Chesapeake Bay Harmful Algal Blooms Overview of Emerging Issues

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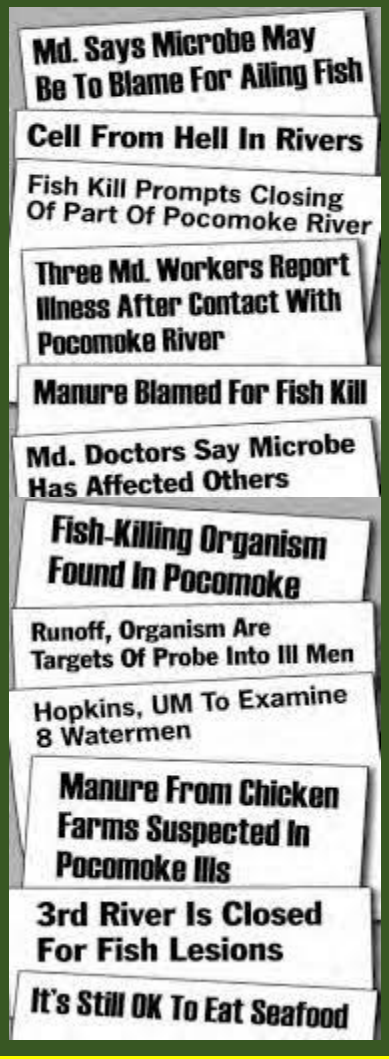
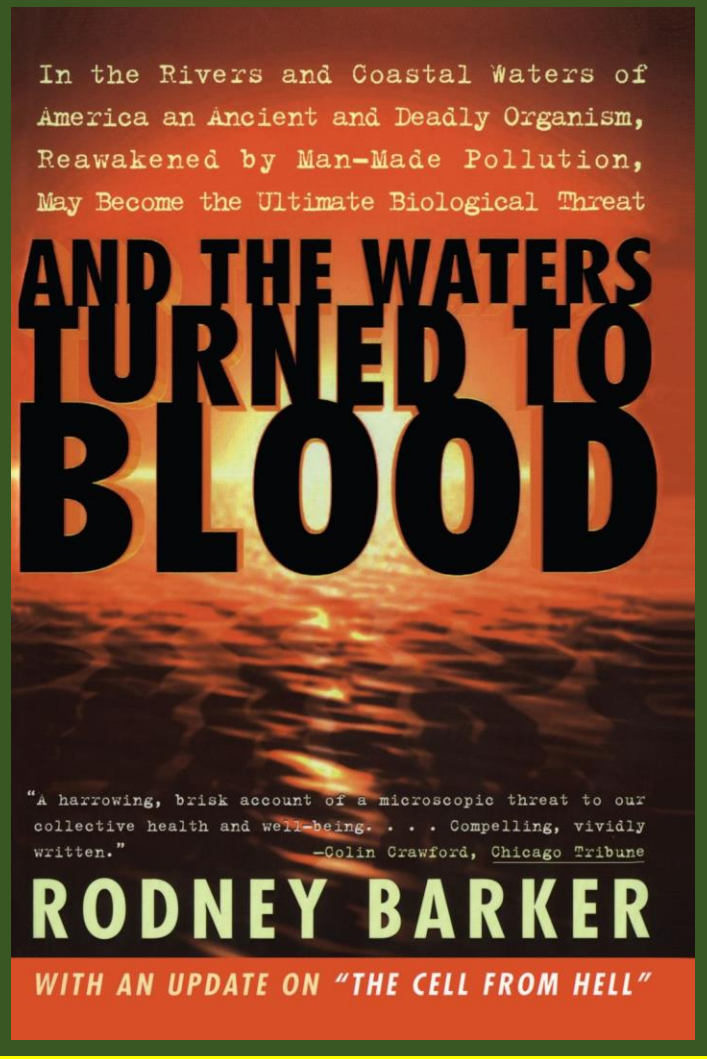
Toxics WG meeting

2/13/2019

1990s/early 2000s: 12 Toxin-producing phytoplankton recognized for Chesapeake Bay (Marshall 1996)

- Diatoms:
  - *Amphora coffeaformis*
  - *Pseudo-nitszschia pseudodelicatissima*
  - *P. seriata,*
  - *P. multiseries* (pre-1985)
- Dinoflagellates:
  - *Cochlodinium heteroblatum*
  - *Dinophysis acuminata, D. acuta, D. caudata, D. fortii, D. norvegica,*
  - *Gyrodinium aureolum*
  - *Pfiesteria piscicida*
  - *Prorocentrum minimum*
  - *Alexandrium catenella* (pre-1985)
  - *Gonyaulax polyedra* ((pre-1985)





- 708 total phytoplankton taxa recognized in our tidal waters (Marshall 1994)

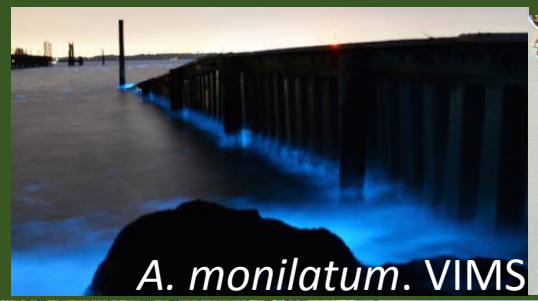
Phytoplankton diversity in Chesapeake Bay today

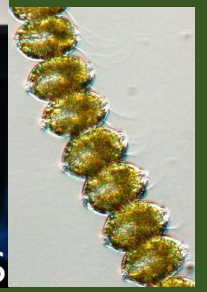
- > 1400 species (Marshall et al. 2005)
- < 2% potentially toxic
- ~1% proven toxic activity

Chesapeake Bay and Watershed HABs: What's new?

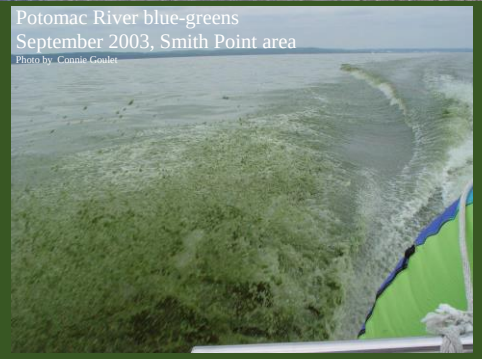
- Diatoms: Didymo (aka Rock snot) Ecosystem disruptor (nontoxic)
- Toxic dinoflagellates
  - *Alexandrium monilatum* (oyster/fish killing toxins in Chesapeake Bay)
  - *Karlodinium micrum* (fish tissue dissolves)
- Raphidophytes (2+ possibly toxic spp.)
- Not previous described among the potentially toxic plankton community
  - Cyanobacteria
    - *Microcystis aeruginosa* (Hepatotoxic)
    - *Anabaena* spp. (Neurotoxic)
    - *Aphanizomenon* (Hepato+Neurotoxic)
    - *Cylindrospermopsis* (Hepatotoxic)


Rock snot CBP


A. monilatum. VIMS




A. monilatum. York River, VIMS



- ~~708 total phytoplankton taxa recognized in our tidal waters (Marshall 1994)~~
- UPDATE: 1434 total phytoplankton taxa recognized (Marshall et al. 2005)

STUDY SHOWS HARMFUL ALGAL BLOOMS IN CHESAPEAKE BAY ARE MORE FREQUENT

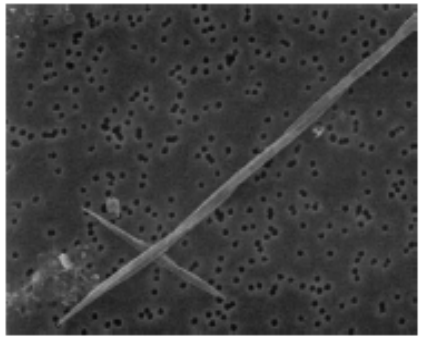
June 1, 2015

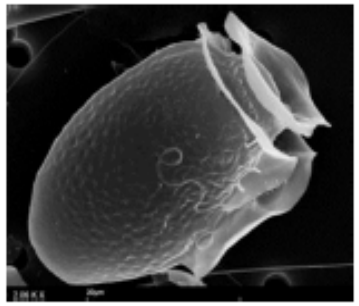
Horn Point Laboratory

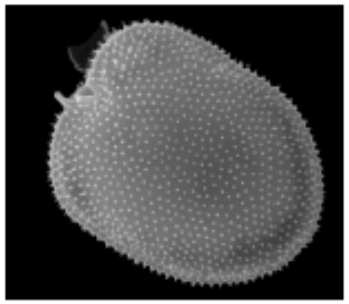
A recent study of harmful algal blooms in the Chesapeake Bay and its tributaries by the University of Maryland Center for Environmental Science show a marked increase in these ecosystem-disrupting events in the past 20 years that are being fed by excess nitrogen runoff from the watershed. While algal blooms have long been of concern, this study is the first to document their increased frequency in the Bay and is a warning that more work is needed to reduce nutrient pollution entering the Bay's waters.

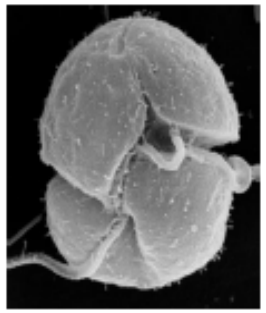
Blooms: Species importances range across all seasons.

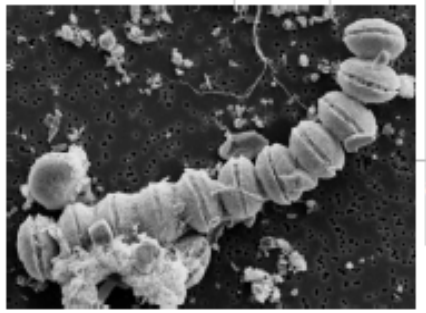
Seasonal bloom succession in Virginia

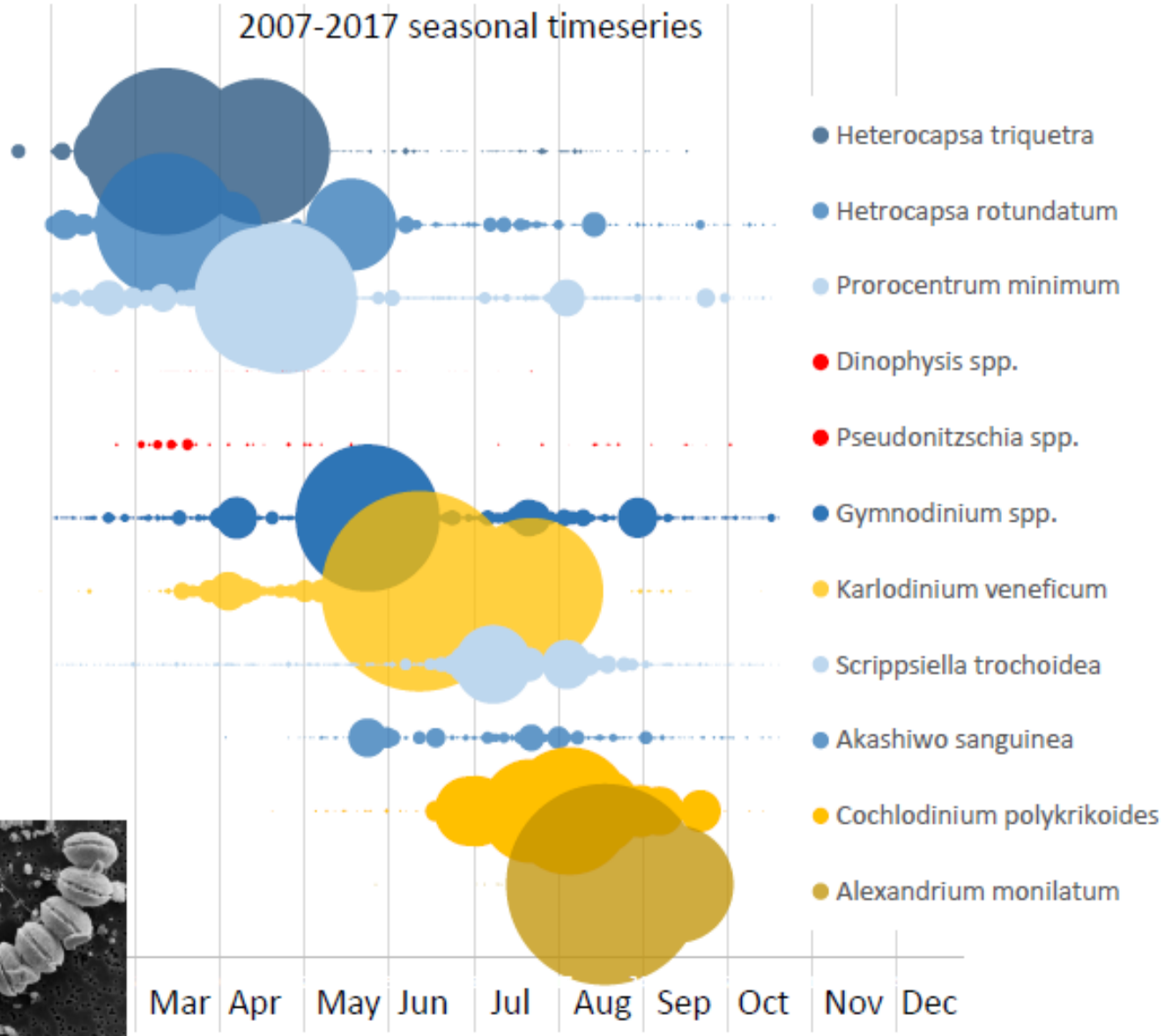












We have potentially toxic plankton species. Are they actively toxic? Where, when, how often?

Bloom and crab jubilee


Karlotoxin associated fish kill
Corsica River 2005

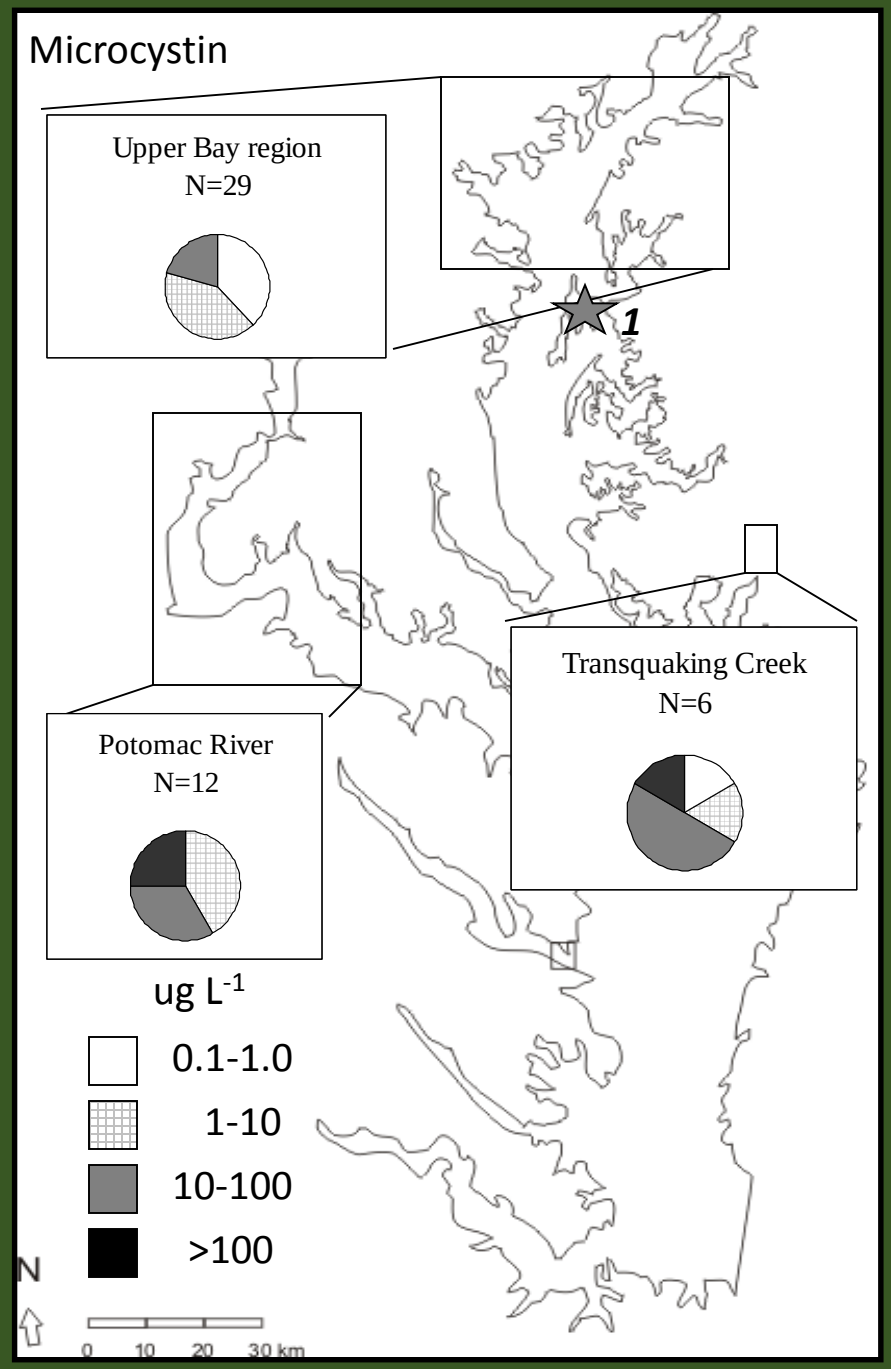

Toxic bloom and bird deaths:

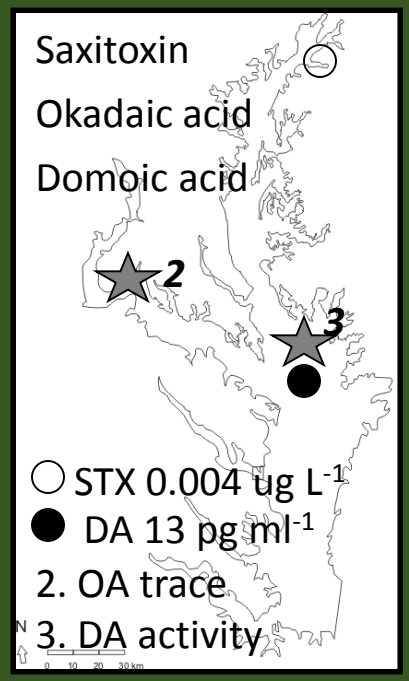
Early cyanotoxin history in the bay region

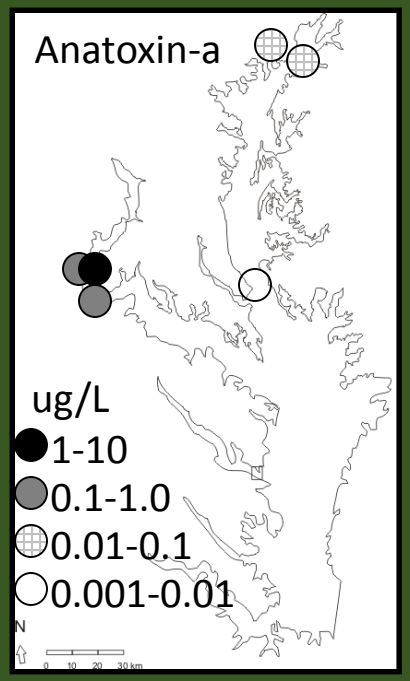
• Tisdale (1931a,b) and Veldee (1931) *Am. J. Public Health*: describe a regional epidemic of water-borne gastroenteritis in 1930-31, related to 'a chemical irritant' in the water, and associated with algae blooms including the Potomac River drainage near Washington, DC; the authors refer to the musty taste and odors of the water among rivers.

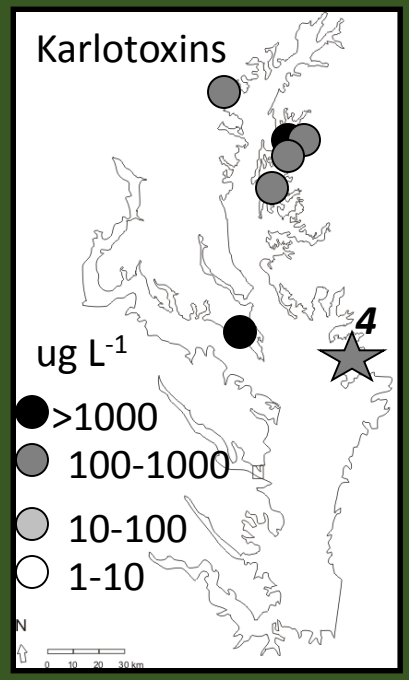
Tisdale (1931a) noted heavy blooms were made up of 'algae'; algae in the second paper referred to blue-greens.

• In 1975, endotoxic shock of 23 dialysis patients in Washington, DC, was attributed to a cyanobacterial bloom in a drinking water reservoir (WHO 2003).



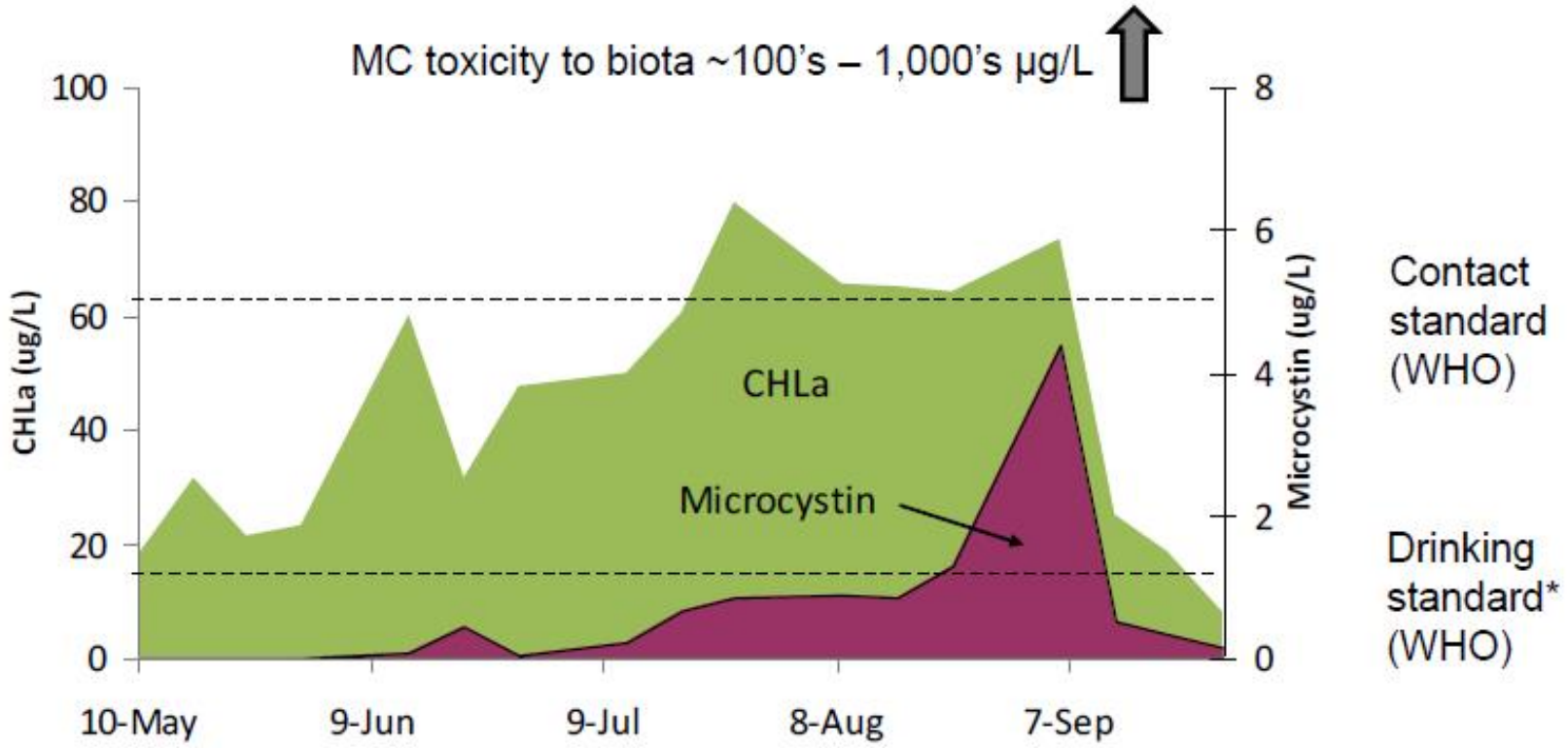






Source: Tango and Butler 2008

CHLa & Microcystin in the James

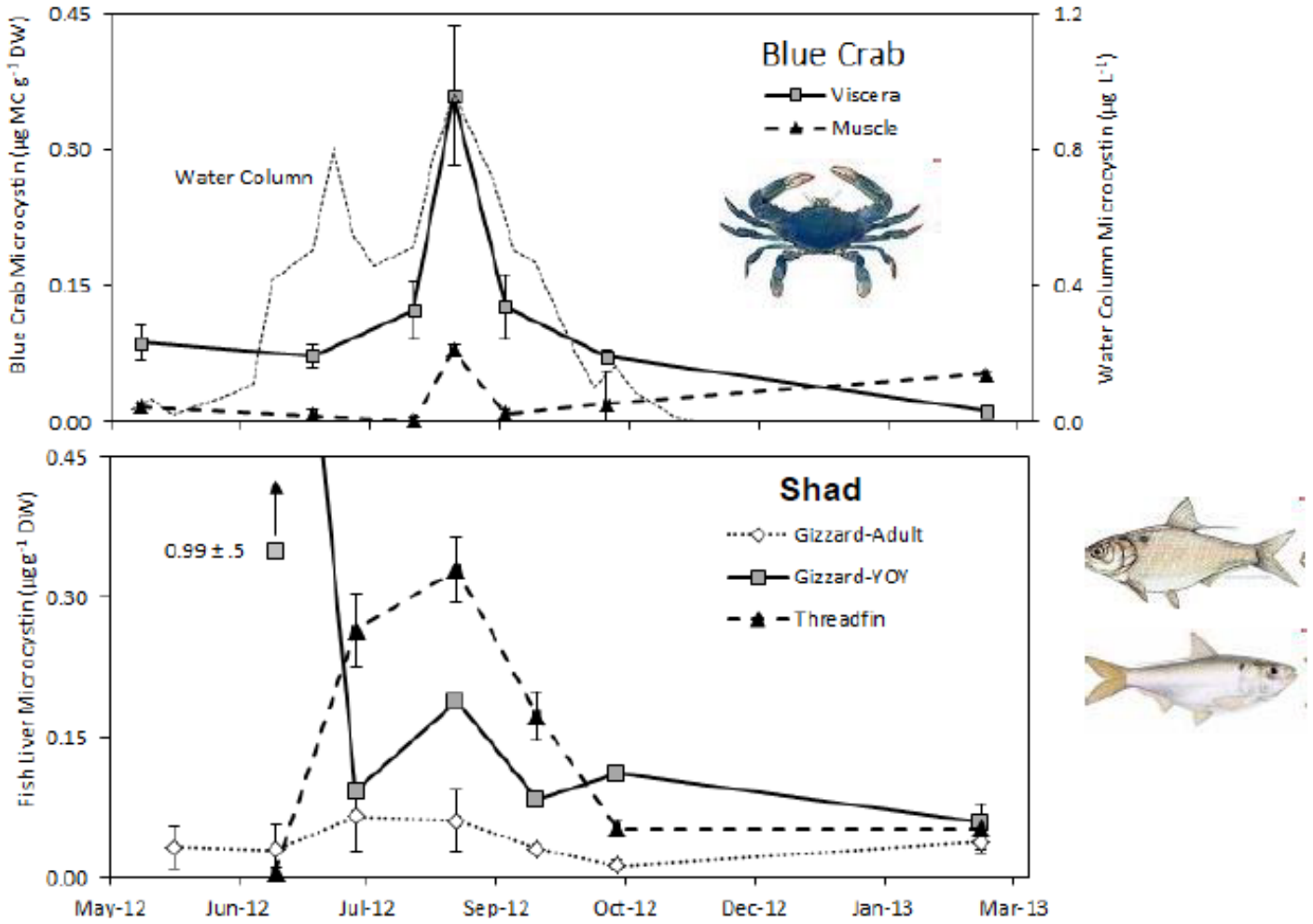


CHLa and cyanotoxins in the James River during 2011.

*for treated water

Source: P. Bukaveckas. 2016. Cyanotoxins in the James River.
Results from Research and Monitoring: http://www.vdh.virginia.gov/content/uploads/sites/12/2016/12/PaulBuk_2016HAB_VCU.pdf

Research on Microcystin in Food Webs



Source: P. Bukaveckas. 2016. Cyanotoxins in the James River.
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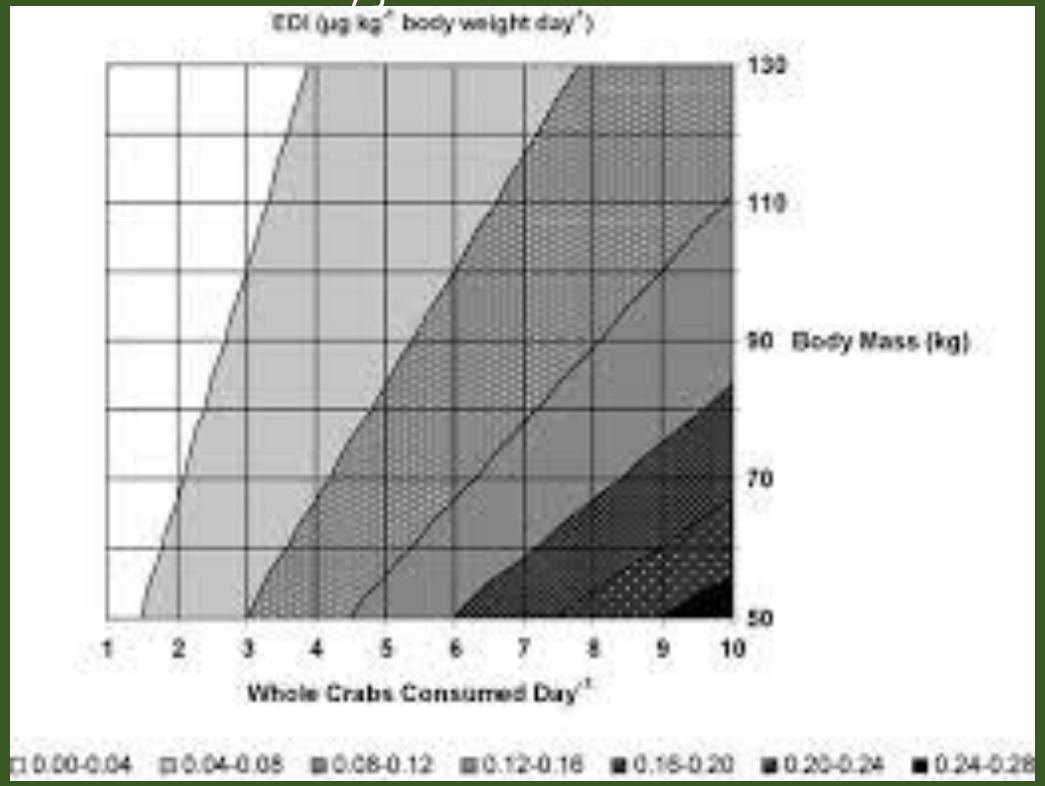
Food consumption risks:

E.g., Garcia et al. 2010. Evaluating the potential risk of microcystins to blue crab (*Callinectes sapidus*) fisheries and human health in a eutrophic estuary. February 2010. Harmful Algae 9(2):134-143.
DOI: 10.1016/j.hal.2009.08.011



Consumption risk profile

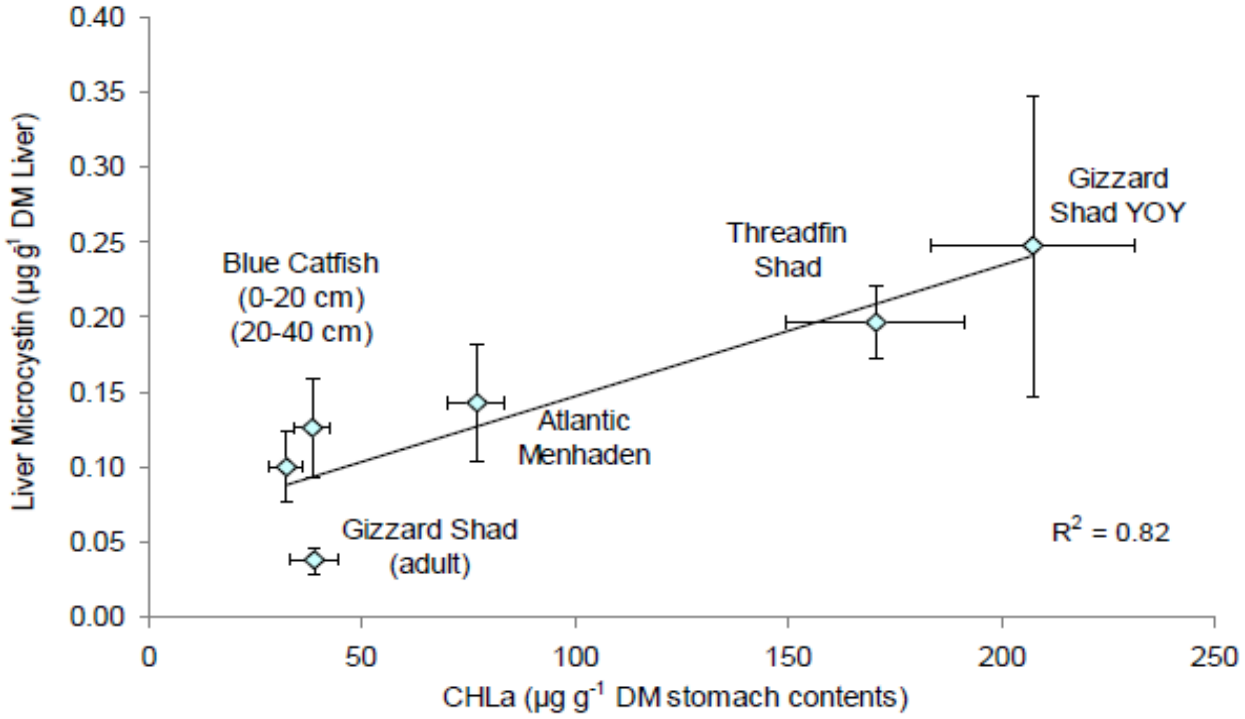
- EDI (Estimated daily intake)
- Body mass of person eating toxic crabs.
- Number of crabs consumed per day
- Shading = Microcystin levels in crab tissues

Most cyanobacteria produce **β-Methylamino-L-alanine**, or **BMAA.**

- BMAA is a neurotoxin and its potential role in various neurodegenerative disorders (e.g. ALS ("Lou Gehrig's Disease" and Parkinkson's Disease) is the subject of ongoing scientific research.

- Field et. al. 2013. **Linking β-methylamino-L-alanine exposure to sporadic amyotrophic lateral sclerosis in Annapolis, MD.** Toxicon. 2013 Aug;70:179-83. doi: 10.1016/j.toxicon.2013.04.010. Epub 2013 May 6.
  - "One common factor among the ALS patients was the frequent consumption of blue crab. Samples of blue crab from the patients' local fish market were tested for BMAA using LC-MS/MS. BMAA was identified in these Chesapeake Bay blue crabs. We conclude that the presence of BMAA in the Chesapeake Bay food web and the lifetime consumption of blue crab contaminated with BMAA may be a common risk factor for sporadic ALS in all three patients."

Microcystin in the Food Web – Why are some taxa more vulnerable than others?



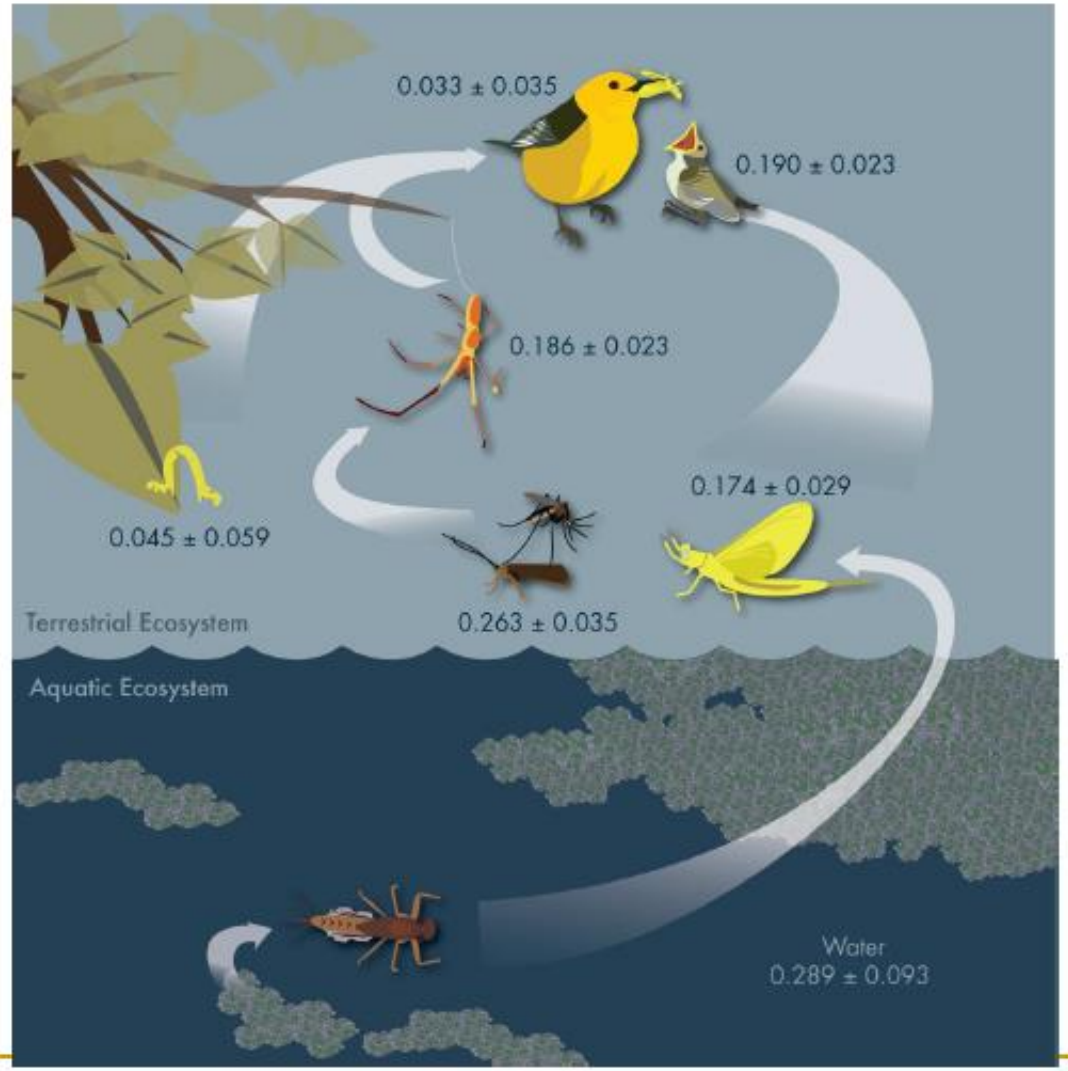
Fish that feed in the w e toxin, then those feeding on the bottom

Source: P. Bukaveckas. 2016. Cyanotoxins in the James River.
Results from Research and Monitoring: http://www.vdh.virginia.gov/content/uploads/sites/12/2016/12/PaulBuk_2016HAB_VCU.pdf

Export of Algal Toxins to Riparian Food Webs

Emerging aquatic insects (mayflies) were found to contain algal toxins, which are then ingested by terrestrial consumers.

Moy et al. 2016



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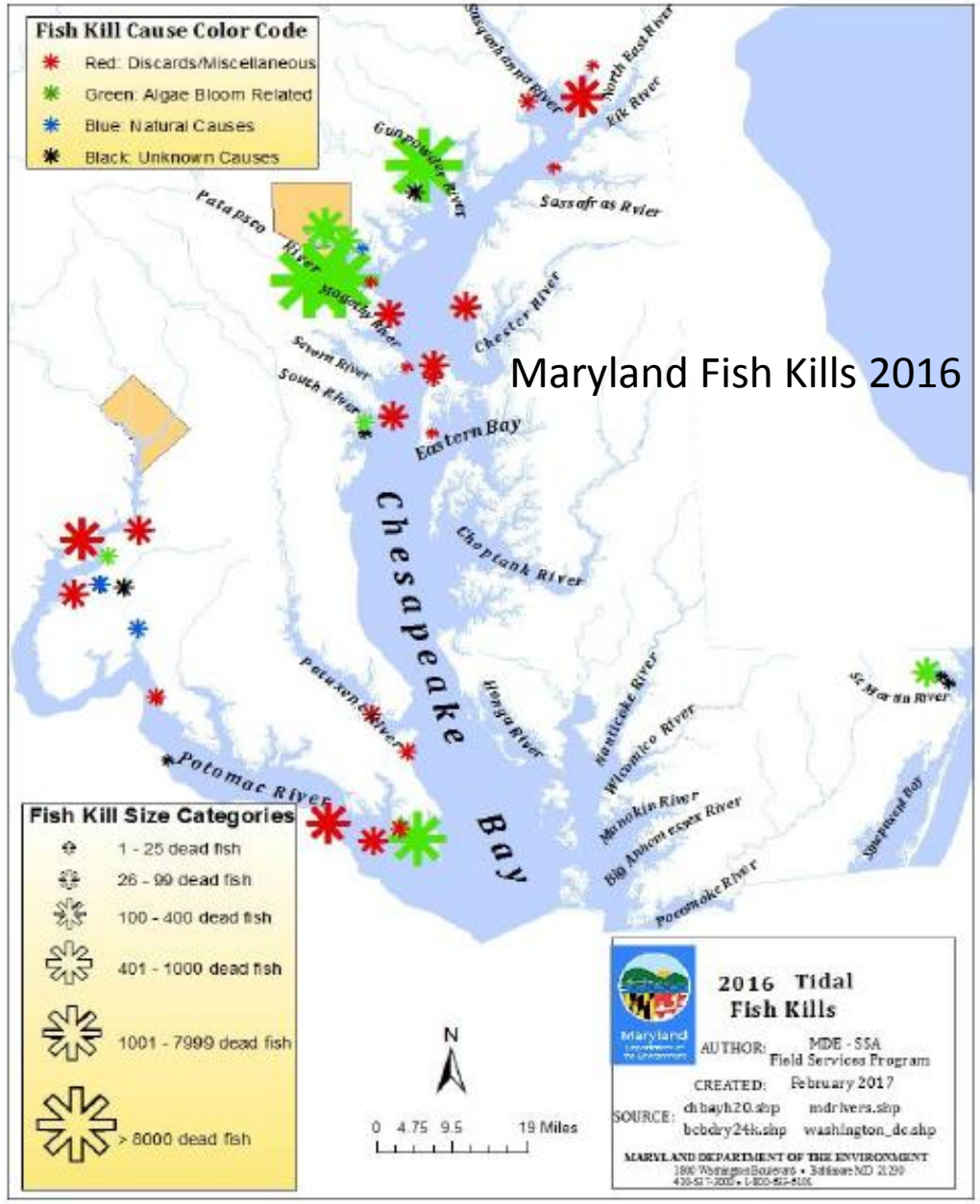
Harmful Algal Blooms and Bird Die-offs in Chesapeake Bay: A Potential Link?

Barnett A. Rattner, Glenn H. Olsen, Peter C. McGowan, Betty K. Ackerson, and Moira A. McKernan.
USGS-Patuxent Wildlife Research Center and Fish and Wildlife Service, Chesapeake Bay Field Office

https://www.pwrc.usgs.gov/health/Rattner/rattner_blackwaternwr.cfm

Figure 3: Distribution of fish kills throughout Maryland tidal waters.



MDE

Relative importance of toxic algal blooms for fish kills 1984-2016 Maryland

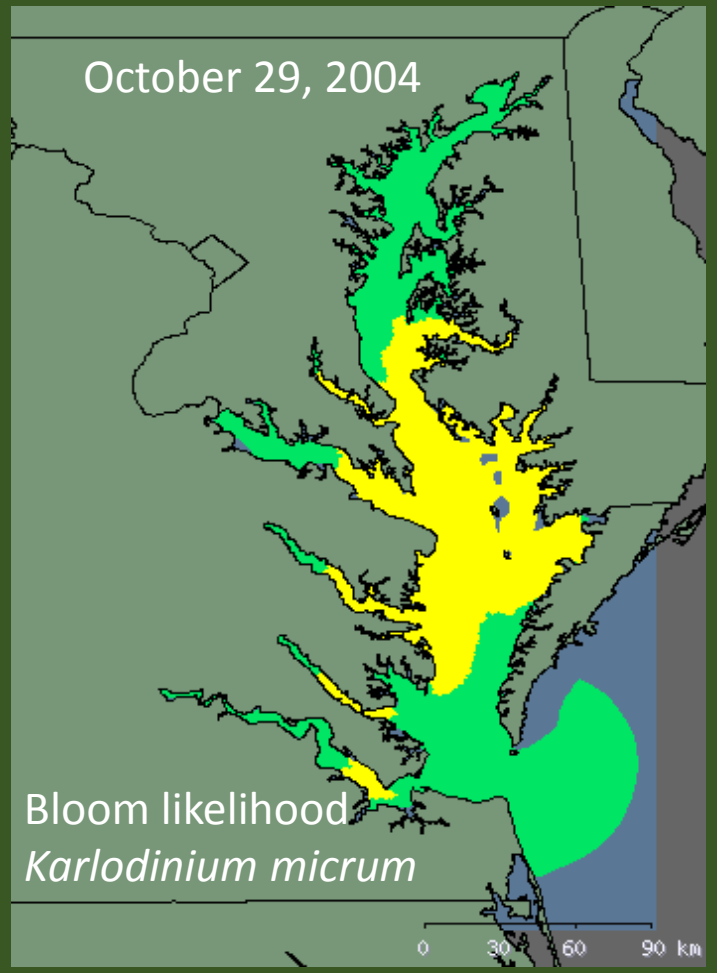
Table 2: Probable causes of fish kill reports, 2016.

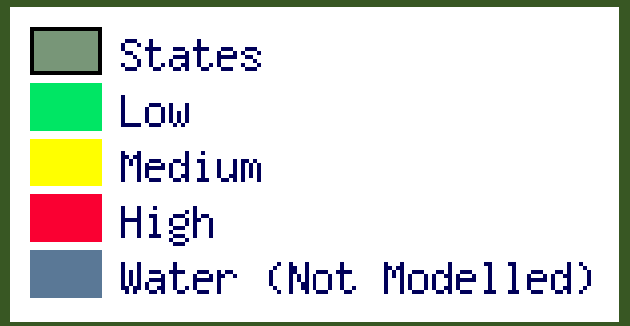
Probable cause	2016 Only	*Percent of Annual Total*	# of Reports 1984-2016	*Percent of Historic Total*
Natural	25	37.88%	1432	40.90%
Disease	1		235	
Low dissolved O_2	13		834	
Seasonal / Spawning stress	5		224	
Stranding	4		65	
Salinity shock	0		3	
Thermal shock	0		28	
Toxic algae bloom	1		22	
Toxic algae/water quality synergism	0		16	
Storm surge	0		1	
Predation	1		4	
Pollution	2	3.03%	283	8.08%
Agriculture	0		32	
Municipal sewage	0		46	
Industrial discharge	0		52	
Swimming pool discharge	0		19	
Fuel/Oil spills	0		30	
Unidentified source	0		54	
Construction	0		11	
Municipal discharge	1		25	
Pond Management chemicals	1		14	
Miscellaneous	24	36.36%	733	20.94%
Discards	24		515	
Entrapment	0		146	
Stocking stress, pond Mgmt.	0		64	
Scientific discards, exotic species control	0		8	
Unknown	11	16.67%	805	22.99%
Non-kill	4	6.06%	248	7.08%
TOTAL	**66**		**3501**	

MDE Fish Kill Report for 2016

Developing Predictive Models for Possibly Toxic Bloom Species

http://coastwatch.noaa.gov/cbay_hab/index.phtml#map





"The annual occurrences of *Karlodinium veneficum* blooms have increased significantly… from 2003 to 2008. These blooms, also found worldwide, are more likely in the summer, produce a toxin that has been implicated in fish-kill events in the Chesapeake Bay, as well as associated with failure of oyster spawning and development."

UMCES 2015, Glibert , others.

Also: Anderson et al. 2010. Predicting potentially toxigenic *Pseudo-nitzschia* blooms in the Chesapeake Bay. J. Marine Systems.

Toxin-producing HAB impacts: Risk areas of interest

Cyanobacteria blooms

- Historical impacts on water supply and human health (Tisdale 1931, Veldee 1931, WHO results)
- 2000-2004: Multiple beach closures in MD (Tango and Butler 2008)
- Microcystin in the food web, James R, Virginia, low impact to date. (Wood et al, Moy et al.)
- BMAA/Food web links of interest.

Dinoflagellates

- *Dinophysis acuminata* bloom 2003: Potomac River shellfish bed closure (Tango et al. 2004)
- *Karlodinium micrum* – diverse years; widespread occurrence, infrequent fish kills.
- *Pfiesteria piscicida* – late 1990s, early 2000s. Neurotoxic events, fish kills, human health effects?
  - Morris et al. 2006. **Occupational Exposure to *Pfiesteria* Species in Estuarine Waters Is Not a Risk Factor for Illness.** Environ Health Perspect. 2006 Jul; 114(7): 1038–1043. doi: 10.1289/ehp.8627.
- *Prorocentrum minimum* – toxic bioassays but not direct field toxicity. Various crab jubilees and fish kills associated with large blooms of P. minimum across time. No recent toxic activity.
- *Alexandrium monilatum* - Oyster kills, lab fish/shellfish kills. Unknown full field effects.
- ***Ciguatera Fish Poisoning in VA? Fish brought in from FL, not locally sourced issue.