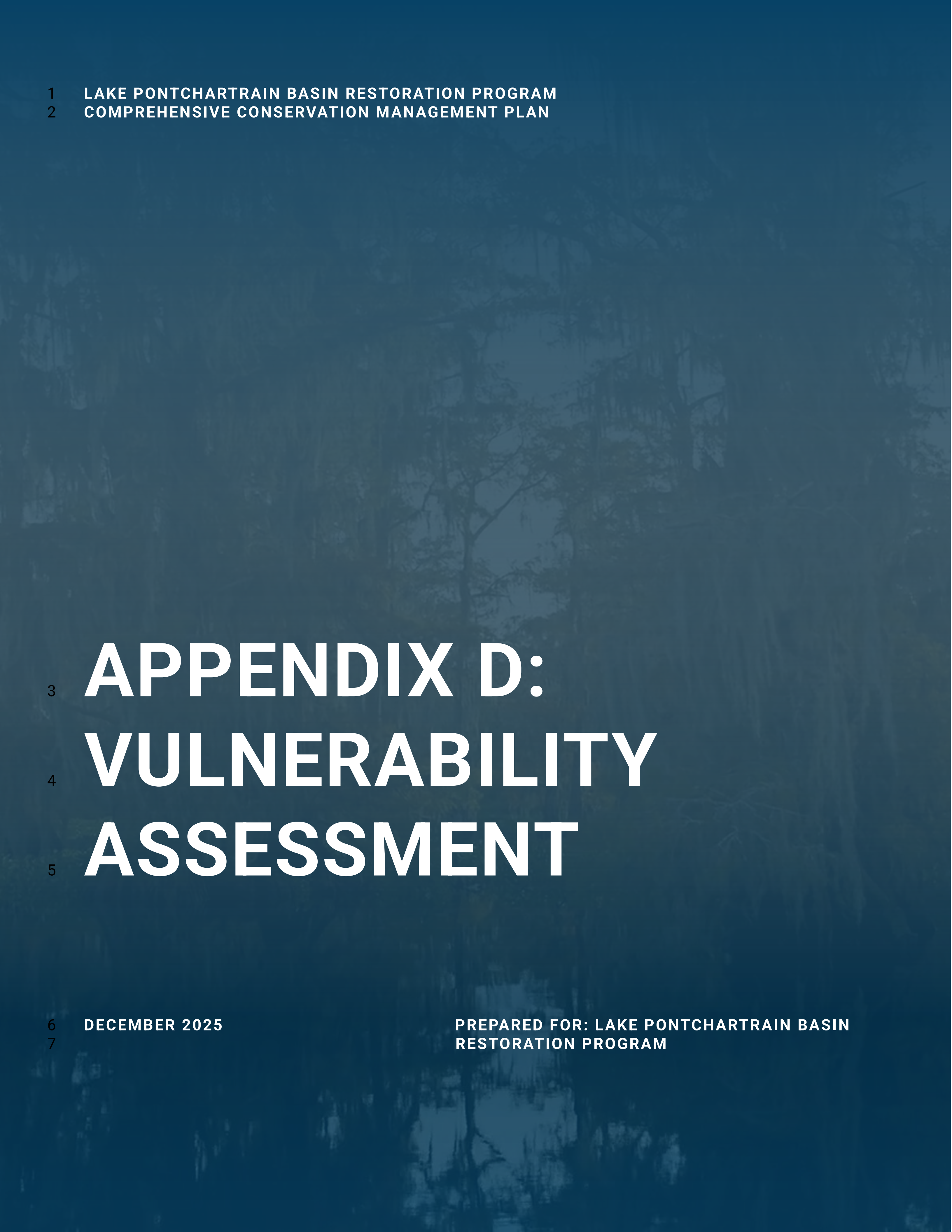

LAKE PONTCHARTRAIN BASIN RESTORATION PROGRAM
COMPREHENSIVE CONSERVATION MANAGEMENT PLAN

APPENDIX D: VULNERABILITY ASSESSMENT

DECEMBER 2025

PREPARED FOR: LAKE PONTCHARTRAIN BASIN RESTORATION PROGRAM

LAKE PONTCHARTRAIN BASIN RESTORATION PROGRAM

The purpose of the Lake Pontchartrain Basin Restoration Program is to restore the ecological health of the basin by developing and funding restoration projects and related scientific and public education projects to reduce the risk of pollution.

CITATION

Lake Pontchartrain Basin Restoration Program. (2025). Appendix D: Vulnerability Assessment. (pp. 1-65).

ACKNOWLEDGMENTS

This document was developed in support of the Lake Pontchartrain Basin Restoration Program's Comprehensive Conservation Management Plan update. The document was prepared by members of the Theodore Roosevelt Conservation Partnership team:

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Additional contributions were made by Work Group members.

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EXECUTIVE SUMMARY

This Vulnerability Assessment was undertaken to determine how climate stressors might affect the goals and objectives of the Lake Pontchartrain Basin Restoration Program's (PRP) Comprehensive Conservation Management Plan (CCMP). The assessment followed the first five steps of the U.S. Environmental Protection Agency's (USEPA) "Being Prepared for Climate Change: A Workbook for Developing Risk-Based Adaptation Plans" (U.S. Environmental Protection Agency (USEPA), 2014). It led to identification and prioritization of 69 risks that could impact the PRP's water quality, habitat, and education and involvement goals. The approach based on the five steps listed in the EPA's Workbook is summarized below:

- **Step 1 – Communication and Consultation:** Engaging with key stakeholders regarding vulnerability assessment topics and getting their input.
- **Step 2 – Establishing the Context for the Vulnerability Assessment:** The goals and objectives related to water quality, habitat health, and education and involvement developed through stakeholder and work group engagement.
- **Step 3 – Risk Identification:** Seven stressors were used: warmer summers, warmer winters, warmer water, increasing drought, increasing storminess, sea level rise, and ocean acidification. Each stressor was examined in relation to CCMP objectives.
- **Step 4 – Risk Analysis:** Potential risks were initially assessed using four criteria: 1) consequence, 2) likelihood, 3) spatial extent, and 4) time horizon; each scored on a three-level scale. This step provided a structured basis for comparing risks across different stressors and objectives.
- **Step 5 – Risk Evaluation:** Results were organized into visual grids that illustrate how consequence and likelihood combine to highlight the distribution of vulnerabilities.

The assessment highlighted that water quality and habitat are directly vulnerable to multiple stressors, including warmer temperatures, increased storminess, and SLR. Several risks rise to the level of high consequence and high likelihood, indicating areas where adaptation and mitigation should be prioritized. While not all risks can be fully addressed, the assessment provides a transparent framework for understanding relative vulnerabilities and aligning those with the program's goals and objectives.

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LIST OF ABBREVIATIONS

Abbreviation	Definition
BMP	Best Management Practice
CCMP	Comprehensive Conservation Management Plan
DO	Dissolved Oxygen
HAB	Harmful Algal Bloom
ID	Increasing Drought
IPCC	Intergovernmental Panel on Climate Change
IS	Increasing Storminess
MRGO	Mississippi River Gulf Outlet
OA	Ocean Acidification
PRP	Lake Pontchartrain Basin Restoration Program
PPT	Parts per Thousand
SAV	Submerged Aquatic Vegetation
SGCN	Species of Greatest Conservation Need
SL	Sea Level
SLR	Sea Level Rise
SPEI	Standardized Precipitation-Evapotranspiration Index
SST	Sea Surface Temperatures
TSD	Temperature-dependent Sex Determination
USEPA	U.S. Environmental Protection Agency
WS	Warmer Summers
WWa	Warmer Water
WWi	Warmer Winters

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INTRODUCTION

This Vulnerability Assessment was undertaken as part of the 2026 update to the Lake Pontchartrain Basin Restoration Program (PRP) Comprehensive Conservation Management Plan (CCMP). The purpose of this assessment is to ensure that climate considerations are integrated into the CCMP development process. As the Pontchartrain Basin continues to experience rapid environmental change, this assessment provides a structured approach to evaluating how climate stressors may influence ongoing restoration, management, and community resilience efforts.

The need for this document arose from both local and national priorities. The U.S. Environmental Protection Agency (USEPA) encourages programs to incorporate climate resilience into their planning processes to better protect water quality, habitats, and communities. Within the Pontchartrain Basin, recurring coastal storms, increasing rainfall variability, rising air temperatures, and land subsidence have intensified concerns about long-term ecosystem health and infrastructure resilience. Developing a basin-specific assessment allows the PRP to systematically identify, assess, and prioritize these risks so that adaptive strategies can be embedded within the updated CCMP.

The Pontchartrain Basin encompasses approximately 10,000 square miles across 16 Louisiana parishes, spanning freshwater, brackish, and saline environments. It supports extensive wetlands, bottomland hardwoods, barrier islands, and open-water systems. Climate data for the region show increasing average annual temperatures (National Oceanic and Atmospheric Administration [NOAA], n.d.) and greater variability in precipitation patterns (Figure 1) over the past several decades (Calvin et al., 2023; U.S. Environmental Protection Agency (USEPA), 2016b). These trends, coupled with accelerating relative sea level rise (Calvin et al., 2023; Marvel et al., 2023) and changes in storm frequency and intensity (U.S. Environmental Protection Agency (USEPA), 2016e), are already influencing salinity regimes, water quality, and habitat distribution throughout the basin (see Appendix B).

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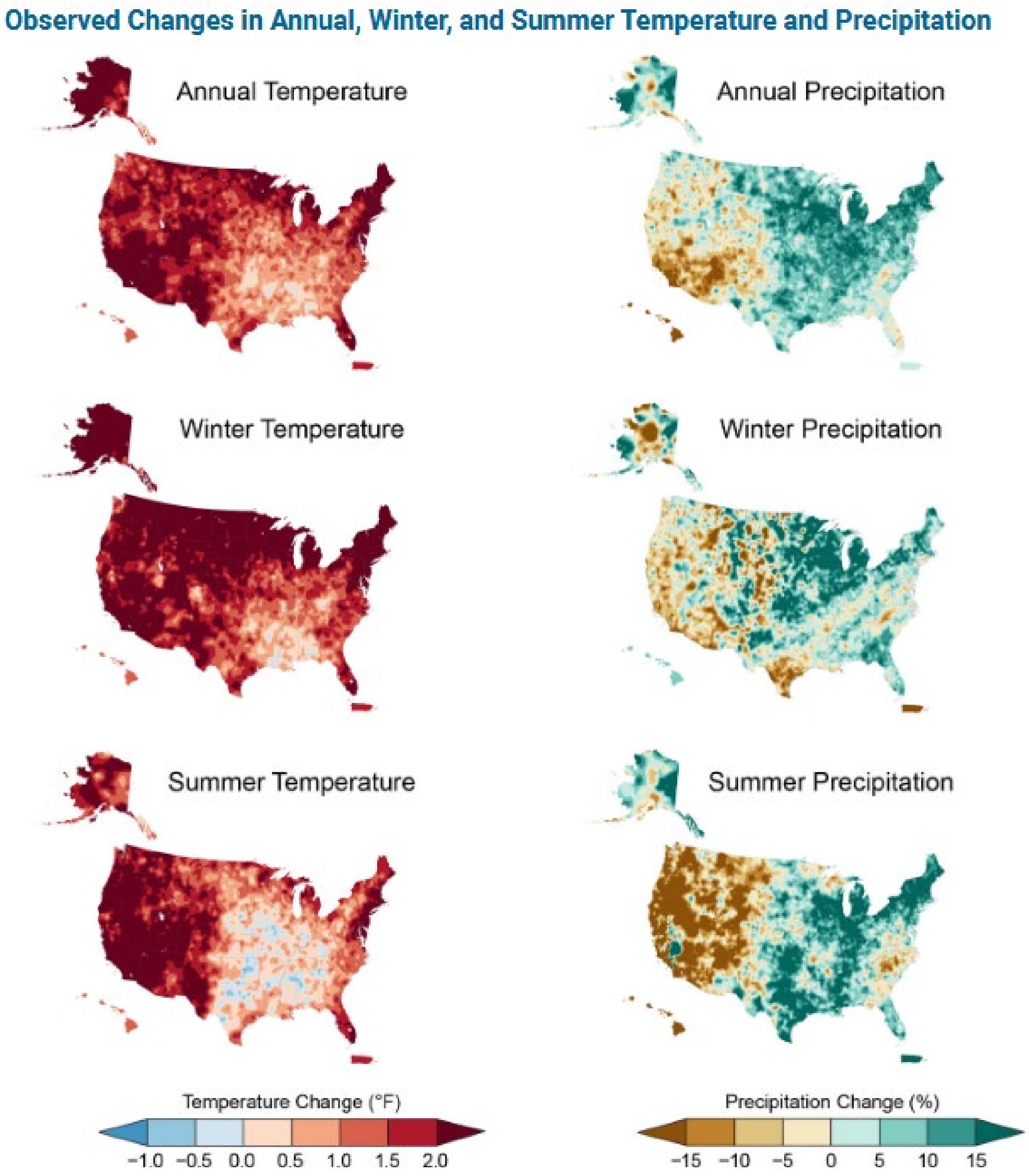

Figure 1. Changes shown are the difference between the annual average or seasonal temperatures (left column) and precipitation totals (right column) for the present day (2002–2021) compared to the average for the first half of the last century (1901–1960) (from Marvel et al. 2023).

Development of this assessment also included engagement with key stakeholders and regional partners to identify shared priorities, refine issue topics and categories, and ensure that the results are meaningful for ongoing planning and implementation (see Appendix H). Stakeholder input helped identify locally relevant concerns and verify that the most pressing risks to the CCMP's water quality, habitat, and education and involvement goals were captured.

The first five steps of USEPA's "Being Prepared for Climate Change: A Workbook for Developing Risk-Based Adaptation Plans" (hereafter referred to as the Workbook; U.S. Environmental Protection Agency (USEPA), 2014) were followed to learn and prepare for how climate stressors might affect the three CCMP goals and nine objectives. This risk-focused approach was developed to consider how the identified risks impact the CCMP. The assessment identified 69 risks that could impact the PRP's water quality, habitat, and education and involvement goals.

Vulnerability Assessment Process

The purpose of the Workbook is to "assist organizations that manage environmental resources to prepare a broad, risk-based adaptation plan." (USEPA, 2014). The Workbook is a step-by-step methodology where Steps 1 through 5 comprise the Vulnerability Assessment and Steps 6 through 10 are used to develop an Action Plan. The Vulnerability Assessment steps are described below:

- **Step 1**—Communication and Consultation
    - Informing key people about the vulnerability assessment and asking for input.
- **Step 2**—Establishing the Context for the Vulnerability Assessment
    - Identifying organizational goals that are susceptible to environmental change.
- **Step 3**—Risk Identification
    - Brainstorming about how climate stressors will interact with your goals.
- **Step 4**—Risk Analysis
    - Developing an initial characterization of consequence and likelihood for each risk.
- **Step 5**—Risk Evaluation: Comparing Risks
    - Using a consequence/probability matrix to build consensus about each risk.

VULNERABILITY ASSESSMENT STEPS

Introduction

A vulnerability assessment is a valuable tool that supports communication, coordination, and decision-making with leadership, partners, and other agencies, while also helping identify risks and potential mitigation options before action planning begins. The assessment can be used to compare systems, find common challenges, and build partnerships, as well as to secure resources and support.

Step 1: Communication and Consultation

Climate considerations were incorporated throughout the stakeholder and working group engagement process. During development of the Issue Report (Appendix B), Working Group members discussed climate-related concerns as part of broader conversations on land loss, water quality degradation, flooding, and habitat change. Work group members reviewed and provided feedback directly on the draft vulnerability assessment. Public engagement activities captured local perspectives on extreme weather, flood risk, and environmental change, which in turn informed the identification of priority issues and subsequent vulnerability considerations.

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The overall engagement process, as summarized in Appendix H, ensured that the Vulnerability Assessment reflects the collective input of basin stakeholders, local governments, and resource managers. The influence of climate-related drivers was consistently recognized, and these perspectives helped shape the framing of risks, the refinement of objectives, and the development of management actions.

Step 2: Establishing the Context for the Vulnerability Assessment

The CCMP goals and objectives were developed to guide restoration and protection efforts within the Lake Pontchartrain Basin in a way that reflects the region’s environmental realities and long-term resilience needs. Their development was grounded in the same context and understanding that underpins this Vulnerability Assessment. They recognize that changing conditions such as increasing temperatures, sea level rise, altered precipitation patterns, and storm impacts influence every aspect of basin management.

Through this robust stakeholder and workgroup engagement process, the following goals and objectives were developed:

Water Quality Goal: Improve Pontchartrain Basin water quality through point and nonpoint pollutant source reduction to support ecological health.

Water Quality Objectives

- WQ1: Provide a technical basis for the formulation of water quality improvement actions through water quality monitoring, needs assessment, and research.
- WQ2: Reduce adverse impacts of urban runoff; sewage; and agricultural, industrial, and commercial activities by improving stormwater management, promoting best management practices, and implementing restoration projects.

Habitat Goal: Promote sustainability of important land-based and aquatic habitat in the Pontchartrain Basin.

Habitat Objectives

- H1: Reduce loss of wetlands and restore the hydrologic exchanges that sustain them where possible.
- H2: Promote sustainable aquatic habitats, including submerged aquatic vegetation, to support diverse native flora and fauna.
- H3: Manage invasive species to reduce impacts to ecological health.
- H4: Protect and restore habitat for species of greatest conservation need and threatened natural communities.

Education and Involvement Goal: Increase awareness of current and future ecological health issues in the Pontchartrain Basin to encourage active participation in efforts to increase environmental sustainability.

Education and Involvement Objectives

- E1: Educate the public on the effects of the changing ecological health of the basin to promote responsible stewardship.

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- E2: Identify and promote local efforts to improve the ecological health of the basin.
- E3: Promote increased public participation in water quality improvement and habitat restoration projects.

Step 3: Risk Identification

To assess the vulnerability of the Pontchartrain Basin to climate-related risks, this assessment includes seven key stressors. These stressors were selected based on a combination of: (a) the national and regional evidence for changing climate conditions based on the USEPA Workbook, (b) documented historical or emerging trends within the basin and its watershed (Appendix B), and (c) the relevance of these conditions to the basin's three CCMP goals around water quality, habitat, and education and involvement.

Over the past 50 years, the average annual temperature for parishes/counties in the basin has had a consistent upward trend (see Figure 5 in Appendix B). Between 2010 and the present (2024), average summer temperatures have increased to between 83 °F and 85 °F (National Oceanic and Atmospheric Administration [NOAA], n.d.). The number of extreme heat days in Louisiana rose from 47 in 2021 to 82 in 2023, equivalent to nearly three months of intense heat (Plyer et al., 2025). Combined, these trends underline the importance of the increasing ambient air/habitat temperature stressor (Figure 2). These national and statewide patterns are reflected at the basin scale, where long-term station data show a consistent increase in average temperatures across the basin.

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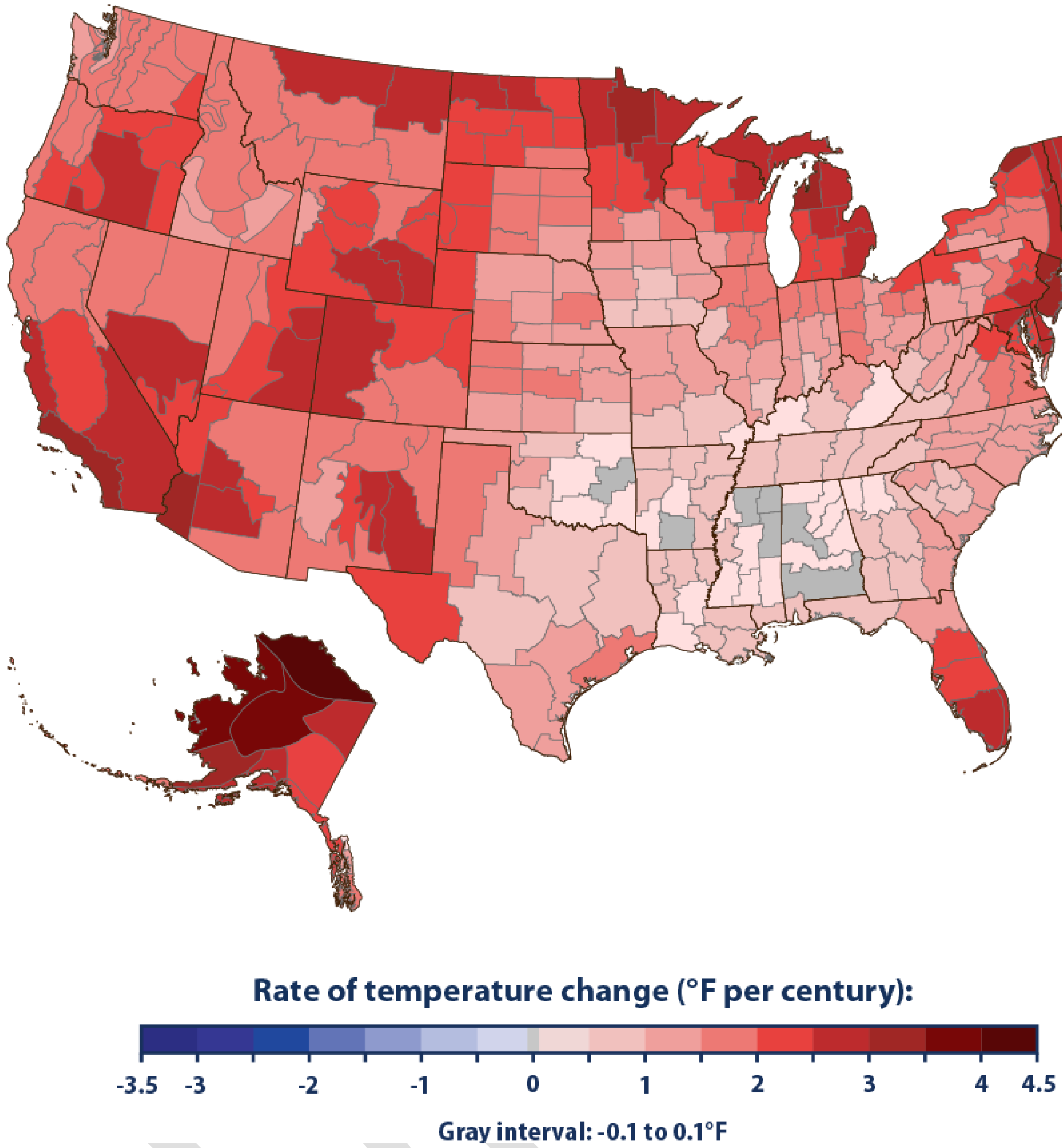

Figure 2. Rate of Temperature Change in the United States, 1901–2023 (U.S. Environmental Protection Agency (USEPA), 2016f)

To supplement national and statewide trends, a basin-specific analysis was conducted using long-term temperature records from representative weather stations located within the basin (NOAA National Centers for Environmental Information (NCEI), 2025). The stations included four in Louisiana, located in New Orleans (Airport and Lakefront), Baton Rouge, and Slidell, and one station in Mississippi, located in McComb (Figure 3). For each station, mean annual temperature by decade was calculated by first deriving daily mean temperature as the average of daily maximum and minimum temperatures, then averaging daily values to annual means and aggregating those annual means by decade to reduce interannual variability and highlight long-term trends.

Across all stations, the results show a clear and consistent warming signal beginning in the mid- to late-20th century, with the most pronounced increases occurring from the 1990s through the 2010s and into the 2020s. Absolute temperatures vary spatially across the basin, reflecting differences in latitude, urbanization, and proximity to Lake Pontchartrain. The direction and magnitude of change are consistent, indicating that rising ambient air temperatures are a basin wide phenomenon rather than a localized anomaly.

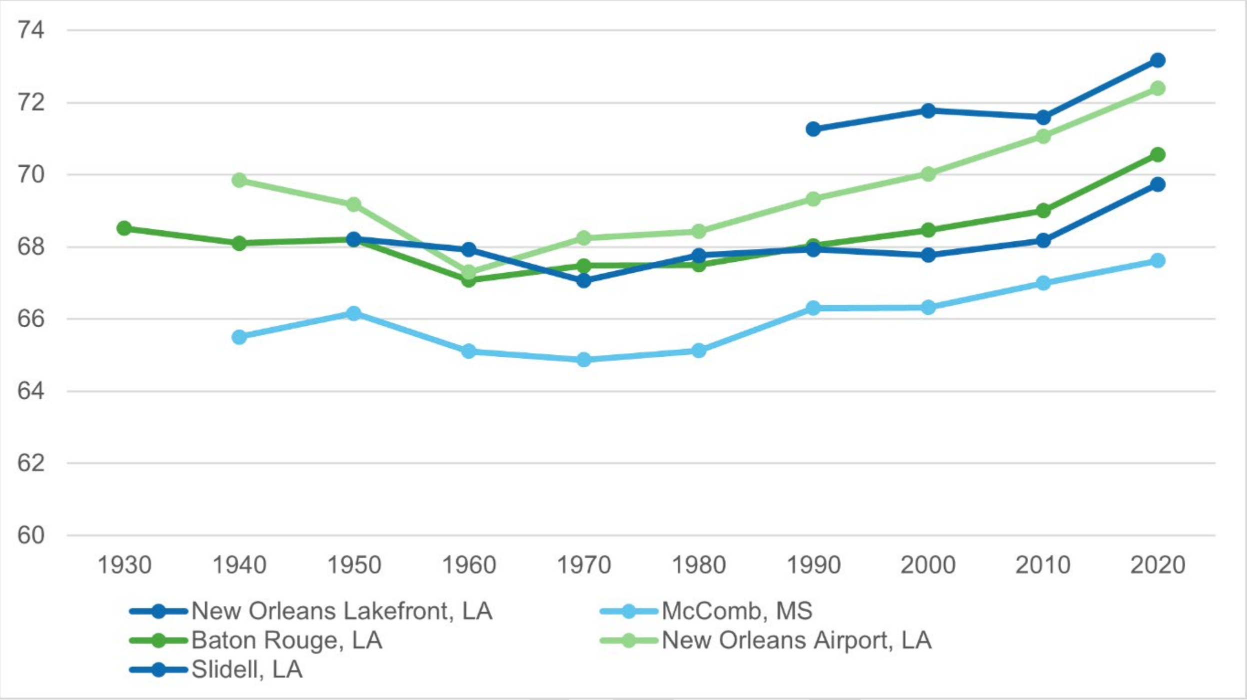

Figure 3. Mean decadal temperature trends (°F) derived from long-term weather stations located within the Pontchartrain Basin, including New Orleans (Lakefront and Airport), Baton Rouge, Slidell, and McComb, 1930–2020 (NOAA National Centers for Environmental Information (NCEI), 2025).

Historical sea surface temperature (SST) records for the northern Gulf of America show a clear long-term warming trend that is consistent with, and in some seasons exceeds, global ocean warming rates. The in-situ observations synthesized by Allard et al., (2016) indicate that SSTs across the Gulf increased throughout the twentieth century, with basin wide warming evident in both winter and summer (Figure 4). More recent analyses extending the record through 2020 show that Gulf SSTs have warmed by approximately 1°C since 1970, which is roughly double the global average SST warming rate over the same period (Day et al., 2024; Z. Wang et al., 2023). This warming has been most pronounced during summer, although winter temperatures have risen as well, contributing to overall higher annual minimums and a longer warm-water season. Collectively, these results demonstrate that Gulf waters adjacent to the Pontchartrain Basin are warming in every season, reinforcing the broader regional stressor of increasing ocean and nearshore water temperatures.

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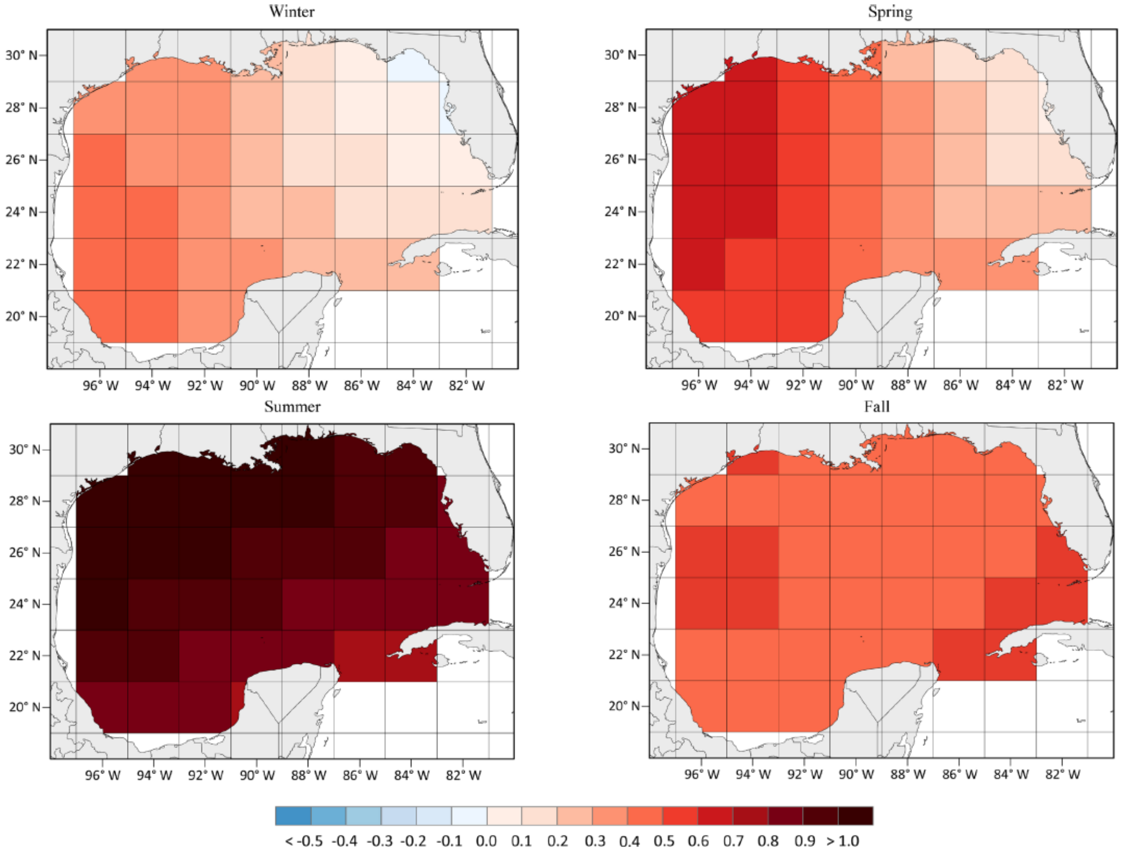

Figure 4. Seasonal mean sea surface temperature (SST) trends (°C) derived from slope of trendlines form 2° by 2° grid cells between 1901 and 2010 for winter, spring, summer, and fall (Allard et al., 2016)

Although these analyses focus on Gulf-wide SST patterns, the observed warming trends are directly relevant to the Pontchartrain Basin, which is hydrologically and oceanographically connected to the northern Gulf through tidal inlets and exchange with Lake Borgne and the Mississippi Sound. Elevated Gulf SSTs influence thermal conditions in nearshore waters and estuarine receiving areas, increasing baseline water temperatures within the basin and amplifying seasonal heat stress on temperature-sensitive habitats and species. As a result, Gulf-scale SST warming provides a critical indicator for understanding ongoing and future changes to aquatic conditions within the basin.

While the basin has not historically been identified as strongly drought-prone based on the EPA's "Average Change in Drought (5-Year Standardized Precipitation–Evapotranspiration Index [SPEI])" dataset (Figure 5), the potential for shifting precipitation/evapotranspiration balances makes drought stress relevant. In recognition of long-term climate projections (Marvel et al., 2023) and the Workbook's inclusion of drought among possible stressors, this factor is retained. Even if past conditions may not have shown large drought increases in the basin, the trend toward greater variability and the possibility of extended dry periods warrant inclusion.

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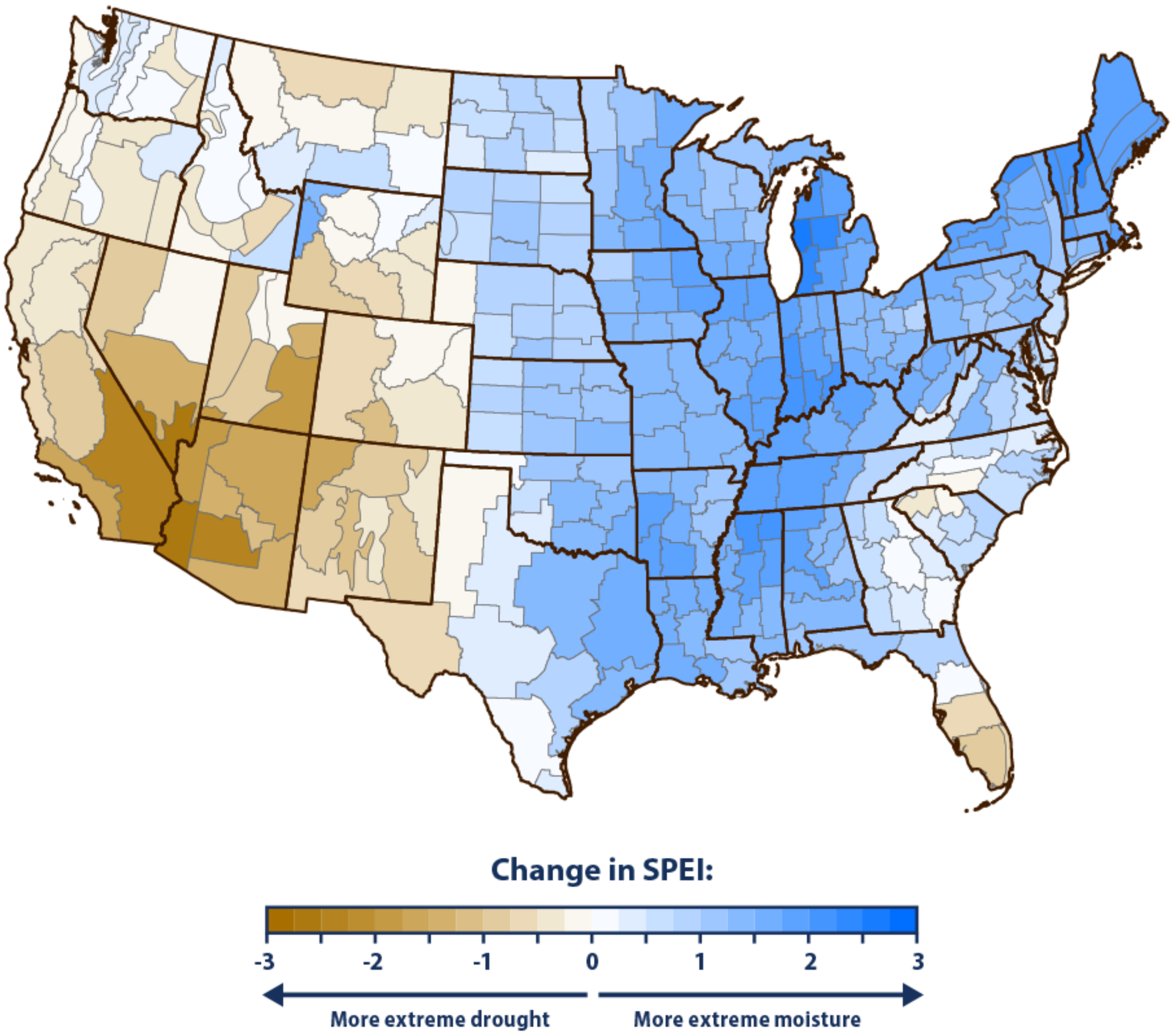

Figure 5. Average Change in Drought (Five-Year SPEI) in the Contiguous 48 States, 1900–2023 (U.S. Environmental Protection Agency (USEPA), 2016a).

Louisiana's coastal areas, including the basin, are grappling with rapid sea level rise and coastal inundation (Figure 6), with projections of 22–32 inches of rise by 2050 (relative to 2000) in places like Grand Isle (Hoffman et al., 2023). Observed rates of about 4 inches per decade are documented (Marvel et al., 2023; see Figure 19 in Appendix B). This stressor is central for the basin given its low-lying wetlands, subsidence, salt-water intrusion, and coastal storm surge exposure, all of which impact habitat integrity and water-quality pathways.

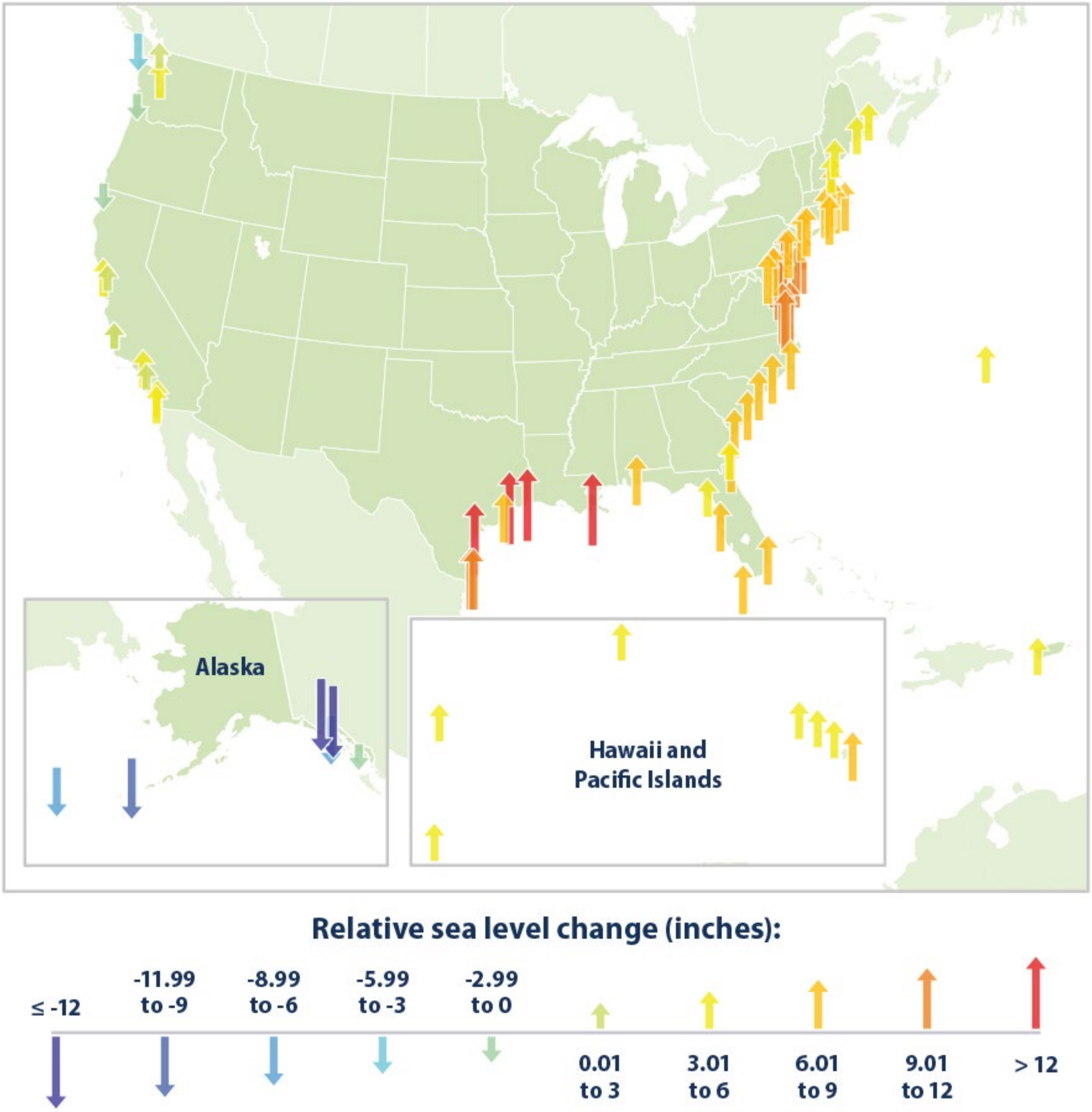

Figure 6. Relative Sea Level Change Along U.S. Coasts, 1960–2023 (U.S. Environmental Protection Agency (USEPA), 2016d).

Although long-term trends in tropical cyclone frequency at U.S. landfall remain uncertain (Figure 7), warmer sea-surface temperatures and increased atmospheric moisture create conditions conducive to more intense storm rainfall and rapid intensification (Seneviratne et al., 2021). Accordingly, the extreme precipitation and intense-storm event stressor is relevant to the basin, where heavy rainfall, storm surge, and flash flooding are key drivers of both water quality and habitat risk. The difficulty in attributing historical changes in storm frequency specifically to the basin further supports focusing on storm intensity and rainfall impacts, which represent the dominant pathways of hurricane-related risk within the basin.

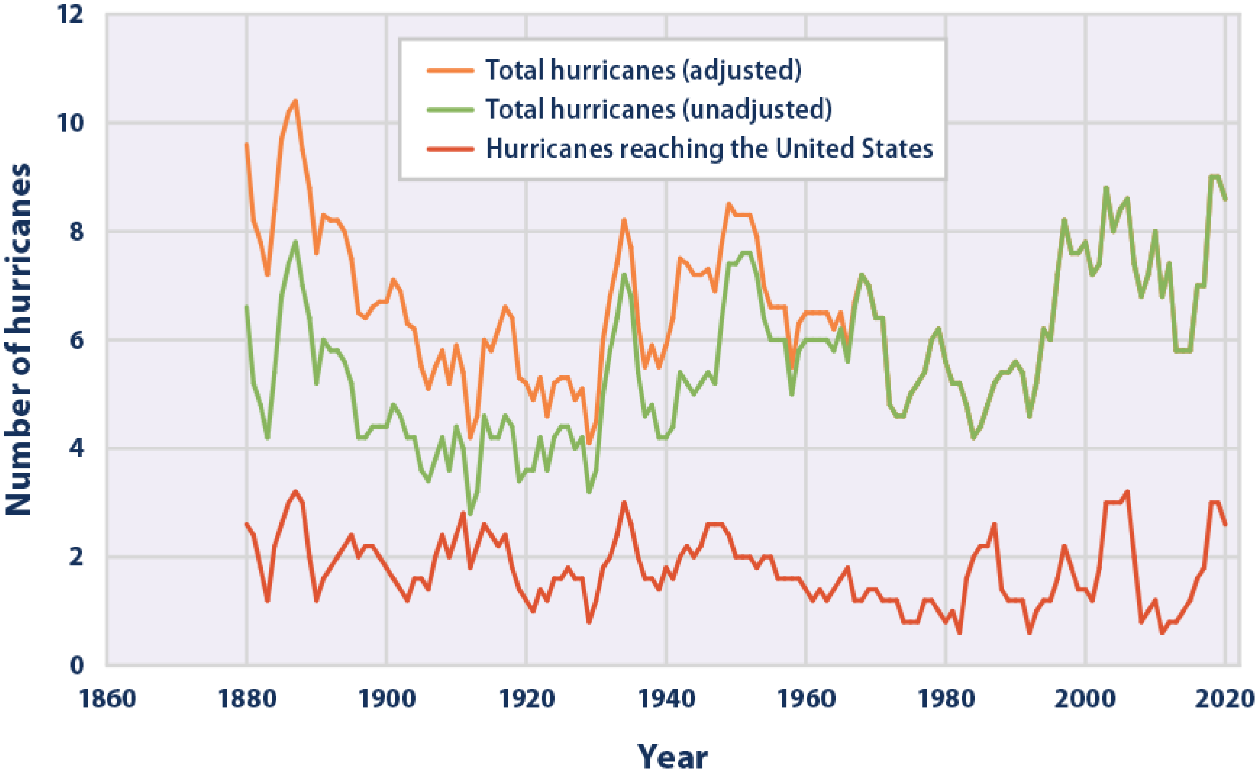

Figure 7. Number of Hurricanes in the North Atlantic, 1878–2022 (U.S. Environmental Protection Agency (USEPA), 2016e).

The seventh stressor, ocean acidification, is included for completeness, given the EPA Workbook framework, although its direct application to the Pontchartrain Basin is comparatively limited. Estuarine acidification remains an emerging concern in coastal systems globally, and while the basin's salinity-driven tidal/estuarine dynamics differ from open-ocean systems (Figure 8), inclusion of this stressor helps maintain consistency with the Workbook's list of potential vulnerabilities and preserves flexibility for future monitoring or management focus.

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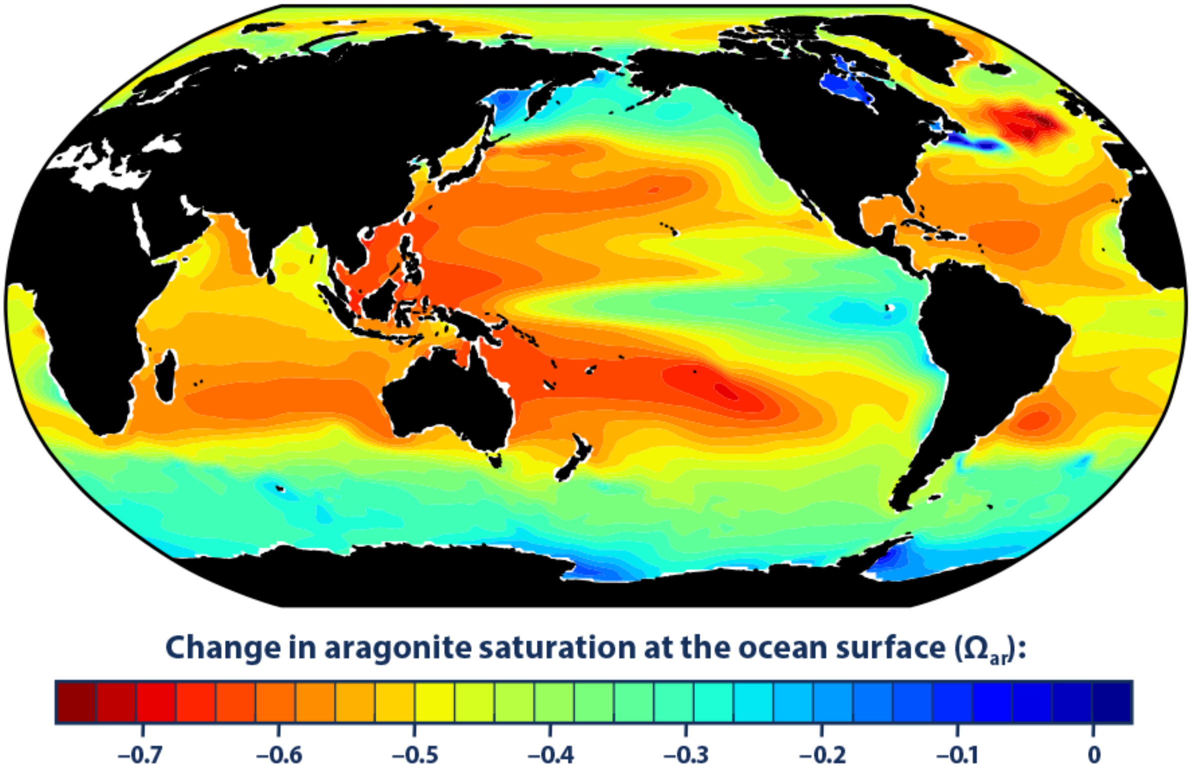

Figure 8. Changes in Aragonite Saturation of the World's Oceans, 1880–2015 (U.S. Environmental Protection Agency (USEPA), 2016c)

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Each of these seven stressors is supported either by documented basin conditions (e.g., rising temperatures, sea level rise) or broader climate science and national indicator sets (e.g., heavy precipitation, drought potential) that align with the basin's CCMP goals. The list below presents each stressor from Step 3 of the Workbook along with its summary:

- Warmer Summers (overall climate)
    - This stressor is generally about the warm season being even warmer. This stressor (like warmer winters, below) is about the general climate. Air, surface, soil, and groundwater temperatures will be warmer and for longer periods of time. The general climate effects of having warmer oceans or lakes are included here.
- Warmer Winters (overall climate)
    - This stressor is about a cold season not being as cold as it formerly was, with significant implications for the PRP in terms of the loss of freeze events.
- Warmer Water
    - This stressor (regardless of season) comes from a higher temperature of water bodies (including the ocean) and affects the chemical, physical, or biological characteristics of the water body itself.
- Increasing Drought
    - Drought is a deficiency in precipitation over an extended period. The magnitude of the deficiency, the duration, or the number of droughts could be greater.
- Increasing Storminess

  - This category encompasses all aspects of intensifying precipitation in any form: more seasonal precipitation, more total precipitation during events, and higher rates of precipitation during events. Stronger or more frequent occurrences of extratropical and tropical cyclones, blizzards, or other weather conditions are included here. If they are acting as stressors, then floods, waves, coastal storm surge, and winds are part of this storminess category.
- Sea Level Rise (SLR)
  - This stressor is about the ocean being higher than it formerly was. It includes effects of higher water levels right at the shore, as well as how elevated coastal water levels affect inland systems.
- Ocean Acidification
  - This category is primarily conceptualized as related to ocean acidification driven by the higher atmospheric concentrations of carbon dioxide.

These stressors are listed as column headers in the table below (Table 1) and are linked to the CCMP goals, which are listed in the first column of the table via objectives listed out in each cell. This is an important brainstorming exercise to start understanding how the stressors will impact the goals and objectives of the CCMP.

Table 1. CCMP goals and objectives linked to each of the Workbook stressors.

GOALS	WARMER SUMMERS	WARMER WINTERS	WARMER WATER	INCREASING DROUGHT	INCREASING STORMINESS	SEA LEVEL RISE	OCEAN ACIDIFICATION
Water Quality: Improve Pontchartrain Basin water quality through point and nonpoint pollutant source reduction to support ecological health	WQ1; WQ2	WQ1; WQ2	WQ1	WQ1; WQ2	WQ1; WQ2	WQ1; WQ2	WQ1
Habitat: Promote sustainability of important land-based and aquatic habitat in the Pontchartrain Basin	H1; H2; H3; H4	H1; H2; H3; H4	H2; H3; H4	H1; H2; H3; H4	H1; H2; H3; H4	H1; H2; H3; H4	H2; H4
Education and Involvement: Increase awareness of current and future ecological health issues in the Pontchartrain Basin to encourage active participation in efforts to increase environmental sustainability	E1; E2; E3	E3	E1; E2; E3	E2; E3	E1; E2; E3	E1; E2; E3	N/A

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Step 4: Risk Analysis

Step 4 is the risk analysis stage, where an initial list of risks was developed and characterized for the Pontchartrain Basin. These risks were analyzed using available studies/data, expert analysis, and stakeholder engagement. Each risk was evaluated according to four parameters: consequence of impact, likelihood of occurrence, spatial extent of impact, and time horizon until the risk occurs. To ensure consistency, the Workbook framework was used, which applies a three-level scale (A–C) for each parameter. These scales provide a standardized way to judge the relative severity and timing of risks across a wide range of potential climate stressors.

1. **Consequence** - is the effect the risk would have on the CCMP's goals and objectives were it to occur
    a. Low (life will go on; not as important as many other things; could adjust)
    b. Medium
    c. High (major disruption; goal is out of reach or not even attainable)
2. **Likelihood** - is the chance of the risk actually occurring (i.e., probability) and how likely it is to affect the CCMP's goals and objectives.
    a. Low
    b. Medium
    c. High
3. **Spatial Extent** – is the proportion of the CCMP's geographic area that the risk will affect
    a. Site (e.g., a few waterfront lots, a bridge, a sewage treatment plant)
    b. Place or region (e.g., community, harbor, state park, wildlife refuge, sub-watershed)
    c. Extensive (most of the watershed or most of the estuary)
4. **Time Horizon** – is the time until the problem begins to have an impact
    a. More than 30 years
    b. 10-30 years
    c. Already occurring or 0-10 years

The analysis is organized by the seven climate stressors identified for this assessment: warmer summers, warmer winters, warmer water, increasing drought, increasing storminess, SLR, and ocean acidification. For each stressor, separate subsections address risks to water quality and to habitat. Within most subsections, a table (Tables 2-13) presents the risks associated with that stressor, including:

- The assigned risk number (for cross-referencing in Step 5),
- A short description of the risk,
- The CCMP objectives that may be affected,
- The four scaled parameters (consequence, likelihood, spatial extent, time horizon).

Each table is followed by a series of narrative paragraphs that summarize the risks and provide additional explanation for the scales. These descriptive summaries help place the tabular information into context, clarifying why risks were scored as they were and highlighting the implications for CCMP goals. Education and Involvement (E&I) risks are not presented in individual tables since education and involvement risks tend to be secondary to the water quality and habitat risks. E&I risks are discussed more at the end of the Step 4 section with direct references to the water quality and habitat risk tables.

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By organizing Step 4 in this way, the assessment creates a clear, stressor-specific inventory of risks to both water quality and habitat in the Pontchartrain Basin. This structured analysis forms the foundation for Step 5, where the risks are compiled into matrices to visualize their relative importance across CCMP goals.

WARMER SUMMERS STRESSOR

Water Quality Risks

Table 2. Warmer summer stressor water quality risks.

RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
WS-1	Increased eutrophication (excess nutrients in water) and hypoxia (low oxygen) in all bodies of water.	WQ2	B	B	B	B
WS-2	More harmful algal growth.	WQ1; WQ2	C	C	B	B
WS-3	Increased evapotranspiration within the watershed will increase surface water pollutant concentrations.	WQ1	A	C	C	C
WS-4	Increased degradation of grass/pasture, which may require greater irrigation and increase nutrient runoff.	WQ2	B	B	C	B

WS-1: Warmer summer temperatures can lead to increased decomposition rates of organic matter, increasing nutrient availability (U.S. Environmental Protection Agency (USEPA), 2025). The increased temperatures will also decrease the amount of oxygen dissolved in water and, in concert with increased decomposition, will deplete the oxygen more quickly. These risks are highly likely to be realized in the coming decades, with the watershed streams at greater risk than in Lake Pontchartrain and the estuary due to differences in water volume (depth).

WS-2: Warmer summer temperatures will increase primary production, creating more favorable conditions for harmful algal blooms (HABs) (Wells et al., 2020). Warmer conditions can extend bloom duration and potentially expand the seasonal window when HABs occur. These events negatively impact water quality, affect oxygen levels, and may release toxins that threaten fish, birds, and other wildlife, while also diminishing recreational use of lakes and estuaries. Within the Pontchartrain Basin, such blooms are likely to disrupt ecological balance and limit opportunities for safe swimming, boating, and fishing. These HABs are already impacting the basin, with high and increasing consequences projected further into the future as sustained higher summer temperatures intensify.

WS-3: Warmer summer temperatures will increase evapotranspiration rates in the watershed, decreasing surface water volume. This decrease in volume will increase the measured concentration of pollutants in the surface water. Within the Pontchartrain Basin, shallow streams and water bodies are at the greatest risk, but

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assuming normal precipitation levels with warmer summer temperatures, the percent change in concentration would be relatively minor. Given the slow rate of temperature increase over time, this is happening now and should slowly increase, becoming more severe in the future.

WS-4: Warmer summer temperatures will increase evapotranspiration rates in grass/pasture areas, leading to a water deficit and desiccation of the vegetation. Consequently, increased irrigation may be required, increasing the runoff of nutrients (non-point) discharged into waterways. This risk applies to both developed lands, where the majority of turfgrass is located, as well as agricultural lands where pastures are found. This risk is expected to increase in the future.

Habitat Risks

Table 3. Warmer summer stressor habitat risks.

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RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
WS-5	More stressed natural communities allow for an increased likelihood of the establishment of invasive species.	H3; H4	B	C	C	B
WS-6	Change in the male/female ratio due to temperature-dependent sex determination of certain nesting reptiles (e.g., sea turtles, alligators, and terrapins).	H2; H4	C	C	B	B
WS-7	Decreased riverine flow from increased human water consumption and evaporation.	H1; H2	B	A	B	B
WS-8	Changes to birding and ecotourism activities due to changes in species composition and/or migration timing.	H2; E3	A	C	B	A

WS-5: Warmer summers can increase transpiration and potential dehydration, leading to premature leaf drop of trees that need to conserve water and negatively impact the effectiveness of photosynthesis (Teskey et al., 2015). These changes can result in reduced growth and productivity. Any disturbance in natural communities can be exploited by invasive species such as Chinese tallow (*Triadica sebifera*) (Yang et al., 2021). In the Pontchartrain Basin, these risks are highly likely to be realized in future decades and cover large areas. Consequences are considered medium if invasive species management is actively pursued.

WS-6: The sex of a sea turtle hatchling is determined by the incubation temperature of the eggs during a critical period of development, and higher incubation temperatures lead to a higher proportion of female hatchlings (Laloë et al., 2024). This is also the case for American alligators (*Alligator mississippiensis*) (Ferguson & Joanen, 1983) and diamond-backed terrapins (*Malaclemys terrapin*) (Lamont et al., 2024). A heavily female-biased population leads to limited reproduction, reduced genetic diversity, and, for some species, increased risk of extinction. Several sea turtles and terrapins are considered Species of Greatest Conservation Need (SGCN) in the Pontchartrain Basin.

WS-7: Decreased river flows can have impacts on adjacent habitats and those within the stream channel. Lower water levels decrease the overall area of rivers and streams, eliminating riffles, pools, and other features important for fish and other aquatic organisms. Dropping water levels expose riverbanks, leading to the loss of riparian vegetation (Larsen & Alp, 2015), which can be important for mammals, piscivorous birds, and reptiles. Within the Pontchartrain Basin, these effects would be most felt in the rivers and streams draining into Lake Pontchartrain (e.g., the Amite, the Tickfaw, and the Tangipahoa). These effects are expected to have medium consequences due to the array of species potentially impacted (Alford, 2014), but the likelihood is low, as water for human consumption is mostly from groundwater. Any effects will be over a decade into the future.

WS-8: As temperatures increase, conditions may move outside those most suitable for the life cycle of avian species, and their geographic range can change. Changes in climate and vegetation can alter plant and insect communities, influence the availability of food and water, and shelter for birds. Eastern forest species, including warblers, thrushes, woodpeckers, and flycatchers, are considered most vulnerable to increasing summer temperatures[1], and several of these are already seen as SGCN within the Pontchartrain Basin. There is a high likelihood of such range changes occurring, but these are associated with higher increases in temperatures expected more than 30 years out. As few species migrate through Louisiana in the summer, the effect via migration patterns is low.

WARMER WINTERS STRESSOR

Water Quality Risks

Table 4. Warmer winter stressor water quality risks.

RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
WWi-1	Less dissolved oxygen (DO) due to increased water temperature.	WQ1	B	C	C	C
WWi-2	Increased aquatic debris from an increase in recreational activities.	WQ2; E3	B	B	B	B

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[1] Access at the following link: https://www.audubon.org/climate/survivalbydegrees/state/us/la

RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
WWi-3	Increased use of insecticides/herbicides due to higher overwintering survival rates of pests and invasives.	WQ2	C	B	C	B
WWi-4	More expressions of eutrophication and longer hypoxia events in estuarine bodies of water.	WQ1; WQ2	B	A	C	B
WWi-5	Longer growing seasons, which may result in more inputs of chemicals and nutrients into groundwater (from increased application of fertilizers, pesticides, etc.).	WQ2	A	B	B	C

WWi-1: Warmer winters will lead to greater water temperatures, which decreases the amount of oxygen dissolved in the surface waters. These lower DO levels can negatively impact fisheries, including fish and benthic organisms. There is a low level of risk impacting most fisheries. However, consequences are high for benthic (things living on the bottom) organisms, at greater risk from low DO levels. This condition is already expressed in the shallow rivers of the basin during low or no flow and will more severely impact small lakes, which do not have significant mixing of the water column (Chapra et al., 2021).

WWi-2: Warmer winter conditions may extend the length of the year when people actively participate in recreational boating and other water-related activities. An increase in these activities can increase the amount of debris that litters the coastal shorelines and river launches, ending up in the surface waters. The risk is moderate in navigable rivers and in the Pontchartrain Estuary. The risk could be mitigated with public awareness campaigns focused on decreasing littering. The lower part of the Pontchartrain Basin would be at the greatest risk.

WWi-3: Warmer winters could increase survival rates of pests and weedy plant species, as well as lengthen their active season. Consequently, there would be an increase in the use of pesticides/herbicides to mitigate negative consequences to agricultural and ornamental plants. Runoff from these application areas would transport the pesticides and herbicides into surface waters. The risk would be in both the developed and less developed regions throughout the basin. The overall risk for this outcome is medium since it is likely low for surface water quality but high for sediments, which tend to accumulate these compounds.

WWi-4: Warmer winters could lengthen the time of the year where expressions of eutrophication are observed. These events include algal blooms and low DO. The consequences for the basin are degraded water quality, which directly impacts aquatic species, with benthic organisms receiving the greatest negative consequences (Day et al., 2021). The shallow rivers, lakes, ponds, and estuaries of the basin are all potentially at risk. The impact of this issue is likely to slowly increase over time.

WWi-5: Warmer or more mild winters lengthen the growing season, expanding the plant hardiness zones over time. This can extend agricultural activities and increase fertilizer or pesticide usage, negatively impacting the surface water quality of the basin, particularly in the less developed areas. Warmer winters can also lead

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to a change in which crops are grown, shifting to higher-value crops that may require greater fertilization. This outcome is a relatively low risk in the short term.

Habitat Risks

Table 5. Warmer winter stressor habitat risks.

RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
WWi-6	Increased disease prevalence and survival in overwintering populations.	H2; H4	A	A	C	C
WWi-7	Disruption of plant phenology could decrease survival rates.	H2; H4	A	C	C	C
WWi-8	Changes in the pattern and timing of migratory birds.	H2; H4	A	C	C	C
WWi-9	Increased establishment, spread, and damage caused by invasive species.	H3	B	C	C	C
WWi-10	Shift in species composition (e.g., expansion of tropical species northward like black mangroves into salt marshes).	H1; H2	A	C	B	B

WWi-6: Warmer temperatures can allow certain diseases or their vectors (like mosquitoes) to persist for longer periods in the winter, increasing the risk of transmission to overwintering birds. In the Pontchartrain Basin, this may include impacts of West Nile virus on bird populations, as milder winters contribute to the virus being active year-round (Hahn et al., 2015). While these consequences could already be being felt across the area, the consequences could be low as birds develop immunity and West Nile Virus has started to reach an equilibrium with the most sensitive bird species.

WWi-7: Warmer winters can impact plant growth cycles. Unseasonably warm temperatures can trick some perennial plants into budding and flowering, potentially increasing aboveground plant biomass in the short term (Stuble et al., 2021). However, this can also increase the risk of frost damage if cold conditions occur in late spring. Shifts in the timing of plant growth and reproduction can disrupt the synchronized emergence of plants and animals, potentially affecting pollinators, herbivores, and other members of the food web, with cascading consequences. In the Pontchartrain Basin, long, hot, and humid summers, coupled with short, mild winters, create a long growing season and affect when plants bud, flower, and senesce. While these impacts are already occurring over large areas, the magnitude of the effects across the Pontchartrain Basin is expected to be low.

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WWi-8: Warmer winters in Louisiana can impact bird migrations by potentially delaying fall migrations and shortening the duration of stay in southern wintering areas. Waterfowl, for example, are adapted to stay as close as possible to their breeding grounds. With milder winters in states to the north, they may not need to migrate as far south (Andersson et al., 2022) or stay as long in Louisiana, a traditional wintering spot. Temperature itself may not be the primary factor driving changes in migration patterns. For example, as temperatures increase, insects hatch earlier. If the food supply at a stopover site is no longer readily available, migrating birds will stay for less time. The birds will move to where there is an abundant food supply, thereby adjusting the timing of migration. While these impacts are already occurring over large areas, the magnitude of the effects across the Pontchartrain Basin is expected to be low, as few areas are considered important stopover habitat or wintering for migratory birds. However, there may be species-specific regional effects, such as redhead duck wintering in the Chandeleur Islands.

WWi-9: Warmer winters in Louisiana can exacerbate the spread and impact of invasive species. Mild winters allow some invasive species to survive and reproduce more easily, potentially expanding their ranges and increasing their populations. This can lead to greater ecological and economic damage. For example, nutria are limited by freezing conditions (Hilts et al., 2019), and warmer winters allow nutria to survive, potentially leading to larger populations and increased damage to vegetation and wetlands. Also, warmer winters may increase the survival of apple snails (Matsukura et al., 2009) and aquatic weeds like water hyacinth and giant salvinia (Nesslage et al., 2016). Within the Pontchartrain Basin, these effects are expected to be widespread and are already occurring. The consequences may be medium if invasive specific management efforts continue.

WWi-10: Mangrove expansion due to warming winters and less risk of freezing is already occurring in the Pontchartrain Basin. Mangroves can negatively impact fisheries, bird habitats, and alter the composition of coastal ecosystems (Osland et al., 2022). Shrimp and blue crab populations may be less abundant in mangrove-dominated marshes compared to salt marshes (Scheffel et al., 2017). Also, some wading birds may avoid mangrove areas (Armitage et al., 2021). While the shift to mangroves is very likely to occur in the future in the outer parts of the estuary, it is presently limited by periodic freezes. Consequences to the ecosystem may be low, as there is expected to be adequate non-mangrove habitat to support fish and wildlife.

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WARMER WATER STRESSOR

Water Quality Risks

Table 6. Warmer water stressor water quality risks.

RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
WWa-1	Increased phosphorus and nitrogen release from sediment could trigger algal blooms.	WQ1	B	B	B	B
WWa-2	Increased length of time of stratification of water column.	WQ1	C	B	B	B
WWa-3	Reduction of DO available to aquatic organisms.	WQ1; H2	C	B	B	C
WWa-4	Increased algal bloom growth, including HABs affecting human health, will also cause a large swing in DO and an increase in fish/shellfish/marine die off.	WQ1; H2; E3	C	C	B	C
WWa-5	Pathogens from on-site wastewater treatment can increase concentrations with warmer water conditions.	WQ1	C	C	B	B

WWa-1: Warmer waters will increase the decomposition rate of organic matter in the sediments of rivers, lakes, streams, and estuaries. Consequently, the increase in decomposition will release more bioavailable nitrogen and phosphorus from the sediments into the water column. The greatest risk is from aquatic systems with a greater percentage of organic-rich sediments and shallow systems. This issue is more likely a longer-term risk.

WWa-2: Warmer water temperatures can lead to increased length of time of stratification of the water column. When this occurs, there will be an increase in the period of time of low bottom water oxygen concentrations, stressing benthic organisms like crabs and bivalves. Low DO can also lead to increased nutrient release from sediment, impacting water quality. Stratification can occur in all water bodies, e.g., low dissolved oxygen has been detected in recent years in northern Chandeleur Sound, but the greatest risk is to deeper systems such as aquatic sand borrow pits. This risk should increase slowly over time.

WWa-3: Warmer water temperatures can accommodate less total DO than colder waters. Therefore, warmer surface water temperatures in the summer will increase respiration in the water column, also leading to a reduction in DO. Hypoxic conditions can be mitigated by wind waves mixing oxygen through the water column, and both shallow and deeper systems are at risk (Shinohara et al., 2023). This risk has high consequences and rises with increasing temperature.

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WWa-4: Warmer water temperatures can lead to faster development and more persistent bloom conditions. When a bloom is active, the DO concentrations are high because the algae release oxygen directly into the surface water column. Only when nutrients become depleted, and the bloom organisms begin to die off and sink, does hypoxia become an issue. With more persistent blooms, there will be more algae biomass sinking, leading to lower DO levels. The risk here could be for shallow systems as well as deeper systems. This risk grows with increasing temperature.

WWa-5: The increase in water temperatures can lead to quick multiplication of pathogenic bacteria in surface waters (Dupke et al., 2023). In general, an increase of 10 degrees Celsius leads to a doubling in biological response. Therefore, the same number of pathogens in water will multiply more quickly, leading to greater water quality impairment and greater risk to human health.

Habitat Risks

Table 7. Warmer water stressor habitat risks.

RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
WWa-6	Increased diebacks of submerged aquatic vegetation (SAV) and microalgae.	WQ1; H2	B	C	B	B
WWa-7	Increased diseases and parasites will impact the health of aquatic organisms.	H2; H3; H4	A	A	B	C
WWa-8	Changes in aquatic species composition, breeding, and range.	H2; H3; H4	A	B	C	A
WWa-9	Negative impacts on the migratory and dispersal patterns of animals.	H2; H3; H4; E3	A	B	C	B
WWa-10	Increased mortality of fish, crustaceans, and amphibians occurs as they exceed their biological limits for temperature and DO needs.	H2; H4; E3	B	C	C	B
WWa-11	Increased physiological stress as aquatic organisms reach their thermal limits.	H2; H3; H4	C	C	C	A
WWa-12	Changes to the sex of species due to temperature-dependent sex determination.	H2; H4	C	C	B	A

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RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
WWa-13	Increased invasive aquatic species.	H3	B	C	B	C
WWa-14	Altered distribution of fish stocks will pose serious risks to commercial and recreational fishers' livelihoods.	H2; E3	B	C	C	A

WWa-6: Elevated water temperatures pose a significant risk to SAV by directly increasing seagrass respiration rates and reducing their photosynthetic efficiency, leading to a decline in net productivity (Moore et al., 2014). Increased water temperatures can also lead to changes in leaf characteristics, such as shoot density and leaf size, and alterations in carbohydrate storage in rhizomes, impacting overall plant health. Warmer waters can also indirectly harm SAV by exacerbating other stressors like nutrient enrichment and promoting HABs (Lewellen et al., 2020). These blooms can reduce water clarity and lead to hypoxia and sulfide production, both detrimental to SAV health. Within the Pontchartrain Basin, these impacts could occur within SAV beds in Lake Pontchartrain as well as in seagrass beds near the Chandeleur Islands. Effects will be felt several decades into the future as waters warm with moderate habitat consequences.

WWa-7: Many bacteria and parasites thrive in warmer temperatures, and these can impact important recreational and commercially harvested species. For example, shrimp black gill is an emerging disease caused by a parasitic ciliate that attacks gill tissue in white shrimp and brown shrimp (Frischer et al., 2022). It has been shown to be more prevalent in the Gulf of America at high water temperatures. Lake Pontchartrain is known to harbor several types of aquatic parasites, including amoebas like *Naegleria fowleri*, which can be pathogenic (Xue et al., 2018), and two species of myxozoan parasites found in naked gobies (Whipps & Font, 2013). Higher *N. fowleri* detection rates have been observed at higher temperatures than at lower temperatures. However, there have been few detailed studies of the impacts of disease and parasites on the ecosystem, and so even though the effects may already be occurring, there is little evidence that the likelihood of severe consequences is high.

WWa-8: Higher water temperatures in general lead to increased metabolic rates in fish, causing them to potentially seek deeper, cooler waters. Some species have a specific temperature range for spawning, and warmer temperatures could impact their reproductive success. Some species may shift their distribution to find more suitable temperatures, leading to changes in the overall fish community. However, changes in fish community composition will also occur in response to other factors, such as prey availability, anthropogenic pressures, etc. (O'Connell et al., 2004). There is such an array of aquatic species in the Pontchartrain Basin that specific trends in risk cannot be identified. Effects are likely to increase in future decades, as waters warm more and spread across the system.

WWa-9: As water temperatures rise, a range of species are expected to shift their distributions into deeper, cooler waters, potentially disrupting existing fisheries. Some species, like snook (*Centropomus undecimalis*),

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typically found in more tropical waters, may move further north, including into coastal Louisiana, due to warming Gulf of America waters (Purtlebaugh et al., 2020; Torres Ceron et al., 2023). Northern shifts in species result in interactions with existing estuarine fish populations (Gericke et al., 2014). While many species across the Pontchartrain Basin are likely to alter their distribution due to warmer waters, the consequences for the ecosystem are unlikely to be high.

WWa-10: Warmer temperatures can stress fish and lead to die-offs due to decreased oxygen levels. Warm water holds less DO than cold water, making it harder for fish to breathe, and fish have higher metabolic rates in warmer water, increasing their need for oxygen, further exacerbating the problem. Amphibians rely on external temperatures to regulate their body temperature and physiological functions. Increases in temperature beyond their optimal range can disrupt these processes, leading to heat stress (Rollins-Smith & Le Sage, 2023). These impacts are expected to be widespread across the Pontchartrain Basin and will increase in the next decade or two. The likelihood of some impacts is high, but the consequences may be mixed by species.

WWa-11: Both fish and crustaceans in Louisiana are experiencing significant physiological stress due to rising water temperatures, particularly during heat waves and sustained high temperatures. Higher water temperatures increase fish metabolic rates and oxygen demands. Fish respond to increasing temperatures by altering their behavior, including feeding habits and movement patterns, in an effort to find cooler waters or adapt to the new conditions. Crustacean metabolic rates increase with higher temperatures, potentially leading to metabolic acidosis as the animals struggle to maintain their acid-base balance (Tripp et al., 2022). Also, temperature can significantly affect the growth of crustaceans, e.g., blue crabs, by influencing the duration of the molting process and the time between molts (Cunningham & Darnell, 2015). These effects are expected to be widespread across the Pontchartrain Basin, especially several decades into the future as temperature increases.

WWa-12: In some Louisiana fish species, particularly the southern flounder (*Paralichthys lethostigma*) (Corey et al., 2017), temperature plays a significant role in determining sex, a phenomenon known as temperature-dependent sex determination (TSD). Warmer temperatures during a critical developmental period can lead to a higher proportion of males in the population. Temperature-dependent sex determination is also found in the alligator snapping turtle (*Macroclemys temminckii)* (Ligon & Lovern, 2009), which is found in the Pontchartrain Basin. The population impacts as temperatures rise over decades could be severe in the areas of the basin that these species inhabit.

WWa-13: Temperature plays a significant role in the establishment, spread, and impact of aquatic invasive species in the Pontchartrain Basin. Long, hot summers create favorable conditions for many invasive species from tropical and subtropical regions to thrive and expand their range into areas that might otherwise be too cool. Rising temperatures generally stimulate aquatic plant growth (Nesslage et al., 2016). Giant salvinia and water hyacinth flourish in warmer water temperatures and can reproduce rapidly, forming dense mats that obstruct waterways and harm native ecosystems. Impacts are ongoing and expected to be moderate across the aquatic ecosystems, assuming invasive species management efforts continue.

WWa-14: As water temperatures rise, a range of species are expected to shift their distributions into deeper, cooler waters, potentially disrupting existing fisheries. For shrimp, rising temperatures can lead to increased growth rates (Li & Clarke, 2005; Schlenker et al., 2023), but also force shrimp to move into deeper, cooler waters earlier in the year, potentially impacting when and where they are caught. Redfish (*Sciaenops*

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ocellatus), an important recreational catch, are generally comfortable in warmer waters, although prolonged exposure to extreme heat can potentially lead to reduced feeding activity and even fish kills. The location of recreational and commercially caught fish throughout the Pontchartrain Basin is likely to change, especially in future decades. The consequences for fishers will vary and may depend on their dependence on specific areas or stocks.

INCREASING DROUGHT STRESSOR

Water Quality Risks

Table 8. Increasing drought stressor water quality risks.

RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
ID-1	Increasing wildfires could increase contamination from use of fire retardants and suppressants (PFAS).	WQ2	C	B	B	B
ID-2	Increased nutrient runoff due to higher use of irrigation in the residential, commercial, and agricultural sectors.	WQ2	A	B	B	B
ID-3	Decreased water flow will lead to higher concentrations of nutrients and pollutants in receiving waters.	WQ1; WQ2; H1; H2	C	C	C	B

ID-1: Drought conditions are brought on by a reduction of precipitation, leading to desiccation of plant matter and soils. These conditions are supportive of wildfires, which are fought with chemical retardants containing ammonium phosphate and foams. Therefore, a greater occurrence of fires will lead to nutrient salts in fire retardants being sprayed into the environment. With more fires, there is an increased risk of runoff of soil and contaminants into surface water, affecting water quality. This risk is highest in the forested upland and wetland regions of the basin; however, efforts are underway to remove PFAS from firefighting foams (U. S. Government Accountability Office (GAO), 2024).

ID-2: With the onset of drought conditions, it can be expected that the residential, commercial, and agricultural sectors will increase the use of water to minimize ornamental and agricultural plant water stress. The increased irrigation can lead to runoff of both sediments and contaminants associated with the soils, leading to a degradation in water quality. The risk is intermittent and hard to predict since it is based on the severity of any drought and efforts in the watershed to capture non-point source runoff.

ID-3: Drought conditions are defined by a water deficit. Therefore, increased evaporation and lower precipitation lead to a loss of surface water. As the water evaporates, the nutrients and contaminants are left behind, and the concentration of these increases leads to concerns over water quality impairment by

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concentrations over allowable limits. Severe droughts have recently been experienced at the decadal scale. It is unclear over what time an increase can be expected, suggesting this is a longer-term risk.

Habitat Risks

Table 9. Increasing drought stressor habitat risks.

RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
ID-4	Increased salinity of the estuary affects the distribution of plant species.	WQ1; H2	A	C	B	A
ID-5	Reduction of headwater flows in rivers from increasing drought will affect discharge and salinity, therefore impacting freshwater-dependent organisms, up to and including spawning and mortality.	WQ1; H2	B	B	B	A
ID-6	Decreased riverine flow may deposit too much sediment upstream.	H1; H2	A	A	A	A
ID-7	Increased droughts, especially during the growing season, will cause more stressed vegetation, which will decrease the success rate of restoration projects.	H1; H2	B	B	A	A
ID-8	Increasing drought could cause a shift in species composition.	H2	B	B	B	A
ID-9	Drier climate may support high levels of invasive species.	H3	B	C	B	B
ID-10	Increased wildfire risk due to longer dry periods.	H2	B	C	B	C
ID-11	Increasing drought may decrease the effectiveness of newly implemented best management practices (BMPs).	H4	A	A	B	B

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ID-4: Increased salinity in Louisiana's coastal wetlands can negatively impact vegetation, reducing plant diversity (Visser et al., 2002). Many common coastal plant species, including bald cypress (Taxodium distichum), are sensitive to even subtle increases in salinity (Shaffer et al., 2016). As salinity increases, salt-sensitive plants may decline, while salt-tolerant species, such as smooth cordgrass (Sporobolus alterniflorus, previously Spartina alterniflora), may become dominant. If the salinity increase is gradual, transitions in vegetation can occur, as opposed to the abrupt change in salinity in the Pontchartrain Basin, which occurred in association with the opening of the Mississippi River Gulf Outlet (MRGO), which led to large areas converting to open water. Salinity increase due to drought is exacerbated by SLR. The effects of drought are likely to be greater in future decades across much of the coastal area. However, if the transition is gradual, the consequences may not be severe. These effects can also be mitigated in some areas using freshwater diversions from the Mississippi River (e.g., the River Reintroduction to Maurepas Swamp project).

ID-5: Lower water levels in rivers, streams, bayous, and wetlands shrink the available habitat for fish. This can lead to fragmentation of habitats, isolating fish populations and hindering their ability to migrate for spawning or finding food (Nagrodski et al., 2012). Shallow, stagnant pools created by low flows can become ecological traps, increasing vulnerability to predators, disease, and competition for resources. Extreme droughts can cause temporary shifts in stream fish assemblages. However, assemblages that have evolved in environments where such events occur tend to be resistant or resilient to these events in the long term. These effects can be compounded by dams on rivers to support water supply, which can further limit flows, or, depending on operational decisions, may be used to supplement flows during droughts. The vulnerability of freshwater fishes in the Pontchartrain Basin depends on the magnitude and frequency of drought and salinity effects in the future. The effects are expected to be greater in later decades.

ID-6: Riverine sedimentation significantly impacts aquatic habitats by altering water quality, reducing habitat availability, and affecting aquatic life (Stewart et al., 2005). Excessive sediment can lead to increased turbidity, smothering of benthic organisms, and reduced DO levels, ultimately impacting the health and biodiversity of the ecosystem. Sediment deposition can bury gravel spawning grounds, fill in crevices used by insects and other invertebrates, and smother aquatic vegetation, reducing the overall habitat diversity and complexity. However, most of the sediment transported by Pontchartrain Basin rivers is moved during floods, so a decrease in flow is unlikely to impact overall sedimentation patterns. Any impact is expected to be limited in extent and of minor consequence.

ID-7: Droughts naturally decrease soil moisture, impacting plant germination, growth, and overall health. This can make it difficult for new plantings to establish and thrive (Hillmann et al., 2024). Within the Pontchartrain Basin, the Maurepas Land Bridge, historically covered with bald cypress swamps, is undergoing a major reforestation program to restore wildlife habitat. Although the closure of MRGO has limited the effects of drought on salinity compared to when drought occurred in previous decades (e.g., 2000-2001) dry summers can still impact newly planted vegetation, potentially limiting survival. The new River Reintroduction into Maurepas Swamp project should mitigate these effects by providing a consistent upstream source of freshwater to counter drought effects within restored areas of the basin.

ID-8: Drought may cause temporary or permanent shifts in species composition. Previous droughts in the Pontchartrain Basin have shown deterioration in swamp (Shaffer et al., 2016), often replaced with herbaceous species, and a switch in species composition of SAV (Cho & Poirrier, 2005). Some of these effects were associated with increased soil salinity, while SAV composition was influenced by water clarity, with the species again shifting when drought conditions were alleviated. In inland areas, shifting conditions may mean the loss of globally imperiled fauna and flora where the opportunity for habitat transition can be limited. The effects are likely to be greater as drought frequency increases in future decades. Some effects in the coastal area may be alleviated by planned river diversion projects.

ID-9: Drought can create conditions that favor the establishment and spread of invasive species. Dry conditions can stress native plants, making them more vulnerable to competition from invasive species that are better adapted to dry conditions (Paudel et al., 2018). Some invasive species can outcompete natives by growing rapidly, developing deeper roots, or altering soil conditions (like reducing water-holding capacity). Chinese tallow, for example, exhibits fast growth, high fecundity, a persistent seed bank, aggressive resprouting, abiotic stress tolerance, and the ability to transform fire-maintained ecosystems (Pile et al., 2017). Effects in the Pontchartrain Basin are likely to increase in the next decade or so, and effects may be only moderate if invasive species control efforts are implemented.

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ID-10: Drought conditions cause vegetation to dry out quickly, creating abundant and highly flammable fuel for wildfires. Once a fire starts, drought can worsen its intensity and severity, leading to larger and more intense blazes (An et al., 2015). Wildfires can destroy vegetation, alter soil composition, and change the landscape, leading to habitat loss and fragmentation for various species. Rare or endangered species with limited mobility or reliance on specific habitats are particularly vulnerable to wildfire impacts. Drought conditions also reduce the number of suitable days for prescribed burning, which is critical to Longleaf Pine habitats and is a useful tool for invasive species management. The threat of wildfire is already here in the Pontchartrain Basin and is expected to increase. Land management practices may be able to mitigate some of the worst impacts.

ID-11: BMPs apply to several activities across the Pontchartrain Basin, including forestry, oil and gas activities, and sand and gravel mining. In addition, BMPs apply to the many designated scenic rivers within the Pontchartrain Basin. Where commercial activities disrupt natural land cover, BMPs frequently require revegetation and/or regrading of slopes. Drought conditions may impact the success of revegetation efforts (Clark et al., 2016), and unless vegetation is reestablished, bare soils may be readily eroded following droughts or during periodic rainfall. These effects are likely more impactful in inland areas of the Pontchartrain Basin and will increase as drought conditions worsen in future decades. Effects can be minimized if those implementing the BMPs consider these vulnerabilities due to drought.

INCREASING STORMINESS STRESSOR

Water Quality Risks

Table 10. Increasing storminess stressor water quality risks.

RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
IS-1	More frequent flooding of contaminated sediments.	WQ2	C	C	A	B
IS-2	Overwhelmed septic tanks, drain fields, and municipal wastewater treatment plants, including emergency releases of partially treated wastewater from treatment facilities overloaded by inflow and infiltration during storm events, further intensifying flooding.	WQ1; WQ2	C	C	B	B
IS-3	Increasing storminess could cause contaminated fluids and debris from storm-damaged structures/facilities/vehicles to wash into the bays.	WQ2	C	C	A	B
IS-4	High-volume rain events can lead to backwater flooding.	WQ1; WQ2	C	C	B	A

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RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
IS-5	Increased erosion and resuspension of sediment will lead to increased nutrients, turbidity, and decreased light penetration in the water column, negatively impacting phytoplankton and SAV.	WQ1; H2	B	C	C	C

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IS-1: Increased number and strength of storms can lead to highly saturated soil conditions from greater precipitation events, as well as from coastal flooding. Under this scenario, contaminated sites located proximal to backwater flooding areas or coastal areas could become flooded, liberating and discharging contaminants and contaminated sediments into surface waters. While this risk is very site-specific, the outcome for water quality is a concerning consequence. This risk increases over time.

IS-2: Increased number and strength of storms can lead to highly saturated soil conditions from greater precipitation events. These saturated soil conditions can impact both point and non-point sources of pollution. Overwhelmed wastewater systems, especially those with combined sewer and stormwater systems, would require emergency discharges or releases before complete wastewater treatment, negatively impacting water quality. Septic systems can also become saturated by releasing under-treated wastewater into nearby surface waters. This risk is spread across developed and less developed areas of the basin. This risk will increase at the same rate as the increase in storms, which is not well defined.

IS-3: Increased storminess, especially increased strength of storms along the coastlines, can lead to damaged infrastructure. Contamination can leak from damaged hydrocarbon storage facilities, other industrial chemical storage facilities, as well as from commercial and residential buildings, which experience catastrophic failure or flooding, compromising containment integrity. These releases of contaminants typically cannot be immediately addressed because of the immediate post-storm focus on repairs to critical infrastructure like electricity, drinking water, and wastewater treatment. Therefore, the risk is episodic, linked to the most severe hurricanes, and the impact is severe at a local level.

IS-4: More frequent storms with significant precipitation can lead to longer periods of time where the soil is saturated, and the water table is shallow. Under these conditions, closely spaced rain events lead to decreased infiltration, increasing runoff potential. This condition impacts flooding, due to the low-sloping coastal plain, where high river levels slow tributary flow, leading to overflow of the banks and flooding of the surrounding landscape (Feng et al., 2022). The impact of this flooding can be widespread as floodwater spreads out over the flat terrain.

IS-5: An increasing number and strength of storms can lead to greater disruption of the aquatic sediments. Stronger winds lead to increased wave energy, which imparts a bed load shear to the sediments, lifting sediments up into the water column through mixing (Soulsby & Damgaard, 2005). The impact of this mixing has two impacts on water quality: increased turbidity through particle resuspension, which will impact light penetration in the water column, and increased nutrient loading to the water column from the disturbed porewater. Most streams, rivers, lakes, and estuaries would be at risk from this stressor because of the shallow depths, which magnify the impact from wind-driven waves. This outcome is episodic.

Habitat Risks

Table 11. Increasing storminess stressor habitat risks.

RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
IS-6	Loss of inland habitat due to higher rates of riverbank and streambed erosion and damage to forests.	H1; H2	C	C	B	C
IS-7	Loss of estuarine habitat due to higher rates of shoreline and barrier island erosion.	H1; H2	B	C	B	C
IS-8	Increased physiological stress to freshwater plants and animals due to saline intrusion from storm surge.	H1; H2	A	C	B	B
IS-9	Disruption to bird migration patterns due to the loss of shoreline as armoring increases to protect properties.	H1; E3	B	A	B	C
IS-10	Stream restoration projects designed for current conditions may not be able to handle higher flows and from increasing storminess.	H1; H2; E3	A	C	A	C
IS-11	Higher maintenance costs of coastal habitat restoration projects.	H1	B	C	B	C
IS-12	Introduction of aquatic invasive species to new areas due to flooding.	H3	A	A	C	C
IS-13	Larger magnitude storms can wash fish into new and unfavorable areas.	H2; H4	A	B	A	C
IS-14	Increasing storminess could disrupt fisheries and the ability to fish and transport fish, cause spoilage, and cause damage to infrastructure.	H2; E3	B	B	B	C

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IS-6: Heavy rainfall from hurricanes can cause widespread and severe inland flooding, flash floods, and erosion, even far inland from the coast. Saturated ground from heavy rain can exacerbate wind damage, increasing the risk of downed trees along stream banks, and exacerbating erosion (Wu & Xu, 2007). When increased flooding impacts populated areas, it can result in increased calls for clearing and snagging of streams, potentially damaging instream and riparian habitat. In addition, the impacts of hurricane winds on coastal and inland forests have been well documented, impacting tree health, wood quality, and forest structure (F. Wang & Xu, 2009). Wind damage and debris from fallen trees can lead to immediate tree mortality and long-term forest decline, altering wildlife habitats (Negrón-Juárez et al., 2010). This can also create conditions that favor insect infestations. The effects are already occurring when storms impact the Pontchartrain Basin, and there is potential vulnerability over large areas.

IS-7: Barrier island erosion and damage to coastal wetlands are some of the most obvious impacts of coastal storms on habitat. The Pontchartrain Basin has already suffered major damage, and this is expected to continue (Fearnley et al., 2009). Some aspects of habitat can recover over time (e.g., barrier shorelines gradually rebuild). However, damage to wetlands along shorelines and interior areas can only be addressed by restoration (Reed et al., 2009). Restoration and shoreline protection efforts, such as living shorelines, are expected to mitigate some of the damage in the future, and efforts to add more sand to the Chandeleur Islands increase their resilience.

IS-8: Storms can bring temporary incursions of saline waters into areas that are fresh during non-storm conditions (Keim et al., 2019). This results in stress to plants and animals. Many freshwater animals are intolerant to increased salinity and may struggle to regulate the salt balance in their systems, potentially leading to dehydration, internal organ damage, and even death (Schriever et al., 2009). This stressor is most likely to impact those with limited mobility to move to upland refuge areas or aquatic organisms. It may result in fish kills. The effect on freshwater vegetation largely depends on how long the salt persists. Many freshwater plants will die back as salt can draw moisture out of plant tissues, leading to dehydration and leaf burn. However, if conditions return to fresh quickly, many plant species will survive (Howard & Mendelssohn, 2000). These effects will increase as storms become more common and could impact a large area, albeit at a low level.

IS-9: Shoreline areas around lakes and marshes are crucial for a vast array of bird species, providing both year-round habitat and vital stopover points along migratory routes. They provide abundant food sources like submerged aquatic vegetation, seeds, tubers, invertebrates, fish, and shellfish (Patton et al., 2020). These important aspects of natural shorelines can be lost when bulkheads and seawalls are constructed to prevent storm damage and shoreline erosion. Migratory birds will not dwell in areas without food resources. These effects can be mitigated through increased use of living shorelines or softer approaches to shoreline protection that seek to maintain high-quality habitat while providing protection (Leu et al., 2023). The impact of armoring is already occurring as many shorelines have already been hardened, but practices are expected to change toward living shorelines and softer solutions in the future, so the likelihood of a major effect is low.

IS-10: Heavy rainfall from hurricanes can cause widespread and severe inland flooding and erosion. Saturated ground from heavy rain can increase the risk of downed trees along stream banks, exacerbating erosion and potentially damaging stream restoration projects. Natural streams are dynamic, and periodic high flows cause changes to which the river gradually adjusts over time (Dewberry, 2025). Stream restoration projects that target specific outcomes in local areas are more likely to be impacted. Effective restoration of streams should be designed to cope with high flows. The Pontchartrain Basin has already experienced high river flows due to storms, and this is likely to continue.

IS-11: Storms and hurricanes significantly impact coastal restoration efforts, hindering progress and requiring ongoing maintenance and adaptation. While coastal restoration projects, like barrier island restoration and wetland creation, aim to reduce storm surge and erosion, intense storms can damage or even

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undo these efforts, necessitating repeated interventions. Storm damage necessitates more frequent repairs and maintenance of restoration projects, increasing the overall cost of coastal restoration. The impact of storms underscores the need for coastal restoration projects to be adaptable and resilient (Freeman et al., 2021). These impacts are already being felt[2]. As restoration efforts increase, the likelihood of storms impacting the restoration process and outcomes increases across the coastal area of the Pontchartrain Basin.

IS-12: Flooding, particularly from events like hurricanes, can significantly accelerate the spread of invasive species by transporting them to new areas. Floodwaters can carry plants and animals, including non-native species, into previously unaffected areas, potentially establishing new populations and disrupting existing ecosystems. In addition, storms can damage or disrupt existing habitats, creating opportunities for invasive species to outcompete native species and establish themselves (Henkel et al., 2016). For example, apple snails and their egg masses can be carried by water currents during floods, spreading them to new areas that they otherwise cannot access (Pierre et al., 2017). The impact on the Pontchartrain Basin may not be that great, as most invasives that can be spread in this way are already widely distributed. Effects can also be lowered through invasive species management efforts.

IS-13: Storms can disrupt fish habitats and migration patterns, leading to fish being moved or displaced into areas with unfavorable conditions. Hurricanes can bring heavy rains that drastically reduce the salinity of coastal waters and estuaries. Storm surges and rising floodwaters can push fish into areas they wouldn't normally inhabit, such as urban areas (Lorenz & O'Connell, 2011). When floodwaters recede, fish may become stranded and die as the temporary ponds or pools dry up, or they may persist. Strong currents can also flush fish, especially smaller ones, out to sea from their river habitats. These effects already occur during storms (Vrancken & O'Connell, 2010), and while there may be mortality, the impact on fish populations is minimal.

IS-14: Fisheries are an important activity in the Pontchartrain Basin, including commercial, recreational, and charter operations. Hurricanes cause widespread damage to vessels, docks, processing facilities, and other infrastructure essential to the fishing industry activities (Buck, n.d.). The result can be significant revenue losses for fishers, seafood dealers, processors, charter operators, and marinas, and potential loss of access to subsistence food resources (Caffey et al., 2007). In addition, hurricanes can negatively impact fish and shellfish populations through habitat destruction, changes in water quality (like salinity and DO levels), and physical displacement. These effects have already been felt in the Pontchartrain Basin. They are expected to continue and may be mitigated through hardening of infrastructure over time.

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[2] Access at the following link: https://lailluminator.com/briefs/shelved-by-hurricane-damage-terrebonne-coastal-restoration-project-sees-progress/

SEA LEVEL RISE STRESSOR

Water Quality Risks

Table 12. Sea level rise stressor water quality risks.

RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
SL-1	Coastal land loss will reduce the amount of nutrients removed via natural processes.	WQ1; WQ2	B	C	B	A
SL-2	Incursions of water upland that could flood toxic containment sites.	WQ2	C	C	A	C
SL-3	Increased pollution to surrounding areas from abandoned infrastructures (e.g., ghost towns) from community relocations.	WQ2	B	C	A	A
SL-4	Higher water tables will inundate septic drain fields and lead to increased pathogen contaminants from sewage overflow.	WQ1; WQ2	B	C	B	C
SL-5	Increased aquifer salinity.	WQ1	C	C	B	C
SL-6	Sea level flooding may increase connectivity between shallow groundwater and surface water systems. More connectivity may affect water quality (less land-based filtering/buffering) and lead to more saltwater intrusion.	WQ1; WQ2	A	B	B	B
SL-7	Decreased efficiency of stormwater control structures requires increased investment in overall stormwater control.	WQ1; WQ2	B	C	A	B

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SL-1: Sea level continues to rise, adding stress to coastal wetland systems, killing the vegetation, increasing erosion, and leading to the loss of wetlands (Couvillion et al., 2017). Consequently, there is less land to help remove nutrients and sediments from surface waters through the natural filtering processes. This risk is high along the coastline and within the inland bays and enclosed estuary. Other factors exacerbate coastal land loss, including subsidence, levees and spoil banks, and ground extraction of oil and gas.

SL-2: Contaminated upland soils can become flooded by a combination of storm surges superimposed on top of the rising sea level. This rising water can then increase runoff of contaminants in the soil, degrading surface water quality. This risk increases slowly over time and is constrained to the coastal parishes in the Pontchartrain Basin.

SL-3: As sea levels continue to rise, community and industrial infrastructure will become abandoned. This is never a controlled withdrawal but usually occurs after a severe storm impact. Contaminants associated with the decomposing infrastructure will be released into the environment, locally impacting water quality. This is a longer-term risk, and sea level is interrelated with storminess for this outcome, with more localized impact areas.

SL-4: Higher sea levels increase shallow groundwater levels and soil saturation along the low-sloping coastal plain. This condition can lead to failure of septic system drain fields, potentially releasing pathogens and nutrients, degrading surface water quality. This risk is more closely associated with less developed coastal parishes, especially ones more reliant on septic systems versus centralized wastewater treatment. This risk is occurring and slowly increasing over time.

SL-5: The rising sea level, in concert with high extraction rates of groundwater for drinking, agricultural, and industrial uses, can lead to salinization of the groundwater aquifers, and this is already occurring in the basin (Anderson, 2012). This risk puts pressure on coastal communities to develop an alternative source of drinking water. Communities closer to rivers are at less risk, as treated river water can provide a freshwater source. Communities further from rivers are at a greater risk, especially coastal communities. An increasing rate of groundwater withdrawal for an increasing population changes the long-term risk to a near-term risk.

SL-6: SLR will cause greater saturation of the shallow, surficial aquifer, increasing connectivity to the surface waters. This situation can increase the salinity of our coastal surface waters. Nutrients and contaminants from the surface water can bypass potential water quality improvement in the coastal wetlands and discharge to coastal waters. This risk is constrained to the coastline with a low overall consequence. This risk increases with time as the sea level continues to rise.

SL-7: Rising sea level can limit the effectiveness of stormwater control structures in coastal communities through increased coastal flooding, which will limit stormwater discharge. The result of this change is that contaminants will potentially remain in the landscape longer, leading to a decrease in surface water quality and soil contamination. In addition, the more saturated soil decreases infiltration, requiring greater investment in stormwater control (pump and storage) infrastructure over time. The coastal parishes infrastructure sites are at greatest risk from this issue. This risk slowly increases with time.

Habitat Risks

Table 13. Sea level rise stressor habitat risks.

RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
SL-8	Loss of habitat for fish, birds, and plants.	H2; H4; E3	B	C	B	C

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RISK NUMBER	RISKS TO CCMP GOALS/OBJECTIVES	CCMP OBJECTIVE(S) AT RISK	CONSEQUENCE (A-C)	LIKELIHOOD (A-C)	SPATIAL EXTENT OF IMPACT (A-C)	TIME HORIZON (A-C)
SL-9	Reduction in nesting area suitable for sea turtles, aquatic birds, and other marine creatures.	H2; H4	B	B	B	C
SL-10	Change in species distribution and range due to the intrusion of sea water into freshwater systems.	H2; H4	A	B	C	C
SL-11	Inability of species to migrate further inland due to physical barriers from flood mitigation structures.	H2; H4	C	C	B	A
SL-12	SLR may cause a dramatic loss of tidal wetland habitat, limiting the areas available for plant and animal species and recreational pursuits, thus increasing use pressure on the remaining wetlands.	H1; H2; E3	A	A	A	C
SL-13	A loss of habitat for recreational and commercially important species will reduce fishery harvests.	H2; E3	C	B	A	A

SL-8: SLR is widely recognized as a key contributing factor to the loss of coastal wetlands and barrier islands. The 2023 Coastal Master Plan[3] predicts that the Pontchartrain Basin may lose between 100 and 350 km^2 of land to open water in the next 50 years, depending on the rate of SLR. Coastal Master Plan analysis also showed that increased salinities from SLR could increase habitat for species that prefer salinities greater than 5 parts per thousand (ppt), like brown shrimp, white shrimp, and spotted seatrout. Increased water levels had a negative effect on habitat suitability for alligator and seaside sparrow. The effects of SLR are already being felt and are expected to continue, but some of the consequences for fish, birds, and plants can locally be mitigated by restoration projects.

SL-9: SLR poses a significant threat to bird and turtle nesting in the Pontchartrain Basin. As sea levels rise, sandy beaches along the barrier islands, crucial for nesting, are submerged and eroded, which leads to the loss of suitable nesting areas for sea turtles (Fujisaki et al., 2018) and shorebirds like the piping plover. Higher water levels due to SLR exacerbate the effects of storm surges that can flood nesting sites, drowning eggs, and hatchlings (Seavey et al., 2011). Restoration activities can mitigate these effects to some extent but will need to be continued over time to ensure habitat is available.

SL-10: 2023 Coastal Master Plan analysis showed that increased salinities from SLR over the next 50 years could increase habitat for species that prefer > 5ppt, like brown shrimp, white shrimp, and spotted seatrout (White, 2023). SLR was shown to decrease habitat suitability for low-salinity species, such as alligator and largemouth bass. The response of organisms to SLR in the lower estuary is influenced by both dynamic and

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[3] Access at the following link: https://coastal.la.gov/our-plan/2023-coastal-master-plan/

structural habitat. Important factors include temperature change related to an organism's development patterns, loss of habitat due to SLR, and related changes in food availability and habitat structure for aquatic fauna. The effects of SLR on species distribution in the Pontchartrain Basin are expected to be mixed, but it is not expected to fundamentally limit any species at a decadal time scale.

SL-11: Barriers such as sea walls, levees, dams, and tide gates can directly block the movement of animals, particularly those that migrate between marine and freshwater environments or across different estuarine habitats. However, within the Pontchartrain Basin, most of the existing and planned coastal flood protection structures are built directly adjacent to developed areas or are planned to be open to tidal exchange except during periods of hurricane storm surge. As sea levels rise, gates may need to be closed more often (Chen et al., 2020); thus, this impact is more likely decades into the future rather than at present. When these systems are closed, they are expected to impact the ingress and egress of nekton through the estuary.

SL-12: SLR is widely recognized as a key contributing factor to the loss of coastal wetlands in the Pontchartrain Basin. The 2023 Coastal Master Plan predicts that the Pontchartrain Basin may lose between 100 and 350 km^2 of land to open water in the next 50 years, depending on the rate of SLR. Most of the wetland loss, depending on the rate of SLR, occurs in the Biloxi marshes and east of Lake Pontchartrain. Depending on the species distribution, many recreational fishing activities that rely on wetland habitats will need to move to the west, into the lake. However, shallow coastal waters replacing lost wetlands are also productive areas but may not be accessible under all conditions. While fishing pressure in some areas may increase, the resource is still extensive and is not considered limiting.

SL-13: The 2023 Coastal Master Plan predicts that the Pontchartrain Basin may lose between 100 and 350 km^2 of coastal wetlands to open water in the next 50 years, depending on the rate of SLR. SLR will also increase salinities. Species of recreational commercial importance include brown shrimp (*Farfantepenaeus aztecus*), white shrimp (*Litopenaeus setiferus*), blue crab (*Callinectes sapidus*), redfish, spotted sea trout (*Cynoscion nebulosus*), and catfish. SLR is unlikely to eliminate habitat for any of these species, but harvest may be reduced if suitable habitat is in areas that are less accessible to fishers. The effect is not expected to be substantial for several decades but could be locally important for some industries or groups.

OCEAN ACIDIFICATION STRESSOR

Unlike other climate stressors evaluated in this assessment, ocean acidification was assessed differently. This reflects the comparatively lower potential impact of acidification within the Pontchartrain Basin, where freshwater influence limits exposure to marine-driven pH changes. In addition, there is limited research specific to ocean acidification effects in Louisiana's coastal and estuarine environments, particularly within the Pontchartrain system. Thus, it was not feasible to assign quantitative rankings for consequence, likelihood, spatial extent, or time horizon. Instead, a qualitative discussion of potential relevance and information needs is provided for habitat and water quality.

Water Quality Risks

Ocean acidification (OA) occurs because the CO_2 concentrations in the atmosphere have doubled since the Industrial Revolution. When there is higher CO_2 in the atmosphere, more CO_2 will be dissolved in the water due to equilibrium. Atmospheric CO_2 combines chemically with a piece of water, specifically, the OH^-, which leaves behind H^+. This excess H^+ is what is causing the oceans to be more acidic. The ocean has little

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buffering capacity because it has a large water column and limited sediment contact. Shallower coastal areas, with shallower water depths and a much higher contact with the sediments, have a chemical buffering capacity. As the acid interacts with $CaCO_3^-$, dissolving shells and minerals, the H^+ is neutralized by combining with the released carbonate. For this reason, coastal systems containing carbonate sediments, such as the coastal areas of the Pontchartrain Basin, are well buffered for pH changes. While a recent study found that marsh porewaters have much higher CO2 concentrations, they appeared unconnected to the adjacent surface waters and surmised this is not a significant issue for coastal Louisiana (He et al., 2022).

Therefore, in shallow coastal systems, there are few water quality impacts for a small step down in pH. The greatest risk to the acidity is that it can negatively impact the development of bivalve shells and crustaceans' carapaces, which contain variable $CaCO_3$. These organisms are particularly vulnerable in early stage development when the shells are amorphous and not well developed. Given that the oyster fishery in LA provides 30% of the US oyster landings by weight, impacts to this fishery would impact the economy. In addition, oysters and other bivalves are filter feeders, improving water quality. An adult oyster filters as much as 220 liters of water each day, removing algae and other organic particulates.

Habitat Risks

OA changes ocean chemistry, which can disturb marine organisms and ecosystems. The Gulf of America remains a relatively understudied region with respect to acidification. In general, the warmer waters are better buffered from acidification compared to higher latitude seas for two reasons. There are sufficient carbonates in our coastal soils to buffer pH changes, and there is less dissolved CO_2 in warmer water and therefore less impact on pH. However, OA has been noted within the coastal zone where numerous physical and biogeochemical processes contribute to carbonate chemistry dynamics (Savoie et al., 2022). Within the coastal waters of the Pontchartrain Basin, relatively acidic waters from the Pearl River can further reduce pH levels and the availability of carbonate minerals for fish and crustaceans.

There are several ways that OA could influence aquatic organisms and different fish species. Different life stages of the same species may respond differently to changes in water chemistry. Young fish are generally considered more susceptible to environmental stressors, including altered water chemistry. Fish may need to expend more energy to maintain their internal acid-base balance, leaving less energy for crucial functions like growth and reproduction. Reduced energy can potentially affect the development of eggs and sperm, as well as spawning and fertilization processes. In addition, OA can negatively affect fish sensory abilities like smell and hearing, making it harder for them to find food, avoid predators, or navigate. OA can also affect bone and skeletal formation in fish, potentially leading to reduced mineralization in some areas. Maintaining internal physiological balance in acidic waters can be energetically costly for fish, potentially diverting energy away from growth and reproduction. Notably, OA can impact mollusks such as oysters. Reduced pH and carbonate ion concentrations hinder their ability to build and maintain shells, potentially leading to thinner, weaker shells, reduced growth, and even death, especially in early life stages.

Despite these concerns, there have been few studies of the effects of OA on organisms of interest within the Pontchartrain Basin. Because of the somewhat lower threat posed by OA in warmer waters, there is no information available to assess the vulnerability of aquatic organisms in the Pontchartrain Basin.

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EDUCATION AND INVOLVEMENT RISKS

E&I risks emerge primarily as secondary consequences of climate-driven changes to water quality and habitat. While no separate E&I tables are developed for each stressor, multiple risks flagged in the ecological analysis also carry clear implications for E&I objectives. These include impacts on livelihoods, recreation, cultural practices, and public participation in stewardship activities. Examples of these impacts linked to water quality and habitat risks include:

- **Shifts in wildlife and fisheries**: Altered distribution of fish stocks (WWa-13) and loss of habitat for recreational and commercially important species (SL-13) threaten both subsistence and commercial harvests, reducing economic security and cultural traditions tied to fishing.
- **Recreation and tourism pressures**: Changes to recreational fishing (WWa-13), hunting, birding (WWa-8), and ecotourism opportunities (WS-8), combined with wetland loss (SL-12), affect both outdoor recreation and nature-based tourism industries.
- **Public safety and engagement**: Longer algal bloom seasons (WWa-4) and increased fish mortality (WWa-9) may reduce safe recreational access and dampen public willingness to participate in water quality improvement or habitat restoration projects.
- **Community projects and infrastructure**: Stream restoration designed for current flow regimes (IS-10) may be challenged by stormier conditions, risking setbacks for restoration outcomes and public confidence.

By highlighting these risks, Step 4 establishes how climate stressors extend beyond ecological metrics to influence human well-being, recreational access, and community engagement. The linkages underscore the importance of aligning ecological adaptation with education, outreach, and involvement strategies.

Step 5: Risk Evaluation

Step 5 is the risk evaluation stage, where the risks identified in Step 4 are organized into risk matrices that align with the CCMP goals. This step provides a structured way to visualize how the identified risks vary in both consequence of impact and likelihood of occurrence, highlighting where management attention may be most critical.

Two matrices are presented. Figure 9 compiles the risks associated with the water quality goal, while Figure 10 compiles the risks associated with the habitat goal. Each risk is placed into the matrix according to the consequence and likelihood values assigned in Step 4. Within the matrices, risks located in the upper right corner (colored red) represent those with High-High or High-Medium scores. These risks are expected to have the greatest effect on achieving CCMP objectives and therefore warrant heightened attention for planning and adaptive management. Risks located in the middle of the matrices (colored yellow) have High-Low or Medium-Medium scores and indicate moderate levels of concern. Those in the lower left (colored green) with Medium-Low or Low-Low rankings reflect risks that are either less likely to occur or have relatively minor impacts.

By compiling risks in this way, Step 5 provides a transparent, goal-specific overview of how vulnerabilities may influence the effectiveness of the CCMP. This format also facilitates direct comparison between water quality and habitat risks, supporting prioritization of management actions in subsequent steps.

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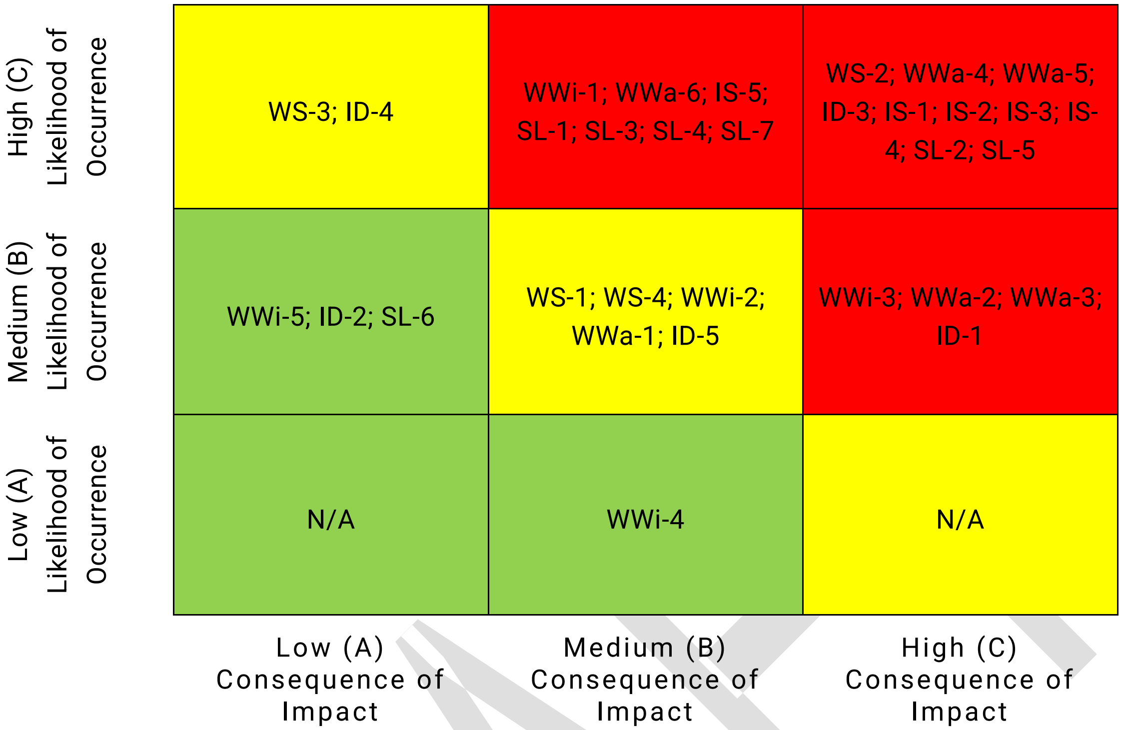
WATER QUALITY RISK EVALUATION



	Low (A) Consequence of Impact	Medium (B) Consequence of Impact	High (C) Consequence of Impact
High (C) Likelihood of Occurrence	WS-3; ID-4	WWi-1; WWa-6; IS-5; SL-1; SL-3; SL-4; SL-7	WS-2; WWa-4; WWa-5; ID-3; IS-1; IS-2; IS-3; IS-4; SL-2; SL-5
Medium (B) Likelihood of Occurrence	WWi-5; ID-2; SL-6	WS-1; WS-4; WWi-2; WWa-1; ID-5	WWi-3; WWa-2; WWa-3; ID-1
Low (A) Likelihood of Occurrence	N/A	WWi-4	N/A

Figure 9. Improve Pontchartrain Basin water quality through point and nonpoint pollutant source reduction to support ecological health.

Note: Climate stressors include warmer summers (WS), warmer winters (WWi), warmer water (WWa), increasing drought (ID), increasing storminess (IS), and sea level rise (SL).

To expand on the water quality risk matrix (Figure 9), Table 14 links identified climate risks to representative CCMP water-quality actions. These examples illustrate how stressors with High-High or High-Medium rankings could influence the effectiveness of current or planned management activities. The degree to which climate risks affect water-quality actions will depend on factors such as watershed characteristics, hydrologic connectivity, and pollutant sources. In many cases, actions may be modified or adapted to account for projected climate changes, ensuring they continue to achieve their intended outcomes. Table 14

provides examples of such linkages, describing the nature of potential impacts and potential adaptation approaches that could enhance long-term resilience.

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Table 14. Water quality example action adaptations due to climate risks.

RISK	ACTION	NATURE OF IMPACT	POTENTIAL ADAPTATION
ID-3: Decreased water flow will lead to higher concentrations of nutrients and pollutants in receiving waters.	1.2.18: Provide additional funding to continue establishing minimum flow and levels to prevent and mitigate impairments.	Variability in precipitation can make it difficult to maintain excess water supply during drought conditions to maintain minimum flows and levels.	Increase capacity in the watershed by creating or deepening reservoirs or using sand mining pits to provide additional water storage.
WS-2: More harmful algal growth.	1.2.1: Initiate sediment tracking of river sediments to identify sources of phosphorus to waterbodies (e.g., Lake Pontchartrain) to prioritize areas in the watershed needing reduction actions.	Warmer temperatures with the same nutrient load could lead to faster and more intensive algal blooms.	Enact dredging along the rivers of highest phosphorus concentrations to reduce the nutrient load initiating blooms.
IS-2: Overwhelmed septic tanks, drain fields, and municipal wastewater treatment plants, including emergency releases of partially treated wastewater from treatment facilities overloaded by inflow and infiltration during storm events.	1.1.3: Prioritize pathways/ funding for low-cost solutions for incorporating homes and businesses on individual wastewater treatment systems to regionalized or centralized treatment systems where infrastructure is nearby.	The more people connected to centralized wastewater treatment systems will lead to greater risk that increased storms can overwhelm the volumetric capacity of the system.	Design increased system capacity to account for variability or provide temporary storage of wastewater during high flow, which can later be passed through the treatment system.
SL-4: Higher water tables will inundate septic drain fields and lead to increased pathogen contaminants from sewage overflow.	1.2.4: Provide financial incentive to inspect and repair/replace faulty on-site wastewater treatment systems to help reduce pathogens in surface water.	Greater flooding from higher water tables will decrease the effectiveness of on-site wastewater systems and failing drain fields.	Increase the frequency of inspections to properties located closest to the surface waters.
IS-3: Increasing storminess could cause contaminated fluids and debris from storm damaged structures/ facilities/vehicles to wash into the bays.	1.2.13: Support local and state efforts to address marine debris/trash/litter in the basin and promote the expansion of residential recycling programs.	This risk would be an episodic impact from large storms and require greater efforts in removing much greater amounts of debris/trash from water bodies.	Develop plans for removal of debris post-storm, including identifying potential disposal sites.

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RISK	ACTION	NATURE OF IMPACT	POTENTIAL ADAPTATION
IS-4: High-volume rain events can lead to backwater flooding.	1.2.14: Coordinate with local government agencies (ordinances, development codes, and regulations) to implement best management practices (BMPs), such as nature-based solutions and green infrastructure (GI) in new development and construction projects, to include detention and retention design features.	Faster drainage and discharge will come with greater development due to increased impervious surfaces overwhelming the natural drainage.	Designing storage in the basin for the infrequent but large rain events will help prevent the backwater flooding in concert with additional nature-based solutions, such as bioswales.
SL-1: Coastal land loss will reduce the amount of nutrients removed via natural processes.	1.1.2: Increase the use of assimilation wetlands from the subdivision up to municipal wastewater treatment plant scale to further improve water quality.	Natural, assimilation wetlands located close to coastal regions could erode over time, providing less treatment effectiveness.	Provide sufficient buffer capacity when utilizing assimilation wetlands to account for potential erosive wetland loss in the future.

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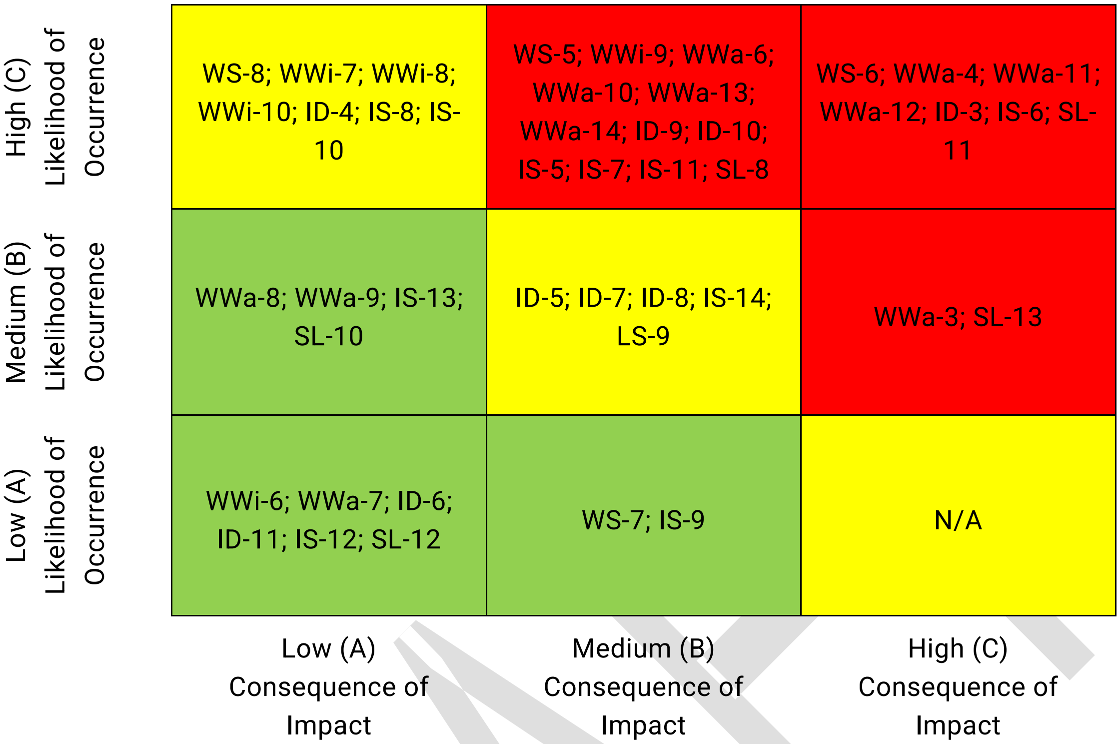
HABITAT RISK EVALUATION



	Low (A) Consequence of Impact	Medium (B) Consequence of Impact	High (C) Consequence of Impact
High (C) Likelihood of Occurrence	WS-8; WWi-7; WWi-8; WWi-10; ID-4; IS-8; IS-10	WS-5; WWi-9; WWa-6; WWa-10; WWa-13; WWa-14; ID-9; ID-10; IS-5; IS-7; IS-11; SL-8	WS-6; WWa-4; WWa-11; WWa-12; ID-3; IS-6; SL-11
Medium (B) Likelihood of Occurrence	WWa-8; WWa-9; IS-13; SL-10	ID-5; ID-7; ID-8; IS-14; LS-9	WWa-3; SL-13
Low (A) Likelihood of Occurrence	WWi-6; WWa-7; ID-6; ID-11; IS-12; SL-12	WS-7; IS-9	N/A

Figure 10. Promote sustainability of important land-based and aquatic habitat in the Pontchartrain Basin.

Note: Climate stressors include warmer summers (WS), warmer winters (WWi), warmer water (WWa), increasing drought (ID), increasing storminess (IS), and sea level rise (SL).

Some of the risks identified in the habitat matrix (Figure 10) with High-High or High-Medium scores may directly influence habitat-related CCMP actions (Table 15). The effects of these risks depend on the species or natural communities targeted and their ecological responses to changing conditions. In many instances, management or restoration actions can be adjusted or augmented to incorporate climate considerations. Table 15 provides examples of how specific CCMP habitat actions could be affected by climate stressors, the nature of those impacts, and potential adaptations that can be applied to maintain or improve project effectiveness under future conditions.

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Table 15. Habitat example action adaptation due to climate risks.

RISK	ACTION	NATURE OF THE IMPACT	POTENTIAL ADAPTATION
WS-5: More stressed natural communities allow for an increased likelihood of the establishment of invasive species.	2.3.5: Work with Louisiana Master Naturalists, LDWF, and other local organizations to conduct education and training programs for government employees, develop rapid response approaches for new invasions, and coordinate volunteer events focused on invasive species removal.	As invasive species distribution increases due to warmer summers, the effectiveness of volunteer removal programs will become more limited.	Utilize the spread in invasive species and their increased visibility to increase awareness and motivate participation in volunteer programs.
WWa-6: Warmer water could cause increased diebacks of SAV and microalgae.	2.1.5: Opportunistically build marsh terraces in shallow coastal lakes and in areas where they can be accessed by the public to promote the growth of submerged aquatic vegetation (SAV) and public awareness of their role.	Increased diebacks of SAV will lessen the habitat value of terrace fields for waterfowl.	Locate terraces in areas where there is ongoing tidal exchange to limit warming of stagnant water. Replant SAV periodically following severe diebacks.
WWa-10: An increased mortality of fish, crustaceans, and amphibians occurs as they exceed their biological limits for temperature and dissolved oxygen needs.	2.1.4: Strategically install cultch material, broodstock reefs, and living shorelines in critical areas to improve resilience for oysters. 2.1.11: Identify areas where the deployment of artificial reefs could improve recreational fishing opportunities.	Areas that are presently identified as suitable for actions to deploy substrate for oysters or to promote fishing may no longer be located in areas suitable for the target organisms.	Site oyster substrate or artificial reefs in areas that are presently suitable and where predictive modeling shows temperatures are likely to continue to be suitable for decades to come.

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RISK	ACTION	NATURE OF THE IMPACT	POTENTIAL ADAPTATION
ID-10: An increase in wildfire risk due to longer dry periods.	2.2.1: Develop and disseminate materials to educate landowners, adjacent residents, developers, local decision makers, and the general public about the crucial role of prescribed burning in the management of longleaf pine systems, the advantages of growing longleaf pine and associated herbaceous ground cover, and promote value-added products produced from longleaf pine to encourage landowners to replant longleaf pine instead of loblolly pine.	Increasing wildfires not related to the management of Longleaf Pine areas could increase concern about burning by local residents and make them more wary of prescribed burns used for forest management, in case they get out of control.	Improved forest management for all areas can limit the potential for wildfires. Adjust educational materials to emphasize the difference between prescribed burns and wildfires.
IS-11: Higher maintenance costs of coastal habitat restoration projects.	2.1.1: Support the implementation of restoration projects approved as part of federal, state, or parish planning documents that address coastal issues to increase the extent and quality of coastal habitats, including in areas accessible to the public where projects can promote awareness and interest in restoration.	Increased storm activity may result in some restoration projects being abandoned, e.g., not maintained, due to a lack of resources.	Identify sources of funding specifically for maintenance of habitat restoration projects, which can build over time between storms, ensuring funds are available when needed.
IS-6: Loss of inland habitat due to higher rates of riverbank and streambed erosion, and damage to forests.	2.2.5: Promote the value of instream, riparian, and floodplain habitat, and its compatibility with flood storage and conveyance by developing and disseminating outreach materials (e.g., on the importance of adhering to no wake zones).	Storm impacts to riparian areas and stream banks can result in downed trees and erosional features that some may consider need to be fixed, resulting in calls for clearing and snagging, and damage to habitat.	Provide specific guidance to local authorities and others following storms to ensure any debris removal is compatible with the habitat and flood storage values of natural communities.

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RISK	ACTION	NATURE OF THE IMPACT	POTENTIAL ADAPTATION
SL-11: Inability of species to migrate further inland due to physical barriers from flood mitigation structures.	2.1.3: Maintain and reconnect natural flow pathways to facilitate fish movement and/or restore degraded habitats (e.g., on Bayou Sauvage National Wildlife Refuge).	Flood mitigation structures need to be closed more often due to sea level rise, resulting in frequent barriers to fish movement and impaired hydrology in impounded habitats.	Review closure thresholds in relation to current land use to ensure closures are not over precautionary. Add automation to structures to allow gates to be opened as soon as conditions change, not relying on the availability of personnel and equipment.

RISK EVALUATION SUMMARY

The risk evaluation summarized in the matrices (Figure 8 and Figure 9) and adaptation tables (Table 14 and Table 15) collectively illustrate the range of climate-related risks identified for the basin, yet the relationships among those risks extend beyond what can be shown in discrete categories or rows. In practice, these climate stressors interact, potentially influencing and compounding on each other. For example, sea level rise can amplify the effects of storm-driven flooding, while increased precipitation intensity can accelerate nutrient loading, erosion, and habitat degradation. Because these systems are connected, a single stressor frequently influences multiple environmental components, requiring coordinated and adaptive management responses.

The adaptation tables (Table 14 and Table 15) expand this evaluation by linking specific climate risks to representative CCMP actions, illustrating how those actions might be influenced and what adaptive strategies could sustain their effectiveness. Although each example is presented discretely, the risks and actions are deeply interconnected. For instance, a marsh terrace project that mitigates temperature-related diebacks of submerged aquatic vegetation may also buffer nutrient loading and wave energy, while improvements to wastewater infrastructure not only reduce pollutant discharge but also enhance flood resilience. Collectively, the tables demonstrate that adaptations often yield cross-benefits, reinforcing resilience across water-quality and habitat objectives rather than addressing isolated risks

Addressing these risks will depend on maintaining and expanding actions that improve watershed and ecosystem resilience. Many of the CCMP's ongoing and planned efforts, such as green infrastructure, stormwater retrofits, wetland and shoreline restoration, and hydrologic reconnection projects, directly mitigate vulnerabilities identified in this assessment by enhancing natural storage, buffering storm impacts, and improving water-quality function. Coastal and wetland restoration activities strengthen habitat integrity, reduce storm-surge and saltwater intrusion risks, and support carbon sequestration co-benefits. These efforts collectively build resilience across both the water-quality and habitat objectives while complementing existing management frameworks within the basin.

The integrated nature of climate stressors also reinforces the importance of continued monitoring and research (see Appendix E). Because the magnitude and rate of climate-driven changes remain uncertain, tracking indicators such as salinity, inundation frequency, temperature, and nutrient flux will be essential for refining restoration and management strategies over time. Through this iterative process, the PRP and its

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partners can ensure that CCMP implementation continues to protect and restore basin resources effectively, even as environmental conditions evolve.

EDUCATION AND INVOLVEMENT SUMMARY

Unlike water quality and habitat, E&I risks are not evaluated in a standalone Step 5 matrix. Instead, their importance is interpreted through the ecological consequence–likelihood grids. When ecological risks are ranked high in both consequence and likelihood, the secondary E&I risks should also be viewed as high-priority concerns. Examples of these connections include:

- The risk of longer algal bloom seasons (WWa-4), ranked high for water quality, also carries significant E&I implications by constraining recreational activities and eroding public trust in local waters.
- Sea level rise impacts such as habitat loss (SL-12, SL-13), already severe for habitat objectives, translate into equally severe risks for recreational and commercial harvests, with cascading economic and cultural effects.

Even where ecological risks are ranked lower, the E&I dimension may amplify their importance. For instance, highly visible outcomes such as bird migration disruptions (IS-9) or spikes in aquatic debris from recreation (WWi-2) may disproportionately affect public perception and willingness to engage in restoration efforts.

Step 5 for E&I provides the interpretive bridge from ecological rankings to human dimensions. It emphasizes that successful adaptation in the Pontchartrain Basin requires not only ecological resilience but also sustained community participation, effective communication, and support for cultural and economic practices tied to the basin.

Conclusion

This Vulnerability Assessment for the Pontchartrain Basin applied the framework outlined in USEPA's Workbook (USEPA, 2014) to systematically evaluate how climate stressors may affect the CCMP's three core themes: water quality, habitat, and E&I. This assessment identified priority stressors, mapped them to basin objectives, and evaluated risks in terms of consequence, likelihood, spatial extent, and time horizon.

The analysis highlighted that water quality and habitat are directly vulnerable to multiple stressors, including warmer temperatures, increased storminess, and SLR. These ecological changes influence secondary but significant E&I risks, such as impacts on recreation, ecotourism, fisheries, and public engagement in stewardship. By integrating E&I linkages, the vulnerability assessment underscores the need to consider both ecological and human dimensions of environmental change.

The Step 5 evaluation demonstrated that several risks rise to the level of high consequence and high likelihood, indicating areas where adaptation and mitigation should be prioritized. While not all risks can be fully addressed, the vulnerability assessment provides a transparent framework for understanding relative vulnerabilities and aligning those with the program's goals and objectives. All CCMP actions were reviewed with climate relevance in mind, and none were included that would be undermined or rendered ineffective by foreseeable climate risks.

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As a planning tool, this vulnerability assessment does not prescribe specific adaptation actions but sets the stage for future refinement, prioritization, and integration into basin wide decision-making. Importantly, it considers each of the stressors independently in terms of their risks, while the effects may be compounding (e.g., increased drought may be associated with warmer summer temperatures). On the ground, risks need to be considered in the context of the local environment, antecedent conditions, and the opportunity for management and mitigation actions. Further, some of the stressors considered are acute, such as the effects of droughts and storms, while others may have more chronic effects, such as sea level rise. How these work together to result in change within this system is complex and site- and time-specific.

This vulnerability assessment establishes a foundation for continued engagement with partners, agencies, and communities, ensuring environmental change considerations are woven into restoration and management efforts across the Pontchartrain Basin.

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