Exercise 1. Project Scoping

1. Habitat Selection

Select one habitat type to focus on for your assessment. Some examples include: rocky intertidal, beaches and dunes, mangroves, coral reefs, seagrasses, and pelagic, among others.

SALT MARSH

2. Habitat Definition

Describe/define this habitat type. For example: Coastal Cliffs are located along rocky portions of the coastline; these are vertical or near-vertical rocky faces above the water line that provide habitat for seabirds and are subject to erosion due to exposure to wave action, sun, wind, and rain.

Salt marshes are intertidal estuarine ecosystems dominated by salt-tolerant plants, often grasses such as the smooth cordgrass Spartina alterniflora. Along the North American Atlantic, this highly productive carbon-sequestering ecosystem is found in the Gulf of Mexico and from northern Florida through Newfoundland. This ecosystem is under multiple threats including pollution, development, invasive species, and, in southern locations, conversion to mangrove forest. Further, while this ecosystem has been capable of accreting sufficient sediment to keep up with past rises in sea level, unprecedented rates of sea level rise, altered hydrology leading to reduced sediment inflows, and development that prevents landward migration could result in unprecedented rates of salt marsh loss as a result of modern sea level rise.

3. Project Boundary

Describe/define the project boundary. For example: We are considering coastal cliffs that extend from the Oregon border south to the Sonoma County border in California.

North Atlantic (Gulf of Maine and environs)

4. Human Uses and Ecosystem Services

Describe the human uses and/or ecosystem services provided by this habitat type. Ecosystem services include things such as provisioning (e.g., food, fiber, natural medicines, fresh water), regulating (e.g., flood and erosion control, water purification, natural hazard regulation), supporting (e.g., primary production, nutrient cycling), and cultural (e.g., spiritual and religious, cultural heritage, recreation, educational values).

Salt marshes provide valuable ecosystem services such as coastal protection, carbon sequestration, and nursery habitat for fishery species, among others.

5. Assessment Timescale

From the following list, select the timescale you will use for the vulnerability assessment. Write it in the box below.

- Near term (present to 10 years)
- Medium term (next 50 years)
- Long term (next 100 years)
- Very long term (next 100+ years)

Timescale: MEDIUM-TERM

6a. Climate Stressors

Rank each climate stressor below on a scale from little to no impact on your habitat type (i.e. Low) to very significant impact on your habitat type (i.e. High).

	Low impact	Moderate impact	High impact
Increased water temperature	○	○	○
Diminished dissolved oxygen	○	○	○
Altered precipitation patterns	○	○	○
Altered storm frequency/severity	○	○	○
Increased wave action/coastal erosion	○	○	○
Sea level rise	○	○	○
Altered upwelling/mixing	○	○	○
Increased ocean acidification	○	○	○
Increased harmful algal blooms	○	○	○
Altered currents	○	○	○
Increased turbidity	○	○	○
Altered salinity	○	○	○
Altered ENSO/PDO	○	○	○
Other (describe)	○	○	○

6b. Select Significant Climate Stressors

From your rankings above, select the three (3) most significant (i.e. High impact) climate stressors for your habitat type. Write these in the text boxes below (i.e., Climate Stressor #1). If you identified more than three (3) High impact stressors in the table above, use the box below to document your rationale for why you selected the final stressors over the others also ranked as High impact.

Climate Stressor #1

Climate Stressor #2

Climate Stressor #3

7a. Non-Climate Stressors

Rank each non-climate stressor below on a scale from little to no impact on your habitat type (i.e. Low) to very significant impact on your habitat type (i.e. High).

	Low impact	Moderate impact	High impact
Land-source nutrient pollution	○	○	○
Land-source non-nutrient pollution (e.g., plastics, PCBs, PAHs)	○	○	○
Marine-source pollution and spills	○	○	○
Development/population growth	○	○	○
Harvest	○	○	○
Aquaculture	○	○	○
Overwater/underwater structures	○	○	○
Invasive species	○	○	○
Disease	○	○	○
Tourism/recreation	○	○	○
Extraction (mining, oil & gas)	○	○	○
Energy production	○	○	○
Roads/armoring	○	○	○
Noise	○	○	○
Dredging	○	○	○
Transport (shipping, oil & gas)	○	○	○
Other (describe)	○	○	○

7b. Select Significant Non-Climate Stressors

From your rankings above, select the three (3) most significant (i.e. High impact) non-climate stressors for your habitat type. Write these in the text boxes below (i.e., Non-Climate Stressor #1). If you identified more than three (3) High impact stressors in the table above, use the box below to document your rationale for why you selected the final stressors over the others also ranked as High impact.

Non-Climate Stressor #1

Non-Climate Stressor #2

Non-Climate Stressor #3

Exercise 2 (Part I). Climate Change Impacts Summary

Habitat: SALT MARSH Timescale: MEDIUM-TERM

Parameter	Change to date	Projected change	Trends in projected change	Confidence	Map
Coastal flooding/ shoreline change	-0.5m (1.6 ft) average rate of long-term shoreline change for New England and Mid-Atlantic coasts in the U.S., with 65% of transects eroding[11]	Current 100-year flood will occur annually by 2100 in most of New England and Mid-Atlantic U.S., due to a combination of SLR and changes in storm patterns[10]	↑	High	County-level projections available for U.S. East Coast[10]
Precipitation/ runoff	Increased annual and seasonal precipitation in the Northeast U.S. and Atlantic Canada, with the greatest changes occurring in the fall[12,13] Increased frequency and intensity of extreme precipitation events since 1901[12]	Slight to moderate increase (up to 20%) in annual and seasonal precipitation by 2100, with the greatest increases in winter and spring[12,13]	↑	High[13]	Figure 7.5[12] Figure 4.17–4.19[13]
Ocean temperature	+0.6°C (2.8°F) in the Northwest Atlantic from 1900–2016[1] From 1982-2016, the Gulf of Maine warmed 3 times faster than the global average, at a rate higher than 99% of the world's oceans[2]	+2.0–3.2°C (3.6–5.8°F) in the Northwest Atlantic by 2080[1]	↑	Very High[1]	Figure 13.3[1]

Ocean acidification	30% increase in surface water acidity globally since 1850 (pH decline from 8.2 to 8.1 units)[1]	100–150% increase in global surface water acidity by 2100 under high-emissions scenario (decline from 8.1 to 7.8 units)[1]	↑	High[1]	Figure 13.5[1]
Salinity	Shift towards freshening of surface waters and increased salinity in deeper waters[3,4]	Reduced salinity in the ocean surface, particularly in coastal waters[3] Increased salinity in deeper, off-shelf waters of the Northwest Atlantic[5]	↑	Moderate[3]	Figure 7[5]
Sea level rise	+16-21 cm (7-8 in) of global sea level rise since 1900[6]	+0.3–1.2 m (1.0–3.9 ft) of global sea level rise relative to 2000 (90% probability within this range)[7] SLR is likely to be higher than the global average for most of the Northwest Atlantic coast[3,7], though uplift is likely to result in falling sea levels around Hudson Bay[3] Extreme global scenario of 2.5 m (8.2 ft) possible if Antarctic ice sheet collapses[7]	↑	Low *(upper bounds & extreme scenario)*[6] Very high *(lower bounds)*[6]	Figure 13[7] Figure 7.6[3]
Storms	Increases in hurricane activity since the 1970s, although the cause is unclear[8] Increased winter storm frequency and intensity since 1950, with slight northwards shift of storm track[8]	Little or no change in hurricane frequency[9] Likely increase in hurricane intensity (including frequency of very intense storms), size, and precipitation rates[8–10] Changes in the frequency and intensity of severe winter storms are largely unknown[8]	↑	Low *(hurricane frequency/changes in winter storms)*[8] Moderate *(intensity/size)*[8] High *(precipitation rates)*[8]	None

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Exercise 2 (Part II). Vulnerability Assessment

Habitat: SALT MARSH **Timescale:** MEDIUM-TERM

Table 1. Climate Change Vulnerability Assessment

A. Climate stressor	**B. Observed or projected change** (direction and magnitude; relevant details)	**C. Anticipated effects on your habitat type**	**D. Likelihood**	**E. Consequence** (Table 2)	**F. Risk** (Figure A)	**G. Adaptive Capacity** (Table 3)	**H. Vulnerability Level** (Figure B)

Exercise 2 (Part II). Vulnerability Assessment

Table 2: Consequences					
A. Non-climate stressor	B. How does this stressor affect your habitat type?	C. Will climate change make this better or worse? (+/-)	D. What is the combined impact of this non-climate stressor and… [Insert your three climate stressors here]		
Consequence Assess the consequence of the direct effect of the climate stressor in tandem with existing non-climate stressors on this habitat type. **(Negligible, Minor, Moderate, Major, Catastrophic)**					

Figure A. Risk = Likelihood x Consequences

Likelihood	Consequences				
	Negligible	Minor	Moderate	Major	Catastrophic
Rare	Low	Low	Low	Low	Low
Unlikely	Low	Low	Moderate	Moderate	Moderate
Possible	Low	Moderate	Moderate	High	High
Likely	Low	Moderate	High	High	Extreme
Almost certain	Low	Moderate	High	Extreme	Extreme

Figure B. Vulnerability = Risk x Adaptive Capacity

Risk	Adaptive Capacity		
	Low	Moderate	High
Low	Low	Low	Low
Moderate	Moderate	Moderate	Low
High	High	Moderate	Moderate
Extreme	High	High	Moderate

Exercise 2 (Part II). Vulnerability Assessment

Table 3: Adaptive Capacity		
Assess the status and condition of each factor of Adaptive Capacity for your habitat type. Rate on a scale from 1-5 (5=Superior, 4=Good, 3=Fair, 2=Poor, 1=Critical)		
Ecological potential	**Rating**	**Rationale & notes**
Extent, Distribution & Connectivity		
Past Evidence of Recovery		
Value/Importance		
Physical Diversity		
Biodiversity		
Keystone & Indicators Species		
Other:		
Average		
Social potential	**Rating**	**Rationale & notes**
Organization Capacity		
Staff Capacity (training, time)		
Responsiveness		
Stakeholder Relationships		
Stability/Longevity		
Other:		
Management potential		
Existing Mandate		
Monitoring & Evaluation Capacity		
Ability to Learn and Change		
Proactive Management		
Partner Relationships		
Science/Technical Support		
Other:		
Average		

Combined Average		
Adaptive Capacity		
Convert average to adaptive capacity rating: Low = 1 – 2.3; Moderate = 2.4 – 3.6; High = 3.7 – 5		

Adaptive Capacity Factor Descriptions

Ecological Potential

To help in the evaluation of the ecological potential factors of adaptive capacity, consider the following explanation of each factor. Keep in mind that you do not need to evaluate a factor that does not apply to your habitat, and that you can add a more relevant factor to evaluate in the "Other" line.

Extent, distribution & connectivity: Habitats that are currently widespread in their geographic extent, with high integrity and continuity likely have greater adaptive capacity, and may be more likely to withstand non-climate and climate stresses and persist into the future. Habitats that are degraded, isolated, limited in extent, or currently declining due to non-climate and climate stresses likely have less adaptive capacity, and may be less likely to persist into the future.

Past evidence of recovery: Some habitats may have more rapid regeneration times and/or are dominated by species with short generation times. Habitats with a shorter recovery period from the impacts of stressors (<20 years) may have greater inherent ecological adaptive capacities than slower developing/recovering habitats (>20 years), as slower recovering habitats may be more inherently vulnerable to the potential intervening effects of climate change.

Value/importance: Is the habitat highly valued ecologically or societally? Habitats with a high societal value likely have higher adaptive capacity, as people may have a greater interest in protecting and/or maintaining them and the ecosystem services they provide. Habitats may be ranked as having high ecological value due to greater compositional heterogeneity/variability, or as a result of their high value they may benefit from greater conservation prioritization, either of which could confer greater adaptive capacity.

Physical diversity: Habitats that include diverse physical and topographical characteristics (e.g.,, variety of aspects, sediment types) may have higher adaptive capacity. Also known as heterogeneity, this could be a site with a more varied depth profile, complex currents, north and south facing habitat, or many other variable physical features that could confer adaptive advantage.

Biodiversity: The level of diversity of component species and functional groups in a habitat may affect the adaptive capacity of that habitat to climate change impacts. For example, habitats with multiple species per functional group likely have greater adaptive capacity because response to changes in climate varies among the species. Greater biodiversity in terms of variety and number of component species and functional groups may increase potential adaptive capacity for a given habitat at a given location.

Keystone and indicator species: A habitat may include populations of important species, whether protected, endangered, or ecologically critical. The adaptive capacity of these species should be evaluated on your assessment of their condition. Habitats where keystone and indicator species are in better condition may have greater adaptive capacity.

Social Potential

To help in the evaluation of the social potential factors of adaptive capacity, consider the following explanation of each factor. Keep in mind that you do not need to evaluate a factor that does not apply to your habitat, and that you can add a more relevant factor to evaluate in the "Other" line.

Staff capacity (training, time): It is useful to consider the diversity of expertise, the understanding and confidence in addressing climate change challenges, and the institution's ability to be flexible and accommodate additional management responsibility and effort. Few resource management professionals have been trained in climate science and adaptation. Adaptive capacity can be greater if you have staff with the right professional training and the time to apply it.

Responsiveness: The ability of an organization to adjust its management and structure may be necessary in responding to climate change. In some cases, this could be a dramatic shift, such as changing a site's management strategies from restoration to retreat for a habitat type. Does your management structure allow you to stop taking action and accept the loss of a once-protected resource? In other cases, responsiveness may be more subtle, such as changing the timing of actions, including seasonal or temporary closures during periods of high stress.

Stakeholder relationships: Many adaptation actions will require changes in management. In some cases, this will require stakeholder buy-in or action. Having good stakeholder relationships can enhance adaptive capacity.

Stability/longevity: Organizations that have short planning horizons, short governance structures or lack long-term commitment will have less adaptive capacity as there may not be any ability to follow through on needed actions.

Existing mandate: If management mandate does not exist for the habitat or it cannot be interpreted to include climate change planning, adaptive capacity is diminished.

Monitoring and evaluation capacity: Even if you have the ability to implement actions, if you cannot measure its efficacy through monitoring and evaluation procedures you will not be able to know if it is effective or if it needs modification to improve outcomes. Adaptive capacity is enhanced when monitoring and evaluation are part of management practice.

Ability to learn and change: Having a culture or structure that allows for modification of management actions as new information is acquired is vital to effective adaptation. Often referred to as adaptive management, organizations where this is common practice will have a higher adaptive capacity.

Proactive management: Often adaptation actions will need to be put into practice before a problem becomes evident. For example, planning for range shifts of species of concern may require changes in species management or habitat restoration before a species arrives at a new location. If proactive management can be practiced, adaptive capacity will be enhanced.

Partner relationships: When adaptation actions require transboundary or interagency cooperation it is essential to have strong partner relationships. Partners will need to have a common understanding of climate projections, vulnerabilities, and adaptation options. In cases where partner relationships are strong, adaptive capacity may be greater owing to the ability to work collaboratively and flexibly to make management changes as needed.

Science/technology support: Climate science advances daily. Having access to science partners or in-house science expertise is essential for maintaining a sufficient awareness of current understanding of processes to make informed management decisions. Adaptive capacity will be improved when science and technology support are available.

Exercise 3. Adaptation Strategy Development

Habitat: SALT MARSH

A. Vulnerability (climate stressors & anticipated effects)	**B. Adaptation strategy**	**C. Cost** (H/M/L)	**D. Efficacy** (H/M/L)	**E. Co-benefits & conflicts**

Exercise 4 (Part I). Adaptation Strategy Implementation

Habitat: SALT MARSH

A. Strategy	B. Leader and potential partners	C. Funding	D. Existing or needed management mechanisms	E. Timeline