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Policy Option Catalog: Natural Systems and Associated Economies (NS)

Note: This listing is underdevelopment and should be considered a draft document not for citation. The limited purpose for this document is to inform the Adaptation Advisory Group at its July 16, 2008 meeting about the range of potential climate change vulnerabilities and potential policy options for Alaska. The Natural Systems and Associated Economies Technical Work Group will be revising this list as the planning process continues. To follow the development of this document visit http://akclimatechange.us/Natural_Systems.cfm. Beyond the general trends outlined at the beginning of each section, forecasting ecosystem responses to global warming stressors is difficult. Many of the forecasts in this section are uncertain on this account. For example, it is not a foregone conclusion that just because the ice recedes in the Arctic there will be substantial new fisheries there as there might not be much in the way of forage fish to support new species advance. Nor is it a foregone conclusion that there will be invasion from the south of substantial numbers of warmer water fish as there are multiple habitat criteria that may not be met. The projections in this section are made to aid understanding about the direction and potential impacts of global-warming trends on Alaskan natural systems and

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NS-1 Agriculture				
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.,		NS-1.1	Improve impact predictions	
		NS-1.2	Define new opportunities	
		NS-1.3	Plan pro-active pest management	
		NS-1.4	Plan integrated pest management strategies	
		NS-1.5	Increase monitoring of pests	

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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 – citation needed); 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.*		NS-1.6	Increase pest management research	
		NS-1.7	Pro-actively plan agricultural water management strategies	
		NS-1.8	Improve agricultural outreach and support	
		NS-1.9	Promote new market opportunities	
NS-2 Boreal and Temperate Forests and Dependent Species				
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; Question-is there a percentage figure to use here?); other forest diseases include larch saw fly (killed 90% of larch near Fairbanks-needs a citation), 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. (Note — there is anecdotal evidence suggesting more impacts than initially reported. For example, in areas ranging from the Y-K up through the western interior to the Kobuk there are a number of expanses of compromised and/or dead spruce stands. *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.*		NS-2.1	Improve impact predictions	
		NS-2.2	Pro-active planning	
		NS-2.3	Increase research	
		NS-2.4	Improve problem detection	
		NS-2.5	Define new opportunities	
Forest Fires Current impacts – more and earlier fires; record breaking		NS-2.6	Re-consider fire management objectives	
		NS-2.7	Conduct priority assessments	

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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 (joint state/federal cost in 2004/2005 was $108 million); less habitat available for some forest dependent species; potential increase in food availability for other species, such as moose. *Future projections – greater fire impacts, including possibility of fires in southeast Alaska.*		NS-2.8	Improve predictions of fire management needs	
		NS-2.9	Experiment with fire management innovations	
		NS.2.10	Implement priority habitats and species management	
		NS-2.11	Improve use of fire as a management tool	
		NS-2.12	Improve the funding base	
		NS-2.13	Investigate recent year experiences	
		NS-2.14	Expand the fire risk management zone	
		NS-2.15	Expand the fire risk management zone	
		NS-2.16	Improved seasonal forecasting of forest fires	
		NS-2.17	Increase fire prevention and management planning	
Warming Effects on Trees		NS-2.18	Improve research base	
		NS-2.19	Improve research base	

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	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. Note—another source of expertise could be Glenn Juday who works on this topic. See: http://www.uaf.edu/snras/faculty/juday.html. *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.*	NS-2.20	Evaluate a new forestry for Alaska	
	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.	NS-2.21	Improve impact predictions	
		NS-2.22	Increase pro-active planning	
		NS-2.23	Increase pro-active planning	
		NS-2.24	Improve intervention planning	
		NS-2.25	Improve pro-active planning	
		NS-2.26	Improve pro-active planning	
		NS-2.27	Improve pro-active planning	
		NS-2.28	Improve pro-active planning	
		NS-2.29	Improve the research base	
		NS-2.30	Increase monitoring	
	Impacts on Forest-Dependent Species Current impacts – few current ecosystem-wide impacts, some	NS-2.31	Improve impact predictions	
		NS-2.32	Conduct priority assessments	
		NS-2.33	Set priorities	

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animals lost or displaced by loss of local habitat after massive fires. *Future projections – greater impacts on forest dependent species due to substantial loss of boreal forest habitat (e.g., forest dependent birds such as passerines).*		NS-2.34	Improve pro-active planning	
		NS-2.35	Plan for specific, priority animal migratory needs	
		NS-2.36	Implement priority habitats and species management	
		NS-2.37	Increase monitoring	
		NS-2.38	Modify harvest management regimes	
NS-3 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.*		NS-3.1	Improve impact predictions	
		NS-3.2	Improve impact predictions	
		NS-3.3	Improve impact predictions	
		NS-3.4	Define new opportunities	
		NS-3.5	Improve pro-active planning	
		NS-3.6	Define new opportunities	
NS-4 Tundra and Alpine Ecosystems and Dependent Species				
Tundra Fires Current impacts – larger and more intense tundra fires (almost 250,000 acres in 2007); modification of tundra habitat from wildfires. *Future projections – more tundra fires and loss of habitat with impacts on dependent species. Research studies are underway now to illuminate impacts from the 2007 fire near Umiat.*		NS-4.1	Improve impact predictions	
		NS-4.2	Improve impact predictions	
		NS-4.3	Improve pro-active planning	
		NS-4.4	Implement priority habitats and species management	
		NS-4.5	Improve impact predictions	
		NS-4.6	Implement priority habitats and species management	
		NS-4.7	Implement priority habitats and species management	
		NS-4.8	Improve the research base	
		NS-4.9	Improve monitoring	
Impacts on Tundra-Dependent Species		NS-4.10	Improve impact predictions	

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Current impacts – some current impacts on caribou, muskoxen, and other species because of decreased food availability due to freezing rain (e.g., porcupine caribou herd has decreased 3.5%/year between 1989 and 2001); decreased food because of tundra fire events; decreased habitat because of increase bush growth and tree-line advance for dall sheep, mountain goats, and other alpine and tundra species; increased tundra plain flooding events (e.g., deaths of muskoxen on North Slope);. *Future projections – further impacts on tundra and alpine species due to loss of habitat, less available food, more flooding, and changing distributions and abundance of pathogens and diseases, resulting in substantial population level impacts; altered patterns of distribution for pathogens and parasites with emergence of disease are predicted for caribou, wild sheep, moose, and muskoxen; diseases interact with habitat perturbation and other stressors to influence reproductive success, survival, and sustainability of wildlife populations.*		NS-4.11	Implement priority habitats and species management	
		NS-4.12	Implement pro-active planning	
		NS-4.13	Plan for specific, priority animal migratory needs	
		NS-4.14	Implement priority habitats and species management	
		NS-4.15	Implement bio-resource savings programs	
		NS-4.16	Implement bio-resource savings programs	
		NS-4.17	Modify harvest management regimes	
NS-5 Freshwater ecosystems and dependent species				
Temperature Increases Current impacts – river temperatures have increased throughout the state (e.g., Yukon River summer temperatures have increased more than 10 degrees Fahrenheit in last 25 years (citation needed), and monitored Kenai Peninsula river temperatures now repeatedly exceed 55 degrees Fahrenheit and occasionally exceed 68 degrees Fahrenheit (above which is deemed "unhealthy for spawning areas"); increased lake temperatures. *Future projections – continued increase in water temperature throughout the state with more 55 degree and 68 degree exceedences; greater impacts on fish spawning, disease, egg development, etc.*		N-5.1	Increase monitoring and reporting	
		NS-5.2	Reserve water	
		NS-5.3	Review trends	
		NS-5.4	Improve research	
		NS-5.5	Improve research	

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River Water Flows	Current impacts – increased flooding events; less water in many non-glaciated rivers during warmer summers, disrupting spawning and other functions; increased summer river flow for glaciated rivers; major landslides into rivers and retrogressive thaw slumps (e.g., Selawik River) resulting in sedimentation and other issues. *Future projections – even less water in many river systems especially those in Alaska's interior and North Slope; increased summer flow in glaciated rivers until glaciers disappear; more major landslides and retrogressive thaw slumps*	NS-5.6	Improve monitoring and reporting	
		NS-5.7	Improve landslide and retrogressive thaw slump monitoring	
		NS-5.8	Examine stream and river flows	
		NS-5.9	Reserve water	
		NS-5.10	Improve research	
		NS-5.11	Convene expert panel	
Loss and shrinkage of ponds and lakes	Current impacts – ponds and lakes are shrinking and disappearing throughout Alaska through evaporation, permafrost loss, coastline erosion, and coastal storm surges; shrinkage of ponds and lakes (e.g., in a statewide study, closed pond areas decreased by 4 to 31% in last 50 years); in northeast Alaska, of 23 lakes studied, 21 decreased in size; salinization of coastal ponds and lakes from storm surges (storm surge in 2005 covered extensive areas on Y-K Delta under 9 feet of saltwater), erosion (loss of lakes on North Slope), and sea ice scouring. *Future projections – greater loss of ponds and lakes, including substantial loss from sea level rise (projected approximate 18-inch sea level rise by end of century); major impacts on many species including waterfowl and migratory birds (Note: see subsector below); increased storm surges causing salinization of coastal lakes, ponds, and wetlands; some possible expansion of wetlands on the North Slope from thawing permafrost.*	NS-5.12	Improve monitoring	
		NS-5.13	Assess future loss and shrinkage	
		NS-5.14	Improve monitoring of sea level rise	
		NS-5.15	Conduct and Alaska Shoreline Impact Assessment	
		NS-5.16	Reserve water	
		NS-5.17	Improve research on impacts of lake and pond loss	
		NS-5.18	Evaluate measures to protect species at risk	
Invasive species in freshwater systems		NS-5.19	Assess scope of impacts from invasive species	

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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*		NS-5.20	Prioritize threats and needs	
		NS-5.21	Create a response plan	
		NS-5.22	Predict future invasives	
		NS-5.23	Convene expert panel	
		NS-5.24	Assess effectiveness of early detection and selected removal	
		NS-5.25	Assess appropriateness of removal from sensitive locations	
		NS-5.26	Improve research on removal methodologies	
		NS-5.27	Expand monitoring and reporting systems	
Impacts on freshwater dependent fish Current impacts – increase in warmer water diseases such as *Ichthyophonus*; migration of salmon to more northern rivers and streams; decrease in salmon fry size in glacial-fed rivers and lakes (Skilak river fry 60% smaller when glacier melted extensively in 2005); greater spring flooding disturbing eggs; increase in warmer water predatory fish; impacts from expanding beaver populations on fish habitat; major landslide and slumping events (e.g., the Selawik slump affecting sheefish). *Future projections – more northerly migration of salmon and other species; threat to and potential elimination of grayling, steelhead, and some salmon from warmer streams and rivers; more predatory fish; more habitat disruption from major slumping events.*		NS-5.28	Convene expert pane	
		NS-5.29	Monitor distributional changes	
		NS-5.30	Identify at-risk species	
		NS-5.31	Regulate water in streams for fish	
		NS-5.32	Research impacts of climate change on cold-water fish	
		NS-5.33	Evaluate strategies to protect at-risk species	
		NS-5.34	Develop guidelines to assess risk	
		NS-5.35	Evaluate relocation options	
		NS-5.36	Evaluate river, stream, and lake management plans	
		NS-5.37	Determine the need for providing protected corridors	
		NS-5.38	Examine need for new protected streams, rivers, and lakes	
		NS-5.39	Improve monitoring of key species	
		NS-5.40	Monitor impacts on fish	
		NS-5.41	Evaluate appropriateness of fish regulations	

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Impacts on birds and other non-fish freshwater dependent species Current impacts – loss of animals due to flooding events; impact on muskrats, waterfowl, migratory birds, and other species from smaller or eliminated ponds and lakes (e.g., scaup declines from over 7 million to 3.2 million). *Future projections – further reductions in waterfowl and other pond and lake dependent species.*		NS-5.42	Convene expert panel	
		NS-5.43	Identify at-risk species	
		NS-5.44	Reserve water	
		NS-5.45	Evaluate strategies to protect at-risk species	
		NS-5.46	Review and modify management plans	
		NS-5.47	Evaluate need for protected corridors	
		NS-5.48	Evaluate need for new protected areas	
		NS-5.49	Improve monitoring of key species	
		NS-5.50	Improve research	
		NS-5.51	Evaluate effectiveness of habitat modification	
		NS-5.52	Review and modify management plans	
NS-6 Marine, Sea Ice, Coastal Environment, and Dependent Species				
Sea ice loss Current impacts – decline of summer Arctic Ocean sea ice (39% smaller in 2007 than recent average, and even greater loss off the coast of Alaska); decline in winter extent of Bering Sea ice; substantial thinning of ice so average is now only approximately 3 feet thick. Loss of sea ice will cause major ecological reorganizations in the Bering Sea and Arctic Ocean, likely resulting in lower overall productivity at the base of these marine food webs. Almost half the primary		NS-6.1	Improve monitoring of sea ice in the Bering Sea and Artic Ocean	
		NS-6.2	Improve sea ice forecasts	
		NS-6.3	Improve research on impacts of sea ice loss, later ice-up times, and earlier ice-out times	
		NS-6.4	Assess costs and benefits from sea ice loss	
		NS-6.5	Improve research on impacts of changing sea ice dynamics	

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productivity (i.e., plant growth) occurs on the underside of sea ice or in the surface meltwater as the ice recedes during spring in these regions. Most of the plants that are not immediately consumed as the ice recedes falls to the seafloor of the continental shelf, supporting a rich bottom-dwelling community of organisms that provide food for whales, walruses and seals. With the ice gone, much of this productivity will be lost, and most of what remains will be consumed by zooplankton before reaching the bottom, because zooplankton will grow faster in the warmer water. This complex of changes will affect the entire food web, by shrinking it overall and by altering the allocation of what is left. *Future projections – greater loss and projected elimination of summer sea ice in Arctic Ocean by as early as 2013; 40% loss of Bering Sea ice projected by 2050 –citation needed; continued thinning*.		NS-6.6	Support actions to reduce greenhouse gas emissions	
Impacts on marine mammal ice dependent species Current impacts – walruses (abandoning calves, females hauling out on land, stampeding; displacement from normal feeding areas as the sea ice edge moves to deeper water); polar bears (drownings, cannibalism, reduced cub survival, smaller skull size —a proxy for body size, more on-land denning), ice seals (collapse of some ice dens, immature seals entering the water before they are ready, less habitat), grey whales (weight decline, population impacts), humpback whales (first documented appearance in Arctic Ocean); decline of benthic habitat in Bering Sea because of less ice thereby affecting walrus and grey whales. *Future projections – with the elimination of sea ice, many marine mammal species face dramatic reductions in numbers and possible extinction; some new marine mammal species from the south*		NS-6.7	Convene expert panel	
		NS-6.8	Evaluate strategies to protect at-risk species	
		NS-6.9	Review and modify management plans	
		NS-6.10	Evaluate need for protected corridors	
		NS-6.11	Evaluate need for creating new protected areas	
		NS-6.12	Examine regulatory, management, and biological impacts of new species	
		NS-6.13	Consider new regulations	
		NS-6.14	Improve protection of polar bear denning sites	
		NS-6.15	Improve monitoring of key species	

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	may move north and compete for available habitat; patterns of distribution for pathogens in marine mammals, including some zoonoses such as Trichinella, will influence exposure in humans (Note: see the Health and Culture sector for a full discussion of impacts on human health).	NS-6.16	Improve monitoring and forecasting of ocean and sea ice conditions	
		NS-6.17	Evaluate "out of the box" strategies	
		NS-6.18	Review and modify regulations	
Impacts on fish, birds, and other species from reduction in sea ice and marine terminus glaciers	Current impacts – loss of marine terminating glaciers with impacts on species such as Kittlitz's murrelets (97% decline in Prince William Sound between 1989 and 2001; 89% decline in Glacier Bay between 1991 and 2000) and other species; in Arctic Ocean declines in species like black guillemot; in Bering Sea declines in fishery species that are benthic residing and/or feeding, such as snow crab (harvest down 85% in last 6 years), other crab, halibut, yellowfin sole, Greenland turbot, as well as certain species of birds (e.g., spectacled eiders); increase in some species (e.g., pollock, cod, arrowtooth flounder); some changes in species distribution; introduction of new species not ice dependent. *Future projections – greater declines in ice dependent species; more introduction and distribution of non-ice dependent species; greater loss of glaciers, potential extinction of Kittlitz's murrelets.*	NS-6.19	Convene expert panel	
		NS-6.20	Evaluate strategies to protect at-risk species	
		NS-6.21	Review and modify management plans	
		NS-6.22	Evaluate need for new protected areas	
		NS-6.23	Improve monitoring of key specie	
		NS-6.24	Improve monitoring and forecasting of ocean and sea ice conditions	
		NS-6.25	Assess changes to existing commercial fisheries	
		NS-6.26	Assess opportunities for commercial fisheries	
		NS-6.27	Reduce stressors on declining species	
		NS-6.28	Review and modify regulations	
Increase in marine water temperatures	Current impacts – in 2007, Arctic Ocean 5 degrees Celsius above normal specify if mean temperature and citation needed; in 2005, Gulf of Alaska 2-3 degrees Fahrenheit above normal; shifts in species distribution (e.g., pollock moving northward); introduction of new species such as tuna, anchovies, sardines, pomfret, and opah; new diseases such as Vibrio; increase in predatory fish such as barracudas	NS-6.29	Improve ocean temperature monitoring and reporting	
		NS-2.30	Examine trends and future projections	
		NS-6.31	Research impacts of warmer ocean temperatures	
		NS-6.32	Research impacts of increased temperatures	
		NS-6.33	Improve monitoring of key species	

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	and sharks; changes in food availability and size; decreased food availability for marine birds and other species because food is lower in the water column; changes in marine productivity; harmful algal blooms adversely affecting crabs, fish, marine mammals, seabirds, and mollusks. *Future projections – greater shifts of many species north, with impacts on other species, human communities, and fishery economics (Note: fishing economics has a separate subsector below); more predatory fish with potential impacts on indigenous fish population levels; further decreases in food availability and algal blooms may result in massive die-offs; decrease in size of plankton in Bering Sea with warmer temperatures leading to problems throughout the marine food chain; potentially significant declines or elimination of sockeye salmon; shifting patterns of distribution and abundance of pathogens and parasites in marine birds, mammals, and fishes are predicted; altered seasonal patterns of abundance for parasites circulating in mollusks and birds can lead to near collapse of intertidal ecosystems through mortality of molluskan hosts.*	NS-6.34	Assess changes to existing commercial fisheries	
		NS-6.35	Assess opportunities for commercial fisheries	
		NS-6.36	Review and modify regulations	
		NS-6.37	Provide funding for fleet modifications	
	Ocean acidification Current impacts – ocean acidity has increased by 30% (where?, over what time? – citation needed). *Future projections – increased ocean acidity, potentially increasing to pH 7.9 by end of century; adverse impacts on calcium carbonate dependent species, from plankton such as pteropods to shellfish such as crabs, especially at larval stages; adverse impacts on deep sea coral and the coral dependent communities; adverse impacts on other species such as squid; adverse impacts on species that consume these species (such as salmon and pteropods).*	NS-6.38	Research impacts of ocean acidification	
		NS-6.39	Research impacts of increasing freshwater from glacier melt	
		NS-6.40	Analyze risk to marine ecosystems and fishing industry from ocean acidification	
		NS-6.41	Convene expert panel	
		NS-6.42	Improve monitoring	
		NS-6.43	Reduce additive threats	
		NS-6.44	Support reducing carbon dioxide emissions	
NS-7 Other Warm Temperature Impacts on Animals				

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Non-fish animal impacts in addition to habitat-based changes	Current impacts – loss of animals due to new or increased viral, bacterial, and parasitic diseases, such as lungworm in muskoxen (a tipping point changing transmission from a 2 year to a 1 year cycle was reached in the 1990s); muscleworms in caribou where responses to extreme warm weather events can drive emergence of disease and mortality; increasing abundance of biting fly vectors linked to the emergence of parasitic diseases in reindeer; new distributions for viral pathogens in rodents (potentially transmissible to humans) through range expansion; earlier arrival and birthing of migratory species including birds, whales, etc. (e.g., hatch dates for geese in Yukon Delta 5-10 days earlier since 1982); new species both to the state as a whole and to specific areas; greater predation threats to eggs after storm surges reduce vole populations. *Future projections – more new or increased emergence of pathogens, diseases, and vectors (e.g., injury or death to moose from excessive ticks and deer-borne pathogens, including winter tick); potential new diseases affecting caribou; more damage to muskoxen and wild sheep from lungworm; other potential disease damage to caribou, muskoxen, and dall sheep; increase in biting flies both as direct nuisance and as vectors.*	NS-7.1	Improve monitoring of species	
		NS-7.2	Establish or expand disease registries and reporting	
		NS-7.3	Convene expert panel	
		NS-7.4	Develop and implement strategies for at-risk species	
		NS-7.5	Research disease control strategies	
		NS-7.6	Research impacts of early migratory arrivals and hatching dates	
		NS-7.7	Research impacts of major storm surges	
		NS-7.8	Review and modify regulations	
NS-8 Fishing: Commercial and Sport				
Commercial fishing	Current impacts – changes in fish distribution and catch composition; northern migration of species such as pollock (in some cases outside of U.S. waters); some fish farther away from on-shore processors, harbors, and communities,	NS-8.1	Convene expert panel	
		NS-8.2	Assess statewide impacts of current and projected climate change on commercial fishing opportunities	
		NS-8.3	Improve monitoring and reporting efforts	

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	requiring further travel; introduction of new species such as tuna; declines in catch of benthic species in Bering Sea and elsewhere such as most species of crab, shrimp, and in some locations, halibut; increase in some pelagic species (e.g., cod). *Future projections – opening up of the northern Bering Sea and Arctic Ocean to the possibility of commercial fishing and potential conflicts with other fishing nations; greater introduction of new species; need for new gear and new infrastructure (harbors, ice plants, processing, airport shipment, etc); continued declines in benthic species; decline of sockeye salmon; potentially more dangerous fishing conditions due to greater storms, and more intensive waves (without sea ice protective barrier), less weather predictability, and the need to travel farther distances*	NS-8.4	Improve monitoring and forecasting of ocean and sea ice conditions	
		NS-8.5	Provide funding for fishermen	
		NS-8.6	Develop new markets	
		NS-8.7	Address strategies for increased foreign competition	
		NS-8.8	Increase Coast Guard presence	
		NS-8.9	Reduce stressors to key species	
		NS-8.10	Assess infrastructure requirements	
		NS-8.11	Review and modify regulations	
		NS-8.12	Improve monitoring and forecasting of ocean and sea ice conditions	
	Sports fishing business *Future projections – likely decline in cold water sports fish such as grayling, steelhead, some salmon in warmer streams, and rainbow trout; longer open water season with potentially higher harvest rates on recreational fish; greater requests to stock non-native warmer water fish; changed access to water bodies for fishing; more dangerous fishing conditions due to greater intensity and/or frequency of storms, less weather predictability, and the need to travel farther distances (e.g., for halibut).*	NS-8.13	Assess statewide impacts of current and projected climate change	
		NS-8.14	Consider criteria for stocking non-native species	
		NS-8.15	Improve observing and reporting	
		NS-8.16	Solicit feedback from the public	
		NS-8.17	Educate the public about impacts of climate change	
		NS-8.18	Review and modify regulations	
NS-9 Subsistence Fishing, Hunting, Trapping and Gathering				
	Decline in traditional subsistence food availability Current impacts – decline and disease in traditional subsistence foods; changed animal migratory routes, seasons,	NS-9.1	Assess statewide impacts of current and projected climate change	
		NS-9.2	Convene a statewide conference	
		NS-9.3	Improve monitoring and reporting	

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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).*		NS-9.4	Provide forum for fishers, hunters, and gatherers to report observed changes	
		NS-9.5	Educate public about impacts of climate change	
		NS-9.6	Educate public about impacts of climate change	
NS-10 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).		NS-10.1	Assess statewide impacts of current and projected climate change	
		NS-10.2	Convene statewide conference	
		NS-10.3	Improve monitoring and reporting	
		NS-10.4	Solicit feedback from sports hunters	
		NS-10.5	Educate public about impacts of climate change	
NS-11 Tourism And Watchable Wildlife				

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Summer and shoulder seasons Current impacts – longer summer and shoulder tourism season; expansion of cruise season; expansion of other summer and shoulder tourism opportunities throughout the state; some adverse impacts on summer tourism, including melting of glaciers, reducing tourism attractions (e.g., Portage), damaged roads, and diseased and dying forests; summer smoke from large wildland fires causes disruption in tourism (e.g., visibility diminished of Denali and other sites, highway closures); health issue for tourists (e.g., smoke and Vibrio); hotter temperatures without air-conditioning. *Future projections – even greater expansion of summer season; increased melting, decline, and/or elimination of glaciers; more dead and dying trees; greater disruption from smoke over a longer season; hotter, especially in interior Alaska.*		NS-11.1	Maintain roads, airports, and bridges	
		NS-11.2	Market Alaska's longer summer season	
		NS-11.3	Help extend services in response to longer seasons	
		NS-11.4	Evaluate cooling needs	
		NS-11.5	Address changed itineraries	
		NS-11.6	Provide adequate health system responses	
		NS-11.7	Locate visitor centers aware of future climate changes	
		NS-11.8	Examine tourism expansion	
		NS-11.9	Modify interpretive signage	
Winter tourism season Current impacts – shorter season; some adverse impacts include canceling of dog sled racing events (cancellation of Fur Rendezvous races 3 times in the last 9 years), changing start of Iditarod, shorter downhill skiing season, less cross-country skiing; positive impacts include warmer temperatures in previously very cold locations such as Chena Hot Springs and Bettles. *Future projections – increased reduction in winter season, dog sled races, downhill skiing, and lower elevation cross-country skiing; continued more comfortable temperatures for previously very cold locations.*		NS-11.10	Report the likely impacts of climate change	
		NS-11.11	Assess benefits of warmer winter temperatures	
		NS-11.12	Examine possibility of expanding higher altitude lands for recreation	
		NS-11.13	Examine alternative winter activities	
		NS-11.14	Consider establishing earlier dates for major winter events	
Watchable wildlife		NS-11.15	Report the likely impacts of climate change	

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Current impacts – less watchable wildlife for such species as Kittlitz's murrelets that have already declined significantly; changes in watchable wildlife distribution and timing (e.g., arrival dates of migratory birds). *Future projections – fewer watchable wildlife opportunities if populations of dall sheep, mountain goats, muskoxen, caribous, certain birds, etc., decline; potentially more watchable wildlife opportunities in the near term for polar bears and walruses on land; new watchable wildlife opportunities as new species arrive*		NS-11.16	Modify or create interpretive signage	
		NS-11.17	Consider new wildlife regulations	
		NS-11.18	Allow wildlife observers to report observed changes	
		NS-11.19	Educate the public about the impacts of climate change	
NS-12 Other Adaptation Issues				
		NS-12.1	Evaluate the claim that Alaska should receive compensation as a carbon sink	
		NS-12.2	Develop research and practitioner training program	
		NS-12.3	Develop climate change indicators	
		NS-12.4	Conduct a vulnerability assessment	
		NS-12.5	Review the CZMA and other laws	
		NS-12.6	Ensure that revenues from auctioning emission allowances are dedicated to conserving wildlife and other natural resources threatened by climate change	