Opportunities and Challenges in Predicting Harmful Algal Blooms

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- First noticed around Alameda, early August 2022
- Consumed most of the nitrogen in South Bay
- Observed fish kills
- Swift termination
- Rare, but not unprecedented, event

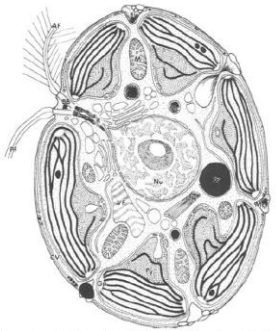
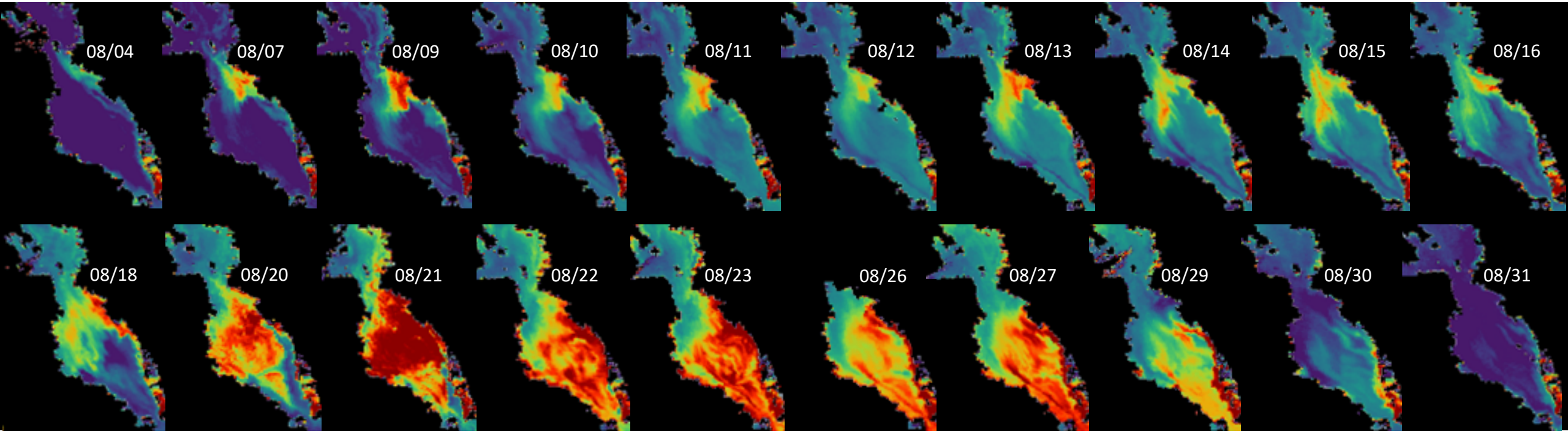


Fig. 21. *Heterosigma akashiwo*. Diagrammatic illustration of a motile cell, drawn on the basis of the strain BGN 666. AF, anterior flagellum; CV, compressed vesicle; PF, posterior flagellum; R, rhizoplast; FP, fatty particle; VF, vesicles with fine fibers; VH, vesicles with hollow fibers.

wikipedia

Heterosigma akashiwo

- Causes red tide, fish kills
- Cyst-forming
- Mixotrophic
- Can grow in salinity 16–36 (Kudela)
- Flagellate, capable of 5–10 m/day vertical migration
- Tolerant of low-light conditions (Kudela)



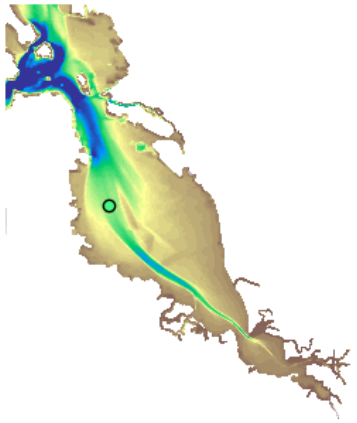
Motivating Questions

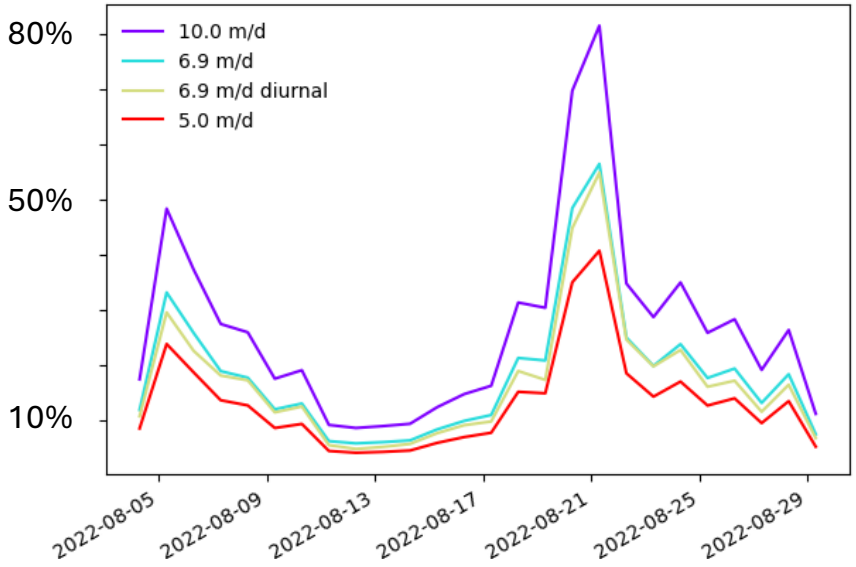
- Isolated event?
- Linked to trends in Bay conditions?
- What attributes of the organism enabled this event?
- What initial state enabled this event?
- What environmental factors enabled this event?

Management Questions

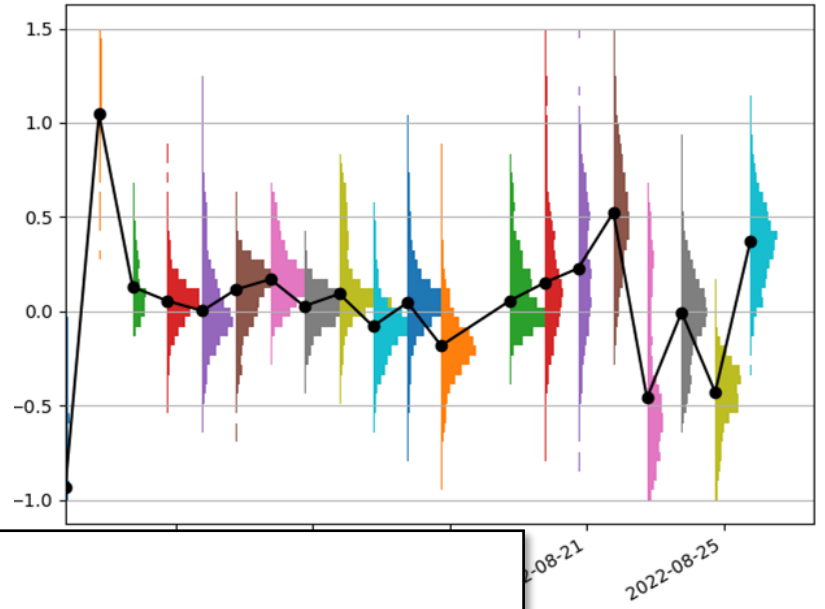
- Recurrence interval?
- Can we anticipate windows of opportunity?
- What mitigations would be effective?

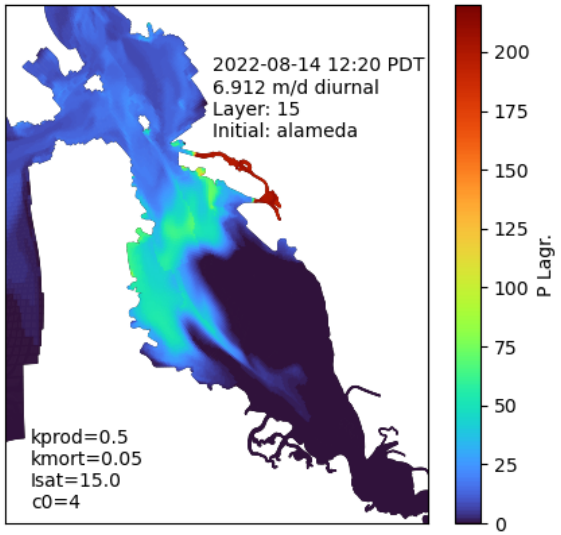
Vertical swimming increases growth rate 10–80%



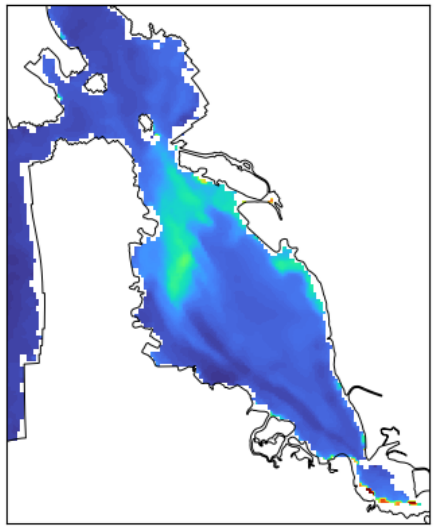


Satellite imagery+advection implies net growth rates of -0.5 – 0.5 day^{-1}





Model chl-a



Satellite chl-a

Light limitation, vertical swimming and physics:

- Explains bloom trajectory
- Brackets parameter values

Modeling Approaches

Prognostic Modeling

- Predictive
- Extensive calibration / validation
- Simulate all important processes at the same time
- Can extrapolate to new scenarios
- Often monolithic

Diagnostic Modeling

- "Forensic"
- Isolate and test individual mechanisms:
  - Transport
  - Vertical migration and mixing
  - Turbidity distribution
  - Tidal dynamics
- Multiple simplified models

Have we been collaborative modelers?

Open-source tools generally foster collaboration

- D-Flow FM*, Delft Water Quality*, GOTM, python, QGIS

Community models

- SFEI's hydrodynamic model of SF Bay descended from USGS CAScADE
- Most setup code open source, on github, but "self-documenting"

Collaboration across organizations

- UC Davis, SFEI, RMA, USGS, UCSC, and others

How can a collaboratory make us better collaborative modelers?

Hiccups – Collaboratory to the rescue?

- Discovered that the water quality model was way too diffusive for the analysis.
  - *How many others have run into this and would have noticed sooner?*
- Discovered that temperature stratification was too strong, due in part to unrealistic input data.
  - *What forcing data are others using?*
- When observations are insufficient, what do other models predict?
  - *What does model XYZ* predict, and how was it configured?*

- What about publishing? How do we navigate the tension between openness and publication?