Overview of the San Francisco Bay Aug 2022 Harmful Algae Bloom

- 1. Aug 2022 HAB event: evolution and water quality impacts
- 2. Mechanisms / Hypotheses...insights into protective N levels?
- 3. On-going work



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Collaborators

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What observational data and tools are needed to inform management decisions?

- Assess current condition
- Predict/anticipate changes
- Establish quantitative linkages



SFEI 2014

SEEL Contribution #979

San Francisco Bay Nutrient Management Strategy Observation Program



SFEI 2016





- Expanded monitoring (space, time, parameters)
 - nutrients
 - Phytoplankton, HABs, toxins
 - DNA-techniques for HAB detection
- Remote-sensing: building capacity for continued use
- Numerical models
 - Transport, biogeochemistry (nuts, phyto, O₂, ...)
 - *'forensic'* modeling

- *late-Jul 2022*: first observed around Alameda/Oakland deep channel
- Heterosigma akashiwo
 - \circ toxic to fish
 - on SFB-NMS harmful algae 'watch-list' (SFEI 2014, 2016, in prep)
- *early-Aug*: Spread to open Bay, throughout South Bay
 - Aug 7-10: spread to South Bay, off Alameda
 - $\circ~$ expanded throughout South Bay by ~Aug 20 $\,$



Engesmoa et al 2019

• Impacts:



- chl-a: >20x typical summer values
- fish mortality: South Bay, Central Bay, San Pablo Bay
- Dissolved O₂ deficits: South Bay, Lower South Bay



What factors 'caused' and shaped this event?

What management options would be effective at preventing or mitigating impacts?

What's the likelihood of something similar occurring again in the near-term (1-2 yrs)?

Catalyst / Motivation for the NMS

- SFB has very high N loads, and N concentrations
- Other factors usually keep a lid on phytoplankton production
- How will SFB respond to changes in those growth-controlling factors?









• DO₂ < 3 mg/L 2-3 days`



Aug 22

first scattered reports

Fish Mortality



What about Nitrogen?



900,000 kg DIN utilized

~20-30 days worth of N loads





What DIN levels would be protective...

• Toxic HAB event(s)

-122.0

• 30

-122.2

34

-122.1

• Potential impacts along the coast

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What happened in 2022?



Sentinel-3; using UWQV, Zlinszky and Padanyi-Gulyas 2020



BIOLOGICAL

- HAB: Swimming
- HAB:
- HAB GROWTH OPTIMA
- MICROBIAL COMMUNITY
- GRAZERS (top-down control)

PHYSICAL

- TIDAL MIXING ENERGY
- TURBIDITY (light atten)
- SUNLIGHT
- EXCHANGE w/ COAST
- TEMPERATURE
- SALINITY

CHEMICAL

- NITROGEN LEVELS
- CONTAMINANTS (e.g., metals)
- VITAMINS

What allowed

- -- open-Bay initiation...west of Alameda?
- -- spreading to rest of South Bay

Two necessary components

--ALLEVIATE GROWTH CONSTRAINT

--SUFFICIENT FUEL TO CONTINUE GROWING





Engesmoa et al 2019

Image:

Heterosigma akashiwo in San Francisco Bay

where and how frequently has H akashiwo been detected in SFB?



H akashiwo: Between 2015-2020, detected in

- ~40% of all samples (Lower South Bay to San Pablo Bay)
- ~65% of Central Bay samples

<u>Nejad et al. 2017; SFEI 2021,2023; Sutula et al.,</u> 2017; Cloern and Dufford 2005



Priority HAB-forming organisms in SFB

(# = % detection 2015-2020, LSB, SB, CB, SPB)

12 / 14 priority HABs are flagellates



SFEI 2020, 2021, SFEI 2023

Images: http://oceandatacenter.ucsc.edu/; https://nordicmicroalgae.org/



Importance of swimming vs. mixing?

Modeling experiment

- hydrodynamic (transport)
- conservative tracers

compare two scenarios

top: w _s : 0	no swimming
bottom: w _s : day:	+10 m/d (up)
night	-10 m/d (down)

4+0



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Summary

- HABs in San Francisco Bay:
 - SFB hosts numerous HAB-forming organisms (10+): moderate frequency, low abundance
 - prior to August 2022, no severe HAB events in SFB

• August 2022 HAB event in San Francisco Bay

- Heterosigma akashiwo
- extremely high abundance (biomass), wide-spread
- Anomalous timing...not typical peak biomass season (Mar-Apr)
- Low oxygen levels throughout South Bay, and Fish mortality

• SFB's high nutrient loads resulted in severe impacts (biomass, area, duration).

*

- High-Nutrients were the fuel.
- But other factors sparked or triggered the event

Major Work Focus going forward

• Intensified monitoring, including 'early-warning systems'



- Identify potential important mechanisms / factors: initial toe-hold, bloom progression (lots more work remains...)
 - Swimming
 - Space-time variability in vertical mixing
 - \circ Space-time variability in K_D
 - Atypically-strong HA-organism source and/or atypically-weak top-down control
 - Uniqueness of 2022: relatively low SSC (but limited data)
- Exploring management scenarios to prevent or mitigate future events

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