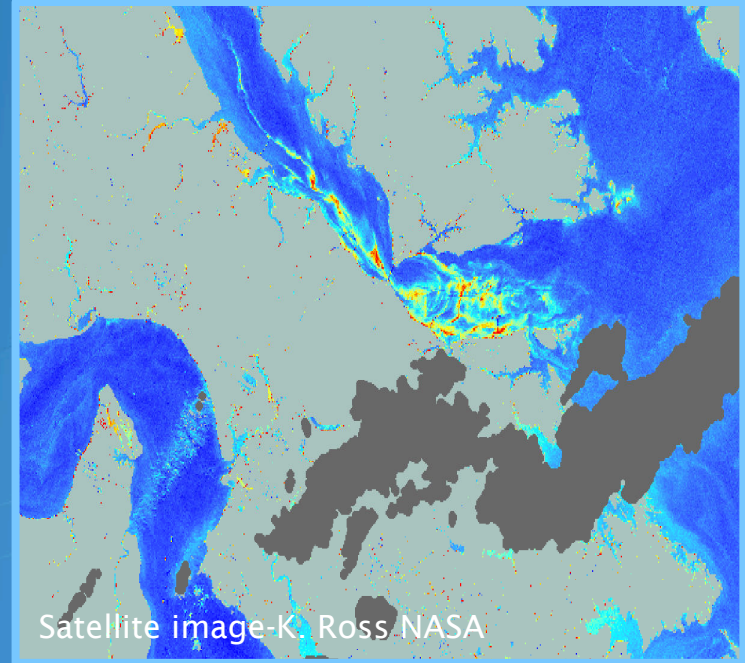


2016 HAB Season: VIMS Report



Photo by W. Vogelbein



Satellite image-K. Ross NASA

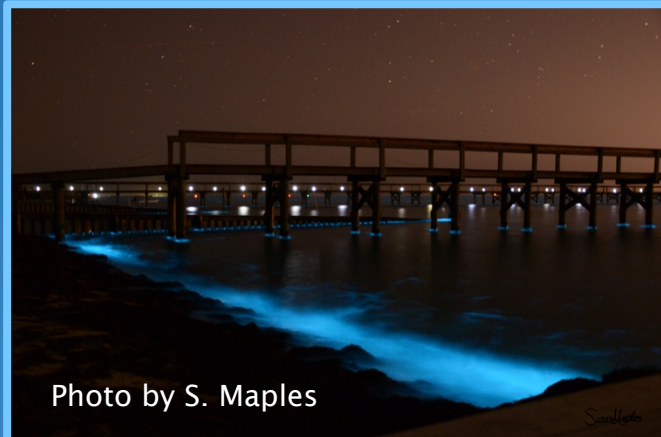
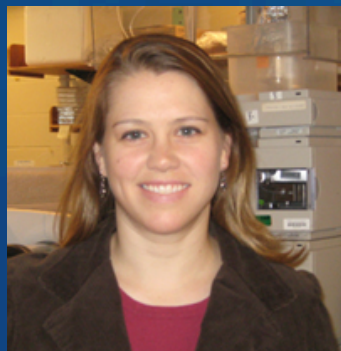


Photo by S. Maples

VIMS HAB Group



Juliette Smith



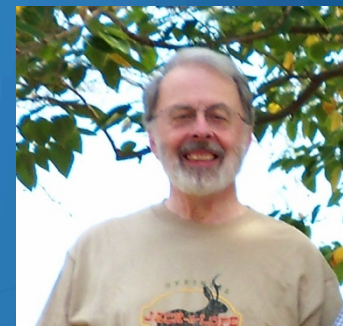
Ryan Carnegie



Kim Reece



Wolf Vogelbein



Tom Harris



Gail Scott



Patrice Mason



Bill Jones



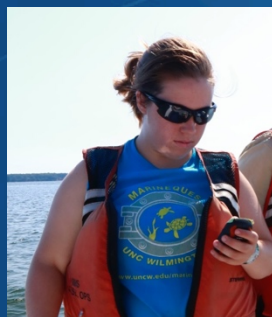
Alanna
MacIntyre



Marta
Sanderson



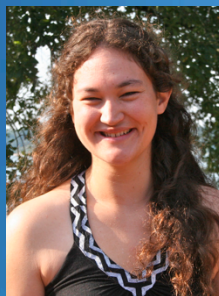
Rita Crockett



Shannon Jones



Clara Robison



Sarah Pease



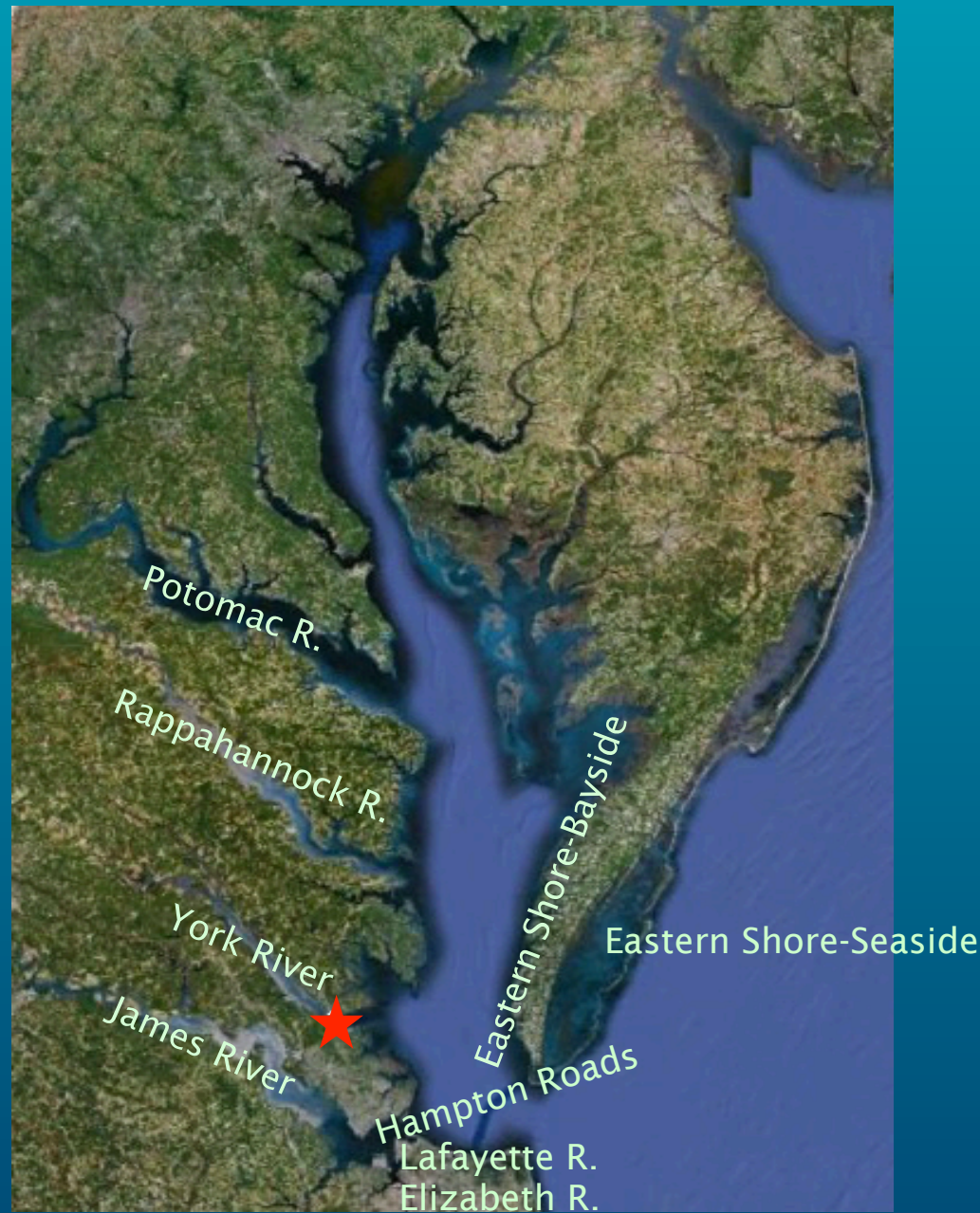
Blake Ivey



Leigha Stahl



Taylor
Armstrong



2016 Notable HAB Blooms

- Feb 22: Tarkill Creek Eastern Shore Bayside – Oysters with green gills, *Heterocapsa triquetra* 215 cells/ml
- Feb 24: Cherrystone Creek *Dinophysis* sp.– 10 cells/ml
- March 10: Rappahannock River *Heterocapsa rotundata* bloom - ~75,000 cells/ml
- March 13: Bioluminescence in Yorktown, *Karlodinium veneficum* 64 cells/ml, *Prorocentrum micans* 215 cells/ml, *Scrippsiella trochoidea*, *Heterocapsa triquetra*, *Protoperidinium* sp., *Mesodinium rubra*
- April 4: Rappahannock River *K. veneficum* 6,104 cells/ml
- April 4: Milford Haven near Gwynn's Island *K. veneficum* 12,460 cells/ml
- July 20: Sarah's Creek off of the York River: *Vicicitus globosus* (= *Chattonella globosa*) ~435,000 cells/ml

2016 Notable HAB Blooms (cont.)

- Aug-Sept- *C. polykrikoides* and *A. monilatum* bloom-details to follow
- Sept 17: Piankatank River – citizen reported reddish water, sample collected 9/19 *A. monilatum* = 2,050 cells/ml
- Sept. 19: Windmill point near the mouth of the Rappahannock, sample collected 9/21 *A. monilatum* = 921 cells/ml

2016 Notable Fish/Shellfish Mortalities

- May 4: Seaside Eastern shore-oyster veliger mortality. No evidence of a bloom. *K. veneficum* =1 cell/ml
- May 9: Bayside Eastern Shore, Nandua Creek - adult triploid oyster mortality. *Prorocentrum* spp. 350 cells/ml, *K. veneficum* 225 cells/ml
- May 12: Bayside Eastern Shore, Nandua Creek - adult triploid oyster mortality. *Prorocentrum* spp. 10 cells/ml, *K. veneficum* 27 cells/ml
- June 2: Potomac River, Colonial Beach – Fish kill and *Prorocentrum minimum* bloom 63,400 cells/ml
- Aug. 4: Seaside Eastern Shore, Tom's Cove in Chincoteague- adult triploid oyster mortality. *P. minimum* 211 cells/ml
- Aug. 15: Dandy Point mouth of the York River-oyster spat mortality observed-reported to VIMS on Aug. 19. *C. polykrikoides* ~3,000's cells/ml, *A. monilatum* ~100 cells/ml in samples collected 8/11 and 8/12

2016 Notable Fish/Shellfish Mortalities (cont.)

- Aug. 24: Dandy Point mouth of the York River-oyster spat mortality collected ~50% mortality.
- Aug. 24: Ware River (Mobjack Bay trib) mouth - Fish kill reported.
- Aug. 25: Ware River mouth – Ray kill reported. VDH collected water samples
- Aug. 30: Dandy Point mouth of the York River-additional oyster spat mortality ~90-95% mortality. *A. monilatum* = 3,400 cells/ml
- Sept. 9: Yeocomico River – Citizen reported dead crabs, DEQ responded.

Adult Oyster Exposed to *A. monilatum*



Morten Svendsen- student from U
Copenhagen



C. polykrikoides and *A. monilatum* Bloom Progression

2012

C. polykrikoides: July 18 – Aug. 7 (York, persisted in the James and Rapp through early Sept.)

A. monilatum: Aug. 24 – Sept. 14 (York region)

2013

C. polykrikoides: July 26 – Aug. 25 (Lower James early Sept.)

A. monilatum: Aug. 30 – Sept. 10 (Primarily York, but expanding)

2014 (Very low bloom year)

C. polykrikoides: July 1 – Lafayette River – 6,272 cell/ml

July 30 – Aug. 13 - bloom in the James mesohaline (1,000's cells/ml)

A. monilatum: - <1 cell/ml in all samples

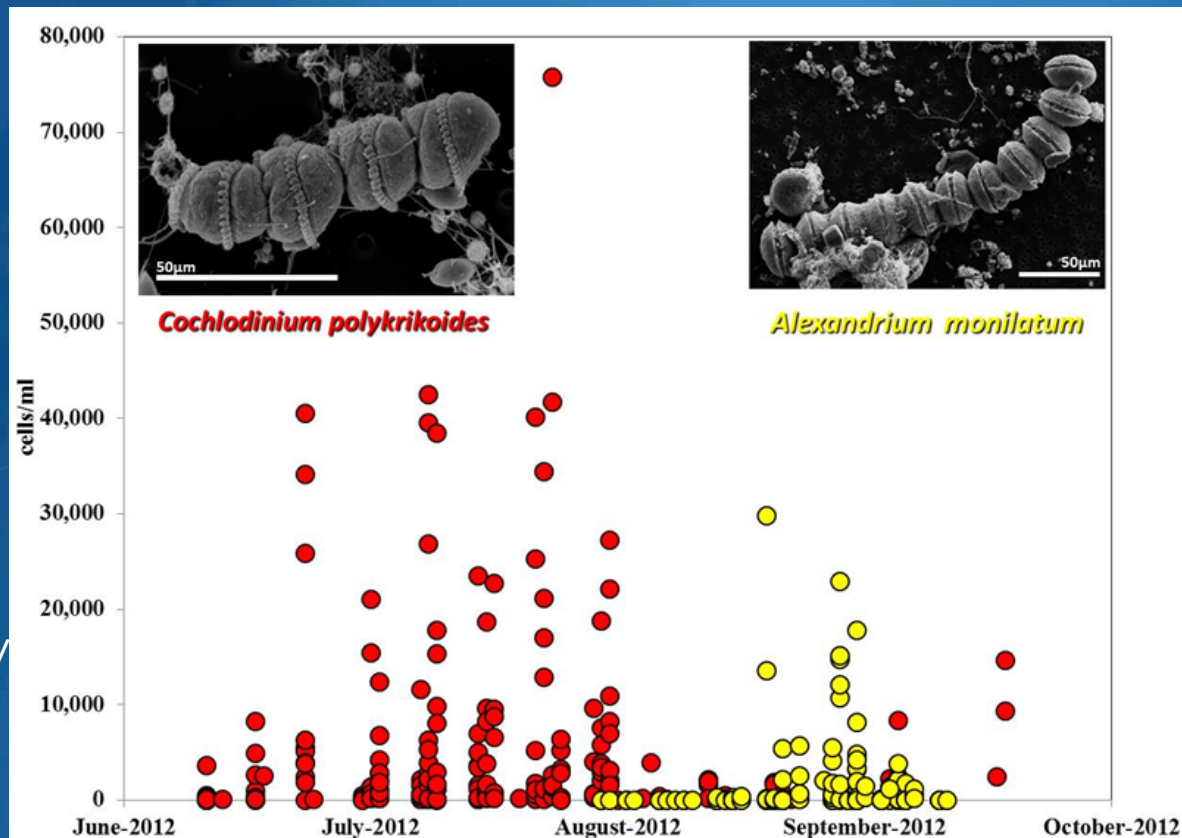
2015

C. polykrikoides : July 16-August 10 (20,000 -45,000 cells/ml)

A. monilatum: August 6 - Sept 3. Expansion to the South-VA Beach and James River and North-Rappahannock

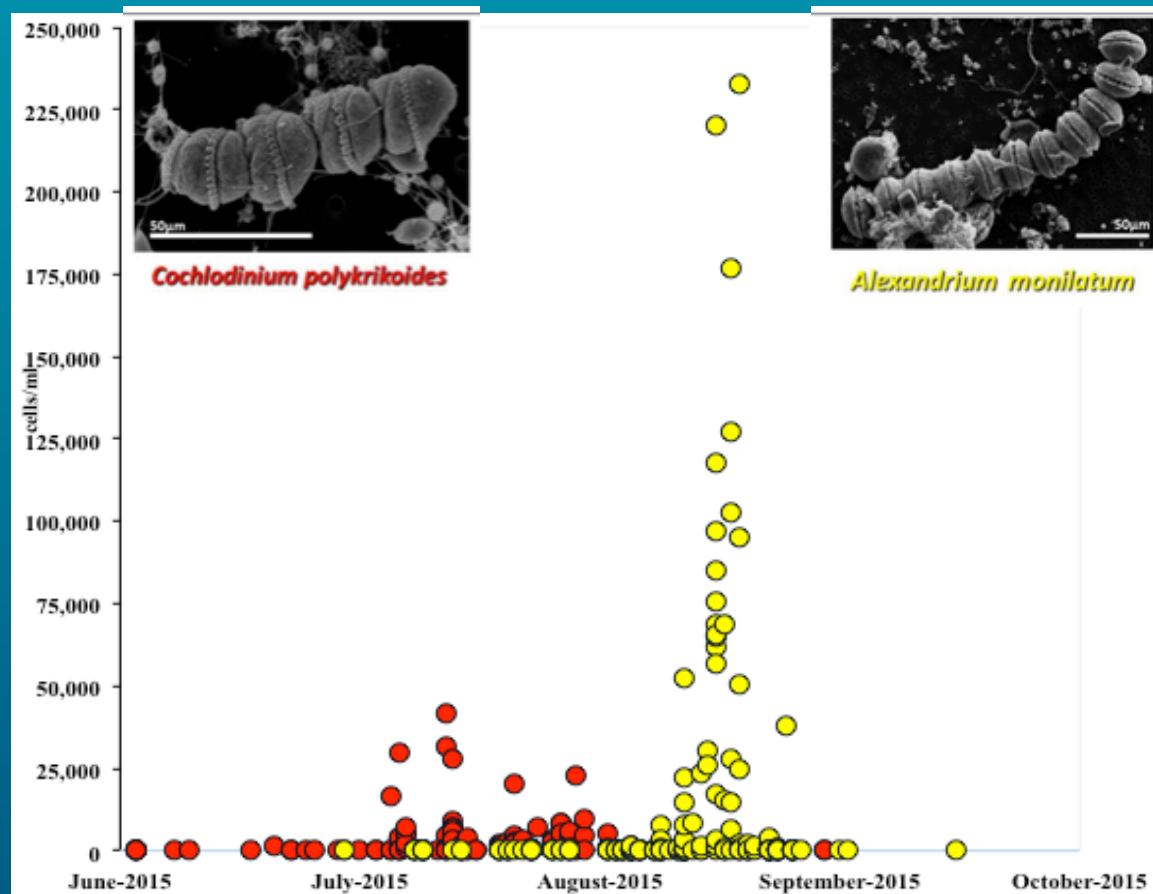
Summer York River Bloom Progression:

- *C. polykrikoides* typically starts blooming in July through August/September throughout lower Chesapeake Bay
- York River region since 2007 the peak *C. polykrikoides* bloom is followed 2-3 weeks later by the peak *A. monilatum* bloom in some locations and levels of *C. polykrikoides* drop dramatically.



Data from ODU/
Egerton and
VIMS/Reece

York River (2015)



- *C. polykrikoides* bloom late July-mid August
- *A. monilatum* late August-early September (earlier in 2015/2016 and longer in 2016)

C. polykrikoides and *A. monilatum* Bloom 2016

HAB #	Date	Location	<i>A. monilatum</i> cells/ml	<i>C. polykrikoides</i> cells/ml
294	6/20/16	Sarah's Creek		3.4
362	7/8/16	Sarah's Creek VIMS/CBF	9.2	
442	7/31/16	York River under the bridge		4,790
445	8/2/16	York River under the bridge		2,886
453	8/3/16	York River under the bridge	9.3	836
459	8/3/16	York River	12.9	1,139
470	8/4/16	York River cruise	59	2,232
471	8/4/16	York River cruise	95	1,993
472	8/4/16	York River cruise	116	1,525
473	8/4/16	York River cruise	102	1,661
474	8/4/16	York River cruise	98	1,023
491	8/8/16	VIMS hatchery	29	2,057
495	8/9/16	York River under the bridge	95	2,726
528-530	8/11/16	Goodwin Island Dandy Point	3.1	2,932
531	8/12/16	York River DF	18	2,208
535	8/12/16	York River DF	9	3,660
537	8/12/16	York River DF	80	9,040
539	8/12/16	York River DF	68	2,580
541	8/13/16	York River under the bridge	27	1,360
553	8/15/16	York River DF	293	2,924
562	8/16/16	VIMS hatchery	88	9
566	8/16/16	York River subtidal site	776	4
576	8/17/16	Rappahannock River subtidal site	1,493	0
586	8/20/16	York River under the bridge	4,793	<1
594	8/20/16	North River, Mobjack Bay	1,420	<1
596	8/20/16	Bay at mouth of York River	1,420	13
613	8/23/16	Lafayette River, Knitting Mill Creek	<1	877
614	8/23/16	Goodwin Island	7,661	2.7
616	8/23/16	York River south of bridge	7,008	0
617	8/23/16	York River DF	5,062	0
619	8/23/16	York River DF	13,640	0

Transition in
the York R.



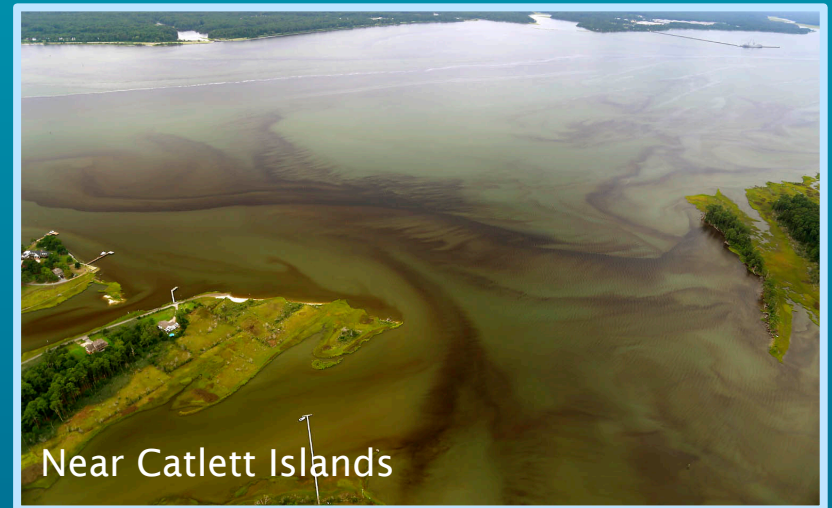
C. polykrikoides and *A. monilatum* Bloom 2016

HAB #	Date	Location	<i>A. monilatum</i> cells/ml	<i>C. polykrikoides</i> cells/ml
621	8/23/16	York River DF	2,907	0
622	8/23/16	York River DF	27,960	0
623	8/23/16	York River DF	13,636	0
624	8/23/16	York River DF	1,735	0
625	8/23/16	York River DF	44,800	0
626	8/23/16	York River DF	21,418	0
639	8/24/16	Off of Deep Creek, 24-CB7	<1	2.9
644	8/24/16	York River under the bridge	5,757	0
645	8/24/16	VIMS hatchery	1,560	0
660	8/26/16	Perrin Creek	4,260	0
663	8/26/16	Perrin Creek	7,772	0
666	8/26/16	York River Cruise	8,688	0
667	8/26/16	York River Cruise	7,004	0
668	8/26/16	York River Cruise	7,243	0
669	8/26/16	York River Cruise	10,028	0
675	8/28/16	York River under the bridge	13,165	0
677	8/28/16	Sarah's Creek, VIMS/CBF	2,880	0
678	8/28/16	York River under the bridge	14,680	0
680	8/29/16	York River VIMS beach	119,772	0
688	8/30/16	VIMS hatchery	3,878	0
689	8/30/16	Goodwin Island	3,400	0
690	8/30/16	Goodwin Island	2,283	0
698	8/30/16	York River under the bridge	5,126	0
699	8/30/16	York River, VIMS beach	61,244	0
701	8/30/16	York River DF	6,164	0
702	8/30/16	York River DF	1,007	0
703	8/30/16	York River DF	12,392	0
705	8/30/16	York River DF	15,124	0
706	8/30/16	York River DF	15,124	0
710	8/30/16	York River DF	2,928	0
713	8/31/16	Perrin Creek	4,116	0

C. polykrikoides and *A. monilatum* Bloom 2016

HAB #	Date	Location	<i>A. monilatum</i> cells/ml	<i>C. polykrikoides</i> cells/ml
717	9/1/16	York River, VIMS beach	1,755	0
773	9/9/16	Cherrystone CMON, 5-CB7	113	0
784	9/9/16	Rappahannock River	5,080	0
797	9/14/16	York River, Yorktown docks	1,082	0
799	9/14/16	York River Cruise	90,096	0
800	9/14/16	York River Cruise	16,747	0
801	9/14/16	York River Cruise	3,639	0
802	9/14/16	York River Cruise	8,159	0
803	9/15/16	York River, Yorktown docks	1,682	0
818	9/18/16	Piankatank River	2,900	0
819	9/19/16	York River under the bridge	9,340	0
838	9/19/16	Mouth of Craddock Creek, 15-CB7	1.3	0
829	9/20/16	Bay between GWR and Rappahannock	2,575	0
847	9/20/16	Off of Deep Creek, 24-CB7	7.4	0
848	9/20/16	Bay below mouth of Onancock Creek	45	0
861	9/22/17	Piankatank River	2,734	0
862	9/22/16	Piankatank River	3,046	0
864	9/23/16	Bay south of Goodwin Island	2,170	0
865	9/23/16	Bay south of Goodwin Island	6,880	0
885	9/26/16	Hungar's Creek, ES	4	0
886	9/26/16	Cherrystone Creek	22	0
911	10/3/16	Bay south of Savage Neck Dunes, 6-CB7	1.6	0
912	10/4/16	Bay, north of Hungar's Creek, 7-CB7	1.5	0
915	10/4/16	Nassawadox CMON, 10-CB7	1.3	0

C. polykrikoides- Aug. 5, 2016



York River



Elizabeth River

Photos by W. Vogelbein

C. polykrikoides- Aug. 10, 2016



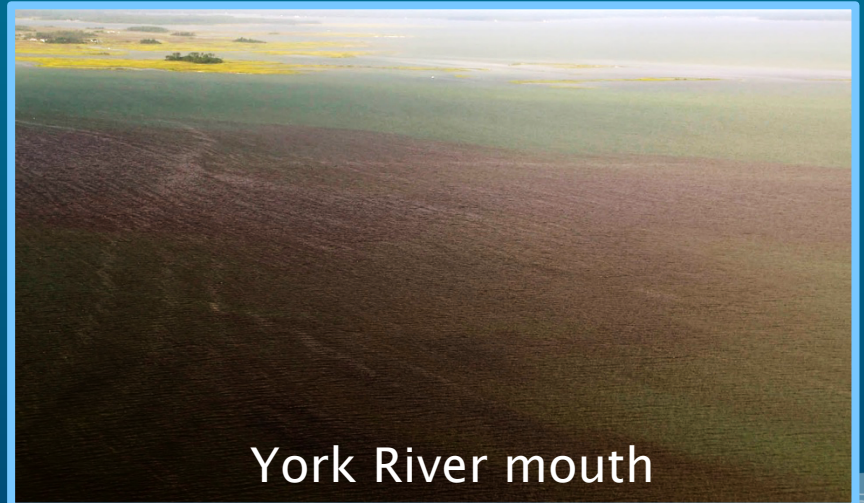
VIMS Beach- York River



York River-north of the Coleman Bridge



Elizabeth River



York River mouth

A. monilatum and *C. polykrikoides* Aug. 24, 2016



Lafayette River-*C. polykrikoides*



Elizabeth River-*C. polykrikoides*

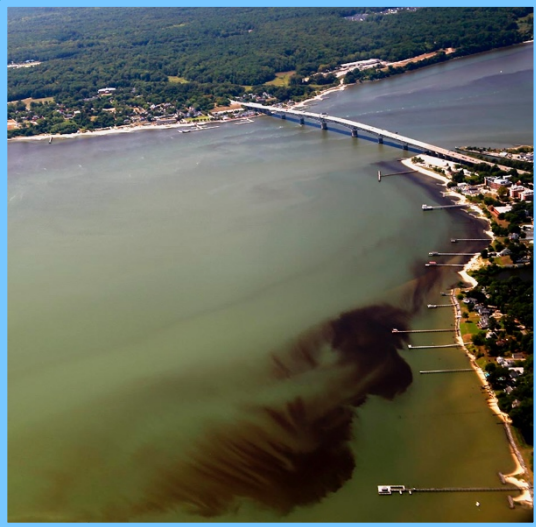


Mouth of the Rappahannock– likely *A. monilatum* based on samples collected near Gwynn's Island



York River mouth- *A. monilatum*

A. monilatum Aug. 29, 2016



York River



CB mainstem near Gwynn's Island



CB mainstem near Gwynn's Island



Mouth of the Rappahannock

Photos by W. Vogelbein

A. monilatum Sept. 12, 2016



Mouth of the York River



Eastern Shore looking west



Mouth of the Poquoson River



CB Mainstem
looking south to the Rappahannock

A. monilatum Sept. 23, 2016



Rappahannock River



Goodwin Islands/Mouth of York



Mouth of the Piankatank River

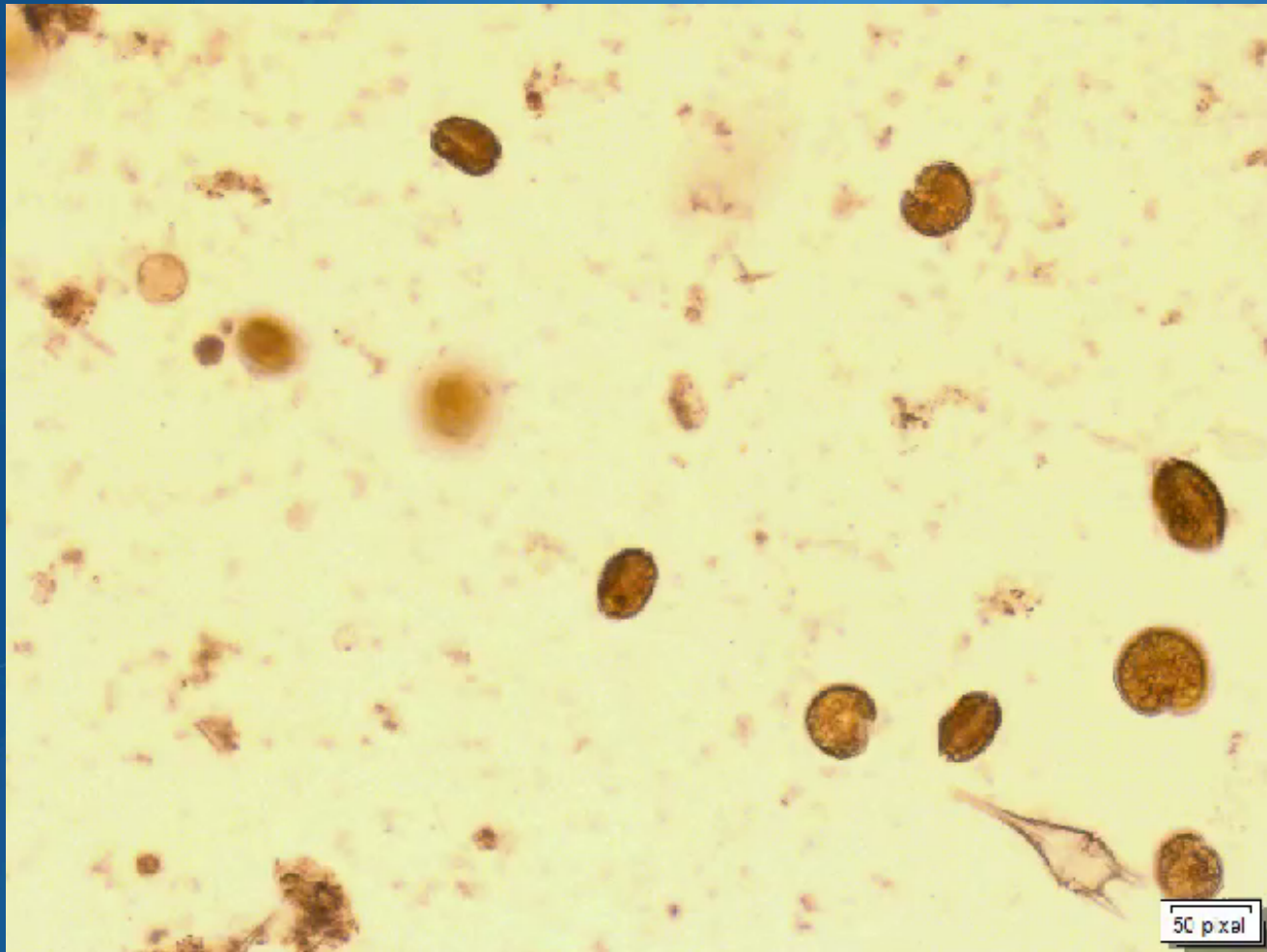
Photos by W. Vogelbein

Bloom progression:
Long chains (asexual stage) of *A. monilatum*

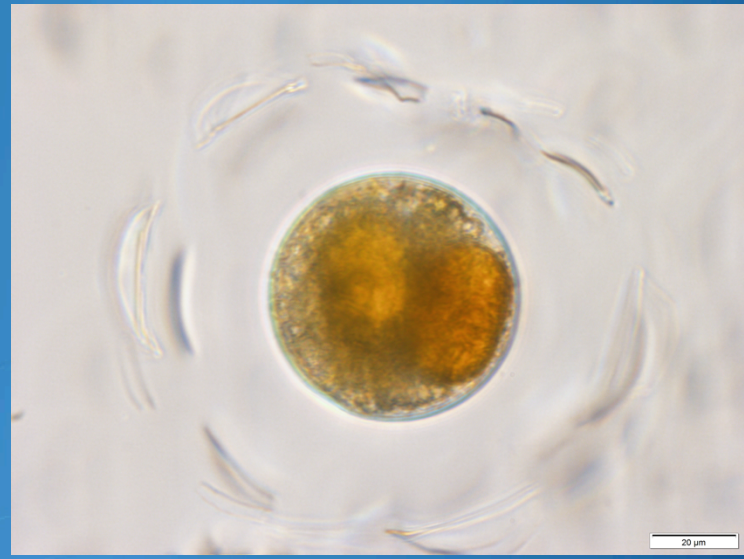
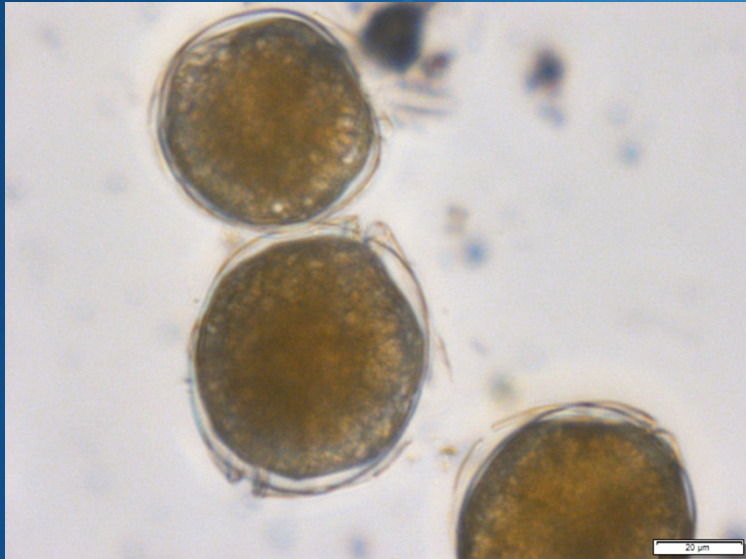


Sexual Stage

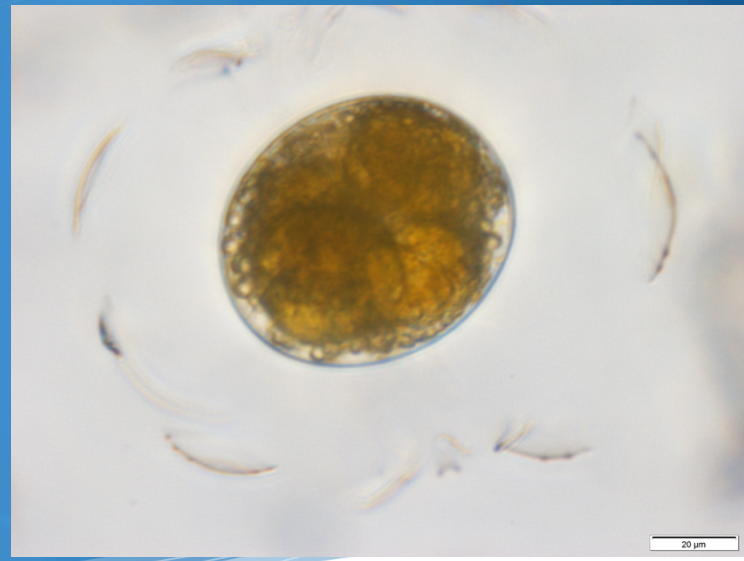
Gametes beginning to fuse to form planozygotes: Seen much earlier during the 2016 bloom



Bloom progression: Sexual reproduction Planozygotes of *A. monilatum* (Fused gametes)



Photos by W. Jones



Bioluminescence was reported throughout the region from Mobjack Bay down into VA Beach and NC Outer Banks in 2016



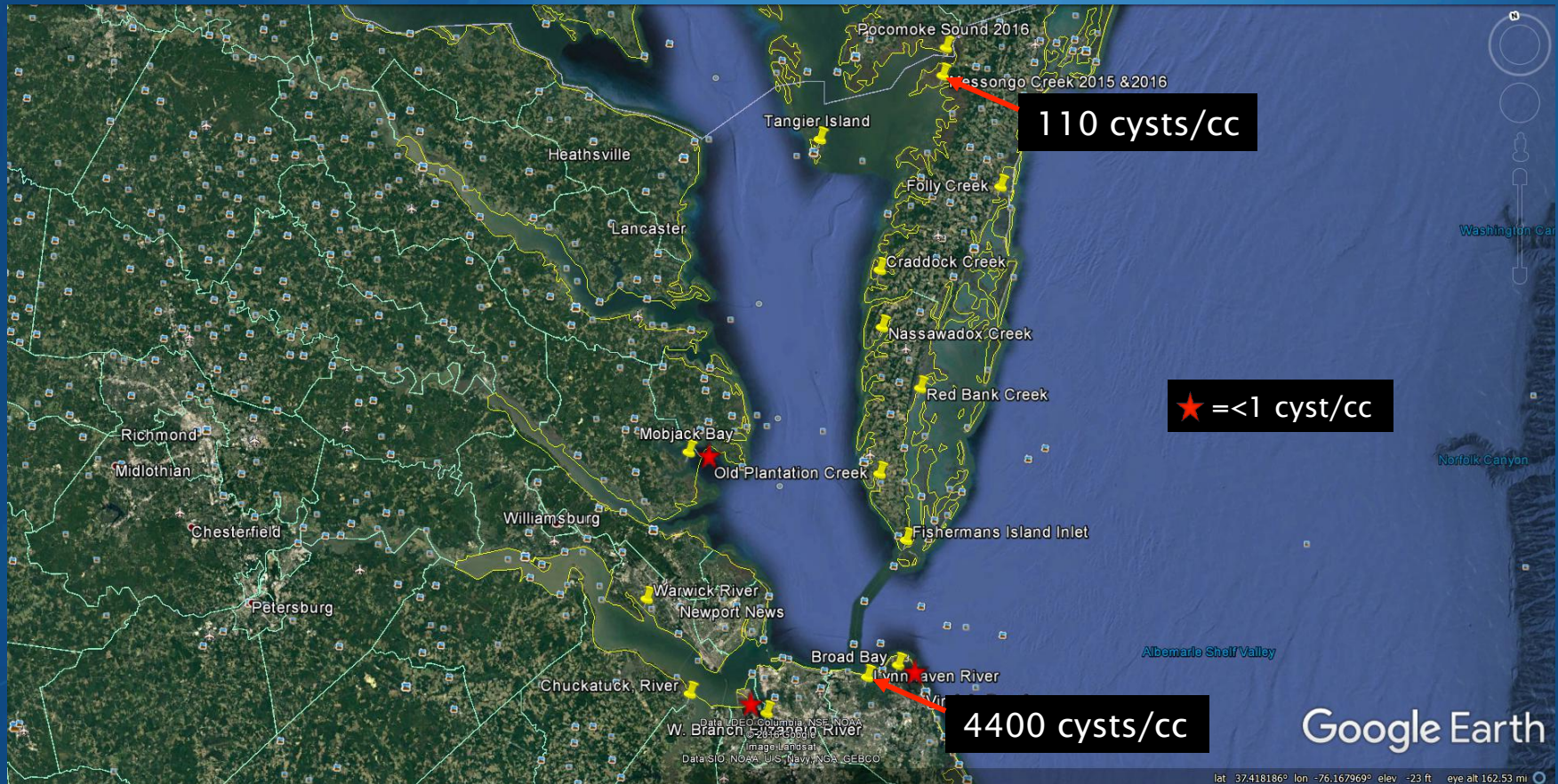
Photo by W. Vogelbein



Photo by S. Maples

Additional Sediment Samples from VDH

(Need to do additional extractions and qPCR runs)



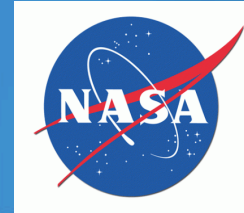
A. monilatum sediment cyst densities

New Tools and Collaborations

(Remote Sensing, Early Warning, Focused Sampling)

NASA- Flyover with Hyperspectral Sensors, UAV Technology

Frank Jones
Craig Nickol
Jeremy Smith
Richard Yasky
Ly Vyong
David Williams-EPA



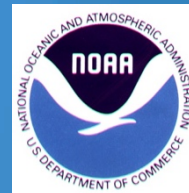
NASA DEVELOP Program, Satellite Imagery

Kenton Ross
Sara Lubkin
Cassandra Morgan



NOAA- Satellite HAB Remote Sensing Group

Richard Stumpf
Michelle (Shelly) Tomlinson



VMRC

Pilot (Flyovers, aerial photography)- Mark Hill



More VIMS scientists working on HABs



Mark Brush



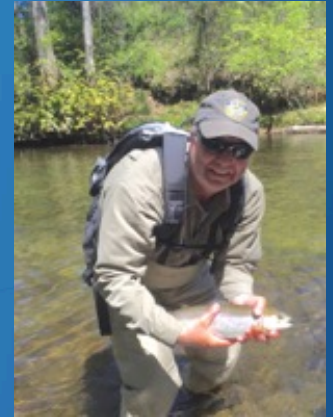
Iris Anderson



BK Song



Ken Moore



Willy Reay



Shanna
Williamson



Hunter Walker



Betty Neikirk



Jian Shen



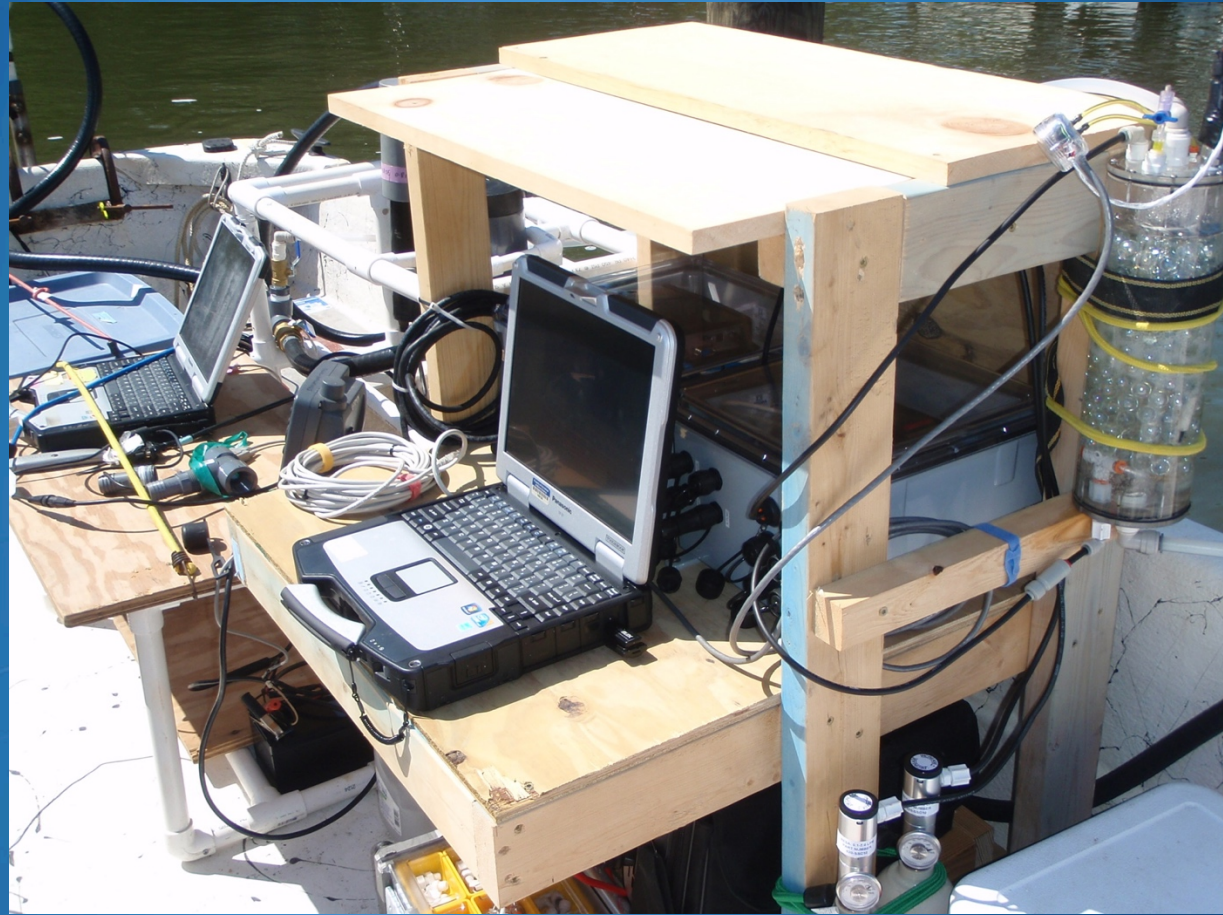
Qubin Qin

Dataflow: compact, surface water quality mapping system

Temperature
Salinity
pH
Chlorophyll
Turbidity
Dissolved oxygen

Water samples collected
for laboratory analyses:

Species composition
 microscopy
 molecular (DNA)
Nutrients



Aerial Chlorophyll/Hyperspectral Sensor System: Mounted on a plane or unmanned aerial vehicle (UAV)



August 17, 2015: Field Sampling and Remote Sensing

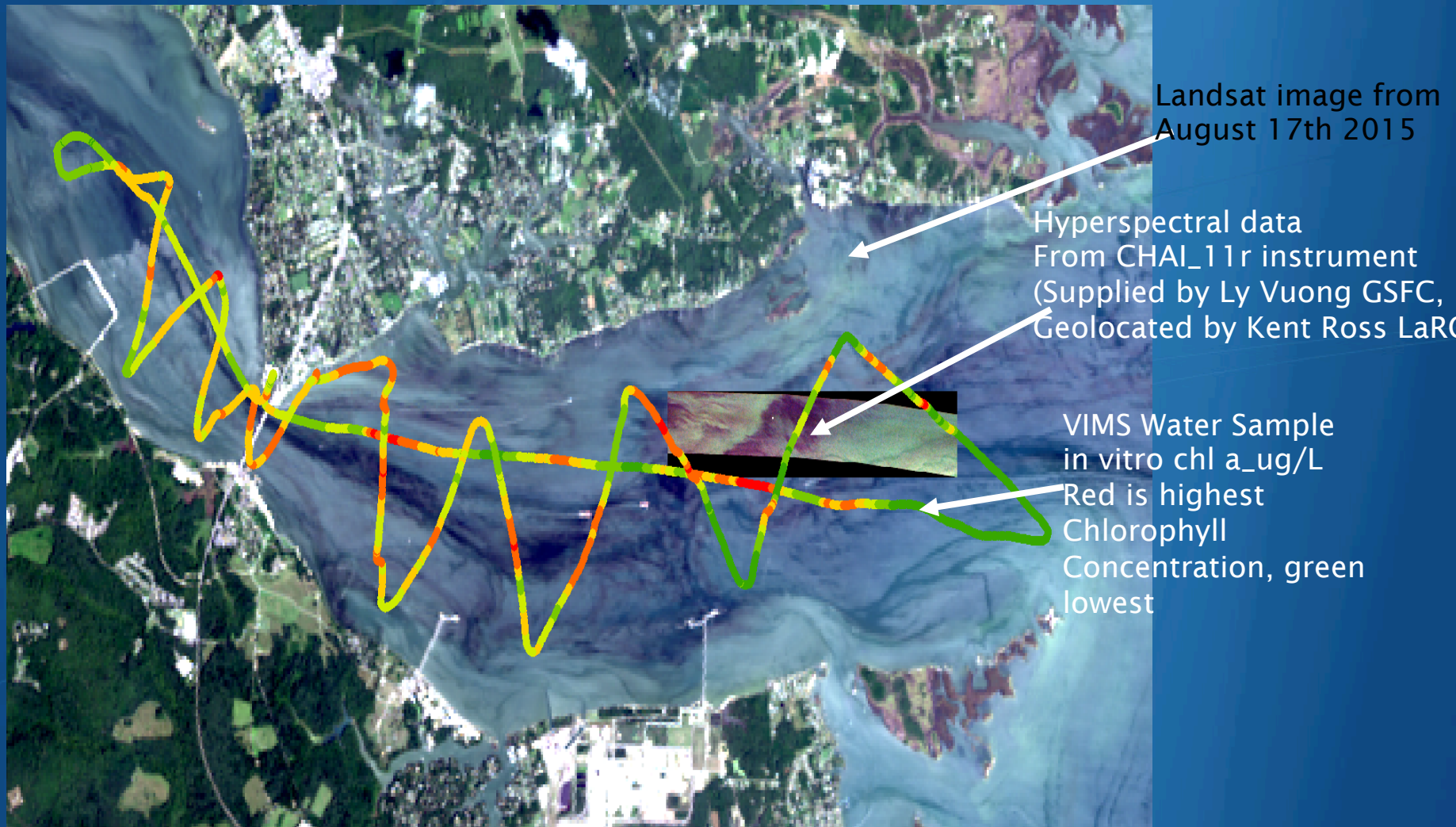
Peak of the *A. monilatum* bloom in the York River

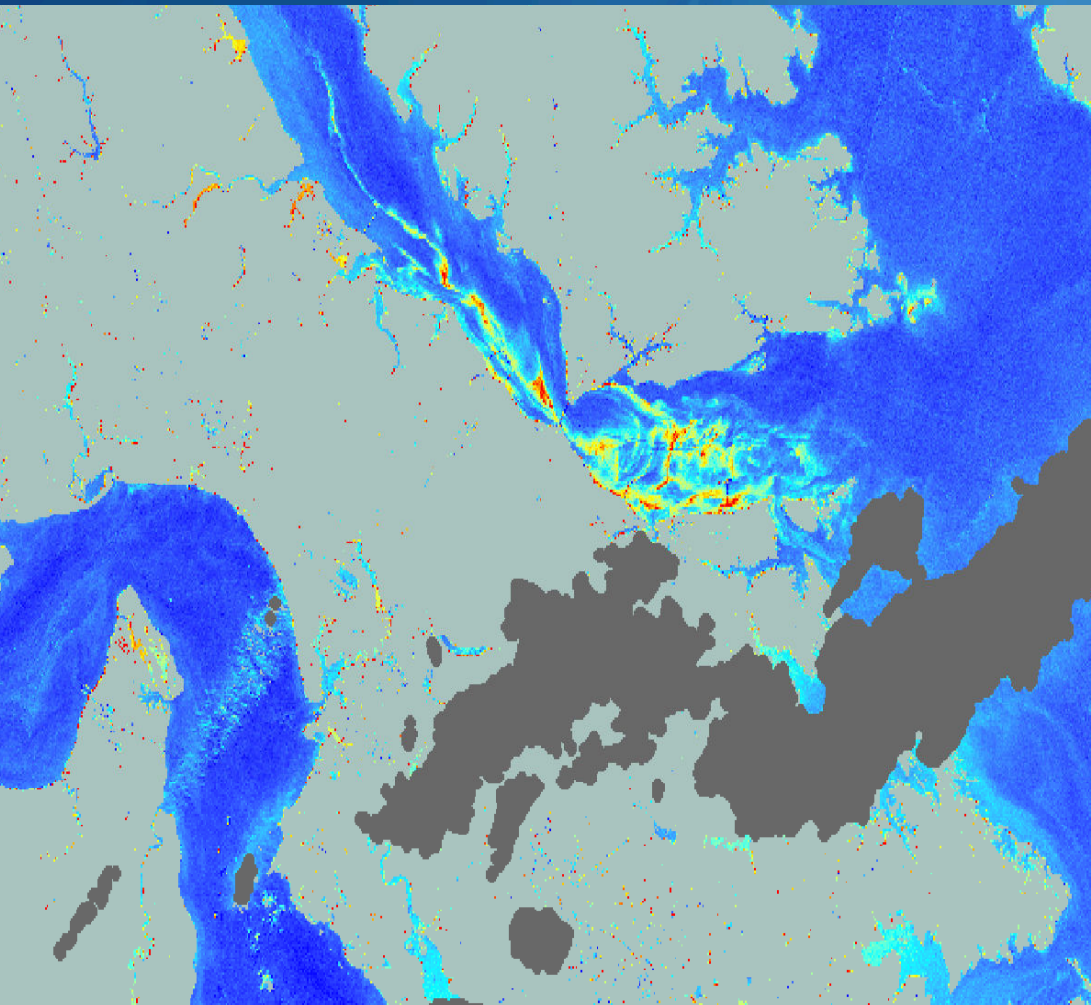
10,000's cell/ml visual and 100,000's cells/ml qPCR (ploidy)

Coordinated efforts of several groups:

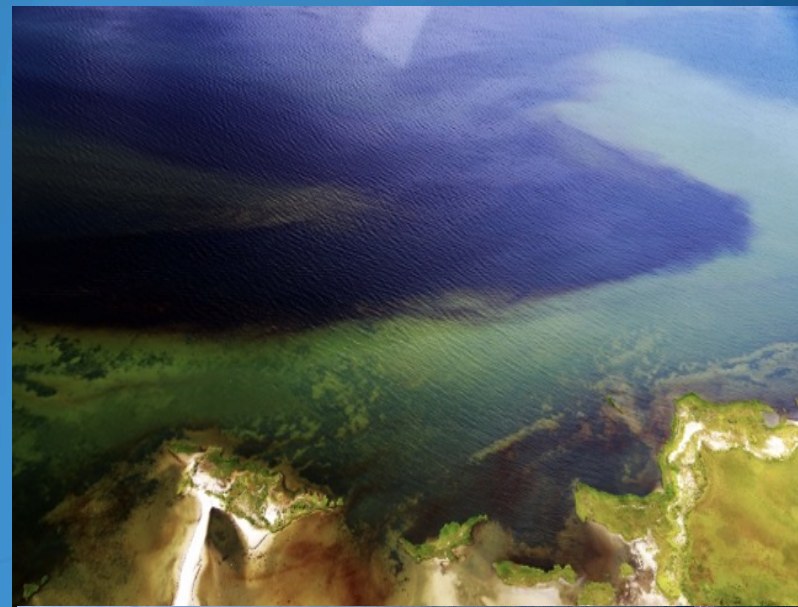
- Dataflow (Iris Anderson group) from mouth of river to Naval Weapon's Station with sampling for cell counts (Reece group)
- Dataflow for photosynthesis and respiration (Brush)
- NASA Cessna plane equipped with hyper-spectral sensors flew over the York River during the dataflow sampling
- NASA satellite (MODIS) passed over during the dataflow cruise AND it was a clear day!!
- Higher resolution NASA satellite (LANSAT) passed over on Aug. 18
- Afternoon: Wolf Vogelbein flew over with the VMRC pilot and took photographs documenting the massive extent of the bloom throughout the lower Chesapeake Bay. York River from West Point to the mouth.

Remote Sensing of HABs via Air (flyovers) and Satellites (Tested on August 17, 2015)

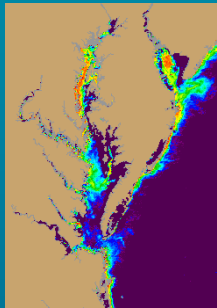
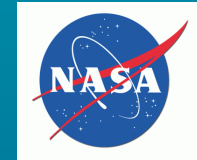




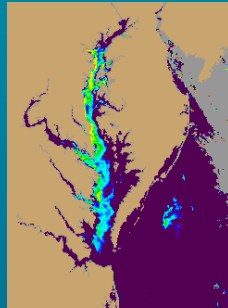
NASA algorithm applied to new Sentinel
satellite image- Aug. 29, 2016



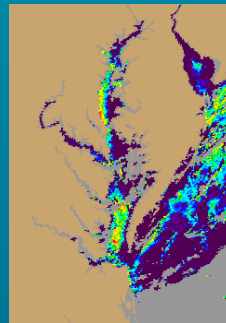
Satellite Images During 2016 Blooms Helping to Guide Sampling



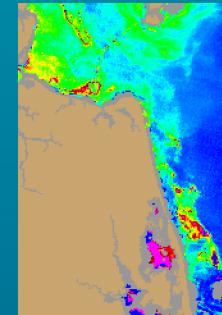
8-12-16



9-6-16

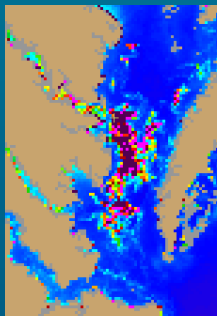


9-12-16

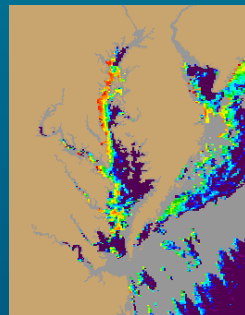


9-14-16

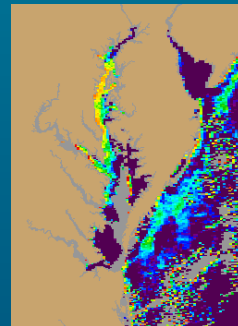
A. monilatum bloom down
to VA/NC border



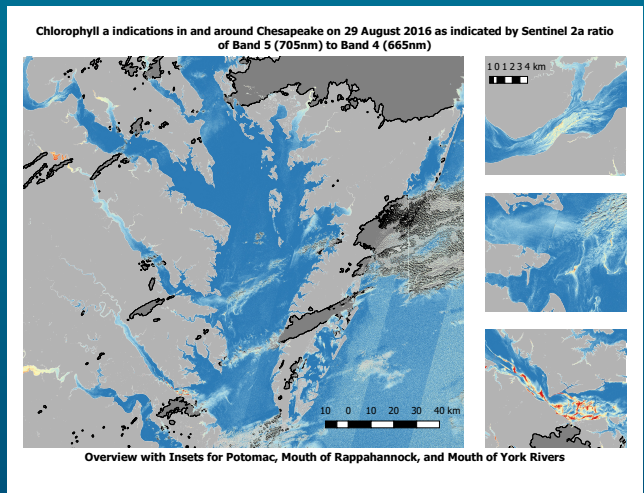
9-17-16



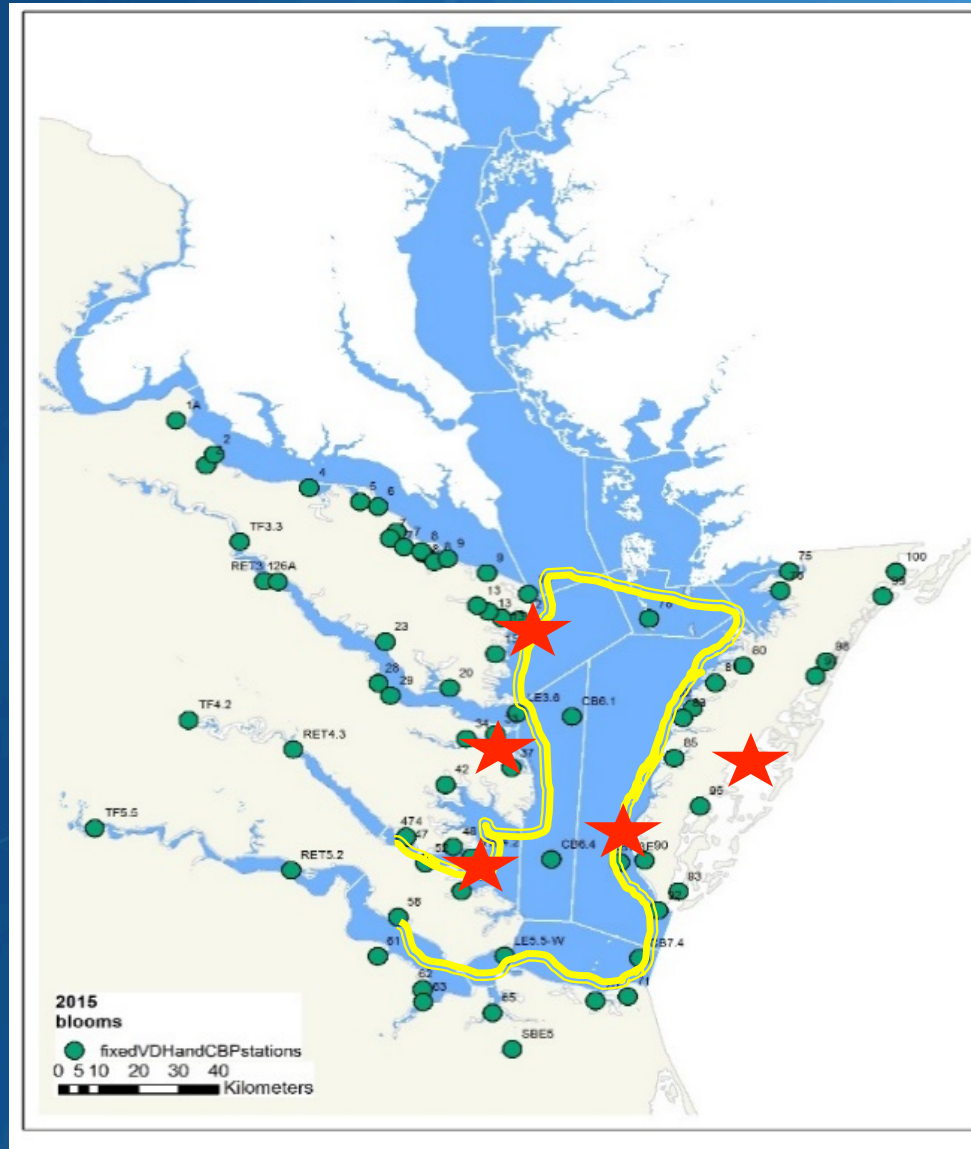
9-18-16



9-25-16



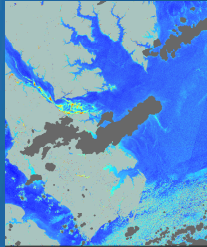
Vision: Develop a Network to Establish an Early Warning System



by land

by sea

by air



VDH VIRGINIA DEPARTMENT OF HEALTH
To promote and protect the health of all Virginians

Bioluminescence video

<https://youtu.be/KzkF8MNBh58>