
PETITION

of

Our Children

to the

Washington State Department of Ecology

For the promulgation of a rule to recommend to the Legislature an effective emissions reduction trajectory that is based on best available climate science and will achieve safe atmospheric concentrations of carbon dioxide by 2100.

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On Behalf of Youth Petitioners

June 17, 2014

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Re: Petition For Promulgation of a Rule to Recommend to the Legislature an Effective Emission Reduction Strategy that is Based on Best Available Climate Science and Aimed at Restoring a Concentration of 350 ppm Atmospheric Carbon Dioxide by 2100.

On behalf of the youth petitioners, I hereby submit the following Petition for Rulemaking.

Climate change and ocean acidification are the most pressing and dangerous issues of our time. The harmful impacts of climate change and ocean acidification are already being felt in Washington and are a direct result of human activity primarily due to excessive carbon dioxide emissions. Climate change, ocean acidification, and their associated adverse effects will continue to occur unless decisive, immediate and bold action is taken. Anthropogenic climate change is threatening the stability of the global climate system and ocean acidification is occurring at a geologically unprecedented rate. Best available climate science finds that atmospheric carbon dioxide levels must be reduced from the current global annual mean concentration of 397 ppm to 350 ppm by 2100 in order to achieve climate stabilization and protect our oceans from catastrophic acidification.

The State of Washington has an affirmative and mandatory duty to protect its natural resources for future generations under the Public Trust Doctrine as inherent rights embodied in and protected by the common law and the Washington State Constitution.¹ As stated in Article 17, Section 1 of the Washington Constitution: “The state of Washington asserts its ownership to the beds and shores of all navigable waters in the state up to and including the line of ordinary high tide, in waters where the tide ebbs and flows, and up to and including the line of ordinary high water within the banks of all navigable rivers and lakes”² This constitutional provision “was but a formal declaration by the people of rights which our new state possessed by virtue of its sovereignty” and embodies the Public Trust Doctrine, an inalienable and constitutionally-based doctrine that requires all sovereign governments to prevent substantial impairment of essential natural resources owned in trust on behalf of present and future generations.³

¹ Wash. Const. art. I, § 30 (“The enumeration in this Constitution of certain rights shall not be construed to deny others retained by the people.”).

² Wash. Const. art. XVII, § 1.

³ *Caminiti v. Boyle*, 732 P.2d 989, 993 (Wash. 1987).

In 43.21A.010, the legislature recognized that “it is a fundamental and inalienable right of the people of the state of Washington to live in a healthful and pleasant environment and to benefit from the proper development and use of its natural resources.” To fulfill that policy, the legislature created the Department of Ecology (“Department”) to manage Washington’s natural resources “in a manner that will protect and conserve our clean air, our pure and abundant waters, and the natural beauty of the state.” RCW 43.21A.010. Under existing law, the Department has the mandatory statutory obligation, reiterated in the form of an Executive Order directive by the Governor, to make recommendations regarding the State’s statutory greenhouse gas emission reductions to the legislature. The public’s inherent rights to protected natural resources, including tidelands, shorelands and the wildlife therein, state waters, and the atmosphere, are directly implicated and impacted by the Department’s actions. To protect youth petitioners’ inherent and constitutional rights, the Department must adopt carbon dioxide emission reductions and make equivalent recommendations based upon public input and the best available climate science.

REQUEST FOR ADOPTION OF A RULE

Youth petitioners hereby submit this petition for rulemaking on behalf of themselves, the citizens of the State of Washington, and present and future generations of children, pursuant to the Washington Administrative Procedure Act (APA), chapter 34.05 RCW and Washington Administrative Code section 82-05.⁴ This petition conforms to all rules governing rulemaking petitions before the Department of Ecology. In addition to the form for petitioning supplied by the Office of Financial Management, the petition provides: the name of the agency responsible for administering the rule, an overview of the proposed rule; a detailed description of the youth petitioners; a statement of reasons for the proposed rule, including the factual and scientific bases and the legal bases for the proposed rule; the proposed text of the new rule; and a detailed explanation of why the proposed regulatory language is consistent with and based upon the best available science. Sections A, B, C, D, and E of this petition include the reasons petitioners are requesting this action with the scientific and factual justifications supporting this request. Sections F and G contain the legal principles and justifications for this request.

Overview of the Proposed Rule

The petitioners respectfully request that the Washington State Department of Ecology promulgate a rule that fulfills the Department’s legal obligation to both provide recommendations to the legislature to update the State’s statutory greenhouse gas (GHG) emissions limits and implement science-based emissions limits to put Washington on the global climate stabilization trajectory. The proposed rule also meets the Department’s obligation to limit greenhouse gas emissions in a manner that will protect the integrity of Washington’s and the Earth’s atmosphere, oceans, and climate system, and other state public trust resources, upon which all Washingtonians rely for their health, safety, sustenance, and security. RCW 43.21A.010.

The proposed rule is designed to achieve the Department’s legal obligations by including

⁴ Wash. Admin. Code § 82-05 (2003).

recommendations to update Washington’s greenhouse gas emissions limits to reflect the best available climate science, which requires the State to set its carbon dioxide emission reductions on a global trajectory to return carbon dioxide concentrations to 350 ppm by 2100 and achieve at least an eighty percent (80%) reduction from Washington’s 1990 carbon dioxide emissions by 2050. The GHG emission limits must be updated for Washington to achieve a four percent (4%) annual reduction in overall carbon dioxide emissions. The Department should also take action to provide a biennial accounting of state carbon dioxide emissions, separate from its carbon dioxide equivalent reporting, and assist other state agencies and entities with carbon dioxide reductions.

The Department has the authority to promulgate this rule and the statutory obligation to do so in order to protect Washington’s citizens and natural resources from the worsening effects of climate change and ocean acidification. By putting Washington on a carbon dioxide emission reduction trajectory back to concentrations of 350 ppm, the Department will be fulfilling its constitutional and statutory obligations to protect the State’s natural resources and citizens from the harmful effects of climate change, as well as the Governor’s mandate “to do our part in preventing further climate change, to capture the job growth opportunities of a clean energy economy, and to meet our obligation to our children and future generations.”⁵

The Petitioners

Zoe and Stella Foster

Zoe Foster is finishing the 7th grade at Hamilton International Middle School in Seattle, Washington. Despite only being 12 years old, Zoe is already an accomplished environmental advocate. She is a member of the Plant-For-The-Planet club at school and has planted trees at Carkeek Park, Camp Long, and Discovery Park and on MLK Day, participated in beach cleanups, helped make props at an Earth Day march for children, trained other students as Ambassadors for Climate Justice at Jane Addams Peace Camp and Camp Long, and met with legislative staff from the Washington government on climate change. Zoe has also educated the public on the dangers of climate change by speaking to the City Council Energy and Environment Committee and at the Governor’s CLEW hearings in Seattle and Olympia, the Keystone XL vigil, the Climate Reality Project NW retreat, and rallies at the EPA and Army Corps of Engineers. Zoe is worried about the impact of climate change on her and other children’s futures. She believes that climate change should be taught to the youth in school and gives presentations in school classrooms and Sunday schools, and has presented the film “Taking Root: The Story of Wangari Maathai” for Meaningful Movies. She also participates in the iMatter Youth Movement.

Zoe’s 10 year-old sister Stella Foster is in 5th grade at Lincoln APP Elementary and is also highly involved in climate change advocacy. She volunteers on the Green Team, which reduces waste at lunch, and the Worm Squad, which focuses on composting. Stella is a member of a global activist club called Care for the Planet and is also involved with Plant-For-The-Planet, the Earth Day Network, the Climate Reality Project, Restore My Climate, and the iMatter

⁵ Wash. Exec. Order No. 14-04 (April 29, 2014), *available at* <http://www.governor.wa.gov/office/execorders/documents/14-04.pdf>.

Youth Movement. She is also an avid public speaker and has given speeches at rallies and protests for 350.org's Seattle 'Draw the Line' event with the Mayor and Bill McKibben against the oil trains in Seattle, has talked to the legislature at government hearings, and has trained other students to become ambassadors for Climate Justice. Stella walks, bikes, or is driven to school in the family electric car.

Zoe and Stella have experienced the adverse effects of climate change around the United States. Their relatives in Texas have experienced droughts and water shortages since 2006. On a family trip to Hawaii, Zoe and Stella saw dead coral in the reefs. They and their family will not be returning to Hawaii because long distance travel causes too much carbon pollution and they seek to lessen their own carbon footprint.

Local effects of climate change have directly impacted Zoe and Stella. Longer and warmer seasons mean more mosquitoes in more areas. Since Zoe is allergic to these pests, her family goes camping less now and only at specific times and places, as the bugs have spread and become more populous. Wildfires and burned forests have also disturbed their family outings. Stella likes to play Frisbee and bike, but cannot enjoy these activities as often or for long periods on the increasing number of summer days with high temperatures. Both girls love shrimp tempura, clams, and cod, and gathering shellfish locally, but are worried about contaminated water, consuming toxins in their food, and the decreased availability of these species.

On trips to the zoo and the aquarium, Zoe and Stella have noticed Endangered Species labels everywhere. Stella worries about climate change and its effects on the red pandas and tigers she loves. Zoe and her classmates used a secchi disc to measure phytoplankton activity on a class marine science field trip. She saw that the phytoplankton are less and less active and are dying from the heat.

Zoe and Stella's family have new insulation, windows, and a new metal roof on their house. They also conserve water with low-flow appliances and a high-efficiency water heater, grow their own vegetables, and raise their own chickens. Unfortunately, since they live sixty feet above sea level, their home is threatened by sea level rises from the melting of polar ice and Antarctic ice sheets. Zoe and Stella's home also faces dangers from mudslides, river flooding, and droughts followed immediately by flooding. Stella worries that climate change will never allow her and her family to have a simple life, rather they will increasingly have to deal with these and other dangers from climate change.

Aji and Adonis Piper

Aji Piper is a 14 year-old resident of West Seattle and is finishing the eighth grade. His nine-year-old brother Adonis is in the fourth grade. Both boys attend Pathfinder K-8, a public school focused on the environment. Aji and Adonis are members of Plant-For-The-Planet Leadership Corps, in which they plant trees and help restore local forests. Aji and Adonis both eat local vegetarian food and buy in bulk to reduce waste from packaging materials. Their family also does not drive much, and the boys prefer to take the bus, walk, or carpool. Aji and Adonis also use recycled products and do their clothing shopping at thrift stores.

Aji wants to be involved in setting climate targets in order to make a strong plan for a strong future. He believes that tackling climate change is not a moral obligation, but a logical obligation. Aji wrote an essay at school on climate change and a song about “Exploding Trains,” which he has sung with Adonis at rallies and performed at the Seattle City Council before they passed a resolution against the oil trains.

Aji and his brother are being affected by the wildfires in Washington. On a family trip through the Cascades Mountains he saw helicopters lifting water over and out of Lake Chelan to dump water on wildfires many miles away. He was forced to breathe the smoke in the air, which had travelled a great distance.

Adonis has also noticed droughts in Washington and the negative effects of climate change on freshwater systems and fish. Adonis is concerned with the water quality in the Puget Sound, where dead zones are occurring because of pollution that takes all of the oxygen out of the water, killing all living things. He knows that water quality affects the salmon in Washington, which show slower growth rates in hotter water, more birth defects, and trouble breeding. Adonis does not want the effects of global warming to kill off the fish.

Adonis and Aji are also being affected by the impacts of climate change in other places in the western United States. On a trip to Montana with his grandparents, Adonis saw and took pictures of dead forests where bark beetles burrowed in and killed the trees. Adonis recognizes that cold weather kills the pests and the warmer temperatures from climate change will allow the beetles to live longer. Although their mother is from Albuquerque, New Mexico and the boys often visit family there, Aji, Adonis, and their family will not move back to that state because of water shortage issues and the declining aquifer. However, they have also noticed the lack of snow in Washington this past year. Aji and Adonis fear the lack of water for crops and the rising prices of food and water.

Wren Wagenbach

Wren Wagenbach is a 13 year-old 7th grade student at Hamilton International Middle School in Seattle, Washington. Wren loves going camping, kayaking, fishing, and snorkeling with her family. She has asthma and worries that air pollution will make it worse over time, limiting her ability to do these activities.

Wren has noticed the troubling effects of climate change while snorkeling. She has seen dying coral reefs from ocean acidification. Wren worries that worsening ocean acidification will kill the oysters, mussels, and clams, and cause companies that work with shellfish to shut down. Her favorite beaches on the coast where she visits, snorkels, and fishes will be underwater because of sea level rise from melting glaciers and ice sheets. Heat waves and record-breaking temperatures are threatening the national parks and their natural wildlife where Wren camps in the summer.

Climate disruption has also affected many of Wren’s friends, who live in areas where they are affected by storms like Hurricane Sandy. Wren worries for herself, her friends, and their

futures if the human race does not take action on climate change. She believes that we have the ability to stop climate change if we try harder.

Lara Fain

Lara Fain is 12 years old and lives in Seattle, Washington. She has noticed the weather getting much warmer and drier. Lara notices that it is much drier during the winter when Washington normally gets their rain. She is a skier, but that hobby has been impacted by early season conditions that persist all ski-season long. Lara makes efforts to help the environment, such as becoming a pescatarian, in order to decrease fossil fuel usage and emissions from transporting meat.

Lara is most concerned with losing wildlife from rising levels of ocean acidification and sea level rise. She will be most affected by these ocean changes in her home in Seattle, where a significant sea level rise would eventually turn her city into an archipelago. Though a sea level rise of that magnitude might not occur in her lifetime, certainly her children and grandchildren will suffer these consequences if current concentrations of carbon dioxide and other greenhouse gases continue to climb.

Gabriel Mandell

Gabriel Mandell is a 6th grader from Seattle, Washington. He was among the first group of Climate Justice Ambassadors trained by Plant-For-The-Planet at their first academy in the United States. Gabe is active in Plant-For-The-Planet and has spoken out about environmental and economic justice at Earth Day and at 350.org's Seattle 'Draw the Line' event. He also spoke at a rally and gave testimony opposing the building of coal export terminals in Washington State. Gabriel and several Ambassador friends have addressed the Seattle City Council about climate change.

Gabriel is very concerned about the impacts that man-made climate change will have on his and his children's futures. He thinks it is outrageous that people around the world who had little to do with increased CO₂ emissions will be among the first to suffer the effects of global warming. Gabriel wants to know why the profits of fossil fuel companies are being put ahead of the welfare of this and future generations, especially since the technology exists to replace fossil fuels with renewable energy.

Living in the beautiful Northwest, Gabriel worries about the effects of rising sea levels on coastal communities and the wildlife that inhabits marshes near the beaches where he has spent days flying kites and evenings listening to frog songs. Beaches are disappearing, and Gabriel fears the increased vulnerability to coastal and inland flooding residents of Washington State will experience. For example, with the projected 16.6 cm rise in sea level in Seattle by 2047, Golden Gardens Park – where the Climate Justice Ambassadors were trained- will be underwater.

Gabriel is also concerned about another serious effect of the temperature and precipitation changes from global warming: water availability for ecosystems, agriculture and hydropower production in the Northwest. Currently, Washington produces 40% of the Nation's

hydropower. Decreases in spring snowpack and, thus, spring melt volumes will result in clean power production competing with the irrigation needs of agriculture and target flows for fish, necessitating future tough decisions if we fail to make smart choices today. Gabriel recalls a recent scientific study that says the year of climate departure – when each year will be warmer than the one before it - will happen in 2047. Unless we build a movement of people demanding politicians at all levels of government take appropriate action to ensure a sane world, this is the future we face.

Jenny Xu

Jenny Xu is finishing the 5th grade at Lincoln APP Elementary School and has lived in Seattle her whole life. She is active in a school club in which students talk about climate change. Jenny was part of a video the club made and has been inspired by the climate impacts she has experienced to work towards change. She fundraises to plant trees and educates people by presenting a climate change slideshow. Jenny also presented this slideshow to the Senators of Seattle to show them the effects of climate change.

Jenny has felt the effects of climate change in her Seattle home. She has seen “Do Not Fish” signs occurring more frequently on the Puget Sound as the water has become more and more polluted. She worries about the effects on the economy in the Northwest because of the importance of the fishing industry. With pollution and ocean acidification, the fishing industry will feel the negative impacts of climate change. Jenny also worries about the impacts of sea level rise on her coastal community. She knows that the Arctic sea ice and the glaciers worldwide are melting, posing a serious threat of future land loss to her community as a result of higher ocean levels.

The rising temperatures have also affected Jenny. She has noticed the summers are hotter every year. Living in a home without air conditioning, summers are becoming more difficult for her and her family. Jenny loves playing outside and spending her time outdoors, but the hotter summers keep her inside more.

Jenny spends time every year with her family in China and has felt the impacts of climate change there as well. China has experienced more frequent and severe heat waves the last few years and Jenny had to spend most of her visit inside, away from the extreme heat. Her family lives near a hospital and during record temperatures last year, she heard sirens daily from ambulances transporting people who needed treatment for extreme heat exposure. People even died from the heat waves. Jenny also learned about the reality of rising food costs. In the markets she heard people arguing with shopkeepers about the higher costs of food, who explained that food is becoming harder to grow because of the poor air quality conditions.

Typhoons and other extreme weather events are a concern for Jenny; both at her home in Seattle and her family’s home in China. She has witnessed the growing strength of these storms over the past few years and worries about how dangerous typhoons are becoming. In China, flooding from typhoons in industrial areas has caused more dangerous water pollution. Jenny worries that these same adverse effects are only going to occur more frequently as time progresses and climate change worsens.

Plant-For-The-Planet Foundation is an international children's initiative planting trees to end the climate crisis in their lifetime. Twenty-six thousand (26,000) children, including many Washington residents, now serve as ambassadors worldwide, calling for 1,000 Billion trees to be planted by 2020, to Leave Fossil Fuels in the Ground, and for Climate Justice to End Poverty. As the official United Nations' Tree-Counters, they report almost 13 Billion trees planted on the U.N. Billion Tree Campaign. They plant locally in Washington and globally, speak to leaders, and get creative to begin a future everyone can live with.

STATEMENT OF REASONS

The Department should grant this petition and promulgate the proposed rule for the following reasons.

A. The Science Unequivocally Shows that Anthropogenic Climate Change is Occurring and is Threatening the Stability of the Global Climate

1. Climate Change is Caused by Anthropogenic Activities

As Governor Inslee has recognized, “[h]uman activities have increased atmospheric levels of greenhouse gases to levels unprecedented in at least the past 800,000 years.”⁶ The United States Global Change Research Program⁷ has confirmed that global warming is occurring and adversely impacting the Earth’s climate.⁸ The present rate of global heating is occurring as a result of human activities that release heat-trapping greenhouse gases (GHGs) and intensify the Earth’s natural greenhouse effect at an accelerated rate, thereby changing Earth’s climate.⁹ This

⁶ Wash. Exec. Order No. 14-04 (Apr. 29, 2014).

⁷ “The U.S. Global Change Research Program (USGCRP) was established by Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act (GCRA) of 1990 to “assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.” The organization’s vision is to produce “[a] nation, globally engaged and guided by science, meeting the challenges of climate and global change.” Their mission is “to build a knowledge base that informs human responses to climate and global change through coordinated and integrated Federal programs of research, education, communication, and decision support.” <http://www.globalchange.gov/about>.

⁸ United States Global Change Research Program, *Climate Change Impacts in the United States: Third National Climate Assessment 7* (2014) [hereinafter *Climate Change Impacts*], available at <http://nca2014.globalchange.gov/downloads> (“Evidence for climate change abounds, from the top of the atmosphere to the depths of the oceans Evidence of climate change is also visible in the observed and measured changes in location and behavior of species and functioning of ecosystems. Taken together, this evidence tells an unambiguous story: the planet is warming, and over the last half century, this warming has been driven primarily by human activity.”).

⁹ *Id.* (“Multiple lines of independent evidence confirm that human activities are the primary cause of the global warming of the past 50 years.”); Deutsche Bank Climate Change Advisors, *Climate Change: Addressing the Major Skeptic Arguments* 9 (Sept. 2010), available at http://www.climateaccess.org/sites/default/files/Carr_Address%20Skeptic%20Arguments.pdf

abnormal climate change is unequivocally human-induced,¹⁰ is occurring now, and will continue to occur unless drastic measures are taken to curtail it.¹¹ Climate change is damaging both natural and human systems, and if unrestrained, will alter the planet's habitability.¹²

According to the United States Environmental Protection Agency ("EPA"), "the case for finding that *greenhouse gases in the atmosphere endanger public health and welfare is compelling and, indeed, overwhelming.*"¹³ The EPA further stated in April 2009 that "the evidence points ineluctably to the conclusion that climate change is upon us as a result of greenhouse gas emissions, that *climate changes are already occurring that harm our health and welfare, and that the effects will only worsen over time in the absence of regulatory action.*"¹⁴

Human beings have benefited from living on a planet that has been remarkably hospitable to our existence and has provided conditions that are just right for human life to evolve, expand, and flourish.¹⁵ The Earth is a "Goldilocks" planet with an atmosphere that has fewer GHGs than that of Venus (which is too hot), and more than that of Mars (which is too cold), which is just perfect for the amazing diversity of life that has developed and thrived on planet Earth.¹⁶

GHGs in the atmosphere act like a blanket over the Earth to trap the heat that it receives from the sun.¹⁷ More GHGs in the atmosphere means that more heat is being retained on Earth,

; Intergovernmental Panel on Climate Change (IPCC), *IPCC Fifth Assessment Report: Climate Change 2013*, 1.1, 123 (2013) [hereinafter *AR5*], available at <http://www.ipcc.ch/report/ar5/wg1/>.

¹⁰ USGCRP, *Climate Change Impacts*, *supra* note 8, at 7.

¹¹ *Id.* at 14 ("The cumulative weight of the scientific evidence contained in this report confirms that climate change is affecting the American people now, and that choices we make will affect our future and that of future generations."); IPCC, *AR5* 1.2.2, 124 (2013) ("Warming 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.") (key statement from IPCC Fourth Assessment Report).

¹² USGCRP, *Climate Change Impacts*, *supra* note 8, at 5 ("While some climate changes will occur slowly and relatively gradually, others could be rapid and dramatic, leading to unexpected breaking points in natural and social systems.").

¹³ Proposed Endangerment Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act, 74 Fed. Reg. 18886, 18904 (Apr. 24, 2009) (to be codified in 40 C.F.R. Chapter 1) (emphasis added).

¹⁴ *Id.* (emphasis added).

¹⁵ John Abatzoglou et al., *A Primer on Global Climate Change and Its Likely Impacts*, in *Climate Change: What it Means for Us, Our Children, and Our Grandchildren* 11, 15-22 (Joseph F. C. DiMento & Pamela Doughman eds., 2007) ("The earth's climate system can be thought of as an elaborate balancing act of energy, water, and chemistry involving the atmosphere, oceans, ice masses, biosphere, and land surface.").

¹⁶ James Hansen, *Storms of my Grandchildren* 224-25 (2009); See Abatzoglou, *supra* note 15, at 23.

¹⁷ Abatzoglou, *supra* note 15, at 22.

with less heat radiating back out into space.¹⁸ Without this greenhouse effect, the average surface temperature of our planet would be 0°F (- 18°C) instead of 59°F (15°C).¹⁹ Scientists have understood this basic mechanism of global warming since the late-nineteenth century.²⁰

Human beings have significantly altered the chemical composition of the Earth's atmosphere and its climate system.²¹ Collectively, we have changed the atmosphere and the Earth's climate system by engaging in activities that produce or release GHGs into the atmosphere.²² Carbon dioxide (CO₂) is the key GHG, and there is abundant evidence that its emissions are largely responsible for the current warming trend.²³ Although much of the excess carbon dioxide is absorbed by the oceans, plants, and forests, the increase of GHG concentrations resulting from historic and present human activities has altered the Earth's ability to maintain the delicate balance of energy it receives from the sun and that which it radiates back out into space.²⁴

In 2013, the CO₂ concentration in our atmosphere exceeded 400 ppm for the first time in recorded history²⁵ (compared to the pre-industrial concentration of 280 ppm).²⁶ The monthly average atmospheric CO₂ concentration for May 2014 was 401.88 ppm and the present annual

¹⁸ *Id.* at 16-17.

¹⁹ *Id.* at 17.

²⁰ *See id.* at 35 (describing the efforts of Swedish chemist Svante Arrhenius).

²¹ Naomi Oreskes, *The Scientific Consensus on Climate Change*, in *Climate Change: What it Means for Us, Our Children, and Our Grandchildren* 65, 93 (Joseph F. C. DiMento & Pamela Doughman eds., 2007) (“We have changed the chemistry of our atmosphere, causing sea level to rise, ice to melt, and climate to change. There is no reason to think otherwise.”); Wash. Exec. Order No.14-04 (Apr. 29, 2014).

²² *Id.*

²³ *See* James E. Hansen et al., *Target Atmospheric CO₂: Where Should Humanity Aim?* 2 *The Open Atmospheric Science Journal* 217, 217-231 (2008), available at http://www.columbia.edu/~jeh1/2008/TargetCO2_20080407.pdf.

²⁴ Abatzoglou, *supra* note 15, at 15-22.

²⁵ NOAA, *Greenhouse Gases Continued Rising in 2013, 34 Percent Increase Since 1990*, (May 2, 2012), available at <http://research.noaa.gov/News/NewsArchive/LatestNews/TabId/684/ArtMID/1768/ArticleID/10553/Greenhouse-gases-continued-rising-in-2013-34-percent-increase-since-1990.aspx> (last visited June 12, 2014) (“We continue to turn the dial up on this ‘electric blanket’ of ours without knowing what the resulting temperatures will be.”).

²⁶ IPCC, *AR5*, *supra* note 9, at TS.5.7.2, 100; Nat'l Sci. and Tech. Council (NSTC), *Scientific Assessment of the Effects of Global Change on the United States* 2 (May 2008) [hereinafter *Scientific Assessment*], available at http://downloads.globalchange.gov/ccsp/CCSP_Scientific_Assessment_Full.pdf; Environmental Protection Agency (EPA), *Technical Support Document for Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act* 17 (Dec. 9, 2009) [hereinafter *TS Endangerment Findings*], available at http://www.epa.gov/climatechange/Downloads/endangerment/Endangerment_TSD.pdf.

mean is approximately 397 ppm.²⁷ Current atmospheric GHG concentrations are the highest they have been in the last 800,000 years.²⁸

Concentrations of other GHGs in the atmosphere have also increased from human activities. Atmospheric concentrations of methane, for example, have increased nearly 250% since the pre-industrial period.²⁹ Concentrations of nitrous oxide have also increased by 120%.³⁰

Humans not only continue to add GHGs into the atmosphere at a rate that outpaces their removal through natural processes,³¹ but the current and projected CO₂ increase, for example, is about one hundred times faster than any that has occurred over the past 800,000 years.³² This increase has to be considered in light of the lifetime of greenhouse gases in the atmosphere. In particular, a substantial portion of every ton of CO₂ emitted by humans persists in the atmosphere for as long as a millennium or more.³³ The current concentrations of GHGs in the atmosphere, therefore, are the result of both historic and current emissions. What this means is that the impacts associated with the GHG emissions of today will be mostly borne by our children and future generations.

Changes in different aspects of Earth's climate system over the last century tell a coherent story: the impacts we see today are consistent with the scientific understanding of how the climate system should respond to GHG increases from human activities and how the Earth has responded in the past (reflected in such evidence as: ice cores that have trapped air from thousands and even a few million years ago, tree rings, and seabed sediments that show where

²⁷ *Scripps CO₂ Data – Mauna Loa Observatory*, available at <http://co2now.org/Current-CO2/CO2-Now/> (last visited June 12, 2014).

²⁸ Dieter Lüthi et al., *High-resolution carbon dioxide concentration record 650,000- 800,000 years before present* 453 *Nature* 379, 379-382 (May 2008), available at <http://www.nature.com/nature/journal/v453/n7193/full/nature06949.html> (prior to this publication it was accepted atmospheric CO₂ record extended back 650,000 years, but now research indicates that the record can be extended 800,000 years, or two complete glacial cycles).

²⁹ IPCC, *AR5*, *supra* note 9, at TS.2.8.3, 52 (“The concentration of CH₄ has increased by a factor of 2.5 since pre-industrial times, from 722 [697 to 747] ppb in 1750 to 1803 [1799 to 1807] ppb in 2011.”).

³⁰ *Id.* at TS.2.8.4, 52.

³¹ EPA, *TS Endangerment Findings*, *supra* note 26, at ES-2 (“Atmospheric GHG concentrations have been increasing because anthropogenic emissions have been outpacing the rate at which GHGs are removed from the atmosphere by natural processes over timescales of decades to centuries.”).

³² Lüthi, *supra* note 28, at 379-382.

³³ Hansen, *Target Atmospheric CO₂: Where Should Humanity Aim?*, *supra* note 23, at 220; *See also* EPA, *TS Endangerment Findings*, *supra* note 26, at 16 (“Carbon cycle models indicate that for a pulse of CO₂ emissions, given an equilibrium background, 50% of the atmospheric increase will disappear within 30 years, 30% within a few centuries, and the last 20% may remain in the atmosphere for thousands of years.”); Abatzoglou, *supra* note 15, at 29 (“Since CO₂ has a lifetime of over one hundred years, these emissions have been collecting for many years in the atmosphere.”).

sea level was thousands and even millions of years ago).³⁴ Collectively, these changes cannot be explained as the product of natural climate variability alone.³⁵ A large human contribution provides the best explanation of observed climate changes.³⁶

These well-documented and observable impacts from the changes in Earth's climate system highlight that the current level of atmospheric CO₂ concentration has already taken the planet into a danger zone.³⁷ The Earth will continue to warm in reaction to concentrations of CO₂ from past emissions as well as future emissions.³⁸ Warming already in the pipeline is mostly attributable to climate mechanisms that slowly heat the Earth's climate system in response to atmospheric CO₂.³⁹

2. Global Temperature Increases

One key observable change is the rapid increase in recorded global surface temperatures.⁴⁰ As a result of increased atmospheric GHGs from human activities, based on fundamental scientific principles, the Earth has been warming as scientists have predicted.⁴¹ The increased concentrations of greenhouse gases in our atmosphere, primarily CO₂,⁴² have raised global surface temperature by 0.85°C (1.4°F) from 1880 to 2012.⁴³ In the last century, the Earth has warmed at a rate “roughly ten times faster than the average rate of ice-age-recovery warming.”⁴⁴

³⁴ USGCRP, *Climate Change Impacts*, *supra* note 8, at 23.

³⁵ *Id.* at 24.

³⁶ Susan Solomon et al., *Irreversible climate change due to carbon dioxide emissions*, 106 PNAS 1704, 1704-09 (Feb. 10, 2009), available at <http://www.pnas.org/content/106/6/1704.full.pdf+html>; IPCC, *AR5*, *supra* note 9, at D, 15.

³⁷ USGCRP, *Climate Change Impacts*, *supra* note 8, at 7.

³⁸ EPA, *TS Endangerment Findings*, *supra* note 26, at 26.

³⁹ Fred Pearce, *With Speed and Violence: Why Scientists Fear Tipping Points in Climate Change* 101-04 (2007); IPCC, *AR5*, *supra* note 9, at 1.2.2, 128-29.

⁴⁰ NSTC, *Scientific Assessment*, *supra* note 26, at 51; IPCC, *AR5*, *supra* note 9, at 1.3.1, 131; USGCRP, *Climate Change Impacts*, *supra* note 8, at 22; EPA, *TS Endangerment Findings*, *supra* note 26, 26-30; Nat'l Aeronautics and Space Admin. (NASA) & Goddard Institute for Space Studies (GISS), *Global Surface Temperature*, <http://climate.nasa.gov/keyIndicators/#globalTemp> (illustrating the change in global surface temperatures) (last visited June 10, 2014).

⁴¹ IPCC, *AR5*, *supra* note 9, at TS.2.2.1, 37; USGCRP, *Climate Change Impacts*, *supra* note 8, at 22; EPA, *TS Endangerment Findings*, *supra* note 26, at 48.

⁴² IPCC, *AR5*, *supra* note 9, at TS.2.8, 50; EPA, *TS Endangerment Findings*, *supra* note 26, at ES-1-2.

⁴³ IPCC, *AR5*, *supra* note 9, at B.1, 5; NASA, *Climate Change: Key Indicators*, http://climate.nasa.gov/key_indicators/#globalTemp (last visited June 12, 2014).

⁴⁴ NASA, *How is Today's Warming Different from the Past?*, NASA Earth Observatory, available at <http://earthobservatory.nasa.gov/Features/GlobalWarming/page3.php> (last visited June 12, 2014).

Because of year-to-year variations in these thermometer readings, as with daily readings, scientists compare temperature differences over a decade to determine patterns.⁴⁵ Employing this decadal scale, the surface of the planet has warmed at a rate of roughly 0.12°C per decade since 1951.⁴⁶ Global mean surface temperature has been decidedly higher during the last few decades of the twentieth century than at any time during the preceding four centuries.⁴⁷ Global surface temperatures have been rising dramatically since 1951, and 2010 tied for the hottest year on record, while “[t]he year 2013 tied with 2009 and 2006 for the seventh warmest year since 1880.”⁴⁸ April 2014 tied with April 2010 as the warmest April globally since 1880.⁴⁹

The dramatic increase of the average global surface temperature is alarming. It has become quite clear that the past several decades present an anomaly, as global surface temperatures from 2000-2009 are registering higher than at any point in the past 1,300 years.⁵⁰ The IPCC has observed that “[w]arming of the climate system is unequivocal.”⁵¹ The United States EPA has recognized the scientific consensus that has developed on the fact of global warming and its cause: the Earth is heating up due to human activities.⁵²

Changes in many different aspects of Earth’s climate system over the past century are consistent with this warming trend. Based on straightforward scientific principles, human-induced GHG increases lead not only to warming of land surfaces,⁵³ but also to the warming of oceans,⁵⁴ increased atmospheric moisture levels,⁵⁵ rises in the global sea level,⁵⁶ and changes in rainfall⁵⁷ and atmospheric air circulation patterns that affect water and heat distribution.⁵⁸

⁴⁵ IPCC, *AR5*, *supra* note 9, at TS.2.2.1, 37.

⁴⁶ IPCC, *AR5*, *supra* note 9, at B.1, 5.

⁴⁷ The Nat’l Academies Press (Board on Atmospheric Sciences and Climate), *Surface Temperature Reconstructions for the Last 2,000 Years* 3 (2006), available at http://www.nap.edu/catalog.php?record_id=11676.

⁴⁸ NASA, *Global Climate Change – Global Surface Temperature*, http://climate.nasa.gov/key_indicators#globalTemp (last visited June 12, 2014); NASA, *Global Climate Change: Vital Signs of the Planet*, <http://climate.nasa.gov/> (last visited June 12, 2014) (“January 2000 to December 2009 was the warmest decade on record.”).

⁴⁹ NOAA, *Global Analysis-April 2014*, available at <http://www.ncdc.noaa.gov/sotc/global/> (last visited June 12, 2014).

⁵⁰ USGCRP, *Climate Change Impacts*, *supra* note 8, at 23.

⁵¹ IPCC, *AR5*, *supra* note 9, at B, 4.

⁵² EPA, *TS Endangerment Findings*, *supra* note 26, at ES-2 (“Warming 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 Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in *anthropogenic* GHG concentrations.”) (emphasis added).

⁵³ IPCC, *AR5*, *supra* note 9, at TS.2.2.1, 37.

⁵⁴ *Id.* at TS.2.2.3, 38.

⁵⁵ USGCRP, *Climate Change Impacts*, *supra* note 8, at 33; B.D. Santer et al., *Identification of human-induced changes in atmospheric moisture content*, 104 Proceedings of the National Academy of Sciences 15248, 15248-53 (Sept. 25, 2007), available at <http://www.pnas.org/content/104/39/15248.full.pdf+html>.

As expected (and consistent with the temperature increases in land surfaces), ocean temperatures have also increased.⁵⁹ This has led to changes in the ocean's ability to circulate heat around the globe; which can have catastrophic implications for the global climate system.⁶⁰ The average temperature of the global ocean has increased significantly despite its amazing ability to absorb enormous amounts of heat before exhibiting any indication thereof.⁶¹ In addition, the most significant indicator of the planet's energy imbalance due to human-induced GHG increases, is the long-term increase in global average ocean heat content over the last 50 years, extending down to several thousand meters below the ocean surface.⁶²

3. Precipitation, Storms, and Drought

As predicted, precipitation patterns have changed due to increases in atmospheric moisture levels and changes in atmospheric air circulation patterns, another indicator that the Earth is warming.⁶³ As the Earth warms, moisture levels are expected to increase when temperature increases because warmer air generally holds more moisture.⁶⁴ In more arid regions, however, higher temperatures lead to greater evaporation.⁶⁵

These changes in the Earth's water cycle increase the potential for, and severity of, severe storms, flooding, and droughts.⁶⁶ Storm-prone areas are already experiencing a greater chance of severe storms, and this will continue.⁶⁷ Even in arid regions, increased precipitation is likely to cause flash flooding, and will be followed by drought.⁶⁸

These changes are already occurring. Droughts in parts of the midwestern, southeastern, and southwestern United States have increased in frequency and severity within the last fifty years, coinciding with rising temperatures.⁶⁹ Most of the recent heat waves can be attributed to

⁵⁶ IPCC, *AR5*, *supra* note 9, at TS.2.6, 46.

⁵⁷ USGCRP, *Climate Change Impacts*, *supra* note 8, at 26, 32-33, 36.

⁵⁸ IPCC, *AR5*, *supra* note 9, at TS.2.4, 39.

⁵⁹ Intergovernmental Panel on Climate Change (IPCC), *IPCC Fifth Assessment Report: Climate Change 2013-Working Group II 6.1.1.1, 7* (2013) [hereinafter *AR5-WGII*], available at <http://www.ipcc.ch/report/ar5/wg2/>; EPA, *TS Endangerment Findings*, *supra* note 26 at ES-2.

⁶⁰ USGCRP, *Climate Change Impacts*, *supra* note 8, at 560.

⁶¹ United Nations Environment Programme (UNEP), *Climate Change Science Compendium 2009* 26 (2009), available at <http://www.unep.org/compendium2009/>.

⁶² S. Levitus et al., *Global Ocean Heat Content 1955-2008 in Light of Recently Revealed Instrumentation Problems* 36 *J. Geophysical Res. Letters* L07608 (Apr. 2009), available at <ftp://ftp.nodc.noaa.gov/pub/data.nodc/woa/PUBLICATIONS/grlheat08.pdf>.

⁶³ USGCRP, *Climate Change Impacts*, *supra* note 8, at 1, 27, 32, 36.

⁶⁴ EPA, *TS Endangerment Findings*, *supra* note 26, at 111.

⁶⁵ *Id.*

⁶⁶ *Id.*

⁶⁷ *Id.* at 120-21; USGCRP, *Climate Change Impacts*, *supra* note 8, at 43.

⁶⁸ EPA, *TS Endangerment Findings*, *supra* note 26, at 115.

⁶⁹ *Id.* at 143, 145, 148.

human-caused climate disruption.⁷⁰ As of the end of April 2014, 18% of the contiguous United States was experiencing severe to extreme drought, while 8% can be categorized as severely to extremely wet.⁷¹ Based on the laws of physics and the past climate record, scientists have concluded that precipitation events will increase globally, particularly in tropical and high latitude regions, while decreasing in subtropical and mid-latitude regions,⁷² with longer periods between normal heavy rainfalls.⁷³ Climate change is already causing, and will continue to result in, more frequent, extreme, and costly weather events (such as hurricanes).⁷⁴ The annual number of major tropical storms and hurricanes has increased over the past 100 years in North America, coinciding with increasing temperatures in the Atlantic sea surface.⁷⁵

Other changes consistent with climate modeling resulting from global warming have been observed not just in the amount, intensity, and frequency of precipitation but also in the type of precipitation.⁷⁶ In higher altitude and latitude regions, including in mountainous areas, more precipitation is falling as rain rather than snow.⁷⁷ With early snow melt occurring because of climate change, the reduction in snowpack can aggravate water supply problems.⁷⁸ The snow cover extent of North America in June 2013 was the fourth lowest ever recorded.⁷⁹

As the 2010 Russian summer heat wave graphically demonstrated, heat can destroy crops, trigger wildfires, exacerbate air pollution, and cause increased illness and deaths.⁸⁰ Similar impacts are occurring across the United States. The “number and frequency of forest fires and insect outbreaks are increasing in the interior West, the Southwest, and Alaska. Precipitation and stream temperatures are increasing in most of the continental United States. The western United States is experiencing reduced snowpack and earlier peaks in spring runoff. The growth of many crops and weeds is being stimulated.” Migration of plant and animal species is changing the

⁷⁰ USGCRP, *Climate Change Impacts*, *supra* note 8, at 38 (“The summer 2011 heat wave and drought in Texas was primarily driven by precipitation deficits, but the human contribution to climate change approximately doubles the probability that the heat was record-breaking.”).

⁷¹ NOAA, *State of the Climate: Drought – April 2014* (May 13, 2014), available at <http://www.ncdc.noaa.gov/sotc/drought/2014/4>.

⁷² EPA, *TS Endangerment Findings*, *supra* note 26, at ES-4, 74.

⁷³ EPA, *TS Endangerment Findings*, *supra* note 26, at 74.

⁷⁴ USGCRP, *Climate Change Impacts*, *supra* note 8, at 38.

⁷⁵ NSTC, *Scientific Assessment*, *supra* note 26, at 7.

⁷⁶ *Id.* at ES-2.

⁷⁷ USGCRP, *Climate Change Impacts*, *supra* note 8, at 75.

⁷⁸ *Id.* at 72.

⁷⁹ C. Derksen et al., *Arctic Report Card: Update for 2013 – Snow* (Nov. 15, 2013), available at <http://www.arctic.noaa.gov/reportcard/snow.html> (“[T]he below normal June SCE in North America was driven by rapid snow melt, rather than anomalously low snow accumulation prior to melt onset.”).

⁸⁰ See NOAA Earth System Research Lab, *The Russian Heat Wave 2010* (Sept. 2010), available at <http://www.esrl.noaa.gov/psd/csi/moscow2010/>.

composition and structure of arid, polar, aquatic, coastal, and other ecosystems.”⁸¹ Up to 30% of the millions of species on our planet could go extinct following just a few tenths of a degree warming above present.⁸²

4. Sea Level Rise

As expected, global sea levels have also risen.⁸³ Sea levels have been rising at an average rate of 3.2 millimeters per year based on measurements from 1993 to 2010.⁸⁴ Though sea levels rose about 6.7 inches over the last century, within the last decade, that rate has nearly doubled.⁸⁵ Rising seas, brought about by melting of polar icecaps and glaciers, as well as by thermal expansion of the warming oceans, will cause flooding in coastal and low-lying areas.⁸⁶ The combination of rising sea levels and more severe storms creates conditions conducive to severe storm surges during high tides.⁸⁷ In coastal communities this can overwhelm coastal defenses (such as levees and sea walls), as witnessed during Hurricane Katrina.⁸⁸

Sea level is not uniform across the globe, because it depends on variables such as ocean temperature and currents.⁸⁹ Unsurprisingly, the most vulnerable lands are low-lying islands, river deltas, and areas that already lie below sea level because of land subsidence.⁹⁰ Based on these factors, scientists have concluded that the immediate threats to the United States from rising seas are the most severe on the Gulf and Atlantic Coasts.⁹¹ Worldwide, hundreds of millions of people live in river deltas and vulnerable coastlines along the southern and western coasts of Asia where rivers draining the Himalayas flow into the Indian and Pacific Oceans.⁹²

⁸¹ EPA, *TS Endangerment Findings* at 41 (citing P. Backlund et al., *Executive Summary, in The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States* (2008)).

⁸² IPCC, *AR5-WGII*, *supra* note 59, at 4.3.2.5, 30.

⁸³ USGCRP, *Climate Change Impacts*, *supra* note 8, at 44; EPA, *TS Endangerment Findings*, *supra* note 26, at ES-3; IPCC, *AR5*, *supra* note 9, at B.4, 11

⁸⁴ IPCC, *AR5*, *supra* note 9, at B.4, 11.

⁸⁵ NASA, *Climate Change: How Do We Know? - Sea Level Rise* (last visited June 10, 2014) <http://climate.nasa.gov/evidence/#no4> (citing J.A. Church & N.J. White, *A 20th Century Acceleration in Global Sea Level Rise* 33 *Geophysical Research Letters* (2006)).

⁸⁶ EPA, *TS Endangerment Findings*, *supra* note 26, at ES-7; USGCRP, *Climate Change Impacts*, *supra* note 8, at 45.

⁸⁷ USGCRP, *Climate Change Impacts*, *supra* note 26, at 45; EPA, *TS Endangerment Findings*, *supra* note 26, at 75.

⁸⁸ EPA, *TS Endangerment Findings*, *supra* note 26, at 86, 118.

⁸⁹ IPCC, *AR5*, *supra* note 9, at E.6, 26.

⁹⁰ EPA, *TS Endangerment Findings*, *supra* note 26, at 121.

⁹¹ *Id.* at 128; USGCRP, *Climate Change Impacts*, *supra* note 26, at 589 (Annual damage resulting from sea level rise “in the Gulf region alone could be \$2.7 to \$4.6 billion by 2030, and \$8.3 to \$13.2 billion by 2050.”).

⁹² EPA, *TS Endangerment Findings*, *supra* note 26, at 159.

In a comprehensive review of studies on sea level rise in the 21st century published by the British Royal Society, researchers estimated the probable sea level rise for this century between .5 and 2 meters (1 ½ to 6 ½ feet), continuing to rise for several centuries after that, depending on future CO₂ levels and the behavior of polar ice sheets.⁹³ The IPCC estimates a 0.52 to 0.98 meter rise in sea level by 2100 under a worst-case scenario, which could be even larger with the recent collapse of the Antarctic ice sheet, which locks in 10-13 feet in sea level rise.⁹⁴ Some scientists predict a 2 meter rise in sea level by 2100 if present trends continue.⁹⁵ “Today, rising sea levels are submerging low-lying lands, eroding beaches, converting wetlands to open water, exacerbating coastal flooding, and increasing the salinity of estuaries and freshwater aquifers.”⁹⁶ Low-lying lands are especially vulnerable to sea level rise. Galveston, Texas would experience a 3.5 foot sea level rise if the average global sea level rose just 2 feet.⁹⁷ Between 1996 and 2011, 20 square miles of land were inundated by rising sea levels along the Atlantic coast.⁹⁸ Other coastal states (such as Maryland and Louisiana) are also experiencing wetland loss due to rising sea levels.⁹⁹ Scientists have predicted that wetlands in the Mid-Atlantic region of the United States cannot withstand a 7-millimeter per year rise in sea levels.¹⁰⁰ As wetlands are inundated, further impacts from sea level rise will multiply, as “protection of coastal lands and people against storm surge will be compromised.”¹⁰¹

Glacial and ice cap melting is one of the major causes of global sea level change.¹⁰² When glaciers and ice caps melt, this adds water to the ocean.¹⁰³ Another cause is that as ocean water warms, it expands and takes up more space.¹⁰⁴ Therefore, “sea level rise is expected to

⁹³ R.J. Nicholls et al., *Sea-Level Rise and its Possible Impacts Given a ‘Beyond 4°C World’ in the Twenty-First Century*, *Philosophical Transactions of the Royal Society* 161, 168 (2011), available at <http://rsta.royalsocietypublishing.org/content/369/1934/161.full.pdf+html>.

⁹⁴ IPCC, *AR5*, *supra* note 9, at 1140.

⁹⁵ Martin Vermeer & Stefan Rahmstorf, *Global Sea Level Linked to Global Temperature* 106 *Proceedings of the National Academy of Sciences* 21527, 21531 (2009), available at <http://www.pnas.org/content/early/2009/12/04/0907765106.full.pdf+html>.

⁹⁶ U.S. Climate Change Science Program (USCCSP), *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region 2* (Jan. 2009) [hereinafter *Coastal Sensitivity to Sea-Level Rise*], available at <http://downloads.globalchange.gov/sap/sap4-1/sap4-1-final-report-all.pdf>.

⁹⁷ EPA, *Climate Impacts in the Southeast*, available at <http://www.epa.gov/climatechange/impacts-adaptation/southeast.html#impactscoast> (last visited June 12, 2014) (citing USGRCP, *Global Climate Change Impacts in the United States: Second National Climate Assessment* (2009)).

⁹⁸ EPA, *Climate Change Indicators in the United States* 52 (3d ed. 2014) [hereinafter *Climate Change Indicators*], available at <http://www.epa.gov/climatechange/pdfs/climateindicators-full-2014.pdf>.

⁹⁹ USCCSP, *Coastal Sensitivity to Sea-Level Rise*, *supra* note 96, at 3-4.

¹⁰⁰ *Id.* at 4.

¹⁰¹ USGRCP, *Climate Change Impacts*, *supra* note 8, at 402.

¹⁰² EPA, *Climate Change Indicators*, *supra* note 98, at 60.

¹⁰³ USGRCP, *Climate Change Impacts*, *supra* note 8, at 44.

¹⁰⁴ *Id.*

continue well beyond this century as a result of both past and future GHG emissions from human activities.”¹⁰⁵

5. Glaciers, Sea Ice, and Permafrost

As expected, mountain glaciers, which are the source of freshwater for hundreds of millions of people, are receding worldwide because of warming temperatures.¹⁰⁶ In 2010, Glacier National Park in Montana had only twenty-five glaciers larger than twenty-five acres, down from one hundred and fifty in 1850.¹⁰⁷ Mountain glaciers are in retreat all over the world, including Mt. Kilimanjaro, the Himalayas, the Alps (99% in retreat), the glaciers of Peru and Chile (92% in retreat), and in the United States.¹⁰⁸ In the Brooks Range of northern Alaska, all of the glaciers are in retreat and in southeastern Alaska 98% are in retreat.¹⁰⁹

Although a relatively minor contribution to sea level rise, the melting of mountain glaciers is particularly serious in areas that rely on snow melt for irrigation and drinking water supply.¹¹⁰ In effect, a large snow pack or glacier acts as a supplemental reservoir or water tower, holding a great deal of water in the form of ice and snow through the winter and spring and releasing it in the summer when rainfall is lower or absent.¹¹¹ The water systems of the western United States (particularly California) and the Andean nations of Peru and Chile, among other places, all heavily rely on these natural forms of water storage.¹¹² In addition to providing a more reliable water supply, the storing of precipitation as ice and snow helps moderate potential flooding.¹¹³

Yet as temperatures warm, not only will these areas lose this supplemental form of water storage, but also severe flooding is likely to increase (because when rain falls on snow, it accelerates the melting of glaciers and snow packs).¹¹⁴ Ice is melting most dramatically at the poles.¹¹⁵ Sea ice in the Arctic oceans is expected to decrease and may even disappear entirely in

¹⁰⁵ *Id.* at 45.

¹⁰⁶ See *TS Endangerment Findings*, *supra* note 26, at 111 (“Glaciers throughout North America are melting, and the particularly rapid retreat of Alaskan glaciers represents about half of the estimated loss of glacial mass worldwide.”).

¹⁰⁷ United States Geological Survey (Northern Rocky Mountain Science Center), *Retreat of Glaciers in Glacier National Park* (May 2013), available at http://www.nrm-sc.usgs.gov/research/glacier_retreat.htm.

¹⁰⁸ Lonnie G. Thompson, *Climate Change: The Evidence and Our Options*, 2 *The Behavior Analyst* 153, 155-160 (Fall 2010), available at <http://researchnews.osu.edu/archive/TBA--LTonly.pdf>; USGRCP, *Climate Change Impacts*, *supra* note 8, at 45.

¹⁰⁹ Thompson, *supra* note 108, at 158.

¹¹⁰ IPCC, *AR5-WGII*, *supra* note 59, at 9.3.2, 7.

¹¹¹ See Thompson, *supra* note 108, at 164.

¹¹² See *id.* at 155-160, 164.

¹¹³ EPA, *TS Endangerment Findings*, *supra* note 26, at 111.

¹¹⁴ *Id.*

¹¹⁵ Thompson, *supra* note 108, at 160 (“[P]olar ice sheets are slower to respond to temperature rise than the smaller mountain glaciers, but they too, are melting. . . . The loss of ice in the Arctic

coming decades.¹¹⁶ In 2013, spring snow cover in the Arctic was lower than the average between 1967 and 2013.¹¹⁷

Beginning in late 2000, the Jakobshavn Isbrae Glacier (which has a major influence over the mass of the Greenland ice sheet) lost significant amounts of ice.¹¹⁸ In August 2010, an enormous iceberg (roughly ninety-seven square miles in size) broke off from Greenland.¹¹⁹ Nine Antarctic ice shelves have also collapsed into icebergs in the last fifty years (six of them since 1996).¹²⁰ An ice shelf roughly the size of Rhode Island collapsed in 2002, and an ice bridge collapsed in 2009, leaving an ice shelf the size of Jamaica on the verge of shearing off.¹²¹ The 2002 collapse of the Larsen Ice Shelf, which had existed for at least 11,000 years, was “unprecedented in respect to both area and time.”¹²² The “sudden and complete disintegration” of the Larsen Ice Shelf took a mere 35 days.¹²³

Most recently, researchers found that the Western Antarctic Ice Sheet began “an irreversible state of decline, with nothing to stop the glaciers in this area from melting into the sea.”¹²⁴ This ice sheet contains enough ice to contribute 4 to 13 feet of sea level rise and their

and Antarctic regions is especially troubling because these are the locations of the largest ice sheets in the world.”)

¹¹⁶ EPA, *TS Endangerment Findings*, *supra* note 26, at 120; USGCRP, *Climate Change Impacts*, *supra* note 8, at 28 (“The observed drastic reduction in sea ice can also lead to a “tipping point” – a point beyond which an abrupt or irreversible transition to a different climate state occurs. In this case, the dramatic loss of sea ice could tip the Arctic Ocean into a permanent, nearly ice-free state in summer, with repercussions that may extend far beyond the Arctic.”).

¹¹⁷ C. Derksen et al., *Snow*, in *Arctic Report Card: Update for 2013*, NOAA 103 (Nov. 15, 2013), available at http://www.arctic.noaa.gov/reportcard/ArcticReportCard_full_report.pdf.

¹¹⁸ Gary Braasch & Bill McKibben, *Earth Under Fire* 18-20 (2009); *See also* J.E. Box et. al., *Greenland*, in *Arctic Report Card: Update for 2010*, NOAA at 55 (Oct. 19, 2010), available at <http://www.arctic.noaa.gov/report10/> (“A clear pattern of exceptional and record-setting warm air temperatures is evident at long-term meteorological stations around Greenland.”).

¹¹⁹ NASA Earth Observatory, *Ice Island Calves Off Petermann Glacier* (Aug. 2010), available at <http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=45112&src=eorss-nh>.

¹²⁰ Alister Doyle, *Antarctic Ice Shelf Set to Collapse Due to Warming*, Reuters (Jan. 19, 2009), available at <http://www.reuters.com/article/idUSTRE50I4G520090119>.

¹²¹ NASA Earth Observatory, *Wilkins Ice Bridge Collapse* (Apr. 2009), available at <http://earthobservatory.nasa.gov/IOTD/view.php?id=37806>.

¹²² U.S. Geological Survey, *Coastal-Change and Glaciological Map of the Larsen Ice Shelf Area, Antarctica: 1940-2005* at 10 (2008), available at <http://pubs.usgs.gov/imap/2600/B/Larsenpamphlet12600B.pdf>.

¹²³ *Id.*

¹²⁴ NASA, *NASA-UCI Study Indicates Loss of West Antarctic Glaciers Appears Unstoppable* (May 12, 2014), available at http://www.nasa.gov/press/2014/may/nasa-uci-study-indicates-loss-of-west-antarctic-glaciers-appears-unstoppable/#.U5jBk_ldV3H (last visited June 11, 2014).

rate of melting is exceeding scientists' expectations, requiring scientists to increase global sea level rise predictions.¹²⁵

Scientists have also documented an overall trend of Arctic sea ice (frozen ocean water) thinning.¹²⁶ Arctic sea ice plays an important role in stabilizing the global climate, because it reflects back into space much of the solar radiation that the region receives.¹²⁷ In contrast, open ocean water absorbs much more heat from the sun, thus, amplifying human-induced warming and creating an increased global warming effect.¹²⁸ As Arctic sea ice decreases, the region is less capable of stabilizing the global climate and may act as a feedback loop (thereby aggravating global warming).¹²⁹ During the 2007 melt season, the extent of Arctic sea ice declined precipitously to its lowest level since satellite measurements began in 1979.¹³⁰ By the end of 2010, Arctic sea ice was at the lowest level in the satellite record for the month of December.¹³¹

Similarly, there has been a general increase in permafrost temperatures and permafrost melting in Alaska and other parts of the Arctic.¹³² Substantial methane releases from thawing permafrost have been detected in Alaska and Siberia.¹³³ Because much of the Arctic permafrost overlays old peat bogs, scientists believe (and are concerned) that the melting of the permafrost¹³⁴ may release methane that will further increase global warming to even more dangerous levels.¹³⁵ Carbon dioxide and methane released from thawing permafrost could contribute "as much as 0.4°F to 0.6°F of warming by 2100."¹³⁶

¹²⁵ *Id.*; Hannah Hickey, *West Antarctic Ice Sheet Collapse is Under Way*, University of Washington (May 12, 2014), available at <http://www.washington.edu/news/2014/05/12/west-antarctic-ice-sheet-collapse-is-under-way/>.

¹²⁶ NOAA, *State of the Climate: Global Summary Information – April 2014*, available at <http://www.ncdc.noaa.gov/sotc/summary-info>.

¹²⁷ EPA, *Climate Change Indicators*, *supra* note 98, at 58; See also EPA, *TS Endangerment Findings*, *supra* note 26, at 40.

¹²⁸ EPA, *Climate Change Indicators*, *supra* note 98, at 58.

¹²⁹ *Id.*

¹³⁰ Nat'l Snow and Ice Data Center (NSIDC), Press Release, *Arctic Sea Ice Shatters All Previous Record Lows* (Oct. 1, 2007), http://nsidc.org/news/press/2007_seaiceminimum/20071001_pressrelease.html (last visited June 11, 2014); EPA, *TS Endangerment Findings*, *supra* note 26, at 27 ("Average arctic temperatures increased at almost twice the global average rate in the past 100 years.").

¹³¹ NSIDC, *Repeat of a Negative Arctic Oscillation Leads to Warm Arctic, Low Sea Ice Extent*, Arctic Sea Ice News & Analysis (Jan. 5, 2011), available at <http://nsidc.org/arcticseaicenews/2011/010511.html> (last visited June 11, 2014).

¹³² IPCC, *AR5-WGII*, *supra* note 59, at 4.3.3.4, 46.

¹³³ USGRCP, *Climate Change Impacts*, *supra* note 8, at 48.

¹³⁴ *Id.*

¹³⁵ See IPCC, *AR5-WGII*, *supra* note 59, at 149; USGRCP, *Climate Change Impacts*, *supra* note 8, at 48.

¹³⁶ USGRCP, *Climate Change Impacts*, *supra* note 8, at 48.

6. Agricultural and Forest Losses

Changes in water supply and water quality will also impact agriculture in the US.¹³⁷ Additionally, increased heat and associated issues such as pests, crop diseases, and weather extremes, will all impact crop and livestock production and quality.¹³⁸ For example, climate change in the United States has produced warmer summers, enabling the mountain pine beetle to produce two generations of beetles in a single summer season, where it had previously only been able to produce one. In Alaska, the spruce beetle is maturing in one year when it had previously taken two years.¹³⁹ The expansion of the forest beetle population has killed millions of hectares of trees across the United States and Canada and resulted in millions of dollars lost from decreased timber and tourism revenues.¹⁴⁰

Agriculture is extremely susceptible to climate changes and higher temperatures generally reduce yields of desirable crops while promoting pest and weed¹⁴¹ proliferation.¹⁴² Global climate change is predicted to decrease crop yields, increase crop prices, decrease worldwide calorie availability, and by 2050 increase child malnutrition by 20%.¹⁴³ Climate change threatens global food security and so any effort to mitigate global warming is effectively promoting a secure food supply.¹⁴⁴

7. Health Impacts

Human-caused fossil fuel burning and the resulting climate change are already contributing to an increase in asthma, cancer, cardiovascular disease, stroke, heat-related

¹³⁷ USGCRP, *Climate Change Impacts*, *supra* note 8, at 161; See United States Department of State (USDS), *2014 Climate Action Report (Draft/Not Final)* 6,4 (Sept. 26, 2013) [hereinafter *Climate Action Report*], available at <http://www.state.gov/e/oes/climate/ccreport2014/index.htm>.

¹³⁸ USDS, *Climate Action Report*, *supra* note 137, at 6, 6.

¹³⁹ U.S. Climate Change Science Program (USCCSP), *Weather and Climate Extreme in a Changing Climate, Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands* 15 (June 2008) [hereinafter *Weather and Climate Extremes*], available at http://www.agci.org/dB/PDFs/Publications/07S1_USCCSP.pdf.

¹⁴⁰ *Id.*

¹⁴¹ USCCSP & USDA, *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity, in Synthesis and Assessment Product 4.3* 59 (May 2008), available at http://www.usda.gov/oce/climate_change/SAP4_3/CCSPFinalReport.pdf (“Many weeds respond more positively to increasing CO₂ than most cash crops, . . . Recent research also suggests that glyphosate, the most widely used herbicide in the United States, loses its efficacy on weeds grown at CO₂ levels that likely will occur in the coming decades.”).

¹⁴² Int’l Food Policy Research Inst., *Food Policy Report: Climate Change- Impacts on Agriculture and Costs of Adaptation* vii (Oct. 2009), available at <http://www.ifpri.org/sites/default/files/publications/pr21.pdf>.

¹⁴³ *Id.*

¹⁴⁴ *Id.* at ix (“Climate change will pose huge challenges to food-security efforts. Hence, any activity that supports agricultural adaptation also enhances food security.”).

morbidity and mortality, food-borne diseases, and neurological diseases and disorders.¹⁴⁵ The World Health Organization has stated that “[l]ong-term climate change threatens to exacerbate today’s problems while undermining tomorrow’s health systems, infrastructure, social protection systems, and supplies of food, water, and other ecosystem products and services that are vital for human health.”¹⁴⁶ Climate change is not only expected to affect the basic requirements for maintaining health (clean air and water, sufficient food, and adequate shelter) but is likely to present new challenges for controlling infectious disease and even “halt or reverse the progress that the global public health community is now making against many of these diseases.”¹⁴⁷

8. Security and Global Politics

The changing climate also raises national security concerns, as “climate change will add to tensions even in stable regions of the world.”¹⁴⁸ The U.S. Department of Defense has acknowledged the severity of climate change and its connections to national security.¹⁴⁹ The Quadrennial Defense Review classified climate change as a “threat multiplier.”¹⁵⁰ Specifically, “Pentagon leaders have identified three main ways that climate change will affect security: accelerating instability in parts of the world wracked by drought, famine, and climate-related migrations; threatening U.S. military bases in arid Western states or on vulnerable coastlines; and increasing the need for U.S. forces to respond to major humanitarian disasters.”¹⁵¹ The United States may experience an additional need to accept immigrant and refugee populations as droughts increase and food production declines in other countries.¹⁵² Increased extreme weather events (such as hurricanes) will also present an increased strain on foreign aid and call for military forces.¹⁵³ For instance, by 2025, 40% of the world’s population will be living in

¹⁴⁵ See The Center for Health and the Global Environment, Harvard Medical School, *Climate Change Futures: Health, Ecological, and Economic Dimensions* (Nov. 2005), available at http://coralreef.noaa.gov/aboutcrp/strategy/reprioritization/wgroups/resources/climate/resources/cc_futures.pdf; USGCRP, *Climate Change Impacts*, *supra* note 8, at 221-28.

¹⁴⁶ World Health Organization, *Atlas of Health and Climate* 4 (Oct. 2012), available at <http://www.who.int/globalchange/publications/atlas/report/en/>.

¹⁴⁷ World Health Organization, *Protecting Health from Climate Change: Connecting Science, Policy, and People* 02 (2009), available at <http://www.who.int/globalchange/publications/reports/9789241598880/en/index.html>.

¹⁴⁸ The CNA Corp., Military Advisory Bd., *National Security and the Threat of Climate Change* 7 (Apr. 1, 2007), available at <http://www.cna.org/research/2007/national-security-threat-climate-change> (last visited June 11, 2014).

¹⁴⁹ Keith Johnson, *A Clear and Present Danger*, *Foreign Policy* 3 (May 6, 2014), available at http://www.foreignpolicy.com/articles/2014/05/06/a_clear_and_present_danger (last visited June 11, 2014) (“Environmental issues, energy issues -- they are all connected, and they are all integrated into our national security.”).

¹⁵⁰ Johnson, *supra* note 149, at 3.

¹⁵¹ *Id.*

¹⁵² CNA Corporation, *supra* note 148, at 7.

¹⁵³ *Id.*

countries experiencing significant water shortages, while sea-level rise could cause displacement of tens, or even hundreds, of millions of people.¹⁵⁴

B. The State Government Has Recognized that Climate Change is Already Occurring in the State of Washington and is Projected to Significantly Impact the State in the Future

Governor Jay Inslee acknowledged the severity of the impacts of climate change on the State of Washington, highlighting that “[t]hree key areas of risk, specifically changes in the natural timing of water availability, sea level rise and ocean acidity, and increased forest mortality, will likely bring significant consequences for the economy, infrastructure, natural systems, and human health of the region.”¹⁵⁵ If immediate action is not taken, the costs of climate change impacts to Washington are projected at \$10 billion per year by 2020 “from increased health costs, storm damage, coastal destruction, rising energy costs, increased wildfires, drought, and other impacts.”¹⁵⁶ Governor Inslee has instructed that “Washington needs to take additional actions now” to address climate change.¹⁵⁷

1. Observed and Projected Changes to Washington’s Climate

The global impacts from climate change described above are already being felt here in Washington State. Between 1891 and 2011, the average regional temperatures in the Pacific Northwest rose by about 1.3°F.¹⁵⁸ By 2070 to 2099, the average annual temperature is projected to rise 3.3 to 9.7°F.¹⁵⁹ These warmer temperatures will be observed in each season, but the increase will be the largest in the summer.¹⁶⁰ Extreme heat events will occur more often, while extreme cold events will occur less often.¹⁶¹

¹⁵⁴ *Id.* at 16.

¹⁵⁵ Wash. Exec. Order No. 14-04 (Apr. 29, 2014) at 1.

¹⁵⁶ Department of Ecology, State of Washington, No. 12-01-004, *Preparing for a Changing Climate: Washington State’s Integrated Climate Response Strategy* 3 (2012), <https://fortress.wa.gov/ecy/publications/publications/1201004.pdf>.

¹⁵⁷ Wash. Exec. Order No. 14-04 (Apr. 29, 2014) at 2.

¹⁵⁸ USGRCP, *Climate Change Impacts*, *supra* note 8, at 489; Nat’l Oceanic and Atmospheric Admin. (NOAA), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment, Part 6. Climate of the Northwest U.S.* 83 (2013), available at http://www.nesdis.noaa.gov/technical_reports/NOAA_NESDIS_Tech_Report_142-6-Climate_of_the_Northwest_U.S.pdf.

¹⁵⁹ USGRCP, *Climate Change Impacts*, *supra* note 8, at 489.

¹⁶⁰ *Id.*

¹⁶¹ Climate Impacts Group, *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers* 5-1 (Dec. 2013), available at <http://ceses.washington.edu/db/pdf/snoveretalsok816.pdf>; *Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities* 37 (Meghan M. Dalton et al. eds., 2013), available at <http://ceses.washington.edu/db/pdf/daltonetal678.pdf>.

There have been consistent findings that summer precipitation in the Pacific Northwest will decrease by 10% (average projections), or even up to 30% by the end of this century.¹⁶² Most models project that winter, spring, and fall precipitation will increase by 2% to 7% on average.¹⁶³ Drier summers have already resulted in reduced streamflow west of the Cascades and created a greater risk of wildfires.¹⁶⁴ There could be as much as a 20% increase in extreme daily precipitation.¹⁶⁵ Averaged throughout the Pacific Northwest, the number of days with precipitation greater than one inch will increase by 13% between 2041 and 2070.¹⁶⁶ This increase could result in a greater flood risk in rain-dominant basins and mixed rain-snow basins.¹⁶⁷ The temperature of the ocean off the coast of Washington is projected to rise by 2°F by the 2040s.¹⁶⁸

2. The Meaning of a Changed Environment in Washington: Watersheds and Resulting Water Conflicts

Temperature and precipitation changes will transform the nature of the hydrological systems of the region, impacting water availability for ecosystems and industries that are already constrained by water shortages.¹⁶⁹ Hydropower production, the centerpiece of Washington's existing low-cost energy economy, fueled by spring snowmelt is so significant (comprising 40% of the total hydropower production in the United States) that the Northwest exports 2 to 6 million megawatt hours per month.¹⁷⁰ This snowmelt is also essential for irrigation in the drier parts of the region, whose agricultural production is worth almost \$17 billion.¹⁷¹

By 2050, snowmelt will begin three to four weeks earlier than the average timing in the 20th century. Peak streamflow could shift four to nine weeks earlier in the Sultan, Cedar, Green,

¹⁶² USGCRP, *Climate Change Impacts*, *supra* note 8, at 489.

¹⁶³ Climate Impacts Group, *supra* note 161, at 5-3.

¹⁶⁴ USGCRP, *Climate Change Impacts*, *supra* note at 489; Karin A. Bumbaco & Philip W. Mote, *Three Recent Flavors of Drought in the Pacific Northwest*, *Journal of Applied Meteorology and Climatology* 1244, 2058-68 (2010), available at <http://journals.ametsoc.org/doi/full/10.1175/2010JAMC2423.1>.

¹⁶⁵ USGCRP, *Climate Change Impacts*, *supra* note 8, at 490.

¹⁶⁶ USGCRP, *Climate Change Impacts*, *supra* note 8, at 491; NOAA, *supra* note 158, at 83.

¹⁶⁷ USGCRP, *Climate Change Impacts*, *supra* note 8, at 491.

¹⁶⁸ Climate Impacts Group, *supra* note 161, at 5-4; Philip W. Mote & Eric P. Salathé Jr., *Future Climate in the Pacific Northwest*, *Climate Change* 29-50 (2010), available at http://www.atmos.washington.edu/~salathe/papers/published/Mote_Salathe_2010.pdf.

¹⁶⁹ "Many Washington watersheds are faced with a shortage of water to meet existing and future water needs." Ecology, "Water Market," available at <http://www.ecy.wa.gov/programs/wr/market/market.html> (last visited June 12, 2014).

¹⁷⁰ USGCRP, *Climate Change Impacts*, *supra* note 8, at 488; Energy Info. Admin., *A Quarter of California's Energy Comes from Outside the State* (2011), available at <http://www.eia.gov/todayinenergy/detail.cfm?id=4370>.

¹⁷¹ USGCRP, *Climate Change Impacts*, *supra* note 8, at 488; U.S. Department of Agriculture, *Crop Production 2012 Summary* 96 (2013), available at <http://usda01.library.cornell.edu/usda/nass/CropProdSu//2010s/2013/ CropProdSu-01-11-2013.pdf>.

and Tolt watersheds of the Puget Sound and in the Yakima basin by the 2080s.¹⁷² This shift in snowmelt timing, compounded with reduced snow accumulation, will result in smaller summer streamflows and larger late-winter and early-spring streamflows.¹⁷³ These changes have already been observed with late-winter, early-spring flows more than 20% larger and summer flows observed more than 15% smaller.¹⁷⁴ Models have found that it is nearly 100% likely that reduced summer flows will be observed by 2050.¹⁷⁵ Winter streamflows in Washington are projected to increase by 25 to 34%, increasing the chance of extreme flood events, while summer streamflows are projected to decrease by 34 to 44% by the 2080s, increasing the chance of extreme drought events.¹⁷⁶ These low summer flows are projected to occur in 80% of Washington's watersheds.¹⁷⁷

The overall hydrology of the State will shift toward rain-dominant basins, with the elimination of snow-dominant basins by the 2080s.¹⁷⁸ The area-averaged snowpack in the Cascades on April 1 has already decreased by 20% since 1950.¹⁷⁹ The average snowpack is projected to decrease by 56 to 70% by the 2080s.¹⁸⁰ It is likely that only two of the twelve glaciers of the North Cascades will “survive the current climate.”¹⁸¹ This will result in a number of severe regional impacts as these glaciers are the source of 10 to 44% of the total summer

¹⁷² Climate Impacts Group, *supra* note 161, at 6-3; Marketa M. Elsner et al., *Implications of 21st Century Climate Change for the Hydrology of Washington State*, *Climatic Change* 102(1-2), 225-60 (2010), available at <https://www.uni-hohenheim.de/fileadmin/einrichtungen/klimawandel/Literatur/Elsner-et-al-CC2010.pdf>.

¹⁷³ USGCRP, *Climate Change Impacts*, *supra* note 8, at 490; Climate Impacts Group, *supra* note 161, at 2-3.

¹⁷⁴ USGCRP, *Climate Change Impacts*, *supra* note 8, at 489; Philip W. Mote, *Climate-Driven Variability and Trends in Mountain Snowpack in Western North America*, *Journal of Climate* 19, 6209-20 (2006), available at <http://journals.ametsoc.org/doi/pdf/10.1175/JCLI3971.1>; Iris T. Stewart et al., *Changes Toward Earlier Streamflow Timing Across Western North America*, *Journal of Climate* 18, 1136-55 (2005), available at <http://journals.ametsoc.org/doi/pdf/10.1175/JCLI3321.1>.

¹⁷⁵ USGCRP, *Climate Change Impacts*, *supra* note 8, at 491; Elsner, *supra* note 172, at 225-60.

¹⁷⁶ Climate Impacts Group, *supra* note 161, at 6-3; Elsner, *supra* note 172, at 225-60.

¹⁷⁷ Climate Impacts Group, *supra* note 161, at 6-4; Ingrid M. Tohver et al., *Impacts of 21st Century Climate Change on Hydrologic Extremes in the Pacific Northwest Region of North America*, *Journal of the American Water Resources Association* (2013), available at <http://ces.washington.edu/db/pubs/abstract829.shtml>.

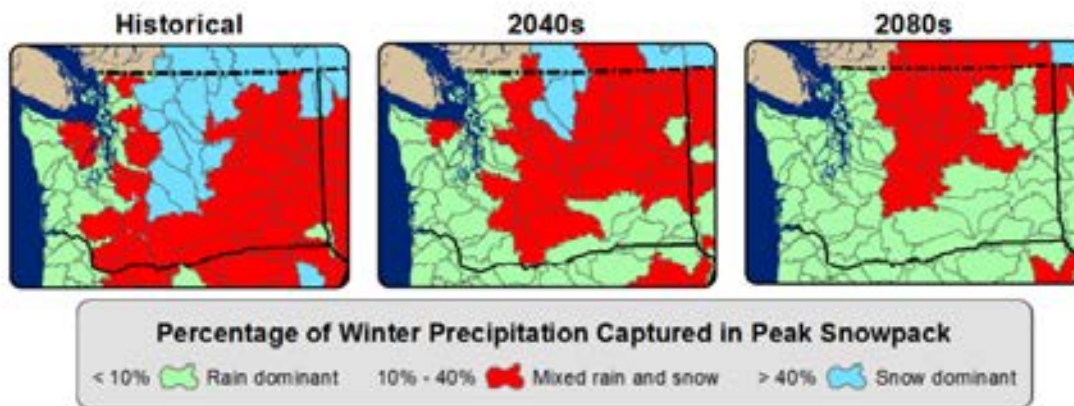
¹⁷⁸ Climate Impacts Group, *supra* note 161, at 6-2; Alan F. Hamlet et al., *An Overview of the Columbia Basin Climate Change Scenarios Project: Approach, Methods, and Summary of Key Results*, *Atmosphere-Ocean* 51(4), 392-415 (2013), available at <http://www.tandfonline.com/doi/abs/10.1080/07055900.2013.819555#.U5qKHPIdV3E>.

¹⁷⁹ USGCRP, *Climate Change Impacts*, *supra* note 8, at 489; Mote, *supra* note 174, 6209-20.

¹⁸⁰ Climate Impacts Group, *supra* note 161, at 6-1; Elsner, *supra* note 172, at 225-60.

¹⁸¹ Climate Impacts Group, *supra* note 161, at 6-3; M.S. Pelto, *Forecasting Temperature Alpine Glacier Survival from Accumulation Zone Observations*, *The Cryosphere* 4(1), 67-75 (2010), available at <http://www.the-cryosphere.net/4/67/2010/tc-4-67-2010.pdf>.

streamflows in the North Cascades.¹⁸²



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Hydrological shifts, and specifically reduced summer flows, will result in conflicts over existing competing uses of the resource, which include agriculture, hydropower, and fisheries. Added stresses on the water supply also include the need for increased hydropower production to meet rising electricity demands that will accompany rising temperatures, reduced runoff from dry forest ecosystems, and increased demands for irrigation.¹⁸⁴ This has the potential to negatively affect the already-constrained instream flows in many of Washington’s rivers. Furthermore, “over-allocation of existing water supply, conflicting objectives, limited management flexibility caused by rigid water allocation and operating rules, and other institutional barriers to changing operations continue to limit progress towards adaptation in many parts of the Columbia River basin.”¹⁸⁵

¹⁸² Climate Impacts Group, *supra* note 161, at 6-3; Jon L. Riedel and M.A. Larrabee, *North Cascades National Park Complex Glacier Mass Balance Monitoring Annual Report, Water Year 2009: North Coast and Cascades Network*, Natural Resource Technical Report NPS/NCCN/NRTR – 2011/483 (2011), <http://www.nps.gov/noca/naturescience/glacial-mass-balance1.htm>.

¹⁸³ Climate Impacts Group, *supra* note 161, at 6-2 (“Maps above indicate current and future watershed classifications, based on the proportion of winter precipitation stored in peak annual snowpack.”); Hamlet, *supra* note 178, at 392-415.

¹⁸⁴ USGCRP, *Climate Change Impacts*, *supra* note 8, at 491.

¹⁸⁵ USGCRP, *Climate Change Impacts*, *supra* note 8, at 491; *See also* A.F. Hamlet, *Assessing Water Resources Adaptive Capacity to Climate Change Impacts in the Pacific Northwest Region of North America*, *Hydrology and Earth System Sciences* 15, 1427-43 (2011), available at <http://www.hydrol-earth-syst-sci.net/15/1427/2011/hess-15-1427-2011.pdf>; *See also* E.L Miles et al., *Pacific Northwest Regional Assessment: The Impacts of Climate Variability and Climate Change on the Water Resources of the Columbia River Basin*, *Journal of the American Water Resources Association* 36, 399-420 (2000), available at <http://cses.washington.edu/db/pubs/abstract90.shtml>.

Stresses upon multiple industries will require significant tradeoffs, as “changes in water management to alleviate impacts on one sector . . . could exacerbate impacts on other sectors.”¹⁸⁶ For example, in order to preserve the flow targets for fish in the Columbia River basin, it might be necessary to reduce hydropower production by 20% as soon as 2080.¹⁸⁷ Regional power planners have already expressed concern for the possibility that hydropower production will not be able to meet summer needs given increased demands, new conflicts, and changes in flows.¹⁸⁸

3. The Meaning of a Changed Environment in Washington: Forests

Climate impacts will cumulatively impact Washington’s forests by increasing tree stress, vulnerability to insects, and flammability, and “are virtually certain to cause forest mortality by the 2040s and long-term transformation of forest landscapes.”¹⁸⁹ Drier summers will cause forests to become more water-limited. The area of water-limited forests will increase by 32% by the 2020s, followed by another 12% increase in the 2040s and in the 2080s.¹⁹⁰

The range in Washington that is favorable for Douglas-fir and pine species will decline by 32% and 85%, respectively, by the 2060s because of shifts in climate.¹⁹¹ Climate range shifts will also result in the loss of 21 to 38 plant species that will no longer have a suitable habitat in the Northwest.¹⁹² Subalpine and alpine forests are highly vulnerable and will be converted into different vegetation types by the 2080s.¹⁹³

¹⁸⁶ Climate Impacts Group, *supra* note 161, at 6-5; Jeffrey T. Payne et al., *Mitigating the Effects of Climate Change on the Water Resources of the Columbia River Basin*, *Climatic Change* 62(1-3), 233-56 (2004), available at http://ces.washington.edu/cig/outreach/workshopfiles/Apr03_Scenarios_water/Payne_crb_v7_112502.pdf.

¹⁸⁷ USGCRP, *Climate Change Impacts*, *supra* note 8, at 491; Payne, *supra* note 186, at 233-56.

¹⁸⁸ Climate Impacts Group, *supra* note 161, at 6-5; Northwest Power and Conservation Council, *The Sixth Northwest Electric Power and Conservation Plan* (2013), available at <http://www.nwcouncil.org/energy/powerplan/>; Matthew S. Markoff & Alison C. Cullen, *Impact of Climate Change on Pacific Northwest Hydropower*, *Climatic Change* 87(3-4), 451-69 (2008), available at <http://www.hydroreform.org/sites/default/files/Markoff%20and%20Cullen-%20Impact%20of%20climate%20change%20on%20pacific%20Northwest%20hydropower.pdf>.

¹⁸⁹ USGCRP, *Climate Change Impacts*, *supra* note 8, at 494.

¹⁹⁰ Climate Impacts Group, *supra* note 161, at 7-3; Jeremy S. Littell et al., *Forest Ecosystems, Disturbance, and Climatic Change in Washington State, USA*, *Climatic Change* 102, 129-58 (2010), available at http://www.fs.fed.us/wwetac/publications/littell_etal_2010.pdf.

¹⁹¹ Climate Impacts Group, *supra* note 161, at 7-1; Littell, *supra* note 190, at 129-58.

¹⁹² USGCRP, *Climate Change Impacts*, *supra* note 8, at 495; Daniel W. McKenney et al., *Revisiting Projected Shifts in the Climate Envelopes of North American Trees Using Updated General Circulation Models*, *Global Change Biology* 17, 2720-30 (2011), available at http://www.researchgate.net/publication/229883798_Revisiting_projected_shifts_in_the_climate_envelopes_of_north_american_trees_using_updated_general_circulation_models?ev=prf_cit.

¹⁹³ USGCRP, *Climate Change Impacts*, *supra* note 8, at 495; James M. Lenihan et al., *Simulated Response of Conterminous United States Ecosystems to Climate Change at Different Levels of Fire Suppression, CO₂ Emission Rate, and Growth Response to CO₂*, *Global and Planetary*

Forest habitat that is suitable for pine beetles is projected to expand by 27% as higher elevations warm, but then decrease as the temperatures rise beyond suitable temperature.¹⁹⁴ Warmer temperatures will cause forests to be more susceptible to diseases, such as yellow-cedar decline and *Cytospora* canker of alder.¹⁹⁵

The median annual area burned by wildfires in the Northwest will increase to 2 million acres by the 2080s, four times the area burned annually between 1916 and 2007.¹⁹⁶ Fires may also begin to occur in areas where they do not usually occur, with annual area burned west of the Cascade Range crest projected to increase by 150 to 1000% in 2070-2099 than in 1971-2000.¹⁹⁷ These impacts could seriously harm local timber and bioenergy industries, as well as other economic, recreational and aesthetic activities dependent upon existing healthy forests.¹⁹⁸ Increased forest fires will also reduce the ability of Washington's forests to sequester carbon, which could be reduced by 17 to 37%.¹⁹⁹

Change 64, 16-25 (2008), available at

http://www.fs.fed.us/pnw/pubs/journals/pnw_2008_lenihan001.pdf?; Brendan M. Rogers et al., *Impacts of Climate Change on Fire Regimes and Carbon Stocks of the US Pacific Northwest*, *Journal of Geophysical Research* 116 (2011), available at http://terraweb.forestry.oregonstate.edu/pubs/Rogers_2011.pdf; Gerald E. Rehfeldt et al., *North American Vegetation model for Land-Use Planning in a Changing Climate: A Solution to Large Classification Problems*, *Ecological Applications* 22, 119-41 (2012), available at http://www.fs.fed.us/rm/pubs_other/rmrs_2012_rehfeldt_g001.pdf?

¹⁹⁴ USGCRP, *Climate Change Impacts*, *supra* note 8, at 495; Climate Impacts Group, *supra* note 161 at 7-4; Barbara J. Bentz et al., *Climate Change and Bark Beetles of Western United States and Canada: Direct and Indirect Effects*, *BioScience* 60, 602-13 (2010), available at http://www.fs.fed.us/rm/pubs_other/rmrs_2010_bentz_b001.pdf?

¹⁹⁵ Climate Impacts Group, *supra* note 161, at 7-4; John T. Kliejunas, *A Risk Assessment of Climate Change and the Impact of Forest Diseases on Forest Ecosystems in the Western United States and Canada*, U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station 70 (2011), available at

http://www.fs.fed.us/psw/publications/documents/psw_gtr236/psw_gtr236.pdf.

¹⁹⁶ USGCRP, *Climate Change Impacts*, *supra* note 8, at 494; Littell, *supra* note 190, at 129-58.

¹⁹⁷ Climate Impacts Group, *supra* note 161, at 7-4; Rogers, *supra* note 193, at 116.

¹⁹⁸ USGCRP, *Climate Change Impacts*, *supra* note 8, at 495.

¹⁹⁹ Climate Impacts Group, *supra* note 161, at 7-5; C. Raymond and J.A. McKenzie, *Carbon Climate Impacts Group*, *supra* note 161, at 7-5; C. Raymond & J.A. McKenzie, *Carbon Dynamics of Forests in Washington, USA: 21st Century Projections Based on Climate-Driven Changes in Fire Regimes*, *Ecological Applications* 22, 1589-1611 (2012), available at http://www.fs.fed.us/pnw/pubs/journals/pnw_2012_raymond.pdf.

4. The Meaning of a Changed Environment in Washington: Fish & Wildlife

Changes in flows and increased water temperature will threaten freshwater fish species, including salmon, steelhead, and trout.²⁰⁰ Trout populations are projected to decline by 33 to 77% in the western United States by the 2080s.²⁰¹ Salmon habitat will be harmed by a variety of climate change impacts. Earlier migrations of sockeye have already been observed.²⁰² Rising stream temperatures will result in stress on adult salmon, and in many streams the temperatures will rise beyond the tolerance levels of salmon.²⁰³ Suitable stream temperatures could move up to 100 miles upstream.²⁰⁴ Increases in forest fire frequency can completely burn out root systems, which contribute to erosion and sedimentation of rivers that salmon frequent.²⁰⁵ Increased sedimentation in rivers and streams can reduce areas of suitable gravel for salmon spawning and can kill eggs and juveniles.²⁰⁶ Sea level rise may flood estuaries, a critical habitat for salmon transitioning between river and ocean life.²⁰⁷ Flooding from increasingly heavy winter precipitation can wash away salmon eggs and destroy spawning beds completely.²⁰⁸

The loss of alpine tundra and subalpine vegetation, and in turn wildlife habitat, could harm populations of American pika, wolverine, and American marten.²⁰⁹ Changes to seasonal

²⁰⁰ USGCRP, *Climate Change Impacts*, *supra* note 8, at 491; Nathan Mantua et al., *Climate Change Impacts on Streamflow Extremes and Summertime Stream Temperature and Their Possible Consequences for Freshwater Salmon Habitat in Washington State*, *Climatic Change* 102, 187-223 (2010), available at <http://link.springer.com/article/10.1007%2Fs10584-010-9845-2#page-1>.

²⁰¹ Climate Impacts Group, *supra* note 161, at 6-6; Seth J. Wenger et al., *Flow Regime, Temperature, and Biotic Interactions Drive Differential Declines of Trout Species Under Climate Change*, *Proceedings of the National Academy of Sciences* 108(34), 14175-80 (2011), available at <http://www.pnas.org/content/early/2011/08/09/1103097108.full.pdf+html>.

²⁰² USGCRP, *Climate Change Impacts*, *supra* note 8, at 491; Lisa G. Crozier et al., *Using Time Series Analysis to Characterize Evolutionary and Plastic Responses to Environmental Change: A Case Study of a Shift Toward Earlier Migration Date in Sockeye Salmon*, *The American Naturalist* 178, 755-73 (2011), available at <http://europemc.org/abstract/MED/22089870>.

²⁰³ Climate Impacts Group, *supra* note 161, at 6-3; Mantua, *supra* note 200, at 187-223.

²⁰⁴ Climate Impacts Group, *supra* note 161, at 8-3; Daniel J. Isaak and Bruce E. Rieman, *Stream Isotherm Shifts from Climate Change and Implications for Distributions of Ectothermic Organisms*, *Global Change Biology* 19, 742-51 (2013), available at <http://onlinelibrary.wiley.com/doi/10.1111/gcb.12073/abstract>.

²⁰⁵ Nat'l Wildlife Fed'n, *Salmon and Global Warming* (2014), available at <https://www.nwf.org/Wildlife/Threats-to-Wildlife/Global-Warming/Effects-on-Wildlife-and-Habitat/Salmon.aspx>.

²⁰⁶ The IUCN Red List of Threatened Species, *Salmon and Climate Change: Fish in Hot Water*, (2009), available at http://www.wildsalmoncenter.org/pdf/salmon_and_climate_change.pdf

²⁰⁷ Nat'l Wildlife Fed'n, *supra* note 205.

²⁰⁸ *Id.*

²⁰⁹ Climate Impacts Group, *supra* note 161, at 8-1; Erik A. Beever et al., *Testing Alternative Models of Climate-Mediated Extirpations*, *Ecological Applications* 20, 164-78 (2010), available at <http://www.nationalparkstraveler.com/files/Beever-Climate-Mediated%20Extirpations.pdf>;

events have already caused migratory birds to arrive only after the peak of their food resources has occurred.²¹⁰ Climate change will allow for an increase in the spread of invasive species, such as western juniper and cheat grass.²¹¹

Sea level rise will alter coastal habitats, as brackish marshlands are converted into tidal flats and other salt water habitats.²¹² Up to 11% of inland swamps are projected to be flooded by salt water.²¹³ Marine animal habitats will also be affected by sea level rise, and resulting erosion, potentially impacting Chinook salmon, Pacific mackerel, Pacific hake, oysters, mussels, English sole, and yellowtail rockfish, as well as phytoplankton and zooplankton.²¹⁴

5. The Meaning of a Changed Environment in Washington: Coastal Flooding and Infrastructure

Sea level rise has the potential to seriously impact coastal infrastructure, which may be subject to “more frequent flooding or permanent inundation.”²¹⁵ This coastal infrastructure includes: roads, rail lines, ferry terminals, wastewater treatment plants, and stormwater systems.²¹⁶ Sea level rise is projected to rise 4 to 56 inches by 2100, relative to 2000.²¹⁷ While

Kevin S. McKelvey et al., *Climate Change Predicted to Shift Wolverine Distributions, Connectivity, and Dispersal Corridors*, *Ecological Applications* 21, 2882-97 (2011), available at http://www.fs.fed.us/rm/pubs_other/rmrs_2011_mckelvey_k001.pdf; T.N. Wasserman et al., *Simulating the Effects of Climate Change on population Connectivity of American Marten (Martes americana) in the Northern Rocky Mountains, USA*, *Landscape Ecology* 27, 211-25 (2012), available at http://www.fs.fed.us/rm/pubs_other/rmrs_2012_wasserman_t002.pdf.

²¹⁰ Climate Impacts Group, *supra* note 161, at 8-2; Tim Jones & Will Cresswell, *The Phenology Mismatch Hypothesis: Are Declines of Migrant Birds Linked to Uneven Global Change?*, *Journal of Animal Ecology* 79, 98-108 (2010), available at <http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2656.2009.01610.x/pdf>.

²¹¹ Climate Impacts Group, *supra* note 161, at 8-2; USGCRP, *Climate Change Impacts*, *supra* note 8, at 200.

²¹² Climate Impacts Group, *supra* note 8, at 8-4; Patty Glick et al., *Sea-Level Rise and Coastal Habitats in the Pacific Northwest: An Analysis for Puget Sound, Southwestern Washington, and Northwestern Oregon*, National Wildlife Federation (2007), available at <http://www.nwf.org/pdf/Wildlife/PacificNWSeaLevelRise.pdf>.

²¹³ Climate Impacts Group, *supra* note 161, at 8-4; Glick, *supra* note 212.

²¹⁴ Climate Impacts Group, *supra* note 161, at 9-4; Washington Shellfish Initiative Blue Ribbon Panel on Ocean Acidification, *Scientific Summary of Ocean Acidification in Washington State Marine Waters*, NOAA OAR Special Report (Richard A. Feely et al. eds., Nov. 2012) [hereinafter *Scientific Summary of Ocean Acidification*], available at <https://fortress.wa.gov/ecy/publications/publications/1201016.pdf>;

Isaac C. Kaplan et al., *Fishing Catch Shares in the Face of Global Change: A Framework for Integrating Cumulative Impacts and Single Species Management*, *Canadian Journal of Fisheries and Aquatic Sciences* 67(12), 1968-82 (2010), available at http://www.nrcresearchpress.com/doi/abs/10.1139/F10-118#.U5spa_lV3F.

²¹⁵ Climate Impacts Group, *supra* note 161, at 10-4.

²¹⁶ USGCRP, *Climate Change Impacts*, *supra* note 8, at 493.

tectonic uplift is gradually raising much of the coastline of the Northwest, some areas in the Puget Sound are undergoing subsidence which will compound the rising of global sea levels.²¹⁸ Any uplift that is occurring along the coastline could be reversed immediately by a single major earthquake, instantly raising the sea level by up to 40 inches.²¹⁹ This sea level rise can also be compounded with shorter-term rise resulting from El Nino conditions that can increase the sea level by 4 to 12 inches for several months.²²⁰

More than 140,000 acres of lands in Washington and Oregon are located within 3.3 feet of high tide and are therefore vulnerable to rising sea levels.²²¹ By 2050, the average projection shows that Seattle will experience 16.6 centimeters of sea-level rise, and 61.8 centimeters by 2100.²²² This sea level rise could completely inundate at least three King County Wastewater Treatment Division facilities.²²³ Over 1,100 acres, or 15%, of Swinomish Indian Tribal Community Reservation lands could also be inundated, including their primary economic area.²²⁴

²¹⁷ Climate Impacts Group, *supra* note 161, at 5-3; Nat'l Research Council, *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future* (The National Academies Press 2012), available at <http://ssi.ucsd.edu/scc/images/NRC%20SL%20rise%20W%20coast%20USA%2012.pdf>.

²¹⁸ USGCRP, *Climate Change Impacts*, *supra* note 8, at 492.

²¹⁹ USGCRP, *Climate Change Impacts*, *supra* note 8, at 492; Brian F. Atwater et al., *The Orphan Tsunami of 1700 – Japanese Clues to a Parent Earthquake in North America*, U.S. Geological Survey Professional Paper 144 (2005), available at <http://pubs.usgs.gov/pp/pp1707/pp1707.pdf>; Nat'l Research Council, *supra* note 217, at 201.

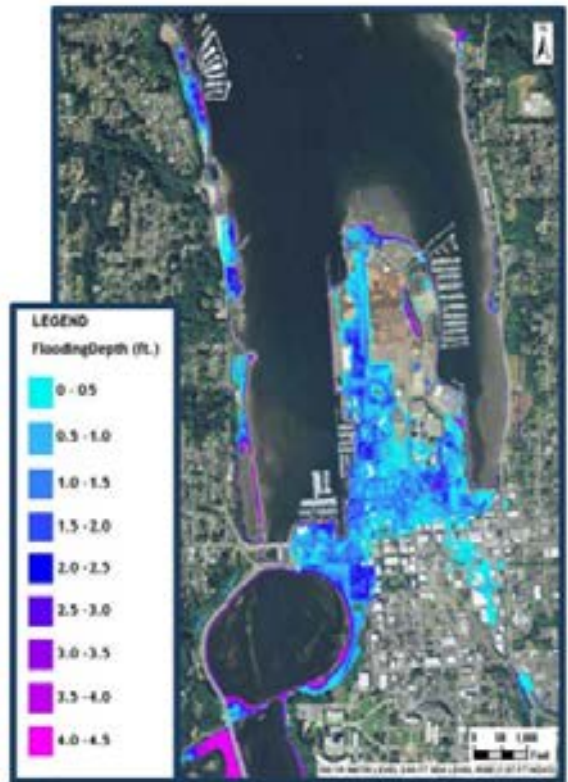
²²⁰ USGCRP, *Climate Change Impacts*, *supra* note 8, at 493; Nat'l Research Council, *supra* note 217, at 201.

²²¹ USGCRP, *Climate Change Impacts*, *supra* note 8, at 493; Benjamin H. Strauss et al., *Tidally Adjusted Estimates of Topographic Vulnerability to Sea Level Rise and Flooding for the Contiguous United States*, *Environmental Research Letters* 7 (2012), available at http://iopscience.iop.org/1748-9326/7/1/014033/pdf/1748-9326_7_1_014033.pdf.

²²² Nat'l Research Council, *supra* note 217, at 96.

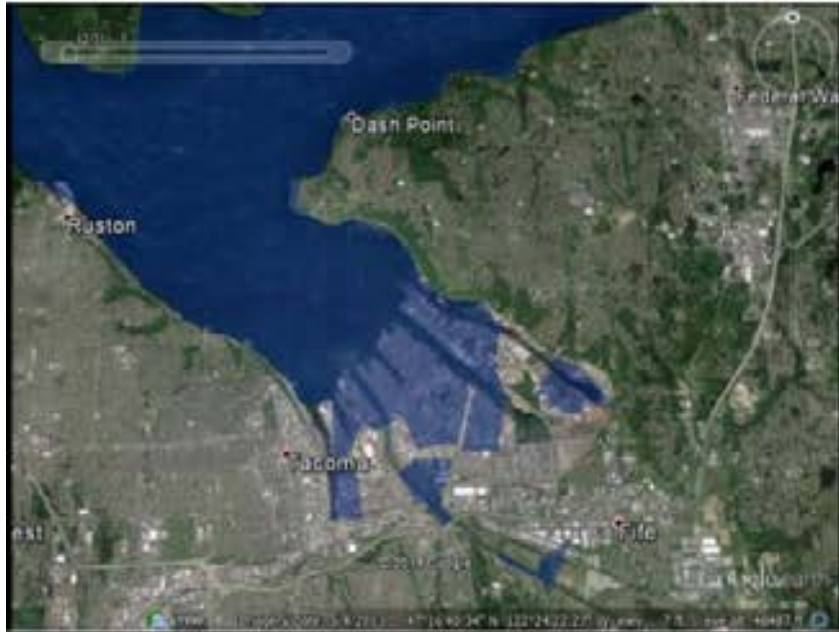
²²³ Climate Impacts Group, *supra* note 161, at 10-3; King County Wastewater Treatment Division, *Vulnerability of Major Wastewater Facilities to Flooding from Sea Level Rise*, Department of Natural Resources and Parks (2008), available at http://your.kingcounty.gov/dnrp/library/archive-documents/wtd/csi/csi-docs/0807_SLR_VF_TM.pdf.

²²⁴ Climate Impacts Group, *supra* note 161, at 10-4; Swinomish Indian Tribal Community, *Swinomish Climate Change Initiative: Climate Adaptation Action Plan* (2010), available at http://www.swinomish.org/climate_change/Docs/SITC_CC_AdaptationActionPlan_complete.pdf.



²²⁵ USGCRP, *Climate Change Impacts*, *supra* note 8, at 493 (“Areas of Seattle projected by Seattle Public Utilities to be below sea level during high tide (Mean Higher High Water) and therefore at risk of flooding or inundation are shaded in blue under three levels of sea level rise, assuming no adaptation.”).

²²⁶ Climate Impacts Group, *supra* note 161, at 10-4 (“Projected flooding in the City of Olympia during a 100-year flood event with +6 inches of sea level rise.”).



Sea level rise will compound inland flooding, as floodwaters will be less able to drain into the ocean. Increased rainfall and sea level rise combined will cause an increase in the area flooded in the Skagit basin by 74% by the 2080s.²²⁸ Sea level rise will also increase the frequency of extreme coastal events. After 6 inches of sea level rise, the probability of a 100-year flood event increases from 1% to 5.5%, and after 24 inches of sea level rise it would become an annual event.²²⁹

²²⁷ Map shows the inundation of Tacoma if the sea level rose by 13 feet, which is projected to occur if the Western Antarctic Ice Sheet completely melts; Evan Pappas, *How Washington Coastal Cities Will Look When the Antarctic Ice Sheet Melts*, Seattle PI (May 14, 2014), available at <http://blog.seattlepi.com/bigscience/2014/05/14/how-washington-coastal-cities-will-look-when-the-antarctic-ice-sheet-melts/#23379101=6>.

²²⁸ Climate Impacts Group, *supra* note 161, at 6-4; Joseph J. Hamman, *Effects of Projected Twenty-First Century Sea Level Rise, Storm Surge, and River Flooding on Water Levels in Puget Sound Floodplains and Estuaries*, University of Washington (2012), available at https://digital.lib.washington.edu/researchworks/bitstream/handle/1773/20735/Hamman_washington_02500_10613.pdf?sequence=1.

²²⁹ Climate Impacts Group, *supra* note 161, at 9-3; David P. Simpson, *City of Olympia Engineered Response to Sea Level Rise* (2012) (technical report prepared by Coast Harbor Engineering for the City of Olympia, Public Works Department, Planning and Engineering), available at http://olympiawa.gov/community/sustainability/~/_/media/Files/PublicWorks/Sustainability/Sea%20Level%20Rise%20Response%20Technical%20Report.ashx.

6. The Meaning of a Changed Environment in Washington: Agriculture

In 2009, agricultural commodities comprised 3%, and food production comprised 11%, of the gross domestic product of the Northwest.²³⁰ Changes in precipitation and snowmelt will result in irrigation water scarcity, while temperature changes will increase heat stress of crops.²³¹ Years when Yakima basin junior water rights holders are only allocated 75% of their right amount, or water-short years, will increase up to 32% by 202 and 77% by 2080.²³² Decreased soil moisture could reduce wheat yield by 25% in Washington, relative to 1975 to 2005.²³³ Water availability will also impact livestock industries.²³⁴ Many agricultural pests are projected to increase with rising temperatures, including the codling moths and cereal leaf beetles.²³⁵

7. The Meaning of a Changed Environment in Washington: Human Health

The increased occurrence and scale of wildfires could severely impact human health by worsening respiratory and cardiovascular illnesses because of the resulting air pollution.²³⁶ Extreme heat events (days above 95°F) could increase from three days to more than ten days annually by 2050.²³⁷ These events will result in increased occurrences of heat exhaustion, heart attacks, strokes, and drownings and will compound problems with respiratory illnesses,

²³⁰ USGCRP, *Climate Change Impacts*, *supra* note 8, at 496; Michael Brady & Justin Taylor, *Agriculture's Contribution to Washington's Economy*, IMPACT Center Fact Sheet 2 (2011), available at <http://www.impact.wsu.edu/report/WashingtonAgEconomicImpact.pdf>; Idaho State Department of Agriculture, *Idaho Agriculture Facts 2011* (2012), available at <http://www.agri.idaho.gov/Categories/Marketing/Documents/English%20Final%202011%20-%20for%20emailing.pdf>.

²³¹ USGCRP, *Climate Change Impacts*, *supra* note 8, at 497.

²³² USGCRP, *Climate Change Impacts*, *supra* note 8, at 497; Julie A. Vano et al., *Climate Change Impacts on Water Management in the Puget Sound Region, Washington State, USA*, *Climatic Change* 102, 261-86 (2010), available at http://www.researchgate.net/publication/226371241_Climate_change_impacts_on_water_management_in_the_Puget_Sound_region_Washington_State_USA.

²³³ USGCRP, *Climate Change Impacts*, *supra* note 8, at 497; Claudio O. Stöckle et al., *Assessment of Climate Change Impact on Eastern Washington Agriculture*, *Climatic Change* 102, 77-102 (2010), available at <http://cses.washington.edu/db/pdf/wacciach5ag648.pdf>.

²³⁴ Climate Impacts Group, *supra* note 161, at 11-4.

²³⁵ Climate Impacts Group, *supra* note 161, at 11-4; Stöckle, *supra* note 233, at 77-102; E.W. Evans et al., *Warm Springs Reduce Parasitism of the Cereal Leaf Beetle Through Phenological Mismatch*, *Journal of Applied Entomology* (2012), available at <http://onlinelibrary.wiley.com/doi/10.1111/jen.12028/abstract>.

²³⁶ USGCRP, *supra* note 8, at 495.

²³⁷ Climate Impacts Group, *supra* note 161, at 12-3; Kenneth E. Kunkel et al., *Part 6: Climate of the Northwest U.S.*, NOAA Technical Report NESDIS 142-6, 76 (2013), available at http://scenarios.globalchange.gov/sites/default/files/NOAA_NESDIS_Tech_Report_142-6-Climature_of_the_Northwest_U.S_0.pdf.

cardiovascular disease, and kidney failure.²³⁸ One study projected that there could be 157 more heat-related deaths per year by 2045 in Seattle alone.²³⁹

Increased winter flooding will result in injuries or deaths caused directly, exposure to dangerous substances, respiratory illnesses from resulting mold growth, and the disruption of infrastructure.²⁴⁰ Increased forest fires due to drought conditions will result in more respiratory problems, include asthma and pneumonia.²⁴¹ The Chelan and Kittitas Counties' fires in 2012 resulted in 350 hospitalizations for respiratory issues caused by smoke.²⁴² Increased production of allergens due to longer pollination seasons will result in more severe allergies and increased asthma attacks.²⁴³

C. Ocean Acidification, the Counterpart to Climate Change and the Other Direct Adverse Impact of Carbon Dioxide Emissions, is Harming Oceans Worldwide

The negative effects of increased CO₂ emissions are not limited to changes in our climate systems. Rather, CO₂ emissions are also having a severe impact on our oceans. As it stands, the oceans absorb around 30% of global CO₂ emissions.²⁴⁴ This absorption has greatly mitigated the effects CO₂ otherwise would have had on our climate.²⁴⁵ However, the cost of this mitigation has been a pernicious change in our ocean's chemistry.²⁴⁶

Ocean acidification is defined as "a reduction in the pH of seawater for an extended period of time due primarily to the uptake of carbon dioxide from the atmosphere by the ocean."²⁴⁷ Over the last 250 years, humans have increased atmospheric CO₂ concentrations by 40%.²⁴⁸ The oceans, in turn, have absorbed about a quarter of this CO₂.²⁴⁹ As CO₂ has been

²³⁸ Climate Impacts Group, *supra* note 161, at 12-3.

²³⁹ Climate Impacts Group, *supra* note 161, at 12-3; J. Elizabeth Jackson et al., *Public Health Impacts of Climate Change in Washington State: Projected Mortality Risks Due to Heat Events and Air Pollution*, Climatic Change 102(1-2), 159-86 (2010), available at <http://ces.washington.edu/db/pdf/wacciach10health653.pdf>.

²⁴⁰ Climate Impacts Group, *supra* note 161, at 12-4.

²⁴¹ Climate Impacts Group, *supra* note 161, at 12-5.

²⁴² *Id.*

²⁴³ *Id.*

²⁴⁴ Ellycia Harrould-Kolieb & Jacqueline Savitz, *Acid Test: Can We Save Our Oceans From CO₂?*, Oceana 2 (2d ed. 2009) [hereinafter *Acid Test*], available at http://www.salemsound.org/PDF/Acidification_Report-09.pdf (last visited June 14, 2014).

²⁴⁵ *Id.*

²⁴⁶ *Id.*

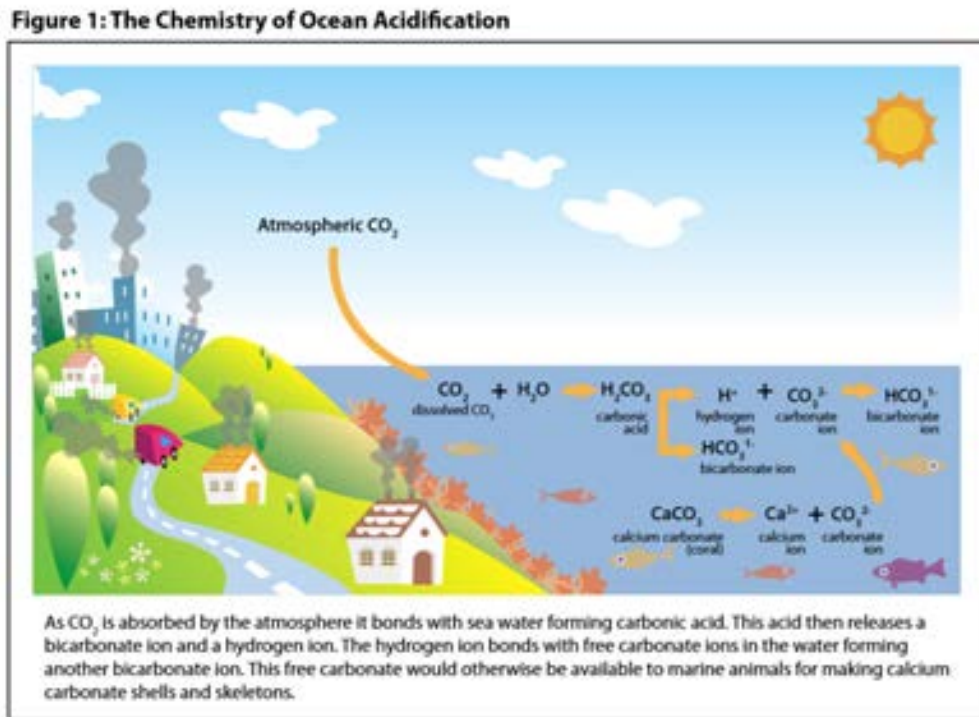
²⁴⁷ Washington State Blue Ribbon Panel on Ocean Acidification, *Ocean Acidification: From Knowledge to Action, Washington State's Strategic Response* xi (H. Adelman & L. Whitely Binder eds., 2012) [hereinafter *Strategic Response*], available at <https://fortress.wa.gov/ecy/publications/publications/1201015.pdf> (last visited June 14, 2014).

²⁴⁸ *Id.* at 9.

²⁴⁹ *Id.*

absorbed and dissolved in the seawater it has had an acidifying effect.²⁵⁰ As a result, “[o]ver the last 250 years, the average upper-ocean pH has decreased by about 0.1 units, from about 8.2 to 8.1.”²⁵¹ This drop in pH corresponds with a 30% increase in surface ocean acidity.²⁵²

This carbon dioxide absorption and resulting acidity in oceans cause a decrease in the concentration of carbonate ions, which threatens the formation of calcium carbonate shells and skeletons in many marine organisms. When CO₂ enters into solution with water (H₂O), carbonic acid (H₂CO₃) is formed. The carbonic acid then breaks down, releasing a bicarbonate ion (HCO₃⁻) and a hydrogen ion (H⁺).²⁵³ As increasing quantities of CO₂ dissolves in seawater, the concentration of hydrogen ions increases, causing a decrease in pH (pH is a measure of the concentration of hydrogen ions) and an increase in acidity.²⁵⁴ The newly free hydrogen ion then bonds with a free carbonate ion, forming another bicarbonate ion (HCO₃⁻).²⁵⁵ Thus as the concentration of hydrogen ions increases, the concentration of carbonate decreases.²⁵⁶ This is significant because carbonate is essential to many life-functions, such as forming calcium carbonate shells and skeletons.²⁵⁷ This process has been described in the following figure.²⁵⁸



²⁵⁰ *Id.*

²⁵¹ *Id.*

²⁵² *Id.*

²⁵³ Harrould-Kolieb, *Acid Test*, *supra* note 244, at 8.

²⁵⁴ *Id.*

²⁵⁵ *Id.*

²⁵⁶ *Id.*

²⁵⁷ *Id.*

²⁵⁸ *Id.*

Ocean acidity has been rising at a geologically unprecedented rate. Currently, acidity is rising at least 100 times faster than at any other period during the last 100,000 years.²⁵⁹ There have been periods during which atmospheric CO₂ concentration and oceanic pH have been higher than today's levels. However, the rate at which these levels were reached was much slower than the rate at which atmospheric CO₂ and oceanic pH are changing today.²⁶⁰ For example, around 55 million years ago, during the Paleocene-Eocene Thermal Maximum (PETM), atmospheric CO₂ concentrations increased to around 1800 ppm and the pH of the oceans declined by around 0.45 units over roughly 5000 years.²⁶¹ This rise in pH resulted in an extinction event, during which "about half of benthic foraminifera (tiny shelled protists) species went extinct over a 1000-year period."²⁶² Today, the rate at which acidity is rising is nearly ten times faster than during the period leading up the PETM extinction event.²⁶³ The danger here is that the rate of acidification may outpace the natural capacity of the ocean to buffer the excess CO₂ levels.²⁶⁴ Scientists have projected that if anthropogenic CO₂ emissions continue at present trends, oceanic pH may drop another 0.5 units by 2100.²⁶⁵ This represents a threefold decrease from pre-industrial times. Such a drop would also bring oceanic pH outside the natural range of CO₂.

The oceans have a limited ability to buffer increases in the availability of hydrogen ions.²⁶⁶ As the concentration of hydrogen ions increases, due to increased concentrations of atmospheric CO₂, more of these newly available hydrogen ions react with carbonate ions to form bicarbonate.²⁶⁷ This process, known as a carbonate buffer, then reduces the total resulting decrease in pH.²⁶⁸ However, as more and more carbonate is consumed through the natural dissolution of CO₂, and through the buffering processes, "[t]he capacity of the buffer to restrict

²⁵⁹ *Id.* at 7

²⁶⁰ Washington Shellfish Institute Blue Ribbon Panel on Ocean Acidification, *Scientific Summary of Ocean Acidification*, *supra* note 217, at 9.

²⁶¹ *Id.*; P. Jardine, *Patterns in Palaeontology: The Paleocene-Eocene Thermal Maximum*, Paleontology Online (Jan. 10, 2011), available at <http://www.palaeontologyonline.com/articles/2011/the-paleocene-eocene-thermal-maximum/> (last visited June 12, 2014) ("This warming has been linked to a similarly rapid increase in the concentration of greenhouse gases in Earth's atmosphere, which acted to trap heat and drive up global temperatures by more than 5 °C in just a few thousand years. The fossil record gives us the means of understanding how life was affected by the PETM, and so provides an excellent opportunity to study the relationships between evolution, extinction, migration and climate change.").

²⁶² *Id.*

²⁶³ *Id.*

²⁶⁴ *Id.*

²⁶⁵ The Royal Society, *Ocean Acidification Due to Increasing Atmospheric Carbon Dioxide* vi (2005), available at

http://coralreef.noaa.gov/aboutcrp/strategy/reprioritization/wgroups/resources/climate/resources/oa_royalsociety.pdf (last visited June 14, 2014).

²⁶⁶ *Id.* at 6.

²⁶⁷ *Id.*

²⁶⁸ *Id.*

pH changes diminishes as increased amounts of CO₂ are absorbed by the oceans.”²⁶⁹ As such, as carbonate ions become less readily available, the oceans will acidify at increasingly rapid rates.²⁷⁰

Many important marine organisms, including shellfish and corals, require sufficient concentrations of carbonate and bicarbonate in order to build structures, such as shells, out of calcium carbonate (CaCO₃).²⁷¹ Calcium carbonate will dissolve in seawater unless the water is saturated with carbonate ions.²⁷² Calcium carbonate also becomes more soluble as temperature decreases and pressure increases.²⁷³ As a result, as depth increases, causing temperature to decrease and pressure to increase, calcium carbonate becomes more soluble.²⁷⁴ These variables (carbonate ion concentrations, temperature, and pressure) interact to create a natural barrier, known as a saturation horizon, below which calcium carbonate will dissolve, and above which calcium carbonate is capable of forming.²⁷⁵ As more and more anthropogenic CO₂ has dissolved, the carbonate ion concentration has decreased causing the saturation horizon for calcium carbonate to rise.²⁷⁶ To survive, calcium carbonate-dependent species must live above the saturation horizon.²⁷⁷ As the saturation horizon rises, it poses a greater threat to calcium carbonate-dependent marine species by encroaching upon their habitat.²⁷⁸

The shoaling, or rising, of calcite and aragonite (two forms of calcium carbonate) saturation horizons poses a real threat to the world’s coral reefs. Scientists have found that “where coral reefs occur, carbonate-ion concentrations over the past 420,000 years have not fallen below 240 mmol kg⁻¹.”²⁷⁹ Today, “carbonate-ion concentrations (~210 mmol kg⁻¹) [are] lower than at any other time during the past 420,000 years.”²⁸⁰ As can be seen from the figure below, as concentrations of atmospheric CO₂ increase, the aragonite saturation levels decrease (depicted by the shift from blue to yellow and red).²⁸¹ Today, coral reefs are not found in waters with aragonite concentrations below 3.25 mmol kg⁻¹, represented in the figure below by the blue regions.²⁸² As is clear from the image below, as the concentration of atmospheric carbon dioxide increases, the potentially viable coral habitats decrease.²⁸³

²⁶⁹ *Id.* at 6.

²⁷⁰ *Id.* at 6.

²⁷¹ *Id.* at 10.

²⁷² *Id.*

²⁷³ *Id.*

²⁷⁴ *Id.*

²⁷⁵ *Id.*

²⁷⁶ *Id.*

²⁷⁷ *Id.* at 11.

²⁷⁸ *Id.*

²⁷⁹ O. Hoegh-Guldberg et al., *Coral Reefs Under Rapid Climate Change and Ocean Acidification*, 318 *Science* 1757, 1757 (2007).

²⁸⁰ *Id.*

²⁸¹ *Id.* at 1740.

²⁸² *Id.*

²⁸³ *Id.*

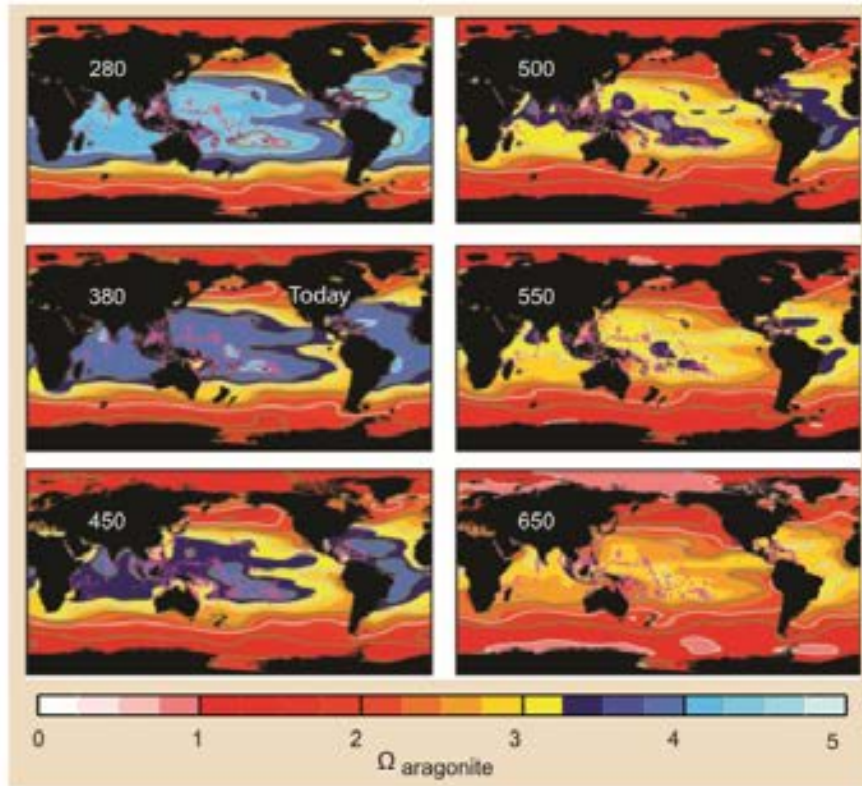


Fig. 4. Changes in aragonite saturation ($\Omega_{\text{aragonite}} = ([\text{Ca}^{2+}][\text{CO}_3^{2-}]/K_{\text{sp, aragonite}})$) predicted to occur as atmospheric CO_2 concentrations (ppm) increase (number at top left of each panel) plotted over shallow-water coral reef locations shown as pink dots (for details of calculations, see the SOM). Before the Industrial Revolution (280 ppm), nearly all shallow-water coral reefs had $\Omega_{\text{aragonite}} > 3.25$ (blue regions in the figure), which is the minimum $\Omega_{\text{aragonite}}$ that coral reefs are associated with today; the number of existing coral reefs with this minimum aragonite saturation decreases rapidly as $[\text{CO}_2]_{\text{atm}}$ increases. Noticeably, some regions (such as the Great Barrier Reef) attain low and risky levels of $\Omega_{\text{aragonite}}$ much more rapidly than others (e.g., Central Pacific).

The current rate at which carbonate ion concentrations are decreasing is likely to outpace the ability of the world's corals to adapt to, let alone mitigate against, the changes.²⁸⁴ The table provided below compares the rate of change in atmospheric CO_2 concentration and global temperature of the past 420,000 years to the past 136 years and two IPCC scenarios based on possible projected increases in the concentration of atmospheric CO_2 .²⁸⁵

²⁸⁴ *Id.* at 1738.

²⁸⁵ *Id.*

Table 1. Rates of change in atmospheric CO₂ concentration ([CO₂]_{atm}, ppm/100 years) and global temperature (°C/100 years) calculated for the past 420,000 yr B.P. using the Vostok Ice Core data (5) and compared to changes over the last century and those projected by IPCC for low-emission (B1) and high-emission (A2) scenarios (8). Rates were calculated for each successive pair of points in the Vostok Ice Core record by dividing the difference between two sequential values (ppm or °C) by the time interval between them. Rates were then standardized to the change seen over 100 years. Ratios of each rate relative to the mean rate seen over the past 420,000 years are also calculated.

Period	[CO ₂] _{atm} (ppm century ⁻¹)	Ratio (relative to past 420,000 years)	Temperature (°C century ⁻¹)	Ratio (relative to past 420,000 years)
Past 420,000 years (99% confidence interval; n = 282)	0.07 + 0.223	1	0.01 + 0.017	1
Past 136 years (1870–2006)	73.53	1050	0.7	70
IPCC B1 scenario: 550 ppm at 2100	170	2429	1.8	180
IPCC A2 scenario: 800 ppm at 2100	420	6000	3.4	420

As is clear, over the past 136 years (from 1870-2006) atmospheric CO₂ changed 136 times faster than during the previous 420,000 years, and temperature changed 70 times faster.²⁸⁶ As the present and projected future rates of change “dwarf even those of the ice age transitions . . . it is likely that [the rate of these] changes will exceed the capacity of most organisms to adapt.”²⁸⁷

Given that “[c]oral reefs are among the most biologically diverse and economically important ecosystems on the planet, providing ecosystem services that are vital to human societies and industries through fisheries, coastal protection, building materials, new biochemical compounds, and tourism,” the impact of their loss on the planet cannot be overstated.²⁸⁸

D. Ocean Acidification Is Already Harming Washington’s Citizens, Natural Resources and the Economy

The Washington State Blue Ribbon Panel on Ocean Acidification described the devastating effects of ocean acidification on the Washington oyster industry as a “canary in a coalmine.”²⁸⁹ Just as canaries once alerted miners to the presence of poisonous gases, the devastation of Washington’s oyster industry has alerted the world to the presence of a global threat to our oceans with disastrous global and local impacts.²⁹⁰

Washington is feeling the effects of ocean acidification earlier than other parts of the world due to a naturally occurring process known as coastal upwelling. Upwelling occurs from approximately April through October when strong northerly winds blow along Washington’s

²⁸⁶ *Id.*

²⁸⁷ *Id.* at 1737.

²⁸⁸ *Id.*

²⁸⁹ Washington State Blue Ribbon Panel on Ocean Acidification, *Strategic Response*, *supra* note 247, at 4.

²⁹⁰ *See Id.*

coast.²⁹¹ As the surface waters are displaced, deeper offshore water is drawn up, or upwelled, to replace it.²⁹² The waters that are upwelled onto Washington's coast are drawn from depths of around 150 and 200 meters.²⁹³ This zone, from which upwelled waters are drawn, is known as the upwelling zone.²⁹⁴

Scientific studies have shown that the saturation horizon for aragonite has already risen into the upwelling zone.²⁹⁵ As a result, waters that are corrosive to aragonite are already upwelling onto Washington's coast.²⁹⁶ Waters with perilously low carbonate concentrations, once found only at depths where marine life is rare, are now upwelling into depths as shallow as 20 meters where life is abundant.²⁹⁷

There is a 30-50 year gap between when ocean water comes into contact with the atmosphere and when it upwells onto Washington's coast.²⁹⁸ Therefore, the water that is upwelled today was exposed to atmospheric CO₂ levels from the 1970s.²⁹⁹ Because atmospheric CO₂ levels are higher today than in the 1970s, Washington will continue to feel worsening effects for at least the next 30-50 years and even longer if emissions are not immediately limited. Choices made today leave a long legacy of ocean acidification to our children and future generations of Washingtonians.

While the uptake of atmospheric carbon dioxide is the primary driver of open-ocean acidification, secondary contributions, such as nutrient pollution from land-based sources, also contribute to the acidification of Puget Sound. In the spring and summer the waters of the Puget Sound experience algal blooms. These blooms, while partly natural, are amplified by anthropogenic nutrient pollution, a process called eutrophication. Algal growth temporarily increases the dissolved oxygen of surface waters, which in turn causes a corresponding increase in pH. Eventually, the algae die and their organic matter settles towards the bottom. Here, in these subsurface waters, microbes consume this organic matter, rapidly consuming oxygen and respiring carbon dioxide. This microbial respiration is thus directly responsible for low oxygen levels ("hypoxia") in subsurface waters and increased localized acidification like the kind seen in the Puget Sound.³⁰⁰

²⁹¹ Washington Shellfish Institute Blue Ribbon Panel on Ocean Acidification, *Scientific Summary of Ocean Acidification*, *supra* note 217, at 8.

²⁹² *Id.*

²⁹³ *Id.*

²⁹⁴ *Id.*

²⁹⁵ *Id.*

²⁹⁶ *Id.* at 20

²⁹⁷ *Id.* at 8, 11

²⁹⁸ Washington State Blue Ribbon Panel on Ocean Acidification, *Strategic Response*, *supra* note 247, at 11.

²⁹⁹ *Id.*

³⁰⁰ Richard A. Feeley, et al., *The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary*, 88 *Estuarine, Coastal and Shelf Science* 442 (2010); Wei Long, et al., *Approach for Simulating Acidification and the Carbon Cycle in the Salish Sea to Distinguish Regional Source Impacts*, Washington State Dep't. of

Washington’s seafood industry is exceptionally vulnerable to the effects of ocean acidification. Over 30% of the marine life in Washington’s Puget Sound are calcifiers.³⁰¹ These calcifiers include oysters, clams, scallops, mussels, abalone, crabs, geoducks, barnacles, sea urchins, sand dollars, sea stars, and sea cucumbers.³⁰² Many common single-celled organisms and protists that act as prey for many marine species and some forms of seaweed all produce calcium carbonate structures.³⁰³

Calcifiers are dependent on waters with sufficient carbonate ion saturation levels, in order to form the mineral calcium carbonate.³⁰⁴ When saturation levels fall below certain levels, calcifiers have “greater difficulty in making and maintaining their shells, slower growth rates, and higher mortality rates.”³⁰⁵ As such, Washington’s calcifiers are particularly vulnerable to the upwelling of waters with low carbonate ion saturation levels.³⁰⁶

Washington’s at risk calcifying organisms are an important economic resource. Washington’s seafood industry, of which calcifying shellfish are a major contributor, “generates over 42,000 jobs in Washington and contributes at least \$1.7 billion to gross state product.”³⁰⁷ Specifically, Washington shellfish growers are responsible for the direct or indirect employment of over 3,200 people, and “[t]he estimated total annual economic impact of shellfish aquaculture is \$270 million.”³⁰⁸ Washington produces more farmed oysters, clams and mussels than any other state in the country.³⁰⁹ Sales of “shellfish grown in Washington exceed \$107 million [annually], accounting for almost 85 percent of West Coast sales.”³¹⁰ Farmed oysters alone generate \$58 million in annual sales and account for more than 80 percent of the State’s farmed shellfish harvest.³¹¹ Washington clams and geoducks each contribute another \$20 million in sales.³¹²

Washington’s tribal communities are also highly dependent on shellfish. Washington tribes rely on shellfish for both subsistence and ceremonial purposes.³¹³ The majority of the

Ecology Publication No. 14-03-002 (2014), *available at* <https://fortress.wa.gov/ecy/publications/publications/1403002.pdf>.

³⁰¹ Washington State Blue Ribbon Panel on Ocean Acidification, *Strategic Response*, *supra* note 247, at 16.

³⁰² *Id.*

³⁰³ *Id.*

³⁰⁴ *Id.* at 29.

³⁰⁵ *Id.* at 17.

³⁰⁶ *Id.* at xiii.

³⁰⁷ *Id.* at 5.

³⁰⁸ *Id.*

³⁰⁹ *Id.* at 3.

³¹⁰ *Id.*

³¹¹ *Id.*

³¹² *Id.*

³¹³ *Id.* at 5.

commercial clam fisheries in Puget Sound are tribal.³¹⁴ Washington's shellfish are thus both an important economic and cultural resource.

In addition, Washington's calcifiers also provide important services to society, other organisms and local food webs.³¹⁵ For instance, "oysters, clams, and crabs improve water quality by removing floating organic particles."³¹⁶ Washington's deepwater corals "provide habitat, shelter, and host food for many plants and animals, including rockfish and sharks."³¹⁷ Washington's pteropods provide "an important food source for young salmon and other high-latitude animals, such as seabirds and whales."³¹⁸

Copepods, which provide an important food source to juvenile herring and salmon, experience increased mortality and decreased growth, egg production and hatching success when exposed to acidified waters.³¹⁹ Sea urchin egg fertilization is also negatively impacted by high levels of CO₂.³²⁰ Sea urchins help maintain local food webs by consuming kelp and severely limiting its abundance.³²¹

The intricacies of the interactions between individual calcifying organisms and their surrounding food webs are not fully understood.³²² However, scientists believe that the disruption of these calcifying organisms may reverberate throughout the entire food web.³²³ For example, sea urchins, sea stars and salmon, all of which are at risk due to acidification, have been classified as potential keystone species.³²⁴ Keystone species "are of particular interest because their fates can determine the fates of whole communities."³²⁵ These species act as lynchpins which are key to the structural integrity of entire food webs.³²⁶ Removing a single keystone and the entire web may collapse.³²⁷ For example, during an experiment, the removal of a single predatory star fish led to increased competition for space which ultimately resulted in rapid decline among other local inhabitants.³²⁸ Thus the removal of a single species "could have strong domino effects on local ecosystems."³²⁹

³¹⁴ *Id.*

³¹⁵ *Id.* at 17

³¹⁶ *Id.*

³¹⁷ *Id.* 17-21

³¹⁸ *Id.* at 21

³¹⁹ *Id.*

³²⁰ *Id.*

³²¹ *Id.*

³²² *Id.*

³²³ *Id.*

³²⁴ *Id.*

³²⁵ *Id.*

³²⁶ *Id.*

³²⁷ *Id.*

³²⁸ *Id.*

³²⁹ *Id.*

Washington's oyster hatcheries are already feeling the effects of ocean acidification.³³⁰ Beginning in 2005, "Pacific Northwest oyster hatcheries experienced disastrous production failures when billions of oyster larvae (the youngest oysters), mysteriously died."³³¹ Reports from many major oyster hatcheries indicated that the larvae were dissolving in the tanks.³³² Research has shown that ocean acidification was the primary cause of this "massive mortality."³³³ As scientists began monitoring the causes of these failures, they found that "measurements of pH alone were not sufficient to identify seawater conditions that would support normal larval growth."³³⁴ Rather, aragonite saturation levels, are more predictive of larval growth.³³⁵ Scientists found that "larval production and mid-stage growth were significantly impaired when the [aragonite saturation levels] of seawater in which they were spawned and reared for the first 48 h[ours] of life was low."³³⁶

These results demonstrate that the dramatic drop in oyster production was likely not due to a simple change in pH, but rather a drop in the concentration of carbonate ions in the water. As noted previously, the saturation horizon for aragonite has already risen into the zone from which water is upwelled onto Washington's coast.

E. The Best Available Climate Science Dictates that Safe Concentrations of Atmospheric Carbon Dioxide are 350 ppm or Lower.

1. To Stabilize the Global Climate System, Atmospheric Carbon Dioxide Concentrations Must Return to 350 ppm or Lower by the End of the Century Through Urgent Emission Reductions and Reforestation

Paleoclimate data provides sobering evidence that major climate change can occur in decades, and that the consequences would be much more severe, and even disastrous, if a 2°C (3.6°F) change occurs over decades rather than hundreds of years.³³⁷ In order to avoid catastrophic and permanent change, it is imperative that global CO₂ emission reduction targets are calibrated to restore atmospheric CO₂ levels 350 ppm by the end of the century in order to limit the global temperature increase to 1°C above pre-industrial temperatures. However, the European Union in 1996 and the 2009 Copenhagen Accord both set targets for reducing

³³⁰ *Id.* at 3

³³¹ Washington State Blue Ribbon Panel on Ocean Acidification, *Strategic Response*, *supra* note 247, at 3

³³² *Id.*

³³³ *Id.*

³³⁴ Washington State Blue Ribbon Panel on Ocean Acidification, *Strategic Response*, *supra* note 247, at 70.

³³⁵ *Id.*

³³⁶ *Id.* at 71

³³⁷ See James E. Hansen & Makiko Sato, *Paleoclimate Implications for Human-Made Climate Change* (Jan. 18, 2011), available at http://www.columbia.edu/~jeh1/mailings/2011/20110118_MilankovicPaper.pdf.

emissions to limit the global temperature increase to 2°C, “relative to pre-industrial times.”³³⁸ This target is based on the 2007 Intergovernmental Panel on Climate Change’s assessment which found that significant negative impacts will begin with a warming of 2.6 to 3.6°C.³³⁹ The IPCC found that if atmospheric CO₂ levels are limited to 450 ppm, then it is more than 66% likely that the temperature will not rise above 2°C, while if emissions reach 550 ppm, there is only less than a 50% chance of avoiding a temperature increase greater than 2°C.³⁴⁰ The 2007 compilation of science from the early 2000’s is now outdated and has been shown to underestimate the catastrophic impacts associated with warming of 2°C above preindustrial temperatures.

In a more recent and precise scientific study based on new observations and the paleoclimate record, Dr. James Hansen has classified this goal of limiting the temperature increase to 2°C as a “fallacy of logic.”³⁴¹ Considering the many effects that are manifesting much faster than most models predicted, such as the rapid decline of the Arctic sea ice and Greenland and Antarctic ice sheets, as well as substantial omissions in the modeling used to determine the 2°C target, global warming must actually be limited to 1°C, meaning a global CO₂ concentration of 350 ppm or lower, in order to avoid catastrophic global impacts.³⁴² Emission reduction targets aimed at a 450 ppm global standard, as the limits in RCW 70.235 appear to be aimed at best, will result in a temperature increase much greater than 2°C and in turn will not avoid these grave impacts.

The widely used models that allow for 2°C temperature increase, and therefore advocate for a global CO₂ emission reduction target aimed at a 450 ppm CO₂ standard, do not take into account significant factors that will compound climate impacts. Most importantly, they do not include the slow feedbacks that will be triggered by a temperature increase of 2°C.³⁴³ Slow feedbacks include the melting of ice sheets and the release of potent greenhouse gases, particularly methane, from the thawing of the tundra.³⁴⁴ These feedbacks might show little change in the short-term, but can hit a point of no return, even at a 2°C temperature increase, that will trigger further warming and sudden catastrophic impacts. For example, the Greenland and Antarctic ice sheets “required millennia to grow to their present sizes. If ice sheet disintegration reaches a point such that the dynamics and momentum of the process take over, reducing greenhouse gases may be futile to prevent major ice sheet mass loss, sea level rise of many meters, and worldwide loss of coastal cities – a consequence that is irreversible for practical purposes.”³⁴⁵ A new study published in May 2014 indicated that the Western Antarctic Ice Sheet has already reached this point of no return and is in an “irreversible state of decline.”³⁴⁶ As one

³³⁸ James Hansen et al., *Assessing “Dangerous Climate Change”: Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature*, 8 PLOS ONE 1, 2 (2013).

³³⁹ *Id.* at 3.

³⁴⁰ IPCC, *AR5*, *supra* note 9, 1.3.3, 34.

³⁴¹ Hansen, *Assessing “Dangerous Climate Change,” supra* note 338, at 4.

³⁴² *Id.* at 4, 5, 15.

³⁴³ *Id.* at 15.

³⁴⁴ *Id.*

³⁴⁵ *Id.* at 13.

³⁴⁶ NASA, *NASA-UCI Study Indicates Loss of West Antarctic Glaciers Appears Unstoppable* (May 12, 2014), available at <http://www.nasa.gov/press/2014/may/nasa-uci-study-indicates-loss->

climate scientist stated, “we have indeed lit the fuse on West Antarctica . . . But there’s a bunch more fuses, and there’s a bunch more matches, and we have a decision now: Do we light those?”³⁴⁷

These slow feedbacks are a part of the inertia of the climate system, where “[t]he inertia causes climate to appear to respond slowly to this human-made forcing, but further long-lasting responses can be locked in.”³⁴⁸ Thermal inertia is primarily a result of the global ocean, which stores 90% of the energy surplus, and therefore perpetuates increased global temperature even after climate forcings, or emissions, have declined.³⁴⁹ Thus, the longer we wait to reduce global CO₂ concentrations, the more thermal inertia will already be in play and climate impacts will continue to escalate.

Furthermore, 2°C targets would lead to an increase in the use of fossil fuels that are more difficult to extract, and thus are compounded with the expenditure of greenhouse gases due to the transport and intensive mining process resulting in “more CO₂ [emissions] per unit useable energy.”³⁵⁰ The 2°C target also reduces the likelihood that the biosphere will be able to sequester CO₂ due to carbon cycle feedbacks and shifting climate zones.³⁵¹ Under the allowable emissions with this target, other greenhouse gases, such as methane and nitrous oxide would continue to increase, further exacerbating climate change impacts.³⁵² These factors are missing from the 2°C scenarios, which have been widely accepted and used in the creation of climate policies and plans, seemingly including those of Washington.³⁵³

A temperature rise of 2°C will not only lock in a further temperature increase due to thermal inertia, but it will also trigger irreversible impacts, including rapid, nonlinear sea level rise and species loss described above.³⁵⁴ Most models look at sea level rise as a gradual linear response to melting ice sheets. However, “it has been argued that continued business-as-usual CO₂ emissions are likely to spur a nonlinear response with multi-meter sea level rise this century.”³⁵⁵ This sea level rise would occur at a pace that would not allow human communities

[of-west-antarctic-glaciers-appears-unstoppable/#.U5jBk_ldV3H](#) (last visited June 11, 2014) (“The accelerating flow speeds and retreating grounding lines reinforce each other. As glaciers flow faster, they stretch out and thin, which reduces their weight and lifts them farther off the bedrock. As the grounding line retreats and more of the glacier becomes waterborne, there's less resistance underneath, so the flow accelerates.”).

³⁴⁷ Justin Gillis & Kenneth Change, *Scientists Warn of Rising Oceans from Polar Melt*, New York Times (May 12, 2014), available at http://www.nytimes.com/2014/05/13/science/earth/collapse-of-parts-of-west-antarctica-ice-sheet-has-begun-scientists-say.html?_r=0 (last visited June 16, 2014).

³⁴⁸ Hansen, *Assessing “Dangerous Climate Change,” supra* note 338, at 1.

³⁴⁹ *Id.* at 4-5, 13.

³⁵⁰ *Id.* at 15.

³⁵¹ *Id.* at 15, 20.

³⁵² *Id.* at 20.

³⁵³ See Wash. Rev. Code § 70.235.020 (2008).

³⁵⁴ *Id.* at 6.

³⁵⁵ *Id.*

or ecosystems to respond. According to the IPCC, if global warming goes past 1.6°C, 9 to 31% of species “will be committed to extinction.”³⁵⁶ If the temperature increase exceeds 2.9°C, this number increases to 21 to 52% of species that will be lost.³⁵⁷ This loss will have severe impacts for ecosystem functions and resiliency and violates the Department’s obligation to manage, protect and preserve the public trust resources in this state that are under its regulatory authority.³⁵⁸

An emission reduction target aimed at 2°C would “yield a larger eventual warming because of slow feedbacks, probably at least 3°C.”³⁵⁹ Once a temperature increase of 2°C is reached, there will already be “additional climate change “in the pipeline” even without further change of atmospheric composition.”³⁶⁰ Dr. James Hansen warns that “distinctions between pathways aimed at 1°C and 2°C warming are much greater and more fundamental than the numbers 1°C and 2°C themselves might suggest. These fundamental distinctions make scenarios with 2°C or more global warming far more dangerous; so dangerous, we [James Hansen et al.] suggest, that aiming for the 2°C pathway would be foolhardy.”³⁶¹ “A target of limiting warming to 2°C has been widely adopted,”³⁶² based on outdated science, which also formed the basis of Washington’s current limits, which do not put the state on a trajectory towards doing their part to reduce the global CO₂ emissions level to below 350 ppm, or reach global climate stabilization. This target is at best the equivalent of “flip[ping] a coin in the hopes that future generations are not left with few choices beyond mere survival. This is not risk management, it is recklessness and we must do better.”³⁶³

It is imperative that Washington set GHG emission limits targeted at 1°C temperature change, or a maximum of 350 ppm in global CO₂ levels, in order to avoid the cascading impacts that will occur with a 2°C or 450 ppm target. To reduce global atmospheric CO₂ to 350 ppm by the end of this century, this target would require that if global fossil fuel emissions had peaked in 2012, they be reduced by 6% per year beginning in 2013, alongside 100 GtC of global reforestation throughout the century.³⁶⁴ If emissions peaked and reductions began in 2005, only a 3.5% per year reduction would have been necessary to reach 350 ppm by 2100.³⁶⁵ However, if emission reductions do not begin until 2020, a 15% per year reduction rate will be required to reach 350 ppm by 2100.³⁶⁶ If reductions are delayed beyond 2020, it might not be possible to

³⁵⁶ *Id.* at 7.

³⁵⁷ *Id.*

³⁵⁸ *Id.*

³⁵⁹ *Id.* at 15.

³⁶⁰ *Id.* at 19.

³⁶¹ *Id.* at 15.

³⁶² *Id.* at 6.

³⁶³ Matt Vespa, *Why 350? Climate Policy Must Aim to Stabilize Greenhouse Gases at the Level Necessary to Minimize the Risk of Catastrophic Outcomes*, 36 *Ecology Law Currents* 185, 186 (2009), available at http://www.biologicaldiversity.org/publications/papers/Why_350.pdf.

³⁶⁴ Hansen, *Assessing “Dangerous Climate Change,”* *supra* note 338, at 10.

³⁶⁵ *Id.*

³⁶⁶ *Id.*

return to 350 ppm until well after 2500.³⁶⁷ Continued delay makes it harder and harder for the youth petitioners and future generations to take the actions they will need to take to adapt to living in a climate-changed world.

If an atmospheric concentration target of 350 ppm CO₂ or less were achieved by the end of the century, there would only be a 7% chance that the temperature increase would exceed 2°C.³⁶⁸ Thus, this goal could keep us from passing the point of no return found in many of the slow feedback cycles. The safe level of global CO₂ is at most 350 ppm, not 450 ppm as has been accepted in most climate policies and plans, and government action towards this safe goal of 350 ppm must be taken immediately. “Climate deterioration and gross intergenerational injustice will be practically guaranteed” if we keep our targets at 450 ppm.³⁶⁹ In order to avoid the compounded effects of exceeding a 2°C temperature increase, it is imperative that the Department calibrate state emission limits to put Washington on a trajectory aimed for 350 ppm and then establish a plan that will put Washington on a track towards meeting these limits. In order for the State of Washington to “do its part to reach global climate stabilization levels,” the Department must recommend to the legislature that the State’s GHG emissions limits must reflect a global atmospheric CO₂ emissions level of 350 ppm.³⁷⁰

2. To Protect Oceans from Destructive Ocean Acidification Through Carbon Absorption, Atmospheric Carbon Dioxide Concentrations Must Return to 350 ppm or Lower by the End of the Century Through Urgent Emission Reductions and Reforestation.

Humans, marine organisms and ecosystems are already feeling the effects of ocean acidification.³⁷¹ Unfortunately, the current effects are but a foreshadowing of what is to come.³⁷² To prevent potential mass extinction-level events, it is imperative that atmospheric CO₂ concentrations be returned to 350 ppm.³⁷³

Scientists estimate that if current emission levels are maintained, atmospheric carbon dioxide concentrations will reach 570 ppm.³⁷⁴ This will result in pH dropping by .2 units or a 60 percent increase in the concentration of hydrogen ions by 2050, and a drop of .7 units, or a 210 percent increase in the concentration of hydrogen ions by 2100.³⁷⁵

If atmospheric CO₂ concentrations reach 570 ppm, “ocean acidification will be extremely severe within the next few decades.”³⁷⁶ On a business-as-usual emissions path or the path

³⁶⁷ *Id.*

³⁶⁸ Vespa, *Why 350?*, *supra* note 363, at 186.

³⁶⁹ Hansen, *supra* note 338, at 21.

³⁷⁰ Wash. Rev. Code § 70.235.020 (2008).

³⁷¹ Harrould-Kolieb, *Acid Test*, *supra* note 244, at 4.

³⁷² *Id.* at 22.

³⁷³ *Id.*

³⁷⁴ *Id.*

³⁷⁵ *Id.* at 7.

³⁷⁶ *Id.* at 22.

allowed under the levels required by RCW 70.235, this level of atmospheric carbon dioxide can be expected around the middle of this century.³⁷⁷ As a result, aragonite under-saturation will spread through the polar oceans, the sub-polar Southern Ocean and portions of the sub-Arctic North Pacific making it almost impossible for aragonite structures to exist in these areas.”³⁷⁸ This “would have devastating consequences for cold-water corals, pteropods and other organisms that create their shells and skeletons out of aragonite or magnesium calcite.”³⁷⁹

Previous projections based on maintaining atmospheric carbon concentrations at or below 450 ppm are not sufficient to avoid severe, irreversible damage as a result of ocean acidification. According to the best available science, 450 ppm represents a tipping point for coral reefs worldwide.³⁸⁰ If atmospheric CO₂ levels reach this tipping point, “coral reefs as we know them will be extremely rare, if not non-existent,” and “at least half of coral-associated wildlife will become rare or extinct.”³⁸¹ As a result, “coral reef ecosystems will likely be reduced to crumbling frameworks with few calcareous corals remaining.”³⁸²

The following group of images provide a visual representation of how the areas suitable for coral growth will change as atmospheric CO₂ levels increase.³⁸³ As is clear, a great deal of territory which was once adequate for coral growth at 350 ppm will shift to marginal and even low adequacy levels when atmospheric CO₂ reaches 450 ppm.³⁸⁴ The shifting territory contains a high concentration of the world’s current coral reefs (represented by pink dots).³⁸⁵

³⁷⁷ *Id.*

³⁷⁸ *Id.* at 10.

³⁷⁹ *Id.* at 10.

³⁸⁰ *Id.* at 22.

³⁸¹ *Id.*

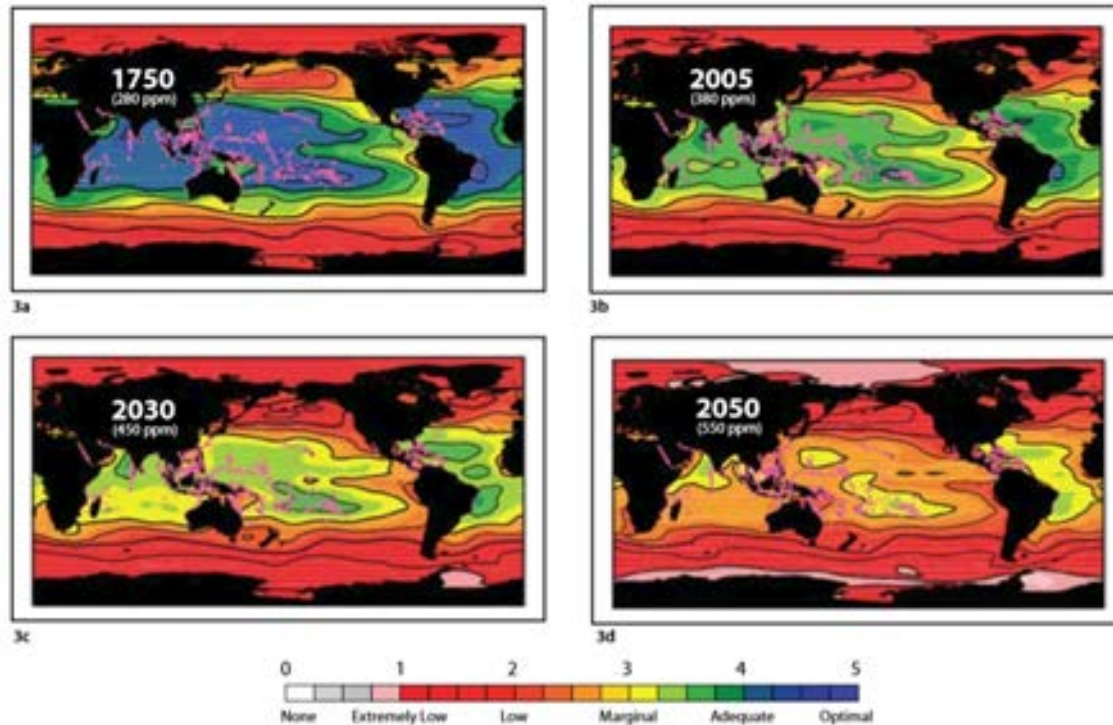
³⁸² *Id.*

³⁸³ *Id.* at 12.

³⁸⁴ *Id.*

³⁸⁵ *Id.*

Figure 3: Aragonite Saturation State of the Ocean and Adequacy for Coral Growth



Source: Adapted from: Cao L., & Caldeira K. (2008) Atmospheric CO₂ stabilization and ocean acidification. *Geophysical Research Letters*, in press, with permission from the authors.

The best available science indicates that atmospheric CO₂ concentrations must be returned to 350 ppm in order to avoid serious damage to oceanic ecosystems and marine life. Atmospheric CO₂ concentrations are already above safe levels.³⁸⁶ As a result, significant coral bleaching and decreases in coral growth rates are already occurring.³⁸⁷ In order to prevent the loss of coral reefs, atmospheric carbon dioxide levels must be returned to below 350 ppm.³⁸⁸

The loss of the Earth's coral reefs would be felt across the globe. Coral reefs provide shelter to a quarter of all marine species.³⁸⁹ In addition, over 100 million people rely on reefs for their livelihoods.³⁹⁰ The loss of coral reefs "would cost society billions of dollars annually due to losses in fishing, tourism and coastal protection services."³⁹¹ Significant coral loss would also place many communities, which rely on the reefs for subsistence, at considerable risk.³⁹² Given the severity of these impacts, it is inevitable that these effects would not be limited to the communities located within proximity to the lost reefs.

³⁸⁶ *Id.* at 22.

³⁸⁷ *Id.* at 22.

³⁸⁸ *Id.*

³⁸⁹ *Id.* at 22.

³⁹⁰ *Id.* at 4.

³⁹¹ *Id.*

³⁹² *Id.*

Just as the devastation of Washington’s oyster hatcheries has been characterized as a “canary in a coalmine,” scientists have stated that “[w]hat happens to coral reefs will foreshadow other catastrophic changes that are likely to take place around the world due to ocean acidification.”³⁹³ As such, it would be fallacious to assume that because Washington does not contain coral reefs that the coral-specific tipping points will not also affect Washington’s calcifiers, their respective ecosystems, and its citizens. In both cases, the effected organisms are calcifiers. As such, both are impacted in similar ways by decreases in the availability of carbonate ions. Furthermore, in both cases, the adverse effects of ocean acidification are already being felt as a result of exposure to today’s atmospheric CO₂ levels. In Washington, today’s effects are the result of water that was exposed to atmospheric CO₂ levels from the 1970s. As the atmospheric concentration of CO₂ in the 1970s was below below 350 ppm (a level exceeded for the first time in 1989), it is clear that Washington’s oysters are at least as, if not more, sensitive to increases in atmospheric CO₂ as the coral reefs discussed above and safe levels of atmospheric CO₂ can be no higher than 350 ppm. An emission reduction trajectory, which results in an atmospheric CO₂ concentration that is greater than 350 ppm, is not sufficient to avoid the most serious impacts of ocean acidification. Such a trajectory places Washington’s calcifying organisms, surrounding marine ecosystems and its citizens at considerable risk to potentially catastrophic impacts.

F. Washington’s Current Targets Are Not Based On Best Available Climate Science

Washington declares itself to be a leader amongst state and international governments in “energy conservation and environmental stewardship, including air quality protection, renewable energy development and generation, emission standards for fossil fuel based energy generation, energy efficiency programs, natural resource conservation, vehicle emission standards, and the use of biofuels.”³⁹⁴ However, the State’s current greenhouse gas emissions limits are not based on standards designed to stop irreversible damage to the world’s climate system and oceans, or protect Washington’s own essential natural resources. Currently, RCW 70.235.020 sets the following floor for greenhouse gas emissions limits:

- (i) By 2020, reduce overall emissions of greenhouse gases in the state to 1990 levels.
- (ii) By 2035, reduce overall emissions of greenhouse gases in the state to twenty-five percent below 1990 levels;
- (iii) By 2050, the state will do its part to reach global climate stabilization levels by reducing overall emissions to fifty percent below 1990 levels, or seventy percent below the state’s expected emissions that year.

This trajectory of reducing greenhouse gas emissions does not put the State on a path towards reaching global climate stabilization and is not in line with the best available climate science. Therefore, it is imperative that the Department initiate a rulemaking process to fulfill its legal responsibility to recommend to the legislature that the GHG emissions limits be updated to reflect current best available science. Global atmospheric CO₂ levels must be reduced to 350

³⁹³ *Id.* at 22.

³⁹⁴ Wash. Rev. Code § 70.235.005(1) (2008).

ppm or less in order to achieve climate stability and protect against destructive ocean acidification.³⁹⁵ In order to do its part in reducing global carbon emissions and maintain its leadership role in reducing emissions, Washington must reduce its CO₂ emissions by at least 4 percent or more each year through 2050.

G. The Department has the Statutory Authority and the Obligation to Initiate Rulemaking and Adopt the Proposed Rule.

In order to prevent and mitigate the catastrophic climate change and ocean acidification impacts described above and fulfill its legal obligation, the Department must promulgate a rule that establishes, and recommends to the legislature, an update and amendment of RCW 70.235, setting a CO₂ emission reductions trajectory to 4 percent per year, and achieve at least an 80% reduction in CO₂ emissions from 1990 levels by 2050.

The Department has the following existing statutory obligation:

Within eighteen months of the next and each successive global or national assessment of climate change science, the Department *shall* consult with the climate impacts group at the University of Washington regarding the science on human-caused climate change and provide a report to the legislature summarizing that science and make recommendations regarding whether the greenhouse gas emissions reductions required under RCW 70.235.020 need to be updated.³⁹⁶

In addition, the Governor has ordered and directed the Department to:

[R]eview the State's enacted greenhouse gas emissions limits and recommend any updates to the limits by July 15, 2014.³⁹⁷

In fulfilling these legal obligations, the Department has an unprecedented opportunity to reinforce its international leadership on climate change and ocean acidification issues by setting standards for reducing carbon emissions that are based upon best available science. The impacts of climate change and ocean acidification on Washington will only increase in severity as time progresses without substantial action. Youth petitioners and future generations of Washingtonians will be the ones to suffer the adverse environmental, economic, and social impacts of climate change if global GHG emissions are not reduced. The Department has the opportunity, and legal obligation, to promulgate a rule and recommend that the legislature do its part to ensure that Washington is on a path towards reaching global climate stabilization levels. Given its regulatory management authority over natural resources in this state, the Department has the responsibility and the obligation to take the appropriate measures to ensure the reduction of the state's GHG emissions to protect the State and its people from future impacts. By ensuring that its recommendations to the legislature are based upon the best available climate science and recommending scientifically-defensible GHG emissions limits for carbon emissions, the

³⁹⁵ Hansen, *Assessing "Dangerous Climate Change," supra* note 338, at 2.

³⁹⁶ Wash. Rev. Code § 70.235.040 (2008) (emphasis added).

³⁹⁷ Wash. Exec. Order No. 14-04 (Apr. 29, 2014) at 7.

Department will be making the best decisions for the youth petitioners, the State, its citizens, and its future.

1. A Rule is Required to Encompass Ecology’s Recommendations to the Legislature

There is no question that Ecology’s obligation to “make recommendations [to the Legislature] regarding whether the greenhouse gas emissions reductions required under RCW 70.235.020 need to be updated” is mandatory because the Legislature has used the term “shall” in the text of the statute.³⁹⁸ Because Ecology’s legislative recommendations implicate youth petitioners’ and future generations’ rights to essential public trust resources, it is imperative that Ecology make its recommendations through the rulemaking process. The Legislature has found that:

(a) One of its fundamental responsibilities, to the benefit of all the citizens of the state, is the protection of public health and safety, including health and safety in the workplace, *and the preservation of the extraordinary natural environment with which Washington is endowed*;

(b) Essential to this mission is the delegation of authority to state agencies to implement the policies established by the legislature; and that the adoption of administrative rules by these agencies helps assure that these policies are clearly understood, fairly applied, and uniformly enforced³⁹⁹

“Under the Washington Administrative Procedure Act (APA), chapter 34.05 RCW, any person may petition an agency to adopt, amend or repeal a rule.”⁴⁰⁰ The Youth Petitioners have filed this petition for rulemaking on behalf of themselves and the future generations of this State to ensure that the recommendations Ecology makes to the legislature are based on the best available science. In making their recommendations to the legislature, the Governor has directed Ecology to “maximize coordination and effectiveness of local and state climate initiatives” and “inform affected and interested parties, and the general public . . . and solicit comments and involvement, as appropriate.”⁴⁰¹ A rulemaking process is the most appropriate mechanism to fulfill that directive.⁴⁰²

³⁹⁸ *Wash. State Coal. for the Homeless v. DSHS*, 949 P.2d 1291, 1298 (Wash. 1997) (“the word ‘shall’ . . . imposes a mandatory duty.”) (citations omitted).

³⁹⁹ Wash. Rev. Code § 34-05-328 note (1995) (Findings- Short title- Intent) (emphasis added).

⁴⁰⁰ *Squaxin Island Tribe v. Wash. State Dep’t of Ecology*, 312 P.3d 766, 769-70 (Wash. Ct. App. 2013) (citing Wash. Rev. Code § 34.05.330(1) (1998)).

⁴⁰¹ Wash. Exec. Order No. 14-04 (Apr. 29, 2014) at 8.

⁴⁰² Wash. Rev. Code § 34.05.370 (1998) (describing the rule-making file and the contents thereof that “shall be available for public inspection.”)

2. Ecology’s Enabling Statute Authorizes the Proposed Rulemaking

“Administrative agencies are ‘creatures of the legislature without inherent or common-law powers,’ and they may exercise only those powers conferred on them ‘either expressly or by necessary implication.’”⁴⁰³ In order to promulgate a regulation, the agency’s enabling statute must explicitly authorize or necessarily imply the appropriateness of the particular regulation.⁴⁰⁴ In sum, “an agency may only do that which it is authorized to do by the Legislature.”⁴⁰⁵

The Department of Ecology has both the legal obligation and authority to act to protect the citizens and natural resources of Washington from catastrophic climate change and ocean acidification resulting from excessive carbon dioxide pollution, and to make the same recommendations to the legislature. Pursuant to RCW 43.21A.010 (Legislative declaration of state policy on environment and utilization of natural resources), the Department was created because:

[I]t is a fundamental and inalienable right of the people of the state of Washington to live in a healthful and pleasant environment and to benefit from the proper development and use of its natural resources. The legislature further recognizes that as the population of our state grows, the need to provide for our increasing industrial, agricultural, residential, social, recreational, economic and other needs will place an increasing responsibility on all segments of our society to plan, coordinate, restore and regulate the utilization of our natural resources in a manner that will protect and conserve our clean air, our pure and abundant waters, and the natural beauty of the state.⁴⁰⁶

In order to fulfill this policy, the legislature purposefully granted the Department powers and duties, including “the authority to manage and develop . . . air and water resources in an orderly, efficient, and effective manner and to carry out a coordinated program of pollution control involving these and related land resources.”⁴⁰⁷ As a result, the Department is the delegated manager of many of Washington’s public trust resources, and has vested authority “to provide for the systematic control of air pollution from air contaminant sources and for the proper development of the state’s natural resources.”⁴⁰⁸ The State of Washington also has a declared “public policy to preserve, protect, and enhance the air quality for current and future generations.”⁴⁰⁹ This policy recognizes that “air is an essential resource that must be protected from harmful levels of pollution.”⁴¹⁰ Without additional efforts to reduce carbon dioxide

⁴⁰³ *Wash. Independent Telephone Ass’n v. Telecommunications Ratepayers Ass’n for Cost-Based & Equitable Rates (Tracer)*, 75 Wash. App. 356, 363, 880 P.2d 50, 54 (Wash. Ct. App. 1994) (citations omitted).

⁴⁰⁴ *Id.*

⁴⁰⁵ *Rettkowski v. Dep’t of Ecology*, 858 P.2d 232, 236 (Wash. 1993).

⁴⁰⁶ Wash. Rev. Code § 43.21A.010 (1970).

⁴⁰⁷ Wash. Rev. Code § 43.21A.020 (1970).

⁴⁰⁸ Wash. Admin. Code § 173-490-010 (1991).

⁴⁰⁹ Wash. Rev. Code § 70.94.011 (1991).

⁴¹⁰ Wash. Rev. Code § 70.94.011 (1991).

emissions, current and future generations of Washingtonians will be deprived a healthy environment and the beneficial use of the State's natural resources, in violation of the law.

3. The Statutory Limits on Greenhouse Gas Emissions Set the Minimum Requirement for Curbing Carbon Pollution

The Greenhouse Gas Emission Limits Statute, RCWA 70.235.020, sets specific GHG emission limits, which must be achieved for 2020, 2035, and 2050, but does not specify how any particular GHG shall be reduced. Washington's Court of Appeals has interpreted this statutory provision as a mandate to limit and reduce overall greenhouse gas emissions in the state.⁴¹¹

The mandatory limits set by statute create a ceiling for state greenhouse gas emissions, not a floor. The dictionary definitions of "limit" are: "a point beyond which it is not possible to go," "an amount or number that is the highest or lowest allowed," "a restriction or restraint," or "a boundary."⁴¹² By enacting the Greenhouse Gas Emission Limits Statute, the legislature established the "highest level" of emissions that would be allowed in each of three years, 2020, 2035, and 2050. Those emission reduction levels, or limits, reflect a "point beyond which" Washington's greenhouse gas emissions "must not go." Indeed, the legislature set these mandatory "boundaries" in order to keep Washington's gross greenhouse gas emissions from exceeding levels deemed unacceptable based on information the legislature had available to it in 2008, when it responded to the threat of climate change.

Conversely, the statute does not set a minimum level of greenhouse gas emissions the State must allow. In fact, the very purpose of the statute is to reduce the State's greenhouse gas emissions in order to address climate change and put the State's emissions on track with global climate stabilization.⁴¹³ Thus, a higher level of emission reductions would be entirely consistent with the purpose of the statute and its plain language to "limit" greenhouse gas emissions and to require Ecology to provide recommendations to update the limits.

In addition, the Court of Appeals recognized last year that "the state can achieve the mandated greenhouse gas reductions by eliminating some emission sources or, alternatively, by reducing some sources by more than the required amount and others by less."⁴¹⁴ Because carbon dioxide emissions are the most critical to address in terms of climate disruption and ocean acidification, it is entirely consistent with the statute for the Department to specially regulate carbon dioxide emissions according to the best available science on global climate stabilization and ocean protection.⁴¹⁵ The proposed rule is consistent with this approach, recognized by the Court and in compliance with the statute, and would also result in statewide emissions within the limits set forth in RCWA 70.235.020.

⁴¹¹ *Cascade Bicycle Club v. Puget Sound Reg'l Council*, 175 Wn. App. 494, 504 (2013).

⁴¹² LIMIT, Merriam-Webster Online Dictionary (June 16, 2014); Black's Law Dictionary (9th ed. 2009).

⁴¹³ Wash. Rev. Code § 70.235.020 (1)(a)(iii) (2008).

⁴¹⁴ *Cascade Bicycle Club v. Puget Sound Reg'l Council*, 175 Wn. App. 494, 504 (2013).

⁴¹⁵ Wash. Rev. Code § 70.235.020 (1)(a)(iii) (2008).

To be clear, petitioners are not asking the Department to change the statutory limits for overall GHG emissions for 2020, 2035, or 2050. Only the legislature may make those statutory changes. Instead, petitioners are asking the Department to adopt and implement regulations for carbon dioxide that: 1) are within the GHG emission reduction limits set forth in RCWA 70.235.020; 2) reduce carbon dioxide emissions by specific amounts annually and for each statutory timeframe established in RCWA 70.235.020; and 3) are based on the best available science for climate stabilization and ocean protection.

Section (1)(a) of RCWA 70.235.020 cannot be read to establish a limitation on the ability of the Department to reduce carbon dioxide emissions or other GHGs beyond the statutory emissions limits, which the legislature has said the state shall meet. Such a reading would be counterproductive and contradictory to one of the intended purposes of the statute - “creating accountability for achieving the emission reductions established in RCWA 70.235.020.”⁴¹⁶ If the emission reductions were both a floor and a ceiling, they would not be a limit, but a precise target, and nearly impossible to hit on the mark. In such a case, it would be far more likely that emissions would exceed the legal limits. RCWA 70.235.020 sets a cap on the total amount of statewide GHG emissions for 2020, 2035, and 2050, but does not prohibit the Department from developing and implementing regulations that exceed the minimum reductions set forth in the statute. Therefore, the Department is well within its authority to adopt the proposed rule and reduce carbon dioxide emissions in the manner that petitioners seek, according to the best available science.

H. The Washington Constitution, the Public Trust Doctrine, and the Greenhouse Gas Emission Limits Statute Require that the Department Make Recommendations and Promulgate the Rule According to the Best Available Science

The State of Washington has a constitutional obligation to protect and manage its natural resources for its citizens under the Public Trust Doctrine. Washington must protect and manage the lands, navigable waters, atmosphere, oceans, climate, and other resources for the benefit of present and future generations. The Public Trust Doctrine is an inalienable and constitutionally-based attribute of sovereignty that requires all sovereign governments, including the State of Washington, to act to prevent degradation of essential natural resources held in trust on behalf of present and future generations. The Public Trust Doctrine holds that certain crucial natural resources, such as the atmosphere, are the shared, common property of all citizens, cannot be subject to private ownership, and must be preserved and protected by the government.

The Public Trust Doctrine is reiterated in state constitutional provisions across the nation. In *PPL Montana, LLC v. Montana*, the United States Supreme Court recognized that the Public Trust Doctrine “is of ancient origin” dating back to Roman civil law; that the Public Trust Doctrine is reflected in state laws and constitutional provisions throughout our nation; and that federalist principles of our nation affirm the State’s rights and duties over public trust resources within their borders.⁴¹⁷ The universal constitutional application of the Public Trust Doctrine is evident in that citizens’ rights to essential natural resources reflect “inherent and independent

⁴¹⁶ Wash. Rev. Code § 70.235.005

⁴¹⁷ *PPL Montana, LLC v. Montana*, 132 S. Ct. 1215, 1235-36 (2012).

rights' of mankind relative to the environment."⁴¹⁸ As the Pennsylvania Supreme Court decided in *Robinson Township*, Article I, § 27 of the Pennsylvania Constitution requires government to "conserve and maintain" the State's natural resources, and imposes the duty "to refrain from permitting or encouraging the degradation, diminution, or depletion of public natural resources, whether such degradation, diminution, or depletion would occur through direct state action or indirectly, *e.g.*, because of the state's failure to restrain the actions of private parties."⁴¹⁹ Government also has the duty "to act affirmatively to protect the environment" via legislative or regulatory action.⁴²⁰ A court in the State of Texas recently held that pursuant to the Texas Constitution, all natural resources, including the air and atmosphere, are trust assets and must be protected by the State.⁴²¹

Washington has an affirmative and mandatory duty under the Public Trust Doctrine to prevent substantial impairment to the State's essential natural resources. The public's right to essential natural resources reflects inherent rights that are preserved, and not extinguished, by the State Constitution.⁴²² The State Constitution expressly recognizes that "[a]ll political power is inherent in the people, and governments derive their just powers from the consent of the governed, and are established to protect and maintain individual rights"⁴²³ and that "[t]he enumeration in this Constitution of certain rights shall not be construed to deny others retained by the people."⁴²⁴ Further, in express recognition of the Public Trust obligation, Article XVII, § 1 states, "The state of Washington asserts its ownership to the beds and shores of all navigable waters in the state up to and including the line of ordinary high tide, in waters where the tide ebbs and flows, and up to and including the line of ordinary high water within the banks of all navigable rivers and lakes."⁴²⁵ This constitutional provision grants responsibility to manage public lands and waters to the State, as a trustee of the beneficiaries, present and future generations of Washingtonians.

Washington courts have also found that this constitutional provision explicitly requires the State, through its various administrative agencies, to hold its resources in trust. In *Washington State Geoduck Harvest Ass'n v. Washington State Dept. of Natural Resources*, the court determined that "the public trust doctrine ensures state management of public lands, in part, through our Constitution's express reservation of "the beds and shores of all navigable waters in

⁴¹⁸ *Robinson Twp. v. Commonwealth*, 83 A.3d 901, 947 (Pa. 2013) (plurality opinion).

⁴¹⁹ *Id.* at 956.

⁴²⁰ *Id.* at 957.

⁴²¹ *Angela Bonser-Lain v. Texas Commission on Environmental Quality*, Case No. D- 1-GN-11-002194 (on review of denial of petition for rulemaking)

http://ourchildrenstrust.org/sites/default/files/Texas-letter-ruling_0.pdf.

⁴²² *Robinson Township*, 83 A.3d at 947 n.35 (recognizing that citizens' rights to essential natural resources reflect "inherent and independent rights' of mankind relative to the environment.") (stating that citizens' environmental rights codified and protected by state constitution are "inherent in man's nature and preserved rather than created by the Pennsylvania Constitution.").

⁴²³ Wash. Const. art. I, § 1, 30.

⁴²⁵ Wash. Const. art. XVII, § 1.

the state” for state ownership.”⁴²⁶ The Washington Supreme Court has interpreted Article XVII, § 1, stating “that the sovereignty and dominion over this state’s tidelands and shorelands, as distinguished from title, always remains in the state and the state holds such dominion in trust for the public.”⁴²⁷

In addition to protecting natural resources, the State is also responsible for safeguarding various public interests in those resources. Traditionally protected interests are commerce, navigation, and commercial fishing.⁴²⁸ Other interests include “incidental rights of fishing, boating, swimming, water skiing, and other related recreational purposes generally regarded as corollary to the right of navigation and the use of public waters.”⁴²⁹ The Public Trust Doctrine also extends to protect the public interest in shellfish embedded in the navigable water beds of state-owned lands,⁴³⁰ a resource that will be heavily impacted by the effects of climate change and ocean acidification. Washington has a constitutional obligation to protect the public’s interests in natural resources held in trust for the common benefit of Washingtonians. The Department of Ecology, in implementing its delegated authority, must act to ensure that the public trust resources under its regulatory jurisdiction are not substantially impaired by climate change, and that analysis must be informed by the best available science.

The Department has the statutory obligation under Wash. Rev. Code § 70.235.040 (consultation with climate impacts group at the University of Washington--Report to the legislature) to produce a report to the legislature recommending that the minimum greenhouse gas emissions limits required under Wash. Rev. Code § 70.235.020 be updated. The recently released IPCC⁴³¹ and NCA reports,⁴³² issued in 2013-14 and 2014, respectively affirm the urgent need to implement carbon dioxide emission limits necessary to stabilize the global climate system.

Given the aforementioned grants of authority, description of obligations, and statements of policy, petitioners respectfully request that the Director of the Department adopt the proposed rule because it is “necessary and appropriate to carry out the provisions” of the chapter creating the Department and establishing its purpose.⁴³³ Additionally, the Department must meet the obligations imposed by the Public Trust Doctrine, as well as Washington’s constitution, statutes, and executive orders. Cumulatively, the proposed rule will put Washington back on course to achieve emission reductions on the scale necessary to avert disastrous consequences and substantial impairment to public trust resources. These actions will also allow the Department to

⁴²⁶ *Washington State Geoduck Harvest Ass’n v. Washington State Dept. of Natural Resources*, 101 P.3d 891, 895 (Wash. Ct. App. 2004).

⁴²⁷ *Caminiti v. Boyle*, 732 P.2d 989, 994 (Wash. 1987).

⁴²⁸ *Orion Corp. v. State*, 747 P.2d 1062, 1073-109 Wash.2d 621, 641 (Wash. 1987).

⁴²⁹ *Caminiti v. Boyle*, 732 P.2d at 747-107 Wash. at 994-2d 662, 669 (quoting *Wilbour v. Gallagher*, 77 Wash.2d 306, 316, 462 P.2d 232, 239 (Wash. 1969)).

⁴³⁰ *Washington State Geoduck Harvest Ass’n*, 101 P.3d at 451.

⁴³¹ IPCC, *AR5*, *supra* note 9.

⁴³² USGRCP, *Climate Change Impacts*, *supra* note 8.

⁴³³ See Wash. Rev. Code § 43.21A.080 (1995) (rule-making authority for the Director of the Department).

follow through on the intent of the legislature to “reduce emissions at the lowest cost to Washington's economy, consumers, and businesses” because every delay in emission reductions increases future reductions, as well as making those reductions more costly and less effective.⁴³⁴ Enabling the Department and other state agencies to implement more stringent emission reduction policies, grounded in science, will help fulfill the original legislation’s long-term goals, goals that will not be achieved with current policy. Failure to take immediate action to significantly reduce carbon dioxide emissions will increase the cost and magnitude of future reduction requirements and, more significantly, will result in irreversible adverse effects on youth petitioners, other children and future generations of Washingtonians.

PROPOSED NEW RULE

A. Text of Proposed Rule

(1) In order to meet the statutory requirements of chapter 14, Laws of 2008, **RCW 70.235.005-70.235.901**, and **Executive Order 14-04**, and achieve the state’s greenhouse gas emission reductions needed to do its part to reach global climate stabilization levels pursuant to **RCW 70.235.020 (1)(a)(iii)**, the Department of Ecology (the Department):

(a) Recommends to the Governor and the Legislature that in order to do its part to reach global climate stabilization levels, Washington must set its carbon dioxide emission reductions trajectory to aim for a return of atmospheric carbon dioxide levels of 350 ppm by 2100, and achieve at least an eighty (80) percent reduction in carbon dioxide emissions from 1990 levels by 2050.

(b) Recommends to the Governor and the Legislature that based on the best available science of global climate stabilization, Washington’s minimum statewide greenhouse gas emissions limits should be updated to achieve a **four (4) percent** annual reduction in overall carbon dioxide emissions in the state so that:

- (i) By 2020, overall emissions of carbon dioxide in the state are reduced to **thirty-one (31) percent below 1990 levels**;
- (ii) By 2035, overall emissions of carbon dioxide in the state are reduced to **sixty-two (62) percent below 1990 levels**; and
- (iii) By 2050, overall emissions of carbon dioxide in the state are reduced to **eighty (80) percent below 1990 levels**.

(c) Independent of, and prior to any legislative action as a result of the update provided to the legislature in (1)(a) and (1)(b) *supra*, shall ensure that:

- (i) Starting in 2015, statewide carbon dioxide emissions are reduced by an aggregate 4 percent per year through 2050 across all sectors over which it has control;

⁴³⁴ See Wash. Rev. Code § 70.235.005(3)(c) (2008) (describing legislative intent for GHG emission reduction policy).

- (ii) An overall carbon dioxide emission reduction plan for the state calibrated to achieve the reductions in (1)(b) is developed and implemented across all sectors over which it has control; and
- (iii) Other state agencies and entities with the authority to reduce carbon dioxide pollution in their operations and policies receive assistance as needed.

(d) Shall ensure that other greenhouse gases are reduced consistent with the requirements of chapter 14, Laws of 2008.

(2) Consistent with (1)(c), the Department shall:

(a) Provide an accounting to Washington citizens of its management of the atmospheric trust asset by publishing biennial progress reports on statewide carbon dioxide emissions, in addition to carbon dioxide equivalent emissions, on the Department's website for public review. These reports must include an accounting and inventory for each and every substantial source of carbon dioxide emissions within Washington, including, but not limited to the transportation, electricity, industrial, residential, commercial, agriculture, and waste sectors and a total carbon dioxide accounting for the state as a whole. This inventory and accounting must be verified by an independent, third-party. Reports must be available to the public no later than January 31 of each year, beginning in the year 2015.

(b) Estimate the carbon dioxide emission reductions that proposed policies will achieve within a given time frame.

(c) Prepare and advocate for a budget that enables the Department to:

(i) Satisfy its legal obligations - as a trustee of public resources - under the Constitution of the State of Washington.

(ii) Meet the requirements of **RCW 70.235.005-70.235.901** and **Executive Order 14-04**.

(iii) Meet the requirements of this proposed rule in its entirety.

(3) To the extent that any rule in this section conflicts with any other rule in effect, the more stringent rule, favoring full disclosure of emissions and protection of the atmosphere, governs.

B. The Emission Reduction Limits Proposed in the Rule are Based on the Best Available Science for Climate Stability and Protecting Oceans from Acidification and are Calibrated for Washington Specifically

Youth Petitioner's Proposed Rule is based on the best available science. The best available science indicates that atmospheric CO₂ concentrations must return to 350 ppm by century's end.⁴³⁵ In order to meet this target, CO₂ emissions must be reduced by an adequate

⁴³⁵ James Hansen et al., *Assessing "Dangerous Climate Change": Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature*, 8 PLOS ONE 1, 5, 10, 17-18 (2013).

margin each year.⁴³⁶ The rate of emission reductions required to return the atmospheric CO₂ concentration to a safe level depends on the year in which emissions peaked.⁴³⁷ For example, “if emissions reduction had begun in 2005, reduction at 3.5%/year would have achieved 350 ppm at 2100.”⁴³⁸ A peak in 2012 or 2020 would require annual reductions of 6% and 15%, respectively.⁴³⁹

According to Washington’s emissions data, CO₂ emissions in Washington peaked in 2007. The proposed rule is based on calculations of Washington’s peak emissions year using CO₂e data received from the Department.⁴⁴⁰ As the best available science is based on CO₂, and not CO₂e, and because Washington does not disclose its CO₂ emission levels, Petitioners estimated the proportion of the CO₂e values for which CO₂ accounted. Based on information obtained from the Department, Petitioners estimated that CO₂ accounted for 96% of the CO₂e emissions.⁴⁴¹

Based on this accounting of CO₂ emissions, Petitioners calculated Washington’s CO₂ emissions from 1990-2010 to find the CO₂ peak year of 2007, reflected in the chart below.

Year	MM CO ₂ e	MM CO ₂ Adjusted for CO ₂ Only (subtract 4%)
1990	88.406504572763	84.870244389853
1991	89.893334716278	86.297601327627
1992	92.314038340237	88.621476806628
1993	95.001626879409	91.201561804232
1994	99.439739231605	95.462149662341
1995	99.319271804792	95.346500932600
1996	101.663299074594	97.596767111610
1997	101.561333171003	97.498879844163
1998	102.995291853984	98.875480179825
1999	104.691041500634	100.503399840608
2000	110.340792877936	105.927161162819

⁴³⁶ *Id.*

⁴³⁷ *Id.* at 10, 18.

⁴³⁸ *Id.*

⁴³⁹ *Id.* 10, 18.

⁴⁴⁰ June 11, 2014 Personal Communication with Gail Sandlin of the Washington Department of Ecology (providing Washington’s CO₂e data for the years: 1990-2011).

⁴⁴¹ June 11, 2014 Personal Communication with Ecology employee Gail Sandlin regarding the best method for obtaining Washington’s statewide CO₂ emissions in different years for which data was available. Ms. Sandlin explained that Washington’s CO₂ (as opposed to CO₂e) emissions data was not readily available and recommended that a reasonable estimate of Washington’s CO₂ emissions could be determined by reducing the CO₂e values by 4%, since the non-CO₂ GHG emissions accounted for approximately 4% of CO₂e emissions.

2001	100.538120172010	96.516595365130
2002	90.775921362845	87.144884508331
2003	95.536839010698	91.715365450270
2004	96.387014055768	92.531533493537
2005	98.252995818594	94.322875985850
2006	100.754790938123	96.724599300598
2007	104.028088889099	99.866965333536

Dr. Pushker A. Kharecha, co-author with Dr. James Hansen on the scientific publication, *Assessing “Dangerous Climate Change”: Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature*, consulted on the scientific basis for the proposed rule.⁴⁴² Dr. Kharecha confirmed that with a peak year of 2007, CO₂ emissions must be reduced by 4% per year in order to achieve safe atmospheric CO₂ concentrations by century’s end.

Petitioners applied this annual rate of reduction (4%) to Washington’s estimated CO₂ emissions value for the year 2007 (peak year) in order to calculate Washington’s annual emission limits. These annual emission reductions were used to calculate the difference in CO₂ emissions relative to Washington’s estimated CO₂ emissions from 1990 (84.8702443898525 mm CO₂).⁴⁴³ The following emission CO₂ limits for a given year, based on the 4% annual reduction were calculated using the method described above:

Year	MM CO ₂	Relative to 1990
2008	95.872286720194	
2009	92.037395251386	
2010	88.355899441331	
2011	84.821663463678	
2012	81.428796925131	
2013	78.171645048125	
2014	75.044779246200	
2015	72.042988076352	
2016	69.161268553298	
2017	66.394817811166	
2018	63.739025098720	

⁴⁴² Dr. Pushker A. Kharecha conferred with petitioners regarding the best method of calculating the required annual rate of emissions reductions if the peak year was 2007. Dr. Kharecha confirmed that his recommendations are based upon best available science.

⁴⁴³ Washington’s CO₂ emissions for 1990 were estimated based on the assumption that CO₂ accounts for 96% of Washington’s CO₂e emissions (see above). The 1990 CO₂e value was received from the Department of Ecology. If there are more precise values for these emission levels, the Department should update these charts to determine the comparative emission levels for 2020, 2035, and 2050 against the 1990 background level, and adjust the proposed rule accordingly.

2019	61.189464094771	
2020	58.741885530980	31%
2021	56.392210109741	
2022	54.136521705351	
2023	51.971060837137	
2024	49.892218403652	
2025	47.896529667506	
2026	45.980668480805	
2027	44.141441741573	
2028	42.375784071910	
2029	40.680752709034	
2030	39.053522600672	
2031	37.491381696646	
2032	35.991726428780	
2033	34.552057371629	
2034	33.169975076763	
2035	31.843176073693	62%
2036	30.569449030745	
2037	29.346671069515	
2038	28.172804226735	
2039	27.045892057665	
2040	25.964056375359	
2041	24.925494120344	
2042	23.928474355531	
2043	22.971335381309	
2044	22.052481966057	
2045	21.170382687415	
2046	20.323567379918	
2047	19.510624684721	
2048	18.730199697333	
2049	17.980991709439	
2050	17.261752041062	80%

CONCLUSION

For the reasons set forth above, Youth Petitioners respectfully request that Ecology initiate rulemaking proceedings in accordance with RCW 34.05.320.

Respectfully submitted,

A handwritten signature in black ink, appearing to read "Andrea Rodgers Harris". The signature is written in a cursive style with a large, decorative flourish at the end.

Andrea Rodgers Harris
Law Offices of Andrea K. Rodgers Harris
Counsel for Youth Petitioners