

SF Estuary MERHAB Project: Enhancing HABs Monitoring and Management

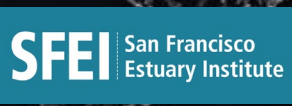
Keith Bouma -Gregson ¹, Ellen Preece ², Ariella Chelsky ³,
David Senn ³

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² California Department of Water Resources

³ San Francisco Estuary Institute

RMP Annual Meeting, October 21, 2026



This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information is provided on the condition that neither the U.S. Geological Survey nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the information.

Acknowledgements

Thanks to all the field and lab staff collecting and processing samples & data. It could not be done without you!



Photos: USGS CAWSC

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SFEI San Francisco Estuary Institute

Acknowledgements

Funding from

NOAA MERHAB

SFEI: Nutrient Management Strategy

*U.S. Geological Survey, Priority
Ecosystems Program*

State Water Board – Division of
Water Rights

CA Dept. of Water Resources

Delta Science Program

Delta Regional Monitoring
Program

Bureau of Reclamation

Sacramento Area Sewer District

State Water Contractors



CALIFORNIA DEPARTMENT OF
WATER RESOURCES



Delta
Science
Program

DELTA STEWARDSHIP COUNCIL



— BUREAU OF —
RECLAMATION



**STATE WATER
CONTRACTORS**
FOUNDED 1982



San Francisco Estuary



Sooner or later
after meeting the ocean,
river water loses its stream identity.

It loses parts of the burdens peculiar to it and it
acquires other burdens peculiar to sea water
until the union is complete and it has become
again an indistinguishable part of the sea

– *W. E. Allen, 1937*

https://www.esa.int/Applications/Observing_the_Earth/Earth_from_Space/The_B

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- Harmful algal blooms are more common in estuaries and coastal waters
- Higher nutrients, shallower waters, longer transport timescales
- SF Bay *Heterosigma* bloom in August 2022

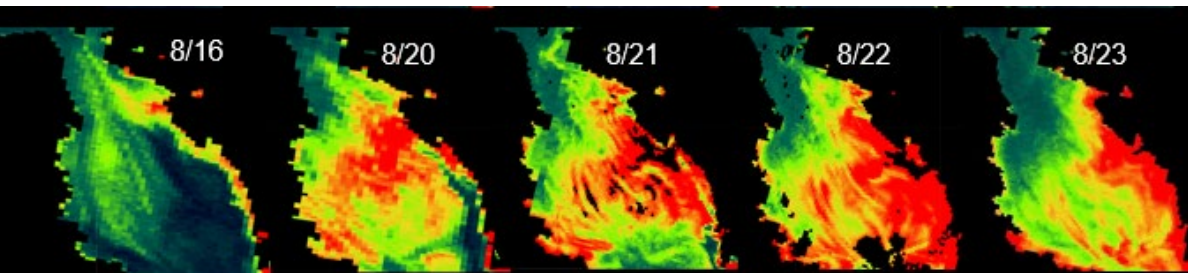
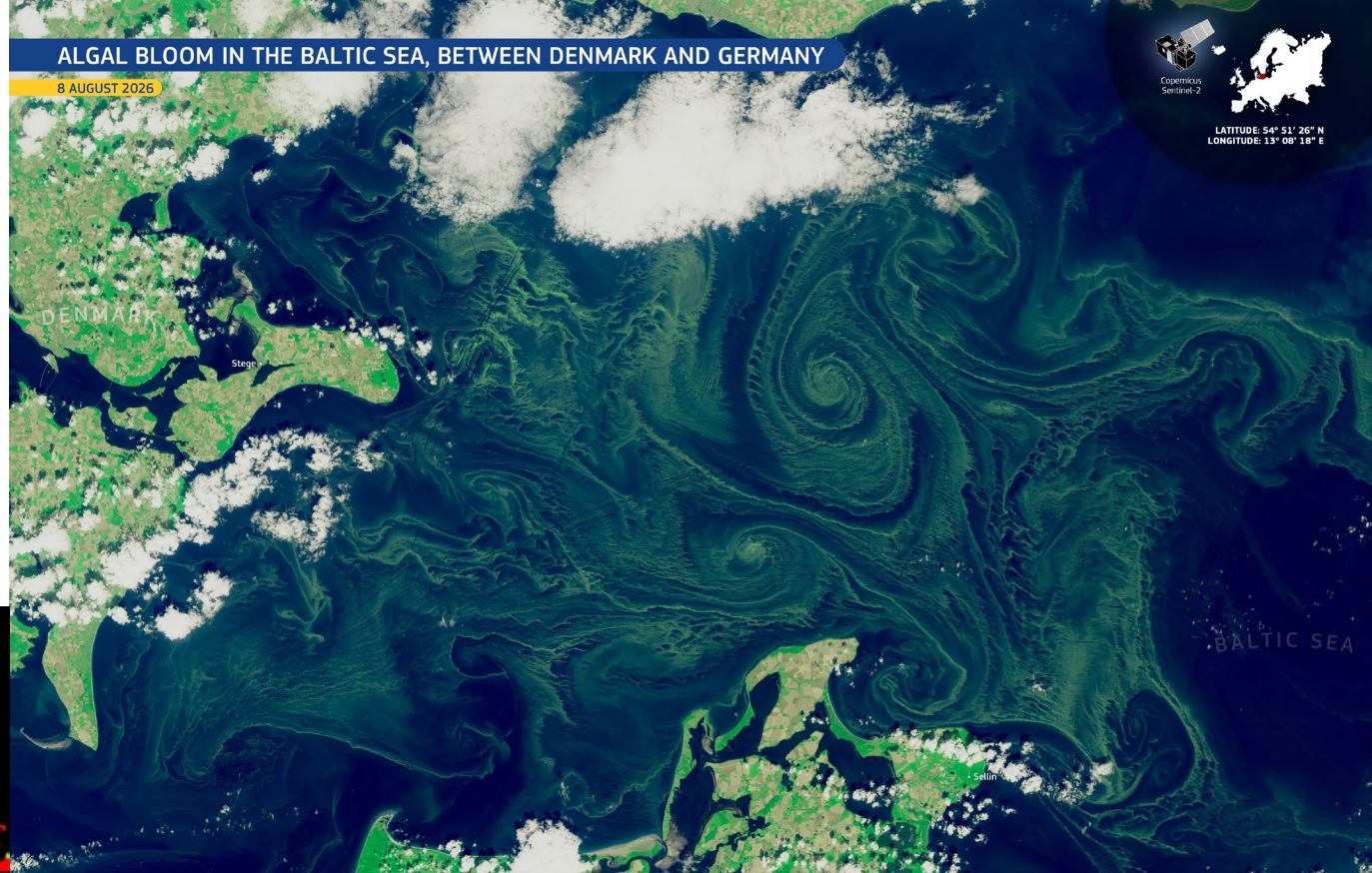


Figure: D. Senn, SFEI



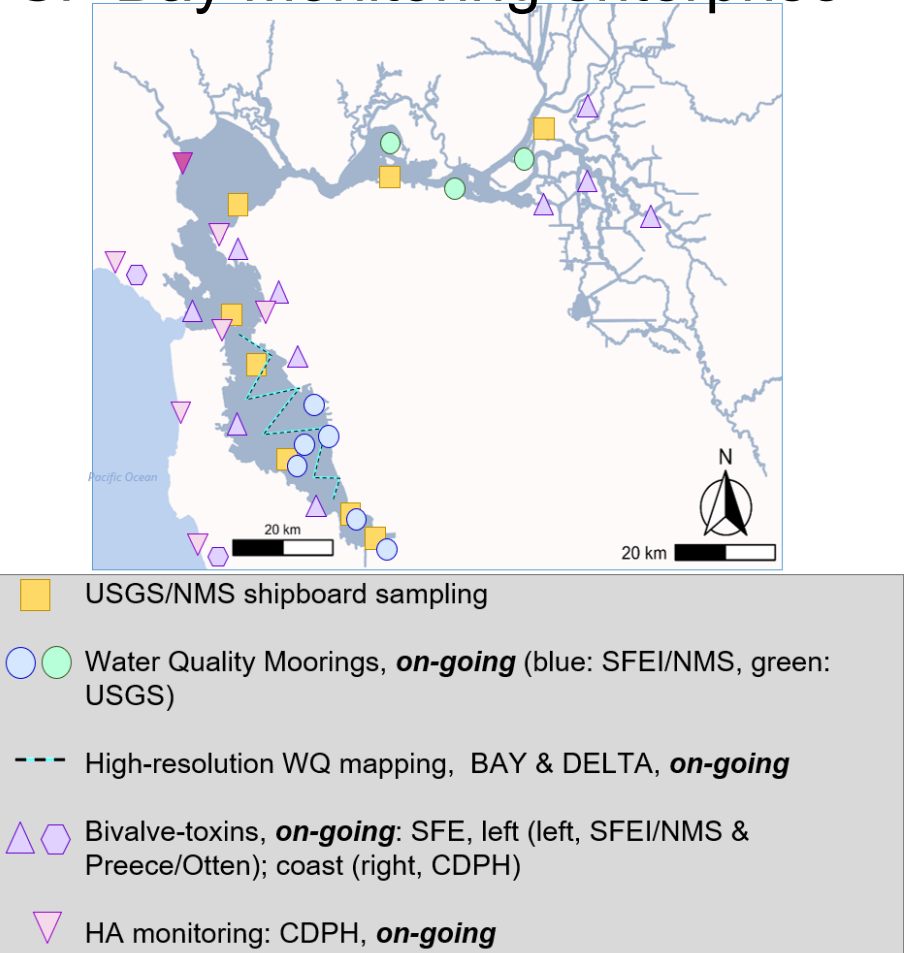
<https://eu-space.europa.eu/components/earth-observation-copernicus/image-of-the-day/algal-bloom-swirls-across-western-baltic-sea>



Photo: SF Baykeeper

What SF Estuary needs: new technologies and coordination

HAB-related elements of the SF Bay monitoring enterprise



SFEI Harmful Algae Watchlist

<i>Akashiwo</i>		<i>Heterosigma</i>	
<i>Alexandrium</i>		<i>Karlodinium</i>	
<i>Dinophysis</i>		<i>Karenia</i>	
<i>Gonyaulax</i>		<i>Noctiluca</i>	
<i>Gymnodinium</i>		<i>Prorocentrum</i>	
<i>Gyrodinium</i>		<i>Prymnesium</i>	
<i>Heterocapsa</i>		<i>Pseudo-nitzschia</i>	



Monitoring and Event Response for HABs (MERHAB)

- Build local, regional, and national capacity for monitoring and response through enhanced HAB monitoring
- Support partnerships enabling the demonstration (or piloting) of improvements to routine monitoring or observing programs using proven HAB technologies
- Not intended to provide long-term support for routine monitoring or observing efforts

MERHAB SF Estuary Project:

New Technologies and a Coordination Framework for an Integrated HAB Detection and Monitoring System across the San Francisco Estuary

Co-Lead PIs: D. Senn (SFEI), K. Bouma-Gregson (USGS), E. Preece (DWR)

PIs: R. Kudela (UCSC), A. Chelsky (SFEI), T. Otten (Bend Genetics), M. Howard (CVRWQCB), T. Mumley (SFBRWQCB)

Partners: SF Baykeeper, Restore the Delta, Cal Poly Maritime Academy

Timeline: 2023–2028

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Project Objectives

- 1. Enhance** existing monitoring data with new technologies and tools for rapid HAB detection and to further our understanding of HAB ecology.
- 2. Integrate data streams** to deliver data rapidly to managers as decision support tools.
- 3. Fill data and knowledge gaps** about the **transport** of cells and toxins along the freshwater to marine continuum to inform monitoring strategies across ecological and management boundaries.
- 4. Develop** a coordinated **HAB monitoring and management strategy** across the estuary to improve HAB event response and manage HAB impacts.

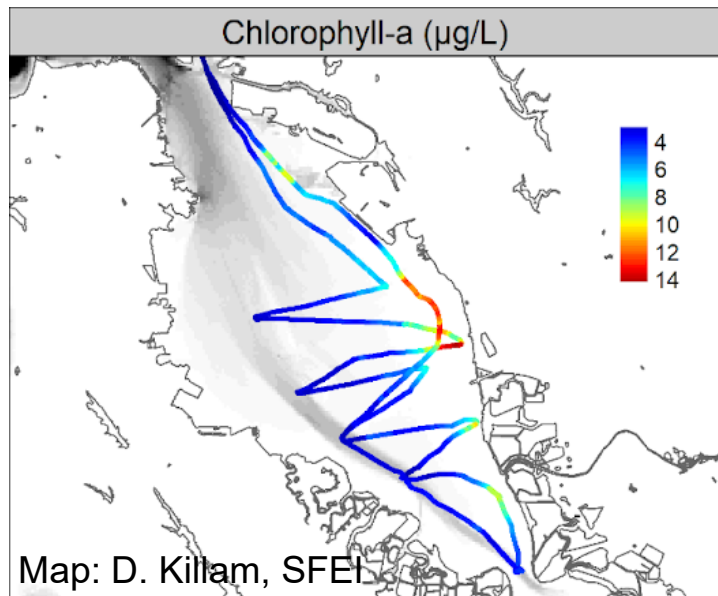


Photo: USGS

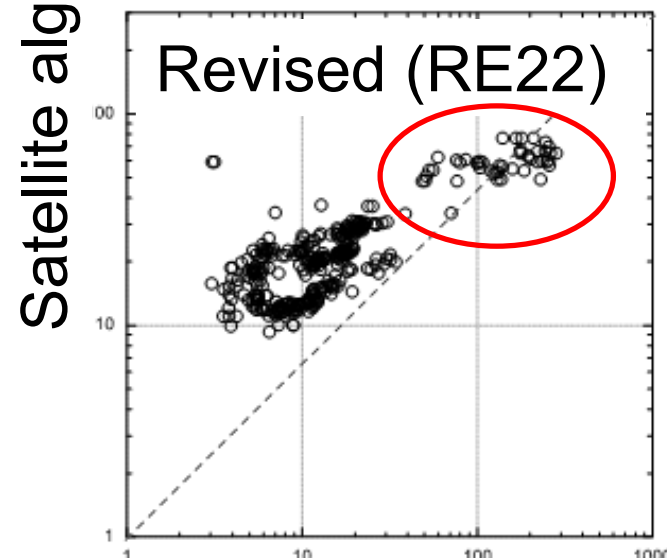
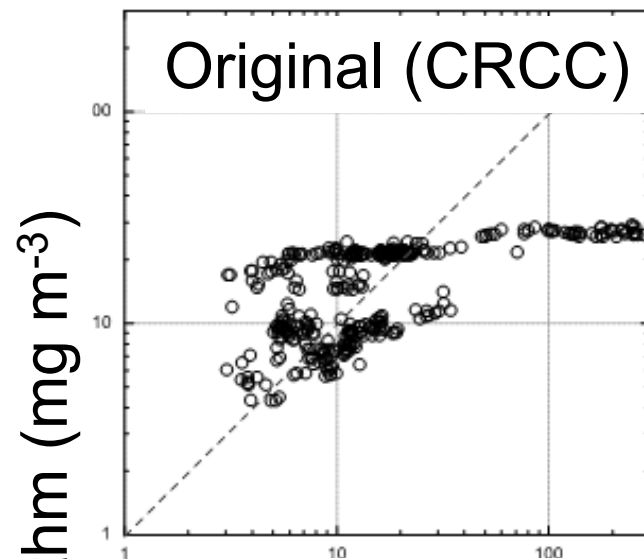
1) Enhance monitoring

- **1A) Remote Sensing:** improved chlorophyll *a* (chl-*a*) algorithms
- **1B) Molecular methods:** DNA-based assays for phytoplankton detection and enumeration
- **1C) Community science:** monitoring HAB detection

Improved Chl-a algorithms



High resolution boat-based mapping data used for satellite validation



Mapping chl-a (mg m^{-3})



Photos: USGS

Improved algorithm better captures “bloom-level” chlorophyll values

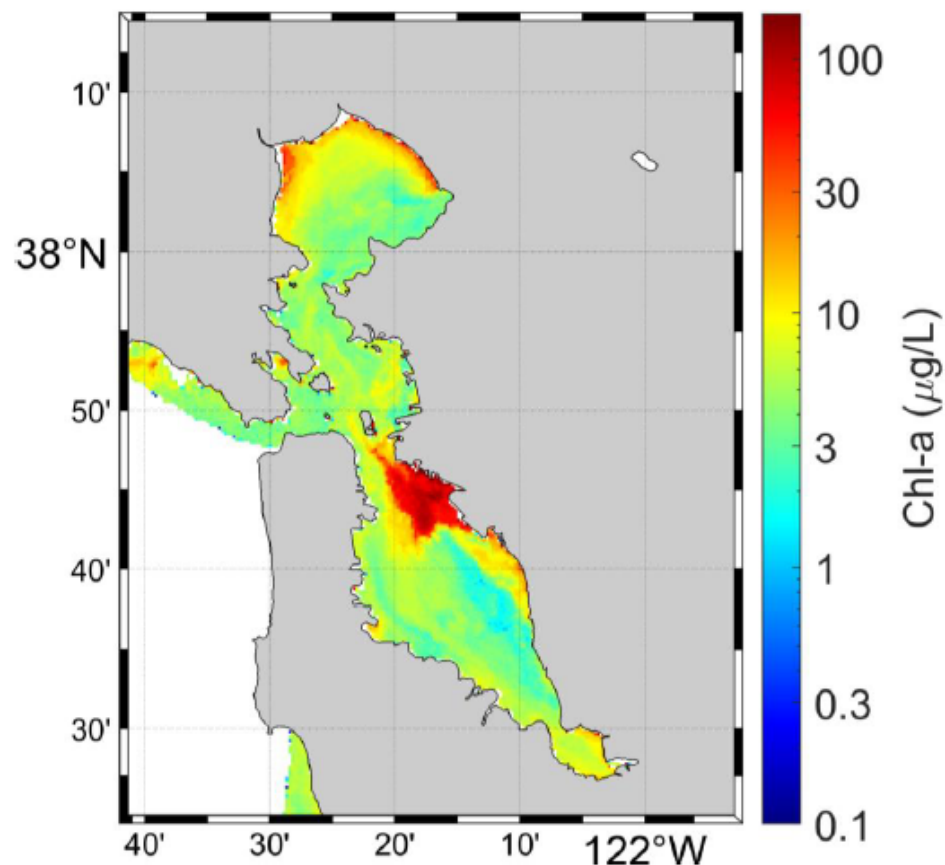
Kudela, R. M., et al. (2024). Evaluation and Refinement of Chlorophyll-a Algorithms for High-Biomass Blooms in San Francisco Bay (USA). *Remote Sensing* 16, 1103. doi: [10.3390/rs16061103](https://doi.org/10.3390/rs16061103)



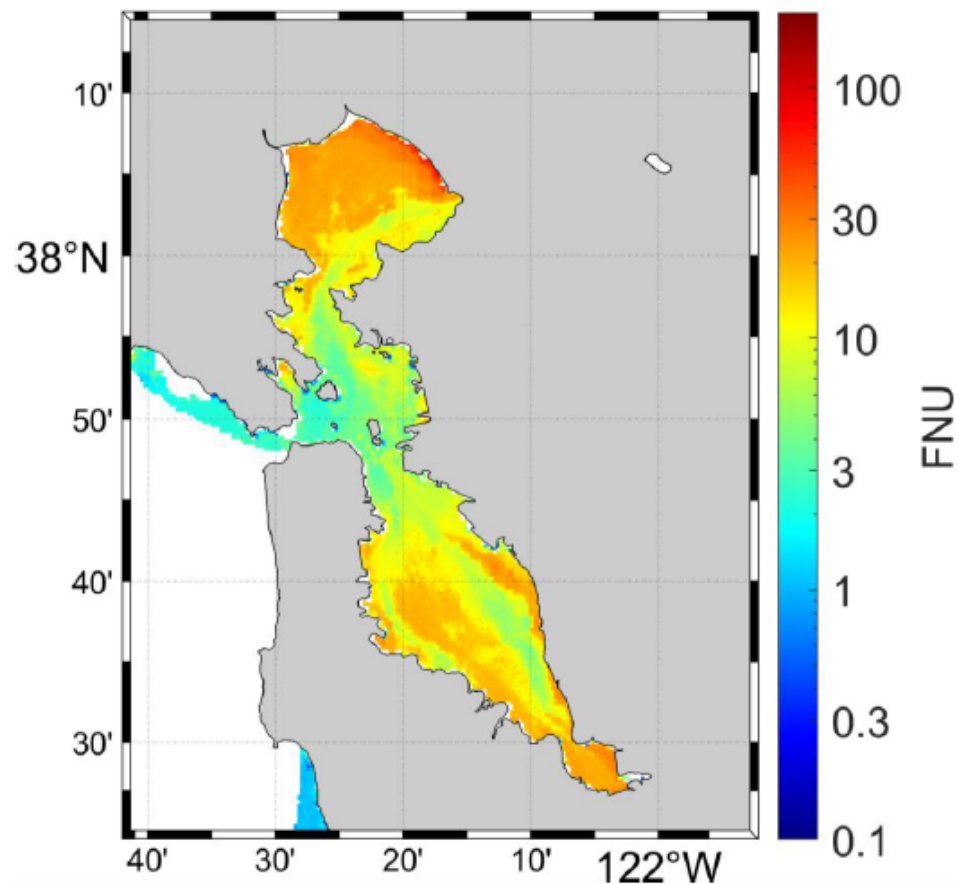
1A) Improved Chl-a algorithms

Turbidity interferes with the chl-a algorithm

Kudela et. al. (2024) Chl-a algorithm



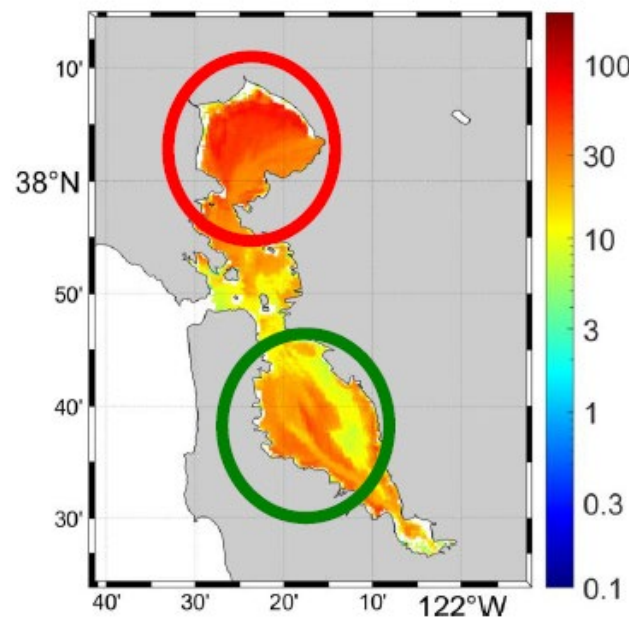
Nechad et. al. (2010) Turbidity algorithm



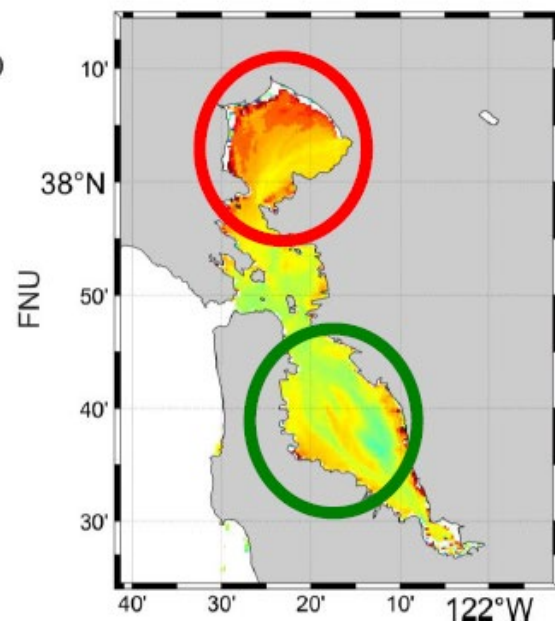
August 7,
2022

1A) Improved Chl-*a* algorithms

**High
Turbidity**



**High
Chl-*a***

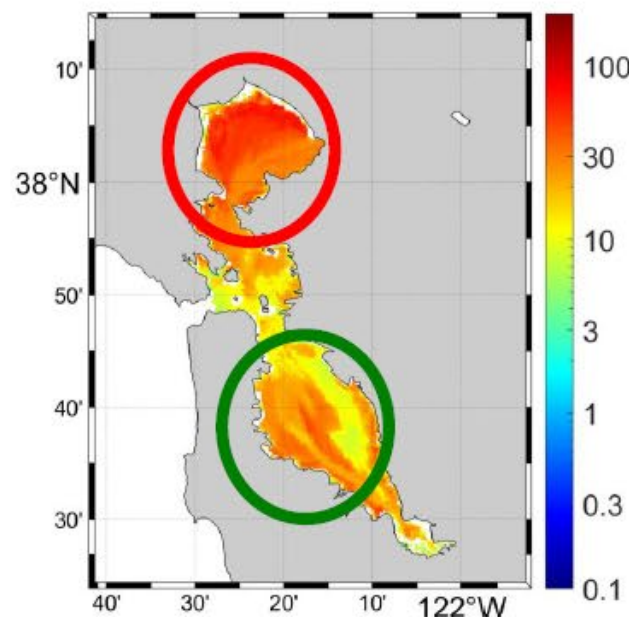


Moderate

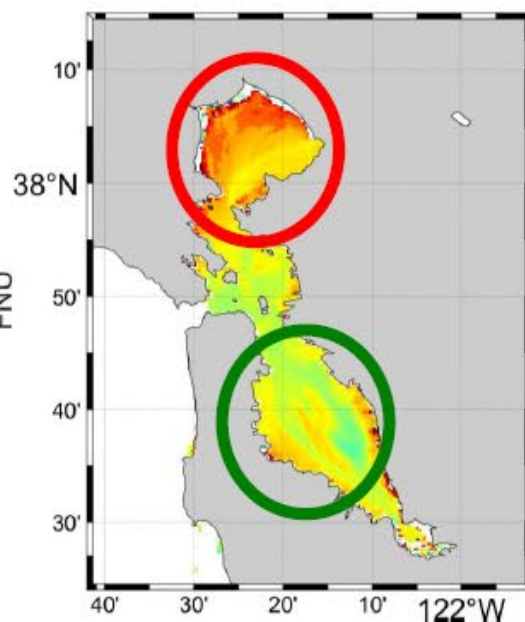
Figures from Aurpita Saha (UCSC; in prep)

1A) Improved Chl-*a* algorithms

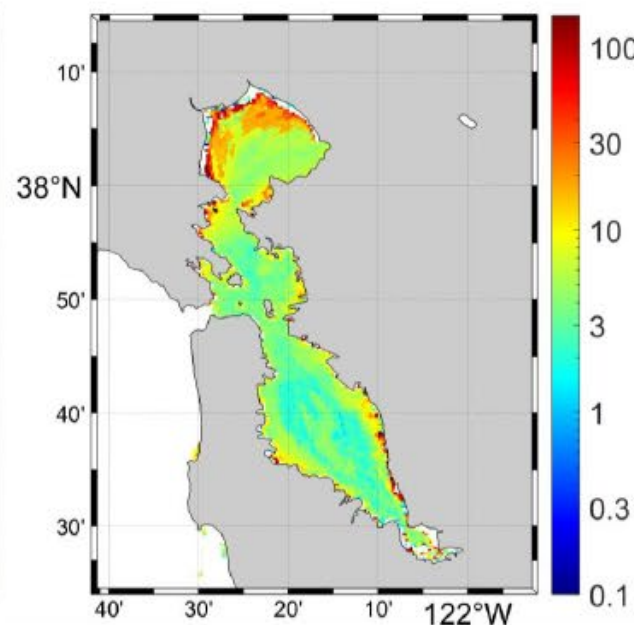
High Turbidity



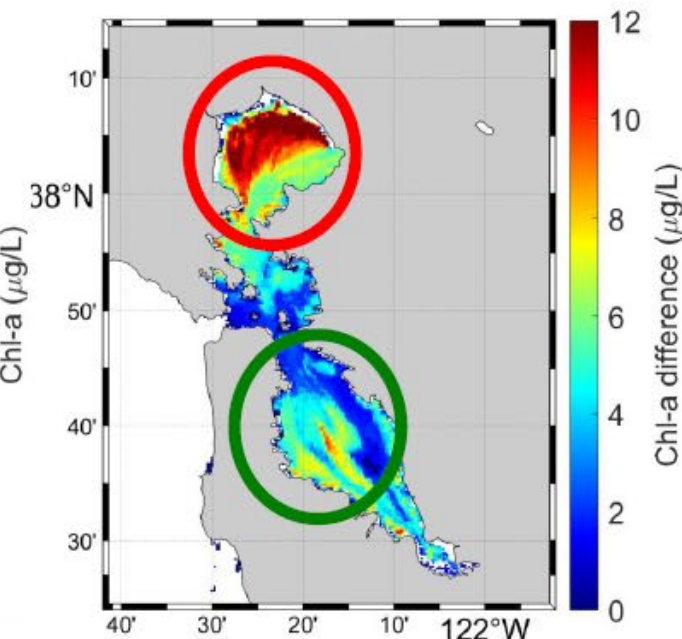
High Chl-*a*



Corrected Chl-*a*



Difference Chl-*a*



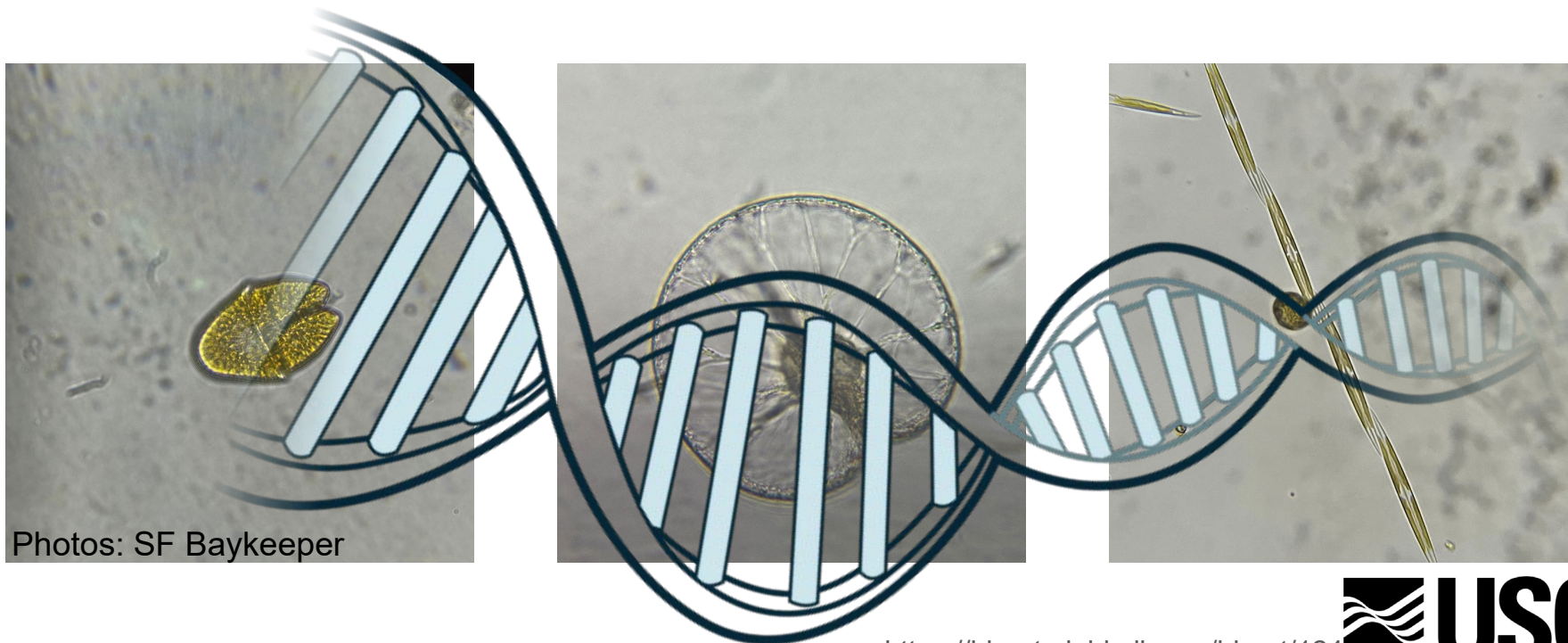
Moderate

Moderate

1B) Enhance monitoring – Molecular Methods

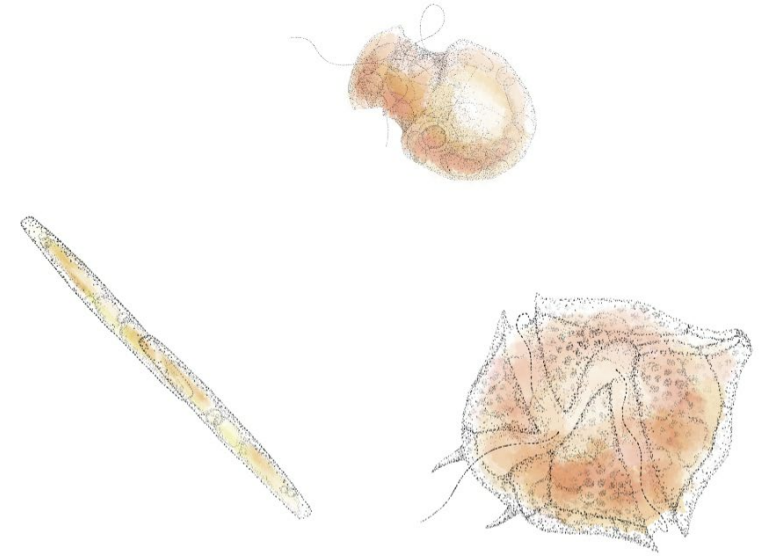
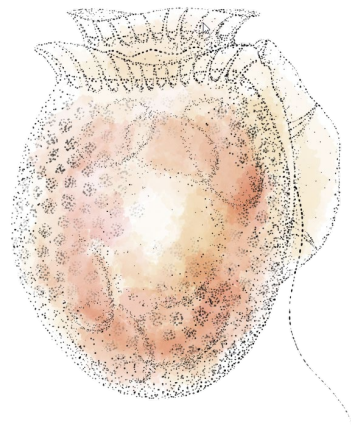
Key issue: microscopic phytoplankton ID is slow, expensive, subject to preservation biases, and difficult to compare across methods and microscopists.

DNA based molecular methods can complement microscopy



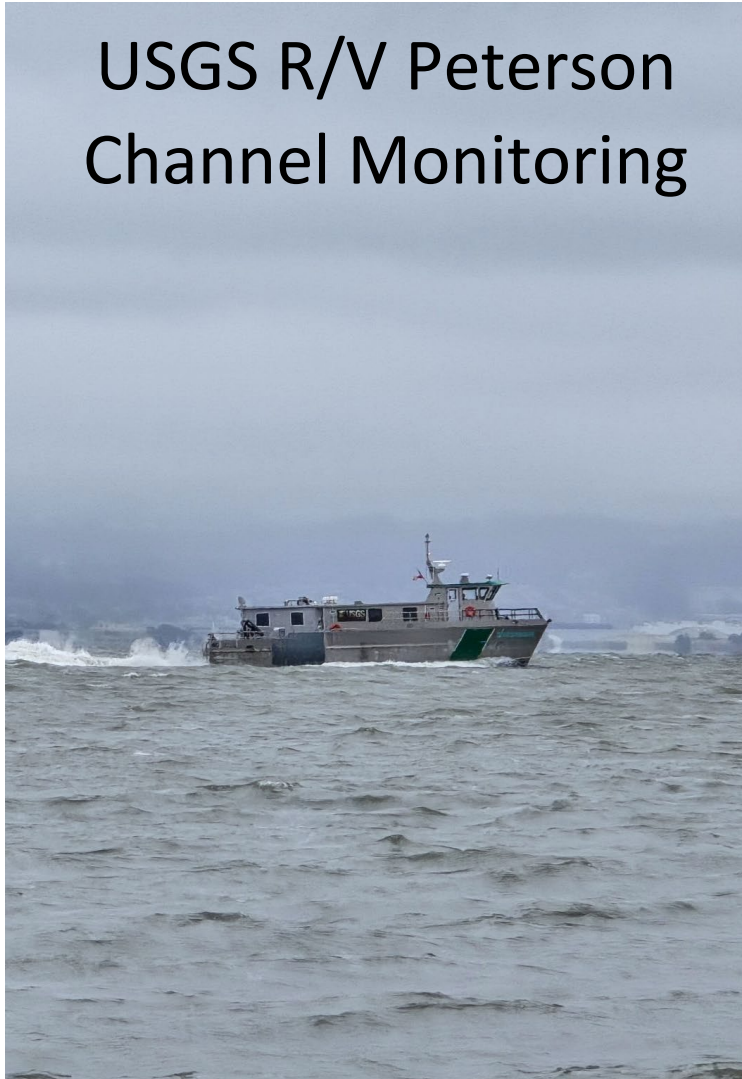
1B) Enhance monitoring – Molecular Methods

- **Metabarcoding:** whole community analysis
- **qPCR:** quantification of targeted gene abundance

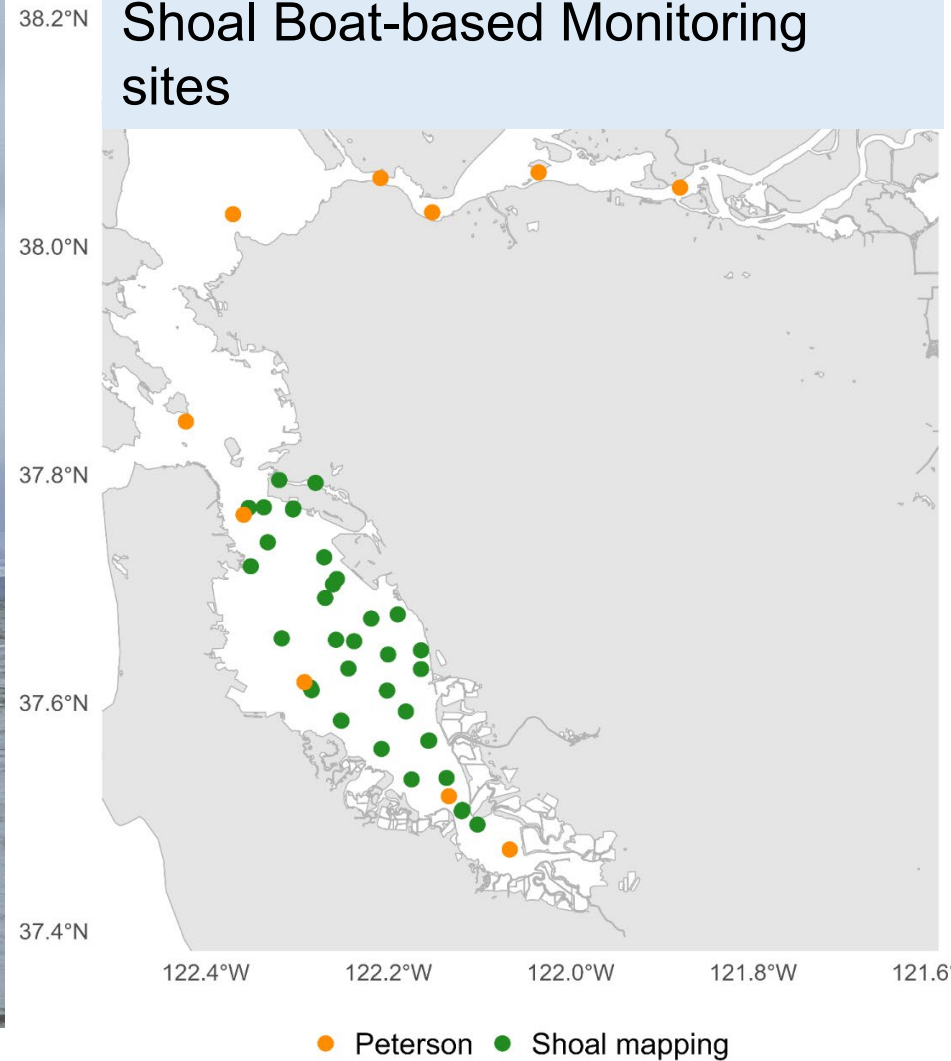


1B) Enhance monitoring – Molecular Methods

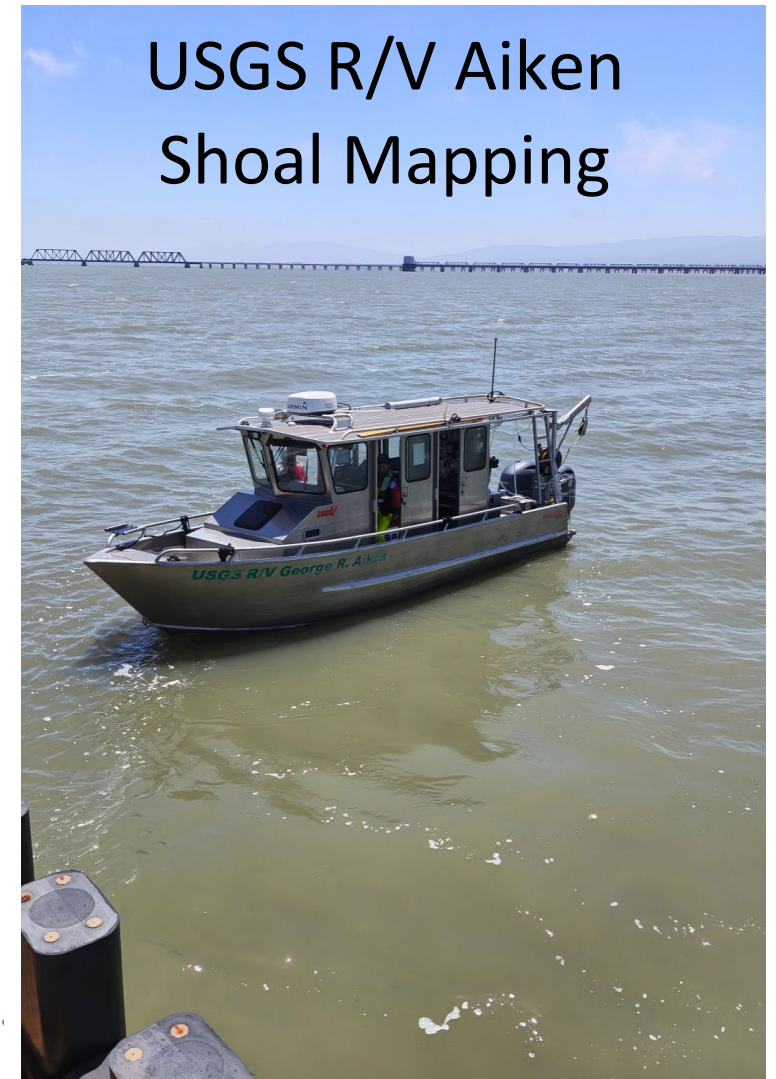
USGS R/V Peterson Channel Monitoring



USGS & NMS Channel and Shoal Boat-based Monitoring sites



USGS R/V Aiken Shoal Mapping



Photos and map from Dan Killam, SFEI

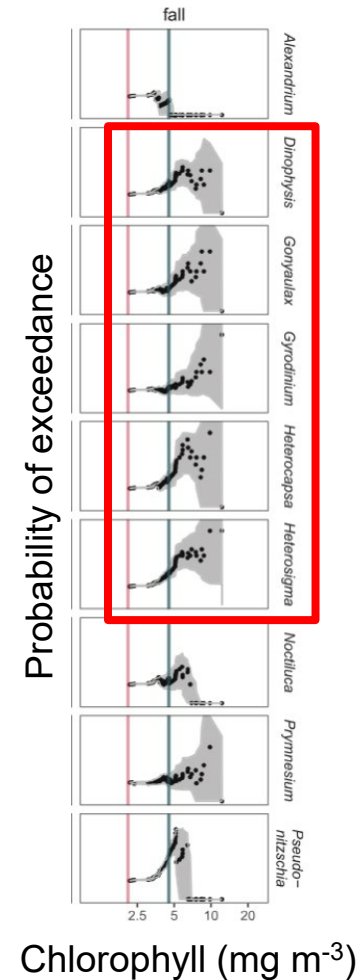
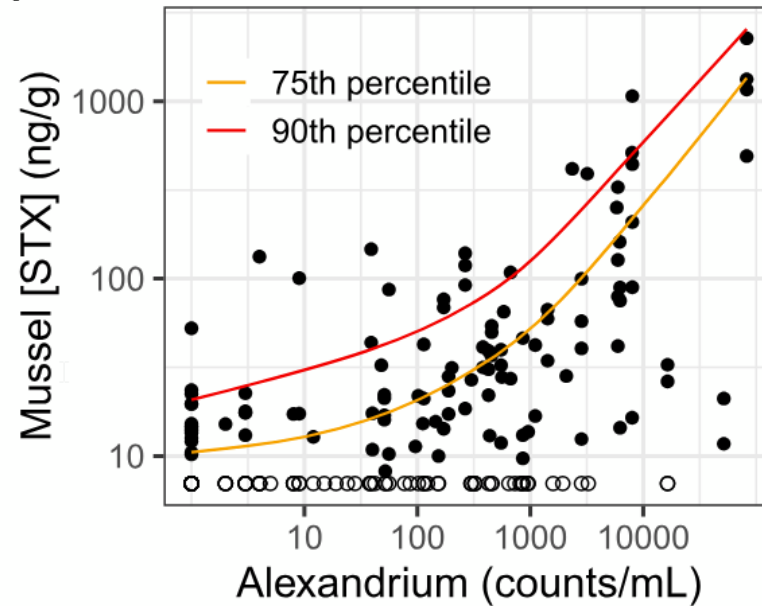
Preliminary Information-Subject to Revision. Not for Citation or Distribution.



1B) Enhance monitoring – Molecular Methods

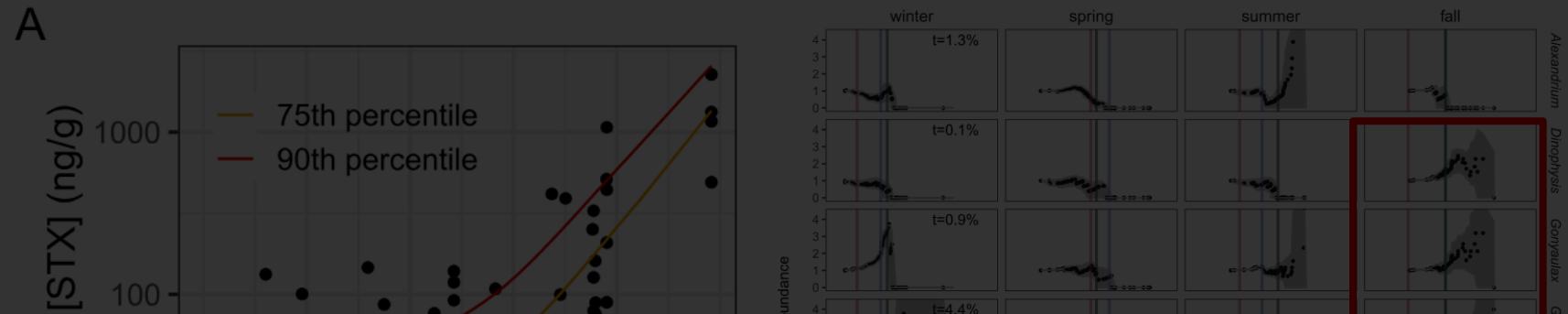
qPCR and metabarcoding data used to assess probabilities of HAB taxa based on chlorophyll concentrations

A

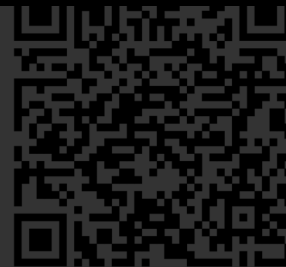


Killam, D., et al. (2026). Revisiting chlorophyll a thresholds for San Francisco Bay: insights from observations of phytoplankton molecular abundance. *Harmful Algae* 154, 103086. doi: [10.1016/j.hal.2026.103086](https://doi.org/10.1016/j.hal.2026.103086)

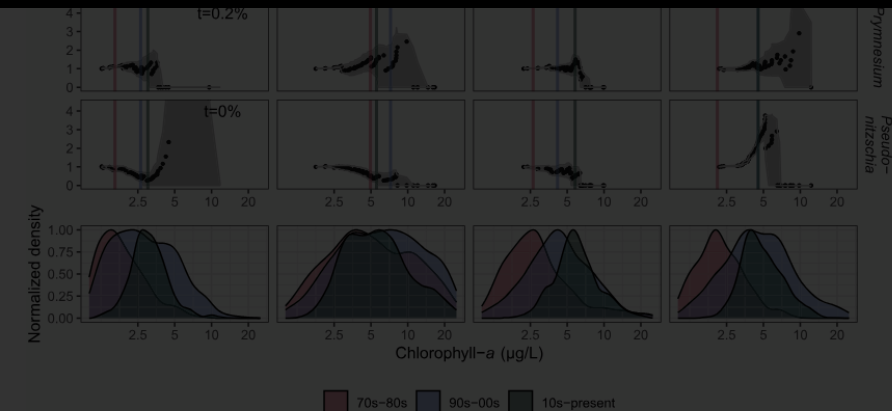
1B) Enhance monitoring – Molecular Methods



These efforts help the meet the need for faster and more reproducible monitoring methods and align with larger regional and national efforts to incorporate molecular methods into phytoplankton monitoring.



Killam et al. 2026,
Harmful Algae





2022 *Heterosigma* Bloom

INITIAL REPORTS FROM
COMMUNITY MEMBERS
THROUGH BAYKEEPER
HOTLINE

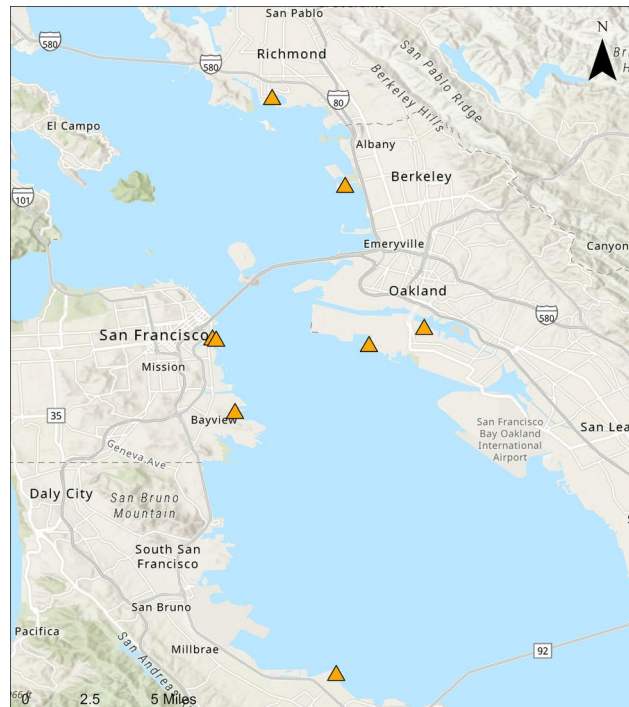
COMMUNITY SCIENTISTS
SAMPLED WATER TO
IDENTIFY BLOOMING
ORGANISM

HOTLINE REPORTS OF
DEAD FISH ALL
AROUND SF BAY



1C) Community Science Monitoring

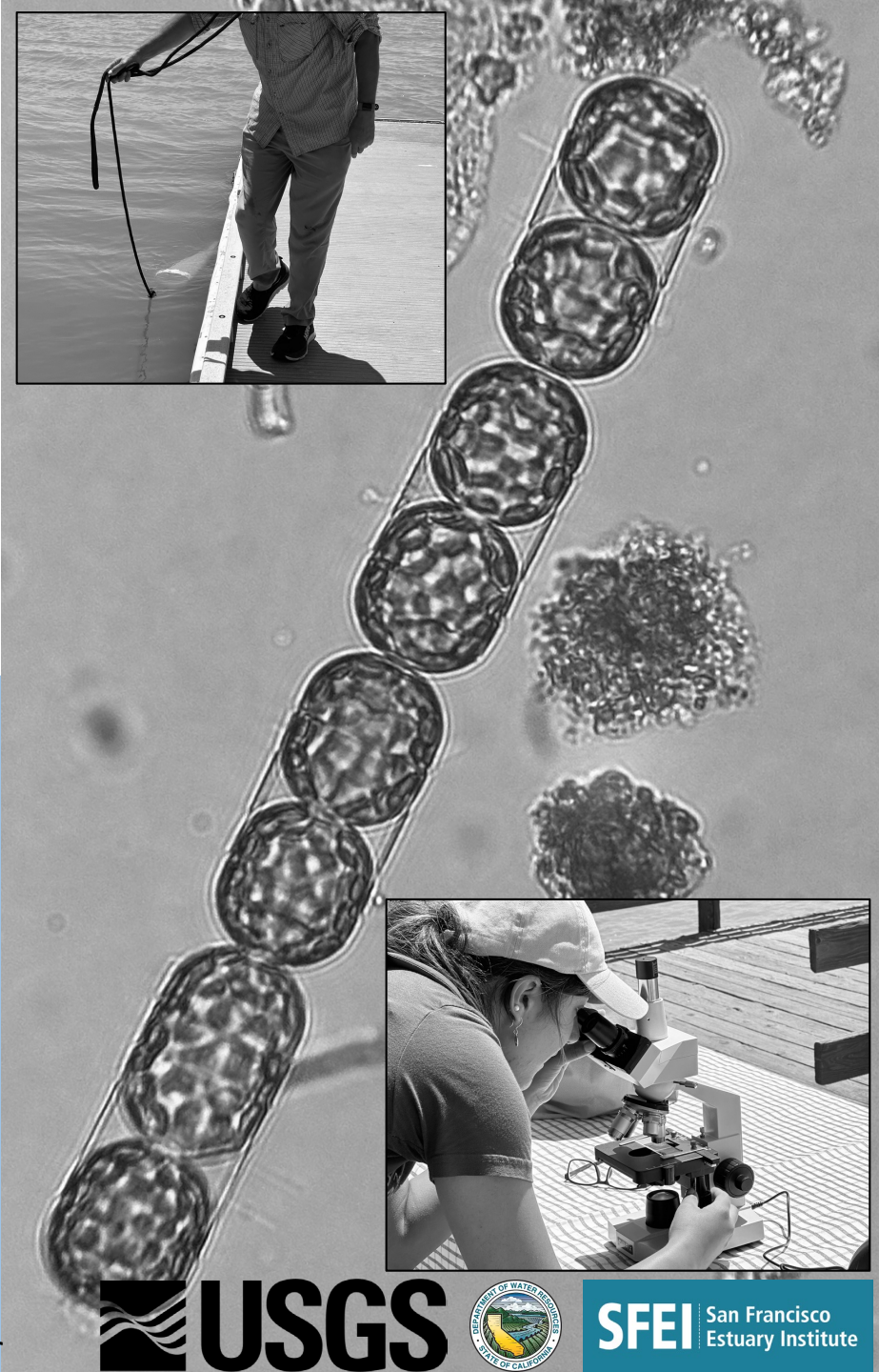
- SF Baykeeper has developed community science monitoring network for the detection of HABs in the Bay
- Integrated into NOAA's Phytoplankton Monitoring Network (PMN)



**9
SITES
18
VOLUNTEERS
504
SAMPLES**

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Images: SF Baykeeper

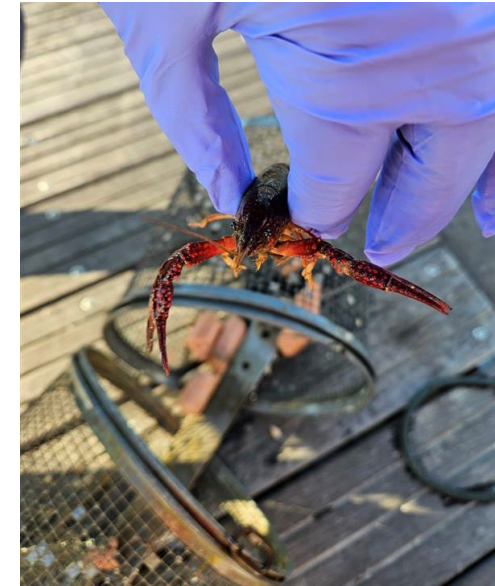
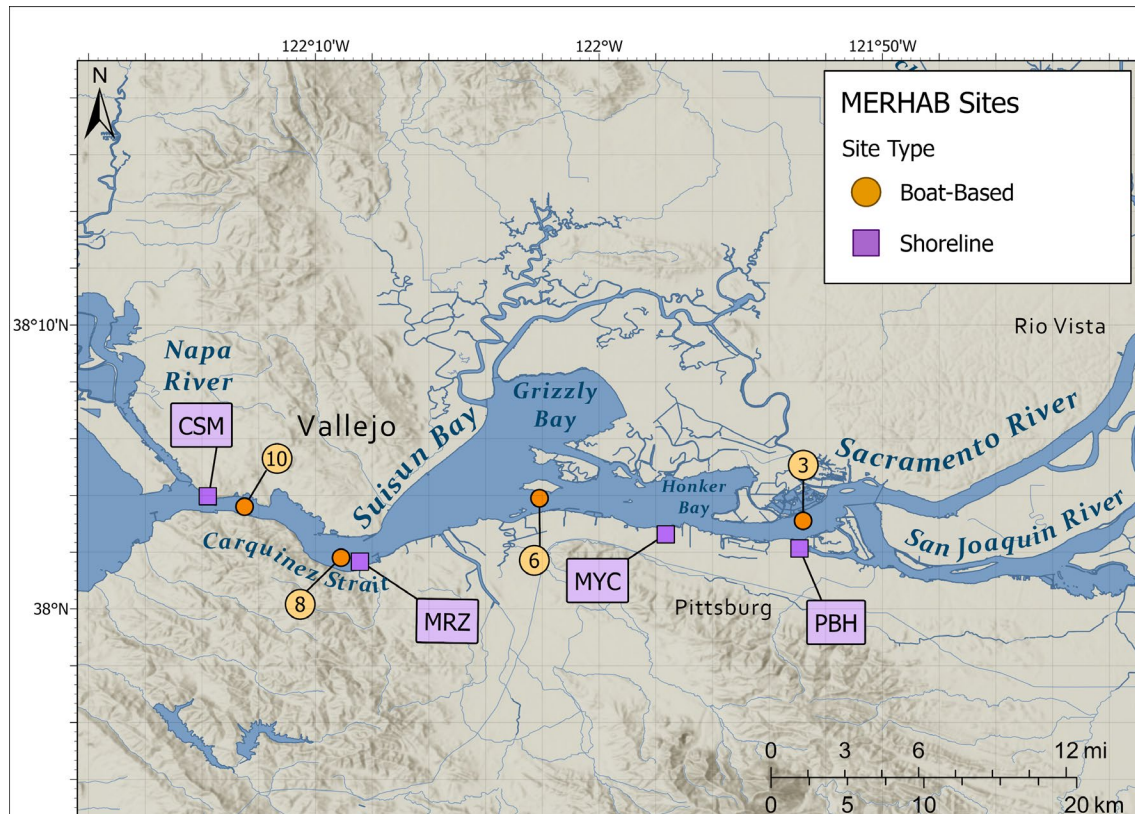


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3) Toxin transport

Key gap: how freshwater and marine HAB taxa and their toxins occur in the mesohaline zone

Approach: sample shellfish and water from Carquinez Strait to confluence to analyze for freshwater and marine toxins



Photos: CA DWR

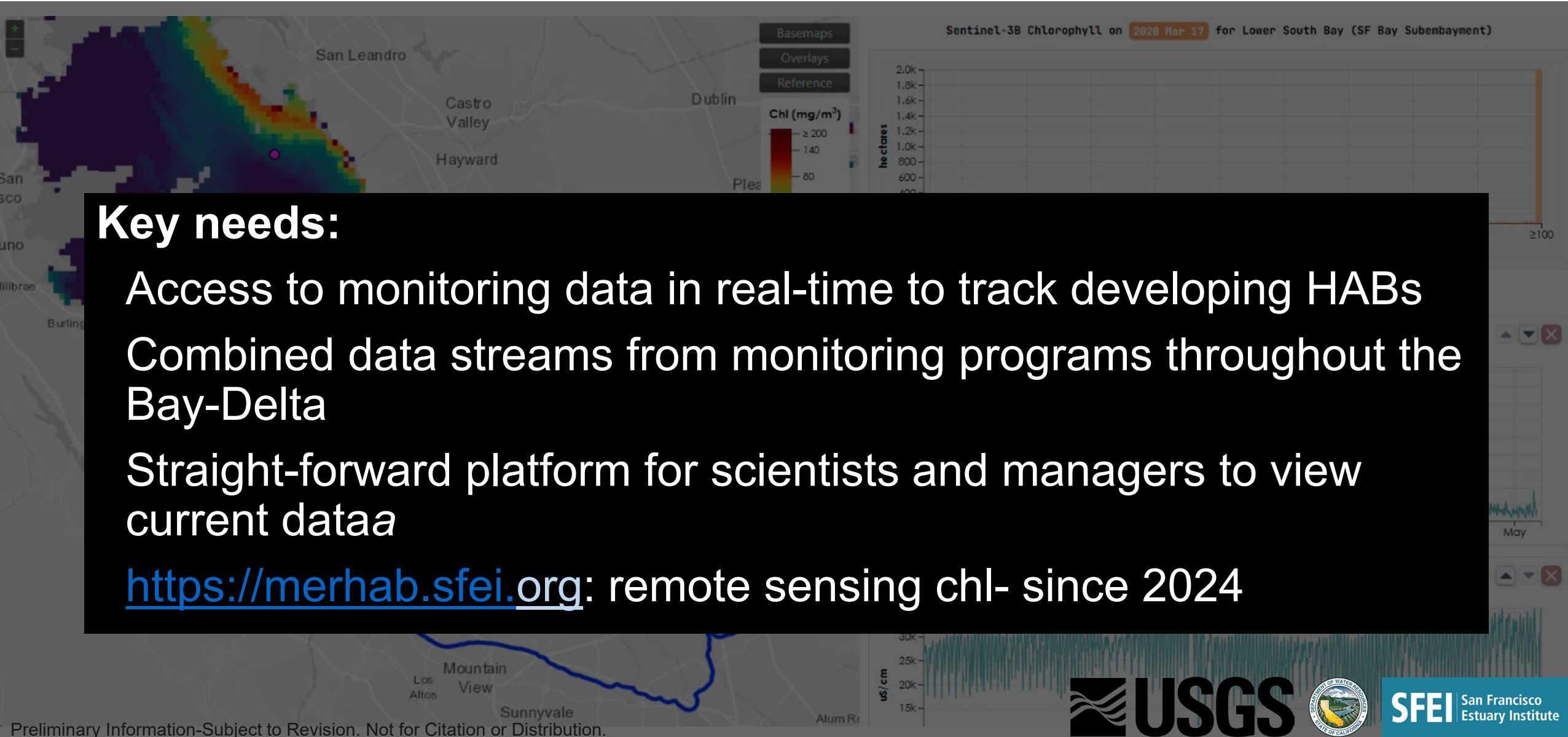


2) Data integration and visualization

Key needs:

- Access to monitoring data in real-time to track developing HABs
- Combined data streams from monitoring programs throughout the Bay-Delta
- Straight-forward platform for scientists and managers to view current dataa

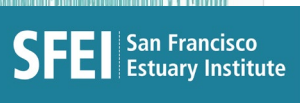
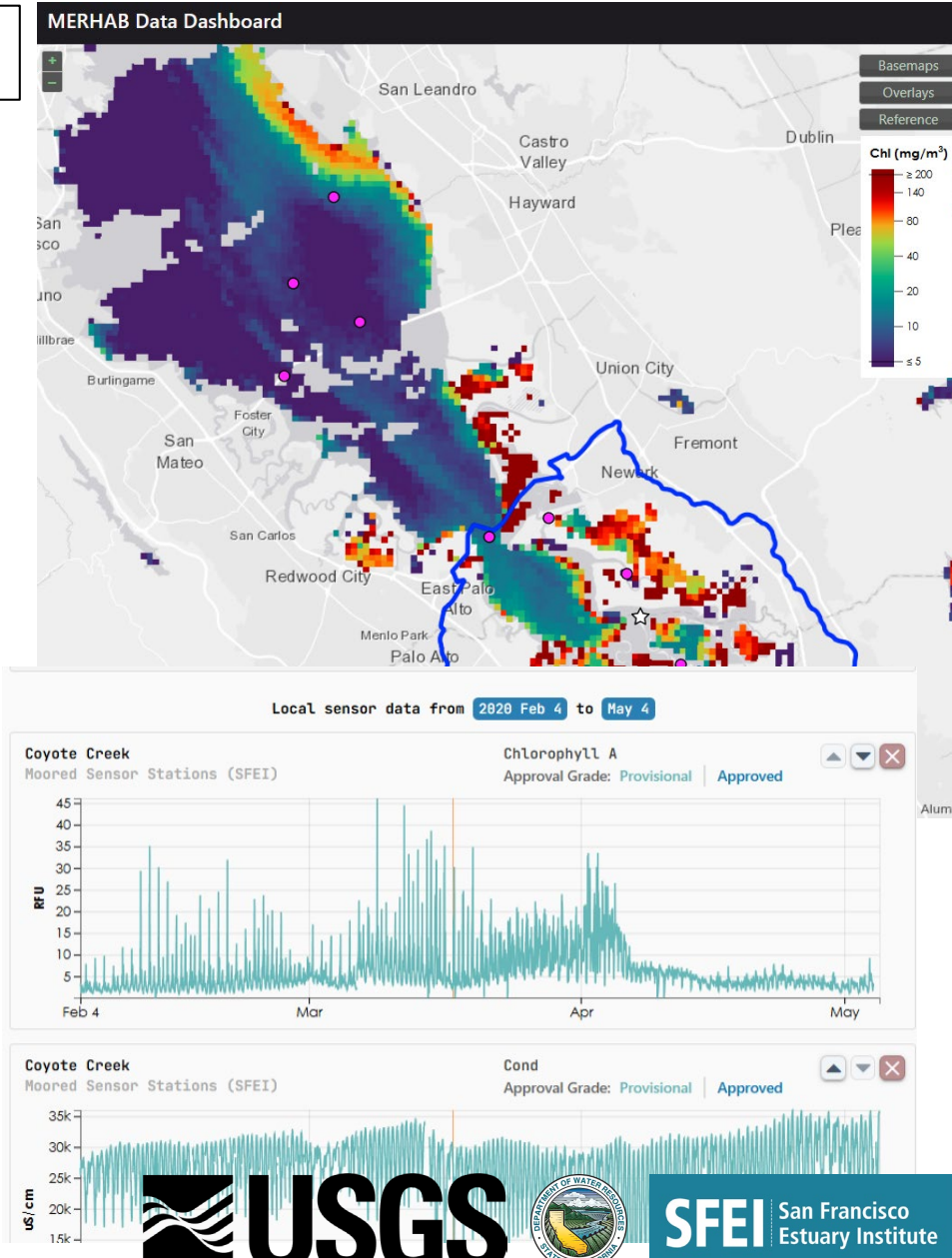
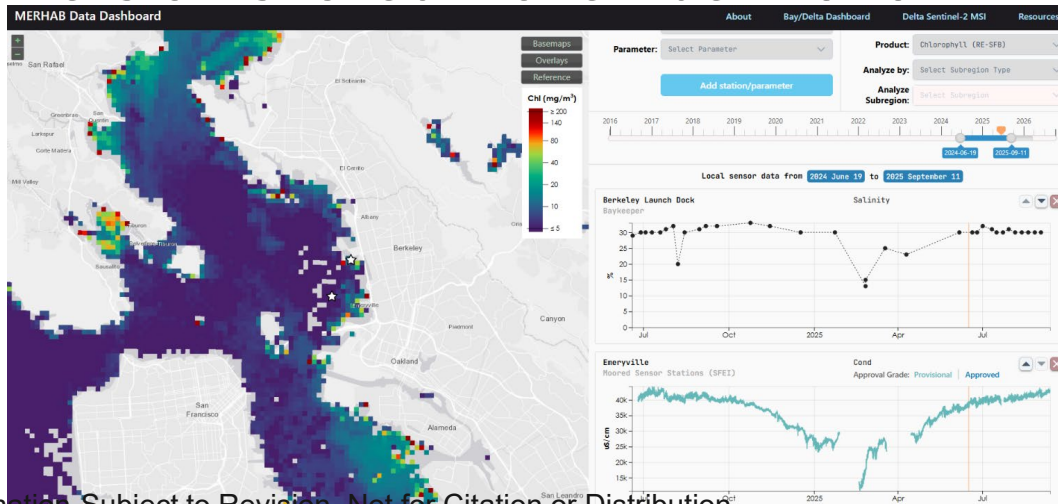
<https://merhab.sfei.org>: remote sensing chl- since 2024



2) Data integration and visualization

SFEI: Gemma Shusterman, Lindsey Simm, Tony Hale

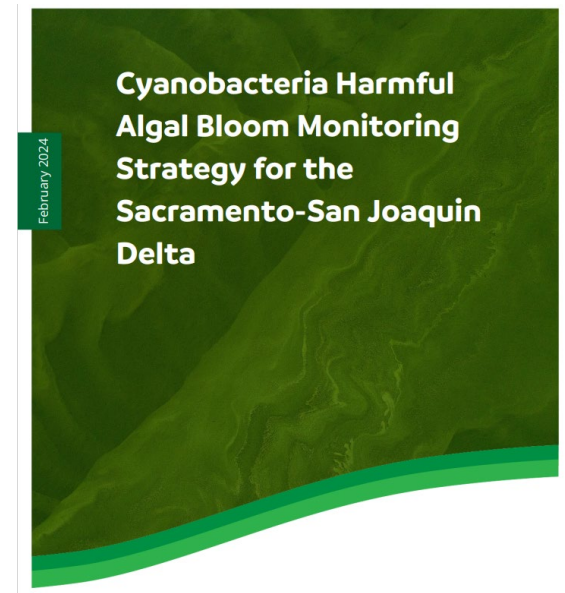
- Assembles open data, harmonizes dissimilar formats
- Data across different temporal and spatial scales
- Management focused analyses
- Beta version shared November 2026



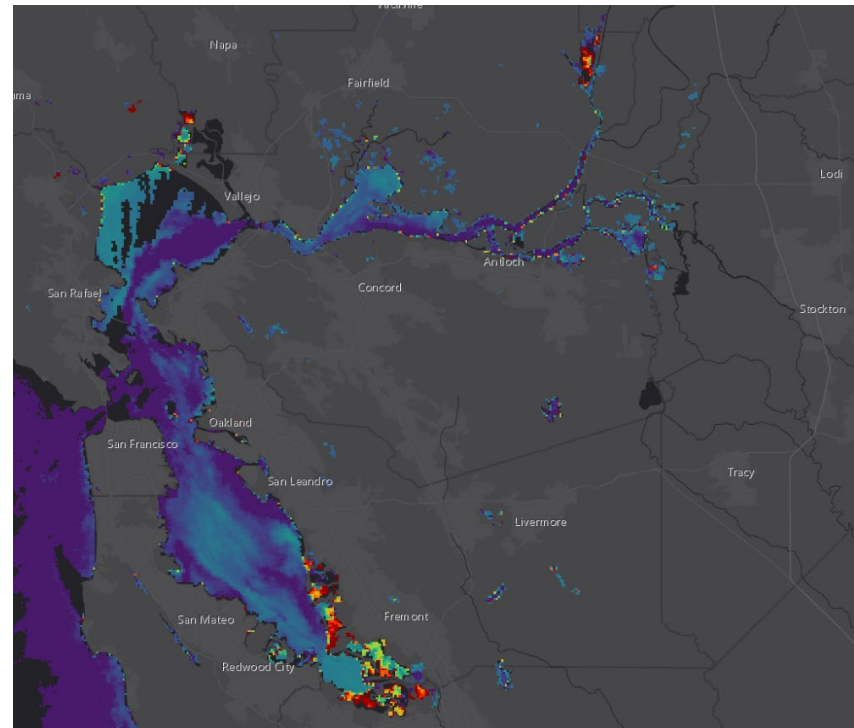
4) Bay-Delta Monitoring strategy

Develop an integrated Bay and Delta HABs monitoring and management strategy

Beginning fall 2027



Preece et al. 2024



<https://merhab.sfei.org>

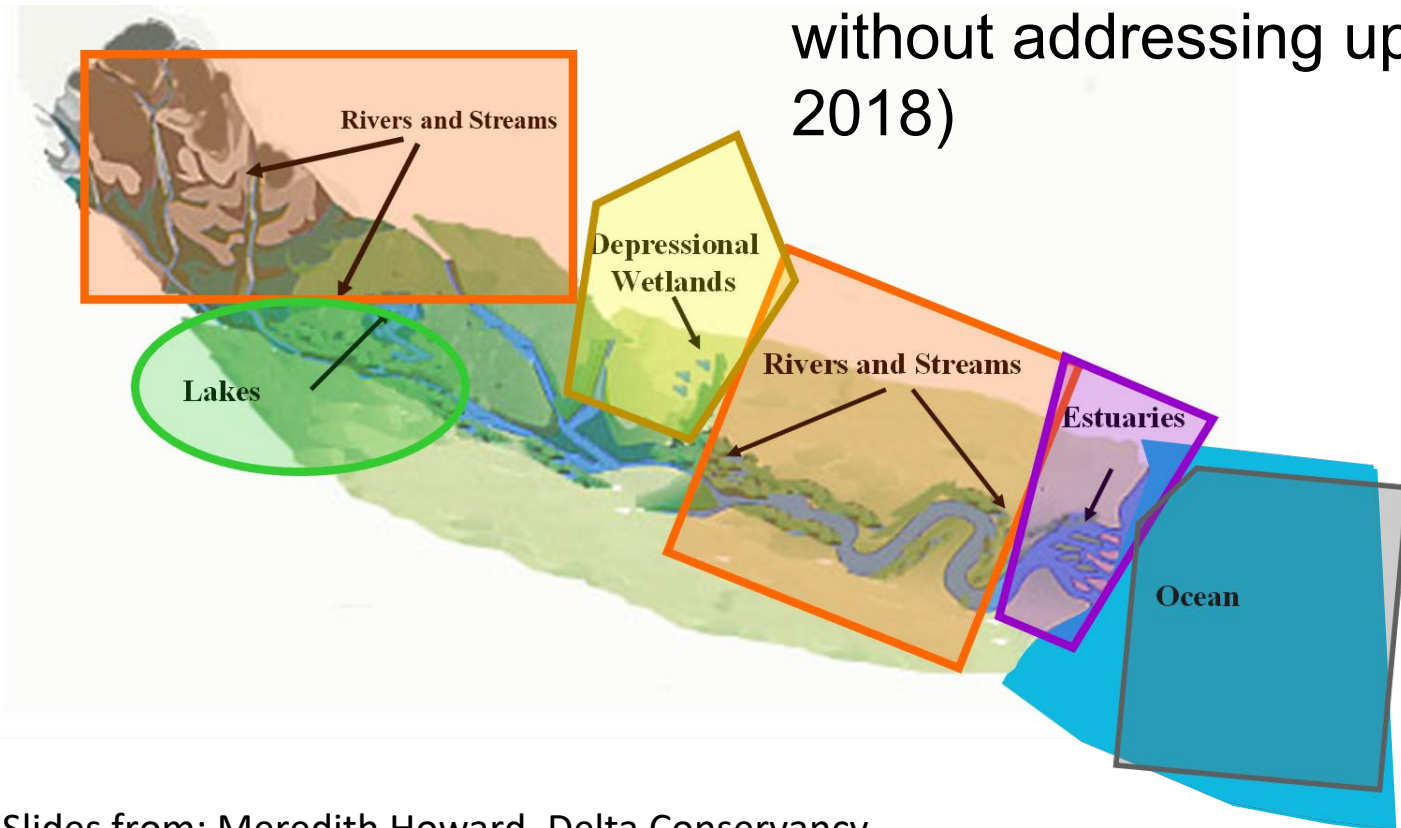


Photos: SF Baykeeper

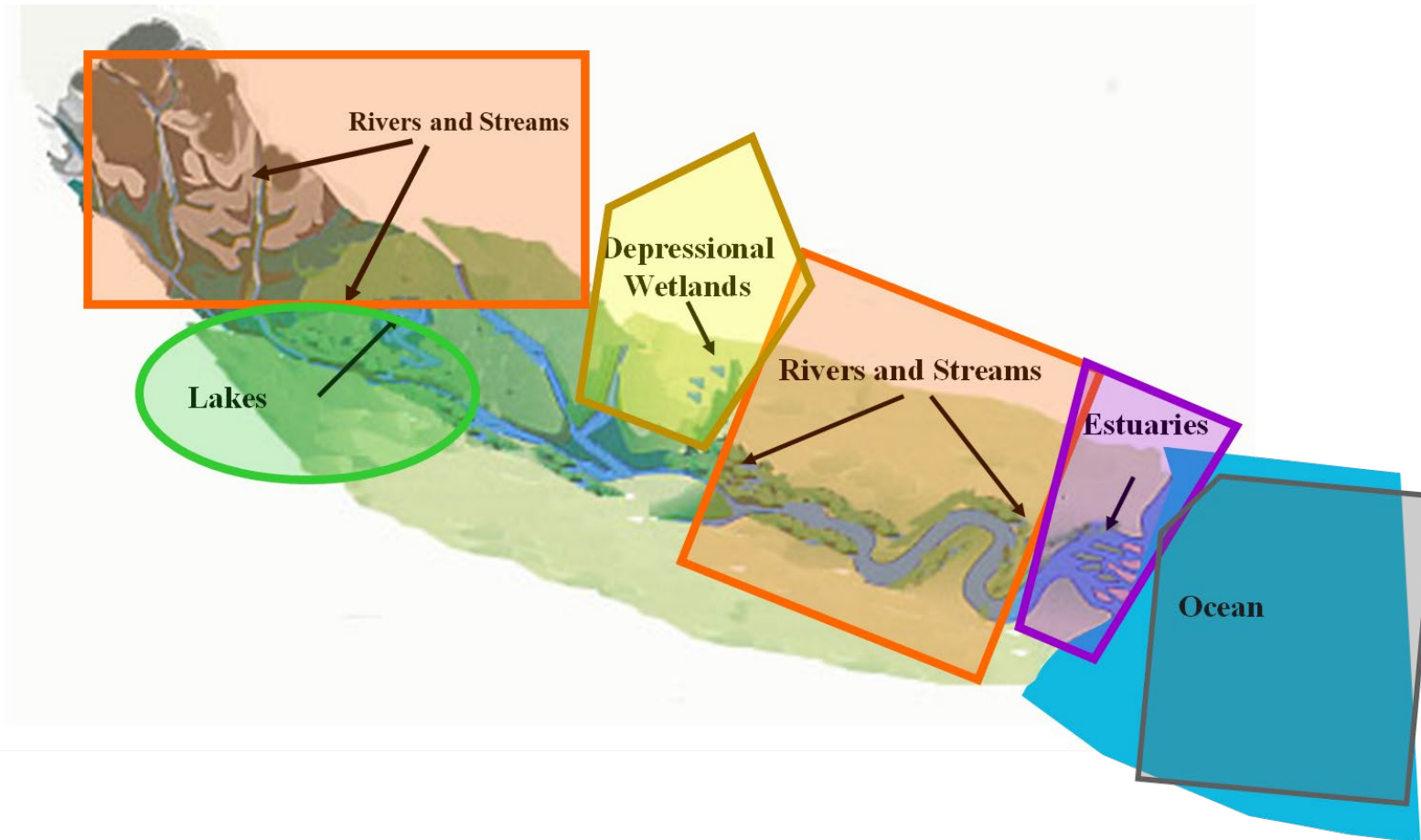


Historically, data collection and monitoring has been fractioned by water body type

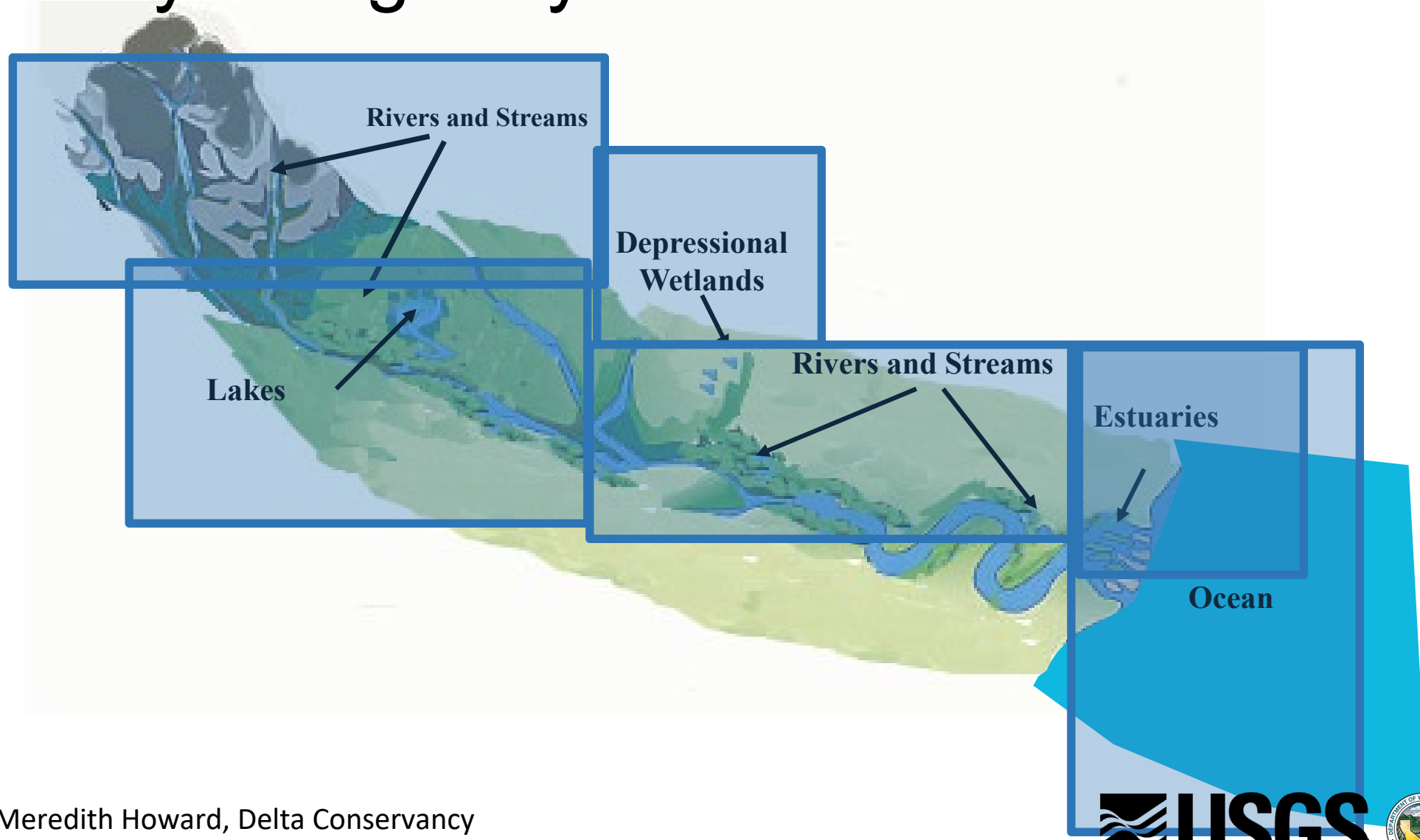
“Management in downstream waterbodies is ineffective without addressing upstream headwaters first” (Paerl et al., 2018)



Implementing Bay-Delta HAB strategy recommendations will transition from this...



To a cohesive, coordinated monitoring program across hydrologically connected waterbodies



Monitoring one interconnected system, rather than separate water bodies



Project Objectives

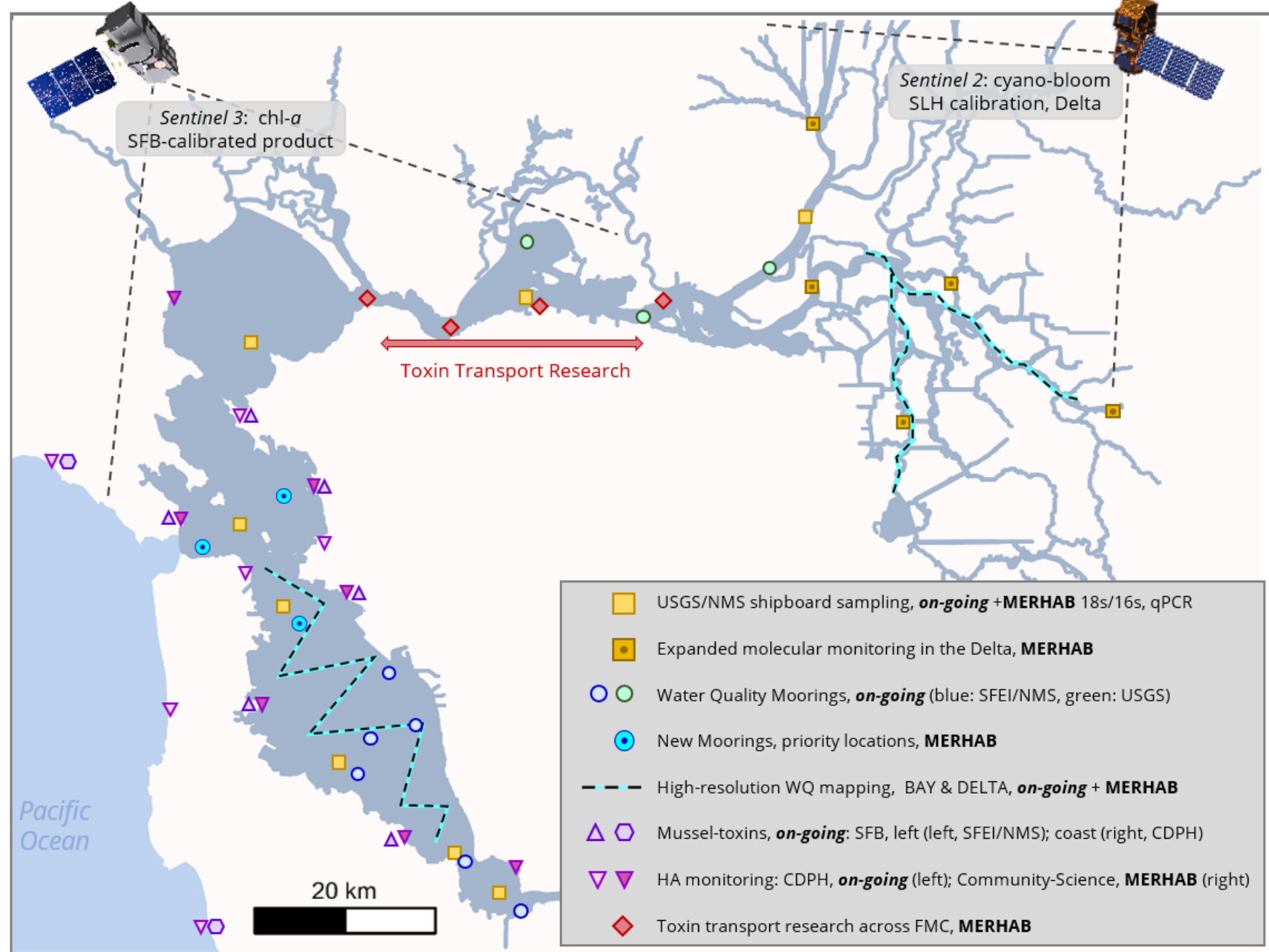
- 1. Enhance** existing monitoring data with new technologies and tools.
- 2. Integrate data streams** to deliver data rapidly to managers as decision support tools.
- 3. Fill data and knowledge gaps** about the **transport** of cells and toxins.
- 4. Develop** a coordinated **HAB monitoring and management strategy** across the estuary.



Photo: USGS

Enhancing the Bay-Delta HABs Monitoring Enterprise

- Boat-based
- Fixed stations
- Remote sensing
- Community science



Thank You

Keith Bouma-Gregson

U.S. Geological Survey | California Water Science Center

kbouma-gregson@usgs.gov

References

Allen, W. E. (1937). River and Sea. *The Scientific Monthly* 44, 405–408.

<https://www.jstor.org/stable/16149>

Paerl, H. W., Otten, T. G., and Kudela, R. (2018). Mitigating the Expansion of Harmful Algal Blooms Across the Freshwater-to-Marine Continuum. *Environ. Sci. Technol.* 52, 5519–5529. doi:

[10.1021/acs.est.7b05950](https://doi.org/10.1021/acs.est.7b05950)

Preece, E., Berg, G. M., Lee, T., and Odkins, K. (2024). Cyanobacteria Harmful Algal Bloom Monitoring Strategy for the Sacramento-San Joaquin Delta. Available at:

<https://deltacouncil.ca.gov/pdf/science-program/2024-10-21-final-delta-chabs-monitoring-strategy.pdf>



Photo: USGS

