Statement of Need

1. Title: Establishing an Ecological Forecasting System: Predicting Sea Nettles in the Chesapeake Bay

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3. Submitting Authority: Office of Climate, Water and Weather Services (OCWWS)

4. Description: *(Provide a description of the mission need. This could be a deficiency or potential efficiency gain.)* *

Ecological forecasting, or the prediction of the impacts of physical, chemical, biological, and human-induced change on ecosystems and their components, is an emerging requirement for NOAA environmental prediction services to protect lives and property, enhance economic security, and meet its Great Lakes, estuarine, coastal and ocean stewardship mandates. A recent review of NOAA's ecosystem science enterprise identifies ecological forecasting as a pivotal issue which needs to be addressed by NOAA to meet emerging ecosystem management challenges (Fluharty et al., 2006). Ecological forecasts have made great strides as our scientific understanding of ecosystem structure and function have matured along with advances in integrated observations and modeling, computational power, data managegment, IT and telecommunications, and our ability to generate and issue operational ecological forecasts and outlooks, analogous to and linked with weather and hydrologic predictions, is now possible for a number of critical coastal environment, health, and safety issues, e.g. harmful algal blooms, water-borne pathogens, and concentration of dissolved oxygen.

While numerous success stories exist, the ongoing development of ecological products at NOAA remains primarily in a research mode. There has been no comprehensive, coordinated and systematic approach in NOAA toward transitioning research advancements into ecological products and services delivered to stakeholders and beneficiaries. This has resulted in the inefficient development and maintenance of service products, limited agility to mobilize capacities, lost opportunities for leveraging and collaborating, and underutilization of NOAA's extensive environmental prediction enterprise infrastructure and products to affect ecosystem management decisions where the need is greatest.

The proposed project – to demonstrate an operational ecological forecasting capability for sea nettle predictions in the Chesapeake Bay – represents a simple first step to develop a framework and repeatable process for generating guidance and future transitioning of ecological forecasts and knowledge-based products into operations. This will address the deficiency of existing services and optimize use of the NWS infrastructure and earth system view to advance the proof-of-concept for a NOAA

Ecological Forecasting System that is scalable and extensible for use throughout the U.S. and for a broad range of ecosystem applications.

4.1 The Chesapeake Bay sea nettle prediction system
High concentrations of sea nettles (*Chrysaora quinquecirrha*), a species of stinging jellyfish, seasonally inhabit the Chesapeake Bay from late spring to early autumn. The painful and unprovoked sting may cause certain individual to experience breathing difficulties or go into anaphylactic shock. Knowing where and when to expect these jellyfish will help people avoid biotic nuisance or mitigate their effects. Moreover, sea nettles, like other jellyfish in coastal and estuarine waters, can impact water quality and quantity that can disrupt commercial and industrial processes including energy supply. Improved predictions over short and long time scales are needed for spatial planning and resource management.

The nettle forecasts provides timely information on where to expect sea nettles so that users can avoid areas of the bay affected by this biological nuisance. Over the past six years, demonstration predictions of sea nettle encounter probability, currently generated and disseminated by the NOAA Chesapeake Bay Office, have been heavily utilized by the Chesapeake Bay recreational community and Calvert Cliffs Nuclear Plant. Daily nowcasts and forecasts are generated by using real-time and forecast data simulated by a 3D hydrodynamic model of the bay to drive a multi-variate, empirical habitat model that predicts the probability of sea nettles. The demonstration forecasts, in the form of digital images, are currently available via the World Wide Web (http://155.206.18.162/seanettles/) to individuals and interested agencies. These sea nettle predictions are deemed ready for operational generation and dissemination, but no existing pathway is available.

The objective of the proposed project is to demonstrate the production of this prototype ecological product under the framework of NWS operations, and thereby initiate the development of an operational ecological forecasting system at NOAA that provides the nation with accurate, reliable, and understandable ecological forecasts for decision making and stewardship of the oceans, coastal zones, and the Great Lakes. The regional prediction system can be easily modified to predict the other important ecological parameters in the Bay, specifically the likelihood of water-borne pathogens and the concentration of dissolved oxygen, and we plan to transition these products to operations at a later date.

5. Justification

5.1 Origination, Documentation, and Drivers: *(Identify the origin of this need, citing appropriate documentation and other drivers)*

NOAA's unique mission is to provide its customers with scientifically sound environmental predictions. This includes ecological information in the form of forecasts,

scenarios and long term projections. Ecological forecasts represent a relatively new and growing component of NOAA's future operational suite of products that will serve a wide range of customers, ranging from Federal, state and local coastal and resources managers, industry, NGOS, decision-makers and the public at large. Many ecological products are needed, and some, such as harmful algal bloom (HAB) and hypoxia forecasts, are legislatively mandated.

Several prior publications (CENR, 2001; NOAA, 2001; Valette-Silver and Scavia, 2003; Brandt et al., 2006; Cloyd et al., 2007) have indicated the importance of forecasting ecological conditions, and the benefits derived from ecological forecasts in the marine environment. Specific user needs are already being addressed across NOAA through Line Offices and Programs through research and development activities. For example:
- National Ocean Service (NOS) forecasts trajectories of pollutant spills, the size of the dead zone in the Gulf of Mexico, and the effectiveness of restoration of coastal habitats (http://oceanservice.noaa.gov/topics/coasts/ecoforecasting/welcome.html).
- Office of Oceanic and Atmospheric Research (OAR) has strengths in forecasting coral health, invasive species, and Great Lakes water levels and air and water quality, especially for beach management (http://www.research.noaa.gov/oceans/t_ecologicalobserving.html).
- National Environmental Satellite, Data Information Service (NESDIS) is nowcasting and forecasting coral bleaching over 3-months in advance (http://coralreefwatch.noaa.gov/satellite/bleachingoutlook/index.html).
- NESDIS, OAR and NOS together contribute to forecasts of harmful algal blooms and sea nettle occurrences.

The Harmful Algal Bloom and Hypoxia Amendments Act (HABHRCA) of 2004 (Public Law 108-456) represents one legal mandate to establish and generate ecological forecasting at NOAA. This Act reaffirms and expands the mandate for NOAA to advance the scientific understanding and ability to detect, monitor, assess, and predict HABs. The original Act, established in 1998, recognized that many of our Nation's coastal areas suffer from HAB conditions each year, threatening coastal ecosystems and endangering human health. HABHRCA provided recognition and authorization for NOAA to respond to the growing national HAB threat and hypoxia, or low oxygen, impacts that have devastated habitats in many of the nations estuaries and coastal waters. The implementation of HABHRCA is being led by NOAA through the Administration's Joint Subcommittee on Ocean Science and Technology.

Tools and technology being developed through NOAA HAB research under HABHRCA are also helping NOAA to meet its ocean and human health responsibilities under the Oceans and Human Health (OHH) Act. Coordination with HABHRCA is specifically called for in the OHH Act. Also, the U.S. Commission on Ocean Policy Report highlighted HABs as a major stressor degrading water quality and specifically identifying the pressing need to establish a forecasting system for HABs. Furthermore, the Chesapeake Bay Executive Order (#13508) report 202(f): Science and Decision Support calls for both ecological forecasting and operational monitoring and observing system.

The sea nettle forecasts are used during the summer months, principally by recreational boaters and fishers. The Calvert Cliffs Nuclear Power Plant also monitors the forecasts as a means to schedule the frequency of cleaning the filters of their intake valves. The site received 1842 hits in July 2009 and numerous emails applauding the forecasts. (Excerpts from three of the many emails received are enclosed below in the "Supporting Information" section.)

In the Chesapeake Bay, the ecological prediction system that generates the sea nettle likelihood product is being expanded to predict the probability of water-borne pathogens and blooms of three harmful algal species, and the concentration of dissolved oxygen in the Bay. These predictions are expected to be transitioned to operations at a later date.

5.2 Linkages: *(Identify how this need links to the NOAA/NWS strategic plans, PPBES, other validated requirements, etc. Make appropriate document citations.)*

An operational ecological forecasting capability is an essential element for NOAA to achieve the Ecosystem Goal of protecting, restoring and managing the use of coastal and ocean resources through ecosystems-based management, and Weather & Water Goal of serving society's needs for weather and water information. In particular, this demonstration project supports the following NOAA Goals and Programs: Ecosystem Goal Team Programs: Habitat, Ecosystem Research, Coastal and Marine Resources, Ecosystem Observations, and Fisheries Management; Weather and Water Goal Team Programs: Science, Technology, and Infusion, and Coasts, Estuaries, & Oceans.

Within the NWS, establishing an operational ecological forecasting capability will aid NCEP in achieving its goal of supporting the nation's growing need for environmental information.

The sea nettle forecasts constitute a significant educational and outreach success for NOAA by attracting the attention of both the media and people who frequent Chesapeake Bay. Numerous emails have been received complimenting the web site and the forecasts for their informational value and practical use. The project has also garnered considerable interest from the popular media with reports of the project appearing in newspapers (e.g., The Capital, The Washington Post), magazines (e.g., Science News), television / cable (e.g., Tech TV), and radio (e.g., NPR, All Things Considered). This media coverage serves both to inform the public of sea nettles and to publicize NOAA's involvement in providing regional ocean products of practical use to its constituents.

6. Existing capabilities/capacities and limitations related to the need: *(Identify what existing capabilities/capacities NOAA/NWS has related to the need. Describe the limitations of these capabilities/capacities or what new ones are needed.)*

As alluded to earlier, with a few exceptions, there is no strategic plan within NOAA that addresses cost effective and efficient life-cycle operation of ecological products. There is

no consolidated plan to monitor and validate requirements for most ecological forecasting capabilities, so individual projects and demonstrations are championed by individual offices and programs. Uncertainty continues on whether the ecosystem based approach to environmental prediction is making optimal use of NOAA modeling systems, integrated observing systems, data and communication networks, and dissemination capacities. NOAA lacks an integrated, multipurpose ecosystem architecture to refocus the distributed and stove-piped efforts to a more collaborative cross-LO effort and thus improve operational efficiency and effectiveness.

Currently, only a few of NOAA's ecological products are operational, such as the Gulf of Mexico harmful algal bloom (HAB) Bulletin (http://tidesandcurrents.noaa.gov/hab/) and the Coral Bleaching Hotspot maps (http://www.osdpd.noaa.gov/ml/ocean/cb/hotspots.html). More experimental ecological products are in the pipeline and include both new products, e.g. probability of specific water-borne pathogens, and the expansion of an existing product into new regions, e.g. HAB forecasts. The sea nettle prediction product represents a new capability for NWS, NOS, and NOAA.

The proposed sea nettle product will leverage the Chesapeake Bay Operational Forecasting System (CBOFS2), a version of the 3-dimensional hydrodynamic model Regional Ocean Modeling System (ROMS) configured for the Chesapeake Bay. CBOFS2 was developed and operated by NOS' Coast Survey Development Laboratory and will be run at the NCEP Central Operations. It also represents the foundation of the ecological prediction system that will forecast HABs and hypoxia, as well as other products, in the Chesapeake Bay.

7. Benefits and Performance Impact
7.1 Performance Measure Impacts: *(Identify relevant Government Performance Requirements Act (GPRA) Goals and other performance measure impacts. Describe how meeting this need would improve these measures.)*

A key metric in the Governments Performance Results Act (GPRA) is the percent of U.S. Large Marine Ecosystems with science-based warning systems to decrease human health risks. Science –based warning systems (e.g. for harmful algal bloom landfall, contaminated shellfish beds, etc.) decrease human health risk by providing information to resource managers, public health officials, and the public on which to issue pubic health warnings or change behaviors. The goal is to increase the percentage of the ten U.S. Large Marine Ecosystems with operational science-based warnings systems from 10% in 2004 to 50% in 2012. The proposed activity and products directly addresses this need and will aid NOAA in achieving this metric.

7.2 Socio-economic Impacts: *(Citing appropriate documentation, quantify any socio-economic benefits that would occur if this need were met.)*

The socio-economic benefits of only a few ecological forecasts have been estimated. For example, harmful algal blooms (HABs) affect almost every coastal state and are one of the

most economically significant coastal issues facing the nation; they have caused an estimated $1 billion in economic losses in the U.S. over the past decade. In the Chesapeake Bay, the sport fishing industry annually yields nearly $300 million, and swimming and boating are supported by numerous beaches and safe harbors. In addition to providing a livelihood to many fishers, the value of its finfish and shellfish harvested annually is approximately $1 billion. But extreme natural events can degrade the bay's health and jeopardize the viability this important natural resource.

High concentrations of sea nettles are linked to unspecified economic losses in tourism (due to stinging), commercial fish (by their predation on fish larvae and their prey) and energy production (from blocking power plant water intakes).

8. Key Customers and Stakeholders
8.1 Customers: *(Identify who will benefit from meeting this need.)*
Recreational boaters, swimmers; commercial waterman, and energy producers (Calvert Cliffs Nuclear Power Plant).

8.2 Stakeholders: *(Identify organizations that should be involved in meeting this need.)*
NOS, NESDIS, NWS, and NOAA Chesapeake Bay Office.

9. Supporting Information: *(List any additional supporting information available, i.e. testimonials, potential alternatives, resources, work already done, analysis...etc.)*

The scientific foundation for the sea nettle forecasts are detailed in the following article: http://155.206.18.162/seanettles/decker.pdf.

Funding for the sea nettle prediction project was provided by the NOAA Ocean Remote Sensing Program and the NOAA Center for Sponsored Coastal Ocean Research EcoForecasting 2004 Program.

Doug Wilson of the NOAA Chesapeake Bay Office, when he requested that NESDIS transition the sea nettle probability product to operations, deemed the product mission optimal, i.e. requirement not critical but would provide significant improvement to operational capability.

Christopher Brown and Thomas Gross received the Administrator's Award in 2004 for developing and implementing the first ecological nowcast system to predict sea nettles, *Chrysaora quinquecirrha*, in Chesapeake Bay.

The demonstration forecasts constitute a significant educational and outreach success for NOAA by attracting the attention of both the media and people who frequent Chesapeake Bay. Numerous emails have been received complimenting the forecasts for their informational value and practical use. The following excerpts are from just three of the many emails received from local residents applauding the nettle forecasts:

"I hope you can keep this [nettle nowcast] map posted as a permanent feature on the web; it is a valuable resource for boaters to decide where to travel, especially on these hot summer days when swimming is almost a necessity. I have posted a link to it on our Catalina 36 Fleet 3 club's web site, found at http://groups.msn.com/C36Fleet3/homepage.msnw. Keep up the good work!"

Ted Simpson, Lancaster, PA

"As a sailboat owner who really NEEDS to swim when the temps are above 90F (and the cabin is over 100) - I was delighted to find your probability map and put it to use this weekend. After turning tail from the bottom of the Choptank (Chlora's Point) on June 29 (always a nettle wherever you looked) - we checked your map and trailered the sailboat to Claiborne, MD on July 2. The Bay was nettle-free all the way to the Western Shore (near Herring Cove) and back - except for a sting just outside Claiborne at 7:30PM - then more sightings. … Thanks for your work on the map."

Vaughn Volungis, Denton, MD

"How cool. … Learned alot on this site."

Greg Seidel, Burwell Bay, VA

10. References

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