Solutions Network Formulation Report

Integrating Salinity Measurements from Aquarius into the Harmful Algal Blooms Observing System

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1. Candidate Solution Constituents

a.   Title: Integrating Salinity Measurements from Aquarius into the Harmful Algal Blooms Observing System

b.   Authors: Daniel Anderson, David Lewis, Kent Hilbert

c.   Identified Partners: National Oceanic and Atmospheric Administration/National Coastal Data Development Center, National Oceanic and Atmospheric Administration/National Ocean Service, Centers for Disease Control and Prevention

d.   Specific DST/DSS: Harmful Algal Blooms Observing System

e.   Alignment with National Application: Coastal Management, Public Health

f.   NASA Research Results – Table 1:

Missions	Sensors/Models	Data Product
Aquarius	Aquarius	Sea Surface Salinity

g.   Benefit to Society: Better identification and mapping of HAB events to help manage coastal areas and benefit public health.

2. Abstract

This Candidate Solution suggests the use of Aquarius sea surface salinity measurements to improve the NOAA/NCDDC (National Oceanic and Atmospheric Administration's National Coastal Data Development Center) HABSOS (Harmful Algal Blooms Observing System) DST (decision support tool) by enhancing development and movement forecasts of HAB events as well as potential species identification. In the proposed configuration, recurring salinity measurements from the Aquarius mission would augment HABSOS sea surface temperature and in situ ocean current measurements. Thermohaline circulation observations combined with in situ measurements increase the precision of HAB event movement forecasting. These forecasts allow coastal managers and public health officials to make more accurate and timely warnings to the public and to better direct science teams to event sites for collection and further measurements.

3. Detailed Description of Candidate Solution

a.   Purpose/Scope

Given the proper conditions, algae or phytoplankton can grow very fast or "bloom" in the sea and accumulate into dense, visible patches near the surface of the water. "Red Tide" is a commonly described observation that occurs when a specifically pigmented species of algae accumulates in sufficient quantities that it appears to discolor the surface of the water. The phenomenon of

disproportionate toxic algal growth is known as a HAB (harmful algal bloom). Alarmingly, the frequency, extent, and severity of HAB events appear to be increasing (NCDDC, 2006). The Harmful Algal Bloom and Hypoxia Research and Control Act of November 13, 1998, recognized that many coastal areas suffer from HAB events each year. People can be sickened by eating contaminated seafood or by inhaling airborne algae, common problems during HAB events. HABSOS, a DST based at NOAA/NCDDC, is an integrated information and communication system for managing HAB data, events, and effects. HABSOS is used for identifying potential HAB events and for predicting movement to issue warnings and to direct missions for data collection and sampling.

Algal bloom events, whether of toxic or non-toxic species, can have detrimental effects to local ecosystems. Even non-toxic algal blooms can seriously deplete oxygen levels at bottom water, leading to hypoxic stress and death in aquatic organisms. Harmful or toxic bloom events can be even more dangerous. Humans can become sick when they breathe HAB-laden aerosols near the beach. Because shellfish, zooplankton, and fish larvae feed on algae, each trophic level of the food chain is indirectly affected up to and including humans who consume seafood of all kinds. Toxins produced by harmful algae can cause myriad health problems in humans and have been linked to deaths in the United States and abroad. Amnesic Shellfish Poisoning, Ciguatera Fish Poisoning, Diarrhetic Shellfish Poisoning, Neurotoxic Shellfish Poisoning, and Paralytic Shellfish Poisoning are all linked to different species of toxic algae that occur in various coastal waters worldwide, including the United States (WHOI, 2007). Symptoms of these syndromes are generally gastrointestinal and neurological in nature and can be severe, even fatal. Large-scale monitoring programs have been designed to prevent mass outbreaks of any of the more lethal poisonings. HABSOS serves the public by providing critical information to managers in the form of early alerts of HAB events, timely forecasts of HAB movement, and predictions of when and where HABs are most likely to occur (NCDDC, 2006). HAB events also have economic impacts. Anderson et al. (2000) estimates that nearly $50 million USD annually are lost to public health costs, tourism shortfalls, and commercial fishing losses. Enhancements to HABSOS can benefit public safety and can help protect coastal ecosystems.

b. Identified Partner(s)

The National Coastal Data Development Center's mission is to support ecosystem stewardship by providing access to the Nation's coastal data resources (NCDDC, 2007). To that end, the NCDDC is developing HABSOS through a partnership of federal, state, and academic organizations as a proof-of-concept for a coastal observing system. While the HABSOS pilot project is initially focused on the Gulf of Mexico, the project will ultimately expand throughout the coastal United States. A Gulf-wide network of HAB experts, data providers, and data managers are organizing relevant data and information from across the Gulf into a regional format applicable to forecasting, establishing the process and network for linking and integrating multiple data types from multiple data sources, and establishing a Web-based presentation system subject to user feedback. The Web-based presentation system will provide tools to visualize and simulate conditions before, during, and after blooms and will demonstrate the benefits of timely data collection, integration, and information dissemination (NCDDC, 2006). The eventual goal is an operational HAB forecasting system as a component of the Gulf of Mexico regional ocean observing system.

The CDC (Centers for Disease Control and Prevention) also study the problem of HABs. The CDC have responded to congressional mandates to investigate the health effects of certain species of waterborne algae. The CDC also have a vested interest in collaborating with other partners that are studying and providing data about HAB events in an effort to fulfill their mission of expanding a system that tracks human illness associated with HABs (CDC, 2007).

NOAA/NOS (National Oceanic and Atmospheric Administration's National Ocean Service) also plays a role in monitoring and forecasting Harmful Algal Bloom events. NOAA/NOS places focus on

research to determine environmental factors that trigger HABs and to predictHAB events (NOS, 2007).

The HABSOS DST already has several NASA sensor inputs. The Jason/Poseidon missions provide mean sea level data. QuikSCAT provides wind speed and direction. Overland-freshwater modeling is a key component to the DST as well because eutrophication from upstream agricultural processes is a major factor in bloom events. These same freshwater runoff models are used to estimate coastal salinity measurements. The salinity component of HASBOS can be augmented with Aquarius salinity data products, which support the HABSOS goal of providing coastal mangers and public health officials with relevant data for regional dissemination.

While some forms of algae are able to thrive in dense salinity concentrations and others in light concentration, Aquarius measurements may help to define the range of intensity or dilution in which any one particular species is able to thrive and eventually "bloom." More importantly, however, is the contribution that salinity gradients measured from Aquarius may make to forecasting bloom movement. These gradients may provide a level of understanding about the Gulf of Mexico Loop Current oscillation during warm summer months when the temperature in the Gulf is generally uniform and therefore less useful in modeling ocean currents. Also onboard the Aquarius mission is a scatterometer that can be used to derive ocean surface winds, further augmenting information related to ocean currents. Understanding the direction and pace of the Loop Current will serve both local public health officials and coastal managers by providing advance warning of approaching HAB events.

c. NASA Earth-science Research Results

Aquarius is a joint U.S. and Argentine (NASA – CONAE) mission scheduled to launch in 2009. It will carry a payload of three L-band radiometers and an L-band scatterometer. The swath width of the onboard instruments will be ~350 km with a spatial resolution of ~76 km x 94 km (finest of the three radiometers) and a spectral range of 1.413 GHz ± 13 MHz (passive). The repeat cycle of Aquarius is 7 days. Aquarius' specific science goals are to observe and model processes relating salinity variations to climate change and the global cycling of water and general ocean circulation (Parkinson et al., 2006). These science missions relate directly to the use proposed in this candidate solution.

d. Proposed Configuration's Measurements and Models

Blooms can be caused by several factors. An increase in nutrients can cause algae growth and reproduction to increase dramatically and to develop into a bloom. For this reason, overland freshwater modeling is a major component to understanding the downstream effect of agricultural runoff on bloom events. Since Aquarius' resolution will be too coarse for near-shore salinity measurements, the freshwater model and Aquarius salinity measurements should augment and complement one another. In other instances, something may change in the environment so that certain algae can out-compete the other algae for food, which can result in a bloom of the dominant algae. This environmental change can be related to the water quality, temperature, nutrients, sunlight, or other factors. Aquarius can help to understand salinity as one of the environmental factors contributing to HAB events.

Thermohaline circulation models can also assist in predicting where known HAB events will move over time. Although the NCDDC analyzes various measurements to predict HAB movement, density-driven circulation is not currently measured. While most research has focused on the temperature-salinity relationship with respect to deep water ocean currents, freshening or salinization can also affect shallow, wind-driven circulation (Semtner and Chervin, 1992; Cooper, 1988; Fedorov et al., 2004). In summer months, ocean temperature in the Gulf becomes more uniform and therefore less useful in modeling ocean current by itself. Aquarius salinity measurements along with sea surface temperature could provide identification of loop currents and other driving forces that are unique in

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the open waters. By using Aquarius salinity studies to better understand ocean circulation, HABSOS benefits from better HAB movement prediction models.

4. Programmatic and Societal Benefits

Harmful Algal Bloom events cause environmental stresses along the coastal areas of occurrence, including biomass accumulation, light attenuation, and hypoxia. HABs kill a variety of aquatic life, including fish, shellfish, and marine mammals (HARRNESS, 2005). In fact, The H. John Heinz III Center for Science, Economics and the Environment has called Harmful Algal Blooms one of the top three critical health indicators for the coastal ecosystems of the United States (The Heinz Center, 2002). Consequently, this solution is strongly aligned with the Coastal Management National Application.

HABs have also demonstrated the capacity to cause public health crises. With the increase in interstate and international transport of seafood, as well as international travel by seafood consumers, virtually no human populations are free of risk. Therefore, this candidate solution is also closely related to the Public Safety National Application.

5. References

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