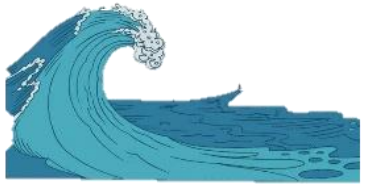
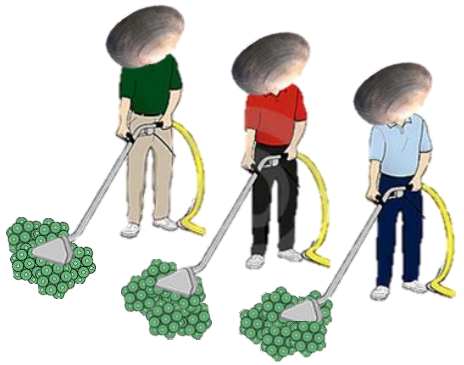
San Francisco Bay Nutrient Management Strategy

SF Land Use and Transportation Committee
October 17, 2022

Thomas Mumley
Assistant Executive Officer
SF Bay Water Board

CALIFORNIA Water Boards

San Francisco Bay **has been** Resilient to Nutrients

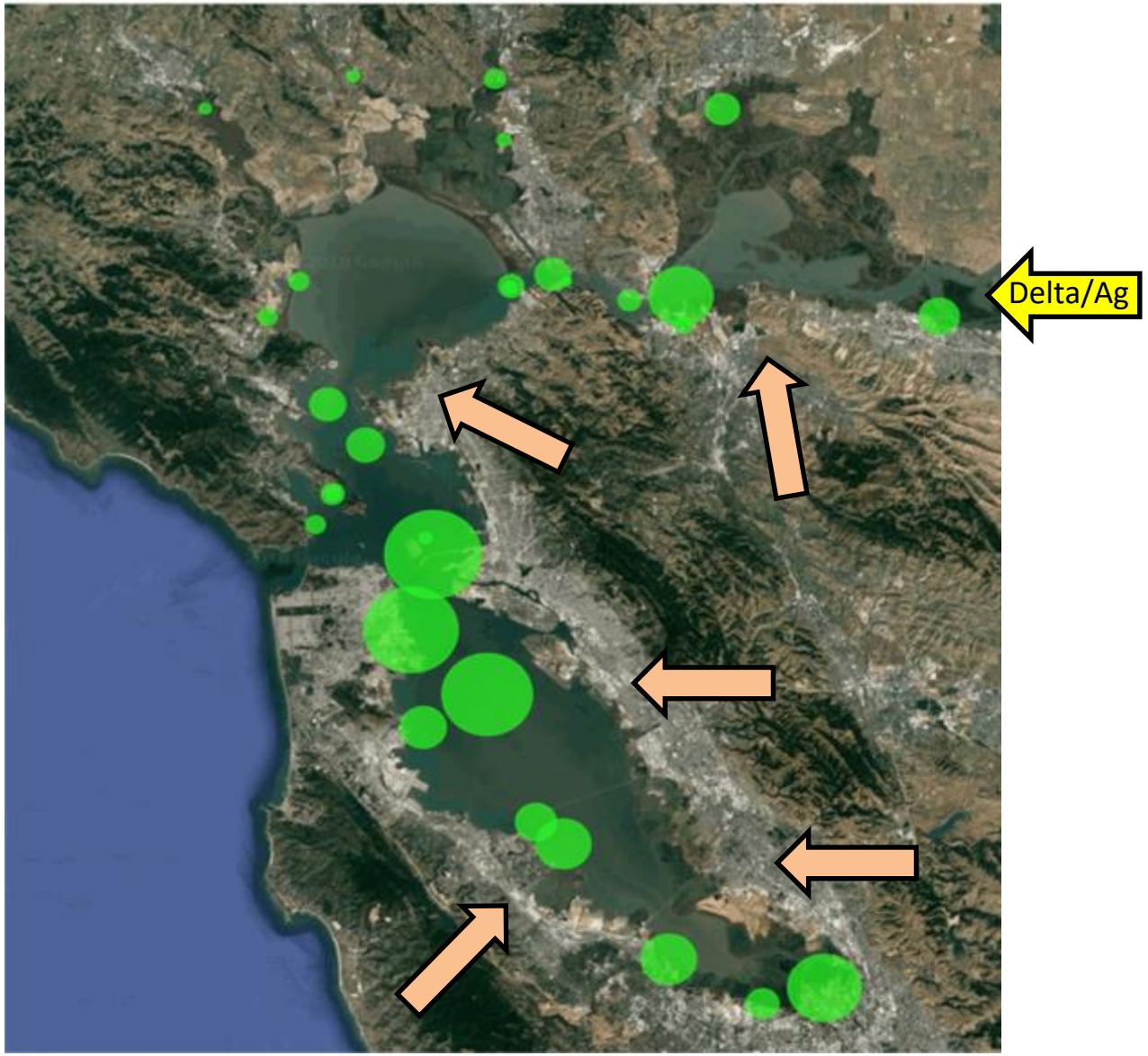
1. High Turbidity 
2. Strong Tidal Mixing 
3. Filter-feeding clams 

But resilience is waning

Nutrient Management Strategy

- Water quality standard
  - Antidegradation
- Science strategy
- Management options
  - Grey and green alternatives
  - Other pollutants
  - Multi-benefits

Nutrient Loads to SF Bay



Baywide Loads

N: 50,000 kg/d

P: 5,000 kg/d

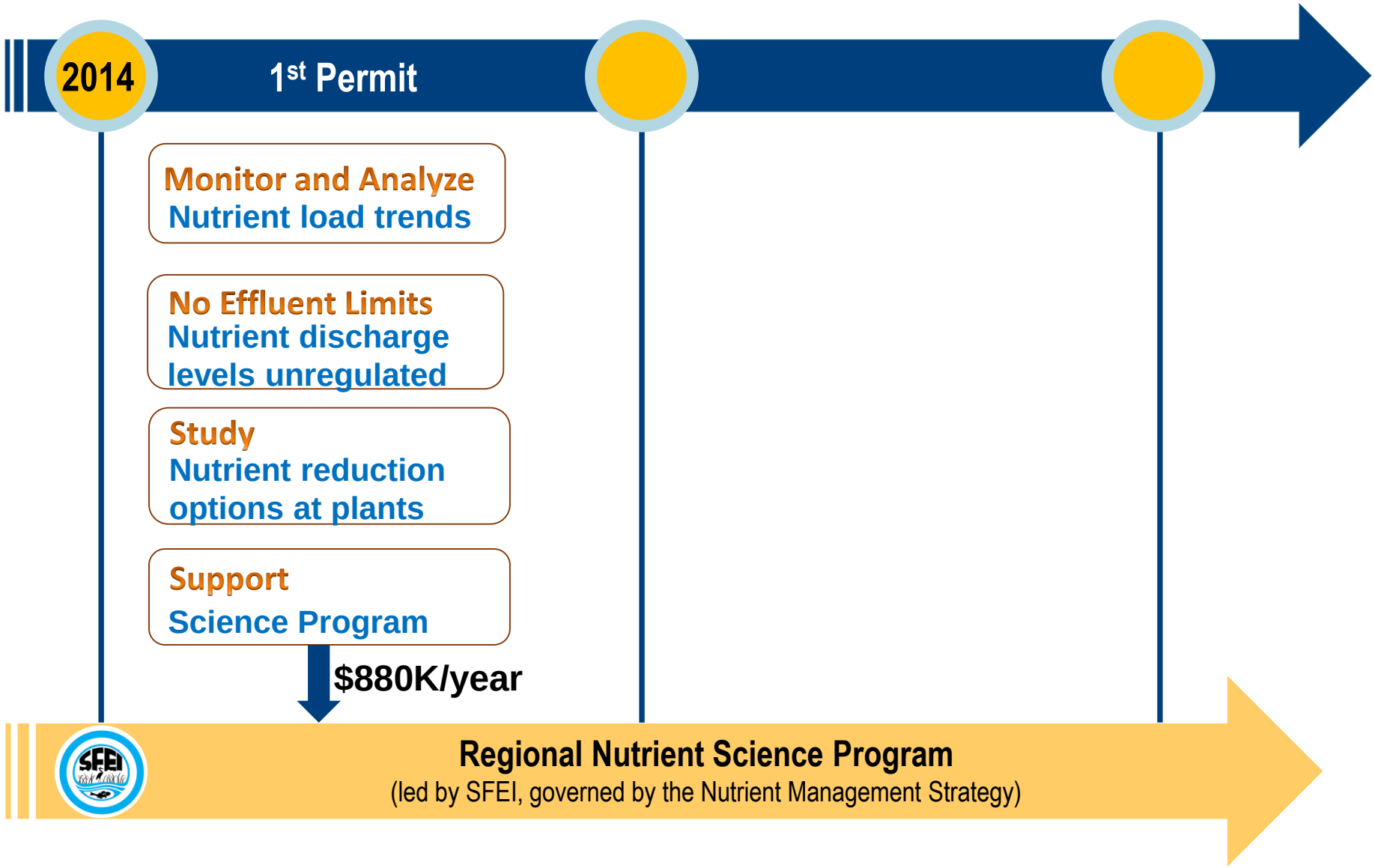
65% Wastewater

20% Delta/Ag

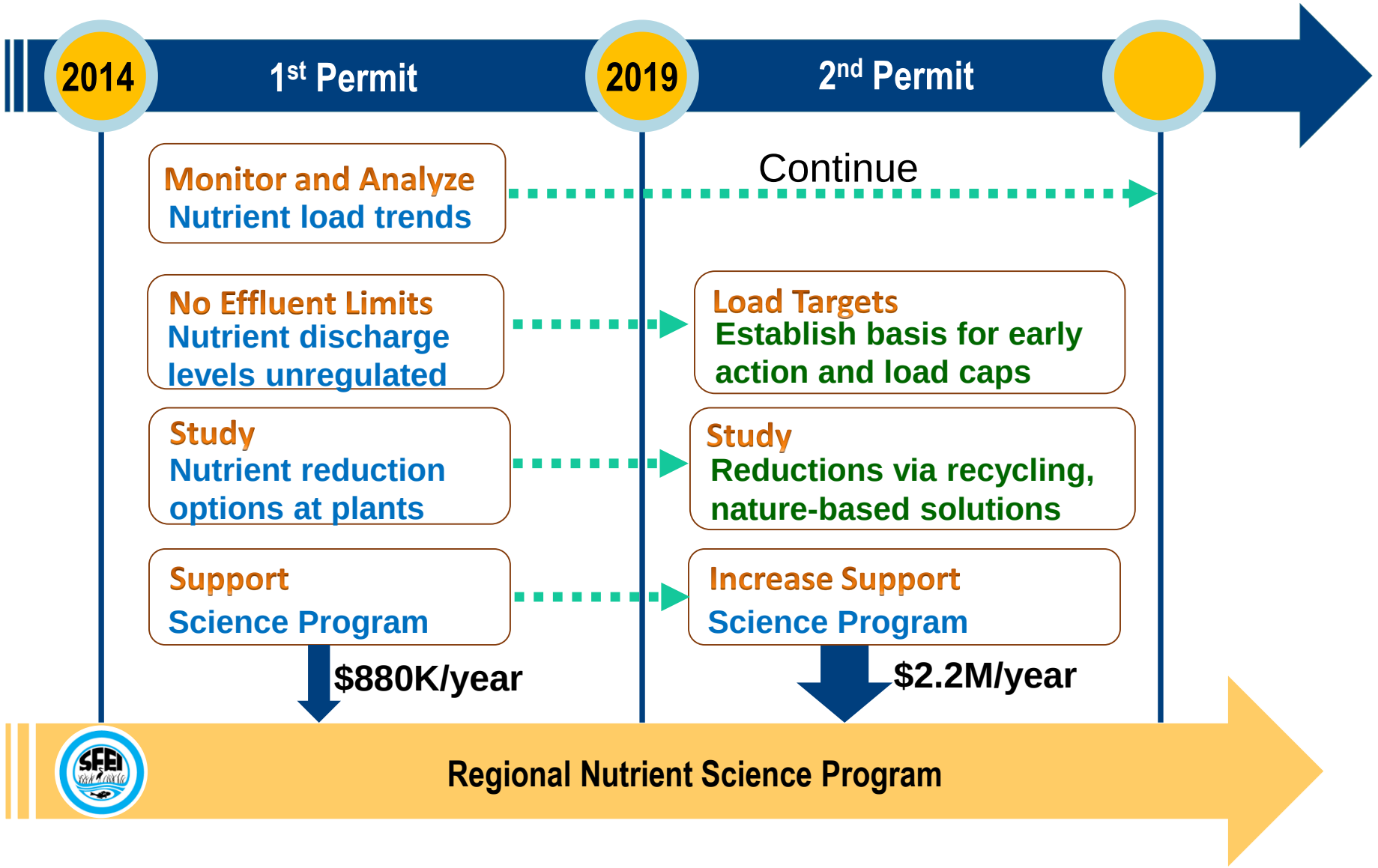
15% Urban runoff

San Francisco Bay Nutrient Watershed Permit

All municipal wastewater dischargers

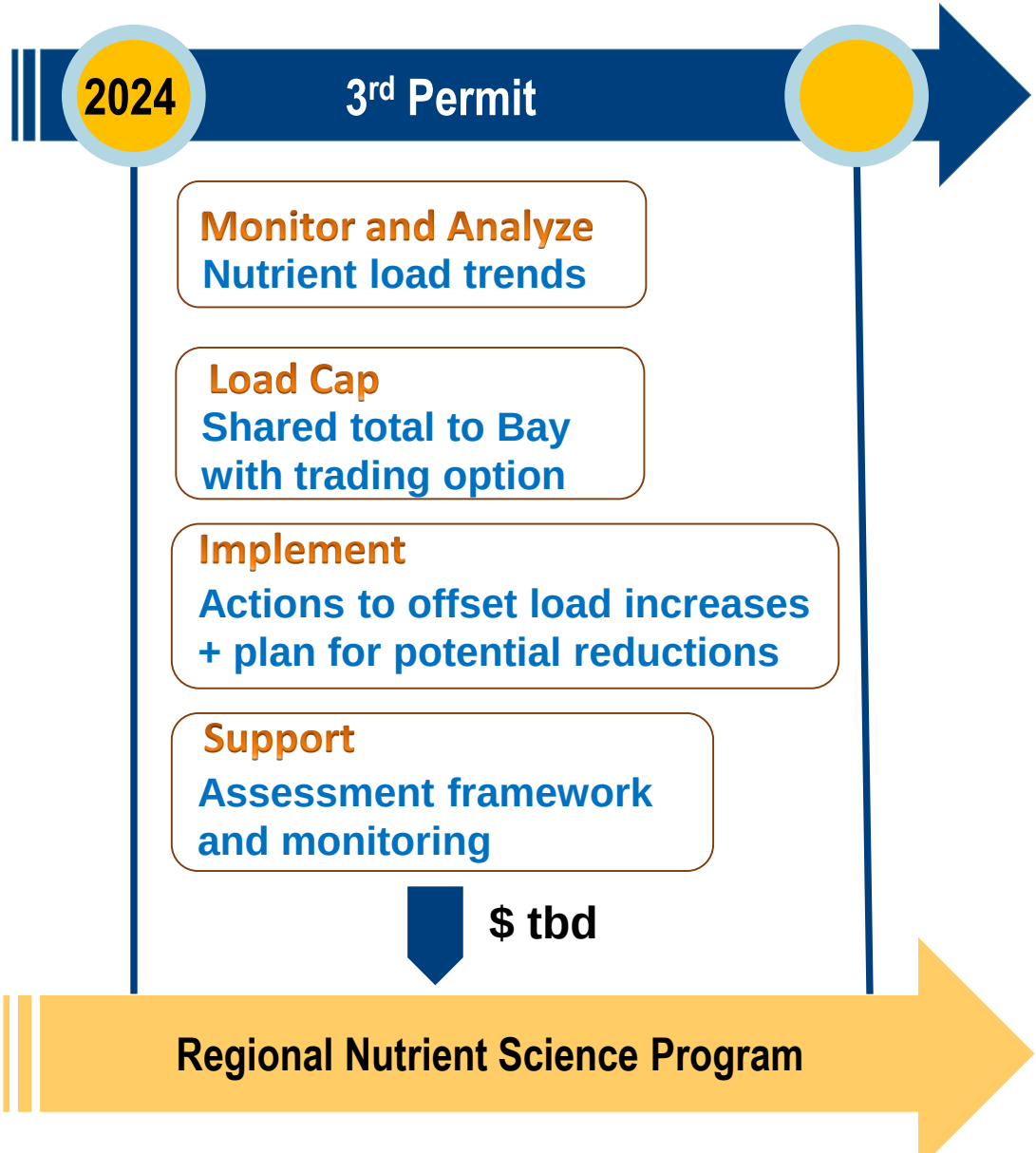


San Francisco Bay Nutrient Watershed Permit



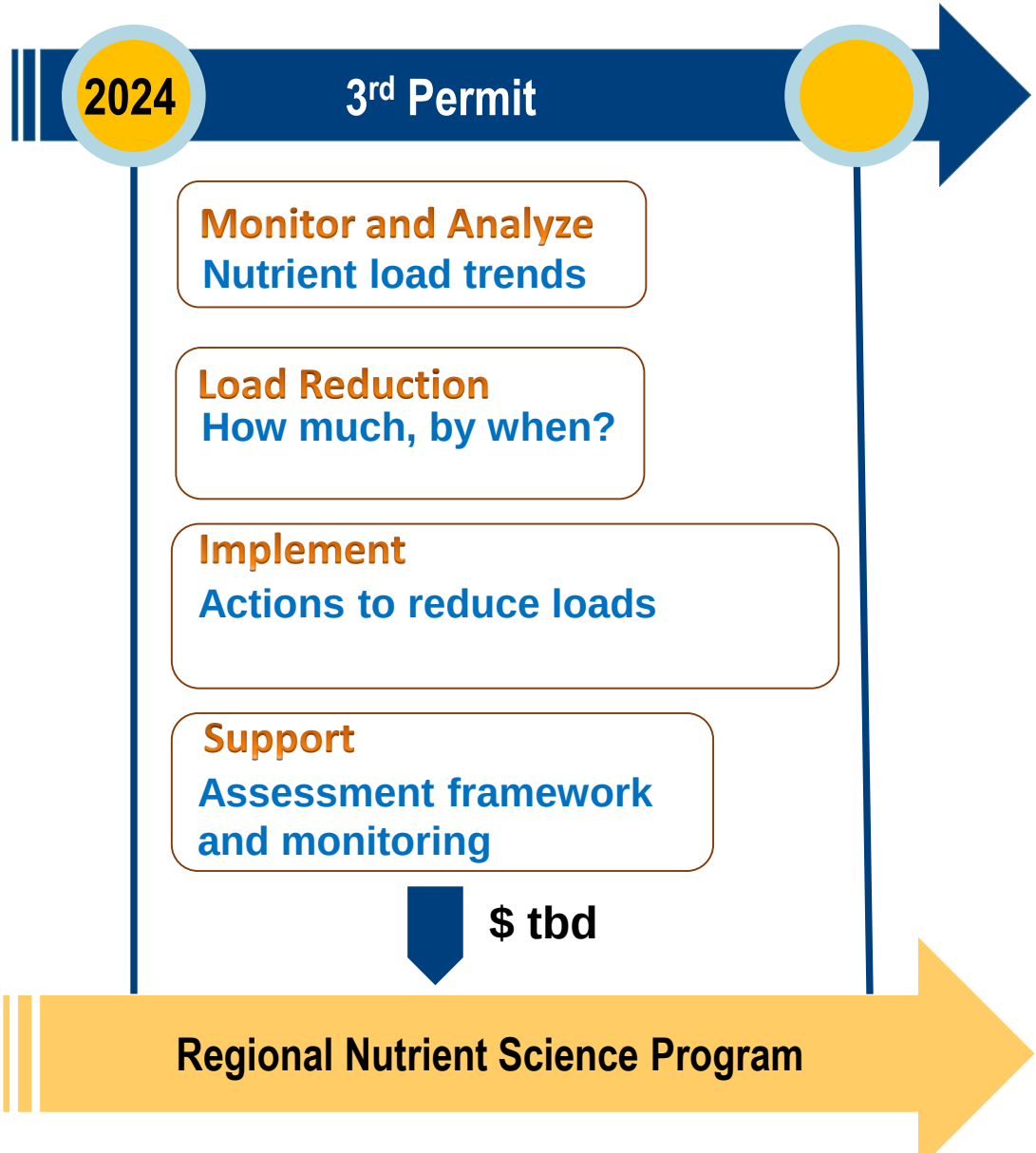
San Francisco Bay Nutrient Watershed Permit

Pre-bloom



San Francisco Bay Nutrient Watershed Permit

Post-bloom



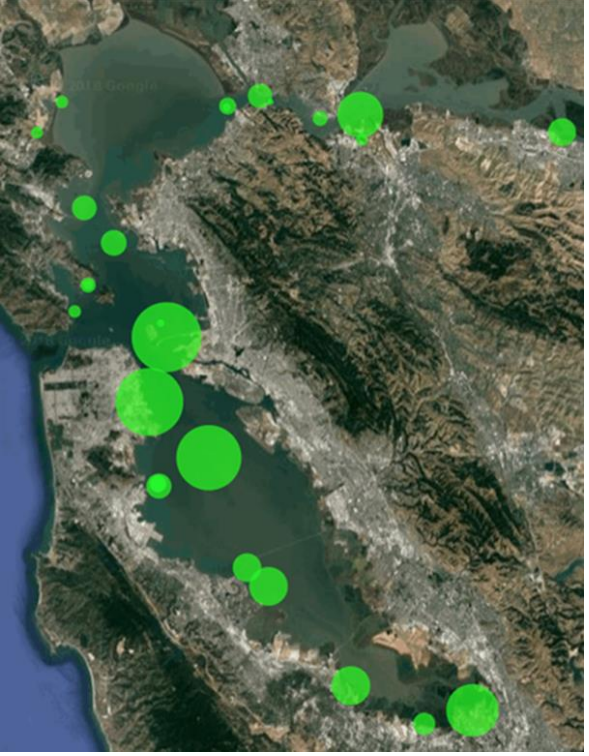
San Francisco is a Regional Leader

- SF Bay Water Board Pollution Prevention Award for PFAS reduction efforts
- Green stormwater infrastructure
- Large nutrient load to the Bay
- Add nutrient control to sewer system improvement program

August 2022 Harmful Algae Bloom

Overview of impacts and potential causes

David Senn
San Francisco Estuary Institute
October 17 2022
davids@sfei.org
sfbaynutrients.sfei.org



- Do nutrient loads to SFB result in adverse impacts to ecosystem health, either now or under future scenarios?
- What management actions are needed to prevent or mitigate current or future impairment?

San Francisco Bay

- Highly-enriched in N: primary source POTW effluent
- Relatively resistant to its nutrient-enriched status
- At risk of impacts should conditions change

SFEI 2014a,b; Cloern et al 2020

Historically:

- Resistant to classic eutrophication symptoms

'Recently':

- Evidence consistent with changing responsiveness or sensitivity to nutrients. *Cloern et al. 2007; SFEI, in prep*
- Potential adverse impacts along some under-explored pathways. *SFEI 2014, 2018; Sutula et al. 2017; Peacock et al., 2018*

Phytoplankton (or Algae)

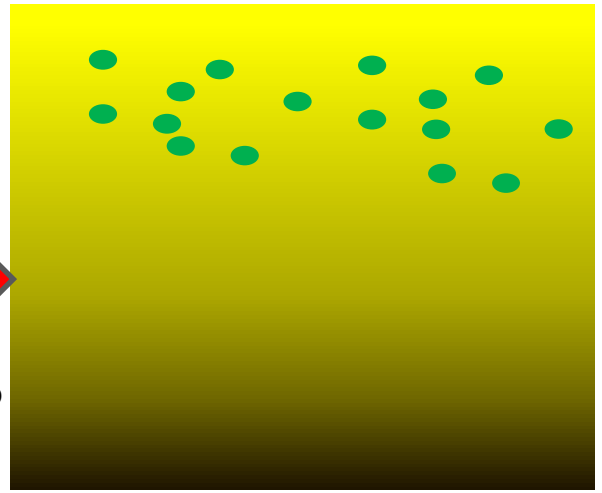
- Microscopic plants
- Base of food web, essential food resource
- Require
  - light
  - nutrients

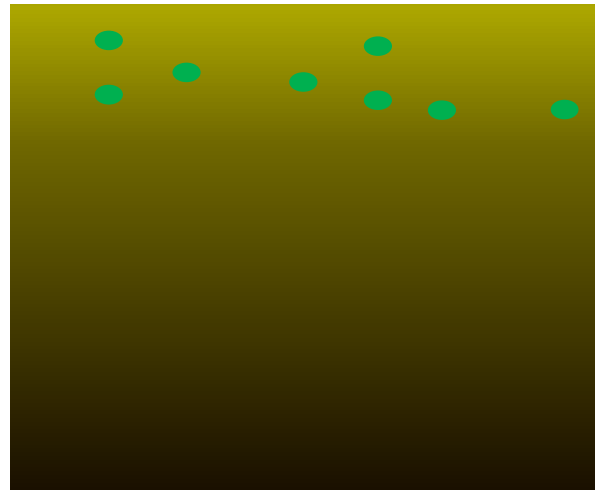
Nutrients: N and P

- Natural sources
  - N-fixing plants or phytoplankton
  - P-rich minerals
  - Runoff

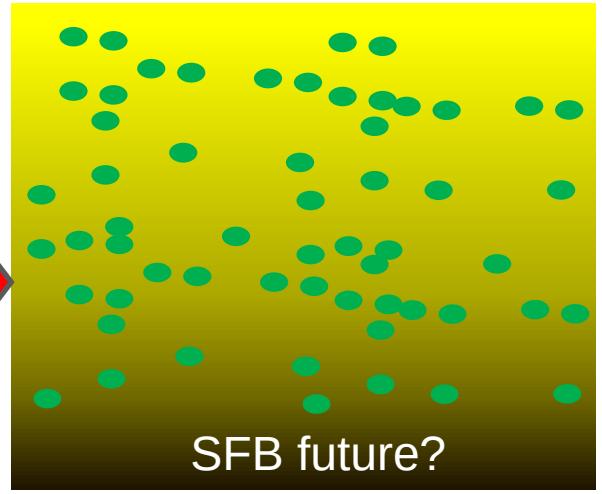
- Human sources
  - Agriculture (fertilizers)
  - WWTP discharges
  - Other human activitties

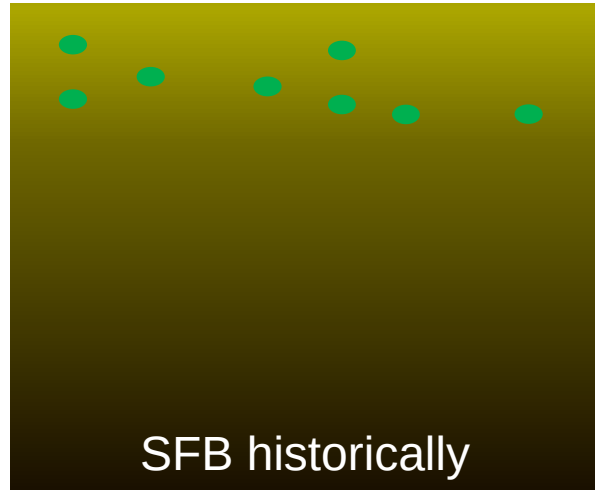
High suspended sediments = Low Light





Natural or low N and P





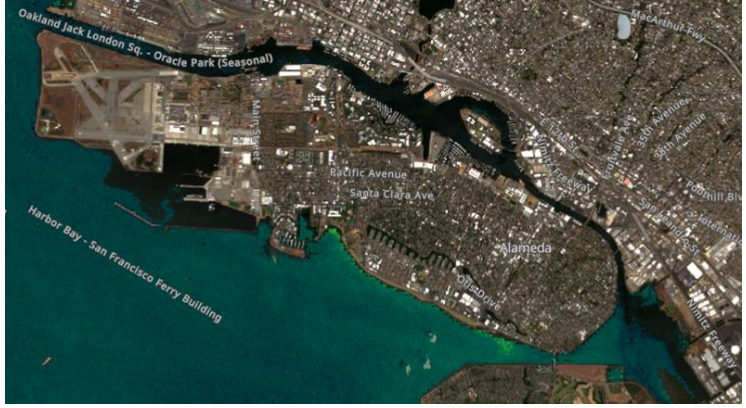
Enriched N and P inputs

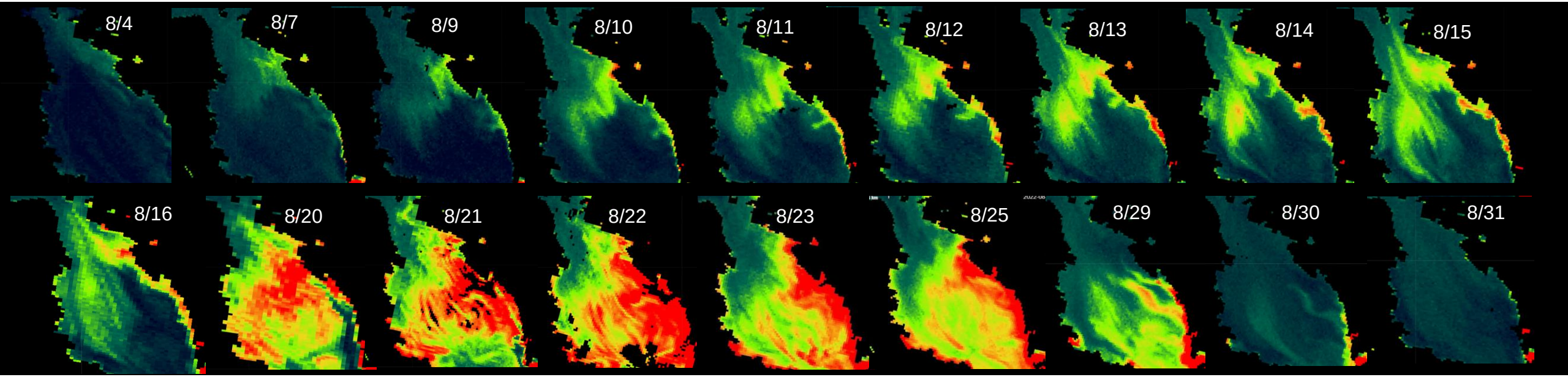
Excessive Blooms, Low O_2

Harmful Algal Blooms

- *late-Jul 2022*: first observed around Alameda/Oakland
- *Heterosigma akashiwo*
  - toxic to fish
  - on NMS harmful algae 'watch-list' (SFEI 2014, 2016)
- *early-Aug*: Spread to South Bay, off Alameda
  - expanded throughout South Bay by ~Aug 20
  - South Bay chl-a ≥ 100 μg L^{-1} (20x typical values)

Engesmoa et al 2019

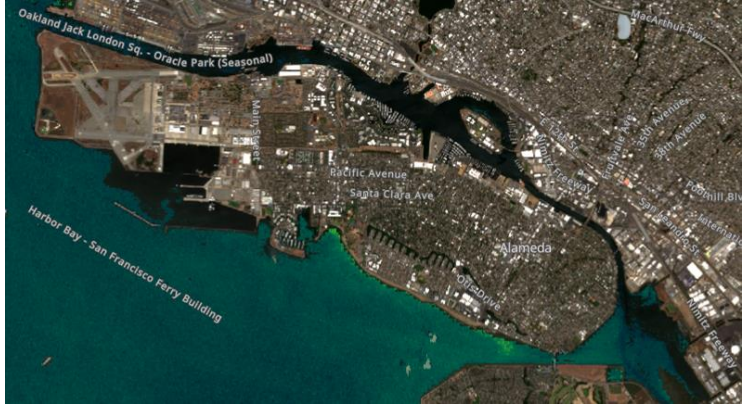


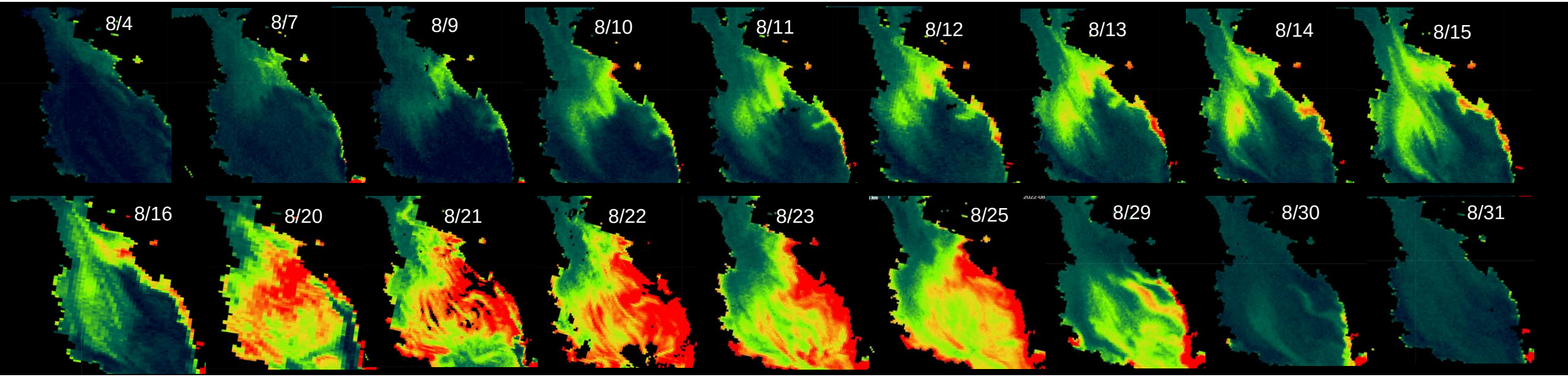


Sentinel-3; using UWQV, Zlinszky and Padanyi-Gulyas 2020

- What were the impacts to water quality and ecosystem health?
- What factors caused the event?
- What are the risks/likelihood it will happen, again, when?
- What are the ways to prevent/mitigate?

Engesmoa et al 2019

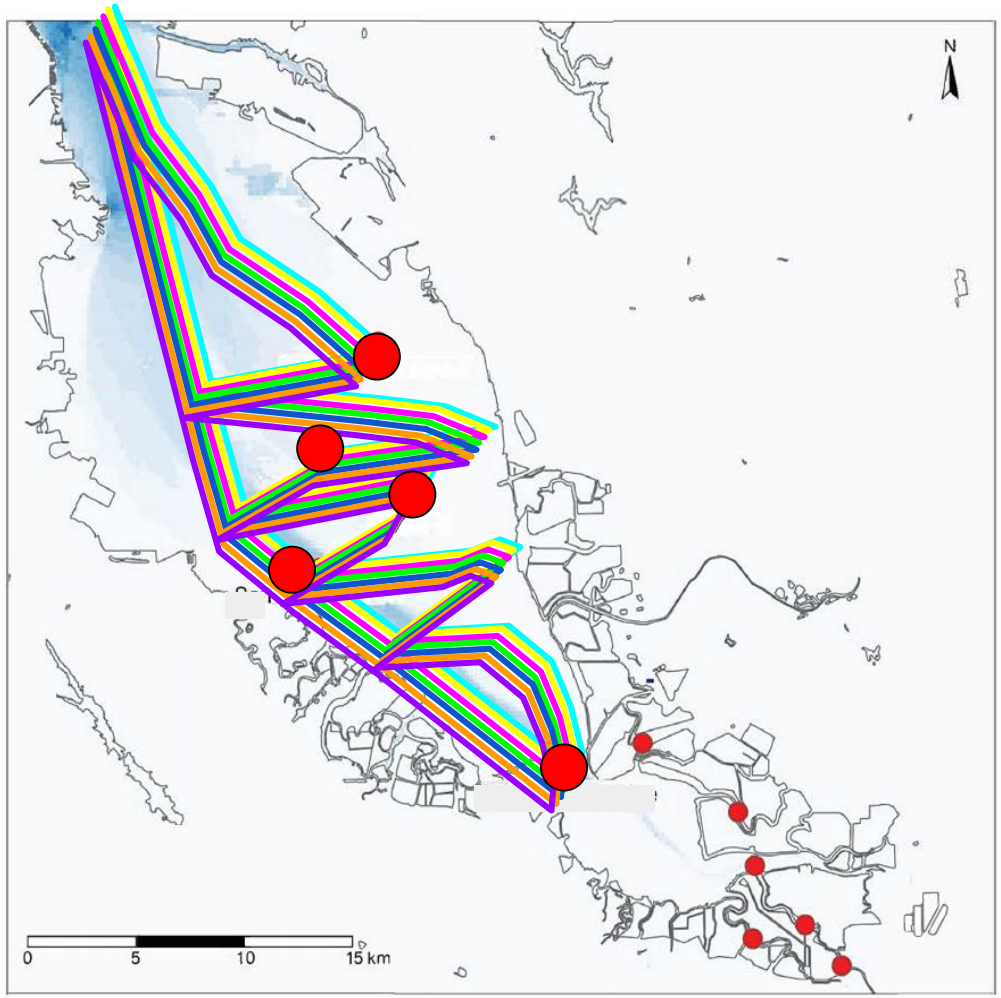




Sentinel-3; using UWQV, Zlinszky and Padanyi-Gulyas 2020

Fieldwork and Analysis Approaches

15 ship-days over 5 weeks



Remote Sensing

Water Quality moorings

- 5 locations in South Bay, measurements every 15min

Water quality 'mapping' (w/ USGS-BGC)

- high-speed, water quality 'snapshots'

8/10, 8/16, 8/17, 8/18, 8/25, 8/31, 9/7, 9/14

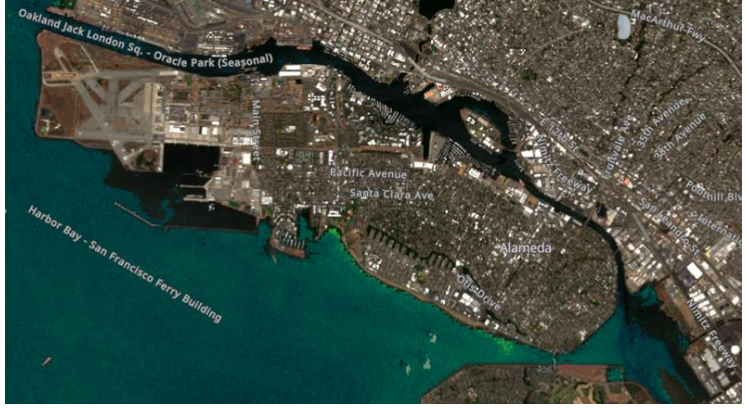
Long-term deep channel monitoring (USGS R/V Peterson)

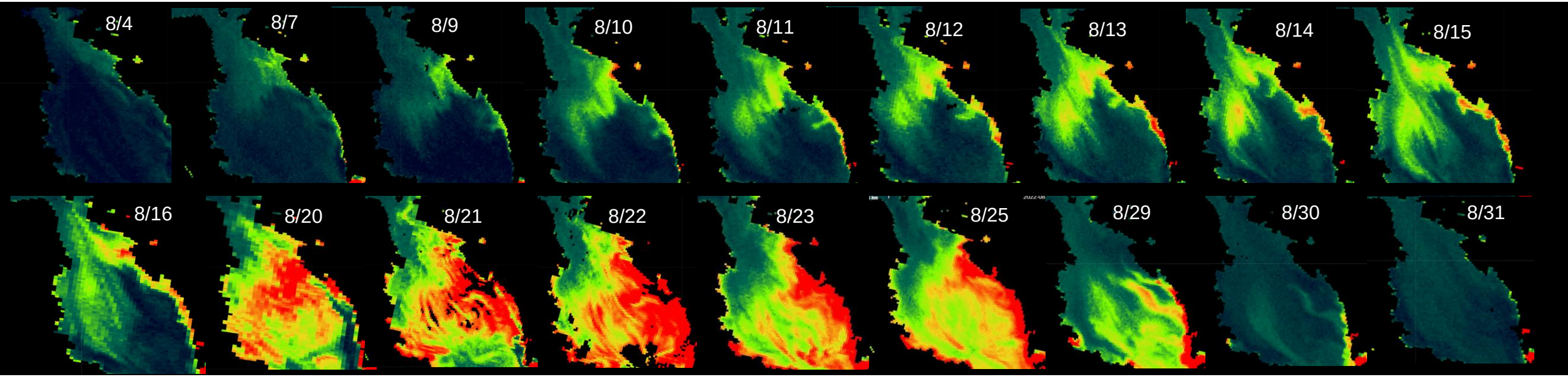
Numerical Modeling

Note: Provisional data, Please do not cite or distribute.

- Exceptional high phytoplankton biomass throughout South Bay
  - >20x typical summer values

Engesmoa et al 2019



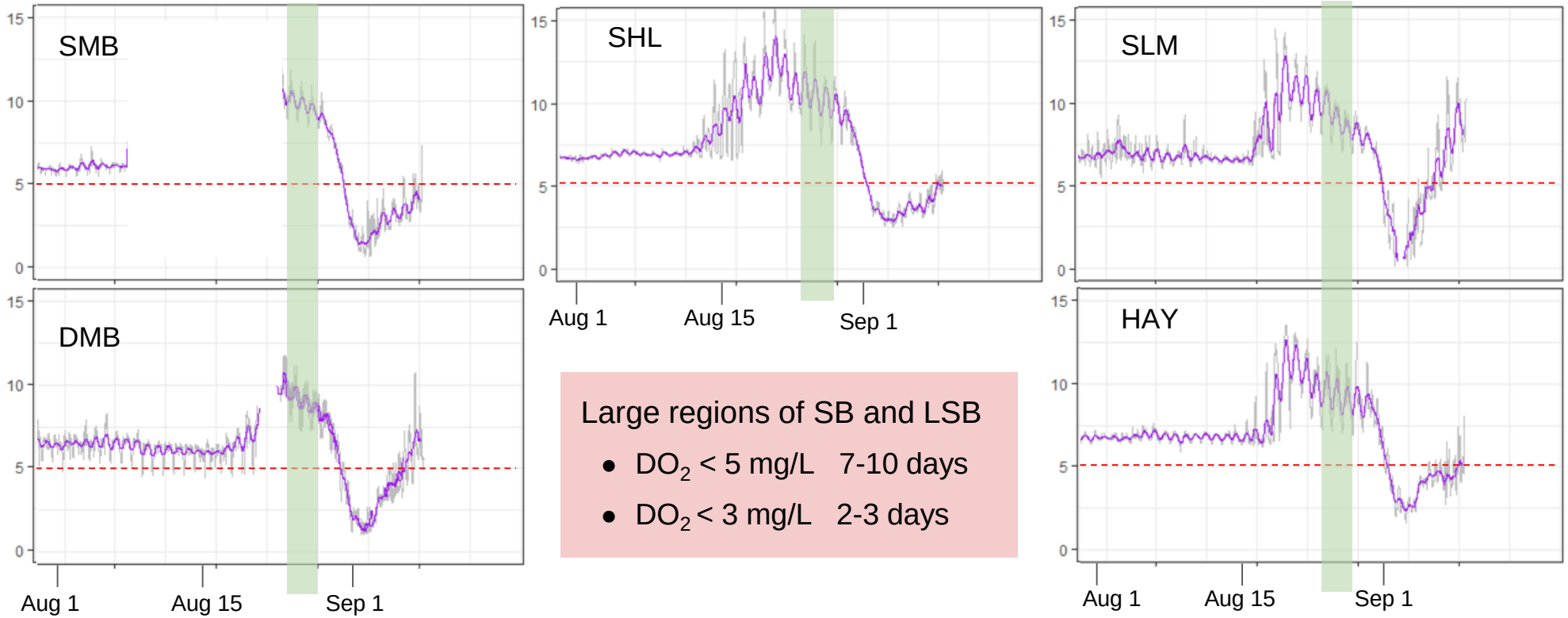


Sentinel-3; using UWQV, Zlinszky and Padanyi-Gulyas 2020

Fish Mortality

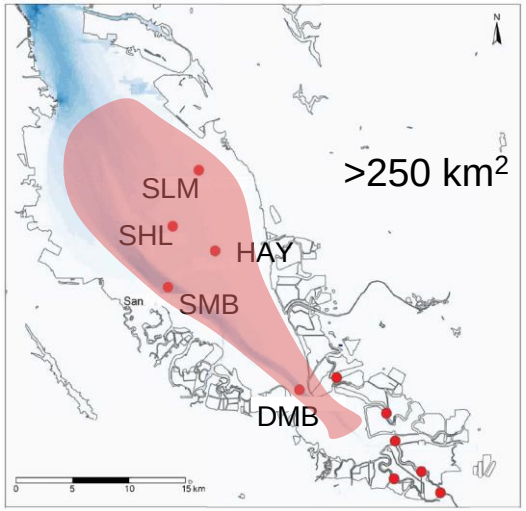
Aug 22	first scattered reports (Baykeeper)
Aug 23-Apr30	increasing reports

How did Dissolved O_2 respond ? (mg/L)



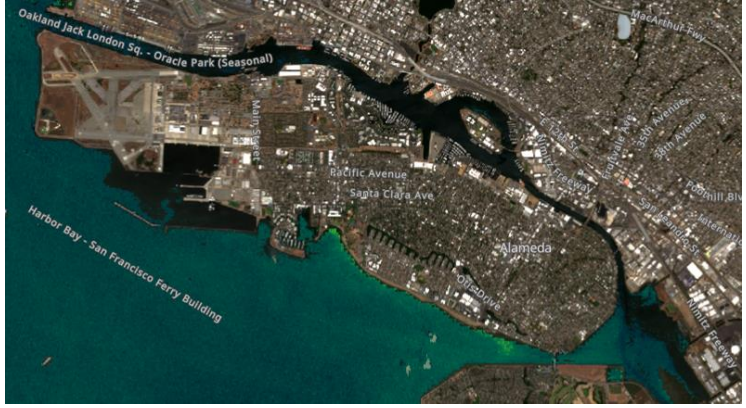
Large regions of SB and LSB

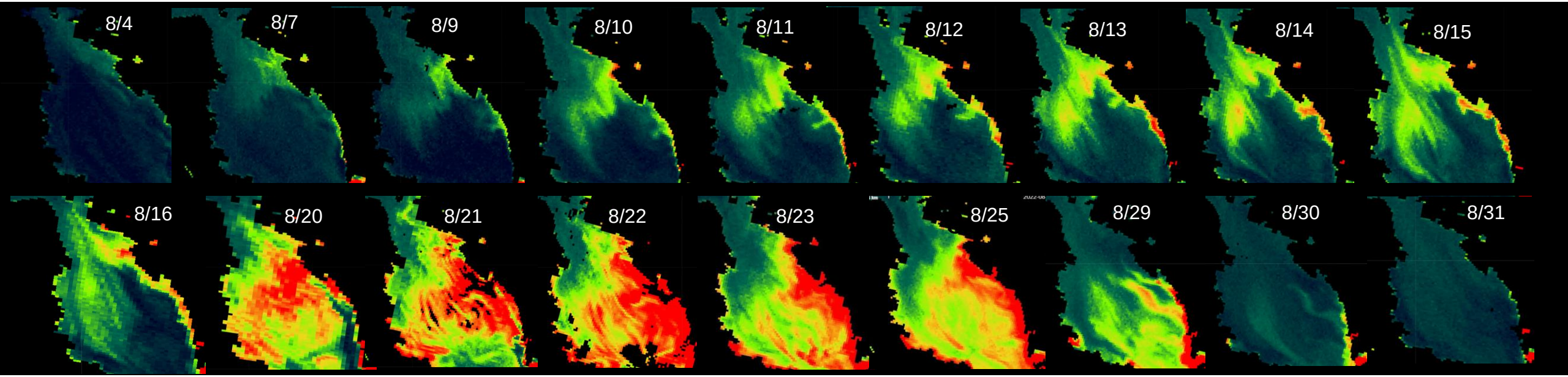
- DO_2 < 5 mg/L 7-10 days
- DO_2 < 3 mg/L 2-3 days



- What were the impacts to water quality and ecosystem health?
- What factors caused the event?
- What are the risks/likelihood it will happen, again, when?
- What are the ways to prevent/mitigate?

Engesmoa et al 2019



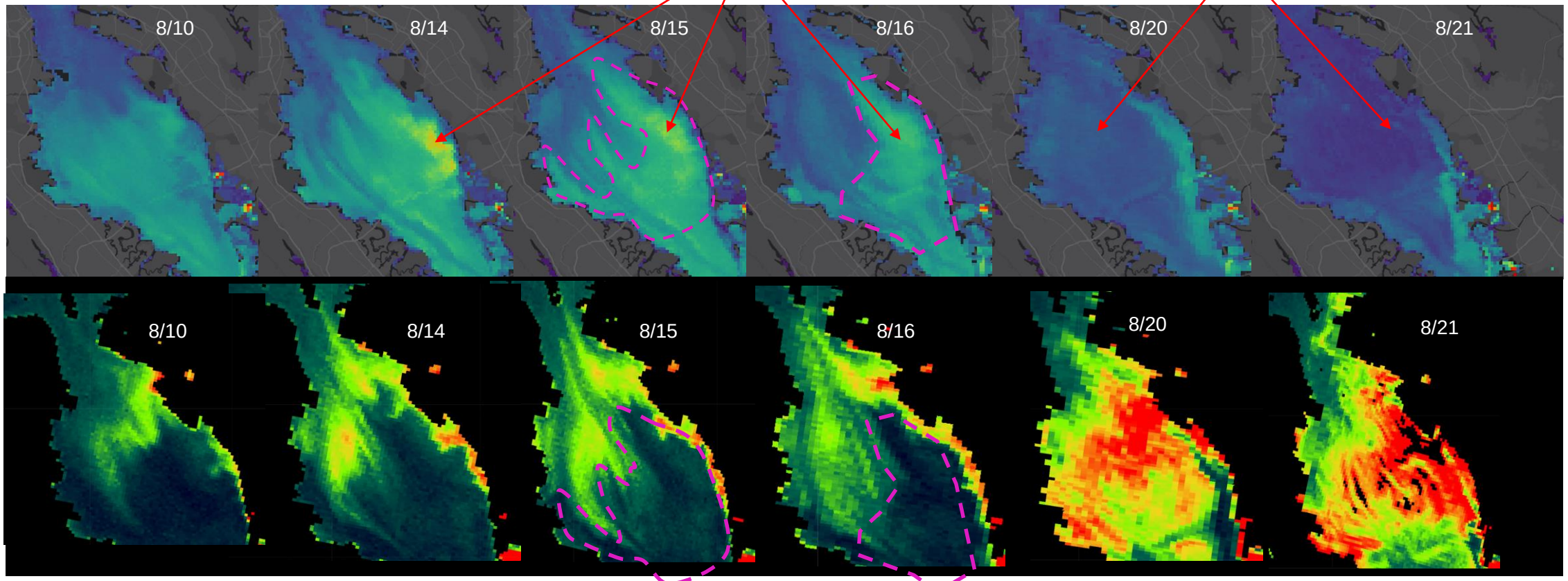


Sentinel-3; using UWQV, Zlinszky and Padanyi-Gulyas 2020

Remote-Sensed Turbidity

Photic depth: ~3-4 ft

~10-15 ft



8/9 – 8/16

2022: #3 out of 21 years,
total sunlight

8/19 – 8/26

2022: #2 out of 21 years,
total sunlight

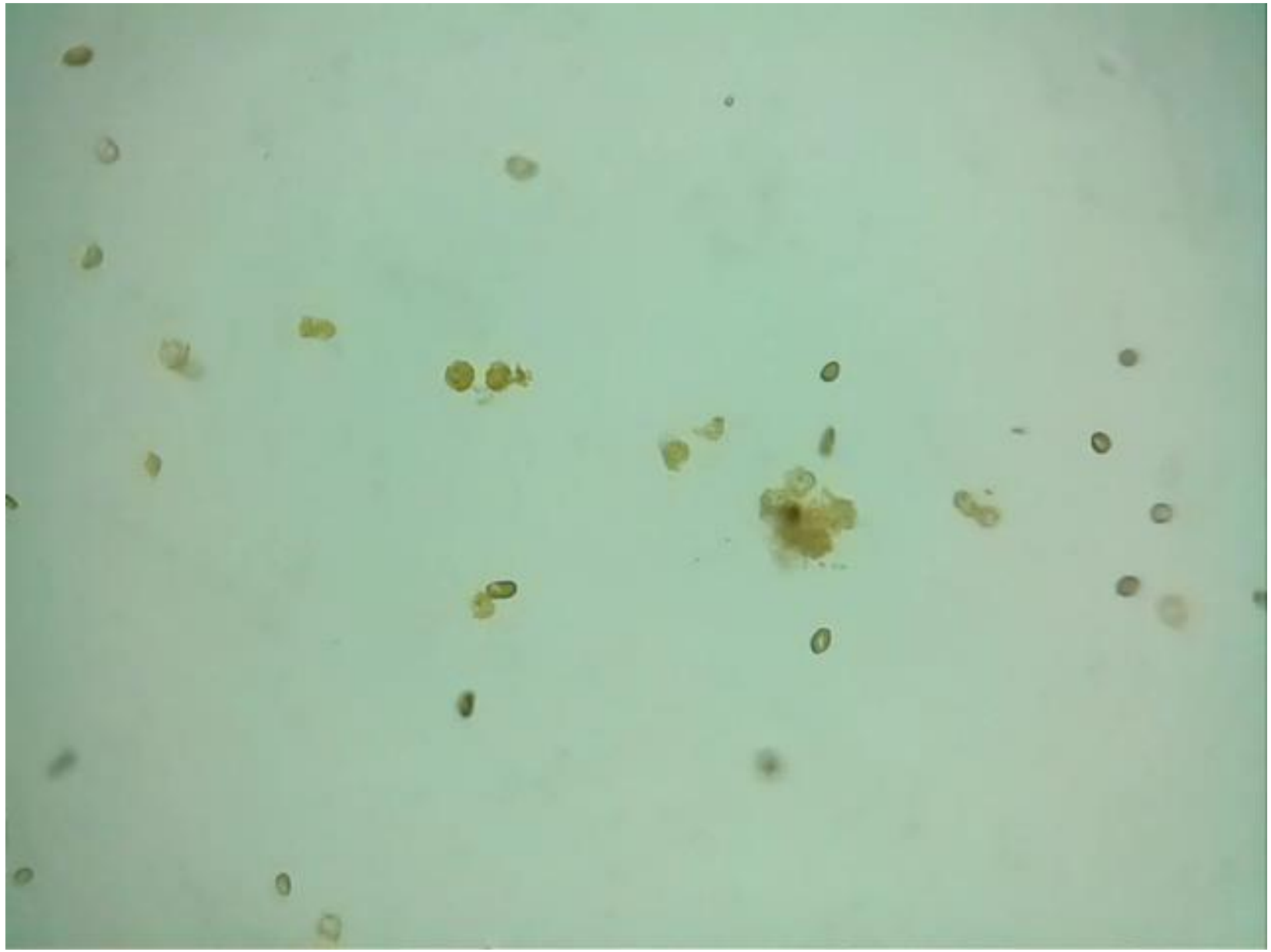
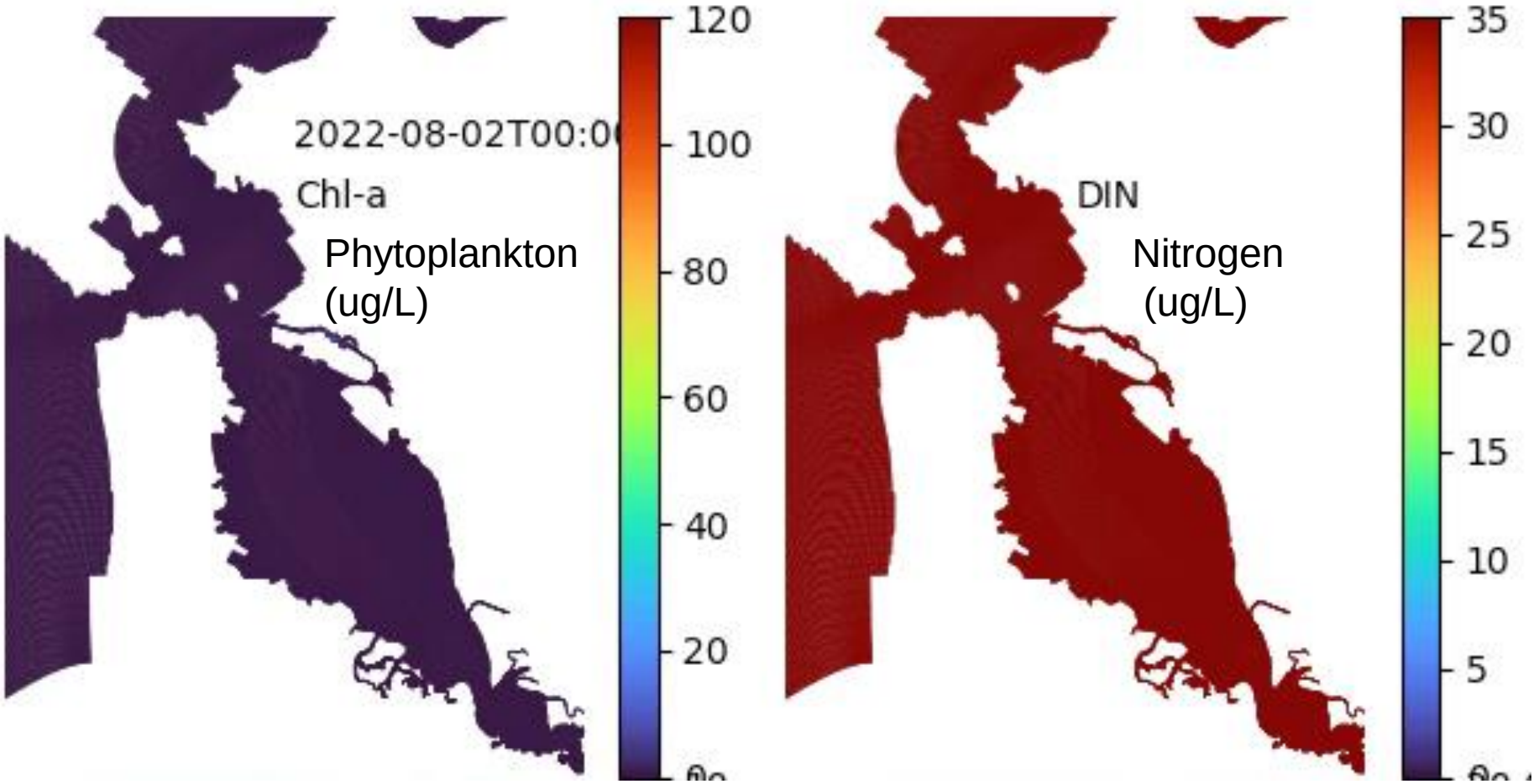


Image: K Bouma-Gregson (USGS)



Simplified phytoplankton and nutrient model (with transport)

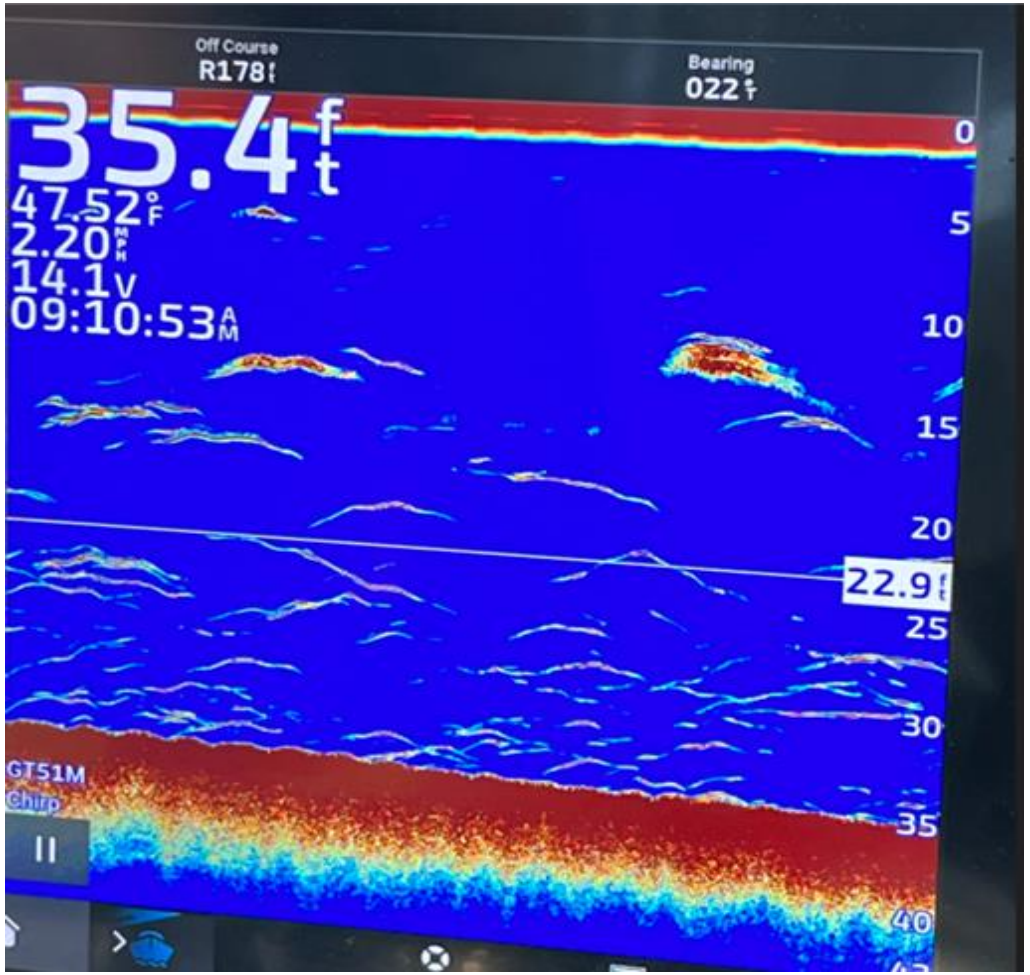
Bloom dies-off after consuming N

Summary

- Major HAB event in August 2022
  - Centered in South Bay (and Lower South Bay), with additional impacts in Central Bay and San Pablo Bays
  - Highest phytoplankton biomass levels on record
  - Low oxygen levels throughout South Bay (1.5-2 mg/L)
  - Fish mortality

- SFB's high nutrient loads resulted in more severe impacts (biomass, areal extent, duration).
  - *Something else sparked or triggered the event*
  - *But nutrient levels were the fuel*

- Potential factors contributing to the event's triggering (*much more work remains*)
  - Low suspended sediment concentrations
  - Many sunny-days, high multi-day cumulative solar insolation
  - (windows of calm winds?)



SF Bay Algal Bloom & SFPUC Nutrient Contributions

Ian Wren
Staff Scientist
ian@baykeeper.org

SAN FRANCISCO BAYKEEPER®

The New York Times

Toxic Red Tide Kills 'Uncountable' Numbers of Fish in the Bay Area

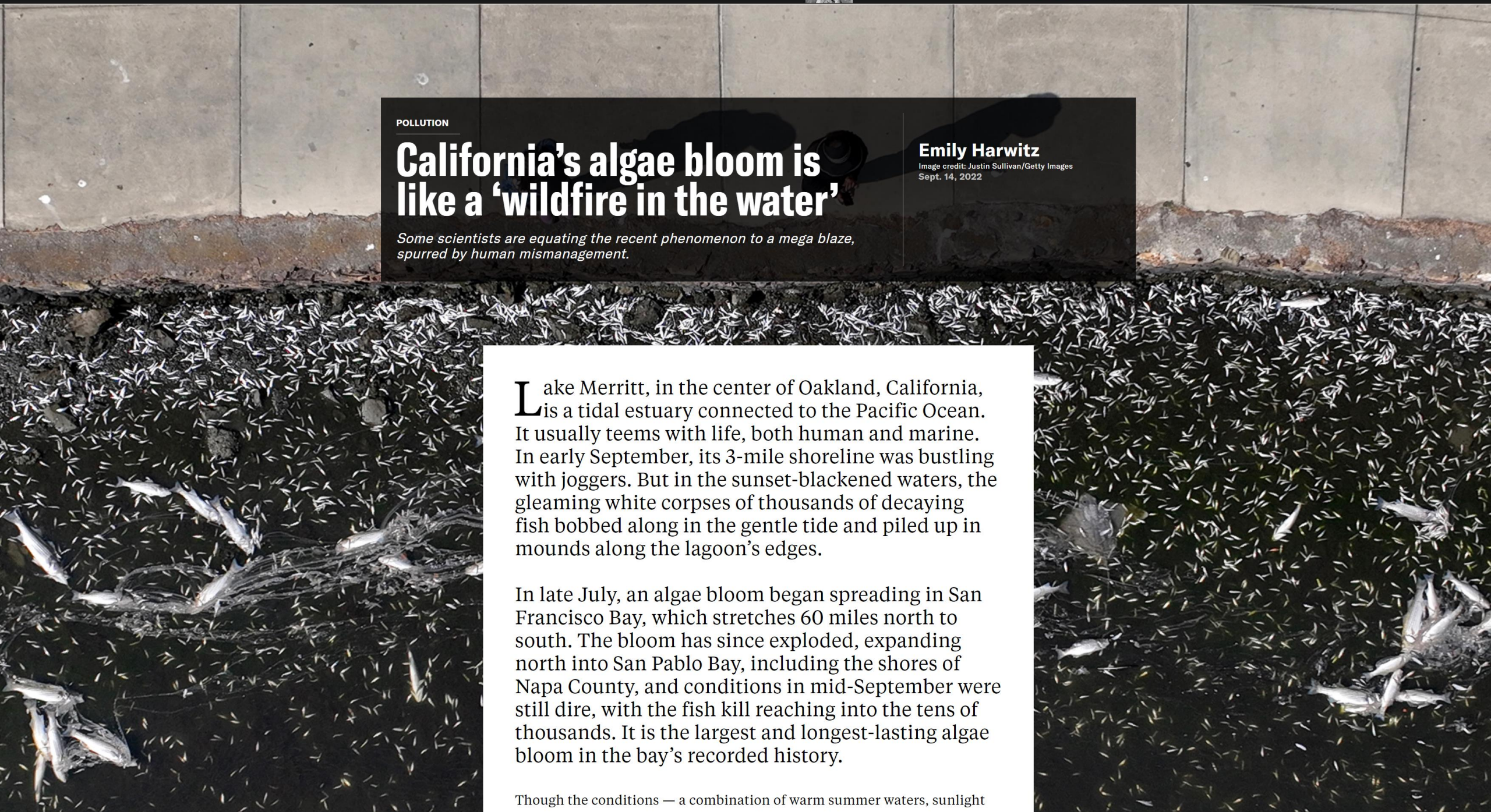
A harmful algal bloom in the San Francisco Bay is killing fish, sharks and stingrays. Some are washing ashore.

A harmful algal bloom in the San Francisco Bay Area has killed numerous fish, sharks and stingrays. Justin Sullivan/Getty Images

By Livia Albeck-Ripka

Aug. 30, 2022

A harmful algal bloom known as a red tide is killing off



POLLUTION

California's algae bloom is like a 'wildfire in the water'

Some scientists are equating the recent phenomenon to a mega blaze, spurred by human mismanagement.

Emily Harwitz

Image credit: Justin Sullivan/Getty Images

Sept. 14, 2022

Lake Merritt, in the center of Oakland, California, is a tidal estuary connected to the Pacific Ocean. It usually teems with life, both human and marine. In early September, its 3-mile shoreline was bustling with joggers. But in the sunset-blackened waters, the gleaming white corpses of thousands of decaying fish bobbed along in the gentle tide and piled up in mounds along the lagoon's edges.

In late July, an algae bloom began spreading in San Francisco Bay, which stretches 60 miles north to south. The bloom has since exploded, expanding north into San Pablo Bay, including the shores of Napa County, and conditions in mid-September were still dire, with the fish kill reaching into the tens of thousands. It is the largest and longest-lasting algae bloom in the bay's recorded history.

Though the conditions — a combination of warm summer waters, sunlight

Harmful Algal Bloom in San Francisco Bay Results in Aquatic Mortality, Fish Kills

Waters in San Francisco Bay have turned reddish-brown this summer due to a multi-week harmful algal bloom (HAB) identified as *Heterosigma akashiwo*, an invasive species of marine algae responsible for some of the 'red tides' that are toxic to fish and aquatic life.

HABs, which result from the overgrowth of algae, or phytoplankton such as *Pseudo-nitzschia*, can produce cyanotoxins that can affect human and aquatic ecosystem health, cause acute and chronic illnesses, and in some cases mortality in pets who come in contact with harmful algae. These blooms also result in low dissolved oxygen that suffocate fish and can cause widespread fish mortality, known as 'fish kills.'

HABs are becoming more frequent and more intense across California as waters warm. Decreased flows from inland rivers and streams, and increased concentrations of nutrients and other land-based pollutants additionally exacerbate the growth of algae and cyanotoxins.

Evidence of the San Francisco bloom first appeared near Alameda, CA in late July 2022. The bloom later spread to open-bay regions of South San Francisco Bay and continued to expand into San Pablo Bay, making this bloom the largest in recorded history.

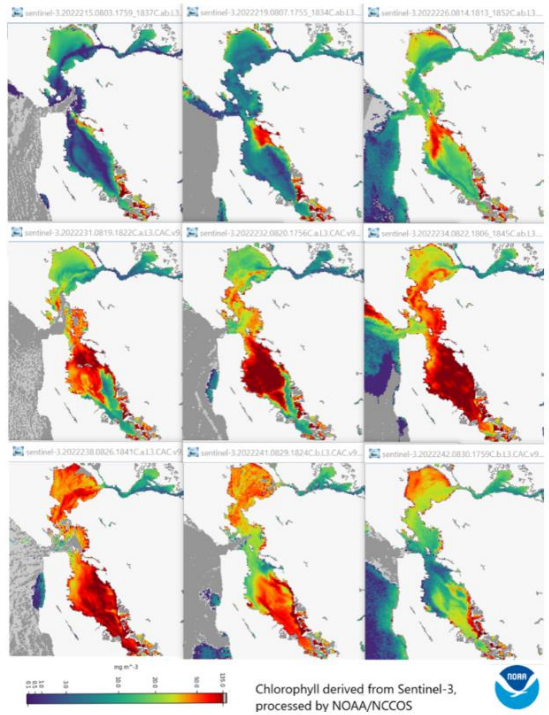
The massive bloom appears to be in decline as of Labor Day weekend, although the State Water Resources Control Board, San Francisco Regional Water Quality Control Board, and California Department of Fish and Wildlife (CDFW) have warned that depleted oxygen levels could continue to lead to large-scale aquatic deaths as algae decays and winds stagnate.

The bloom has already resulted in the death of thousands of fish, including both white and green sturgeon, leopard sharks, striped bass, bat rays, and anchovy. At Lake Merritt, which is connected to San Francisco Bay, reports suggest as many as 10,000 fish died in late August. Both boat and shore-based surveys will continue to take place at various locations around San Pablo and Suisun bays to determine the geographic extent of the fish kill, any expansion into new areas, the species affected, and the numbers of dead fish including white and green sturgeon.

The full ecological impact of the San Francisco Bay HAB is not yet known; although, it is locally reported as "a wildfire in the water."

While this type of HAB is not considered a human health threat, it is advised that people and pets avoid contact with the water until further notice.

Monitoring to identify algal species and density, toxins, dissolved oxygen, and fish mortality associated with the San Francisco Bay HAB is conducted in partnership between the Water Boards, the San Francisco Estuary Institute (SFEI) and teams of researchers and citizen monitoring, including the U.S. Geological Survey and San Francisco Baykeeper. California further maintains a statewide Harmful Algal Bloom Monitoring and Alert Program (HABMAP), which collects weekly phytoplankton and water quality data at ten locations along the California coast from San Diego to Santa Cruz.



Chlorophyll presence associated with algae production in San Francisco Bay, August 2022. Image: National Oceanic and Atmospheric Administration (NOAA).

CLIMATE

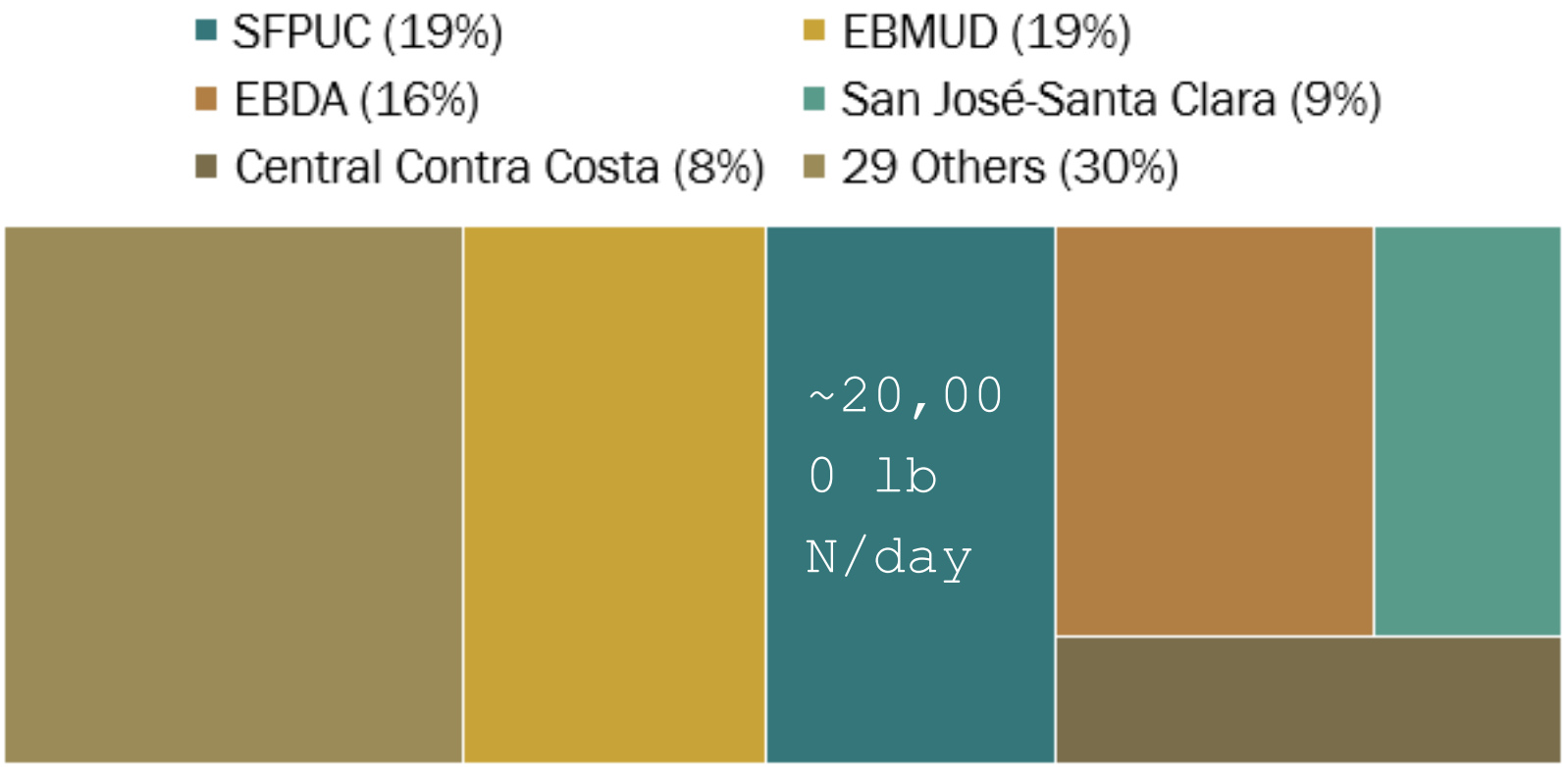
Poop and pee fueled the huge algae bloom in San Francisco Bay. Fixing the problem could cost $14 billion

Noah Berger/Special to The Chronicle

TARA DUGGAN Sep. 5, 2022 | Updated: Sep. 5, 2022 4:10 p.m.

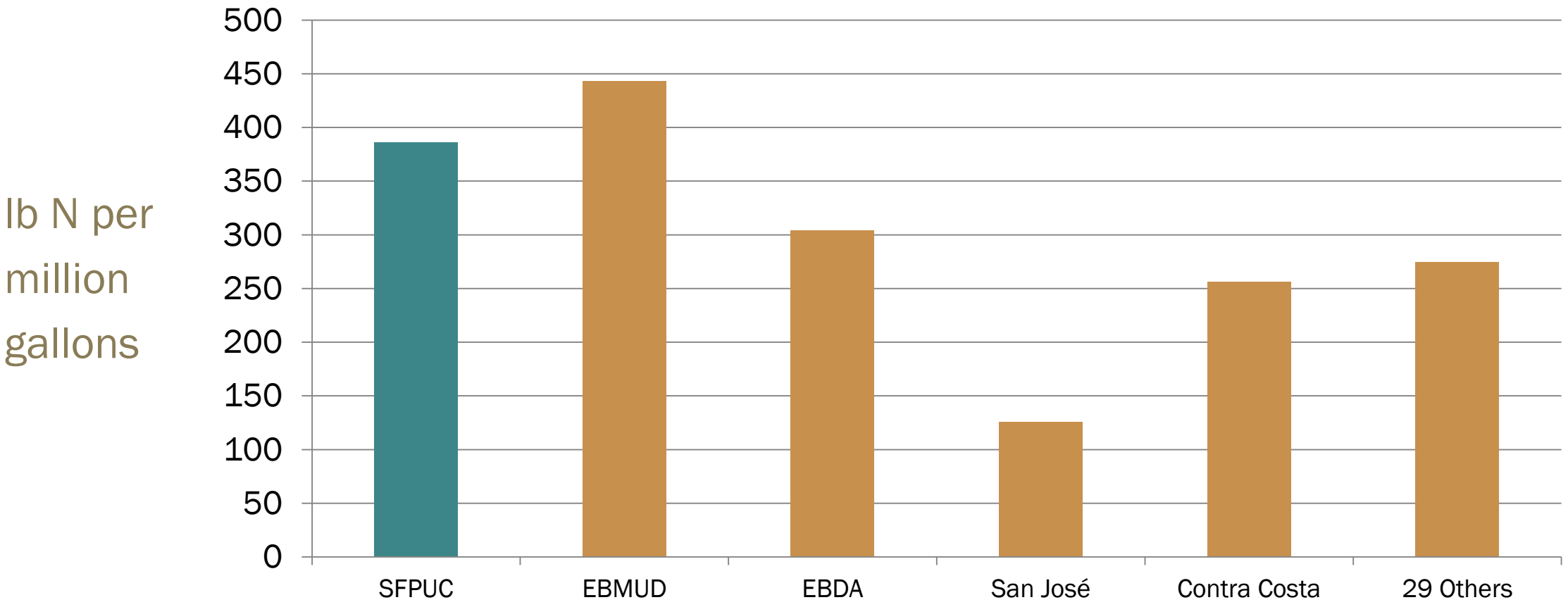
After an unprecedented harmful algae bloom first turned San Francisco Bay a murky brown color and then littered its shores with dead fish, many

SFPUC Discharges High Amount of Bloom-Fueling Nutrients



Source: Dry season average 2013-2021: BACWA Nutrient Annual Report 2021

SFPUC Plays an Outsized Role in Nutrient Loading



Source: : Dry season average TIN Load vs Flow: 2013-2021: BACWA Nutrient Annual Report 2021

600 workers will build $2B mega-project in Sacramento

Regional sewage treatment plant to undergo massive upgrade

KCRA 3 Updated: 7:57 PM PST Feb 2, 2015

David Bienick
Reporter

An artist rendering shows the planned biological nutrient removal facility planned for the Sacramento regional sewage treatment plant in Elk Grove. SOURCE: Courtesy: Sanitation District

ELK GROVE, Calif. (KCRA) — It may be the biggest construction project you have never heard of.

A massive project to upgrade the Sacramento region's sewage treatment plant is about to begin -- and it will employ up to 600 construction workers at its peak, officials said.

WATER

San Francisco Is Fighting California's Plan to Save Salmon. Wait. What?

By Lauren Sommer Aug 20, 2018 Save Article

This article is more than 4 years old.

More than 2.5 million Bay Area residents get their water from Hetch Hetchy Reservoir. *(Lauren Sommer/KQED)*

POLITICS

How SF's Recycled Water Program Stumbled Into Performative Environmentalism

Written by **Josh Koehn**
Art by **Lu Chen**
Updated at Sep. 21, 2022 • 9:50am
Published Sep. 20, 2022 • 12:43pm

sf bay algal bloom

Multi-benefit Options For Nutrient Management

Build an agency that reflects our city's principles

Plan now for a One Water future

Embrace innovation

- **Wastewater Recycling & Concentrate Management**
- **Nutrient Recovery**
- **Nature-based Solutions & Irrigation Diversions**

Multi-benefit Options For Nutrient Management

type	examples	Constraints
Wastewater Recycling	• Purple Pipe for Urban Use & Irrigation • Land Application • Long-distance exports	• Still need to remove nutrients from concentrated effluent • New piping network • Requires partnerships

sf bay algal bloom

Multi-benefit Options For Nutrient Management

type	examples	Constraints
Nutrient Recovery	• Fertilizer production	• Part of a wider strategy • Faces skepticism • Requires partnerships

Multi-benefit Options For Nutrient Management

type	examples	Constraints
Nature-based Solutions	• Treatment Wetlands • Land Application • Habitat Restoration	• Land/space limitations • New piping network • Requires partnerships

Wastewater nutrient discharges to San Francisco Bay

San Francisco Board of Supervisors meeting
October 17, 2022

Lorien Fono, BACWA Executive Director

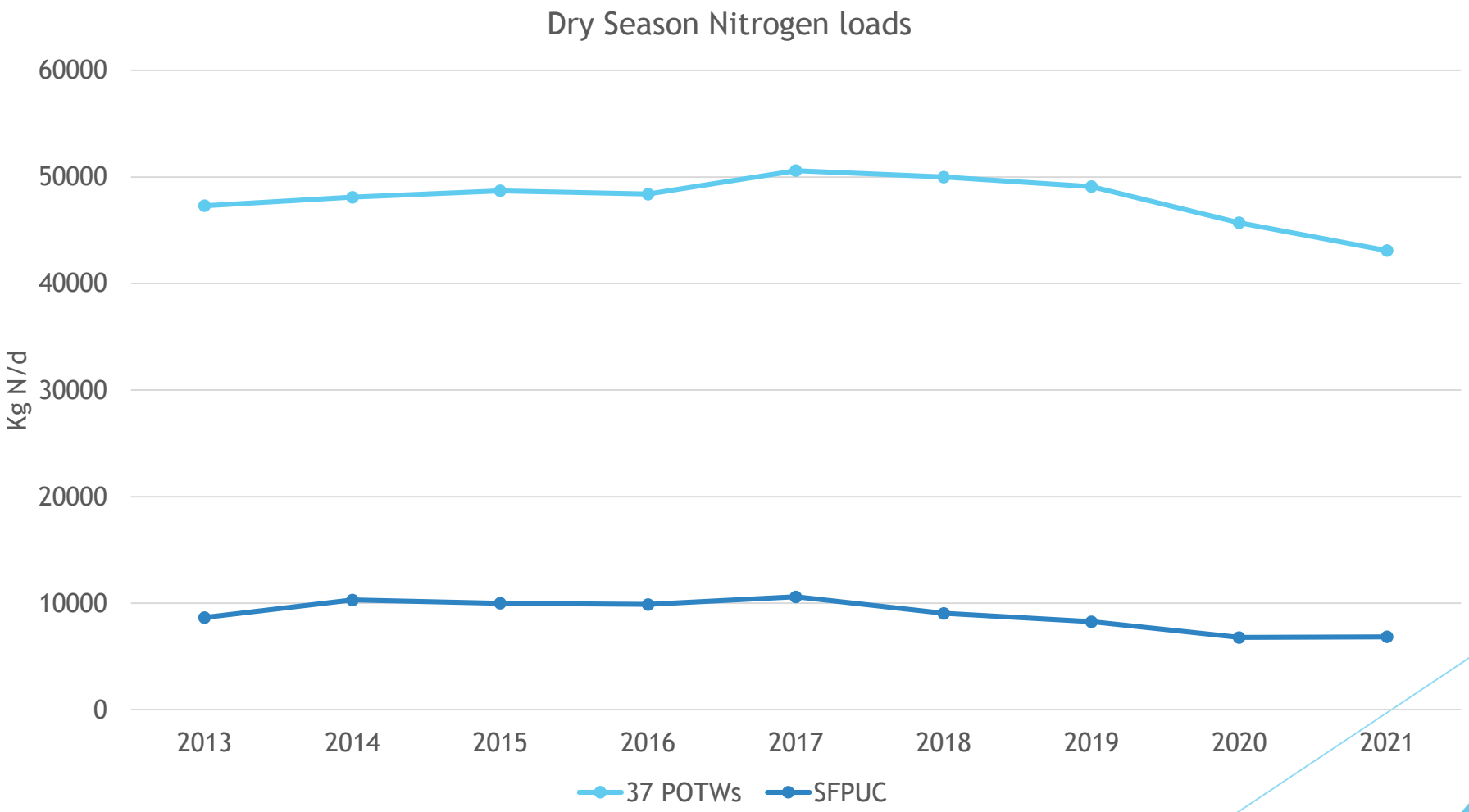
BACWA
BAY AREA
CLEAN WATER
AGENCIES

POTWs: Largest Source of Nutrient Loads

BACWA
BAY AREA
CLEAN WATER
AGENCIES

BACWA is a joint powers authority formed by the five largest Bay Area Publicly Owned Treatment Works (POTWs)

SFPUC discharges 15-20% of total wastewater nitrogen load



Bringing the science under one tent

- BACWA and the Regional Water Board envisioned stakeholder driven governance of the science program, recognizing that the Regional Water Board retained ultimate authority on regulatory issues.
- Retained facilitator to develop a Charter on a stakeholder driven process for overseeing the scientific investigation, with key tenet the creation of a Steering Committee
- The Nutrient Management Strategy kicked off in 2012
- Since 2013, BACWA has contributed >$14M to study nutrients in the SF Bay

Working Together for Practical Regulation

BACWA
BAY AREA
CLEAN WATER
AGENCIES

BACWA
(wastewater utilities)

California
Water Boards

Regional Water Board
(regulatory)

SFEI | AQUATIC SCIENCE CENTER
SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER

San Francisco Estuarine Institute
(science)

SAN FRANCISCO
BAYKEEPER®

Non-Govt Organizations
(NGOs)

The approach in the Bay Area for managing nutrients has received national attention and lauded for its collaboration, as evidenced by receipt of a National Environmental Achievement Award in 2019 from the National Association of Clean Water Agencies (NACWA). NACWA is the nationally recognized leader in legislative, regulatory, and legal clean water advocacy.

NATIONAL Environmental Achievement AWARDS

2014 & 2019 Nutrient Watershed Permits

NO LOAD CAPS YET

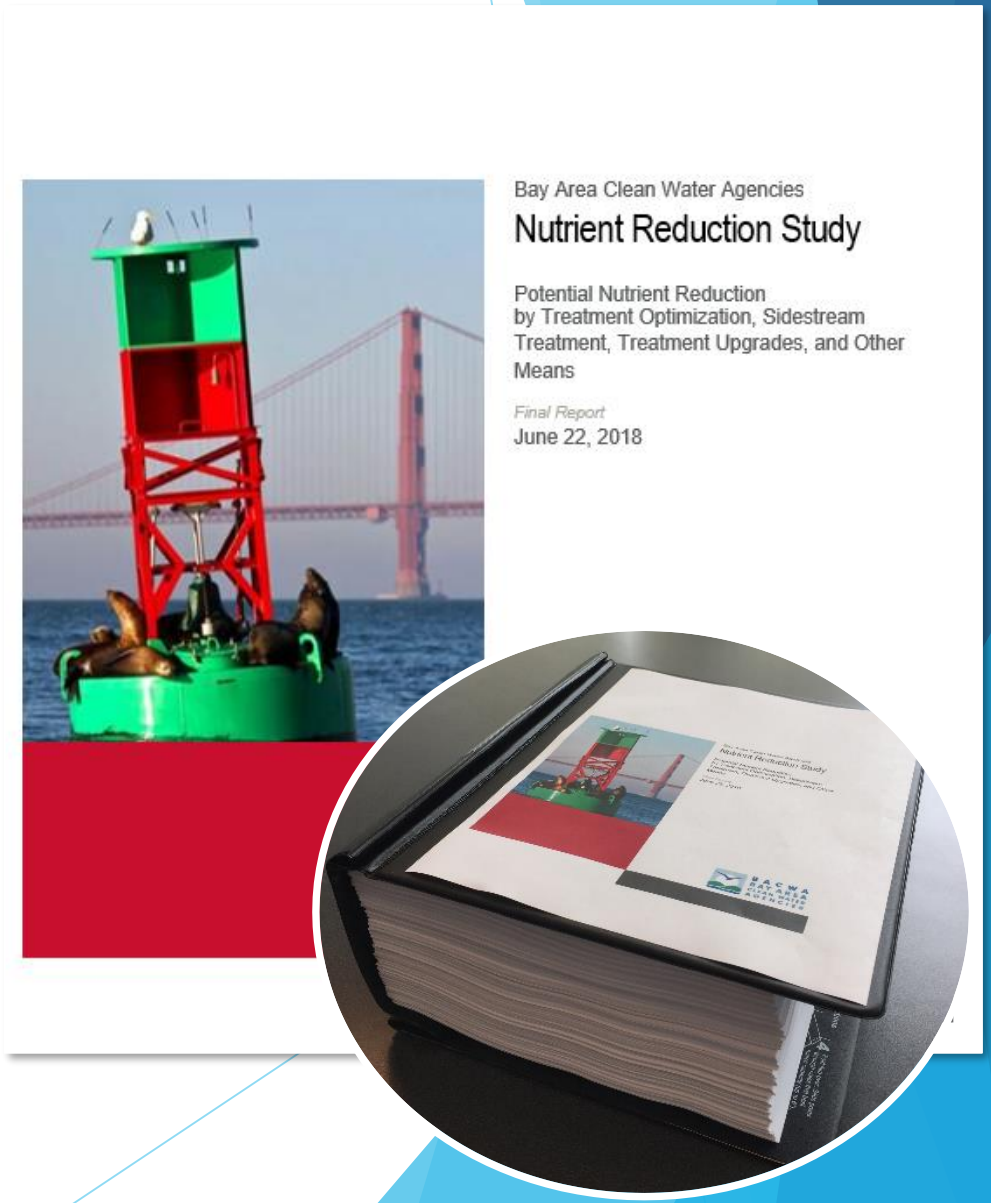
SUPPORT FOR SCIENCE

GROUP REPORTING

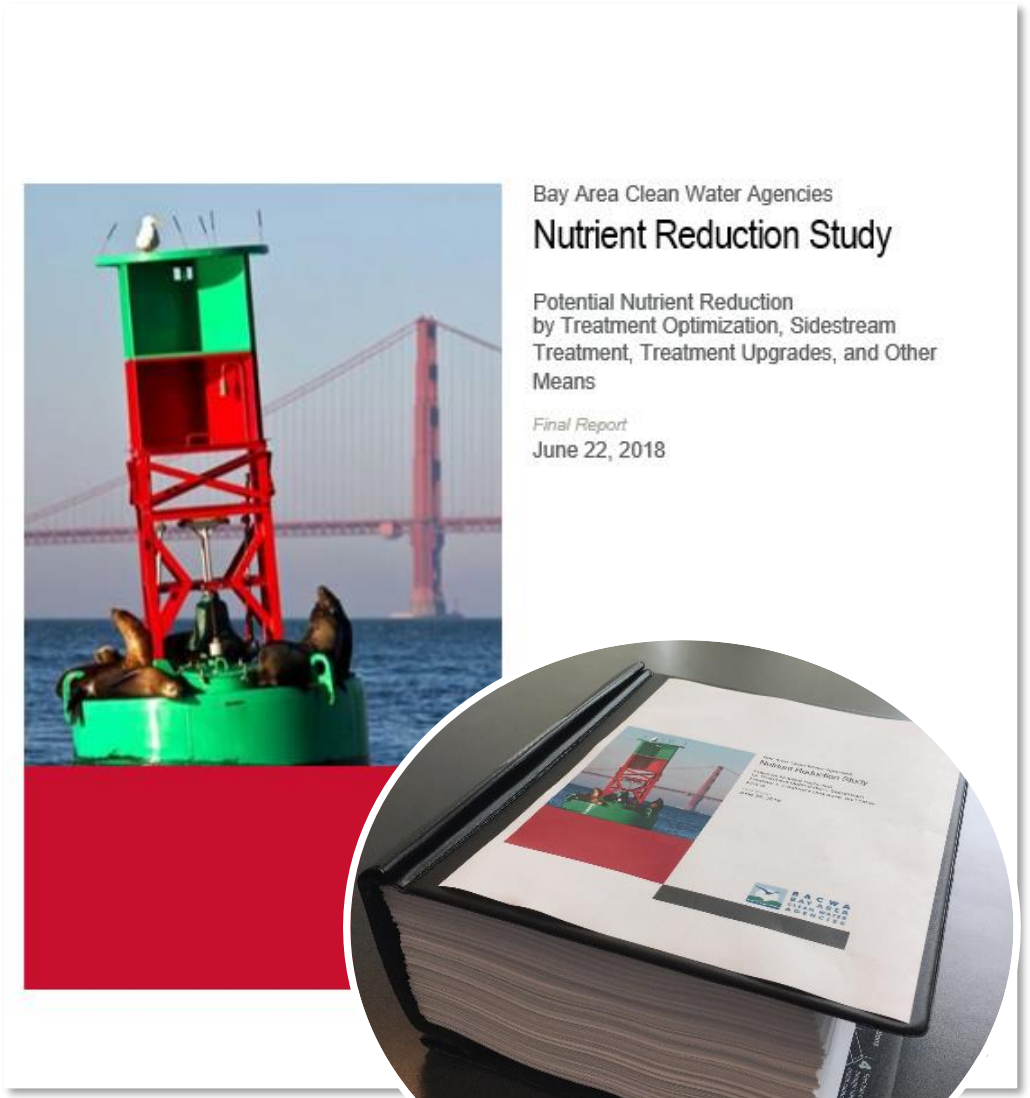
REGIONAL STUDIES

Nutrient Reduction Study Report (June 2018)

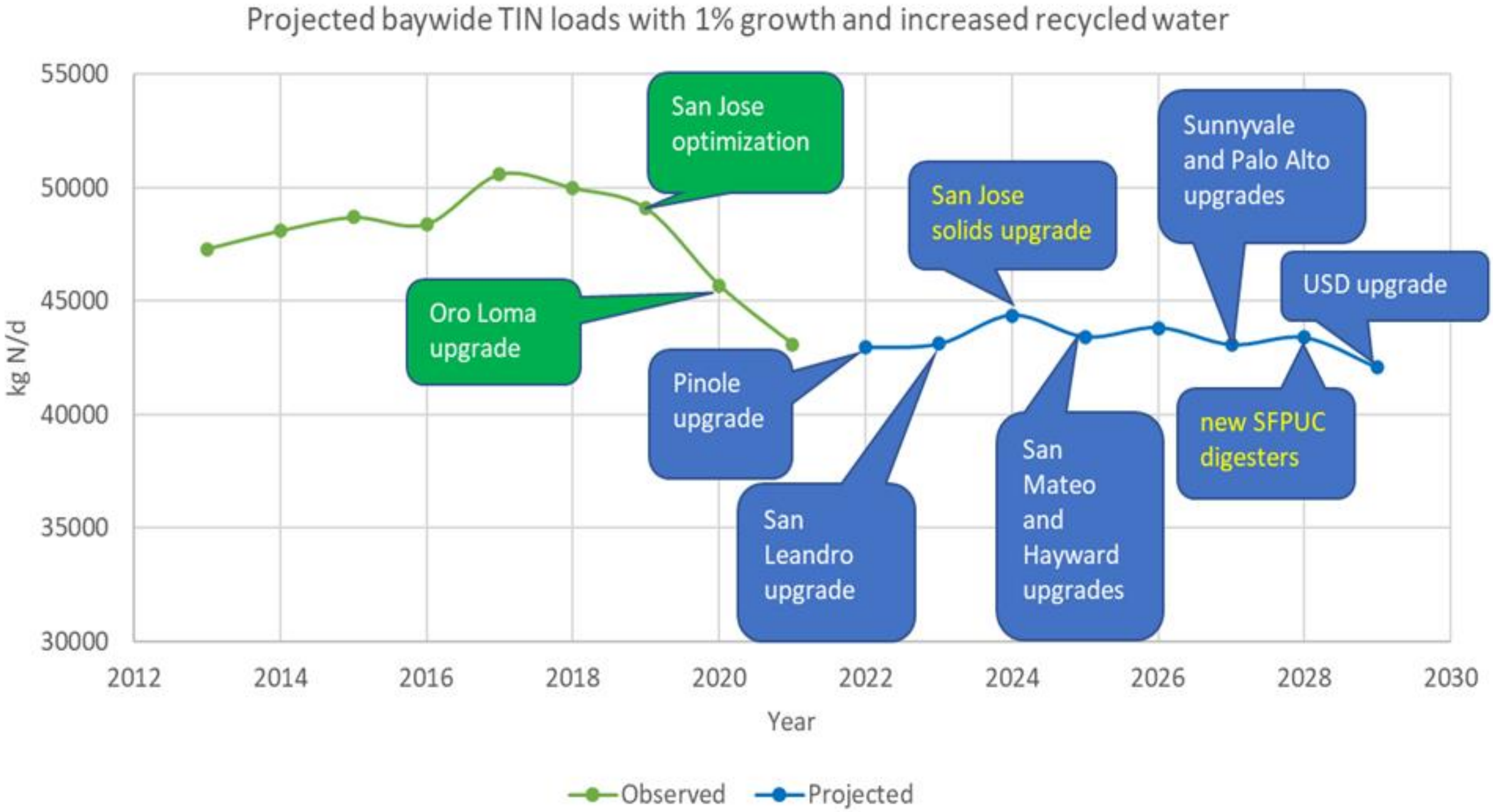
- Main report summarizes study findings for all plants
- 37 individual plant appendices:
  - Existing plant data
  - Optimization
  - Sidestream treatment
  - Plant upgrades
  - Emerging technologies



Regional Study Key Observations



Strategy	TN Load Reduction to the Bay	Total Present Value ($ Mil)
Optimization	**7%**	**$266 M**
Sidestream Treatment	**19%**	**$766 M**
Upgrade Level 2 (15 mg/L N)	**57%**	**$9.4 B**
Upgrade Level 3 (6 mg/L N)	**82%**	**$12.4 B**


Projected baywide TIN loads with 1% growth and increased recycled water
55000
50000
45000
40000
35000
30000
kg N/d
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Year
San Jose optimization
Oro Loma upgrade
Pinole upgrade
San Leandro upgrade
San Jose solids upgrade
San Mateo and Hayward upgrades
Sunnyvale and Palo Alto upgrades
new SFPUC digesters
USD upgrade
Observed
Projected

The now

- 3rd Watershed Permit will include nutrient limits, likely implemented on a Baywide basis
- BACWA's members will consider and propose load reductions:
  - Emergency response
  - Medium term optimization
  - Long term capital upgrades

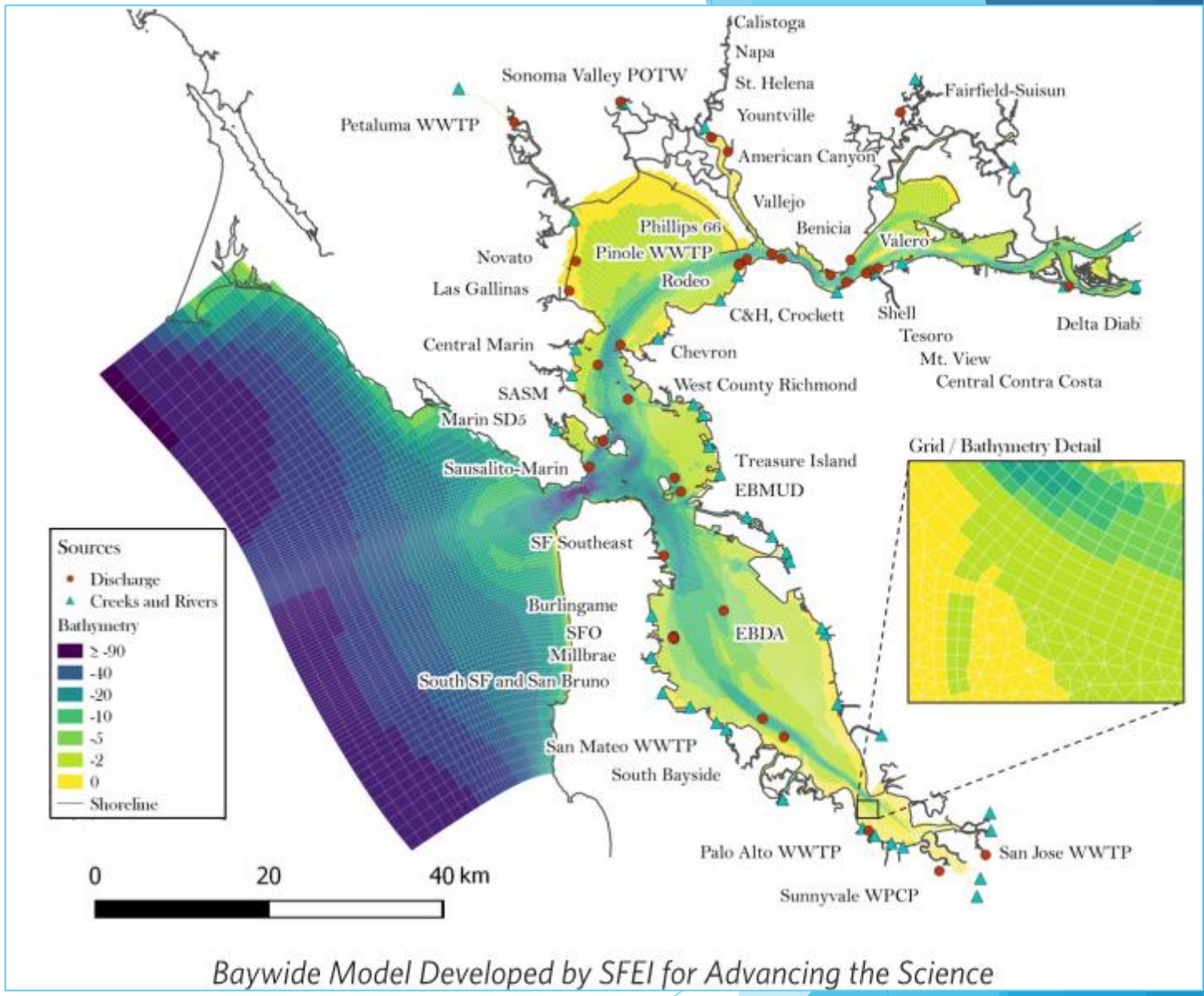
The now

- Work closely with Science Team to predict the impact of nutrient reduction actions
- Guiding principle:

↑ Cost

↑ Benefits

↑ Certainty of Water Quality Improvements



Baywide Model Developed by SFEI for Advancing the Science

SFEI | AQUATIC SCIENCE CENTER

SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER

Paying for nutrient upgrades

- Adoption of 1972 Clean Water Act came with $1B ($7B in today's dollars) in construction grants
- Now, improvements are paid largely by ratepayers
  - Prop 218 requires that rates be set based on the cost of service, not affordability
- Federal investment is key to a more equitable funding solution

Questions?

Lorien Fono, BACWA Executive Director
lfono@bacwa.org

BACWA
BAY AREA
CLEAN WATER
AGENCIES