No. 19-1818

UNITED STATES COURT OF APPEALS FOR THE FIRST CIRCUIT

STATE OF RHODE ISLAND,

Plaintiff-Appellee,

v.

SHELL OIL PRODUCTS COMPANY, LLC; CHEVRON CORP.; CHEVRON USA, INC.; EXXONMOBILE CORP.; BP, PLC; BP AMERICA, INC.; BP PRODUCTS NORTH AMERICA, INC.; ROYAL DUTCH SHELL PLC; MOTIVA ENTERPRISES, LLC; CITGO PETROLEUM CORP.; CONOCOPHILLIPS; CONOCOPHILLIPS COMPANY; PHILLIPS 66; MARATHON OIL COMPANY; MARATHON OIL CORP.; MARATHON PETROLEUM CORP.; MARATHON PETROLEUM COMPANY, LP; SPEEDWAY, LLC; HESS CORP.; LUKOIL PAN AMERICAS LLC; DOES 1-100,

Defendants-Appellants,

GETTY PETROLEUM MARKETING, INC.,

Defendant.

On Appeal from the United States District Court,
For the District of Rhode Island, No. 1-18-cv-00395-WES-LDA
(Hon. William E. Smith)

BRIEF OF AMICI CURIAE MARIO J. MOLINA, MICHAEL OPPENHEIMER, ROBERT E. KOPP, FRIEDERIKE OTTO, SUSANNE C. MOSER, DONALD J. WUEBBLES, GARY B. GRIGGS, PETER C. FRUMHOFF and KRISTINA DAHL IN SUPPORT OF PLAINTIFF-APPELLEE AND AFFIRMANCE

William A. Rossbach
ROSSBACH LAW, PC
401 N. Washington Street/P. O. Box 8988
Missoula, MT 59807
(406) 543-5156

Counsel for Amicus Curiae

CORPORATE DISCLOSURE STATEMENT

Pursuant to Fed. R. App. P. 26.1, amicus curiae Mario J. Molina, Michael Oppenheimer, Robert E. Kopp, Friederike Otto, Susanne C. Moser, Donald J. Wuebbles, Gary B. Griggs, Peter C. Frumhoff, and Kristina Dahl certify that they are individuals, not corporations.

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AMICUS CURIAE'S IDENTITY, INTEREST AND AUTHORITY TO FILE

Amici curiae, as scientists and scholars, have devoted much of their professional lives to studying, writing, and teaching one or more aspects of climate science, including sea-level rise and its impacts on coastal communities.

Mario J. Molina is a Professor at the University of California, San Diego (UCSD, **Michael Oppenheimer** is the Albert G. Milbank Professor of Geosciences and International Affairs at Princeton University. **Robert E. Kopp** is the Director of the Institute of Earth, Ocean, and Atmospheric Sciences at Rutgers University. **Friederike Otto** is the Acting Director of the Environmental Change Institute. **Susanne C. Moser** is on the Research Faculty in the Environmental Studies Department of Antioch University New England. **Donald J. Wuebbles** is The Harry E. Preble Professor of Atmospheric Sciences in the School of At the University of Illinois at Urbana-Champaign. **Gary B. Griggs** is Professor of Earth & Planetary Sciences at the University of California Santa Cruz. **Peter C. Frumhoff** is Director of Science and Policy and Chief Climate Scientist at the

Union of Concerned Scientists (UCS). **Kristina Dahl** is a Senior Climate Scientist in the Climate and Energy program at the Union of Concerned Scientists.

As courts address cases involving the damage to coastal communities caused by climate change and ongoing sea-level rise, we feel it is essential for judicial decisions to be based on an understanding of the relevant science and the unavoidable adaptation expenses these communities are facing. We submit this *amicus* brief in order to assist the Court in that regard.

All parties have consented to the filing of this brief. No party's counsel authored the brief in whole or in part, no party or party's counsel contributed money that was intended to fund preparing or submitting the brief, and no person other than counsel for amici contributed money that was intended to fund preparing or submitting the brief.

(Additional amici information in Appendix.)

SUMMARY OF ARGUMENT

There is broad consensus among climate scientists that the impacts of global warming, including rising seas, are accelerating. Carbon dioxide (CO_2) from combustion of fossil fuels—of which the Appellants' products are a primary source—is the largest single contributor to this warming. Global warming has produced a well-documented rise in the world's sea levels through thermal expansion of ocean water, the melting of mountain glaciers, and losses of ice from the Greenland and Antarctic ice sheets.

Rhode Island faces the daunting and expensive challenge of protecting its citizens and its infrastructure—roads, bridges, airports, rail lines, port facilities, sewage treatments systems, drinking water supply systems, storm drainage systems, and public utilities—from these rising sea levels now and for decades to come. Even with huge reductions in fossil fuel use, the ocean will continue to rise because of the slow nature of the processes governing sea-level rise.

Despite the recent United Nations Paris Agreement, by which 195 governments agreed to reduce global emissions in order to keep global warming from progressing to dangerous levels, global CO_2 emissions grew to record levels in 2017 (1.6% increase) and increased again in 2018 (2.7% increase).[1] Continued production, marketing, and combustion of fossil fuels on this high emission path will likely result in at least 2-feet of mean global sea-level rise by 2100.[2] There is a small, but very real possibility, that collapse of parts of the Antarctic ice sheet could result in over 6-feet of global sea-level rise by 2100.[3] Even the most aggressive emissions reduction scenarios would likely result in at least one

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[1] Le Quéré, C., et al., *Global Carbon Budget 2018*, 10(4) Earth System Science Data (Online) (2018).

[2] About 85% probability according to Kopp, R. E., et al., *Probabilistic 21st and 22nd Century Sea-Level Projections at a Global Network of Tide-Gauge Sites*, 2(8) Earth's Future 383–406 (2014).

[3] Bamber, J. L., et al., *Ice sheet contributions to future sea level rise from structured expert judgement*, 116(23) Proceedings of the National Academy of Sciences 11195–11200 (2019).

foot of mean global sea-level rise by 2100[4,5] and these scenarios are generally recognized as unachievable with current policies.

These predictions mean that the damage already caused by coastal flooding will inevitably increase as global warming causes sea levels to rise further. This will compel coastal communities to take costly remedial steps to harden infrastructure so they can withstand flooding, or communities will have to retreat from coastal locations.

Rhode Island seeks to recover from the fossil fuel companies, whose products cause global warming and the sea-level rise that threatens the city, a fair share of the cost of adapting its coastal infrastructure to these rising seas.

We detail in our brief the scientific evidence showing that Appellants' fossil fuels are a substantial factor in global warming

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[4] About 92% probability according to Kopp, R. E., et al., *Probabilistic 21st and 22nd Century Sea-Level Projections at a Global Network of Tide-Gauge Sites*, 2(8) Earth's Future 383–406 (2014).

[5] Sweet, W. V., et al., *Global and Regional Sea Level Rise Scenarios for the United States (NOAA Technical Report NOS CO-OPS 083)*, Center for Operational Oceanographic Products and Services National Ocean Service, National Oceanic and Atmospheric Administration (2017).

and the sea-level rise affecting Rhode Island. We also describe the peer reviewed data showing the relative contribution of each of the top 90 producers of fossil fuels to the carbon dioxide in the atmosphere. Scientists have used this methodology to calculate the relative contribution of each of the top 90 to the increases in carbon dioxide in the atmosphere, surface temperature, and sea level from 1880 to 2010. These methodologies prove that fossil fuel products are a substantial factor in the injuries and damages that Rhode Island has and will continue to suffer.

ARGUMENT

I. Advances In Climate Science Have Shown That During The Period of Human Civilization, Stable Levels Of Atmospheric Carbon Dioxide And Relatively Stable Global Temperatures And Sea Level Permitted Civilization To Flourish.

The foundation of modern climate science can be traced back to the 19th century. In 1824, Joseph Fourier proposed that Earth's atmosphere acts to raise the planet's temperature. Fourier wondered how Earth could be so warm as it was so far from the sun. Fourier knew that energy from the sun was reflecting off Earth and escaping back to space. He hypothesized that the atmosphere must capture some of that radiation, otherwise the planet would be significantly cooler. Fourier was the first to describe what would become known as "the greenhouse effect."[6]

In 1856, Eunice Foote demonstrated experimentally that the presence of CO_2 in the atmosphere causes the sun to heat the air to a higher temperature compared to atmosphere without CO_2.[7] Soon after, in 1861, John Tyndall expanded on Foote's discovery by studying the amount of infrared energy absorbed by different gas molecules, including CO_2.[8] In 1896, Svante Arrhenius used principles of physical chemistry to estimate the extent to which increases in atmospheric CO_2 would raise Earth's surface temperature through the greenhouse effect. Arrhenius calculated that doubling CO_2 in the atmosphere would increase surface temperatures of the Earth by 4 degrees Celsius (4˚C). That

[6] Fourier, J., *General Remarks on the Temperature of the Earth and Outer Space*, 32 American Journal of Science 1–20 (1824).
[7] Foote, E., *Circumstances Affecting the Heat of the Sun's Rays*, 22 The American Journal of Science and Arts 382 (1856).
[8] Tyndall, J., *On the Absorption and Radiation of Heat by Gases and Vapours, and On the Physical Connexion of Radiation, Absorption, and Conduction*, 151 Philosophical Transactions of the Royal Society of London 1–36 (1861).

estimate remains within the range of today's state-of-the-art climate model predictions.[9,10]

The greenhouse effect is an atmospheric process that warms Earth's surface. The sun provides energy primarily in the form of visible light and ultraviolet radiation. Though some of that energy is reflected back to space (by snow, clouds, etc.), most is absorbed by Earth's surface. The planet's surface then emits infrared radiation back toward space. Greenhouse gases in the atmosphere, such as CO_2, absorb this emitted infrared radiation. This energy is then re-emitted in all directions in the form of infrared radiation, roughly half upwards towards space and half back down to Earth.

Carbon dioxide is the most important greenhouse gas due to its potency, longevity, and abundance in the atmosphere. Water vapor is the most abundant greenhouse gas and also plays an

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[9] Arrhenius, S., *On the Influence of Carbonic Acid in the Air Upon the Temperature of the Ground*, 41(251) Philosophical Magazine 237–276 (1896).

[10] Stocker, T.F., et al., *Technical Summary*, Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)] 33–115 (2013).

important role in regulating Earth's temperature. The amount of water vapor in the atmosphere is modulated by air temperature: warmer conditions cause liquid water to evaporate and warm air holds more water vapor than cold air. Rising CO_2 leads to an increase in temperature, which in turn increases water vapor in the atmosphere. This feedback loop amplifies the warming effect CO_2 has on the planet.[11] Without CO_2, water vapor, and other greenhouse gases in the atmosphere, the mean surface temperature of Earth would be 33˚C (60˚F) cooler than it currently is.[12,13]

Earth's history is punctuated by naturally driven climate change events. Large, continental ice sheets in the northern hemisphere advanced and retreated many times during the last

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[11] Solomon, S., et al., *Contributions of Stratospheric Water Vapor to Decadal Changes in the Rate of Global Warming*, 327(5970) Science 1219–1223 (2010).
[12] Schneider, S., *The Greenhouse Effect: Science and Policy*, 243(4892) Science 771–781 (1989).
[13] Collins, M., et al., *Long-term Climate Change: Projections, Commitments and Irreversibility*, Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change 1029–1136 (2013).

2.6 million years. Periods with large ice sheets are called *glacial periods*, or *ice ages*, and those without are known as *interglacial periods*. This pattern of climate change was driven primarily by changes in incoming solar radiation due to variations in Earth's orbit. For the last 800,000 years, glacial periods have lasted around 100,000 years and were separated by relatively warm interglacial periods that lasted between 10,000 to 30,000 years. The most recent glacial period occurred between 11,500 and 116,000 years ago. Since then, Earth has been in an interglacial period called the Holocene Epoch.[14]

At the end of the last glacial period (during a 12,000-year span beginning around 20,000 years ago), global mean sea-level (GMSL) rose approximately 400–450 feet at an average rate of 0.4 inches per year.[15] However, this deglaciation was punctuated by

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[14] Masson-Delmotte, V., et al., *Information from Paleoclimate Archives*, Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)] 383–464 (2013).
[15] *Id.*

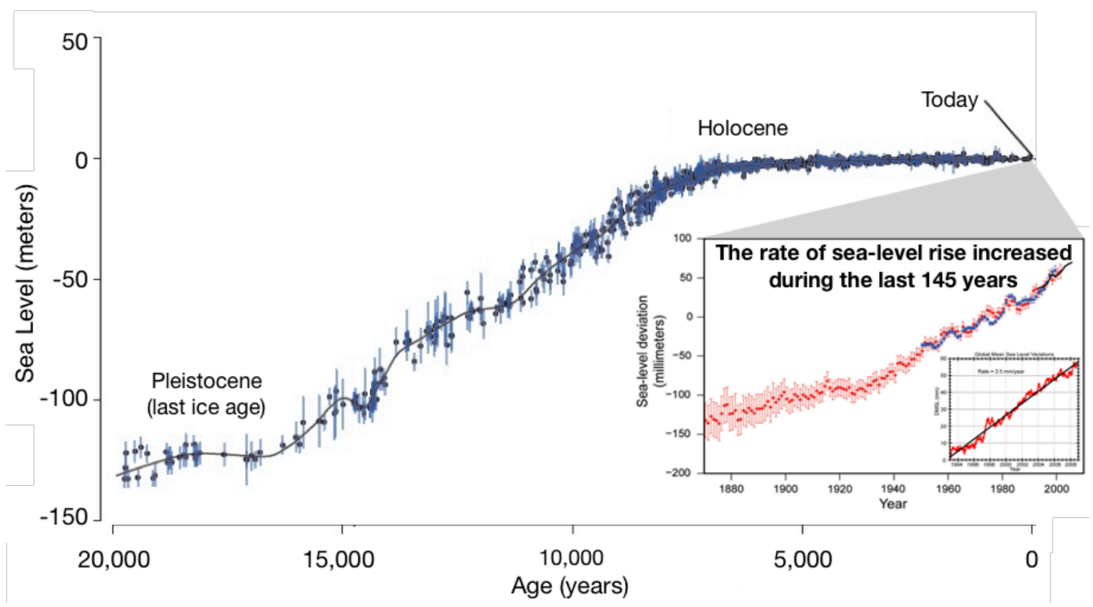
episodes of very rapid sea-level rise. For example, 14,000 years ago, sea level rose between 28–48 feet over 350 years.[16] Around 7,000 years ago, in the midst of the subsequent interglacial period (the Holocene), the rate of sea-level rise markedly decreased. Between 6,700 and 4,200 years ago, sea level rose about 10 feet, at a rate of about 0.05 inches per year. Sea level rose no more than about 3 feet between 4,200 years ago and the time of onset of recent sea-level rise (about 150 years ago)[17], or less than approximately 0.01 inches per year.[18] Human civilization

[16] Liu, J., et al., *Sea Level Constraints on the Amplitude and Source Distribution of Meltwater Pulse 1A*, 9(2) Nature Geoscience 130 (2016).
[17] Kopp, R., et al., *Temperature-driven global sea-level variability in the Common Era*, 113(11) Proceedings of National Academy of Science E1434–E1441 (2016).
[18] Lambeck, K., et al., *Sea Level and Global Ice Volumes from the Last Glacial Maximum to the Holocene*, 111(43) Proceedings of the National Academy of Science 15296–15303 (2014).

flourished during the Holocene period of sea-level stability and has never had to contend with rapid changes in sea level (Figure 1).[19]

[19] Masson-Delmotte, V., et al., *Information from Paleoclimate Archives*, Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)] 383–464 (2013).

Figure 1. Global mean sea-level over the last 20,000 years. During the termination of the last ice age, massive continental ice loss led to 120–135 meters (400–450 feet) of sea level rise. Around 7,000 years ago, the rate of sea level rise dropped to a "pre-industrial" rate of <1 mm per year. Figure inset depicts estimated sea-level change (mm) since 1870. GMSL has been rising at an average rate of 1.7-mm per year over the past 100 years. Since 1993, the rate increased to about 3.5-mm per year. Red: sea level since 1870. Blue: tide-gauge data. Black: satellite observations. Figures modified from: Clark, P., et al., *Consequences of twenty-first-century policy for multi-millennial climate and sea level change*, 6 Nature Climate Change 360–369 (2016), and NOAA National Centers for Environmental Information, *Warming Climate: Sea Level is Rising*, NOAA Global Climate Change Indicators, https://www.ncdc.noaa.gov/monitoring-references/faq/indicators.php (last visited Dec. 19, 2019).



II. With The Commencement Of The Industrial Revolution, Previously Stable Atmospheric Carbon Dioxide Levels Began Increasing, Causing Rising Atmospheric And Ocean Temperatures And Sea-Level Rise That Is Unprecedented In The History Of Human Civilization.

For most of the history of human civilization, the amount of CO_2 in the Earth's atmosphere remained in a stable range between 260–280 parts per million (ppm).[20] During the past 200 years, commencing with the Industrial Revolution (1720–1800 CE), increased combustion of fossil fuels, cement production, and deforestation[21] have raised the average concentration of CO_2 in the atmosphere to greater than 410 ppm[22] – higher than any time in at least 800,000 years (Figure 2).[23] Most critically, however, more

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[20] Lourantou, A., et al., *Changes in Atmospheric CO_2 and Its Carbon Isotopic Ratio During the Penultimate Deglaciation*, 29(17–18) Quaternary Science Reviews 1983–1992 (2010).

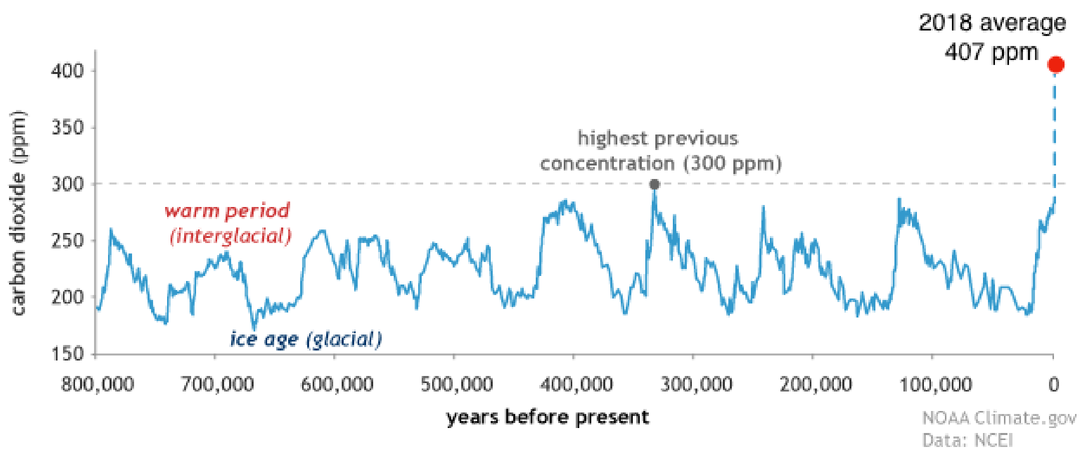
[21] Le Quéré, C., et al., *Global Carbon Budget 2018*, 10(4) Earth System Science Data (Online) (2018).

[22] Dlugokencky, E. and Tans, P., *Trends in Atmospheric Carbon Dioxide*, NOAA Earth System Research Laboratory (2019), www.esrl.noaa.gov/gmd/ccgg/trends/.

[23] Masson-Delmotte, V., et al., *Information from Paleoclimate Archives*, Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)] 383–464 (2013).

than half of all industrial emissions of CO_2 have occurred since 1988.[24]

Figure 2. Changes in atmospheric CO_2 concentrations over the last 800,000 years. Historic CO_2 levels are from ice core data, and current data are from the Mauna Loa Observatory. Average 2018 concentration indicated by red dot. Figure modified from NOAA.



Due primarily to the increased concentration of anthropogenic CO_2 from fossil fuel combustion, global mean surface temperature (GMST)[25] has increased by 1˚C (1.8˚F) since the late nineteenth century.[26,27] One way to conceptualize the

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[24] Frumhoff, P., et al., *The Climate Responsibilities of Industrial Carbon Producers*, 132(2) Climatic Change 157–171 (2015).
[25] *Global mean surface temperature* is calculated by combining measurements from the air above land and the ocean surface.
[26] Hawkins, E., et al., *Estimating Changes in Global Temperature Since the Preindustrial Period*, 98(9) Bulletin of the American Meteorological Society 1841–1856 (2017).
[27] IPCC, *Summary for Policymakers*, IPCC Special Report on Global Warming of 1.5°C (2018).

immense amount of heat that Earth is absorbing is to combine measurements of ocean, land, atmosphere, and ice heating. Based on these data, over the last two decades Earth's climate system has been absorbing the heat equivalent of detonating four Hiroshima atomic bombs per second, or nearly 400,000 Hiroshima A-bombs per day.[28,29]

If there is sustained greenhouse gas emissions growth, by the end of the century, GMST is projected to increase between 3.6–5.8˚C above pre-industrial temperature.[30] The last time

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[28] Church, J. A., et al., *Revisiting the Earth's Sea-Level and Energy Budgets from 1961 to 2008*, 38(18) Geophysical Research Letters L18601 (2011).

[29] Nuccitelli, D., et al., *Comment on Ocean Heat Content and Earth's Radiation Imbalance II, Relation to Climate Shifts*, 376(45) Physics Letters A 3466–3468 (2012).

[30] Collins, M., et al., *Long-term Climate Change: Projections, Commitments and Irreversibility*, Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change 1029–1136 (2013).

GMST was comparable to today[31,32], GMSL was 20–30 feet higher than today.[33]

Global warming contributes to sea-level rise in multiple ways. As the ocean warms from climate change, seawater expands, takes up more space, and the oceans rise to accommodate this basic physical expansion. This process is known as *ocean thermal expansion*. Ocean thermal expansion accounts for about 50% of the increased volume of the world's oceans in the past 100 years. The remaining sea-level rise of the past century has been largely due to melting mountain glaciers (about 25%) and Antarctic and Greenland ice sheet loss (about 25%).[34,35]

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[31] The Last Interglacial, 130,000–115,000 years ago.

[32] Hoffman, J., et al., *Regional and Global Sea-Surface Temperatures During the Last Interglaciation*, 355(6332) Science 276–279 (2017).

[33] Dutton, A., et al., *Sea Level Rise Due to Polar Ice-Sheet Mass Loss During Past Warm Periods*, 349(6244) Science aaa4019 (2015).

[34] Griggs, G., et al., *Rising Seas in California: An Update on Sea-Level Rise Science*, California Ocean Science Trust (2017), http://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf.

[35] Church, J. A., et al., *Sea Level Change*, Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change 1137–1216 (2013).

III. Even If All Carbon Dioxide Emissions Were To Cease Immediately, Sea Levels Would Continue To Rise For The Rest Of The Century Because Of The Additional Global Warming That Is Locked In By Cumulative Past Emissions

There is a delay between rising air temperatures and sea-level rise. Ocean thermal expansion and ice loss occur on timescales slower than the rate at which air temperature increases in response to increasing atmospheric CO_2 concentrations. It can take over a thousand years for ocean thermal expansion to equilibrate with warmer air temperatures.[36]

Since 1900, sea level along the U.S. coast increased by about 9 inches[37], but it was not a steady progression. The rate of sea-level rise is dramatically increasing. Since 2005, the rate of sea rise increased about two and a half times the rate of the last century, and the rate of sea-level rise is continuing to

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[36] Levermann, A., et al., *The Multimillennial Sea-Level Commitment of Global Warming*, 110(34) Proceedings of the National Academy of Sciences 13745–13750 (2013).
[37] Sweet, W. V., et al., *Sea level rise*, Climate Science Special Report: Fourth National Climate Assessment, Volume I 333–363 (2017).

accelerate.[38,39] This sea-level rise can increase damage caused by daily tides, king tides, and extreme weather events. In Superstorm Sandy, sea-level rise was estimated to have inflicted an additional $2 billion in flooding damage.[40]

Current atmospheric CO_2 concentrations have committed the world to significant levels of sea-level rise for centuries to come. There is no combination of emissions reductions, no matter how aggressive, that can prevent the now inevitable rise of seas over the next one hundred years or more. The recently published Fourth National Climate Assessment warns that:

> Even if significant emissions reductions occur, many of the effects from sea-level rise over this century (and particularly through mid-century) are already locked in due to historical emissions, and many communities are already dealing with the consequences.[41]

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38 Oppenheimer, M., et al., *Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities*, IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (2019).
39 Griggs, G., et al., *Rising Seas in California: An Update on Sea-Level Rise Science*, California Ocean Science Trust (2017), http://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf.
40 Leifert, H., *Sea Level Rise Added $2 Billion to Sandy's Toll in New York City*, 96 Eos (2015).
41 NCA4, *Summary Findings: Oceans and Coasts*, Fourth National Climate Assessment, Volume II 25–32 (2018).

The Intergovernmental Panel on Climate Change (IPCC), a body of the United Nations, is the internationally accepted authority on climate change science. The IPCC reviews the state of climate science and issues global consensus scientific assessment reports every five to seven years. The IPCC's Fifth Assessment Report utilized a set of future scenarios, known as Representative Concentration Pathways (RCPs) (Figure 3)[42] to help decision makers understand the impact of policies designed to reduce emissions.

The four RCPs in the Fifth Assessment describe scenarios based on different assumptions about energy consumption, energy sources, land use change, economic growth, and population. At one end of the spectrum, RCP2.6 represents a suite of extremely aggressive reduction scenarios which require that CO_2 emissions

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[42] RCPs are named for the associated radiative forcing level in watts per square meter (the difference between sunlight absorbed by Earth and energy radiated back to space) by the year 2100 relative to pre-industrial values.

worldwide plateau by 2020 and are reduced by 50% by 2050.[43,44] At the other end, RCP8.5 represents a future in which there is no significant global effort to limit greenhouse gas emissions and a sustained growth of fossil-fuel emissions. Between the two extremes are RCP4.5 and RCP6.0, stabilization scenarios by which total radiative forcing is stabilized shortly after 2100. Each RCP represents a family of climate outcomes, including temperature and sea-level rise.[45]

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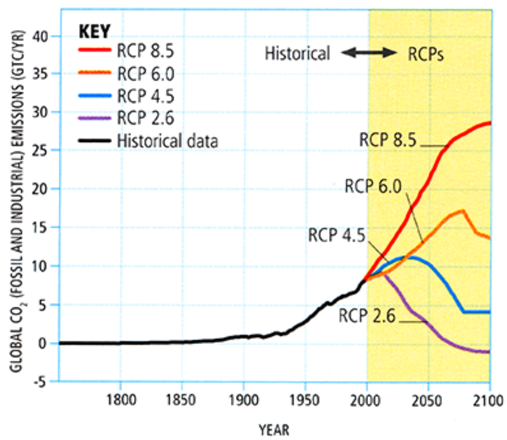
[43] Compared to 1990 CO_2 emissions.
[44] Jones, C., et al., *Twenty-First-Century Compatible CO_2 Emissions and Airborne Fraction Simulated by CMIP5 Earth System Models Under Four Representative Concentration Pathways*, 26(13) Journal of Climate 4398–4413 (2013).
[45] Collins, M., et al., *Long-term Climate Change: Projections, Commitments and Irreversibility*, Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change 1029–1136 (2013).

Figure 3. Observed and projected CO_2 emissions. Historical rate of annual carbon emissions in gigatons (black line) compared to IPCC projected scenarios. Figure source: Mann, M. E. and Kump, L. R. *Dire Predictions: Understanding Climate Change* (DK 2015).



The recent IPCC Special Report on the Ocean and Cryosphere in a Changing Climate reassessed projected sea-level rise for RCP2.6 and RCP8.5. By 2100, mean global sea-level is projected to rise between 1.4 feet (1.0–1.9 feet, likely range) under RCP2.6 and 2.8 feet (2.0–3.6 feet, likely range) under RCP8.5.[46,47]

The IPCC projections under the Representative Concentration Pathways do not fully account for the possibility that changing ice sheet dynamics could dramatically increase sea

[46] Oppenheimer, M., et al., *Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities*, IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (2019).
[47] Relative to GMSL over 1986–2005.

levels by the end of the century.[48,49,50] A recent structured expert judgment study, factoring into account the possibility of such rapid ice loss, suggested a high-emissions scenario would likely give rise to 31–69 inches (2.6–5.7 feet) of GMSL rise over the course of this century, with a 1-in-20 chance of giving rise to more than 94 inches (7.8 feet) of GMSL rise.[51] Different approaches to estimating the likelihood of such high-end sea-level rise outcomes lead to highly divergent high-end estimates.[52]

In October 2018, the IPCC issued a special report assessing: 1) the possibility of restricting global warming to 1.5˚C above pre-industrial temperatures, and 2) what the avoided damages might

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[48] DeConto, R. and Pollard, D., *Contribution of Antarctica to Past and Future Sea-Level Rise*, 531(7596) Nature 591 (2016).
[49] Shepherd, A., et al., *Mass Balance of the Antarctic Ice Sheet from 1992 to 2017*, 558 Nature 219–222 (2018).
[50] Bamber, J. L., et al., *Ice sheet contributions to future sea level rise from structured expert judgement*, 116(23) Proceedings of the National Academy of Sciences 11195–11200 (2019).
[51] Kopp, R. E., et al., *Sea-level science on the frontier of usability*, Earth's Future (2019).
[52] *Id.*

be between 1.5˚C and 2˚C warming, the two goals adopted at the 2016 Paris Climate Summit.[53,54]

Capping global warming at 1.5˚C would require exceptional measures, even more aggressive than those contemplated in the IPCC's RCP2.6 scenario, which was the most aggressive emissions reduction pathway previously assessed by the group. To prevent the world from warming more than 1.5˚C above pre-industrial levels, global CO_2 emissions would need to decline about 45% by 2030 – just 10 years from now – and reach net zero emissions globally by 2050.[55] Given the current trajectory of global economic development and the weak voluntary commitments of the world's nations to curbing the problem, communities faced with increasingly severe climate change impacts cannot rely on this level of emissions reductions being achieved. Indeed, between

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[53] IPCC, *Summary for Policymakers*, IPCC Special Report on Global Warming of 1.5°C (2018).
[54] UN Climate Change, *Process and Meetings: The Paris Agreement*, United Nations, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (last visited Dec. 21, 2019).
[55] IPCC, *Summary for Policymakers*, IPCC Special Report on Global Warming of 1.5°C (2018).

2017 and 2018, global energy-related CO_2 emissions *increased* by 2.7% (range of +1.8% to +3.7%).[56,57] And even if global net emissions were cut to zero by 2050, the seas would continue to rise over at least the next few centuries to levels that would threaten billions of dollars of property and infrastructure in Rhode Island and beyond.

Local sea level rise may differ from GMSL rise due to a number of factors:

a. Large ice sheets exert a gravitational pull on the nearby ocean, drawing water towards it. If that ice melts, this gravitational force weakens, causing a lowering of sea level near the ice sheet and an enhanced sea-level rise further away. Consequentially, the loss of Antarctic ice has an enhanced effect on Northern Hemisphere sea-level rise, while the loss of Greenland ice has an enhanced

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[56] Le Quéré, C., et al., *Global Carbon Budget 2018*, 10(4) Earth System Science Data (Online) (2018).

[57] IEA, *Global Energy and CO2 Status Report 2018*, OECD/IEA (2019), https://www.eenews.net/assets/2019/03/26/document_cw_01.pdf.

effect on Southern Hemisphere sea-level rise.[58,59] These detectible patterns of sea-level variability are known as "sea-level fingerprints."

b. *Glacial isostatic adjustment* is the ongoing vertical movement of land that was once beneath or adjacent to ice-age glaciers and ice sheets. Regions near the centers of ice sheets of the last ice age may experience post-glacial rebound, which is the rise of land masses that were depressed by massive ice sheets during the last ice age. Conversely, land pushed up during the building of ice sheets in the last ice age ("the forebulge") may now be sinking (e.g. Chesapeake Bay).[60]

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[58] Mitrovica, J. X., et al., *On the Robustness of Predictions of Sea Level Fingerprints*, 187(2) *Geophysical Journal International* 729–742 (2011).

[59] Griggs, G., et al., *Rising Seas in California: An Update on Sea-Level Rise Science*, California Ocean Science Trust (2017), http://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf.

[60] DeJong, B., et al., *Pleistocene Relative Sea Levels in the Chesapeake Bay Region and Their Implications for the Next Century*, 25(8) GSA Today 4–10 (2015).

c. Prevailing winds can push water across oceans. For example, the Trade Winds in the Pacific blow water westward, increasing sea level in the western Pacific (e.g. the Philippines) by about 24 inches, and decreasing sea level in the eastern Pacific (e.g. northern South America).[61] In the long term, global wind patterns change as climate changes, geographically re-allocating mounds of sea water. Short term changes in winds, such as those associated with the North Atlantic Oscillation, can have large effects on local sea-level.[62]

d. In addition to ocean currents generated by surface wind, currents that are driven by differences in water density due to temperature and salinity variations in different

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[61] Griggs, G., et al., *Rising Seas in California: An Update on Sea-Level Rise Science*, California Ocean Science Trust (2017), http://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf.

[62] Kenigson, J. S., et al., *Decadal shift of NAO-linked interannual sea level variability along the U.S. Northeast Coast*, 31(13) Journal of Climate 4981–4989 (2018).

parts of the ocean (*thermohaline circulation*) can have large effects on local sea level.[63]

e. Localized processes such as plate tectonics and sediment compaction can cause land masses to fall or rise.[64]

f. Oil and gas extraction, as well as groundwater withdrawal can cause the continental shelf to "deflate," raising sea level at coastal deltas (e.g. Louisiana).[65,66]

Sea-level in the mid-Atlantic region (the U.S. East Coast north of Cape Hatteras, NC) has been increasing at a rate greater than the global average.[67] The primary reason for this

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63 Levermann, A., et al., *The Multimillennial Sea-Level Commitment of Global Warming*, 110(34) Proceedings of the National Academy of Sciences 13745–13750 (2013).

64 Griggs, G., et al., *Rising Seas in California: An Update on Sea-Level Rise Science*, California Ocean Science Trust (2017), http://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf.

65 Nienhuis, J. H., et al., *A New Subsidence Map for Coastal Louisiana*, 27(9) GSA Today 58–59 (2017).

66 Kopp, R. E., et al., *Probabilistic 21st and 22nd Century Sea-Level Projections at a Global Network of Tide-Gauge Sites*, 2(8) Earth's Future 383–406 (2014).

67 Sweet, W. V., et al., *Global and Regional Sea Level Rise Scenarios for the United States (NOAA Technical Report NOS CO-*

enhancement in regional sea-level rise is due to glacial isostatic adjustment, but is also affected by subsidence due to groundwater withdrawal and ocean currents.[68] All of these processes operate on different time scales, making it difficult to parse out the individual contributions to local sea-level rise.[69]

The mid-Atlantic region is in close proximity to the former Laurentide Ice Sheet and its associated forebulge. As a result, this coast undergoes vertical land motion due to glacial isostatic adjustment, leading to variable rates of sea-level rise within the region. Kopp (2013) estimates the rate of subsidence in the mid-Atlantic coastal plain area to be approximately 0.04 inches per year. Models predict that a slowdown in the Gulf Stream current

OPS 083), Center for Operational Oceanographic Products and Services National Ocean Service, National Oceanic and Atmospheric Administration (2017).

[68] Kopp, R. E., *Does the mid-Atlantic United States sea-level acceleration hot spot reflect ocean dynamic variability?* 40(15) Geophysical Research Letters 3981–3985 (2013).

[69] Haigh, I. D., et al., *Timescales for detecting a significant acceleration in sea level rise*, 5 Nature Communications 3635 (2014).

would increase relative sea-level along the mid-Atlantic coast.[70] However, recent observational studies suggest that changes in relative sea-level along this coast are more likely driven by changes in local winds rather than a Gulf Stream slowdown.[71] Longer observational data sets are needed (i.e. twenty more years of data collection) in order to fully understand how Atlantic Ocean dynamic variability impacts sea-level rise along the mid-Atlantic coast, and whether the observed changes represent short-term variability or long-lived trends.[72]

The Newport, Rhode Island tide-gauge, in operation since 1930, indicates that sea level along the outer Rhode Island coast

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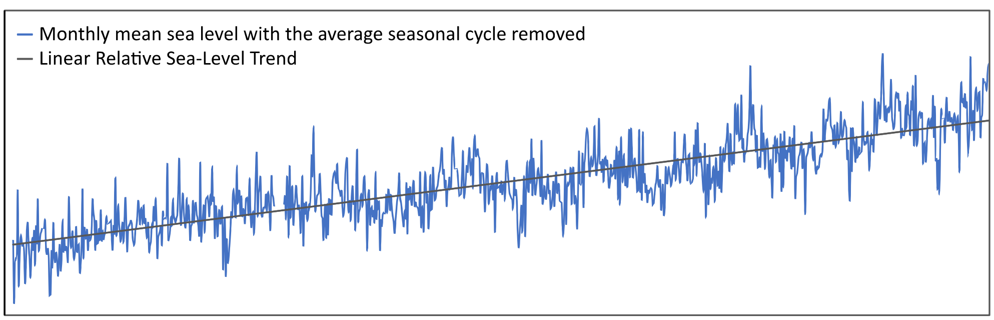
[70] Yin, J., et al., *Model projections of rapid sea-level rise on the northeast coast of the United States*, 2(4) Nature Geosciences 262–266 (2009).

[71] Piecuch, C. G., et al., *How is New England Coastal Sea Level Related to the Atlantic Meridional Overturning Circulation at 26°N?* 46(10) Geophysical Research Letters 5351–5360 (2019).

[72] Kopp, R. E., *Does the mid-Atlantic United States sea-level acceleration hot spot reflect ocean dynamic variability?* 40(15) Geophysical Research Letters 3981–3985 (2013).

rose about 9 inches since 1930 at a rate of approximately 0.11 inches per year (Figure 4).[73]

Figure 4. Relative Sea-Level Trend in Newport, Rhode Island. Historical sea-level change (blue line) from 1930 to October 2019 in Newport, Rhode Island, recorded by NOAA tide-gauge #8452660. The plot illustrates the long-term linear increasing trend in sea-level (black line), and excludes regular seasonal sea-level fluctuations due to water temperatures, salinities, winds, atmospheric pressures, and ocean currents. The relative sea-level trend in Newport, Rhode Island is 0.11 inches per year. Figure modified from: Center for Operational Oceanographic Products and Services, *Relative Sea Level Trend, Newport, Rhode Island*, NOAA Tides and Currents.



[73] Center for Operational Oceanographic Products and Services, *Relative Sea Level Trend, Newport, Rhode Island*, NOAA Tides and Currents, https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8452660 (last visited Dec. 1, 2019).

Under RCP2.6, an extremely aggressive emissions reduction scenario, sea level along the Rhode Island outer coast will most likely rise an additional 1.9 feet by 2100 (Figure 5).[74,75] Under RCP8.5, a scenario that assumes sustained emissions growth, local sea-level will most likely rise 3.1 feet by 2100 (Figure 5).[76,77,78] If warming triggers the rapid decay of the Antarctic ice sheet, local sea level could rise 9 feet or more.[79]

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[74] 1.9 feet is a median value and has a 67% probable range of 1.2 – 2.7 ft, with a 1-in-20 chance of exceeding 3.4 ft. These estimates come from a study using assumptions essentially consistent with the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

[75] Relative to mean sea-level between 1991–2009.

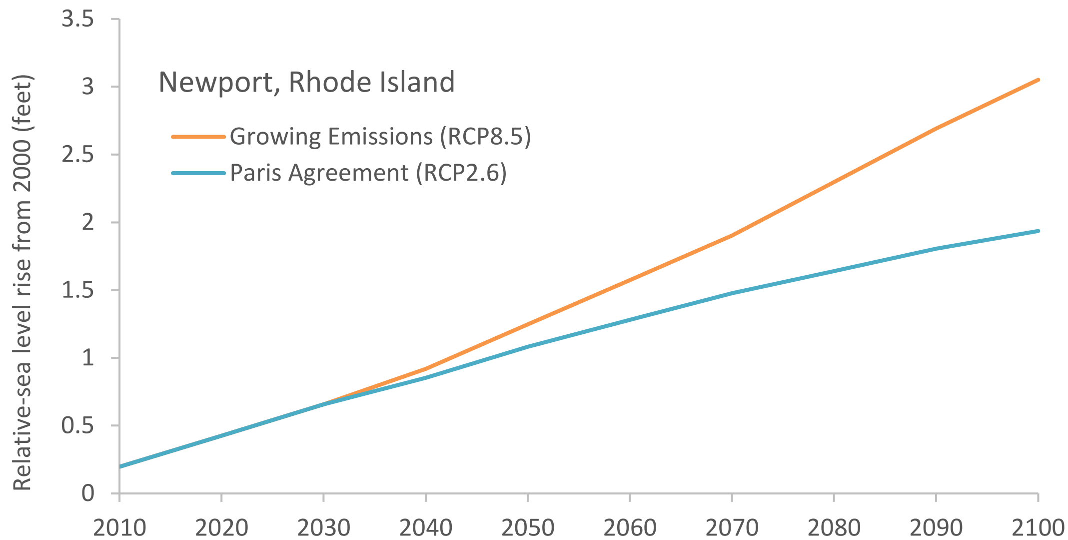
[76] 3.1 feet is a median value and has a 67% probable range of 2.1 – 4.1 feet, with a 1-in-20 chance of exceeding 5.0 feet. These estimates come from a study using assumptions essentially consistent with the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

[77] Relative to mean sea-level between 1991–2009.

[78] Kopp, R. E., et al., *Probabilistic 21st and 22nd Century Sea-Level Projections at a Global Network of Tide-Gauge Sites*, 2(8) Earth's Future 383–406 (2014).

[79] Sweet, W. V., et al., *Global and Regional Sea Level Rise Scenarios for the United States (NOAA Technical Report NOS CO-OPS 083)*, Center for Operational Oceanographic Products and Services National Ocean Service, National Oceanic and Atmospheric Administration (2017).

Figure 5. Projected Sea-Level Rise in Newport, Rhode Island. Median projections of sea-level rise in Newport, Rhode Island through 2100 under two greenhouse gas emissions pathways. Kopp, R. E., et al., *Probabilistic 21st and 22nd Century Sea-Level Projections at a Global Network of Tide-Gauge Sites*, 2(8) Earth's Future 383–406 (2014).



IV. Rhode Island Is Facing Unavoidable And Costly Infrastructure Damage From Flooding Due To Rising Sea Levels

Sea-level rise is a major threat to Rhode Island's transportation infrastructure both from daily tidal flooding and increased severity of storm surge events. A study conducted by NOAA found that between 2000 and 2015, the frequency of high tide flooding along the Northeast Atlantic coast (from Virginia to Maine) increased 75% (from 3.4 days to 6 days per year). If sea-level rise is restricted to 1.6 feet by 2100 (roughly RCP2.6), high-tide flooding will be *at least* an every-other-day occurrence along this coastline. If the world continues to emit greenhouse gases at a rate similar to today and sea-level rises by more than 3 feet (roughly RCP8.5), the Northeast Atlantic will experience *daily* high-tide flooding.[80]

The Rhode Island Division of Statewide Planning Program, in collaboration with the Coastal Resources Management Council, analyzed the length of roadway, number of bridges, and the number of residences that will flood at high tide under 1 foot, 3 feet, 5 feet, and 7 feet of sea-level rise.[81] Their analysis reveals that virtually all of Rhode Island's coastal communities will be

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[80] Sweet, W. V., et al., *Patterns and Projections of High Tide Flooding Along the U.S. Coastline Using a Common Impact Threshold (NOAA Technical Report NOS CO-OPS 086)*, Center for Operational Oceanographic Products and Services National Ocean Service, National Oceanic and Atmospheric Administration (2018).

[81] Rhode Island Statewide Planning Program, *Vulnerability of Municipal Transportation Assets to Sea Level Rise and Storm Surge (Technical Paper 167),* Rhode Island Department of Administration (2016), http://www.planning.ri.gov/documents/sea_level/2016/TP167.pdf.

impacted by rising seas. At a minimum, 1.9 miles of Rhode Island's roadways will flood under 1 foot of sea-level rise, 34 miles of roadway under 3 feet of sea-level rise, 102 miles of roadway under 5 feet of sea-level rise, and 175 miles of roadway will flood and 81 bridges will be impacted under 7 feet of sea level rise.

The study also analyzed the extent of flooding due to a 100-year storm surge event. Under current conditions, a 100-year storm would flood 337 miles of roadway. With 1 foot of sea-level rise, that number increases to 373 miles. With 3 feet, 436 miles of road will flood. With 5 feet, 505-miles of road will flood. And with 7 feet, 573-miles of road will flood and 183 bridges will be impacted.

This study is based on current conditions and did not account for projections of coastal erosion, precipitation, riverine flooding, and other factors that will likely increase Rhode Island's vulnerability to sea level rise. Additionally, the storm surge model used in this study is based on a national model that may underestimate the rate of sea-level rise for Rhode Island.

Adapting to rising seas will be very costly for Rhode Island. A study conducted by Resilient Analytics and The Center for Climate Integrity investigated the cost to protect Rhode Island and other coastal communities from sea-level rise by 2040.[82] Sea-level rise estimates were produced using the same model that generated the aforementioned sea-level rise projections for Rhode Island.[83] In addition to sea-level rise, the authors added a 1-year storm surge that represents the average annual storm surge that occurs along the shoreline of Rhode Island. The study identified 247 miles of tidal shoreline within Rhode Island that require protective infrastructure in order to prevent flooding. Using regional construction cost data, the study estimated the cost to build a linear foot of seawall in Rhode Island is $2,207. Using these estimates, by 2040 Rhode Island must invest at least $2.9

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[82] LeRoy, S. and Wiles, R., *High Tide Tax: The Price to Protect Coastal Communities from Rising Seas*, The Center for Climate Integrity (2019), https://www.climatecosts2040.org/files/ClimateCosts2040_Report-v4.pdf.

[83] Kopp, R. E., et al., *Probabilistic 21st and 22nd Century Sea-Level Projections at a Global Network of Tide-Gauge Sites*, 2(8) Earth's Future 383–406 (2014).

billion in coastal defenses in order to protect its most vulnerable shoreline from sea-level rise.

In 2015, the nations of the world, including the United States, signed the Paris Climate Agreement, committing to put forward their best efforts to reduce greenhouse gas emissions in line with a goal of keeping global temperature rise to well below 2˚C over pre-industrial levels (roughly equivalent to RCP2.6). Current national plans fall short of this goal and would lead to about a 3˚C temperature increase by 2100.[84] In the U.S., the Trump Administration has begun a yearlong withdrawal process to leave the Paris Agreement.

Responsible local governments must prepare for the consequences of global warming of *at least* 2˚C above pre-industrial levels.[85] If emissions are not mitigated, GMSL is likely

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[84] Rogelj, J., et al., *Paris Agreement Climate Proposals Need a Boost to Keep Warming Well Below 2 C*, 534(7609) Nature 631–639 (2016).
[85] Bamber, J. L., et al., *Ice sheet contributions to future sea level rise from structured expert judgement,* 116(23) Proceedings of the National Academy of Sciences 11195–11200 (2019).

to rise between 2–3.6 feet (RCP8.5), with a small possibility of more than 6.6 feet of sea-level rise.[86]

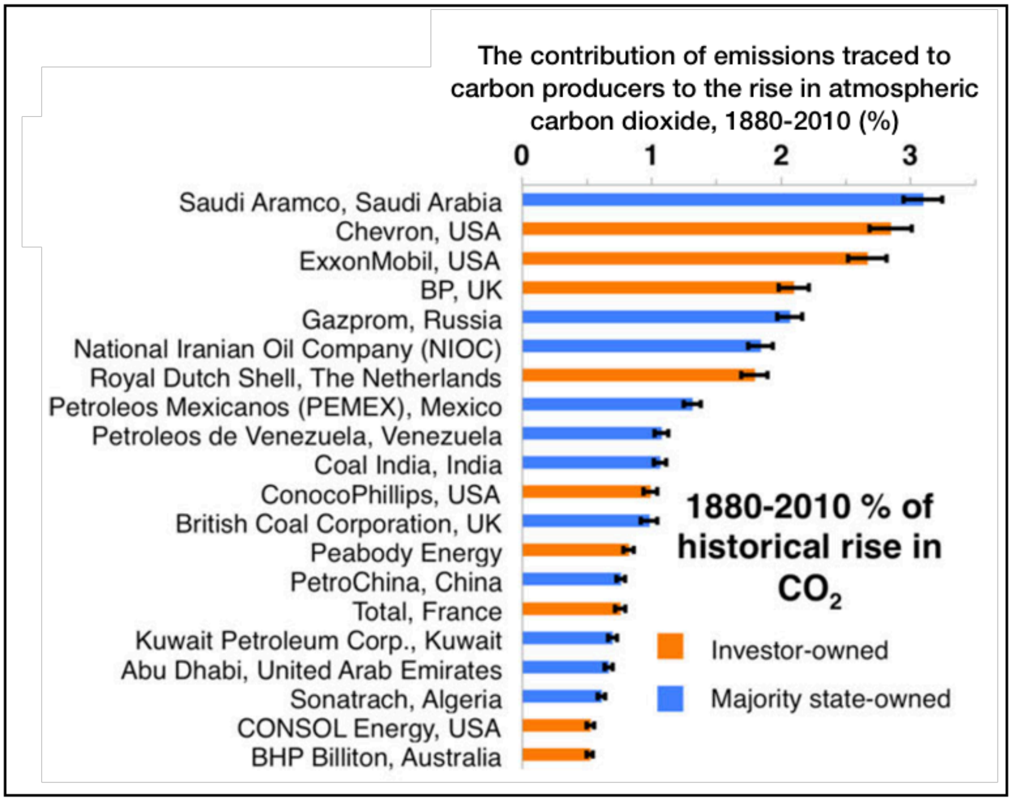
Even under the most ambitious emissions reductions scenario, the world's oceans will continue to rise as the climate system comes into balance with the roughly 50% increase in atmospheric CO_2 concentration since the dawn of the industrial revolution. Given that fact, and the Rhode Island's vulnerability to sea-level rise of just one or two feet, there is no plausible emissions reduction scenario where Rhode Island can avoid the substantial cost of adapting to and protecting itself from rising seas that result primarily from the combustion of fossil fuels, including the Appellants' products.

The portion of total CO_2 in the atmosphere attributable to each company's fossil fuel products is well established.[87] This work demonstrates that the emissions produced by the products of 90 major carbon producers contributed 57 (±2.9) % of the total

[86] *Id.*
[87] Ekwurzel, B., et al., *The Rise in Global Atmospheric CO_2, Surface Temperature, and Sea Level from Emissions Traced to Major Carbon Producers*, 144(4) Climatic Change 579–590 (2017).

increase in atmospheric CO_2 from 1880 through 2010 (Figure 7). Nearly half of that was attributable to the 20 largest entities. And nearly half of that was attributable to five of the Appellants in this case. Chevron was the 2nd largest CO_2 producer during that period. ExxonMobil is the 3rd largest, BP is the 4th largest, Shell ranks 7th and ConocoPhillips is 11th. This information provides a reasonable basis for allocation of the costs of adaptation.

Figure 6. Top twenty investor- & state-owned entities and attributed CO_2 emissions. Emissions from these companies contributed about 27.2 (±2.9) % of increase in cumulative atmospheric CO_2 between 1880 and 2010. Figure modified from: Ekwurzel, B., et al. *The Rise in Global Atmospheric CO_2, Surface Temperature, and Sea Level from Emissions Traced to Major Carbon Producers*, 144(4) Climatic Change 579–590 (2017).



CONCLUSION

In sum, we know that the present damage and future risk to coastal communities such as the Rhode Island, posed by rising sea levels, is caused in significant part by global warming. We know that the Appellants' production and marketing of fossil fuels is a significant cause of that global warming. We can prove what portion of global CO_2 emissions are associated with each of their products and can attribute some portion of sea-level rise to these products. All of these matters can be proven at trial through the introduction of evidence in the form of well-established scientific facts.

We therefore urge the Court to affirm remand of this case to state court for further pretrial proceedings and trial.

DATED: January 2, 2020

Respectfully submitted,

/s/ William A. Rossbach

William A. Rossbach
ROSSBACH LAW, P.C.
401 N. Washington Street
Missoula, MT 59807
Tel: (406) 543-5156
Fax: (406) 728-8878

CERTIFICATE OF COMPLIANCE

Pursuant to Federal Rule of Appellate Procedure 29(a)(4)(g), I certify that:

This Brief complies with Rule 29(a)(5)'s type-volume limitation, because it contains 6,499 words as determined by the Microsoft Word 2016 word-processing system used to prepare the brief, excluding the parts of the brief exempted by Rule 32(a)(7)(B)(iii).

This Brief complies with Rule 32(a)(5)'s typeface requirements, and Rule 32(a)(6)'s type-style requirements because it has been prepared in a proportionately spaced typeface using the 2016 version of Microsoft Word in 14-point Times New Roman font.

/s/ William A. Rossbach
William A. Rossbach

CERTIFICATE OF SERVICE

I hereby certify that I caused the foregoing to be electronically field with the Clerk of the Court for the United States Court of Appeals for the First Circuit by using the appellate CM/ECF system on January 2, 2020.

I certify that all participants in the case are registered CM/ECF users and that service will be accomplished by the appellate CM/ECF system.

/s/ William A. Rossbach
William A. Rossbach

APPENDIX

APPENDIX OF AMICI QUALIFICATIONS

Mario J. Molina received the 1995 Nobel Prize in Chemistry (with F. Sherwood Rowland and Paul Crutzen) for his work on atmospheric chemistry. He is a Professor at the University of California, San Diego (UCSD), with a joint appointment in the Department of Chemistry and Biochemistry and the Scripps Institution of Oceanography. **Michael Oppenheimer** is the Albert G. Milbank Professor of Geosciences and International Affairs at Princeton University. He is a coordinating lead author on the Intergovernmental Panel on Climate Change's Special Report on Oceans, Cryosphere and Climate Change and is coeditor-in-chief of the journal *Climatic Change*. He is also the Director of the Center for Policy Research on Energy and the Environment at Princeton's Woodrow Wilson School and a science advisor at the Environmental Defense Fund. **Robert E. Kopp** is the Director of the Institute of Earth, Ocean, and Atmospheric Sciences and co-directs the Coastal Climate Risk & Resilience Initiative at Rutgers University as well as the Climate Impact Lab. He is a lead author of the U.S. Global Change Research Program's 2017 Climate Science Special Report and was a contributing author to the Intergovernmental Panel on Climate Change's Fifth Assessment Report. Prof. Kopp is a recipient of the American Geophysical Union's James B. Macelwane and William Gilbert

Medals and the International Union for Quaternary Research's Sir Nicolas Shackleton Medal. **Friederike Otto** is the Acting Director of the Environmental Change Institute and an Associate Professor in the Global Climate Science Programme at the University of Oxford. She is a lead author on the Intergovernmental Panel on Climate Change's Sixth Assessment Report, contributing to the chapter Weather and Climate Extreme Events in a Changing Climate, and a co-investigator on the International World Weather Attribution Project, providing an assessment of the human-influence on extreme weather in the immediate aftermath of the event. **Susanne C. Moser** is on the Research Faculty in the Environmental Studies Department of Antioch University New England. With more than 120 publications, Dr. Moser is an expert on adaptation to sea-level rise. She has advised states and local communities) on coastal adaptation. **Donald J. Wuebbles** is The Harry E. Preble Professor of Atmospheric Sciences in the School of Earth, Society, and Environment, Department of Atmospheric Sciences at the University of Illinois at Urbana-Champaign. Dr. Wuebbles has over 500 scientific publications related to the Earth's climate, air quality, and the stratospheric ozone layer. He was a co-author on the 2013 Intergovernmental Panel on Climate Change, as well as the 2014, 2017, and 2018 U.S. National Climate Assessments. **Gary B. Griggs** is Professor of

Earth & Planetary Sciences at the University of California Santa Cruz, where he also served as Director of the Institute of Marine Sciences for 26 years. He is an expert on sea-level rise, publishing over 180 articles in scientific journals and book chapters, and has written 11 books. He was a member of the National Academy of Sciences committee that prepared the report: Sea-Level Rise for the Coasts of California, Oregon and Washington (2012). **Peter C. Frumhoff** is Director of Science and Policy and Chief Climate Scientist at the Union of Concerned Scientists (UCS). Dr. Frumhoff has published widely at the nexus of climate science and policy, including on the climate responsibilities of fossil fuel companies and the attribution of extreme events to climate change. He currently serves on the US National Academy of Sciences' Board on Atmospheric Sciences and Climate. He was lead author of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. **Kristina Dahl** is a Senior Climate Scientist in the Climate and Energy program at the Union of Concerned Scientists. Dr. Dahl's research focuses on the impact of climate change, particularly sea-level rise, on people and places. She was the lead analyst and co-lead author on UCS's report that quantified the risks of sea-level rise for communities and real estate in the contiguous United States and has performed detailed GIS analyses showing the projected extent of sea-level rise and chronic flooding along the U.S. coasts.