Illustrative Adaptation Planning Exercise for Coastal Impoundments in Delaware	
1. Identify Conservation Goals and Targets	
• *What are your current conservation goals?*	Examples of impoundment management goals: • Maintain/enhance waterfowl abundance to support waterfowl hunting • Maintain/enhance fish populations to support sportfishing • Maintain/enhance autumn shorebird abundance • Provide habitat for breeding shorebirds • Provide habitat for breeding marshbirds • Provide foraging habitat for wading birds • Provide non-consumptive wildlife use (e.g., birdwatching)
• *What are your conservation targets (i.e., habitats, species, ecosystems)?*	• Freshwater habitat for within the coastal impoundment • Freshwater habitat throughout management unit (including in impoundment and other areas) • Species of concern (e.g., American black ducks, red knots, other)
• *What is the current status of your targets (e.g., what conservation challenges do you currently face in managing your system)?*	• Maintaining appropriate water levels and flows for target species • Invasive plant species are outcompeting native species • Mosquito problems
• *What conservation approaches are you currently planning/implementing to maintain or improve the status of your targets?*	• Managing water control structures • Controlling invasive species through pulling, herbicides • Maintaining native plants through mowing, controlled burns • Manage ditch system for mosquito control
2. Assess Climate Change Effects and Vulnerabilities	
a. Determine Scope and Objectives	
• *What decisions do you want this assessment to support? Who is your audience?* • *What is your timeframe?*	• Public education • Inform management decisions within single impoundment • Inform management decisions refuge-wide • Just within planning period (e.g., 15 years) vs. longer term
b. Assess Elements of Sensitivity	
• *How and to what degree are your management targets sensitive to climate conditions/variables?*	• Waterbirds, shorebirds, and wading birds will have varying sensitivity to climate change depending on the species. Many species will be sensitive to changes in water levels. If coastal impoundment levels are not able to fluctuate as necessary to provide food sources, habitat, nesting areas, the system will not support associated species.

	• Certain species also may be sensitive to saltwater intrusion (e.g., if it affects key food sources such as fish or vegetation). • Target fish species may be sensitive to higher average air temperatures and associated increases in water temperatures.
• *How and to what degree are your management approaches sensitive to climate conditions/variables?*	• The infrastructure of coastal impoundments may be sensitive to sea-level rise/storm surge, possibly changes in precipitation patterns. Current water control structures may not be able to remove/draw down enough water for management goals.
c. Assess Elements of Exposure	
• *How are climate conditions projected to change in the area?*	• Sea-level rise is projected to accelerate. Possible scenarios: 0.5 m, 1 m, 1.5 m by 2100. • Average temperatures are projected to rise. • Possible increase in intensity of coastal storms.
• *Is there evidence of climate change already being observed in the area?*	• Most areas in the Northeast, including Delaware Bay, are already experiencing relative sea-level rise both from naturally occurring subsidence and eustatic sea-level rise. • The region is also experiencing higher average temperatures and more extreme precipitation events.
d. Assess Elements of Adaptive Capacity	
• *What is your system's adaptive capacity relative to climate change?*	• By their nature, coastal impoundments have a certain degree of adaptive capacity as their water levels can be controlled. • Infrastructure surrounding coastal impoundments also may be modified to deal with changes in sea level rise and storm surges. • Adaptive capacity of target species may vary: some species may be able to make use of habitat elsewhere; others (e.g., already beleaguered populations with special habitat needs) may not.
3. Identify Potential Management Options	
• *What is your initial desired objective [i.e., are you managing for persistence (P), looking to enhance resilience (R), or facilitating change (C)]?*	• P/R: Managers want to work to ensure that the impoundment continues to support existing target waterbird species.
• *What actions may reduce sensitivity?*	• C: Manage habitat to support species more tolerant of (less sensitive to) changing conditions.
• *What actions may reduce exposure?*	• P: Build higher/wider dikes (for sea-level rise, storm surge) • R: Create buffer of habitat on either side of dikes to minimize storm surge. Habitat build in front of dike could consist of beach habitat extending seaward/upward; Behind dike could

	be buffer of tidal marsh. • P/R: Plant vegetation that might provide some shading (for temperature)
• *What actions may enhance adaptive capacity?*	• P/R: Add additional or modify existing water control structures with intent to increase potential for water outflow; add additional structures within existing levees.
• *Other actions (e.g., alternatives to reducing vulnerability of existing targets)*	• R/C: Let nature take its course, assuming breach will ultimately occur and habitat will change to tidal marsh. • C: Actively breach existing impoundment to allow for habitat change. • P/C: Build additional impoundment upland.
4. Select and Implement Management Options	
• *Importance/urgency*	• Inaction would mean loss of important ecosystems services (e.g., habitat for endangered species, lost recreational opportunities)
• *Technical feasibility/cost*	• Some of the technical options would be costly (e.g., modifying or putting in new infrastructure) • Availability of appropriate alternative land/water for new impoundment limited
• *Equity/co-benefits*	• Efforts to manage for waterfowl may not support fish important to anglers
• *Other*	• Legal requirements?
5. Monitor, Review, Revise	
• *Monitor elements of exposure*	• Temperature changes, precipitation changes, sea-level rise
• *Monitor ecological responses*	• Populations of target species, habitat changes, hydrology changes, invasive species
• *Monitor effectiveness of management actions*	• Status of infrastructure (e.g., integrity of existing dike) • Effectiveness of old/new water control technology