James River CHLa Study
Literature Review

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DEQ

Outline

- Why are we doing a literature review?
- How are we doing the lit review?
- What are we finding?
- Where do we go from here?

Why do the lit review?

- One of our key questions: **Are our current CHLa criteria protective of aquatic life?**
- How to answer that question?
  - Experiments
  - Bioassays
- Limited by time and resources so we used a literature review to uncover what other scientists have found
- While there has been an increased number of HAB studies, not many directed towards regulatory applications.
  - Hence need for our own studies

Phytoplankton Species of Concern

- Created species list of primary concern in the James River with input from Dr. Marshall
- Criteria for inclusion on the list
  - Toxin producers
  - High concentrations in recent years - potential for other effects (reduced oxygen levels)
  - Species whose ranges may be expanding

Phytoplankton Species List

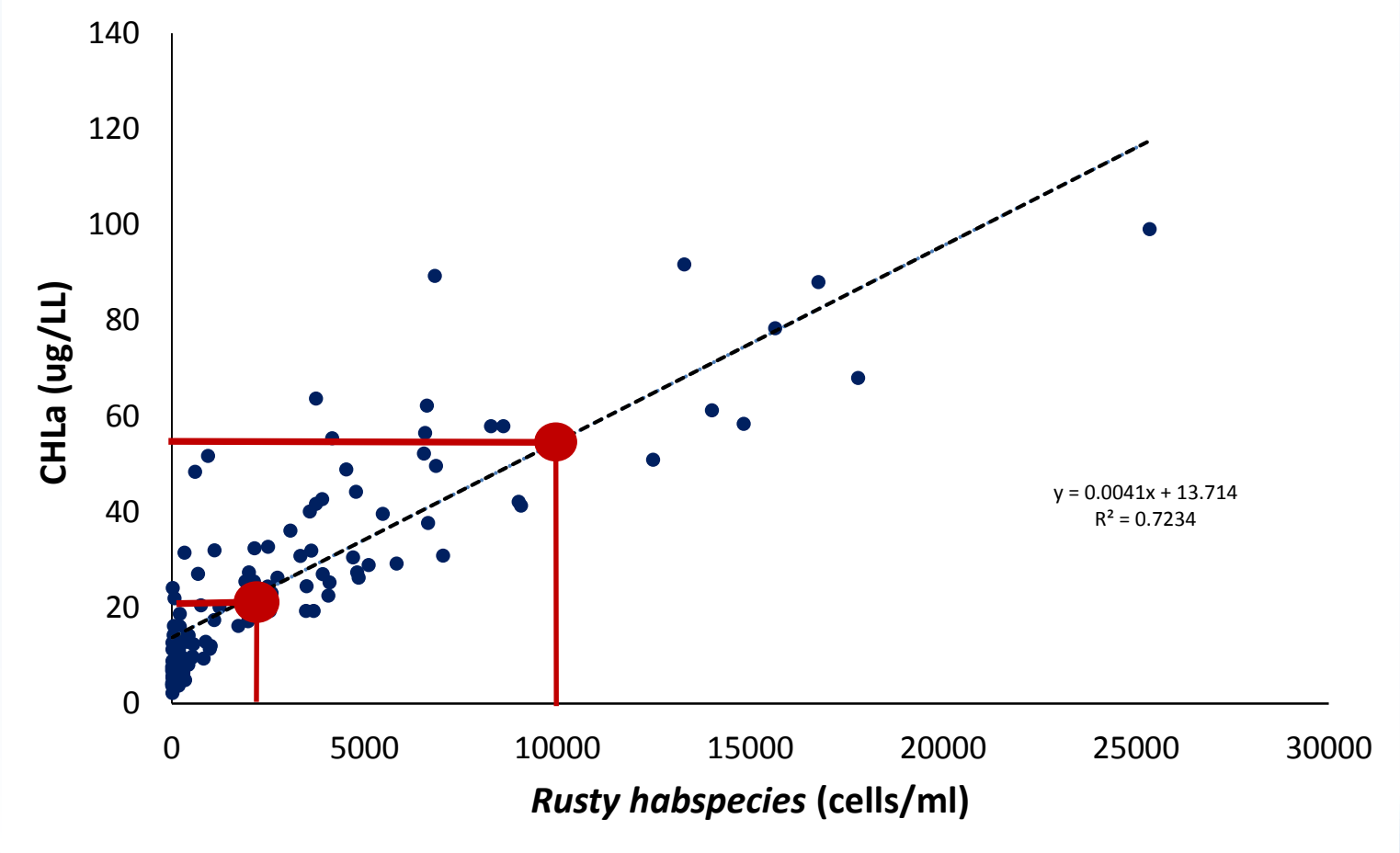
Level of Concern	Algal species of major concern	Potential Toxin Producer?	Taxa Group	TF or Lower?
Algal species of major concern	*Microcystis aeruginosa*	Y	Cyanobacteria	TF
	Cochlodinium polykrikoides	Y	Dinoflagellate	Lower
	Karlodinium veneficum	Y	Dinoflagellate	Lower
	Prorocentrum minimum	Y	Dinoflagellate	Lower
	Akashiwo sanguinea	N	Dinoflagellate	Lower
	Heterocapsa rotundata	N	Dinoflagellate	Lower
	Heterocapsa triquetra	N	Dinoflagellate	Lower
	Scrippsiella trochoidea	?	Dinoflagellate	Lower
Algal species of potential concern	*Aphanizomenon flos-aquae*	Y	Cyanobacteria	TF
	Cylindrospermopsis raciborskii	Y	Cyanobacteria	TF
	Alexandrium monilatum	Y	Dinoflagellate	Lower
	Gymnodinium instriatum	N	Dinoflagellate	Lower
	Prorocentrum micans	?	Dinoflagellate	Lower
	Myrionecta rubra	N	Ciliate	Lower
	Heterosigma akashiwo	Y	Raphidophyte	Lower
	Chattonella subsalsa	?	Raphidophyte	Lower

How are we performing the lit review?

Criteria used in selection of journal articles

- Test species had to be relevant to the James River
- Growth, reproduction, mortality (things that can potentially affect a population)
- Cell concentration or toxin concentration was provided
  - Need to be able to compare the cell [] at which an effect is seen (or not) with []s observed in the James River
  - And relate cell [] to CHLa
    - (Virtually none of the results included CHLa)

Example: Relationship between *Rusty habspecies* cell concentrations and CHLa

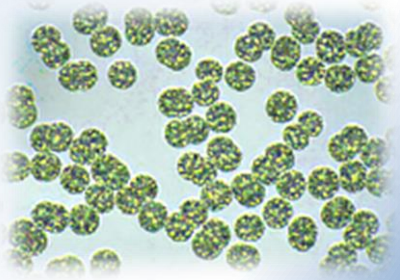


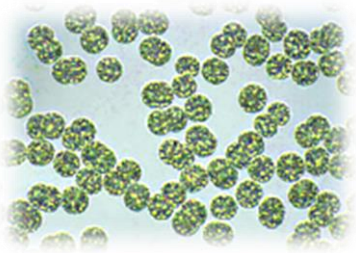
What have we found in the literature?

Species of concern in the tidal fresh James

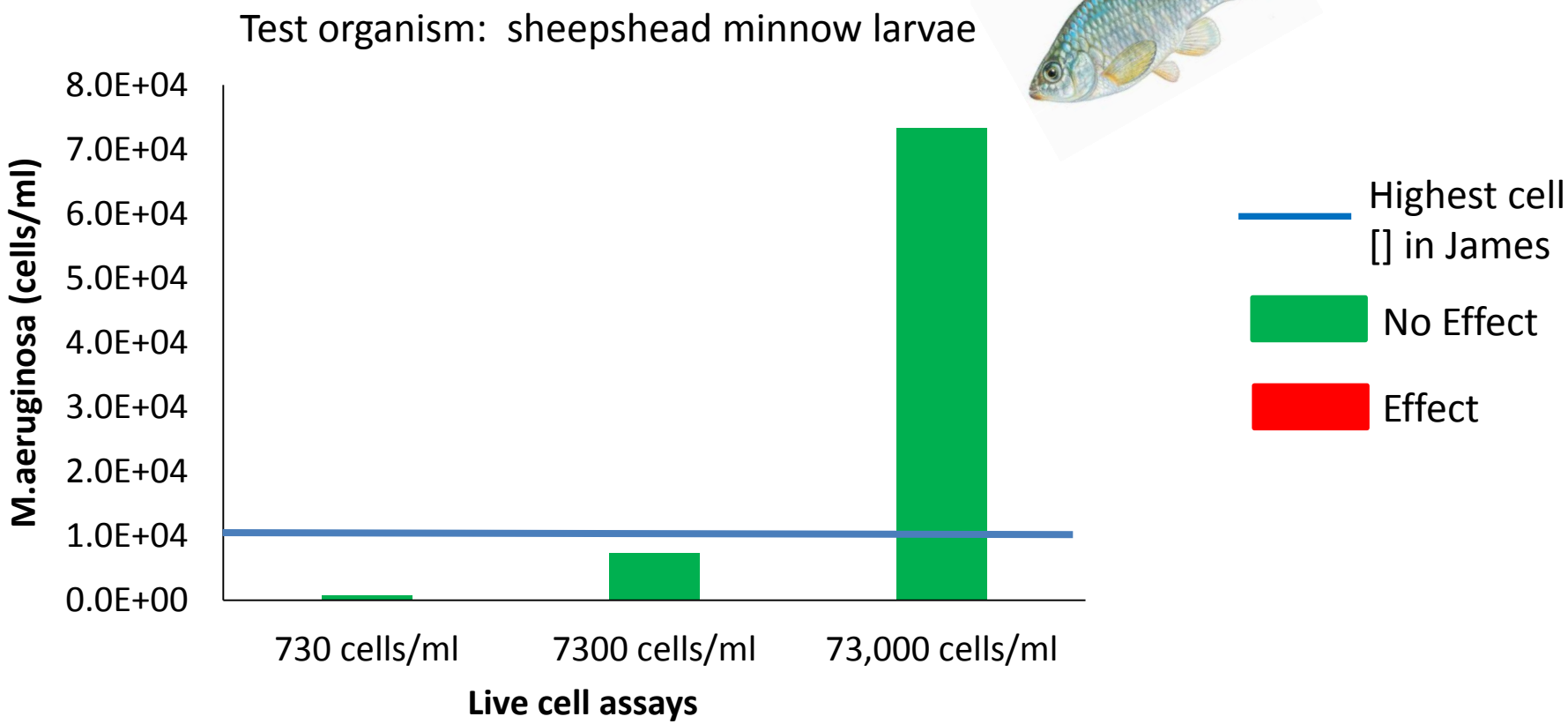
- *Cylindrospermopsis raciborskii*
  - Not observed in James the last 2 years
  - One study
    - Mortality of *Daphnia sp.* at cell concentrations ~ 1.8*10^6
- *Aphanizomenon flos-aquae*
  - Averaged <5% of total abundance
  - No studies found thus far

- *Microcystis aeruginosa*
  - Peak [] in James last 2 years: 2150 cells/ml (10K in 2011)
  - Averaged <10% of total abundance
  - Most studies use the toxin (microcystin)
  - Few live cell studies some of which are Kim's



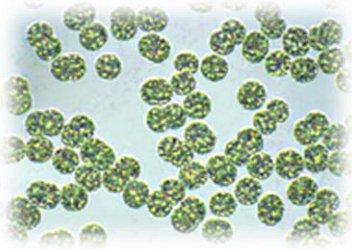


M.Aeruginosa

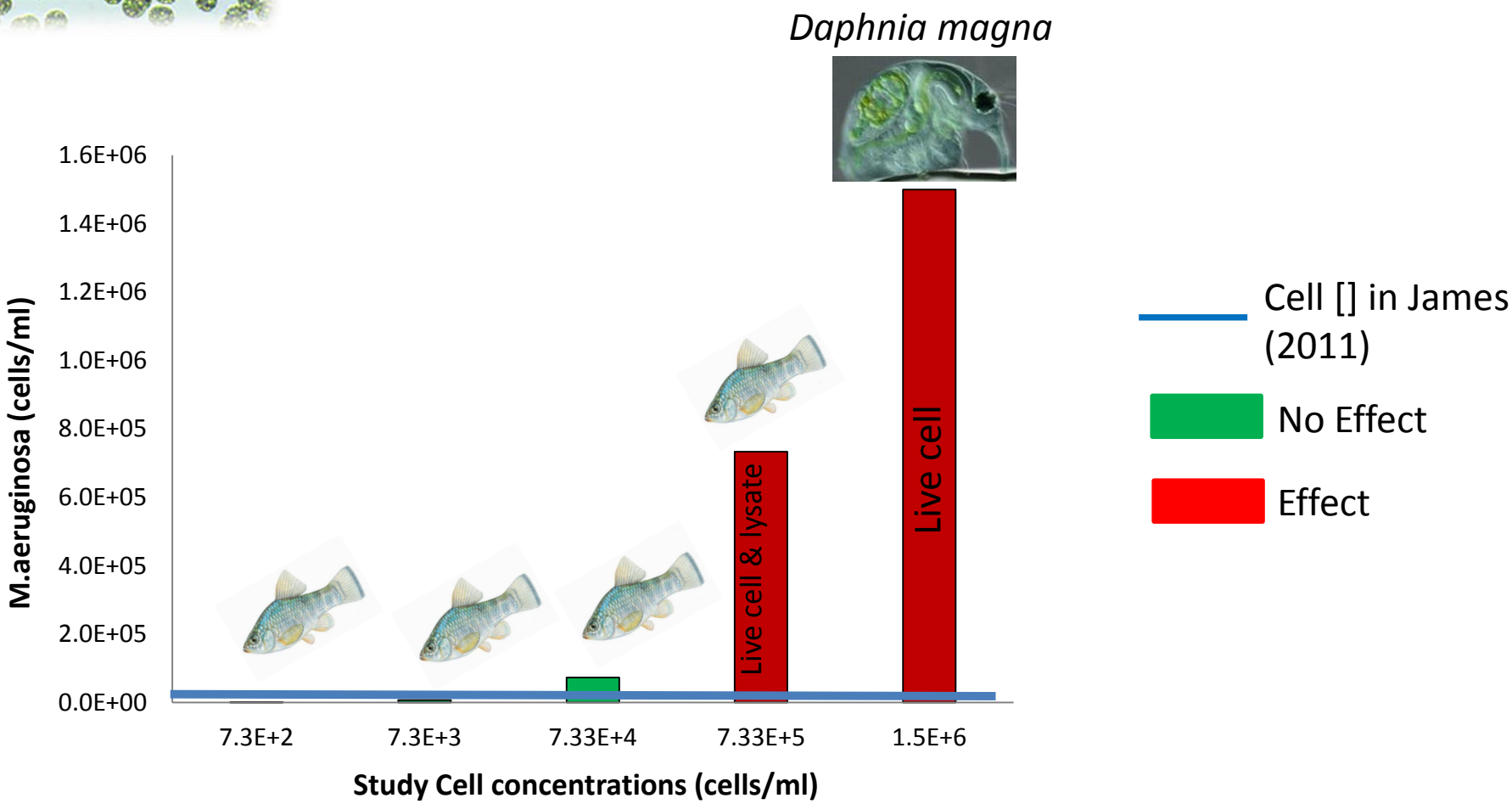


Results: Reece found no effect at any of these cell concentrations

Reece, PC



M.Aeruginosa live cell assays



Results: Significant mortality at both the 7.33E+5 and 1.5E+6 cell concentrations
Suggest microcystis may not be an issue in the James

Reece, personal communication
Liping et.al., 2011

Microcystin (MC) Studies

MC concentration (dissolved)	Test Organism	Effect	Authors
1.6 ug/L	Bosmina	no effect on survivorship or longevity; observed fecundity effect but not statistically sigificant	Bukaveckas and Wood, Personal communication
3.2 ug/L	American shad and Blueback herring	no effect on viability of eggs and larvae	Bukaveckas and Wood, Personal communication
4.5 µg/L Total Microcystin in the James River			
10 ug/L	Mayfly hatchlings	20% mortality	Smith et.al., 2007
49 ug/L	Mayfly hatchlings	96 hr LC50	Smith et.al., 2007
270 ug/L	Eurytemora	48 hr LC50	Reinikainen et.al., 2002
10,000 ug/L	Mayfly eggs	Egg hatching delayed but no effect on overall number of eggs hatched	Smith et.al., 2007

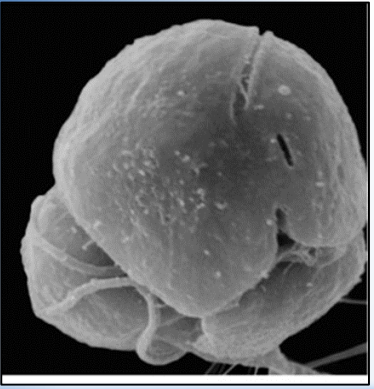
Species of concern in the lower James

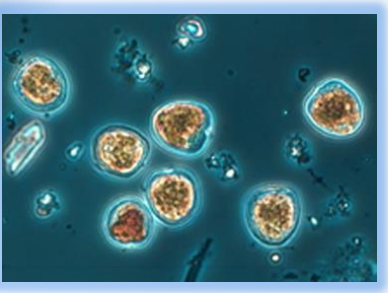
No relevant studies so far on the following species:

Species	Recent Range of Cell Concentrations in the James (cells/ml)	% Total Abundance
Akashiwo sanguinea	10-5820	Avg <20% but dominant at times
Heterocapsa rotundata	10-7730	Avg <15% but dominant at times
Chattonella subsalsa	10-220	Avg <10%
Heterosigma akashiwo	10-380	Avg < 15%
Prorocentrum micans	10-310	Avg < 5%
Myrionecta rubra	none	n/a

Species for which little to no effect found:

Species	Range of Cell Concentrations in the James (cells/ml)	% Total Abundance
Heterocapsa triquetra	10-191,200	Avg 55%; close to 100% at times
Gymnodinium instriatum	10-11,350	Avg <50% but dominant at times

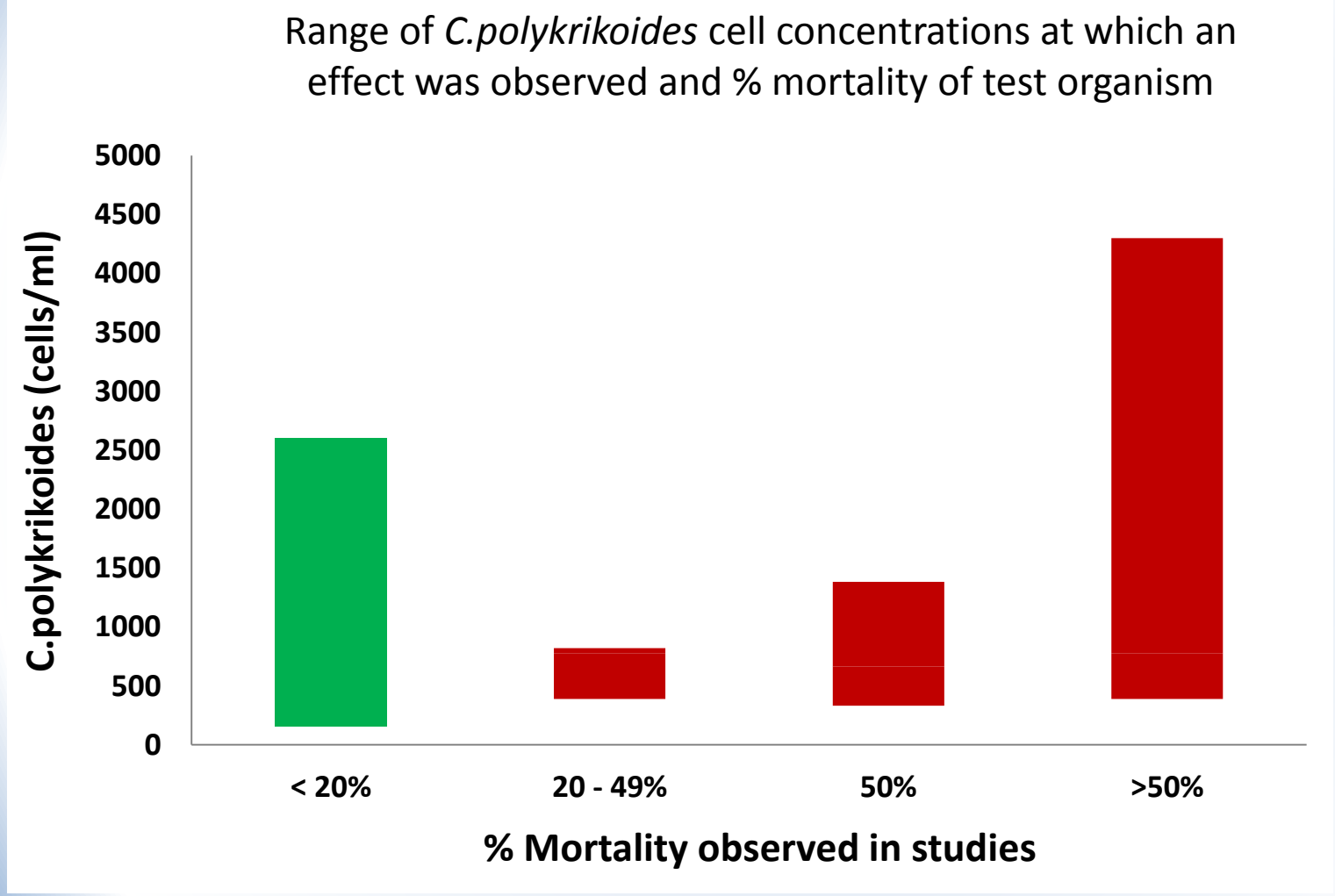


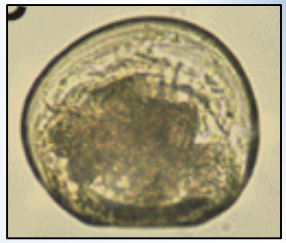


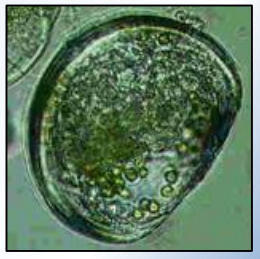
Species	Observed in James (cells/ml)	Cell concentrations with observed effect
Karlodinium veneficum	10-2500 (2 observations in 2013)	2500 – 133,000
Prorocentrum minimum	10-7400 (<10% total abundance)	3900 – 10,000
Scrippsiella trochoidea	10-51,200 (avg 10% total abundance)	7200 – 23,000
Alexandrium monilatum	1-1020 (avg 5% total abundance)	550 – 10,000

Cochlodinium polykrikoides

Results from mono-culture live cell studies





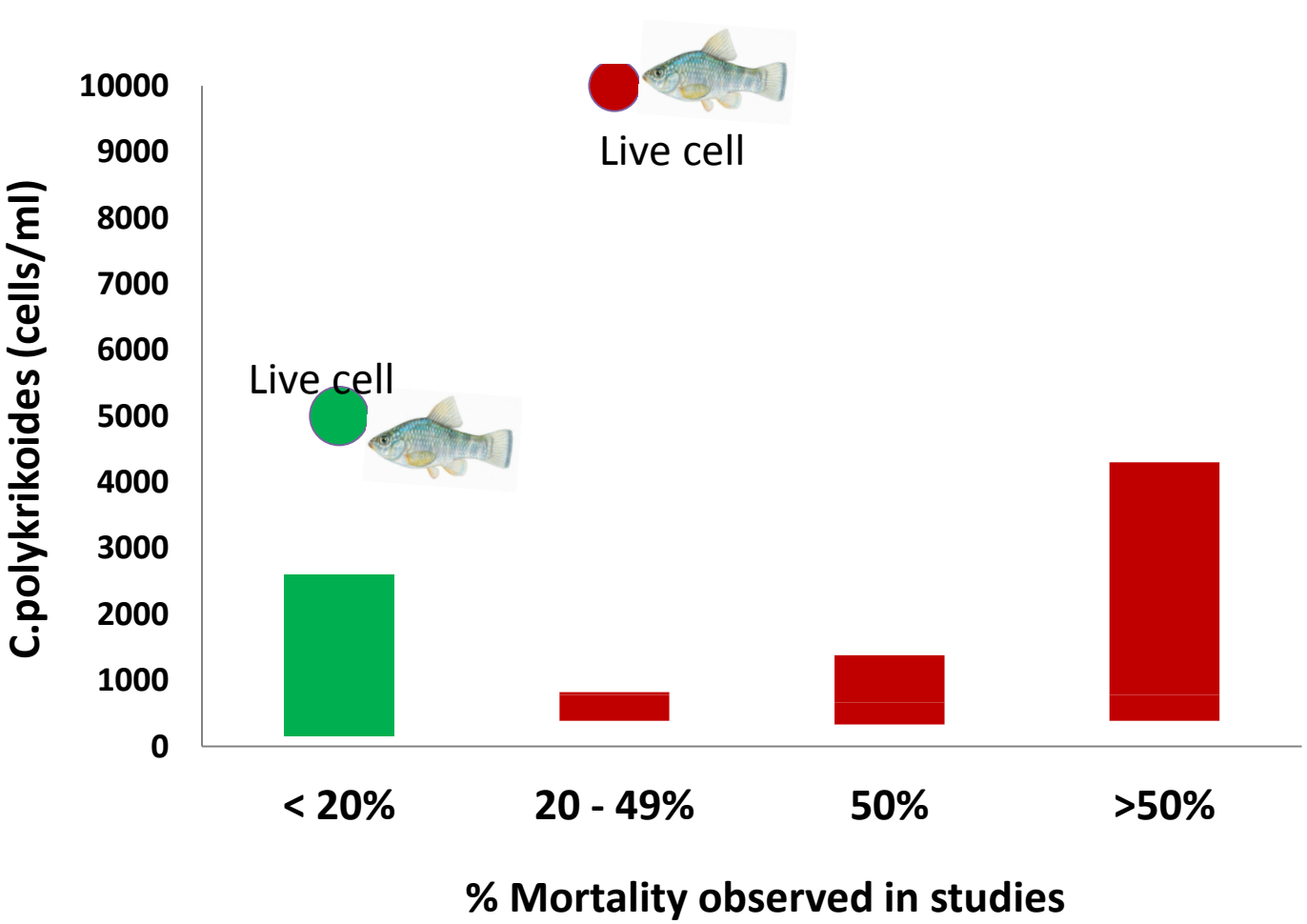


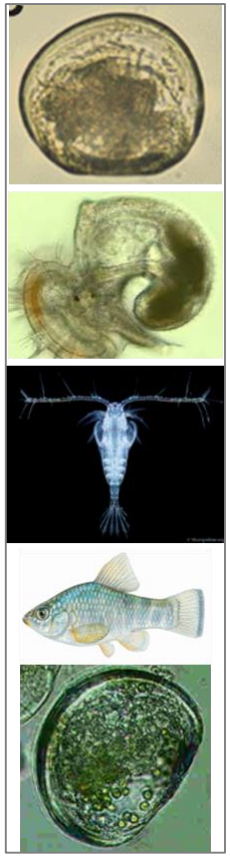
Tang and Gobler, 2009(a)
Tang and Gobler, 2009(b)
Jiang et al., 2009

Cochlodinium polykrikoides

Results from mono-culture studies

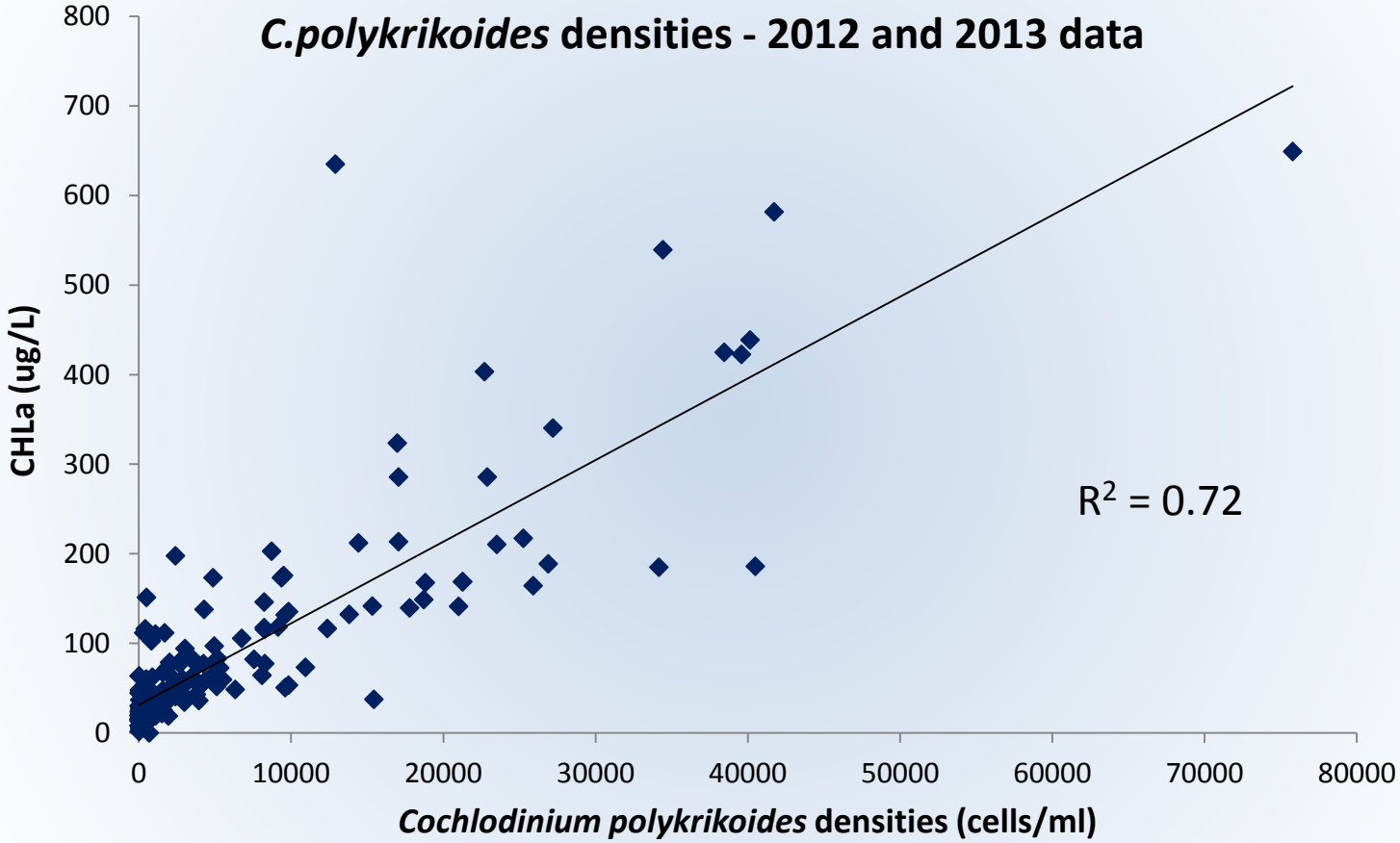
Range of cell concentrations and % effect of test organisms





Tang and Gobler, 2009(a)
Tang and Gobler, 2009(b)
Jiang et al., 2009
Kim Reece, personal communication

C.Polykrikoides and CHLa observations 2012 and 2013

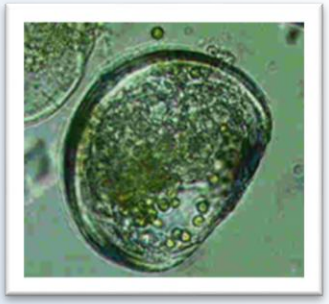


Using regression equation:
1000 cells/ml = ~40 µg/L
10K cells/ml = ~122 µg/L

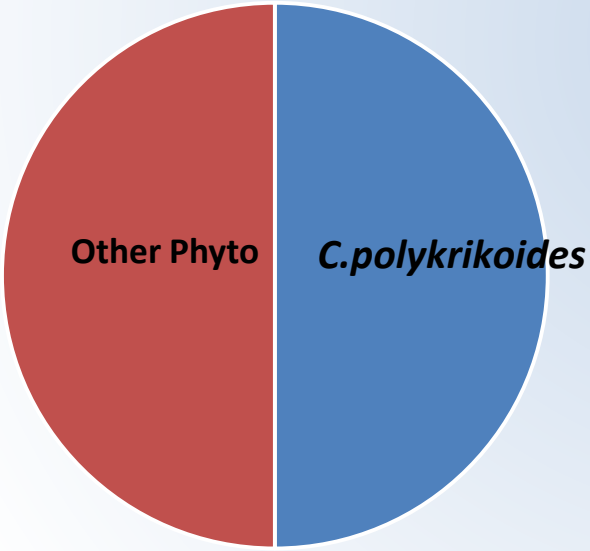
Measurement from a Reece bioassay:
10K cells/ml CHLa = 79µg/L

Cochlodinium polykrikoides bloom samples

Test organism: 1 d old northern quahog

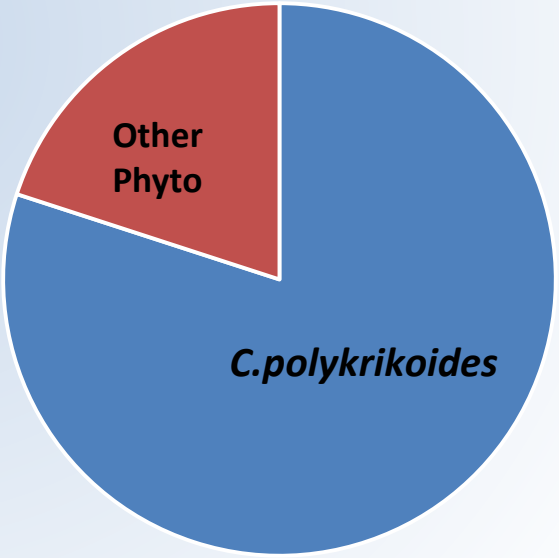


Bloom Sample: *C.polykrikoides*
~1800 cells/ml (50% of bloom)



~11% mortality in 24 h
~23% mortality in 72 h

Bloom Sample: *C.polykrikoides*
~800 cells/ml (80% of bloom)



~23% mortality in 24 h
~97% mortality in 72 h

Tang and Gobler, 2009

Summary

- Tidal Fresh James River Algal Species
  - Microcystis and microcystin - Little to no effect on aquatic life at observed levels.
- Lower James River Algal Species
  - A few species have shown effects at low cell concentrations however, their relative abundances in the James tends to be low. Unfortunately, we cannot yet predict CHLa concentrations for these species. Therefore, it may be difficult to determine if the current CHLa criteria are protective of aquatic life.
    - *Karlodinium veneficum*
    - *Scrippsiella trochoidea*
    - *Prorocentrum minimum*
    - *Alexandrium monilatum*
  - *C.polykrikoides* effects have been observed at low cell concentrations and within concentrations frequently observed in the James. CHLa is less predictable at these densities. These low densities are often part of a mixed community so additional work with bloom samples may be warranted.

Where do we go from here?

- Which studies most appropriate for inclusion in the Project?
- Consider bloom assays for this year
- Relate observed effect (cell density) to CHLa levels both spatially and temporally

Questions?