No. 22-1096

In the
United States Court of Appeals for the Third Circuit

STATE OF DELAWARE, ex rel.
Kathleen Jennings, Attorney General of the State of Delaware,
Plaintiff-Appellee,

v.

B.P. AMERICA INC.; BP P.L.C; CHEVRON CORPORATION; CHEVRON U.S.A. INC.; CONOCOPHILLIPS; CONOCOPHILLIPS COMPANY; PHILLIPS 66; PHILLIPS 66 COMPANY; EXXON MOBIL CORPORATION; EXXONMOBIL OIL CORPORATION; XTO ENERGY INC.; HESS CORPORATION; MARATHON OIL CORPORATION; MARATHON PETROLEUM CORPORATION; MARATHON PETROLEUM COMPANY LP; SPEEDWAY LLC; MURPHY OIL CORPORATION; MURPHY USA INC.; ROYAL DUTCH SHELL PLC; SHELL OIL COMPANY; CITGO PETROLEUM CORPORATION; TOTAL S.A.; OCCIDENTAL PETROLEUM CORPORATION; DEVON ENERGY CORPORATION; APACHE CORPORATION; CNX RESOURCES CORPORATION; CONSOL ENERGY INC.; OVINTIV, INC.; AMERICAN PETROLEUM INSTITUTE; TOTALENERGIES MARKETING USA, INC.,

Defendants-Appellants.

On Appeal from the United States District Court for the District of Delaware No. 20-cv-01429 (The Hon. Leonard P. Stark)

BRIEF OF AMICUS CURIAE ROBERT KOPP, MICHAEL OPPENHEIMER, KRISTINA DAHL, BRENDA EKWURZEL, PETER C. FRUMHOFF, GARY B. GRIGGS, SVERRE L. LEROY, L. DELTA MERNER, DONALD J. WUEBBLES IN SUPPORT OF APPELLEE AND AFFIRMANCE

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April 21, 2022

CORPORATE DISCLOSURE STATEMENT

Pursuant to Fed. R. App. P. 26.1, amicus curiae Robert Kopp, Michael Oppenheimer, Kristina Dahl, Brenda Ekwurzel, Peter C. Frumhoff, Gary B. Griggs, Sverre L. LeRoy, L. Delta Merner and Donald J. Wuebbles certify that they are individuals, not corporations.

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INTEREST OF THE AMICI CURIAE

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

Robert Kopp is a professor in the Department of Earth & Planetary Sciences at Rutgers University. **Michael Oppenheimer** is the Albert G. Milbank Professor of Geosciences and International Affairs in the Princeton School of Public and International Affairs, the Department of Geosciences, and the Princeton Environmental Institute at Princeton University. **Kristina Dahl** is a Senior Climate Scientist in the Climate and Energy program at the Union of Concerned Scientists. **Brenda Ekwurzel** is a Senior Climate Scientist and the Director of Climate Science for the Climate & Energy Program at the Union of Concerned Scientists. **Peter C. Frumhoff** is the former Director of Science and Policy and Chief Climate Scientist at the Union of Concerned Scientists. **Gary B. Griggs** is a Distinguished Professor of Earth Sciences at the University of California Santa Cruz. **Sverre L. LeRoy** leads the climate science program at the Center for Climate Integrity. **L. Delta Merner** is the lead for the Science Hub for Climate Litigation at the Union of Concerned Scientists. **Donald J. Wuebbles** is the Harry E. Preble Professor of Atmospheric Sciences at the University of Illinois at Urbana-Champaign.

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.

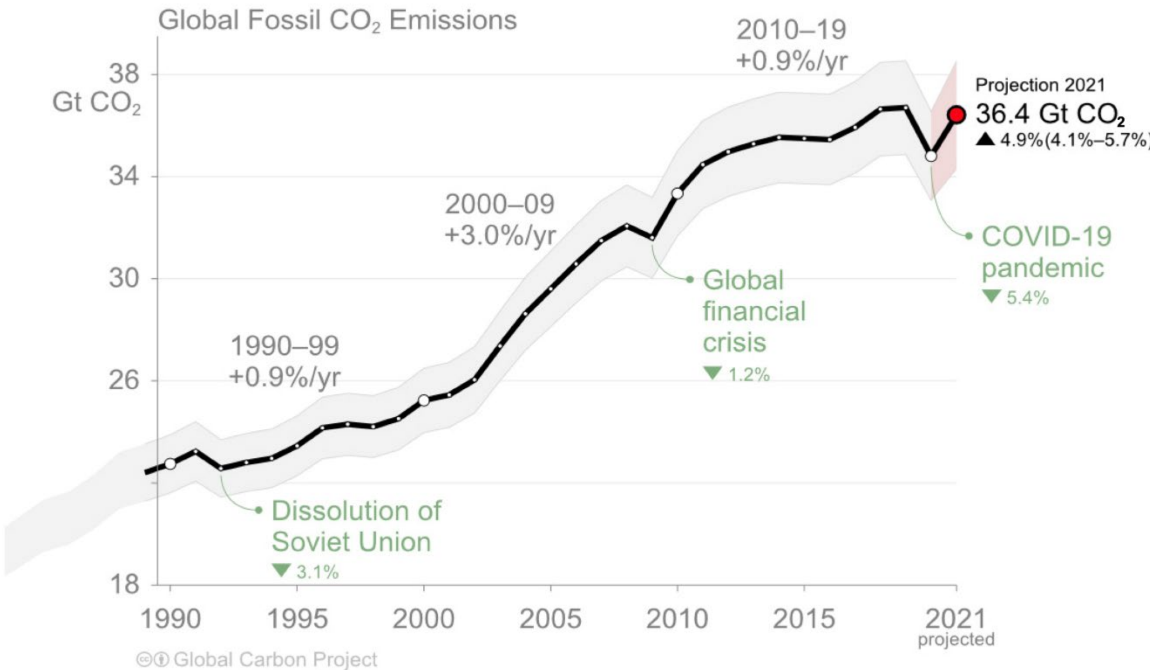
All parties have consented to the filing of this brief. No party's counsel authored the brief in whole or in part, no party or party's counsel contributed money that was intended to fund preparing or submitting the brief, and no person other than counsel for amici contributed money that was intended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

INTRODUCTION AND SUMMARY OF ARGUMENT

There is clear consensus among climate scientists that sea level rise is accelerating and some impacts of our changing climate are increasing faster than temperature is changing. Carbon dioxide (CO_2) from combustion of fossil fuels—of which the Appellants' products are a significant source—is the largest single contributor to this warming. Climate change 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.

Delaware 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 centuries to come. Even with huge reductions in fossil fuel use, the ocean will continue to rise for centuries because of the slow nature of the processes governing sea level rise.

Despite the 2015 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 2019. Following a sharp 5.4% reduction due to the COVID-19 pandemic, emissions in 2021 rebounded 4.9% (Figure 1).[1]



Continued production, marketing, and combustion of fossil fuels at the current emissions path is projected to result in 2.0 feet (1.6–2.7 feet, likely range) of global mean sea level (GMSL) rise over the course of the 21st century.[2,3] There is also the possibility that rapid losses from parts of the Antarctic and Greenland

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[1] Pierre Friedlingstein, et al., *Global Carbon Budget 2021*, EARTH SYS. SCI. DATA DISCUSS. [preprint] (2021).
[2] Global sea level rise projection (relative to a 1995–2014 baseline) for exceedance of 3°C warming (relative to preindustrial global temperature).
[3] Baylor Fox-Kemper, et al., *Ocean, Cryosphere and Sea Level Change*, In: CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, CONTRIBUTION OF WORKING GROUP I TO THE SIXTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2021).

ice sheets could cause GMSL rise to exceed 5 feet by 2100 and 15 feet by 2150.[4] Even stringent emissions reductions consistent with the most ambitious international targets would likely result in 1.4 feet (1.1–1.9 feet, likely range) of GMSL rise by 2100.[5,6]

These analyses mean that, absent extensive and expensive adaptation measures, 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 and protect infrastructure so they can withstand flooding, and, in some cases, communities may, of necessity, have to retreat from coastal locations.

Delaware seeks to recover from the fossil fuel companies, whose products are the primary driver for the changes in climate and the sea level rise that threatens the state, 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 combustion of the Appellants' fossil fuel products is a substantial contributor to global warming and the sea level rise affecting Delaware. We describe peer-reviewed data showing the

[4] Global sea level rise projection (relative to a 1995–2014 baseline) for exceedance of 1.5°C warming (relative to preindustrial global temperature).
[5] Fox-Kemper, et al., *supra* note 3.
[6] *Id.*

relative contribution of each of the top 88 producers of fossil fuels, including almost all the Appellants named herein, to the amount of CO_2 in the atmosphere. Scientists have used these data to calculate the relative contribution of each of the top 88 to the increases in CO_2 in the atmosphere, surface temperature, and sea level from 1880 to 2010. These calculations prove that the Appellants' fossil fuel products are a substantial factor in the injuries and damages that Delaware has and will continue to suffer. Delaware state courts are uniquely qualified to address the exclusively state law claims seeking recovery for the State's injuries and damages.

ARGUMENT

I. During the Period of Human Civilization, Atmospheric Carbon Dioxide, Global Temperature and Sea Level Have Been Relatively Stable.

The foundation of modern climate science dates back to the 19^{th} century when, 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. He realized that Earth's atmosphere must retain heat radiation from the sun, but that some radiation must escape, otherwise the temperature of the planet would rise unmitigated. Though Fourier lacked the theoretical tools to calculate the balance of Earth's temperature, he accurately hypothesized that Earth's heated surface must emit infrared radiation, carrying some heat energy back to space. Fourier was the first to describe what would later become known as "the greenhouse effect."[7]

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 an atmosphere without CO_2.[8] 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.[9] 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 heat-trapping properties of CO_2. Arrhenius calculated that a doubling of CO_2 in the atmosphere would increase surface temperatures by 5–6 degrees Celsius (°C; 9–10.8° Fahrenheit, °F), somewhat more than the upper bound of today's best climate model analyses.[10,11]

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[7] Joseph Fourier, *General Remarks on the Temperature of the Earth and Outer Space*, 32 AM. J. SCI. 1–20 (1824).

[8] Eunice Foote, *Circumstances Affecting the Heat of the Sun's Rays*, 22 *AM. J. SCI. ARTS* 382 (1856).

[9] John Tyndall, *On the Absorption and Radiation of Heat by Gases and Vapours, and On the Physical Connexion of Radiation, Absorption, and Conduction*, 151 PHILOS. TRANS. R. SOC. 1–36 (1861).

[10] Svante Arrhenius, *On the Influence of Carbonic Acid in the Air Upon the Temperature of the Ground*, 41(251) PHILOS. MAG. 237–276 (1896).

[11] Deliang Chen, et al., *Framing, Context, and Methods*, In: CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, CONTRIBUTION OF WORKING GROUP I TO THE SIXTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2021).

The greenhouse effect is a natural atmospheric process that warms the Earth's surface. The sun provides energy primarily in the form of visible light, with lesser contributions from infrared and ultraviolet radiation. Though some 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 (GHGs) in the atmosphere, such as CO_2, absorb this emitted infrared radiation which is re-emitted in all directions, roughly half upwards towards space and half back down to Earth.

Water vapor is the most abundant, naturally occurring GHG and plays a key role in regulating Earth's temperature. Carbon dioxide is the most important human-made GHG due to its longevity and abundance in the atmosphere; it also has a variety of natural sources. The amount of water vapor in the atmosphere is modulated by air temperature: warmer conditions cause liquid water to evaporate, primarily from the ocean, and warm air can hold more water vapor than cold air. Rising CO_2 leads to an increase in temperature, which in turn leads to increased evaporation and more water vapor in the atmosphere. This feedback loop amplifies the warming effect that CO_2 has on the planet.[12] Without GHGs in the atmosphere,

[12] Euiseok Chung, et al., *Upper-tropospheric Moistening in Response to Anthropogenic Warming*, 111(32) PNAS 11636–11641 (2014).

the mean surface temperature of Earth would be 34°C (61°F) cooler than it currently is.[13,14]

Today, the Intergovernmental Panel on Climate Change (IPCC), a body of the United Nations established in 1988, is the internationally accepted authority on climate change. The IPCC evaluates the current state of climate change knowledge and issues a global consensus assessment report every five to seven years. The Sixth Assessment Report (AR6) was published in three parts in 2021 and 2022.

Earth's history is punctuated by naturally driven climatic changes. Large, continental ice sheets in the northern hemisphere have advanced and retreated many times during the last 2.6 million years, 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 have been 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.[15]

During the Last Glacial Maximum (approximately 23,000 to 19,000 years ago), sea level was 410–440 feet below present-day sea level. At the end of the last

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[13] Stephen Schneider, *The Greenhouse Effect: Science and Policy*, 243(4892) SCIENCE 771–781 (1989).
[14] Rasmus E. Benestad, *A Mental Picture of the Greenhouse Effect*, 128(3) THEOR. APPL. CLIMATOL. 679–688 (2017).
[15] Michael Bender, PALEOCLIMATE (2013).

glacial period (a 7,000-year span beginning around 18,000 years ago), GMSL rose approximately 230 feet at an average rate of 0.4 inches per year.[16] However, this deglaciation was punctuated by episodes of very rapid sea level rise, the greatest of which occurred about 14,500 years ago when seas rose between 26–49 feet over 350 years at an average rate of 0.9–1.7 inches per year.[17] The rate of sea level rise decreased during the subsequent Holocene Epoch. By the Mid-Holocene (6,500 to 5,500 years ago), GMSL was within 12 feet of its current level.[18]

The abundance of geological sea level indicators for the last three thousand years yields a more precise Late Holocene GMSL estimate.[19] It is very likely that since the start of the 20th century, GMSL has risen at a faster rate than any preceding century in the last 3,000 years. Since 1901, GMSL has risen about 8 inches at an average rate of 0.07 inches per year. The rate of sea level rise is accelerating, reaching 0.15 inches per year between 2006–2018, and is expected to continue accelerating.[20] Human civilization flourished during the Holocene period of relative sea level stability and the previous eight thousand years of civilization

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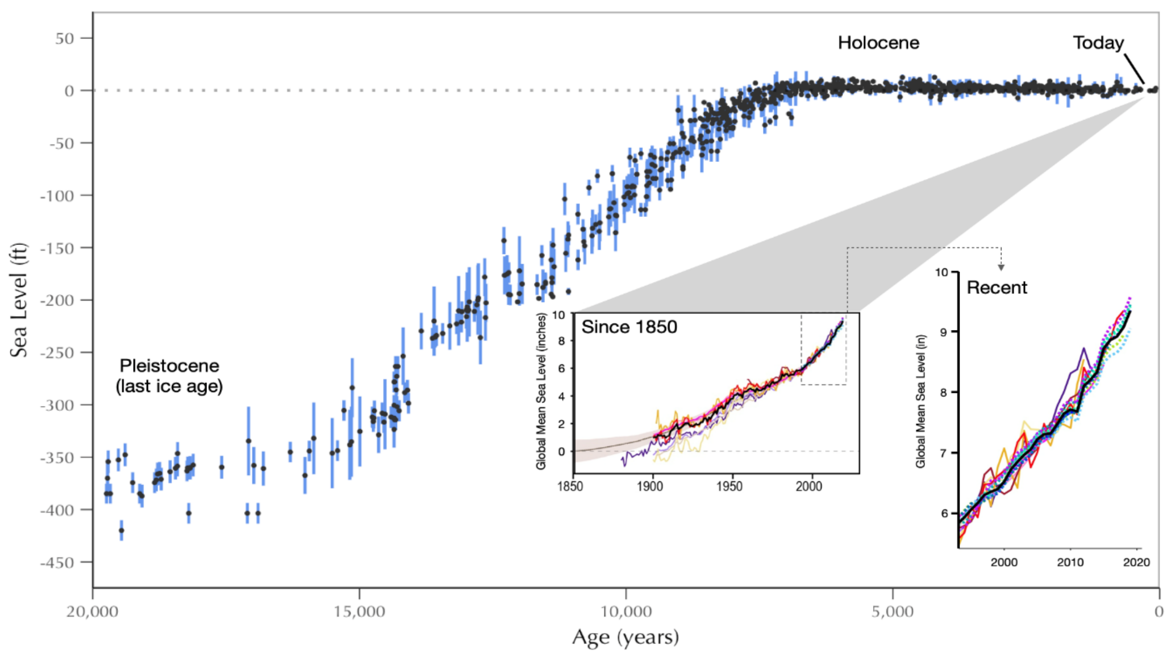
[16] Sergey Gulev, et al., *Changing State of the Climate System*, In: CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, CONTRIBUTION OF WORKING GROUP I TO THE SIXTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2021).
[17] *Id.*
[18] Fox-Kemper, et al., *supra* note 3.
[19] Gulev, et al., *supra* note 16.
[20] *Id.*

which included fixed, largescale settlements has never had to contend with rapid changes in sea level of this scale (Figure 2).

Figure 2. Global mean sea level over the last 20,000 years. Sea level reconstruction from geological sea level indicators in blue. Figure insets depicts estimated sea level change (in) since 1850. GMSL has been rising at an accelerating rate since 1901. Figures modified from: Kurt Lambeck, et al., *Sea level and global ice volumes from the Last Glacial Maximum to the Holocene*, 111(43) PNAS 15296–15303 (2014) & IPCC, *Summary for Policy Makers* (2021).



II. With the Start 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 stable between 260–285 parts per million (ppm).[21] Commencing with the Industrial Revolution (1720–1800 CE), increased combustion of fossil fuels, cement production, and deforestation have raised the average concentration of CO_2 in the atmosphere to greater than 417 ppm[22,23] – higher than any time in at least 800,000 years (Figure 3).[24] Strikingly, more than half of all industrial emissions of CO_2 have occurred since 1991.[25]

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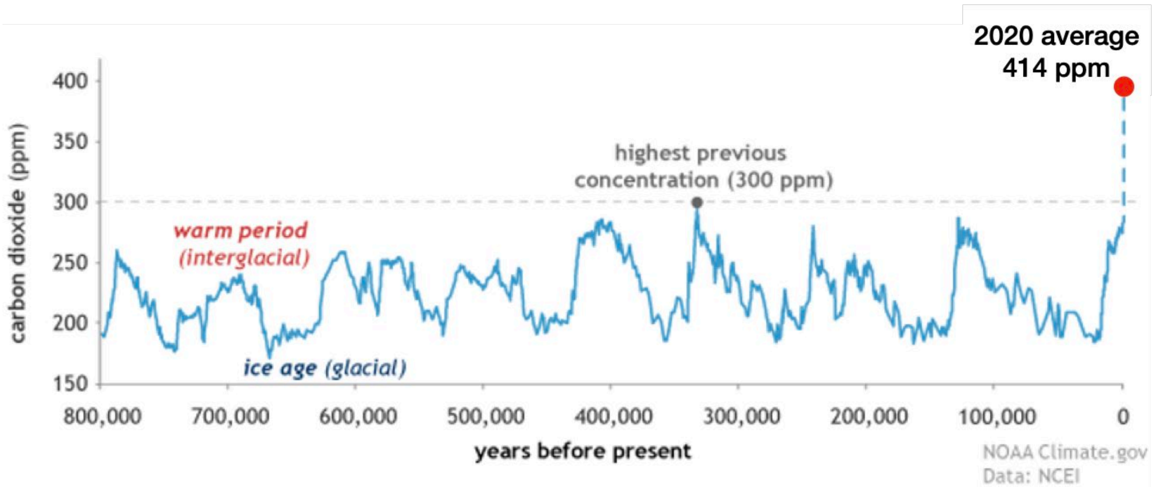
[21] *Id.*
[22] Friedlingstein, et al., *supra* note 1.
[23] Ed Dlugokencky & Pieter Tans, *Trends in Atmospheric Carbon Dioxide*, NOAA/GML (2019), available at gml.noaa.gov/ccgg/trends/
[24] Gulev, et al., *supra* note 16.
[25] Friedlingstein, et al., *supra* note 1.

Figure 3. 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 Global Monitoring Division of NOAA/ESRL and are available at gml.noaa.gov/ccgg/trends/. Figure modified from NOAA.



Due primarily to the increased concentration of anthropogenic CO_2 from fossil fuel combustion, the mean surface temperature of Earth has increased by 1.1°C (2.0°F) since the late nineteenth century. [26,27] One way to conceptualize the immense amount of heat that Earth is absorbing is to combine measurements of ocean, land, atmosphere, and ice heating; based on these data, Earth's climate system has absorbed about 2.7 watts per square meter, or 1,500 terawatts total, since the Industrial Era, which is roughly equivalent to the energy output of 3 million 500 megawatt power plants.[28]

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[26] *Global mean surface temperature* is calculated by combining measurements from the air above land and the ocean surface.
[27] Gulev, et al., *supra* note 16.
[28] Piers Forster, et al., *The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity*, In: CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS,

Without strengthened policies, by the end of the 21st century, global mean surface temperature is projected to increase 2.2–3.5°C (4.0–6.3°F) above the pre-industrial temperature. Such warming would result in a broad range of negative impacts, including widespread extinctions, more frequent and severe flooding, and greater food insecurity.[29] The last time global mean surface temperature was comparable to today[30], sea level ultimately rose to 16–33 feet higher than today.[31,32,33]

Changes in climate contribute 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 process, known as *ocean thermal expansion*. Ocean thermal expansion accounts for about 38% of the increased volume of the world's oceans since 1901. The remaining sea level rise has been due to melting mountain glaciers (about 41%) and combined losses of ice into the oceans from the

CONTRIBUTION OF WORKING GROUP I TO THE SIXTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2021).

[29] Jim Skea, et al., *Summary for Policy Makers*, In: CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE, CONTRIBUTION OF WORKING GROUP III TO THE SIXTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2022).

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

[31] Jeremy Scott Hoffman, et al., *Regional and Global Sea-Surface Temperatures During the Last Interglaciation*, 355(6332) SCIENCE 276–279 (2017).

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

[33] Gulev, et al., *supra* note 16.

Antarctic and Greenland ice sheets (about 29%). Increased water storage on land has counteracted GMSL rise, reducing the above total by about 8%.[34]

III. Even if All Carbon Dioxide Emissions Were to Cease Immediately, Sea Levels Would Continue to Rise 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 during which sea level would continue to rise, at a slower and slower rate.[35]

Current atmospheric CO_2 concentrations have committed the world to significant levels of sea level rise for centuries to come. There is no plausible combination of policies, no matter how aggressive, that can completely halt sea level rise for the foreseeable future.[36] Long term damage to Delaware coastal areas is thus inevitable and resilience measures are mandatory.

In 2015, nations of the world, including the United States, signed the Paris Climate Agreement, committing to put forward their best efforts to reduce GHG

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[34] Fox-Kemper, et al., *supra* note 3.
[35] Anders Levermann, et al., *The Multimillennial Sea-Level Commitment of Global Warming*, 110(34) PNAS 13745–13750 (2013).
[36] Fox-Kemper, et al., *supra* note 3.

emissions "consistent with holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels."[37] Current national plans (*Nationally Determined Contributions*, or *NDCs*) to 2030 fall far short of this goal.[38] If we remain on our current emissions trajectory, global mean temperature will likely rise 2.2–3.5°C (4.0–6.3°F) by the end of the century.[39]

The IPCC's Sixth Assessment Report (AR6) utilizes a set of scenarios for future concentrations of atmospheric gases and particles called Shared Socio-economic Pathways (SSPs) (Figure 4).[40] These future scenarios help policymakers understand the impact of policies on GHG and particle emissions. The SSPs describe a range of scenarios based on assumptions about energy consumption, energy sources, land use change, economic growth, and population, and include a narrative component that describes possible paths societies may take and the resulting impact on emissions and climate change.

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[37] UNFCCC, *Paris Agreement*, 21st Conference of the Parties (2015).
[38] Keywan Riahi, et al., *Mitigation and Development Pathways in the Near- to mid-Term*, In: CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE, CONTRIBUTION OF WORKING GROUP III TO THE SIXTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2022).
[39] Skea, et al., *supra* note 29.
[40] SSPs 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.

The AR6 focuses on five SSPs that cover a broad range of potential outcomes. At one end of the spectrum, SSP1-1.9 represents an extremely aggressive mitigation scenario that is in line with the 1.5°C goal of the Paris Agreement and which requires net zero CO_2 emissions by the second half of the century and global temperature rises by no more than 1.5°C (2.7°F).[41,42] At the other end, SSP5-8.5 represents a future in which not only is there no significant global effort to limit GHG emissions, but there is instead a reversal in current technology and mitigation policy or strong positive feedbacks in the climate system that are not fully accounted for in the global emissions budgets, such as Arctic wildfires and thawing of carbon-rich permafrost.[43,44] In this dire scenario, global temperature rises 4.2°C (7.6°F) by 2100 and continues to rise thereafter.[45] Between the two extremes are SSP1-2.6 (roughly equivalent to the 2°C goal of the Paris Agreement), SSP2-4.5 and SSP3-7.0. Current policy falls somewhere between SSP2-4.5 and SSP3-7.0.[46] Each SSP represents a family of climate outcomes, including temperature and sea level rise.[47]

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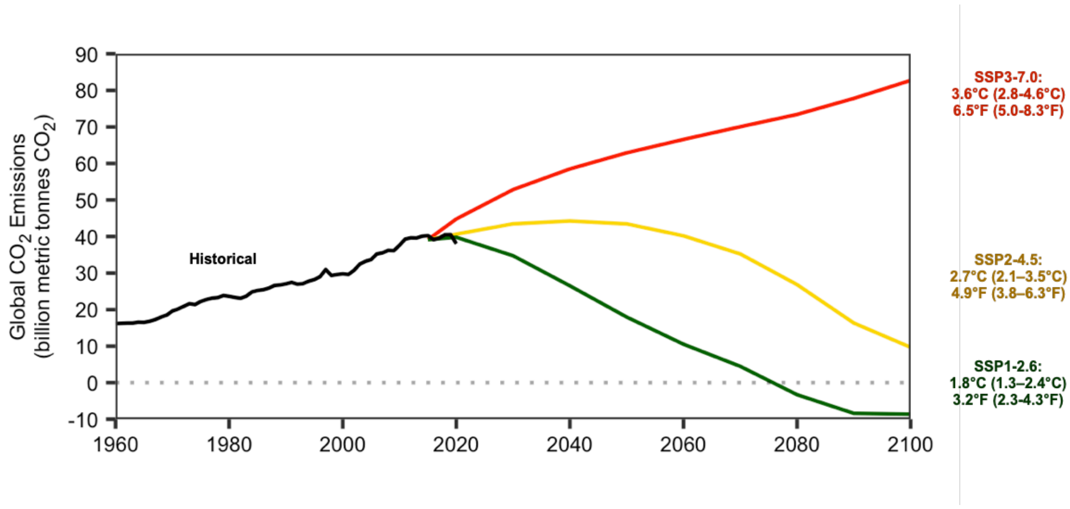
[41] Relative to the median CO_2 emissions between 1850–1900.
[42] Skea, et al., *supra* note 29.
[43] Fox-Kemper, et al., *supra* note 3.
[44] Susan M. Natali, et al., *Permafrost Carbon Feedbacks Threaten Global Climate Goals*, 118(21) PNAS (2021).
[45] Relative to the median CO_2 emissions between 1850–1900.
[46] Skea, et al., *supra* note 29.
[47] Chen, et al., *supra* note 11.

Figure 4. Shared socio-economic pathways and their carbon dioxide trajectories. The green line represents the CO_2 trajectory of SSP1-2.6, yellow represents SSP2-4.5 and is the closest approximation of current policy, and red SSP3-7.0. Historic data source: Global Carbon Project (2021). Projection source: Skea, et al., *supra* note 29.



The IPCC's AR6 assesses sea level rise that occurred before (1901–1990) and during the satellite era (1993–present), as well as projections of GMSL out to 2150. If warming is limited to a 1.5°C increase by 2100, sea level is projected to rise 1.4 feet (1.1–1.9 feet, likely range) by the end of the century. If we remain close to our current emissions trajectory (between SSP2-4.5 and SSP3-7.0) and global temperature rises by 3°C, sea level is projected to rise 2.0 feet (1.6–2.7 feet, likely range). In the unlikely, but not impossible, event that GHGs are emitted at a higher rate than our current trajectory and global mean surface temperature rises

5°C (roughly SSP5-8.5), sea level is projected to rise 2.7 feet by 2100 (2.2–3.4 feet, likely range).[48,49]

The IPCC's primary sea level rise projections do not incorporate some Antarctic and Greenland ice-sheet dynamics that scientists are currently evaluating. These processes are not well understood within the scientific community, but have the potential to substantially increase sea level projections. The IPCC AR6 therefore complements its main projections with a set of *low confidence* projections that reflect these potentially important processes. The AR6 finds that they are unlikely to make a substantial contribution to 21st century sea level rise in a world in which warming is limited to 2°C, but in higher-emissions futures could lead to sea level rise of more than 5 feet by 2100 and 15 feet by 2150.[50]

The likelihood of capping global warming at 1.5°C has decreased since the 2015 Paris Agreement because of continued emissions in the intervening years. The few published pathways that limit warming to 1.5°C require exceptionally aggressive measures that would result in a 34–60% reduction of global GHG emissions by 2030, and 73–98% by 2050.[51,52] In contrast, pathways that follow

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[48] Projected sea level rise is relative to GMSL over 1995–2014.
[49] Fox-Kemper, et al., *supra* note 3.
[50] *Id.*
[51] Relative to 2019 levels.
[52] Riahi, et al., *supra* note 38.

current NDCs until 2030 reduce GHG emissions by only 0–14% by 2030 and 56–82% by 2050.[53]

Given the current trajectory of global economic development and the inadequate voluntary commitments of the world's nations to curbing emissions, communities faced with increasingly severe climate change impacts cannot rely on either of the ambitious Paris Agreement goals being met. Between 2010 and 2019, global fossil CO_2 emissions grew an average of 0.9% per year.[54,55] Even if global net emissions were reduced to meet the 1.5°C goal, the seas would continue to rise for centuries to millennia to levels that would threaten billions of dollars of property and infrastructure in Delaware and beyond.[56]

IV. Numerous Processes Cause Local Sea Level to Differ From Global Mean Sea Level.

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

a. Sea Level Fingerprints

A large ice sheet exerts a gravitational pull on the nearby ocean, drawing water towards it. If that ice melts, this gravitational force weakens, causing a

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[53] *Id.*
[54] Glen Peters, et al., *Carbon Dioxide Emissions Continue to Grow Despite Emerging Climate Policies*, 10 NAT. CLIM. CHANG. 3-6 (2020).
[55] Friedlingstein, et al., *supra* note 1.
[56] IPCC, *Summary for Policymakers*, In: CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, CONTRIBUTION OF WORKING GROUP I TO THE SIXTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2021).

lowering of sea level near the ice sheet and enhanced sea level rise further away. The shrinking of the ice sheet also affects Earth's rotation and deforms the crust of the Earth. 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 effect in the Southern Hemisphere.[57,58] These detectible gravitational, rotational, and deformational patterns of sea level are known as *sea level fingerprints*.

b. *Glacial Isostatic Adjustment*

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. 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).[59]

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[57] Jerry X. Mitrovica, et al., *On the Robustness of Predictions of Sea Level Fingerprints*, 187(2) GEOPHYSICAL JOURNAL INTERNATIONAL 729–742 (2011).
[58] Gary Griggs, et al., *Rising Seas in California: An Update on Sea-Level Rise Science*, CALIFORNIA OCEAN SCIENCE TRUST (2017).
[59] Benjamin DeJong, 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. Ocean Dynamic Sea Level Change

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).[60] 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 atmospheric pattern called the North Atlantic Oscillation, can have large effects on local sea level.[61]

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 parts of the ocean can have large effects on local sea level.[62] These circulation patterns also change as the climate changes, resulting in further alterations of sea level regionally and locally over time.

d. Localized Processes

Some drivers of local sea level are not directly caused by climate change but can cause changes in local sea level as large or larger than climate change.

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[60] Griggs, et al., *supra* note 58.

[61] Jessica S. Kenigson, et al., *Decadal Shift of NAO-linked Interannual Sea Level Variability Along the U.S. Northeast Coast*, 31(13) J. CLIM. 4981–4989 (2018).

[62] Levermann, et al., *supra* note 35.

Of these localized processes, several are directly related to or can be accelerated by human activity.

Compaction occurs when sediments in low-lying coastal areas are compressed into a smaller volume. Compaction often results in *subsidence*, which is when the ground surface sinks, or "deflates".[63] Both compaction and subsidence occur naturally, but can be accelerated by human activity, such as oil and gas extraction, groundwater withdrawal, and changes in sediment delivery (e.g., due to flood-protection levees).[64,65]

Finally, unrelated to human activity, *plate tectonics* is an important process that causes land masses to rise or fall and can impact relative sea level in coastal areas.[66]

Sea level in the mid-Atlantic region has increased at a rate greater than the global average, primarily due to glacial isostatic adjustment, but subsidence due to

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[63] Matthew J. Brain, *Past, Present and Future Perspectives of Sediment Compaction as a Driver of Relative Sea Level and Coastal Change*, 2 CURR. CLIM. CHANGE REP. 75–85 (2014).
[64] Jaap Nienhuis, et al., *A New Subsidence Map for Coastal Louisiana*, 27(9) GSA TODAY 58–59 (2017).
[65] Robert E. Kopp, 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).
[66] Griggs, et al., *supra* note 58.

groundwater withdrawal and changes in ocean currents also contribute.[67,68] The 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 geographically varying 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 also indicate that it is very likely that rising temperatures will cause the Atlantic Meridional Overturning Circulation (AMOC) to weaken in the future, which would increase relative sea level along the mid-Atlantic coast.[69,70] However, recent studies suggest that observed changes in relative sea level along this coast are more likely driven by changes in local winds rather than a slowdown in the AMOC.[71] Longer observational data sets are needed (i.e. twenty more years of data collection) in order to fully understand how Atlantic Ocean dynamic

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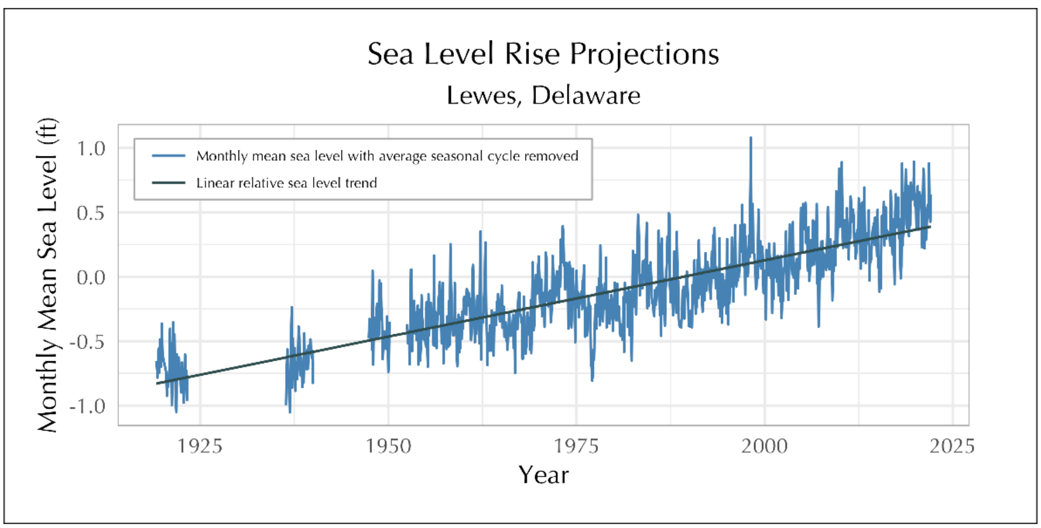
[67] William V. Sweet, et al., *Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines,* NOAA TECHNICAL REPORT NOS 01, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, NATIONAL OCEAN SERVICE (2022).
[68] Robert E. Kopp, *Does the Mid-Atlantic United States Sea-level Acceleration Hot Spot Reflect Ocean Dynamic Variability?* 40(15) GEOPHYS. RES. LETT. 3981–3985 (2013).
[69] Jianjun Yin, et al., *Model Projections of Rapid Sea-level Rise on the Northeast Coast of the United States*, 2(4) NAT. GEOSCI. 262–266 (2009).
[70] Sweet, et al., *supra* note 67.
[71] Christopher G. Piecuch, et al., *How is New England Coastal Sea Level Related to the Atlantic Meridional Overturning Circulation at 26°N?* 46(10) GEOPHYS. RES. LETT. 5351–5360 (2019).

variability is impacting sea level along the mid-Atlantic coast, and whether the observed changes represent short-term variability or long-lived trends.[72]

The Lewes, Delaware, tide gauge, in operation since 1919, indicates that sea level at the mouth of Delaware Bay has risen about 14 inches since 1919 at an average rate of approximately 0.14 inches per year (Figure 5).[73]

Figure 5. Relative Sea Level Trend in Lewes, Delaware. Historical sea level change (blue line) from 1919 to January 2022 in Lewes, Delaware, recorded by NOAA tide-gauge #8557380. 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 Lewes, Delaware is 0.14 inches per year. Figure modified from: COOPS, *supra* note 73.



[72] Kopp, *supra* note 65.
[73] COOPS, *Relative Sea Level Trend, Lewes, Delaware*, NOAA TIDES AND CURRENTS, accessed 24 Mar. 2022 at https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8557380

Under SSP1-1.9, an extremely aggressive emissions reduction scenario, sea level along the Delaware coast will likely rise 2.1 feet by 2100.[74] If we remain on our current trajectory, local sea level is projected to rise between 2.8 to 3.2 feet by 2100.[75] Alternatively, if there is a reversal in current technology and mitigation policy, or intensified positive feedbacks and emissions continue to increase (SSP8-8.5), local sea level is projected to rise 3.5 feet by 2100 (Figure 6).[76,77] If warming triggers the rapid decay of the Antarctic ice sheet, local sea level could rise 6 feet or more by 2100 and 18 feet by 2150.[78,79,80]

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[74] 2.1 feet is a median value relative to GMSL level between 1995–2014 and has an at least 67% probable range of 1.4–3.0 feet.

[75] Median sea level rise projections for SSP2-4.5 and SSP3-7.0, respectively, relative to GMSL level between 1995–2014.

[76] Natali, et al., *supra* note 44.

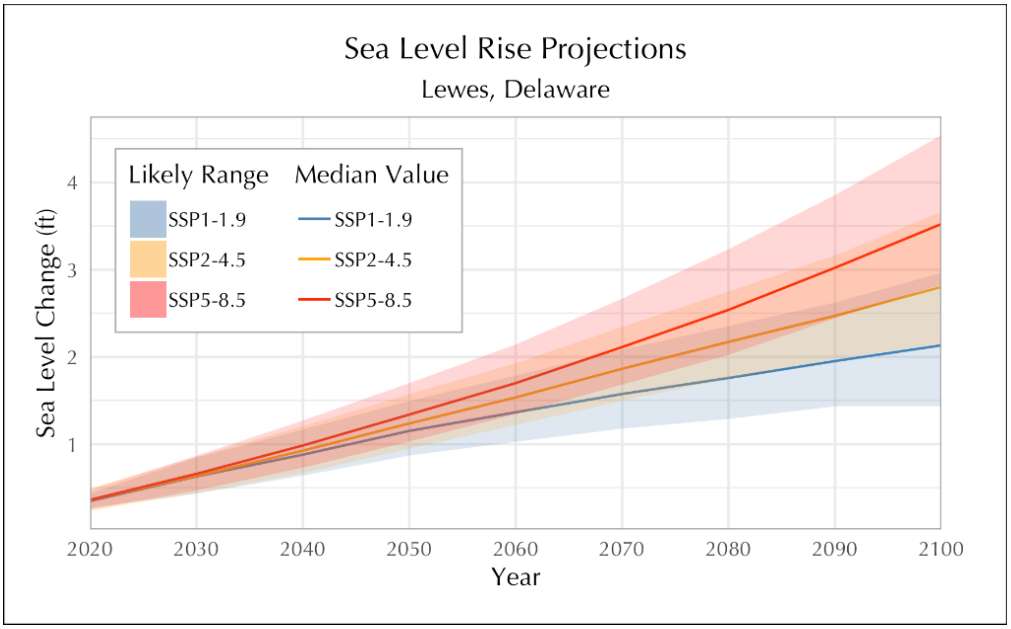
[77] 2.8 feet is a median value relative to GMSL level between 1995–2014 and has an at least 67% probable range of 2.2–3.7 feet.

[78] Gregory G. Garner, et al., *Framework for Assessing Changes to Sea-level (FACTS)*, GEOSCI. MODEL DEV. [in prep].

[79] Gregory G. Garner, et al. IPCC AR6 Sea-Level Rise Projections. Version 20210809. PO.DAAC, CA, USA. (2021), accessed 24 Mar. 2022 at https://podaac.jpl.nasa.gov/announcements/2021-08-09-Sea-level-projections-from-the-IPCC-6th-Assessment-Report.

[80] Fox-Kemper, et al., *supra* note 3.

Figure 6. Projected Sea Level Rise in Lewes, Delaware. Median projections of sea level rise in Lewes, Delaware through 2100 under three GHG emissions pathways. Shaded regions show the 17th-83rd percentile ranges. Fox-Kemper, et al. *supra* note 3.



V. Delaware is Facing Unavoidable and Costly Infrastructure Damage From Flooding Due to Rising Sea Levels

Sea level rise is a major threat to Delaware's infrastructure both from daily tidal flooding and increased severity of storm surge events. The average annual frequency of high tide flooding at the Lewes tide gauge increased 92% (from 2.7 days to 5.2 days per year between 1919–2021).[81] Under a lower emissions scenario,

[81] NASA, *Flooding Days Projection Tool*, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, accessed at https://sealevel.nasa.gov/flooding-days-projection/

by 2050, high tide flooding will increase to 54 days per year and 257 days per year by 2100.[82,83]

Delaware is exceptionally vulnerable to sea level rise due to its geography – no location within the state is more than 12 miles from tidally-influenced waters.[84] Of great concern is the potential loss of Delaware's 73,000 acres of tidal wetlands which provide important benefits to the state, such as improving water quality and buffering the impacts of storms on coastal communities. Nearly 100 percent of these vast tidal wetlands will be impacted by sea level rise by 2100, reducing many of the services they provide.[85] In certain circumstances, tidal marshes can adapt to sea level rise, but whether Delaware's marshes can dynamically respond to rising seas is uncertain and remains an active area of research.[86]

Another primary impact of sea level rise of concern in Delaware is increases

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[82] NASA, *supra* note 81.

[83] The NOAA "intermediate-low" emissions scenario projects 0.5 m (1.6 ft) GMSL by 2100, comparable to SSP2-4.5.

[84] Delaware Coastal Management Program, *State of Delaware Coastal and Estuarine Land Conservation Program Plan*, DELAWARE COASTAL PROGRAMS AND NOAA (2014).

[85] John A. Callahan, et. al., *Recommendation of Sea-Level Rise Planning Scenarios for Delaware: Technical Report*, prepared for: DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL DELAWARE COASTAL PROGRAMS (2017).

[86] Erika Lentz, et al., *Evaluation of Dynamic Coastal Response to Sea-level Rise Modifies Inundation Likelihood*, (6) NAT. CLIM. CHANGE 696–700 (2016).

in the rate of coastal erosion. The State of Delaware maintains 24 miles of Atlantic Ocean shoreline and many more miles of tidal estuarine, bay shoreline, and coastal shoreline and beach nourishment and dune restoration are constant and ongoing efforts.[87] Between 2001 and 2016, beach nourishment and dune restoration cost Delaware about $200 million. After Hurricane Sandy, Delaware spent $38 million alone on beach nourishment. Coastal erosion is expected to be increasingly worsened by sea level rise.[88]

Higher sea levels can result in increased damages from daily tides, king tides, and extreme weather events. During Superstorm Sandy, for example, human-caused sea level rise was estimated to have inflicted an additional $5-14 billion in flooding damage.[89] Coastal flooding will increase losses of public and private property within Delaware. Over 20,000 homes with an approximate value of $1.1 billion are located within 5 feet of mean high tide.[90] With 2 feet of sea level rise,

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[87] DNREC, *Preparing for Tomorrow's High Tide: Sea-Level Rise Vulnerability Assessment for the State of Delaware*, TECHNICAL REPORT, PREPARED FOR THE DELAWARE SEA LEVEL RISE ADVISORY COMMITTEE BY THE DELAWARE DEPARTMENT OF ENVIRONMENTAL CONTROL (2012).

[88] Callahan, et. al., *supra* note 85.

[89] Benjamin Strauss, et al., *Economic Damages from Hurricane Sandy Attributable to Sea Level Rise Caused by Anthropogenic Climate Change*, 12 NAT. COMMUN. 2720 (2021).

[90] Benjamin Strauss, et al., *Delaware and the Surging Sea: A Vulnerability Assessment with Projections for Sea Level Rise and Coastal Flood Risk*, CLIMATE CENTRAL RESEARCH REPORT, (2014).

more than 5,600 homes in Delaware are at risk of becoming chronically flooded.[91] Public infrastructure in coastal Delaware, such as roads and utilities, will be impacted by sea level rise and high tide flooding; many roads within the state already experience regular flooding due to spring high tides, and will potentially experience year-round flooding within the century.[92]

Responsible local governments must prepare for the consequences of global warming of *at least* 3°C above pre-industrial levels.[93] If we remain on our current GHG emissions trajectory, GMSL is projected to rise between 1.6–2.7 feet, with the possibility of more than 5 feet.[94]

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 Appellee's vulnerability to sea level rise of just one or two feet, there is no plausible emissions reduction scenario where Delaware 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.

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[91] Kristina Dahl, et al., *Underwater: Rising Seas, Chronic Floods, and the Implications for US Coastal Real Estate*, UNION OF CONCERNED SCIENTISTS (2018).
[92] Callahan, et. al., *supra* note 85.
[93] Skea, et al., *supra* note 29.
[94] Fox-Kemper, et al., *supra* note 3.

The portion of total CO_2 in the atmosphere attributable to each company's fossil fuel products is well-established (Figure 7). This work demonstrates that the emissions produced by the products of 88 major carbon producers contributed 60.8 (±4.4)% of the total increase in atmospheric CO_2 from 1880 through 2015, of which the vast majority was produced since 1965 — their emissions between 1965–2015 account for 56.5 (±3.6)% of the rise in atmospheric CO_2 between 1880 and 2015.[95,96] More than half of that change 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 was the 3rd, BP the 4th, Shell the 7th and ConocoPhillips the 11th.

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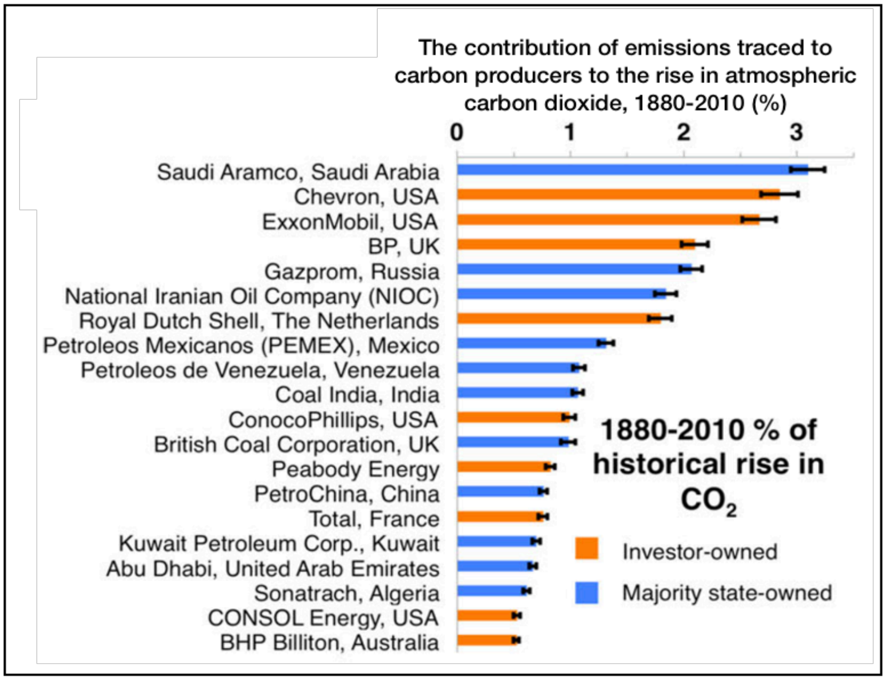
[95] Brenda Ekwurzel, et al., *The Rise in Global Atmospheric CO_2, Surface Temperature, and Sea Level from Emissions Traced to Major Carbon Producers*, 144(4) CLIM. CHANGE 579–590 (2017).
[96] Rachel Licker, et al., *Attributing Ocean Acidification to Major Carbon Producers*, 14 ENVIRON. RES. LETT. 124060 (2019).

Figure 7. 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 et al., *supra* note 98.



CONCLUSION

We know that the present damage and future risk to coastal communities such as the Appellee, posed by rising sea levels, is caused in significant part by the changing climate. We know that the Appellants' production and marketing of fossil fuels is a significant cause of that climate change. We know what portion of CO_2 emissions are associated with each company's products. All of these matters can be proven at trial in Delaware state courts through the introduction of evidence in the form of well-established scientific facts.

Dated: April 21, 2022

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CERTIFICATE OF COMPLIANCE

1. Pursuant to this Court's Local Rule 28.3(d), I certify that at least one of the attorneys whose names appear on this brief, including William A. Rossbach, is a member of the bar of this Court.

2. Pursuant to this Court's Local Rule 31.1(c), I certify (1) that the text of the electronic brief is identical to the text of the paper document and (2) that this document has been scanned with Microsoft Defender Antivirus and is free from viruses.

3. Pursuant to Federal Rule of Appellate Procedure 32(a)(7)(B)(i), this brief contains 6,381 words as determined by the word-count function of Microsoft Word for Office, excluding those parts exempted by Federal Rule of Appellate Procedure 32(f).

4. Pursuant to Federal Rule of Appellate Procedure 32(a), this brief has been prepared using the proportionally spaced typeface, Times New Roman, 14-point font.

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CERTIFICATE OF SERVICE

I hereby certify that I electronically filed the foregoing document with the Clerk of Court for the United States Court of Appeals for the Third Circuit by using the Appellate CM/ECF system on April 21, 2022.

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

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APPENDIX A

Robert Kopp is a climate scientist who serves at Rutgers University as a Professor in the Department of Earth & Planetary Sciences and as Co-Director of the University Office of Climate Action. He also directs the Megalopolitan Coastal Transformation Hub, a National Science Foundation-funded consortium that advances coastal climate adaptation and the scientific understanding of natural and human coastal climate dynamics. He is also a director of the Climate Impact Lab, a multi-institutional collaboration of more than two dozen economists, data scientists, climate scientists, and policy experts, working to bring Big Data approaches to the assessment of the economic risks of climate change. Professor Kopp's research focuses on understanding uncertainty in past and future climate change, with major emphases on sea-level change, the interactions between physical climate change and the economy, and the use of climate risk information to information decision-making. He has authored over 120 scientific papers, as well as popular articles in numerous venues. Professor Kopp is a lead author of the Intergovernmental Panel on Climate Change's 2021 Sixth Assessment Report and of the U.S. Global Change Research Program's 2017 Fourth National Climate Assessment. Professor Kopp received his Ph.D. in Geobiology from the California Institute of Technology and his undergraduate degree in Geophysical Sciences from the University of Chicago. He is a fellow of the American Geophysical

Union, a past Leopold Leadership Fellow, and a recipient of the American Geophysical Union's James B. Macelwane medal.

Michael Oppenheimer is the faculty director of the Center for Policy Research on Energy and the Environment (C-PREE) and the Albert G. Milbank Professor of Geosciences and International Affairs in the Princeton School of Public and International Affairs, the Department of Geosciences, and the High Meadows Environmental Institute at Princeton University. He is also Faculty Associate of the Atmospheric and Ocean Sciences Program and the Princeton Institute for International and Regional Studies. Oppenheimer is a long-time participant in the Intergovernmental Panel on Climate Change (IPCC) that won the Nobel Peace Prize in 2007, serving as an author during all six IPCC assessment cycles, including most recently as a Coordinating Lead Author on IPCC's Special Report on Oceans and Cryosphere in a Changing Climate (2019) and as a Review Editor on the Sixth Assessment Report (2022). He is also the Kravis Senior Contributing Scientist at the Environmental Defense Fund, as well as coeditor-in-chief of the journal Climatic Change.

Kristina Dahl is a principal climate scientist for the Climate & Energy program at the Union of Concerned Scientists. Her research focuses on the impacts of climate change, particularly sea level rise and extreme heat, on US communities. Prior to joining UCS, Dr. Dahl was the associate director of a school-wide climate change initiative at Rutgers University. She also served as a science communicator for Al Gore's Climate Project and a science educator for the American Museum of Natural History. Dr. Dahl earned a PhD in paleoclimate from the MIT/Woods Hole Oceanographic Institution Joint Program and a BA in Earth sciences from Boston University.

Brenda Ekwurzel is a senior climate scientist and the director of climate science for the Climate & Energy Program at the Union of Concerned Scientists (UCS). Dr. Ekwurzel is a co-author of the fourth National Climate Assessment Volume II. In 2016, she was named a AAAS fellow. Prior to joining UCS, Dr. Ekwurzel was on the faculty of the University of Arizona in their department of hydrology and water resources, with a joint appointment in the geosciences department. She has studied climate variability in places as disparate as the Arctic and the desert Southwest. Earlier in her career, Dr. Ekwurzel was a hydrologist, working with communities to protect groundwater. Dr. Ekwurzel earned a B.S. in geology from Smith College, and an M.S. in geoscience from Rutgers University. She holds a Ph.D. in isotope geochemistry from the Department of Earth and Environmental Sciences at Columbia University's Lamont-Doherty Earth Observatory and conducted post-doctoral research at Lawrence Livermore National Laboratory.

Peter C. Frumhoff is former 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 U.S. 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.

Gary Griggs is a Distinguished Professor of Earth 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 200 articles in scientific journals and book chapters, and has written 12 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).

Dr. L. D. Merner is the lead for the Science Hub for Climate Litigation at the Union of Concerned Scientists. Her research has focused on hydroclimatic variability, flood hydrology, and vulnerability analysis. She is trained as an interdisciplinary scientist in critical physical geography. Prior to joining UCS, she was a senior scientist at the American Institute of Physics. Dr. Merner earned a PhD in geography and environmental systems from the University of Maryland, Baltimore County. She also holds bachelor degrees in geography and environmental science and policy from Clark University.

Sverre L. LeRoy leads the climate science program at the Center for Climate Integrity. Her work focuses on climate impacts and costs at the community level, with an emphasis on sea level rise. She was lead author on CCI's report quantifying the cost to protect coastal communities in the Contiguous U.S. from sea level rise by 2040. She earned a BS in Environmental Science from Mills College and an MS and PhD from Stanford University in Environmental Earth System Science where she studied paleoclimate archives from nearshore environments.

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.