January 27, 2023

Dr. Jane Lubchenco
Deputy Director for Climate and Environment
Office of Science and Technology Policy
1800 G Street, NW, Suite 9100
Washington, D.C. 20006

Dear Dr. Lubchenco:

We are writing to commend you for the significant and important work to develop the draft Fifth *National Climate Assessment* and to provide comments focused on the coastal aspects of the draft assessment. These comments will also be submitted to the electronic comment data base at https://review.globalchange.gov/.

The Coastal Flood Resilience Project (CFRP) is a coalition of national nonprofit organizations and individuals working for stronger national programs to prepare for coastal storm flooding and rising seas along the American coast.

The Fifth *National Climate Assessment* will be an important milestone on the road toward building understanding of the complex and inter-related threats that a warming climate poses for the United States. The draft document makes a compelling case for expanding efforts to meet greenhouse gas reduction goals and for adapting to the changes that a warming climate will bring in ways that are effective and that recognize environmental justice challenges.

The coastal effects elements of the draft *National Climate Assessment* present important new scientific understanding of the risks that rising sea level poses for the American coast drawing on the 2022 report of the Sea Level Rise and Coastal Flood Hazard and Tools Interagency Task Force. The draft document also includes useful information on the changing nature of coastal storms and the impacts of coastal storms and rising seas on communities and ecosystems.

Although there are many strong aspects of the discussions of coastal effects in the draft document, there are areas that should be strengthened. In general, some key needed changes are:

- **Highlight Unprecedented Changes that Rising Sea Levels Will Bring to Coasts:** Among the multiple significant impacts of a changing climate, rising sea level stands out as a massive challenge and will bring major, unprecedented changes to coastal areas far beyond what is generally understood today. The NCA5 can play a major role in helping shape the public understanding of the dramatic changes caused by sea level rise compounded by more intense and frequent storms. The draft document needs to make this point more forcefully in the Overview as well as the Coastal Effects chapter.

- **Explain that Relocation of Coastal Communities, Ecosystems, and Infrastructure is Inevitable:** Although the NCA5 is not intended to be a national climate change adaptation plan, it can play an important role in identifying adaptation strategies that are both effective and cognizant of environmental justice issues. In the case of more severe storms and rising sea levels, relocation of communities, ecosystems, and major infrastructure to higher ground is inevitable. The science presented in the draft assessment makes clear that significant sea level rise is built into future decades and centuries, regardless of the degree of future warming. The draft document needs to make clear that relocation of many coastal assets is a matter of when, not if, and that interim strategies (e.g., structural protection) should be considered in the context of future relocation.

- **More Fully Describe Coastal Storm and Sea Level Rise Risks to Infrastructure:** The current draft assessment describes risks that more severe storms and rising seas pose to homes, communities, and ecosystems, but does not give sufficient attention to the impacts to major infrastructure assets along the coast. Managing flood risks to major coastal infrastructure, including transportation assets (e.g., highways, railroads, bridges, and ports), water treatment facilities, energy production and transmission facilities, hospitals, and military bases is critical to maintaining diverse social services, economic capacity, and national security. Information concerning potential impacts on infrastructure is available and should be added to the Coastal Effects chapter.

- **Describe Needed Research on Ice Sheet Dynamics:** A key issue for understanding the rate of future sea level rise is to improve assessments of the potential for increments of sea level rise to occur sooner than now expected due to rapid loss of ice sheets. Issues related to current low confidence in understanding of ice sheet dynamics should be more fully explained in the assessment and research needed to reduce this uncertainty should be described. Recent science indicating that significant losses of ice sheets in the near term are possible should be recognized.

- **Highlight the Central Role of Coastal Storms in Climate Change Disasters:** Coastal storms on both the Atlantic and Pacific coasts play a key role in climate change related

disasters. Atlantic hurricanes are an especially significant cause of costly damage and lives lost. NOAA reports that "The distribution of damage from U.S. billion-dollar disaster events from 1980 to 2022 is dominated by tropical cyclone losses." Some 54 percent of all costs from billion-dollar disasters over this period were from hurricanes as were the highest number of deaths (6,890), far outpacing any other category of disaster or extreme event. The Overview, Chapter 2 addressing Climate Trends, and Chapter 9 addressing Coastal Effects each need to be expanded to highlight the exceptional damages caused by recent coastal storms and the expectation that these storms will become both more intense and, in the case of Atlantic hurricanes, more frequent.

These changes, and additional suggested improvements, are addressed in greater detail in the attachment. Please note that the views expressed in this letter are those of the contributors listed below. Contributors' affiliations are identified for informational purposes and this identification does not represent endorsement by their organization.

We are happy to answer any questions or provide clarifying comments. We look forward to working with you on this important project.

Sincerely,

- Jay Austin; Environmental Law Institute
- John Englander; Rising Seas Institute
- Harriet Festing and Stephen Eisenman; Anthropocene Alliance
- Rich Innes; Association of National Estuary Programs
- Bethany Kraft; Audubon Society
- Charles Lester; Director of the Ocean and Coastal Policy Center at UC Santa Barbara and former Executive Director of the California Coastal Commission
- Jeffrey Peterson; author of *A New Coast: Strategies for Responding to Devastating Storms and Rising Seas*
- Susan Ruffo; United Nations Foundation and former Associate Director for Climate Preparedness and Resilience, White House Council on Environmental Quality
- Mark Rupp; Georgetown Climate Center and former Deputy Associate Administrator for Intergovernmental Relations, U.S. Environmental Protection Agency
- Jason Scorse; Middlebury Center for the Blue Economy
- Stefanie Sekich-Quinn; Surfrider Foundation
- Mary-Carson Stiff; Wetlands Watch
- Shana Udvardy; Union of Concerned Scientists

Draft Fifth National Climate Assessment: Comment Summary

Overview

- Clarify Central Role of Coastal Storms in Climate Disasters/Extreme Events
- Recognize Sea Level Rise Threats to Homes and Infrastructure

Climate Trends Chapter

- Recognize Expected Future Increases in the Frequency of Atlantic Hurricanes
- Add Text Clarifying Higher Annual Rate of Sea Level Rise on US Coast
- Add Data Describing the Acceleration of Annual Rate of Sea Level
- Clarify Near Term Risks of Very High Sea Level Rise
- Clarify Infrastructure Planning Period

Coastal Effects Chapter

Introduction

- Add Economic Costs of Coastal Storms and Sea Level Rise
- Add Increasing Storm Damage Risk
- Address Risks to Ecosystems and Infrastructure
- Highlight Need to Plan for Coordinated Relocation of Coastal Communities, Ecosystems, and Infrastructure

Key Message 9.1. Coastal Hazards Are Increasing Rapidly

- Expand Critical Information about Acceleration of Sea Level Rise
- Clarify Flood and Inundation Character of Coastal Hazards
- Clarify Permanent Nature of Sea Level Rise vs. Temporary Nature of Storm Flooding
- Resolve Different Sea Level Rise Estimates by 2050 and 2100

Key Message 9.2. Coastal Impacts on People and Ecosystems Are Increasing

- Clarify Flood and Inundation Character of Coastal Impacts
- Identify Coastal Flood Impacts on Major Infrastructure Assets
- Describe Community Impacts of Coastal Inundation by Rising Sea Level
- Describe Expected Extent of Wetland Loss to Sea Level Rise

Key Message 9.3 Transformative Adaptation for Coastal Communities

- Clarify Meaning of “Transformative” Adaptation
- Clarify Limits of Nature-Based Solutions in Reducing Sea Level Rise Inundation
- Managed Retreat/Relocation of Many Coastal Places is Inevitable

Major Uncertainties and Research Gaps

- Describe Needed Research Related to Ice Sheet Dynamics
- Develop US Sea Level Rise Annual Rate of Acceleration Reporting Tools

Draft Fifth National Climate Assessment
Detailed Comments

Overview

- **Clarify Central Role of Coastal Storms in Climate Disasters/Extreme Events:** The Overview does a good job of summarizing a wide range of risks but does not make clear the critical role of coastal storms and hurricanes as the principal cause of major disaster impacts. NOAA reports that:

  "In short, tropical cyclones are the most costly of the weather and climate disasters….Accounting for just under a fifth (17.5%) of the total number of events, tropical cyclones have caused more than half (52.0%) of the total damages attributed to billion-dollar weather and climate disasters since 1980."

  Page 1-12; line 11 add: "Coastal storms and tropical hurricanes result in just over half the total cost of all billion-dollar weather and climate events, while accounting for just under 20 percent of all such high-cost events."

- **Recognize Sea Level Rise Threats to Homes and Infrastructure:** Sections 3.3 and 3.4 address risks posed by extreme climate and weather event to homes and to infrastructure but do not clearly identify the significant threats that rising sea level poses to these assets. For example, sea level rise poses a threat to some two million homes in the United States. Rising sea level also poses risks to diverse major types of infrastructure assets located along the coast, including transportation (highways, rails, bridges, ports), water treatment facilities, energy facilities, and defense assets (see comment on page 12 for more information).

  Revise the titles of 3.3 and 3.4 to add at the end "and rising sea level." {Note that, although sea level rise is a threat to some supplies of drinking water, this risk is notably smaller than sea level rise risks to communities, ecosystems, and infrastructure assets.}

  Page 1-20; line 5: Insert a new sentence: "Rising sea level poses a risk of permanent inundation of land areas now occupied by over two million homes."

  Page 2-21; lines 21-23: The existing sentence is:

  "In coastal communities, sea level rise and associated impacts such as flooding and saltwater intrusion are anticipated to severely impact infrastructure, communities, and natural resources, with inequities in how these impacts are experienced."

It should be revised as follows:

"In coastal areas, rising sea levels pose a risk of permanent inundation to major infrastructure including transportation assets (e.g., highways, railways, bridges, ports), water treatment facilities, power plants, hospitals, and defense assets."

Climate Trends Chapter

This chapter makes important points about sea level rise along the United States coast but several key statements should be clarified.

- **Recognize Expected Future Increases in the Frequency of Atlantic Hurricanes:** Atlantic hurricanes are one of the most destructive impacts of a changing climate in the U.S. in terms of damage costs and lives lost. NOAA reports that "The distribution of damage from U.S. billion-dollar disaster events from 1980 to 2022 is dominated by tropical cyclone losses." Some 54 percent of all costs from billion-dollar disasters over this period were from hurricanes as were the highest number of deaths (6,890).

  Although the likelihood of Atlantic hurricanes becoming more intense as a result of climate change is generally accepted (see page 2-3; line 23), new research points to such events as becoming more frequent. A recent study of likely future hurricanes in the Atlantic concluded:

  "Projected Atlantic TCs become more frequent in the future by approximately 34% during El Niño and negative AMM and by 66% during La Niña and positive AMM, with a significant increase in the portion of intense TCs."

  Page 2-14; line 7-8 refers to the increased intensity of hurricanes but not the increasing frequency:

  "Hurricanes are intensifying more rapidly (high confidence) and causing heavier rainfall and higher storm surges (high confidence)."

  This sentence should be revised to read:

  "Hurricanes are intensifying more rapidly (high confidence) and causing heavier rainfall and higher storm surges (high confidence) while Atlantic hurricanes are expected to become more frequent."

  Page 2-16; line 15: Insert:

"Recent research points to a significant increase in the future frequency of Atlantic hurricanes (Sena et al. 2022)."

- **Add Text Clarifying Higher Annual Rate of Sea Level Rise on US Coast**: The text paragraph explaining the higher rate of sea level rise along the US coast than globally should be clarified to add the data from the graphic to the text to highlight the data and make it easier to cite:

  Page 2-11; line 6: Add the following sentence: "Although the global average rate of sea level rise in 2022 [note need to clarify date] was 3.4mm/year, the average along the coast of the contiguous US was significantly higher at 4.7mm/year."

- **Add Data Describing the Acceleration of Annual Rate of Sea Level**: The text refers to an acceleration in the rate of change of sea level rise (see page 1-4; line 13), but the rate of acceleration, mentioned on page 9-4, is not described in this "Trends" chapter and should be added. The text on page 2-11 refers to Appendix, but the discussion on page 14-14 does not address acceleration. Understanding the rate of acceleration of sea level rise is critical to effective planning of response actions. Both NOAA and NASA have documented this acceleration, although both speak to only global rates rather than US coastal rates.

  Page 2-11; line 6: add the following:

  "In addition, NOAA reports that the rate of global sea level rise is accelerating: it has more than doubled from 0.06 inches (1.4 millimeters) per year throughout most of the twentieth century to 0.14 inches (3.6 millimeters) per year from 2006–2015." [Note that 3.6mm/year needs to be aligned with the 3.4mm/year reported on p 2-11; see graphic.]

- **Clarify Near Term Risks of Very High Sea Level Rise**: The text on page 2-24 refers to long-term risks of sea level rise of 4-7 feet in the event of temperatures over 2 degrees C and rapid and irreversible ice loss. Recent science points to potential ice loss sooner than 100-150 years without the assumption of greater than 2 degree temperature increases (e.g., "less than a decade").

  The current text at page 2-24; line 36 reads:

  "At a 2°C GWL, it is very unlikely, but not impossible, that sea level rise in CONUS would exceed 4 feet in 2100 and 7 feet in 2150. At higher GWLs, such extreme sea level rise becomes more likely within the next 100–150 years. The total rise in sea level that will be realized beyond 2150 can differ by many feet depending on global warming levels

over the next 50–100 years due to the potential for rapid and irreversible loss of ice from Greenland and Antarctica starting next century."

Revise the sentences above as follows:

"It is unlikely, but not impossible, that sea level rise in CONUS would exceed 4 feet in 2100 and 7 feet in 2150. Such sea level rise becomes more likely due to the potential for rapid and irreversible loss of ice from Greenland and Antarctica."

Page 2-27; line 12-13: delete "in far-future sea level rise.".

The text on page 2-29; line 30 "Extreme Sea Level Rise Cannot Be Ruled Out" makes a critically important point for planning of response strategies but lacks sufficient explanation of the reasons for these estimates (e.g., description of the known unknowns related to ice-sheet processes and feedbacks) and the probability of these projections occurring.

It would be helpful to include a discussion on how well the rapidly evolving understanding of ice sheet dynamics are represented in the climate models on which SLR is predicted (e.g., changes in albedo due to the accumulation of meltwater on the surface of ice, or the impacts of changes in ocean circulation patterns on marine-terminating glaciers). Note that although line 23 on page 2-29 refers to a 1% probability, table 2.4 of the NOAA sea level rise scenarios report indicates a 20% probability of 1.5m of sea level rise by 2100 in the case of high impact very high emissions scenario.

Page 2-37; line 3: delete "On longer timescales (2100 and beyond),".

- **Clarify Infrastructure Planning Period:** Although the period of a home mortgage is commonly 30 years, infrastructure plans often include time horizons of 50 or 100 years. Homes financed for 30 years require roads, sewers, power, and related services that often are in place for much longer than 30 years. Large commercial and industrial investments are also often in place for far longer than 30 years. Planning for new homes or other infrastructure with just a 30-year time horizon will dramatically underestimate the risk of inundation by rising seas for many projects in coastal areas.

Page 2-27; line 15: Revise the sentence below to delete "On timescales relevant to infrastructure planning (around 30 years)"

"On timescales relevant to infrastructure planning (around 30 years), sea level along US coastlines is expected to continue rising at accelerating rates above the global average."

Coastal Effects Chapter
Introduction

- **Add Economic Costs of Coastal Storms and Sea Level Rise:** The Fourth National Climate Assessment estimated the costs of storms and sea level rise to exceed $3.6 trillion by 2100 in a scenario without adaptation actions and $820 billion in the event that cost-effective adaptation measures are implemented. The scale of damages associated with storms and rising seas is a critical consideration and should be added to the Introduction to the Chapter as it was in NCA4.

  Page 9-3; line 9: Add a new sentence: "EPA estimates that the costs of cumulative damages to coastal property by sea level rise and storms could exceed $3.6 trillion by 2100 and that these damage costs could be reduced substantially, to under $1 trillion, if cost effective adaptation measures are implemented."

- **Add Increasing Storm Damage Risk:** It is important to point out that, in addition to sea level rise accelerating, coastal storms are increasing in intensity as a result of climate change and, like sea level rise, are projected to result in increased impacts in decades ahead. These storm changes are documented in Chapter 2; p 2-17 and "compound event risk" as documented on p 2-24.

  Page 9-3; Line 11: Add new sentence recognizing more damaging future storm risk: "In addition, warmer air temperatures are projected to result in more destructive coastal storms, as documents in Chapter 2."

  Page 9-3; line 29: the term "changing storm patterns" is too vague to describe the clear shift toward more intense storms likely to cause more damage to communities, ecosystems, and infrastructure. Revise to read: "more damaging coastal storms".

- **Address Risks to Ecosystems and Infrastructure:** This Chapter documents that more damaging storms and rising sea level will cause damage to ecosystems and infrastructure, but the introduction addresses community impacts without mentioning harm to ecosystems and infrastructure.

  Page 9-3; following line 20: After addressing storm and sea level rise future impacts on human communities, the text should briefly identify the impacts of more intense storms and rising sea level on coastal ecosystems and major infrastructure assets (i.e., more than just human settlements are at risk). Add new paragraph:

"In addition to damage to communities, more damaging storms and rising sea level will cause coastal ecosystems (e.g., wetlands, marshes, beaches, and dunes) to migrate inland and pose a risk of flooding to major infrastructure assets ranging from transportation systems (e.g., highways, railroads, bridges, ports, and airports), water treatment systems, defense facilities, and industrial capacity. Protection structures can reduce risks for existing infrastructure on an interim basis but many major infrastructure assets along the coast will need to relocate to higher ground. Coastal ecosystems require interaction with marine waters and will need to migrate landward as sea levels rise and sustaining these assets will require removal of obstacles to their landward migration."

- **Highlight Need to Plan for Coordinated Relocation of Coastal Communities, Ecosystems, and Infrastructure:** Lines 19-26 on page 29 generally refer to options for managing impacts of more severe storms and rising seas, including protective structures and relocation, and for "transformative adaptation allows for deliberate and fundamental reimagination of coastal communities." This statement begins to capture the huge scale of the changes needed to cope with more severe storms and rising seas, but does not adequately highlight the need for coordinated planning and program implementation to focus on relocation of communities, ecosystems, and infrastructure to higher ground.

  Revise lines 19-26 on page 29 after "best chance of success" to read:

  "The combined impacts of more damaging storms and accelerating sea level rise will require fundamental reimagining of the coast. For some coastal assets, such as homes and infrastructure facilities, engineered structures and enhanced nature-based solutions can provide temporary protection. (Oestreich et al. 2019; Green et al. 2021; Siders et al. 2021. Engineered protection structures, however, can't protect all communities and infrastructure or most ecosystems. Gradual relocation of communities, ecosystems, and infrastructure to higher ground will be needed. Coordinated and deliberate coastal relocation, implemented in a manner that serves all people equitably, is the highest priority for coastal adaptation to a changing climate. (Fedele et al. 2019; Kuhl et al. 2021; Shi and Moser 2021)."

Key Message 9.1. Coastal Hazards Are Increasing Rapidly

- **Expand Critical Information about Acceleration of Sea Level Rise**: As discussed in comments on Chapter 2, understanding of the acceleration of the sea level rise is critical to effective planning.

  Page 9-3; line 7: Add the following sentences:

"In addition, NOAA reports that the rate of global sea level rise is accelerating: it has more than doubled from 0.06 inches (1.4 millimeters) per year throughout most of the twentieth century to 0.14 inches (3.6 millimeters) per year from 2006–2015." [Note that 3.6mm/year needs to be aligned with the 3.4mm/year reported on p 2-11; see graphic.]

- **Clarify Flood and Inundation Character of Coastal Hazards:** This key message describes coastal hazards primarily in terms of flooding due to storms and rising sea levels. The general reference to "Hazards" in the title obscures the essential flood and inundation nature of the risks described in the text of the message. Note that "erosion" is a result of flooding. Although saltwater intrusion is a coastal risk separate from flooding or permanent inundation, it is minor compared to flooding and only briefly addressed on page 9-4.

  Page 9-3; Line 27: change title of Key Message to "Coastal Flood Hazards Are Increasing Rapidly".

  Page 9-3; Line 28: change to "risk of coastal flood hazards".

- **Clarify Permanent Nature of Sea Level Rise vs. Temporary Nature of Storm Flooding:** The first paragraph on page 9-4 needs to clarify that sea level rise will result in both more extensive, temporary flooding due to storm surges and gradual, permanent inundation of places that are now dry land and above the current high tide line. This permanent inundation begins as more extensive reach of a regular high tide and gradually changes to permanent inundation during all stages of tide to a growing geographic extent.

  Page 9-4; Line 7-9: This sentence is:

  "SLR has escalated the frequency and severity of large and small flooding events (e.g., impacts from extreme storms and more frequent high tide flooding [HTF])."

  It should be revised to be:

  "SLR has escalated the geographic extent and severity of large and small temporary flooding events (e.g., impacts from storms) and are most noticeable at times of high tides [HTF]. Rising sea level will increasingly drive these storm event high tides further inland as well as bring permanent inundation to places that are now dry land. This permanent inundation begins as increased extent of high tides and gradually becomes permanent during all stages of the tide."

Additional edits are needed to the references to “frequency of high tide flooding”.

- **Resolve Different Sea Level Rise Estimates by 2050 and 2100:**

  Page 9-4; line 14 estimates average sea level rise along the US coast by 2050 to be 10-12 inches by 2050. But, page 2-27 gives an estimate of 12-20 inches. The estimates should be consistent (i.e., use a 2000 or a 2020 baseline) or a difference in assumptions should be more clearly described.

  Page 9-20; line 8 repeats the 10-12 inches by 2050 estimate.

  Page 9-4; line 17 refers to sea level rise of 3.6-7.1 feet by 2100 compared to 2020 whereas page 2-29 refers to 3-6 feet. The estimates should be consistent or a difference in assumptions described.

Key Message 9.2. Coastal Impacts on People and Ecosystems Are Increasing

- **Clarify Flood and Inundation Character of Coastal Impacts:** The coastal impacts addressed in this Key Message are primarily flood and inundation. The title should be changed to better identify this risk.

  Page 9-8; Line 7: Change title of Key Message to “Coastal Flood Impacts on People and Ecosystems Are Increasing”.

- **Identify Coastal Flood Impacts on Major Infrastructure Assets:** This Key Message does a good job of addressing the ecosystem risks posed by coastal flooding. The significant impacts of coastal flooding on infrastructure need to be addressed in this Chapter by revising this key message or adding a new key message focused directly on flood and sea level rise risks to major infrastructure. Some impacts of coastal flooding and sea level rise include:
  - Transportation facilities, including highways, railroads, bridges, and ports;
  - Defense assets, including military bases and construction and repair facilities;
  - Wastewater treatment and drinking water treatment facilities;
  - Hospitals and major medical centers; and
  - Energy generation and transportation assets and petroleum refining plants.

  Note that “major infrastructure” generally includes large scale assets that provide services on a regional or national basis. Issues related to management of small-scale infrastructure (e.g., local roads, local power networks, localized water pipes and septic systems) and should be addressed through a community focused planning process.

Risks to major coastal infrastructure facilities are well documented in prior National Climate Assessments and in other chapters of the draft NCA5 (e.g., brief mention of sea level rise in Transportation Chapter). However, the consequences of the cumulative losses of multiple types of infrastructure assets in coastal areas need to be recognized in the Coastal Effects chapter.

The Coastal Effects chapter needs to address flood and sea level rise risk to major infrastructure assets for several reasons:

- Coastal infrastructure assets are critical to the economy and national security and clear assessment of risks of damage or loss of these assets is needed in order to prompt implementation of public and private sector measures to reduce potential damage;
- Planning for new, major infrastructure assets needs to include avoidance of coastal flood and sea level rise risks and new facilities are less likely to be poorly sited in coastal flood and sea level rise risk areas if risks to existing infrastructure assets are well understood; and
- Major infrastructure assets are often a key source of local employment and planning for relocation of communities from coastal flood risk areas needs to be coordinated with planning for relocation of existing facilities and siting of new facilities on higher ground.

- **Describe Community Impacts of Coastal Inundation by Rising Sea Level:** Page 9-9; line 25 refers to the long-term challenges of rising sea level but then speaks to the impacts of saltwater intrusion and related impacts. Although rising groundwater is an important coastal impact of storm flooding and rising sea level, it is far less critical than the expected loss of homes and communities to more expansive and permanent inundation. Local governments face difficult choices about managing development in coastal areas and implementing coastal flood resilience strategies and this chapter should more fully describe expected impacts on homes and communities.

  Page 9-9; line 25: Add a new paragraph describing the extensive, permanent inundation of existing coastal homes and communities expected as a result of rising sea level similar to the following draft paragraphs:

  "Rising sea level will result in the gradual inundation of land area that is now occupied by millions of homes, neighborhoods, and communities in the decades ahead. Some two million homes, about two percent of all US homes, are at risk of inundation as a result of six feet of sea level rise. Almost 300 U.S. cities would lose at least half their homes, and 36 U.S. cities would be completely lost. One in eight Florida homes would be under water. These properties have a value of over $800 billion.

As coastal communities gain understanding of inundation risks, implementation of response strategies, such as protective structures, can delay inundation. In most cases, however, the high cost of such structures and the millions of properties seeking such protection, will limit the percentage of the properties at risk that can be protected. In addition, the expected continuation of sea level rise for decades and centuries will result in the overtopping of even the most ambitious protection structures. Gradual relocation of homes in flood risk areas is likely to be needed."

- **Describe Expected Extent of Wetland Loss to Sea Level Rise:** Although very gradual sea level rise may allow some wetlands to survive in place through a process of accretion, accelerated sea level rise will overcome accretion in many places. A recent USGS study found that coastal wetlands will migrate landward, transforming coastlines but not compensating for the area expected to be lost on the seaward side. This study predicted significant loss of wetlands in several states including Louisiana (29%), Florida (25%), North Carolina (10%), Texas (8%), and South Carolina (7%). On the Pacific coast, some 83% of wetlands are projected to become open water by 2110 and along the Gulf of Mexico, estimated conversion of wetlands to open water varies for each state, with rates from 24% to 37% by 2060.

  Page 9-11; line 8: The phrase "both expanding and declining" is confusing and may be misunderstood to suggest that wetlands benefit from "expanding" in area, rather than expanding into upland areas as they are forced to migrate landward as sea level rises. This landward migration will often result in reduced area and function when it occurs, and many existing wetlands will face obstacles to landward migration and thus will become open water. This sentence should be revised to read: "Tidal wetlands may migrate landward where landscape and lack of human obstructions allow and may transition to open water where migration is not possible. Studies of potential for landward migration suggest that landward migration will not compensate for wetland area lost on the seaward side, with losses exceeding twenty percent in some states."

  Page 9-11; line 10: change "expanded" to "shifted landward".

Key Message 9.3 Transformative Adaptation for Coastal Communities

- **Clarify Meaning of "Transformative" Adaptation**

  Page 9-12; line 10: The Key Message is not really a "message" and should be revised to be more action oriented, e.g., "Transformative Adaptation Needed to Reduce Coastal Storm Flooding and Sea Level Rise Risk".

Page 9-12; lines 15-18: This sentence describing "transformative adaptation" is broadly written to apply to almost any response strategy and does not explain how "transformative" adaptation is different from adaptation that is not transformative (e.g., does attention to inequity make it "transformative," or inclusion of nature-based solutions, or implementation of managed retreat? The sentence as written suggests that almost any response strategy is "transformative":

"Transformative adaptation, including incremental adaptations, community co-development of adaptation strategies, nature-based solutions, and managed retreat, can equitably respond to coastal climate change impacts (high confidence)."

A clearer statement of the need to reimagine the coast and support new policies and programs that are scaled to meet the significant challenges of adapting millions of homes, ecosystems, and major infrastructure assets to more severe storms and rising seas, such as:

"Transformative adaptation strategies consider both storm flooding and sea level rise risks, use nature-based solutions where appropriate, and account for significant long-term sea level rise by making coordinated relocation of communities, ecosystems, and major infrastructure part of coastal flood resilience plans. Although transformative coastal flood resilience strategies need to be coordinated with state and federal programs, they reflect sustained engagement of diverse, local populations and recognize the needs and interests of disadvantaged people. Local governments need both technical and financial support to undertake these strategies."

- **Clarify Limits of Nature-Based Solutions in Reducing Sea Level Rise Inundation:** Although nature-based solutions have many benefits, they are most effective in reducing flooding resulting from storms and have only modest benefits in preventing permanent inundation resulting from rising sea level. A new sentence making this point is needed.

  Page 9-15; line 8: "Nature-based solutions are especially effective in reducing temporary flooding resulting from storm surges and are less effective in preventing inundation of communities and infrastructure from rising seas."

- **Managed Retreat/Relocation of Many Coastal Places is Inevitable:** The discussion of managed retreat focuses on current public reluctance and does not point to the inevitability of relocation in light of the scientific projections of near and long-term sea level rise or the critical importance of coordination of community relocation with efforts to support landward migration of ecosystems and repositioning of major infrastructure.

Page 9-16; line 28: The sentence "Managed retreat may become the only viable response for many coastal communities in the future…." Should be replaced by a new paragraph:

"Managed retreat or relocation will become the only viable response for many coastal communities in the future and should be a central element of transformational adaptation to more severe storms and especially rising sea level. Relocation plans for communities need to be coordinated with plans to facilitate the landward migration of ecosystems as sea level rises and with relocation of major infrastructure assets. Managed retreat policies can initially apply to new construction, steering new homes and businesses away from areas at risk of rising seas. Alignment of local and state policies with existing federal provisions such as the Coastal Barrier Resources Act (CBRA) can facilitate short-term implementation. As sea level rise increasingly threatens existing structures, communities can counter reluctance to relocate with education about long-term sea level rise risks, requirements for disclosure of flood and sea level rise risk at time of property sale or rent, and voluntary buyouts programs. Advancements in social science can enhance insights into how to move policies forward in ways that are most likely to be effective."

Major Uncertainties and Research Gaps

- **Describe Needed Research Related to Ice Sheet Dynamics:** A critical issue in sea level rise projections is the timing of future degradation of the West Antarctic Ice Sheet, and most immediately, the Thwaites Glacier. The current description does not convey the potential for large changes in future sea level rise as a result of changes in Antarctic ice sheets, up to two feet of additional sea level rise due to loss of the Thwaites Glacier, or the potential for these changes to occur within the next decade.

  Page 9-19; lines 31-35: the current text reads:

  "For longer-term impacts (after 2050), major uncertainties and research gaps include improving modeling and observational capabilities to assess long-term global mean SLR trajectories as a function of uncertainties in both emissions pathways and the sensitivity of ice-sheet dynamical processes to a given level of warming, particularly the "low confidence" ice-sheet processes, as per IPCC AR6 (Fox-Kemper et al. 2021)."

  The paragraph should be revised as follows:

  "Major uncertainties and research gaps include improving modeling and observational capabilities to assess long-term global mean SLR trajectories as a function of uncertainties in both emissions pathways and the sensitivity of ice-sheet dynamical

processes to a given level of warming in both Greenland and Antarctica. In Antarctica, new research points to instability in the West Antarctic Ice Sheet and the potential for loss of glaciers in as little as ten years leading to two feet or more of additional sea level rise. Given the large scale of impacts flowing from earlier than expected sea level rise, research to resolve the "low confidence" judgement on ice sheet dynamics per IPCC AR6 (Fox-Kemper et al. 2021) should be a high priority."

- **Develop U.S. Sea Level Rise Annual Rate of Acceleration Reporting Tools:** A key factor in public under-recognition of sea level rise risks is the perception that sea level is barely changing at all and that impacts are far in the future. The steady increases in the annual rate of change (i.e., the acceleration in the rate of sea level rise) are not understood by the public. Although projections of sea level change include many other factors, public failure to appreciate the cumulative impacts of annual increases in sea level rise that are bigger and bigger each year (i.e., acceleration in the rate of sea level rise) undermines recognition of risks and degrades public support for implementation of response measures.

  The data and graphics showing the rate of change of sea level rise available from NOAA, NASA, and EPA generally show the measured or projected cumulative change without noting the annual rate of change. The graphics also show a rising trend line that looks like an increase each year (i.e., straight line) but not a year-to-year increase in the annual rate of increase (e.g., rising curve).

  It would be useful if a federal agency would establish an online indication/metric reporting annual change in sea level for the United States, lower 48, and NCA5 regions expressed as total change from a baseline and as an annual increment, rather than simply global annual total change/increment. Showing this data for the U.S. coast, including each NCA5 region, rather than globally, would also be useful.

  Page 9-19; line 9: add the following:

  "In order to strengthen public recognition of the acceleration of the rate of sea level rise, federal agencies should collaboratively develop web-based graphics showing the year-to-year increment of sea level rise (i.e., acceleration) for the U.S. coast and the NCA5 regions."