CLIMATE CHANGE

CC-1

CLIMATE CHANGE

Improve ability of bay habitats to adapt to a changing climate

OBJECTIVES:

Identify coastal habitats vulnerable to climate change and potential buffer areas upslope of coastal habitats. Identify methods to improve the resiliency of vulnerable bay habitats to sea level rise. Continue to investigate the carbon sequestration benefits of coastal habitats ("blue carbon"). Enhance community understanding of the potential impacts of changing climate on coastal habitats, and encourage actions to help mitigate effects.

STATUS:

New action adopted in 2014 to support ongoing and future research and restoration or mitigation of sea level rise and other projected climate change impacts on coastal habitats.

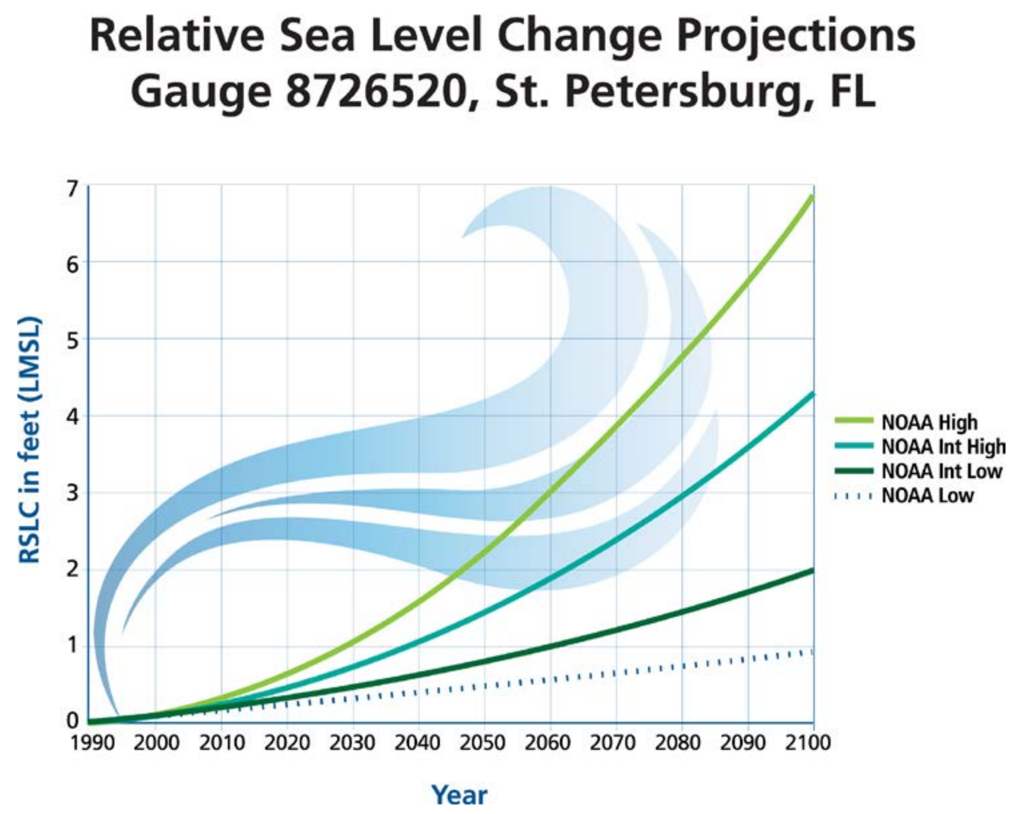
RELATED ACTIONS:

- BH-1 *Implement the Tampa Bay Habitat Master Plan*
- BH-6 *Encourage habitat enhancement along altered waterfront properties*
- BH-8 *Expand habitat mapping and monitoring programs*
- BH-9 *Enhance ecosystem values of tidal tributaries*
- CC-2 *Understand and address effects of ocean acidification*

BACKGROUND:

Estuaries like Tampa Bay are particularly vulnerable to many climate change stressors, such as sea level rise (SLR), ocean acidification (see Action CC-2), warming temperatures and changes in precipitation and storm intensity. These stressors pose a variety of risks to coastal habitats. Sea level rise may increase shoreline erosion and lead to loss of beaches, salt marshes and coastal wetlands. As higher salinity waters move upslope and upstream, plant zonation will shift; where adjacent areas are developed and there is no room to migrate, coastal wetlands will become submerged. Warmer waters may promote the spread of existing or new invasive species, increased algal growth rates, decreased water clarity and low dissolved oxygen. Frequent drought or extreme flooding may alter hydrologic conditions resulting in changes to species composition and ecological function of habitats. Increased storm intensity may lead to increased nutrient pollution to the bay and shoreline erosion.

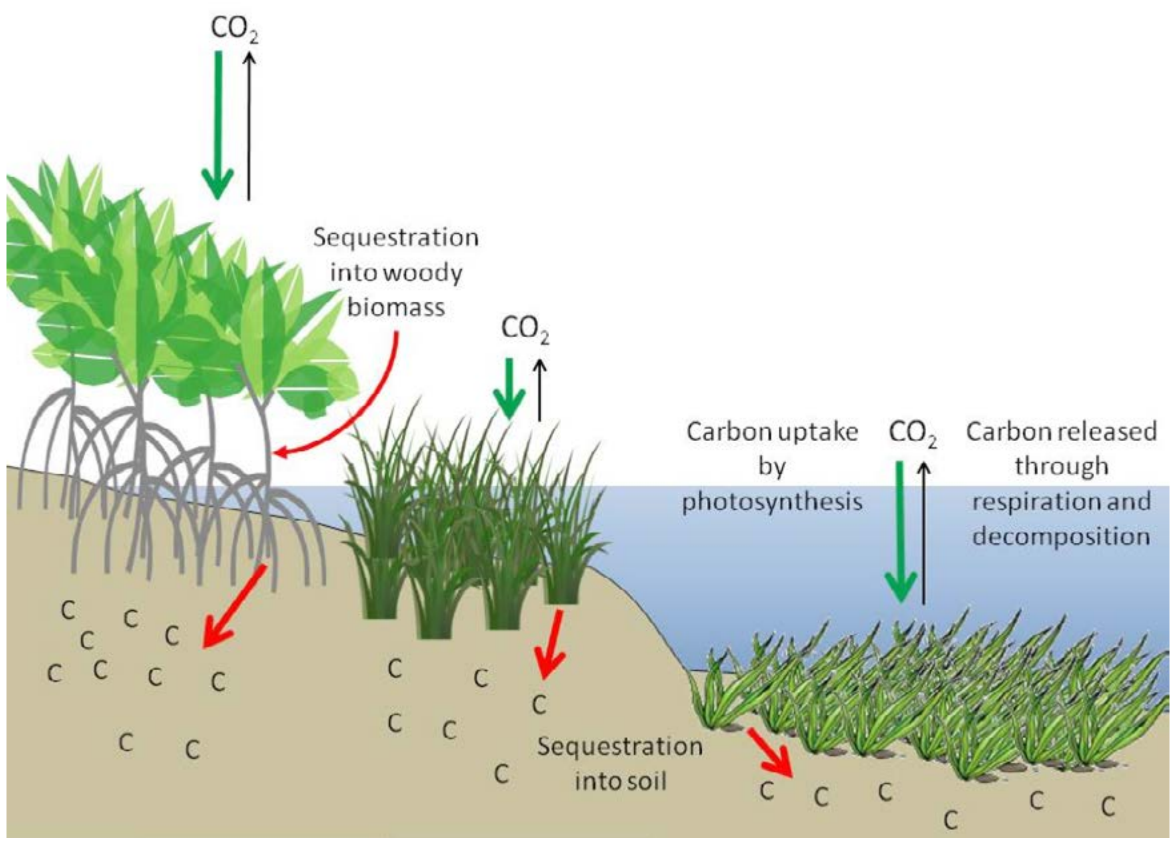
At left: A lifeguard station during a King Tide at Fort De Soto Park provides a preview of rising sea levels. Photo by Holly Greening.



Tampa Bay Climate Science Advisory Panel Relative Sea Level Change Projections

Blue Carbon

Coastal habitats are among the first to experience these impacts, but also have an important role in mitigating their effects. Tidal wetlands and seagrass habitats take up carbon dioxide and store so-called "blue carbon" in plant biomass and associated wet soils. Blue carbon ecosystems — seagrass beds, mangroves and salt marshes — store carbon at roughly 25 times the annual rate of temperate and tropical forests. This is due to high primary productivity and efficiency in trapping sediments and associated carbon transported by runoff and tidal flow.[1] In addition, seagrass beds may have a localized mitigating effect on ocean acidification (see *Action CC-2*).



Mangroves, marshes and seagrass take up carbon dioxide from the air and water through photosynthesis and store this "blue carbon" in plant biomass and associated wet soils. Image courtesy of NOAA Fisheries Habitat Conservation.

In 2016, Restore America's Estuaries, along with the Tampa Bay Estuary Program (TBEP) and its partners, completed the *Tampa Bay Blue Carbon Assessment* to determine the climate mitigation benefits of coastal habitat restoration and conservation in Tampa Bay. The study found that Tampa coastal wetland habitats will remove over 73 million tons of CO_2 from the atmosphere over the next 100 years.[2] This is equivalent to taking 160,000 passenger cars off the road every year until 2100. The assessment also provides new data to help bay managers understand what actions are most needed to help mitigate the effects of sea-level rise. Potential actions include protection of upslope buffers for important habitats and species.

Sea Level Rise

Regional projections of sea level rise for use in local planning efforts across the Tampa Bay Area were developed in 2015 by the Tampa Bay Climate Science Advisory Panel (CSAP), an ad hoc network of scientists and planners working in the Tampa Bay region. The regional projections cover a set of four global sea level rise scenarios calculated by the National Oceanic and Atmospheric Administration (NOAA) that are included in the 2014 U.S. National Climate Assessment. The projections are regionally corrected to the NOAA tide gauge in St. Petersburg and range from 0.5 to 2.5 feet in 2050 and 1 to 7 feet in 2100.

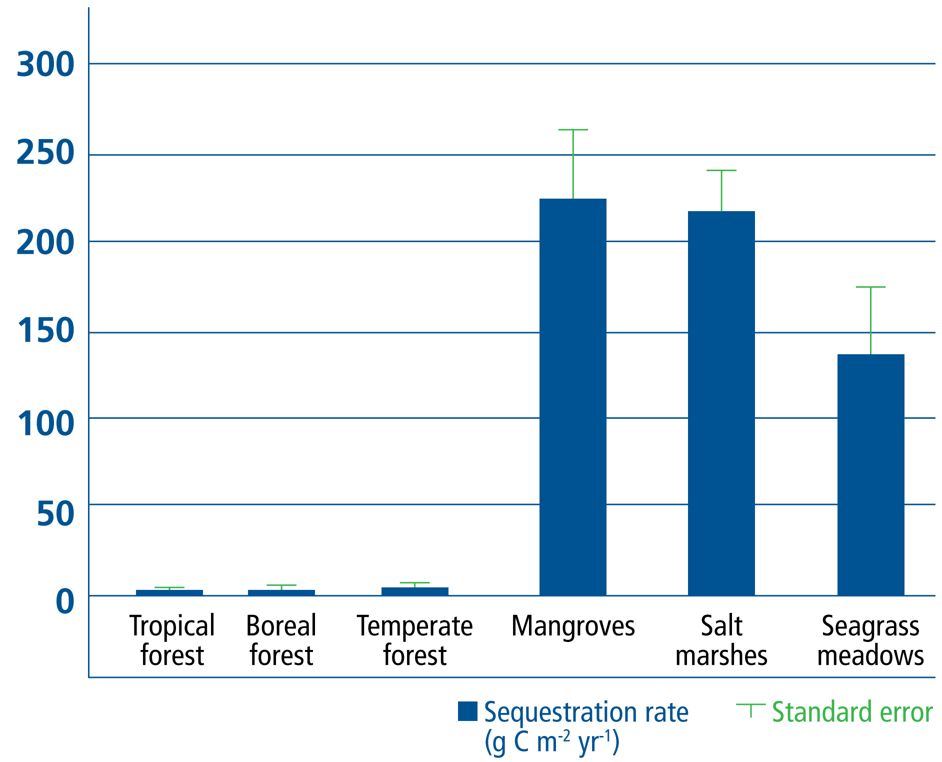
TBEP evaluated potential impacts and management implications of sea level rise on Tampa Bay's critical coastal habitats such as mangroves, salt marshes and salt barrens.[3] Modeled habitat changes showed an overall loss of critical coastal habitats by 2100, with mangrove forests increasing at the expense of salt marshes and salt barrens. Protecting remaining coastal wetland ecosystems remains an important priority for TBEP (see *Action BH-1*).

In 2016, baseline monitoring was completed at five permanent transects throughout Tampa Bay as part of the *Critical Coastal Habitat Assessment* (CCHA) program. The overall goal of the long-term monitoring program is to track and assess the effects of sea level rise on the natural zonation of critical coastal habitat (i.e., mangroves, saltmarsh, salt barrens and coastal uplands) in Tampa Bay. The monitoring design seeks to collect comparable data on sites with human-related impacts, as well as other ancillary effects, such as shifts in plant or animal communities). The CCHA will be expanded to five more sites in 2017, with the assistance of a Wetland Development Grant from the U.S. Environmental Protection Agency. Future assessments at these locations will allow comparison of habitat zonation and condition over time.

Establishing upslope habitat 'refugia' may allow coastal wetlands to persist under anticipated climate change and SLR impacts and provide new areas for recreational opportunities. Where upslope migration of coastal habitats is impeded by development, strategies such as implementing rolling easements, funding public land acquisition, requiring wetland conservation as part of new infrastructure, prohibiting construction of hardened shorelines and promoting living shorelines may be recommended (see Action BH-6). Where downstream sediment transport is necessary to protect wetlands and promote blue carbon, removal of barriers may be recommended (see *Action BH-9)*.

Already, sea level rise is being addressed in habitat restoration projects conducted by the Southwest Florida Water Management District's (SWFWMD) Surface Water Improvement and Management (SWIM) program. SWIM biologists are building in space and contouring elevation so vulnerable coastal habitats can migrate upslope as water levels rise. For example, restoration of former agricultural land at Robinson Preserve's 150-acre expansion in Manatee County will create about 85 acres of coastal upland habitats resistant to near-term sea level rise and about 55 acres of wetland and sub-tidal habitats. Efforts to restore coastal habitat mosaics that are resilient to climate change should be continued so habitats can transition, and ecosystems important to fish and wildlife can persist.

The full scope of climate change risks to the Tampa Bay Estuary is not well understood by the public; therefore, educating citizens on potential impacts and actions to mitigate these impacts is an important goal of TBEP. In partnership with the Sarasota Bay Estuary Program, TBEP coordinated a photo-documentary project called "Chasing the Waves." Local citizens were recruited to become "Tide Watchers" by taking photos of areas at low tide and at extremely high, or "king" tides, to document impacts of rising waters on structures and shorelines. While only a temporary phenomenon, king tides provide a preview of possible impacts of sea level rise when today's high tides will become tomorrow's low



Annual mean carbon sequestration rates for blue carbon habitats per unit area compared to terrestrial forest habitats. The annual sequestration rate of a given ecosystem is the quantity of CO_2 removed from the atmosphere and/or ocean and trapped in natural habitats. Modified from McLeod et al. 2011.

tides. Citizen photos were featured on a photo-sharing website, and a traveling exhibition was viewed by more than 155,000 people at county buildings, libraries and museums throughout the Tampa Bay watershed.

STRATEGY:

Activity 1 Identify coastal habitats most vulnerable to impacts of climate change and potential buffer areas upslope of coastal habitats. Identify effective methods to improve the resiliency of vulnerable bay habitats to sea level rise.

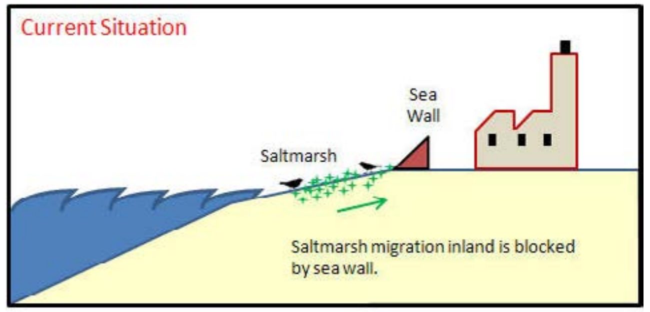
Responsible parties: TBEP (lead), SWFWMD, USFWS, local governments

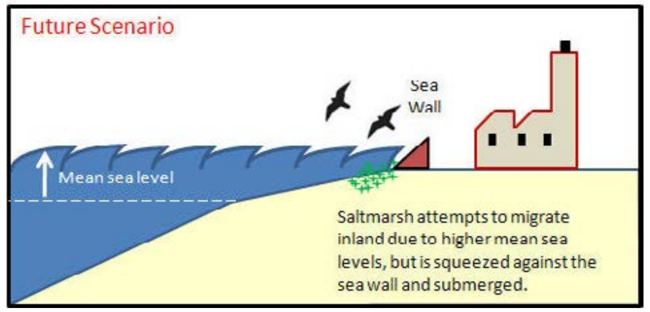
Timeframe: Initiated in 2017, through the Tampa Bay Habitat Masterplan

Cost and potential funding sources: $$ CWA Section 320 funds, RESTORE Act, local partners

Location: Baywide

Benefit/Performance measure: Evaluation of coastal and adjacent upland habitat quality and methods for conservation and restoration





Coastal squeeze occurs when upslope migration of habitat is impeded by development. Image courtesy of news.caloosahatchee.org.

appropriate to projected sea level rise scenarios.

Results: Better information for management decisions on critical bay habitats.

Deliverables: Updated list of vulnerable areas to be prioritized for acquisition and restoration activities. Report on best practices for habitat conservation and restoration in the face of sea level rise.

Activity 2 Continue to implement Critical Coastal Habitat Assessment monitoring at permanent transects to track long-term changes from climate change and other stressors to coastal habitats and species.

Responsible parties: TBEP (lead), local government and agency partners

Timeframe: Finalize baseline data collection in 2017, then every 5 years after that

Cost and potential funding sources: $$$ CWA Section 320 funds, grants

Location: Permanent transects throughout the bay

Benefit/Performance measure: Evaluation of change in habitat extent and quality over time.

Results: Proactive management decisions for critical bay habitats that consider climate change, land use changes and effects from other factors.

Deliverables: Final report of initial baseline monitoring, then reports evaluating successive changes observed every five years.

Activity 3 Support and assist with purchase, protection and/or restoration of priority sites to serve as climate change refuges and upslope buffers for critically important habitats and species. Support adoption of land management strategies such as rolling easements, coastal construction setbacks and living shorelines.

Responsible parties: SWFWMD, USFWS, FDEP, other state, federal and local government land acquisition programs and land trusts; FDOT, CSX, TECO and other entities that own or manage linear properties, easements or infrastructure, as appropriate

Timeframe: Priority list of environmental lands is updated every 10 years as part of the update to the Habitat Master Plan, scheduled for completion in 2018

Cost and potential funding sources: $$$–$$$$ federal, state, regional and local land acquisition programs, grants

Location: Baywide

Benefit/Performance measure: Restored and protected habitat used by fish and wildlife and for recreational opportunities resilient to near-term sea level rise projections.

Results: Increased quantity and quality of climate-resilient coastal habitats.

Deliverables: Annual reporting of protected and restored habitat, as required by the Government Performance and Results Act.

Activity 4 Continue to identify carbon sequestration benefits and economic incentives to preserve coastal habitats through voluntary carbon markets or other mechanisms. Assist land management agencies in developing site management plans that maximize carbon sequestration benefits of appropriate coastal habitats held in preservation or conservation.

Responsible parties: Restore America's Estuaries, TBEP, academic institutions, SWFMWD, local governments, FDEP

Timeframe: Initiate by 2019

Cost and potential funding sources: $$$ External grants, TBERF, EPA CRE

Location: Baywide

Benefit/Performance measure: Evaluation of blue carbon cost-benefit solutions.

Results: Better information for management decisions and incentives for conserving and restoring critical bay habitats.

Deliverables: Updated report on blue carbon storage potential for Tampa Bay habitats. Site management plans for maximizing carbon sequestration benefits of coastal habitats.

Activity 5 Enhance community understanding of the potential impacts of climate change on coastal habitats, and encourage actions by state and local entities and citizens to help adapt to or mitigate effects. Develop metrics to measure citizen outreach effectiveness.

Responsible parties: Florida Sea Grant, local government sustainability programs, TBEP, UF/IFAS Extension, St. Petersburg College Sea Level Rise Group

Timeframe: Ongoing

Cost and potential funding sources: $$ Operating budgets of partner organizations; CWA Section 320 funds and/or Bay Mini-Grants for TBEP activities, other grants

Location: Baywide

Benefit/Performance measure: Public education and outreach programs with metrics for engagement and behavior change.

Results: Citizen engagement in habitat restoration volunteer projects and behavior changes to adopt recommended mitigation actions.

Deliverables: Educational outreach materials and program metrics.

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[1] McLeod, E., Chmura, G.L., Bouillon, S., Slam, R., Bjork, M., Duarte, C.M., Lovelock, C.E., Schlesinger, W.H., and Silliman, B.R. 2011. A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2. *Front. Ecol. Environ.* 9(10): 552-560.

[2] Sheehan, L., Crooks, S. et al. Tampa Bay Blue Carbon Assessment. 2016. Technical Report #07-16 of the Tampa Bay Estuary Program.

[3] Sherwood, E.T. & Greening, H.S. Potential Impacts and Management Implications of Climate Change on Tampa Bay Estuary Critical Coastal Habitats. *Environmental Management* (2014) 53: 401. (Tampa Bay Estuary Program *Technical Reports #03-12 and #07-14*)

CLIMATE CHANGE

CC-2

CLIMATE CHANGE

Understand and address effects of ocean acidification

OBJECTIVES:

Improve understanding of acidification status of Tampa Bay. Examine potential role of seagrasses in Tampa Bay to buffer ocean acidification trends in the Gulf of Mexico and provide refuges for organisms vulnerable to increasing acidification. Include ocean acidification issues and mitigation solutions in outreach and education materials.

STATUS:

New Action

RELATED ACTIONS:

BH-1 Implement the Tampa Bay Habitat Master Plan

CC-1 Improve ability of bay habitats to adapt to a changing climate

FW-3 Achieve a sustainable bay scallop population

FW-6 Preserve the diversity and abundance of bay wildlife

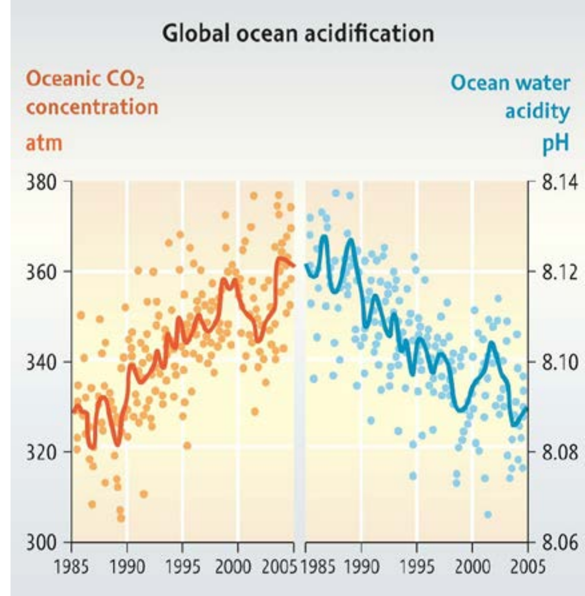
BACKGROUND:

Despite the vast size of the oceans, data show that ocean chemistry has shifted in response to increased carbon dioxide in the atmosphere. Carbon dioxide reacts with sea water to produce carbonic acid, increasing the acidity (lowering the pH) of seawater. This phenomenon, known as ocean acidification (OA), has produced a 30% increase in ocean acidity since the Industrial Revolution (a decrease in pH of 0.11). As the concentration of carbon dioxide in the atmosphere increases, the ocean absorbs more of it, and as surface layers gradually mix into deep water, the entire ocean is affected.

At left: Seagrasses may provide an important marine refuge by buffering the impacts of ocean acidification for fish and shellfish. Photo by Jimmy White.

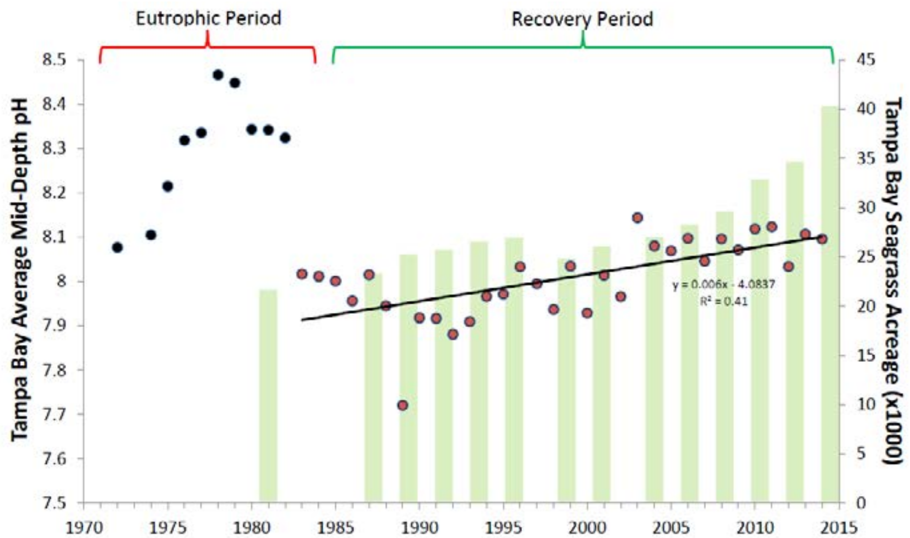
The decrease in ocean pH disrupts the balance of minerals in the water and makes it more difficult for marine organisms such as shellfish, plankton and corals to produce and maintain calcium carbonate, the primary component of their hard skeletons and shells. Ocean acidification can cause deformities in larval stages of organisms, increasing mortality. In some species of shellfish and fish, especially in the juvenile stages, OA can also impair metabolism, immune system, sensory functions and reproduction. This can impact the entire marine food web and negatively affect recreational and commercial fisheries.

Long-term water quality monitoring data from the Environmental Protection Commission of Hillsborough County (EPCHC) indicates that pH in the Tampa Bay estuary has actually steadily increased (become more basic) since the 1980s, as local management strategies improved water quality and seagrass abundance. Seagrasses are expected to benefit from elevated atmospheric carbon dioxide through increased primary productivity, and photosynthesis can increase seawater pH and availability of the mineral calcium carbonate. Thus, seagrasses may provide an ocean acidification refuge to organisms closely associated with seagrass beds, particularly shellfish and other economically important fish species.



Ocean carbon versus ocean pH.
SOURCE: Intergovernmental Panel on Climate Change.

TAMPA BAY SEAGRASS ACREAGE VERSUS PH LEVELS



Green bars represent seagrass acreage; points represent average mid-depth pH.
SOURCE: EPCHC and SWFWMD

In 2016, Tampa Bay Estuary Program (TBEP) along with the United States Geological Survey (USGS), Florida Fish and Wildlife Commission's Fish and Wildlife Research Institute (FWC FWRI) and University of South Florida (USF) College of Marine Science (with equipment funded by a U.S. Environmental Protection Agency grant) initiated an intensive OA monitoring program in Tampa Bay. The program will examine the extent to which seagrass recovery has helped buffer the chemical impacts of ocean acidification.

Sampling in seagrass beds and adjacent bare substrates will evaluate the role of seagrass beds in maintaining and elevating pH. Spatial and temporal differences within the estuary, as well as the effects of inflow and circulation, will be evaluated. Additionally, a continuous pH monitoring system will be co-located with an existing monitoring platform in the middle of the bay; a companion station is proposed for Gulf waters near Port Manatee. Results from these studies will be useful to examine implications for Tampa Bay shellfish populations, identify potential habitat protection and restoration activities and support regional and Gulfwide ocean acidification assessments.

Actions already being taken to reduce CO_2 emissions from the burning of fossil fuels will help slow the effects of ocean acidification. Furthermore, conserving and restoring marine habitats will strengthen ecosystem resilience to climate change and enhance ecosystem health (See Actions *CC-1, BH-1, FW-3* and *FW-6)*.

Reducing nutrient loading to estuaries can also help prevent acidification caused by excess CO_2 production when nutrient-fueled algal blooms die and decay. Continuing to manage nutrient loading to Tampa Bay is therefore an important action that also helps address global ocean acidification (see *Actions WQ-1, WQ-3, SW-1, SW-8* and *SW-10)*.

Increasing acidification of coastal waters can affect the viability of oysters and other organisms that produce calcium carbonate for their shells. Photo by Nanette O'Hara.

STRATEGY:

Activity 1 Improve understanding of ocean acidification levels in Tampa Bay. Establish at least one long term monitoring station within the Tampa Bay estuary and one directly outside the bay to track changes in Tampa Bay estuarine and Gulf of Mexico pH conditions. Co-locate stations with existing ecological or meteorological monitoring platforms.

Responsible parties: USGS (lead), USF College of Marine Sciences, FWC FWRI, TBEP

Timeframe: Initiated in 2016. Funding for bay pH monitoring station through 2018; funding not yet secured for Gulf of Mexico pH monitoring station.

Cost and potential funding sources: $$ EPA grants, additional federal grants, TBERF

Location: Baywide

Benefit/Performance measure: Long-term measurements of seawater pH inside and outside the bay.

Results: Better understanding of environmental conditions important for conservation and restoration of critical habitats, fish and shellfish populations.

Deliverables: Periodic reports on water quality parameters tracking long-term changes in pH.

Activity 2 Investigate the potential role of seagrass in Tampa Bay to buffer ocean acidification trends in the open Gulf and provide refuge to organisms vulnerable to acidification.

Responsible parties: USGS (lead), USF College of Marine Science, FWC FWRI, TBEP, academic and agency partners

Timeframe: Initiate in 2017

Cost and potential funding sources: $$ federal grants, TBERF

Location: Baywide

Benefit/Performance measure: Measures of water chemistry in seagrass beds and adjacent bare substrates over time.

Results: Increased seagrass coverage may provide OA refugia and contribute to the overall resilience and health of the bay's ecosystem as climate changes.

Deliverables: Reports evaluating the spatial and temporal effect of seagrass buffering.

Activity 3 Expand education about ocean acidification, including economic impacts related to OA, such as reduced shellfish harvest, reduced blue crab or stone crab harvests, impact on oyster and scallop restoration efforts and reduced fitness of important juvenile fishery species.

Responsible parties: Florida Sea Grant, TBEP

Timeframe: Initiated by 2018

Cost and potential funding sources: $ Grant funds, staff time

Location: Baywide

Benefit/Performance measure: Public education and outreach programs with metrics for engagement and behavior change.

Results: Citizen engagement in habitat restoration projects and community behavior changes that adopt recommended, locally-relevant mitigation.

Deliverables: Education and outreach materials and program metrics.