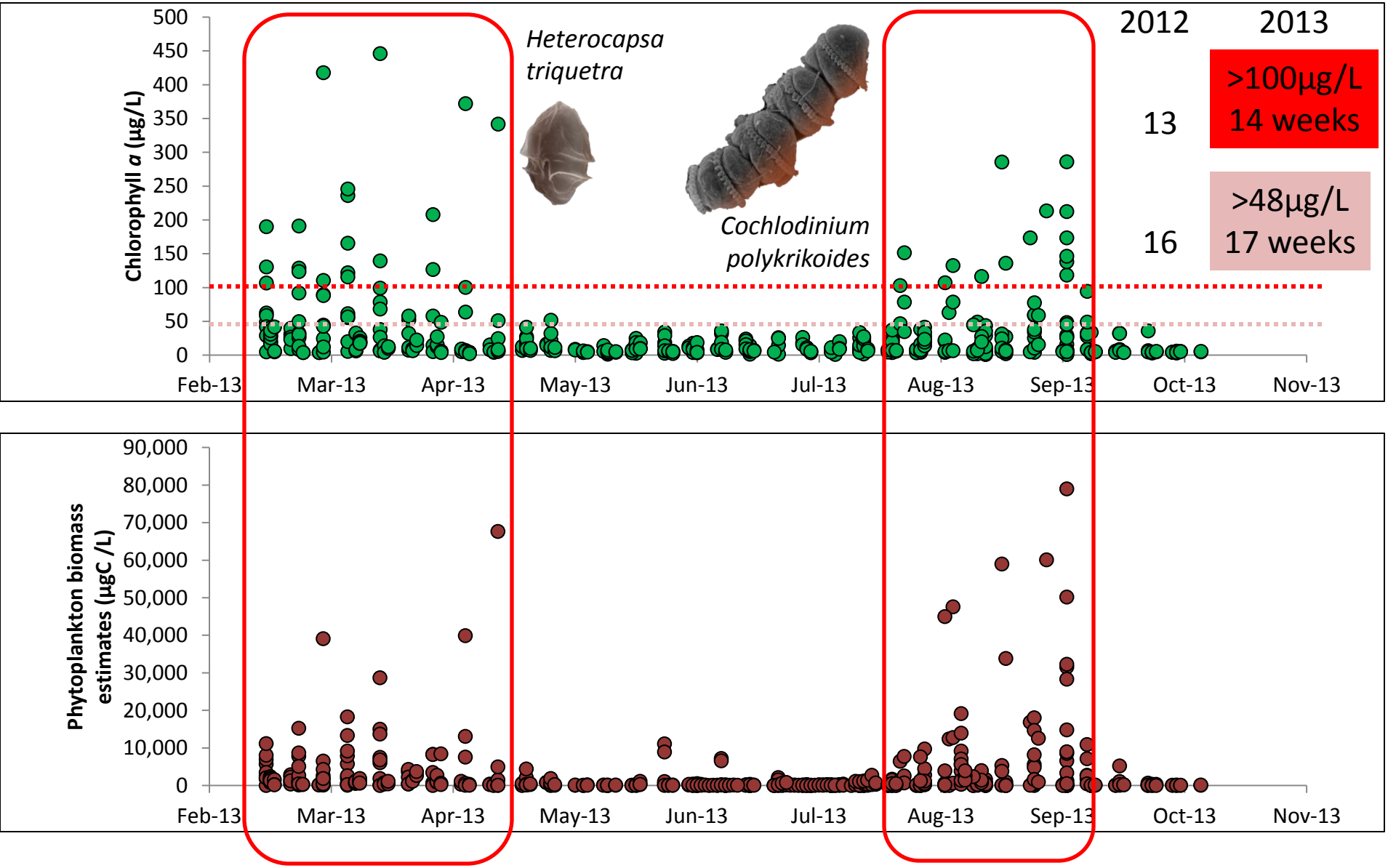
Phytoplankton composition, abundance, biomass and HAB relationships to chlorophyll *a* of the James River Estuary: 2013

Todd Egerton, Harold Marshall

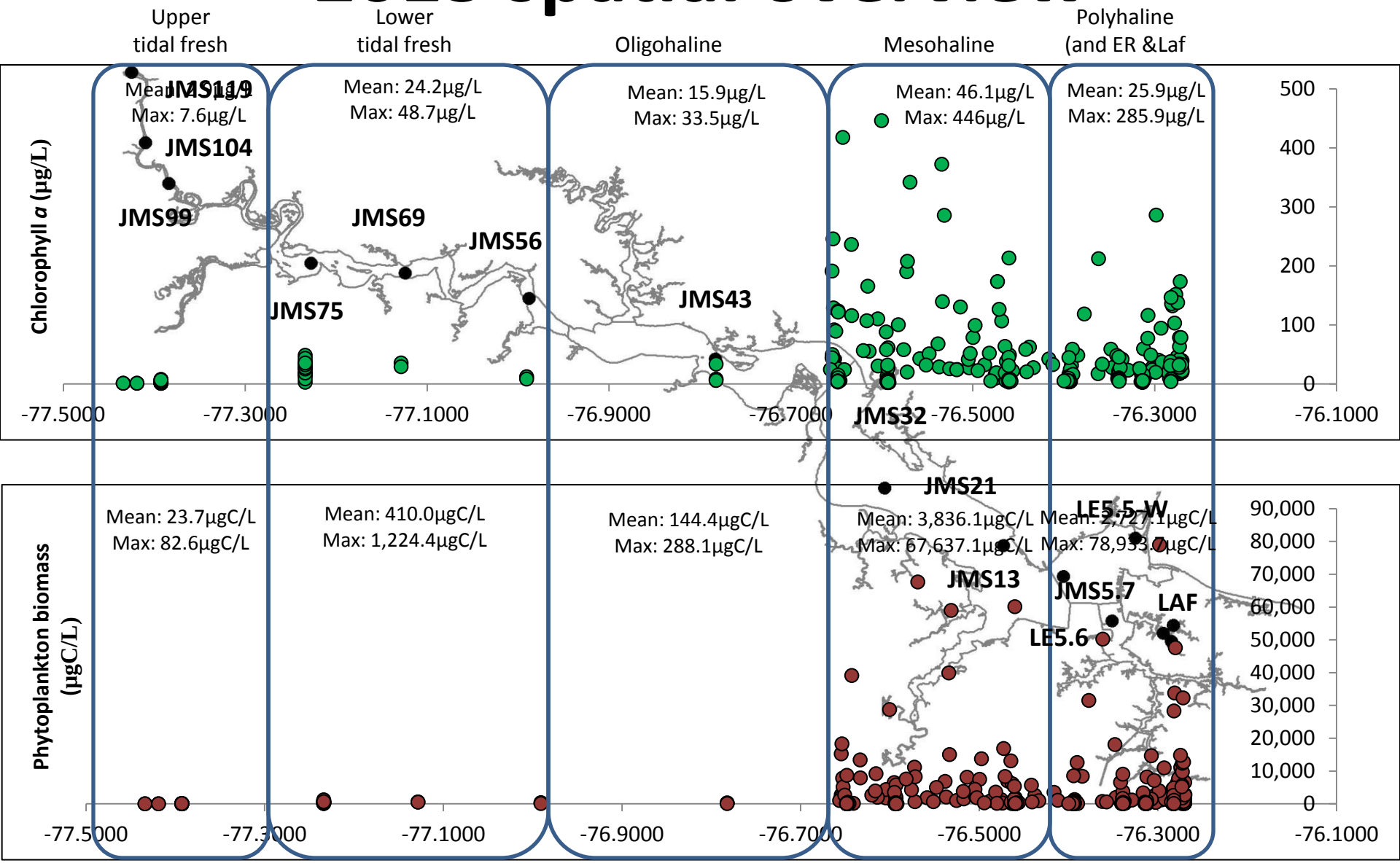
Old Dominion University: Department of Biological Sciences

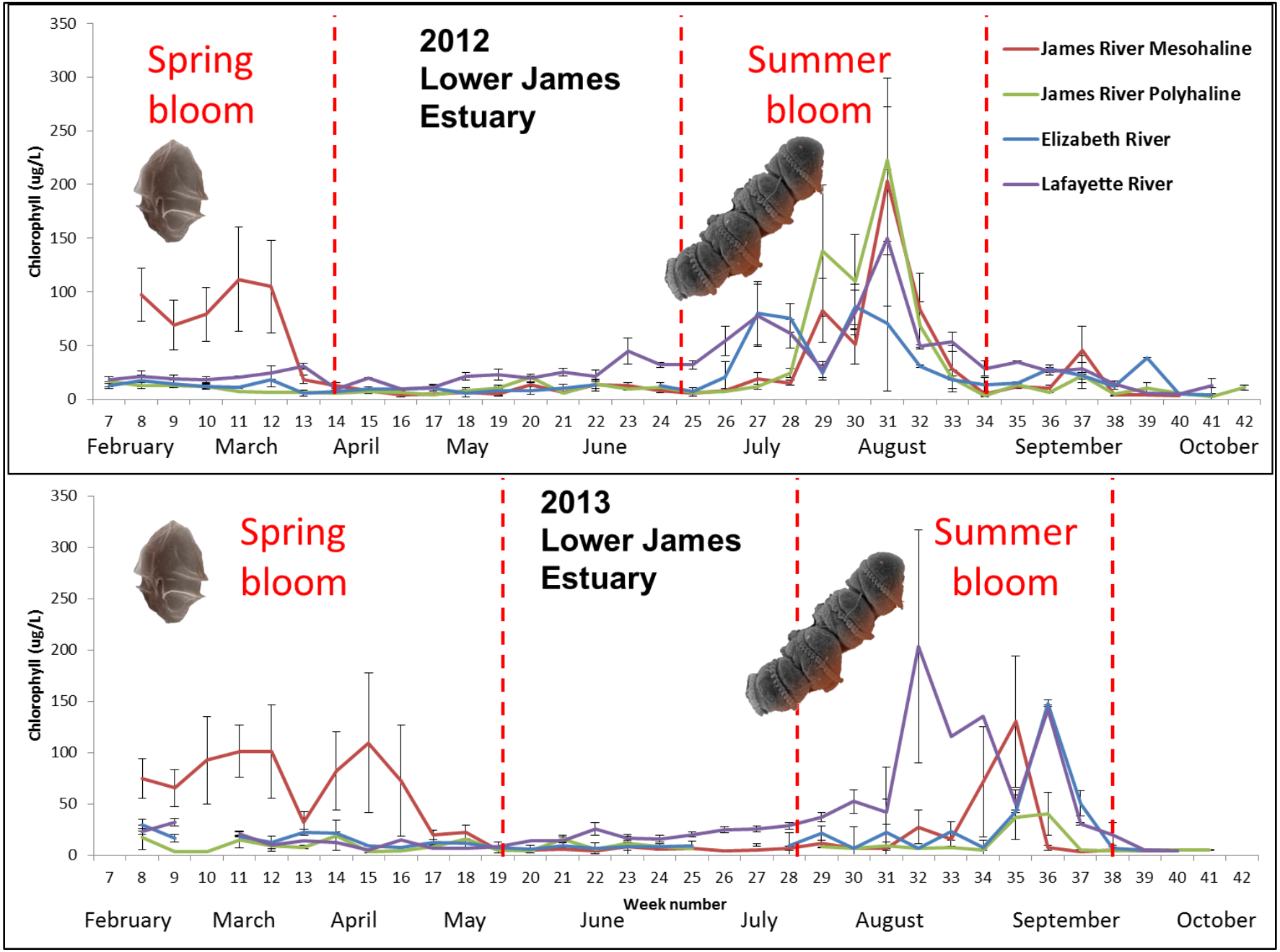
- Upper James:
  - VCU weekly samples: JMS75 & JMS99 (May-Oct)
  - DEQ additional monthly samples (July-Sept)
- Lower James:
  - HRSD weekly samples:
    JMSMH, JMSPH, ER & Laf (Feb-Oct)
  - ODU OEAS: daily sampling: Lafayette River (June-Aug)
  - ODU OEAS: 24hr study: Aug 9
- Total samples: 503

2013 temporal overview

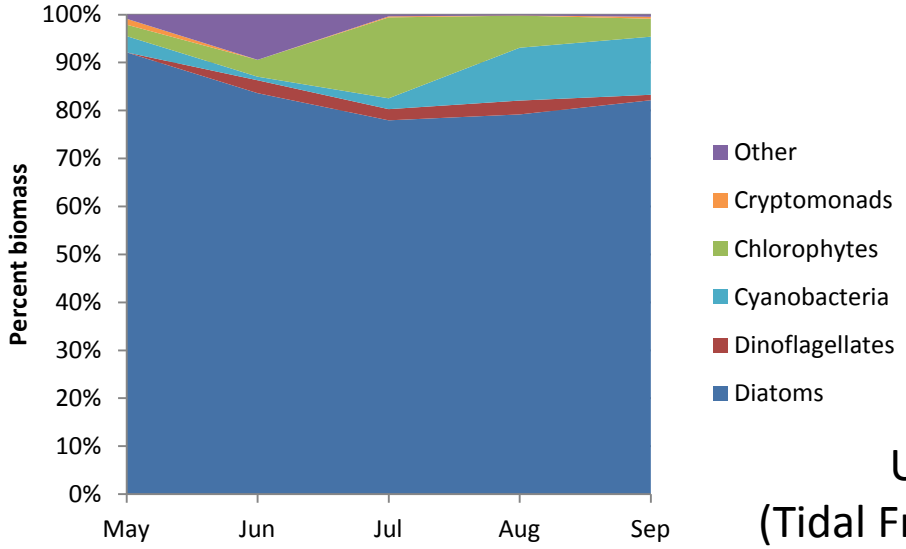


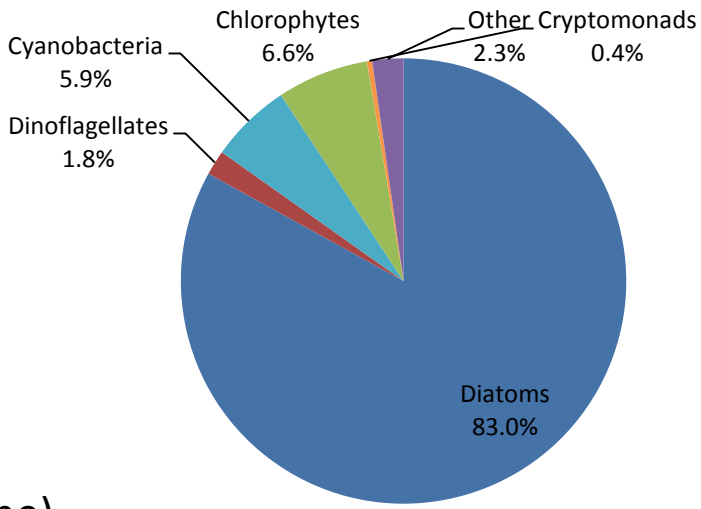
2013 spatial overview




2012
Lower James
Estuary
Spring
bloom
Summer
bloom
James River Mesohaline
James River Polyhaline
Elizabeth River
Lafayette River
Chlorophyll (ug/L)
0
50
100
150
200
250
300
350
7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
February
March
April
May
June
July
August
September
October
2013
Lower James
Estuary
Spring
bloom
Summer
bloom
Week number

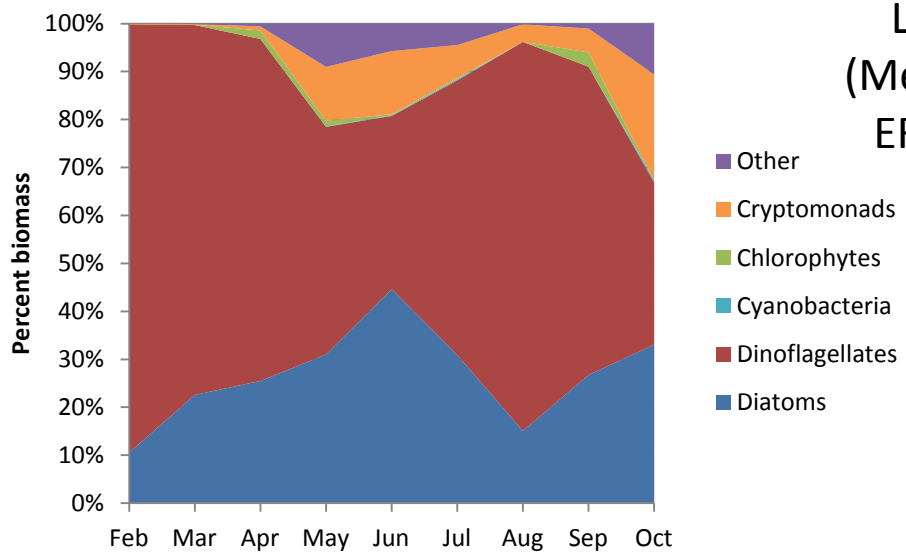
Algal community composition: 2013

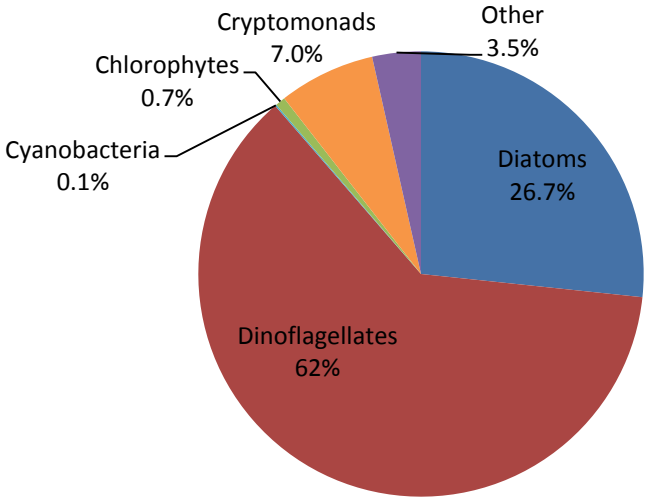




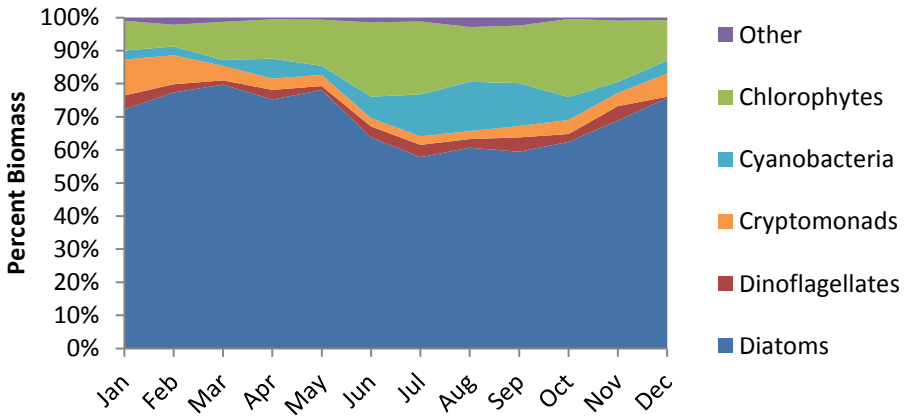
Upper James
(Tidal Fresh & Oligohaline)

Lower James
(Meso/polyhaline
ER &Lafayette)

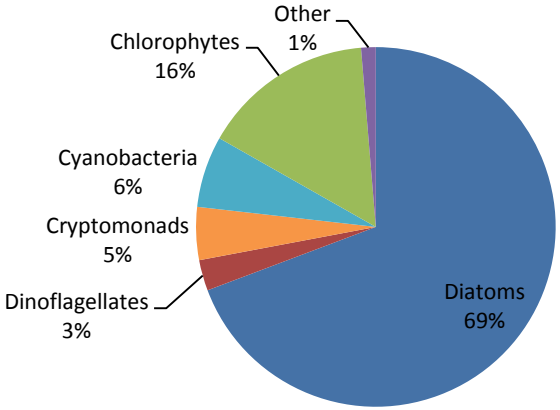


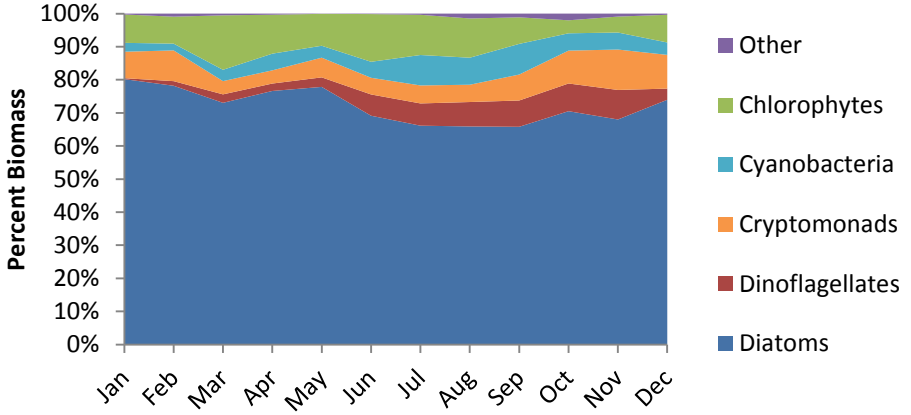


Algal community composition: long term perspective

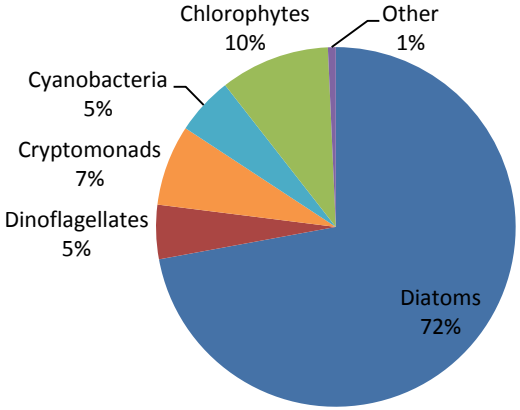


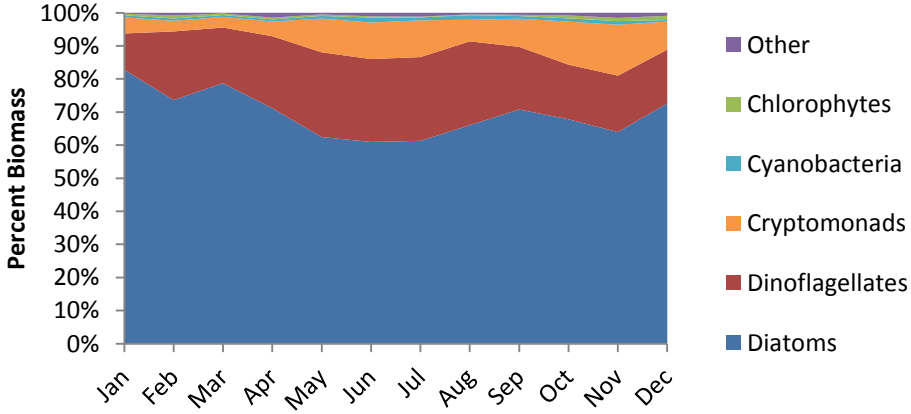
TF5.5
1986-2012



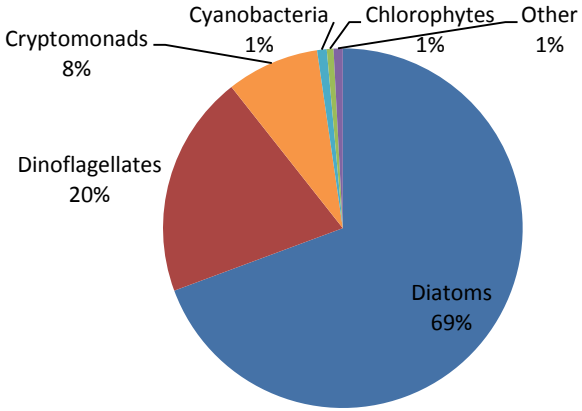


RET5.2
1986-2012



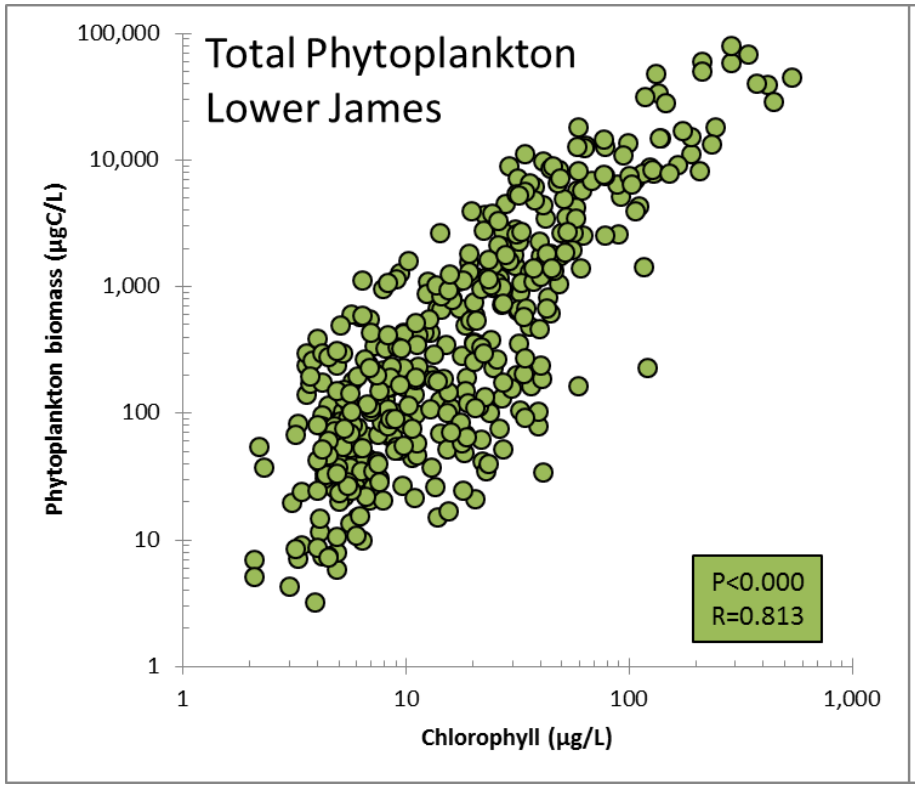


LE5.5-W
1985-2012

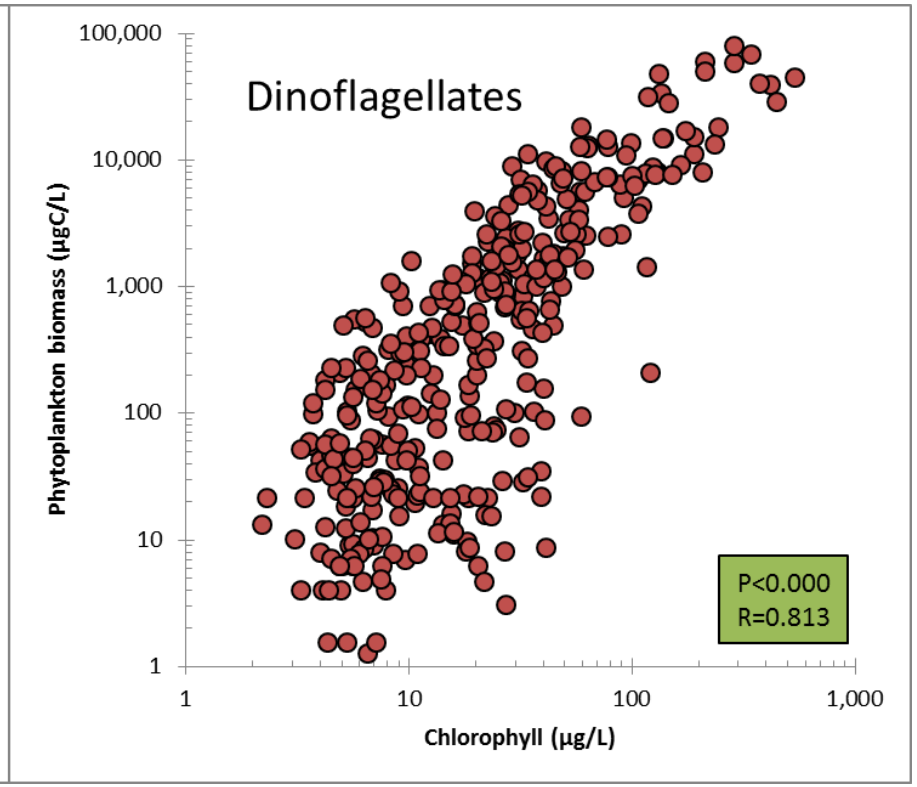


Phytoplankton biomass/ chlorophyll *a* relationships Lower James

Total Phytoplankton

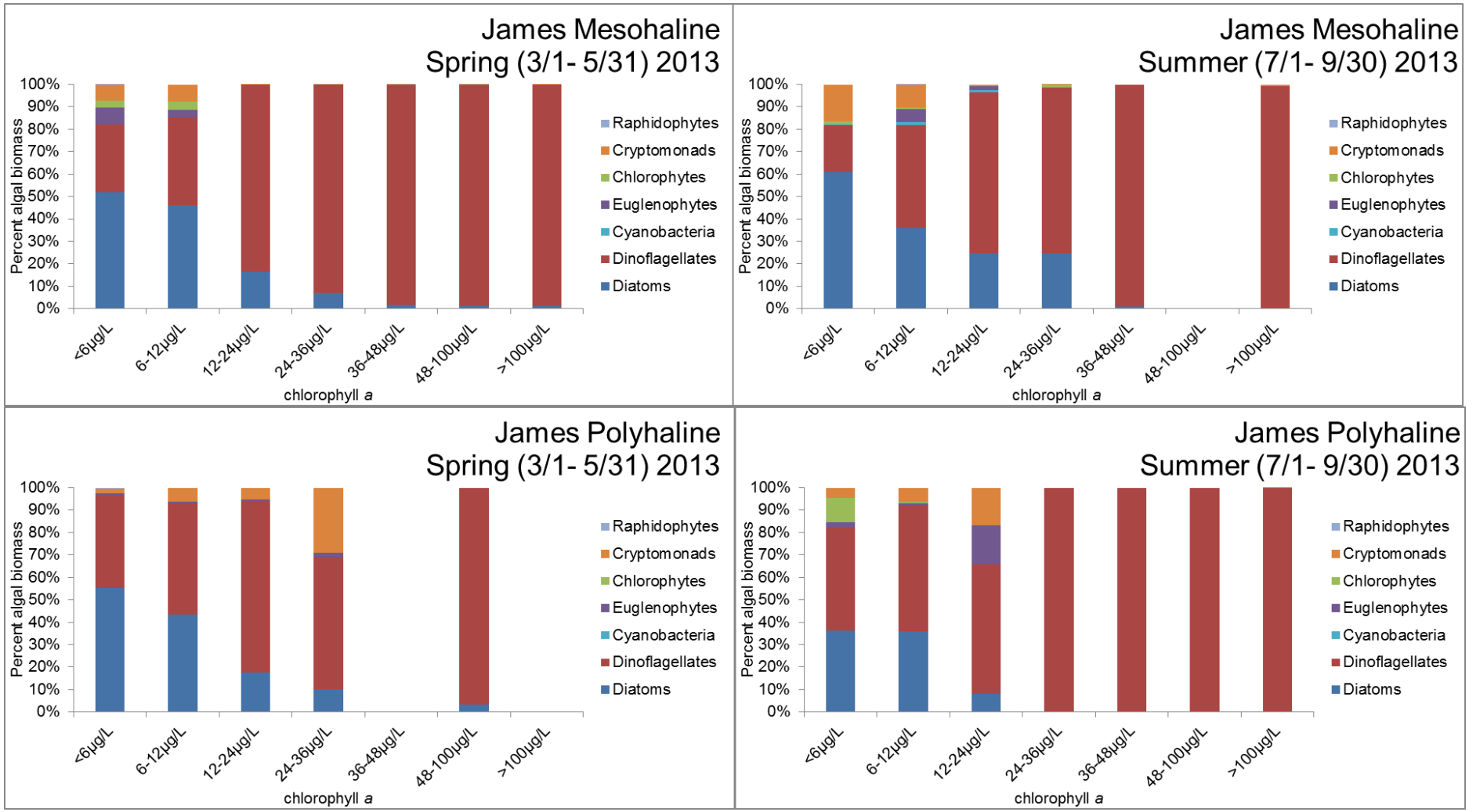


Dinoflagellates

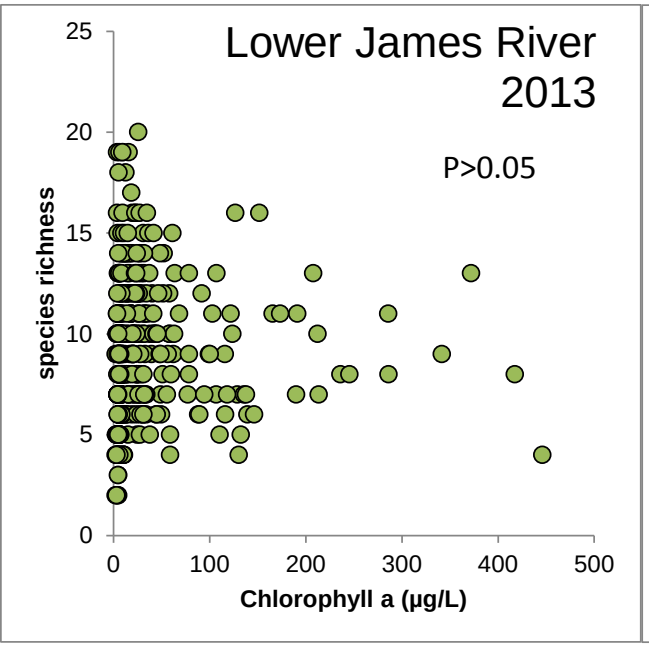


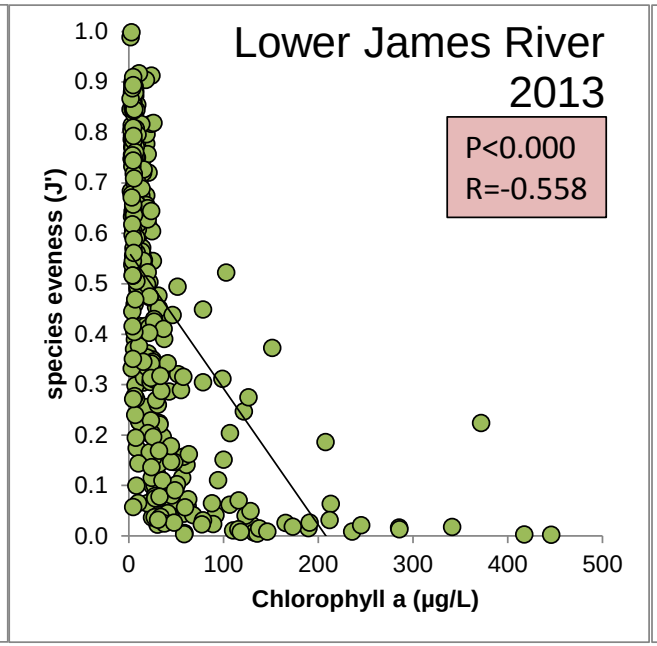
Signal driven by dinoflagellate blooms in Lower James

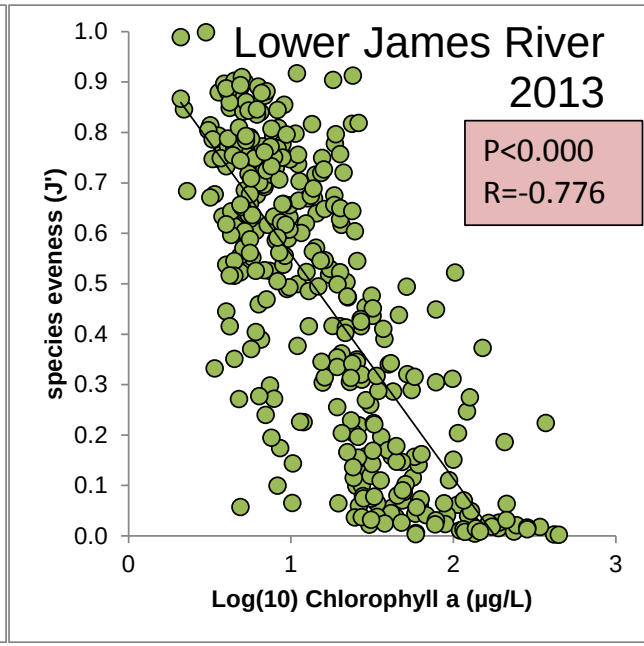
Not significant:
diatoms (p=.273), cyanobacteria (p=.493), chlorophytes (p=.619), cryptomonads (p=.344), euglenoids (p=.194), raphidophytes (p=.704)



- Higher Chl *a* concentrations dominated by dinoflagellate blooms in lower James River.

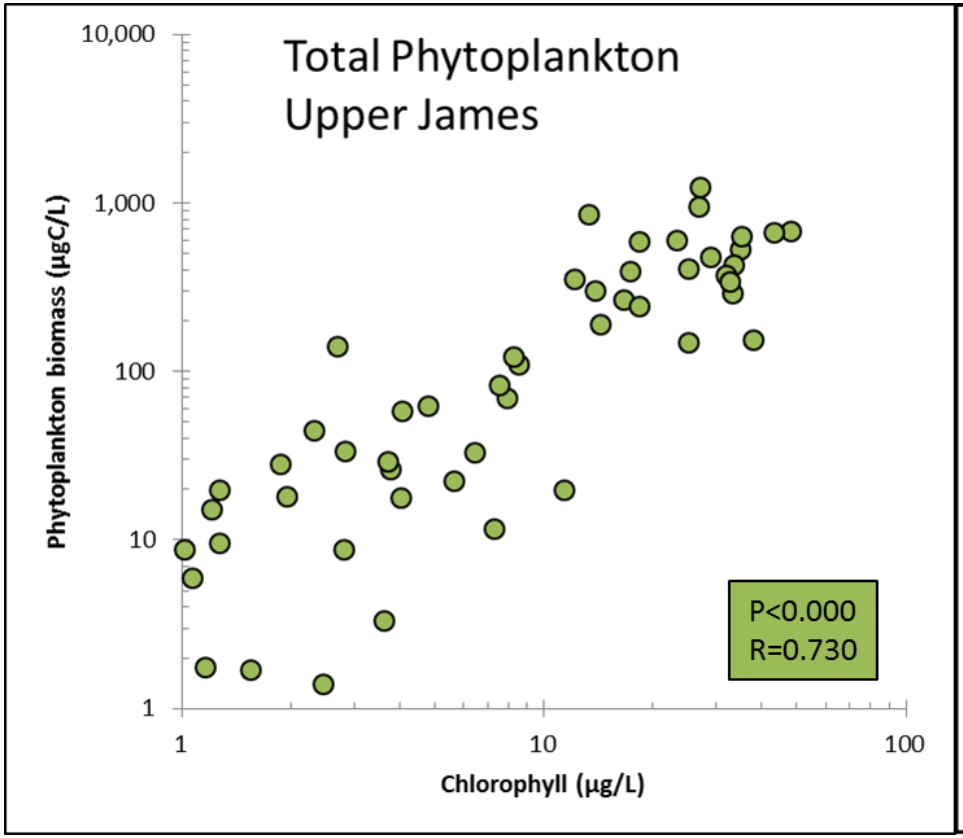


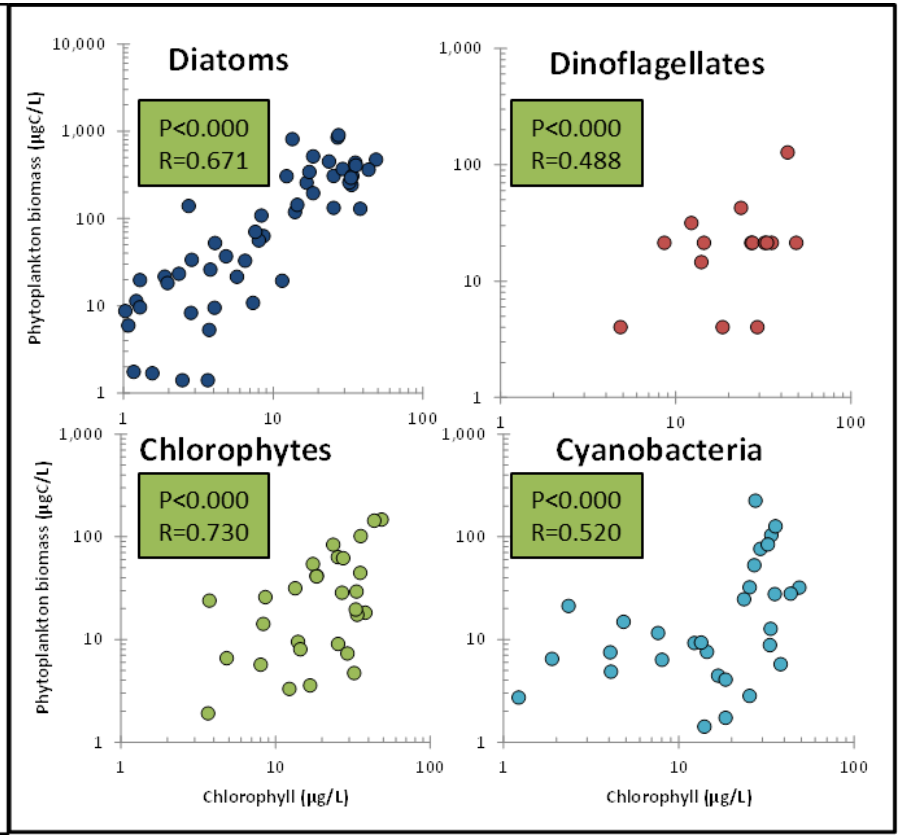




- Strong negative relationship (logarithmic) between Chl *a* and species evenness in lower James. (due to monospecific dino blooms)

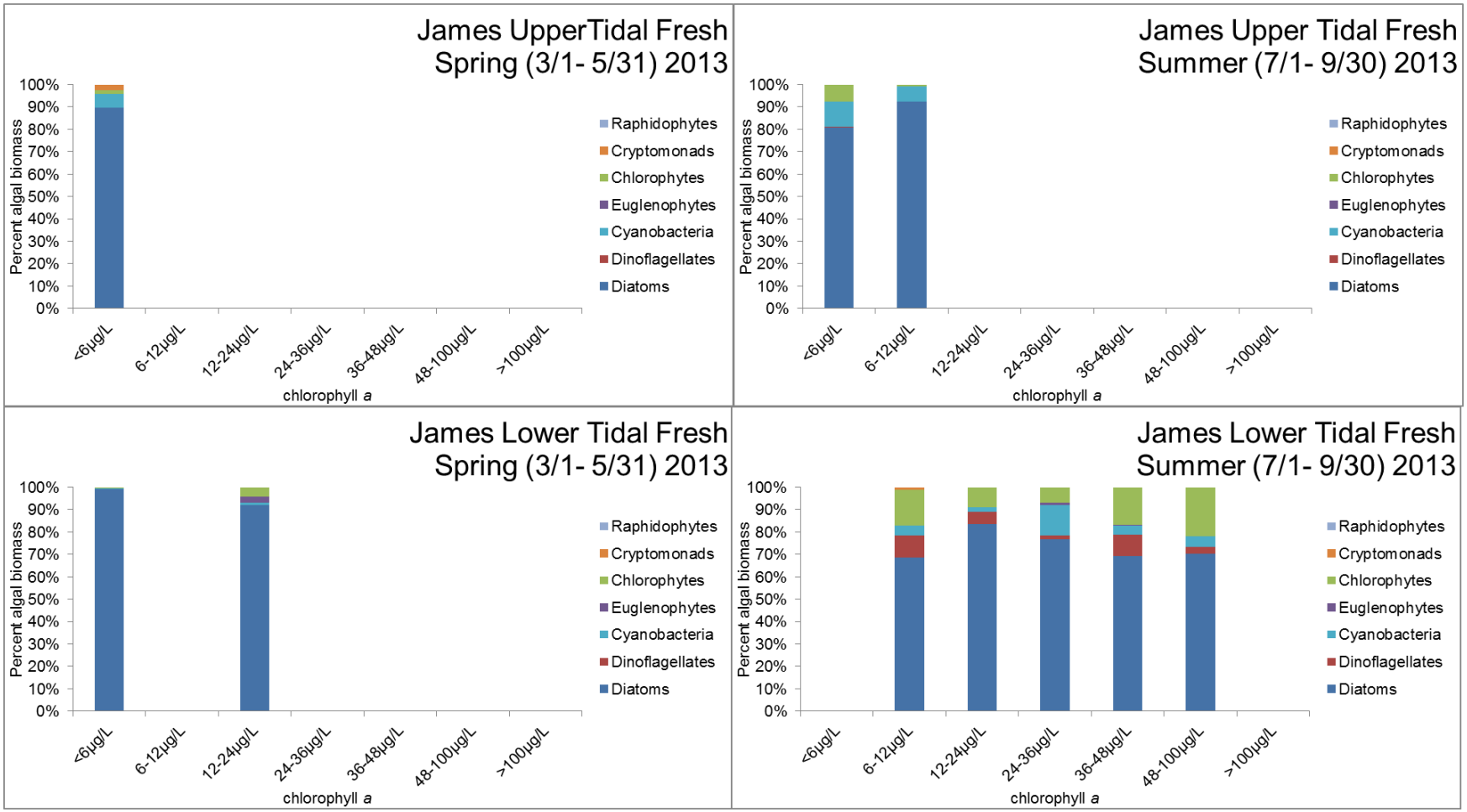
Phytoplankton biomass/ chlorophyll *a* relationships Upper James



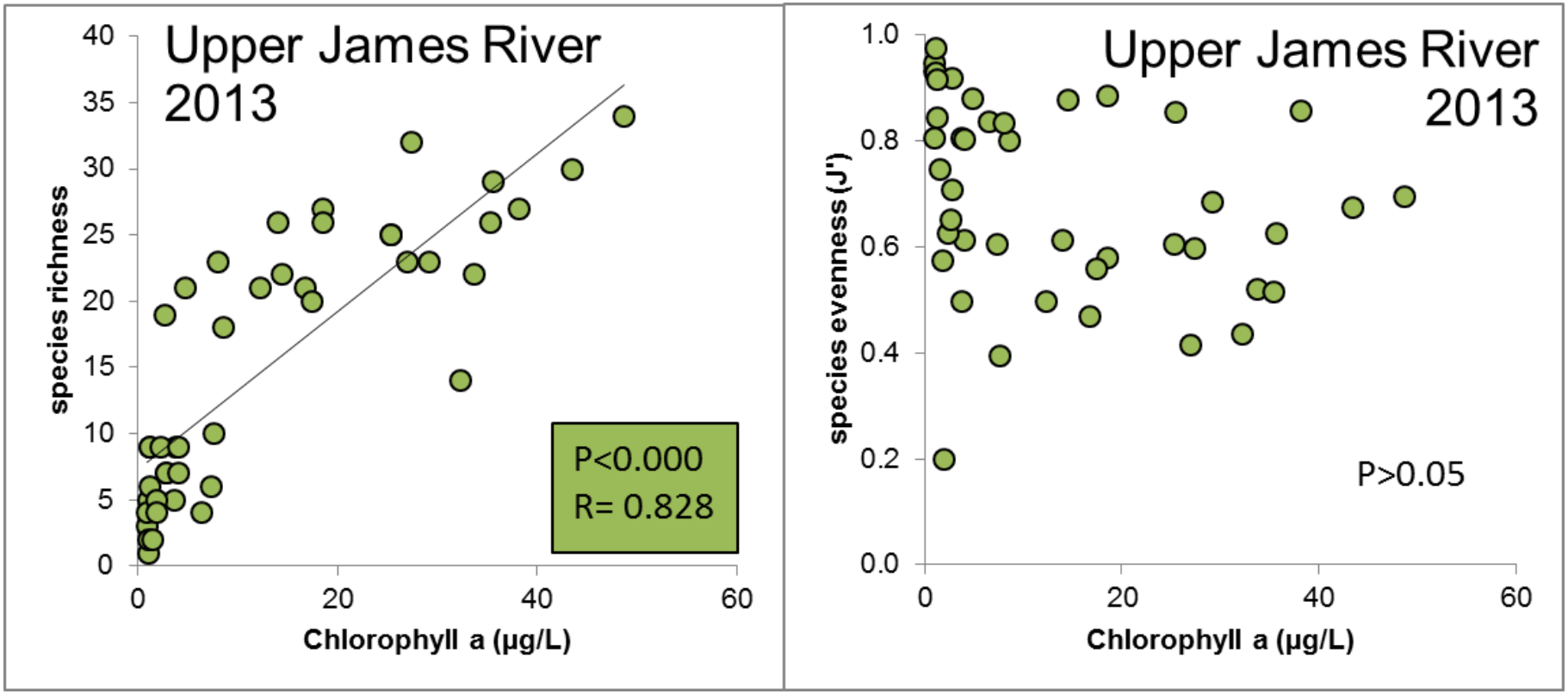


Increased biomass of several algal phyla, primarily diatoms

Not significant:
cryptomonads (p=.488), euglenoids (p=.565)

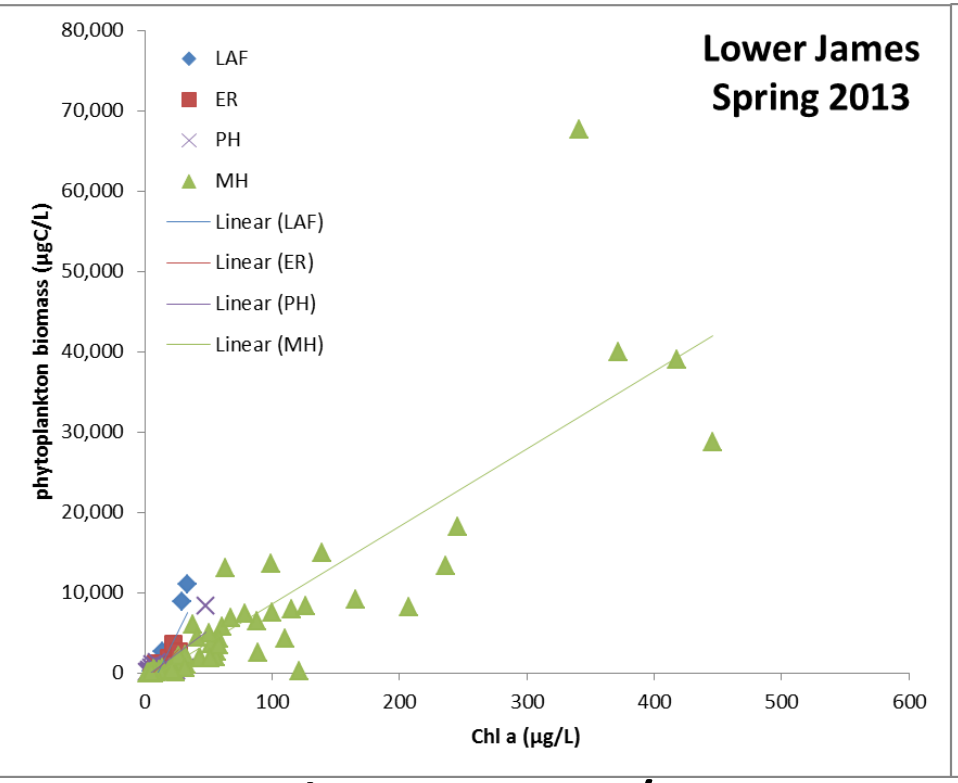


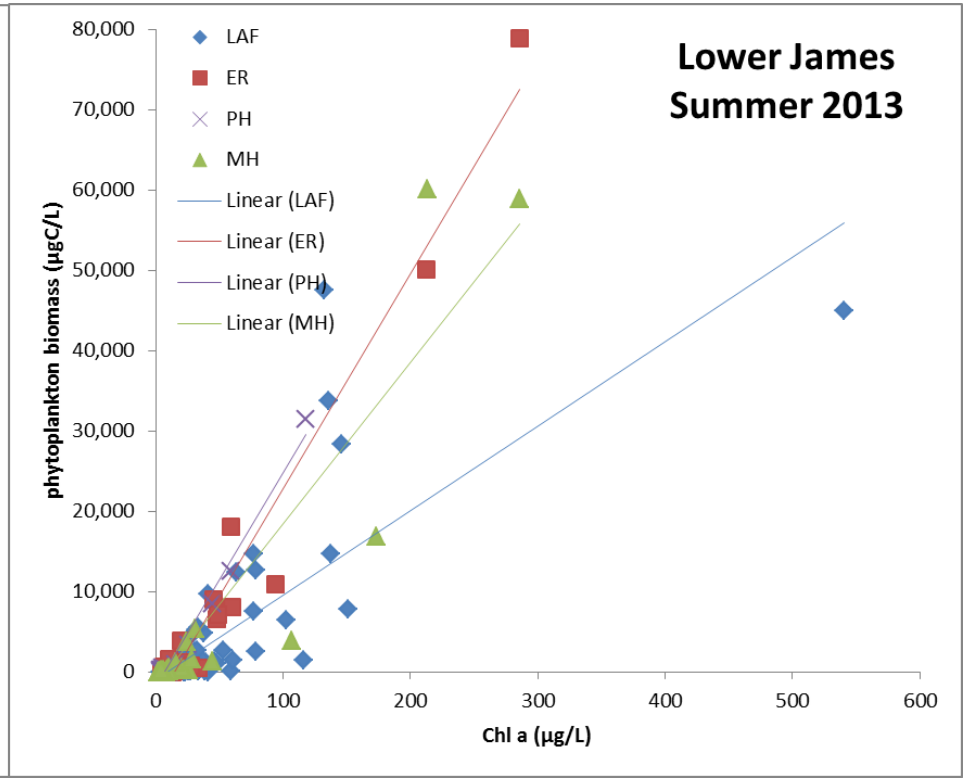
- Similar phytoplankton composition in relation to increasing Chl *a* concentrations in Upper James.



- Positive relationship between species richness and Chl *a* in Upper James.

Chl *a* to biomass relationships





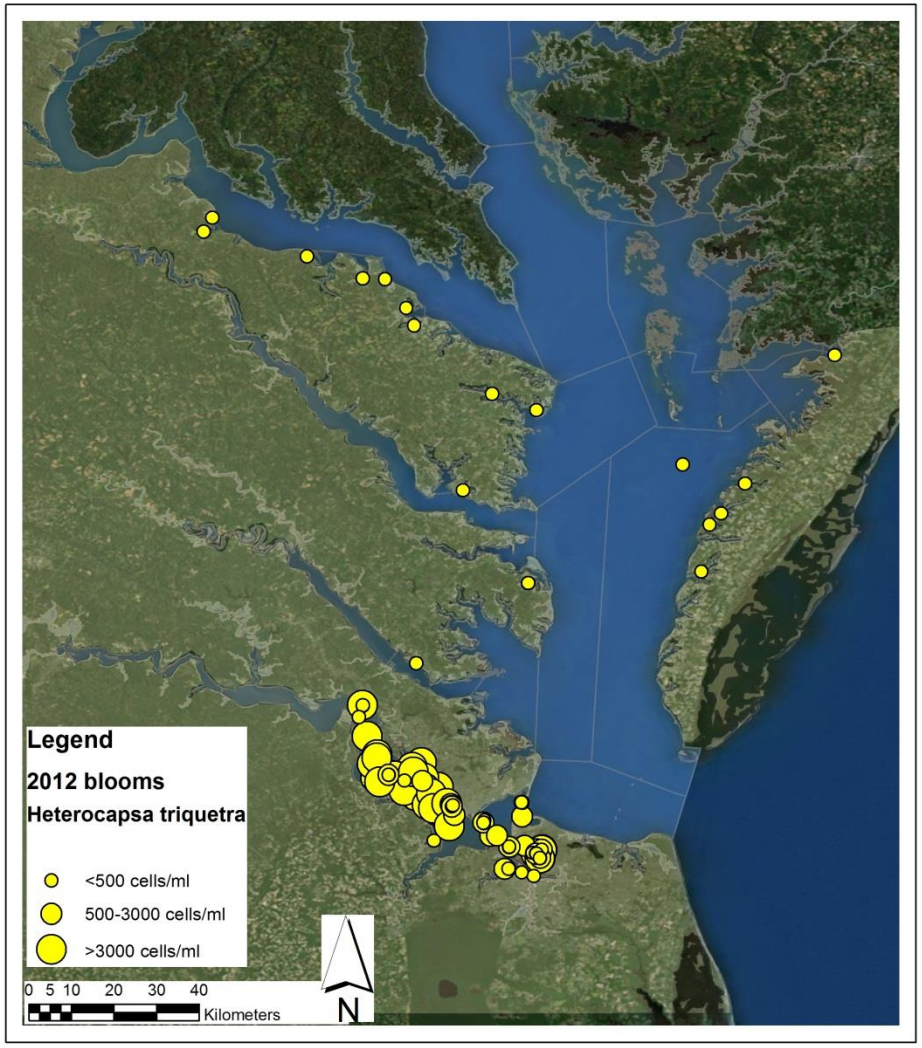
- Vary by season/segment (p, R, m, b)
- Calculated for all segments/seasons/taxonomic groups for 2013
- Species composition changes (spatial/temporal)
- Inter-annual variability… **need more high bloom data**

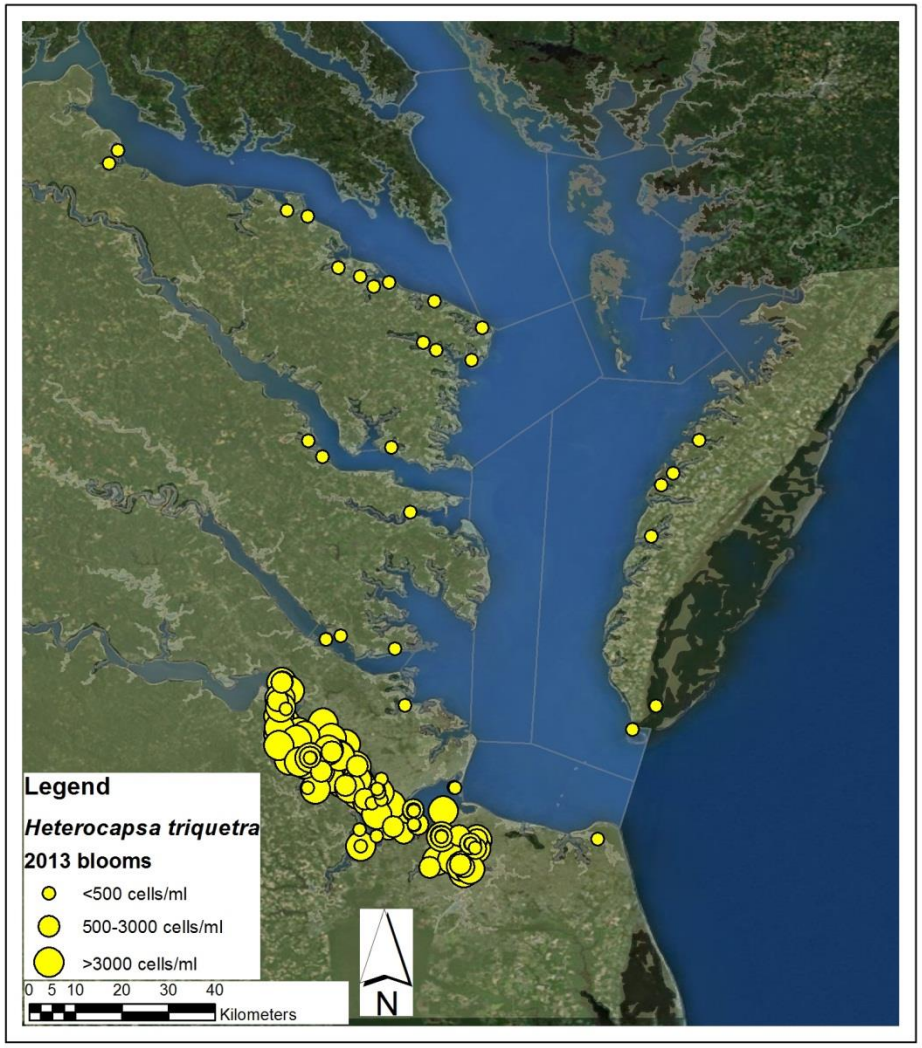
Bloom intensity

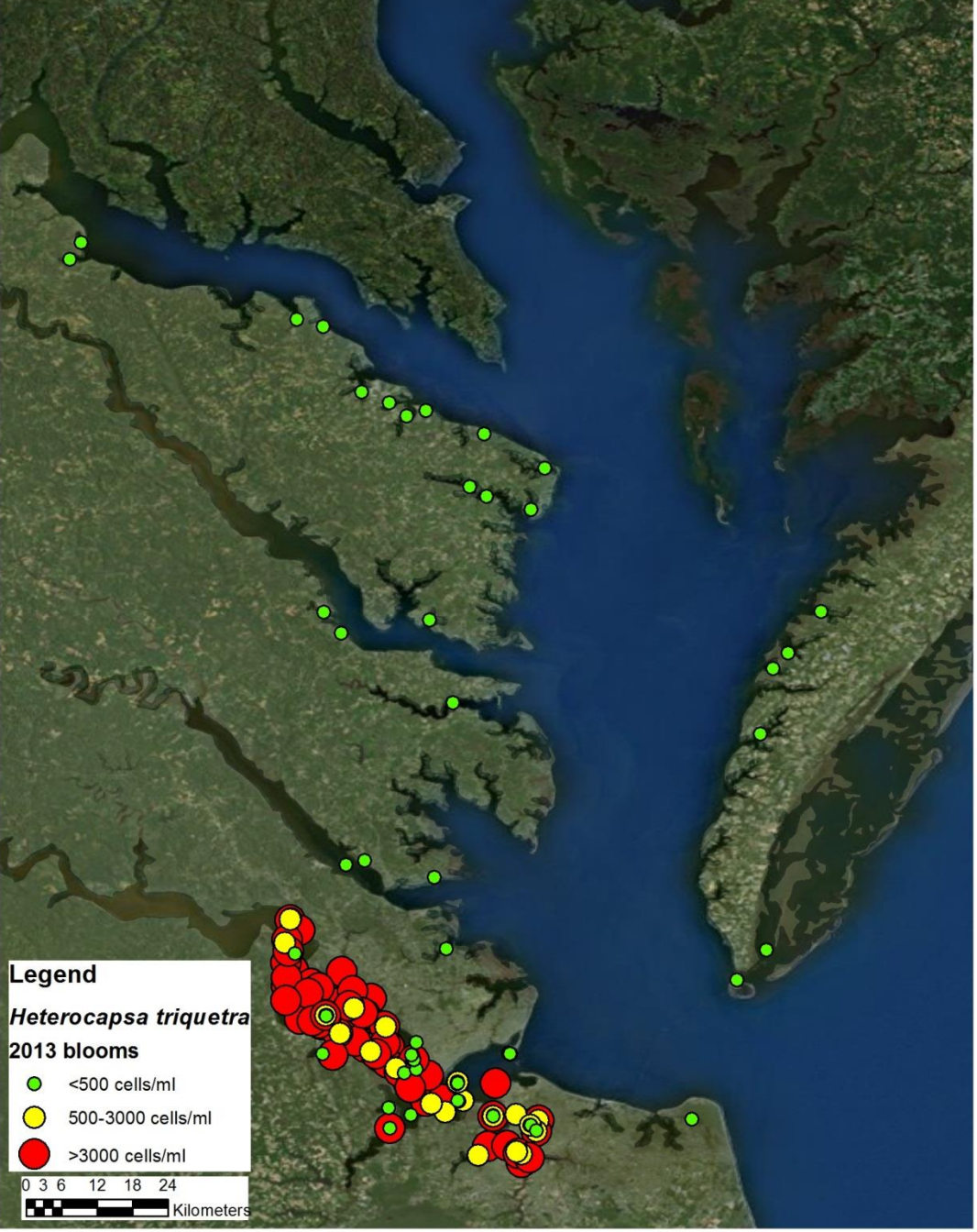
- *Heterocapsa triquetra* (February-April)
  - Mesohaline James River
  - Max Chl*a*: 446 µg/L
    - 2012: 481 µg/L, 2011: 367 µg/L
  - Max density: 178,100 cells/ml (*233,600 cells/ml-DEQ, Deep Creek 3/14)
    - 2012: 191,000 cells/ml, 2011: 65,000cells/ml
- *Cochlodinium polykrikoides* (August-September)
  - Initiation in upper Lafayette and possibly Warwick Rivers
  - Max Chl*a*: 285.9 µg/L
    - 2012: 649 µg/L, 2011:253 µg/L
  - Max density: 22,880 cells/ml (*62,800 cells/ml-VDH, mouth of Warwick River 8/20)
    - 2012: 75,780 cells/ml, 2011: 4350 cells/ml
- *Akashiwo sanguinea* (July-August)
  - Upper Lafayette and mesohaline James
  - Max Chl*a*: 151.5 µg/L Max density: 5820 cells/ml
- *Gymnodinium* cf. *instriatum* (April)
  - Mouth of Warwick River
  - Max Chl*a*: 372 µg/L Max density: 14,730 cells/ml

Other HABs

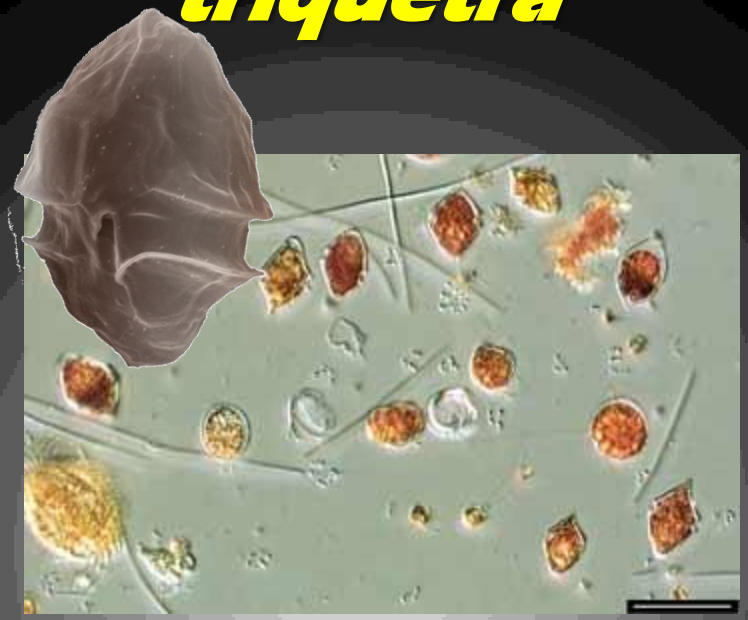
- Dinoflagellates
  - *Alexandrium monilatum*
    - James Polyhaline and Elizabeth River
  - *Karlodinium veneficum*
    - Lafayette River
  - *Prorocentrum minimum*
    - Mesohaline James, Lafayette River
- Cyanobacteria
  - *Microcystis aeruginosa*
    - Lower Tidal Fresh segment (JMS 56,69,75)
    - max 2150 cells/ml (0.3-4.5% of biomass when present)
    - 2012: max 6900 cells/ml
  - *Anabaena circinalis* and *A. spiroides*- Lower Tidal Fresh
- Raphidophytes
  - *Chatonella subsalsa*, *Heterosigma akashiwo*
    - Lafayette and Elizabeth Rivers


Legend
2012 blooms
Heterocapsa triquetra
<500 cells/ml
500-3000 cells/ml
>3000 cells/ml
0 5 10 20 30 40
Kilometers
N


Legend
Heterocapsa triquetra
2013 blooms
<500 cells/ml
500-3000 cells/ml
>3000 cells/ml
0 5 10 20 30 40
Kilometers
N

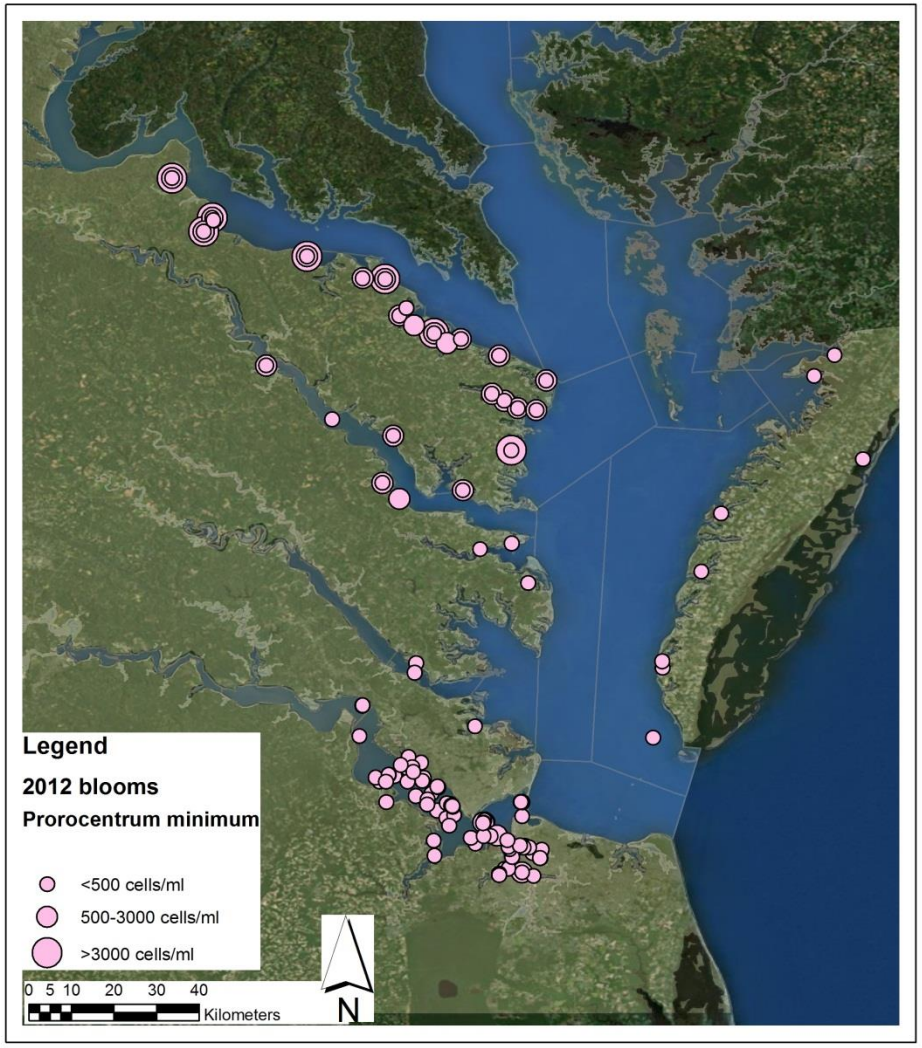


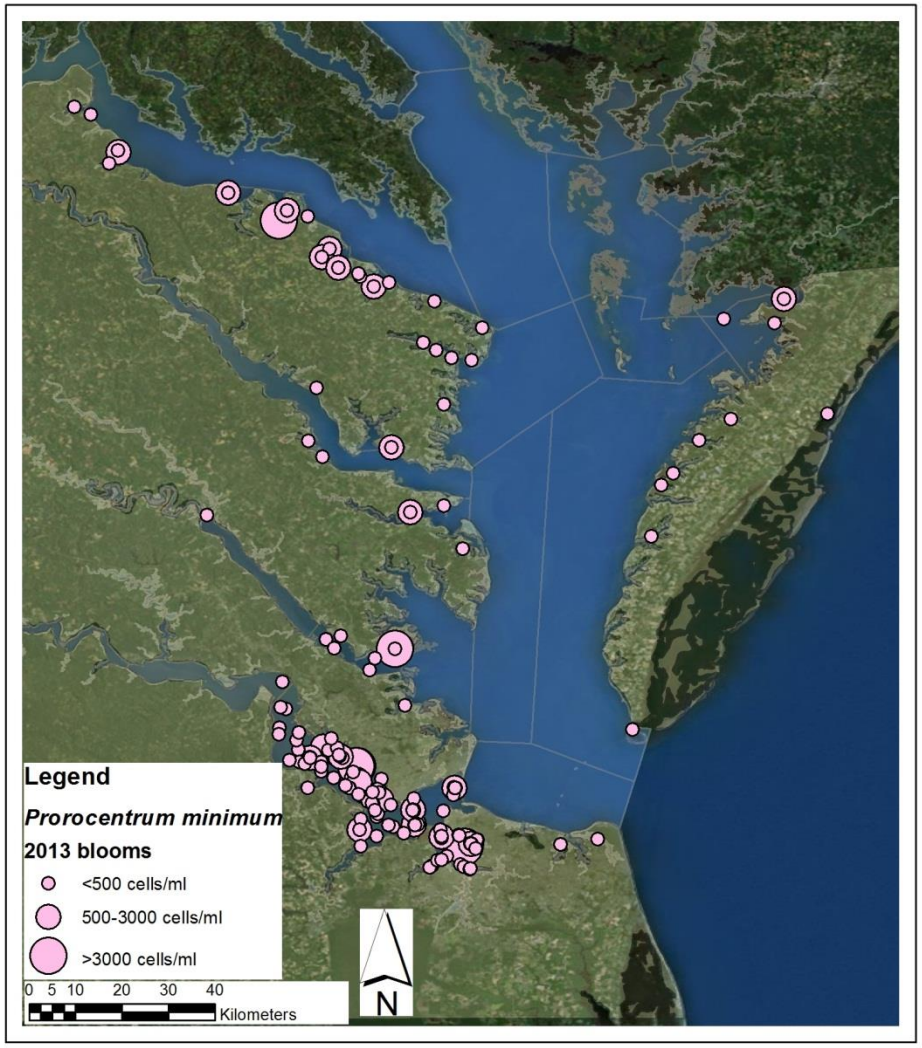
Heterocapsa triquetra

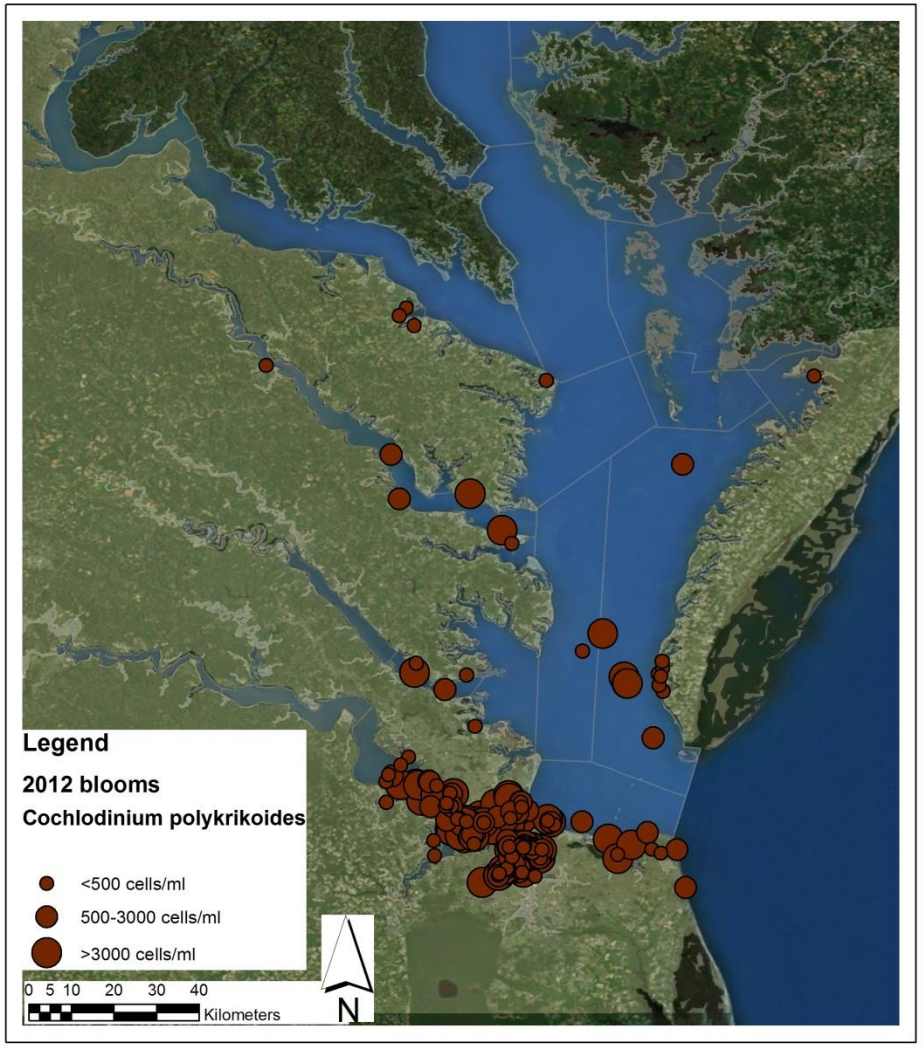


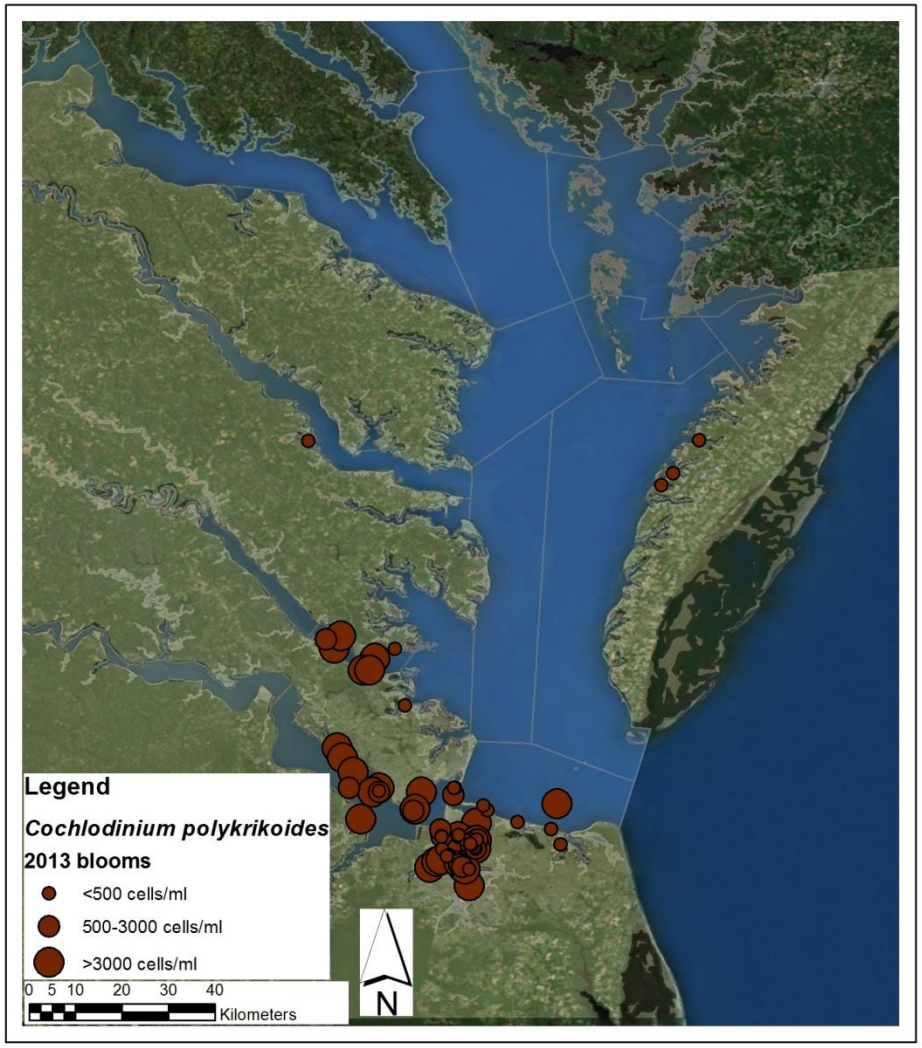
2013

- Similar bloom magnitude as 2012
- 178,000 cells/ml (max)
- Longer duration
- Feb, March, April
- ~11 weeks
- chl*a* >400µg/L

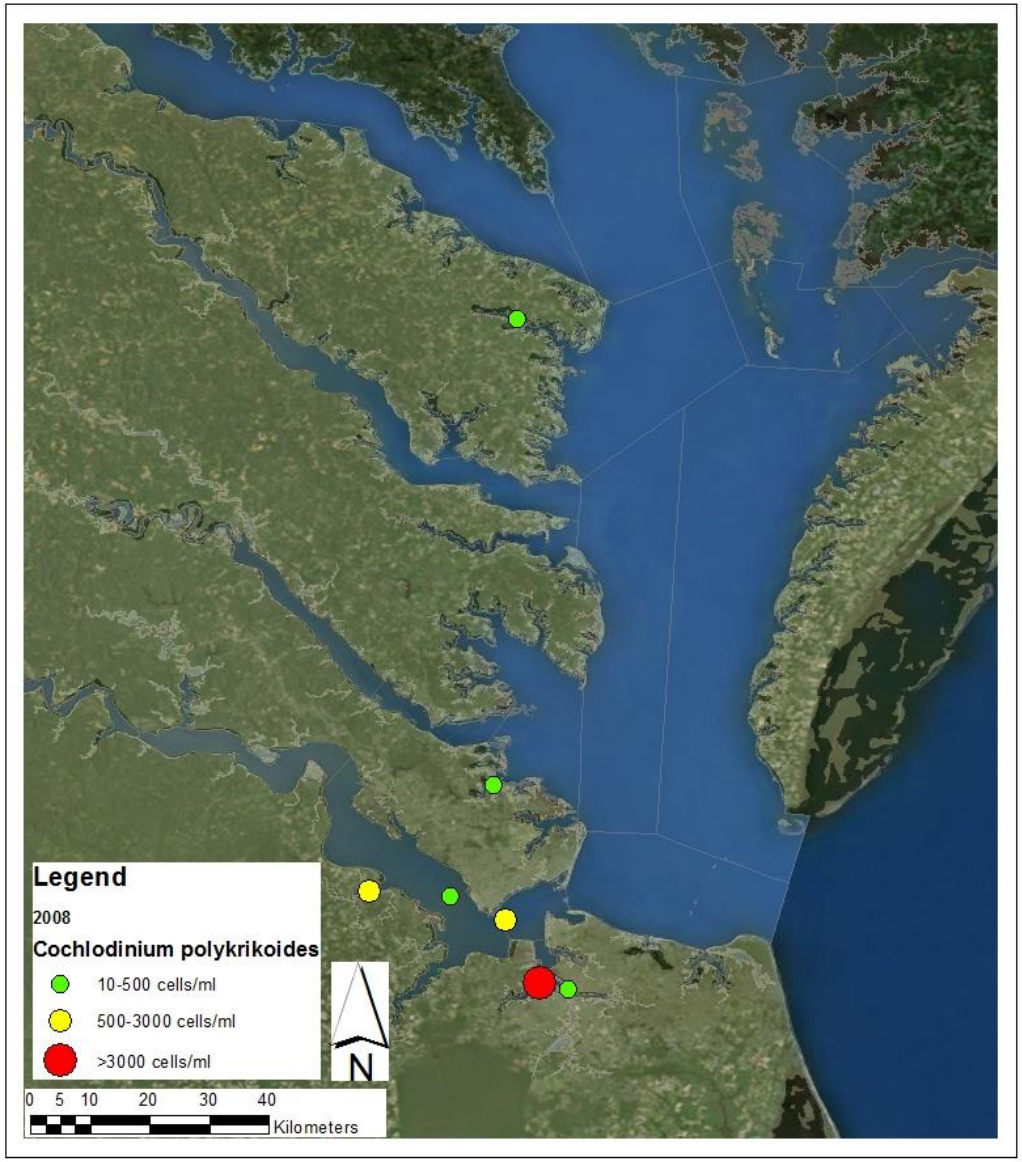

Legend
2012 blooms
Prorocentrum minimum
<500 cells/ml
500-3000 cells/ml
>3000 cells/ml
0 5 10 20 30 40
Kilometers
N

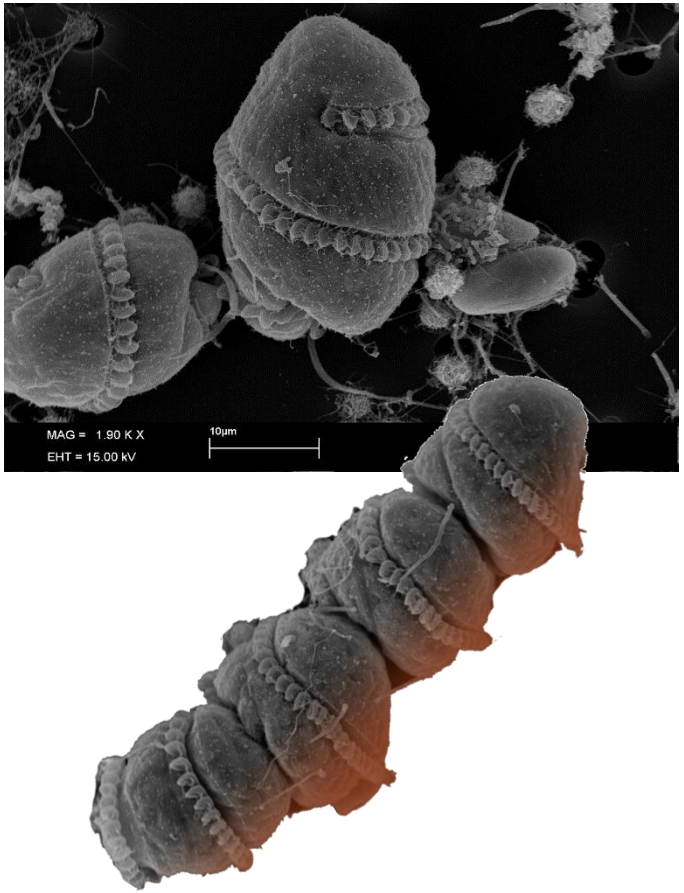

Legend
Prorocentrum minimum
2013 blooms
<500 cells/ml
500-3000 cells/ml
>3000 cells/ml
0 5 10 20 30 40
Kilometers
N


Legend
2012 blooms
Cochlodinium polykrikoides
<500 cells/ml
500-3000 cells/ml
>3000 cells/ml
0 5 10 20 30 40
Kilometers
N

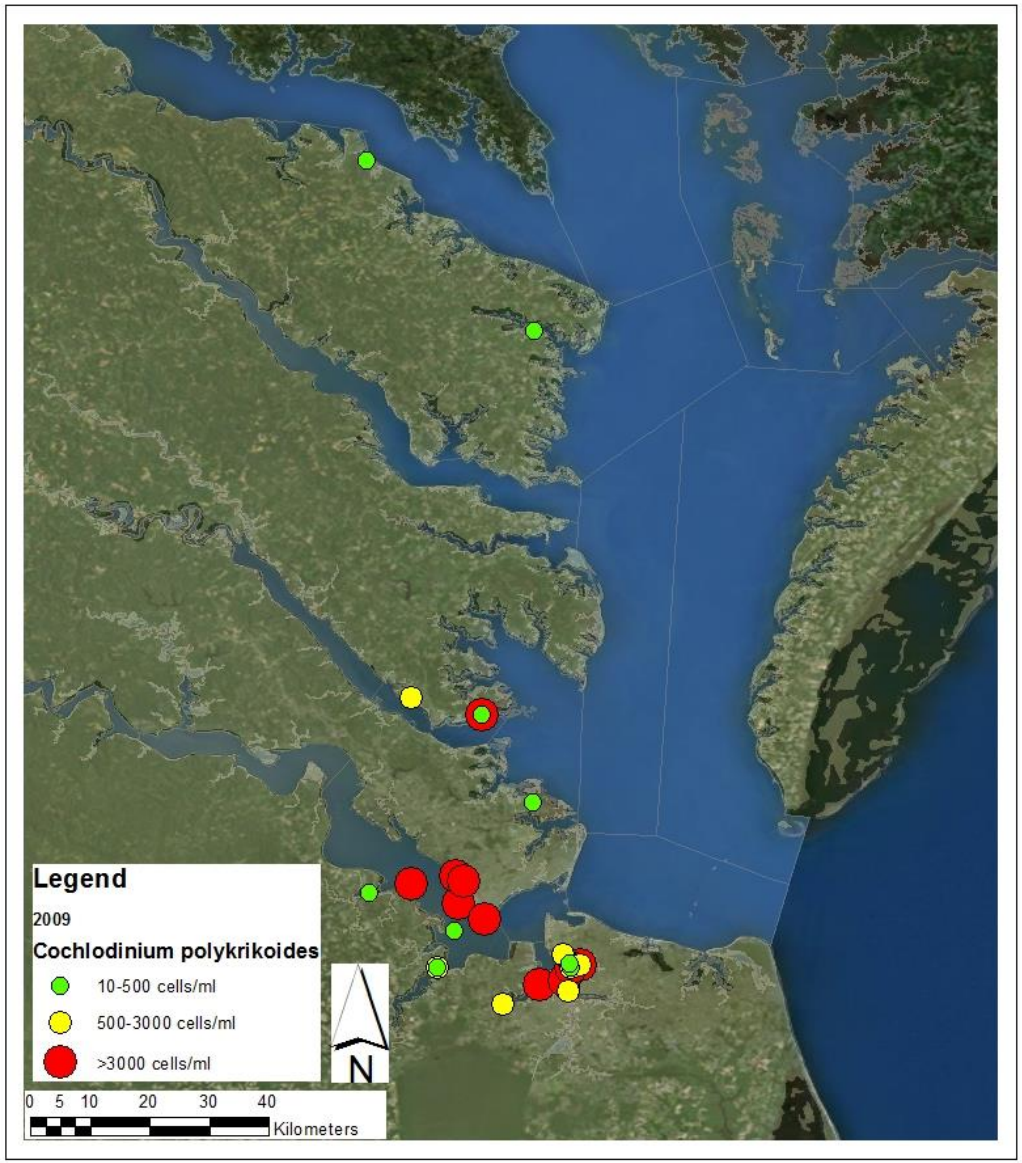

Legend
Cochlodinium polykrikoides
2013 blooms
<500 cells/ml
500-3000 cells/ml
>3000 cells/ml
0 5 10 20 30 40
Kilometers
N

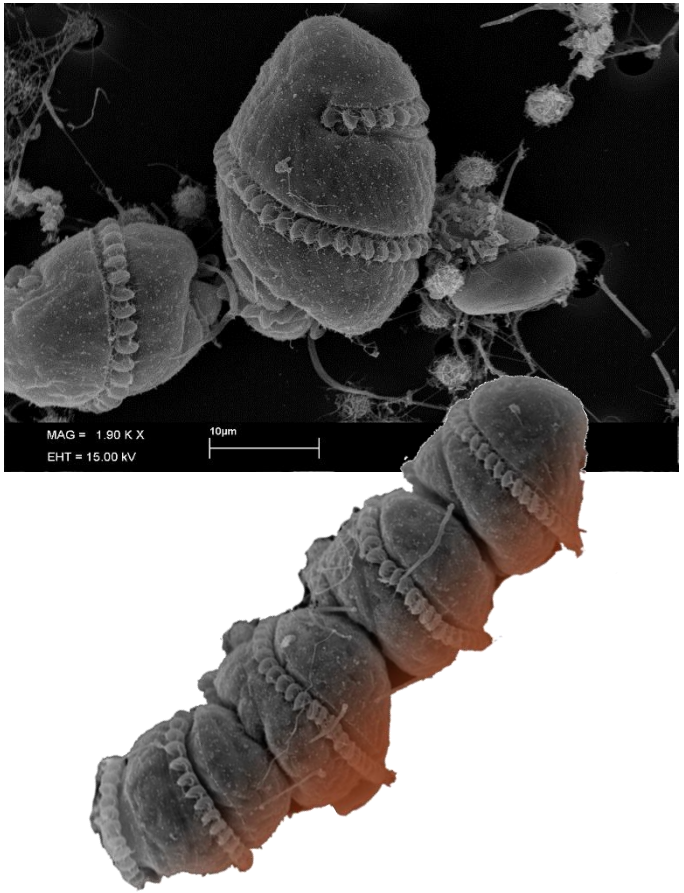
Cochlodinium polykrikoides 2008

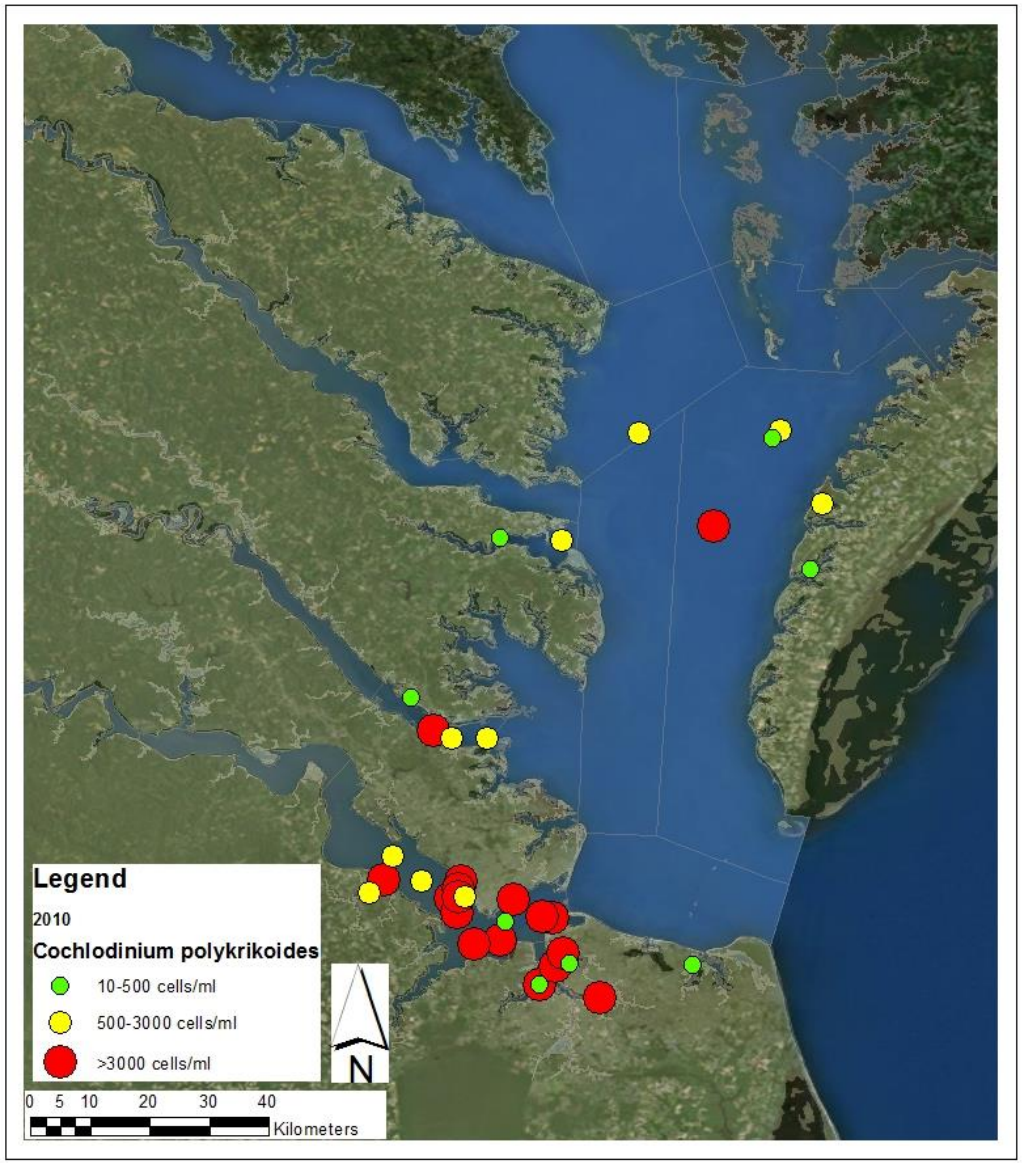




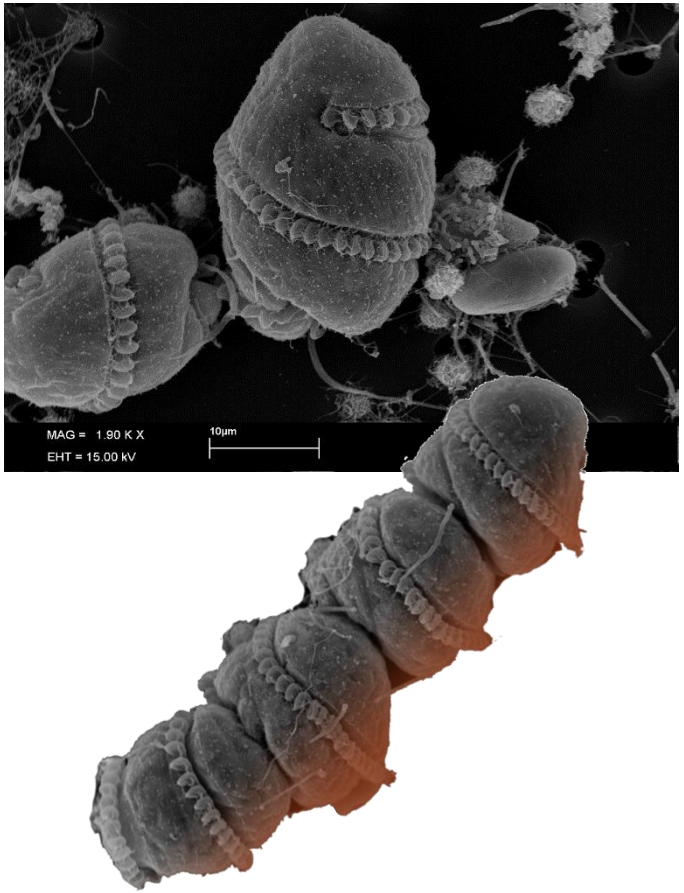
Cochlodinium polykrikoides 2009

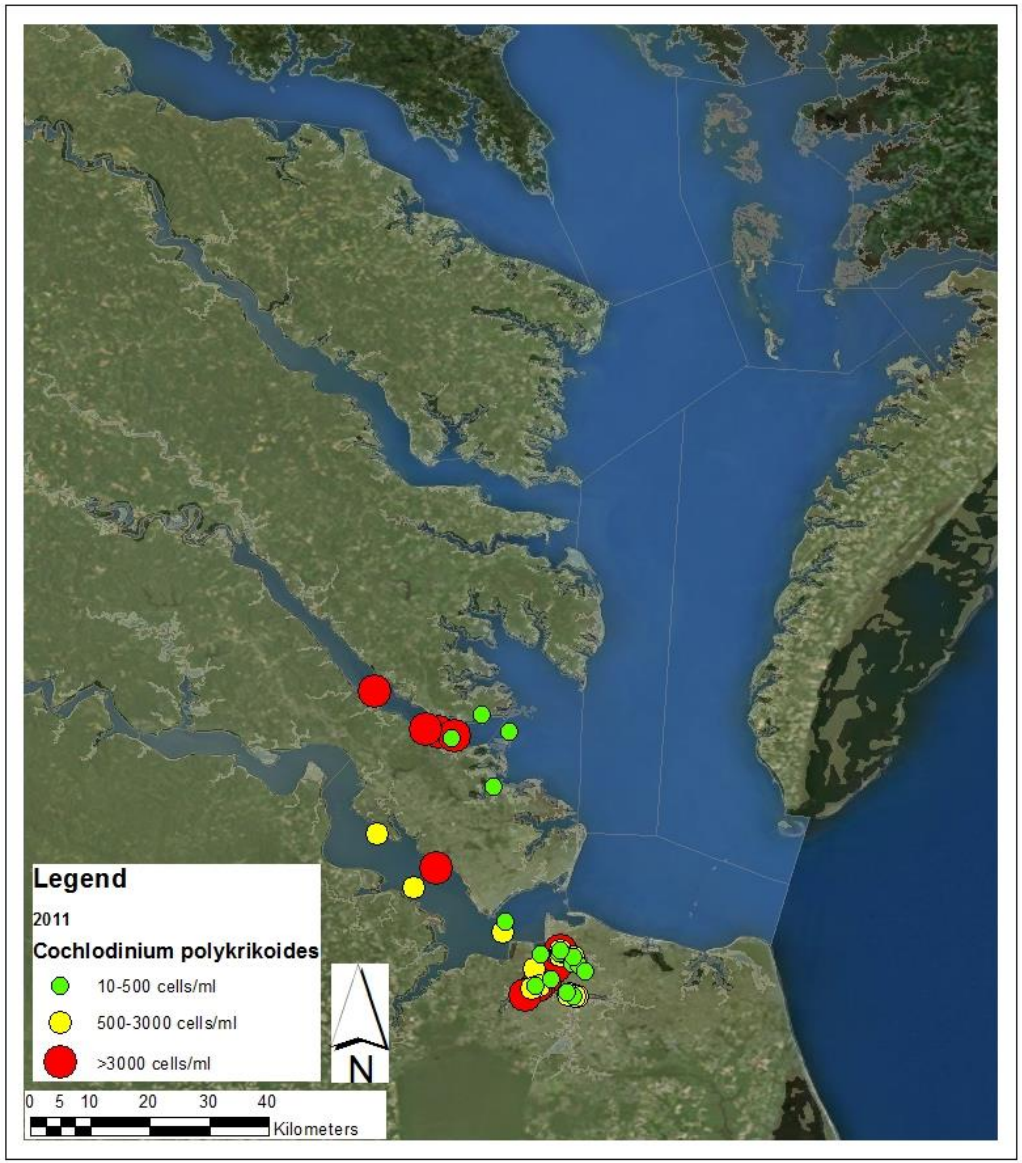




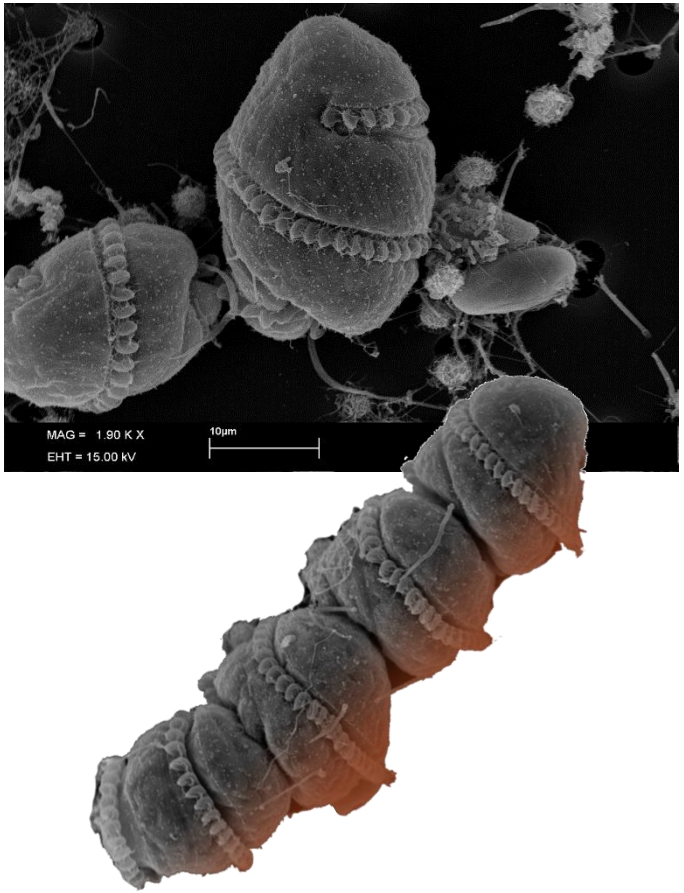


Cochlodinium polykrikoides 2010

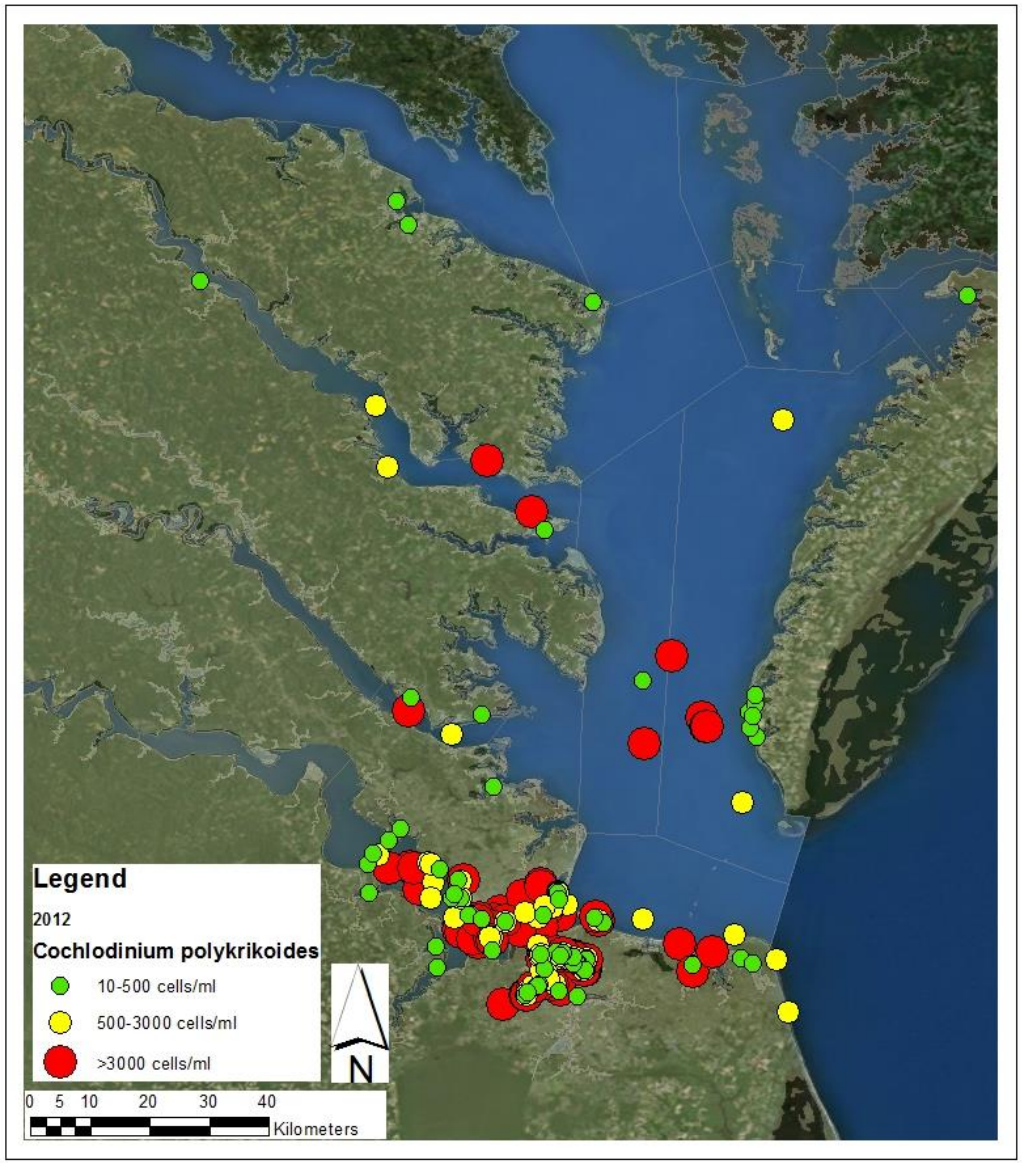


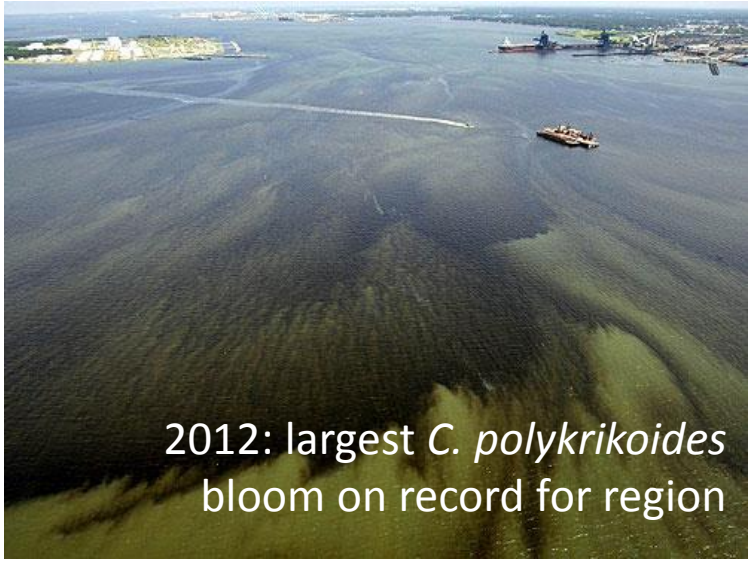


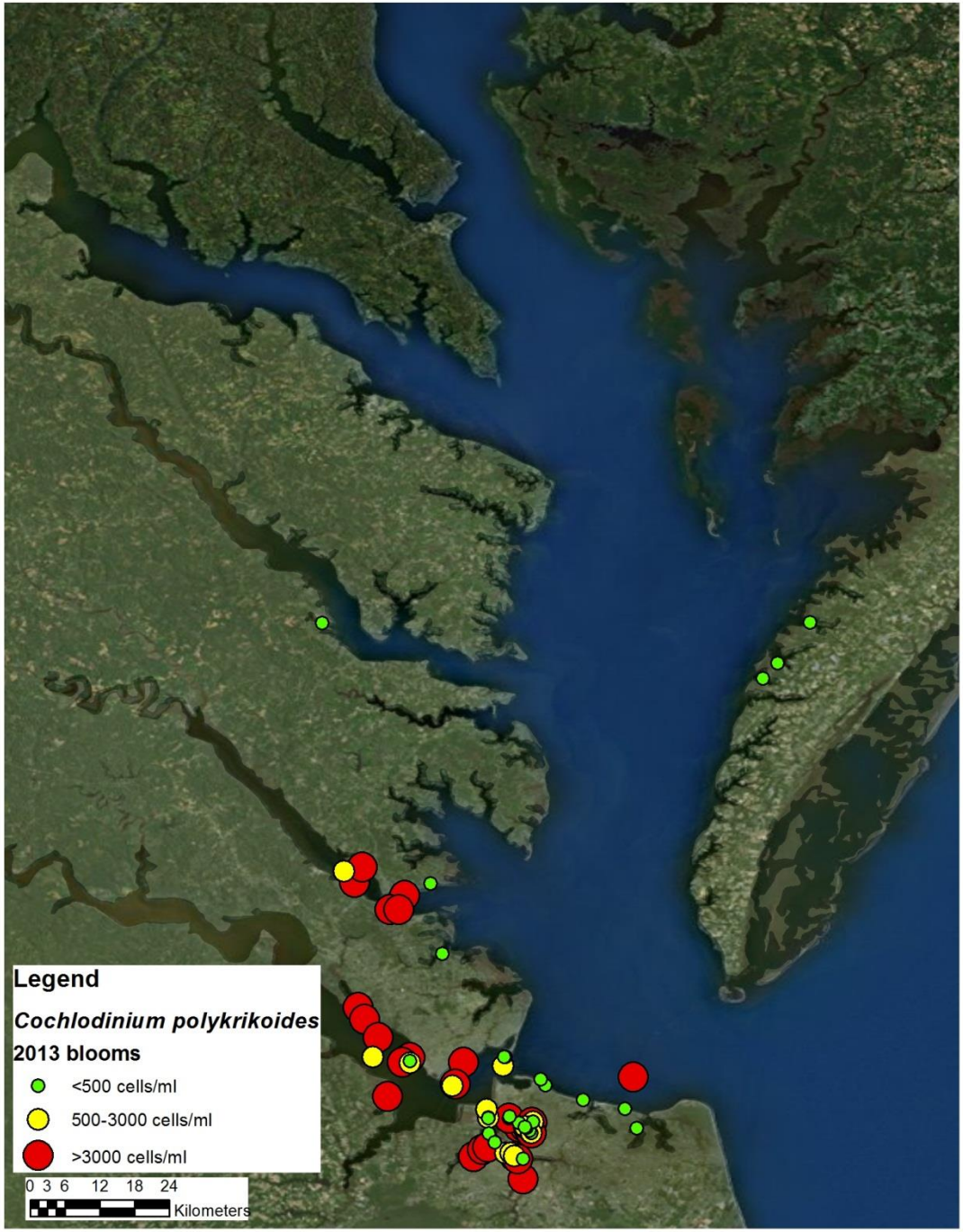
Cochlodinium polykrikoides 2011



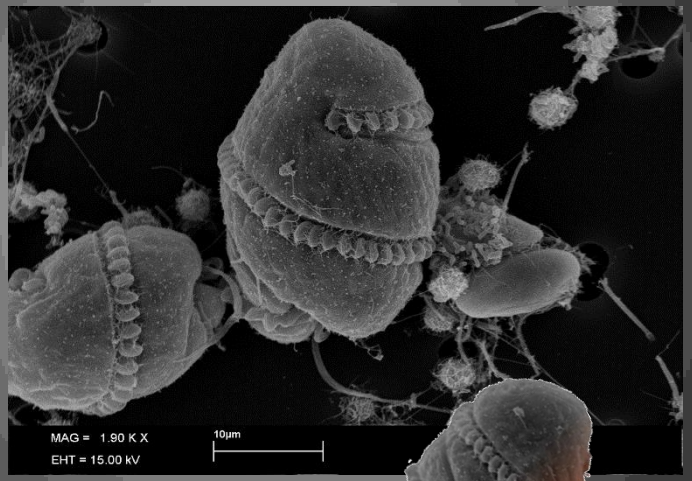
Cochlodinium polykrikoides 2012

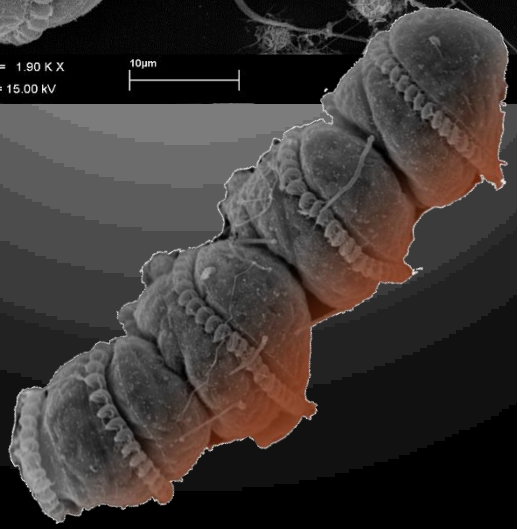




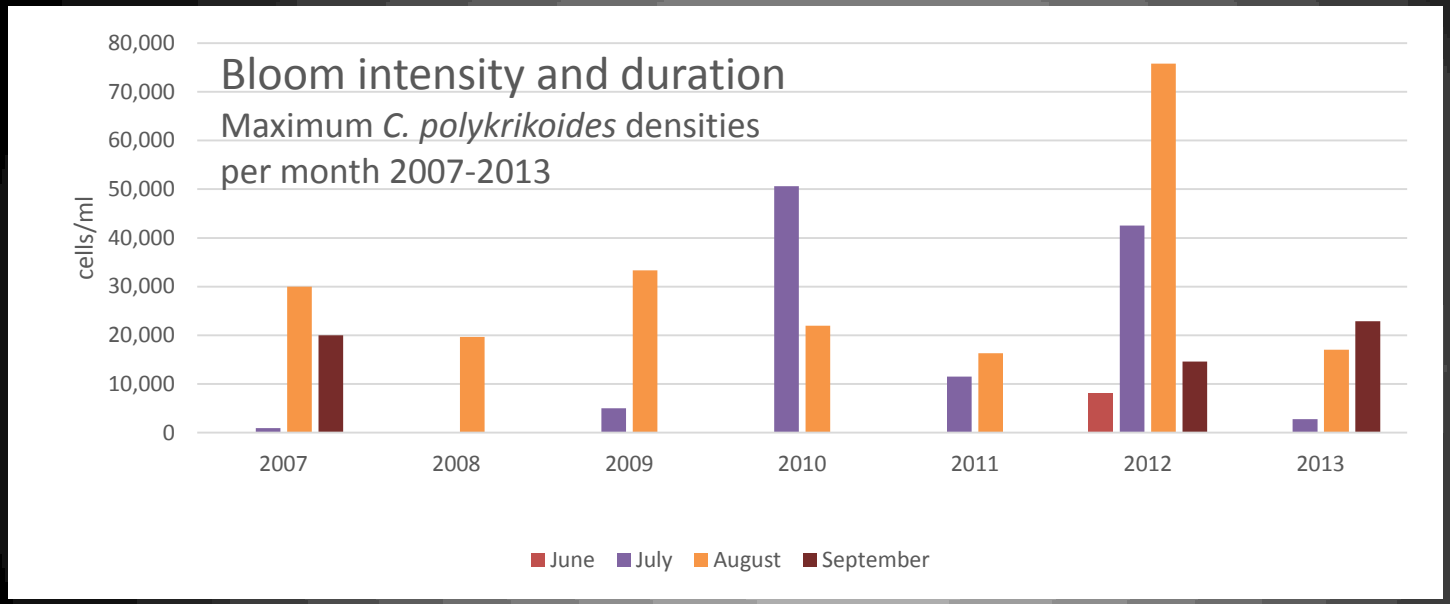


Cochlodinium polykrikoides 2013

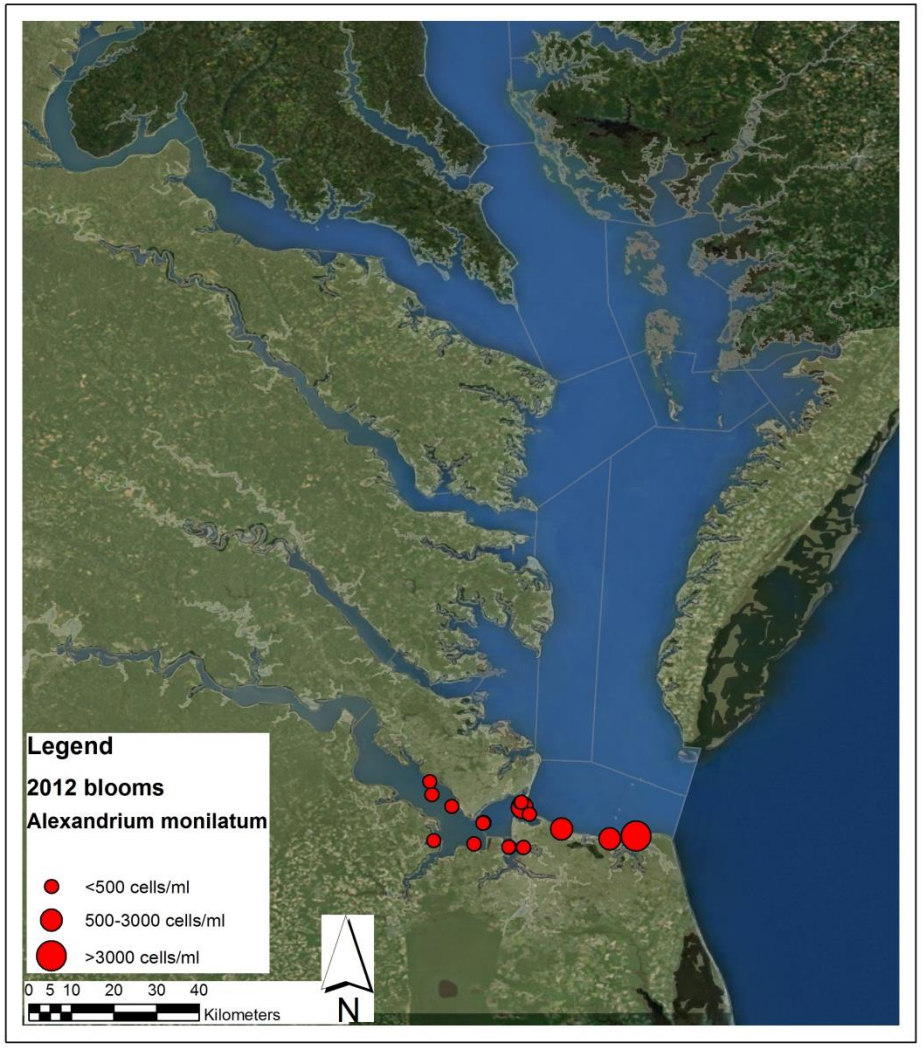


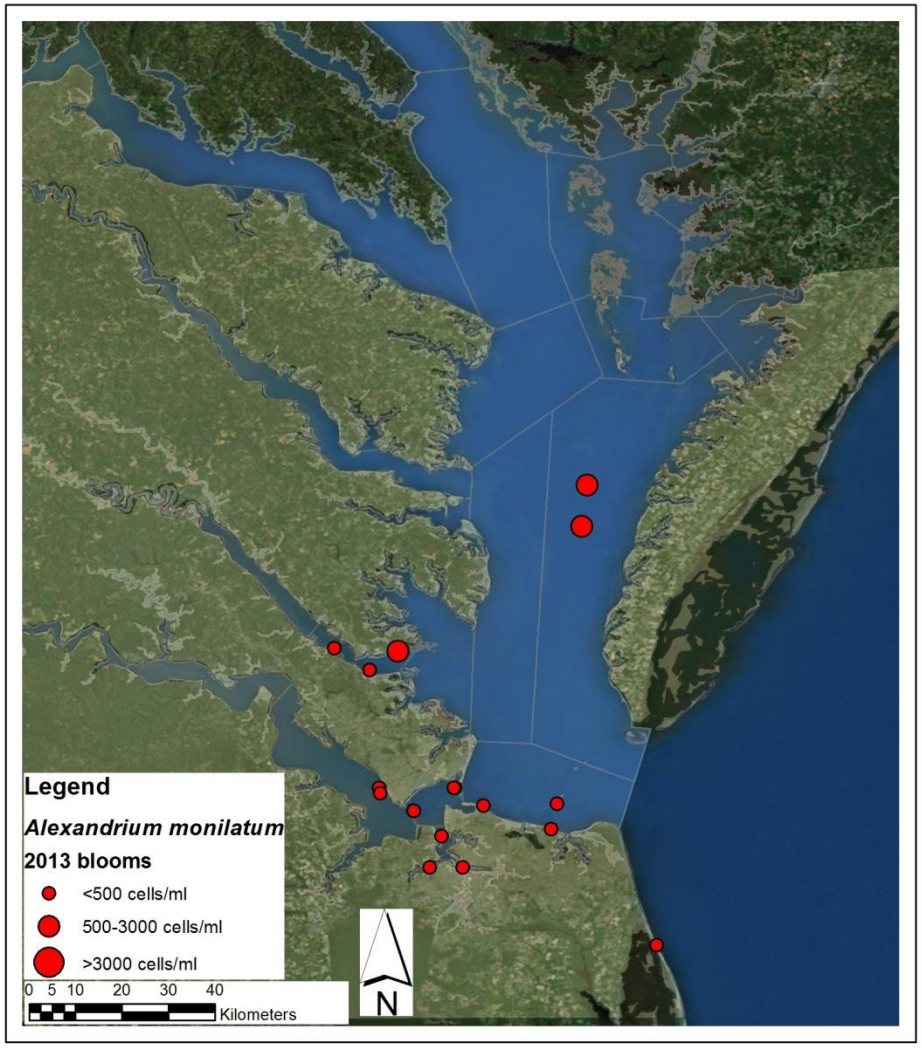


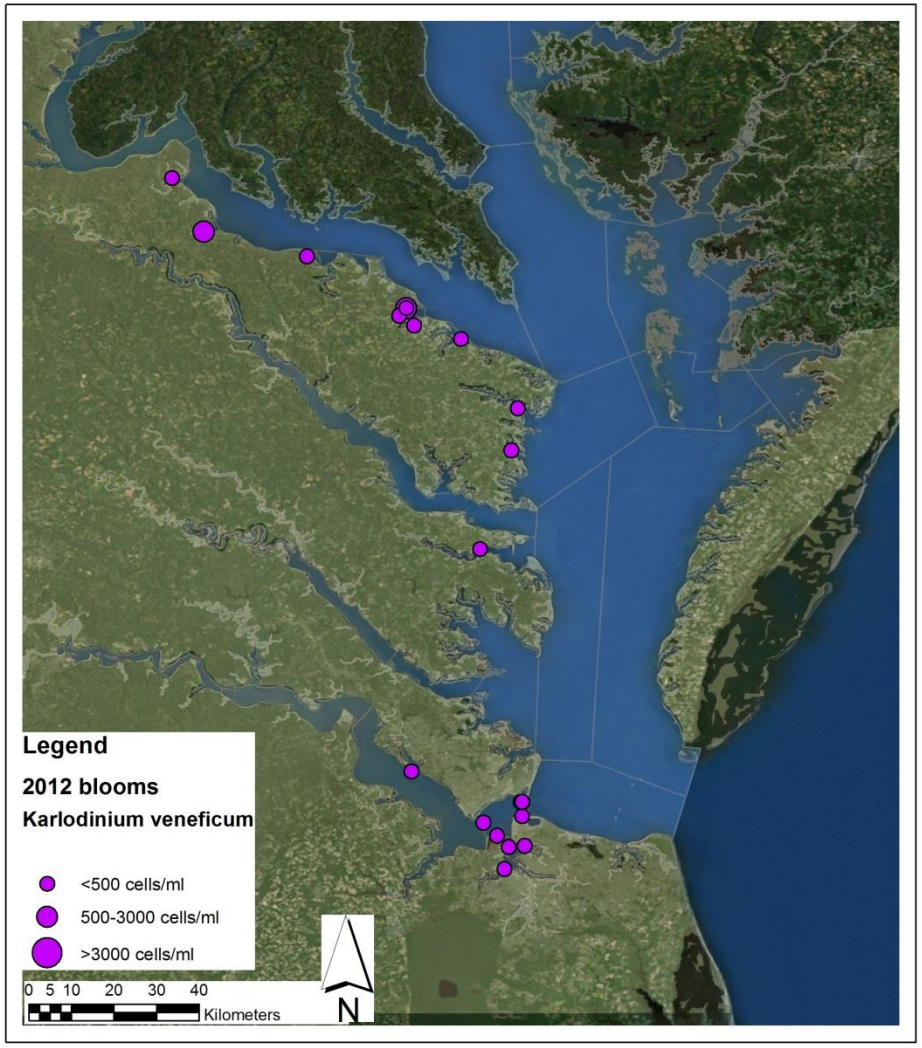
Comparisons to past years

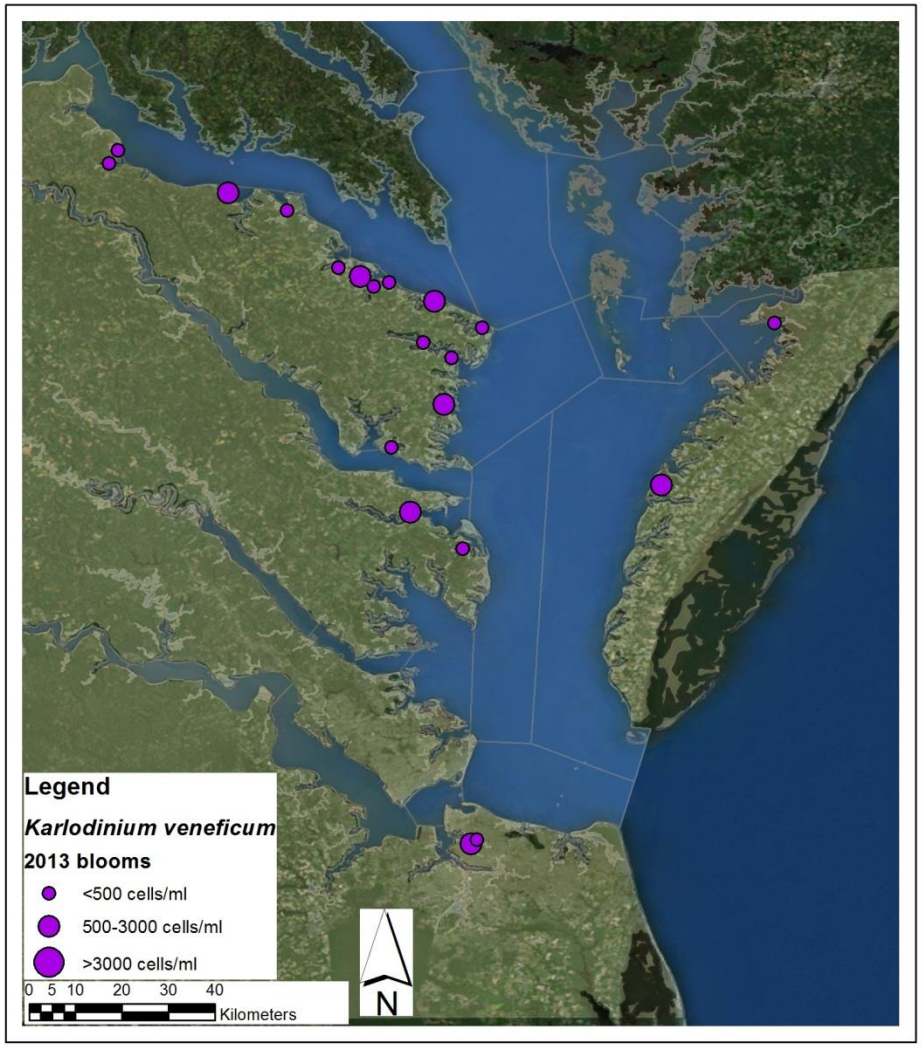


- 2012 bloom had earliest initiation (June), longest duration and highest magnitude
- density ≥ 3000 cell/ml 2012: 7 weeks
- 2012 bloom maxima 75,800 cells/ml
- 2013 bloom: began late July, duration ~5 weeks, max= 22,800 cells/ml


Legend
2012 blooms
Alexandrium monilatum
<500 cells/ml
500-3000 cells/ml
>3000 cells/ml
0 5 10 20 30 40
Kilometers
N


Legend
Alexandrium monilatum
2013 blooms
<500 cells/ml
500-3000 cells/ml
>3000 cells/ml
0 5 10 20 30 40
Kilometers
N

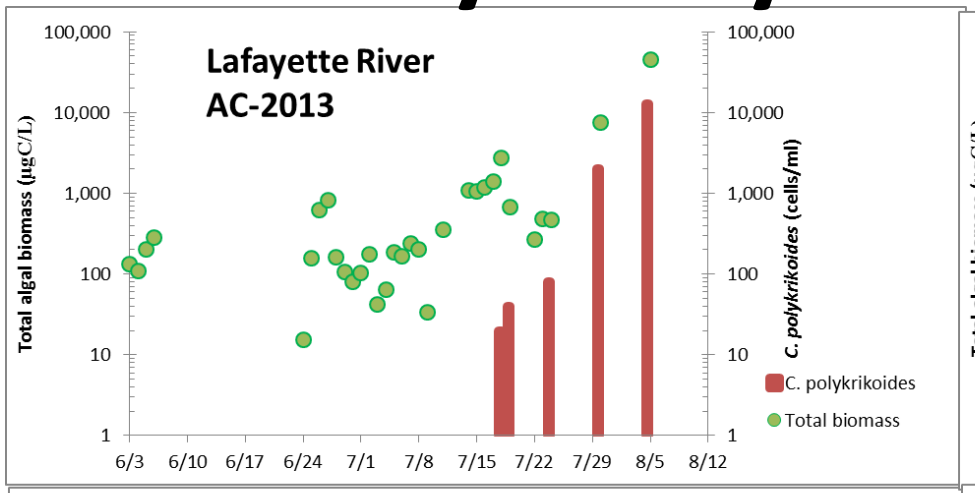

Legend
2012 blooms
Karlodinium veneficum
<500 cells/ml
500-3000 cells/ml
>3000 cells/ml
0 5 10 20 30 40
Kilometers
N

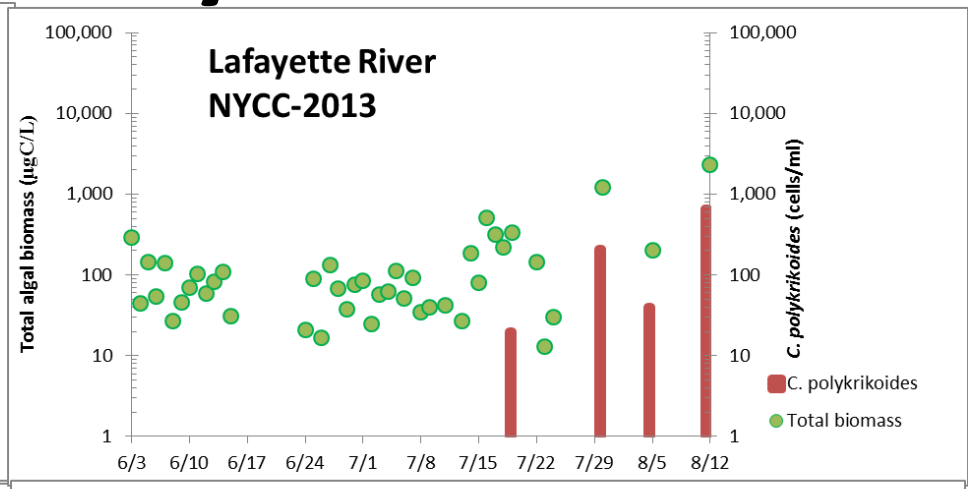

Legend
Karlodinium veneficum
2013 blooms
<500 cells/ml
500-3000 cells/ml
>3000 cells/ml
0 5 10 20 30 40
Kilometers
N

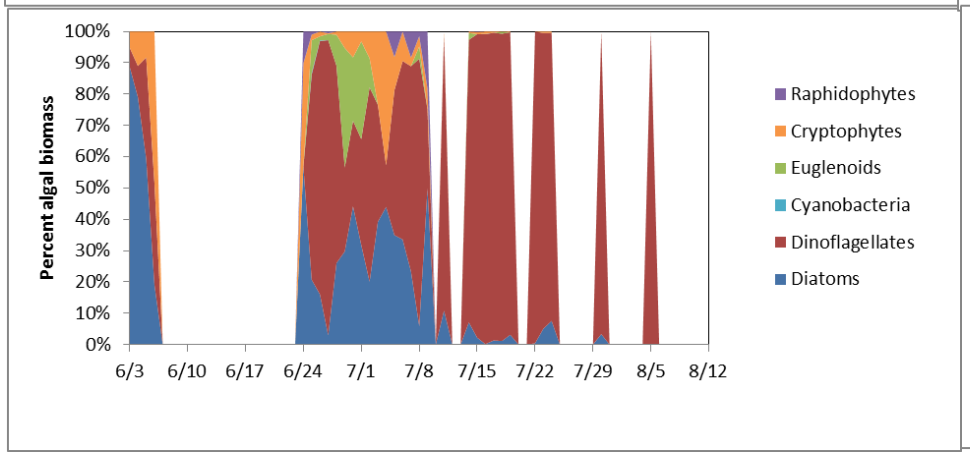
Bloom Duration/Frequency: Table 5: Summary of maximum Chl *a* concentrations measured in each river segment during spring and summer 2012/2013.

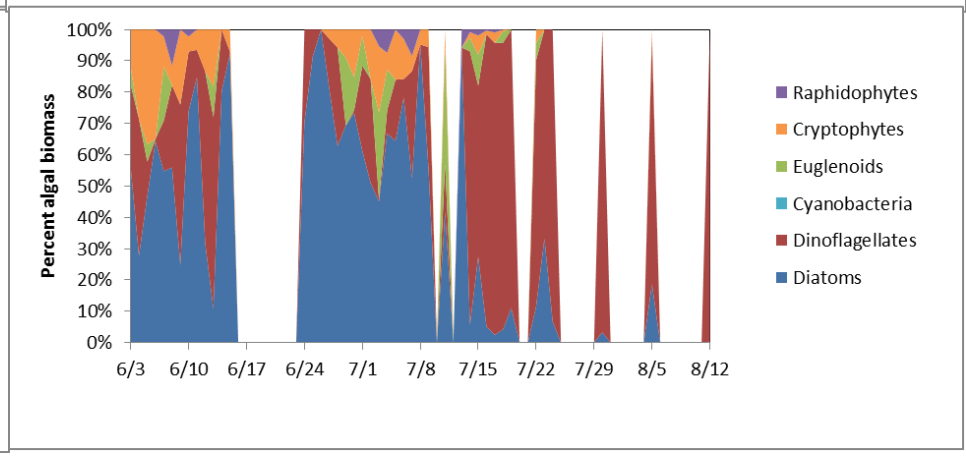
Season/ Year	River Segment	# weeks sampled	Number of weeks with chlorophyll levels were present greater than:					
			>6µg/L	>12µg/L	>24µg/L	>36µg/L	>48µg/L	>100µg/L
Spring 2012	UTF	4						
	LTF	4	**4**	**3**	**2**	**2**	**1**	
	MH	8	**8**	**5**	**3**	**2**	**2**	**2**
	PH	9	**7**	**1**				
	ER	8	**6**	**2**				
	LAF	9	**9**	**8**	**3**			
Summer 2012	UTF	11	**5**	**1**				
	LTF	11	**10**	**10**	**9**	**4**	**1**	
	MH	9	**9**	**8**	**6**	**6**	**5**	**4**
	PH	9	**8**	**8**	**6**	**5**	**5**	**4**
	ER	9	**9**	**9**	**6**	**5**	**4**	**4**
	LAF	9	**9**	**9**	**9**	**9**	**7**	**4**
Spring 2013	UTF	0						
	LTF	2	**2**	**2**				
	MH	10	**12**	**9**	**9**	**9**	**8**	**6**
	PH	10	**8**	**5**	**3**	**1**	**1**	
	ER	9	**11**	**5**	**1**			
	LAF	9	**11**	**7**	**2**			
Summer 2013	UTF	11	**3**					
	LTF	11	**11**	**10**	**9**	**2**	**1**	
	MH	12	**9**	**6**	**5**	**4**	**3**	**3**
	PH	11	**9**	**3**	**2**	**2**	**2**	**1**
	ER	12	**11**	**6**	**6**	**3**	**3**	**1**
	LAF	12	**12**	**12**	**12**	**10**	**9**	**5**

Daily study in Lafayette River









- During initiation of *C. polykrikoides* bloom (~2weeks), 20- 13,000 cells/ml
- 98% of biomass at peak
- Headwaters= bloom initiation (?) and higher magnitude
- Diatoms→*Gymnodinium instriatum*→*A. sanguinea*→*C. polykrikoides*

2013 Summary

Upper James:

- Significantly reduced biomass from 2012
- Species composition similar to 2012 and long-term dataset
- Highest phytoplankton biomass in lower Tidal-fresh (JMS 75/TF5.5) August/ September
- Diverse community (highest species richness and evenness)
- Higher chlorophyll related to greater abundance/biomass of many species belonging to multiple algal phyla
- Characterized by centric diatom dominance
  - *Aulacoseira granulata*
- Continued cyano HAB presence observed in 2013, background (non-bloom) densities

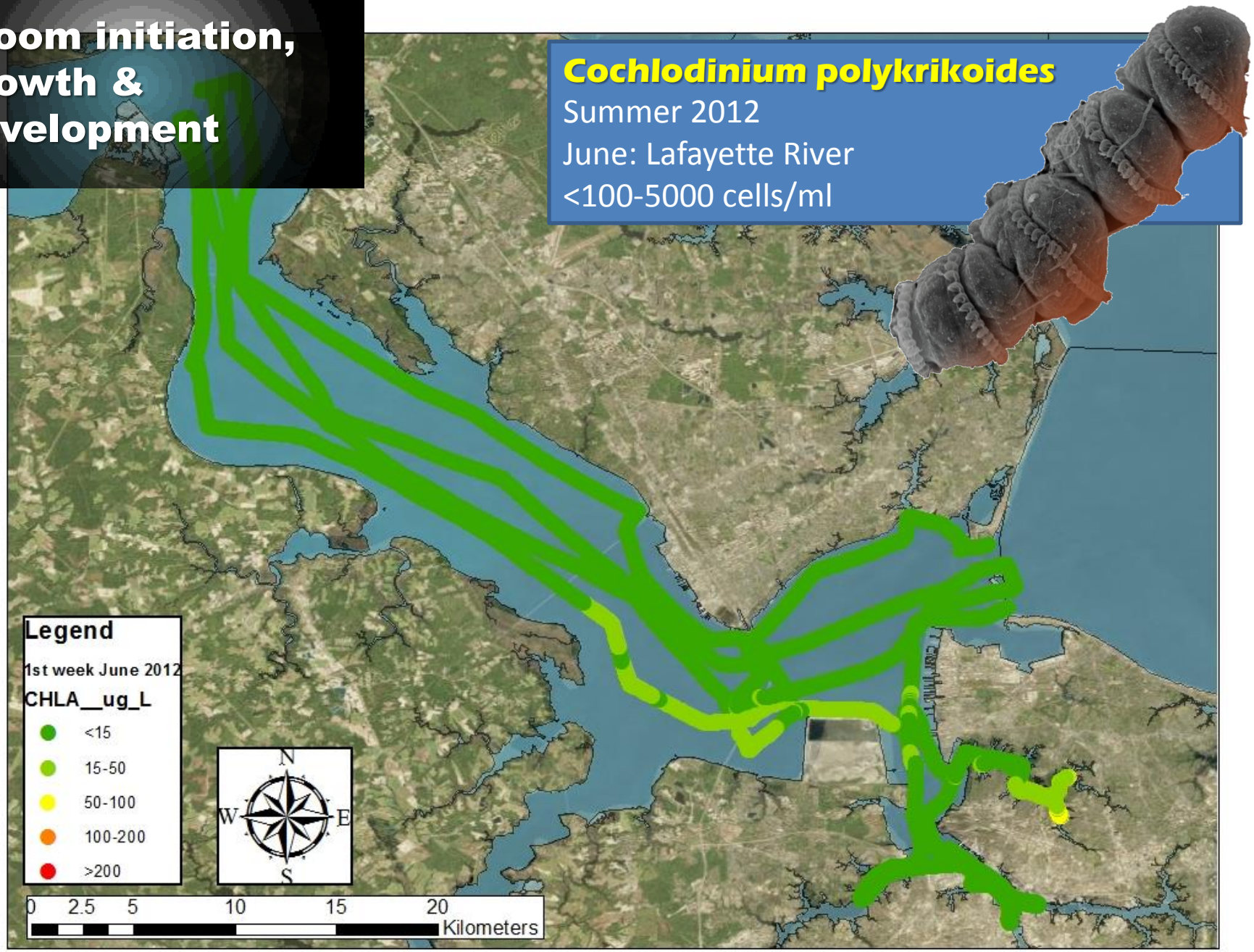
2013 Summary

Lower James:

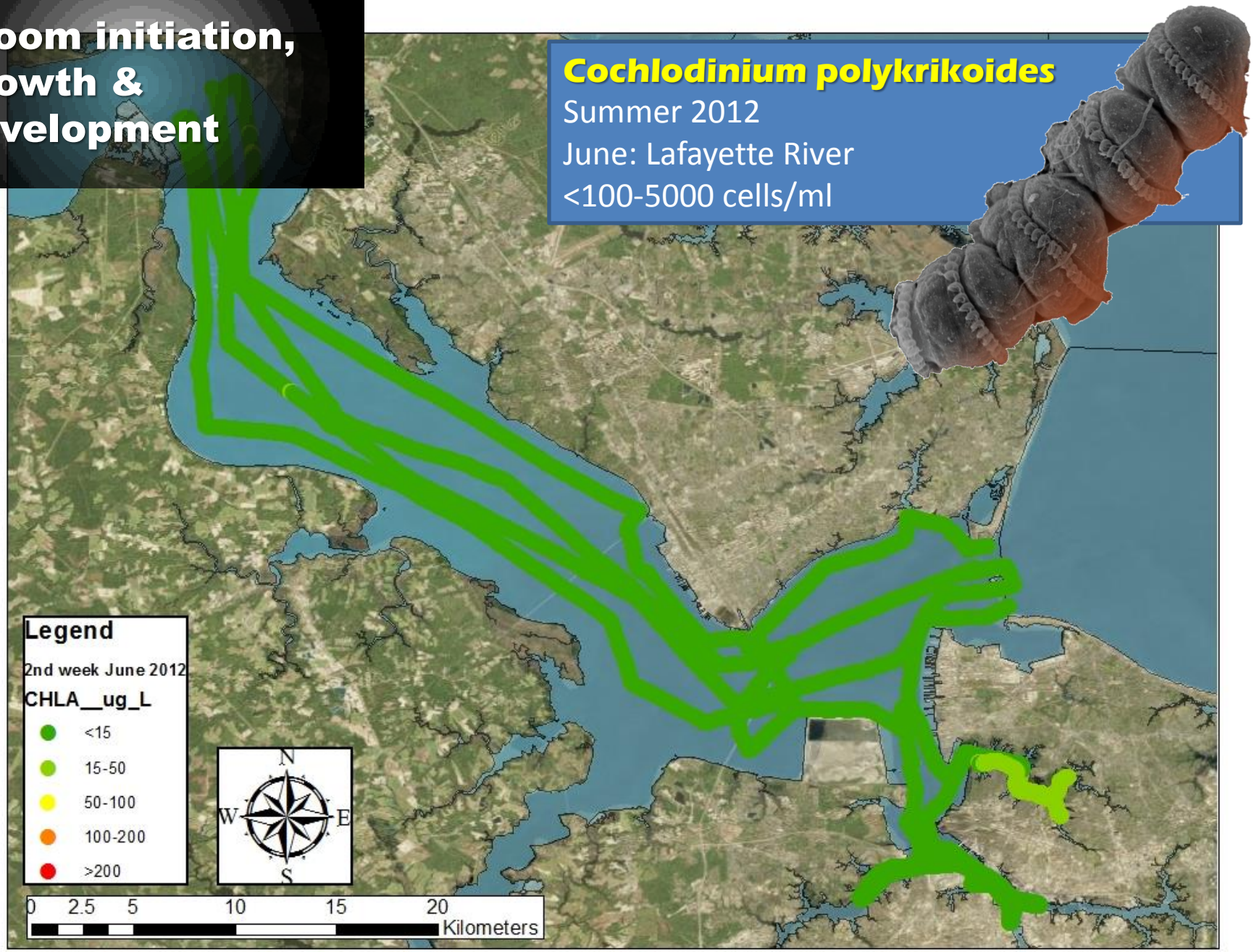
- Meso/polyhaline James, Elizabeth and Lafayette Rivers have highest chlorophyll, biomass (Max values ~order of magnitude greater than upper James)
- Reduced biomass from 2012 (~50% lower than last year) and 5-7 weeks later
- Composition similar to 2012, Long-term monitoring station (LE5.5-W) not representative of bloom conditions for region.

  No long-term record of meso/poly composition.- **Need Data**
- High chlorophyll/algal biomass associated with monospecific dinoflagellate blooms (lower richness, very low evenness)
  - *C.polykrikoides, H. triquetra, et al.*
- Continued presence of HABs, increased number of major bloom species (>100µg/L Chl *a*)
- Bloom initiation in Lafayette and possibly Warwick Rivers (**further investigation needed**)

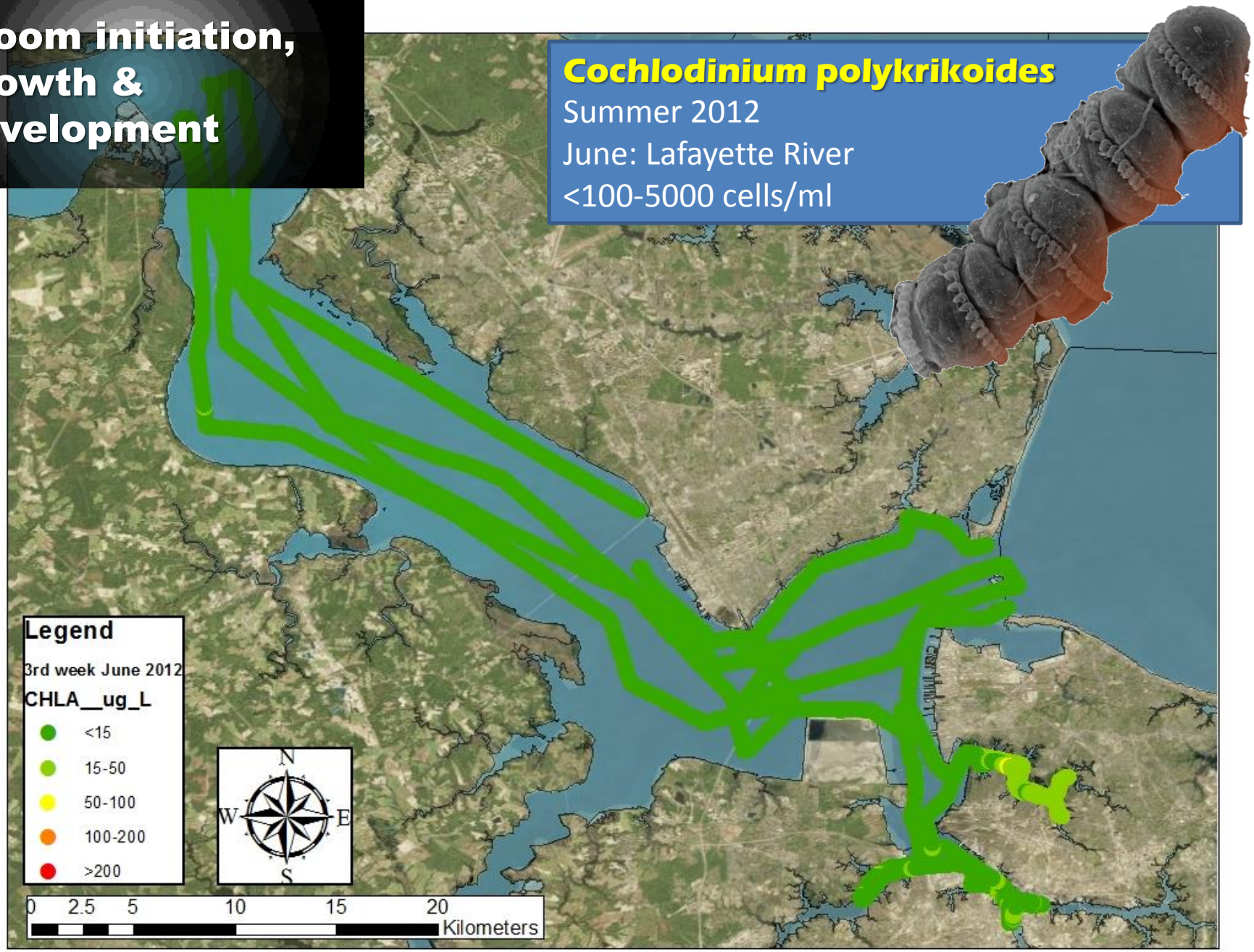
Bloom initiation, growth & development



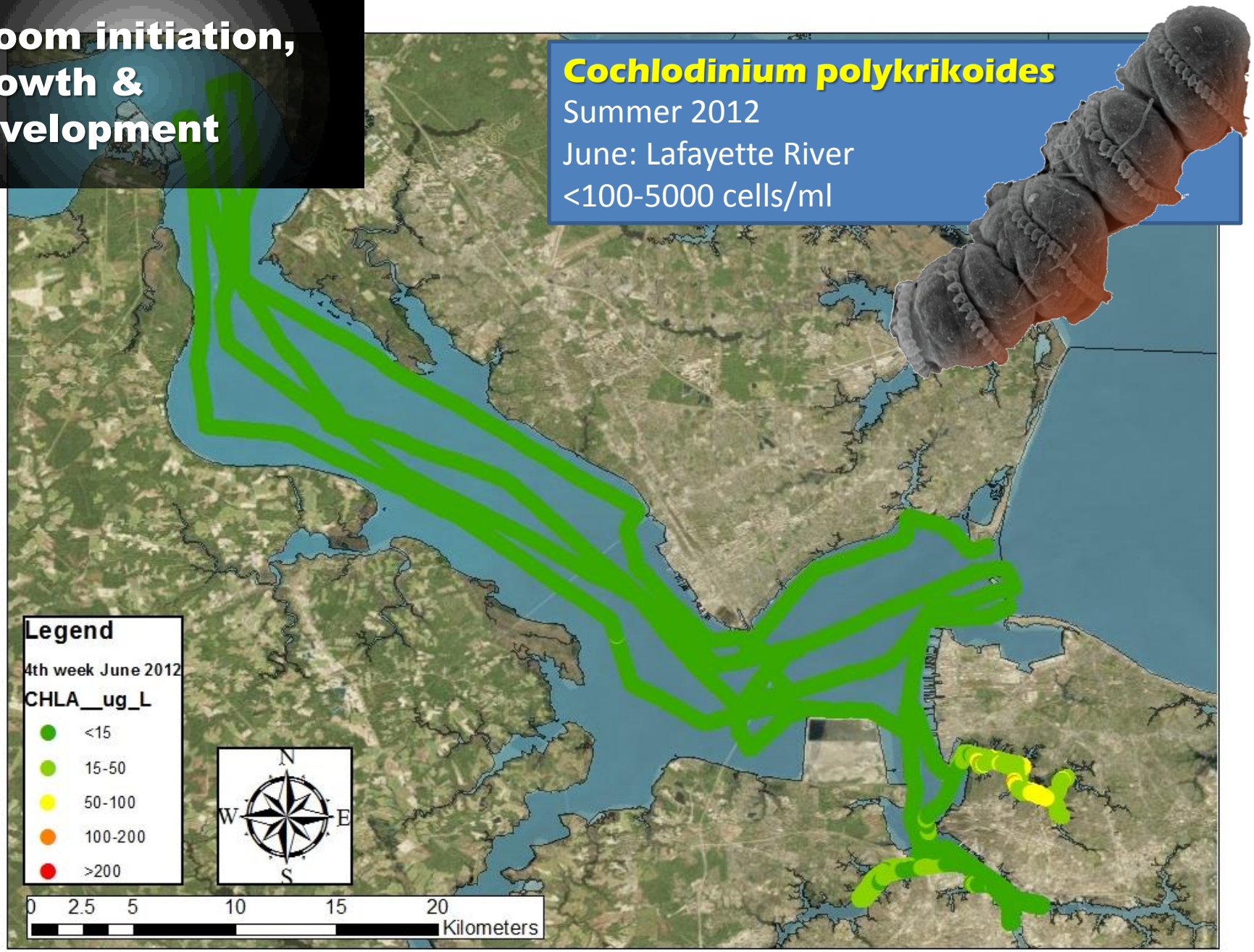
Bloom initiation, growth & development



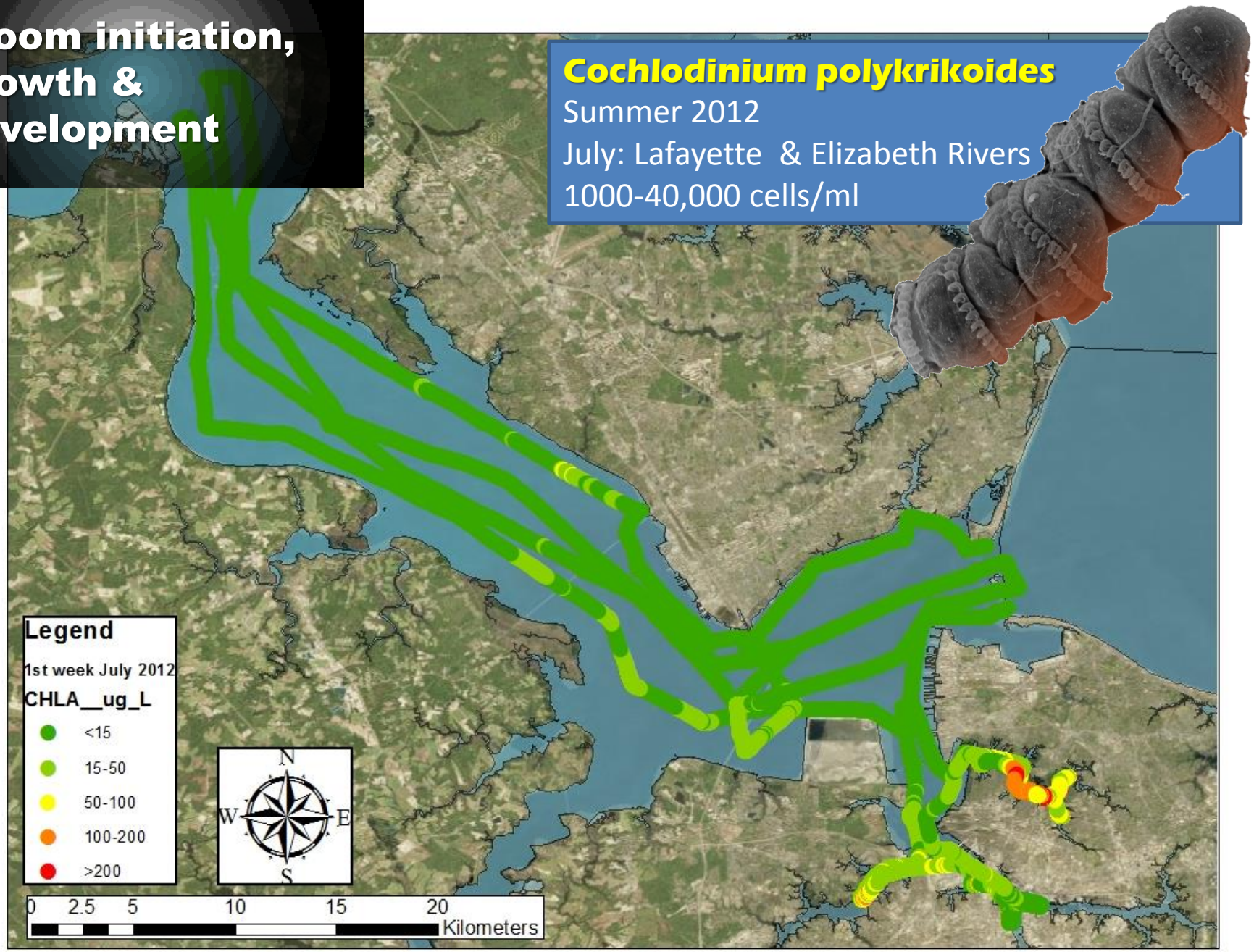
Bloom initiation, growth & development



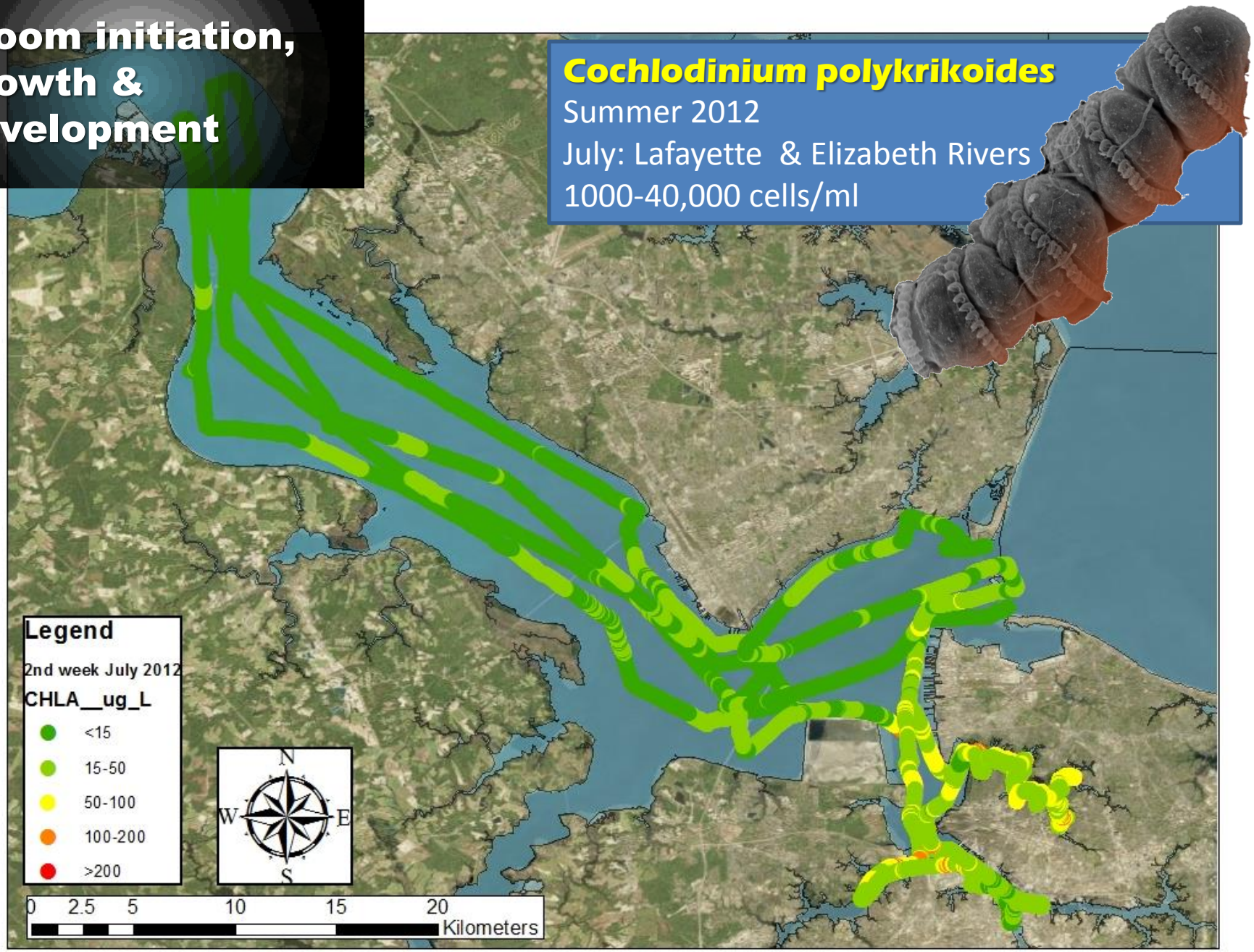
Bloom initiation, growth & development



Bloom initiation, growth & development



Bloom initiation, growth & development



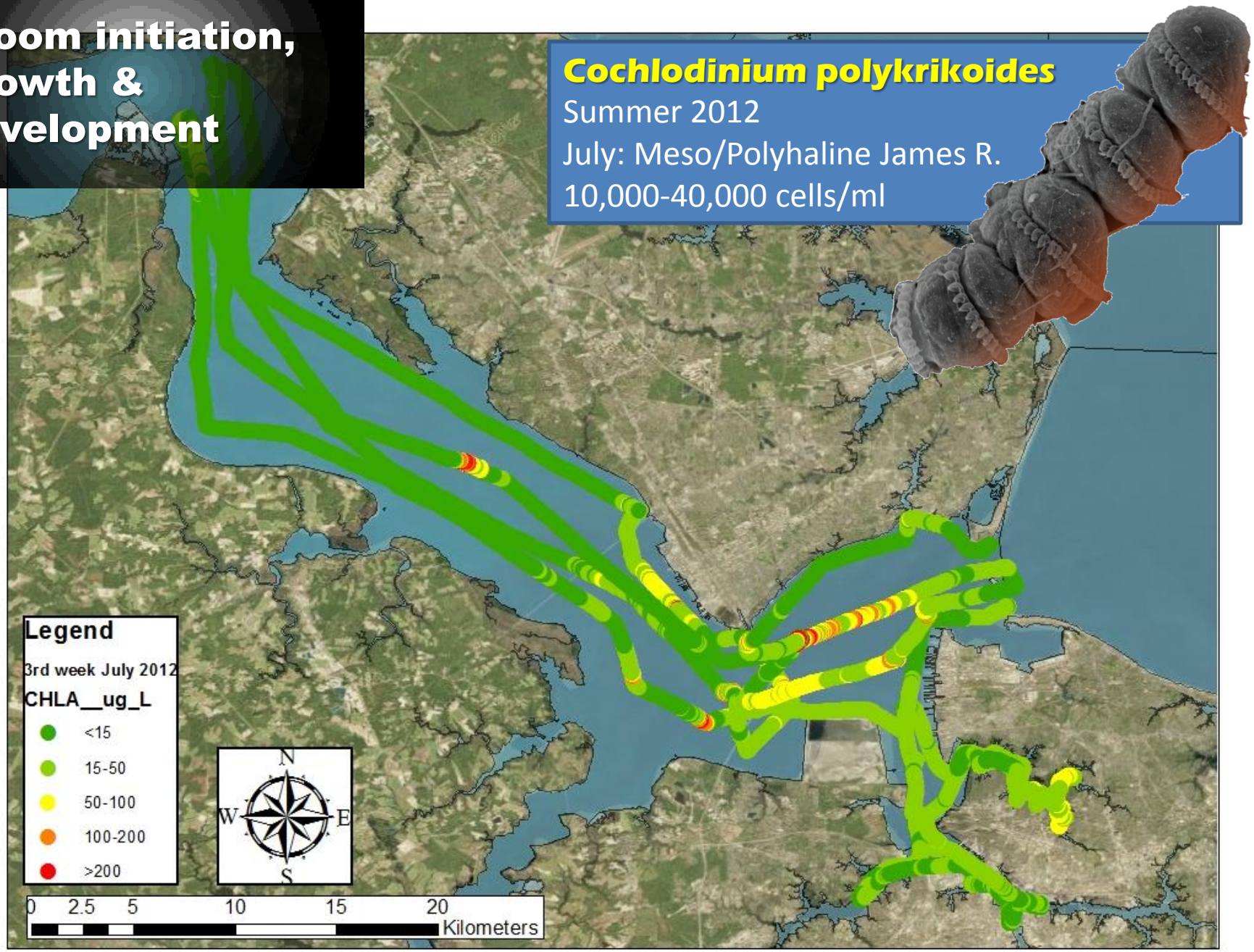
Bloom initiation, growth & development

Cochlodinium polykrikoides

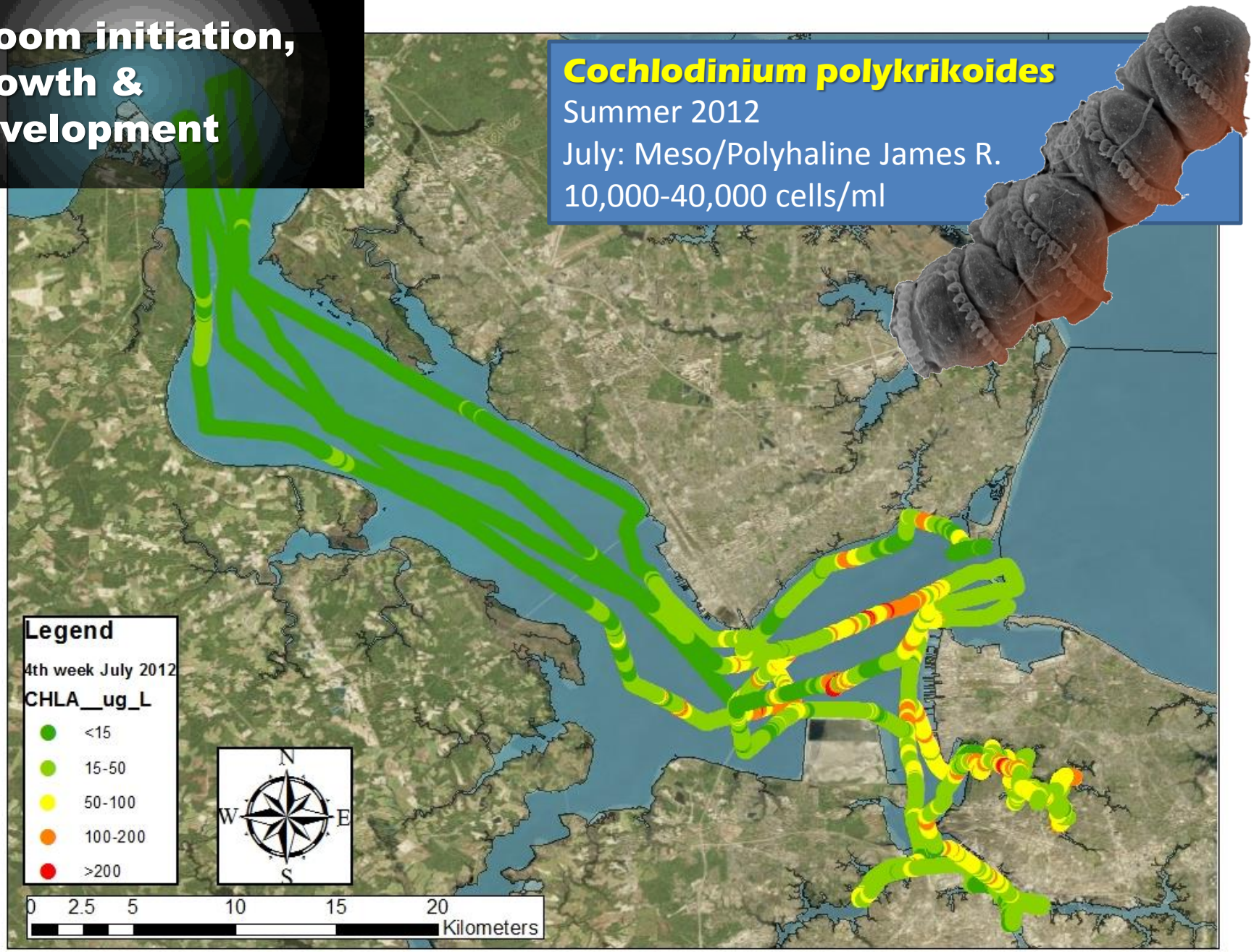
Summer 2012

July: Meso/Polyhaline James R.

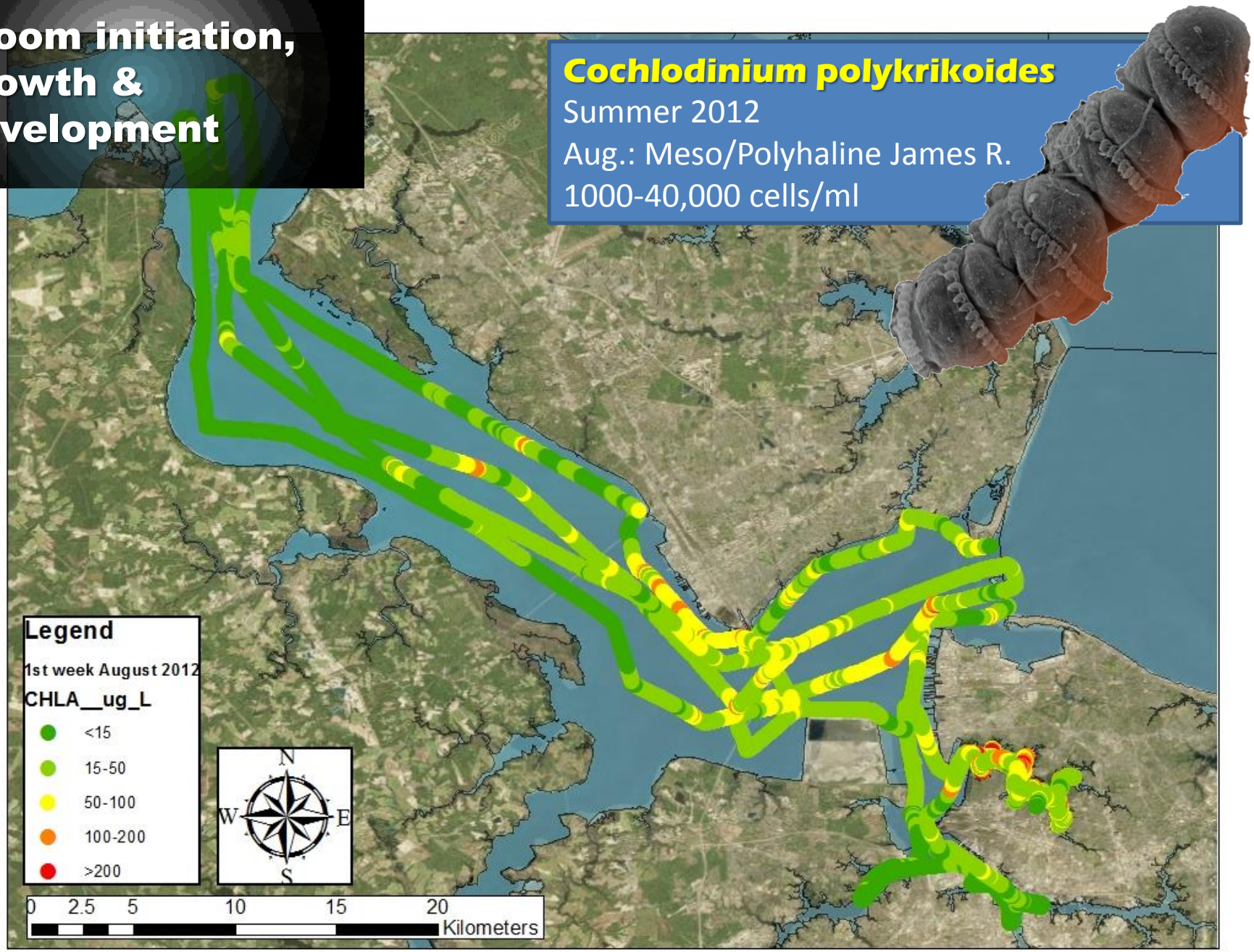
10,000-40,000 cells/ml



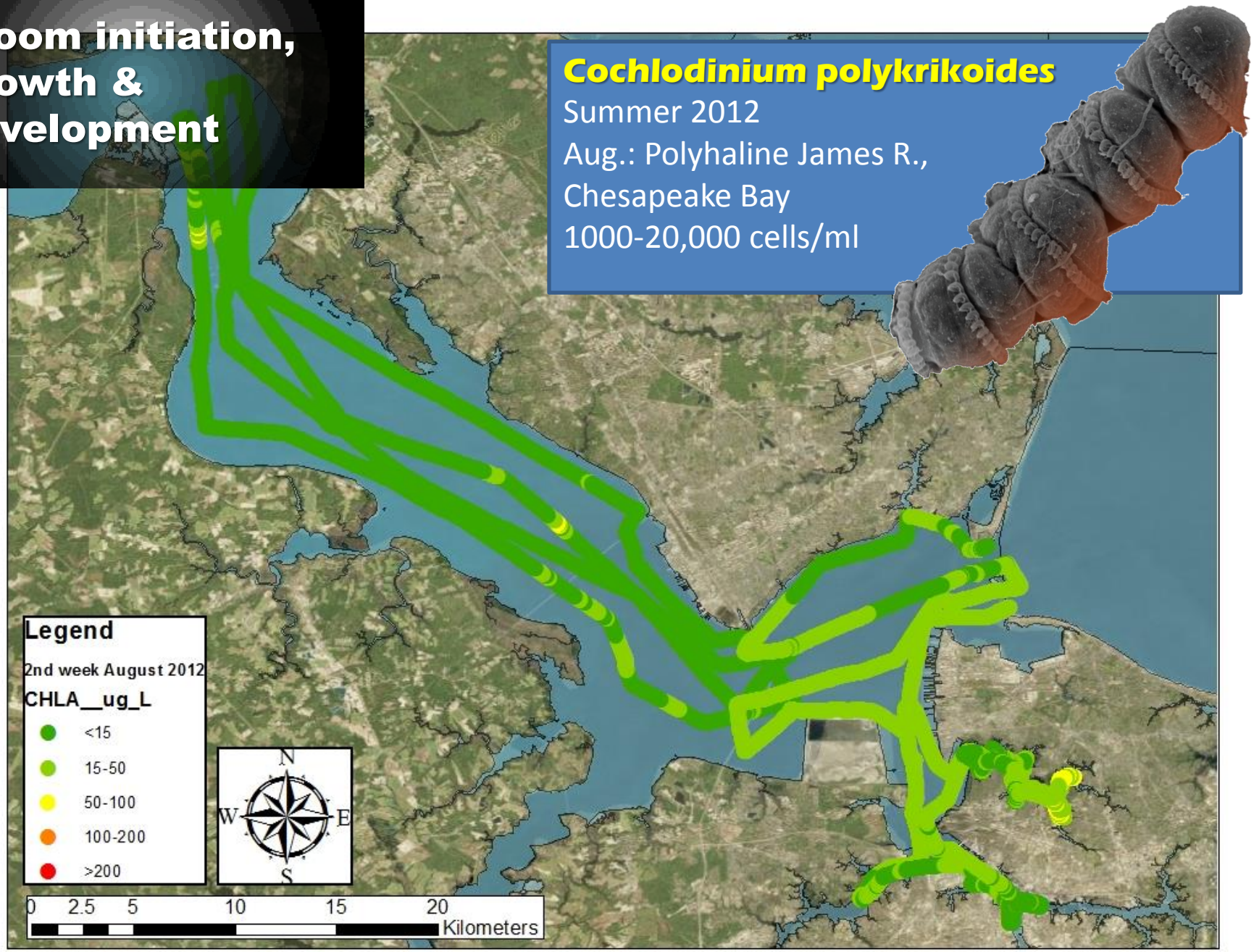
Bloom initiation, growth & development



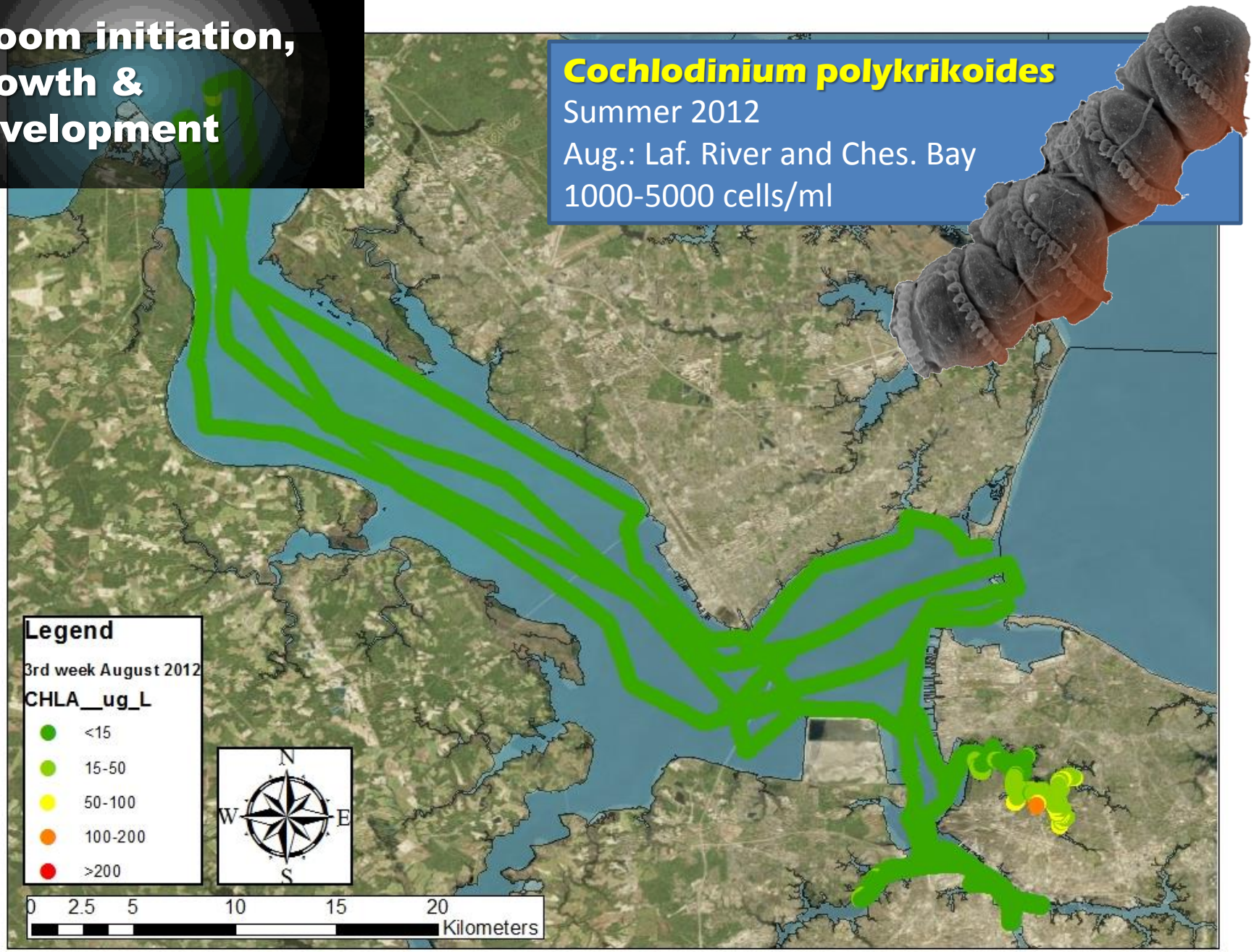
Bloom initiation, growth & development

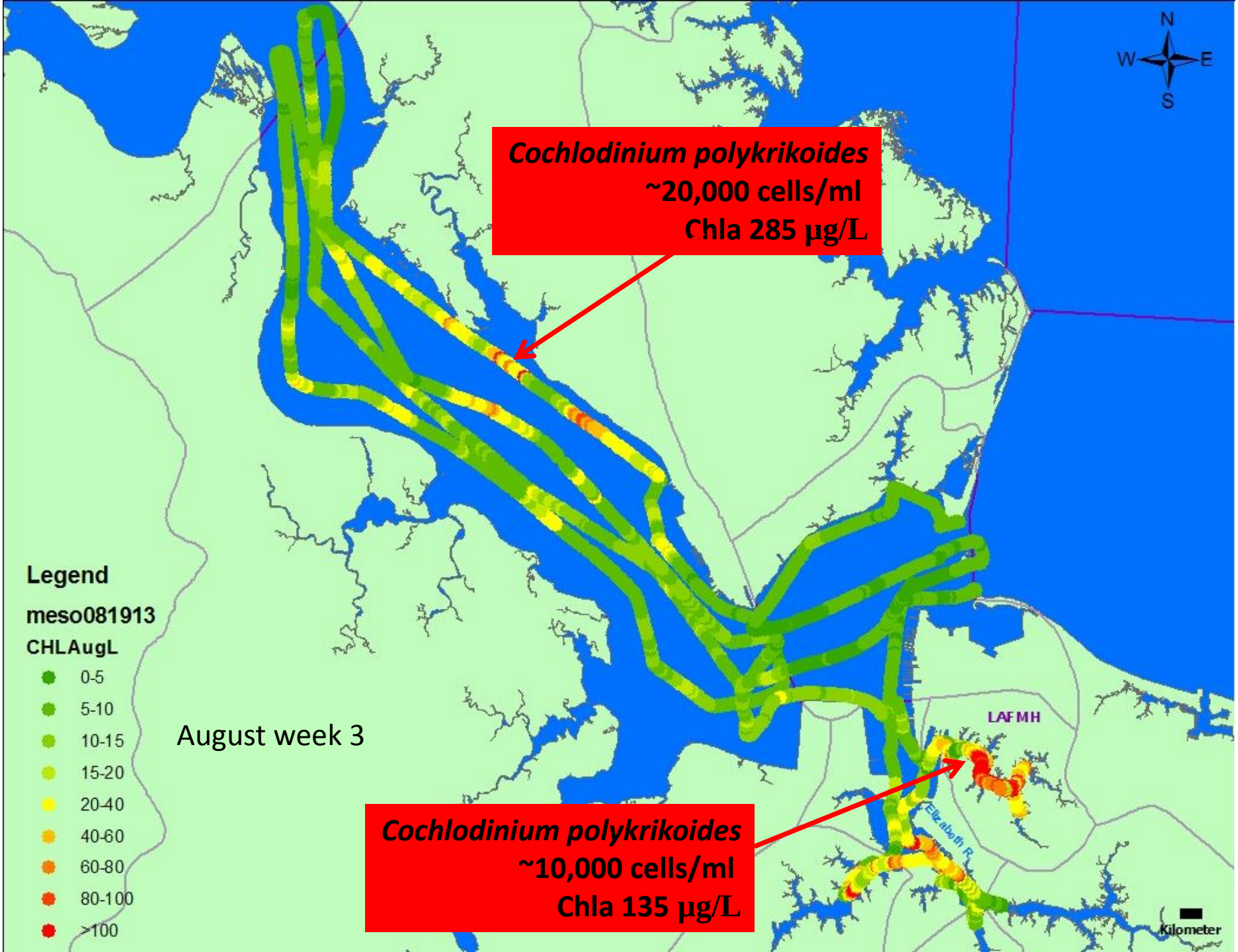


Bloom initiation, growth & development



Bloom initiation, growth & development

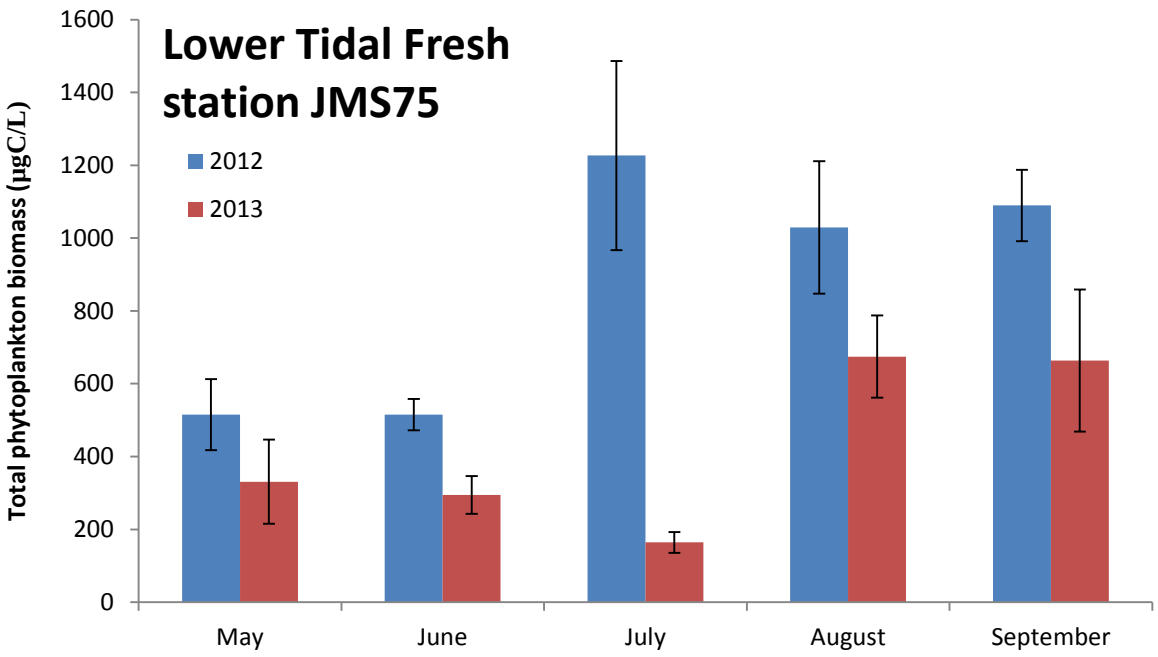



N
W
E
S
Cochlodinium polykrikoides
~20,000 cells/ml
Chla 285 µg/L
Legend
meso081913
CHLAugL
0-5
5-10
10-15
15-20
20-40
40-60
60-80
80-100
>100
August week 3
LAFMH
Elizabeth R.
Cochlodinium polykrikoides
~10,000 cells/ml
Chla 135 µg/L
Kilometer

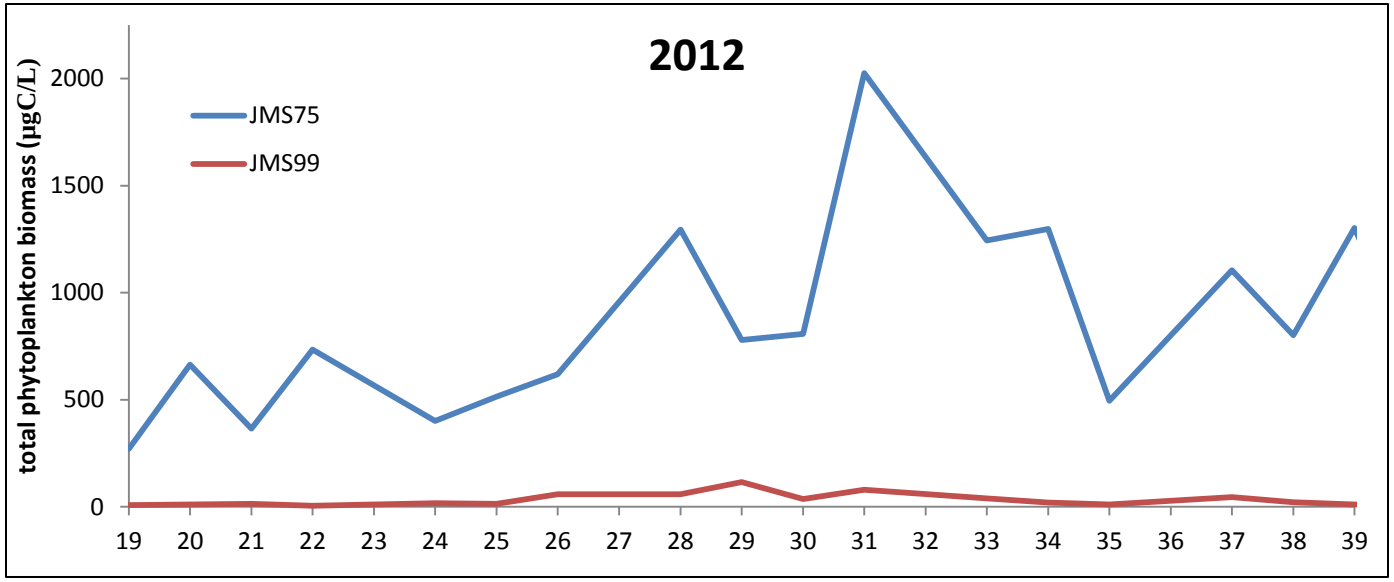
Phytoplankton analysis needs in 2014

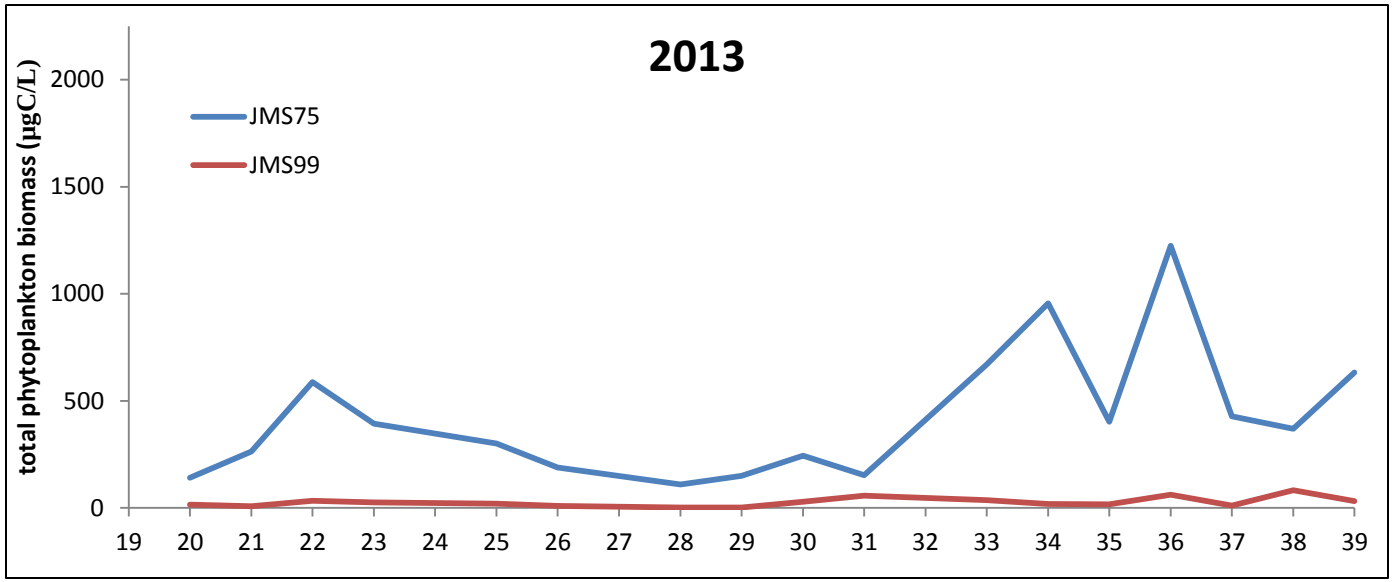
- Support additional HRSD Dataflow monitoring in Lower James, Elizabeth and Lafayette
- Analyze vertical distribution of blooms
- Characterize species composition in tidal-fresh James (JMS75) including *M. aeruginosa* and other HABs
- Measure short-term variability in composition and abundance of blooms in Lafayette

Appendix/ supplemental slides

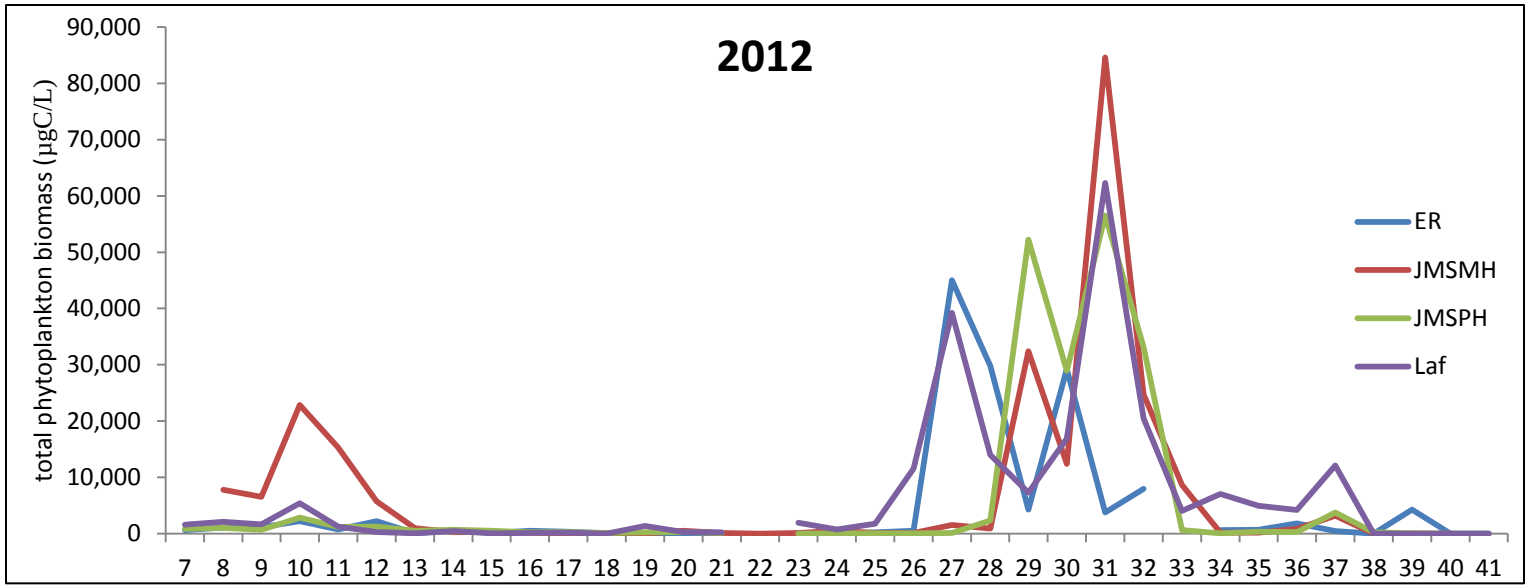


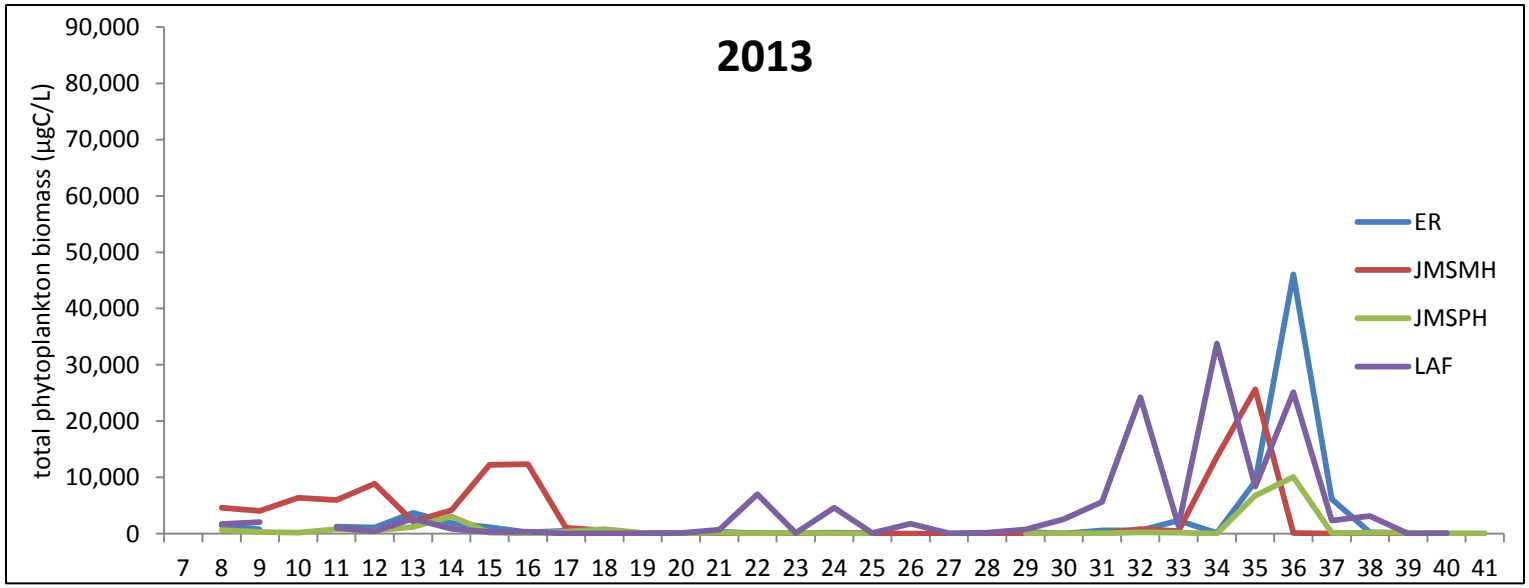
Upper James


2012
JMS75
JMS99
total phytoplankton biomass (µgC/L)
0
500
1000
1500
2000
19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39


2013
JMS75
JMS99
total phytoplankton biomass (µgC/L)
0
500
1000
1500
2000
19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39

Lower James


2012
total phytoplankton biomass (µgC/L)
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
ER
JMSMH
JMSPH
Laf


2013
total phytoplankton biomass (µgC/L)
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
ER
JMSMH
JMSPH
LAF