As Goes The Arctic, So Goes The Planet

Petition for rulemaking under the Clean Air Act to regulate greenhouse gas emissions from mobile and stationary sources to protect the health and welfare of the Arctic and the world

EXECUTIVE SUMMARY

"Alaska, the rest of the United States, and the world are heading toward catastrophe as greenhouse gases have immediate, dramatic and rapidly escalating impacts on the Arctic, its people, oceans, and ecosystems that will ultimately affect the public health and welfare of the United States and the world."

— Dr. Jeffrey Short

For much of the last three decades, the United States government has been at the center of a vociferous debate about global climate change. Domestic arguments about the effects and causes of climate change prevented any meaningful action to address the problem at a national level. That part of the debate has ended; the climate is changing, and humans are causing it. Emissions of greenhouse gases from human sources—such as cars, trucks, power plants, aircraft, and marine vessels—are warming the Earth, altering climate, and acidifying the oceans.

For most people in the United States and the world, changes caused by greenhouse gas emissions have not yet greatly affected day-to-day life. The same cannot be said for the communities, peoples and wildlife of the Arctic, where the climate is warming on average at about twice the rate of the rest of the world. The Arctic is home to four million people and sensitive, functioning ecosystems. Its inhabitants are seeing their very way of life threatened as sea ice is lost, ecosystems are restructured, and weather patterns change.

The dramatic effects already being seen in the Arctic are measurable and are only the beginning. The rapid warming now occurring in the Arctic has worldwide implications, and the decline of Arctic sea ice, in particular, provides measurable evidence suggesting that we may be approaching a point beyond which dangerous interference with the global climate system will result in significant impacts to the rest of the United States and the world.

This formal petition to the Environmental Protection Agency (EPA) gives voice to those concerns and calls upon the United States to accept its legal and moral responsibility to protect the Arctic so as to safeguard the public health and welfare. The petition itself presents a scientific explanation of the effects climate change is having in the Arctic and the ways those changes affect the rest of the United States and the world. Relying on the United States Supreme Court's landmark holding in Massachusetts v. EPA that greenhouse gases are air pollutants under the Clean Air Act, this petition makes the case that EPA is obligated to regulate greenhouse gases in order to protect the public health and welfare. It argues that, in exercising its authority, EPA must act equitably, to ensure that regulatory burdens are not placed unfairly, and wisely, to maintain economic opportunities.

Scientific evidence suggests that the atmospheric concentration of carbon dioxide must be reduced to no more than 350 parts per million in order to preserve a planet similar to the one to which life on Earth is adapted. While international cooperation will be necessary to achieve that goal, the United States has the moral and legal responsibility to lead the way by establishing a measurable trajectory for reducing its greenhouse gas emissions. The success of this effort can be measured by the health of the Arctic, and, while it is not yet too late, the changes already occurring there make it clear that greenhouse gas reductions must begin now.

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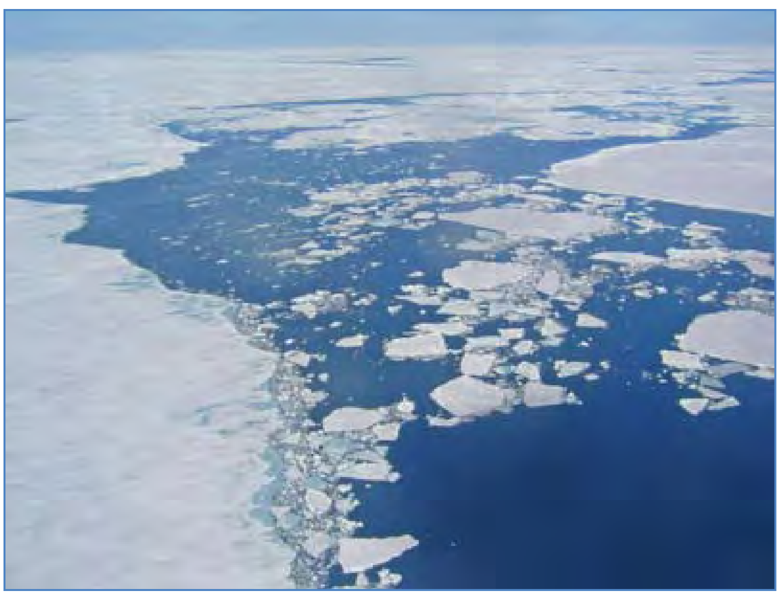
[W]e have used up all slack in the schedule for actions needed to defuse the global warming time bomb. The next President and Congress must define a course next year in which the United States exerts leadership commensurate with our responsibility for the present dangerous situation. Otherwise it will become impractical to constrain atmospheric carbon dioxide, the greenhouse gas produced in burning fossil fuels, to a level that prevents the climate system from passing tipping points that lead to disastrous climate changes that spiral dynamically out of humanity's control. . . . I argue that a path yielding energy independence and a healthier environment is, barely, still possible. It requires a transformative change of direction in Washington in the next year.

— Dr. James Hansen[1]

Ice is a supporter of life. It brings the sea animals from the north into our area and in the fall it also becomes an extension of our land. When it freezes along the shore, we go out on the ice to fish, to hunt marine mammals, and to travel . . . . When it starts disintegrating and disappearing faster, it affects our lives dramatically.

— Caleb Pungowiyi[2]

The Arctic is at once one of the most beautiful and forbidding places on Earth and a critical component of the planet's ability to sustain life. In the Arctic, life swings between twenty-four hour days of sunshine in the summer and the long, cold, and dark winter. Despite those harsh conditions, the Arctic is home to vibrant communities and functioning ecosystems. It provides vital habitat for iconic wildlife, including polar bears, whales, walrus, fish, and birds. Arctic peoples have lived a subsistence lifestyle dependent on their environment since time immemorial and continue to do so today. In addition, this region plays a vital role in the planet's climate system.



Arctic sea ice forms eerie and beautiful landscapes.

The Arctic, also, is warming at twice the rate of the rest of the planet. This warming is having immediate, negative effects on Arctic people and ecosystems, including coastal erosion, melting permafrost, increased wild fires, and loss of important habitat. The most dramatic of these impacts is the incredible loss of Arctic sea ice. In

[1] *The Climate Threat to the Planet: Hearing Before the House Select Comm. on Energy Independence and Global Warming*, 110th Cong. 1 (2007) (statement of Dr. James Hansen, NASA Goddard Institute for Space Studies, entitled "Global Warming Twenty Years Later: Tipping Points Near"), *available at* http://globalwarming.house.gov/pubs/pubs?id=0045# [hereinafter "Hansen testimony"].

[2] Arctic Climate Impact Assessment, Impacts of a Warming Arctic 24 (2004) [hereinafter ACIA 2004] (quoting Caleb Pungowiyi, Native leader from Savoonga, AK).

2007, sea ice extent fell to its lowest level in recorded history, and according to the National Snow and Ice Data Center, that record was almost matched in 2008. Arctic communities rely on sea ice for hunting, fishing, and other activities necessary for survival. Sea ice also serves as a platform for birthing seals, feeding walruses, roaming polar bears, and other Arctic life, and it is preventing at least some of the increased carbon dioxide in the atmosphere from entering and acidifying the Arctic Ocean.

Sea ice also plays a critical role in regulating the world's climate. The loss of sea ice accelerates warming both in the Arctic and the rest of the world by opening areas of the much darker ocean that absorb solar radiation rather than reflecting it. This increased warming alters weather patterns and climate in the northern hemisphere, will likely release additional greenhouse gases from carbon stores frozen in the Arctic permafrost, and may accelerate melting of the Greenland ice sheet, which could cause a substantial rise in sea level this century. These potential changes present a serious danger to the rest of the United States and the world.

The only practical way to prevent dangerous climate change is to reduce human-caused emissions of greenhouse gases. As the Intergovernmental Panel on Climate Change, an international body comprised of scientists and governments (including the United States), concluded, "[w]arming of the climate system is unequivocal . . ., [and m]ost of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."[3] The United States government has recognized explicitly that "climate change is a serious global challenge" and that observed "increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level" make global warming evident.[4]

Yet the United States government has taken no specific action to address this problem. Information about the causes and effects of climate change in the Arctic, in particular to Arctic peoples, has been collected and presented in the 2005 Petition to the Inter American Commission on Human Rights Seeking Relief from Violations Resulting from Global Climate Warming Caused By Acts and Omissions of the United States.[5] That information is incorporated fully here.

Moreover, scientific evidence suggests that "[i]f humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted," we must reduce the atmospheric concentration of carbon dioxide from

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[3] Intergovernmental Panel on Climate Change, *Summary for Policymakers*, in Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change 1, 5 & 10 (2007) (emphasis in original) [hereinafter IPCC 2007b].

[4] Regulating Greenhouse Gas Emissions Under the Clean Air Act, 73 Fed. Reg. 44,354, 44,396 (July 30, 2008) (Advanced Notice of Proposed Rulemaking) (to be codified at 40 C.F.R. Chapter I) [hereinafter "ANPR"]; IPCC 2007b, *supra* note 3, at 5.

[5] S. Watt-Cloutier et al., *Petition to the Inter American Commission on Human Rights Seeking Relief from Violations Resulting from Global Warming Caused by Acts and Omissions of the United States* (Dec. 7, 2005), *available at* http://www.inuitcircumpolar.com/files/uploads/icc-files/FINALPetitionICC.pdf.

the current 385 parts per million (ppm) concentration to no more than 350 ppm.[6] Petitioners recognize that such a reduction will require international cooperation. That truth, however, is not an excuse for the United States' continued inaction. Instead, the United States must become a world leader in the effort to reduce atmospheric greenhouse gas concentrations to a level that protects and maintains the health of the Arctic environment, including sea ice, in order to protect public health and welfare of the Arctic, the United States, and ultimately the world.

The federal government, through the Environmental Protection Agency (EPA), has both the authority and responsibility to protect the public health and welfare of the Arctic and United States from the impacts of climate change in the Arctic.[7] Recently, EPA released an Advanced Notice of Proposed Rulemaking (ANPR) seeking public comment regarding the regulation of greenhouse gas emissions under the Clean Air Act.[8] The ANPR was issued in response to the Supreme Court's holding that EPA does, in fact, have the authority to regulate greenhouse gases and to several petitions seeking regulation of various sources of greenhouse gases.[9] This ANPR is not sufficient. Rather than seeking general comments, EPA must promulgate comprehensive regulations to protect the Arctic from the effects of climate change. It must do so in an equitable manner while striving to maintain economic opportunities and a strong economy.[10]

EPA has clear authority to achieve these goals by regulating greenhouse gas emissions from stationary and mobile sources under the Clean Air Act. Accordingly, Petitioners request that the EPA Administrator abide his obligations under the law by:

> 1. Making a finding that emissions of greenhouse gases may reasonably be anticipated to endanger the public health and welfare and that mobile and stationary sources cause or contribute to this air pollution; and
>
> 2. Promulgating comprehensive regulations to reduce greenhouse gas emissions from mobile and stationary sources pursuant to Clean Air Act sections 202(a), 213(a)(4), 231, and 111(b).[11]

Taking these actions is a necessary first step for the United States toward becoming a world leader in the effort to reduce atmospheric carbon dioxide concentrations to no more than 350 ppm. It is the best way to protect the Arctic, the public health and welfare, and life on Earth as it is currently known.

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[6] J. Hansen et al., *Target Atmospheric CO_2: Where Should Humanity Aim?* 1 (2008), *available at* http://www.columbia.edu/~jeh1/2008/TargetCO2_20080407.pdf.; *see also* L. Cao & K. Caldeira, *Atmospheric CO_2 Stabilization and Ocean Acidification*, 35 Geophysical. Res. Letters. L19609 (2008).

[7] This authority is granted under the Clean Air Act, 42 U.S.C. §§ 7521(a)(1), 7547(a)(4), 7571, 7411(b) (1990).

[8] ANPR, 73 Fed. Reg. at 44,354.

[9] *Id.* at 44,396; *see also Massachusetts v. EPA*, 127 S. Ct. 1438, 1459 (2007).

[10] Nonetheless, in order to ensure that all relevant documentation is considered, Petitioners will submit this document and all references both as a separate petition for rulemaking and as public comments during the ANPR comment period.

[11] 42 U.S.C. §§ 7521(a)(1); 7547(a)(4); 7571; 7411(b). This petition is submitted pursuant to the Administrative Procedure Act, 5 U.S.C. § 553(e), which requires federal agencies to give "an interested person the right to petition for the issuance, amendment, or repeal of a rule," the Clean Air Act, 42 U.S.C. §§ 7401-7671q (1990), and the Clean Air Act's implementing regulations, 40 C.F.R. Chapter I.

PETITIONERS

As of November 17, 2008, Petitioners include an Arctic community, mayors of four cities, and international conservation organizations. Their residents, constituents, and members are affected by warming in the Arctic caused by greenhouse gas emissions.

The Native Village of Shishmaref, Alaska is home to approximately 590 people and is represented by the Indian Reorganization Act Council. It is located on Sarichef Island, in the Chukchi Sea, and is surrounded by the 2.6 million-acre Bering Land Bridge National Reserve. Archaeological excavations show evidence of Eskimo habitation at Shishmaref dating back several centuries. Today, Shishmaref remains a traditional Inupiat Eskimo village with a fishing and subsistence lifestyle. During October 1997, a severe storm eroded over 30 feet of the north shore, requiring 14 homes and the National Guard Armory to be relocated. Five additional homes were relocated in 2002, and the shoreline has continued to erode approximately 3 to 5 feet per year on the north shore. In July 2002, residents voted to relocate the community.

The mayors of San Francisco, California; Juneau and Homer, Alaska; and Pacific Grove, California are the chief elected officials of their respective municipalities. The mayors know that climate change in the Arctic will affect their communities and their constituents, and they recognize the urgent need for regulation of greenhouse gas emissions in such a way that accounts for the diverse geographic, social, and economic conditions in their cities.

Oceana is a nonprofit international advocacy organization dedicated to protecting and restoring the world's oceans through policy, advocacy, science, law, and public education. Oceana has over 280,000 members and supporters around the world. Oceana's Pacific Team is headquartered in Juneau, Alaska and includes scientists, Alaska Native leaders with extensive traditional knowledge, attorneys, and policy advisors with more than 200 years of collective experience living and working in Alaska. They draw on that scientific, legal, and policy experience to work with industry, government partners, and the public to forge strategies to achieve protection and sustainable living.

Ocean Conservancy is a national nonprofit organization with more than 126,700 members and volunteers dedicated to protecting ocean environments and marine life. Through science-based advocacy, research, and public education, Ocean Conservancy informs, inspires, and empowers people to speak and act for the oceans. For over 30 years, Ocean Conservancy has worked to restore sustainable fisheries, protect ocean wildlife from human impacts, conserve special ocean places, and reform government for better ocean stewardship. Among other places, Ocean Conservancy has an office in Anchorage and a long history in Alaska, where it seeks to protect Arctic ecosystems and the people dependent on them.

I. The Arctic, home to unique people and ecosystems, is warming at twice the rate of the rest of the planet.

A. The Arctic is home to vibrant communities of indigenous peoples, functioning ecosystems, and numerous species adapted to thrive at the top of the world.

The "Arctic" does not have a single definition. Many scientists describe the Arctic as the area in the northern hemisphere in which the average temperature does not rise above 10° C (50° F) for any month of the year. This region roughly corresponds to the area north of the treeline. It includes areas in eight countries: the United States, Canada, Russia, Denmark, Iceland, Norway, Sweden, and Finland. It is the area within the red line on the map below.

Map depicting the eight Arctic nations, and the ten degree "isotherm" line, the area in the northern hemisphere in which the average temperature does not rise above 10° C (50° F) for any month of the year. This line is used by many scientists to define the Arctic.

1. Arctic people.

Worldwide, more than four million people live in the Arctic:

> A true understanding of the Arctic requires an understanding of my people, their traditions and their culture. The traditions and culture of the Eskimo are a part of the wildlife, the land, the sea, and the Arctic environment.[12]

Tens of thousands of people inhabit the Arctic region of the United States, which is entirely in Alaska. The majority of these residents consider themselves to be Alaska Natives,[13] and anthropological and archaeological information suggest that this area has been inhabited for approximately 12,000 years.[14] Though organized into towns and villages like elsewhere in the country, inhabitants of the far north lead a much different life.

Tens of thousands of people live in Arctic villages in Alaska.

"The harsh climate of Alaska's North Slope shapes and limits the ways that people there live and work. The most notable factor is the extreme cold, which influences the availability of natural resources, restricts transportation and communication, and limits the ways that communities incorporate the amenities of modern western culture."[15] Indeed, "[t]he average temperatures there are too low to grow food or timber. Agriculture as a cash-producing activity, and gardens—a

[12] Edward T. Hopson, Sr., *Foreword* to James Lukin & Hilary Hilscher, Alaska's Arctic 7 (1991).

[13] National Research Council, Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope 19 (2003) [hereinafter NRC 2003].

[14] *See* M.L. Kunz et al., *BLM-Alaska Open File Report 86, The Mesa Site: Paleoindians above the Arctic Circle* 4 (2003); NRC 2003, *supra* note 13, at 20.

[15] NRC 2003, *supra* note 13, at 20.

traditional supplemental source of food in many other rural areas—are not possible."[16]

Accordingly, many Arctic residents still depend on the subsistence lifestyle that has been the hallmark of their existence since time immemorial. "Subsistence" is not an indigenous word, and it is not subject to simple definition. It is a word created to describe what has been perceived as a way of life dependent on natural resources and carried out in concert with the ecosystem. To an Alaska Native, however, "subsistence" is more than a way of life:

> Subsistence is more than the sum of harvest and resource procurement . . . . Subsistence is ideological, value-driven, and value-laden—an idiom that defines self and community. It is illustrated by specific forms of knowledge about sustainable use of land and resources. It includes a specific suite of behaviors and actions, through which wild resources are procured, consumed, and distributed among relatives and neighbors across a wide network of communities.[17]

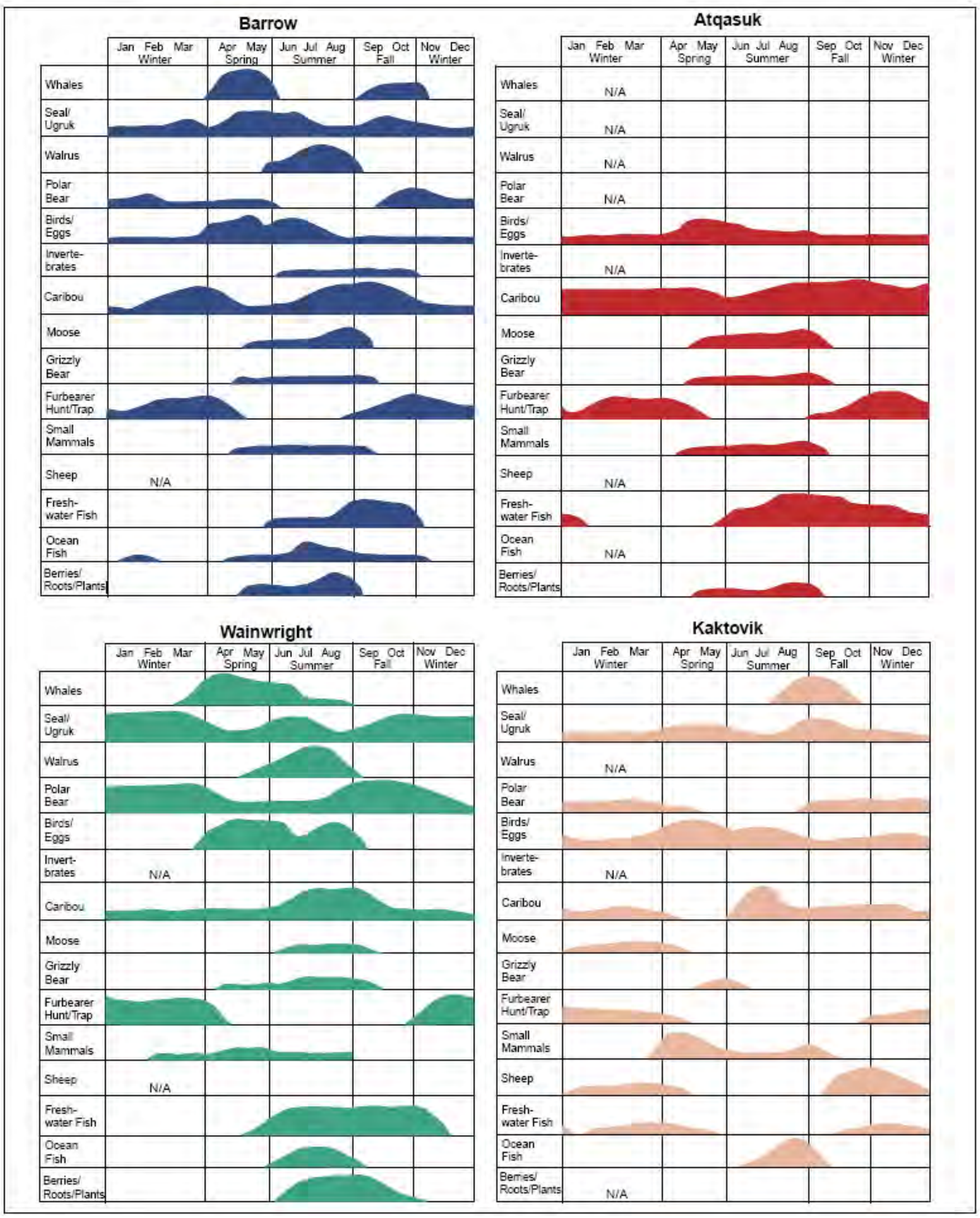
The word "subsistence" connotes food, culture, and spirituality. The various communities depend on different subsistence resources. "In inland Arctic Alaska . . . caribou are the most important subsistence resource, with lesser use of sheep, moose, and fish. Many people maintain strong cultural and spiritual ties to the resources, so that disruption of subsistence activities affects far more than food supplies."[18]

The Gwich'in people, for example, "continue to maintain strong cultural and spiritual ties to the Porcupine Caribou Herd and the Arctic Coastal Plain,"[19] and the bowhead whale has been described as "the foundation of the sociocultural system" for the coastal Inupiat.

Caribou are an important subsistence resource for inland Arctic communities.

[16] *Id.*
[17] *Id.* at 22.
[18] *Id.* at 21.
[19] *Id.* at 22.

For coastal villages, the Arctic seas are the centerpiece of life. "If the polar bear, because it spends so much of its life hunting on the ice offshore, is classified by biologists as a sea mammal, rather than a terrestrial one, a similar logic might easily hold true for the [people of the coastal Arctic]."[20] Coastal people, of course, depend on marine plants and animals for food, clothing, and other necessities of everyday life. "We Inupiat are meat eaters, not vegetarians. We live off the sea mammals. . . . The Bering Sea and the Chukchi Sea are our gardens."[21]



Seasonal subsistence cycle of four North Slope villages, in which the thickness of bars indicates relative importance.

[20] Dan O'Neill, *The Firecracker Boys* 4 (1994).

[21] T.R. Berger, *Village Journey: The Report of the Alaska Native Review Commission* 48 (1985).

For those villages not geographically positioned to "take advantage of the spring or fall bowhead whale migrations . . ., ringed seal, fish, and caribou are typically the important subsistence resources."[22]

For those villages that hunt bowhead whales, that hunt is at the heart of their existence:

> [T]he whale is more than food to us. It is the center of our life and culture. We are the People of the Whale. The taking and sharing of the whale is our Eucharist and Passover. The whaling festival is our Easter and Christmas, the Arctic celebrations of the mysteries of life.[23]

Described another way,

> For the coastal Inupiat Eskimo, the hunting of the bowhead whale [agviq] is the heart of our culture. It is the preparation for the hunt, the hunting, and the sharing of the successful hunt that are important. They must all be considered together. The successful hunt feeds us. The successful hunt affirms our shared values and traditions. The successful hunt gives us reason to celebrate together our spirit and sense of identity.[24]

While relatively few whales are taken each year and the hunt is carefully regulated, the importance of the bowhead to coastal Arctic communities cannot be overstated. Arctic peoples have adapted across generations to the weather, isolation, and rhythms in the Arctic.

Walruses are one of the species that have adapted to the Arctic environment.

2. Arctic ecosystems and sea ice.

In addition to the vibrant communities that have adapted to the top of the world, the Arctic also supports some of the last remaining relatively pristine terrestrial and marine ecosystems. These systems provide vital habitat for a variety of plants and animals and play an important role in regulating the world's climate.

The Arctic is home to populations of some of the world's most iconic wildlife species. Bears, caribou, wolves, foxes, and others patrol the land while the Arctic seas are home to dozens of species of marine mammals, including polar bears; bowhead, beluga, and gray whales; narwhals; walruses; and bearded, ringed, and ribbon seals. A diversity of fish and invertebrates can be found in the Arctic as well, including forage species like krill, Arctic cod, and capelin,

[22] NRC 2003, *supra* note 13, at 22.

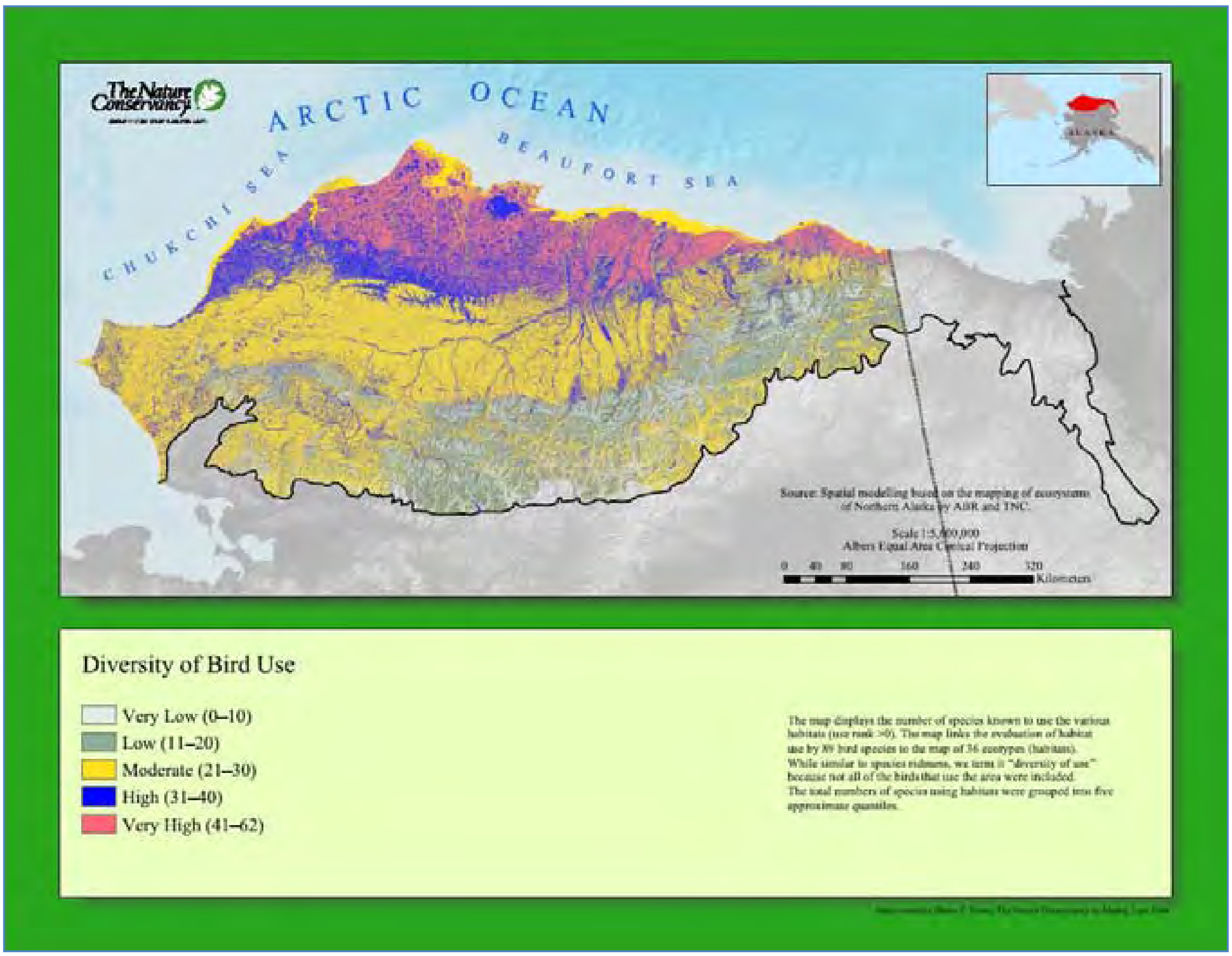
[23] Rupa Gupta, *Indigenous Peoples and the International Environmental Community: Accommodating Claims Through a Cooperative Legal Process*, 74 N.Y.U. L. Rev. 1741, 1745 (1999) (quoting Eben Hopson and describing him as the "former Inuit activist and native leader of the North Slope borough in Alaska").

[24] Hopson, Sr., *supra* note 12, at 7.

which are vital to the marine food web.[25]

Many of these species are uniquely adapted to the Arctic environment. Walruses, for example, are the last living representatives of the family Odobenidae, or "those that walk with their teeth."[26] Using its tusks, a walrus can lift itself from the water onto the ice, where it rests with others and hunts. In addition, as the ice retreats and advances, walruses are transported to new areas in which to seek the bivalves—clams, for example—that are the mainstay of their diets.[27]

The Arctic hosts some of the largest seabird populations in the world, and more than 280 species breed there.[28] Several Arctic areas are critical to the birds' survival and have been designated by the National Audubon Society as Important Bird Areas.[29]



[25] Arctic Climate Impact Assessment, *Arctic Climate Impact Assessment* 482-87 (2005) [hereinafter ACIA 2005].

[26] Natalie Angier, *Who is the Walrus?*, N.Y. Times, May 20, 2008, *available at* http://www.nytimes.com/2008/05/20/science/20walrus.html.

[27] *Id.*

[28] *See* ACIA 2005, *supra* note 25, at 259.

[29] Audubon Alaska, *Important Bird Areas of Alaska* (Apr. 2008), *available at* http://www.audubonalaska.org/PDFs/AK_IBA_map.pdf.

Habitat is dwindling for many of the species found in the Arctic. Additionally several species—including the polar bear, bowhead whale, and Steller's eider—are protected as threatened or endangered under the Endangered Species Act.[30] Others, including ice seals and walruses, are under consideration for such protection.[31]

"You need thick ice for the weight of the whale to bring it up. You need at least six feet of solid ice to bring up a whale. When it's like three, four feet, especially if somebody got a bigger whale, it's going to keep breaking up."

—Roy Nageak
Barrow, Alaska

For many Arctic species, sea ice is habitat necessary for survival.[32] It serves as the platform for birthing seals, feeding walruses, roaming polar bears, and other animals. Sea ice also affects productivity in the Arctic by shading the ocean, setting the timing of algal blooms, and functioning as a substrate for a unique food web that starts with microscopic algae and bacteria that grow on the underside of the ice and ends with predators like the polar bear.[33] Over the eons that sea ice has existed in the Arctic, marine life has adapted to and been shaped by it.

Sea ice is fundamental to the functioning of the Arctic systems. It "is the defining physical characteristic of the marine Arctic environment . . . ."[34] Each year, sea ice forms during the winter months and melts back during the summer, and people living along the Arctic coast have always known an Arctic with sea ice:

> Ice is a supporter of life. It brings the sea animals from the north into our area and in the fall it also becomes an extension of our land. When it freezes along the shore, we go out on the ice to fish, to hunt marine mammals, and to travel . . . . When it starts disintegrating and disappearing faster, it affects our lives dramatically.[35]

Arctic people use sea ice as an extension of land for traveling, fishing, and hunting.[36] They depend on this aspect of their landscape.[37]

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[30] *See* Determination of Threatened Status for the Polar Bear (Ursus maritimus) Throughout Its Range, 73 Fed. Reg. 28,212 (May 15, 2008) (to be codified at 50 C.F.R. pt. 17) [hereinafter "Polar Bear Listing Decision"]; 50 C.F.R. § 17.11(h) (2007) (bowhead whale and Steller's eider); *see also* 50 C.F.R. § 17.959(b) (designation of critical habitat for Steller's eider).

[31] *See* Notice of 90–Day Finding on a Petition to List the Three Ice Seal Species as a Threatened or Endangered Species, 73 Fed. Reg. 51615 (Sept. 4, 2008) (to be codified at 50 C.F.R. pts. 223, 224); Associated Press, *Group Seeks Protection for Walrus Under Endangered Species Act*, Seattle Times, Feb. 7, 2008, *available at* http://seattletimes.nwsource.com/html/localnews/2004169987_webwalrus07m.html

[32] B.A. Bluhm & R. Gradinger, *Regional Variability in Food Availability for Arctic Marine Mammals*, 18 Ecological Applications, S77, S83-84, S86-87 (2008); K.L. Laidre et al., *Quantifying the Sensitivity of Arctic Marine Mammals to Climate-induced Habitat Change*, 18 Ecological Applications S97, S98-99 (2008); ACIA 2005, *supra* note 25, at 456, 496-97.

[33] B.A. Bluhm & R. Gradinger, *supra* note 32, at S83-84; ACIA 2005, *supra* note 25, at 490-97.

[34] Polar Bear Listing Decision, 73 Fed. Reg. at 28,219.

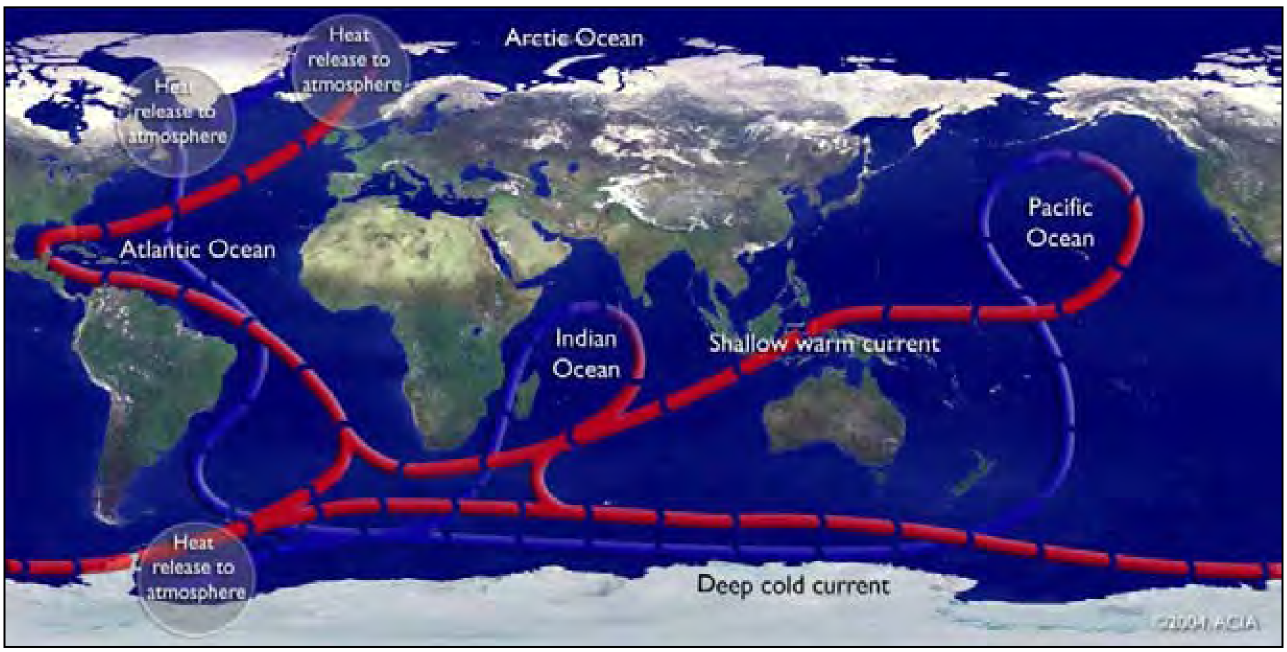
[35] ACIA 2004, *supra* note 2, at 24.

[36] *Id.* at 94-95.

[37] *Id.*; *see also* ACIA 2005, *supra* note 25, at 659-60.

3. The Arctic plays a critical role in regulating the world's climate.

In addition to being home to people and animals, the Arctic plays a critical role in regulating the global climate system,[38] including weather patterns in the northern hemisphere.[39] The colder Arctic is a sink for heat from the rest of the world. It is colder for two reasons. First, during the course of a year, incoming solar energy is greatest near the equator and lowest at the poles. Second, much of the solar energy that does reach the Arctic is reflected by ice and snow back to space. The heat imbalance between the warmer tropics and colder polar regions is a primary driver of atmospheric circulation and ocean currents. Without these currents moving energy away from the equator to the poles, where it eventually escapes to space, the tropics would overheat.[40] In that sense, the polar regions are the air conditioners for the planet.



Global ocean circulation patterns showing warm shallow ocean currents carrying heat to the poles where it is released.

The movement of heat from the tropics to the poles affects weather patterns. The cold air over the Arctic forms a polar front with the warmer air to the south. The jet stream forms over this front, and the temperature gradient across the front determines its speed. Storm tracks are related closely to the position, strength, and orientation of the jet stream.[41] Fluctuations in polar regions affect the location and speed of the jet stream, which affects weather patterns, especially at mid-latitudes where the jet stream occurs.

[38] ACIA 2004, *supra* note 2, at 34-45.

[39] M.C. Serreze et al., *Perspectives on the Arctic's Shrinking Sea-ice Cover*, 315 Science 1533, 1536 (2007).

[40] ACIA 2004, *supra* note 2, at 36-37.

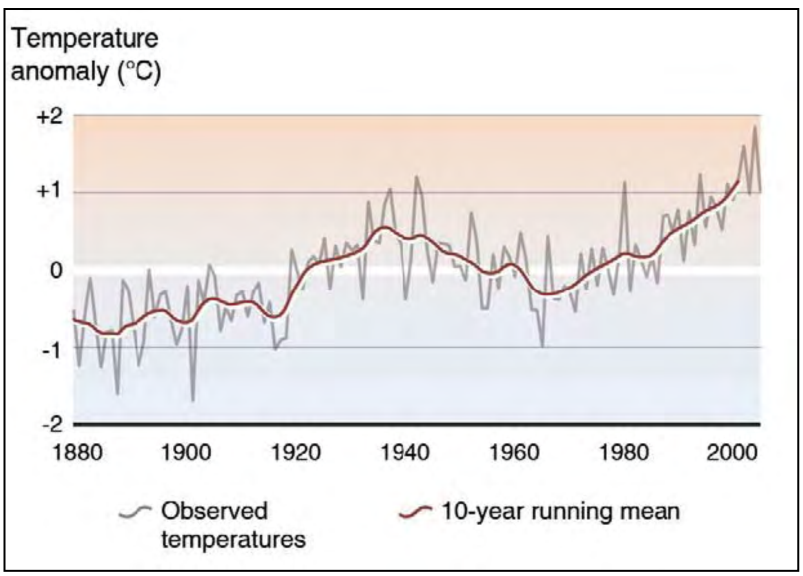
[41] C.L. Archer & K. Caldeira, *Historical Trends in the Jet Streams*, 35 Geophysical Res. Letters 1 (2008).

Sea ice plays a critical role in this process by reflecting most of the solar radiation that strikes it during the long Arctic summers. Additionally, by insulating the relatively warm Arctic Ocean from the atmosphere, sea ice cover in fall and winter affects Arctic temperature patterns and, consequently, weather patterns in the northern hemisphere.[42]

B. The Arctic is warming twice as fast as the rest of the planet, which, along with other climate fluctuations, is causing sea ice to decline and may result in dangerous worldwide impacts.

In addition to being fragile and important, the Arctic also is changing as a result of greenhouse gas emissions. Temperatures in the Arctic are rising nearly twice as fast as they are in the rest of the world, and this warming, together with other climate changes and fluctuations, is causing a dramatic decline in Arctic sea ice. Without a substantial reduction in atmospheric greenhouse gas concentrations, the Arctic will continue to warm rapidly and sea ice extent and thickness will continue to decline. These changes, and their consequences, may result in dangerous worldwide impacts and could push the world into a dramatic new climatic regime.[43]

1. The Arctic is warming and will continue to warm until and unless greenhouse gas emissions are substantially reduced.



Arctic temperatures have increased since 1880.

The Arctic climate is changing more quickly than anywhere else on Earth. Indeed, over the last 100 years, the Arctic, on average, has warmed twice as fast as the rest of the planet.[44] This warming has not been spread evenly across the Arctic, and there has been a strong seasonal component to it, with most areas warming more in winter than summer. Alaskan winters, for example, have warmed, on average, by 3-4°C (5-7°F) in just the last 50 years.[45]

The Arctic is predicted to continue warming more rapidly than the rest of the planet. This phenomenon is referred to as "Arctic amplification,"[46] and there are several reasons for it. First, as explained in more detail below, warming is causing snow and sea ice to melt. Snow and sea ice reflect solar energy and, as they melt, new areas of open ocean and land are opened; these

[42] M.C. Serreze et al., *supra* note 39, at 1536.

[43] T.M. Lenton et al., *Tipping Elements in the Earth's Climate System*, 105 Proc. of the Nat'l Acad. of Sci. of the U.S. 1786, 1786-93 (2008); Hansen et al., *supra* note 6, at 10.

[44] IPCC 2007b, *supra* note 3, at 7.

[45] ACIA 2004, *supra* note 2, at 12.

[46] M.C. Serreze & J. A. Francis, *The Arctic Amplification Debate*, 76 Climatic Change 241, 241 (2006).

darker areas absorb substantially more energy than the ice-covered areas. Once it is absorbed, this energy is converted to heat, which warms the Arctic.[47]

Second, the shape of the troposphere causes the Arctic to warm faster than other parts of the planet. The troposphere is the atmospheric layer over the Earth's surface, and warming of it causes the air at the earth's surface to warm.[48] The troposphere is less than half as thick at the poles, where it is about 23,000 feet deep, than it is at the equator, where it is about 60,000 feet deep. Because the troposphere is thinner in the Arctic, less energy is necessary to warm it there than would be required to warm the much thicker atmospheric layer in the tropics. In addition, strong shallow atmospheric inversions can further reduce the depth of the atmosphere layer that must be warmed to result in increased surface air temperatures.[49] Thus, the same amount of energy added to the atmosphere will cause more rapid warming in the Arctic than it would elsewhere in the world.

Finally, lower evaporation rates leave more energy available to warm the atmosphere in the Arctic. Evaporation, the process by which a liquid becomes a gas, requires energy and occurs more readily at higher temperatures. In warmer places in the world, a greater fraction of the available energy goes toward evaporation of water from the surface—oceans, lakes, etc.—than it does at the poles. Since a smaller fraction of energy goes to evaporation at the poles, more energy goes directly to heating the atmosphere. Accordingly, in the Arctic, a greater portion of the energy trapped by increasing concentrations of greenhouse gases goes towards warming the atmosphere than it does in other regions where more goes into evaporation.[50]

Scientists predict that, absent a substantial reduction in greenhouse gas emissions, these processes will continue to amplify warming in the Arctic. First, sustained anthropogenic emissions themselves will cause more warming.[51] These continuing emissions are particularly troubling because "some fraction (about 20%) of emitted CO_2 remains in the atmosphere for many millennia."[52] Thus, greenhouse gas concentrations in the atmosphere will not decrease immediately and, in fact, will continue to increase for some time, until a near complete reduction in emissions is achieved.[53]

[47] *See, infra*, pp. 22-23 for a more complete discussion of this effect and its ramifications.

[48] ACIA 2004, *supra* note 2, at 98.

[49] ACIA 2005, *supra* note 25, at 24.

[50] ACIA 2004, *supra* note 2, at 20.

[51] *See, e.g.*, National Oceanic and Atmospheric Administration, *Carbon Dioxide, Methane Rise Sharply in 2007* (2008), *available at* http://www.noaanews.noaa.gov/stories2008/20080423_methane.html ("The 2007 rise in global carbon dioxide (CO_2) concentrations is tied with 2005 as the third highest since atmospheric measurements began in 1958.").

[52] Intergovernmental Panel on Climate Change, Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change 125 (2007) [hereinafter IPCC 2007a].

[53] *Id.*

The Arctic also is predicted to continue to warm because the rapid increase in greenhouse gas concentrations has resulted in a planetary energy imbalance in which more energy is being absorbed by the planet than is leaving it.[54] This imbalance results from the fact that the Earth, especially its oceans, takes time to heat up.[55] Just like a pot of cold water on a hot stove, the earth's oceans will not instantaneously heat up from the increased energy the planet absorbs as a result of increased greenhouse gas concentrations in the atmosphere. The inertia of the oceans is delaying a significant amount of warming that will occur with or without further greenhouse gas emissions.[56] In other words, there is substantial warming "in the pipeline" from the anthropogenic greenhouse gases already in the atmosphere.[57]

Scientists are predicting that the Arctic Ocean may be seasonally ice-free as early as 2030.

2. Arctic climate change is causing sea ice to melt at rates faster than even the most dramatic predictions from several years ago.

Rapid climate change is affecting the Arctic in numerous ways. The most apparent of these changes is the staggering decline of sea ice. For a number of years, Arctic peoples in coastal communities have noted declines in sea ice off their villages.[58] Across the Arctic they have noted that sea ice is both forming off their communities later in the year and it is melting away earlier in the year.[59] The common findings of people from around the circumpolar Arctic are a powerful testament to the widespread changes occurring.

Indeed, scientists are predicting that the Arctic Ocean may be seasonally ice-free as early as 2030.[60] Such a dramatic change in sea ice extent likely has not occurred for roughly 125,000 years, at a time when sea level was 4 to 6 meters (13 to 20 feet) higher than it is today.[61] The rate at which sea ice is melting exceeds even the most dire predictions from just a few years ago and indicates the severity of the changes occurring as a result of greenhouse gas emissions.

Satellite data for sea ice, which has been available since 1979, shows that sea ice extent in the Arctic has been declining in all months of the year, with the largest declines occurring with the September sea ice minimum.[62] The linear trend for ice loss in September over this time is 11.8% per decade.[63] From 1979-2006, the average

[54] J. Hansen et al., *Earth's Energy Imbalance: Confirmation and Implications*, 308 Science 1431, 1431-34 (2005).

[55] *Id.*

[56] *Id.*

[57] J. Hansen, *A Slippery Slope: How Much Global Warming Constitutes "Dangerous Anthropogenic Interference"?* 68 Climatic Change 269, 276 (2005).

[58] ACIA 2004, *supra* note 2, at 92-97; ACIA 2005, *supra* note 25, at 62, 66-90.

[59] ACIA 2005, *supra* note 25, at 62, 66-90.

[60] Stroeve et al., *Arctic Sea Ice Extent Plummets in 2007*, 89 Eos 13, 13 (2008).

[61] National Snow and Ice Data Center, *Arctic Sea Ice Down to Second-Lowest Extent; Likely Record-Low Volume* (Oct. 2, 2008), *available at* http://nsidc.com/news/press/20081002_seaice_pressrelease.html (last visited Nov. 2, 2008) (Press Release) [hereafter NSIDC 2008].

[62] J.C. Comiso et al., *Accelerated Decline in the Arctic Sea Ice Cover*, 35 Geophysical Res. Letters 1, 1 (2008).

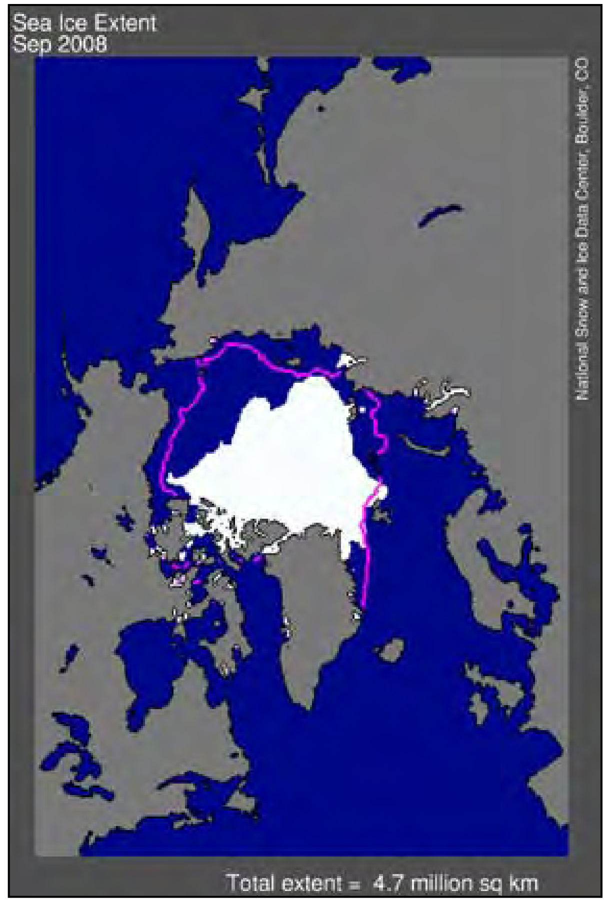
[63] NSIDC 2008, *supra* note 61.

decline in September sea ice extent was 23,328 square miles per year[64]—an area approximately equivalent in size to West Virginia. In addition, the sea ice minimum is now occurring later in the year, which indicates that the melt season likely is lengthening.[65]

This downward trend was punctuated by a record minimum sea ice extent in September 2007. The 2007 record minimum ice extent was 23% lower than the previous record low, which occurred in 2005, and had 50% lower extent than was typical for the same period from the 1950s-70s.[66] To put this in perspective, since the 1950s, an area of sea ice about half as big as the land area of the United States has been lost.[67] This loss demonstrates both the seriousness and scale of climate change impacts occurring in the Arctic.[68]

According to recent information from the National Snow and Ice Data Center, the 2008 sea ice minimum was very close to the 2007 record. This indicates that the 2007 sea ice minimum is not an anomaly but instead part of a troubling trend.[69] The sea-ice loss during the summer melt period has emerged beyond natural variability, which is a clear indicator that the climate is changing.[70]

In addition, the Arctic ice pack has thinned considerably as older, thicker sea ice has been replaced by younger, thinner sea ice.[71] Measurements of ice draft from submarine data indicate sea ice thickness declined by about a third between 1975 and 2000, losing about 1.25m in thickness,[72] and further declines have been measured by satellite.[73]



This map illustrates the dramatic loss of Arctic sea ice as our climate changes due to higher concentrations of CO_2 and other greenhouse gases in the atmosphere. The pink line shows the average yearly low of ice since 1979, and the white area shows this year's amount.

[64] *See* Polar Bear Listing Decision, 73 Fed. Reg. at 28,220.

[65] National Snow and Ice Data Center, *Arctic Sea Ice Shatters All Previous Record Lows: Diminished Summer Sea Ice Leads to Opening of the Fabled Northwest Passage* (Oct. 1, 2007), *available at* http://nsidc.org/news/press/2007_seaiceminimum/20071001_pressrelease.html.

[66] *Id.; see also* Stroeve et al., *supra* note 60, at 13.

[67] Stroeve et al., *supra* note 60, at 13.

[68] NSIDC 2008, *supra* note 61; Comiso et al., *supra* note 62, at 1; Stroeve et al., *supra* note 60, at 13.

[69] *See* NSIDC 2008, *supra* note 61.

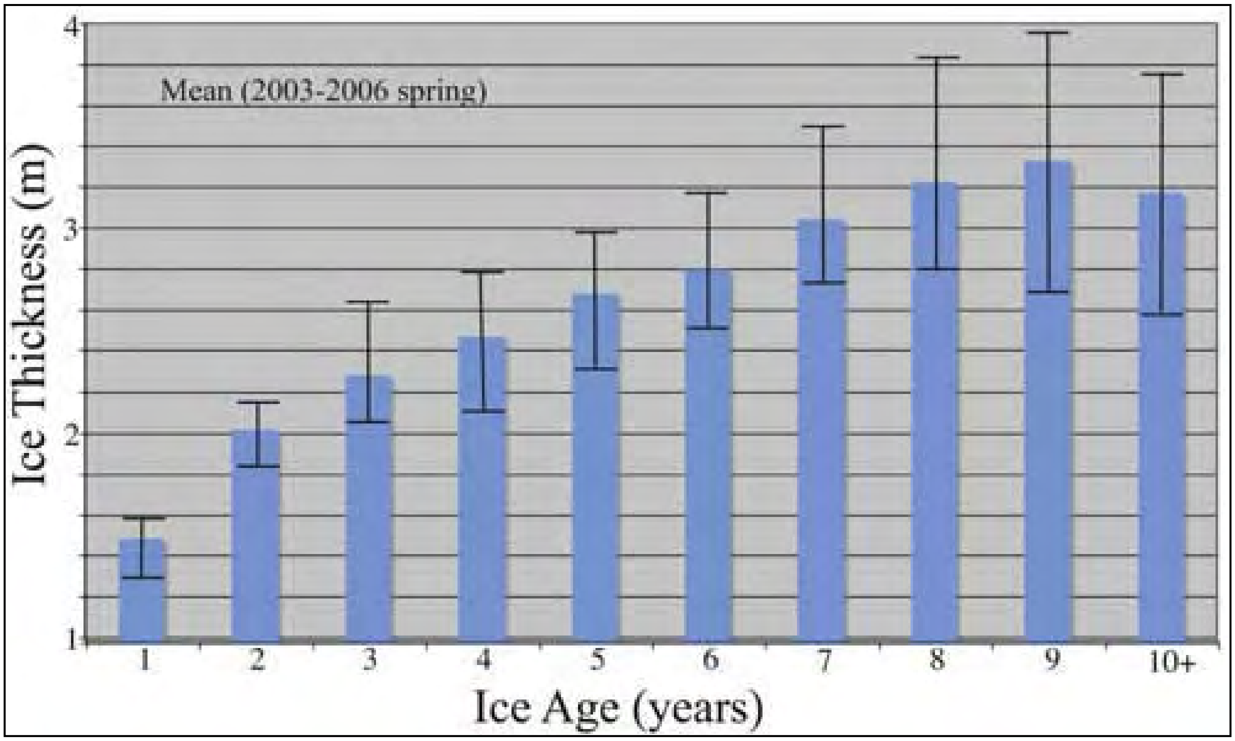
[70] J. Stroeve et al., *Arctic Sea-Ice Variability Revisited*, 48 Annals of Glaciology 71, 71-81 (2008).

[71] R.W. Lindsay & J. Zhang, *The Thinning of Arctic Sea Ice, 1988-2003: Have We Passed a Tipping Point?*, 18 J. of Climate 4879, 4879 (2005); J. A. Maslanik et al., *A Younger, Thinner Arctic Ice Cover: Increased potential for rapid, extensive sea-ice loss*, 34 Geophysical Res. Letters L24501, 1-5 (2007); S.V. Nghiem et al., *Rapid Reproduction of Arctic Perennial Sea Ice*, 34 Geophysical Res. Letters 1,1-6 (2007); Comiso et al., *supra* note 62, at 1; Stroeve et al., *supra* note 60, at 14; National Aeronautics and Space Admin., *NASA Media Briefing Provides Check-up on Polar Sea Ice* (2008), *available at* http://www.nasa.gov/topics/earth/features/seaice_conditions_main.html; National Snow and Ice Data Center, *Arctic Sea Ice Extent at Maximum Below Average, Thin* (April 7, 2008), *available at* http://nsidc.org/arcticseaicenews/2008/040708.html.

[72] D.A. Rothrock et al., *The Decline in Arctic Sea-Ice Thickness: Separating the Spatial, Annual, and Interannual Variability in a Quarter Century of Submarine Data*, 113 J. of Geophysical Res. 1, 7 (2008).

[73] Maslanik et al., *supra* note 71, at 1-5.

Sea ice thickness increases with the age of the ice.[74] The oldest ice, more than nine years old, is now gone, and ice older than five years decreased by 56% between 1982 and 2007.[75] Perennial sea ice (the ice that survives each year's melt season) has declined by 9-10% per decade since 1979.[76] The loss of older sea ice has been especially rapid since 2000, including a loss of 23% of the perennial sea ice between March 2005 and March 2007.[77]



Older sea ice is significantly thicker than younger sea ice.

"This is significant because older ice . . . requires more energy to melt,"[78] and recent research indicates that when sea ice thins considerably, as it has, the Arctic becomes vulnerable to rapid loss of summer ice cover.[79] Thus, the fact that the proportion of thinner and more easily melted ice has increased,[80] indicates that further declines are likely to occur.[81]

Indeed, sea ice decline is likely to continue at a pace that, until recently, was not anticipated by even the most dramatic predictions. Predictions from earlier this decade did not even include forecasts that the Arctic would be seasonally ice-free

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[74] *Id.*

[75] *Id.*; Stroeve et al., *supra* note 60, at 13.

[76] Comiso et al., *supra* note 62, at 1.

[77] Nghiem et al., *supra* note 71, at 2.

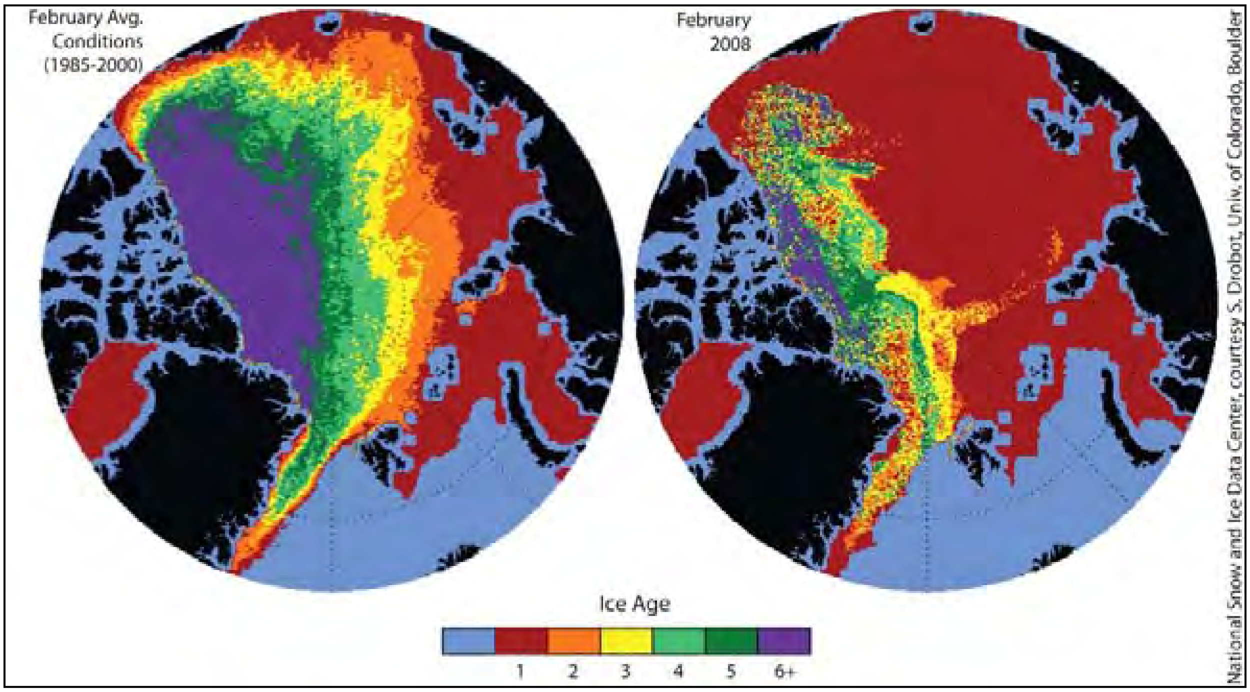
[78] Polar Bear Listing Decision, 73 Fed. Reg. at 28,223.

[79] M.M. Holland et al., *Future Abrupt Reductions In The Summer Arctic Sea Ice*, 33 Geophysical Research Letters L23503, L23503 (2006); Maslanik et al., *supra* note 71, at 3.

[80] National Snow and Ice Data Center, *supra* note 71.

[81] Stroeve et al., *supra* note 60, at 14; M.C. Serreze and J.C. Stroeve, *Standing On The Brink* 2008 Nature Reports Climate Change 142 (2008).

during this century.[82] In other words, scientists did not contemplate that the Arctic seas would lose all ice cover during any part of the year. More recent models predict that the Arctic seas will be seasonally ice-free at the end of this century, if not earlier.[83] However, when compared to the actual summer sea ice levels, these models have all underestimated the current loss and thinning of Arctic sea ice,[84] even if the dramatic losses from 2007 are excluded.[85]



Older, thicker ice has been largely replaced by younger, thinner ice in the last few years. Thinner ice melts faster, which is increasing the odds of an ice-free Arctic summer within the next few decades.

Considering the dramatic loss of summer sea ice in 2007 and 2008 and including the considerable thinning of the Arctic pack ice, several prominent researchers predicted a seasonally ice-free Arctic Ocean as early as 2030.[86] At least one scientist predicted in 2007 that the Arctic could be ice-free by 2013, and because that estimate did not take into account the dramatic 2007 ice melt, even it may be overly conservative.[87] Whether it is 2013 or 2030, the Arctic is racing towards a new seasonally ice-free state.

[82] *See, e.g.*, ACIA 2004, *supra* note 2, at 30.

[83] Overpeck et al., *Arctic System on Trajectory to New Seasonally Ice-free State*, 86 Eos 309, 312-13 (2005); M.M. Holland et al., *Future Abrupt Reductions in the Summer Arctic Sea Ice*, 33 Geophysical Research Letters L23503 (2006).

[84] Stroeve et al., *Arctic Sea Ice Decline: Faster than Forecast*, 54 Geophysical Res. Letters 1, 1 (2007).

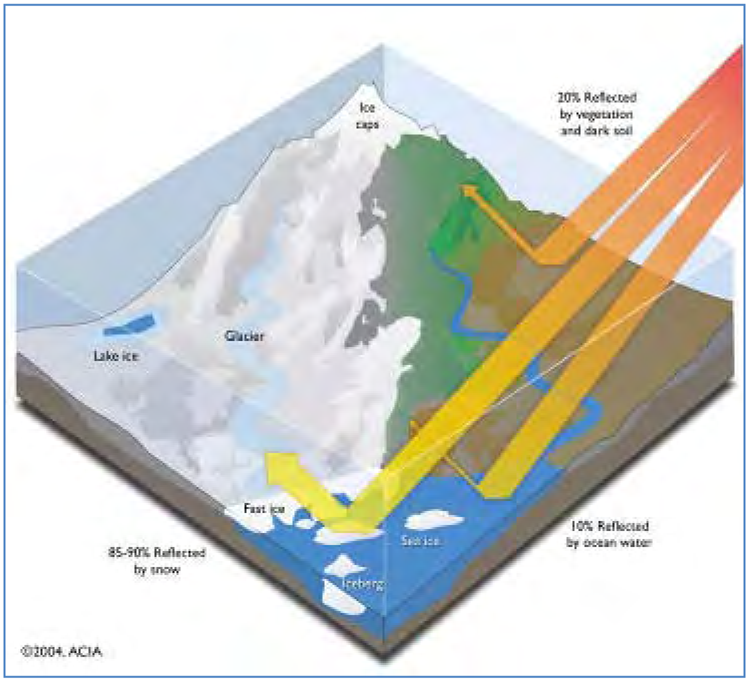
[85] Comiso et al., *supra* note 62, at 1-6.

[86] Stroeve et al., *supra* note 60, at 14.

[87] *See* Jonathan Amos, *Arctic Summers Ice-Free 'by 2013'* (BBC News radio broadcast, Dec. 12, 2007), http://news.bbc.co.uk/2/hi/science/nature/7139797.stm.

3. Loss of Sea Ice Begins a "Positive Feedback Loop" That Results in More and More Warming and Sea Ice Loss.

The loss of sea ice has significant implications for the Arctic and the planet. Indeed, because it is sensitive to warming, Arctic sea ice is a bellwether of global climate change.[88] The loss of sea ice also will lead to further rapid warming of the Arctic and will almost certainly cause serious consequences for the people living in the Arctic and the rest of the world.



The albedo effect: Less sea ice means that less of the sun's energy is reflected back into space and is instead absorbed by darker ocean waters.

Sea ice reflects sunlight back to space and, thereby, helps prevent further warming of the planet. This phenomenon can be measured in terms of reflectivity, or albedo. An ideal white surface, which reflected all the light that shone on it, would have an albedo of one, and an ideal black surface, which absorbed all the light, would have an albedo of zero.[89] The albedo of sea ice covered in snow is about 0.9, meaning that it reflects 90% of the sunlight that hits it;[90] thus, areas covered in sea ice reflect solar energy that would otherwise warm the planet. By contrast, the albedo of sea water is less than 0.1. Accordingly, as snow and ice melt away, they reveal darker land and ocean surfaces that absorb more solar radiation and, thereby, result in more warming.[91]

The loss of sea ice can initiate a positive feedback loop in which future warming is accelerated by the effects of past warming.[92] As more ice melts, more ocean is revealed. This open ocean absorbs much more sunlight than ice does, which, in turn, leads to more warming. More warming leads to more sea ice melt which, in turn, leads to more open ocean, and so on.[93] This self reinforcing loop is referred to as the "positive ice-albedo feedback." While it occurs naturally every year, the additional warming from greenhouse gas emissions amplifies the effect and tips the balance towards less sea ice.

The positive ice-albedo feedback is a key reason for the current loss of Arctic sea ice and is the primary basis for predictions of a seasonally ice-free Arctic in the next few decades, if not sooner. Indeed, the ongoing positive feedback indicates that a tipping point may already have been crossed,[94] which, along with the thinning

[88] ACIA 2004, *supra* note 2, at 24.

[89] National Snow and Ice Data Center, *All About Sea Ice: Processes: Thermodynamics: Albedo*, *available at* http://www.nsidc.org/seaice/processes/albedo.html.

[90] *Id.* The albedo of bare sea ice is 0.5-0.7.

[91] *Id.*; *see also* ACIA 2004, *supra* note 2, at 34-35; F.S. Chapin et al., *Role of Land-Surface Changes in Arctic Summer Warming* 310 Science 657, 657 (2005).

[92] ACIA 2004, *supra* note 2, at 20.

[93] *Id.*; *see also* Chapin et al., *supra* note 91, at 658.

[94] Lindsay & Zhang, *supra* note 71, at 4879; Overpeck et al., *supra* note 83, at 312-13; Stroeve et al., *supra* note 60, at 14.

of the Arctic ice pack, could result in an abrupt shift to a seasonally ice-free Arctic Ocean.[95] While there remains uncertainty about the potential for open water to enhance cloud formation, which would block sunlight,[96] there is strong evidence that declines in sea ice cover have led to an increase in solar energy input during the last few decades over most of the area of the Arctic Ocean and surrounding seas.[97] In parts of the Chukchi Sea where sea ice loss has been very rapid, the increases of solar energy into the water have been up to 4% per year.[98]

The positive ice-albedo feedback is a key reason for the current loss of Arctic sea ice and is the primary basis for predictions of a seasonally ice-free Arctic in the next few decades, if not sooner.

The record low sea ice extent during the summer of 2007 showed overwhelming evidence of this positive feedback. The loss of sea ice cover in the Beaufort Sea north of Alaska resulted in a 500% increase in the input of solar energy to the ocean. This increased energy, in turn, resulted in warming that further increased sea ice melt.[99] Similarly, in the neighboring Chukchi Sea, ice loss was associated with considerable increases in ocean heat content. Sea surface temperature was 5° C (9° F) higher in some places.[100] The Chukchi Sea did not freeze over until late December 2007, which is much later in the year than typical. Similar sea surface temperature anomalies are being seen again in 2008.[101]

The additional solar energy absorbed by the ocean warms the Arctic and world. As fall approaches and the sun retreats below the horizon, the additional heat in the ocean is lost to the atmosphere, which raises air temperatures. For example, the anomalously warm sea surface temperatures in the Chukchi Sea may have led to a late freeze of sea ice in the region and were associated with an unusually

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[95] M. Holland et al., *supra* note 79, at 1.

[96] ACIA 2005, *supra* note 25, at 196.

[97] Lindsay & Zhang, *supra* note 71, at 4888; D.K. Perovich et al., *Increasing Solar Heating of the Arctic Ocean and Adjacent Seas, 1979-2005: Attribution and Role in the Ice-Albedo Feedback*, 34 Geophysical Res. Letters 1, 1 (2007).

[98] *See generally*, Perovich et al., *supra* note 97.

[99] D.K. Perovich et al., *Sunlight, Water, and Ice: Extreme Arctic Sea Ice Melt During the Summer of 2007*, 35 Geophysical Res. Letters 1, 1 (2008).

[100] M. Steele et al., *Arctic Ocean Surface Warming Trends over the Past 100 Years*, 35 Geophysical Res. Letters 1, 1 (2008).

[101] National Snow and Ice Data Center, *Record Ice Loss in August* (Sept. 4, 2008), *available at* http://nsidc.org/arcticseaicenews/2008/090408.html.

warm November in Barrow, Alaska, where the average high and low temperatures in 2007 were 8° C (14° F) and 9° C (16° F) above normal, respectively.[102] Further, during periods of particularly rapid ice loss, surrounding Arctic land masses could warm by as much as 3° C (5° F) per decade in autumn.[103] This warming is expected to penetrate up to 1,500 km inland.[104]

June, July, August, we used to be able to see the polar pack of ice, out in front of Barrow. That's no longer happening. Our people are going bearded seal hunting, walrus hunting, in the spring, are having to go farther and farther out to find the game. This summer, we were hearing of crews going 20 to 30 miles past Point Barrow north to try and find game. The people were trying to get their subsistence hunting done while the ice was close to us, but there are a lot of people who are still short their normal supply of sea mammals for the year. I'm one of those very unfortunate ones who didn't land any bearded seals this spring. My boys went out trying, and some of my crew members went out trying but they didn't land any.

—Eugene Brower
Barrow, Alaska

Ultimately, a seasonally ice-free Arctic would almost certainly result in considerably more solar energy absorbed by the Arctic Ocean instead of being reflected back to space. This increase will substantially contribute to further warming of the Arctic, especially in fall and winter.[105]

Whale bone arch and umiak in Barrow, Alaska.

[102] Data available from National Weather Service, Barrow Weather Service Office, pabr.arh.noaa.gov/climate.php.

[103] D.M. Lawrence et al., *Accelerated Arctic Land Warming and Permafrost Degradation During Rapid Sea Ice Loss*, 35 Geophysical Res. Letters 1, 1 (2008).

[104] *Id.*

[105] *See* Serreze & Francis, *supra* note 46, at 14; Lawrence et al., *supra* note 103, at 1.

II. Climate change and ocean acidification are affecting the public health and welfare in the Arctic, the United States, and ultimately the world.

The rapidly changing Arctic climate, particularly the extreme decline of sea ice, is having significant impacts both in the Arctic and worldwide. In the Arctic, climate change is altering weather patterns, decreasing snow and ice cover, increasing coastal erosion, degrading permafrost, transforming Arctic ecosystems, and opening the region to rapid industrialization.[106] These changes are likely to be compounded by ocean acidification caused by emissions of carbon dioxide and may be greatly exacerbated by warming associated with further loss of sea ice.[107] Amplified warming in the Arctic may accelerate melting of the Greenland ice sheet,[108] release large quantities of greenhouse gases from thawing permafrost,[109] alter weather patterns in the northern hemisphere,[110] and increase the amount of area burned by wildfires.[111] These changes are having direct effects on the public health and welfare in the Arctic and are likely, in turn, to result in further warming of the Arctic and planet.

The decline of Arctic sea ice and the potential cascade of impacts could quickly result in dangerous climate change with serious worldwide impacts.

The decline of Arctic sea ice and the potential cascade of impacts could quickly result in dangerous climate change with serious worldwide impacts.[112] In particular the potential for a large release of methane, which is 25 times more potent a greenhouse gas than carbon dioxide, from thawing permafrost or methane clathrates (frozen methane) is particularly disturbing and could push the global climate system past a tipping point.[113] If the planet were to pass such a threshold, it would mean that, no matter how far emissions of greenhouse gases are reduced, humans could no longer stop or reverse the changes occurring. The climate would continue to warm until it reached a new equilibrium, and humans would have little control over where it ended up. In other words, humans would lose their ability to maintain the current climate structure and would simply have to wait to see what the new one looked like. The loss of sea ice in the Arctic could be one factor pushing the planet past such a tipping point.[114]

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[106] ACIA 2004, *supra* note 2, at 85, 96-97.

[107] Serreze & Francis, *supra* note 46, at 5.

[108] Hansen et al., *supra* note 54, at 1434.

[109] Lawrence et al., *supra* note 103, at 2.

[110] Serreze et al., *supra* note 39, at 1536.

[111] ACIA 2005, *supra* note 25, at 840.

[112] Hansen et al., *supra* note 54, at 1434; Lenton et al., *supra* note 43, at 1792.

[113] ACIA 2004, *supra* note 2, at 38-39.

[114] Lenton et al., *supra* note 43, at 1786-87.

A. Climate change and ocean acidification are having direct effects on the public health and welfare in the Arctic.

1. Warming has changed, and likely will continue to change, Arctic biodiversity, which will alter ecosystems and affect opportunities for the subsistence way of life.

Climate changes, including the loss of sea ice, profoundly affect Arctic ecosystems. Habitats, the distribution of plants and animals, and the productivity in Arctic ecosystems are changing, and these effects may be particularly severe because Arctic ecosystems are likely to be highly sensitive to change.[115]

The changes associated with warming and loss of sea ice have been noted first by indigenous peoples in the circumpolar Arctic who have long noted many of the findings recently brought to light by western scientists.[116] Indigenous peoples have a history of being closely connected to their surrounding environment, and the biodiversity that makes up Arctic ecosystems has been an integral part of their subsistence way of life.[117] Arctic peoples have observed insects and birds, such as robins, at places where their elders have never seen them before.[118] They also have noticed the spring bird migration occurring earlier and unusual die offs of some seabirds.[119] In addition, Arctic peoples have identified the fact that Pacific walruses are healthier in good ice years and skinnier in warmer years.[120] They are aware that some caribou herds are changing their migration routes and that there are now caribou deaths due to exhaustion from heat and attempts to escape swarms of mosquitoes.[121] Arctic peoples have noted that shrubs are moving northward,[122] crowding out lichens on the tundra.[123]

As indigenous Arctic peoples have observed and western scientists now predict, the ranges of animal species will shift on land and in the sea as the Arctic warms.[124] Southern species are expected to expand northward to the Arctic, taking advantage of increasingly mild conditions.[125] For example, it is likely that some marine mollusks will move northward to the Arctic Ocean from the Bering Sea and cross over to the Atlantic Ocean.[126] For species already in the Arctic, ranges are predicted to contract once they expand as far northward as possible and cannot use warmer habitat to the south. Even though most Arctic species are not monitored well, there are several examples of species already shifting northward, including humpback,

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[115] ACIA 2004, *supra* note 2, at 5.

[116] P.L. Cochran & A.L. Geller, *The Melting Ice Cellar: What Native Traditional Knowledge is Teaching Us About Global Warming and Environmental Change*, 92 Am. J. Pub. Health 1404, 1404 (2002).

[117] *Id.*

[118] ACIA 2005, *supra* note 25, at 70-71.

[119] *Id.* at 71.

[120] *Id.*

[121] *Id.*

[122] *Id.* at 67.

[123] ACIA 2004, *supra* note 2, at 46.

[124] *Id.* at 46-77.

[125] *Id.*

[126] G.J. Vermeij & P.D. Roopnarine, *The Coming Arctic Invasion*, 321 Science 780, 780-81 (2008).

fin, and gray whales; [127] pollock;[128] pink and chum salmon;[129] and several species of shrubs.[130] These changes in species' ranges will decrease the availability of some species to indigenous hunters and gatherers and result in uncertainty about the availability of natural resources.[131]

Further, Arctic warming is already resulting in northward shifts in vegetation zones, and future changes are expected to be considerably greater.[132] As the Arctic warms, it will become more hospitable to large vegetation, like trees. Currently, there are few trees in the Arctic, but the treeline is expected to move northward, which will decrease the area of tundra between the boreal forests and the Arctic Ocean.[133] These changes will have dramatic consequences for species that rely on the tundra ecosystem or have adapted to a specialized life in a cold climate, such as many tundra mosses and lichens. Some threatened species are likely to go extinct, and some common species are likely to decline sharply.[134]

When I was younger, there was more ice . . . . The seals, you had time, you had the whole summer to hunt, you had June and July; when the shore ice broke up was usually around the second week of July to the middle week of July, the break of the shore-fast ice . . . . But this year, when all the ice went away from the shore-fast ice, it never came back.

—Roy Nageak
Barrow, Alaska

Caribou and reindeer, which are of primary importance to many communities throughout the circumpolar Arctic as sources of food, shelter, fuel, tools, and other cultural items, may be particularly vulnerable to Arctic climate change.[135] Tundra vegetation is critical forage for caribou, particularly during calving season.[136] Accordingly, declines of that vegetation could have substantial effects on caribou. In addition, changes in snow conditions affect the ability of caribou and reindeer to forage in the winter.[137] The warmer autumns and winters are increasing the occurrences of "rain on snow events," in which rain falls on the tundra and freezes into a solid layer of ice. The ice layers make it difficult for caribou and reindeer to dig down to forage on lichens under the snow, which affects their survival during the cold winter months.[138]

Additionally, the earlier thaw of rivers and lakes is changing the routes along which caribou migrate to their breeding grounds.[139] Rivers and lakes that used

[127] *See* Dan Joling, *Straying Whales in Arctic May be Sign of Climate Change*, USA Today, Nov. 7, 2007, *available at* http://www.usatoday.com/weather/climate/globalwarming/2007-11-07-arctic-whales_n.htm?loc=interstitialskip; K.M. Stafford et al., *Gray Whale Calls Recorded Near Barrow, Alaska, Throughout the Winter of 2003-04*, 60 Arctic 167, 167 (2007).

[128] A.J. Benson & A.W. Trites, *Ecological Effects of Regime Shifts in the Bering Sea and Eastern North Pacific Ocean*, 3 Fish and Fisheries 95, 105 (2002).

[129] Minerals Management Service, *Chukchi Sea Planning Area: Oil and Gas Lease Sale 193 and Seismic Surveying Activities in the Chukchi Sea, Final Environmental Impact Statement* III-38 (2007).

[130] ACIA 2005, *supra* note 25, at 271-72, 278, 298, 320.

[131] ACIA 2004, *supra* note 2, at 61, 92-95.

[132] *See* Alaska Climate Impact Assessment Commission, *Final Commission Report to the Legislature*, (2008), *available at* http://www.housemajority.org/coms/cli/cli_finalreport_20080301.pdf [hereinafter ACIAC 2008]; ACIA 2004, *supra* note 2, at 46-57.

[133] ACIA 2004, *supra* note 2, at 46.

[134] *Id.*

[135] *Id.* at 70; ACIAC 2008, *supra* note 132, at 7.

[136] ACIA 2004, *supra* note 2, at 70-73.

[137] *Id.*

[138] *Id.*

[139] *Id.*

to be frozen over during their migration are now open, which results in longer migration times, increased drowning, and additional births before the herd reaches its calving grounds.[140] Further rapid warming of the Arctic from sea ice loss is likely to exacerbate these impacts, which would result in declines of caribou and reindeer and, accordingly, substantial impacts to many Arctic communities.[141]

In addition to changes on land, warming in the Arctic also will almost certainly result in a fundamental restructuring of Arctic marine ecosystems.[142] Sea ice is an important habitat in the Arctic marine environment and significantly affects the productivity of Arctic waters.[143]

Seals are one of the species that struggle for food as Arctic sea ice dramatically recedes.

Sea ice is important habitat for many species of marine mammals, including polar bears, walrus, and ice seals.[144] Declining sea ice is reducing and altering this unique habitat. The projected impacts to polar bears from loss of sea ice led the United States Department of Interior to list the species as threatened under the Endangered Species Act.[145] Even using conservative estimates of sea ice loss, scientists predict that two-thirds of the world's polar bear population will be lost by the middle of the 21st century.[146]

In addition to polar bears, the loss of sea ice in the Bering, Chukchi, and Beaufort seas will affect other ice-dependent marine mammals, including ringed seals, spotted seals, ribbon seals, bearded seals, and walrus.[147] Ringed seals, for example, have a close association with sea ice, and they depend on it for resting, pupping, mating, molting, and feeding. Ringed seals excavate caves, or lairs, under the snow on stable sea ice, where they give birth to and raise their pups. The snow caves offer protection from weather and predators. Increased temperatures and loss of the protective snow covering will make ringed seals more vulnerable to predation.[148] Loss of sea ice also may affect seals' prey species, such as Arctic cod.[149]

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[140] *Id.*

[141] *Id.*

[142] ACIA 2005, *supra* note 25, at 504-14; J.M. Grebmeier et al., *A Major Ecosystem Shift in the Northern Bering Sea*, 311 Science 1461, 1461-64 (2006); Bluhm & Gradinger, *supra* note, 32 at S77-96 (2008).

[143] *See generally* K.L. Laidre et al., *supra* note 32.

[144] *Id.*

[145] *See* Polar Bear Listing Decision, 73 Fed. Reg. at 28,212.

[146] *Id.* at 28,274.

[147] *See* K.L. Laidre et al., *supra* note 32.

[148] B.P. Kelly, *Climate Change and Ice Breeding Pinnipeds*, in "Fingerprints" of Climate Change 43, 43 (Walther et al. eds., 2001).

[149] C. Tynan & D. DeMaster, *Observations and Predictions of Arctic Climate Change: Potential Effects on Marine Mammals*, 50 Arctic 308, 308 (1997); Bluhm & Gradinger, *supra* note 32, at S89.

These seals, in turn, are an important component of polar bear diets. Thus, impacts to seals will cause effects further up the food chain. Loss of sea ice is very likely leading to declines in these seals, and ice seals currently are under consideration for protection under the Endangered Species Act.[150]

The rapid and early sea ice loss that has occurred since 2004 in the Bering and Chukchi seas also may be affecting walrus recruitment, distribution, and abundance.[151] Walruses, especially females nursing pups, use sea ice as a mobile platform from which to feed on the rich benthic productivity of the shallow northern Bering and Chukchi sea floors.[152] Walruses are unable to forage in the open ocean because they need a place to haul out and rest between foraging bouts.[153] They follow the sea ice edge as it melts northward in the spring and summer and southward as it freezes in the fall and winter.[154]

Communities on Saint Lawrence Island such as Savoonga (pictured) are already experiencing dramatic changes from the loss of sea ice.

In 2007, sea ice retreated far offshore in the Chukchi Sea to a place where ocean depth and lack of food made it impossible for walruses to feed. Instead of following the sea ice, many walruses came to shore congregating in large haulouts,[155] where disturbances led to stampeding and crushing of thousands of pups and juveniles. In addition to higher mortality rates from stampeding, a shift to using terrestrial haulouts will reduce foraging areas to coastal margins, potentially leading to increased food limitation.[156] In 2007, other walruses, followed remotely by satellite tags, remained in sparse ice patches above important feeding areas near the continental shelf,[157] and walrus pups were found abandoned on the sea ice or in open water. Similarly, Yup'ik hunters on St. Lawrence Island believe that

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150 *See* Endangered and Threatened Wildlife; Notice of 90–Day Finding on a Petition to List the Three Ice Seal Species as a Threatened or Endangered Species, 73 Fed. Reg. 51615, 51615-17 (Sept. 4, 2008) (to be codified at 50 C.F.R. pts. 223, 224).

151 L.W. Cooper et al., *Rapid Seasonal Sea-Ice Retreat in the Arctic Could Be Affecting Pacific Walrus (Odobenus rosmarus) Recruitment*, 32 Aquatic Mammals 98, 98 (2006); S. Milius, *Hey,What About Us? There's More Life on Ice Than Celebrity Bears*, 172 Sci. News No. 22 at 346 (2007), *available at* http://www.sciencenews.org/view/feature/id/9156/title/Hey,_What_about_Us%3F.

152 ACIA 2004, *supra* note 2, at 59.

153 ACIA 2005, *supra* note 25, at 488, 510.

154 *Id.* at 497.

155 Dan Joling, *Walruses Flee Shrinking Ice for Shoreline*, Anchorage Daily News, Oct. 5, 2007, *available at* http://www.adn.com/news/alaska/story/9355578p-9269576c.html.

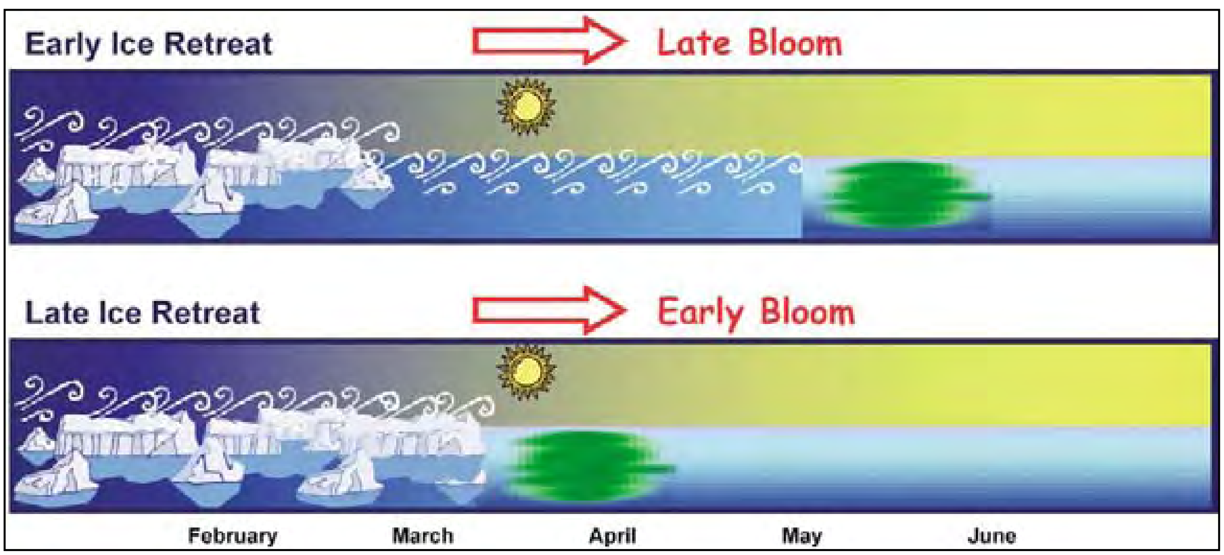
156 See C.V. Jay & A. S. Fischbach, *Pacific Walrus Response to Arctic Sea Ice Losses, U.S. Geological Survey Fact Sheet* No. 2008-3041 1-2 (2008).

157 *Id.* at 4.

there may be little ice and too few walruses to hunt in the near future.[158] They also fear that the walruses that do arrive may pass by communities more rapidly and at greater distances.[159]

The events of 2007 highlight the potential impacts to walruses in future years with less sea ice. Those impacts would significantly affect local peoples who depend on walruses as an important part of their subsistence way of life. In the Bering Strait region, walruses make up the majority by weight of subsistence food harvested.[160] Their ivory tusks are used extensively in native artwork, and the hides are used to make skin boats.

In addition to reducing habitat for marine mammals, the rapid decline of sea ice to a seasonally ice-free Arctic is likely to fundamentally alter marine productivity in the region. Sea ice affects marine primary productivity in multiple ways, including by: 1) limiting the amount of sunlight that reaches the ocean,[161] 2) acting as a platform for algal communities,[162] and 3) driving the timing of algal blooms.[163] Loss of sea ice likely would cause primary productivity in the Arctic Ocean and its surrounding seas to shift from flowing primarily through sea floor and ice associated food webs to flowing through an open water food web.[164] This change is likely to have dramatic effects, especially on those species that have evolved as a part of the sea floor and ice associated food webs.



When ice retreats in late winter, the bloom is delayed until late spring when solar heating has stratified the water column sufficiently. When the ice retreat comes later, the bloom can start earlier under the ice, or at the ice edge.

[158] I. Krupnik & G. C. Ray, *Pacific Walruses, Indigenous Hunters, and Climate Change: Bridging Scientific and Indigenous Knowledge*, 54 Deep-Sea Research II 2946, 2954 (2007).

[159] *Id.*

[160] *Id.* at 2947.

[161] ACIA 2005, *supra* note 25, at 456, 472, 476, 481, 490; Bluhm, & Gradinger, *supra* note 32, at S89-90.

[162] Bluhm & Gradinger, *supra* note 32, at S83-84.

[163] *See generally* J.M. Grebmeier et al., *supra* note 142; G.L. Hunt et al., *Climate Change and Control of the Southeastern Bering Sea Pelagic Ecosystem*, 49 Deep-Sea Research II 5821, 5821-53 (2002); ACIA 2005 *supra* note 25, at 490-94.

[164] *See generally* Bluhm & Gradinger, *supra* note 32; Grebmeier et al., *supra* note 142.

Growth of phytoplankton, which are microscopic algae and which form the base for much of the Arctic food web, is limited in much of the Arctic by the amount of sunlight available for photosynthesis.[165] Sea ice and snow cover reflect most of the sunlight that hits them,[166] which keeps areas of the Arctic Ocean relatively dark during the long summer days. The rapid loss of sea ice is very likely to increase the penetration of sunlight into Arctic waters,[167] which would increase phytoplankton growth.[168] This change would occur even though less sea ice cover is likely to result in increased cloudiness.[169]

Many species of algae and bacteria use the underside of ice and brine channels as substrate for growth.[170] These ice-associated marine algae and amphipods provide the base of a productive food web that includes Arctic cod, sea birds, ice seals, whales, polar bears, and Arctic foxes.[171] Ice algae contribute 4-26% of the total primary production in seasonally ice-covered waters and more than 50% in the permanently ice-covered central Arctic.[172] Sporadic observations of algae and other ice-associated organisms from the central Arctic indicate that substantial changes may already be occurring as the loss of sea ice causes less productive species of ice algae to become increasingly prevalent.[173] The ice edge is also an important region for primary productivity during spring and summer months.[174] Loss of sea ice, and the potential for seasonally ice-free conditions across the Arctic, will likely lead to the local loss or even extinction of those species in the ice-associated food web that are unable to adapt fast enough to changing conditions.[175]

In seasonally ice-covered waters, the timing of sea ice melt influences the timing and location of biological production, which ultimately affects whether productivity primarily flows through benthic (ocean bottom) or pelagic (mid-water) food webs.[176] As sea ice retreats each spring it creates a layer of fresh water that stabilizes the top of the water column, which allows phytoplankton to stay in the surface layer. If there is enough sunlight, phytoplankton grow quickly and form a bloom.[177] The cold melt water slows reproduction of zooplankton (the small animals that live in the water column and eat phytoplankton), keeping them from consuming much of the phytoplankton bloom, which falls to the seafloor, where it supports a rich benthic food web.[178] When sea ice retreats earlier in the spring, insufficient sunlight is available at that time to fuel a phytoplankton bloom, and the stability

[165] *See* ACIA 2005, *supra* note 25, at 456, 472, 476, 481, 490; Bluhm & Gradinger, *supra* note 32, at S89-90.

[166] National Snow and Ice Data Center, *supra* note 89.

[167] *See generally* Perovich et al., *supra* note 97.

[168] Bluhm & Gradinger, *supra* note 32, at S89-90.

[169] ACIA 2005, *supra* note 25, at 195.

[170] Bluhm & Gradinger, *supra* note 32, at S83.

[171] ACIA 2004, *supra* note 2, at 60-61.

[172] Bluhm & Gradinger, *supra* note 32, at S83.

[173] *Id.* at S87.

[174] *Id.* at S77.

[175] U.S. Geological Survey, *supra* note 156, at 1; Laidre et al., *supra* note 143, at S112.

[176] Hunt et al., *supra* note 163, at 5821; ACIA 2005, *supra* note 24, at 497, 506; Grebmeier et al., *supra* note 142, at 1461; Bluhm & Gradinger, *supra* note 32, at S83.

[177] Hunt et al., *supra* note 163, at 5824.

[178] *Id.* at 5833.

of the water column from the fresh water layer is broken down by wind mixing before a bloom can occur. A phytoplankton bloom then is delayed until there is enough warming from the sun to heat the upper ocean and stabilize the surface layers once again.[179] The warmer water allows zooplankton to reproduce quickly enough to consume much more of the bloom, which in turn is eaten by fish in the water column, resulting in the productivity supporting the pelagic community.[180]

The shift towards an earlier retreat of sea ice is likely resulting in a shift in productivity from the benthic food web to the pelagic food web, which has significant consequences for Arctic marine ecosystems.[181] For example, in the Chukchi Sea, an incredible abundance of bottom feeding birds, such as eiders, and marine mammals, such as walruses and gray whales, relies on the high benthic productivity that depends on the timing and placement of algal blooms.[182] These species will feel the effects of earlier sea ice retreat and the accompanying change in timing of algal blooms.

All of the changes described above could be severe, because Arctic ecosystems may be particularly sensitive to disturbance. Compared to warmer regions, Arctic ecosystems typically have fewer species filling similar roles in the system, which makes it more likely that changes to one species will affect others.[183] For example, declines in caribou would be expected to affect their predators, like wolves, as well as scavengers, such as Arctic foxes.[184] Any effects from caribou declines, however, are exacerbated in the Arctic because there are fewer other species upon which the predators and scavengers can prey. Similarly, in the marine environment, Arctic cod comprises the majority of the diet for several species at higher trophic levels.[185] Accordingly, impacts to cod from climate change are likely to cascade through the food webs and restructure the ecosystem.[186]

2. Coastal erosion is threatening Arctic villages.

One of the most obvious effects of climate change in the Arctic has been coastal erosion, which threatens the very existence of several Alaskan communities. Shishmaref and Kivalina, for example, will most likely need to be relocated in the next 10-15 years,[187] and communities such as Barrow, Unalakleet, Shaktoolik, and Kaktovik are likely to be affected substantially by coastal erosion.[188]

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[179] *Id.* at 5825.

[180] *Id.* at 5833.

[181] Mueter & Litzow, *Sea Ice Retreat Alters the Biogeography of the Bering Sea Continental Shelf*, 18 Ecological Applications 309, 309 (2008); Grebmeier et al., *supra* note 142, at 1461.

[182] Grebmeier et al., *supra* note 142, at 1461.

[183] ACIA 2004, *supra* note 2, at 68.

[184] *Id.*

[185] *See* Bluhm & Gradinger, *supra* note 32, at S77-96.

[186] *Id.*

[187] State of Alaska, *Alaska Baseline Erosion Assessment: Alaskan Communities Affected by Erosion* (Oct. 16, 2007), *available at* http://www.climatechange.alaska.gov/docs/iaw_erosion_18jan08.pdf.

[188] *See id.* at 2; Rachel D'Oro, *State Gives $3 Million to Fight Newtok Erosion*, Anchorage Daily News, June 11, 2008, *available at* http://www.adn.com/news/alaska/story/433580.html.

Coastal erosion is caused primarily by big storm surge waves.[189] Thinner, less extensive sea ice cover leaves more open water for storms to generate waves, and the resulting increase in wave activity is quickly eroding the shoreline.[190] Additionally the later freeze up of shore-fast ice is taking away an important buffer that used to protect the coastline from fall storms, and the warmer air and water are also melting coastal permafrost, making them more susceptible to erosion.[191]

Shishmaref, Alaska.

The rate of erosion is increasing. For example, twice as much land area was lost to erosion along a portion of the Beaufort Sea between 1985 and 2005 as was lost since record-keeping was begun in 1955.[192] The increasing rate of erosion and potential problems have garnered Congressional attention[193] and have been the subject of several Alaska state government studies.[194]

Shishmaref, which has become the public face of coastal erosion,[195] is located on a small barrier island in the southern Chukchi Sea, just north of the Bering Strait. Large fall storms have resulted in significant erosion events there. A storm in October 2001 eroded vulnerable areas by as much as 125 feet and coastal erosion has claimed multiple buildings in the village already.[196] This erosion is causing concern among residents:

> Who and what we are is based on where we live and the way we live. We have been here for countless generations. We value our way of life, we value the environment as it sustains us; it provides for our very existence . . . . We are a community tied together by family, common goals, values, and traditions. We are different from our neighbors. The community of Shishmaref has a long and proud history . . . . We deserve the attention and help of the American people and the federal government.[197]

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[189] N. Kobayashi et al., *Erosion of Frozen Cliffs Due to Storm Surge on Beaufort Sea Coast*, 15 J. Coastal Res. 332, 332 (1999).

[190] *Id.*

[191] *Id.*

[192] J.C. Mars & D.W. Houseknecht, *Quantitative Remote Sensing Study Indicates Doubling of Coastal Erosion Rate in Past 50 Yr Along a Segment of the Arctic Coast of Alaska*, 35 Geology 583, 583 (2007).

[193] *See, e.g.*, U.S. Senate Committee on Homeland Security and Governmental Affairs, Ad Hoc Subcommittee on Disaster Recovery, Field Hearing: The State and Federal Response to Storm Damage and Erosion in Alaska's Coastal Villages, *available at* http://hsgac.senate.gov/public/index.cfm?Fuseaction=Hearings.Detail&HearingID=809e5a80-5953-479b-abf0-b8d4c61ecfdb.

[194] *See, e.g.*, State of Alaska, *supra* note 187.

[195] *See, e.g.*, Arctic Change, *Human and Economic Indicators - Shishmaref* (Dec. 2006), *available at* http://www.arctic.noaa.gov/detect/human-shishmaref.shtml; David Willis, *Sea Engulfing Alaskan Village*, (BBC News radio broadcast, July 30, 2004), *available at* http://news.bbc.co.uk/2/hi/europe/3940399.stm.

[196] Shishmaref Erosion & Relocation Coalition, Shishmaref: We Are Worth Saving (undated), *available at* http://www.shishmarefrelocation.com/index.html.

[197] *Id.*

Location of Kivalina and Shishmaref in Alaska's Kotzebue Sound.

Similarly, winter storms in October and November of 2004 and 2005 resulted in significant erosion in Kivalina.[198] The erosion triggered by these storms threatens both the school and the Alaska Village Electric Cooperative (AVEC) tank farm.[199] The United States Government Accountability Office determined in a December, 2003 report that "the right combination of storm events could flood the entire village [of Kivalina] at any time." The GAO concluded that "[r]emaining on the island . . . is no longer a viable option for the community."[200]

These problems are in their infancy as further sea ice loss, rising temperatures, and rising sea level will greatly increase coastal erosion in the future.[201] The very existence of those villages most at risk from coastal erosion and rising sea level is threatened.

3. Climate change directly impairs the health and cultural identity of Arctic residents.

In addition to threatening animals, villages, and infrastructure, warming in the Arctic also challenges "individuals' and communities' relationships with their local environment."[202] These relationships have been the "bases" for the "identity, culture, social and physical well-being" of many Arctic residents, and "reliance on the local environment for aspects of everyday life such as diet and economy" makes them particularly vulnerable to climate change.[203] In the rapidly changing Arctic, traditional knowledge and the predictions based upon it are less reliable; thus climate change threatens the physical and societal well-being of Arctic residents.[204]

Indigenous peoples rely on their knowledge of sea ice conditions, climate, weather and the relationships among them to ensure their safety and as an integral structuring component of daily life in the Arctic.[205] For example, an Inupiat hunter's understanding of shore-fast ice dynamics comes from his own years spent on the ice traveling, camping, and hunting as well as from information passed down

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[198] *The State and Federal Response to Storm Damage and Erosion in Alaska's Coastal Villages, Hearing Before the S. Comm. on Homeland Security and Governmental Affairs, Ad Hoc Subcommittee on Disaster Recovery*, 110 Cong. 4, (2007) (testimony of C.E. Swan), *available at* http://hsgac.senate.gov/public/index.cfm?Fuseaction=Hearings.Detail&HearingID=809e5a80-5953-479b-abf0-b8d4c61ecfdb.

[199] U.S. Army Corps of Engineers, Alaska District, *Alaska Village Erosion Technical Assistance Program: An Examination of Erosion Issues in the Communities of Bethel, Dillingham, Kaktovik, Kivalina, Newtok, Shishmaref, and Unalakleet* 23 (April 2006).

[200] Government Accountability Office, *Alaska Native Villages: Most are Affected by Flooding and Erosion, but Few Qualify for Federal Assistance* 32 (Dec. 2003).

[201] ACIA 2005, *supra* note 25, at 940.

[202] IPCC 2007a, *supra* note 52, at 672.

[203] *Id.* at 661.

[204] ACIA 2004, *supra* note 2, at 92-97.

[205] *Id.*

between generations.[206] This knowledge is used to avoid dangerous situations and is critical to the success of a hunt.[207] According to one Alaska Native leader:

> Our culture is based on knowledge of the natural environment and its resources. Knowledge of the Arctic tundra, rivers and lakes, of the lagoons, and oceans, and all of the food resources they provide are our foundation. Further, knowledge of snow and ice conditions, of ocean currents, weather patterns, and their effects on natural systems becomes necessary for navigation, finding and trailing game, and locating shelter and each other. This knowledge has value.[208]

The utility of this knowledge is being called into question as indigenous peoples are noticing sea ice and climate changes. These observations have been grouped into five main categories: increased variability in weather events, fewer extreme cold days in early winter, change in the pattern and rate of the transition from fall to winter, increased number of extreme events, and increased unpredictability in conditions.[209] Recently, observations gathered from Alaskan sources of indigenous knowledge have also included observations of sudden wind direction changes, in many places increasingly cloudy conditions, and increasing frequency of storms in some locations.[210]

As a result of these changes, elders and experienced hunters are frequently unable to predict weather, which makes travel and hunting more dangerous and difficult. Many Arctic peoples rely on snow and ice to travel safely across tundra, rivers, and lakes.[211] Changes in snow pack and river ice are also making hunting and travel more difficult.[212] River and lake ice are freezing later and breaking up earlier, reducing the ice season by one to three weeks in some areas.[213] The snow cover season is shrinking as well.[214]

As Arctic sea ice recedes, travel conditions become more difficult to predict.

[206] J.C. George et al., *Observations on Shorefast Ice Dynamics in Arctic Alaska and the Responses of the Inupiat Hunting Community*, 57 Arctic 363, 363 (2004).

[207] ACIA 2005, *supra* note 25, at 660.

[208] NRC 2003, *supra* note 134, at 232.

[209] G.J. Laidler, *Inuit and Scientific Perspectives on the Relationship Between Sea Ice and Climate Change: The Ideal Compliment?*, 78 Climate Change 407, 417 (2006).

[210] J.C. George et al., *supra* note 206, at 372.

[211] ACIA 2004, *supra* note 2, at 61, 80, 86, 94; ACIA 2005, *supra* note 25, at 659-60, 934.

[212] ACIA 2005, *supra* note 25, at 659-60, 934; Laidler et al., *supra* note 209, at 412-13.

[213] ACIA 2004, *supra* note 2, at 75.

[214] *Id.* at 12; Chapin et al., *supra* note 91, at 257.

These changes are making it harder for Arctic peoples to access food resources safely and create problems for other subsistence activities, such as drying fish.[215] Indeed, there have been several accidents and deaths attributed to increased erratic weather patterns, like sudden storms, catching travelers off guard.[216] In some places, there are also increased incidences of people falling through the ice.[217]

The ongoing changes in the distribution and abundance of marine mammals from sea ice declines and changes also are making it more difficult for Arctic hunters. The timing and location of ice-dependent prey, such as ice seals and walrus, is becoming less predictable, and declines of important subsistence species are expected.[218]

These changes threaten the subsistence diet that now contributes both cultural and physical benefits to indigenous communities.[219] In addition to climate change, ties to subsistence activities "are deteriorating because of changes in lifestyles, cultural, social, economic and political factors."[220] Less access to traditional subsistence foods and a shift to a more market food-based diet has been associated with "a rise in levels of cardiovascular diseases, diabetes, dental cavities and obesity[.]"[221] If the fundamental role of subsistence is displaced by industrial development in the region, very significant increases in obesity, diabetes and other health problems in the impacted communities would predictably ensue.

These changes also affect indigenous cultures. Traditional knowledge of sea ice patterns that has been honed over millennia is becoming less relevant.[222] When information and knowledge that has been passed down from generation to generation becomes increasingly unreliable, it will eventually be lost.[223] Thus, as Arctic climate change presents serious challenges to human health and food security, it also threatens the very survival of some aspects of Arctic cultures.[224] These ties "are expected to continue to decrease as climate-driven changes in terrestrial ecosystems influence conditions for hunting, decreases in natural resources, and loss of traditional knowledge[] …," which has been described as threatening to turn Arctic communities into "strangers in their own lands[.]"[225]

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215 George et al., *supra* note 206, at 365; Laidler et al., *supra* note 209, at 424; ACIA 2004, *supra* note 2, at 75; ACIA 2005, *supra* note 25, at 659-62.

216 ACIA 2005, *supra* note 25, at 82.

217 *Id.* at 80.

218 Krupnik & Ray, *supra* note 158, at 2954.

219 IPCC 2007a, *supra* note 52, at 671.

220 *Id.* at 668.

221 *Id.; see also generally* S.O. Ebbesson et al., *Diabetes is Related to Fatty Acid Imbalance in Eskimos*, 58 International J. of Circumpolar Health 108 (1999); R. Shephard & A. Rode, *The Health Consequences of Modernization: Evidence from Circumpolar Peoples* (1996); T. Curtis et al., *Changing Living Conditions, Lifestyle, and Health*, 64 International J. of Circumpolar Health 442 (2005); M. Jorgensen et al., *Diabetes and impaired glucose tolerance among the Inuit of Greenland*, 26 Diabetes Care 1766 (2002); B. Zinman, *Diabetes in indigenous populations: genetic susceptibility and environmental change, available at* http://www.d4pro.com/idm/site/vol_16,_no_1,_2004.htm; S Ebesson et al., *Diabetes and impaired glucose tolerance in three Alaskan Eskimo Populations*, 21 Diabetes Care 563 (1998); P. Hogan et al., *Economic Costs of Diabetes in the U.S. in 2002*, 26 Diabetes Care 917 (2003).

222 George et al., *supra* note 206, at 372.

223 *Id.*

224 ACIA 2004, *supra* note 2, at 11.

225 IPCC 2007a, *supra* note 52, at 668.

4. Thawing permafrost affects Arctic ecosystems, impacts subsistence activities, and disrupts transportation, buildings, and other infrastructure.

Permafrost is soil that remains at or below 32 degrees Fahrenheit (0° C). The majority of the Arctic tundra overlies permafrost. As the Arctic warms, permafrost is degrading, and the rate of that degradation has been increasing over the past 50 years.[226] The rapid loss of Arctic sea ice is likely to enhance warming and could lead to rapid degradation of vulnerable permafrost in the future.[227] The loss of stable permafrost impacts subsistence activities, ecosystem dynamics, transportation, building stability, and other infrastructure.

Permafrost degradation can significantly disrupt the landscape. In areas of continuous permafrost, the melting of permafrost ice can cause lakes to form.[228] In areas in which permafrost is not continuous, thawing can shrink lakes and ponds as they become connected to the groundwater table.[229] The creation and disappearance of lakes affects vegetation, aquatic communities, water fowl, and the migration of animals across the landscape.[230] In some areas, black spruce utilize the ice-rich permafrost to maintain the structure of the soil in which they are rooted. Thawing of the frozen ground can lead to what appear to be "drunken forests" of leaning and toppled trees.[231]

Enormous mudslides caused by thawing permafrost can fundamentally change local ecosystems. The red circle shows a person standing in the aftermath of this mudslide.

Thawing permafrost also affects daily life in many Arctic communities in which people dig ice cellars to store meat and other subsistence foods. The ice cellars are often a few meters deep, where temperatures were typically well below freezing. Recent warming of permafrost has made some ice cellars too warm for food storage, which makes it difficult for Arctic peoples to store food for the long winter.[232]

[226] M.T. Jorgenson et al., *Thermokarst in Alaska, in* Ninth International Conference on Permafrost 869-76 (D.L. Kane & K.M. Hinkel, eds.) (2008).

[227] Lawrence et al., *supra* note 103, at 1.

[228] ACIA 2004, *supra* note 2, at 91.

[229] *Id.* at 90.

[230] *Id.* at 90-91.

[231] *Id.* at 90.

[232] Stefan Milkowski, *Melting Permafrost Poses Threats to Infrastructure, Alaska Economy*, Fairbanks Daily News-Miner, July 30, 2008, *available at* http://newsminer.com/news/2008/jul/30/melting-permafrost-poses-threats-infrastructure-al.

Further, traveling across the tundra is much easier during the winter when the ground is frozen than it is during the summer, when the tundra is boggy. In fact, many communities rely on ice roads and frozen ground for travel and the transportation of goods and other materials. As a result of climate change, the number of days the tundra is frozen is decreasing, and future declines are expected.[233]

In addition, as permafrost thaws and the ice within it melts, the ground sinks. This sinking can damage infrastructure and cause it to fail entirely. In Alaska the cost of additional repairs and maintenance to buildings, bridges, and other structures due to degraded permafrost is projected to exceed ten billion dollars by 2080.[234] Further, as explained in more detail below, thawing permafrost could release large quantities of methane, a powerful greenhouse gas.

5. Loss of sea ice is opening the Arctic to industrialization from shipping, fishing, and oil and gas activities that would further alter the natural environment and opportunities for the subsistence way of life.

While the remoteness and unforgiving climate of the Arctic have provided some protection from the extraordinary human expansion of the last 200 years, the pressures of that expansion are now closing in. The incredible reduction in Arctic sea ice over the last few years not only makes the lives of northern peoples and marine mammals more difficult, it also opens the Arctic Ocean to the possibility of unprecedented industrialization. The expansion of high-risk activities like commercial fishing, shipping and transport, and oil and gas exploration and development would add additional pressures on the already-stressed communities, animals, and ecosystems of the far north.[235]

For now, there are no large-scale industrial fisheries in Arctic waters. Such fisheries, however, are burgeoning at the Arctic margin both in the U.S. and internationally, principally in the Bering and Barents seas.[236] Further, there already is evidence of northward migration of both fish stocks and the fleets in these seas.[237] Unbridled commercial fishing in the Arctic is likely to damage habitat, alter food webs, and harm marine mammals and other species of importance to the subsistence way of life.[238] As sea ice retreats and fish migrate north, pressure to open these areas to commercial fishing almost certainly will grow.

The decline in area and thickness of sea ice is likely to provide vast areas of open water that ships can navigate. In the next decade, even the fabled Northwest Passage may be open for travel on a regular basis.[239] The remoteness and shifting sea ice, however, not only make shipping dangerous, but also make spill response

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[233] ACIA 2004, *supra* note 2, at 86.

[234] P. Larsen et al., *A Probabilistic Model to Estimate the Value of Alaska Public Infrastructure at Risk to Climate Change*, Inst. of Soc. and Econ. Res., Univ. of Alaska, Anchorage (2007).

[235] F.S. Chapin et al., *Building Resilience and Adaptation to Manage Arctic Change*, 35 Ambio 198, 201 (2006).

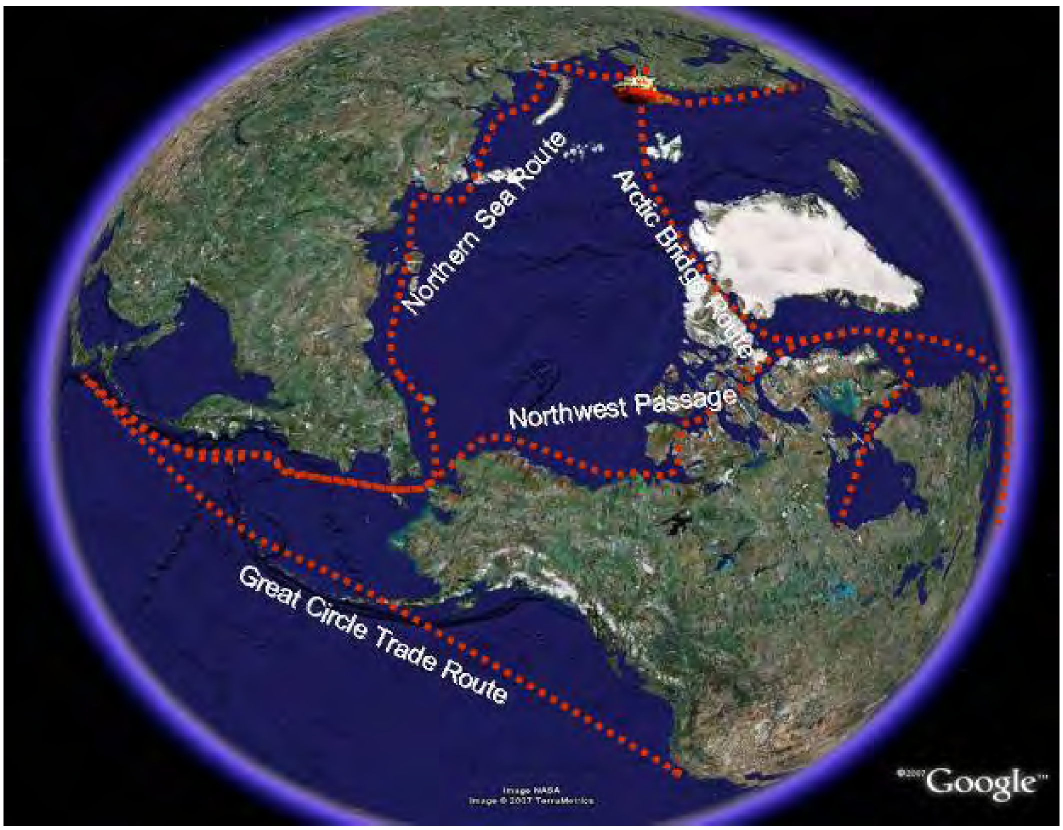
[236] ACIA 2005, *supra* note 25, at 695, 709-10, 731-32, 746-47.

[237] *See* Grebmeier et al., *supra* note 142, at 1461; Mueter & Litzow, *supra* note 181, at 309.

[238] Chapin et al., *supra* note 235, at 201.

[239] ACIA 2004, *supra* note 2, at 82-84.

and recovery after a shipping accident nearly impossible.[240] Nonetheless, because sailing across the top of the world shortens the trip from Germany to Japan dramatically, we can expect a substantial increase in the number of large ships transiting the Arctic.[241] There already is substantial evidence of this trend; in 2007 there were 132 voyages in the Canadian Arctic, up from 78 in 2005,[242] and an increase in ship traffic in the Bering and Chukchi seas already has been documented.[243] Additionally, there is an increasing demand for reinforced vessels.[244] As sea ice retreats, there will likely be an increased number of vessels transiting the Arctic, including cruise ships, and the demand for vessels is expected to increase.



Melting sea ice will open new shipping routes across the Arctic, increasing the likelihood of a major shipping accident in remote and treacherous Arctic waters.

The risks of a disastrous spill in the Arctic from a shipping accident are relatively high due to the harsh conditions, distance from response capabilities, and lack of technology to clean up a spill in broken ice conditions. A large spill in the Arctic would have devastating impacts on the ecosystem that likely would linger for decades.[245]

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[240] *Id.* at 84-85.

[241] *Id.* at 82-84.

[242] H. Miller, *Global Warming Melts New Sea Lanes for Norilsk, ConocoPhillips*, Bloomberg, *available at* http://www.bloomberg.com/apps/news?pid=20601109&sid=aQ4ROJIItxvU&refer=home.

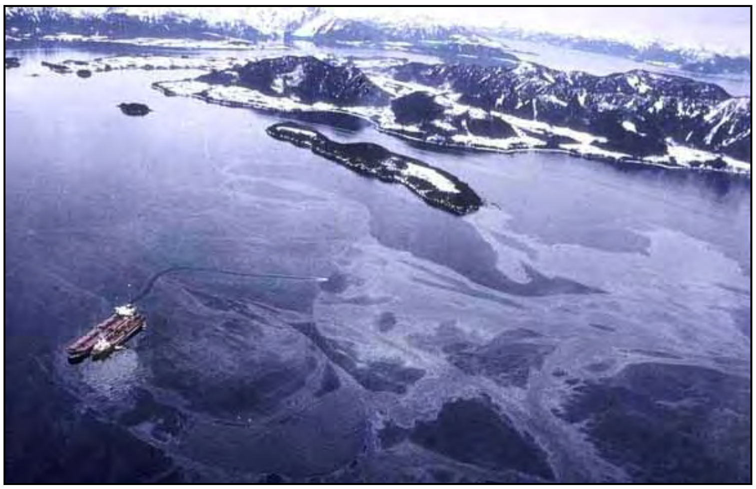
[243] ACIAC 2008, *supra* note 132, at 42.

[244] Miller, *supra* note 242.

[245] ACIA 2004, *supra* note 2, at 85.

Increased shipping would add to the amount of black carbon—a component of soot—and other pollution released directly into the Arctic.[246] Nitrogen oxides and carbon monoxide from shipping could triple ozone levels in the Arctic, which would lead to additional warming of the region.[247] Further, the direct release of black carbon would almost certainly exacerbate sea ice declines by reducing albedo and, thereby, amplify warming in the Arctic.[248]

In addition, retreating sea ice has opened new areas to oil and gas exploration and development. These activities pose significant threats to Arctic ecosystems and to the people who depend on them. Indeed, drilling and other exploratory activities are planned for sensitive wildlife habitat, including the bowhead whale migration corridor.[249] Placing wells, pipelines, and vessels in the remote Arctic creates a substantial risk of a catastrophic oil spill, and as highlighted above, there is no proven method to clean up an oil spill in the icy conditions often found in the Arctic.[250] The United States Minerals Management Service has predicted that two large oil spills are likely to result from its planned activities in the Arctic.[251]



The 1989 Exxon Valdez oil spill in Prince William Sound was a powerful reminder of the dangers associated with oil development.

Seismic exploration, drilling, and vessel traffic associated with oil and gas activities would bring significant noise to the otherwise relatively quiet Arctic Ocean. That noise may disrupt wildlife during important times of the year. Noise can severely impact whales and other marine life, damaging eardrums and driving them away from feeding areas and migratory routes. Biologists have observed bowhead whales reversing their direction when they encounter a noisy working exploration vessel.[252]

The impacts of unbridled expansion of industrial activities in the Arctic would add additional stress to ecosystems and Arctic peoples already feeling the direct impacts of climate change. The combination of stressors make ecosystem- or population-level effects more likely, especially if the stressors work synergistically. For example, climate fluctuations are more likely to lead a fish stock to collapse if it is being fished.[253]

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[246] P.K. Quinn et al., *Short-lived Pollutants in the Arctic: Their Climate Impact and Possible Mitigation Strategies*, 8 Atmospheric Chemistry and Physics 1723, 1725-32 (2008).

[247] C. Granier et al., *Ozone Pollution from Future Ship Traffic in the Arctic Northern Passages*, 33 Geophysical Res. Letters 1, 4 (2006).

[248] Quinn et al., *supra* note 246, at 1723-35.

[249] Minerals Management Service, *Environmental Assessment, Shell Offshore Inc. Beaufort Sea Exploration Plan* 10-11 (February 2007).

[250] Minerals Management Service, *Outer Continental Shelf Oil & Gas Leasing Program: 2007-2012, Final Environmental Impact Statement* IV-236 (April 2007).

[251] *Id.* at Table IV-4.

[252] R.S. Schick & D.L. Urban, *Spatial Components of Bowhead Whale (Balaena mysticetus) Distribution in the Alaskan Beaufort Sea*, 57 Can. J. Fisheries and Aquatic Sci. 2193, 2193 (2000).

[253] C.-h. Hsieh et al., *Fishing Elevates Variability in the Abundance of Exploited Species*, 443 Nature 859, 861 (2006).

Large swaths of the Alaskan Arctic have been made available for oil and gas leasing.

As increased human activities and development occur, both ecosystems and communities will be forced to deal with multiple novel stresses simultaneously.[254]

> 6. Increases in atmospheric carbon dioxide are predicted to lead to acidification of the Arctic and North Pacific Ocean with subsequent impacts to marine ecosystems and the people who depend upon them.

In addition to warming the planet, increasing levels of atmospheric carbon dioxide are causing the ocean surface to acidify.[255] This effect, called ocean acidification, occurs because approximately one-third of the carbon dioxide added to the atmosphere from fossil fuel combustion dissolves into seawater, where it forms carbonic acid, which, in turn, lowers the pH of the ocean waters.[256] Left unconstrained, carbon dioxide emissions are predicted to triple the average acidity of the oceans by the end of this century.[257] Such a change in pH would disrupt

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[254] M. Robards & L. Alessa, *Timescapes of Community Resilience and Vulnerability in the Circumpolar North*, 57 Arctic 415, 415 (2004).

[255] K. Caldeira & M. E. Wickett, *Ocean Model Predictions of Chemistry Changes from Carbon Dioxide Emissions to the Atmosphere and Ocean*, 110 J. of Geophysical Res. 1, 3 (2005).

[256] *Id.* at 1.

[257] K. Caldeira & M.E. Wickett, *Anthropogenic Carbon and Ocean pH*, 425 Nature 365, 365 (2003).

some of the most important chemical and biological processes in the oceans and, thereby, affect the people and industries that rely on them worldwide.[258]

The oceans are the largest repository, or carbon sink, for anthropogenic emissions of carbon dioxide.[259] Prior to the Industrial Revolution, the oceans were in relative equilibrium with the atmosphere, absorbing about the same amount of carbon dioxide each year as they released.[260] However, as the concentration of carbon dioxide in the atmosphere has increased, the amount of carbon dioxide absorbed by the oceans has also increased.[261] The acidity of the ocean surface has already increased on average by 30%, and if current emission trends continue, acidity could increase by almost 100% by the end of this century.[262]

While the absorption of carbon dioxide by the oceans moderates the impacts of climate change on terrestrial life, it has dramatic effects in the oceans. One major consequence of increasing ocean acidity is a reduction in carbonate available for use by marine animals.[263] Carbonate in the ocean is necessary for the formation of structures such as coral skeletons, shells, and pearls. Thus, a broad swath of marine life, including corals, sea stars, crabs, and clams, would be affected by reduced availability of carbonate.[264] Further, important phytoplankton and zooplankton species at the base of many marine food webs also depend on carbonate, and ocean acidification may disrupt these food webs, destroy living habitat, and impair ecosystem functioning.[265] Geologic history indicates that multiple mass extinction events were the result of ocean acidification and that recovery of that diversity required millions of years.[266]

Ocean acidification also is likely to affect a wide variety of organisms in ways beyond its impact on carbonate. These effects include raising disease infection rates,[267] affecting the efficiency of respiration in fish and other marine life,[268] and changing the ability of hemoglobin to carry oxygen in marine animals.[269]

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[258] V.J. Fabry et al., *Impacts of Ocean Acidification on Marine Fauna and Ecosystem Processes*, 65 ICES J. Marine Sci. 414 (2008).

[259] C.L. Sabine et al., *The Oceanic Sink for Anthropogenic CO_2*, 305 Science 367, 367 (2004).

[260] R. Schubert et al., *The Future Ocean – Warming Up, Rising High, Turning Sour: Special Repor*t, German Advisory Council on Global Change 68 (2006).

[261] *Id.* at 68.

[262] J.C. Orr et al., *Anthropogenic Ocean Acidification Over the Twenty-first Century and its Impact on Calcifying Organisms*, 437 Nature 681, 681 (2005).

[263] *Id.*

[264] Fabry, *supra* note 258, at 414-27.

[265] *Id.*

[266] C.M. Turley et al., *Corals in Deep-Water: Will the Unseen Hand of Ocean Acidification Destroy Cold-Water Ecosystems?*, 26 Coral Reefs 445, 445-48 (2007); J. Zachos et al., *Rapid Acidification of the Ocean During the Paleocene-Eocene Thermal Maximum*, 308 Science, 1611, 1611-15 (2005).

[267] H. Kurihara et al., *Sub-Lethal Effects of Elevated Concentration of CO_2 on Planktonic Copepods and Sea Urchins*, 60 J. Oceanography 743, 744 (2004).

[268] H.O. Portner et al., *Biological Impact of Elevated Ocean CO_2 Concentrations: Lessons from Animal Physiology and Earth History*, 60 J. Oceanography 705, 705 (2004).

[269] *Wildlife and Oceans in a Changing Climate: Hearing Before the Subcomm. on Fisheries, Wildlife and Oceans*, 110th Cong. 6-7 (2007) (written testimony of Ken Caldeira entitled "Climate Change and Acidification are Affecting Our Oceans," Department of Global Ecology, Carnegie Institution of Washington), *available at* http://resourcescommittee.house.gov/images/Documents/20070417b/testimony_caldeira.pdf.

The Arctic and Northern Pacific oceans may be particularly vulnerable to ocean acidification, and they are predicted to undergo fundamental ecosystem changes sooner than most other regions.[270] There are three primary reasons these regions are particularly susceptible to ocean acidification.[271] First, widespread deep-water upwelling occurs in the North Pacific Ocean, and the waters that are brought up from depth are already naturally rich in dissolved CO_2. Second, the North Pacific and Arctic oceans have relatively low salinity, in part due to the high runoff of freshwater from the North American and Arctic coastlines. The ability of ocean waters to buffer against acidification is directly proportional to salinity. Third, CO_2 is absorbed in cooler water temperatures faster than in warmer water temperatures.[272]

The Arctic and Northern Pacific oceans may be particularly vulnerable to ocean acidification.

If current trends continue, a substantial portion of the North Pacific Ocean may become uninhabitable for a wide array of calcifying organisms within the next 50-100 years.[273] Cold water corals and pteropods are important to the health of the marine ecosystem and are particularly susceptible to ocean acidification.[274] Cold water corals make up living habitat for many fish and invertebrate species, and pteropods are small snails that live in the open ocean and are a critical part of the food web as prey for species including salmon.

In the Arctic, sea ice may act as a barrier between the water and the atmosphere, slowing the acidification rate of the Arctic Ocean's surface waters.[275] This mitigating factor will diminish as the Arctic loses its ice cover due to climate change.[276] As ice disappears, the near-freezing surface waters of the Arctic Ocean will be able to absorb carbon dioxide from the atmosphere rapidly.[277]

If current increasing rates of carbon dioxide emissions are left unconstrained, the acidity of the ocean's surface will rise sharply, and a substantial portion of species dependent on the surface waters will not be able to adapt quickly enough to avoid extinction.[278] Tripling the acidity of ocean surface waters within a century would far outstrip the adaptive capability of myriad marine species, which would make mass extinctions throughout the oceans likely and fundamentally transform ocean ecosystems.[279] The Arctic and sub-arctic North Pacific oceans are already beginning to see these changes.[280]

[270] Orr et al., *supra* note 262, at 681-85.

[271] *Id.*

[272] *Id.*

[273] *Id.*

[274] *Id.*

[275] A. Poisson & C.-T. A. Chen, *Why is There Little Anthropogenic CO_2 in the Antarctic Bottom Water?*, 34 Deep-Sea Research, Pt. A, 1255, 1273 (1987).

[276] ACIA 2004, *supra* note 2, at 8.

[277] Orr et al., *supra* note 262, at 682.

[278] *Id.*

[279] *Id.* at 685.

[280] *See* J.M. Guinotte & V. J. Fabry, *Ocean Acidification and its Potential Effects on Marine Ecosystems*, 1134 Annals of the N.Y. Acad. of Sci. 320 (2008).

B. The effects of climate change currently being felt first in the Arctic are predicted to affect the public health and welfare in the United States and, ultimately, the world.

The Arctic climate is changing, which is resulting in sea ice loss and the other significant effects to Arctic peoples and ecosystems described above. It also will likely affect the rest of the United States and the world in two fundamental ways: indirectly, by triggering further warming and emissions of greenhouse gases and, directly, by affecting sea level, weather, migratory species, and people around the world.

Arctic warming, and in particular the loss of sea ice, will likely cause additional warming worldwide by triggering a series of "positive feedback loops."

Arctic warming, and in particular the loss of sea ice, will likely cause additional warming worldwide by triggering a series of "positive feedback loops." A "positive feedback loop" is a self-reinforcing cycle that, absent some interruption, continues to accelerate. A primary example is the positive ice-albedo feedback loop described above.[281] In that cycle, melting sea ice exposes more of the ocean's surface, which absorbs much more sunlight than ice does. Absorbing that additional sunlight leads to more warming, which leads to more sea ice melt which, in turn, leads to more open ocean, and so on. In addition to the ice-albedo feedback loop, Arctic warming and melting sea ice are likely to contribute to three other important positive feedback loops:

1) melting of terrestrial ice and snow;

2) degradation of permafrost, which could result in the release of trapped greenhouse gases; and

3) increases in the frequency and size of wildfires at high latitudes, which will release black carbon directly into the Arctic.

In concert with the ice-albedo feedback loop, these processes have the potential to accelerate warming on a global scale.[282] By so doing, they risk pushing the planet across a "tipping point" that would result in abrupt climate change.[283] In that case, the positive feedback loops would begin, and there would be no way to stop them. The Earth's climate would be changing and humans would have little ability to control it or affect what new state resulted. Loss of sea ice in the Arctic could be a tipping element of the global climate system,[284] and, through the feedback loops described below, it could result in dangerous warming of the planet.[285]

[281] *See supra* pp. 22-24.

[282] *See generally* A.D. McGuire et al., *Integrated Regional Changes in Arctic Climate Feedbacks: Implications for the Global Climate System*, 31 Ann. Rev. of Env't & Res. 61, 67-68 (2006); Serreze & Francis, *supra* note 48, at 257.

[283] Lenton et al., *supra* note 43, at 1786.

[284] *Id.*

[285] Hansen et al., *supra* note 54, at 1434.

1. In addition to reducing albedo, warming in the Arctic may trigger three other positive feedback loops that will accelerate warming worldwide.

a. Warming from sea ice loss will likely accelerate melting of terrestrial ice and snow, including the Greenland ice sheet, which would further reduce Arctic albedo, accelerate warming, and raise sea level.

The loss of sea ice is predicted to result in several degrees of warming over land in the Arctic.[286] This warming will likely exacerbate the widespread decline in snow cover, the retreat of glaciers and melting of the Greenland ice sheet.[287] In turn, the loss of snow and ice cover will further decrease the albedo of the region, which will almost certainly result in additional warming.

The extent of snow cover in the Arctic has decreased by approximately 10% over the past 30 years. Most of the change results from the earlier disappearance of snow in spring. For example, in Barrow, Alaska the snow has melted approximately one month earlier on average since the 1950s.[288] Earlier snow melt lengthens the snow-free season and, therefore, reduces albedo and results in additional warming.[289] As the Arctic warms, snow cover will likely decline further, which would result in additional warming from reductions in albedo.

In addition, Arctic warming has resulted in a decline of the volume of ice in glaciers and ice fields (regions of ice cover smaller than 50,000 km^2 that feed numerous glaciers).[290] Glaciers and ice fields are spread irregularly through the Arctic and cover an area of about 400,000 km^2.[291] Their smaller area and mass make them highly susceptible to change, and, as a result, their melting has contributed disproportionately to the loss of ice volume in the Arctic. As these glaciers and ice fields melt, new areas of dark earth are exposed to the sun's rays, which changes the albedo and leads to additional warming in the Arctic. Scientists predict that further warming will lead to substantial additional loss of ice, which will, in turn, lead to more warming.

Comparison photos of Muir and Riggs Glaciers in Alaska between 1941 and 2004.

[286] Lawrence et al., *supra* note 103, at 1.

[287] ACIA 2004, *supra* note 2, at 8, 10, 120.

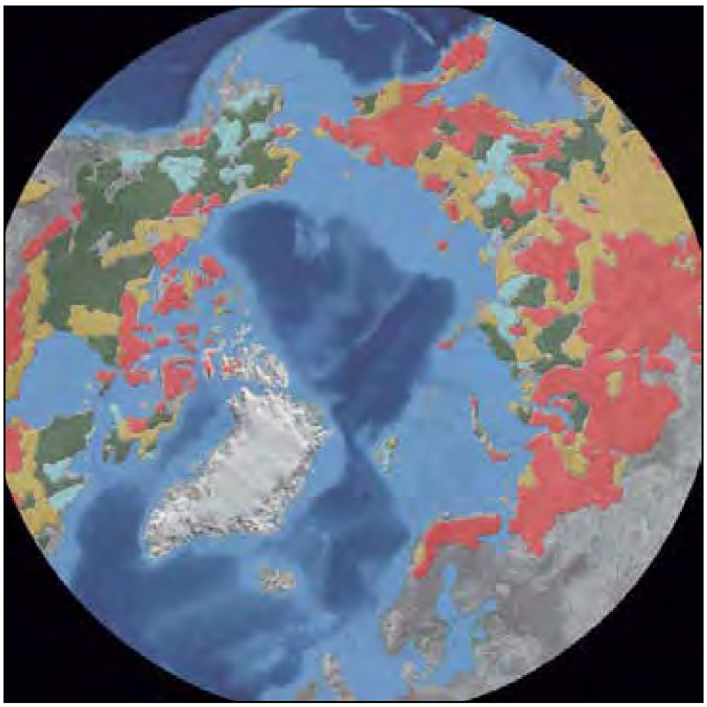
[288] A.H. Lynch & R.D. Brunner, *Context and Climate Change: An Integrated Assessment for Barrow, Alaska* 82 Climatic Change 93, 98 (2007).

[289] R.S. Stone et al., *Earlier Spring Snowmelt in Northern Alaska as an Indicator of Climate Change*, 107 J. of Geophysical Res. 4089, 4089 (2002); E.S. Euskirchen et al., *Energy Feedbacks of Northern High-latitude Ecosystems to the Climate System Due to Reduced Snow Cover During 20th Century Warming*, 13 Global Change Biology 2425, 2425 (2007).

[290] ACIA 2005, *supra* note 25, at 184; M.F. Meier et al., *Glaciers Dominate Eustatic Sea-Level Rise in the 21st Century*, 317 Science 1064, 1064 (2007).

[291] J. Dowdeswell & J.O. Hagen, *Arctic Ice Masses, in* Mass Balance of the Cryosphere 527, 527 (J.L. Bamber and A.J. Payne eds., Cambridge University Press) (2005).

The mass of the Greenland ice sheet is declining and the rate of its decline is accelerating.[292] In 2007, the ice sheet lost more mass than in any other year on record.[293] In 2008, the days of snowmelt in northern Greenland were three times greater than the 1979-2007 average. These observations coincide with preliminary measurements from the World Meteorological Organization showing that surface air temperatures between June and August were 3 degrees Celsius higher than the average for the same period.[294] These large melting events suggest that the Greenland ice sheet, as well as the other Arctic glaciers and ice fields, may be more sensitive to warming than previously considered.[295] It also suggests that ice loss due to warming is likely a nonlinear process, which means that, as melting begins, its rate increases.[296] One explanation for this phenomenon is that surface melt reaches the base of glaciers and ice sheets, which lubricates the ice-bedrock interface and accelerates ice flow.[297] Increases in ice flow result in additional glacial calving and move more ice from the colder accumulation zone to the melt zone. The nonlinear response of glaciers and ice sheets to the current level of warming indicates further warming may initiate the collapse of the Greenland ice sheet[298] and other Arctic glaciers.[299] Thus, the Greenland ice sheet may not be able to survive the loss of Arctic sea ice,[300] and its loss will uncover more dark land surface and likely result in additional warming.



Areas in which infrastructure is in danger due to permafrost melting by 2050, color code: teal, stable; green, low risk; yellow, moderate risk; and red, high risk.

In addition to the contribution to warming from surface albedo change, glacial ice loss raises sea level. The amount of water in Arctic glacial ice corresponds to about 7 m (23 ft) of sea level.[301] While it may take over 300 years for the Greenland ice sheet to disintegrate, significant sea level rise, on the order of 2 m (6.5 feet)

[292] S.B. Luthcke et al., *Recent Greenland Ice Mass Loss By Drainage System From Satellite Gravity Observations*, 314 Science 1286, 1286 (2006); E. Rignot & P. Kanagaratnam, *Changes in the Velocity Structure of the Greenland Ice Sheet*, 311 Science 986, 986 (2006); I. Velicogna & J. Wahr, *Acceleration of Greenland Ice Mass Loss in Spring 2004*, 443 Nature 329, 329 (2006).

[293] A. Witze, *Losing Greenland: Is the Arctic's Biggest Ice Sheet in Irreversible Meltdown? And Would We Know If It Were?*, 452 Nature 798, 798 (2008).

[294] M. Tedesco et al., *Extreme Snowmelt in Northern Greenland During Summer*, 89 EOS 391, 391 (2008).

[295] H.J. Zwally et al., *Surface Melt-Induced Acceleration of Greenland Ice-Sheet Flow*, 297 Science 218, 218 (2002); Hansen, *supra* note 57, at 269; Velicogna & Wahr, *supra* note 292, at 329, Meier et al., *supra* note 290, at 1064; Lenton et al., *supra* note 43, at 1789.

[296] Hansen, *supra* note 57, at 269.

[297] Zwally et al., *supra* note 295, at 218; Meier et al., *supra* note 290, at 1064; S. Das et al., *Fracture Propagation to the Base of the Greenland Ice Sheet During Supraglacial Lake Drainage*, 320 Science 778, 778 (2008); I. Joughin et al., *Seasonal Speedup Along the Western Flank of the Greenland Ice Sheet*, 320 Science 781, 781 (2008).

[298] Hansen, *supra* note 57, at 274; Lenton et al., *supra* note 43, at 1789.

[299] Meier et al., *supra* note 290, at 1064.

[300] Hansen *supra* note 57, at 269.

[301] Dowdeswell & Hagen, *supra* note 291, at 613.

could occur this century.[302] This level of sea level rise would threaten low lying areas around the world, such as parts of Florida and Manhattan.[303]

In another example, conservative estimates show that sea level in the Gulf of Mexico region between Texas and Alabama is projected to rise 0.3-2 m (1-7 ft). According to a study conducted by the U.S. Climate Change Science Program and the Department of Transportation, 27% of the major roads, 9% of the rail lines and 72% of the ports in this area are below this level. In addition, this area serves as a center of commerce as roughly two-thirds of all imported oil and 40% of water-based cargo in the United States is transported through this region.[304]

b. Accelerated Arctic warming related to the loss of sea ice may release greenhouse gases from thawing permafrost and decomposition of methane hydrates, which would further contribute to Arctic and worldwide warming.

Arctic permafrost contains a large amount of trapped organic material.[305] As permafrost thaws, organic material that was previously frozen can begin to decompose and release carbon dioxide. In addition, thawing permafrost in the tundra often creates new wetlands or small, shallow lakes called thermokarst lakes. Decomposition of organic matter at the bottom of thermokarst lakes occurs in anoxic conditions, which produces methane,[306] a greenhouse gas 25 times more potent than carbon dioxide. Rapid formation of new thermokarst lakes along the north slope of Alaska is evidence that this phenomenon is occurring already.[307] Further, long-term monitoring in subarctic Sweden showed dramatic changes in the distribution of permafrost and vegetation with substantial increases in methane emissions.[308] As the Arctic warms, it is likely that more permafrost will thaw, releasing more carbon dioxide and methane and, in turn, causing more warming.[309] The potential release of greenhouse gases may be mitigated to some extent by the sequestration of carbon dioxide in new growth of shrubs and trees, but such sequestration is unlikely to compensate fully for increases in warming caused by the decreased albedo of the relatively dark shrubs.[310]

In addition, a vast amount of methane, in solid icy forms called methane hydrates or clathrates, is trapped in permafrost and cold ocean sediments at shallow depths. If the temperature of the permafrost or water at the seabed rises a few degrees,

[302] Hansen, *supra* note 57, at 270; Lenton et al., *supra* note 43, at 1789.

[303] Hansen, *supra* note 57, at 274.

[304] *See* Department of Transportation: Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research 4T-2, ES-3 (Savonis et al. eds.) (2007).

[305] S.A. Zimov et al., *Permafrost and the Global Carbon Budget*, 312 Science 1612, 1612 (2006).

[306] K.M. Walter et al., *Methane Bubbling from Siberian Thaw Lakes as a Positive Feedback to Climate Warming*, 443 Nature 71, 71 (2006).

[307] M.T. Jorgenson et al., *Abrupt Increase in Permafrost Degradation in Arctic Alaska*, 33 Geophysical Res. Letters 1, 1 (2006).

[308] T.R. Christensen et al., *Thawing Sub-Arctic Permafrost: Effects on Vegetation and Methane Emissions*, 31 Geophysical Res. Letters 1, 1 (2004).

[309] ACIA 2004, *supra* note 2, at 38; Zimov et al., *supra* note 250, at 1613.

[310] ACIA 2005, *supra* note 25, at 324.

it could initiate the decomposition of these hydrates, which would release large quantities of methane into the atmosphere. Although this scenario is less likely than the one described above, its potential impacts could be very large.[311]

In sum, thawing permafrost could release potent greenhouse gases, which will lead to more warming and therefore more permafrost melting. Once this process starts, it will result in amplified warming and further emissions.[312]

c. Arctic warming from albedo changes will likely increase the frequency and size of wildfires at high latitudes.

Arctic warming due to loss of sea ice and reduced snow cover will likely result in more tundra fires like the one pictured above. Tundra fires release black carbon directly into the Arctic, which increases warming.

Arctic and subarctic climate change is increasing the number and size of high latitude forest fires.[313] The average area burned each year more than doubled in North America since 1970,[314] and there is a similar trend for northern Russia.[315] Arctic and subarctic warming is predicted to further increase the yearly area burned of boreal forests,[316] and to result in greater tundra fire activity as well.[317] Indeed, the largest recorded tundra fire in Alaska occurred in 2007.[318]

These wildfires are a significant source of black

[311] ACIA 2004, *supra* note 2, at 38-39.

[312] Zimov et al., *supra* note 305, at 1613; Q. Zhuang et al., *Net Emissions of CH_4 and CO_2 in Alaska: Implications for the Region's Greenhouse Gas Budget*, 17 Ecological Applications 203, 210 (2007).

[313] B.J. Stocks et al., Climate Change and Forest Fire Activity in North American Boreal Forests, in Fire, Climate Change, and Carbon Cycling in the Boreal Forest, 368-76 (E. S. Kasischke and B. J. Stocks eds.) (2000); ACIA 2005, *supra* note 254, at 840; E.S. Kasischke et al., *Influences of Boreal Fire Emissions on Northern Hemisphere Atmospheric Carbon and Carbon Monoxide*, 19 Global Biogeochemical Cycles 1, 1 (2005).

[314] Stocks et al, *supra* note 313, at 374-88.

[315] Kasischke et al, *supra* note 313, at 2.

[316] T.S. Rupp et al., *Response of Subarctic Vegetation to Transient Climatic Change on the Seward Peninsula in North-West Alaska*, 6 Global Change Biology 541, 541 (2000); ACIA 2005, *supra* note 254, at 849.

[317] P.E. Higuera et al., *Frequent Fires in Ancient Shrub Tundra: Implications of Paleorecords for Arctic Environmental Change*, 3 PLos ONE 1 (2008).

[318] Anchorage Daily News, *Largest recorded tundra fire burning on Slope*, Sept. 28, 2007, *available at* http://dwb.adn.com/news/alaska/rural/story/9337371p-9252045c.html.

carbon in the Arctic.[319] Black carbon, the light absorbing component of soot that comes from the incomplete burning of organic matter (e.g., wood and fossil fuels) contributes to Arctic warming in two ways. First, it absorbs solar radiation in the atmosphere, which leads to direct warming of the atmosphere.[320] Second, deposition of black carbon darkens snow and ice, which reduces albedo and increases warming.[321] Large forest fires in North America[322] and Russia[323] have been found to elevate black carbon concentrations throughout the Arctic, increasing solar radiation absorption and decreasing the albedo of ice and snow.

While the majority of atmospheric black carbon originates from mid and low latitudes,[324] black carbon from high latitude wildfires may be a more direct source of warming in the Arctic because, in addition to causing atmospheric warming, it is deposited on snow and ice where it reduces albedo.[325] An atmospheric transport barrier, the Arctic front, isolates the lowest region of the atmosphere, the troposphere, over the Arctic.[326] During summers this barrier makes the Arctic more vulnerable to black carbon deposition from sources within the region.[327] Additionally, black carbon is a more dangerous warming agent during summer because of the higher availability of solar radiation.

The amplified warming from loss of sea ice[328] and reduced snow cover in spring[329] in the Arctic and subarctic is likely to result in more high latitude wildfires. Increases in the area of boreal forest and tundra burned would increase black carbon in the Arctic,[330] which would cause further warming,[331] and could result in more fires, and so on.

[319] A. Stohl et al., *Pan-Arctic Enhancements of Light Absorbing Aerosol Concentrations Due to North American Boreal Forest Fires During Summer 2004*, 111 J. of Geophysical Res. 1, 1 (2006); M.G. Flanner et al., *Present-Day Climate Forcing and Response from Black Carbon in Snow*, 112 J. of Geophysical Res. 1, 9 (2007); Quinn et al., *supra* note 246, at 1726.

[320] V. Ramanathan & G. Carmichael, *Global and Regional Climate Changes Due to Black Carbon*, 1 Nature Geoscience 221, 221 (2008).

[321] Flanner et al., *supra* note 319, at 1.

[322] A. Stohl, *Characteristics of Atmospheric Transport into the Arctic Troposphere*, 111 J. of Geophysical Res. 1, 2 (2006).

[323] S. Generoso et al., *A Satellite- and Model-Based Assessment of the 2003 Russian Fires: Impact on the Arctic Region*, 112 J. of Geophysical Res. 1, 1 (2007).

[324] Ramanathan & Carmichael, *supra* note 320, at 221.

[325] *Id.* at 223.

[326] K.S. Law & A. Stohl, *Arctic Air Pollution: Origins and Impacts*, 315 Science 1537, 1537 (2007).

[327] Stohl, *supra* note 322, at 14.

[328] Lawrence et al., *supra* note 103, at 1.

[329] Chapin et al., *supra* note 91, at 255.

[330] Stohl, *supra* note 322, at 15.

[331] Flanner et al., *supra* note 319, at 1.

2. Arctic warming will likely alter global climate patterns by changing atmospheric circulation and potentially changing ocean circulation.

In addition to affecting Arctic ecosystems and people, the loss of Arctic sea ice is predicted to affect atmospheric circulation and could alter ocean currents. These changes would have dramatic consequences.

Changes in Arctic sea ice cover are anticipated to alter atmospheric circulation patterns, which would influence climate patterns in the northern hemisphere.[332] Sea ice has its most significant effect on atmospheric circulation in the fall and winter when it functions as an insulating barrier between the ocean and the frigid atmosphere.[333] When the ice is lost, this insulation is gone, which allows heat to be transferred from the ocean to the atmosphere.[334] This warming of the atmosphere alters atmospheric pressure, which in turn affects wind patterns.[335] Growing evidence suggests that the change in atmospheric pressure from sea ice loss alters storm paths in the northern hemisphere.[336]

Further, sea ice loss could change climatic patterns, including changes in precipitation from altered storm tracks that would likely result in droughts in some regions and floods in other regions. For example, one set of studies predicts that Arctic sea ice loss will shift storm tracks northward in western North America, resulting in decreased precipitation in most of the western United States and increased precipitation in British Columbia and Southeast Alaska.[337]

Arctic warming may also affect the global climate through changes in ocean circulation. These changes come about because ocean currents bring heat from the equator to the poles.[338] In the northern Atlantic Ocean, for example, the Gulf Stream brings warm water northward from the Caribbean towards northern Europe and the subarctic. This movement of heat brings moisture and warmth to northern Europe, moderating the climate of the region. As the northward moving water cools and becomes denser, it sinks deep into the ocean, becoming "deep-water"

[332] Serreze, et al., *supra* note 37, at 1533

[333] *See* McGuire, et al., *supra* note 282, at 62; Serreze & Francis, *supra* note 46, at 254; Lawrence, et al., *supra* note 103, at 1

[334] Lawrence et al., *supra* note 103, at 1.

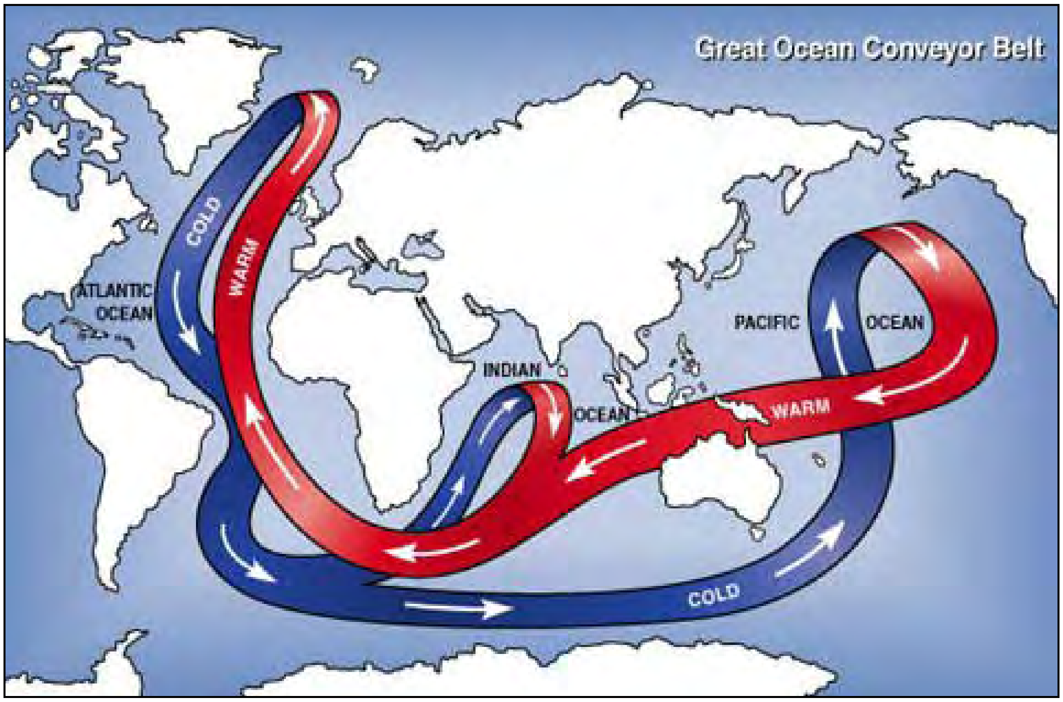
[335] *See generally* M.E. Alexander et al., *The Atmospheric Response to Realistic Arctic Sea Ice Anomalies in an AGCM During Winter*, 17 J. Climate 890 (2004); C. Deser et al., T*he Effects of North Atlantic SST and Sea Ice Anomalies on the Winter Circulation in CCM3, Part II: Direct and Indirect Components of the Response*, 17 J. Climate 877 (2004); K. Dethloff et al., *A Dynamical Link Between the Arctic and the Global Climate System*, 33 Geophysical Res. Letters 1 (2006); C. Deser et al., *The Transient Atmospheric Circulation Response to North Atlantic SST and Sea Ice Anomalies*, 20 J. Climate 4751 (2007).

[336] *See generally* Alexander, *supra* note 335; G. Magnusdottir et al., *The Effects of North Atlantic SST and Sea Ice Anomalies on the Winter Circulation in CCM3. Part I: Main Features and Storm Track Characteristics of the Response*, 17 J. Climate 857 (2004); J. O. Sewall & L. C. Sloan, *Disappearing Arctic Sea Ice Reduces Available Water in the American West*, 31 Geophysical Res. Letters 1 (2004); J.O. Sewall, *Precipitation Shifts over Western North America as a Result of Declining Arctic Sea Ice Cover: The Coupled System Response*, 9 Earth Interactions 1 (2005); Dethlof, *supra* note 335; E. Sokolova, et al., *Planetary and Synoptic Scale Adjustment of the Arctic Atmosphere to Sea Ice Cover Changes*, 34 Geophysical Res. Letters (2007); *see also* J.S. Singarayer, et al., *Twenty First Century Climate Impacts from a Declining Arctic Sea Ice Cover*, 19 J. Climate 1109, 1109 (2006).

[337] Sewall & Sloan, *supra* note 336, at 3; Sewell, *supra* note 335, at 1.

[338] ACIA 2004, *supra* note 2, at 32.

and pulling more warm water northward. This process is a critical part of the global thermohaline[339] circulation that flows through all the world's oceans in what is sometimes referred to as the "ocean conveyor belt."



The Arctic plays a significant role in worldwide currents, including the "Great Ocean Conveyer Belt" depicted above, and changes in the Arctic will likely alter those currents.

Arctic warming may affect the formation of deep-water, a key driver of the thermohaline circulation, by increasing the presence of freshwater and decreasing sea ice formation.[340] Deep-water is formed in the northern part of the Atlantic and in subarctic seas because cooling temperatures and increased salinity make it denser.[341] The formation of sea ice is important in this process. During sea ice formation, salt is rejected from the ice into the surrounding waters, making those waters dense enough to sink into the deep ocean.[342] Arctic climate change is projected to decrease the formation of sea ice in these waters and, therefore, may affect deep-water formation.[343]

Arctic warming also is predicted to increase the freshwater flowing into subarctic seas and the northern Atlantic waters.[344] The increase in fresh water would result

[339] The term comes from "thermo" for heat, and "haline" for salt.

[340] ACIA 2004, *supra* note 2, at 36.

[341] ACIA 2005, *supra* note 25, at 461.

[342] *Id.*

[343] *See* ACIA 2004, *supra* note 2, at 36; *see generally* Comiso, et al., *supra* note 62.

[344] *See* ACIA 2004, *supra* note 254, at 36; ACIA 2005, *supra* note 24, at 466; Lenton et al., *supra* note 43, at 1788-89; *see also generally* B.J. Peterson et al., *Trajectory Shifts in the Arctic and Subarctic Freshwater Cycle*, 313 Science 1061 (2006).

from additional precipitation in the Arctic[345] and melting of the Greenland ice sheet,[346] other Arctic glaciers,[347] and sea ice.[348] There already is a strong indication that the north Atlantic is becoming less salinated due to fresh water from the Arctic.[349] The lighter fresh water could create a lens on the surface of the ocean, much as oil does on water, keeping deep-water from forming.[350]

Slowing or altering the flow of the thermohaline circulation would have far-reaching consequences. It would decrease the amount of heat and moisture transported to northern Europe, which would substantially alter the climate of the region.[351] Changes in thermohaline circulation also would likely lead to more rapid warming of the tropics due to the loss of an important heat transfer mechanism between the equator and the Arctic.[352]

While there is still uncertainty about the likelihood of alterations to thermohaline circulation due to Arctic warming,[353] especially the potential for negative feedbacks to stabilize the circulation,[354] the potential ramifications for the rest of the world are substantial. Given the rapid changes occurring in the Arctic now,[355] substantial changes in thermohaline circulation and, therefore the Earth's climate, could be triggered this century.[356]

3. Changes to Arctic ecosystems are likely to reverberate globally by affecting migratory species.

Arctic ecosystems are connected to the rest of the planet through the migrations of different species.[357] Numerous species come to the Arctic during the short summer to feed on the seasonal abundance of forage vegetation and prey species and, in many cases, to breed.[358] As explained above, climate change is predicted to affect some of the Arctic habitats on which these migratory species depend. Because these species are found throughout the world, changes in the Arctic will affect the health, structure, and functioning of ecosystems in other parts of the world and, in turn, the uses and benefits people derive from the ecosystems in those other regions.

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[345] ACIA 2004, *supra* note 2, at 36-37; ACIA 2005, *supra note 25,* at 470, 477.

[346] *See* Rignot & Kanagaratnam, *supra* note 314, at 988.

[347] *See generally* Meier, et al., *supra* note 290.

[348] *See* Comiso et al., *supra* note 62, at 3-4; Stroeve et al., *supra* note 60, at 13-14.

[349] Peterson, et al., *supra* note 344, at 1064.

[350] *Id.* at 1061, 1065; ACIA 2004, *supra* note 2, at 37.

[351] *See* J. Marotzke, *Abrupt Climate Change and Thermohaline Circulation: Mechanisms and Predictability*, 97 Proc. of the Nat'l. Acad. of Sci. of the U.S. 1347, 1347 (2000); ACIA 2004, *supra* note 2, at 36-37.

[352] *See* Marotzke, *supra* note 351, at 1347; ACIA 2004, *supra* note 2, at 37.

[353] *See* Marotzke, *supra* note 351, at 1347; Lenton et al., *supra* note 43, at 1789

[354] *See* Marotzke, *supra* note 351, at 1350; M. Holland, et al., *Simulated Arctic Ocean Freshwater Budgets in the Twentieth and Twenty-First Centuries*, 19 J. Climate 6221, 6221 (2006).

[355] *See* Serreze et al., *supra* note 39, at 1533.

[356] *See* Lenton et al., *supra* note 43 at 1789.

[357] *See* ACIA 2004, *supra* note 2, at 68.

[358] For example, gray whales migrate to the North Pacific and Bering Sea during the summer. *See* ACIA 2005, *supra* note 25, at 489.

For example, about 280 species of birds breed mainly in the Arctic and migrate there regularly.[359] The species' breeding success in the Arctic determines their abundances in other parts of the world.[360] Many of these waterfowl play an important role in the health of wetlands in other parts of the world. These wetlands and waterfowl provide important uses and benefits to people, including water quality, food provisioning, recreation, and other cultural opportunities.[361] When in the Arctic, many of these species depend on tundra as an important breeding and feeding habitat. As explained above, the area of tundra is predicted to shrink in the Arctic due to climate change as boreal forests and shrub vegetation expand northward.[362] Accordingly, waterfowl that nest in the tundra may be particularly vulnerable to warming,[363] and any negative impacts will be felt both in the Arctic and in the other ecosystems throughout North America and the world in which these birds play important roles.

"The core concern is succinctly stated: climate change endangers human health . . . ."

-Margaret Chan, Director-General of the World Health Organization

4. Residents of other parts of the world are harmed by climate change as well as the disruptions to Arctic peoples and ecosystems it causes.

According to the World Health Organization's Director-General Dr. Margaret Chan, "[t]he core concern is succinctly stated: climate change endangers human health . . . . The warming of the planet will be gradual, but the effects of extreme weather events—more storms, floods, droughts and heat waves—will be abrupt and acutely felt."[364] These effects will be exacerbated by loss of sea ice and other changes in the Arctic. Moreover, the changes to Arctic ecosystems themselves caused by climate change will affect people worldwide.

Most broadly, the health effects of climate change, both direct and indirect, are already being felt across the globe. In 2000, more than 150,000 deaths could be attributed to the effects of climate change from the previous 30 years.[365] In the future, human health is likely to be affected by changing weather patterns, including "temperature, precipitation, sea-level rise and more frequent extreme events" caused by climate change.[366] Indirect impacts, such as changes to "water, air, and food quality and changes in ecosystems, agriculture, industry and settlements and the economy" also are likely to affect human health.[367] Moreover, "health" includes aspects of "physical, mental, and social well-being,"[368] that may be affected by changes in climate and weather.

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[359] *See* ACIA 2005, *supra* note 25, at 259.

[360] *See id.* at 289; ACIA 2004, *supra* note 2, at 45.

[361] Millennium Ecosystem Assessment, *Ecosystems and Human Well-being: Wetlands and Water Synthesis* 1-2 (2005).

[362] *See* ACIA 2004, *supra* note 2, at 45.

[363] Millennium Ecosystem Assessment, *supra* note 361, at 45.

[364] Statement by World Heath Organization Director-General Dr. Margaret Chan, *available at* http://www.finfacts.com/irishfinancenews/article_1013137.shtml.

[365] World Health Organization, Climate & Health Fact Sheet (2005), *available at* http://www.who.int/globalchange/news/fsclimandhealth/en/index.html.

[366] IPCC 2007a, *supra* note 52, at 393.

[367] *Id.*

[368] ACIA 2005, *supra* note 25, at 865.

The World Health Organization has identified several weather changes that may be attributable in part to climate change and that may cause adverse health effects: increased frequency of heatwaves, variation in precipitation patterns that could increase water-borne diseases, rising sea levels increasing risk of coastal flooding, and longer seasons favorable to vector-borne diseases.[369] As climate change continues to accelerate, these impacts to human health are projected to increase. As described above, warming in the Arctic will exacerbate these effects.

Moreover, the Arctic itself is intrinsically valuable:

> The Arctic is magnificent. It is not wilderness, for almost every square kilometer is used, known, and named. Inuit hunters travel hundreds of kilometers for seals, walrus, polar bear, whales, and caribou. Our rich and vibrant traditional knowledge is passed forward from generation to generation. [370]

For those lucky enough to visit the Arctic oceans, the images, sounds, and emotions evoke lasting memories:

> My frigid nights on the sea ice are now a quarter-century in the past, but the intense beauty of that place teaches me still: the luminous nights, the immense graceful curve of a bowhead suddenly breaking the surface of the sea, the collective focus of a flock of murres so large it took several minutes to pass—none of these images has dimmed in my mind. One cannot stare with concentration and anticipation at the polar sea for weeks and come away unchanged . . . . Polar bears roaming the broken ice; a pod of belugas abruptly slashing through the surface of the subpolar sea; the sudden swoop of an ivory gull, its ice-white wings unexpectedly tilting past your face; the steady, urgent migration of seabirds. These experiences echo across the years and sustain a lifelong commitment to conservation.[371]

Others are taken by the dark of night: "Nothing more wonderfully beautiful can exist than the Arctic night. It is dreamland, painted in the imagination's most delicate tints; it is color etherealized. One shade melts into the other, so that you cannot tell where one ends and the other begins, and yet they are all there. No forms—it is all faint, dreamy color music, a far-away, long-drawn-out melody on muted strings."[372]

It is clear, therefore, that people derive benefit from knowing there are wild places on the planet and other cultures inhabiting them.[373] This fact is further reinforced

[369] World Heath Organization, *supra* note 365.

[370] S. Watt-Cloutier et al., *supra* note 5, at 13.

[371] T.L. Fleischner, *Natural History and the Deep Roots of Resource Management*, 45 Nat. Res. J. 1, 12-13 (2005).

[372] Fridtjof Nansen, *The Winter Night from Farthest North* (1897) in The Ends of the Earth, 47-48 (Elizabeth Kolbert ed.) (2007).

[373] Millennium Ecosystem Assessment, *supra* note 361, at 60.

by the 2007 United Nations declaration on the rights of indigenous peoples,[374] the several decades of Congressional debate about the Arctic National Wildlife Refuge, and, more recently, the hundreds of thousands of public comments seeking protection for the polar bear under the Endangered Species Act.[375] By negatively impacting Arctic peoples and ecosystems, climate change is causing harm to people all over the world who care about it.

Polar bears face enormous challenges due to loss of their sea ice habitat.

[374] International Work Group for Indigenous Affairs, Declaration on the Rights of Indigenous Peoples (2007), *available at* http://www.iwgia.org/sw248.asp.

[375] *See* Polar Bear Listing Decision, 73 Fed. Reg. at 28,235.

III. EPA should promulgate comprehensive regulations to control emissions of greenhouse gases.

The Arctic is warming, and that warming is having dramatic effects on people and ecosystems in the Arctic itself, the rest of the United States, and the world. This increased warming—and the associated melting of sea ice, disruptions in traditional lifestyles, changes in world climate, and all of the other effects described above—are caused by human emissions of greenhouse gases.[376] The United States government has taken no significant action to reduce or control these emissions.

Given the harm to the public health and welfare of the Arctic and the rest of the United States being caused by the emissions of greenhouse gases, and the future harm that will result if emissions are not reduced, the Clean Air Act[377] does not allow such inaction. The Clean Air Act is intended to address Congress' "deep concern for protection of the health of the American people,"[378] and "to protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare."[379] Accordingly, the statute is "'preventative' and 'precautionary'"[380] and requires regulation both to address ongoing harms and to control air pollution before harm to the public health or welfare occurs.[381]

To effectuate those goals, the Clean Air Act explicitly grants the Environmental Protection Agency (EPA) the authority and responsibility to regulate emissions of air pollutants from mobile and stationary sources.[382] EPA is empowered to exercise that authority to regulate greenhouse gases if three conditions are satisfied: 1) greenhouse gases are "pollutants" as defined in the Act; 2) emissions of greenhouse gases may reasonably be anticipated to endanger the public health or welfare; and, 3) the mobile and stationary sources of those emissions must cause or contribute to air pollution. In the case of greenhouse gases, three tests are easily satisfied, and EPA must implement comprehensive regulations to control and reduce greenhouse gas emissions.[383]

[376] *See* IPCC 2007a, *supra* note 52, at 5 (stating that "warming of the climate system is unequivocal" and "most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations").

[377] Clean Air Act, 42 U.S.C. §§ 7401-7671q (1990).

[378] *Am. Lung Ass'n v. EPA*, 134 F.3d 388, 388 (D.C. Cir. 1998) (quoting S. Rep. No. 91-1196, at 1 (1970)).

[379] 42 U.S.C. § 7401(b)(1) (1990).

[380] *Am. Lung Ass'n*, 134 F.3d at 389 (quoting *Lead Industries Ass'n, Inc. v. EPA*, 647 F.2d 1130, 1155 (D.C. Cir. 1980)); *see also* H.R. Rep. 95-294, at 49 (1977).

[381] H.R. Rep. 95-294, at 49 (1977).

[382] *See* 42 U.S.C. §§ 7411, 7521-7590 (1990).

[383] Petitioners hereby incorporate the detailed discussion and arguments set forth in two Petitions previously submitted by Oceana and others. These petitions further detail the statutory authority under which regulation is permitted. *See* EPA-HQ-OAR-2008-0318-0046 "Petition for Rulemaking Under the Clean Air Act to Reduce the Emission of Air Pollutants from Marine Shipping Vessels that Contribute to Global Climate Change" submitted October 3, 2007 [hereinafter "Marine Vessels Petition"]; EPA-HQ-OAR-2008-0318-0026 "Petition for Rulemaking Under the Clean Air Act to Reduce the Emission of Air Pollutants From Aircraft that Contribute to Global Climate Change" submitted December 5, 2007 [hereinafter "Aircraft Petition"].

A. EPA is authorized to regulate emissions of air pollutants from both mobile and stationary sources.

The Clean Air Act authorizes EPA to regulate emissions of air pollutants from mobile and stationary sources. The Act describes the conditions under which such regulation is permitted in several separate sections. Though expressed somewhat differently in each section, the same basic test is required: a determination that the pollutant is reasonably anticipated to endanger public health or welfare, and a determination that emissions from the sources cause or contribute to air pollution.

1. Mobile Sources.

Under the Clean Air Act, "mobile sources" include cars, light trucks, heavy trucks and buses, motorcycles, nonroad recreational vehicles, farm and construction machines, lawn and garden equipment, marine engines, aircraft, and locomotives.[384] The Act groups the regulation of emissions from these mobile sources into three categories—on-road vehicles, nonroad vehicles, and aircraft.

On-road vehicles, which include cars, light trucks, heavy trucks and buses, and motorcycles, are regulated under Section 202(a) of the statute.[385] That provision requires EPA to "prescribe (and from time to time revise) . . . standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines, which in his judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare."[386]

Emissions from nonroad vehicles, which range from marine vessels and engines to lawn and garden equipment,[387] are regulated pursuant to Section 213 of the Clean Air Act.[388] Under this provision, EPA sets emissions standards for pollutants from nonroad vehicles once the agency "determines that any emissions [of that pollutant] from new nonroad engines or vehicles significantly contribute to air pollution which may reasonably

[384] *See* Emission Standards for Moving Sources, 42 U.S.C. Subchapter II; Regulating Greenhouse Gas Emissions Under The Clean Air Act, 73 Fed. Reg. 44,354, 44,432 (July 30, 2008) (Advanced Notice of Proposed Rulemaking) (to be codified at 40 C.F.R. Chapter I) [hereinafter ANPR].

[385] 42 U.S.C. § 7521.

[386] *Id.* § 7521(a)(1).

[387] Non-road engines and vehicles also include farm and construction equipment, airport service equipment, and recreational vehicles–like off-road motorcycles, all-terrain vehicles, and snowmobiles. ANPR, 73 Fed. Reg. at 44,462 (All-Terrain Vehicles), 44,432 (off-road motorcycles, snow mobiles, and farm and construction equipment); *see also Bluewater Network v. EPA*, 370 F.3d 1, 7 (D.C. Cir. 2004).

[388] Section 213(a)(3) of the Clean Air Act directs EPA regulate emissions of carbon monoxide, nitrogen oxides, and volatile organic compounds (VOCs) from non-road vehicles. Section 213(a)(4) then allows for the future regulation of additional pollutants, which is the focus of this Petition. 42 U.S.C. §§ 7547(a)(3), (a)(4); *see also* Marine Vessels Petition, *supra* note 383, at 5-6.

be anticipated to endanger public health or welfare[.]"[389]

Finally, Section 231 of the Clean Air Act provides EPA the authority to regulate emissions of air pollutants from aircraft.[390] This section requires EPA to "issue proposed emission standards applicable to the emission of any air pollutant from any class or classes of aircraft engines which in his judgment causes, or contributes to, air pollution which may reasonably be anticipated to endanger public health or welfare."[391] Section 231 requires the EPA to consult with the Administrator of the Federal Aviation Administration when promulgating aircraft emission standards, and Section 232 requires the Secretary of Transportation to prescribe regulations to ensure compliance with those standards.[392]

2. Stationary Sources.

Stationary sources include "any building, structure, facility, or installation which emits or may emit any air pollutant."[393] Under the New Source Performance Standards (NSPS) program, EPA is empowered to set national standards for new and modified stationary sources.[394] This program requires EPA to "publish (and from time to time thereafter . . . revise) a list of categories of stationary sources . . . that cause[], or contribute[] significantly to[] air pollution which may reasonably be anticipated to endanger public health or welfare." [395]

Once a category has been added to the list, EPA has one year to set performance standards for new or modified stationary sources in that category.[396] EPA has developed standards for "more than 70 source categories and subcategories," including sources like fossil fuel-fired boilers, incinerators, sulfuric acid plants, lead smelters, and petroleum refineries. [397] EPA must revise these standards at

[389] 42 U.S.C. § 7547(a)(4). Section 213 envisions a multi-step process to regulation of emissions (that are not carbon monoxide, nitrogen oxides, and volatile organic compounds) from non-road vehicles. First, EPA must determine whether emissions from new nonroad engines or vehicles "significantly contribute to air pollution which may reasonably be anticipated to endanger public health or welfare" as a whole. *Id.* Once the Administrator has made that determination, he may then set regulations for specific "classes or categories of new nonroad engines and new nonroad vehicles" which "cause[] or contribute to" such air pollution. *Id.*

[390] 42 U.S.C. § 7571; *see also* Aircraft Petition, *supra* note 384, at 4.

[391] *Id.* § 7571(a)(2)(A).

[392] *Id.* §§ 7571(a)(2)(B), 7572(a).

[393] 42 U.S.C. § 7411(a)(3).

[394] *See* 42 U.S.C. § 7411(b)(1)(B). Petitioners recognize that § 111 provides two mechanisms for regulation of greenhouse gas emissions: pursuant to an implementation program for National Ambient Air Quality Standards (NAAQS) under Sections 108 and 109 or as a separate program not attached to NAAQS. Petitioners' speak only to the latter, "freestanding program" as identified in the ANPR, 73 Fed. Reg. at 44,486.

[395] 42 U.S.C. § 7411(b)(1)(A).

[396] *Id.* § 7411(a)(1) ("The term 'standard of performance' means a standard for emissions of air pollutants which reflects the degree of emission limitation achievable through the application of the best system of emission reduction which (taking into account the cost of achieving such reduction and any nonair quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated."); *see also id.* § 7411(b)(1)(B) ("Within one year after the inclusion of a category of stationary sources in a list under subparagraph (A), the Administrator shall publish proposed regulations, establishing Federal standards of performance for new sources within such category.").

[397] ANPR, *supra* note 5, at 44,486-87; *see also generally* 40 C.F.R. Part 60.

least every eight years.[398] EPA also has discretion to revise existing standards and, in so doing, may add standards for previously unregulated pollutants.[399]

3. Regulation.

As explained above, the language authorizing regulation of air pollutants from mobile and stationary sources is slightly different. The basic test, however, is the same: EPA may—and in most cases must—regulate sources of air pollutants if emissions of those pollutants may reasonably be anticipated to endanger the public health or welfare and the mobile and stationary sources of those emissions cause or contribute, or significantly cause or contribute, to air pollution. This two-part test, known as the "endangerment test," stems from the 1977 Clean Air Act Amendments.[400] Thus, even though several provisions of the Act state the endangerment test in slightly different iterations, the test "share[s] a common legislative history that sheds light on the meaning of this language."[401]

[398] 42 U.S.C. § 7411(b)(1)(B).

[399] *Id.* § 7411(b).

[400] Pub. L. No. 95-95 § 401, 91 Stat. 790-91 (1977).

[401] ANPR, 73 Fed. Reg. at 44,421. This language specifically

> (1) emphasizes the precautionary or preventive purpose of the CAA; (2) authorizes the Administrator to reasonably project into the future and weigh risks; (3) requires the consideration of the cumulative impact of all sources; (4) instructs that the health of susceptible individuals, as well as healthy adults, should be part of the analysis; and (5) indicates an awareness of the uncertainties and limitations in information available to the Administrator. H.R. Rep. 95–294 at 49–50, 4 LH at 2516–17. Congress also wanted to standardize this language across the various sections of the CAA which address emissions from both stationary and mobile sources which may reasonably be anticipated to endanger public health or welfare.

Id. at 44,422 (citing H.R. Rep. 95–294 at 50, 4 LH at 2517; Section 401 of CAA Amendments of 1977).

B. The Supreme Court has determined that greenhouse gases are air pollutants subject to regulation by EPA.

Under all sections of the Clean Air Act, an "air pollutant" is "any air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive . . . . substance or matter which is emitted into or otherwise enters the ambient air."[402] The Supreme Court has described this definition as "sweeping" and "capacious."[403] It also has resolved conclusively that greenhouse gases are "air pollutants" subject to regulation under the Clean Air Act.[404] According to the Court:

> On its face, the definition embraces all airborne compounds of whatever stripe, and underscores that intent through the repeated use of the word 'any.' Carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons are without a doubt 'physical [and] chemical . . . substance[s] which [are] emitted into . . . the ambient air.' The statute is unambiguous.[405]

Although the Supreme Court made its decision in the context of rejecting EPA's position that it lacked authority to regulate new motor vehicles, the definition of "air pollutant" applies to all sources. Accordingly, the Court's holding would apply to any source of greenhouse gases—stationary or mobile—for which regulation under the Act is allowed. It is clear, therefore, that greenhouse gases are air pollutants subject to regulation under the Clean Air Act.

C. Emissions of greenhouse gases may reasonably be anticipated to endanger the public health and welfare.

Since greenhouse gases are air pollutants, EPA must determine if emissions of those pollutants "may reasonably be anticipated to endanger public health or welfare."[406] The Clean Air Act sets a low bar for EPA in making this determination and allows for regulation based on a conclusion that a pollutant could endanger public health or welfare. Based on the evidence laid out above detailing the current and projected impacts of climate change on the Arctic and the world, greenhouse gases may reasonably be anticipated to endanger both the public health and welfare.

The phrase "may reasonably be anticipated to endanger public health or welfare" is explicitly intended to be precautionary. Indeed, "[t]he meaning of 'endanger' is not disputed. Case law and dictionary definition agree that endanger means something less than actual harm. When one is endangered, harm is threatened; no

[402] 42 U.S.C. § 7602(g).

[403] *Massachusetts v. EPA*, 127 S. Ct. 1438, 1460 & 1462 (2007).

[404] *Id.*

[405] *Id.*

[406] *See* 42 U.S.C. §§ 7411 (stationary sources), 7521 (motor vehicles), 7547 (non-road vehicles), 7571 (aircraft).

actual injury need ever occur."[407] By adopting the "may be reasonably anticipated" language, Congress "buil[t] upon the precautionary and preventative goals already provided in the use of the term 'endanger.' The Administrator is to assess current and future risks rather than wait for proof of actual harm."[408] Thus, "proof of actual harm" is not required, and regulation of air pollution should "precede, and, optimally, prevent the perceived threat."[409]

Moreover, EPA cannot justify a refusal to act to protect the public health or welfare based on uncertainty.

> [R]equiring EPA to wait until it can conclusively demonstrate that a particular effect is adverse to health before it acts is inconsistent with both the Act's precautionary and preventive orientation and the nature of the Administrator's statutory responsibilities. Congress provided that the Administrator is to use his judgment . . . precisely to permit him to act in the face of uncertainty.[410]

"Congress directed the Administrator to err on the side of caution in making the necessary decisions."[411] Indeed, "[a]ll that is required by the statutory scheme is evidence in the record which substantiates [the Administrator's] conclusions about the health effects on which the standards were based."[412]

In this case, emissions of greenhouse gases "may reasonably be anticipated to endanger public health or welfare" by causing warming and climate changes in the Arctic that affect people and ecosystems in the Arctic, the rest of the United States, and the world. As the United States government has recognized, "[w]arming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."[413] It further described "climate change [a]s a serious global challenge."[414] As explained above, dramatic changes as a result of this warming are occurring in the Arctic, which is warming, on average, at about twice the rate as the rest of the world.

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[407] *Ethyl Corp v. EPA,* 541 F.2d 1, 13 (D.C. Cir. 1976).

[408] ANPR, 73 Fed. Reg. at 44,422 (citing H.R. Rep. 95–294 at 51, 4 LH at 2518).

[409] *Ethyl Corp.*, 541 F.2d at 13.

[410] *Lead Industries Ass'n, Inc. v. EPA*, 647 F.2d 1130, 1155 (D.C. Cir. 1980); *see also Am. Lung Ass'n*, 134 F.3d at 389 (stating that "the Administrator must then decide what margin of safety will protect the public health from the pollutant's adverse effects—not just known adverse effects, but those of scientific uncertainty or that 'research has not yet uncovered'").

[411] *Lead Industries Ass'n*, 647 F.2d at 1155.

[412] *Id.*

[413] ANPR, 73 Fed. Reg. at 44,396. *See also Massachusetts v. EPA*, 127 S. Ct. at 1455 ("[T]he NRC Report itself—which EPA regards as an 'objective and independent assessment of the relevant science,' – identifies a number of environmental changes that have already inflicted significant harms, including 'the global retreat of mountain glaciers, reduction in snow-cover extent, the earlier spring melting of rivers and lakes, [and] the accelerated rate of rise of sea levels during the 20th century relative to the past few thousand years.") (citations and punctuation omitted).

[414] ANPR, 73 Fed. Reg. at 44,396.

Increased warming and its associated effects in the Arctic are primarily the result of anthropogenic emissions of greenhouse gases. According to the Intergovernmental Panel on Climate Change (IPCC), an international scientific organization comprised of governments, including the United States, and hundreds of scientists, "most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations[.]"[415] As the Supreme Court noted, EPA "agree[d] with the President that 'we must address the issue of global climate change,'" and supported "various voluntary emission-reduction programs . . . EPA would presumably not bother with such efforts if it thought emissions reductions would have no discernable impact on future global warming."[416]

Warming, caused by emissions of greenhouse gases, already is affecting the public health and welfare.

Warming, caused by emissions of greenhouse gases, already is affecting the public health and welfare. These effects, which will almost certainly worsen in the years to come if emissions are not capped, are described in detail above and only summarized here.[417] In addition, these effects will vary geographically and could disproportionately affect those with limited resources available to adapt to change.

As explained above, warming in the Arctic will almost certainly continue to affect human health in the region. Warming trends may enhance the migration of diseases northward.[418] Warming and sea ice loss are also predicted to affect marine mammals and other subsistence foods, which would affect human health in Arctic communities. If these subsistence foods are less available, chronic health conditions may result from changing to a largely western diet.[419] Sea ice declines, changes in ice conditions, and increased inclement weather also make hunting more difficult, which increases the risks of drowning and hypothermia.

Arctic warming also may reasonably be anticipated to affect the public health in the rest of the world by amplifying climate change and increasing the occurrence of floods and droughts.[420] Amplified climate change also will likely increase the number of heat waves, increase heavy precipitation events, intensify tropical cyclone activity, decrease agriculture in some regions, alter biodiversity, decrease the ability of many ecosystems to provide important services, and increase economic hardship.[421] Projected human health impacts include malnutrition, cardio-respiratory diseases, spread of infectious disease, and increased deaths.[422]

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[415] IPCC 2007a, *supra* note 52, at 10.

[416] *Massachusetts v. EPA*, 127 S. Ct. at 1458 (citation omitted).

[417] *See supra* pp. 25-55.

[418] F. Giorgi & N. Diffenbaugh, *Developing regional climate change scenarios for use in assessment of effects on human health and disease*, 36 Climate Research 141, 141 (2008); *see also* ACIAC 2008, *supra* note 132, at 25.

[419] ACIAC 2008, *supra* note 132, at 25.

[420] *See generally* Sewall, *supra* note 273; *see also* IPCC 2007b, *supra* note 34, at 7.

[421] Intergovernmental Panel on Climate Change, Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate, Summary for Policy Makers 12 (2007) [hereinafter IPCC 2007c].

[422] *Id.*; *see also* National Public Health Week, Climate Change Is a Public Health Issue, *available at*: http://www.nphw.org/nphw08/NPHW%202008%20Blueprint.pdf.

In addition, sea level rise will lead to flooding of coastal areas.[423]

Warming caused by greenhouse gas emissions also may be reasonably anticipated to endanger the public welfare. The Clean Air Act defines "effects on welfare" very broadly:

> All language referring to effects on welfare includes, but is not limited to, effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and personal comfort and well-being, whether caused by transformation conversion, or combination with other air pollutants.[424]

Because it specifically includes the term climate, "effects on welfare" encompasses the warming caused by emissions of greenhouse gases. Moreover, as described above, Arctic climate change is resulting in significant changes to soil, water, vegetation, animals, wildlife, weather, property, transportation, as well as "economic values and personal comfort." Accordingly, warming caused by emissions of greenhouse gases "may be reasonably anticipated to endanger the public welfare."

D. Greenhouse gas emissions from mobile and stationary sources in the United States contribute to global climate change.

Once EPA concludes that pollutants may reasonably be expected to endanger the public health and welfare, it must then determine whether sources "cause or contribute to" air pollution. As stated above, the provisions of the Clean Air Act contain slightly different iterations of the "cause or contribute" language.[425] Generally, however, EPA must focus on the amount or portion of pollution that is contributed by a particular source. With respect to greenhouse gases, the pollution contributed by mobile and stationary sources in the United States satisfies the requisite causal threshold.

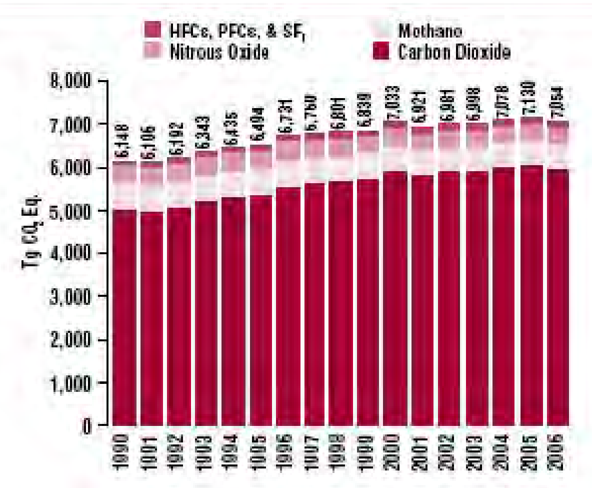
[423] *See* IPCC 2007c, *supra* note 421 at 20; Hansen 2005, *supra* note 57, at 274.

[424] 42 U.S.C. § 7602(h) (emphasis added).

[425] *See supra* pp. 57-59; *see also* Marine Vessels Petition, *supra* note 383, at 16-17 & n. 71 (analyzing the "contribution" language of § 213). In addition, for certain sources or groups of sources, EPA must determine that the source contributes "significantly," and for others, the finding of significance is not required. For motor vehicles, EPA must determine that an air pollutant from any class or classes of new motor vehicles or new motor vehicle engines cause or contribute to air pollution. 42 U.S.C. § 7521(a)(1). For nonroad vehicles and engines, EPA must determine whether the vehicles or engines "significantly contribute" to air pollution and then whether individual class or categories of nonroad vehicles or engines "cause[] or contribute to" air pollution. *Id.* § 7547(a)(4). For aircraft, EPA must determine whether aircraft engines "cause[ ], or contribute[ ] to, air pollution." *Id.* § 7571(a)(2)(A). For stationary sources, EPA must determine if a category of sources "causes, or contributes significantly to, air pollution." *Id.* § 7411(b)(1)(A). Because these sources satisfy the more stringent "significantly contribute" test, the distinction is not explained here.

In the aggregate, in 2006, the United States was responsible for emitting more than 7 billion metric tons of greenhouse gases.[426] As of 2004, the United States accounted for approximately 22 percent of carbon dioxide emissions worldwide.[427] In 2000, United States emissions of methane (CH_4) and nitrous oxide (N_2O) accounted for 9.5 and 12.4 percent of the global total, respectively, and just over a third of global hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexaflouride (SF_6) combined emissions came from the United States.[428] The United States also accounts for roughly 6 percent of global emissions of black carbon-containing soot emissions.[429]

Greenhouse Gas Emissions by Gas 1990-2004[430]



These emissions have been rising steadily just in the last decade and are projected to continue to increase.[431] "Overall, total U.S. GHG emissions have risen by 14.7% from 1990 to 2006."[432]

Indeed, absent some change in practice, gross emissions of greenhouse gases from the United States are projected to rise an additional 30 percent between 2000 and 2020.[433] As the federal government has acknowledged, "[f]uture projections show that, for most scenarios assuming no additional GHG emission reduction policies, atmospheric concentrations of GHGs are expected to continue climbing for

[426] *See* ANPR, 73 Fed. Reg. at 44,401; Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006, at ES-6 (April 15, 2008) *available at* http://www.epa.gov/climatechange/emissions/downloads/08_ES.pdf. [hereinafter EPA Inventory]. These emissions are measured in "CO_2 equivalents," which standardizes the measurements according to the gases' warming potential. In addition, approximately 900 million metric tons of these emissions were subsumed by "carbon sinks" and, therefore, did not reach the atmosphere. *Id.*

[427] Energy Information Administration, *Emissions of Greenhouse Gases in the United States Report 2006*, DOE/EIA-0573(2006), Table 3 (November 2007), *available at*: http://www.eia.doe.gov/oiaf/1605/ggrpt.

[428] *See* EPA, 2006 Global Anthropogenic Non-CO_2 Greenhouse Gas Emissions: 1990-2020, June 2006 Revised, at 1-3 & Table 1-2 (2006); *see also* EPA Inventory, *supra* note 426, at 2-3 – 2-4.

[429] *Hearing on Black Carbon and Arctic, Before H. Comm. on Oversight and Government Reform*, 110th Cong. (2007) (statement of Mark Z. Jacobson) Table 3, *available at*: http://oversight.house.gov/story.asp?ID=1550. This information excludes aircraft and shipping, which are major contributors of black carbon.

[430] EPA, GHG Fast Facts, Inventory of U.S. Greenhouse Gas Emissions and Sinks (2008), *available at*: http://www.epa.gov/climatechange/emissions/downloads/2008_GHG_Fast_Facts.pdf.

[431] *Id.*; United States Department of State, Fourth Climate Action Report to the UN Framework Convention on Climate Change—Chapter 5 63-64 (2006) [hereinafter Fourth Climate Action Report].

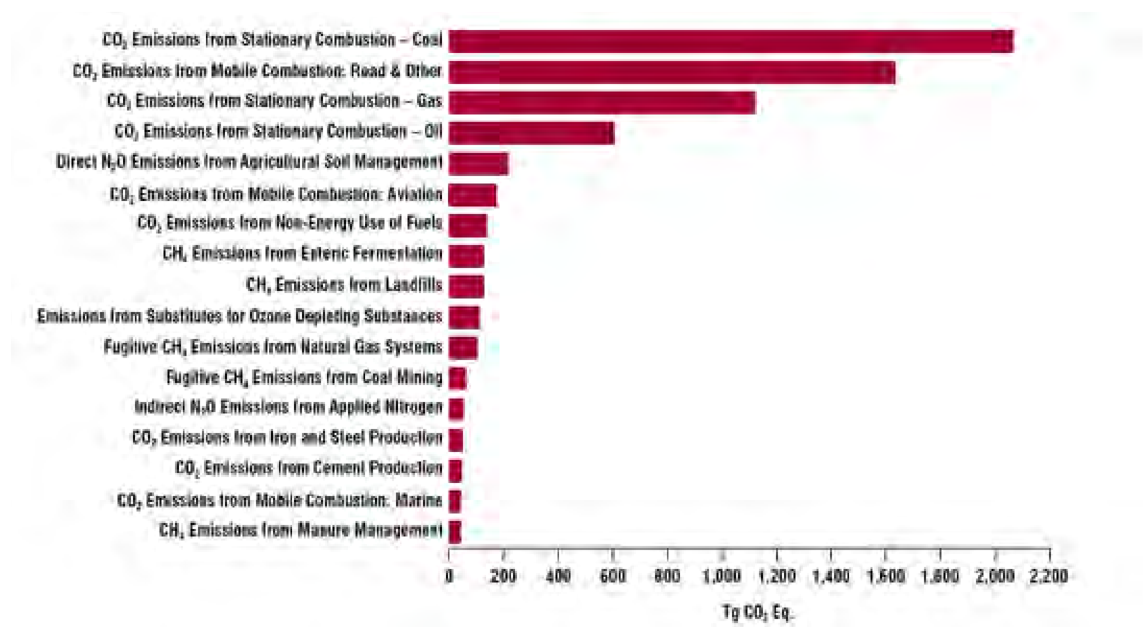
[432] ANPR, 73 Fed. Reg. at 44,401 ("Greenhouse gases" are abbreviated GHG.).

[433] *See* Fourth Climate Action Report, *supra* note 431, at 64.

most if not all of the remainder of this century, with associated increases in average temperature" and that "[o]verall risk to human health, society and the environment increases with increases in both the rate and magnitude of climate change."[434] Accordingly, greenhouse gas emissions in the United States clearly contribute significantly to climate warming and will continue to do so in the future.

EPA has identified 17 "key categories" of sources of greenhouse gas emissions for the years 1990-2006.[435] "By definition, key categories are sources . . . that have the greatest contribution to the absolute overall level of national emissions[.]"[436] For 2006, the 17 key categories together account for 95 percent of the United States' greenhouse gas emissions.[437] These 17 categories and their contributions to United States emissions are depicted in the figure below. Mobile and stationary sources of emissions subject to regulation under the Clean Air Act are clearly significant and cause and contribute to air pollution. By regulating these sources, EPA could substantially reduce emissions of greenhouse gases.

Key Sources of US Greenhouse Gas Emissions, 2006[438]



For purposes of developing regulations, it may be useful to organize the emissions by economic sector. EPA has taken that approach in its emissions inventory: "[a]ll U.S. [greenhouse gas] sources can be grouped into the electricity, industrial, commercial, residential, transportation and agriculture sectors. Additionally, there are changes in carbon stocks that result in emissions and sinks associated with land-use and land-use change activities."[439]

[434] ANPR, 73 Fed. Reg. at 44,396

[435] *See* EPA Inventory, *supra* note 426, at 1-12 – 1-13 & Table 1-4.

[436] *Id.* at ES-19.

[437] *See infra* note 440.

[438] EPA Inventory, *supra* note 426, at Figure ES-16.

[439] *Id.* at 44,402.

Overview of Greenhouse Gas Emissions by Sector[440]

Sector/Activity		GHG Emissions (Tg CO_2 Eq.)							
		CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total	%
Energy: Stationary		3970	200.7	14.7				4185	59.3
	Coal Combustion	2065	0.7	10.1				2076	29.4
	Natural Gas Combustion	1122	0.9	0.6				1123	15.9
	Petroleum/Oil Combustion	594.3	0.7	1.1				596.1	8.5
	Non-Energy Use, Fossil Fuels	138						138	2.0
	Natural Gas Systems	28.5	102.4					130.9	1.9
	Coal Mining		58.5					58.5	0.8
	Petroleum Systems	0.3	28.4					28.7	0.4
	Municipal Solid Waste Comb.	20.9		0.4				21.3	0.3
	All Other Sources	0.4	9.1	2.5				12.0	0.2
Energy: Mobile		1856	2.5	33.1				1892	26.8
	Road and Other	1643	2.2	31				1676	23.8
	Aviation	170.6	0.2	1.7				172.5	2.4
	Marine Transport	42.4	0.1	0.4				42.9	0.6
Agricultural Uses			174.4	279.8				454.2	6.4
	Agricultural Soil Management			265				265	3.8
	Enteric Fermentation		126.2					126.2	1.8
	Manure Management		41.5					41.5	0.6
	All Other Sources		6.7	14.8				21.5	0.3
Industrial Processes		149.5	1.9	21.5	124.5	6.1	17.4	320.9	4.5
	Subs. of Ozone Depl. Subs.				110.4			110.4	1.6
	Iron and Steel Production	49.1						49.1	0.7
	Cement Manufacture	45.7						45.7	0.6
	HCFC-22 Production				13.8			13.8	0.2
	Electrical Trans. And Dist.						13.2	13.2	0.2
	Ammonia Man/Urea Cons.	12.4						12.4	0.2
	Aluminum Production	3.9				2.5		6.4	0.1
	Adipic Acid Production			5.9				5.9	0.1
	All Other Sources	38.4	1.9	15.6	0.3	3.6	4.2	64	0.9
Waste			151.2	9.9				161.1	2.3
	Landfills		125.7					125.7	1.8
	Wastewater Treatment			8.1				8.1	0.1
	All Other Sources		25.5	1.8				27.3	0.4
Land Use/Forestry, Solvent Use		8	24.6	8.7				41.3	0.6
Total Emissions									
	17 2006 Key Categories	5870	454.3	265	110.4			6700	95.0
	All Emissions	5983	555.3	367.7	124.5	6.1	17.4	7054	100.0
	All Emissions Minus Sinks	5100	555.3	367.7	124.5	6.1	17.4	6171	

[440] This information is extracted from EPA Inventory, *supra* note 426, at 2-3 - 2-4 & Table 2-1. All activities except 'Other' are Key Categories for the United States (1994-2006). Totals may not be precise due to independent rounding, and blank cells indicate no emissions.

E. The government's actions to date have been insufficient.

Despite the clear evidence that climate change is occurring and being caused by human emissions of greenhouse gases, the United States government has thus far refused to take action to reduce emissions. This failure goes back more than three decades and has continued with the recent issuance of an Advanced Notice of Proposed Rulemaking (ANPR) in which EPA "seeks comment on analyses and policy alternatives regarding greenhouse gas (GHG) effects and regulation under the Clean Air Act."[441]

The United States government has thus far refused to take action to reduce emissions of greenhouse gases.

The federal government first "began devoting serious attention to the possibility that carbon dioxide emissions associated with human activity could provoke climate change" in the 1970s, and in 1978, Congress enacted the National Climate Program Act "which required the President to establish a program to 'assist the Nation and the world to understand and respond to natural and man-induced climate processes and their implications.'"[442] The resulting study by the National Research Council "was unequivocal: 'If carbon dioxide continues to increase, the study group finds no reason to doubt that climate changes will result and no reason to believe that these changes will be negligible . . . . A wait-and-see policy may mean waiting until it is too late.'"[443]

In 1987, "Congress directed EPA to propose to Congress a 'coordinated national policy on global climate change,' and ordered the Secretary of State to work 'through the channels of multilateral diplomacy' and coordinate diplomatic efforts to combat global warming."[444] In 1992, the first President Bush attended the "Earth Summit" and signed the United Nations Framework Convention on Climate Change (UNFCCC), which is "a nonbinding agreement among 154 nations to reduce atmospheric concentrations of carbon dioxide and other greenhouse gases for the purpose of 'prevent[ing] dangerous anthropogenic [i.e., human-induced] interference with the [Earth's] climate system.'"[445]

Five years later, in 1997, the UNFCCC signatories met and adopted the Kyoto Protocol, which "assigned mandatory targets for industrialized nations to reduce greenhouse gas emissions."[446] The United States did not sign the protocol.

Thus, the United States had taken no concrete action to reduce greenhouse gas emissions by 1999, when the International Center for Technology Assessment and 18 other environmental and renewable energy organizations submitted a petition to EPA seeking the regulation of greenhouse gases from new motor vehicles pursuant to section 202(a)(1) of the Clean Air Act.[447] In 2003, EPA denied that

[441] ANPR, 73 Fed. Reg. at 44,354.

[442] *Massachusetts v. EPA*, 127 S. Ct. at 1448 (citations and punctuation omitted).

[443] *Id.* (quoting Climate Research Board, Carbon Dioxide and Climate: A Scientific Assessment, p vii (1979)).

[444] *Id.* (citations omitted)

[445] *Id.*

[446] *Id.* at 1449.

[447] *Id.* at 1462.

petition, giving two reasons: first that "contrary to the opinions of its former general counsels," greenhouse gases are not "air pollutants" subject to regulation under the Clean Air Act and, second, "that even if the agency had the authority to set greenhouse gas emission standards, it would be unwise to do so at this time."[448] The petitioners challenged this decision, and the case was decided by the United States Supreme Court.

As explained above, the Supreme Court dismissed EPA's first argument, concluding that greenhouse gases are air pollutants.[449] The Court similarly dismissed EPA's second assertion, described by the Court as "a laundry list of reasons not to regulate"[450] and stated that those reasons "have nothing to do with whether greenhouse gas emissions contribute to climate change. Still less do they amount to a reasoned justification for declining to form a scientific judgment."[451]

Upon rejecting EPA's reasons for denying the petition, the Supreme Court directed EPA to comply with the law:

> Under the clear terms of the Clean Air Act, EPA can avoid taking further action only if it determines that greenhouse gases do not contribute to climate change or if it provides some reasonable explanation as to why it cannot or will not exercise its discretion to determine whether they do.[452]

That decision was issued in April 2007. In the time since, EPA has not made the determination required.

Instead, EPA released the ANPR on July 30, 2008 seeking public comment on issues related to the potential regulation of greenhouse gas emissions under the Clean Air Act.[453] The ANPR discusses EPA's work to date in response to the Supreme Court's decision in Massachusetts v. EPA and some possible approaches for regulating emissions under the Clean Air Act.[454] The ANPR also discusses and seeks comments on seven petitions submitted to the EPA from states, localities, and environmental organizations, seeking regulation of emissions of greenhouse gases from mobile sources under the Clean Air Act.[455]

[448] *Id.* at 1450.

[449] *Id.* at 1459-60.

[450] *Id.* at 1462. The Court recited several of the reasons given:

> EPA said that a number of voluntary executive branch programs already provide an effective response to the threat of global warming, that regulating greenhouse gases might impair the President's ability to negotiate with "key developing nations" to reduce emissions, and that curtailing motor-vehicle emissions would reflect "an inefficient, piecemeal approach to address the climate change issue[.]"

Id. at 1462-63 (citations omitted).

[451] *Id.* at 1463.

[452] *Id.* at 1462.

[453] ANPR, 73 Fed. Reg. 44,354.

[454] *Id.* at 44,397-98.

[455] *Id.* at Parts VI, VII, and VIII. The ANPR also discusses the relevant public comments and legal challenges the EPA is also involved in regarding potential regulation of greenhouse gases.

The ANPR, however, does not reflect any decisions or policy recommendations by the EPA as to whether or how greenhouse gases should be regulated. It only requests public comment regarding the many opinions of federal agencies, legal questions, and policy choices that regulation of greenhouse gases by EPA would involve. The ANPR includes an introduction from the EPA Administrator that reflects an agency still in denial about the size and scope of the problem:

> I believe the ANPR demonstrates the Clean Air Act, an outdated law originally enacted to control regional pollutants that cause direct health effects, is ill-suited for the task of regulating global greenhouse gases. Based on the analysis to date, pursuing this course of action would inevitably result in a very complicated, time consuming and, likely, convoluted set of regulations. These rules would largely pre-empt or overlay existing programs that help control greenhouse gas emissions and would be relatively ineffective at reducing greenhouse gas concentrations . . . .[456]

As explained above, the Supreme Court rejected these precise contentions. Moreover, while the Administrator may believe the Clean Air Act to be an imperfect tool, the fact remains that it is the only tool available with which to regulate greenhouse gas emissions.

The ANPR simply creates more process without substance and does not address the problem. As a result, no action is being taken that will result in actual regulation or reduction of greenhouse gas emissions.

[456] *Id.* at 44,355.

IV. The United States must regulate greenhouse gases in order to establish itself as a world leader in the effort to reduce atmospheric greenhouse gas concentrations to below 350 parts per million.

Climate "is nearing dangerous tipping points. Elements of a 'perfect storm', a global cataclysm, are assembled."

-Dr. James Hansen

Climate change in the Arctic coupled with the continued lack of action to control greenhouse gas emissions is likely to trigger planetary change humans cannot control. As Dr. James Hansen, one of the world's leading experts on climate change stated in testimony to Congress, "climate is nearing dangerous tipping points. Elements of a 'perfect storm', a global cataclysm, are assembled."[457] To avert this crisis, fundamental change is required, and, while it is difficult to determine the scope of all changes required, even Dr. Hansen "argue[s] that a path yielding energy independence and a healthier environment is, barely, still possible."[458]

Discussions of this issue have focused on the change in degrees, over a particular period of time, that could be endured by the climate system. Dr. Hansen and his colleagues[459] as well as Drs. Cao and Caldeira[460] have provided a more concrete framework within which to understand the implications of increasing anthropogenic greenhouse gas concentrations and a benchmark atmospheric concentration of CO_2 for which to strive. They begin from the premise that global environmental changes, including the rapid and alarming loss of Arctic sea ice and acidification of the planet's oceans, demonstrate clearly that greenhouse gases in the atmosphere are having substantial, negative effects on the planet. Accordingly, atmospheric concentrations of carbon dioxide, which have increased from 275 parts per million (ppm) before the industrial revolution to 385 ppm today—and continue to increase at a rate of 2 ppm per year—are too high.[461]

Using paleoclimate data and other evidence, these same scientists conclude that to "preserve a planet similar to that on which life on Earth is adapted," including rebuilding Arctic sea ice and stopping ocean acidification, atmospheric carbon dioxide concentrations must be reduced to no more than 350 ppm.[462] As Dr. Hansen stated to Congress, "We must draw down atmospheric carbon dioxide to preserve the planet we know."[463] Further, this reduction must take place quickly because the longer the planet remains in its current state of imbalance, the harder it will become to maintain.[464]

Reducing atmospheric carbon dioxide concentrations to no more than 350 ppm and reducing emissions of other greenhouse gases will require fundamental change. Of course, regulation of United States emissions of greenhouse gases under the Clean Air Act, by itself, will not achieve this goal. It is, however, a necessary first step,

[457] Hansen testimony, *supra* note 1, at 1.
[458] *Id.*
[459] *See* Hansen et al., *supra* note 6.
[460] *See* Cao & Caldeira, *supra* note 6.
[461] Hansen et al., *supra* note 6, at 2.
[462] *Id.* at 1; *see also* Cao & Caldeira, *supra* note 6.
[463] Hansen testimony, *supra* note 1, at 2.
[464] *See* Hansen et al., *supra* note 6.

and the United States must put into place a comprehensive system of regulations to reduce its greenhouse gas emissions. Opponents of such regulation have argued that it will negatively affect the United States' economy. The economic and social costs of failing to act, however, far outweigh those concerns, and in establishing regulations, EPA must consider economic impacts and craft a system that creates new opportunities. Further, EPA must act equitably to ensure that any regulatory burden is not shouldered disproportionately.

Once the United States has begun the process of capping its own emissions, it must use that example to become a world leader in the effort to reduce atmospheric carbon dioxide concentrations to no more than 350 ppm. The United States, as the wealthiest nation and biggest contributor of greenhouse gases, is uniquely situated to play this role. As it did during World War II, the United States can—and must—lead the world through a global crisis.

A. The United States must implement a comprehensive regulatory structure to reduce greenhouse gas emissions that is equitable and strives to maintain economic opportunities.

Though EPA has both the authority and responsibility to regulate greenhouse gas emissions from mobile and stationary sources, it has thus far refused to take action. Comprehensive regulations are required to begin the process toward reducing atmospheric carbon dioxide concentrations to below 350 ppm and reduce emissions of other anthropogenic greenhouse gases in order to preserve "the planet we know."

The United States has been the largest contributor to worldwide emissions of greenhouse gases.[465] Accordingly, its citizens must take personal responsibility to reduce emissions and find ways to live more sustainably. Collectively, individual actions—such as changing to compact fluorescent light bulbs, conserving electricity, carpooling, keeping a vehicle properly tuned up and others—can make a significant difference.

While necessary, however, this personal responsibility will not be enough by itself to address the United States' emissions. In 2006, almost 34 percent of all United States greenhouse gas emissions resulted from electricity generation. Primarily, these emissions resulted from burning coal in power plants.[466] Similarly, industrial facilities were responsible for nearly 20 percent of all greenhouse gas emissions.[467] To achieve substantial reductions in emissions on a national scale, these and other facilities must transition away from burning fossil fuels and toward sustainable energy sources. That transition will require a strong federal commitment and comprehensive national investment and oversight.

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465 *See supra* pp. 63-66.

466 ANPR, 73 Fed. Reg. at 44,402.

467 *Id.* at 44,403.

As it undertakes that process, however, the federal government must carefully balance potential impacts to the economy. In fact, the Clean Air Act specifically requires EPA to consider the costs of any measures it requires. For example, in setting standards for non-road vehicles, EPA must "tak[e] into account costs, noise, safety, and energy factors associated with the application of technology."[468] Accordingly, EPA will be required to consider economic impacts and structure the regulations and timing of implementation accordingly.

This approach is not unprecedented. The United States overcame significant economic issues when it required seat belts in automobiles and banned lead from gasoline. In both cases, certain sectors of industry argued that the economic ramifications would be dire. The regulations were structured in such a way as to avoid those problems, and these safety standards are now taken for granted.[469]

Moreover, the potential economic consequences of taking no action to address climate change are severe. According to United States Government Accountability Office (GAO), "climate change has implications for the fiscal health of the federal government, affecting federal crop and flood insurance programs, and placing new stresses on infrastructure and natural resources."[470] Further,

> the economic costs of unchecked global warming will be severe. Precise quantification is difficult given the myriad uncertainties and subjective judgments involved in making such calculations. In 2007, the IPCC estimated that global warming could lead to continuing global GDP losses of one to five percent and even greater losses at the regional and local levels.
>
> The least developed countries are by far the most vulnerable to climate change. Increased flooding could wipe out low-lying areas in countries such as Bangladesh, and worsening drought would devastate countries in sub-Saharan Africa. Emerging industrial powerhouses, such as China, are also highly vulnerable to the fallout from global warming, including extreme weather, disease, and reduced agricultural productivity. Yet these countries are understandably loath to bear the burdens of transitioning to clean economies while wealthy countries continue to pollute apace.[471]

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[468] 42 U.S.C. § 7547(a)(4); *see also id.* § 7411(a) (stating that "standard[s] of performance" must take into account "the cost of achieving such reduction"); §§ 7521(a)(2), 7571(b) (requiring EPA to set the date for implementation "giving appropriate consideration to the cost of compliance within such period.").

[469] *See, e.g.*, 42 U.S.C. § 7545(n) (prohibition on leaded gasoline).

[470] Expert Opinion on the Economics of Policy Options to Address Climate Change, U.S. General Accounting Office, GAO-08-605, 1 (2008) [hereinafter "GAO Report"].

[471] C.F. Bales & Richard D. Duke, C*ontaining Climate Change: An Opportunity for U.S. Leadership* 87(5) Foreign Affairs 78, 78-79 (September/October 2008).

The United States can avoid at least some of this economic impact by reducing its greenhouse gas emissions. "[M]any scientists believe slowing the increase in global mean temperatures and the related rise in sea level may limit damage to coastal areas, which are home to the majority of the U.S. population and account for nearly one-third of the gross domestic product."[472]

In addition to national economic concerns, the government must also consider local and cultural issues when establishing regulations. Arctic communities, for example, are feeling the impacts of climate change most concretely. These communities, which have done little to cause these changes, are already struggling to adapt as Arctic ecosystems and traditional hunting and fishing areas are affected. These changes threaten the subsistence lifestyle that has existed in these communities since time immemorial by making it more difficult and dangerous to gather food and carry out traditional cultural practices. In addition, changes in the Arctic threaten the very physical existence of these villages as coastal erosion and rising sea levels threaten to wash them into the ocean.

The United States must first get its house in order, then engage in a major international effort to reduce atmospheric greenhouse gas concentrations.

Thus, warming is threatening the very existence of Arctic communities and their cultures. To fulfill its moral and legal obligation to protect this way of life, the United States must reduce its greenhouse gas emissions. Moreover, in so doing, the government must be careful to minimize the economic impact on small villages that can least afford it. So long as it is begun in the very near future, a phased approach, like the one taken for seat belts and leaded gasoline, would be preferable.

[472] GAO Report, *supra* note 470, at 5.

B. The United States must establish itself as a world leader.

The United States has the ability and infrastructure to help spur collective action.

Clearly, regulation under the Clean Air Act of United States emissions of greenhouse gases will not, by itself, reduce atmospheric carbon dioxide concentrations to below 350 ppm. That fact, however, is not an excuse for the United States' continued inaction. Rather than waiting for the rest of the world to act, the United States must first get its house in order, then engage in a major international effort to reduce atmospheric greenhouse gas concentrations.

The Supreme Court rejected the notion that EPA can refuse to regulate greenhouse gases under the Clean Air Act because it cannot accomplish the entire goal itself.[473] The Court went on to state:

> But EPA overstates its case. Its argument rests on the erroneous assumption that a small incremental step, because it is incremental, can never be attacked in a federal judicial forum. Yet accepting that premise would doom most challenges to regulatory action. Agencies, like legislatures, do not generally resolve massive problems in one fell regulatory swoop. . . . They instead whittle away at them over time, refining their preferred approach as circumstances change and as they develop a more-nuanced understanding of how best to proceed. . . . That a first step might be tentative does not by itself support the notion that federal courts lack jurisdiction to determine whether that step conforms to law. [474]

The Court concluded, "Nor is it dispositive that developing countries such as China and India are poised to increase greenhouse gas emissions substantially over the next century: A reduction in domestic emissions would slow the pace of global emissions increases, no matter what happens elsewhere."[475] Thus, the Clean Air Act clearly requires regulation.

Further, the United Nations Framework Convention on Climate Change, of which the United States is a member, binds signatories to take action to "prevent dangerous anthropogenic interference with the climate system."[476] The Convention urges the Parties to "protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof."[477]

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[473] *See Massachusetts v. EPA*, 127 S. Ct. at 1461-62 (rejecting EPA's argument "that it cannot regulate carbon dioxide emissions from motor vehicles because doing so would require it to tighten mileage standards, a job (according to EPA) that Congress has assigned to DOT").

[474] *Id.* at 1457 (citations omitted); *see also Williamson v. Lee Optical of Okla., Inc.*, 348 U.S. 483, 489 (1955) ("[A] reform may take one step at a time, addressing itself to the phase of the problem which seems most acute to the legislative mind.").

[475] *Id.* at 1458. The Supreme Court also rejected EPA's contention that it could "avoid its statutory obligation by noting the uncertainty surrounding various features of climate change and concluding that it would therefore be better not to regulate at this time." *Id.* at 1463.

[476] United Nations Framework Convention on Climate Change art. 2, 31 I.L.M. 849 (May 9, 1992).

[477] *Id.* at Art. 3.

The United States must take action to fulfill these mandates by implementing comprehensive national regulations for greenhouse gas emissions. It must then use that example to engage other countries in an international effort to reduce atmospheric greenhouse gas concentrations.

As the wealthiest nation in the world, the United States is uniquely situated to take on this leadership role and, as it did during World War II, lead the world through this global crisis. The United States has the ability and infrastructure to help spur collective action by the international community. It can help create the technology and standards necessary to combat global climate change. The United States' leadership will make it more likely that the rest of the world will join a robust and directed effort to reduce greenhouse gas emissions. The United States must be seen as a nation working towards protection of the global climate system rather than as part of the problem.[478]

Other countries will follow the United States' lead:

> As with the ozone problem, developing countries can be allowed limited extra time to reduce emissions. They will cooperate: they have much to lose from climate change and much to gain from clean air and reduced dependence on fossil fuels.
>
> We must establish fair agreements with other countries. However, our own tax and dividend should start immediately. We have much to gain from it as a nation, and other countries will copy our success.[479]

The United States must begin this process now by establishing a comprehensive system of regulations to control and reduce greenhouse gas emissions.

[478] P.G. Harris, Collective Action on Climate Change: The Logic of Regime Failure, 47 Nat. Resources J. 195, *220 (2007). Addressing climate change, even unilaterally, also makes economic sense. A majority of a GAO panel of experts "agreed that the United States should establish a price on greenhouse gas emissions as soon as possible, regardless of the extent to which other countries adopt similar policies." See GAO Report, *supra* note 470, at Highlights p. 1. The experts also "said that it was important for the United States to participate in international negotiations to facilitate climate agreements or to enhance the credibility or influence of the United States." *Id.*

[479] Hansen testimony, *supra* note 1, at 4.

Conclusion

The science is sound, the law is clear, and the need for policy change is indisputable: the United States must take immediate action to reduce greenhouse gas emissions in order to protect the public health and welfare of the Arctic and, ultimately, the planet. As a first step, Petitioners request that EPA abide its obligations under the law by:

1. Making a finding that emissions of greenhouse gases may reasonably be anticipated to endanger the public health and welfare and that mobile and stationary sources cause or contribute to this air pollution; and

2. Promulgating comprehensive regulations to reduce greenhouse gas emissions from mobile and stationary sources pursuant to Clean Air Act sections 202(a), 213(a)(4), 231, and 111(b).

The world must move away from a carbon and fossil fuel-based economy to a sustainable way of living and the United States has both the responsibility and opportunity to lead the way. The task begins in the Arctic, which is telling an important story, perhaps the most important story, about human lives and the world. It provides the measure for our successes and failures in addressing climate change.

EPA must develop a comprehensive, measurable trajectory to reduce greenhouse gas emissions and lead the world toward reducing atmospheric CO_2 to below 350 ppm. It is not too late to begin the process, but there is no longer time to waste. "[A] path yielding energy independence and a healthier environment is, barely, still possible. It requires a transformative change of direction in Washington in the next year."[480]

[480] *Id.* at 1.

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