposed between Nome and Port Moller, and between the Red Dog Mine dock and Prudhoe Bay for Chukchi and Beaufort Sea measurements.

However, these are not consistent with anticipated Arctic shipping interests or the need for predictive tools in planning for coastal flooding and erosion with storms and storm surge. To accomplish this, the State of Alaska should identify the transportation and public safety needs in terms of a complete NWLON station network that supports the coastal Bering Sea communities between Port Moller and the Beaufort Sea. The State of Alaska should encourage NOAA to establish a timetable to install the NWLON stations consistent with the transportation and public safety needs.

In the Aleutians East Borough, a region where we did not hold public hearings, residents in Nelson Lagoon observe that erosion has increased noticeably in the last six to eight years. According to the borough manager, this is due to later and lighter freeze-up activity, which has historically served as a buffer to fall and winter storm-related tidal encroachment. This is not unique or unprecedented as all areas on the north side of the Alaska Peninsula are susceptible to erosion and coastal flooding associated with strong winds and lack of sea ice protection.

However, as with other areas better documented, the dependence on anecdotal data and lack of physical measurements make the estimates of impact and coastal change marginally accurate at best. This is particularly true if few state or federal disasters have been declared in the area. And without impacts to physical structures or limitations to navigation, the impacts to the environment and ecology can not be assessed. The State of Alaska should encourage community involvement in coastal management plans to develop a pictorial history and anecdotal data base of environmental and ecological changes that support local concerns, including subsistence and sustainability.

ENGINEERING FOR ADAPTATION:

Alaska is a land of extremes, and successful engineering solutions must address these extremes, often without the benefit of refined regional codes of practice and extensive data common to areas with longer histories. Alaskan tides vary from one to forty feet, and the presence of ice and/or permafrost is common. Waves, currents, variable soils, and other terrain features offer complex combinations in the tidal and riverine zones. A tour down the Trans-Alaska Pipeline System corridor crosses every kind of climate variation, terrain feature, and complex engineering challenge Alaska has to offer.

According to the Institute of Social and Economic Research at the University of Alaska, Anchorage (UAA-ISER, Larson et al 2007), both temperature and precipitation will continue to increase in Alaska. Adverse climate change conditions could make the cost of building and maintaining public infrastructure 10% more expensive, or greater, by the year 2030. Public infrastructure includes federal, state, and local facilities which serve society:

Bridges, roads, buildings, schools, airports, harbors, docks, sanitation systems, power generation & transmission facilities, fuel tank farms, post offices, the Alaska Railroad, and the like. Private facilities are likewise vulnerable to significant climate change. With well over 300 communities in Alaska, UAA-ISER has identified 16,000 separate elements of public infrastructure that are affected by changes in climate.

Unusual warming conditions will affect our infrastructure situated in places where flooding, erosion, and permafrost damage are most acute. According to UAA-ISER, this will mean accelerated degradation of roads, runways, and water-sewer systems, which are particularly vulnerable to these adverse conditions. There may be some offsetting benefits as warming trends might lessen the eventual damage to facilities designed and engineered for the change, however, in the near term, damage to older infrastructure designed for colder conditions, will be more substantial. As sea ice recedes and marine transportation routes open up, the cost of building materials in Western and Arctic Alaska will be reduced.

Improved engineering strategies and techniques are vital adaptation responses to this increasing challenge. Competitive and dynamic engineering practices have the potential to reduce incremental cost estimates associated with climate warming in the Arctic. The success of engineering projects is not strictly related to project costs. Expensive engineering structures have failed considerably sooner than the expected service life of the project in question. The Commission took testimony and inspected sites, notably at Kivalina, where failed design and construction strategies cost millions, failed to protect citizens, and perpetuated threats to other village infrastructure.

By taking action to find the best new techniques, aggressively engaging in research and development, and by establishing a peer-review process, the state can have a strategy to develop hazard-resilient public infrastructure, and reduce financial loss due to premature failure. The Commission supports development of engineering standards that reflect this strategy. Standards should be developed in conjunction with other public and private entities engaged in Arctic engineering to assure use of the best available design, material, and engineering applications.

"Best practices" must be reflected in all requests for engineering proposals submitted to the state. The state may then institute an oversight peer-review panel to ensure best practices applications. Greater emphasis must be placed on suitable Arctic or Sub-Arctic professional experience. The Commission also recognizes the need to expand the network of monitoring stations throughout Alaska, both terrestrial and marine observing stations. Engineers here work under conditions of relatively severe climate change

impacts, yet have a much less substantial system of monitoring stations than any other state. An improved knowledge base reduces risky guesswork in the design process, and reduces project costs.

Alaska enjoys a wealth of cold regions expertise in engineering and research. Engineering challenges in a time of climate warming call for many more engineering graduates from our university system than can presently be managed, including those in graduate programs. The University of Alaska should be encouraged to continue expansion of its existing programs to meet this demand. Among those institutions at the forefront of Arctic engineering in Alaska (in addition to the University of Alaska), are the Cold Regions Research and Engineering Lab and the Cold Climate Housing Research Center. The Commission supports the work of these, and public research entities such as UAA-ISER, and the U.S. Arctic Research Commission.

STATE and OTHER AGENCY CONSIDERATIONS:

SUB-CABINET FOR CLIMATE CHANGE:

Recognizing the threats climate warming brings upon Alaska, the Governor issued Administrative Order 238 in September of 2007, establishing the Alaska Sub-Cabinet for Climate Change. Its chief purpose is to advise the Governor on the preparation and implementation of an Alaska climate change strategy. It currently has five working subcommittees, and will soon form advisory and technical working groups. Chairman of the Sub-Cabinet is the Commissioner of the Department of Environmental Conservation. Sharing inherent responsibilities for the State of Alaska from the perspectives of two branches of government, the Sub-Cabinet and the Commission have worked closely together to develop a state strategy to best address responses.

STATE AGENCY IMPACTS:

The Commission approached seven departments of the state government to ascertain their perceptions and identifiable experiences of impacts under climate warming conditions. A few state officials had testified to the Commission in 2007. Those state departments considered most likely impacted by climate change are the Alaska Departments of Commerce, Community, and Economic Development, Environmental Conservation, Fish and Game, Health and Social Services, Military and Veterans' Affairs, Natural Resources, and the Department of Transportation and Public Facilities.

Generally, the Commission feels that we are early in the period of climate change understanding when it comes to determining precise budget impacts and service delivery changes by state government. State agencies were mostly speculative or suggestive in describing budget impacts, but with

the elevation of climate change awareness and impacts now reaching program management levels, the Commission is confident that the Sub-Cabinet for Climate Change can pursue an agenda for long term action. As has been noted throughout this report, this recognition underscores the need for data collection and monitoring activities. Highlights of the affected state agencies' responses follow, and complete responses may be found at Attachment F.

COMMERCE, COMMUNITY, and ECONOMIC DEVELOPMENT:

DCCED leads the effort on behalf of communities most immediately threatened by flooding, erosion, and storm surge - Kivalina, Newtok, Shaktoolik, Shismaref, and Unalakleet. Other villages are in varying degrees of less-threatening circumstances. State funding is considered essential to attract meaningful federal funding for helping these villages. The agency specifically recommends a statewide comprehensive management plan for a framework of response to climate change threats.

A host of other departmental responsibilities are seen for small communities, certain types of infrastructure, subsistence resources, commercial fishery financing and permit values, investment portfolio collateral, and certain insurance issues, including the National Flood Insurance Program (NFIP). DCCED contains the Division of Insurance, the Alaska Industrial Development and Export Authority, the Alaska Energy Authority, the Office of Economic Development, the Division of Community Advocacy, and the Division of Community and Regional Affairs.

ENVIRONMENTAL CONSERVATION:

In addition to providing leadership and staff support to the Sub-Cabinet for Climate Change, DEC has direct responsibility for a host of climate change impacts, including flooding and erosion threats to community infrastructure such as water and sewer systems, marine spill prevention and containment, air quality issues related to wildfires, newly anticipated food-borne pathogens, fuel delivery, storage, and power generation facilities threatened by erosion and flooding, water quality standards for warming estuaries and fresh water habitat which support fisheries, and more. DEC is also the state's action agency for anticipated carbon-reduction mandates from the federal government.

In the longer term, the department perceives greater incidents of exposure of old military, community, and industrial landfill sites due to permafrost degradation, encroachment of surface waters, and manmade system failures, as well as with increased risks of oil spills and marine vessel accidents in the Beaufort Sea / Arctic Ocean. DEC also speculates that certain Congressional actions could positively affect market demands for Alaska natural gas, clean fuels from coal, and may enhance the attractiveness of renewable energy alternatives.

FISH and GAME:

The department carries substantial responsibility for commercial and sport fisheries, subsistence activities, sport hunting, a wide-ranging regulatory program, wildlife conservation, and manages considerable research and monitoring activity.

F&G perceives threats to commercial, recreational, and personal use fisheries under climate warming assumptions. A host of new regulatory provisions may be needed to address migrating fish stocks, harvest limits, commercial entry, ocean acidification, loss of stock due to increasing natural predation, and parasites. Under some assumptions, fish tax revenues, for both the state and local communities, may see reductions.

F&G also recognizes impacts to Alaska's wildlife and bird populations. Changes in species distribution and behaviors would necessitate changes in management plans and harvest limits. Habitat may likely be threatened by invasive plant and animal species, increased wildfires, flooding, changing weather patterns, and erosion. As with fisheries impacts, increased monitoring and research strategies would be vital in support of management needs.

HEALTH and SOCIAL SERVICES:

Identified areas of significant impact within the Health and Social Services Department focus on respiratory illnesses, air/food/water-borne diseases, adverse dietary changes due to a reduction in subsistence provisions, increased participation and costs associated with food assistance programs, and accidents due to negotiating changing weather and ice conditions. Rural water and sewer systems, vulnerable to permafrost melt, increased flooding and erosion, imply greater demands on outbreak response and mitigation activity. Several agencies within the department would have responsibility to address impacts brought about by climate change activity.

MILITARY and VETERANS' AFFAIRS:

The Division of Homeland Security and Emergency Management (DHS&EM) is the primary agency within the Department of Military and Veterans' Affairs which confronts perceived impacts from climate warming. Since 1978, the division has experienced 226 declared disasters, costing \$378 million in state and federal funds. The division has observed an increase in community fuel shortage incidents, due to barge delivery impediments from weather-related activity. Fuel shortages potentially threaten life, public safety, and damage to public facilities. For riverine communities, successful fuel delivery is affected by water level, sand, and siltation matters. For coastal and island communities, the challenge is delivery in the fall prior to the storm

season. In any case, air delivery of fuel is considerably more expensive, less efficient, and impacts budgets at several levels.

Over the past sixteen years, the division has observed trends showing greatly increased costs for disaster response, coupled with a rising number of repair projects. Disasters occur due to erosion, often exacerbated by a lack of shore ice, storm surge, ivu (ice encroachment onshore), flooding, severe wind and rain, permafrost deterioration, and wildfires. All adversely impact Alaska's citizens, natural resources, public health, and the economy.

DHS&EM works extensively with the Federal Emergency Management Agency (FEMA), and has developed formal hazard mitigation plans with participating Alaskan communities. These agreements qualify as locally adopted FEMA plans, which will avail the local community of federal hazard mitigation funds. To date, Alaska has twenty-four approved plans, and fifty under development. DHS&EM is itself prevented from engaging directly in pre-disaster mitigation activity, due to the federal Stafford Act.

NATURAL RESOURCES:

Climate change impacts pervade most operations of the Department of Natural Resources (DNR). In the near term, DNR identifies a greater need for essential data to identify and monitor changes. LIDAR imagery and satellite data will identify trends in erosion, vegetation, and other surface changes in the geomorphology. Hazards mapping needs to be enhanced to track permafrost conditions, wildfire fuel sources, and other conditions which influence permitting and development actions in and near communities.

The department also identifies potential changes in its permitting and regulatory scheme, affecting energy exploration and other extraction development. A tundra travel season which continues to shrink has significant implications for industry, and the state. In the mining industry, tailings dams will need to be engineered and monitored to recognize changes in permafrost, precipitation patterns, and other hazards. DNR also concerns itself with the stability of the Trans Alaska Pipeline (TAPS) in terms of its heat pipes and possible permafrost degradation below support structures.

Within the department's Division of Agriculture is recognized a potential for increased commercial production of food sources, such as grains and vegetables, under a climate warming assumption. However, with that would come increased invasive pests, weeds, and plant diseases, all of which would require control or containment measures.

TRANSPORTATION and PUBLIC FACILITIES:

Most activities within the Department of Transportation and Public Facilities (DOTPF) are or will be impacted by climate change, most notably planning, design, engineering, construction, and maintenance & operations activities. In the maintenance & operations area, the department has confronted changing permafrost conditions for decades under infrastructure throughout Southwest, Northern, and Interior Alaska. According to DOTPF, its maintenance & operations costs average \$10 million annually to address the impacts of permafrost on the highway system, and does not adequately address the entire needs base.

The department has not systematically studied the need for, or implemented specific changes to policy or regulations relative to climate change, nor does it have pertinent data upon which to base such changes. DOTPF does not have a mechanism available to identify costs strictly assignable to climate change factors. It has, though, undertaken an assessment of the possible future effects of climate warming trends on its mission. Among their findings:

- ~ Longer seasonal transitions, fall to winter and winter to spring, may mean a more costly approach to snow and ice control, and lead to changes in roadway weight restriction policies.
- ~ Degrading permafrost may increase highway and runway integrity, and imply greater maintenance and capital expenditures.
- ~ Airports in Western, Northern, and Interior Alaska, built over permafrost, would need rehabilitation, reconstruction, and relocation at a greater rate.
- ~ State buildings in the same regions would be vulnerable to the same needs.
- ~ Increased avalanche, flooding, erosion, and debris flow would require a greater M & O response, and additional funding.
- ~ DOTPF assets and facilities in coastal areas prone to flooding and storm surge would need to eventually be relocated along with communities.

DOTPF is currently assisting several communities significantly impacted by conditions associated with climate warming. There are active projects currently in Kivalina, Newtok, Kotzebue, Nome, Unalakleet, Shishmaref, Noatak, Allakaket, and Alakanuk.

DOTPF sites the need for increased data collection for stream flow records, precipitation and other weather-related data, geotechnical and foundation data, hazards mapping updates, and other hydrologic data.

OTHER AGENCIES:

The Commission recognized a greater need for interagency action among state and federal agencies, almost exclusively where threatened communities are struggling with relocation issues. These problems, while recognized as serious, dwell somewhere between routine matters and pure emergencies. The Sub-Cabinet for Climate Change is reaching a level of activity to address the state element of this equation, being officially in existence for less than a year now. As the State of Alaska becomes more involved in relocation matters, it will join the U.S. Army Corps of Engineers (COE) and the Denali Commission, among others, in continuing to address these considerable challenges.

In the opinion of the Commission, major obstacles in this arena appear less a function of management intent and capability, than with various agency authorities and missions. While we heard frequently of a desire to establish a centralized, command-style dynamic for major decision-making, such does not appear possible without changes in various federal charters, and of course, the funding to accommodate new responsibilities.

The Denali Commission, a federal-state partnership designed to provide critical utilities, infrastructure, and support for economic development, delivers federal services throughout the state. Congress mandated that new and innovative solutions be found to address these unique challenges, and that includes consideration for the impacts of climate change. While the Denali Commission does not have a direct mission in coastal and river flooding and erosion, it does have a mission to protect infrastructure, and it has been participatory. In its estimation, responding to broader threats to vulnerable communities will require alignment of state and federal policies.

The Commission found that state agencies are dependent on federal services and data bases. These services, including weather, engineering, census, resource assessment, fire suppression, and insurance, have not had adequate funds to fully meet federal mandates, particularly in their base programs. The Commission recommends the state work with federal agencies to ensure that adequate funding is available to provide services in Alaska consistent with services in the other states. This would include updating networks for data collection so that they provide adequate information to understand potential climate change impacts. Planning the appropriate adaptation strategy for areas at risk, e.g. Western Alaska and the North Slope, would then follow.

RESEARCH and MONITORING:

OVERVIEW:

The research factor throughout the array of climate change issues, has positive implications for Alaska. Research activity and the funding it brings to the state are of considerable significance to the University of Alaska (UA), other entities, and therefore, the economy in general. UA refers to research as the "silent giant," which provides nearly 2,400 jobs and a \$92 million payroll. Active UA research exceeded \$151 million in value in 2006, nearly all of which is new money into the economy. The Commission perceives a healthy continuation, even expansion of research activity throughout the state and its proximity, as a direct result of a warming Arctic climate. Other indirect benefits of research activity will continue beyond the academic community, as well.

The Commission has identified a need to better communicate, manage, coordinate, and disseminate the aggregation of research projects among institutions in Alaska. A central project and/or data inventory source would be beneficial to effective and efficient research planning. The Alaska State Research Committee should be supported in pursuit of this undertaking.

Global climate models have projected that the Arctic is an area where changes to the climate may be the largest in the world. The models predict a greater warming for the Arctic than the rest of the world. Alaska, as part of the Arctic, is already experiencing dramatic climate change. Observed data indicate that over the last 50 years, mean annual surface temperatures have increased 3-5 °C with some of the largest increases occurring along the Alaska North Slope. The extent of Arctic sea ice reached an all time low in September 2007, shattering the previous record in 2005 by 23 percent. It was also 39 percent below the long-term average from 1979 to 2000.

Additionally, winter freeze up and spring melt conditions are now arriving more than three weeks later and earlier, respectively. The waters around Alaska are showing an increase in sea level. On land, an increased seasonal thaw depth of the active layer is causing accelerated permafrost thaw. There is increasing evidence of changes in storm frequency, intensity and shift in storm track. These observations all point to climate change occurring now and that change is affecting weather patterns. There is a greater incidence of aviation icing conditions especially along the coasts of the Bering and Chukchi Seas. There are more frequent high amplitude weather episodes such as mid-winter "break ups"; heavy precipitation causing local flooding; low water events affecting river transportation and subsistence; episodic high wind events; more variable weather affecting moisture conditions resulting in the greatest wildfire season (6.5 million acres) ever, in 2004. Alaskan coastal ecosystems also continue to be threatened by natural and manmade coastal hazards, including

tsunamis, earthquakes, volcanic eruptions, severe (including hurricane force) storms, harmful algal blooms, invasive species (including pathogens) and oil spills, among others.

Temperature and precipitation trends are two essential climate variables that most directly influence the Arctic region and impact a wide range of societal and environmental factors. Significant physical characteristics readily measureable and monitored are sea ice, sea surface temperature, sea level change, and the thawing of the permafrost and melting of glaciers. Changes in these characteristics present opportunities and challenges to people and ecosystems.

Less sea ice will cause shifts in the migration patterns of marine mammals, as well as the productivity of fish stocks and other levels in the marine food chain. Open coastal waters already have resulted in extensive and rapid coastal erosion as experienced at Shishmaref, and threaten other coastal Alaskan villages. In the past twelve months an area of the Alaska North Slope experienced as much as 100 meters retreat of the coastline due to wind driven wave erosion. Storm surge, and to a lesser extent sea level rise, increase the extent of coastal inundation and threatens coastal ecosystems and infrastructures.

Permafrost thaw has affected terrestrial and coastal marine environments and threatens overland transportation routes through the collapse of the ground surface, draining of lakes and wetlands, toppling of trees, collapse of structures in susceptible areas, and accelerated coastal erosion in certain locations.

The Alaska Ocean Observing System (AOOS) provides a template for maximizing the data collection among various ocean-oriented federal and state agencies. To improve access to the monitoring data, the State of Alaska should work with federal agencies to insure the AOOS program is fully supported with instruments and deployment plans appropriate for the remote locations particularly in the northern Bering Sea, and the Chukchi and Beaufort Seas. Given the above observations, especially in the marine environment, the Commission recognizes the following research and monitoring priority needs:

COORDINATION AND COLLABORATION:

Many agencies, universities and individuals are currently conducting research or monitoring activities relevant to climate change and its impacts in Alaska. A number of coordinating forums currently exist whose mission is to share current and planned projects relating to climate change: the Alaska Marine Ecosystem Forum, the State-Federal Climate Change Roundtable, the Alaska Ocean Observing System, and the Governor's Sub-Cabinet on Climate

Change. The Commission recommends that the State of Alaska review these initiatives and consider how to better coordinate state, local, federal, university, and private activities in order to maximize the benefits of these efforts and minimize duplication.

DATA MANAGEMENT:

Many of the entities described above are currently conducting research or monitoring activities relevant to climate change and its impacts in Alaska. Yet we lack a comprehensive inventory of data management archive and access locations for observations, data, and information. We also lack a central web-based "gateway" to easily access Alaska/Arctic projects, data, and information. There are some initiatives currently underway such as the Alaska Marine Information System for ocean and coastal information, sponsored by the Alaska Ocean Observing System, the North Pacific Research Board, and the Geographic Information Network of Alaska. The Commission recommends that the primary state and federal data providers develop a consensus process and system for archiving and accessing climate change data in Alaska that is integrated and interoperable with other data across the nation and globe.

IMPROVED OBSERVATIONS OF WEATHER AND OCEAN CONDITIONS:

Over half of the coastline of the U.S. is in Alaska. Within this challenging environment, the Alaska marine transportation system continues to grow and expand. Receding sea ice has begun to open up these waters to commercial and recreational interests. New sea routes, development of oil and gas resources, and increased tourism will all require an increase in the need for the best weather and ocean information available.

Existing coastal observations in Alaska are inadequate to support existing and future local, state and federal agency resource management, marine transportation, emergency response, and public health responsibilities. These include observations of basic physical and biological parameters such as winds, waves, currents, temperature, salinity, nutrients, acidification, contaminants, and invasive species. Research scientists require adequate quality and number of observations to monitor the present rate of change. Applied scientists need access to more observations and improved models to assist in the daily operational monitoring and generation of forecasts for use by the public.

Recent real world observed changes in the Arctic region indicate the projections of current models are in some cases not adequately forecasting the recently documented rate and extent of change. Typical historical observations and conditions are no longer proving to be a solid basis for plausible future projections and predictions. The Commission recommends that the state work with federal agencies to inventory current observing systems that can

contribute to measuring and monitoring climate change trends across Alaska and the adjacent marine environment. Also, we would support developing a plan to close the critical observational and modeling gaps to improve monitoring of change across Alaska through timely analysis of new observations linked to the historical observational records.

In particular, we recommend that the state work to increase the number of weather buoys and stations, climate reference network stations, tide and river gauges, sea ice radars, high frequency radar, and other ocean observing platforms. We need to develop forecast models (weather, wind, wave, and ocean circulation) to better support Alaska's communities and commercial operations.

IMPROVING SEA ICE FORECASTS:

Recent events have highlighted the importance of accurate sea ice forecasts. Improving these forecasts requires two major research components. First, since existing forecast models use multiyear sea ice concentration as a proxy for ice thickness, a comprehensive program of airborne measurements of sea ice thickness to integrate into forecast models would significantly increase the accuracy of these models. Increased precision measurement of sea ice thickness is viewed as one of the top priorities of the sea ice research community. Monitoring the Freezing Index, which is important to the engineering community among others, is also a necessary component of improving sea ice forecasts.

The second component is creation of a sea ice climatology database, or atlas, which would provide a complete and accurate historical record, essential in making timely and accurate decisions, and forecasts of Arctic sea ice. Such an atlas would integrate knowledge from the indigenous people, empirical observations, human analyses, as well as remote sensing tools.

A need exists to develop and implement a data mining application to sift through large amounts of data to produce data content relationships, and extract hidden patterns in the Arctic seas database. Then, developing a scalable, interactive Decision Support System (DSS) that integrates all Arctic sea ice-related resources in a systematic fashion would be necessary. No DSS exists to assist those with Arctic interests, to make consistent, informed decisions that affect safety of navigation, the economy, resource management, and ecosystem protection. Without a comprehensive sea ice database, atmospheric, oceanographic, ocean circulation, and ice model forecasts cannot be validated properly. Such a database would allow the U.S. to implement a methodology to categorize ice regimes in a consistent manner such as the method used by the Canadian Coast Guard for decisions on passage of ships of a certain ice class.

We encourage the State of Alaska to work with the appropriate federal agencies and research entities to implement a sea ice thickness measurement program and to develop an Arctic sea ice atlas that would establish Arctic sea ice trend analyses for the Bering, Chukchi and Beaufort Seas. This would also provide a baseline for understanding climate change and its potential impact on the Arctic ecosystem and Arctic commerce to include data and information prior to the advent of satellite imagery. The Commission supports ensuring Synthetic Aperture Radar image availability in order to continue monitoring sea ice extent.

IMPROVED AVIATION WEATHER OBSERVATIONS:

While pilot fatality rates in Alaska have decreased 51% during the period 2000-06, they remain well above the national average. The old weather paradigms that guided much of Alaska's air traffic are no longer reliable. The need exists to continue the reduction in the number of fatal aircraft accidents in Alaska through 2015 by providing more accurate forecasts and warnings delivered to aviators in a format which best meets their needs. Specifically, we should pursue the acquisition of additional weather data, to include additional weather radars, meteorological satellite information, expansion of Tropospheric Airborne Meteorological Data Reporting (TAMDAR) systems, and support of the Arctic Observing Network (AON) projects.

TECHNOLOGY (UAS, GLIDERS, AUV, AIS, HF RADAR, SATELLITE SERVICES):

Routine monitoring of key atmospheric, ice, and ecosystems conditions is very difficult in the Arctic. Frequent cloudiness, long intervals without daylight, extreme temperatures, and weather conditions – these are all part of Alaska's conditions. Current observation systems are not adequate to detect the full suite of changes that are underway. For that reason we recommend that 21st Century science and observations be applied to address these changes. The Commission recommends that the University of Alaska develop a plan to test and implement in the Arctic, new technology that is being developed elsewhere, including unmanned aircraft systems (UAS), gliders and remotely operated vehicles for underwater research, automated information systems and high frequency radars. In addition, we recommend that a program be implemented to test the potential of ocean and tidal energy in Alaska.

COMMERCIAL FISHERIES RESEARCH:

Robust and sustainable fisheries are critical to Alaska's commercial and subsistence economies. Projected warming of the marine waters off Alaska, particularly in the eastern Bering Sea shelf region, could profoundly alter ecosystem structure by changing energy pathways and the spatial distribution and species composition of fish, seabird, and marine mammal communities. Climate-ocean conditions could impact the abundance and distribution of

commercial and subsistence fisheries and influence how fisheries are conducted and their economic viability. With potential impacts due to climate change, these questions arise:

- a. For commercial fishermen, will these changes lead to: (1) a change in home ports and distribution of fishing vessel rents, (2) vessels traveling further, incurring greater fuel costs and peril at sea, and (3) greater burden on smaller vessels?
- b. For subsistence users, will these changes lead to: (1) greater reliance on owners of larger vessels that can travel farther to harvest and distribute subsistence goods, (2) decreased consumption of species with decreased local abundance, and (3) adoption of new species into the diet as these species colonize local areas?

Will changes be needed in current management strategies for fish, seabirds, and marine mammals to accommodate changes in population

- c. abundance and range? What will be the impacts on endangered and threatened species?
- d. Will pollock and other fish stocks move northward and thus closer to the US-Russia boundary and lead to more transboundary fishery management issues?
- e. How will increased presence of Sub-Arctic species, particularly salmon, in the Chukchi and Beaufort shelf region impact oil and gas development?

Research is needed in the following areas:

a. Basic Food Web Research

Earlier ice retreat could result in later spring phytoplankton blooms and more energy flow through the pelagic ecosystem, and less to the benthic system. These climate-induced changes could modify the availability and partitioning of food for all trophic levels, thus impacting juvenile fish production and over-wintering conditions.

b. Distribution of Species

Fish reproduction, survival, and distribution all are influenced by climate and ocean conditions that impact water temperatures and circulation patterns, and in turn, the domain boundaries for various species.

c. Fronts and Other Prey-Concentrating Mechanisms

Climate and ocean conditions influence circulation patterns and domain boundaries that in turn affect the distribution, frequency, and persistence of fronts and other prey-concentrating features that act together to determine the foraging success of marine birds and mammals.

There presently exists very little information of fish species distribution, abundance, or habitat north of the Bering Straits. Biomass surveys must be undertaken to assess current fish and marine mammal species, their relative abundance, and their likelihood to change. Change agents include a loss of sea ice, increased water temperature, changes to upwelling and currents, and increased fishing activity.

Ship surveys must continue in the Bering Sea and Aleutian Islands regions to monitor shifts in migratory patterns of fish and marine mammal species. Researchers must produce products and services that can be used by managers and the industry to define the environmental baseline in these regions. The state should work with NOAA to start planning for scientific research in the Chukchi and Beaufort Seas. This includes establishing a network with coastal residents for purposes of collecting data and sponsoring joint US-Russia scientific projects.

NOAA Fisheries is planning a Beaufort Sea Marine Fish Survey for August, 2008 through collaboration with the Alaska Fisheries Science Center, the Universities of Alaska and Washington, and the Minerals Management Service. We should support the establishment of a regulatory regime (a Fishery Management Plan) that will prevent unrestricted exploration and exploitation of marine species until sufficient research has been conducted.

ECOSYSTEM EFFECTS:

Alaskan coastal ecosystems, include human communities, are experiencing changes associated with accelerating climate change and increasing coastal development, including offshore oil and gas activities, large-scale mines, and increased population. These ecosystems also continue to be threatened by natural and manmade coastal hazards, including tsunamis, earthquakes, volcanic eruptions, severe (including hurricane force) storms, coastal erosion, harmful algal blooms, and oil spills, among others.

Alaska's coastal managers need science-based information and decision support tools that are integrated across multiple disciplines. Little coastal ecosystem forecast capability exists in Alaska. Models need to be developed that help coastal managers better assess the risk of action or inaction on their part. Operational ecosystem modeling will ultimately require investments in

human and facility infrastructure to develop and run the models, as well as provide output products and services.

OCEAN ACIDIFICATION:

Approximately 30-50% of global anthropogenic CO₂ emissions are absorbed by the world's oceans. Increased CO₂ uptake by the oceans is expected to reduce surface ocean pH by 0.3-0.5 units over the next century, which would be the largest change in pH to occur in the last 20-200 million years. Ocean acidification reduces the calcium carbonate (CaCO₃) saturation point. Dramatic reductions in calcium carbonate saturation have been observed in the North Pacific since the industrial revolution, but the concern is that with warmer oceans, increased absorption of CO₂ likely will impact the ability of marine calcifiers, such as corals and mollusks such as mussels, crabs, oysters, and clams, to make shells and skeletons from calcium carbonate. We recommend that the state support federal funding for an ocean acidification research and monitoring plan. This plan should include:

- Monitoring ocean pH using ships, moorings, fisheries and marine mammal surveys;
- Understanding processes of how high carbon dioxide levels affect calcification, respiration, reproduction, settlement, and re-mineralization in order to develop models to forecast the impacts of ocean acidification in Alaskan waters;
- Understanding whether/how well marine calcifying organisms can acclimatize to ocean acidification effects;
- Understanding how our important species (important for economic, social, and biological reasons) are likely to adapt to life in water that is more acidic than recent historic states; and
- Developing adaptive management techniques to mitigate impacts of Alaskan ocean acidification scenarios.

COASTAL INUNDATION, EROSION, TSUNAMIS:

Increased coastal erosion and inundation is related to the changing sea ice conditions resulting in later freeze-ups, earlier break-ups, and less multi-year ice, as well as possible increases in "storminess" (frequency and strength). Unlike the occurrence of many other weather hazards, each coastal erosion event creates a more serious situation for the next event that may come along, be it a day later or a year later.