Chesapeake Bay

Sentinel Site Cooperative

Implementation Plan

FY13-FY18

Submitted to NOAA's National Ocean Service
Sentinel Site Program Coordinating Committee

February 2013

Executive Summary

The Chesapeake Bay Sentinel Site Cooperative (CBSSC or "Cooperative") is representative of one of five regions chosen by the National Oceanic and Atmospheric Administration's (NOAA) National Ocean Service (NOS) to demonstrate the value of using a place-based approach to address issues of local, regional and national significance, with an initial emphasis on supporting resiliency to sea level change and coastal inundation. The five Cooperatives are designed to bring together experts spanning the science-service-stewardship continuum to inform management decisions at protected locations like NERRS sites as well as urban areas. CBSSC efforts will be focused on providing data, information, and visualizations of sea level rise and inundation impacts to local citizens, city and county elected officials, managers and planners, builders and developers, and natural resource managers.

This initial 5-year Implementation Plan (FY12-FY17) is provided in response to the requirement of NOAA's NOS Sentinel Site Program Coordinating Committee as a guide for the proposed activities of the initial regional partnership. This plan outlines what is possible, based primarily on existing resources. It identifies existing monitoring stations, models, visualization tools, and education programs that could, with redirection of staff effort, be put into place. It also identifies growth opportunities aimed at providing additional information to inform decisions about issues such as zoning, emergency management, and post storm construction, as well as conservation and protection of coastal and estuarine habitat.

Five core ecological sentinel sites form the foundation of the CBSSC. These include: The Chesapeake Bay National Estuarine Research Reserves (CBNERRS), Virginia Coast Long Term Ecological Research Network (VCR-LTER), Blackwater National Wildlife Refuge (NWR) and Assateague Island National Seashore. These sites collect a suite of parameters used to tell the story of sea level rise and inundation in the Chesapeake Bay region. Each of these sites is representative of a broad geography, such as coastal bays, salt marshes, island ecosystems, and riverine environments.

These 5 ecological sentinel sites are interconnected by an existing distributed network of observing stations collecting water level, temperature, and salinity data. This network is comprised of NOAA buoys and water level stations, as well as fixed monitoring platforms overseen by the State of Maryland and the Commonwealth of Virginia. Together, the ecologically based sentinel sites and the distributed observational network provide extensive spatial coverage to characterize and monitor sea level change and its effects on the Bay.

The Cooperative has also identified sentinel sites and stations that are imperative to connecting with coastal communities but are still in development. Urban area sentinel sites will include Baltimore, Maryland, and Hampton Roads, Virginia. A small coastal community, Crisfield, Maryland, is also a planned sentinel station. As the Cooperative matures, these and other sites

identified in this plan will be further investigated to enhance the scientific and educational value of data related to sea level rise and inundation in the Chesapeake Bay.

Two models and two visualization tools are currently accessible to the Cooperative at little to no cost. The Chesapeake Atlantis ecosystem model (CAM), operated by NOAA, and the Chesapeake Inundation Prediction System (CIPS), operated by the Virginia Institute of Marine Sciences (VIMS); are ideally suited to accept data from the CBSSC. Implications derived from data collected by the CBSSC and results from model runs can be portrayed by visualization tools such as NOAA's CanVis and Sea Level Rise Viewer, and Maryland DNR's Coastal Atlas. Results from these tools will form the basis for education and outreach activities aimed at natural resource managers, community planners, and policy makers working in areas represented by one of the components of the Cooperative as well as the general public.

The premise of NOAA's Sentinel Site Program is to leverage existing resources to better understand sea level rise and inundation impacts. To date, without additional resources except for a short-term Coordinator, the Cooperative has been successful at convening two workshops with representatives from over 20 federal, state, and local governments, universities and non-governmental organizations to better define the desired accomplishments of the Cooperative, conducted a user needs assessment from previous stakeholder surveys and workshops, produced a preliminary gap analysis, established an Education and Outreach Working Group, and developed this IP.

With the addition of a long term coordinator, the Cooperative could move forward on many of the initiatives identified in this plan. Furthermore, with the allocation of staff time from the appropriate offices within NOAA, the Cooperative can be truly successful. In keeping with the five recommendations generated during the development of this document, the CBSSC will thrive and provide a valuable service to the people living and working in the Chesapeake Bay region.

Report Recommendations for the Cooperative

1. Hire a Chesapeake Bay Sentinel Site Coordinator (Cost: reallocation of staff time)

An onsite coordinator, someone with at least 50% of their time dedicated to the Cooperative, is imperative for success. This person will maintain and establish personal connections, develop networking forum for partners to share information, ensure milestones are met, follow up on working group recommendations, and lead constituent engagement with Cooperative experts. The Coastal Programs Division is well positioned to provide this service if they were adequately resourced. An academic institution, such as Virginia Commonwealth, Virginia Institute of Marine Sciences, or University of Maryland would have as much or more community credibility, but they would require resources to dedicate a coordinator to the Cooperative.

2. Implement Data Management (Cost: reallocation of staff time)

Data collected by the Cooperative needs to be standardized and made accessible to modelers and visualization tool developers. The NOAA Integrated Ocean Observing System (IOOS) Office, working with the Mid-Atlantic Regional Association Coastal Ocean Observation System (MARACOOS) can fulfill this role well at the expense of staff time.

3. Capitalize on Models and Visualization Tools (Cost: primarily reallocation of staff time)

The primary sea level rise models that will be employed by the Cooperative and where data from sentinel sites can be ingested include NOAA's Chesapeake Atlantis Ecosystem Model (CAM), VIMS Chesapeake Inundation Prediction System (CIPS), and Maryland DNR's Coastal Atlas. Currently, a CIPS storm surge model has been built for Alexandria, VA and another is underway for Norfolk. These models, which provide the basis for marsh and street level analysis of flooding impacts could be reproduced at representative locations around the Bay. The Atlantis model can be applied to regions around the Bay without significant costs. The CIPS model would require $120K to move beyond the work in Alexandria and Norfolk.

These models can be augmented with static visualization tools such as NOAA's Sea Level Rise Viewer and CanVis. With the proper education and outreach efforts, these tools will improve management efficiency at sentinel sites but, more importantly, at the local county and community level. The CBSSC should work with modelers from the NOAA Chesapeake Bay Office and VIMS, as well as staff from NOAA's Coastal Services Center to implement these models and visualization tools.

4. Establish Urban/Coastal Community Stations (Cost: Provide a range e.g. $25-75K)

The CBSSC's ecological sentinel sites, coupled with the distributed network of water quality monitoring stations, represent excellent coverage for open water, as well as protected and ecologically important regions within the Bay. However, without more concentrated monitoring and engagement in coastal communities (i.e., where people live), the Cooperative will be far less successful at meeting the public's needs.

At least three urban sentinel sites are recommended. These sites should be located in places such as Baltimore, MD; Hampton Roads, VA; and a small coastal community suffering dramatic sea level rise impacts like Crisfield, Maryland. Private industry or academia (via MARACOOS) can install water level and water quality stations that will provide data required for cooperative models and visualization tools for approximately $25,000 per site. By linking these technologies with existing infrastructure in Baltimore and Hampton Roads these costs may be able to be reduced further. Incentives for this type of investment should be created through matching funds provided by NOAA through organizations like IOOS, Office of Coastal and Resource Management, and Sea Grant.

5. Enhance Existing Monitoring Infrastructure (Cost: $20-100K per site)

The 5 ecological sentinel sites are close to being fully instrumented but only one, Virginia Coast Long Term Ecological Research Network, currently collects all core data. NOAA and its partners should continue to invest in the appropriate sensors to complete the monitoring infrastructure at these sites. The Cooperative has identified where equipment and data gaps are at each site and will help facilitate obtaining these additional needs to improve management at these sites. Where appropriate, data from these sits can be extrapolated to other rural communities to inform local decision making.

In addition, long term monitoring protocols should be implemented to document changes in aquatic ecosystems, similar to the terrestrial monitoring conducted at the current ecological sites. This sampling could include monitoring of benthic invertebrates, such as oysters and submerged aquatic vegetation. These surveys could be conducted in a representative location along the central eastern shore of the Chesapeake, thereby overlapping the CBSSC, Habitat Blueprint, and USFWS' Landscape Conservation Cooperative initiatives. This work could be conducted by academic partners, NERRS scientists, or NOAA Chesapeake Bay Office field staff. However, it would require part time personnel funding support.

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ACRONYMS

ACT	Alliance for Coastal Technologies\
CBIBS	Chesapeake Bay Interpretive Buoy System
CBOFS	Chesapeake Bay Operational Forecast System II
CBP	Chesapeake Bay Program
CBSSC	Chesapeake Bay Sentinel Site Cooperative
CORS	Continuously Operating Reference Stations
CSC	Coastal Services Center
EPA	Environmental Protection Agency
FWS	Fish and Wildlife Service
IOOS	Integrated Ocean Observing System
MADECLEAR	Maryland and Delaware Climate Change Education Assessment and Research
MARACOOS	Mid-Atlantic Regional Association for Coastal Ocean Observing Systems
MDDNR	Maryland Department of Natural Resources
NCBO	NOAA Chesapeake Bay Office
NERRS	National Estuarine Research Reserve System
NGO	Non-governmental organization
NGS	National Geodetic Survey
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NPS	National Park Service
NWF	National Wildlife Federation
SERC	Smithsonian Environmental Research Center
SET	Surface Elevation Tables
SLAMM	Sea Level Affecting Marsh Model
SLR	Sea Level Rise
SSP	Sentinel Site Program
TNC	The Nature Conservancy
UMD	University of Maryland
UDE	University of Delaware
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VCU	Virginia Commonwealth University
V-DEQ	Virginia Department of Environmental Quality
VECOS	Virginia Estuarine and Coastal Observing System
VIMS	Virginia Institute of Marine Science

INTRODUCTION

In 2011, the National Oceanic and Atmospheric Administration (NOAA) initiated a Sentinel Site Program (SSP) to encourage federal, state and local partners to cooperatively address impacts of climate change using a place-based approach, with an initial emphasis on supporting resilience to sea level change and coastal inundation. This program builds on the strengths of NOAA's National Estuarine Research Reserve Systems (NERRS) sentinel site program. The premise of the SSP is to establish Cooperatives to coordinate existing assets, programs, and resources to confront climate-related impacts. These efforts will be conducted at specific sites (i.e., sentinel sites) by employing a place-based, issue-driven approach.

CBSSC Vision: *Coastal community planners and natural resource managers understand and are able to effectively plan for climate change impacts, within the Chesapeake Bay.*

CBSSC Mission: *To provide long term data, information, tools, and educational resources, derived from local observations collected at rural and urban sentinel sites, to improve management decisions regarding rising sea levels and inundation.*

Sentinel Site Cooperative Components

Sentinel Site Cooperatives represent a series of sentinel sites, which are often comprised of multiple sentinel stations. A sentinel site is an area in the coastal or marine environment that has the capacity for intensive study and sustained observations to detect and understand changes in the ecosystems they represent. Sentinel stations are discrete instruments and measurement stations (platforms and sensors), within a consistent geospatial framework, that provide information and data that can be synthesized to provide an understanding of the ecological status and trends in physical and biological variables of interest, as well as an understanding of environmental state and past and present impact indicators. The region and partners to which the data apply from a series of sentinel sites constitutes a Sentinel Site Cooperative. This cooperative bounds not only the physical and biological data, but also the socioeconomic information necessary to deliver useful products to coastal communities. The extent of the area will encompass the human communities that are targeted to use the information provided by the program and within which relevant socioeconomic and behavioral changes can be measured.

The Chesapeake Bay Sentinel Site Cooperative (CBSSC or "Cooperative") was established in 2012 as part of the effort to provide coastal communities and resource managers with information on the potential impacts of sea level rise on coastal habitats. Other pilot Cooperatives demonstrating the value of using a place-based approach to address issues of local, regional and national significance include Hawaii, San Francisco Bay, Northern Gulf of Mexico, and North Carolina.

On September 10, 2012, representatives from federal, state and local governments, academia, and non-governmental organizations convened the first Cooperative workshop to develop a plan

for establishing a sentinel site Cooperative within the Chesapeake Bay in an effort to downscale sea level rise projections on a scale commensurate with state and local management decisions. A follow-up workshop was held on December 19, 2012, to refine the scope and actions outlined in the Cooperative's draft Implementation Plan.

The CBSSC will initially focus efforts and resources on addressing sea level rise and inundation impacts on the natural environment and coastal communities. The Cooperative's vision and mission reflect the need to focus on engaging with coastal community planners and managers to create resilient coastal communities. Addressing sea level rise requires regional cooperation and synergies among Federal, State, local, academic, non-profit and other regional players. It also requires a suite of programs, from science (e.g. data collection, model building) to service (e.g. information transfer, decision tools) to stewardship (e.g. education, management decision support). For these tools to be efficient and effective, they need to be integrated, both across different programs and agencies. The Chesapeake Bay region is fortunate to have a number of agencies and institutions that have the capabilities to turn data into tools and translate those messages to stakeholders.

The CBSSC is organized by a coordinator, who oversees the Cooperative's steering committee, Education and Outreach working group, Scientific and Technical working groups, and makes those contacts necessary to fulfill the CBSSC's vision and mission. The coordinator position is currently vacant. The position must be filled by someone who can represent the interests of the entire Cooperative. As such, someone from the academic community, NOAA's Coastal Program's Division, or Coastal Services Center would be a good candidate.

This document fulfills NOAA's Sentinel Site Program requirements to develop a 5-Year Implementation Plan (IP) for fiscal years 2013-17. It describes the Cooperative's strategic and operational approach to engaging a continuum of capabilities from observations and research to application, management, and outreach to address local impacts of sea level change and inundation (Figure 1). Currently, CBSSC partners have strong capabilities in three components of this continuum: observations and monitoring; modeling & predictions; and education and outreach. As the CBSSC gains structure and recognition over the next 5 years, we will strengthen our contribution to other elements by engaging a wider breadth of partners who have expertise in these fields. Using the strategies outlined in this IP, the CBSSC will proactively contribute to informing planning decisions necessary to support resilient coastal environments and communities.

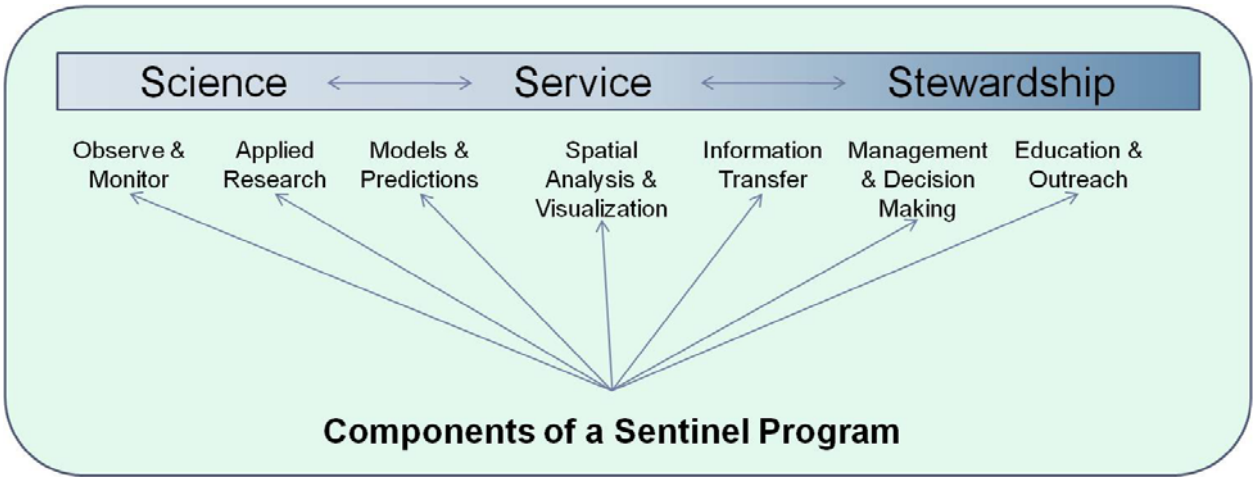


Figure 1: Components of the NOAA Sentinel Site Program.

The Challenge: Chesapeake Bay Sea Level Rise

Relative sea level is increasing along the entire U.S. Atlantic coast, with the fastest rates of change observed in the Mid-Atlantic region (Virginia, Maryland, and Delaware including the Chesapeake Bay) and the Carolinas.. In fact, the Chesapeake Bay is currently experiencing some of the highest relative sea level rise rates, up to 5.8 mm/year (0.23 in/year), reported within the United States (Boone et al., 2010), primarily due to subsidence (CCSP 2009).

Possible causes of subsidence include sediment consolidation, glacio-isostatic adjustment, groundwater extraction, and tectonics (Poag et al. 2004, Hayden et al. 2008). Recent analysis of water level data along the Atlantic Coast, including locally relevant Chesapeake Bay tide gauge stations, supports the claim that RSL rise rates are accelerating in the mid to northeast Atlantic region (Boon 2012).

Built infrastructure and natural resources in both metropolitan and rural areas are experiencing direct impacts of rising tidal water levels including inundation and salt water intrusion. As a result, the Hampton Roads/Norfolk area is re-thinking its coastal development as evidence mounts that local sea levels are rising and low-lying coastal areas are increasingly vulnerable to coastal flooding (Styles, 2011; Figure 2). In addition, Naval Station Norfolk is currently elevating its infrastructure (e.g., piers and docks) to become more resilient to sea level rise.

Historic islands in the Chesapeake Bay are sinking and eroding away at rapid rates, with some islands (e.g. Sharp's Island) now completely submerged (Larson 1998). Wetlands within the Chesapeake Bay appear to be at risk of rapid degradation and loss (Stevenson et al. 1991). Wetlands provide habitat for wildlife and ecosystem services related to socio-economic decisions (e.g., resiliency from storms, infrastructure protection). Therefore, threats to wetlands in the Chesapeake Bay have environmental and socio-economic repercussions.

The Chesapeake Bay annually produces 227 million kg (500 million lbs) of seafood and contains two (Baltimore and Hampton Roads) of the five major North Atlantic ports in the U.S. (EPA/CBP; http://www.chesapeakebay.net/ status.cfm). Loss of fisheries habitat and coastal flooding place these economic drivers at risk. The Sentinel Site Cooperative presents a new business model to better leverage existing resources with the hope of addressing regional challenges such as these.

Coupled with the historical importance of being the Nation's largest estuary and the visibility of the ecosystem to lawmakers in Washington DC, the Chesapeake Bay region provides for an excellent opportunity to demonstrate successful implementation of a Sentinel Site Program.

Figure 2. Mayflower Road at Norfolk's Colonial Place neighborhood was mostly underwater as high tide approached in November 2009 (Stephen M. Katz- Virginian Pilot file photo).

Complimentary Initiatives

There are numerous programs and initiatives in existence within the Chesapeake Bay dedicated to better understanding and reducing sea level rise impacts on the natural and built environments. Increased and more powerful storm events in the mid-Atlantic such as Hurricanes Isabelle and Sandy have pushed sea level rise issues to the forefront of political and community concerns. In addition to meeting several NOAA program goals such as those in the Next Generation Strategic Plan (http://www.ppi.noaa.gov/ngsp/) and the Habitat Blueprint (http://www.habitat.noaa.gov/habitatblueprint/), the establishment of a sentinel site network within the Chesapeake Bay supports numerous local federal and state climate change efforts.

For example, the CBSSC will support the select goals within the *Strategy for Protecting and Restoring the Chesapeake Bay Watershed*, the federal response to President Obama's Chesapeake Bay Protection Executive Order 13508. This Presidential Order has served to focus multi-agency capacities on data and data products to understand the science behind the Chesapeake Bay's natural resources, and deliver this understanding to Bay stakeholders in a coherent, meaningful way.

In 2008, the State of Virginia released its Governor's Commission on Climate Change Action Plan Report calling for local governments in the coastal area of Virginia to include projected climate change impacts, especially sea level rise and storm surge, in all planning efforts, including local government comprehensive plans and land use plans. In addition, the Virginia Institute of Marine Science (VIMS), at the direction of the Virginia General Assembly, recently completed a report that identifies and investigates strategies for adaptation to prevent recurrent

flooding in Tidewater and Eastern Shore localities (Mitchell et al., 2013). Identified and discussed strategies included management/retreat actions, accommodation actions and protection measures.

Most recently, in December 2012, Governor Martin O'Malley (Maryland) signed the Climate Change and Coast Smart Construction Executive Order, directing that all new and reconstructed state structures, as well as other infrastructure improvements, be planned and constructed to avoid or minimize future flood damage. In establishing a number of directives, this Executive Order charges the Maryland Department of Natural Resources (MD DNR) to work with the Maryland Commission on Climate Change, local governments and other parties as appropriate, to develop additional Coast Smart guidelines within nine months, for the siting and construction of new and rebuilt State structures, as well as other infrastructure improvements such as roads, bridges, sewer and water systems, and other essential public utilities as well as develop sea level rise projection models. The CBSSC is well positioned to assist in these efforts and serve in many functions to improve the science, tools, and understanding of local sea level rise impacts on the natural and built environments of the Chesapeake Bay.

CHESAPEAKE BAY COOPERATIVE OVERVIEW

The CBSSC is an open community of scientists, natural resource managers, educators, planners, regulators and natural resource professionals who have interests and investments in better understanding the natural and anthropogenic processes impacting the Chesapeake Bay and improving the health and resilience of the Bay for natural resource and public benefits. Current partner capabilities focus on observation and monitoring, modeling, and outreach and education components of the Science-Service-Stewardship continuum (Figure 1).

The Cooperative recognizes the need to improve upon integrated data management capabilities, model development, and socio-economic analysis, and proactive outreach, with a particular emphasis on elected officials and decision makers. Over the next 5 years, the CBSSC will strive to expand its partnership to identify potential resources and fulfill gaps in capabilities. The group will be significantly strengthened by recruiting regional representatives with experience in applied research related to sea level change, spatial analysis, modeling, and information transfer. In the meantime, the CBSSC will utilize existing investments and develop innovative ways to effectively communicate with Bay stakeholders about the impacts and potential management strategies to address sea level change and coastal flooding.

As the Cooperative matures, partners will represent a diverse and balanced assemblage of federal, state, and local governments, nongovernmental organizations (NGOs), academic institutions, and commercial interest groups (Table 1). It is important to note that the Cooperative is not an advocacy group but a collaboration of objective, unbiased experts and professionals who are dedicated to providing the necessary tools to coastal communities and natural resource managers that will enhance understanding and trust of sea level change impacts.

Table 1: Current Chesapeake Bay Sentinel Site Cooperative Partner Agency/Organizations

FEDERAL	STATE	ACADEMIC	NGOs
Department of Commerce -National Oceanic and Atmospheric Administration Chesapeake Bay Office National Geodetic Survey Office of Ocean & Coastal Resource Management U.S. Integrated Ocean Observing System Center for Operational Oceanographic Products and Services MD and VA Sea Grant Programs	Maryland Department of Natural Resources	University of Maryland -National Socio-Environmental Synthesis Center -Center for Estuarine and Environmental Science	Mid-Atlantic Regional Association for Coastal Ocean Observing Systems
Department of Defense - U.S. Army Corps of Engineers -U.S. Navy	Virginia Department of Environmental Quality	Virginia Institute of Marine Science	National Wildlife Federation
Department of Interior - U.S. Geological Survey - U.S. Fish and Wildlife Service - National Park Service		Old Dominion University	The Nature Conservancy
U.S. Environmental Protection Agency		Virginia Commonwealth University	Hampton Roads Sanitation District
Smithsonian Environmental Research Center		University of Virginia	Chesapeake Bay Foundation
		Christopher Newport University	

Together these representatives can deliver a comprehensive suite of services aimed at improving natural resource management, coastal restoration, conservation, and municipal planning. For example, the Cooperative can provide local county managers with access to and understanding of data and models that inform decisions of how to decrease susceptibility of future infrastructure to rising sea level. Similarly, resource managers such as the National Park Service can use CBSSC-developed tools and expertise to inform land conservation decisions. The recruitment of local representatives (e.g. county level staff) will also be important to leverage from ongoing local efforts, to identify information gaps, and to inform the development of relevant tools and other resources.

Initially, the Cooperative will function in several discrete ways (Figure 3). These include:

1. Collection of high resolution data at sentinel sites;

2. Standardize and make these data available, integrate the data into the Chesapeake Atlantis ecosystem model and Chesapeake Inundation Prediction System (CIPS);

3. Identify interested coastal communities and natural resource managers; develop outreach and education strategies to reach the communities and managers using CanVis and Sea Level Rise Viewer visualization tools.

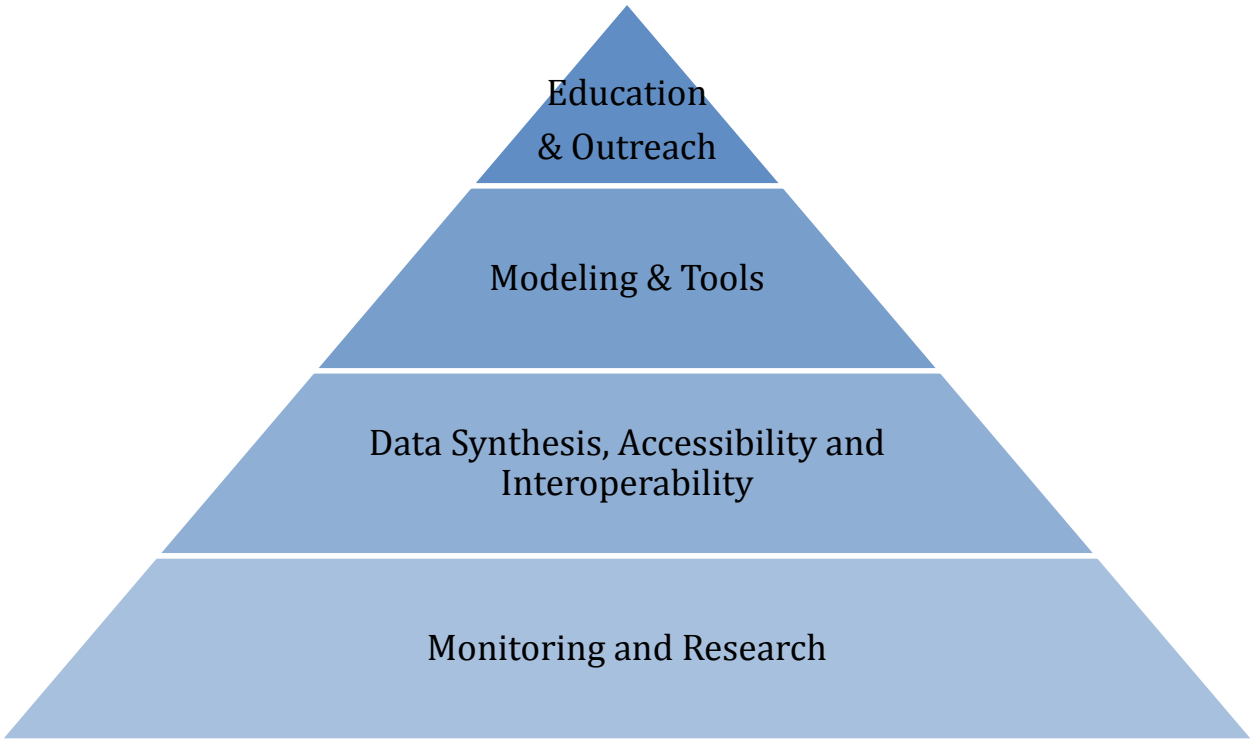


Figure 3. Chesapeake Bay Sentinel Site Cooperative Components Model

CBSSC Boundaries

The boundaries of the Cooperative include the tidal Chesapeake Bay system and the barrier island complex within Maryland and Virginia, and extend into the Atlantic Ocean to the 3 nautical mile line (Figure 4). It includes the coastal bays from the Delaware line to Fishermen's Island. CBSSC partners and resources will extend inland to the fall line located in numerous river systems.

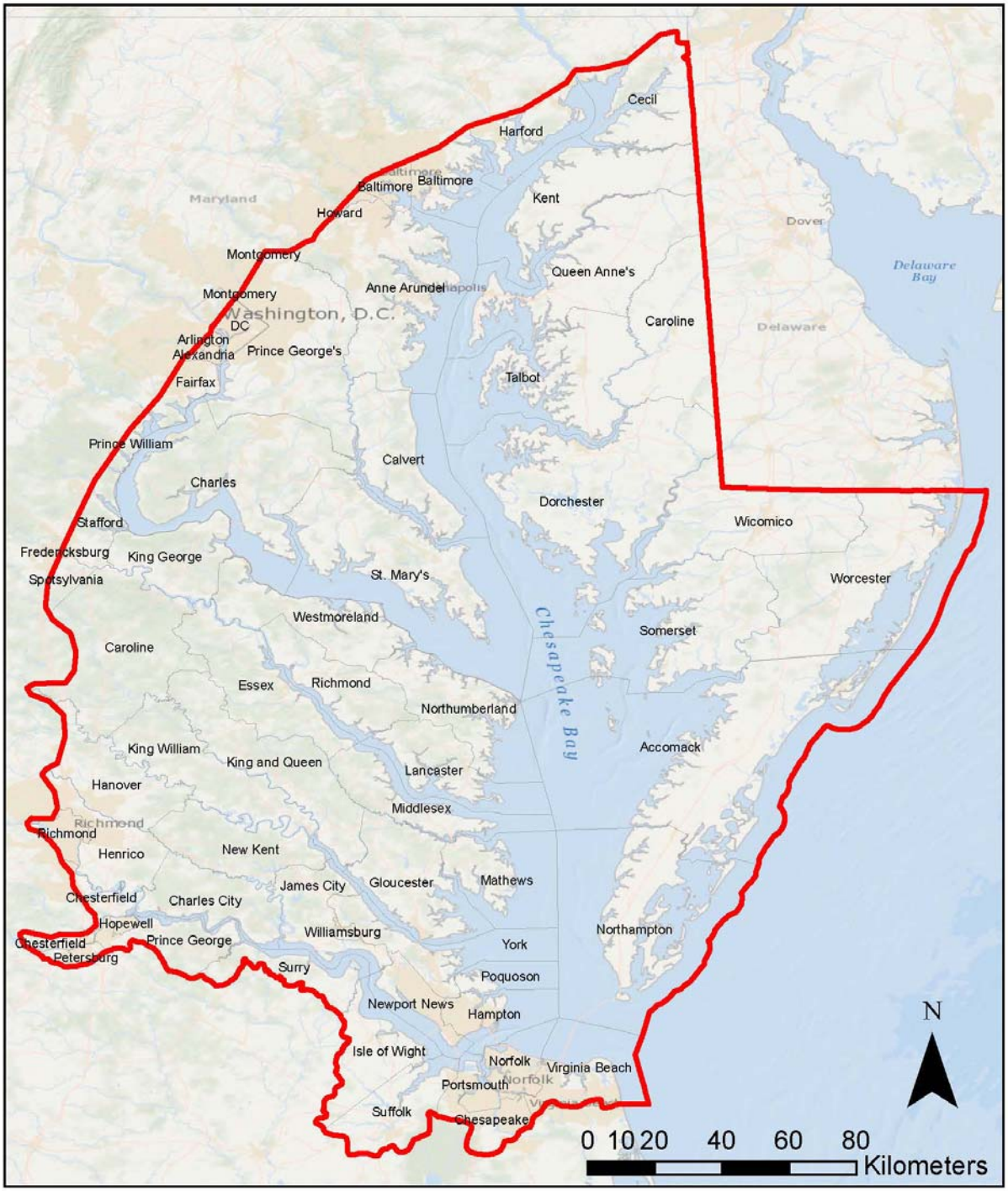


Figure 4: Chesapeake Bay Sentinel Site Cooperative Boundaries.

To fulfill its mission, the CBSSC developed the following initial priority strategies: (1) establish sustainable, managed sentinel sites representative of broad geographies; (2) enhance data management, availability and interoperability, (3) utilize existing models and visualization

programs to better convey sea level rise and inundation impacts, and (4) provide educational and advisory services. To support these strategies, the CBSSC will leverage existing assets, programs, and resources across existing federal, state, local, non-profit, and academic programs. However, investments in the existing ecological sites, as well as developmental sites in underrepresented ecological, urban and small coastal communities remain important gaps to fill.

Targeting current and future investments from multiple stakeholders within the Chesapeake Bay watershed will dramatically increase the effectiveness of these efforts. Examples of strategies may include preservation of marsh retreat areas, changes to waterfront zoning practices, and construction of infrastructure to mitigate flooding impacts.

Collecting High Resolution Data

In order to provide a comprehensive understanding of sea level rise impacts, the CBSSC has identified a number of locations that are currently collecting or have the capability to collect the core ecological data parameters associated with monitoring sea level rise and inundation. The CBSSC recognizes it is important to establish sentinel sites that collectively represent the variety of coastal habitats including natural and developed sites along with transitional ecotones.

Major natural habitat types in the Chesapeake Bay include open water; subaqueous and intertidal benthos (including oyster reefs and grounds), submerged aquatic vegetation meadows, beaches, tidal marshes (from salt to tidal freshwater) tidal swamps and forested wetlands, adjacent uplands and transitional ecotones. The CBSSC has identified sites in both urban and rural or protected areas so that if fully implemented, trends within these areas will be compared, providing a holistic view of the processes and degree of impacts affecting our communities. Establishing sentinel sites in diverse habitats allows for development of various and effective planning options. For example, planning to adapt to sea level rise in a wildlife refuge is very different than planning in an urban developed setting. The CBSSC is committed to linking data generated at these sentinel sites to decision making processes.

The 5 initial sites chosen as core ecological sentinel sites have been evaluated for the effectiveness at providing data critical to informing sea level rise-related management decisions. They have also been selected because they represent existing infrastructure that can be integrated into the Cooperative right away. These sites include: include the NEERS in Maryland and Virginia, Blackwater National Wildlife Refuge (NWR), Virginia Coast Long Term Ecological Research Network (VCR-LTER), and Assateague Island National Seashore.

Figure 5 demonstrates the relationships of various sentinel site elements with the overall sentinel site concept. Each one of the 5 ecological sentinel sites is representative of an important geography in the Bay (Figure 6) and includes riverine, coastal bay and open water systems. Data and other information from these sites will support model and visualization tool development that will provide a basis for outreach to natural resource managers and coastal communities.

Efforts will be designed in order to maximize the potential for extrapolation of results to surrounding areas, with emphasis on finding low cost, innovative approaches to communication and the application of technological innovation.

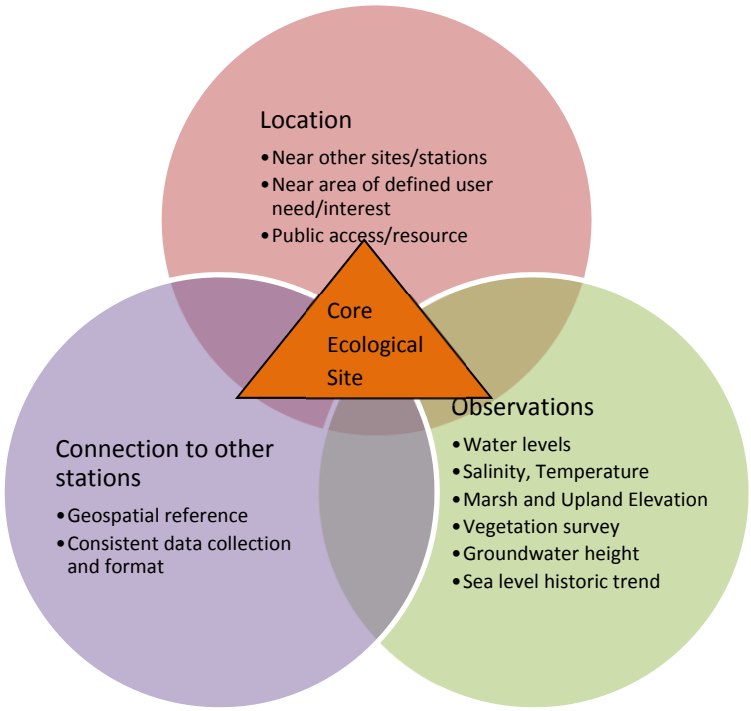


Figure 5. Venn diagram demonstrating relationship among sentinel sites.

The Chesapeake Bay Sentinel Site Cooperative's core ecological sentinel sites are (Fig 6):

- Chesapeake Bay National Estuarine Research Reserves- Maryland (NOAA)
- Chesapeake Bay National Estuarine Research Reserves- Virginia (NOAA)
- Blackwater National Wildlife Refuge (Fish and Wildlife Service)
- Assateague Island National Seashore (National Park Service)
- Virginia Coast Long Term Ecological Research Network (National Science Foundation)

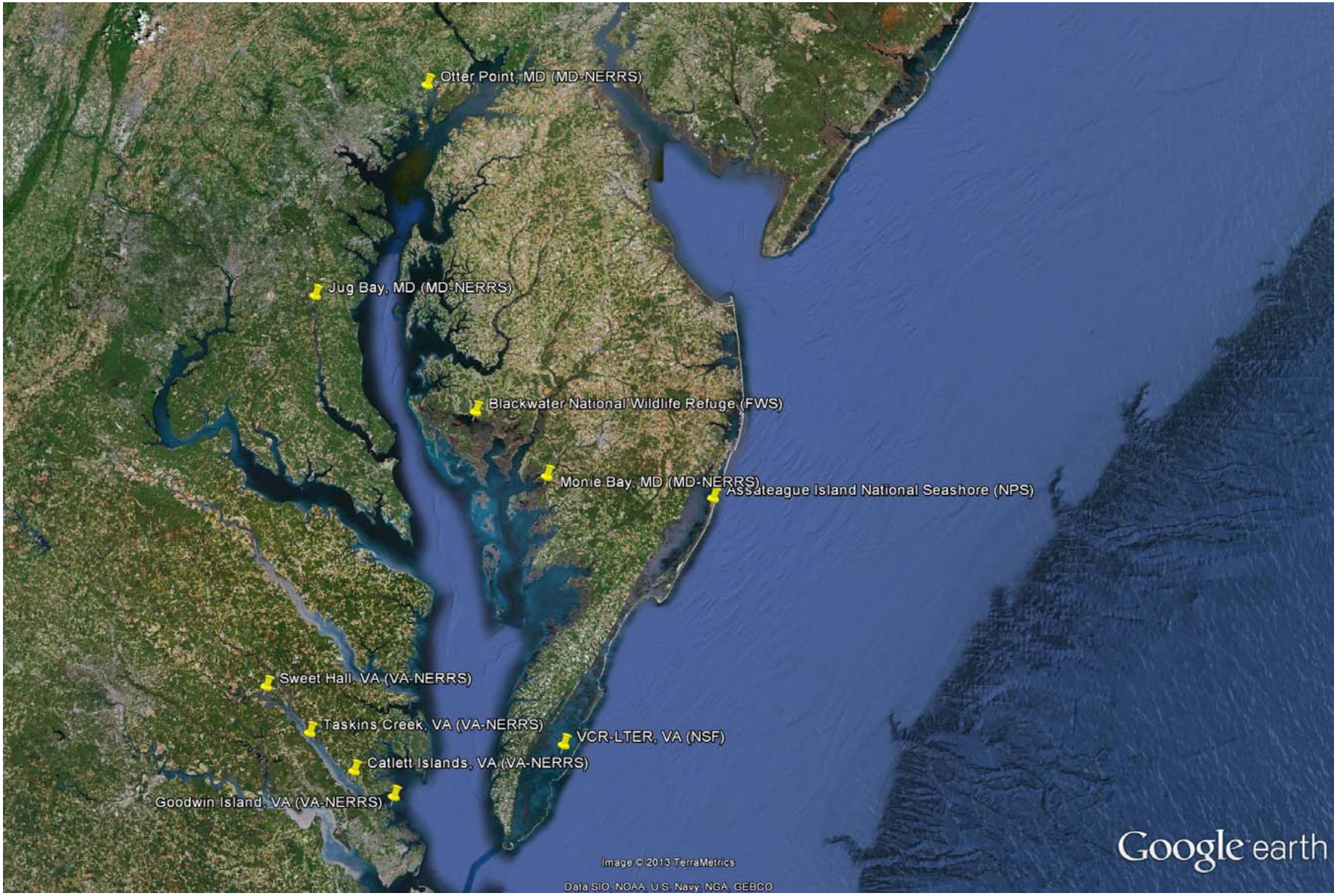


Figure 6. Map of Chesapeake Bay Sentinel Site Cooperative ecological sentinel sites. Note that the Maryland NERRS and Virginia NERRS constitute two sentinel sites comprised of three and four components, respectively.

These sites produce "core" ecological data such as marsh elevation and trajectories, sea level rise historical records, upland and habitat elevation, groundwater height, vegetation mapping, and water level, temperature, salinity. habitat-related variables (Table 2).

Table 2: Identified "core" ecological data and preferred data collection method.

Core Ecological Data	
Variable	**Technique**
Marsh Elevation and trajectory	Surface elevation tables and market horizons
Upland and Habitat Elevation	Lidar, static and kinematic and high GPS differential survey, and precision digital differential leveling techniques
Sea level historic trends	Tide gauge
Groundwater height	Piezometer, automatic data loggers
Vegetation	Transect surveys and mapping
Water Quality (temperature, salinity)	Near-continuous probes
Water levels	Tide gauge

More specifically, ideal, or fully instrumented ecological sentinel sites consist of local positional control networks and high-accuracy geodetic connections to: the National Spatial Reference System (NSRS), tide gauges, water level sensors, Surface Elevation Tables (SETs), and ecological monitoring infrastructure. All 5 sites in the CBSSC are not fully instrumented, but interest remains high to do so as well as to add additional sites to capture the most accurate picture of sea level rise impacts in the Bay (Figure 7). Based on NOAA's Sentinel Site Program guidance, a sentinel site should meet or have the potential to meet the following criteria:

- contain one or more sentinel stations or data collection platforms;
- have a historical data record sufficient to address local-scale changes (or actively take steps to collect such a record);
- be a managed area that is representative of regional ecosystem types;
- be of a size that is practical for testing adaptive management approaches and for education and outreach;
- have the capacity to attract and/or leverage partnerships;\
- have consistent biological, chemical, and physical monitoring referenced to accurate geospatial infrastructure;
- include areas with the management capacity that can support and connect to other regional observing networks;
- facilitate synthesis of information to answer physical and biological questions; and
- have a commitment to uninterrupted, long-term environmental monitoring, including socioeconomic data.

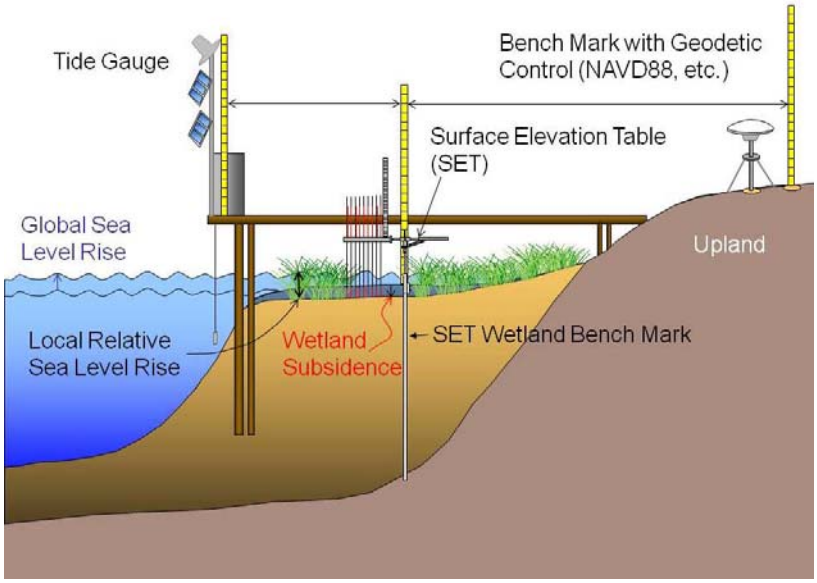


Figure 7: Illustration depicting components of a sentinel site focused on monitoring sea level change.

Chesapeake Bay Sentinel Site Cooperative Ecological Sentinel Sites

Chesapeake Bay National Estuarine Research Reserves

As part of 28 protected areas that make up the NOAA's National Estuarine Research Reserve System, the Chesapeake Bay Research Reserves in Maryland (CBNERRS-MD) and Virginia (CBNERRS-VA) were established for long-term research, education and stewardship in support of informed management of o our Nation's estuaries and coastal habitats. Both CBNERRS in Maryland and Virginia have a number of fully implemented sentinel sites with multiple stations monitoring wetland vegetation community dynamics. These locations have the capacity to serve as both core and educational sentinel sites as CBNERRS also has well developed education programs that currently utilize its natural areas in formal K-12 education, public outreach and professional training offerings.

Virginia CBNERRS

The CBNERRS-VA is a multi-component system established along the salinity gradient of the York River estuary. The Reserve consists of four components, Sweet Hall Marsh, Taskinas Creek, Catlett Islands and the Goodwin Islands, which represent a diversity of coastal ecosystems found within the southern Chesapeake Bay sub region (Figure 8). Sweet Hall Marsh represents an extensive tidal fresh water-oligohaline marsh ecosystem located in the Pamunkey River, one of two major tributaries of the York River. Taskinas Creek encompasses non-tidal portions of Taskinas Creek containing feeder streams that drain oak-hickory forests, maple-gum-ash swamps and freshwater marshes which transition into tidal oligo and mesohaline salt marshes. The Catlett Islands consist of multiple parallel ridges of forested wetland hammocks, forested upland hammocks, emergent mesohaline salt marshes and tidal creeks surrounded by shallow subtidal areas that once supported beds of submerged aquatic vegetation (SAV). The

Goodwin Islands, located near the mouth of the York River, are an archipelago of polyhaline salt-marsh islands surrounded by inter-tidal flats, extensive submerged aquatic vegetation beds, and shallow open estuarine waters. CBNERRS maintains a system wide monitoring program, which includes water, weather and biological (i.e., underwater grasses, emergent wetlands and wetland-forest ecotone) components, within the York River system. Additionally, the Reserve has established an extensive array of sediment elevation tables and supporting vertical control infrastructure. A comprehensive description of individual Reserve components and York River Ecosystem Profile can be found at: http://www.vims.edu/cbnerr/.

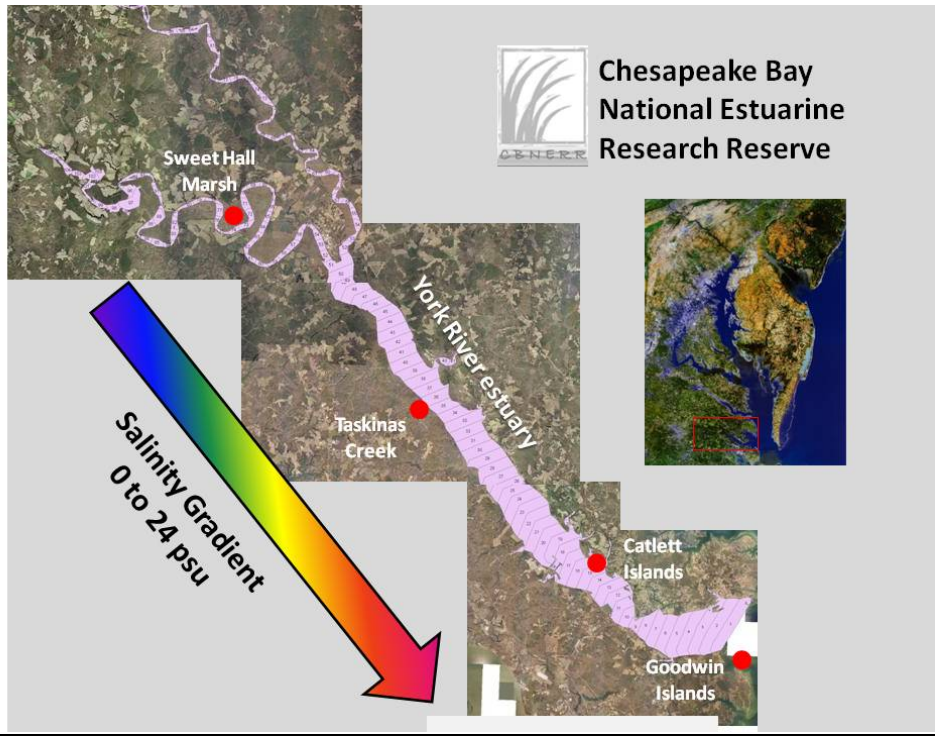


Figure 8: Map showing location of the four Virginia CBNERRS components within the York River Estuary

Maryland CBNERRS

The CBNERRS-MD consists of three components: Monie Bay, Otter Point Creek, and Jug Bay (Figure 9). Otter Point Creek (OPC) and Jug Bay are located on the Western shore while Monie Bay is located on the Eastern shore of the Maryland section of the Chesapeake Bay. All three components are representative examples of estuarine habitats within the Bay. A comprehensive description of the three components can be found in the Reserve' site profile at: http://www.dnr.state.md.us/bay/cbnerr/.

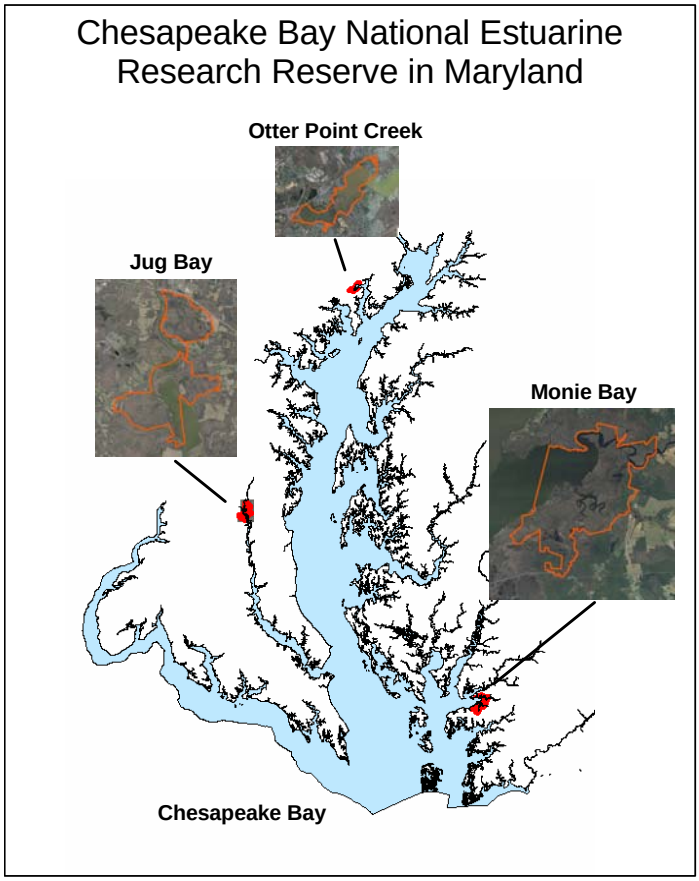


Figure 9. Map showing location of the three Maryland CBNERRS components on the western and eastern shores of the Chesapeake Bay.

Monie Bay is located in the southeastern portion of Chesapeake Bay just southeast of the Wicomico River mouth, in Somerset County. The mesohaline marshes of Monie Bay comprise approximately 1386 hectares (3,426 acres) and are already experiencing the impacts of sea level rise. Marsh loss and marsh migration into the uplands is evident in this area. The processes at Monie Bay are most representative of those in other nearby coastal communities and therefore effort should be focused at this sentinel site out of all the CBNERRS-MD.

Otter Point Creek and Jug Bay are particularly important systems as they host some of the few remnants of tidal freshwater marshes of the country. Tidal freshwater marshes are vulnerable to climate change particularly to salinity intrusion and changes in freshwater input, which may significantly alter their community structure and functioning.

Otter Point Creek is a tributary of the Bush River in Harford County and comprises a total of 299 hectares (736 acres), including tidal freshwater marshes, riparian forest, upland hardwood forests and shallow, open estuarine waters. The entire component is fresh to oligohaline. Jug Bay is located in the upper freshwater tidal reaches of the Patuxent River between Anne Arundel and Prince George's Counties. It encompasses 837 hectares (2068 acres) of wetlands, open water, and terrestrial habitat. Similar to OPC, Jug Bay is an oligohaline system dominated by

freshwater inputs. Long-term monitoring infrastructure already in place in CBNERRS-MD monitors weather, water quality parameters, marsh surface elevation (using SETs), groundwater levels, submerged aquatic and wetland vegetation, secretive marsh birds, and fish in all or some of the Reserve components. The establishment of vertical control infrastructure is completed in the Jug Bay component and is underway at Monie Bay.

Virginia Coast Long Term Ecological Research Network (VCR LTER)

The Long Term Ecological Research (LTER) Network was created by the National Science Foundation (NSF) in 1980 to conduct research on ecological issues that can last decades and span huge geographical areas. Long-term data sets from the LTER program provide a context to evaluate the nature and pace of ecological change, to interpret its effects, and to forecast the range of future biological responses to change. The Virginia Coast Reserve (VCR) LTER program is designed to develop a predictive understanding of the response of coastal barrier systems to long-term environmental changes in climate, sea level and land use, and to relate these to the ecological services the coastal barrier systems provide. Long-term experiments on mainland and lagoon-island tidal marshes include monitoring of all the CBSSC core ecological site variables, as well as, many other variables. These VCR LTER data provide insight into historical sea level rise trends and habitat shifts (Figure 10). Low-lying lagoonal marshes are submerging or the edges are eroding while mainland marshes appear to maintain their relative elevations above the rapidly rising local sea level (4.2-4.5 mm yr^{-1}). Because the lagoonal marshes are not adjacent to uplands, there is no possibility for landward migration. In many cases, mainland marshes migrate into uplands converting agricultural fields, hardwood swamps, and pine-dominated woodlots to high-marsh vegetation, while waves generated by Nor'easters erode the leading edge of mainland marshes.

VCR core ecological monitoring data sets focus on the relative elevations and areal extent of the land, sea, and groundwater surfaces, water quality, and the feedbacks to vegetation and land use patterns. These data are maintained by the VCR LTER information manager and are available through the VCR LTER website (http://www.vcrlter.virginia.edu) or the NSF LTER Network website (http://www.lternet.edu).

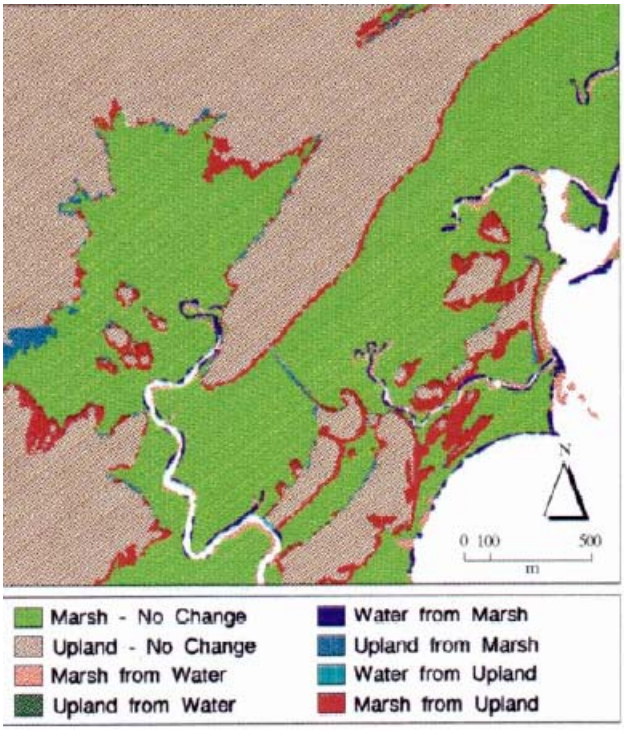


Figure 10. Extent of marsh transgression occurring at a VCR LTER SET site, Phillips Creek marsh (37° 27' 30.39" N, 75° 50' 02.31" W). The change in land cover was determined between 1940 and 1991 from aerial photos. Note that regions in red show upland conversion to salt marsh (from Kastler and Wiberg, 1996).

Blackwater National Wildlife Refuge

Established in 1993, the Blackwater NWR on Maryland's Eastern Shore (Dorchester County) is a large protected area with decades of monitoring data. Managed by the U.S. Fish and Wildlife Service, Blackwater NWR includes over 27,000 acres, composed mainly of rich tidal brackish marsh characterized by fluctuating water levels and varying salinity. Marsh loss has been severe over the past 75 years because the vertical buildup of the marsh surface has lagged behind the rate of local sea-level rise, thus leading to the submergence of the marsh. The loss of brackish marsh could be particularly harmful to species that have adapted to these habitats, including rockfish and white perch and anadromous species such as herring and shad, which use brackish marsh habitat as they transition between their freshwater and saltwater life cycles. Similarly, the loss of tidal fresh marshes could affect minnows, carp, sunfish, crappie and bass, which depend on these habitats for shelter, food, and spawning. Finally, loss of marsh habitat could devastate migrating waterfowl and residential shorebird populations. Gaps in sea level rise monitoring at Blackwater NWR include lack of a monitoring program to measure subsidence rates at various locations within Refuge and funding to continue SET data collection and analysis. Blackwater NWR hosts a number of educational programs and is heavily utilized by the public for recreational activities, making it a both scientifically and educationally important sentinel site.

Assateague Island National Seashore

Established in 1965, the Assateague Island National Seashore has been identified as one of the national seashores facing significant risk from the effects of global climate change. This 57 kilometer long island, located in Berlin, Maryland, ranges from 1- 4 km wide, covers approximately 19,700 hectares (48,697 acres), and is experiencing some of the highest rates of relative sea level rise along the east coast of the United States. Preliminary results from USGS' groundwater and monitoring efforts suggest that simulated changes in sea level of less than 60 cm above present levels will result in substantial changes to the groundwater system including an increase in water-table altitude and increased potential for saltwater intrusion. Assateague currents has 16 SETs in the marsh, good LIDAR data collected regularly, 26 groundwater wells at either shallow or deep depths measured annually, monthly Bay-side and beach-side water quality monitoring. They are equipped with long-term tide gauges in the Sinepuxent Bay and will be installing a one-year tide gauge on the bay side of Assateague Island to calculate a set of tidal datums. No vegetation surveys are conducted and no CORS are established; however, a network on our primary deep rod marks is in place.

As currently outfitted, all 5 ecological sentinel sites can contribute unique and meaningful data to better understand how sea level rise is affecting the ecological processes and habitats at their managed location and inform models such as Atlantis. However, the Cooperative would not be in existence if there were no gaps and missing information to make for more effective management of these areas. Partners managing the ecological sentinel sites have identified where equipment and resources are needed to generate the core data essential to developing a

comprehensive picture of sea level rise (Table 4). As described throughout the document, the Cooperative is also investigating the development of sentinel sites and stations in urban and coastal communities. It is monitoring and observations from these developmental areas that will inform community management planning and policy. These developmental sentinel sites are described in the next section of this IP.

Table 5. Core ecological data collected and missing at each ecological sentinel site. A "yes" indicates that data is currently being collected. Associated values as partner's best estimate at what is would cost to outfit the sentinel site with the proper equipment or conduct the survey. It does not account for staff time.

Sentinel Site		**CORE Ecological DATA**						
		Marsh elevation/trajectory (SETs, marker horizons)	**Upland and Habitat Elevation** (LIDAR, digital and GPS differential surveys)	**sea level historic trends** (tide gauge)	**groundwater height** (piezometer)	**Vegetation** (transect survey/ mapping)	**Water temp/ salinity** (probes)	**Water level** (tide gauge)
MD-NERRS	- Otter Point	NO - $15-20 K/one time installation	NO - $2.5 K/yr*	NO - $35 K **	NO- $ 2.5 K/ one time installation	YES	YES	YES
	-Jug Bay	YES	YES	NO - $35 K **	YES	YES	YES	YES
	-Monie Bay	YES	NO - $2.5 K/yr*	YES	NO- $ 2.5 K/ one time installation	YES	YES	YES
VA-NERRS	Sweet Hall	YES	PARTIAL	NO	YES	YES	YES	YES
	Taskinas	YES	PARTIAL	NO	YES	YES	YES	YES
	Catlett Islands	YES	YES	YES	NO	NO	NO	NO
	Goodwin Islands	YES	PARTIAL	YES	YES	YES	YES	YES
Blackwater NWR		YES	YES	YES	YES	YES	YES	YES
Assateauge National Seashore		YES	YES	YES	YES	NO- $8-10K/year	YES	YES
VCR-LTER		YES	YES	YES	YES	PARTIAL (need mainland marsh mapping)	YES	YES

Collecting downscaled, refined data at sentinel sites will provide a valuable resource to build locally defined maps and models for predicting sea level and inundation impacts. The networking of these sites together will support the validation of broader, regional models which will provide a synoptic picture of sea level change rates and impacts in the Chesapeake Bay. With the knowledge, decision makers will have the tools needed to make the most informed decisions to increase resiliency of coastal areas from the negative impacts of local sea level change. These decisions include preservation of upland areas located behind marshes expected to become inundated, changes to waterfront zoning practices, and proper planning of infrastructure to mitigate flooding impacts.

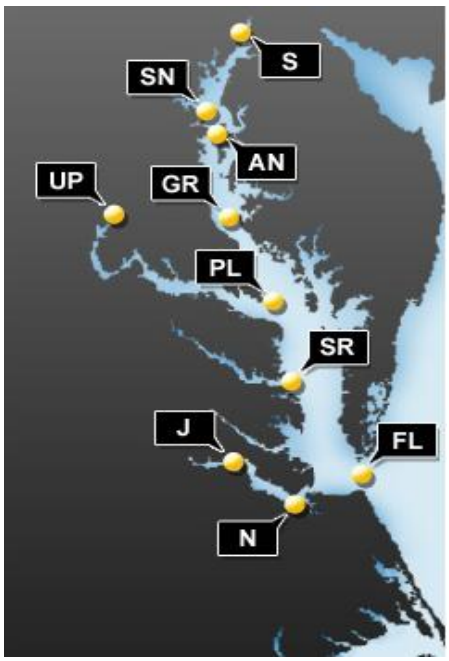
Distributed Observational Network

In addition to the current 5 ecological sentinel sites, there is a number of water quality monitoring sentinel stations within the Chesapeake Bay that can provide vital local water quality information, linking the ecological sites together. This observation network includes Virginia's Estuarine and Coastal Observing System (VECOS), Maryland's Eyes on the Bay, and NOAA's Chesapeake Bay Interpretive Buoy System (CBIBS). VECOS and Eyes on the Bay provide water quality information from a variety of data collection platforms, including high resolution mapping of surface water quality (Dataflow), continuous measurements (15 minute intervals) of water quality taken from fixed, shallow water monitoring stations and continuous measurements taken from deeper waters along multiple depths using a profiler. Web portals for data access and general information on VECOS and Eyes on the Bay are http://www3.vims.edu/vecos/ and http://mddnr.chesapeakebay.net/eyesonthebay/index.cfm, respectively.

CBIBS is a component of the Integrated Ocean Observing System (IOOS transmiting in real-time meteorological, oceanographic and water quality information to a variety of users. CBIBS buoys are located in shallow water (5 -50 meters) at points along the Captain John Smith Chesapeake National Historic Trail, generally running lengthwise down the Bay with some stations in major riverine systems (Figure 12). Data are collected every 10-60 minutes depending on the parameter and are accessible by phone or by visiting http://buoybay.noaa.gov/observations.html. The ease of accessing these data allows for widespread public use.

Figure 12. NOAA's CBIBS Network.

S= Susquehanna
SN= Patapsco
AN= Annapolis
GR= Goose Reef
UP= Upper Potomac
PL=Potomac
SR=Stingray Point
J=Jamestown
N=Norfolk
FL= First Landing



Developmental Sentinel Sites

The 5 ecological sites identified by the CBSSC were selected for their locations as well as the fact that they represent existing assets. They are located in natural, undeveloped, tidal wetland areas that focus on investigating habitat and wildlife changes resulting from sea level change in those coastal areas. There is a substantial need for more detailed information on the impacts to people and infrastructure in developed coastal communities. The being delivered from the ecological sentinel sites may not be applicable to or resonate with residents of coastal towns and cities. Therefore, the Cooperative has identified that sentinel sites and stations in urban areas and coastal towns are of vital to linking science with stewardship. In many of these urban areas, there are elements of water level and water quality infrastructure already in place. An important role driving the CBSSC is integrating data from urban areas into sea level rise models and interpreting these data for the community through higher resolution visualizations and outreach to communities. In the near term, the Cooperative will further investigate and make connections with appropriate personnel to identify the resources within these locations and, if appropriate, develop monitoring and outreach plans. The first 3 locations to be investigated will be Baltimore MD, Norfolk VA, and Crisfield MD. Figure 11 provides the full spatial extent of the sentinel sites and stations that are currently being investigated. A list of the current areas under consideration include:

Urban and Coastal Communities: Baltimore, Maryland, Hampton Roads, Virginia, Crisfield, Maryland, Dyke Marsh (George Washington Memorial Parkway), Anacostia Park, Kenilworth Park and Aquatic Gardens, Piscataway Park (National Capital Parks – East), East Potomac Park (National Mall and Memorial Parks), George Washington Birthplace, Colonial National Historic Park, West Point VA.

University/Research Centers: Virginia Commonwealth University's Rice Center, Chesapeake Biological Laboratory; Smithsonian Environmental Research Center's (SERC) Kirpatrick Marsh; Chesapeake Bay Environmental Center

Educational Stations: Chesapeake Bay Foundation's Port Isobel/Tangier Island and Smith Island.

Military Bases: Aberdeen Proving Grounds, Naval Station Norfolk

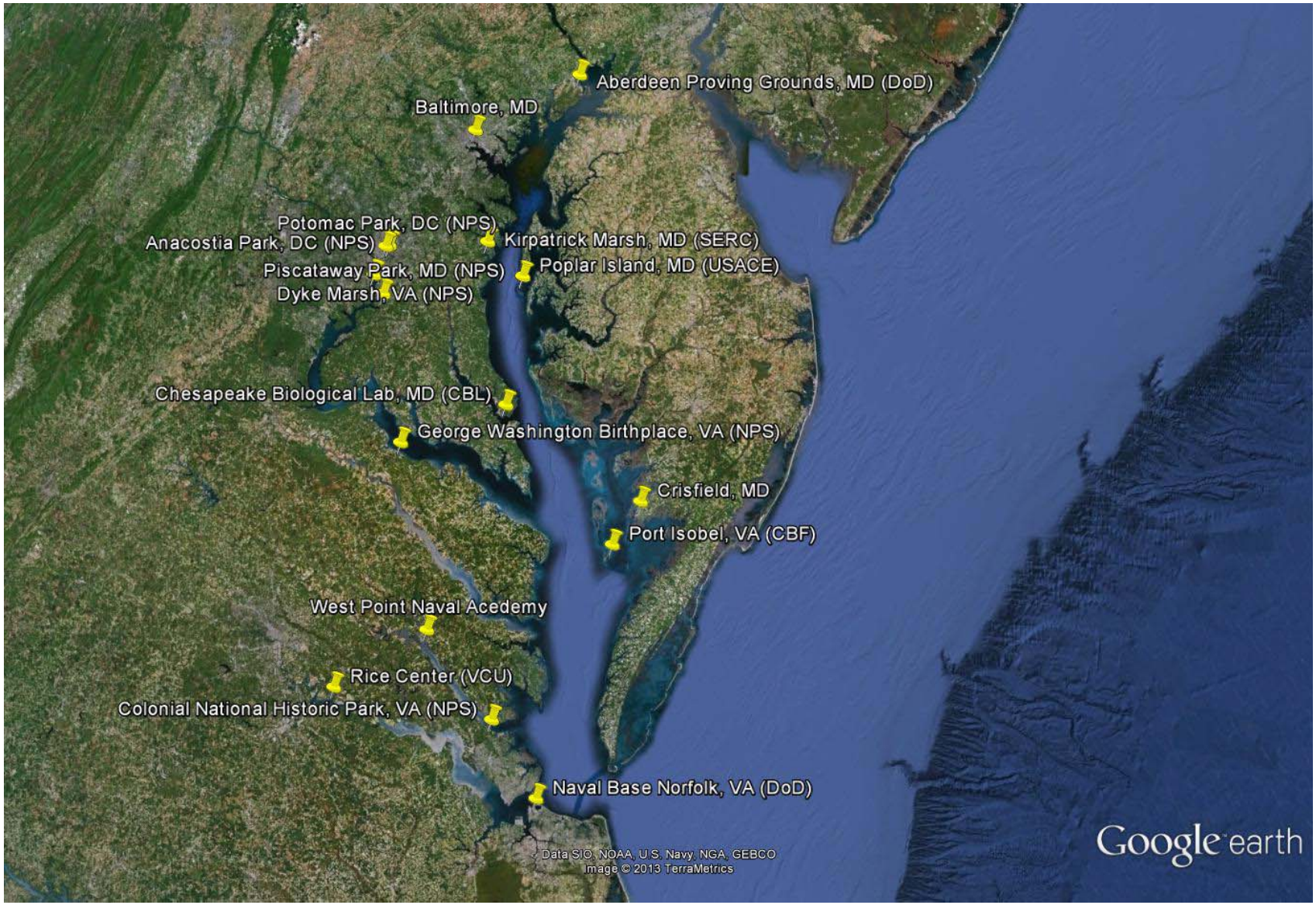


Figure 11. Map displaying locations of developmental sentinel sites and stations.

Data Synthesis and Interoperability

The CBSSC will provide the organizational structure to link relevant data from the 5 ecological sentinel sites and the distributed network of observing stations that is currently scattered, fragmented, and incompatible across agencies, organizations and jurisdictional boundaries. The NOAA Chesapeake Bay Office has a prototype of a data access system that is already collecting the water quality data from Maryland, Virginia, the Chesapeake Bay NERRS, as well as other sources such as USGS gauging stations. Ideally, working with the IOOS program and the Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS), the Cooperative will establish a centralized data access point. A Scientific and Technical working group could also work with IOOS/MARACOOS to standardize the data so that it was properly prepared to be ingested into models and data visualization tools.

Access or knowledge of available information is prerequisite for informed decisions to be made about citing restoration projects, responsible land use planning and management, and long term monitoring of environmental baselines. Strengthening existing collaborations and building new partnerships across federal, state, local and other regional agencies and academic institutes will help ensure that the data collected can validate and support modeling efforts and risk assessments.

Models and Data Visualization

The outcomes of the Cooperative's efforts will include enhanced developmental support and utilization tools designed to inform decision making policy and planning. The CBSSC will support refined hydrodynamic and ecosystem modeling at downsized spatial scales, inform habitat/infrastructure mapping and vulnerability assessments, and advise strategies to facilitate ecosystem and coastal community resiliency and adaptation. Specifically, data from the CBSSC will be used to run scenarios in the Chesapeake Atlantis ecosystem model and Chesapeake Inundation Prediction System (CIPS). CanVis, and Sea Level Rise Viewer are static programs currently in development; however, leveraging these tools will aid in demonstrating the impacts from sea level rise and inundation.

Model runs using CAM will provide natural resource managers an insight into the impacts on ecological communities resulting from varying degrees of marsh loss due to inundation throughout the Bay. NCBO modelers could tailor these runs to suit the Cooperative's needs, for example to identify the ecological impacts of various marsh loss scenarios at different locations around the Bay.

Plans and funding are in place at the Virginia Institute of Marine Science to create inundation modeling in Norfolk VA using CIPS to map out street flooding scenarios similar to those seen in model runs conducted for Alexandria VA. The Cooperative can begin using output from these models to engage local communities.

CIPS and CAM provide extremely specific and broad geographic coverage respectively. Visualization tools will be used to compliment the model output by creating stories and images describing the effects of sea level rise envisioned by the models. In this way, towns and natural areas not specifically modeled by CIPS, but that require more pinpoint information than CAM can offer, will have a tool to help them understand what the impact of flooding could mean to their community.

CanVis and the Sea Level Rise Viewer are visualization programs used to "see" potential impacts from coastal development or sea level rise. CanVis allows users to download background pictures and insert the objects (hotel, house, marina, or other objects) of their choosing. The software is used by municipalities to brainstorm new ideas and policies, undertake project planning, and make presentations. Being able to visualize potential impacts from sea level rise is a powerful teaching and planning tool, and these tools bring this capability to coastal communities.

Education, Transfer & Advisory Service

The CBSCC strives to fully engage a variety of audiences and users, from K-12 educators to elected officials, and be an "expertise resource" to support and guide natural resource managers, coastal communities, and policy-makers through the dissemination of unbiased, science-based information. This service is focused at the local level and can occur in a variety of formats including the development of localized information products, providing topic and/or regional oriented speakers, attending public planning meetings for comment or advice, workshops, and supporting professional training programs. The primary mission of this group will be engaging coastal communities and natural resource managers faced with conservation and zoning choices based on data from sentinel sites and stations. Existing climate oriented education and outreach programs will be leveraged including the NERRS education and coastal training programs in VA and MD, NCBO's Environmental Science Training Center, the Maryland Delaware Climate Change Education Assessment and Research (MADE-CLEAR) initiative, NOAA Sea Grant Programs, and the Chesapeake Bay Foundation's education programs such as those at Port Isobel and Smith Islands. Primary agendas for this group include more effectively informing planning decision by conducting training on sea level rise and inundation models, promoting Cooperative scientists to be more involved at planning meetings, and shifting message delivery to ones that the community can relate to and trust.

CBSSC Focus Areas

The Cooperative will focus efforts and resources on better understanding sea level rise and inundation impacts and planning alternatives within two primary categories: Coastal Communities and Biological Communities. During a workshop on December 19, 2012, Cooperative partners identified the components (i.e., who and what) of these focus areas that are

most relevant to the Cooperative and what primary issues the Cooperative is able to effectively address over the next 5 years (Table 3).

Table 3. Chesapeake Bay Sentinel Site Cooperative Focus Areas.

Focus Area	Components	Primary Issue
Coastal Communities	property owners	private land loss
	state/county governments	damage and loss of infrastructure; restoration and land conservation planning
	rural, agriculture, silviculture activities	planning decisions and increased inundation and salt impacts
	emergency services	road access, emergency preparedness, property insurance
	cultural resources	heritage/culturally important site preservation and restoration
	land conservation and restoration	planning
	underground infrastructure (e.g., groundwater and sewer mains)	flooding, water quality protection, salinity intrusion
Biological Communities	tidal & tidal fresh water marshes	Wetland degradation, loss/conversion to open water
	upland/marsh ecotone	expansion capacity
	resident and migratory species (birds, fish, crabs, oyster, larvae)	temporal and spatial shift in abundance, distribution, and recruitment
	invasive species	temporal and spatial shift abundance and distribution

The discussion of these focus areas at the December 2012 workshop revealed the CBSSC must focus on three critical messages to planners and decision makers. First, the message of sea level rise and inundation impacts and the need for smart planning must be presented in a better way to the public and decision-makers so that they are properly informed and educated. Currently, there is a gap between the science and policy which is primarily due to a lack of communication and interaction as well as different fundamental objectives of the disciplines. It is key that the Cooperative produce more relatable stories about local sea level rise impacts to the community and local decision makers if policy changes are to be made. The public is requesting from scientists and liaisons that a local story is showcased demonstrating that sea level rise and increased coastal inundation are happening within their community. The Cooperative needs to identify those communities where collecting and synthesizing data and producing visualization tools will have maximum impact for safeguarding critical area resources.

Secondly, the Cooperative needs to be proactive in delivering these stories to both the public and local officials. In general, scientific representation at many local planning meetings is missing. There needs to be a shift from simply making information available (e.g., posting on websites) to

being a trusted expert and community member. That is, scientists and professional liaisons should make a dedicated effort to attend meetings and relevant community events and develop professional relationships with decision makers and the community. Shifting from an anonymous scientist to a trusted, recognized expert is highly needed to be effective at influencing planning and policy decisions.

Third, and associated messages must be delivered in a more meaningful and efficient manner. The Cooperative should focus on shifting from the typical "habitat impact" messages to ones that are more personal, such as how sea level rise and increased inundation could impact recreational activities (e.g., park and refuge use, fishing), community aesthetics, local economy, infrastructure and property. Stories should be very succinct while providing data to decision-makers and policy officials. In addition, locally applicable visualization tools can be extremely effective at demonstrating the threat of sea level rise (e.g. Figure 3b). The Cooperative should make these tools easily accessible and create education and outreach programs around those tools to interact with the surrounding community. Empowering the public with the information directly relevant to their county or municipality can benefit the natural and built environment as planners hear from their constituents, creating pressure from both the scientific and the local community.

These recommendations can be addressed by applying data from relevant Sentinel Sites within the Cooperative to create Atlantis, CIPS, CanVis, and Sea Level Rise viewer demonstrations designed to demonstrate the realities of sea level rise in the Tidewater region of VA, and some options for dealing with it. This will require a commitment from the CBSSC Coordinator to work with the relevant VA sites, and technical staff to populate the models and visualization tools needed to engage the community. The Coordinator will also need to work closely with members of the Education and Outreach working group to effectively carry out these recommendations.

GOALS, OBJECTIVES, ACTIONS AND MILESTONES

The goals of the CBSSC describe how the Cooperative will achieve its vision and mission. These broad and ambitious goals drive this initiative. The objectives within this plan attempt to set specific, measureable, achievable, realistic and time bound intentions to keep this effort moving forward strategically. The goals and objectives of the CBSSC can be characterized into three subjects: (1) stakeholder and public understanding and trust (education and outreach); (2) data collection, assimilation and interoperability; and (3) decision support tools. Goals are designed based on the desired outcome (external) while objectives are specific to what the CBSSC is capable of achieving to fulfill those goals. Here we define stakeholders as elected officials, policy makers, resource and land managers, federal, state, and local governments, NGOs, academic scientists, emergency responders, coastal farmers and property owners, and commercial industry groups (e.g., fishing, shipping, power companies, manufactures, etc.). The "public" includes all other general citizens such as coastal residents that live around and utilize Bay resources for recreational purposes, students, and their educators. Collectively, these audiences comprise the Bay's "coastal communities". See Appendix B for a table outlining associated timeframes expected with each action and milestone.

GOAL 1: **Governments, NGOs, and academic institutions have greater access to more reliable and integrated ecosystem and socio-economic data.**

Objective 1.1: Within 3 years, increase the certainty of sea level change impacts at identified sentinel sites.

Major Actions:

- Secure a long-term Cooperative Coordinator: This person is critical to the continuation of the Cooperative and should have capabilities and resources to work across state, federal, and academic boundaries to oversee the development of the Cooperative. Ideally this would be a State, academic, or CSC or Coastal Programs staff member. This person should dedicate 50% of his or her time to the Cooperative for at least 2 years. Essentially, all other actions in this section are contingent on obtaining an appropriate coordinator.

- Identify and prioritize 5-10 sentinel sites and stations within the Bay: Through this document, the Cooperative has identified 5 ecological sentinel sites and provided suggested locations of urban and coastal community sentinel sites/stations that need further investigation.

- Develop an inventory of equipment needed to complete ecological stations as well as cost effective strategies to instrument additional stations in urban locations such as Hampton Roads, Baltimore, and a small coastal community facing severe inundation impacts such as Crisfield.

Supporting Actions:

- At select sentinel sites, support collection of high resolution core ecological data.
- At two locations with long-term records compare data sets and assess similarities and differences to demonstrate certainty of SLR science.

Milestones:

- Sentinel stations are installed in 1-2 communities that are facing severe sea level rise issues (e.g., Crisfield)
- Working group formed to develop protocols focusing on integration of data and data reliability at 2 sites collecting long-term core ecological data;
- Working group produces two reports focusing on data integration and reliability at the two chosen sites above.

Objective 1.2: Within 3 years, establish consistency and inter-operability of regional data related to sea level rise.

Major Actions:

- Establish a centralized data access repository with standardized data formats for Cooperative data. This could be housed within IOOS through a partnership with MARACOOS.

Supporting Actions:

- Form a Science and Data working group to develop a strategy for assimilating available data sets from sentinel sites and stations.
- Identify and inventory SET locations and ancillary data.
- Develop a glossary of SLR data terms, definitions, and acronyms.
- Develop and disseminate a review of common data collection methods and data quality standards.

Milestones:

- Data from sentinel sites are fed into central repository.
- Annually, the Science and Data working group convenes two meetings to discuss improving consistency and inter-operability of regional data.
- Make inventory of existing data available to partners.
- Relevant SLR data is collected in a consistent and comparable manner across sentinel sites.

GOAL 2: Local governments and land and natural resource managers decision support tools to effectively prepare for, respond to, and recover from current and anticipated sea level rise and other related climate change impacts.

Objective 2.1: Within 5 years, provide stakeholders with useful models and tools designed to foster efficient planning efforts.

Major Actions:

- Identify and integrate appropriate data streams from the sentinel sites that can effectively feed Atlantis, CIPS, CanVis, and Sea Level Rise Viewer. Identify gaps in these data streams as well and requirements to fill them.
- Identify an appropriate community to engage with scientific and outreach material.
- Conduct a CIPS model run in an urban area (e.g., Hampton Roads, Norfolk, Baltimore).
- Apply Sea Level Rise Viewer and CanVis to educate decision makers and the community about sea level rise and inundation impacts.

Supporting Actions:

- Develop a sea-level change decision tool to foster local planning and management decisions;
- Develop and provide case study documents summarizing threats, data collection, conservation and restoration methods, adaptation strategies, and lessons learned for a natural (e.g., Blackwater NWR, CBNERR) and urbanized (e.g., Hampton Roads) area to inform decision makers and managers;
- Develop a list of qualified science professionals that could meet with and support content of SLR/sentinel site topics for local government decision-makers, managers, and professional educators.

Milestones:

- Decision support tool and other data-relevant products are available on CBSSC and partner websites and discussed at appropriate stakeholder meetings.
- Case study documents are produced and disseminated to decision-makers and planners in a timely manner.
- Provide local government decision-makers and managers with advisory capabilities of the CBSSC.

GOAL 3: Coastal stakeholders and the general public understand and trust information on sea level change and coastal inundation hazards, and the severity of related impacts to Chesapeake Bay habitats, ecosystems, and built environments.

Objective 3.1: Within 3 years, identify needs of the coastal community to prepare for, respond to, and recover from current and anticipated sea level rise and other related climate change impacts.

Major Actions:

- Using recent (≤5 years) polls, surveys, interviews, public meetings, etc., synthesize known stakeholder and public information, data, and tool needs.
- Based on survey analysis, identify key community needs and develop plan for filling those needs.

Milestones:

- In FY13, inventory all recent stakeholder needs polls, surveys, interviews, etc., conducted in the Bay area related to sea level rise impacts (see Appendix 3);
- In FY13, develop a spreadsheet of partners education and outreach events and tools;

Objective 3.2: Within 2 years, develop and begin to execute a regionally downscaled education and outreach plan.

Major Actions

- Develop a set of SLR messages for various audiences which will resonate and be portable to various communities.
- Develop and implement interpretive program (could be a poster/signage, mobile app., mobile web site) about "urban" site and sentinel site project.
- Compile and disseminate success stories describing the establishment of new best management practices designed to create SLR-resilient communities at two political/planning meetings and community events.

Supporting Actions:

- Establish an Outreach and Education Working Group comprised of climate change and sea level rise educational professionals.
- Support and track Cooperative partners' education and outreach efforts;
- Develop a CBSSC website and social media forums (e.g., "Community of Practice" blog, Facebook page, email list server) that provide links to or stores information relevant to sea level change science, management and educational opportunities;

Milestones:

- Annually, the Outreach and Education working group convenes two meetings to discuss plan for achieving actions under this objective and supports one SLC-related public workshop.
- Annually, Cooperative scientists and educators are present at one local planning meeting in Maryland and Virginia.
- The CBSSC website, currently housed on the VIMS/CBNERRS website, is expanded upon and updated as frequently as needed to include reports, workshop announcements and summaries, new SLR initiatives, funding opportunities, etc.
- In FY14, at least 1 new electronic networking method is developed.

Objective 3.3: Within 3 years, provide stakeholders with information on the utility and limitations of the most relevant regional and local sea level change models.

Major Actions:

- Conduct at least one workshop, annually, that trains users how to correctly use visualization tools (e.g., Digital Coast) and/or aid educators and planners on communicating sea level rise impacts with the public.

Supporting Actions:

- Evaluate applicable models and visualization tools for spatial coverage, output, and limitations and disseminate the analysis to stakeholders.

Milestones:

- In FY14, complete a report inventorying all major sea level rise and inundation models and visualization tools with discussion on parameters, limitations, and relevance of each for various target audiences.

In addition to these goals and objectives, the Cooperative has identified some long-term, aspirational actions that would be ideal to bridging the gap between science and collecting data and natural, undeveloped sentinel sites. These intense actions are contingent upon the proper outfitting of sentinel sites and stations and filling the gaps identified in this IP and include:

- Complete a comprehensive report that compiles and analyzes data collected at sentinel sites and stations to identify potential future landscape scenarios and the degrees of certainty of sea level change impacts within natural and urban areas.

- Characterize ecosystem and human environment sensitivity and adaptive capacity to sea level change, focusing on indicator and economically important species at two sentinel sites. Potential sub-actions to be completed by partners include:
    - Assess species tolerance to changing environment (temp, salinity, etc.)
    - Map distribution of species ranges, migration corridors, compression/expansion range, acres of habitat
    - Map change in invasive/nuisance species presence and abundance
    - Assess species population sizes

- Characterize physical drivers of ecosystem sensitivity to sea level rise at two sentinel sites.

- Evaluate the potential to develop an aquatic ecosystem monitoring protocol for benthic communities such as oysters and SAV, as well as fish and invertebrates. Consider locations of Habitat Blueprint and Landscape Conservation Cooperatives in the Bay. Possible locations include Harris Creek, Little Choptank, Blackwater NWR.

ROLES AND RESPONSIBILITIES

The governance and role-based management structure of the CBSSC described here is designed to act as the organizational umbrella under which the Cooperative operates and conducts business. The governance structure of the CBSSC is provided in Table 4. The principles of the CBSSC governance are:

- The CBSSC is comprised of members who engage in this effort as part of their normal professional duties. The Cooperative business model is designed to promote synergies rather than create additional work.
- The CBSSC is a forum for open discussion designed to foster Bay-invested partner cooperation with no single agency or organization holding absolute authority.
- The CBSSC promotes sharing of information and allows participants to make efficient use of limited staff and monetary resources.
- The committees that comprise the CBSSC will remain open to new members as existence and success about the program spreads and new members seek to participate.
- CBSSC members shall promote commitment to and cooperation with entire range of stakeholders, not just his or her agency.

Steering Committee

The Steering Committee (SC) will lead the CBSSC and include representatives from a subset of Cooperative partners. Participation on the CBSSC Steering Committee is voluntary; however, once committed, each member is expected to reasonably participate in CBSSC activities. A member electing to serve on the steering committee should be willing to participate for at least two (2) years to ensure continuity and efficiency. CBSSC partners with active seats on the SC may name a proxy or recommend a replacement at any time.

Steering Committee members will also nominate and elect a SC Chair and Co- Chair to each serve a one (1) year term. The Chair and Co-Chair will be responsible for organizing and facilitating effective meetings and overall business of the Cooperative. If the SC Chair does not wish to be considered for another term, he or she can be replaced by the current SC Co-Chair. In the event that the Co-Chair is unable or unwilling to take the position of Chair, the SC will nominate and elect a new Chair. In addition, one NOAA employee will act as executive secretariat for, at minimum, a one (1) year term. This person, along with one volunteer, will be responsible for meeting minutes and delivering required documents to NOAA's Sentinel Site Program Coordinating Committee.

This SC will be comprised of representatives from the multiple federal, state, and local agencies, academic, NGO, and commercial Cooperative partners; however, not all partner organizations

may be represented on this committee. Major roles of the SC include organizing and attending regular meetings, delegating and coordinating activities of working groups, developing strategic and implementation planning documents, satisfying any reporting requirements, and providing innovative and effective methods by which the CBSSC can grow and continue the steps necessary to achieving its vision.

Meeting Schedule

The CBSSC Steering Committee will schedule, at minimum, four (4) meetings, either in person or via teleconference, per year. In general, SC members are expected to attend meetings at their organization's expense. The SC may determine when meetings should be restricted to steering committee members (and appointees) or open to all partners in the Cooperative.

Working Groups

The CBSSC SC can organize standing or ad-hoc working groups at any time. As with the SC, working group members are volunteers, and a working group Chair will be selected by the working group members during their first meeting. To facilitate as much involvement from the partnership as possible and to share CBSSC leadership opportunities, at least one member of each working group must sit on the Steering Committee to ensure coordination. However, working group Chairs are not required to be current Steering Committee members. Working groups will be responsible for defining, refining, and accomplishing tasks that help achieve CBSSC's goals and objectives. The actions under Goals 1 and 2 in this Implementation Plan call for at least two working groups to be established: Education and Outreach; Science, Technology, and Data.

Education and Outreach Working Group - A fundamental goal of the CBSSC is to promote smart management decision-making and citizen understanding of climate change impacts on the natural and built environments. The Education and Outreach working group will be integral to transmitting the science based discoveries and tools generated by CBSSC partners to local managers and the public. The Outreach and Education Working group will lead the development of an engaging education and outreach plan and other actions identified in Goal 3. This working group will be responsible for providing decision and policy makers, elected officials, and the public with local sea level rise information generated at sentinel sites and by partner efforts, training workshops on using relevant visualization tools such as Digital Coast's Coastal Atlas, developing a program to use accessible sentinel sites as educational platforms, and promoting working relationships between scientists, educators, and planners.

Science and Data Working Group(s) - To ensure that recommended actions are tied to sound science and in a manner that efficiently builds a sentinel network, science and data working group(s) will be responsible for assimilating and collecting (where necessary) data to support the mission of the CBSSC and modeling and tool development. Some specific working groups could be formed such as a SET working group tasked with inventorying all available SET data

within the Chesapeake Bay, data integration and modeling, and assimilating and managing all sentinel site data. With support from the Partnership-at-Large, these working groups will focus on carrying out activities planned under Goals 1 and 2. In addition, this working group may recommend scientific studies, investigations, sampling protocols, monitoring programs and data streams to the Steering Committee that are necessary to determine the causes of observed or perceived environmental problems related to sea level change. Moreover, this working group, in coordination with the Steering Committee, will be responsible for identifying and establishing strategic sentinel site locations with the Chesapeake Bay and networking the available data sets to develop a more comprehensive understanding of sea level change impacts on coastal communities.

Partnership-At-Large

All partners are completing work that helps support the goals and objectives established for the Cooperative. This work is critical to the success of the CBSSC even if many partners do not serve on the Steering Committee or working groups. The Steering Committee and working groups will be responsible for informing the partnership-at-large on CBSSC activities in an effort to promote the Cooperative's efforts and potential growth and improve or expand opportunities for coordination or collaboration.

Schedule and Budget

The CBSSC will act on the U.S. Government's fiscal year schedule (October 1- September 30).

Quarter 1: October 1- December 31

Quarter 2: January 1- March 31

Quarter 3: April 1- June 30

Quarter 4: July 1-September 30

There is no formal CBSSC budget; resources available to conduct CBSSC activities will collectively come from the participating partners and directed project grants when possible.

Table 4: Overview of Cooperative members and responsibilities.

Entity	Roles	Membership
Cooperative Coordinator	-Oversee development and business of the Cooperative. -Maintain and establish relationships and communications with all working groups and partners. -Ensure actions and milestones are met.	1 Coordinator
Steering Committee	-Develop and submit 5-year implementation plan, milestone and success evaluation to	8-15 members (2 year term) Example breakdown:

	NOAA's Sentinel Site Program Coordinating Committee. -Continually engage and coordinate with the Partnership-at-Large and stakeholders; -Link to National coordination communication by providing success stories, identifying best practices.	3-5 federal reps 2-4 state reps 2-4 university reps 1-2 non-profit reps 1-2 Commercial/Industry reps
Working Groups	-Execute relevant components of implementation plans; -Measure and report performance/evaluate success to steering committee.	Variable based on group duties; at least 1 member to sit on steering committee.

RESOURCE IDENTIFICATION

The Chesapeake Bay contains a large number and wide variety of long-term data streams available for integration within a Sentinel Site Program, especially as it relates to climate change and sea level change impacts. The amount and diversity of data is tremendous, providing a unique opportunity to undertake a much needed coordinated and collaborative endeavor to making the information available, interconnected and transferable to decision makers and the public. As the CBSSC moves forward, the steering committee will continually engage the operators of additional monitoring and modeling capacities and evaluate their participation in the cooperative. Examples of ongoing physical and biological measurements and data streams for the Chesapeake Bay that are currently being collected and could be integrated into CBSSC's collaborative efforts are provided in Table 5.

Table 5. Chesapeake Bay Monitoring Programs (relevant to SLR).

Partner	Program	Description	Data Collected
NOAA	National Water Level Observation Network (NWLON)	14 system gauges	Long term sea level trends
NOAA	Continuously Operating GPS Reference Stations (CORS)	30+active stations; 1 co-located with NWLON station (Solomon's Island)	
Federal, State, Academic partners	Surface Elevation Table (SET) datasets	50+ datasets connected to the National Spatial Reference System; 200+ datasets from partner agencies (100+ in Blackwater Refuge)	Wetland elevation change
NOAA	Chesapeake Bay Operational Forecast System II	3D coastal hydrodynamic model for tides, currents, and storm surge	Water level, wind, currents, water temp, salinity
NOAA	Poplar Island Monitoring and Model	Nested hydrodynamic model based on nested grid with CBOFS	Local sea level rise impacts; elevation, water level, and water current data
NOAA	VDatum	Sea surface topography model	Defines tidal datums (e.g., mean sea level)
NOAA, States, University	Geodetic Control Networks	7 (4 VA, 3MD) high accuracy networks	Permanent survey markers
NOAA	Chesapeake Bay Interpretative Buoy System (CBIBS)	Network of Integrated Ocean Observing System (IOOS) observing systems	Oceanographic, meteorological and water quality data
USGS	Mid-Atlantic Coastal Observing Regional Association		
USGS	National Streamflow Information Program	Stream gauge network	Physical and biological data, water quality, flow

NOAA, USCG, VIMS, UMD, EPA, ACT, NAWC	Chesapeake Bay Observing System	9 monitoring stations as far south as Smith Point	Meteorological, oceanographic and water quality data; soil data at select locations
USGS, USACE, Smithsonian, FWS, NPS	Historic tide gauge datasets and water level observations		
FWS/NOAA	Blackwater National Wildlife Refuge monitoring		SETs, Wetland elevation data along fire management regimes, groundwater height, water quality at 14 locations, various wetland vegetation surveys
Federal, State, Academic, NGO, and local govn't partners	Southern Chesapeake Bay Shallow Water Quality Monitoring Program	38 continuous monitors	Water quality data, vertical profiler
VIMS	Virginia Estuarine and Coastal Observing System (VECOS):	Website designed to distribute water quality data sampled from the Chesapeake Bay and associated tributaries within Virginia	
NERRS	System-wide Monitoring Program	7 NERRS throughout MD and VA	Water quality, marsh productivity, submerged aquatic vegetation, benthic habitat, nekton productivity, ground water dynamics at select sites
UMD, UDE, Towson University, NSF	Maryland and Delaware Climate Change Education Assessment and Research (MADE-CLEAR)	Engaging climate scientists, science educators, students, and the broader community of interest in the development of an implementation strategy for comprehensive climate change education.	
NERRS	Coastal Training Program	Provides up-to-date scientific information and skill building opportunities	

		to individuals who are responsible for making decisions that affect coastal resources	

Evaluation Process/ Measures of Success

Performance management and evaluation is critical to assessing the success of the CBSSC. NOAA's Sentinel Site Coordinating Working Group is provided five Government Performance and Results Act programmatic performance measures that may be applicable to the five pilot Cooperatives. The two performance measures that are most relevant to the key actions of the Chesapeake Bay Sentinal Site Cooperative are listed below with related actions from this plan.

Annual number of coastal marine, and Great Lakes ecological characterizations that meet management needs.

Objective 1.1

Supporting Actions:

- At select sentinel sites, support collection of high resolution core ecological data.
- At two locations with long-term records compare data sets and assess similarities and differences to demonstrate certainty of SLR science.

Percentage of tools, technologies and information services that are used by NOAA partners/customers to improve ecosystem-based management

Objective 2.1
Supporting Actions:

- Develop a sea-level change decision tool to foster local planning and management decisions;

Objective 3.3
Major Actions:

- Conduct at least one workshop, annually, that trains users how to correctly use visualization tools (e.g., Digital Coast) and/or aid educators and planners on communicating sea level rise impacts with the public.

Supporting Actions:

- Evaluate applicable models and visualization tools for spatial coverage, output, and limitations and disseminate the analysis to stakeholders.

In addition to these programmatic measures of success, the CBSSC will, on an annual basis, identify if the actions under each goal and objective have been initiated or completed for that fiscal year. Performance evaluation will be mapped to the completion of each milestone. The Cooperative could evaluate itself for effectively reaching its audience through workshops, training, products, etc. on a poor/good/excellent scale for each goal and objective. For example, the number of hits on the CBSCC website or the number of workshops with positive feedback

could determine the success of reaching partners and the community. Ideally, the efforts of the Cooperative will result in necessary management changes in both natural and urban areas. CBSSC partners will track success throughout the year such as a spreadsheet of workshops and training conducted by partners; data collection efforts; and where local government and managers adopt partner advice and expertise into planning efforts.

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Appendix A: **CBSSC Gap Analysis.**

Chesapeake Bay Sentinel Site Cooperative Gaps		
Location	Gap Item	Description
NERRS- Maryland (Jug Bay, Monie Bay, Otter Point Creek)	Vertical control network	Connect monitoring infrastructure at Monie Bay and Otter Point Creek to a local geodetic control network and the NSRS.
	Water level sensors	Establish dedicated water level sensors at the three CBNERR-MD sites or at least at two of the sites (Jug Bay and Monie Bay) that can be used for long term monitoring.
	SETs	Establish SETs at Otter Point Creek
	Mapping	High resolution mapping of coastal habitats (e.g., wetland mapping) at the three CBNERR-MD sites
	Vulnerability assessments	Conduct habitat, species, and socio-economic vulnerability assessments to climate change at all/any of the CBNERR-MD sites.
	Groundwater monitoring	Expand groundwater monitoring at Jug Bay, and start this monitoring at the other two sites
	Salinity intrusion	Analyze (e.g. using modeling) existing data within the Chesapeake Bay to determine the degree (in time and space) of salinity intrusion from the mouth to the upper Chesapeake Bay
NERRS-ALL SITES	Monitoring- Operational Funding	Operational funding for relative sea level rise and wetland (marsh) impacts needed due to FY13 budget cuts. Infrastructure is in place but field sampling, data collection and processing not funded in FY13.
Blackwater NWR	Monitoring	Develop monitoring program to measure subsidence rates at various locations within Refuge
		Secure funding to continue SET data collection and analysis
Assateague National Seashore	Monitoring	Vegetation Surveys
VCR-LTER	Monitoring	Vegetation Surveys in mainland marshes
Coastal Bays	Tide Gauge	Establish tide gauge in coastal bays-currently there are none along the mid-Atlantic
Non-site specific needs	Coordination	With over 20 agencies, organizations, and universities involved to date, funding is needed to retain a full-time Cooperative Coordinator and host meetings. Among other things, this person would initiate and organize meetings and workshops, maintain and distribute records of communications and documents, report to NOS Sentinel Site Program Committee, promote execution of IP actions, and ensure continued engagement with all involved.

Chesapeake Bay Sentinel Site Cooperative Gaps		
	Outreach - Operational Funding	Materials need to be developed to translate sentinel site products (data, models, tools) for use by local stakeholders to support science-based decision-making (e.g. maps, web products, brochures, teaching tools)
	Data Access and Interoperability	Centralized platform for improved data access and management; Review institutional and organizational data management practices and make recommendations to enhance efficiency and cost effectiveness of data gathering, sharing, maintenance, and processing efforts and to minimize duplication of effort and data and modeling redundancies.
	Modeling	Downscaled modeling tools similar to Harry Wang's Chesapeake Inundation Prediction System(CIPS)- short and long-term. For example, short-term forecasts that provide visual projections of storm surge and inundation that depicts overland flooding with at least 24-48 hours or more in advance. Initial focus could be on specific areas of concern that includes residential, commercial and critical infrastructure. Having these capabilities would more effectively address short-term emergency response- where to deploy resources to reduce impact and speed recovery. Long term (e.g., decadal) projects create resiliency and mitigate losses to future storm surge and inundation. This would allow for promotion of policy changes (e.g., zoning) and promote development in less vulnerable areas, prevent new/hardened development in vulnerable areas, assess costs, and allow for strategic conservation area acquisition.
		Creation of "non-regulatory product" that takes the new FEMA Flood Coast Study data and adds 1, 2, 3 + feet for use as an informational product for sea level rise planning.
		Model changes analyze stream flow and hydrologic data to better understand interactions between groundwater and sea-level rise.
		Altered flood probabilities in light of changes in sea-level.
		Long term wetland transition and loss modeling
		VDATUM: Enhance and downscale VDTAUM sea surface topography model
	Temporary Water Level Stations	Investment in temporary water level sensors to fill data gaps across the Delmarva regarding present-day tidal inundation with respect to natural habitats and human infrastructure (supporting modeling/VDATUM)
	Subsidence	Expand existing subsidence studies programs to assess the risk of elevation declines due to ground water withdrawals, which would exacerbate any impacts of sea level rise.

Chesapeake Bay Sentinel Site Cooperative Gaps		
	GIS	Downscaled user-friendly spatial tools (e.g., a sea level rise viewer) to inform policy, local government planner, and resource manager decision making processes. In concert with public outreach, a mapping tool that could show homeowners their home under "x" scenarios would improve coastal community understanding about sea level rise and their community. In addition, land use planning, watershed planning, stormwater management would benefit from downscaled spatial, sea level rise tools.
		Spatial analysis of wetland transition and loss
	SETs	Inventory and synthesis of Surface Elevation Tables (SET) and other vertical control data infrastructure distribution across region with detailed geospatial information Strategic establishment Surface Elevation Table (SET) sites to address current gaps in wetland elevation change monitoring
	Local/Regional land motion	Update local/regional estimates of vertical land motion from an analysis of repeat leveling, CORS, and GPS surveys in the Delmarva
	Monitoring Networks	Funding needed to maintain monitoring gauges (e.g., CBIBS, VECOS) throughout the Bay to develop long-term climate and water quality record and link sentinel site network
	Rainfall and Groundwater Data	Need groundwater and rainfall data that feeds models for siting/sizing BMPs and impacts on bay species
	Economics	Fund study to quantify the economic benefits of development approaches that incorporate both coastal smart growth and hazard mitigation strategies; develop good evaluation metrics; Include socio-economic considerations to address social equity as part of risk assessment and planning
	Education/Outreach	Develop consistent messaging about the benefits of smart growth and hazard mitigation, emphasizing the economic benefits, and communicate these messages to different stakeholders (for example, developers, real estate agents, land use planners, and local decision makers).
	Assessment of climate change-related impacts on economically important Bay species (e.g., striped bass, menhaden)	Predicting likely effects of increasing variability in rainfall
		Predicting likely effects of rising temperatures (especially in winter);
		Better understanding of how climate cycles that are unrelated to global warming are linked to multi-decadal changes in fishery production (alternating between conditions that favor shelf spawning or anadromous species), so we can separate those cycles from the current and future effects of climate change
		How to bring climate change into stock assessments How to monitor for climate effects in living resources
		How to rank species susceptibilities to climate change

Chesapeake Bay Sentinel Site Cooperative Gaps		
		Measuring and modeling oyster reef role in carbonate cycling and alkalinity modulation

Appendix B. **CBSSC Goals, Objectives, Actions and Milestones Table**

Goals	Objectives	Actions	Milestones	Milestone Completion Schedule				
				FY13	FY14	FY15	FY16	FY17
Goal 1: Coastal stakeholders and the general public understand and trust information on sea level change and coastal inundation hazards, and the severity of related impacts to Chesapeake Bay habitats, ecosystems, and built environments.	Objective 1.1: Within 3 years, identify needs of the coastal community to prepare for, respond to, and recover from current and anticipated sea level rise and other related climate change impacts.	Using recent (≤5 years) polls, surveys, interviews, public meetings, etc., synthesize known stakeholder and public information, data, and tool needs.	Inventory recent stakeholder "needs" polls, surveys, interviews, etc., conducted in the Bay area related to sea level rise impacts	X				
		Identify similar existing efforts and determine where potential partnerships exist	Develop a spreadsheet of partner's education and outreach events and tools.	X				
			Complete a report summarizing stakeholder's needs according to results of the inventoried efforts.		X			
	Objective 1.2: Within 3 years, provide stakeholders with information on the utility and limitations of the most relevant regional and local sea level change models.	Inventory major regional and local sea level change models and visualization tools.	Complete a report inventorying all major sea level rise and inundation models and visualization tools with discussion on target audience, strengths, limitations, and relevance of each		X			
			Conduct at least one workshop, annually, that trains user how to correctly use visualization tools (e.g., Digital Coast) and/or aid educators and planners on communicating sea level rise		X	X	X	X

			impacts with the public					
	Objective 1.3: Within 2 years, develop and begin to execute a regionally downscaled education and outreach plan.	Develop a set of SLR messages for various audiences which will resonate and be portable to different sentinel sites	Compile and disseminate success stories establishing best planning practices at a minimum of two political/community meetings or events, annually.	X	X	X	X	X
		Establish an outreach/education working group comprised of climate change and sea- level rise outreach and education professionals	Annually, the Outreach and Education working group convenes two meetings to discuss plan for achieving actions under this objective and supports one SLC-related public workshop.	X	X	X	X	X
		Support and track Cooperative partners' education and outreach efforts.	Annually, the CBSSC website, currently housed on the VIMS website, is expanded upon and updated as frequently as needed to include reports, workshop announcements and summaries, new SLR initiatives, funding opportunities, etc.	X	X	X	X	X
		Develop a CBSSC website and social media forums (e.g., "Community of Practice" blog, Facebook page, email list server) that provide links to or stores information relevant to sea level change science, management and educational opportunities	At least 1 new electronic networking method is developed.		X			

Goal 2: Governments, NGOs, and academic institutions have greater access to more reliable and integrated ecosystem and socio-economic data.	Objective 2.1: Within 5 years, increase the certainty of sea level change impacts at identified sentinel sites.	Identify and prioritize 5-10 sentinel sites within the Bay;	Identify core data and capabilities of a potential sentinel site or station.	X				
		Identify in which coastal communities sentinel stations are lacking and where data could produce valuable and effective stories.	Sentinel stations are installed in 1-2 communities that are facing severe sea level rise issues.			X		
		At select sentinel sites, support collection of high resolution core data	Complete a comprehensive report that compiles and analyzes data collected at sentinel sites to identify potential future landscape scenarios and identifying the degrees of certainty of sea level change impacts.					X
		At 2 locations with long term records, compare data sets and assess similarities and differences to demonstrate certainty of sea level rise science.	Working group formed to develop a proof-of-concept (e.g., pilot study) focusing on integration of data and data reliability at 2 sites collecting long-term core data; sites might include Anacostia (10 yrs), Dyke Marsh (7 yrs), VCR LTER (15 yrs), or SERC (7 yrs)	X				
			Working group produces two reports focusing on data integration and reliability at the two chosen sites above.			X		

		Improve socio-economic analysis of sea level rise impacts; translate the science into the socio-economic indicators that people care about.	Fill gaps in socio-economic analysis including a social scientist into the Cooperative (e.g., intern capable of working on specific project)					
	Objective 2.2: Within 3 years, establish consistency and inter-operability of regional data related to sea level rise.	Establish a centralized data access repository with standardized data formats for Cooperative data. This could be housed within IOOS through a partnership with MARACOOS.					X	
		Form a Science and Data working group to develop a strategy for assimilating available data sets;	Science and Data working group convenes at least two meetings, annually, to discuss improving consistency and inter-operability of regional data.	X	X	X	X	X
		Identify and inventory of SET locations and ancillary data.	Make inventory of existing data available to partners		X			
		Develop a glossary of sea level rise data terms, definitions, and acronyms;	Relevant SLC data is collected in a consistent and comparable manner across sentinel sites.		X			
		Develop and disseminate a review of common data collection methods and data quality standards.						
					X			
Goal 3: Local governments and land	Objective 3.1: Within 3 years, provide stakeholders	Develop a sea-level change decision tool to foster local	Decision support tool and other data-related products available on			X		

and natural resource managers have decision support tools to effectively prepare for, respond to, and recover from current and anticipated sea level rise and other related climate change impacts.	with useful tools designed to foster efficient planning efforts.	planning and management decisions;	website and discussed at appropriate stakeholder meetings					
		Develop and provide two case study documents (i.e., stories) summarizing threats, data collection, conservation and/or restoration methods, adaptation strategies, and lessons learned for a natural (e.g., Blackwater NWR, CBNERRS) and urbanized (e.g., Hampton Roads) area to inform decision makers and managers.	Case study documents are produced and disseminated to stakeholders in timely manner;				X	X
		Develop a list of qualified science professionals that could meet with and support content on SLR/sentinel site topics for local government decision-makers, managers, and professional educators.	Provide local government decision-makers and managers with advisory capabilities of the CBSSC	X	X	X	X	X
	Objective 3.2 (aspirational): Within 5 years, provide access to updated and spatially downscaled threat and vulnerability assessments of Chesapeake Bay ecosystems and human environment to sea level change at select sentinel sites.	Assist (thru guidance, support, or planning) characterization of ecosystem and human environment sensitivity and adaptive capacity to sea level change, focusing on indicator and economically important species at two sentinel sites	A report is produced that describes the vulnerability of and characterizes the threats to at least 2 protected and 2 urban/suburban sentinel sites from sea level change and coastal inundation					X
		Assist (thru guidance, support, or planning) characterization of physical drivers of ecosystem sensitivity to sea level rise at two	Report is made available on website and discussed at relevant stakeholder meetings					X

		sentinel sites						
		Assist (thru guidance, support, or planning) characterization of threats and vulnerability of built environment to sea level change at two sentinel sites						

Appendix C. **Summary of User Needs from previous surveys and workshops relative to sea level rise.**

Common needs within all or many of the reports referenced (in no particular order):

- Research should be tailored toward end-user needs (e.g., how the 100 year storm will change, how many days above 90°F in a row, etc.)
- Downscaled/Greater Resolution models- spatially (local planning scale) and temporally (10-50 year time)
- LIDAR mapping in Virginia needed
- Wetland mapping needed
- Increased surface elevation monitoring needed
- More accurate precipitation data and models
- Data storage and management- centralized database; coordinated research and data exchange
- User-friendly products that answer end user questions/needs
- Proactive interaction by scientists and experts with local elected officials and city governments in a manner that managers can relate to and understand to drive policy.

Stakeholder Understanding

Where "stakeholder" means local planners and managers, government officials, etc.

Top risks of climate change identified by survey participants:

- Flooding
- Sea level rise
- Erosion
- Property damage
- Loss of land

Rising temperatures

Key Goals of Users:

- Protecting private infrastructure and property
- Ensuring long term cost savings
- Maintaining local planning independence

Trusted sources for climate change information

- National expert on climate change
- University expert
- State agency staff

Types of Data Needed

- High resolution mapping of coastal habitats (e.g., wetland mapping) and land elevation (LIDAR)
- Regional land subsidence monitoring data
- State based vegetation classification and mapping, and rare and invasive species inventories
- More recent land-use/land cover data to better assess impact of precipitation changes on the Bay
- Support for continuous, long-term fishery independent monitoring that provides data for fish stock assessments and ecosystem-based modeling efforts

- Enhanced monitoring and modeling of precipitation patterns and impacts on Bay
- Expand tide gage networks throughout the Chesapeake Bay and it sub-estuaries
- Surface elevation data needed (e.g. SETs at specific locations to monitor short and long-term sea level rise changes, LIDAR mapping of the coastal region)
- Network of groundwater monitoring wells
- Support to expand the Virginia Conservation Lands Needs Assessment (VCLNA) and maintain the Conservation Lands Database on all protected lands in Virginia
- An ecological and infrastructure assessment needs to be conducted for existing Natural Area preserves

Data Access Needs

- Need to unearth and assemble diverse data sets, then make them publicly available through a user friendly clearing house
- Need to develop coordinated research and data exchange capabilities (e.g., centralized database)

Models and Tools

- Uncertainty over rate and amount of climate change impacts a barrier to including in decision–making process.
- Creation of "non regulatory product" that takes the new coastal flood study data and adds 1, 2, 3 + feet for use as an informational product for sea level rise planning.
- Local Governments want local climate trends on short timeframe:
- Climate change impacts need to be downscaled to comparable decision making level (e.g., county level). Center for Watershed Protection has localized mapping for Talbot, Caroline and Dorchester Counties – shows homes under "x" scenario.
- Shorten forecast of climate change models: 100+ years too long. Users want forecasts that align with subject of planning efforts. For example, infrastructure needs based on a 25-yr life cycle of a roads project.
- Need timeframe and severity of impacts
- Need better local climate predictions on seasonal to annual scale: temp, precipitation, SLR DGIF and NWF will contract with Virginia Tech's Conservation Management Institute= (CMI) to predict future climatic conditions within Virginia
- Climate change incorporated into FEMA programs
- Should present answers to questions: temperature (e.g., how many days above 90 degrees in a row), precipitation (e.g., storms, rainfall events during growing season), SLR (e.g., how often and amount of flooding)
- Stormwater-related science needed: includes 1 yr storm depth, rainfall pattern changes in region
- Relate climate change to watershed scale impacts
- Understanding of impacts on infrastructure
- Once climate models have been completed, additional resources (e.g., natural history information, predictive models from agency and academic sources, expert opinion) will be applied to predict how a subset of Virginia's SGCN and their habitats are likely to respond to the predicted conditions.

- Monitor, model and create risk maps for areas potentially most affected by increased pathogens, contaminated water, extreme heat, flooding, harmful algal blooms, food safety and availability concerns, and air quality.
- Short-term forecasts that provide visual projections of storm surge and inundation that depict overland flooding with transparent uncertainty factors 24-48 hours in advance of occurrence- would help address where response efforts should be concentrated.
- Forecasts should account for decadal changes in SLR, land subsidence, and stream flow.

Outreach/Education

- Need common terminology that users relate to/are worried about: e.g., use "hazard mitigation" "sea level rise" instead of "climate change ".
- Need more visualization tools, effective graphics
- Science community needs to communication early and often with local community
- Help states understand the potential equipment and operational changes and impacts of changes to water and wastewater utilities as a result of climate change
- Easy-to-Use information products- e.g., fact sheets, summary statements
- Engage younger audience (e.g., social media tools)
- Scientists and researchers need to summarize their findings or find a group to do this and provide to the end---users

Socio-Economics

- Climate change-related actions should include "return on investment"/economic analysis
- Develop BMP efficiency and effectiveness data
- Quantify the economic benefits of development approaches that incorporate both coastal smart growth and hazard mitigation strategies
- Identify health implications from climate change at high resolution scale
- Assess the economic costs resulting from severe weather events

Insights

- Economy and culture/history of utmost importance
- Religion offers an obstacle and a barrier: may be difficult to reconcile religion with science
- Too many "scary" scenarios may not be effective
- Important for students to work at local level
- Important for grants/projects to be developed based on user needs
- Need stories, not just data charts and graphs, to emphasize importance of action.

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Emails: K. Sellner forwarding Sadie Drescher (Nov 21); Z. Johnson (Nov 21); P. Delgado (Nov 26); K. Sellner forwarding Mike Koterba-CBOS (Nov 21).