Alaska Climate Change Strategy
Natural Systems Adaptation Technical Working Group

DRAFT Catalog of Adaptations and Policy Options

Revised Post-October 27-28 TWG Meeting

The Natural Systems Technical Working Group (TWG) is developing a catalog of adaptation options related to the expected effects of climate change on Alaska's natural systems. This draft document incorporates changes recommended by the NS TWG at its meeting on October 27-28, 2008, and in subsequent communications.

There are two major sections to the Natural Systems Adaptation Catalog:

I. **Changes to Habitats and Dependent Species** – This section summarizes the expected effects of climate change on Alaska's habitats and the fish and wildlife that depend upon those habitats. It addresses potential changes in:
   - Marine habitats and dependent species
   - Terrestrial habitats and dependent species
   - Freshwater habitats and dependent species
   - Future Trends

   This section sets the context for the adaptation analysis by evaluating what changes are likely to occur in Alaska's natural habitats and dependent fish and wildlife species in response to climate change. The section will (1) inform what types of human adaptation will be needed to these changes (presented in Section II, below), and (2) indicate what research and monitoring is needed related to natural systems (to be forwarded to the Research Working Group).

II. **Adaptation of Human Uses of Alaska's Natural Systems** – This section is the "catalog" of relevant actions that the State of Alaska could take to adapt to changes in Alaska's natural systems due to climate change (informed by the summary of natural system change provided in Section I, above). It addresses the following topics, for which adaptation options are recommended:
   - NS-1 Agriculture
   - NS-2 Forestry
   - NS-3 Wildfire
   - NS-4 Invasive Species and Disease
   - NS-5 Commercial Fishing
   - NS-6 Fish and Wildlife Management
   - NS-7 Water Conservation and Management
   - NS-8 Capacity-Building, Education & Outreach (note that this likely spans all TWG areas)

Section I. Changes to Alaska's Habitats and Dependent Species

MARINE ENVIRONMENT: Anticipating Climate Change in Alaska's Seas: Prospects for the 21st Century

Jeff Short is working on a new section for Part I, Future Trends, that will incorporate the future trends info now presented in this Marine Environment section.

The seas around Alaska have responded dramatically to the warming trend of the last few decades, and are now on the brink of fundamental transitions that may substantially alter their productivity. The Bering Sea and the Arctic Ocean are strongly affected by changes in ice cover, which are amplified by multiple feedbacks in the associated ecosystems. Even in the Gulf of Alaska, where sea ice is not a crucial factor, the marine ecosystem will change considerably if current warming trends continue. Like predicting the weather, forecasts of how these seas will respond is necessarily imprecise, but consensus scientific projections provide the best guidance available for evaluating and prioritizing policy alternatives for adapting to these changes. These findings are summarized here, in the hope that the context they provide will constructively inform the difficult decisions that face Alaskans as we try to cope with the changes ahead.

The following summary begins with a basic account of how sub-polar and polar marine ecosystems function, how the three major marine ecosystems around Alaska (roughly associated with the Gulf of Alaska, the Bering Sea and the Arctic Ocean) are thought to interact with the physical environment and a description of the ecosystem changes that have occurred to date. The range of likely warming trajectories is presented next, along with a sense of the reliability of these projections. Forecasts of changes in the effective sizes of these ecosystems and their biological productivity follow, together with an indication of how these ecosystems may reorganize in response. The concluding section addresses the acidifying effects of rising carbon dioxide levels in the atmosphere, and how these interact with the effects from warming.

Marine Productivity around Alaska

As on land, marine productivity is fundamentally determined by the amount of plant growth over the course of the year. Microscopic plants called phytoplankton account for nearly all of this growth in the ocean, and require light and inorganic nutrients (especially nitrogen) to flourish. Processes that affect growth are important because phytoplankton productivity sets a limit on the productivity of everything else, including economically valued resources such as fish.

Little phytoplankton productivity occurs in the winter in sub-polar and polar seas because of low light levels and because of generally stormy weather that mixes the seawater column to depths of hundreds of meters, so the plants do not spend much time exposed to what little light is available at the surface. Calmer weather, increased light and addition of fresh water from rainfall, ice melt or terrestrial runoff create a buoyant layer of water on the sea surface during spring, and phytoplankton in this layer are continuously exposed to increasing light and to relatively high nutrient levels brought to the surface by the winter mixing. These conditions trigger a period of rapid plant growth that lasts until nutrients are exhausted or light levels diminish during fall. Strong storms during spring and summer may interrupt this growth, but if followed by calm weather may increase productivity by re-supplying nutrients.

The presence of sea ice usually affects marine productivity strongly. Because sea ice reflects ~80% of the sunlight reaching it, the productivity beneath continuous ice sheets is generally quite low. But near the margins during spring productivity can be quite high. This is because the underside of the ice provides a surface for algae to grow on that is irradiated by light scattered within nearby open water, and because the melting ice adds relatively fresh water to surrounding sea surface, lowering its buoyancy.

Warming climate affects Alaskan marine productivity processes in three fundamental ways. Shrinking the size and displacing the location of seasonal sea ice is the most important effect, and may have substantial impacts in the Bering Sea and the Arctic Ocean. By increasing the buoyancy and thickness of the sea surface during spring, increased warming suppresses re-supply of nutrients from the deeper waters beneath during summer and fall. And finally, the warmer temperatures increase the phytoplankton growing season, which tends to increase annual productivity. These warming effects have markedly different consequences in the Gulf of Alaska, the Bering Sea and the Arctic Ocean.

Response to Climate Warming in Alaskan Seas

Gulf of Alaska

The Gulf of Alaska is widely suspected of providing one of the first large-scale marine ecosystem transitions in response to climate warming. Following several unusually warm and wet winters, a major “regime shift” in the organization of the marine food web occurred beginning in 1977. Over the course of this transition, the shellfish fishery crashed but the productivity of salmonids and many other finfish soared[1]. Other biological responses include a general decline in abundances of oil-rich forage fish species that prefer cold waters, and a more than doubling of the zooplankton biomass, which are small animals that graze on phytoplankton[2]. These and associated changes in sea surface temperature and other physical factors strongly suggest that the warmer temperatures increased the growing season of the phytoplankton and especially the zooplankton, which reduced the supply of un-grazed phytoplankton falling to the seafloor where it supported a food web favorable for shellfish. The increased biomass of the zooplankton sustained a different food web in the water column that is more favorable for fish. Climate-ecosystem models suggest that these changes have if anything caused modest increases in the overall biological productivity of the Gulf of Alaska[3].

Other responses to warming surface waters in the Gulf of Alaska include northward range incursions of fish that prefer warmer waters such as hake and mackerel, of invasive species and of more widespread occurrences of warmer-water fish diseases and other pests such as paralytic shellfish poisoning.

Bering Sea

The conjunction of the seasonal sea ice edge during spring with the edge of the continental shelf makes the Bering Sea one of the most productive on earth. Tidally-driven currents induce nearly continuous upwelling of nutrients along the shelf edge, and the ice provides a substrate for algae and source of meltwater that stabilizes adjacent surface waters, both of which allow plants to be well-supplied with both nutrients and light. Unfortunately this very favorable production regime is at risk. In recent decades the Bering Sea has supported enormous shellfish and finfish (mainly pollock) fisheries, the relative productivity of each being modulated by the weather during spring[4]. During cold springs, the phytoplankton bloom is closely associated with the sea ice edge, and the cooler temperatures suppress zooplankton population growth that would otherwise graze on the phytoplankton. The result is that most of the un-grazed phytoplankton production eventually sinks to the bottom, supporting a food web favorable for shellfish. During warm springs, the ice melts before the phytoplankton bloom starts, delaying the onset of the bloom until zooplankton abundances are increasing more rapidly. More of the phytoplankton production is consumed by the zooplankton, which are consumed in turn by finfish.

As in the Gulf of Alaska, the surface waters of the Bering Sea have been steadily warming over the last few decades, resulting in marked ecosystem changes. Whereas finfish have flourished, shellfish and cold water adapted forage fish have moved steadily north seeking cooler waters[5]. The edge of maximum sea ice extent has tended to move northwards as well, decreasing the coupling between the ice-melt processes during spring with the nutrient upwelling associated with the continental shelf edge. These responses have likely caused a small reduction in the overall productivity of the Bering Sea.

Arctic Ocean

The most dramatic marine ecosystem changes are underway now in the Arctic Ocean, including Alaska's Arctic coast. In 2007 and again in 2008, the extent of seasonal ice retreat resulted in a minimum ice cap area some 40% smaller than the average from 1979 – 2000[6]. In addition, most of the ice now consists of 1-year ice (ice that is 1 year old or less), compared with predominantly multi-year ice just a decade ago, and nearly half the summertime Arctic ice cap volume has now melted[6]. These sea ice losses will likely increase the productivity of the Alaskan continental shelf in the Arctic substantially, although from such a low base it is unclear whether this will result in commercially viable fishing opportunities. Ice loss in spring and summer allows much more light to penetrate the water column. The shallow seawater depth of the continental shelf insures that phytoplankton are always illuminated, so phytoplankton growth can increase no matter how stormy the weather conditions are. However, except in the westernmost portion of Alaska's Arctic continental shelf, most of the shelf will still likely suffer from nutrient limitation. This is because the coastal waters of Alaska's Arctic are diluted by freshwater discharge from the Mackenzie River, which is nutrient poor. But just north of the Bering Strait lies the most productive patch of marine water anywhere on earth. This region is supplied by the nutrients upwelled from the continental shelf in the Bering Sea and carried northward by surface currents, and fuels a particularly rich benthic food web that supports walrus, gray whales and a variety of seabirds.

Future Trends (NOTE – This information will be moved to a new "Future Trends" section that will address marine, freshwater and terrestrial ecosystems.)

Consensus forecasts of the effects of warming trends on the seas around Alaska are based on models that couple atmospheric and oceanic processes and are driven by changes in the atmospheric concentrations of carbon dioxide and other greenhouse gases[3]. Although some members of the general public are skeptical of such models, they have found widespread acceptance within the scientific community for at least the following three reasons. First, no alternative explanation for all the myriad physical details associated with the warming trend of the last two centuries has been proposed that does not have serious defects, whereas the carbon dioxide hypothesis provides a tidy and elegant explanation of them, and has predicted specific effects that turned out to be true[7]. Second, the models based on the carbon dioxide hypothesis perform reasonably well in their ability to replicate the record of past climate observations, including the results from the geological record that extend well past the instrumental record from which the models are derived[7]. Third and perhaps most compellingly, these models have correctly forecast general climate trends with increasing precision over the last two decades, but have shown an enduring tendency to underestimate the magnitude of these trends, especially in the Arctic. Hence, to the extent skepticism is warranted, most should be in the direction of allowing for more drastic effects than these models predict.

The short-term accuracy of model-based forecasts is limited by uncertainties in the behavior of natural factors that have transient effects on climate. Foremost among these are El Niño-La niña, Pacific decadal and Arctic oscillations, sunspot activity and volcanic eruptions. For example, the last three years have been slightly cooler than the long-term warming trend because the current La niña phase brings cold water to the surface of the tropical Pacific that has a slight cooling effect on the whole planet, and because the sun is in a quiescent period of sunspot activity that temporarily diminished its output. The return of the next El Niño event will tend to warm the planet above the long-term trend. It is conceivable that the sun may remain in its quiescent phase for centuries, as occurred during the "Little Ice Age" during the Middle Ages, but this effect will be overwhelmed by about 5 years of continued increases of emissions of carbon dioxide and other greenhouse gases by humans. As for volcanoes, the particulates injected into the upper atmosphere may lead to planet wide cooling for a couple of years, but the carbon dioxide added is usually negligible in comparison with human emissions (as, for example, the 1992 Mt. Pinatubo eruption that was barely discernable in records of atmospheric carbon dioxide monitoring stations). While these natural perturbations may cause significant discrepancies from climate forecasts on time scales of a few years, they will not likely do so on time scales of decades or longer.

Applied to Alaskan seas, forecasting models based on "business as usual" emissions scenarios[3] indicate that the ecological functioning characteristic of the Gulf of Alaska will expand, whereas that of the Bering Sea will shrink. By about 2050, the subpolar ecosystem of the Gulf of Alaska and southern Bering Sea is forecast to increase modestly by ~14% in area, whereas the highly productive marginal sea ice ecosystem of the rest of the Bering Sea will shrink by ~45%. The productivity per unit seasurface area of these two regions are forecast to increase by 21% and 15% respectively, for an overall increase of total productivity of 31 – 37% in the subpolar ecosystem, but a decrease of 36 – 41% in the marginal sea ice ecosystem. Because the marginal sea ice ecosystem of the Bering Sea is so much more productive than the subpolar ecosystem of the Gulf of Alaska, these changes imply a net loss of productivity overall.

Forecasts for the Arctic Ocean are not available owing to the lack of data for the region, exacerbated by the unforeseen large sea ice losses over the last two years, but it seems likely that most of the Alaskan Arctic shelf will shift from a light- to a nutrient-limited system, with modest increases in productivity except north of the Bering Strait, where increases may be substantial.

These ecosystem changes will continue to put pressure on organisms such as shellfish dependent on food webs associated with the seafloor, and favor mid-water fishes such as pollock in the Gulf of Alaska and the Bering Sea, and Arctic cod in the Arctic Ocean. They will also put pressure on cold-adapted species such as lipid-rich forage fish, because their habitat will continue to contract both in extent and in productivity. Such declines would in turn limit populations of several species of marine mammals and birds that rely in energy-rich prey to provision their young. Ice-dependent marine mammals, including polar bears, walrus and several seal species, face substantial habitat loss as the ice disappears, making them especially vulnerable to the effects of continued warming.

The pace of these anticipated changes in Alaskan seas will be modulated by two intermediate-term climate patterns, the Pacific Decadal Oscillation (PDO) and the Arctic Oscillation (AO). The PDO refers to a distribution pattern of cool and warm surface waters in the North Pacific Ocean, and operates on a time scale of 1 – 3 decades. It has been in a warm phase for about the last 30 years, making the Gulf of Alaska stormier, warmer and wetter than usual, conditions that are conducive to high marine survival of salmon in the region. It now appears to be reverting to a cold phase, which will tend to obscure the effects of global warming in the Gulf of Alaska and the Bering Sea. Hence, sea ice loss in the Bering Sea will decelerate and winter ice cover may even increase for a few years until overwhelmed by continued global warming, but when the PDO changes again to its warm phase after a couple of decades ice loss will be rapid. The AO refers to variations in the intensity of atmospheric pressure in the Arctic basin, and operates on a time scale of several years to over a decade. During periods of low pressure such as have prevailed during the last few years, Pacific storms are brought further north making southern Alaska warmer and wetter during winter, and more warm Atlantic seawater is drawn in to the Arctic which exacerbates ice loss. During high pressure periods, winters are colder in Alaska and most of the rest of North America, and ice loss in the Arctic decelerates. The AO is expected to change from the warm phase to the cold phase sometime during the next few years, which will temporarily suppress the effects of global warming in Alaska even more. But this respite will quickly disappear when the AO reverts to the warm phase again after another few years.

Ocean Acidification

Ocean acidification refers to another consequence of adding carbon dioxide to the atmosphere that is independent of the effects on warming. Some of the carbon dioxide added from human emissions dissolves into the surface layer of the ocean where it reacts with water to form carbonic acid. Enough has dissolved since the advent of the industrial revolution to cause about a 30% increase in the acidity of the oceanic surface waters worldwide, and are projected to triple by the end of this century under "business as usual" emissions scenarios. Increases of this magnitude will likely eliminate important components of the food web in the Gulf of Alaska, threaten some cold water corals in the Bering Sea, and may adversely impact commercially and economically important shellfish such as euphausids, crabs and shrimp.

References

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6. See: http://www.nsidc.org/news/press/20081002_seaice_pressrelease.html

7. See: http://www.aip.org/history/climate/index.html

TERRESTRIAL ENVIRONMENT

Chris – Do you have additional information to add to this regarding forestry?

Tom – I know you are working on additions regarding ecosystems services provided by terrestrial ecosystems.

The Arctic Climate Impact Assessment in 2004 (http://www.acia.uaf.edu/) reviewed effects of climate change on arctic tundra (Chapter 7) and forest (Chapter 14) biomes and selected species. It included several authors and research case studies from Alaska. A more detailed account of the status of wildlife species status in Alaska including the context of climate change was given in the Comprehensive Wildlife Conservation Strategy in 2005 (http://www.sf.adfg.state.ak.us/statewide/ngplan/NG_outline.cfm).

Recent trends in warmer and drier conditions in parts of mainland Alaska have influenced plant growth rates and the expansion of tree line and shrub line northward and to higher elevation. A continued decrease in growth rate of white spruce and Alaska paper birch coincident with warmer, drier conditions could eventually lead to possibly rapid change in species diversity (forest transition to grassland savanna) and the supply of fiber or biomass fuel. Changing bioclimate can also affect the supply of wild foods (e.g., berries) as species distributions change. Lower fitness or growth rate of trees could decrease reforestation success or prolong the harvest rotation period of wood supply.

For the short term (10-25 years), the recent trend toward warmer conditions may be moderated by a cooler phase of the Pacific Decadal Oscillation (http://kenai.fws.gov/overview/notebook/2008/august/29august2008.htm), which could moderate ecological changes or rates of change recently documented as coincident with warmer temperatures. Adaptation during this period should focus on convening scientists and resource managers to forecast changes in biomes, habitats, and species as the basis for recommending revision of resource management policy. Monitoring protocols should be established and implemented to calibrate ecological forecast models. As evidence for change becomes clearer in species distribution or the supply of food or commodities, revision of policy will become more informed. Experimentation in adaptive management (e.g., introduced trees from nearby ranges, such as lodgepole pine; conducting moose hunts during the rut to test effect on subsequent breeding success) should also begin, to understand system performance under new bioclimatic conditions.

Currently there are three projects led by U.S. Department of Interior agencies (U.S. Geological Survey and U.S. Fish and Wildlife Service) in Alaska is attempting to use prediction from global climate models to forecast changes in biome distribution and potential effects on plants and animals (e.g., creation or disruption of migration corridors or range extension pathways) over defined periods. Outcomes may be used to prioritize mitigation (e.g., transplanting of alpine-dependent species to remaining alpine areas to maintain genetic diversity) or suggest adaptive strategies (e.g., major changes in caribou migration routes may require focus on new transportation options or alternative game species by subsistence hunters). Continued warmer and drier conditions are predicted to increase the area or frequency of wildland fire, cause retreat of inland glaciers, and decrease the area of continuous and discontinuous permafrost and lakes.

FRESHWATER ENVIRONMENT

Climate models presently lack the detail to project changes in specific freshwater environments throughout Alaska. Also, because of Alaska vast size, effects will differ significantly regionally across the state. Because of this, it is difficult to project with certainty specific impacts that may occur.

That said, it is possible to predict some general impacts. It is speculated that freshwater systems will face increased winter flooding, reduced summer and fall streamflows, and warmer summer stream temperatures. Also, earlier snowmelt and peak spring streamflow are likely to occur.

These impacts will likely result in changes to both in channel and out of channel freshwater habitat. In channel changes will likely result from shifts in ice, runoff, physical limnology regimes. In turn, these ecosystem shifts will likely affect biological structure and function including biogeochemical processes, trophic structure, food web interactions, and primary and secondary productivity. This in turn will have collateral affects on population structures within the supported ecosystems.

In general, impacts are speculated to be harmful for existing populations of fish adapted to the current conditions. Because of the, there will be winner and losers depending upon the system. In general, species adapted to cold water systems will become more stressed whereas species more adapted to warmer water temperatures will benefit. In addition, new species will be introduced as environmental conditions allow for expanded ranges. For example, salmon may become established in tributaries to the Arctic Ocean. Also, invasive species may spread as well as diseases whose frequency of occurrence increase as temperatures increase.

These impacts will have collateral impacts on people who currently utilize fish and wildlife dependent upon freshwater habitats. Managers will need to adjust management plans to address increased uncertainty associated with changing environmental conditions. Users may need to travel further distances to meet current needs or shift preferences onto available species.

Finally, increased research and monitoring will need to be conducted to learn how environmental conditions are changing at local levels and to assess how these changes may be influencing species. Also, increased education and outreach will need to be conducted to notify users of observed and expected changes.

See also: Wrona, F.J., Prowse, T.D., Reist, J.D., Hobbie, J.E., Levesque, L.M.J., and Vincent, M.F., 2006. Climate Change Impacts on Arctic Freshwater Ecosystems and Fisheries: Key Findings, Science Gapes and Policy Recommendations. Ambio 35:411-415.

Section II. Adaptations in Human Uses of Alaska's Natural Systems

NS-1: Agriculture

NOTE – The following introductory paragraphs are from the initial version of the NS TWG catalog (June/July 2008). Need to review/edit?

AGRICULTURE – IMPACTS DUE TO CLIMATE CHANGE
Current impacts – increased growing degree days (gdd) (e.g., Fairbanks increased from 1,100 to over 1,250 since 1950); longer growing season for current crops (e.g., hay); introduction of new crops and fruit trees (e.g., apples, pears); changes in growing zones and hardiness zones; increase in invasive species, pests, and diseases in agriculture (e.g., potato late blight, Canada thistle, hawkweeds); less water available in certain areas of the state (e.g., interior) suitable for agriculture.
Future projections – continued increase in gdd (e.g., in Fairbanks, under high emissions scenario, gdd double by 2071); agriculture becomes possible in more northerly locations; greater increase in invasive species, pests, and diseases; more water deficits (in Fairbanks, under low emissions scenario, almost a doubling by 2071); potential for increased animal husbandry.

Option No.	Adaptation Action / Policy Option (includes regulatory and management options)	Extended Actions	Parties involved in implementation	Expected Outcomes / Notes/Comments	Ballot re: Priority (completed later)
NS 1.1 Ag and Food Security	TSA and other related food security issues reviewed for Alaska rural and urban communities relative to agricultural products and do the following: • Identify local supply linkages • Determine local demand issues • List out communities/issues of high critical concern	Examples of extended actions: - Identify likely problem areas due to increased TSA regulations due to climate change related concerns. - Identify or build local food storage areas (root cellars etc, especially in rural communities - Increased awareness and listing of local suppliers of shellfish, livestock and produce - Processing of local produce for long term storage - Increased usage of local suppliers - Identification of local food supplies in home gardeners and master gardeners, storing produce.	State of Alaska; Alaska Municipal League; AFN, University of Alaska, Soil and Water Conservation Districts, Farm Service Agency, Farm Bureau, Master Gardeners, Alaska Shellfish Growers and others	From TWG (Technical Working Group)	

Option No.	Adaptation Action / Policy Option (includes regulatory and management options)	Extended Actions	Parties involved in implementation	Expected Outcomes / Notes/Comments	Ballot re: Priority (completed later)
NS 1.1 (continued)		- Strengthen the link between producers and consumers - Strategic plan for sustainable agriculture including indigenous foods.			
NS1.2 Ag Production	Invest in the production of food and the expansion of markets for those products that can be produced economically in Alaska under conditions of longer warmer growing seasons.	Examples of extended actions: This might include grants or start-up funding for garden tractors/rotor-tillers or greenhouses in rural communities that were formerly too cold for gardening; fencing or improved processing facilities for red meat production or game ranching on grasslands, tundra, or recently burned forests; improved food storage and processing facilities (e.g. root cellars, processing kitchens in rural communities); or production of weed-free seed sources for export to organic farmers in the lower 48.	State of Alaska, University of Alaska, AFN, Alaska Shellfish Growers Farm Bureau and Master Gardeners, Municipalities	This is crucial to provide food security for Alaskans and to explore markets for new Alaskan agricultural products.	

Option No.	Adaptation Action / Policy Option (includes regulatory and management options)	Extended Actions	Parties involved in implementation	Expected Outcomes / Notes/Comments	Ballot re: Priority (completed later)
NS 1.3 Ag Working Lands vs. Conservation Lands	Investigate the creation of agricultural protection zones (e.g., land trusts), where tax incentives support long-term agricultural use of private lands near communities and taking into consideration the impact of Ag on sensitive conservation areas.		State of Alaska, Local borough governments	Public comment: *There is a need to look at the affect of increased agriculture on conservation or wildlife or about trying to steer agriculture away from biologically important or sensitive areas. Mapping should be completed to identify the best new potential areas for agriculture under different climate change scenarios and mapping should also be completed to identify conservation focal areas* - *those areas that are most critical to protect and provide stewardship for natural resources and wildlife. If applicable, then new agricultural development could be steered away from these sensitive areas.* Additional public comment on this suggestion (from another party): *Concern that agriculture must be located in areas that are economically accessible (must consider this in siting decisions; may conflict with direction to steer away from environmentally sensitive areas). Notes also that agriculture can increase wildlife.)*	

Option No.	**Adaptation Action / Policy Option (includes regulatory and management options)**	**Extended Actions**	**Parties involved in implementation**	**Expected Outcomes / Notes/Comments**	**Ballot re: Priority (completed later)**
NS 1.4 USDA/FAO definitions	Review USDA definitions impacting Alaska Ag	Request alteration of USDA definitions of food production systems so that Alaskan agriculture (e.g., vegetables) are considered food rather than horticulture and would therefore be eligible for USDA agricultural subsidies USDA now considers aquaculture and fish farming agriculture	State of Alaska	From Ag Strategic Planning Working Group	
NS 1.5 AK ag and University Engagement towards an International View	AK Div of Ag (ADOA) will look at the feasibility of placing Fairbanks based ADOA staff at the Cold Climate Housing Research Center (CCHRC) as per the DOT model where DOT personnel are collocated with engineering faculty and other faculty on the UAF campus. This will help jump start a broader "international" view of Alaska's Ag situation relative to climate change issues.	This would lead to an International Alaska Agriculture Commission (or expand the current Board of Ag) coordinated and staffed by ADOA, with membership including Alaska, U.S. and international experts in the cold climate agriculture and adaptations to climate change in these regions. From the standpoint of economic development, entry into foreign markets using Northwest passage, east and west. Cost of fuel.	ADOA, CCHRC, UAF, AISWG Alaska Invasive Species Working Group, Federal agencies, USDA	From Ag Strategic Planning Working Group (Note, public comment on this option: *Some products may benefit from an international focus, name seed potatoes. However, focus should be on new markets and increased market share to feed Alaskans with local foods.)*	

Option No.	Adaptation Action / Policy Option (includes regulatory and management options)	Extended Actions	Parties involved in implementation	Expected Outcomes / Notes/Comments	Ballot re: Priority (completed later)
NS 1.6 Ag Technology Transfer	Through active research and development, apply the latest technologies to support the sustainability and expansion of agriculture in Alaska under changing climatic conditions. This would include review of laws, policies, technology and practices applied in Alaska and other regions that would contribute to future agricultural sustainability.	The expansion of Ag in Alaska will require the awareness and ability to implement the latest technology and research applicable to Alaskan Ag. The ADOA will work with the Ag industry, state and federal agencies, the UAF to ensure this process. Review Ag related tech and practices in US and other countries to see what common practices prevail and contribute to Ag sustainability.	State of Alaska, University of Alaska Cooperative Extension Service Cold Climate Housing Research Center (CES and CCHRC, Municipal Economic Dev Offices	From Ag Strategic Planning Working Group, and *public comment* Climate change will expand hardiness zones and open the opportunity for additional agriculture products. Organizations transfer the research results on to create economic opportunities. Public comment: *Focus (of entities such as Plant Materials Center) should be on developing and improving food crops suitable for Alaska's climate. Examples include varieties of short-maturing grain (barley, wheat, oats), fall-planted barley able to winter over, shorter season canola and other oilseeds.*	NS 1.6 Ag Technology Transfer
NS 1.7 Ag Best Practices	Incorporate Best Practices for future Alaska Ag and develop a strategic plan for Alaska Ag that looks to the next 50 years	Foster an approach for Alaska Ag that incorporates a best practices model for "future" Alaskan Ag in a changing climate environment. Expand sustainable agriculture awareness and practices ie, profit over long term, protecting land and water and people and communities.	State of Alaska, Alaska Farm Bureau, Alaska Farmers Union, NRCS, SWCD, University of Alaska	Refer also to #6	
NS 1.8 Ag legislation	Review Ag related legislation	Review Ag legislation in Alaska and in US and other countries to see what common practices prevail and contribute to Ag sustainability.	State of Alaska	Refer also to #6	

NS-2: Forestry

NOTE – The following introductory paragraphs are from the initial version of the NS TWG catalog (June/July 2008). Need to review/edit.

CHRIS & TOM – ANY EDITS TO THIS SECTION?

FORESTRY – IMPACTS DUE TO CLIMATE CHANGE

Warming effects on trees: Current impacts – tree growth decline, stress, and death due to warmer temperatures and less water availability (e.g., birch, white spruce, and yellow cedar); overall decrease in boreal forest productivity measured; loss of yellow cedar (over 1/2 million acres); some limited northern and western expansion of boreal forests and some expansion to higher altitudes and into drying wetlands, but a net loss overall. *Future projections – projected elimination of most of Alaska's boreal forest if temperatures continue to increase and water availability continues to decline; loss of boreal forest habitat, turning into grasslands, impact on boreal forest species such as migratory songbirds; greater loss of yellow cedar and other tree species; potential northern and western forest expansion and expansion into drying wetlands.*

Impacts on forestry: Current impacts – loss of some available trees due to fire, disease, and climate stress. *Future projections – likely substantial loss of yellow cedar trees (the most valuable tree economically) in the southeast; further loss of boreal forest trees due to fire, drought, and disease.*

Option No.	Adaptation Action / Policy Option (includes regulatory and management options)	Extended Actions	Parties involved in implementation	Expected Outcomes / Notes/Comments	Ballot re: Priority (completed later)
NS 2.1 Use of climate-damaged wood biomass for fuel/energy	Invest in economic development and infrastructure to attract and facilitate development of industrial capacity at appropriate scales to use insect- or fire-damaged timber, and underutilized and new sources of wood biomass.	Examples of extended actions: - Research available types of harvesting equipment for small diameter timber and biomass to facilitate acceptance and use by local commercial contractors. Demonstrate use; establish lease program. - Conduct demonstration wood biomass projects by UAF and State agencies. - Develop capacity to produce wood pellets, wood chips, or fuel wood from damaged timber near urban	Alaska Division of Forestry; other State agencies; UAF	Expected Outcomes: Offers an element of mitigation via use of carbon neutral wood fuels. Addresses high cost of fossil fuels. Offers economic opportunities. Notes: Electrical generation could be considered by stand-alone wood systems, or co-firing with coal at utilities, but this is more complex than relatively simple space heating wood systems. This will require Alaska-based training to develop	

		and rural communities. - Provide incentives to support installation of wood heat/power systems for public buildings. - Use biomass generated from hazard fuel treatment projects to reduce fire risk to communities. - Use small and low quality trees from current commercial harvest operations for saw-timber logs. - Use hardwood species, birch, aspen, willow that have a large under-utilized allowable cut or no current commercial use for biomass fuels. - Explore alternative harvest strategies such as bringing firewood to access points that are easily accessed by the public.		technologies that are appropriate for Alaska, for example the capacity to efficiently harvest small-diameter woody biomass.	

NS-3: Wildfire

WILDLAND FIRE – IMPACTS DUE TO CLIMATE CHANGE

Forest fires: Current impacts – more and earlier fires; record breaking acreage burned (over 11 million acres in 2004 and 2005); substantial impacts on forests and habitat for species (approximately 25% of all forests in 2004/2005 burned in NE Alaska); also expensive fire fighting (cost in 2004/2005 was $108 million); less habitat available for some forest dependent species but potential increase in food availability for other species, such as moose. *Future projections – greater fire impacts including possibility of fires in southeast Alaska*.

Tundra fires: Current impacts – larger and more severe tundra fires (almost 250,000 acres in 2007); modification of tundra habitat from wildfires. *Future projections – more tundra fires combined with change to climate conditions favorable to shrub or forest growth may result in loss of habitat for tundra-dependent species (e.g., slow response of lichen regeneration for caribou range).*

Option No.	Adaptation Action / Policy Option (includes regulatory and management options)	Extended Actions	Parties involved in implementation	Expected Outcomes / Notes/Comments	Ballot re: Priority (completed later)
NS 3.1 Wildland Fire Management	1. Conduct a comprehensive review of wildland fire policies in the context of climate change (appropriate responses to wildfires in forests and tundra in a warmer climate). 2. Provide information, technical assistance and funding to enable communities to develop and implement wildland fire protection plans.	1. Examine strategic application of wildland fire use to break up extensive areas of fire-prone black spruce forest, in part by creating fuel breaks of less flammable early successional post-fire vegetation that connects to other natural fuel breaks such as wetlands. Also, evaluate change from Limited to Full suppression response in tundra environments. 2. Engage the public in wildland fire prevention, fire protection, and risk mitigation programs near communities	1. Alaska Wildland Fire Coordinating Group (state, federal, Native), Alaska Division of Forestry 2. Alaska Wildland Fire Coordinating Group; Alaska Division of Forestry; stakeholders (local governments, structure and volunteer fire departments, Native organizations, agencies, others)	Expected Outcomes: 1. Updated wildland fire policies and practices that incorporate anticipated effects of climate change on environmental response to fire. Spinoff benefits would depend on fire responses adopted: a) Fuel management projects in boreal forest could improve habitat for moose and other wildlife and generate biomass fuels. b) Reductions in wildfire would reduce CO_2 emissions and smoke/health impacts. c) Reduction in tundra fires could reduce negative impacts on caribou and other wildlife and potentially	

				reduce negative effects of fire on hunting access or activities. 2. More active involvement of rural communities in deciding and implementing fire management and fuel management activities near their communities: a) Reduced risks to life and property, and reduced health risks and economic costs related to smoke events. b) Spinoff benefits could include habitat improvement for moose and other wildlife. Notes: Development of a community wildfire protection plan has been funded by the Immediate Action Working Group for Koyukuk.	

NS-4: Invasive or Erupted Species and Diseases*

(*diseases that may affect Alaskan flora and fauna)

NOTE – The following introductory paragraphs are from the initial version of the NS TWG catalog (June/July 2008).

TRISH – PLEASE EDIT THIS SECTION –

NEED TO ADD IN INTRODUCTORY COMMENTS ABOUT ERUPTED SPECIES & DISEASES

IN ADDITION, ADD EXPLANATION ABOUT HOW THE RECOMMENDATION MAKES AN ESSENTIAL TRANSITION FROM THE EXISTING VOLUNTEER WORKING GROUP TO A DEDICATED GROUP.

Forest insects and diseases: Current impacts – greater incidence of existing diseases such as spruce bark beetle, resulting in massive forest death (over 4 million acres); other forest diseases include larch saw fly (killed 90% of larch near Fairbanks), birch leaf roller, birch leaf miner, aspen leaf miner, and wooly saw fly; introduction of new diseases in forests such as spruce bud worm and aphids, resulting in tree injury and death. *Future projections – greater incidence of existing diseases, resulting in even greater forest death; more new diseases and greater expansion of recently introduced diseases resulting in further tree injury and death.*

Plant invasive species in forests: Current impacts – increased number and distribution of invasive species in the forests, especially following major fires. *Future projections – likely increased invasive species in both the boreal and temperate rain forests; possibility of invasive species reducing biodiversity and food availability for species.*

Invasive species in freshwater systems: Current impacts – there are new invasive plant species that have the potential to adversely impact rivers and streams such as purple loosestrife. *Future projections – greater threat in numbers, types, and abundance of injurious invasive species, seriously impacting freshwater ecosystems.*

Option No.	Adaptation Action / Policy Option (includes regulatory and management options)	Extended Actions	Parties involved in implementation	Expected Outcomes / Notes/Comments	Ballot re: Priority (completed later)
NS 4.1 State commitment to invasive species	Support establishment of an all-taxa Alaska Invasive Species Council and invest in the staffing, policy and program development	Examples of extended actions: • Provide agencies with new and adequate funding for these efforts.	Alaska Invasive Species Working Group	The Alaska Invasive Species Council will be a mechanism for cooperation, communication and collaboration, and will develop a statewide strategic plan of action.	

control	needed to implement a statewide strategic plan of action to address plant invasives, insects, pathogens and marine invasives.	• Conduct training for natural resource and DOT/PF employees in recognizing invasive marine organisms, plants, insects and pathogen outbreaks. • Invest in staff required for invasive species detection, control and response; and enforcement of measures to control invasives. • Invest in early detection / rapid response (EDRR) for insect infestations. • Support local control/response efforts. • Control/respond to invasive on public lands and at public facilities. • Support development of non-invasive plant material supplies. • Provide effective regulatory controls. • Provide public education and outreach regarding identification, control and response to invasives.		State representatives will include ADF&G, DNR, DEC, ADOT&PF and University of Alaska. Council will review current funding mechanisms and levels for state agencies to manage invasives on land and water under their authority. Council will establish criteria for prioritization of invasive species response actions.	

NOTE: The following very specific list of actions was identified during compilation of this section of the Natural Systems Adaptations Catalog:

Cross-Spectrum

1. Support Alaska Weed and Pest Coordinator Position in Alaska Division of Agriculture, and preparation of a strategic plan to address weeds and pests. (Position is responsible for coordinating State response to invasive plans in all settings and insects in agricultural settings. Need active participation of all affected state agencies (e.g., DOT/PF, DNR) in weed and pest strategic planning process. Support and advance the policy recommendations of the plan.)

2. Work with Canada through appropriate diplomatic channels to encourage the control and eradication of a variety of weeds, insects, aquatic nuisance species, and marine invasives (e.g. spotted knapweed, *Spartina*, green crab) in British Columbia, the Yukon, and NWT to reduce their spread towards Alaska.
3. Establish a dedicated plant/wood products quarantine inspector with regulatory authority. (Currently, the only plant/agricultural materials entering the state that are inspected in any way are potatoes and tomatoes. The inspection program should include all nursery materials and Christmas trees entering the state as well as inspection of wood shipping containers, pallets and wood products for exotic wood-borers.)

Invasive Plants

4. Refill the integrated vegetation management position at the Alaska Dept. of Transportation and Public Facilities (vacant since Jan. 08) (Expect position to work closely with Division of Agriculture Weed and Pest Coordinator, particularly in arena of road maintenance operations.)
5. Support Alaska Division of Mining, Land and Water in developing a weed-free gravel pit certification program. (Encourage that gravel used by ADOT&PF and in other state construction projects come from certified pits only.)
6. Support ADNR in developing modern and comprehensive noxious weed regulations. (Current regulations are inadequate, serving only to limit the amount of contamination by 12 species in seed sold in state. Model legislation on that in western US.)
7. Provide consistent State support for local Cooperative Weed Management Area (CWMA) efforts. (Establish small-grants program to assist in funding grass-roots, volunteer-run organizations.)
8. Recognize UAF for Weed Task Force's management plan for significant invasive plan infestations on UAF campus. (Use these projects as a starting point from which to address and manage invasive plant infestations around all state-owned public facilities.)
9. Encourage Alaskan agricultural producers, greenhouses and nurseries to enter the native-plants-as-revegetation-materials market. (Initiate a small grants program to support and expand such production. Currently, there is more demand for native plan seed and containerized native plans for use in revegetation projects than can be met by the few existing growers.)
10. Active participation by State of Alaska (Division of Ag and DOT/PF) in eradication of highly invasive plant species. (Alaska still has the opportunity to eradicate a number of highly invasive plant species with very limited distributions in the state (e.g., garlic mustard, spotted knapweed, purple loosestrife).

Invasive Insects and Pathogens in Forest

11. Establish a dedicated position and consistent dedicated funding to focus on forest insect EDRR (early detection, rapid response.) (Currently, there is no dedicated state funding for detection of either exotic or native-outbreaking insects in Alaska's forests.)
12. Establish a new position in the Division of Forestry focused on introduced forest pathogens. (There is no forest pathology expertise in the Alaska Division of Forestry or elsewhere in state government.)

Marine Invasives

13. Work with shipping industry to adopt treatment technologies now available to reduce impacts of ballast water in Alaska. Consider state regulation (such as in WA and OR) to address ballast water release. (Has potential to transfer pathogens (e.g., Vibrio outbreak). Implications to health of shellfish industry and human health.)
14. Support statewide tunicate/fouling organism monitoring. Develop tunicate/fouling organisms response plan, to address potential for a highly invasive species be found in state marine waters.
15. Support outcomes of an ADF&G funded green crab response plan (funding already dedicated.) (Monitor green crab statewide. Work with mariculture industry to educate and monitor for occurrence. Use habitat suitability modeling to identify potential invasion hot spots.)
16. Fund research to determine salmon pathogens that could be transported to Alaska by Atlantic salmon; develop an anticipatory action plan.
17. Support outcomes of a NMFS-funded Spartina response plan (funding already dedicated.)

18. Determine if State action should be taken to address hull fouling as a vector to Alaska. (Evaluate results of research funded by Prince William Sound Regional Citizen's Advisory Council for possible follow-up on additional research, education or best management practices.)
    (If Invasives Species is recommended to the AAG as a high priority adaptation option, this detailed list could also be incorporated into the "white paper" presented to the AAG.)

NS-5: Commercial Fishing

Need opening paragraph about expected changes

COMMERCIAL FISHING – IMPACTS DUE TO CLIMATE CHANGE

Option No.	**Adaptation Action / Policy Option (includes regulatory and management options)**	**Extended Actions**	**Parties involved in implementation**	**Expected Outcomes / Notes/Comments**	**Ballot re: Priority (completed later)**
NS 5.1 NPFMC Arctic Fishery Management Plan	Support adoption & implementation of the NPFMC Arctic Fishery Management Plan; & take similar action for state waters	Adoption of a precautionary approach to establishment of new commercial fisheries in the Arctic	Coastal Arctic communities, ADF&G, AK Board of Fisheries, NMFS, & NPFMC, Fisheries enforcement officials	Need to monitor adaptively, Is enforcement capability available?	
NS 5.2 Ecosystem-based management	Adopt Ecosystem Based Management principles in fisheries management	Consideration of ecosystem impacts when making decisions on commercial fisheries; adoption of broad range of management options to respond to changing conditions	NOAA, ADF&G, UA researchers	EBM still in its infancy, need better ecosystem models. Essential to have monitoring of ocean conditions included, including ocean temp, salinity, winds, waves & currents, acidification, nutrients, contaminants.	
NS 5.3 Disease/invasives monitoring (NOTE- Put on research/monitoring list)	Develop a statewide monitoring program for diseases (and invasive species) that affect fish & shellfish, including PSP, vibrio, and Harmful Algal Blooms	Testing program, guidelines, & disease (& invasive species) monitoring & forecast program	ADEC, State public health dept., EPA, NOAA, FDA?	Research need: develop a HAB & Vibrio (& invasive species) forecasting program for AK waters.	

Option No.	Adaptation Action / Policy Option (includes regulatory and management options)	Extended Actions	Parties involved in implementation	Expected Outcomes / Notes/Comments	Ballot re: Priority (completed later)
NS 5.4 Socioeconomic impacts of changes in commercial fisheries	Provide socio-economic info to community planners on a regular basis, related to changes in commercial fisheries	Communities have the socio-economic info needed to make informed local decisions about changing commercial fisheries & its impacts on their communities (e.g., need for port expansion or relocation, loss of fishing boats and vessel rents in community, loss or increase of fisheries revenues & taxes; transfer of quotas & permits)	ADF&G, NMFS, ADCCED, UA ISER		
NS 5.5 New fishing gear	Develop new fishing gear to target new species and avoid bycatch species	Gear that can target new fisheries opportunities & reduce bycatch of non-targeted species	UAF FITC, NMFS, ADF&G, commercial fishers, other?		
NS 5.6 Preparation for new fishing opportunities	Develop new harbor capacity, improved weather & ocean condition forecasting, & more accessible & cost-effective processing & delivery options	More cost-effective & efficient fisheries, able to take advantage of new - or changing - fishing opportunities	ADOT, USACE, harbor managers, community planners, NWS,	Some fish farther away from on-shore processors, harbors, and communities, requiring further travel, need for larger vessels, and greater peril at sea	
NS 5.7 Fuel cost transition plan	Develop transition plan to assist commercial fishing industry cope w/ higher fuel costs	Adaptation plan for higher fuel costs	?	Could become more significant issue in light of efforts to limit combustion emissions	
NS 5.8 Education/outreach for new entrants into fishing	Education & outreach program for new entrants into commercial fishing industry	Improved information about future for new entrants into commercial fishing	AK Sea Grant Marine Advisory Program, young fishermen		

Option No.	Adaptation Action / Policy Option (includes regulatory and management options)	Extended Actions	Parties involved in implementation	Expected Outcomes / Notes/Comments	Ballot re: Priority (completed later)
NS 5.9 State-federal commission	Establish a joint state-federal commission to allocate stocks of any fish species that has commercial potential in a fashion consistent with 1) international treaty obligations (e.g., salmon escapement to Canadian portions of Yukon River), 2) in-river subsistence needs, and 3) commercial demands for fish both within rivers and in oceans	State, national & international commercial & subsistence fisheries would be allocated in a comprehensive fashion	State, federal fish managers & US and Canadian State Depts.	Would require new state & federal legislation? How do existing treaties play into this?	
NS 5.10 No-Take reserves	Establish permanent no-take reserves for commercial species threatened by climate change or which have potential to develop into commercial fisheries as climate warms.	Permanent habitat protection for threatened species.	Legislation? NPFMC? State? NOAA?	Might be located adjacent to terrestrial conservation areas, due to tight linkage between terrestrial & marine ecosystems in Arctic. Too extreme an option? Promote precautionary management approaches as alternative?	
NS 5.11 Allocation policies responsive to changing conditions	Establish allocation policies that strengthen incentives to conserve viable fish stocks & promote fishing at times when weather is safe & market prices are high. Provide permits to communities that are likely to require a new subsistence resource as they lose opportunities to hunt marine mammals due to declining sea ice.				

Option No.	**Adaptation Action / Policy Option (includes regulatory and management options)**	**Extended Actions**	**Parties involved in implementation**	**Expected Outcomes / Notes/Comments**	**Ballot re: Priority (completed later)**
NS 5.12 Experimental fish-trap program	Initiate an experimental fish-trap program for salmon that could lead to carefully regulated harvest of high-quality wild fish near river mouths that could compete with farmed fish in terms of quality & price.				

NS-6: Fish and Wildlife Management

NOTE – The following two introductory paragraphs are from the initial version of the NS TWG catalog (June/July 2008). Would need to review/edit if the group judges this to be useful form of introduction to each section.

Decline in traditional subsistence food availability: Current impacts – decline and disease in traditional subsistence foods (e.g., *Ichthyophonus* in Y-K salmon); changed animal migratory routes, seasons, and patterns affecting hunting; hunting more dangerous if associated with ice; other adverse hunting and fishing access issues; decline in some animals traditionally trapped (e.g., muskrats); changes in berry distribution and availability; increased abundance of pathogens and parasites with emergence of diseases in muskoxen, caribou, moose, and wild sheep can influence availability and sustainability of these and other terrestrial, aquatic, and marine animals for exploitation in the subsistence food chain. *Future projections – additional decline and disease in traditional subsistence foods; decrease in hunting opportunities for dall sheep because of loss of alpine habitat, for caribou because of food availability issues and other impacts, for muskoxen because of disease and flooding events, for polar bears, walruses, and ice seals because of decrease in sea ice, and for waterfowl because of loss of ponds and lakes; ice-based and ocean-based hunting increasingly more dangerous because of thinning ice and unpredictable ice behavior; some new subsistence food possibilities (e.g., salmon in northern Alaska).*

Impacts to sport hunting: Current impacts – changes in seasons and location of some species in some locations (e.g., caribou and moose). *Future projections – decrease in hunting opportunities for dall sheep because of loss of alpine habitat, for caribou because of food availability issues and other impacts, for muskoxen because of disease and flooding events, for waterfowl because of loss of ponds and lakes, etc.; new hunting opportunities as new species arrive or are introduced (e.g., possible expanded hunting for Sitka deer, bison).*

The following points were discussed at the October NS TWG meeting – FEEL FREE TO OFFER EDITS

The harvest of fish and wildlife for subsistence and sport harvest is extremely important to Alaskans. For Alaska's tribes and many of its communities, subsistence harvests are interwoven with community culture, health, economy and other attributes. It is essential that Alaska's fish and wildlife regulatory structure be poised to respond in a timely, coordinated and effective manner, as necessary, to changes in fish and wildlife availability, access to harvest areas, changes in patterns of harvest and use, etc.

Option No.	Adaptation Action / Policy Option (includes regulatory and management options)	Extended Actions	Parties involved in implementation	Expected Outcomes / Notes/Comments	Ballot re: Priority (completed later)
NS 6.1 Fish and wildlife harvest	Conduct a comprehensive critical review of the State's fish and wildlife management policies and	Examples of extended actions: • Revise state statute AS 44.62.270, which defines the	ADF&G; Board of Fish; Board of Game; Federal Subsistence	Expect outcomes: Ability to respond in a timely and effective manner to a wide range of climate change effects on the use and	

regulations	practices, and make required changes in law, to allow for the *timely, coordinated and effective* adjustment of state and federal fishing and hunting regulations to adapt to effects of climate change.	situations under which "emergency" regulatory changes can be made by the Alaska Boards of Fish and Game to include "an unforeseen, unexpected weather of climate change effect that would otherwise restrict a reasonable opportunity for customary and traditional fish and wildlife uses, as defined in AS 16.05.258(1)." • Provide the State with a broader suite of effective management tools and adaptive approaches to respond effectively to the impacts of climate change on harvest success. • Improve coordination between state and federal management and decision-makers to ensure a consistent and effective response to the complex and important management issues created by climate change.	Board; Federal agencies; Alaska State Legislature; Fish and Game Advisory Committees; Regional Advisory Councils; other stakeholders	users of fish and wildlife, such as the need to respond to: - changing wildlife migration timing or routes - changes in species diversity, ranges, abundance and distribution - species conversation issues - hunting access and travel safety issues Notes: The successful harvest of fish and wildlife is essential to the economy, health, culture and well-being of many Alaskans, communities and businesses. There seems to be and increase in climatic occurrences that are impacting harvest (e.g., warm, dry fall making it difficult to harvest moose in interior locations; changes in caribou migration). Loss of access to one or more species will cause change in other harvest practices, that must be understood and managed. It is essential that the State have policies, practices and management tools that can adjust fish and wildlife management quickly and effectively, when such change is required.	
NS 6.2 Adaptive fish and wildlife management	Use adaptive management to minimize or slow loss of species, where mitigation of climate change effects is feasible, and ensure that information and tools are in	Examples of extended actions: • Increase funding and efforts to update the Alaska Anadromous Waters Catalog. • Invest in the management plans, monitoring and management			

	place for adaptive management to be implemented.	actions necessary to respond to climate change effects on both game and non-game species. • Improve coordination between state and federal managers to ensure a consistent and effective response to the complex and important management issues created by climate change.			

NS-7: Water Conservation and Management					
Need opening paragraph about expected changes					
Option No.	**Adaptation Action / Policy Option (includes regulatory and management options)**	**Extended Actions**	**Parties involved in implementation**	**Expected Outcomes / Notes/Comments**	**Ballot re: Priority (completed later)**
NS 7.1 Watersheds and Instream Flow	Establish policies and take actions to identify and protect watershed needed to meet the estimated future water needs of Alaskan communities, and to reserve water in streams to ensure there is instream flow needed to maintain essential fish habitat and productivity.	• Gauge rivers to establish flow baselines, from which to evaluate effects of climate change on stream flow. • Review existing water reservations in light of changing flow conditions. • Streamline the adjudication process for applications related to community water supplies and reservation of instream flow for fish. • In future water right adjudication, provide priority for community water supplies and maintenance of fish habitat and productivity.	ADFG ADNR ADEC		

NS-8: Capacity-Building, Education & Outreach

NEED OPENING SECTION

Option No.	Adaptation Action / Policy Option (includes regulatory and management options)	Extended Actions	Parties involved in implementation	Expected Outcomes / Notes/Comments	Ballot re: Priority (completed later)
NS 8.1 Climate change capacity building	Provide centralized source of information (e.g., research, accurate mapping), adaptation tools, technical assistance and funding for communities, agencies, organizations and businesses to access to build their capacity to respond to climate change.	• Extend and expand the scope of the mini-grant program, and establish other technical assistance and funding sources, to support communities in development of locally-appropriate climate change adaptation plans. (See also NS 3.1 regarding community wildfire protection plans.) • Review the Alaska Coastal Management Act and other laws to determine the need for additional authorities and tools for local communities to use to prepare for and respond to climate change effects. • Establish an Alaska Climate Change Action Center at the University of Alaska to provide climate change related expertise, information and technical assistance. • Improve accuracy and currency of mapping and aerial photographs, to assist	Interagency climate change adaptation group ????	The general goal is to build local capacity to engage in decision-making about how to adapt to climate change. There is currently no mechanism to efficiently share expertise in addressing climate change with the communities, agencies, organizations and businesses that need access to expertise. Locally-appropriate climate change adaptation plans are needed to launch adaptation steps by individual communities. Information-sharing would provide mechanism for communities to learn from approaches that have proven successful in other communities.	

		communities with planning for adaptation to climate change.			
NS 8.2 Augment and coordinate existing outreach and education	Increase support for and coordination between existing programs and entities that are addressing climate change education in Alaska's schools	• Increase assistance to K-12 teachers, for example, hire a climate change specialist as a statewide resource (curriculum, teaching materials, trainings) • Increase support at University level for course development and delivery related to climate change • Support and staff development of outreach materials effective with general public		There are many existing programs that are addressing this issue that should be augmented, including University of Alaska Cooperative Extension Service, Alaska Sea Grant Marine Advisory Program, Alaska Center for Ocean Science Education Excellence, etc.	