An aerial photograph of a coastal town and harbor. The town is built on a hillside, with a road and a parking lot visible. The harbor is filled with a large, dark red algal bloom that extends into the open ocean. The water is a deep blue, and the sky is a lighter blue.

Marine Harmful Algal Bloom Programs

Water Quality Monitoring Council Meeting

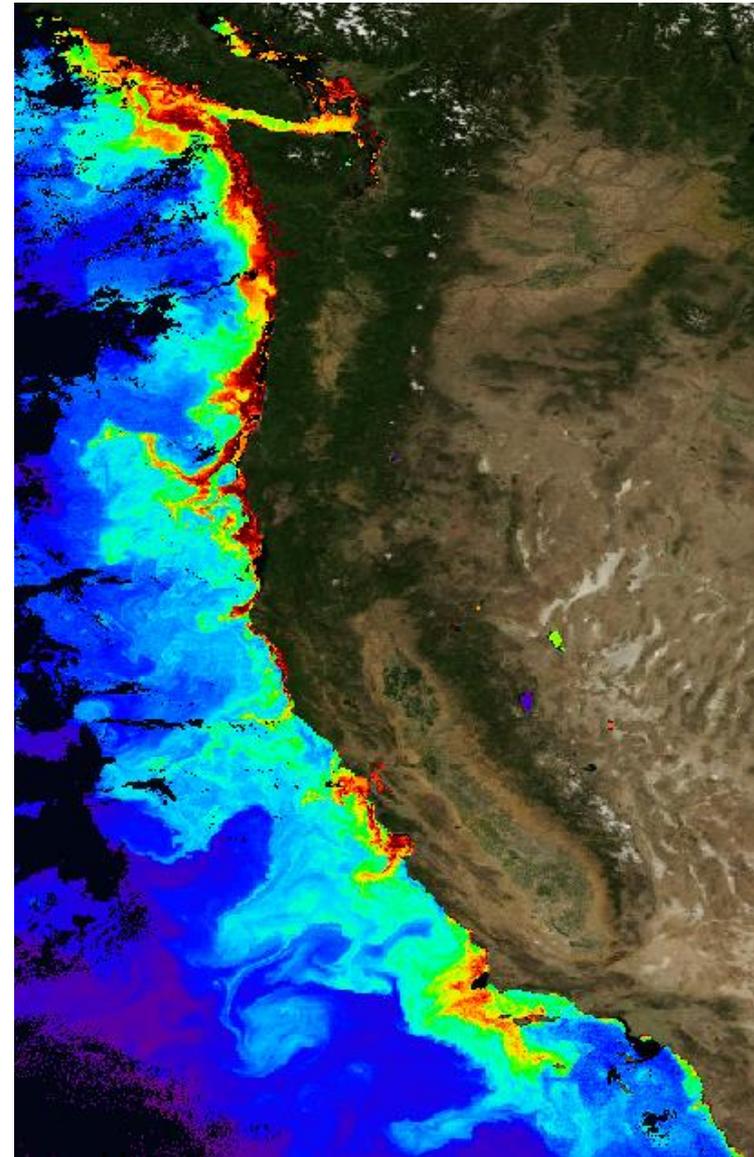
August 23, 2016

Meredith Howard

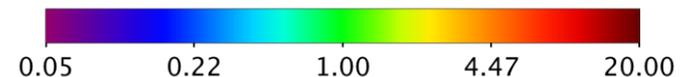
Southern California Coastal Water Research Project

2015: An Unprecedented Year

- Geographically most extensive bloom recorded
 - Kodiak Alaska to Santa Barbara
- Long Lasting (months)
- New record of high toxin levels
- Massive impacts
 - Economic losses
 - Shellfish and crab closures
 - Ecosystem impacts
 - Marine wildlife mortalities

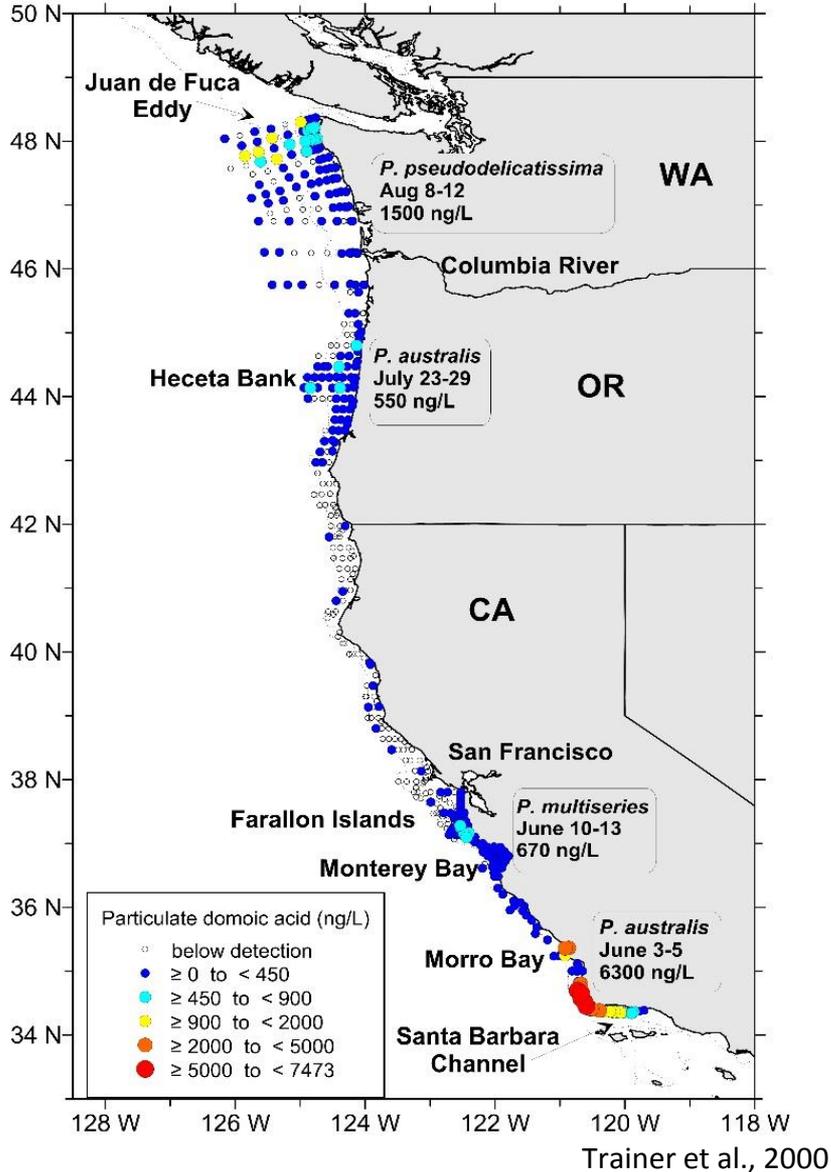


chlora (mg m⁻³)

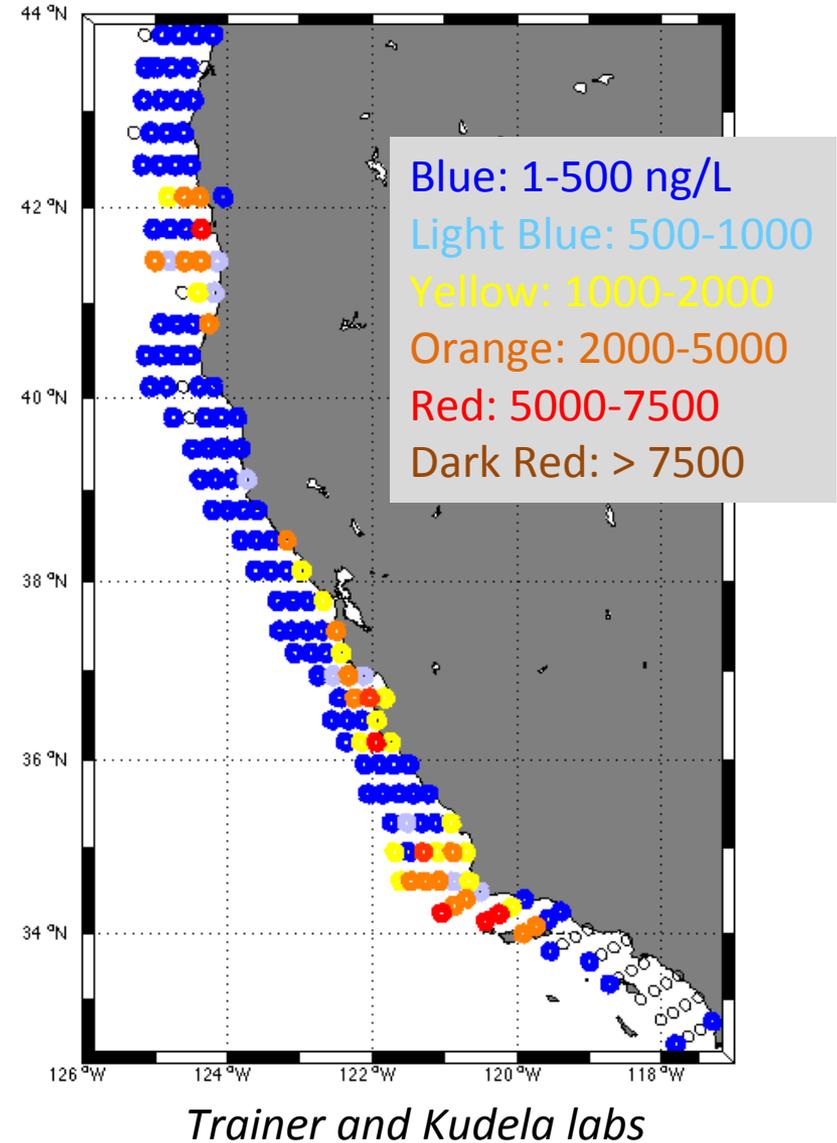


Geographically Most Extensive Bloom Recorded

1998 – Domoic Acid

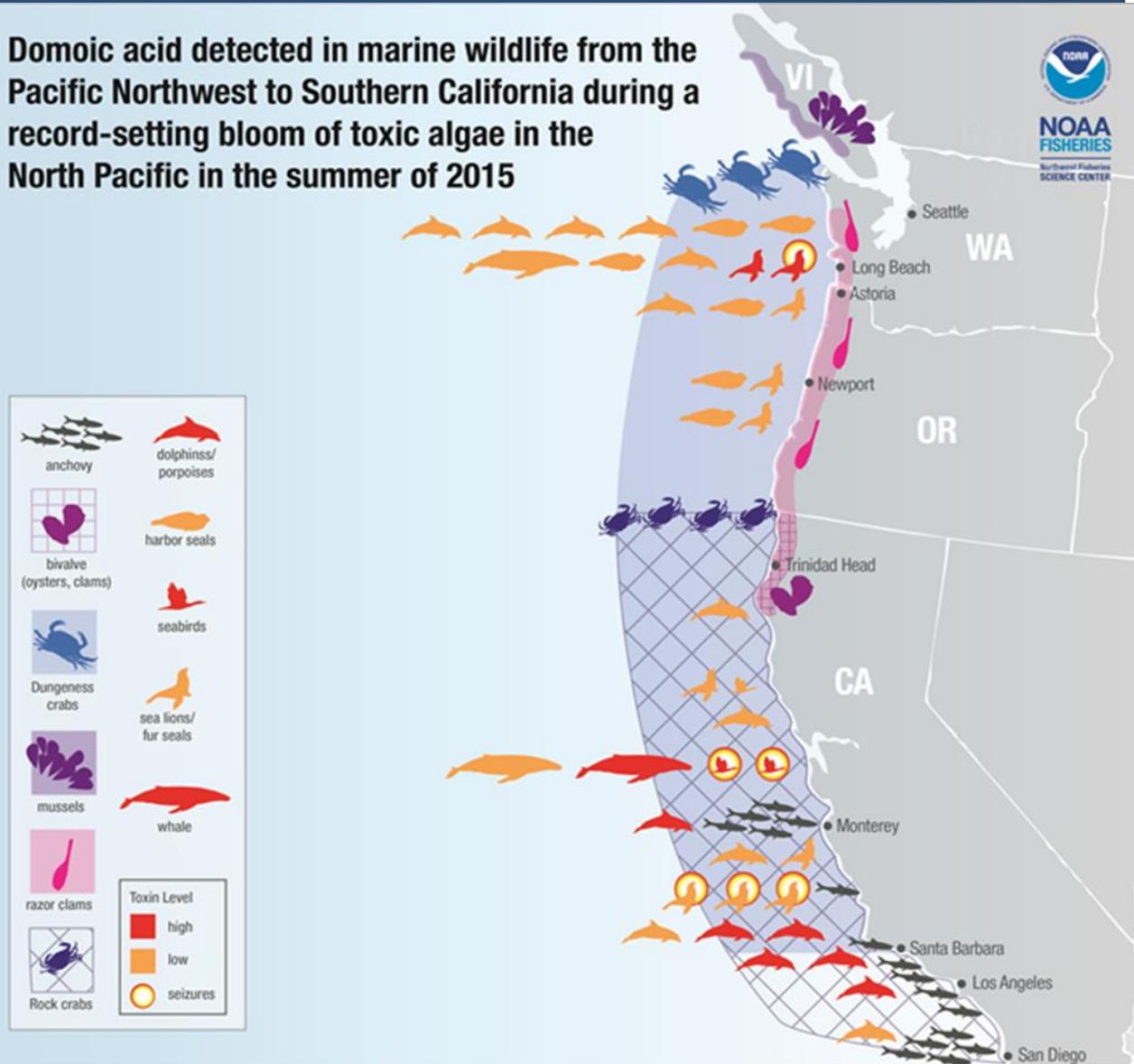


2015 – Domoic Acid



Wide Variety of Impacts

Domoic acid detected in marine wildlife from the Pacific Northwest to Southern California during a record-setting bloom of toxic algae in the North Pacific in the summer of 2015



Graphic: Seattle Times

The Impacts Remain Long After the Bloom Ends

- Fishery disaster related to closure of the Dungeness crab and rock crab fisheries
 - Direct economic losses - estimated \$49 million in the foregone California catch alone
 - Crab Emergency Disaster Assistance Act of 2016



**Bill aims to give crab industry \$138 million
in disaster relief**

By **Kimberly Veklerov** Updated 7:50 pm, Friday, March 4, 2016

Ideal Monitoring Program

- Assessment
 - Screening
 - HABs are episodic events
 - Broad network evaluate presence of toxin producers
 - Event Response
 - Increased frequency of sampling and toxin analysis (water, shellfish, wildlife)
 - Trends
 - Comparison across years
- Communication and Reporting
 - Coordination amongst data collectors, informing public
- Forecasting System
 - Helps with all aspects of monitoring program

Screening Assessment: Volunteer Citizen Scientist Monitoring

- ~500 sites sampled on weekly basis for HAB species composition
- ~100 sites sampled for mussels monthly
- Sampling conducted by volunteers
 - Volunteers are critical in maintenance of monitoring program
 - Public citizens, k-12 school groups, municipal utilities, local agencies etc.



The Future of Volunteer Monitoring

- CellScope Aquatic
 - Lab quality, portable, cell phone-based microscope
- EPA has developed smartphone app to track blooms



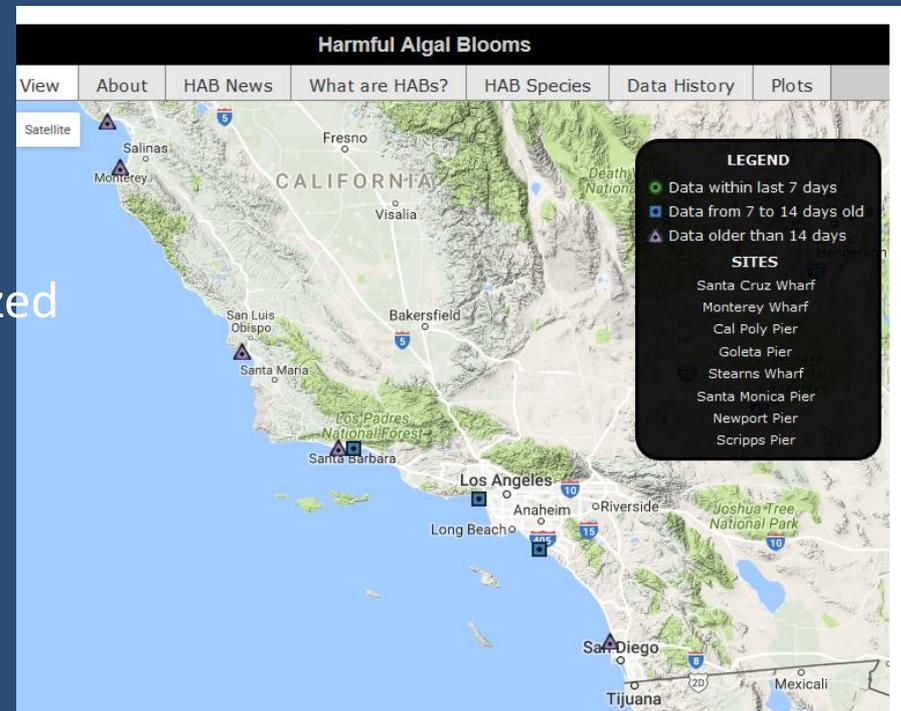
Event Response

- Decision based approach to sample analysis
- Increased frequency of sampling and toxin analysis
 - Water and mussel samples
- Additional types of samples analyzed
 - Ex. Crustacean shellfish and finfish



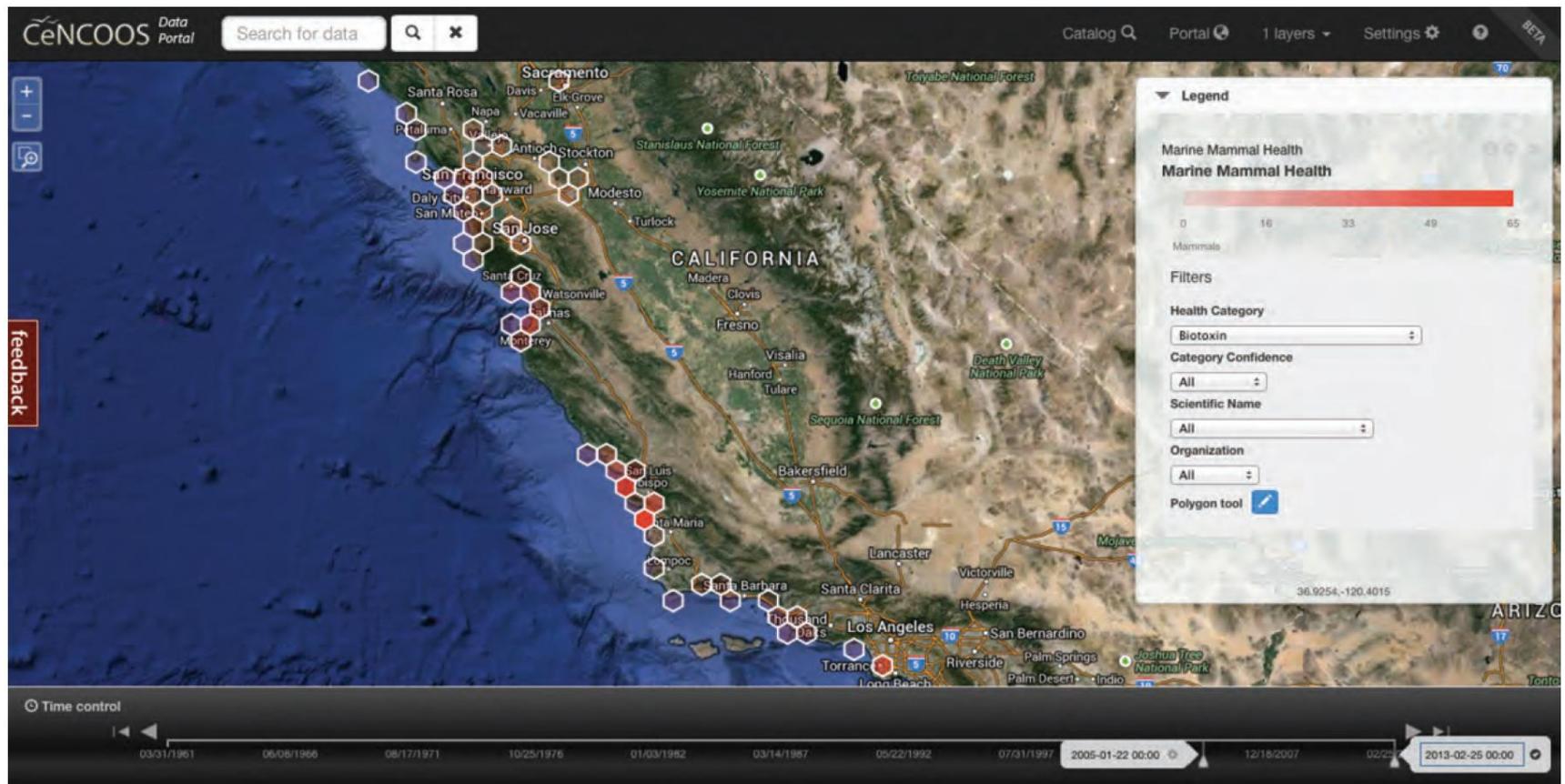
Trend Analysis: Water Samples

- Conducted by the Integrated Ocean Observing Systems
 - 8 sites
- All samples collected weekly are analyzed
 - Toxin analysis
 - HAB species identification
 - Nutrients
 - Chlorophyll
- Continuous monitoring of routine supporting information
 - Chlorophyll, temperature, salinity, dissolved oxygen etc.



Trend Analysis: Marine Mammals

- Marine Mammal Health Map for California
- Part of the national marine mammal health tracking program



Communication and Reporting

- Many types of groups need to coordinate information and efforts
 - Response network (data collectors)
 - User community
 - Marine mammal and wildlife rescue centers
 - Shellfish industry and fisheries
 - Public
 - Shellfish and fisheries quarantines
- Marine HAB Coordinated network (Cal HABMAP)





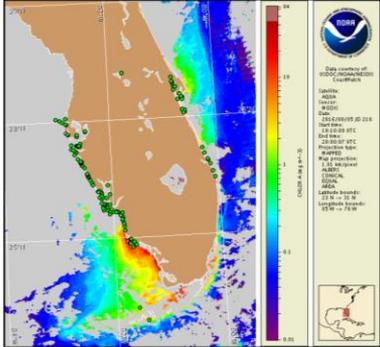
- Integrated, statewide network
 - Coordination of organizations and researchers collecting HAB data
- Program has accomplished initial goals:
 - Created centralize portal for dissemination of HAB info
 - Listserve to integrate groups
 - Weekly results and marine wildlife events
 - Open forum to discuss HAB conditions
 - Conducted comparison of analytical methods
- Current Goal: Establish forecasting system

HAB Operational Forecast System

- Early warning of HABs:
 - Enables informed management decisions
 - Bloom event response to minimize impacts
- Forecasts HABs:
 - Development
 - Intensity
 - Transport



Gulf of Mexico Harmful Algal Bloom Bulletin
Region: Southwest Florida
Monday, 08 August 2016
NOAA National Ocean Service
NOAA Satellite and Information Service
NOAA National Weather Service
Last bulletin: Monday, August 1, 2016



NOAA
Date: 08/08/16 05:00:00
Latitude: 28.0000
Longitude: -81.0000
Scale: 1:1000000
Projection: NAD83
Datum: NAD83
Units: Meters
Color Scale: Chlorophyll a (µg/L)
0.00 0.50 1.00 1.50 2.00

Conditions Report
Karenia brevis (commonly known as Florida red tide) ranges from not present to very low concentrations along the coast of southwest Florida, and is not present in the Florida Keys. No respiratory irritation is expected alongshore southwest Florida Monday, August 8 through Monday, August 15.

Check http://tidesandcurrents.noaa.gov/hab/beach_conditions.html for recent, local observations.

Analysis
Recent samples received from along- and offshore southwest Florida from Pinellas to Monroe counties, including the Florida Keys, all indicate that *Karenia brevis* is not present, with the exception of one 'very low a' concentration sample collected near Longboat Pass on the byside in southern Manatee County (FWRI; 8/1) and four background concentration samples collected in northern Pinellas County, northern Sarasota County, and southern Charlotte County (FWRI, MML, SCHD, CCENRD; 7/29-8/5). Detailed sample information and a summary of impacts can be obtained through FWC Fish and Wildlife Research Institute at: <http://myfwc.com/redtidestatus>.

Recent ensemble imagery (MODIS Aqua, 8/5) is mostly obscured by clouds alongshore southwest Florida from Pinellas to Lee counties, limiting analysis. Patches of elevated to very high chlorophyll (2 to > 20 µg/L) with the optical characteristics of *K. brevis* are present from northern Collier County to Marco Island in central Collier County and extend up to 7 miles offshore.

Forecasted winds over the next week may decrease the potential for *K. brevis* bloom formation at the coast.

Yang, Davis

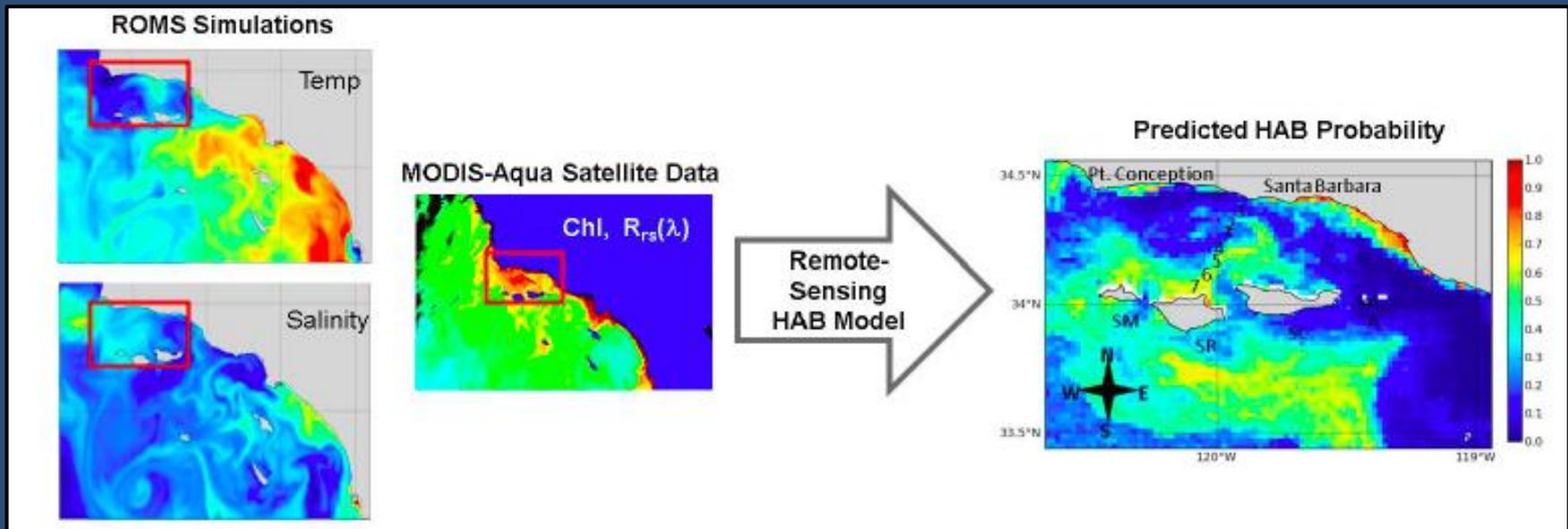
Satellite chlorophyll image with possible *K. brevis* HAB areas shown by red polygon(s), when applicable. Points represent cell concentration sampling data from July 29 to August 5: red (high), orange (medium), yellow (low to hi), brown (low a), blue (very low b), purple (very low a), pink (present), and green (not present). Cell count data are provided by Florida Fish and Wildlife Conservation Commission (FWC) Fish and Wildlife Research Institute. For a list of sample providers and a key to the cell concentration categories, please see the HAB-OFS bulletin guide: http://tidesandcurrents.noaa.gov/hab/hab_publications/hab6_bulletin_guide.pdf

Detailed sample information can be obtained through FWC Fish and Wildlife Research Institute at: <http://myfwc.com/redtidestatus>

To see previous bulletins and forecasts for other Harmful Algal Bloom Bulletin regions, visit at <http://tidesandcurrents.noaa.gov/hab/bulletins.html>

MODELING TO FORECAST HABs IN CALIFORNIA

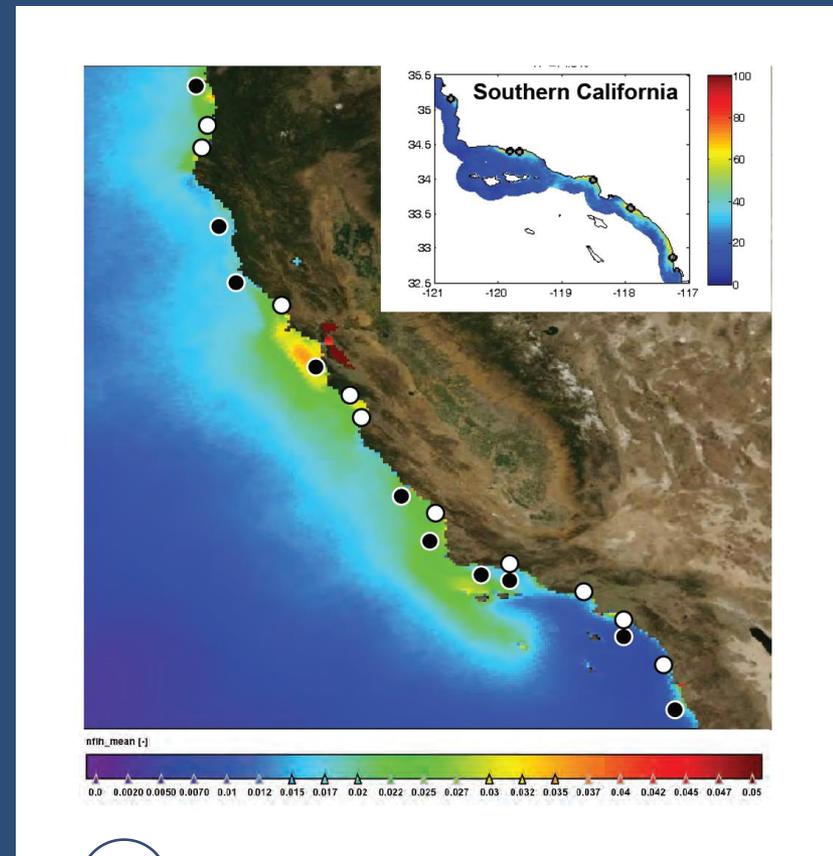
- Nowcasts and forecasts of the probability of cells or toxin through combination of:
 - Satellite observations of chlorophyll, reflectance and historical HAB data
 - Ocean circulation models (temperature, salinity and ocean currents)



NEXT STEP: Link with causal ocean acidification and hypoxia modeling

Next Steps Toward Operational Forecasting System

- Additional stations improves probability of predicting HABs
 - Existing stations shore-based
 - Proposed stations mostly offshore
 - Currently unfunded
- Integrate HAB model with other ocean models being developed
 - Acidification and hypoxia models



Existing stations



Proposed new stations

Standardization

- Methods
 - Standardized methods for sample collection and sample analysis
- Thresholds
 - Human health thresholds established for shellfish
- Data Structure
 - Standardized data structure established for both assessment and trends monitoring
 - Data accessible online

Estuaries Are More Complex

- Longer list of toxins and organisms
 - Both marine and freshwater toxins can be present
- Comprehensive network not developed



Estuaries: Assessment

- Screening
 - Targeted sites (<5), not comprehensive
 - Only marine toxins and species
 - No monitoring of freshwater toxins and species (except SFB, delta and Klamath)
- Event Response
 - Increased frequency in targeted sites
- Trends
 - Not enough data collected to evaluate

Estuaries

- Communication and Reporting
 - Limited to targeted sites included in screening
 - No formal reporting system or coordination effort
- Forecasting
 - Not developed



Summary

- Marine
 - Monitoring program exists
 - Most desired components for a monitoring program in place
 - Forecasting needs further development to become operational
 - Additional offshore stations to develop model
 - Integration with other ocean models
- Estuarine
 - Minimal program exists
 - Only a select few targeted sites included
 - Only marine species and marine toxins are monitored
 - No monitoring for freshwater species or toxins

The marine monitoring program can be a model for what is needed in estuarine and freshwater systems