

Harmful Cyanobacteria and Algae Blooms: Human Dimensions

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Centers for Disease Control and Prevention
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Disclaimer

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position of the Centers for Disease Control and Prevention/the Agency for Toxic Substances and Disease Registry.

Harmful blooms: What can they do?

- Damage ecology
- Limit access to recreation, seafood, drinking water
- Cause illness in animals and people



Photo courtesy of Allan Wilson



Photos by Lorrie Backer

Human dimensions of harmful blooms

- What aspects of society can harmful blooms affect?
 - Socioeconomics
 - Public health
 - Recreational opportunities
 - Drinking water supplies
- How do we address these pressures?
 - Research
 - Risk communication
 - Education and outreach

Study: Blue-green algae a growing threat to drinking water supply

The lack of regulations or monitoring poses a risk to the health of animals and humans, researchers said. (Oregon)

By Stephen Feller | Aug. 13, 2015 at 11:37 AM



Addressing the Human dimensions of blooms: what's needed?

- Effective risk communication strategies
- Assessment of community vulnerability
- Identification of susceptible populations
- Comprehensive assessment of environmental, sociocultural, and economic effects
- Development of effective decision-support tools
- Improved coordination among agencies and stakeholders
- One Health approach



Challenge:

We need accurate, clear risk communication

- Available harmful bloom information is not always accurate or up-to-date
- Uncertainty
 - There is much we don't know about why the organisms produce the toxins, when the toxins are produced, etc.
- Many gaps in understanding health outcomes

Opportunity:

Develop communications tool kit

- Fact sheets
- FAQs
- Characteristics
 - Consistent messages across entities
 - Address needs of specific audiences

Physician Reference

Blue-green Algae Blooms

When in doubt, it's best to stay out!



Grand Lake Saint Mary's , Summer
2010

To report a blue-green algae bloom or related health event:

Call your local or state health department

For more information:

<http://www.cdc.gov/hab/links.htm>

or

Call the National Center for Environmental
Health Harmful Algal Blooms Program
(HABISS) Centers for Disease Control and
Prevention: 866-556-0544

What are blue-green algae?

Cyanobacteria, sometimes called blue-green algae, are microscopic organisms that live in all types of water.

What is a blue-green algae bloom?

- Blue-green algae grow quickly, or bloom, when the water is warm, slow-moving, and full of nutrients.

What are some characteristics of blue-green algae blooms?

- Algae usually bloom during the summer and fall. However, they can bloom anytime during the year.
- When a bloom occurs, scum might form on the water's surface.
- Blooms can be many different colors, from green or blue to red or brown.
- As the bloom dies off, you might smell an odor that is similar to rotting plants.

What is a toxic bloom?

Sometimes, blue-green algae produce toxins.

- The toxins can be present in the algae or in the water.

Other important things to know:

- Swallowing water that has algae or algal toxins in it can cause serious illness.
- Dogs might have more severe symptoms than persons, including collapse and sudden death after swallowing the contaminated water while swimming or after licking algae from their fur.
- There are no known antidotes to these toxins. Medical care is supportive.

You cannot tell if a bloom is toxic by looking at it.

What we know about exposure to blue-green algae and cyanotoxins and possible health effects

Information about human health effects from exposure to blue-green algae and toxins is primarily derived from a few epidemiology studies of recreational exposures; studies with laboratory animals; reports of extreme human exposure events, such as the use of toxin-contaminated dialysis water; and from animal (e.g., cattle and pet dog) exposures. References are available at: <http://www.cdc.gov/hab/links.htm>

Potential exposure route	Information source for possible symptoms and signs	Possible symptoms and signs
Swallowing water contaminated with blue-green algae (cyanobacteria) or toxins	Data from laboratory animal studies, extreme human exposure events, and animal exposures	<p>Hepatotoxins and nephrotoxins</p> <ul style="list-style-type: none"> Nausea, vomiting, diarrhea Bad taste in mouth Acute hepatitis, jaundice Blood in urine or dark urine Malaise, lethargic Headache, fever Loss of appetite <p>Neurotoxins</p> <ul style="list-style-type: none"> Progression of muscle twitches For saxitoxin: high doses may lead to progressive muscle paralysis
Skin contact with water that is contaminated with blue-green algae or toxins	Data from human studies	<ul style="list-style-type: none"> Allergic dermatitis (including rash, itching and blisters) Conjunctivitis
Inhaling aerosols contaminated with blue-green algae or toxins	Anecdotal evidence from human exposures and data from human studies	Upper respiratory irritation (wheezing, coughing, chest tightness, shortness of breath)

Physician Reference card (back)

Veterinarian Reference

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Call your local or state health department

For More Information:

Call the National Center for Environmental Health Harmful Algal Blooms Program (HABISS), Centers for Disease Control and Prevention: 866-556-0544

Exposure and Clinical Information

Information about the health effects from exposure to blue-green algae and toxins is derived from reports of animal poisonings.

Potential exposure route	Likely Symptoms and signs	Time to symptom onset**	Differential diagnosis includes the following	Possible laboratory or other findings
Swallowing water that is contaminated with blue-green algae (cyanobacteria) or toxins or licking it off fur or hair	Hepatotoxins and nephrotoxins Excess drooling, vomiting, diarrhea, foaming at mouth Jaundice, hepatomegaly Blood in urine or dark urine Malaise Stumbling Loss of appetite Photosensitization in recovering animals Abdominal tenderness	Minutes to hours	Acetaminophen or NSAID overdose, rodenticide ingestion, aflatoxicosis and other hepatotoxin poisonings	<ul style="list-style-type: none"> •Elevated bile acids, ALP, AST, GGT •Hyperkalemia •Hypoglycemia •Prolonged clotting time •proteinuria •Presence of toxin in clinical specimens from stomach contents taken from animals that became ill
	Neurotoxins Progression of muscle twitches For saxitoxin, high doses may lead to respiratory paralysis and death if artificial ventilation is not provided.	Minutes to hours	Pesticide poisoning, myasthenia gravis, other toxin poisoning	Presence of toxin in clinical specimens from stomach contents taken from animals that became ill
Skin contact with water contaminated with blue-green algae or toxin(s)	Dermal toxins Rash, hives, allergic dermatitis	Minutes to hours	Other dermal allergens	Blue-green staining of fur or hair

Challenge:

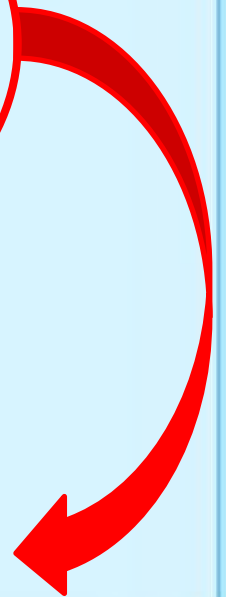
There is no comprehensive assessment of environmental, sociocultural, and economic effects from harmful blooms.

Opportunity:

Assess community needs during a harmful bloom event using CASPER (Community Assessment for Public Health Emergency Response)

- Enables public health practitioners and emergency management officials to rapidly describe the health status and basic needs of the affected community.
- Uses valid statistical methods to gather information about health and basic needs
- Allows public health and emergency managers to prioritize their response and distribution of resources accurately.
- Can be used to assess preparedness and recovery

Opportunities to contribute real-time environmental data and to create a historical data base.



Recent events: Ohio

- August 2014 *Microcystis* bloom in Lake Erie
 - Near Toledo's water supply intake
 - Do Not Drink & Do Not Boil advisories for about 2 days
 - Increase in visits to emergency rooms for GI distress



Satellite photo:
MODIS 8-13-14

Challenge:

Lack of comprehensive assessment of health effects

Opportunity:

Collect new data using epidemiology studies

Human exposures to cyanobacteria blooms during recreational activities

• Study locations

- Michigan—Bear Lake
- California—Klamath River reservoirs

• Exposure

- Microcystins in blood samples and nasal swabs
- Microcystins in air and water

• Health effects

- Self-reported symptoms



Photos by Lorrie Backer

Collaborators

- National Center for Environmental Health, CDC
- National Center for Emerging Zoonotic and Infectious Diseases, CDC
- Mote Marine Laboratory
- Greenwater Laboratory
- Lovelace Respiratory Research Institute
- Wright State University
- Other Federal Agencies (NOAA)
- State and local public health agencies
- Officials or others at study site
- California Department of Health
- Siskiyou County
- Karuk Tribe
- Pacific Corporation



Photo by Lorrie Backer

Epidemiology Study Design

- Study population
 - Planning recreational activities in lake with a cyanobacteria bloom (exposed)
 - Planning recreational activities in lake with no cyanobacteria bloom (control)
- Compared data collected for exposed and control groups



Photos by Lorrie Backer

Environmental Data Collection

- Water samples
 - Viruses
 - Water quality
 - Algal taxonomy
 - Microcystins
- Ambient air samples
 - High-volume
 - Particle size
 - Microcystins
- Personal air samples
 - Microcystins



Photos by Lorrie Backer

Health Data Collection

- Questionnaires
 - Pre-exposure
 - Post-exposure
 - Follow-up (7-10 days later)
- Post exposure plasma samples
 - Microcystins
- Nasal swabs
 - Microcystins



Photos by Lorrie Backer

Results

- Microcystins detected in lake water and air in both blooming lakes
- Microcystins not detected in blood samples
- No change in symptom reporting
- *Microcystins detected on nasal swabs*

Opportunities to:

- Enhance clinical knowledge
- Improve analytic methods
- Create new techniques
- Sustain collaborations



Backer et al., Harmful Algae, 2003;41:1-10
Backer et al., Marine Drugs, 2008; 6 ISSN 1660-3397



Photos by Lorrie Backer

Opportunity: Public health surveillance

What is public health surveillance?

The ongoing, systematic collection, analysis, and interpretation of outcome-specific data for use in the planning, implementation, and evaluation of public health practice.

*Teutsch and Churchill , Principles and Practice of Public Health Surveillance.
2000. Oxford University Press*

One Health HAB Reporting System

- Great Lakes Restoration Initiative (GLRI) funded CDC to:
 - Expand surveillance capacity for waterborne disease in 8 Great Lakes states
 - Build regional capacity through state and federal partnerships to collect data to assess Great Lakes ecosystem health and inform GLRI efforts
 - Build a web-based One Health HAB reporting system linked to the National Outbreak Reporting System (NORs)
 - Nationally available to state agencies for voluntary reporting
 - *Beta*-testing 2015
 - Sustainable



Electronic Case and Outbreak Reporting: One Health Harmful Algal Blooms (OHHABs) in the National Outbreak Reporting System (NORs)

HAB-related illness
and outbreak report

Event and Environment Report

- Form

Human Case Report(s)

- Form 1
- Form 2
- Etc.

Animal Case Report(s)

- Form 1
- Form 2
- Etc.

Electronic Outbreak Reporting – OHHABs in NORS

HAB-related illness
and outbreak report

OHHAB could be
expanded or serve as
a model for public
health surveillance

Event and
Environment
Report

- Form

Human Case
Report(s)

- Form case 1
- Form case 2
- Etc.

Animal Case
Report(s)

- Form case 1
- Form case 2
- Etc.

Opportunities to contribute
environmental data from:

- Ongoing monitoring
- Event response
- Local or regional studies

Opportunities to contribute animal
health data from:

- Companion animal deaths
- Livestock deaths
- Wildlife strandings, mortalities

Challenge:

Incomplete clinical understanding of HAB-related diseases

- Clinical diagnostic tests for algal toxin exposures
- Rapid and affordable water sampling tests for HABs and toxins
- Refined case definitions
- Increased awareness of HAB-related illnesses in the medical community
- Reporting tools to facilitate data collection and analysis

Opportunity: Electronic Outbreak Reporting – OHHABs in NORS

HAB-related illness
and outbreak report

Event and
Environment
Report

- Form

Human Case
Report(s)

- Form case 1
- Form case 2
- Etc.

Animal Case
Report(s)

- Form case1
- Form case 2
- Etc.

Opportunities to contribute
clinical data from suspect or
confirmed cases of HAB-
related illnesses (animals
and people)

Opportunity: Animal sentinels

- Sea lions exposed to microcystins in Monterey Bay
- Birds exposed to surfactants in the Pacific Northwest
- Cattle deaths in Georgia from drinking water contaminated with microcystins
- ...and our pets...



Photo by Lorrie Backer

Review of canine cyanotoxin poisonings in the US: 1920s to 2012 from three data sources

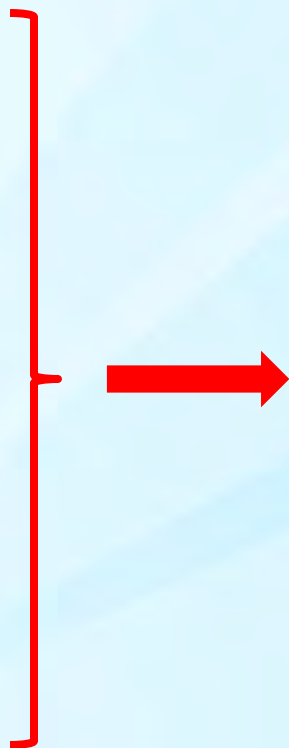
- Harmful Algal Bloom-related Illness Surveillance System
- Veterinary Medical Teaching Hospital (VMTH) necropsy and biopsy case records, University of California, Davis
- Historical records from scientific publications, media, other electronically-available resources

Suspected or confirmed cases of canine cyanobacteria bloom-associated poisonings in the US

Number reported	HABISS 2007-2011	Media Search Late 1920s to 2012	VMTH 1984-2011
Number of events	55	115	44
Reported number of sick or dead dogs	63	260	45
Number (%) of cases where exposure biochemically confirmed	8 (13%)	20 (8%)	2 (4%)
Number (%) of cases published in the peer-reviewed literature	0	62 (25%)	1 (2%)

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Number reported
Number of events
Reported number of sick or dead dogs
Number (%) of cases where exposure biochemically confirmed
Number (%) of cases published in the peer-reviewed literature



Opportunities to:

- Enhance disease surveillance if veterinarians report to a public health system
- Use monitoring data for exposure assessment
- Expand experimental analytic methods to clinical testing
- Share data for diagnosis, treatment
- Provide feedback for ecologic research and monitoring

Challenge:

Defining the total costs of harmful blooms

- **Societal costs**
 - Loss of livelihood
 - Recreation
 - Medical
- **Other economic costs**
 - Routine monitoring
 - Preparedness
 - Response (increased monitoring, disposal)
 - Recovery

Opportunity:

Conduct economic assessments

Annual costs for cyanobacteria blooms in Australia

- Monitoring and testing
 - \$8.7 million
- Treatment
 - \$20,000 to \$50,000 for algicides
 - \$1 million to dispose of copper-contaminated water treatment sludge
- Prevention
 - Covering reservoirs
 - South Australia (3 storages): \$7.1 million
 - Environmental improvement
 - Urban sewage control: \$121 million
 - Waste water control: \$33 million
 - Rehabilitation of land and water: \$45 million

 \$180 to \$240 million

Opportunity:

When prevention fails--New technologies and applications for algae

Utilize algal mass

- Biofuels
- Fertilizer
- Food
- Chemicals (cellulose, lipids, agar)



Source ://www.amazon.com/s/ref=nb_sb_noss?url=search-alias%3Dstripbooks&field-keywords=wide+open+organic+ocean+seaweed+cookbookhttp

Challenge:

Need guidance for public health protection

Opportunity: Water exposure guidance

WHO: Guideline for lifetime drinking water exposure to microcystin-LR is 1 µg/L

US EPA: Guideline for 10-day drinking water exposure to microcystin-LR ≤ 0.3 µg/L for children under 6 and 1.6 µg/L for others

State: Oregon (USA): Public health advisory for recreational use based on visible scum + cell counts/toxin present (e.g., 10 µg/L Microcystin)

Opportunities to create consistent guidance for drinking water and recreational waters.

Opportunity:

Global ciguatera strategy

- Address ongoing issues with diagnosis and treatment of ciguatera fish poisoning (CFP)
- IOC recommended establishing a coordinated IOC-FAO-WHO¹ effort to combine the capabilities of those agencies and that of ecologists, toxin chemists and medical researchers to develop a coordinated Ciguatera Strategy

- Improve organism detection and sampling strategies
- Improve toxin detection
- Improve epidemiologic data collection, reporting and assessments

Opportunities:

- Provide data to support communication on local fish toxicity, exposure assessment, and disease surveillance.
- Create best practices for fish sampling, toxin analysis, human health surveillance

Opportunity: Guidelines for response

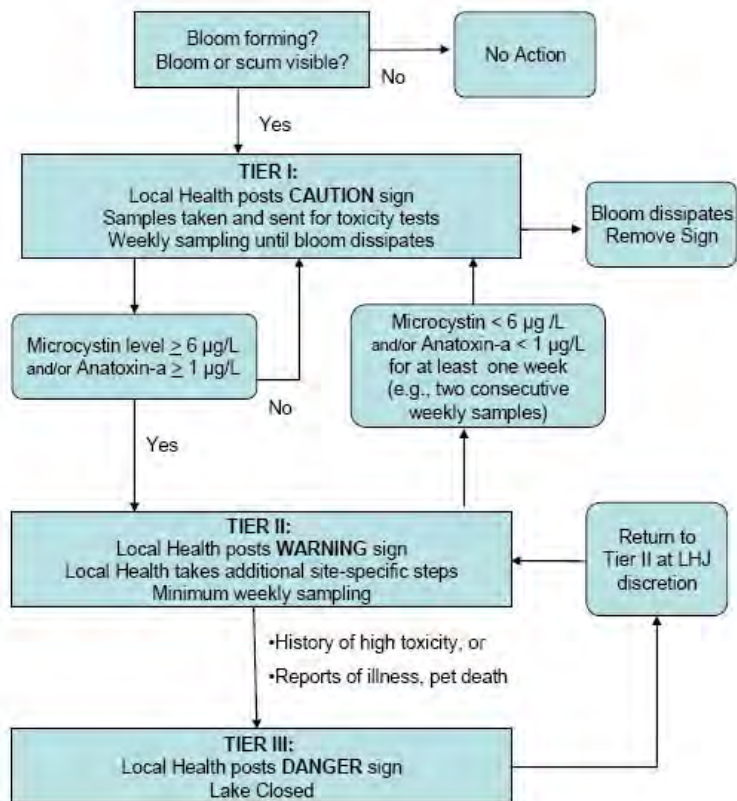
- Create response plans
 - Resource Guide for Public Health Response to Algal Blooms in Florida
 - <http://myfwc.com/research/redtide/research/scientific-products/resource-guide/>
- Create best practices for data collection
 - SWAMP (Surface Water Ambient Monitoring Program) in CA
 - Quality Control and Sample Handling Guidelines
 - http://www.waterboards.ca.gov/water_issues/programs/swamp/mqo.shtml



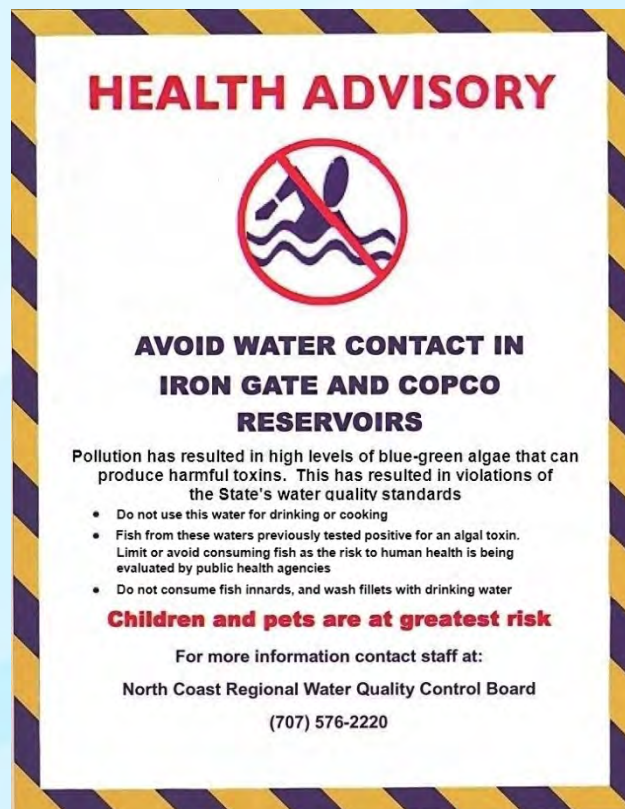
Opportunity: Guidelines for response

Washington State

Figure 1. Three-tiered approach to managing Washington water bodies with cyanobacterial blooms.



California



- Opportunities for:
- Information sharing
 - Consensus on guidance

Opportunity: HAB Forecast

- Data
- Analysis
- Forecast

Opportunities to integrate data on environment, health

NCAA GOM HAB Bulletin



Gulf of Mexico Harmful Algal Bloom Bulletin
2 November 2006
NCAA News Service
NCAA Satellite and Information Service
Last Bulletin: October 30, 2006

Conditions Report

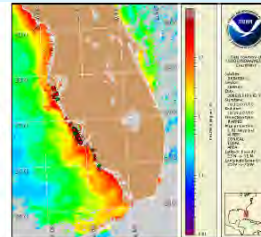
A harmful algal bloom has been identified from Pinellas to central Collier County. Patchy low impacts are possible for Pinellas, Sarasota, and northern Charlotte County today through Sunday. Patchy very low impacts are possible for Pinellas, Manatee, Lee, northern Charlotte, and Collier Counties today through Sunday.

Analysis

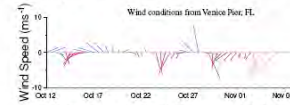
The harmful algal bloom persists in patches from Pinellas to Collier County. High concentrations of *K. brevis* were reported this week at Casey Causeway and at the West End of Pinellas Bayway (FWRL 1930) in Pinellas County. Concentrations have increased from low to medium around northern Pine Island and Carpenter's Shoals (FWRL 1970). Concentrations remain high for Pinellas, northern Charlotte, and Sarasota County, with low to medium concentrations present in Manatee, southern Charlotte, Lee, and Collier Counties. Imagery from 1921 continues to indicate high patches of chlorophyll ($>20 \mu\text{g/L}$) offshore of Sarasota and Manatee Counties, with a central location of 27° 22'48"N, 82° 40'35"W and offshore of northern Pinellas County (20 $\mu\text{g/L}$) with a central location of 27° 42'26"N, 82° 54'31"W. Continued sampling is recommended. Due to technical difficulties, the imagery shown is dated 10/20.

Dead fish were reported around Sanibel Island in Lee County this past week. Northerly and northeasterly winds throughout the weekend will minimize impacts along the coast. Continued northerly transport and stratification is expected.

* Kellie Fisher



Satellite chlorophyll image with possible HAB area shown by red polygons. Cell concentration categories and corresponding cell count range from Florida Fish and Wildlife Research Institute. The key below cell concentration description table indicates the maximum cell concentration sampling date from October 25-November 1 down a red square (high) and orange (medium), red diamond (low to medium), and yellow circle (very low to yellow-green) (very low), green circle (green), and black "x" (not present).



Wind speed and direction are averaged over 10 hours from five measurements. Length of the indicator (spike) indicates direction. An indicator that the wind direction turns spinning near the coast (Venus) is in the left of the indicator bar or nearest value; color is the right measurement.

Wind speed will be mild today, favoring some scum development, although this may be moderated by mostly overcast conditions. Winds up to 10 knots may lead to patchy scums over the next few days. Winds will be mostly northerly Tuesday and Wednesday, favoring southerly transport toward the Florida coast. This stratifies blooms in Sarasota Bay conditions. No other blooms are evident in the central basin and eastern basin.

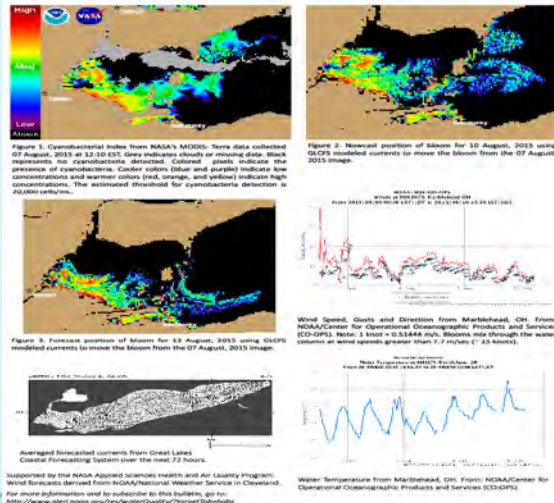
SW Florida: Northerly winds today at 10 knots (5 m/s), strengthening this evening to 15 knots (8 m/s). Northeasterly winds up today through Sunday at 15-20 knots (8-10 m/s). Easterly winds on Monday at 20 knots (10 m/s).

Experimental Lake Erie Harmful Algal Bloom Bulletin 16 August 2015, Bulletin 09

The Microcystis cyanobacteria bloom is present across a large part of the western basin south of West Sister Island from Michigan to the islands. It extends through the islands to the NE reaching the Ontario coast east of Point Pelee. Concentrations are greatest in the western basin, decreasing somewhat through the islands to moderate levels on the Ontario coast. Scum areas were thin and patchy on Friday. Microcystis is present in this bloom, with toxin levels especially high in scums. A Recreational Public Health Advisory has been posted for Maumee Bay State Park by Ohio EPA.

Winds will be mild today, favoring some scum development, although this may be moderated by mostly overcast conditions. Winds up to 10 knots may lead to patchy scums over the next few days. Winds will be mostly northerly Tuesday and Wednesday, favoring southerly transport toward the Ohio coast. This stratifies blooms in Sandusky Bay conditions. No other blooms are evident in the central basin and eastern basin.

Please check Ohio EPA's site on harmful algal blooms for safety information: <http://epa.ohio.gov/habpage.aspx>. Keep your pets and yourself out of the water in areas where scum is forming.



Pacific Northwest HAB bulletin

ORHAB Sampling Sites

Surface Currents

Winds - NDBC Buoy 46029

Pseudo-nitzschia Totals

Modeled Surface Currents

Columbia River Model Output

Pseudo-nitzschia Species

As of August 31, 2007, Pseudo-nitzschia totals are subdivided into the following species groups identified by light microscopy: *seriata*, *plum*, *plum/pungens*, *multicauda*, *polysphaera*, *caudata*, *caudata/seriata*, *delicatissima*, *caudata*.

Threshold levels of each group at various toxin ratings is done as shown in a colored horizontal bar in the Pseudo-nitzschia species graph.

Twice-weekly phytoplankton sampling (for up to 40 HAB toxin sites to monitor data at each site) indicates that numbers of a few at Coquille and Quinaltco beaches exceeded the threshold level of 50,000 cells/L on 8/16/07. Toxin testing of seawater and shellfish by BLSA showed no dangerous levels of domoic acid on that date. Pseudo-nitzschia numbers decreased since 8/16/07 and there is no further need for toxin testing.

Currents at the present time (both modeled and measured) indicate a well developed upwelling system. Cool water is evident all along the coast, indicating upwelling, in the model file. Other plots indicate that the Juan de Fuca eddy now well developed (i.e., offshore) has moved around the eddy.

Satellite-derived chlorophyll (a proxy for phytoplankton) at the sea surface indicates extensive chlorophyll blooms along the coast and at the perimeter of the Juan de Fuca eddy. Surface currents are flowing generally southwest at speeds of 30-50 km per day, as seen in the surface drifters currently deployed in the Juan de Fuca eddy. Drifters permit the entire Washington shelf in less than a week. As shown by the drifters, surface currents would generally be moving phytoplankton slightly offshore, away from the coast as they move southward along the coast, so that a HAB event from the Juan de Fuca source region is unlikely on the Washington coast as long as the winds continue to be from the north. The winds are expected to continue this way for at least a week. Consistent with this pattern, the modeled Columbia plume is trending southwest off Oregon, no remnant plume is seen off the Washington coast at this time.

Microcystis
Demonstration: Lake Erie summer 2015
(National Centers for Coastal Ocean Science and Great Lakes Environmental Research Laboratory)

Opportunity: Expand HAB forecasting

- NCCOS is funding research in support of pilot regional HAB forecasts in the following areas
 - The Gulf of Maine (Alexandrium)
 - The Pacific Northwest (Pseudo-nitzscha) including Puget Sound (Alexandrium)
 - Southern California (Pseudo-nitzschia).

- 
- Data
 - Analysis
 - Forecast

Opportunities to integrate data on environment, health.

- Expand globally?
- Integrate other sources of environmental data (e.g. local coastal sampling—monitoring and response)

Challenge:

Need improved communication and coordination among agencies and stakeholders to develop consistent messaging and response.

Opportunity:

Extensive communication among agencies and stakeholders (Algae-L and others) 

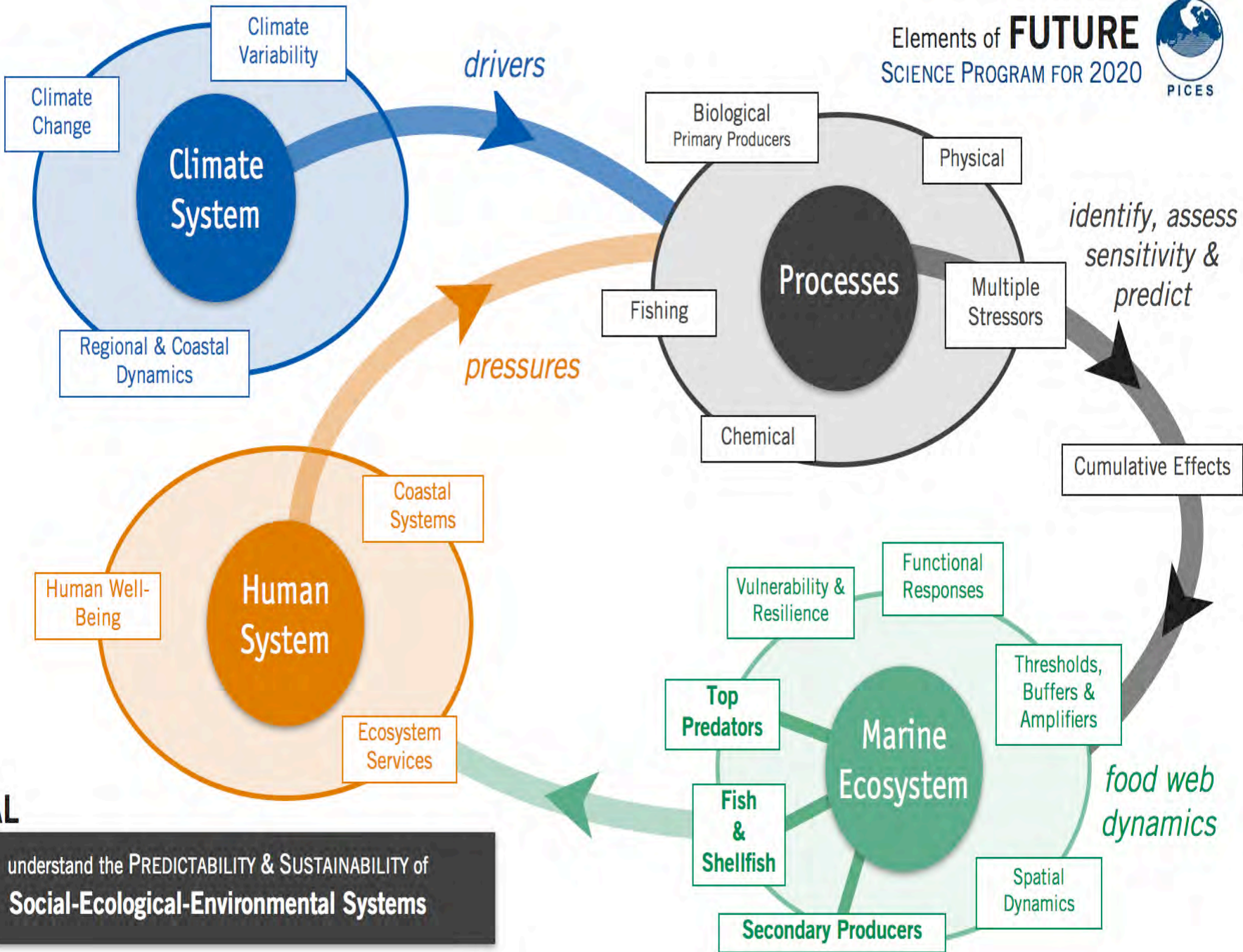
Opportunities

- Share knowledge
- Extend communication to coordination
- Build on HARRNESS (Harmful Algal Research & Response National Environmental Science Strategy)
 - Create global monitoring network
 - Create global access to resources for taxonomy, toxin analysis
 - Global Ciguatera Strategy (UNESCO)
 - Demonstrate need for toxin standards

Opportunity: This meeting!

- Important environmental issue with human dimensions components
 - One Health
 - Social well-being
 - Coastal community economies
- Need a multidisciplinary approach to identify, assess, and respond to mitigate “harm”
 - Strengthen existing and build new multidisciplinary partnerships

Current challenges = future opportunities



GOAL

understand the PREDICTABILITY & SUSTAINABILITY of
Social-Ecological-Environmental Systems

Thank you.

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