



NOAA Sentinel Site Program



**U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Silver Spring, Maryland**

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1401 Constitution Ave., NW
Washington, DC 20230

September 27, 2011

The 2011 Corporate Portfolio Analysis (CPA) identified 24 key issues that pose the greatest risk to NOAA's core business and abilities. To address perceived shortfalls in NOAA's capacity to support community resilience to sea level rise and coastal inundation, the National Ocean Service (NOS) was asked to "document a strategy for sentinel sites, including the specific locations over time".

The CPA request was a natural fit for NOS as it had been involved in previous planning efforts with the Climate Program Office (CPO) to define the Sentinel Site concept to consider the entire 'research to application' continuum of NOS and CPO capabilities. The Sentinel Site Program Working Group (SSPWG), formed in January 2011 to explore NOS-CPO collaboration, took their original vision and expanded the initiative to other Line Offices in response to the CPA request in order to provide NOAA leadership with a strategy that can grow and adapt as more NOAA capabilities are integrated into the operational approach for the NOAA Sentinel Site Program (SSP) concept.

This report is the result of the SSPWG's work, in collaboration with regional colleagues, to describe the potential power of a NOAA Sentinel Site Program. A fully operational SSP will optimize NOAA activities while utilizing the broad portfolio of NOAA capabilities to support federal mandates, drivers, and emerging program requirements. The leadership of the National Ocean Service, the National Climatic Data Center, and the Climate Program Office strongly support the framework laid out in this document and its recommended implementation strategy.

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I. Executive Summary

Overview

The NOAA Sentinel Site Program (SSP) will utilize existing assets, programs, and resources in a place-based, issue-driven approach to ask and answer questions of local, regional, and national significance that affect both NOAA Trust Resources and the surrounding communities. Building off the investments in National Marine Sanctuaries, National Estuarine Research Reserves, observing systems and partnerships, the SSP represents a new way of doing business for NOAA. Beginning with the impacts of climate change, specifically sea level change (SLC) and coastal inundation, NOAA and our federal, state, and local partners will work in a cooperative way to “do more with less.” Common goals will be established and resources leveraged and shared in order to develop science-based management actions that make sense in the face of changing climates – both physical and fiscal.

The NOAA SSP establishes an approach that utilizes a broad swath of NOAA’s infrastructure and resources to track the status of key indicators of ecosystem integrity and socioeconomic health and translate that information into management actions. The NOAA Sentinel Site Program provides a methodology to monitoring and quantifying environmental and socioeconomic changes attributable to local climate change impacts, and applies that information to management by informing mitigation and adaptation. This effort is much more than a monitoring program. It utilizes NOAA and its partner capabilities to apply monitoring and observation data to decision making. The NOAA SSP will engage a continuum of NOAA capabilities from observations and research to application and management (Figure 1) to address local impacts of sea level change and inundation. The SSP will provide an integrated operational approach that utilizes NOAA’s diverse portfolio of assets and capabilities while leveraging existing resources and capacity, such as NOAA Trust Resources and networks of observing infrastructure.

In today’s limited fiscal climate, NOAA’s focus on efficiency becomes increasingly important. The NOAA Sentinel Site Program seeks to address critical societal, environmental, and economic by focusing existing resources through an innovative business model. While the concept of leveraging existing resources to achieve greater outcomes is not new, the specific application outlined in this report describes a unique and innovative approach to achieving this efficiency for NOAA and its partners.

The goals of the NOAA SSP include the utilization of the the outcomes of these coordinated efforts by local communities and local, state, and federal resource managers for adaptation planning as well as providing critical information to researchers grappling with providing locally relevant climate impact information. Additionally, 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. Finally, it is anticipated that this cooperative approach will be applied to addressing other appropriate management issues.

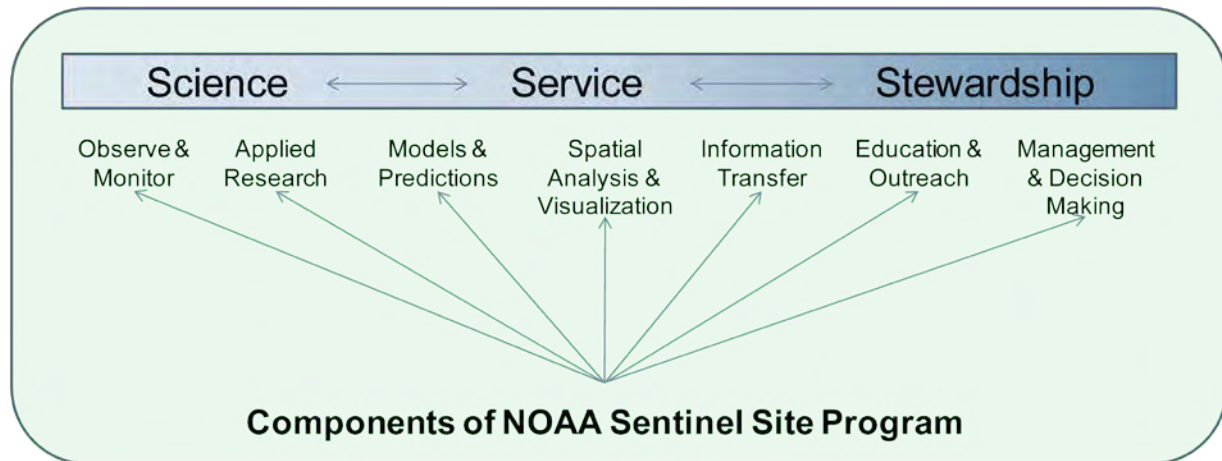


Figure 1. NOAA Science, Service and Stewardship Activities

Place-based focus

The Sentinel Sites concept can be described in three fundamental ways: place-based, issue-driven, and collaborative. The primary issue driving the initiative to date is changing climate, with initial implementation focused on sea level change and coastal inundation. The impacts of climate change are occurring even as efforts to understand ecosystem and socioeconomic impacts are ongoing. Key sectors of government, academia, non-profit environmental organizations, and industry are united in understanding the need for this critical information in order to adapt to the coming changes through management measures.

It is this urgent requirement for understanding, coupled with the breadth of interested parties that creates the third characteristic: collaborative. The multitude of vested stakeholders, each with information needs, mandates, and resource limitations, creates an environment for encouraging integration of assets via coordinated planning and execution in order to achieve a greater combined result. The NOAA Sentinel Site Program establishes the collaborative framework to meet these needs.

Why Address Sea Level Change through the NOAA SSP?

- *Sea level change and coastal inundation is a challenge requiring locally specific climate change forecasts, locally relevant information and management approach.*
- *Storm and climate scale inundation planning, resilience, and response demands the integration of information in a holistic, geospatial approach.*
- *Vulnerabilities from climate and hazards impacts span natural habitats, transportation, health and safety, and socioeconomic factors and affect communities and the coastal ecosystems upon which they depend including NOAA Trust Resources.*

The development of this concept will be locally-driven while also coordinated with national programs at NOAA headquarters to ensure effective communication. It is at the local level that

the need for information is greatest and the resources are often most limited. As communities face an uncertain future in terms of the impacts of SLC and coastal inundation, they are highly motivated to understand and take action. Given the place-based nature of this effort, stakeholder groups share common needs, political climate, and local and regional identities. It is these commonalities that will drive innovation.

A fully-developed NOAA SSP will allow NOAA to fulfill its responsibilities as directed by a number of mandates and laws, as noted in Section XI, in a more efficient and comprehensive manner. The program does not detract from existing responsibilities, but focuses resources in such a way that multiple goals can be achieved through collaborative engagement rather than through parallel efforts.

Implementation

The following report outlines the nested approach to the NOAA SSP, within the context of addressing the needs associated with the impacts of SLC and coastal inundation, and presents a plan for implementation. After careful consideration, five cooperatives have been recommended for initial implementation based on their scientific relevance to addressing SLC and coastal inundation, capacity for leveraging existing resources, partnerships, and assets, and potential to inform and respond with management action. These pilot cooperatives are: Hawaii, the San Francisco Bay Area, the Chesapeake Bay, North Carolina, and the Northern Gulf of Mexico. Each cooperative includes at least one federally managed or funded coastal or marine protected area and a coastal commerce center.

Representatives from these five locations will develop plans for implementation, while coordinating programmatically across all Line Offices and with NOAA Regions. In each cooperative, the concept of Sentinel Sites will be implemented in a way that maximizes the benefit to coastal communities and economies while utilizing NOAA infrastructure. While the time frame and deliverables for implementation in each location may vary, each will strive to achieve outcomes that are scientifically sound and immediately applicable to decision makers, including those who manage NOAA Trust Resources.

II. Vision Statement

The NOAA Sentinel Site Program will bring to life NOAA's science, service, and stewardship continuum by leveraging existing resources and integrating multiple parallel efforts to promote resilient coastal communities and ecosystems in the face of change. This innovative approach will achieve increased management effectiveness through more coordinated and comprehensive science.

III. Background

The concept of Sentinel Sites for monitoring environmental change is not new. For decades, it has been given various names and utilized in various forms by scientists, researchers, and management agencies. Within NOAA, several programs have attempted to integrate a mixture

Integrating physical, ecosystem and socioeconomic factors

Social vulnerability is represented as the social, economic, demographic, and housing characteristic that influence a community's ability to respond to, cope with, recover from and adapt to environmental hazards.

Changes in physical factors such as sea level rise impact the health of the environment and may modify the viability of some critical habitats and species. It also may impact the quality and quantity of services provided by the ecosystem. Sea level rise will exacerbate coastal storm impacts such as inundation of adjacent low lying communities. This often impacts vulnerable populations and critical infrastructure.

Losses or changes in habitats and ecosystems caused by rising sea level will impact the ability of these areas to provide services to the adjacent communities. Services include buffering the community and its infrastructure from extreme events, providing recreational and harvesting opportunities, and trapping and filtering excess nutrients and pollutants. Healthy, productive environments are the basis of sustainable development and human welfare.

An understanding of physical and environmental changes and thoughtful planning are needed so that **communities can prepare and adapt to anticipated changes**. Adaptation steps can be taken to make vulnerable populations more resilient and to protect and incorporate the benefits provided by natural systems into social and economic development plans.

of Sentinel Site components into their research endeavors. Recently, the National Ocean Service and the Climate Program Office began working together to determine how Sentinel Site activities could be implemented in a robust framework that included a broad suite of initiatives to address the impacts of climate change on various NOAA Trust Resources, while leveraging the long-term investments the nation has made in establishing and maintaining National Marine Sanctuaries (NMS) and the National Estuarine Research Reserve System (NERRS).

A New Business Model

While these and other NOAA programs have made progress with their efforts, few are well enough connected across disciplines and activities to fully inform decision makers at relevant spatial and temporal scales. In 2011, a Sentinel Sites Program Working Group (SSPWG) was established to engage NOAA Line Offices in creating a NOAA Sentinel Site Program that would focus on existing NOAA capacity and resources, as well as federal mandates. The SSPWG developed this initiative for measuring and monitoring sea level change and coastal inundation impacts. This model illustrates how associated adaptation and management tools can be developed and disseminated to decision makers and coastal community leaders, and how NOAA will utilize the information gathered to improve its management of NOAA Trust Resources (e.g. National Marine Sanctuaries, National Estuarine Research Reserves, Critical Habitat).

A well-designed and implemented NOAA SSP would address this challenge through four internal objectives:

First, it would integrate capabilities across NOAA Line Offices to improve and enhance predictions, translate data into useful information, and develop management-relevant models. The NOAA SSP would go beyond rigorous scientific observations and analysis examining the processes that control ecosystem

responses to stressors by applying ecosystem data and information to the issues that affect the surrounding human communities that rely on the services provided by functional ecosystems. By attracting, engaging, and supporting a diversity of collaborations between NOAA and

stakeholder scientists, analysts, communicators, educators, and managers who are collecting relevant information, the program will realize higher efficiency at all levels.

Second, the NOAA SSP is designed with the flexibility to address multiple questions of environmental stressors. In the model presented in this report, sea level change and coastal inundation are targeted as primary issues of concern. This model was chosen because these issues will have significant impacts on the people and economies of coastal communities that are associated with NOAA protected areas. The NOAA SSP concept can be adapted to other issues and questions in a wide range of geographic locations and ecosystem types.

Socioeconomic data collected by the NOAA SSP will provide critical contextual metrics and trends for decision makers, which, once integrated and correlated with biophysical data, will help communities anticipate and respond to climate change impacts, including SLC and inundation.

Third, the NOAA SSP will assist the agency in fulfilling its federal mandates to understand and predict changes in climate, weather, oceans, and coasts; to share that knowledge and information with others to make coastal communities more resilient; and to directly conserve and manage coastal and marine ecosystems and resources. It is only through the application of the information and knowledge gathered in this collaborative effort that true benefit to the nation will occur.

Fourth, the NOAA SSP has the advantage of being able to move forward without new resources. Since it is certain that gaps will be discovered, it should be noted that solutions to fill gaps in capacities or capabilities will be sought from within existing partners, by bringing in new partners or through the strategic leveraging of additional funds, as available and deemed an effective investment of NOAA's limited resources. Unlike programs such as the Long Term Ecological Research Program and the National Ecological Observing Network, a fully functional NOAA SSP would utilize a broad array of existing NOAA capabilities along the science, service, and stewardship continuum. The program will improve NOAA's ability to manage human activities that affect natural systems, identify early warnings and indicators of change, and deliver tools and new approaches to improve resource management and environmental literacy, all with no or limited new investments. The end result will be more resilient ecosystems and communities.

Establishing a Framework

The benefits of a SSP offer a compelling reason to establish a framework that encourages collaboration, leveraging a wealth of NOAA assets while addressing the needs of our stakeholders. Through the SSP, NOAA will increase its potential to maximize societal benefit. Stakeholders will be able to inform management with sound science and a clear understanding of ecological and socioeconomic vulnerability.

A Sentinel Sites approach:

- attracts and supports collaborations to understand processes that control ecosystems' responses to stressors;
- Integrates ecological, physical with socioeconomic information for informed decision making at the community level
- improves NOAA's ability to influence human activities that affect natural systems through education and outreach;
- identifies early warnings and indicators of change to support vulnerability assessments and provide opportunity to mitigate or adapt to undesired impacts;
- delivers tools/approaches to improve resource management and environmental literacy;
- brings to bear the broad array of NOAA capabilities along the Science, Service and Stewardship continuum on specific management questions; and
- makes observation and analysis socially relevant by applying ecosystem data and information to the issues that affect surrounding human communities.

When discussing adaptation and mitigation plans for inundation, stakeholders consistently note that local information is most actionable. Thus, the SSP envisions going beyond observation and analysis to provide locally relevant information that decision makers need to support coastal communities and the ecosystem services they rely upon. These ecosystem services may include provision of commercial and recreational fishery habitat, storm surge buffers, water quality enhancement, and recreation.

Potential users of the products and services of a NOAA Sentinel Sites Program include coastal zone, resource, and protected area managers; emergency and disaster response personnel; restoration practitioners; coastal research scientists; commercial fisheries managers; members of the maritime commerce and insurance industries; and local planning, tourism, and economic development boards.

IV. Definitions of the NOAA Sentinel Site Program and its Components

The NOAA SSP uses a nested approach (Figure 2) that incorporates observing systems ranging in scale from individual measurement stations to large scale cooperatives, where NOAA serves and responds to the American public.

NOAA Sentinel Site Program

The NOAA SSP will establish a place-based strategy to track the status of ecosystem integrity and socioeconomic health indicators for specific management issues using existing NOAA infrastructure and resources. The data collected by the program will inform management response and adaptation planning related to stressor impacts on ecosystems, NOAA Trust Resources, and human communities.

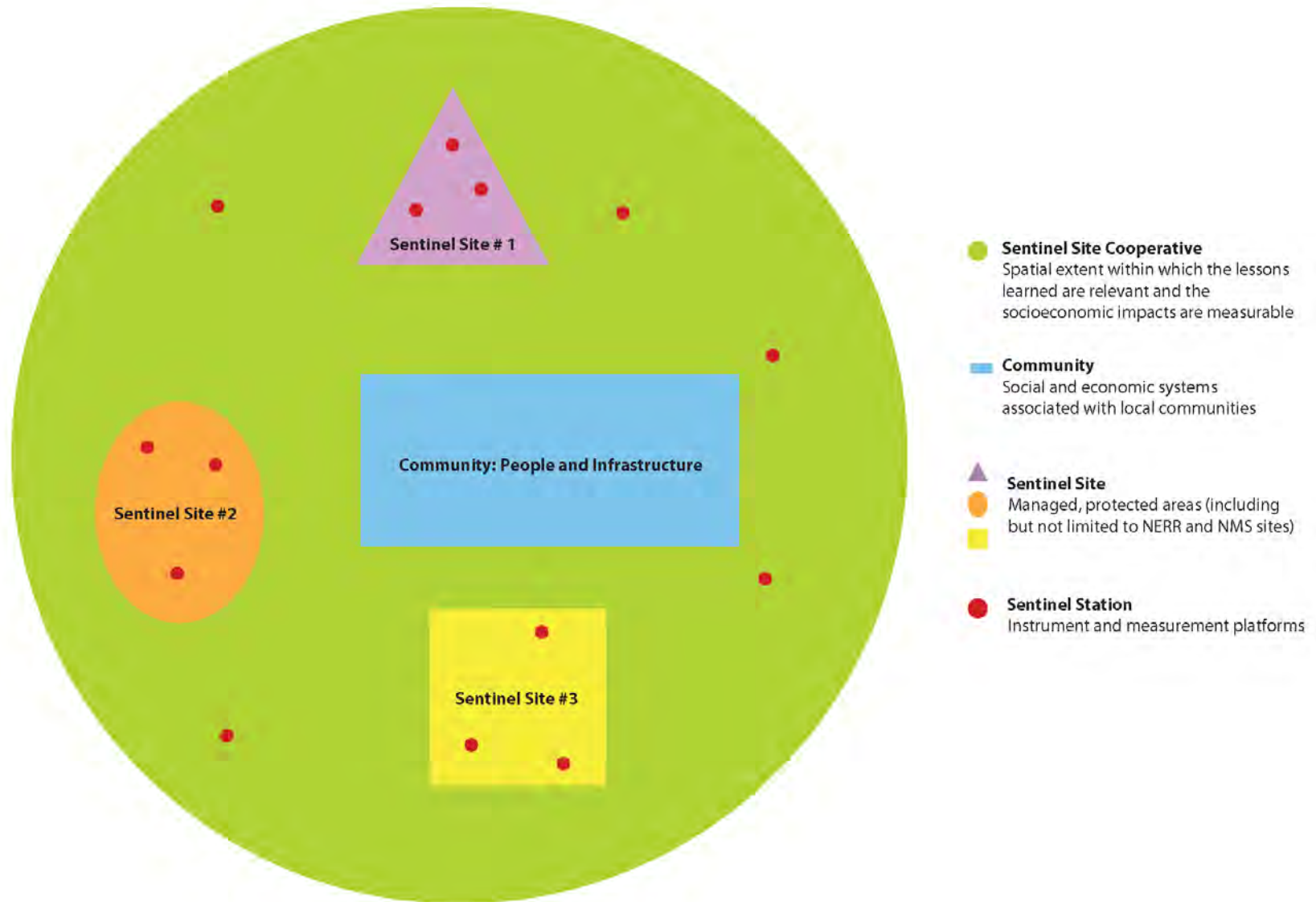


Figure 2. Conceptual representation of a nested NOAA Sentinel Site Program

Sentinel Stations

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.

Sentinel Sites

Areas in coastal and marine environments that have the operational capacity for intensive study and sustained observations to detect and understand physical and biological changes in the ecosystems they represent. A *Sentinel Site* should:

- contain one or more sentinel stations;
- 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 monitoring¹.

Sentinel Site Cooperatives

Spatial extent for which the outputs, products, and services from all applicable Sentinel Sites are both scientifically relevant and applicable to local management issues. 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. A

Sentinel Site Cooperative should:

- expand beyond the physical and biological information collected at Sentinel Sites to account for the socioeconomic components necessary for communities to make informed decisions;
- address interests of managed and protected areas within the cooperative;
- leverage managed and protected areas to address interests and management concerns of surrounding coastal communities; and
- include a coastal commerce center.

¹ In most cases, a sentinel site will also collect and analyze socioeconomic data.

V. Selection Criteria and Initial Location Recommendation

The selection criteria framework to determine candidate Sentinel Site Cooperatives well-poised for successful implementation was developed to determine the scientific significance, readiness, and management relevance of candidate cooperatives, while creating a flexible tool that can continue to be applied whether or not budget and organizational priorities change. The eleven criteria (Appendix A) are grouped into three basic themes, and provide a means of obtaining a thorough, yet precise, consideration of the strengths and weaknesses of proposals. The basic themes are:

- the scientific rationale behind the cooperative, and its ecological significance;
- the practicality of working in the area and the potential for leveraging existing assets;
- the potential relevance of local management issues to Program objectives, and the responsiveness of the local communities and ecosystems to management actions.

For the initial assessment, these criteria were applied in partnership with the NOAA Regional Teams. The NOAA Regional Coordinators, NERRS Coordinators, NMS Research Coordinators, and Regional Climate Service Directors were provided a Sentinel Sites concept paper and given webinars to brief them before being asked to submit narratives on how the Sentinel Sites concept could be implemented within their region. They, or their designees, prepared and submitted narratives for eleven candidate locations for consideration as detailed in the supplementary materials. Narratives were self-assessed by the submitters and then reviewed and normalized by the SSPWG (Appendix B). Each criterion was scored on a scale of 1-5 with a maximum score of 55 possible for the narrative.

Given the budget environment and the current scope of this plan, attention was given to the ability of a Sentinel Site Cooperative to leverage existing investments and assets. This evaluation approach and the criteria that were used are applicable to the review of individual cooperatives, so when looking at Sentinel Sites holistically, it is important to also take a portfolio approach and consider the scale and geographic extent met by multiple locations. The SSPWG applied a portfolio approach to reviewing the narratives, and recommend that for both readiness and geographic diversity, five locations should be considered for further analysis. By promoting the establishment of Sentinel Site Cooperatives in Hawaii, the San Francisco Bay Area, the Chesapeake Bay, North Carolina, and the Northern Gulf of Mexico, (Appendix D) existing NOAA regional investments will be leveraged, and SLC and coastal inundation impacts on a strong diversity of ecosystems and coastal communities will be addressed.

These areas are not the only ones that could eventually be established. The recommendation of the first five cooperatives is based on initial input from the NOAA regional personnel, which will be further analyzed and additional input gathered. Several other locations have components of a potential Sentinel Site Cooperative and might be ready in the next few years.

VI. Sampling Methods and Metrics

Sentinel Site Program Monitoring

The initial goals of the NOAA SSP are to both better understand and monitor impacts associated with SLC and coastal inundation, and to provide decision makers with relevant information and adaptation tools so they can respond smartly. Observations and monitoring data will be the foundation of detecting ecosystem and community response to climate impacts. The extent of monitoring assets to be included in a Sentinel Site Cooperative will be limited to those that are relevant to local management issues. While observations and monitoring provide a critical foundation for the Sentinel Site Program, the tangible benefit of the data and information is their relevance towards informing management action.

The NOAA SSP will leverage existing monitoring programs to better integrate physical, chemical, ecological, social, and economic data in a geospatial framework. This will include data that is directly tied to SLC and coastal inundation as well as more contextual data that can be correlated to changes, and may be at a larger scale. Priority data sets will include those data that enhance the ability to “right scale” some of the models for local and state decision makers.

Initial efforts to coordinate and leverage observation and monitoring data will focus on NOAA’s long-term monitoring efforts that are relevant at a local and state level. The value of these data collection efforts are that they are already part of established programs that include sustainable funding, data standards, collection protocols, and data storage and access. The second tier of observation and monitoring data that will be examined for relevancy are those long-term data that are collected by NOAA’s partners. The third tier will be the information collected by NOAA or other entities at a local level through individual research or restoration projects. These data will fill gaps and establish a baseline for required parameters not currently being collected through a long-term monitoring program.

In identifying key monitoring assets, specifically with a goal to understand and mitigate the effects of SLC and coastal inundation, attention will be paid to the issue of attribution. In observing and quantifying climate change impacts, every effort will be made to be comprehensive with respect to contributions to sea level change (e.g. erosion, subsidence, ground water extraction, global change), and to understand and quantify appropriate forcing functions. Additionally, a fundamental component of the monitoring element to any Sentinel Site Cooperative will be the establishment of a baseline from which to measure change.

All monitoring parameters will be integrated to better support management applications. In addition, applied research and models will be incorporated into the analysis. Information will be made available through relevant models, tools, and translation. Monitoring in later stages of implementation will focus on identified gaps within existing infrastructure and methods.

Physical and Chemical Monitoring

Observational data and modeling systems are vital to improving understanding of the physical and chemical changes that may result from changing sea levels, and initiate biological changes

These changes will affect the frequency and intensity of coastal and inland flooding and erosion, current strength and direction, and will alter associated water quality parameters, for example. A list of physical and chemical parameters that may be measured, depending on the specific needs of each cooperative is found in Appendix C.

Habitat and Ecological Monitoring

NOAA is a federal trustee for coastal and marine resources, including: commercial and recreational fishery resources and the associated fish species that spend a part of their lifecycle in marine systems; marine mammals; endangered and threatened marine species and their habitats; marshes, mangroves, seagrass beds, sand dunes, coral reefs, and other coastal habitats; and resources associated with NMS and NERRS. While it is NOAA's responsibility to protect these resources, monitoring and modeling activities can also provide valuable information on the responses and vulnerabilities of coastal ecosystems and communities to climate change impacts like SLC and coastal inundation. Monitoring of specific key habitats and species will help pinpoint changes to ecosystems and serve as early warning of future impacts. A list of habitat and ecological parameters that may be measured, depending on the specific needs of each cooperative is found in Appendix C.

Social and Economic Monitoring

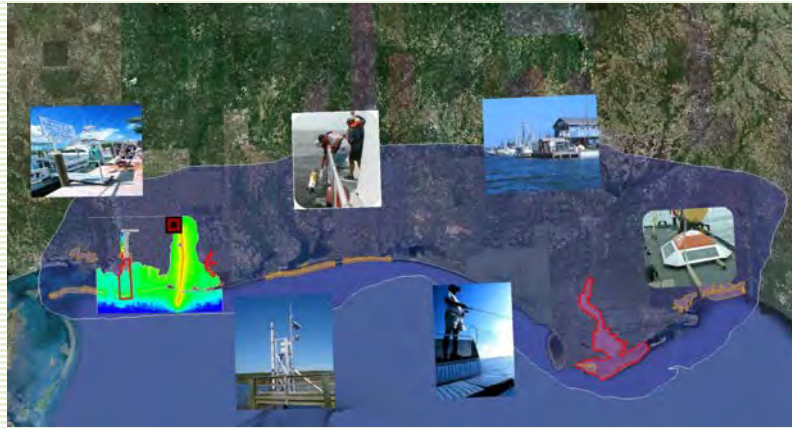
SLC and coastal inundation will not only affect the protected area, it will have a significant impact on the social parameters and economies of coastal communities. NOAA has the responsibility to not only collect information on the biophysical conditions but to make it relevant to decision makers. Integrating the biophysical data and information with the socioeconomic data and information enhances the decision makers' ability to make informed choices. A list of social and economic parameters that may be measured, depending on the specific needs of each cooperative is found in Appendix C.

VII. Observations to Management Applications

The NOAA SSP is about more than observations. One of NOAA's foundational principles is to connect science, service, and stewardship through its core competencies in areas such as observing, modeling, forecasting, information transfer, education, and resource management. The result is the meaningful application of science to solve problems of local, regional, or national scope and relevance. This principle has guided the design of the NOAA SSP and is fundamental to the draft regional narratives (available in the supplementary materials).

Sentinel Site Cooperatives are fundamentally places where integrated observations lead to greater understanding that allows NOAA to predict the types and magnitude of consequences of different phenomena. That data and information is then transferred to decision makers through models, predictions, visualization tools, education, outreach, and training. This full range of integrated science, service, and stewardship activities informs decisions related to NOAA Trust Resources, protection of coastal infrastructure, community planning, or event response. In this way, NOAA can more fully meet the expectations and needs of populations that depend on, live near, or care about the ocean.

What might a Sentinel Site Cooperative look like?



The above graphic provides a conceptual representation of a Sentinel Site Cooperative in the Gulf of Mexico, demonstrates integrating NOAA assets to deliver outputs, products, and lessons learned that are both scientifically relevant and applicable to coastal management issues. The Cooperative bounds not only the physical and biological data, but also relevant socioeconomic components necessary to assist coastal communities. Within this example, there are three NERRs; a commerce center at Mobile; additional NOAA observation and modeling capabilities; and population centers that would be impacted by changing sea levels and inundation patterns.

How would it be successful?

Sentinel Sites, and Sentinel Site Cooperatives are well positioned for implementation through leveraging of existing resources. By contributing existing resources and assets with focused goals and objectives, the benefit of individual monitoring efforts can be multiplied and applied to address specific challenges. Gaps will be identified and strategies developed to address them, including the possibility of incremental changes in planning or resource allocation. For instance:

- A state management agency that is planning to collect LiDAR might increase their area of coverage to include a particular marine protected area;
- The National Ocean Service might adjust the planned location of a particular observing system, such as tide station, to address not only mandated requirements, but also to support tide control within the same MPA, and might also conduct a shallow water bathymetric survey;
- The federal entity managing that area would continue its ongoing biomonitoring program, but take extra steps to tie into local geospatial frameworks (such as elevation);
- The availability of spatially-focused physical and biological data might enable the development of new ecological forecasting models, which could inform resource management decision-making.
- The availability of elevation and bathymetry data could facilitate the development of a new digital elevation model, which would be used to develop a coastal hydrodynamic model.
- The model and geospatial data together might allow NOAA to develop an inundation visualization tool and enhance local storm surge forecast products, which could inform emergency management action, as well as long-term coastal and ocean planning, and sea level rise policy.

The activities listed above demonstrate how no agency has expended additional resources, and yet each is meeting both their own mandates and feeding into the larger framework, as well as gaining additional information, and/or increasing the value of their products.

VIII. Phased Program Implementation Plan

The NOAA SSP will demonstrate how an integrated effort between offices can be maximized within current resource levels. This strategy assumed the level of resources that were available in FY 11. Future decisions about implementation will need to be made based on the actual level of funding and resources available at the time. As the NOAA SSP matures, gaps will become more easily identified and any additional future resources will be used to fill gaps, expand topics and cooperatives, and to further maximize efficiencies.

Phased Implementation

The first phase of the NOAA SSP development will require the first five cooperatives to establish individual implementation plans that determine their paths forward. To ensure that there is internal NOAA collaboration, as well as engagement within the local community, the five recommended cooperatives (i.e. Hawaii, the San Francisco Bay Area, the Chesapeake Bay, North Carolina, and the Northern Gulf of Mexico) will be asked to develop phased implementation plans that address how they will begin to implement the program in year one and generally how activities will evolve over the following four years (Figure 3). In Spring 2012, a workshop will be held at NOAA headquarters in Silver Spring to begin development of these plans and provide Program-wide guidance for consistency and collaboration.

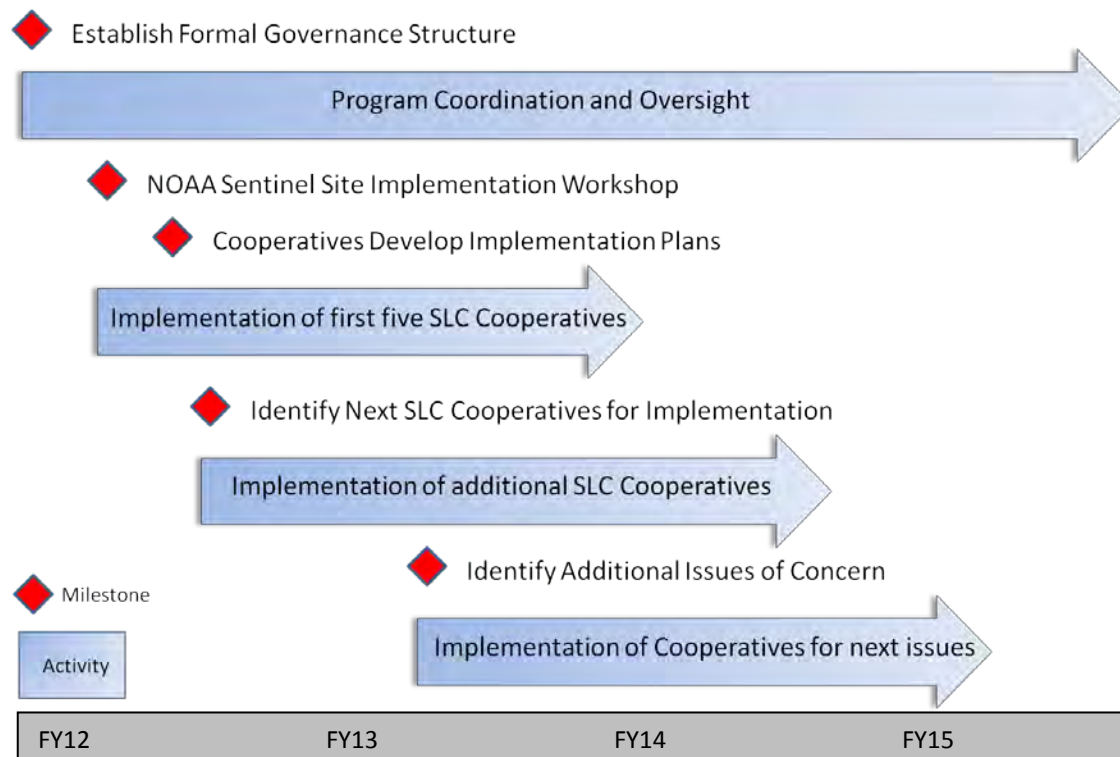


Figure 3. Key NOAA Sentinel Site Program activities over time

During the development of these implementation plans, Sentinel Site Cooperatives will initiate communications with relevant NOAA personnel within the region, other agencies, and

stakeholders. Emphasis will be placed on ensuring all NOAA LOs are engaged at both the planning and execution levels. As these locations begin operating as Sentinel Site Cooperatives, planning will begin for additional cooperatives. As lessons are learned, implementation will be adjusted to improve effectiveness and efficiency. Depending on NOAA priorities and the budget environment at that time, the criteria might be weighted differently to account for ecosystem management needs or science gaps as additional Sentinel Site Cooperatives are developed.

Implementation will occur through four phases (Figure 4). Phase 1 focuses on the identification of initial geographies and sites and the initiation of implementation plan development. Phase 2 includes the full engagement of all partners and early product development and application. Phase 3 will continue implementation and include initial assessments of efficacy. Phase 4 moves into the iterative process for improving efficiencies. Each Sentinel Site Cooperative will move through these phases at different rates, as funding allows.

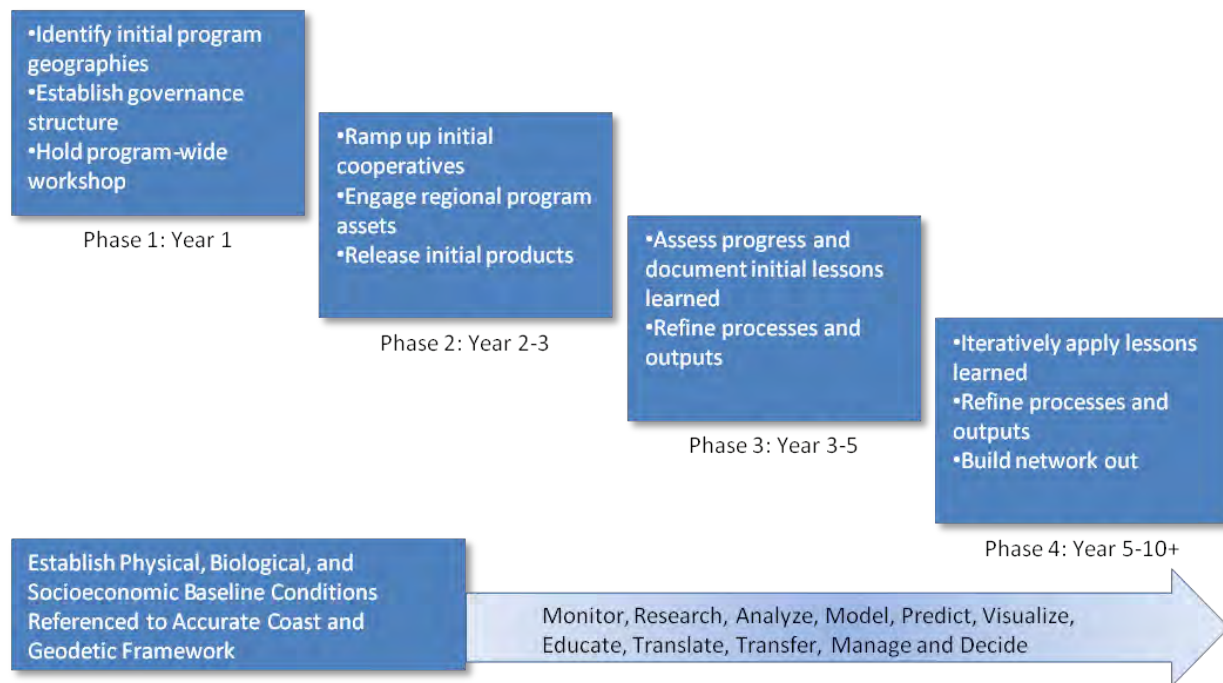


Figure 4. Implementation Phases

Additional Management Issues

The SSP is designed to be dynamic, and readily able to respond to emerging issues. While initial implementation focuses on impacts of sea level change and coastal inundation patterns, other potential focal areas could include ocean acidification, increased drought or precipitation, and changes in land use patterns. However, it is important to note that the cooperatives selected for a particular issue, such as addressing impacts of ocean acidification, will likely differ in composition and geographic extent from those selected to address sea level change, or increased drought or precipitation.

Following implementation of the first five SLC Cooperatives, the NOAA Sentinel Site Coordination Committee will explore opportunities to expand the Sentinel Sites approach to other issues of management concern beyond sea level change and inundation.

Recommendation of additional focus areas will be made by the Coordination Committee, and subject to appropriate council clearance. Upon selection of a focus area, a criteria-based approach to site selection will be utilized, as was done for sea level change, to identify Cooperatives best positioned to move forward with implementation. These efforts will continue in parallel to the continued development and implementation of NOAA Sentinel Site SLC Cooperatives.

Establishing a Governance Structure

In year one of implementation, each Sentinel Site Cooperative will identify a place-based Management Team that will coordinate and integrate local efforts and report on milestones and deliverables associated with these efforts. These Management Teams should incorporate vested individuals in the region and may include individuals from NOAA Headquarters; the establishment of these teams may also draw upon existing regional governance structures. The implementation plan should determine how often the Management Team will meet, how they will report on and track progress, and how local efforts will be coordinated and integrated. As the NOAA SSP moves into implementation, headquarters-based national coordination will continue in order to provide integration, consistency, and completeness in planning. A Sentinel Site Coordination Committee, led by an appointee of the NOS Assistant Administrator, will be the next iteration of the SSPWG and will be a small group with members from each participating LO. As a result, the make-up of the current working group may shift in order to better support the long-term outcomes of the NOAA SSP. The Coordination Committee will first develop a charter outlining membership, responsibilities, accountability, and requirements for interactions with place-based management structures. Relevant NOAA Councils and Goal Teams will be engaged as appropriate. Additionally, the Coordination Committee will engage ongoing complementary efforts, such as the NERRS Sentinel Site Program, to ensure coordination. They will also play an active role in encouraging regional participants to engage in the Cooperatives, and helping to identify incentives to achieving multiple outcomes through integration of efforts. If at any time a cooperative not previously identified for implementation becomes well-positioned to proceed, implementation will be encouraged via the Coordination Committee.

The NOS Assistant Administrator will provide oversight of the Coordination Committee, and other individuals on the NOAA NEP and NOCC will be engaged as decisions are made regarding the direction of the SSP. If appropriate, a small steering committee of cross-NOAA executives could provide hands on guidance and integrated NOAA leadership. Both the Coordination Committee and the place-based Management Teams will be responsible for reporting on specific milestones and performance measures.

Next Steps

Immediate next steps for governance and implementation include:

- establishment of a formal SSP Coordination Committee, led by an appointee of the NOS AA, to be comprised of representatives appointed by Line Office AAs and Deputy AAs;
- establishment of a SSP Coordination Committee charter detailing an internal and external (with the Cooperatives) coordination strategy, formalize interactions with NOAA leadership and councils, and define immediate performance measures and milestones; and
- hosting of a workshop for key technical representatives from each Cooperative to begin development of individual implementation plans.

IX. Defining Success for the NOAA Sentinel Site Program

Early Success

The initial implementation of the NOAA SSP will effectively leverage existing resources and partnerships within specific cooperatives to yield efficiencies and added value. This will be accomplished by collecting, analyzing, translating, and incorporating holistic data and information about SLC and coastal inundation into place-based, local, and regional decision making processes.

Planning would include:

- the development of Sentinel Site Cooperative Implementation Plans;
- engaging coastal decision makers collaboratively in development of SLC and coastal inundation tools and informative products;
- establishing an agreed upon set of standards and protocols for data collection and analysis with the understanding that, given the breadth of partners, there will be some variation in methods used;
- identifying requirements for data integration; and
- identifying resources that can be directed toward developing integrated tools, models, and informative products.

Implementation would include:

- ensuring SLC and coastal inundation research activities in Sentinel Site Cooperatives are coordinated;
- engaging coastal decision makers collaboratively with NOAA in developing tools, models, and informative products for assessing and responding to the effects of SLC and coastal inundation; and
- leveraging external partnerships to bring all available expertise to bear on the issues of SLC and coastal inundation.

Application would include:

- incorporating the Sentinel Site concept into the planning and execution of the individual components of each Sentinel Site Cooperative.

Long Term Success

Following initial implementation, the NOAA SSP will be evaluated for effectiveness in improving coordination of SLC and coastal inundation research, product and tool development, and management. Using an adaptive approach based on the results of initial implementation, additional Sentinel Site Cooperatives may be added. In addition, the NOAA SSP will consider additional climate change impacts such as ocean acidification, changing sea surface temperatures, etc. The NOAA SSP could potentially be applied to broader coastal stressors, including (but not limited to) water quality, harmful algal blooms, establishment of invasive species, and marine debris.

Planning would include:

- ensuring Sentinel Site Cooperatives utilize coordinated long-term planning in order to achieve maximum efficiency; and
- expanding NOAA SSP planning to include additional research questions.

Implementation would include:

- coordinating Sentinel Site Cooperatives' execution of SLC and coastal inundation activities; and
- as possible, enhancing and expanding existing monitoring networks based on gaps analyses to address other impacts issues.

Application would include:

- gathering information for direct application to adaptation planning;
- utilizing NOAA SSP training and technical assistance;
- applying increased understanding of risks and vulnerabilities due to SLC and coastal inundation to management planning;
- increasing effectiveness of NOAA's climate and coastal activities for improved science, service, and stewardship in the coastal zone;
- making NOAA SSP products and services the "gold standard" for information on coastal impacts from climate or other stressors and ensuring these products and services are routinely and effectively utilized by decision makers within Sentinel Site Cooperatives to respond smartly to change; and
- creating resilient coastal communities and maintaining vital ecosystem services.
- Evaluating the effectiveness of sentinel site program

Measuring the Success of the NOAA Sentinel Site Program

In order to chart the progress of the NOAA SSP, NOAA will identify a set of existing outputs, outcomes, and measures which contribute to success and cover the short and long-term objectives of the NOAA SSP as it addresses multiple foci, beginning with SLC and coastal inundation. The measures will represent the entire science, services, and stewardship spectrum.

Output measures will reflect activities that can be reprioritized to address the Sentinel Sites Cooperatives, and outcome measures will represent the goals of a Program. The list of candidate measures is incomplete at this point in time and will benefit from broader NOAA collaboration and input. The Program will identify more existing output measures covering data collection, modeling, and other measures that cover contributing work being done by other parts of NOAA that can be reprioritized to meet NOAA SSP needs.

Candidate measures that can be evaluated for future use include:

- number of U.S. coastal states and territories demonstrating 20% annual improvement in resilience capacity to climate hazards;
- annual percent of U.S. states and territories that use NOAA Climate information and services to improve planning and decision-making in response to changes in coastal events and ecosystem services related to a changing climate;
- decreased impact to community well-being following coastal inundation events;
- percent of U.S. states and territories enabled to benefit from a new national vertical reference system for improved inundation management*;
- sea level trend information for 159 global sea level stations*;
- number of coastal communities in which capacity was built to address coastal hazards, other weather and water conditions;
- number of new or enhanced tools implemented to improve management preparedness and response to climate change and its individual components;
- percentage of tools, technologies, and information services that are used by NOAA partners/customers to improve ecosystem-based management;
- number of decision-makers trained in best management practices to improve management of coastal and marine ecosystems;
- number of acres acquired or designated for long term protection; and
- acres of habitat restored for ocean, coastal, and Great Lakes resources.

Efficiency measures should reflect how NOAA has internally changed its procedures and partnership behavior to improve coordination leading to internal success. At this point, NOAA does not have any efficiency measures to track internal partnerships and collaborative efforts. It should be noted that the SSPWG feels an efficiency measure is crucial to measuring the value of the internal coordination efforts but also recognizes that measuring this effectiveness will pose logistical and potentially financial challenges. In addition, new measures should be developed with ease of reporting as one of the criteria, especially if information will be solicited from partners. Ideas for development into efficiency measures and reporting include:

- Using social network analysis to document changes in scope and complexities of collaboration of the agencies and entities engaged in sentinel cooperatives.

* If the priority order of completion within this measure can be manipulated to address Sentinel Sites Cooperatives first, this measure will suffice. If the priority order is based on other requirements and may not be changed, this measure will be disregarded by the Sentinel Site Program.

- secondary sources of data utilized to analyze community preparedness and resilience;
- bi-annual survey to judge/measure the satisfaction of partners in the cooperatives; and
- capitalize on regional frameworks within NOAA to assist with measures.

X. Strategic Drivers and Future Opportunities

The NOAA SSP will assist NOAA in meeting many of the strategic goals of the agency, the Department of Commerce, and across the federal government, as well as meeting many of the legislative mandates for which NOAA is responsible. Below is a summary table of the relevant strategic drivers that a fully developed NOAA SSP will support:

Strategic Driver	Connection to the NOAA Sentinel Site Program
National Ocean Policy Priority Objectives	<ul style="list-style-type: none"> • Resiliency and Adaptation to Climate Change and Ocean Acidification • Ocean, Coastal, and Great Lakes Observations, Mapping, and Infrastructure • Ecosystem-Based Management • Inform Decisions and Improve Understanding • Coordinate and Support
NOAA’s Next Generation Strategic Plan	<ul style="list-style-type: none"> • Goal: Resilient Coastal Communities and Economies • Objective: Resilient Coastal Communities That Can Adapt To The Impacts Of Hazards And Climate Change. Specifically: <p style="margin-left: 40px;">“NOAA will develop and provide coastal decision makers with updated decision-support tools, technical assistance, training, and management strategies related to adaptation, risk communication, hazard response and recovery, and resource conservation.”</p> • Goal: Climate Adaptation and Mitigation • Objective: Mitigation and adaptation choices supported by sustained, reliable, and timely climate services. Specifically: <p style="margin-left: 40px;">“Coastal resource managers incorporate a greater understanding of the risks of sea level rise, changes in Great Lakes hydrology and water levels, and other climate impacts to reduce the vulnerability of coastal communities and ecosystem resources”, and;</p> <p style="margin-left: 40px;">“Living marine resource managers prepare for and respond to the impacts of a changing climate, ocean acidification, and other climate impacts, and develop management strategies for marine ecosystem conditions”</p> • Goal: Healthy Oceans • Objective: Healthy habitats that sustain resilient and thriving marine resources and communities. Specifically: <p style="margin-left: 40px;">“Climate change impacts addressed in conservation actions to promote long-term habitat resilience and adaptation.”</p>
Draft FY12 Annual Guidance Memorandum	<ul style="list-style-type: none"> • Strengthen core competencies through innovation. <ul style="list-style-type: none"> ○ “Business model innovation for the long-term evolution of core competencies in weather forecasting, coastal zone and fisheries

	<p>management, and research...”</p> <ul style="list-style-type: none"> • Sustain initiatives to deploy new competencies. <ul style="list-style-type: none"> ○ Implementation of the President’s National Ocean Policy, focusing on ecosystem-based management, coastal and marine spatial planning, resiliency and adaptation to climate change and ocean acidification, and observations, mapping, and infrastructure; ○ Advance the observations and research necessary to understand climate change, and transition mature climate science into regular, reliable, and relevant services.
<p>FY11 Annual Guidance Memorandum</p>	<ul style="list-style-type: none"> • Promote resiliency and adaptation to climate change and ocean acidification by implementing the National Ocean Policy. Specifically: “NOAA must provide the information services that communities, natural resource managers..., industries, and others need to reduce the vulnerability to risks associated with changing climate conditions and ocean acidification.”
<p>Key Legislative Mandates</p>	<ul style="list-style-type: none"> • National Marine Sanctuaries Act • Coastal Zone Management Act • Magnuson Stevens Fisheries Management and Conservation Act • Marine Mammal Protection Act • Endangered Species Act • Marine Protection, Research, and Sanctuaries Act • Oceans and Human Health Act • Coast and Geodetic Survey Act • Hydrographic Services Improvement Act • Integrated Coastal and Ocean Observation System Act

Future Opportunities

As Sentinel Site Cooperatives mature, innovation and purpose-driven adaptation will drive their evolution. The future success of the NOAA Sentinel Sites Program relies on each group articulating needs and bringing resources to bear around converging and critical management issues. By initially focusing the issue on SLC and coastal inundation, the needs of the groups are extremely well aligned. The limited resources available to each group can be pooled to provide a much more flexible approach. Some groups bring infrastructure, others bring small amounts of money that can be used to fill the greatest needs, and still others bring primarily the dedicated brainpower of creative, bright people.

Capitalizing on the growing support around the “sentinel” concept

The “sentinel” concept has been gaining recognition as a unifying term for groups acting as custodians for resources or people being threatened by emerging global issues. For instance, “sentinel” has been used by groups addressing impacts from global HIV epidemics to climate change. Within NOAA, “sentinel” has already been utilized by Climate Program Office to describe NOAA’s ability to identifying emerging oceanographic events/impacts. The Arctic Council, through its Circumpolar Marine Biodiversity Monitoring Program has established a set of “sentinel sites” in the Arctic focused on monitoring for specific climate variables. Both the

Office of National Marine Sanctuaries and the National Estuarine Research Reserve System have or are developing Sentinel programs. These programs are linked to the NOAA Sentinel Site Program through the Sentinel Site Program Working Group. "Sentinel" has also been adopted by other agencies like EPA and Long Island Sound Program, in partnership with the local Sea Grant Program, to articulate research and monitoring activities located in that geography.

Leveraging partnerships and fostering further collaborations

The emergence of the NOAA Sentinel Site Program is predicated on the idea that NOAA assets must be leveraged as we move into tougher fiscal times. Initially, the NOAA Sentinel Site Program is focusing on coordinating NOAA assets around key strategic issues (e.g. SLC and coastal inundation). Over time NOAA must foster partnerships with federal, state, and local programs/groups, as well as the business community, in order to fully leverage and exploit the sentinel concept. This need for greater collaboration will increase as NOAA phases into other management issues (e.g. ocean acidification and other climate impacts). In some of the more mature Sentinel Site Cooperatives, collaboration beyond NOS and NOAA has already occurred to include other federal, state, academic, and NGO partners. Some of the key future interagency partners should include USGS, DOI, and EPA.

In order to take full advantage of technological innovation, NOAA will seek opportunities to engage the business and academic sectors. In alignment with the basic tenets of the sentinel site concept, collaboration with these groups must be mutually beneficial and fiscally efficient. For example, the utilization of autonomous underwater vehicles (AUVs) could provide critical contextual information as well as help to clarify the geographic applicability of SSP outcomes. Importantly, as innovation in sensor, communication and design technologies increases, development is becoming cheaper and more reliable. Recently, sensors for increasing understanding about ocean acidification were successfully deployed via AUV by NOAA scientists. Leveraging emerging approaches and technologies will highlight the innovative nature of the NOAA SSP.

Aligning with existing efforts to maximize efficiencies

The limitation of resources, solidarity of mutual needs, and urgency to act in the face of declining budgets creates a hotbed for innovative thinking about how to do more with less. Efficiencies will be gained by better aligning existing efforts. These efficiencies will be created by connecting to existing coordination mechanisms (regional governance frameworks, regional NOAA coordination, Regional Climate programs, IOOS Regional Associations, etc.) and integrating into the local coastal management framework that is offered by implementing a "place based" concept like NOAA SSP. By showing through efficient planning and execution that the NOAA SSP is effective and fiscally responsible, the likelihood of successfully bringing in additional partners and resources increases dramatically. It is intended that, without additional resources, these collaborative efforts will advance local community efforts to address key issues. Should additional funds be available, NOAA will judiciously use these funds to strategically further the efforts of Sentinel Site Cooperatives and continue to assist the groups that are leading the way in innovative collaborations.

Informing planning of other integrated NOAA efforts

Another benefit of a fully functioning NOAA SSP will include the opportunity to inform other integrated efforts. Integrated efforts that could benefit from the existence of a NOAA SSP include efforts like Integrated Ecosystem Assessment, the Habitat Blueprint Program, and the Coastal Storms Program. Instead of spreading assets across a broad range of places, these integrated programs would take a targeted, “place based” approach to ensure that the end-to-end spectrum of products and services could tell a full story about the impacts climate and other environmental changes are having on our resources and elucidate specific management actions that can be taken to address those impacts.

Appendix A: Evaluation Criteria for NOAA Sentinel Site Program Cooperatives


Evaluation Criteria for NOAA Sentinel Site Program (SSP) Cooperatives

Criteria are not listed in order of priority. It is suggested that any proposed cooperative have at least one National Estuarine Research Reserve or National Marine Sanctuary and a center of maritime commerce within its boundaries. Rationale and justification for scores should be explicitly addressed in the narrative to detail the strengths and weaknesses of the overall proposal.

CRITERIA	EXPLANATION
Scientific Rationale and Ecological Significance	
High likelihood of detecting ecosystem change	Strong signal to noise ratio facilitating detection of significant variation and trends in target physical and biological variables
Key physical and biological attributes	Commonality of principal controlling mechanisms that are representative of the larger ecosystem (i.e. proposed cooperative) such as upwelling, habitat type, trophic structure, ecological connectivity, etc. (Specific Sentinel Sites should be listed in the justification section of this criteria element)
High ecological value	May be characterized by indicators such as high levels of biodiversity and biomass, major aggregation or migration events, presence of essential habitat, and keystone species supporting ecosystem structure and function
Practicality and Leveraging	
Documented local stakeholder need with an interested and engaged management community	Stakeholders and institutions have expressed need for NOAA SSP activities and would likely be willing to engage and contribute to NOAA SSP efforts. These efforts may be driven by the need to address specific mandates, such as the Coastal Zone Management Act; National Marine Sanctuaries Act; National Coastal Monitoring Act; Coral Reef Conservation Act; etc.
Existing monitoring and observing infrastructure, data availability, and support for continuity of activities and investments	Robust body of baseline data supported by historical and ongoing monitoring and observing with an emphasis on data that is actively managed. Presence of existing infrastructure that can support logistical needs for data collection, maintenance, information management and dissemination. (Specific Sentinel Sites should be listed in the justification section of this criteria element)
Existing capabilities for data analysis, synthesis, and translation	Existing capacity for transforming data into communicable information and user-friendly products that can be effectively disseminated and would contribute substantively to NOAA SSP goals such as modeling and forecasting, as well as communicating risk, decision alternatives, and ecological outcomes. (Specific assets [i.e. computing capacity, personnel, etc.] should be listed in the justification section of this criteria element)
Quality of existing or potential internal and external partnerships that complement and strengthen the thematic (e.g., SLC and coastal inundation) goals, objectives and priorities of the NOAA SSP	Internal (NOAA) and external (e.g., academia, industry, NGO) partnerships exist, are in development, or could be formed that would contribute substantively to NOAA SSP goals and the science, service, stewardship continuum
Relevance to Management Actions	
Management plans and actions support provision of ecosystem services	Existing management plans for maintenance or restoration of ecosystems and communities (plant, animal, human) provide an understanding of local ecosystem services. Maintenance or restoration of these services will offer measurable and lasting benefits for coastal communities.
NOAA SSP info could be used to make decisions that would reduce vulnerability of ecosystems and communities (plant, animal, human)	Information gathered is likely to help identify viable response options that can be evaluated and acted upon by local coastal decision makers and will support decisions that could reduce the vulnerability of coastal communities
Ability to document changes in local human populations, activities, and economies	Socioeconomic data and information is available regarding coastal communities (e.g., population density, demographics, land-use) and maritime commerce (e.g., tourism, recreation, fishing, port and marina activities, housing, industry)
Utility of lessons learned for other areas with comparable governance and issues	Knowledge gained from application of the sentinel site concept in this cooperative carries value that may be useful to other constituencies and other cooperatives, particularly in the event of NOAA SSP expansion

Appendix B: Scores for Submitted Cooperative Narratives

Site	Scientific Rationale	Practicality/Leveraging	Management Action	Total Score
Chesapeake Bay	15	18	18	51
Florida	9	13	13	35
South Florida	14	14	13	41
Georgia	13	16	16	45
South Carolina	13	15	16	44
North Carolina	15	18	18	51
Northern Gulf of Mexico	15	19	17	51
Amer. Samoa	12	15	20	47
Hawaii	15	17	19	51
San Francisco Bay Area	15	17	18	50
Alaska	N/A	N/A	N/A	N/A

 Red oval indicates Sentinel Site Cooperative recommended for initial implementation

Appendix C: Primary Observation and Monitoring Parameters for NOAA Sentinel Site Program Cooperatives

Physical Monitoring Parameters

Parameter	Significance to SLC and Coastal Inundation	Temporal and Spatial Scale	Responsible Party(ies)	Caveats	Input to Models?
Water level/ Sea level	Water level measured at coastal tide stations provide long-term sea level trends, provide calibration for satellite altimeters measuring sea level, and provide real-time storm tide, extreme water level heights, and frequency and duration of inundation trends. Changes in sea level correspond directly to changes in inundation patterns.	6-minute observations from a network of 210 long-term coastal tide stations, spaced on average 90km apart, observations (historical and real-time) from the Global Sea-Level Observing System, and altimetric records of surface height (historical and real-time)	National Ocean Service/Center for Operational Oceanographic Products and Services; Integrated Ocean Observing System (IOOS); NESDIS/STAR; NOS Estuarine Reserves Division (ERD) in support of the National Estuarine Research Reserve System (NERRS); NOAA Climate Program; NESDIS	Global sea level trends also available; sea level information available at additional historic sites	Critical input to hydrodynamic and inundation models, and to downscaled climate models; EMC/NCEP suite of forecast models
Geodesy (including gravity)	Geodetic datums, and the reference systems upon which they are based, are a critical component of measuring SLC. Without a land-based reference, inundation associated with sea level change cannot be determined. To understand SLC and coastal inundation impacts, the relationship between land and water must be clearly established.	Varies; includes a range from one-time measurements with periodic updates (such as the passive control marks comprising the National Spatial Reference System), to one-time gravimeter flights.	National Geodetic Survey (primary responsibility); Center for Operational Oceanographic Products and Services (responsible for establishing the relationship between tidal and geodetic datums)		Fundamental reference for inundation models

Parameter	Significance to SLC and Coastal Inundation	Temporal and Spatial Scale	Responsible Party(ies)	Caveats	Input to Models?
Vertical Land Motion	Vertical land motion occurs on a range of spatial and temporal scales, yet being able to measure it provides understanding of global and local sea level signals. In order to determine actual rates of SLC, vertical land motion must be accounted for.	Varies; from continuous GPS measurements (through CORS) to Surface Elevation Tables (SETs), read periodically on regular intervals. Spatial scale varies.	National Geodetic Survey	A range of geodetic measurements are necessary to tease apart vertical land motion signals from various sources (e.g. ground water withdrawal, subsidence, rebound, local compaction)	NGS-computed rates of land motion; global rebound models, etc.
Currents	As sea level changes, circulation patterns will shift on a global scale, as well as on a local scale. Conversely, changes in basin-scale circulation can result in regional and local sea-level changes. Local hydrodynamic changes will influence event-driven and long-term inundation patterns, as well as storm tracks.	6-minute observations in 20 major ports, global satellite and in-situ observations of ocean circulation; surface currents from HFR	National Ocean Service, , Climate Program Office, Atlantic Oceanographic and Meteorological Laboratory; Integrated Ocean Observing System (IOOS)		Coastal hydrodynamic models (Coast Survey Development Lab; Center for Operational Oceanographic Products and Services
Salinity	Changes in sea level and inundation will alter salinity levels, particularly in bays and estuaries. Ecological and societal impacts may include needing to alter drinking water outflow, species migration as salinity tolerances are exceeded, saltwater intrusion to coastal habitats, etc. Salinity also drives global and regional ocean circulation.	Collected by several observing systems, with varying spatial and temporal scales	National Ocean Service/Center for Operational Oceanographic Products and Services; ERD in support of the NERRS, National Oceanographic Data Center; Office of Coast Survey; Integrated Ocean Observing System (IOOS); Climate Program Office		Coastal hydrodynamic models (Coast Survey Development Lab; Center for Operational Oceanographic Products and Services); EMC/NCEP suite of forecast

Parameter	Significance to SLC and Coastal Inundation	Temporal and Spatial Scale	Responsible Party(ies)	Caveats	Input to Models?
					models
Wind speed and direction	<p>Wind speed and direction are used to initialize models, such as the NOAA WAVEWATCH III, which is utilized to forecast waves, and SLOSH, which provides coastal inundation risk assessments and operational storm surge forecasts.</p> <p>Additionally, outside studies are indicating that changes in wind patterns could have an effect on SLC in certain regions. Winds impact global and regional ocean circulation, which impacts sea-level</p>	Hourly observations from a network of approximately 90 buoys and 60 Coastal Marine Automated Network (C-MAN) stations; wide array of global in-situ measurements with varying resolutions	National Data Buoy Center (NDBC); National Water Level Observation Network; ERD in support of the NERRS; Climate Program Office, IOOS		NOAA WAVEWATCH III (NWW3) Sea Lake and Overland Surges from Hurricanes (SLOSH) gets input from National Hurricane Center (NHC) official advisories; EMC/NCEP suite of forecast models
Wave height and period	<p>Waves directly contribute to inundation. The WAVEWATCH III model is used to predict wave height, period, and direction.</p> <p>Outside studies are being done to evaluate how changes in wave patterns and rising sea levels will affect beach erosion. NWS is considering usage of a forecast guidance tool that would assist in evaluating coastal erosion due to wave run-up.</p>	Hourly observations from a network of approximately 90 buoys and 60 Coastal Marine Automated Network (C-MAN) stations	NDBC, IOOS	All buoy stations, and some C-MAN stations, measure wave height and period.	NDBC wave height data are utilized to verify nearshore wave models (e.g. SWAN).
Barometric pressure	Having barometric pressure information available is essential in determining the severity of all storm events. This would include coastal storms, such as tropical cyclones. Observations are	NDBC: Hourly observations from a network of approximately 90 buoys and 60 Coastal Marine Automated Network (C-MAN) stations; ASOS: Dissemination occurs hourly.	NDBC; Automated Surface Stations (ASOS); National Water Level Observation Network; ERD in support of the NERRS		

Parameter	Significance to SLC and Coastal Inundation	Temporal and Spatial Scale	Responsible Party(ies)	Caveats	Input to Models?
	valuable for product development, predictions, historical records, etc.				
Ocean temperature	Fundamental ocean state variable: globally impacts sea-level changes; alters ecosystem habitats;	Hourly observations from a network of approximately 90 buoys and 60 Coastal Marine Automated Network (C-MAN) stations; over 3000 platforms	NDBC, IOOS, Climate Program Office, NESDIS	All buoy stations, and some C-MAN stations, measure sea surface temperature.	
Flooding	AHPS disseminates flood forecast level to which a river will rise and when it is likely to reach its peak or crest. Includes: <ul style="list-style-type: none"> the chance or probability of a river exceeding minor, moderate, or major flooding, the chance of a river exceeding certain level, volume, and flow of water at specific points on the river during 90 day periods, and a map of areas surrounding the forecast point that provides information about major roads, railways, landmarks, etc. likely to be flooded, the levels of past floods, etc. 	Covers forecast periods ranging from hours to months.	Available through Advanced Hydrologic Prediction Service (AHPS), observed water level data originates from the Hydrometeorological Automated Data System (HADS), IOOS	Includes valuable information about the chances of flood or drought.	
Sea surface temperature (SST)	Global and regional SST observations, products, and forecasts are fundamental in detecting and studying climate changes, for weather and climate	Hourly observations from a network of approximately 90 buoys and 60 Coastal Marine Automated Network (C-MAN) stations; global ocean SST observations from more	NDBC, IOOS, Climate Program Office, NESDIS, ONMS	All buoy stations, and some C-MAN stations, measure sea	

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Parameter	Significance to SLC and Coastal Inundation	Temporal and Spatial Scale	Responsible Party(ies)	Caveats	Input to Models?
	forecasts, and impact ecosystem food webs, etc.	than 1200 platforms; satellite retrievals		surface temperature.	
Precipitation	The Climate Prediction Center issues 6-10 day, 8-14 day, 1 month, and 3 month precipitation outlooks.	Dissemination occurs hourly.	Automated Surface Stations (ASOS); ERD in support of the NERRS;		
Bathymetry	Frequency and duration of inundation will be directly impacted by seafloor depth and characteristics. Bathymetry impacts hydrodynamics, and will influence changes in range of tide.	NOAA National Geophysical Data Center maintains a database of bathymetry.	NOS/Office of Coast Survey; National Geophysical Data Center		Fundamental component of digital elevation models

Habitat and Ecological Monitoring Parameters

Parameter	Significance to SLC and Coastal Inundation	Temporal and Spatial Scale	Responsible Party(ies)	Caveats	Input to Models?
Water quality	Water quality indicators such as nutrient concentrations and loadings, dissolved oxygen concentrations, chlorophyll <i>a</i> , total suspended solids, contaminant concentrations, and salinity provide information about changes in terrestrial inputs to aquatic ecosystems and are in themselves important influences on ecosystem structure and function. They provide information about other physical processes related to tidal flushing, patterns of sediment erosion/deposition, water turbidity and contaminant loadings.	Collected by several observing systems, with varying spatial and temporal scales.	National Ocean Service/Center for Operational Oceanographic Products and Services; ERD in support of the NERRS; Oceanographic Data Center; Office of Coast Survey; Integrated Ocean Observing System (IOOS), NCCOS		Predictions of harmful algal blooms and eutrophication models
Land Cover / land change	Changes in wetland vegetation extent and developed area footprint may be detected as the environment and communities respond to SLC and coastal inundation. The Coastal Change Analysis Program (C-CAP) is a nationally standardized database of land cover and land change information that provides inventories of coastal intertidal areas, wetlands and adjacent uplands. Changes in land use associated with human activity (such as increased land cover with impervious surface) will also impact flooding.	Mapped in coastal regions every 5 years via remotely sensed imagery. Resolution is 30 meters (higher resolution exists for parts but not all of US	CSC via CCAP program	Dates available for trend information include 1992, 1996, 2001, 2005 This data is already used within the NERRS System-Wide Monitoring Program	

Parameter	Significance to SLC and Coastal Inundation	Temporal and Spatial Scale	Responsible Party(ies)	Caveats	Input to Models?
Vegetative Communities	Monitoring changes in species composition (including invasive species), biomass, and spatial distribution of coastal vegetation provides a sensitive indicator of changes in water levels and water quality.	Annually or biannually after baseline information is established. Can be monitored through "on the ground" transects and by high resolution imagery.	ERD in support of the NERRS; NCCOS		
Benthic Communities	Benthic communities, including shellfish beds and coral reefs are highly sensitive to changes in water quality, sediment loadings, and changes in light penetration that may result from coastal inundation events. Invasive species may reflect changes in salinity, temperature, and nutrient concentrations, along with other water quality parameters such as dissolved oxygen.	Seasonally or annually after baseline information is established. Surveys can be done with physical sampling or by sonar.	NCCOS, NERRS, NMFS		
Planktonic communities	Harmful algal blooms can result from increased nutrient loadings and changes in salinity that may result from coastal inundation events	Continuous monitoring via automated optical sensor arrays. Periodic plankton tows and water sampling with varying temporal and spatial scales Volunteer sampling	NCCOS, NERRS, IOOS		Predictive models of HABs

Parameter	Significance to SLC and Coastal Inundation	Temporal and Spatial Scale	Responsible Party(ies)	Caveats	Input to Models?
		network.			
Fish and other nekton	Changes in the quality and quantity of intertidal habitat do to changing water levels can impact fish and crustacean communities by altering the distribution of suitable nursery grounds and refuges. Changes in disease. Invasive species may reflect a range shift in response to warning trends and/or changes in habitat and water quality parameters.	Periodic water column sampling with varying temporal and spatial scales.	NMFS, NCCOS, NERRS, ONMS, IOOS		Predictive models of fish and crustacean populations; Ecological forecasting of sea nettle probabilities and densities in Chesapeake Bay.
Terrestrial vertebrates	Loss of habitat due to changing water levels and coastal inundation events. Invasive species may reflect a range shift in response to warning trends and/or changes in habitat.	Direct counts of animal densities and species distributions	NERRS		
Marsh birds	Loss of habitat due to changing water levels and coastal inundation events. Invasive species may reflect a range shift in response to warning trends and/or changes in habitat.	Direct counts of animal densities and species distributions	NERRS		
Marine Mammals and Sea Turtles	Loss of habitat for considerable food resources due to changing water levels and coastal inundation events. Changes in marine disease due to temperature changes.	Direct counts of animal densities and species distributions, animal health impacts	NCCOS, OHH, NMFS		Sentinel species models

Social and Economic Monitoring Parameters

Parameter	Significance to SLC and Coastal Inundation	Temporal and Spatial Scale	Responsible Party(ies)	Caveats	Input to Models?
Demographics	Demographics factors of communities are considered in social, economic, and infrastructure resiliency (S. Cutter), well-being, human security, and human development. Demographic factors to be monitored include: population density and change, age, sex, race and ethnicity, language, special needs, employment, and housing type.	Decadal census, at block group. Within the 100 year flood zone	SPO via Census data	These parameters are useful for understanding the communities when planning and making decisions. They can be used to monitor changes in resilience capacity, good governance, human uses of coastal areas, human health/health care and in indices including: Cutter’s social vulnerability index, which includes a total of 5 main types of resilience plus 37 specific factors, and others including Well-being analysis, Human Security Analysis, NMFS has indices that include social indicators relevant to fishing communities, etc. Social Network analysis, input-output models, etc will assist in developing spatial scale of data collection.	Social Vulnerability Index
Social Conditions	Coastal societies are expected to undergo huge changes with SLR and extreme coastal events. Monitoring current society and the response to changes will help us plan to adapt for changes and protect those most vulnerable to impacts.	Long-term monitoring , scaled to collect impacts to adjacent communities and those tied to coastal communities	NCCOS, SPO, CSC, NMFS, and NESDIS	Data available for 2000-2009 Gulf of Mexico. Otherwise, easily accessible for other geographies at multiple spatial scales.	social vulnerability index (Cutter’s) and others including Well-being analysis, Human Security Analysis, NMFS has indices that include social indicators relevant to fishing

Parameter	Significance to SLC and Coastal Inundation	Temporal and Spatial Scale	Responsible Party(ies)	Caveats	Input to Models?
					communities, etc.
Economic Conditions	The economies of coastal societies are expected to undergo huge changes with SLR and extreme coastal events. Monitoring current society and the response to changes will help us plan to adapt for changes and protect those most vulnerable to impacts. Expenditure on climate change adaptation will also be monitored.	Long-term monitoring , scaled to collect impacts to adjacent communities and those tied to coastal communities	NCCOS, NMFS, SPO, CSC and NESDIS	Data available for 2000-2009 Gulf of Mexico. Otherwise, easily accessible for other geographies at multiple spatial scales.	Ocean Jobs, Port Tonnage and Commercial fishing can be included here (commercial fishing also have many social and political implications)
Political Conditions	Local communities, state and federal govts. Are largely responsible for planning and adapting for SLR and Inundation change. Understanding how the local govts are effective and how they interact with larger-scale govt agencies will assist in needs assessments and product development.	Long-term monitoring , scaled to collect impacts to adjacent communities and those tied to coastal communities	NCCOS, SPO, CSC, NMFS, and NESDIS	Data available for 2000-2009 Gulf of Mexico. Otherwise, easily accessible for other geographies at multiple spatial scales.	
Human Uses	Access to water and ecosystem services (provisioning, cultural, regulating) energy production, other commercial and recreational activities	Long-term monitoring , scaled to collect impacts to adjacent communities	NCCOS, CRCP, MPA Centers	Data available for 2000-2009 Gulf of Mexico. Otherwise, easily accessible for other geographies at multiple spatial scales.	
Ocean Jobs	This annual data describes 6 jobs sectors that are ocean / Great Lakes dependent including, living resources, marine construction, marine transportation, offshore mineral resources, ship and boat building, and tourism and recreation. The jobs make up the ocean economy and could be	Coastal county level, annually. Tracking trends	CSC via BLS and BEA data	Have trend information for most counties back to 1996. This is a unique data set derived from BLS and BEA data first demonstrated via NOEP project.	Recreation and tourism numbers could be used in an ecosystem services model

NOAA Sentinel Site Program

September 30, 2011

Parameter	Significance to SLC and Coastal Inundation	Temporal and Spatial Scale	Responsible Party(ies)	Caveats	Input to Models?
	impacted by SLC or potentially coastal inundation.				
Port Tonnage	Ports are often key economic drivers of the local economy and the infrastructure is sensitive to SLC and coastal inundation. They are also tied into the local transportation networks which will also be impacted by SLC and coastal inundation.	Annual including the 150 ports in country in terms of tonnage	SPO - State of the Coast website – via USACOE Navigation Data Center	Information can be sorted by port, import or export, and by type of cargo	
Commercial and Recreational Fishing	This annual data describes the amount of marine fish caught. This is one indicator of a healthy economy for coastal communities.	Annual pounds of fish caught, at state level	SPO – State of the Coast website – via NMFS science and technology office	Trend numbers go back to 1950 for some species.	

Appendix D: Two-pagers for Recommended Cooperatives

The full text for all 11 narratives can be found in “NOAA Sentinel Site Program Supplementary Materials.” This appendix contains summary two-pagers for the five Sentinel Site Cooperatives recommended for initial implementation. They are:

- 1. Chesapeake Bay**
- 2. Hawaii**
- 3. North Carolina**
- 4. Northern Gulf of Mexico**
- 5. San Francisco Bay Area**



NOAA SENTINEL SITE PROGRAM

Chesapeake Bay Sentinel Site Cooperative

Abstract

The Chesapeake Bay area, located in NOAA's Northeast Region, provides an excellent opportunity to showcase the benefit of integrating existing sentinel stations and sentinel sites into NOAA's Sentinel Site Program. The Chesapeake Bay Sentinel Site Cooperative would function within a coherent geography providing integrated observations across a host of environmental monitoring programs. The Cooperative would provide information to Chesapeake Bay communities and managers who need to address challenges such as storm flooding, long term, local sea level rise, barrier island movement, degraded water quality, and wetland loss. The information would also be useful to federal and state restoration planners and living resource managers who are addressing these challenges.

Available Assets

- 20 NOAA tide stations, including 14 National Water Level Observing (NWLON) system gauges with long term sea level trends available
- Numerous historic tide gauge datasets and water level observations from other agencies (e.g. USGS, USACE, the Smithsonian Institution, US Fish & Wildlife Service, National Park Service)
- Over 30 active Continuously Operating GPS Reference Stations (CORS) within 20 miles of the coast or coastal estuaries, including one co-located at a NWLON tide station (Solomon's Island)
- Over 50 surface elevation table (SET) datasets connected to the National Spatial Reference System for monitoring wetland elevation change (over 200 SET datasets available through sister agencies, including over one hundred sites within Blackwater National Wildlife Refuge)
- Chesapeake Bay Operational Forecast System II (CBOFS II): a full 3D coastal hydrodynamic model for tides, currents, and storm surge developed by NOAA Office of Coast Survey (OCS)
- Nested hydrodynamic model for Poplar Island: based on a nested grid within the CBOFS II, Poplar Island is a model for how local sea level rise impacts can be included within a cutting edge physical hydrodynamic model
- NOAA VDatum: sea surface topography model defined for entire Chesapeake Bay and Atlantic coast, used to estimate locally defined tidal datums such as mean sea level
- Local high accuracy geodetic control networks with permanent survey markers within 7 sites across the Bay (4 in VA, 3 in MD)
- NOAA Chesapeake Bay Interpretive Buoy System (CBIBS): a network of Integrated Ocean Observing System (IOOS) based observing platforms that transmit information using wireless technology to a variety of users
- Chesapeake Bay Observing System (federal, state, university, bay-wide collaborative effort)
- Wetland elevation monitoring along fire management regimes at Blackwater NWR (FWS in collaboration with NOAA, using GPS technology)
- Southern Chesapeake Bay Shallow Water Quality Monitoring Program
- Virginia Estuarine and Coastal Observing System (VECOS): website designed to distribute water quality data sampled from the Chesapeake Bay and associated tributaries within Virginia

Available Assets (continued)

- Marsh community assessments (e.g. species distribution, abundance, and diversity) in numerous wetland habitats, from coastal salt marshes to tidal fresh marshes.
- Marsh productivity (e.g. above and below ground biomass) within 7 NERR sites
- Submerged Aquatic Vegetation (SAV) surveys within 7 NERR sites
- Extensive benthic habitat survey data
- Nekton productivity (e.g. recruitment)
- Ground water dynamics in seven wetland NERR sites
- NOAA Coast Watch (East Coast Node): disseminating satellite imagery data, including models of chlorophyll, turbidity, and water temperature
- Watershed-scale habitat mapping and change analysis at Virginia and Maryland Chesapeake Bay NERRs
- Enhancement of local USGS/Virginia Institute of Marine Sciences (VIMS) York River sea level rise and salt intrusion hydrodynamic model
- Vital signs monitoring of estuarine conditions at three Virginia National Park Service Parks
- Historical analysis of wetland change: GIS study quantifying wetland change/loss over time (CB-NERR VA)
- Comprehensive assessment of areas sensitive to coastal flooding
- Poplar Island case study for including sea level rise predictions in wetland creation/restoration – a multi-agency collaboration to address this critical need in the restoration community

Internal and External Partners Currently Involved

- NOAA: NCCOS, OCS, CSC, OCRM, ERD (NERRS), NCBO, NESDIS (CoastWatch), CO-OPS
- Agency: USFWS, NPS, USGS, USACE, State of Maryland, Commonwealth of Virginia
- University: University of Maryland, Virginia Institute of Marine Science, Old Dominion University

Internal and External Partners Targeted for Future Involvement

- NOAA IOOS

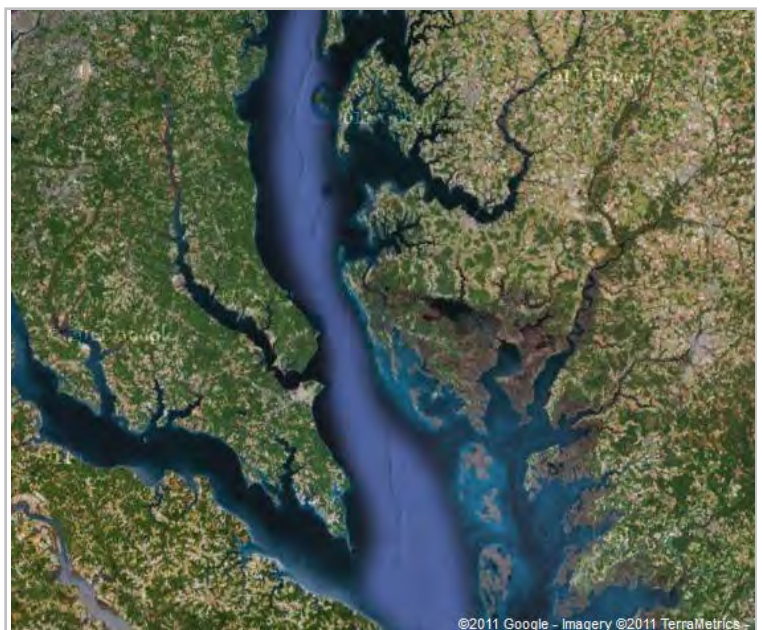
Management Goals Addressed

- Long term monitoring of sea level rise, inundation, storm impacts, water quality, and habitat suitability.

Points of Contact

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NOAA SENTINEL SITE PROGRAM

Hawaiian Islands Sentinel Site Cooperative

Abstract

The Hawaiian Islands Sentinel Site Cooperative is a compilation of sites that includes Midway and French Frigate Shoals in the Papahānaumokuākea Marine National Monument in the Northwestern Hawaiian Islands (NWHI), He'eia Wetland Restoration project (He'eia) on the island of O'ahu, and Kona Coast on the Big Island of Hawai'i. The Cooperative contains some of the most productive and unique ecological sites in US waters and is widely recognized as one of the most valuable ecological locations in the world, which is why Midway and French Frigate Shoals were included in the World Heritage Site designation of the NWHIs.

While separated by great distance, the sites are connected through circulation patterns, species migration, geological origin, and geographic isolation. Midway and French Frigate Shoals have experienced little human impact and remain relatively pristine while He'eia and Kona Coast are more heavily populated and impacted. This human impact gradient provides a unique opportunity to assess how ecosystem health will be impacted for both pristine and heavily stressed ecosystems, thus making it possible to extrapolate out the influence of climate change. Geographic separation makes it imperative to have strong, well established partnerships. Long-standing relationships are being called upon to lead this Cooperative and include NOAA's National Ocean Service in Midway and French Frigate Shoals, the National Marine Fisheries Service in Kona Coast, and the local non-profit Kako'o 'Oiwī in He'eia. As issues of focus change and the Cooperative matures, partnerships will be expanded.

The strength of the Cooperative stems from each site having direct observation data record from several years to several decades. The reefs are some of the best studied in the world resulting in a strong baseline set of data and recent studies on connectivity and evolutionary time have increased our understanding of reef function and processes. The necessary infrastructure for accurate observations of climate change, including sea level and inundation, is in place and has been actively monitored and utilized for management decisions since installation. Because of the robust understanding of the reefs, sea level, and inundation frequencies and magnitudes, small changes will be more noticeable and more easily identified and understood.

Available Assets

- USGS stream gauges
- NOAA tide gauges
- Biochemical baseline data (e.g. salinity, nutrient levels, etc.)
- Land cover and vegetation species data
- Invasive species monitoring and removal
- Coral and biological data
- Spatial carbon chemistry surveys
- High-resolution LIDAR imagery for the entire coastal zone
- Hawaii integrated Ocean Observing system
- Data integration program (PIMS)





Internal and External Partners Currently Involved

- NOS program offices (PSC, NGS, OCRM, ONMS)
- Pacific Islands Fisheries Science Center, NOAA
- US Geological Survey
- University of Hawaii
- US Army Corps of Engineers
- US Fish and Wildlife Service
- Bishop Museum
- Division of Aquatic Resources, State of Hawai'i
- Coastal Zone Management Program, State of Hawai'i
- Koolaupoko Hawaiian Civic Club
- The Nature Conservancy

Internal and External Partners Targeted for Future Involvement

- NOAA's NESDIS
- NOAA's Coral Reef Conservation Program
- Hawai'i Institute of Marine Biology
- UH Hilo Marine Science Department
- Office of Hawaiian Affairs
- State of Hawai'i Dept. of Education
- French Polynesia, New Zealand, Samoa, and other Micronesian and Polynesian countries
- Waikiki Aquarium and the National Aquarium in Washington, D.C.
- National Geographic
- US Coast Guard
- Western Pacific Regional Fisheries Management Council
- University of Hawai'i, Hilo

Management Goals Addressed

The information obtained in the SSP will directly assist in management decisions. Kona Coast is creating an integrated ecosystem assessment with the information obtained feeding back into broader management plans as well as decisions on specific topics, such as aquaculture. He'eia is working with local residents to utilize the data in improving management decisions – such as restoring damaged wetlands by monitoring rainfall, stream flow, and salt water intrusion. Data from French Frigate Shoals and Midway inform management decisions of the Papahānaumokuākea National Monument. Each location is undertaking the studies and management plans in an effort to balance human needs with ecosystem health so both can thrive.

The work undertaken through the SSP would be translatable to other areas of Hawai'i as well as the greater Pacific region. Every place on a coast is susceptible to increased coastal inundation and sea level change, but islands are especially susceptible because of a lack of places to move populations, a high percentage of the population dependent on coastal and oceanic ecosystems, and many islands – such as French Frigate Shoals – are low-lying meaning sea level rise can have devastating effects. The proposed SSP is a unique opportunity to create a framework relatable to a wide range of locations because the proposed sites cover a wide range of populations, ecosystems, topographies, and because the areas already have a large set of data and management schemes in place.

Point of Contact

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NOAA SENTINEL SITE PROGRAM

Name of Sentinel Site: North Carolina Sentinel Site Cooperative

Abstract of the submitted narrative:

This Cooperative will initiate a Sentinel Site Network in the central NC coast, near the multi-partner NOAA laboratory in Beaufort, NC (NERRS, NMFS, and NOS). This location is well instrumented due to the high concentration of marine science facilities in the area, and represents median conditions for the NC coast. Future expansion of this network will include the entire NC coast, which offers a gradient in sea-level rise (SLR) vulnerability from low-lying, lagoonal, microtidal estuaries to small, highly-flushed, mesotidal estuaries. The coast of North Carolina has one of the highest vulnerabilities to SLR on the Atlantic coast due to its high wave exposure, low-relief coastal slope, and abundance of barrier islands. The high concentration of marine science facilities, existing water level and shoreline monitoring stations, updated seamless bathymetry, and layers of coastal and marine protected areas ensures that sea level changes and their consequences, occurring in NC, will be documented with unparalleled accuracy and will inform coastal management decisions. Biogeographic provinces overlap on the NC coast, a geographic frontier, where signals of response to climate change will be first detected and most significant. Furthermore, the extensive marsh and seagrass systems, sweeping beaches, and sheltered harbors support a high concentration of coastal commerce including shipping, commercial and recreational fishing, and tourism. These industries and associated populations are highly vulnerable to SLR nationwide. Thus, the lessons learned at the NC Sentinel Site Cooperative will be transferable to regions with similar economies.

Available assets:

- NOAA National Water Level Observation Network (NWLON) station in Beaufort, NC
- 28 Surface Elevation Tables (SETs) established 2004-2007 in salt marsh habitats
- High-resolution LIDAR imagery for the entire coastal zone
- Continuous, in-situ, water-quality monitoring for temperature, pH, turbidity, salinity, and dissolved oxygen
- Aerial imagery and photo-interpreted GIS layers of seagrass distribution from 2006-2008
- Geodetic infrastructure, including NGS benchmarks and COORS stations
- NOAA NCCOS partnership with NC Geodetic Survey on Height Modernization Program
- Marsh vegetation surveys conducted semi-annually, 2004-present, through NCNERR-NCCOS collaboration, and funded by NOAA Restoration Center and CICEET
- NOAA CSCOR regionalized forecasts on geomorphologic, ecological and saltmarsh response to SLR
- Bathymographic GIS providing elevations from the continental shelf to the fall line to facilitate inundation forecasting
- NOAA CCFHR research in progress including, "Response of coastal marshes to sea level rise" and "Forecast influence of natural and anthropogenic factors estuarine shoreline erosion rates".
- NCCOS partnership with the USACE on erosion and SLR issues related to the Atlantic Coastal Waterway
- NCNERR's Coastal Training Program provides capacity to translate scientific findings for management applications



Internal (NOAA) and external partners currently involved:

- Albermarle-Pamlico National Estuary Program
- Croatan National Forest
- Department of Defense
- Duke Marine Lab
- National Climatic Data Center
- NC Aquarium
- NC Department of Environment and Natural Resources
- NC Division of Coastal Management
- NC Maritime Museum
- NCNERR
- NOAA CO-OPS
- NOAA NCCOS
- NOAA NGS
- NOAA NMFS
- National Park Service
- USACE

Internal (NOAA) and external partners targeted for future involvement:

- East Carolina University
- Elizabeth City State University
- National Marine Sanctuary Program
- NC Coastal Federation
- NC Division of Marine Fisheries
- NC Division of Water Quality
- North Carolina State University
- The Nature Conservancy
- University of North Carolina, Chapel Hill
- University of North Carolina, Wilmington

Management goals addressed:

The NC Coastal Resource Commission's Science Panel on Coastal Hazards (NCCRC 2010) recommended that for policy, development and planning purposes a rise of 1 meter (39 inches) be adopted as the amount of anticipated SLR by 2100. The state and federal management community in NC, including DENR, NMFS Habitat Conservation Division, and the U.S. Army Corps of Engineers has demonstrated clear intent to develop policies which reduce the adverse impacts of SLR on coastal ecosystems and communities. These agencies engage the local scientific community, and make science-based recommendations. Ongoing, the state will rely on NOAA Sentinel Site Program products and information to provide incremental support and rationale for adaptation decisions at the state and local levels.

POC(s) contact information:

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NOAA SENTINEL SITE PROGRAM

Northern Gulf of Mexico Sentinel Site Cooperative

Abstract

The proposed Cooperative would encompass over 250 miles of coastline from the Florida panhandle west to Grand Bay, Mississippi. This region, with low level topography and extensive marsh and other critical habitats, is highly susceptible to the effects of sea level change (SLC). Considerable ongoing monitoring and research activities, particularly within three NERRs sites, provide the baseline information and parameters required for an integrative ecosystem approach to addressing SLC. Building off of an NCCOS-funded project, this Cooperative would leverage the combined capabilities of three NERRs, NOS, the Gulf of Mexico Alliance and the NOAA Gulf Regional Collaboration Team to assess the impacts of SLC and develop capabilities and tools to facilitate conservation of coastal resources by local, state, and regional managers. Key products will include coupled models of hydrodynamics, sedimentation, salinity, and vegetation dynamics as well as classified maps that delineate high and low risk areas. These tools and products are envisioned to allow for assessments of risk and planning, coastal construction guidelines, resource protection and sustainability needs, and set back guidance.

Available Assets

- Suite of surface elevation tables in marsh habitats, in coordination with NGS, GOMA, and NCCOS at three NERRs. Additional ongoing monitoring and research activities on a suite of biological (e.g. oyster and marsh productivity) and physical parameters (e.g. sediment transport and circulation).
- Land cover data sets for the entire Cooperative region derived from 30-m resolution Landsat Thematic Mapper and Landsat Enhanced Thematic Mapper satellite.
- In association with the Northwest Florida Water Management District and FEMA, complete LiDAR coverage of the Cooperative region and recent flood plain mapping.
- Suite of modeling platforms, including ADCIRC-2DDI, POM 3D, SWAN, WASH123D, and MEMII that will be coupled allowing for delineation of new tidal boundaries, marsh erosion estimates, and habitat land cover changes, for example.
- Ongoing NCCOS-funded study, led by the University of Central Florida, on the Ecological Effects of Sea Level Rise in the region that will provide integrative capabilities and lead the development of tools and products to assess and predict impacts of sea level rise.
- Engaged local, state, and federal stakeholders, with an established management advisory committee, that includes resource managers and coastal planners.
- Capabilities for the dissemination of the information, products, and capabilities through partnerships that include the Coastal Training Program, CSC's Sea Level Rise Viewer, and GOMA.

Internal and External Partners Currently Involved

- | | |
|---|--|
| • NOAA NCCOS | • NOAA Gulf Regional Team |
| • NOAA NGS | • Apalachicola, Grand Bay, and Weeks Bay NERRs |
| • NOAA CSC | • MS/AL Sea Grant |
| • NOAA CO-OPS | • Gulf of Mexico Alliance |
| • Mobile Bay NEP | • County planners (e.g., Wakulla, Escambia, Bay) |
| • Northwest Florida Water Management District | • Academia (UCF, UF, FSU, USC) |

Internal and External Partners Targeted for Future Involvement

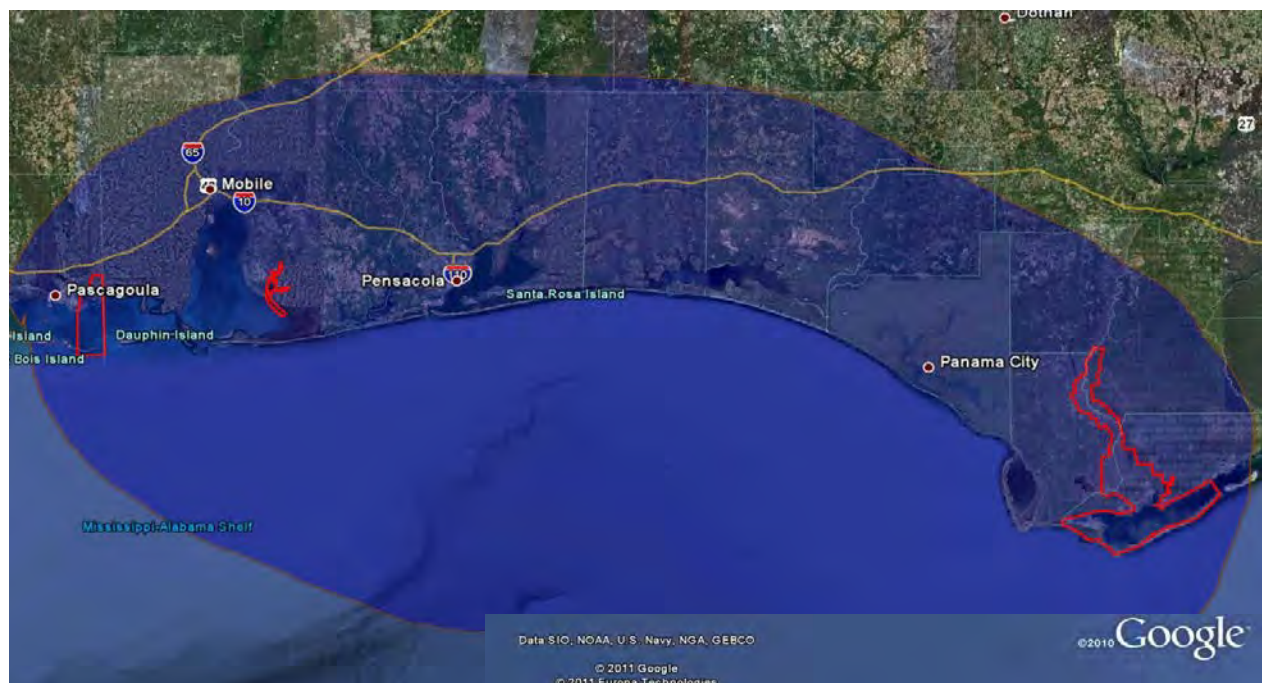
- Gulf of Mexico Disaster Response Center
- Gulf Coast Ecosystem Restoration Task Force
- The Nature Conservancy
- USGS National Wetland Science Center
- NSF LTER
- GCOOS

Management Goals Addressed

The proposed Cooperative addresses several regional and national management goals. The Gulf Alliance Habitat Conservation and Restoration Priority Issue Team (PIT) has several long-term goals relevant to sea level change in this region, including improved conservation and restoration management tools, as does the Coastal Community Resiliency PIT. This Cooperative will also address needs outlined in the Surface Water Improvement and Management plan of the Northwest Florida Water Management District as well as management plans of the numerous protected areas in the region (e.g. NERRs, NWR, Aquatic Preserves). A Management Committee associated with the NCCOS project, will provide guidance and direction for tool and product development to best address these and other management plans and efforts.

Point of Contact

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Blue shading delineates the extent of the proposed Sentinel Site Cooperative in the northern Gulf of Mexico with red outline delineating the location of the three targeted NERRs in the region.

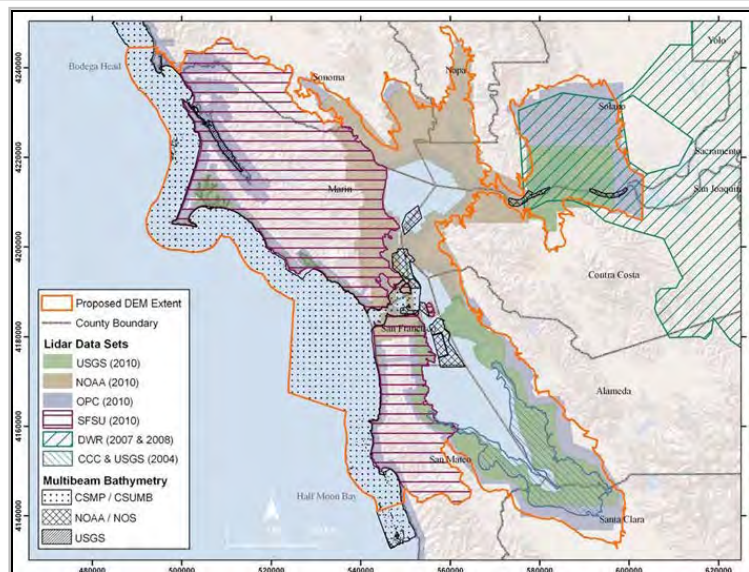
NOAA SENTINEL SITE PROGRAM

San Francisco Bay Area Sentinel Site Cooperative

Abstract

Four years ago, NOAA programs in the Bay Area began to coordinate internally and with numerous partners on climate change efforts. Working in this way, NOAA programs can be more effective in supporting climate adaptation efforts and addressing resource management challenges.

With its mix of natural resources (e.g., national marine sanctuaries and the San Francisco Bay National Estuarine Research Reserve) and its population and economic centers (over 7 million people and 7 ports), the Bay and outer coast provide an ideal platform for a regional Sentinel Site Program. NOAA is uniquely positioned and already active in supporting and leveraging this effort, and could produce high visibility successes on climate change science, tools, adaptation, and outreach.



The vision for a Bay Area Sentinel Site Cooperative would combine and enhance the efforts of climate change projects and programs addressing sea level rise and storms presently underway in the Bay Area, and which NOAA and NOAA partners are leading, including:

- Our Coast—Our Future: Planning for Sea Level Rise and Storm Hazards Along the Bay Area’s Outer Coast
- Bay Area Ecosystem Climate Change Consortium
- Adapting to Rising Tides

Available Assets

- COOPS – water level and PORTS
- NERRS and NMS System-Wide Monitoring Programs
- LIDAR base layer data for sea level rise and inundation mapping
- CeNCOOS data sets and tools (e.g., HF radar, wave frequency and energy)
- SUNTANS model for understanding wetland changes, and restoration options
- NOS Operational Forecast System
- USGS Coastal Storm Modeling System (CoSMoS) – predicts inundation/flooding, wave heights, beach erosion, and cliff failures.
- Delft 3D (limited area) – currently supports the Innovative Wetland Adaptation Techniques in Lower Corte Madera Creek Watershed project.



Internal and External Partners Currently Involved

- Gulf of the Farallones National Marine Sanctuary
- Cordell Bank National Marine Sanctuary
- U.S. Geological Survey
- San Francisco Bay National Estuarine Research Reserve
- NOAA Coastal Services Center
- Bay Conservation and Development Commission
- Bay Area Ecosystem Climate Change Consortium
- Bay Conservation and Development Commission

Internal and External Partners Targeted for Future Involvement

- COOPS (sensor updates)
- CeNCOOS (data and tools)
- Stanford (continued model development)
- NOAA Climate Program Office (funding)
- Federal Transit Administration (funding)

Management Goal Addressed

Improve resilience of coastal communities by providing:

- tools to visualize potential impacts from sea level rise, including inundation, flood frequency, marsh impacts, and socioeconomics
- socio economic vulnerability analysis that can be used as a model for other regions
- adaptation plans for a Bay Area community that is transferable to other communities in and around the Bay region, and for protected area coastal habitats
- communications and training – timely, practical workshops on climate change topics to planners, managers and regulators of coastal are resources.

Point of Contact

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