



Climate Ready Estuaries

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Abstract

The Delaware Estuary was chosen in 2008 as one of EPA's six national pilots in its new Climate Ready Estuaries Initiative. The Delaware Estuary Climate Ready Program seeks to: 1) identify valuable natural resources in the estuary that are most vulnerable to changes in climate, and 2) develop an adaptation strategy that identifies and prioritizes highest value activities that can preserve or enhance these resources as climate effects are realized. For the first year of the pilot, a science and technical workgroup will perform these tasks for up to three resources, as case studies: drinking water (human use example), tidal wetlands (habitat example) and shellfish (living resource example). These resources were selected based on high perceived vulnerability to factors such as increasing sea level and salinity.

Climate change is expected to present unique challenges for each case study resource. Recommendations in the adaptation plan will specify how to maximize natural capital of these resources from the array of adaptation options that might exist. The lessons learned should guide how scientists, managers and policy makers develop approach other natural resources in our region and beyond.

Vulnerability to Climate Change

The Delaware Estuary watershed is characterized by a complex balance of habitats and living resources that coexist with people in a heavily altered landscape. Many, if not most, of our environmental indicators point to ongoing changes in ecosystem status, with problems in all indicator categories. To better predict future changes and vulnerability, climate change must be examined within the context of a complex landscape of change due to other concurrent factors (e.g. habitat conversion, loss of open space, freshwater diversions, etc.)

The perception that gradual changes in climate drivers (temperature, sea level, salinity) will lead to similar gradual changes in ecological conditions is faulty because living resources and habitats typically respond in non-linear, sometimes sudden fashion. The following are examples of expected ecological responses:

- **Disruption** – Species and communities may be directly stressed by changes in physical conditions. All biota have upper and lower bounds for their physiological tolerance to all abiotic conditions.
- **Thresholds** – Populations and communities thrive under optimal conditions but productivity can rapidly decline when conditions become less optimal or species become stress, resulting in breached tipping points.
- **Disconnects** – All species depend on others. Changing physical conditions can cause shifts in the timing of species' life cycles or migratory patterns, thereby de-coupling or unbalancing ecological interactions.
- **Cascades** – The effects of disruptions, breached thresholds and disconnects can cascade through the ecosystem through myriad positive and negative feedbacks. For example, declines in key ecosystem services may further reduce buffering capacity, perpetuating or exacerbating changes.
- **Synergisms** – Climate change is likely to magnify the effects of other existing stressors such as land use change, channel deepening and flow changes.

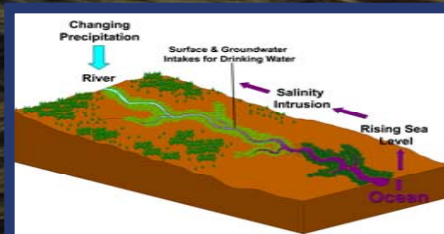


Fig 1. Salinity rise effects on drinking water intakes, especially as freshwater intakes are increasingly diverted to other uses.

Approach

A Climate Workgroup has been formed, consisting of experts in the three case study areas (Fig. 2). Subgroups of the climate workgroup, one per case study, will be tasked with:

- 1) Identifying and ranking likely vulnerability factors associated with the resource.
- 2) Characterizing likely climate change effects on ecosystem goods and services (i.e., natural capital value).
- 3) Identifying adaptation options to preserve or enhance the resource, with perceived natural capital benefits, and
- 4) Providing recommendations regarding the highest value actions that should be taken by managers and policy-makers.
- 5) Using the best scientific judgment to characterize vulnerability, using a qualitative risk assessment approach, and to provide recommendations based on existing information.



Natural Capital Valuation

The climate workgroup will value the natural capital of the case study resources using the Habitat Equivalency Analysis (HEA) method developed by the National Oceanic and Atmospheric Administration (NOAA). HEA was first developed for resource damage mitigation, to determine the amount and type of restoration needed to compensate for the services lost to disturbances like oil spills. The HEA methodology is now being applied around the nation as a way to value and compare ecosystem services.

Adaptation Plan

To prepare this final report, the workgroup will attempt to assess and contrast: 1) expected changes in natural capital resulting from climate change effects, and 2) potential natural capital improvements that might be realized with various adaptation options. The information gained from these exercises will be used to furnish discrete recommendations to managers and policy-makers in the pilot project adaptation report.

PDE Climate Ready Approach

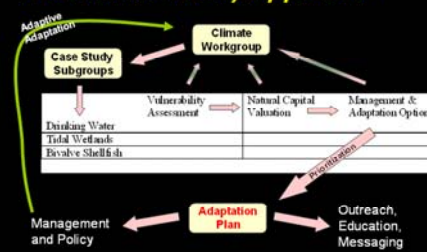


Fig 2. Partnership Diagram for the Climate Ready Approach

Future Steps

Our pilot adaptation plan will be contrasted with outcomes from the other five EPA pilots to determine the most pressing national issues, in order to guide the expansion of the CRE program within the pilots, as well as in other estuaries where little adaptation planning has occurred. Contingent upon resources and perceived utility, the Partnership hopes to:

- 1) Expand this pilot effort with quantitative, geospatial referenced data to strengthen our natural capital assessment and boost the predictive power of outcomes from adaptation scenarios.
- 2) Identify monitoring needed to watch for early warning signs of potential ecosystem thresholds, and
- 3) Share our findings with other climate adaptation efforts in our region and elsewhere because this type of planning requires a coordinated, multi-disciplinary approach that is watershed-based.

Tidal Wetlands: Habitat

Extensive tidal marshes line much of the Delaware Estuary where they play a pivotal role in preserving water quality, preventing flooding, and supporting fish and wildlife species. Currently, the health of these tidal marshes appears to be compromised over much of the region. Tidal marsh extent and condition are affected by sea level, salinity, temperature, freshwater inputs, sediment supply, tidal flooding, and the physical characteristics of the landscape. Climate change is expected to lead to increased storm energy, increased rates of sea level and salinity rise, decreased sediment supply, and increased erosion. There is little land left for tidal wetlands to retreat.



Bivalve Shellfish: Living Resource

Freshwater and estuarine bivalves represent some of our best sentinel indicators of ecosystem conditions. Where they are still abundant they also furnish important ecosystem services by forming complex habitats, stabilizing the bottom, and filtering water. A few species are commercially (and historically) important, most notably oysters, which still support a multi-million dollar industry despite being depleted in numbers. Hence, bivalve shellfish are living resources having high natural capital value in the Delaware Estuary. Increased salinity and temperature, altered water quality, increased storm intensity and altered weather patterns may all affect these resources in various ways, including indirect factors such as disease and non-native species introductions.

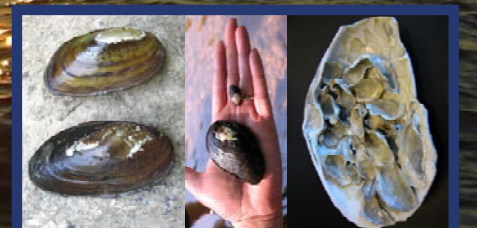


Fig 3. Oysters are threatened by salinity rise; Marsh mussels by loss of marsh habitat from sea level rise; Freshwater mussels by degradation of habitat conditions such as water quality and temperature rise.

Drinking Water: Human Use

The Delaware Estuary and its watersheds provide drinking water for about 16 million people. Much of this is derived from water intakes from the tidal freshwater portion of the Delaware River where sea level and salinity rise from climate change, combined with other potential shifts in freshwater-seawater balance in the watershed, may pose a threat. Population growth, development, land subsidence, freshwater diversions, channel deepening and salt water intrusion into aquifers may also affect drinking water more broadly across the region. The vulnerability of drinking water supplies to various combinations of these factors is not well known.



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