

An aerial photograph of San Francisco Bay, showing the bay's complex coastline, surrounding green hills, and urban areas. A large blue semi-transparent rectangle is overlaid on the center of the image, containing the title and author information in yellow and cyan text.

Changing Phytoplankton Dynamics in San Francisco Bay – Upward Trends

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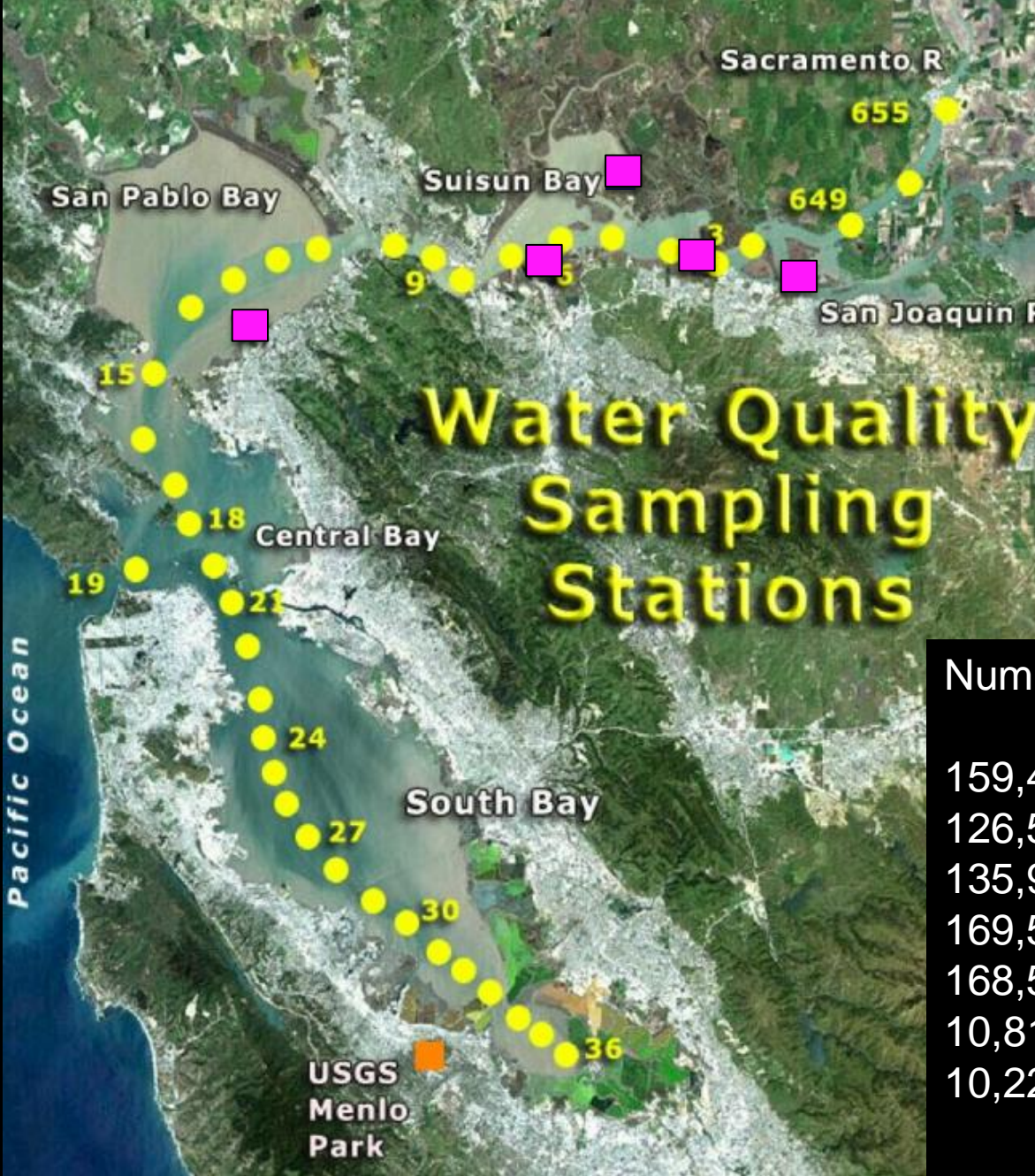
Nutrients in Estuaries

A SUMMARY REPORT OF THE
NATIONAL ESTUARINE EXPERTS
WORKGROUP
2005–2007

“Nutrient over-enrichment is ... a serious threat to estuarine and coastal waters throughout most of the United States”

“The Clean Water Act (CWA) directs states to adopt water quality standards..... to protect designated uses”

“Effective nutrient criteria should be developed within the framework of existing data and knowledge of responses by ecosystems to nutrients.”



IEP

Interagency Ecological Program

+

USGS / RMP

US Geological Survey /
Regional Monitoring Program

Number of Combined Measurements:

159,462 chlorophyll a

126,599 dissolved oxygen

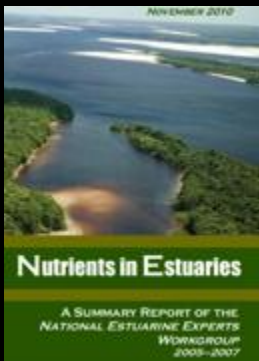
135,958 suspended particulate matter

169,515 salinity

168,588 temperature

10,811 dissolved inorganic nitrogen

10,224 dissolved inorganic phosphorus



San Francisco Bay has high nutrient loads

Estuarine system	Nitrogen load (gN m ⁻² y ⁻¹)	Approx. max NO ₃ ⁻ (mM N)	Approx. max PO ₄ ⁻³ (mM-P)
Narragansett Bay	28	20	4
Delaware Bay	26	175	6
Chesapeake Bay	21	100	1.5
Neuse River		300	2
San Francisco Bay	29	50	4
Yaquina Bay	100	100	3
Barneгат Bay	5	20	< 1
Coastal Bays	2-4	< 5	< 0.5
Florida Bay	10	10	< 1
Pensacola Bay	14	14	< 0.5

But, San Francisco Bay does not have chronic problems of harmful algal blooms (HABs), hypoxia or fish kills



photo credit: Kai Schumann
<http://oceanservice.noaa.gov/hazards/hab/>



Why is San Francisco Bay different from Chesapeake Bay?

Reason 1 – High Turbidity from Sediments in Water



Reason 2 – Filtration by Clams



Mya arenaria



Gemma gemma



Corbula amurensis



Musculus senhousia



Tapes japonica

An aerial photograph of a coastal region. On the left, a large body of water (the bay) is visible. The surrounding land features a mix of green vegetation, brownish-yellow hills, and urban areas with buildings and roads. The text is overlaid on a dark blue rectangular background.

Resilience to nutrient enrichment from:

1. turbidity (slow growth)

Signs that this resilience is changing

2. fast grazing (consumption)

A satellite-style map of the San Francisco Bay Area. The map shows the coastline, major water bodies, and surrounding land. Three specific areas are labeled with white text: San Pablo Bay in the upper left, Suisun Bay in the upper right, and South Bay in the lower left. A large blue rectangular box with yellow text is overlaid on the right side of the map.

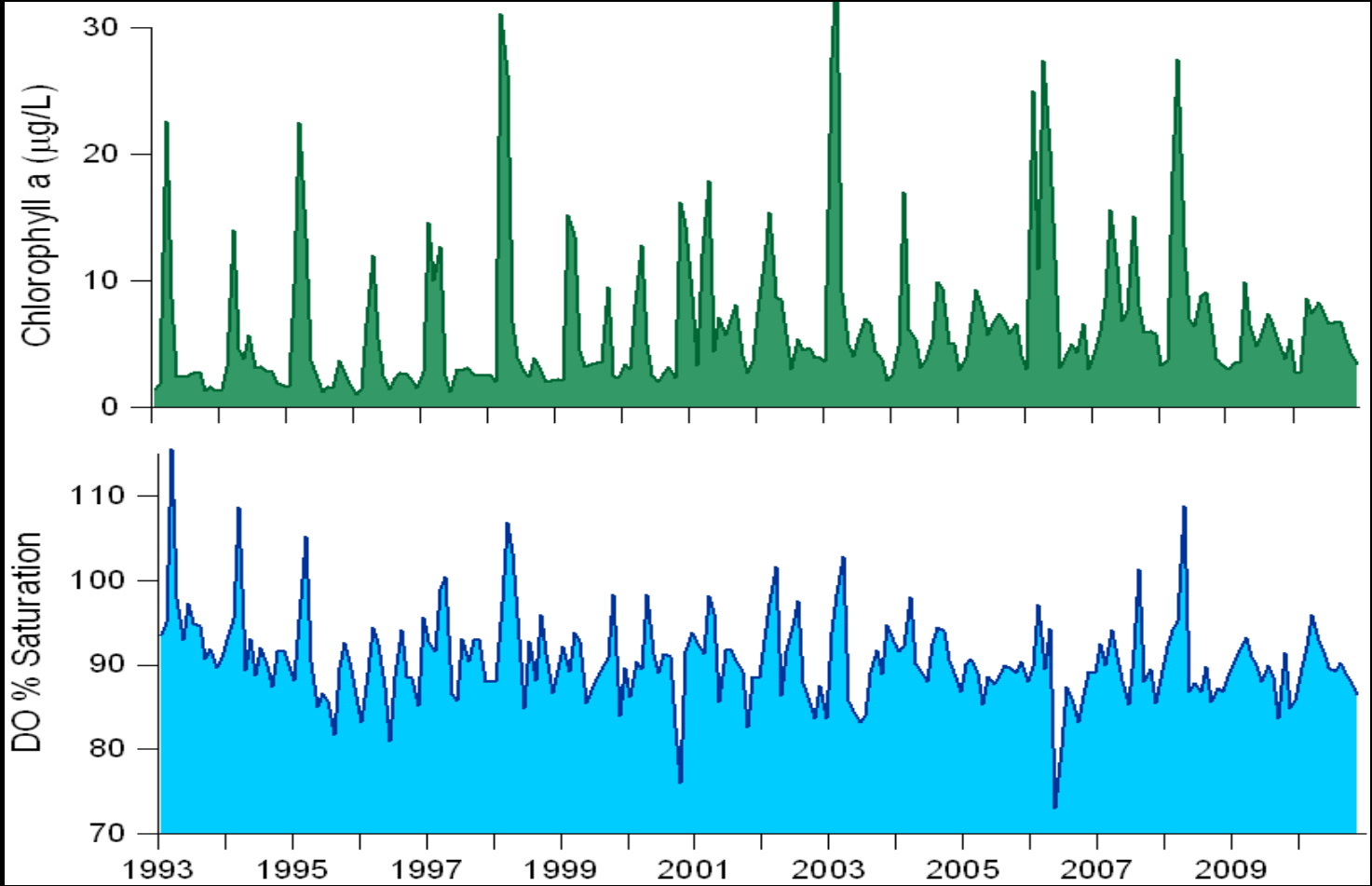
San Pablo

Suisun

Phytoplankton biomass
(chlorophyll) is increasing
and
dissolved oxygen (DO) in the
bottom waters is decreasing
* in all regions *

South
Bay

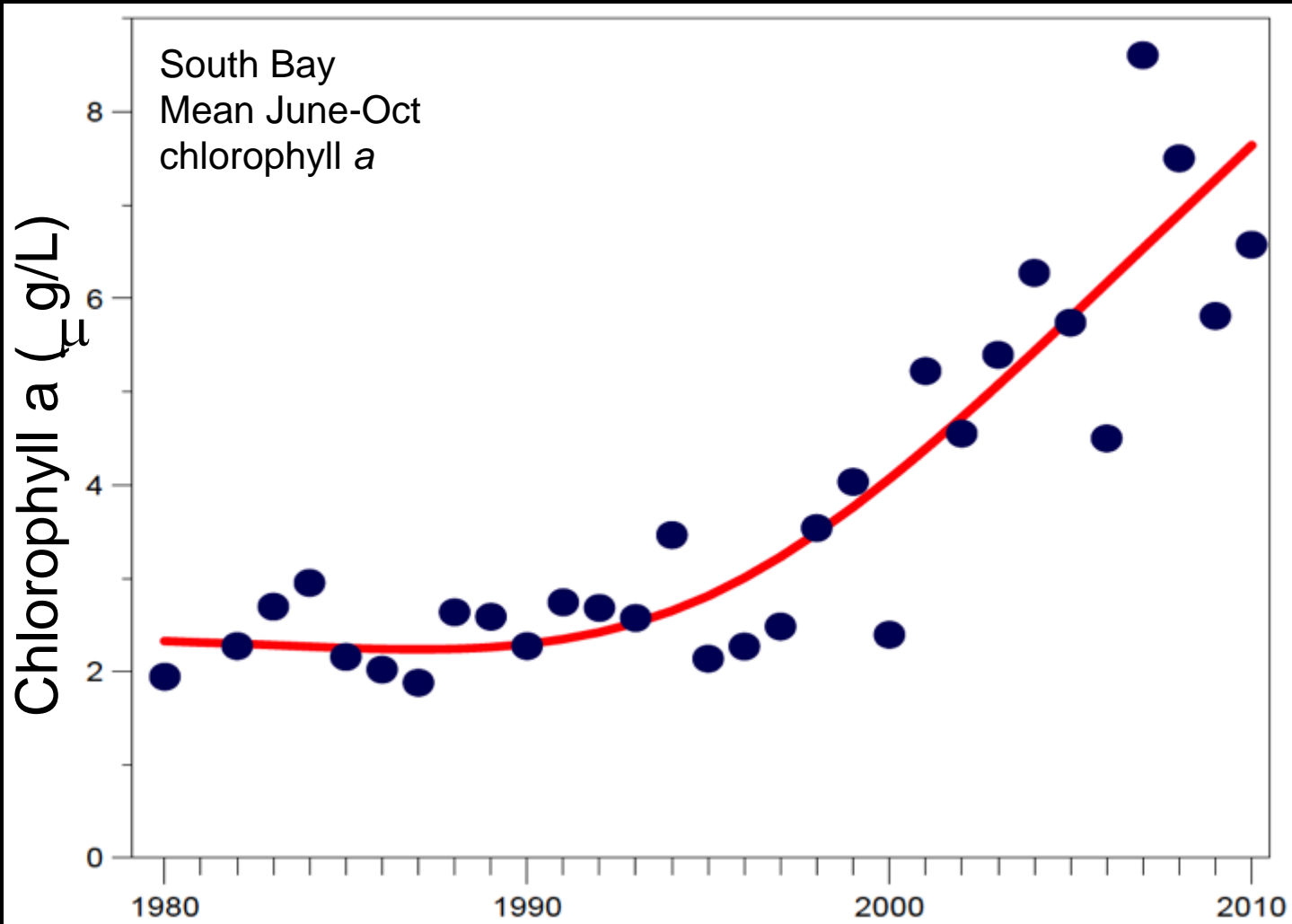
South Bay



+ 105% Chl

- 4% DO

% change = as % of 1988-93 mean



+ 213%
June-Oct
chlorophyll

Largest change occurs during the warm season

Why is chlorophyll increasing?

+ 72% chlorophyll
- 3% bottom DO

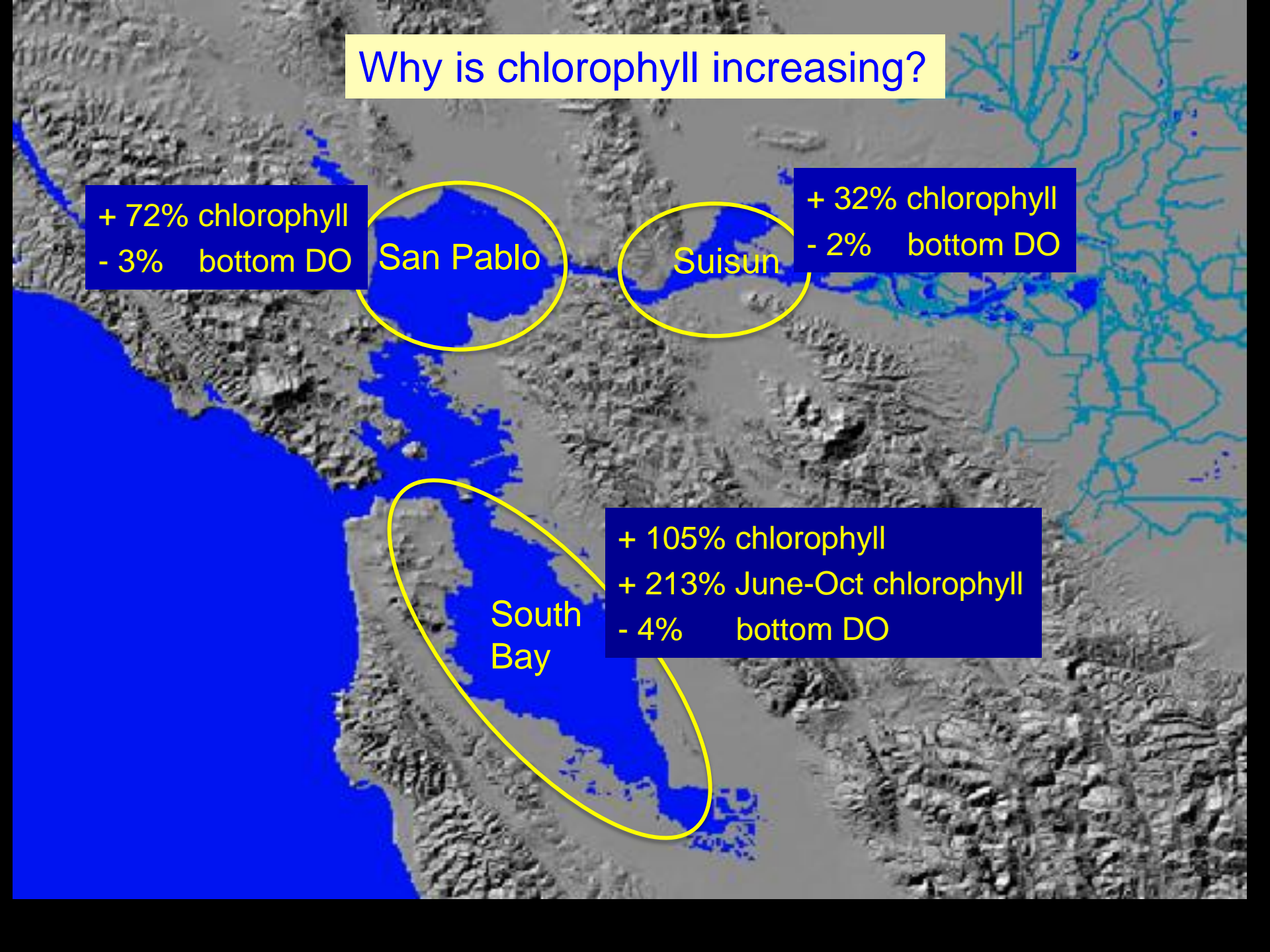
San Pablo

+ 32% chlorophyll
- 2% bottom DO

Suisun

South Bay

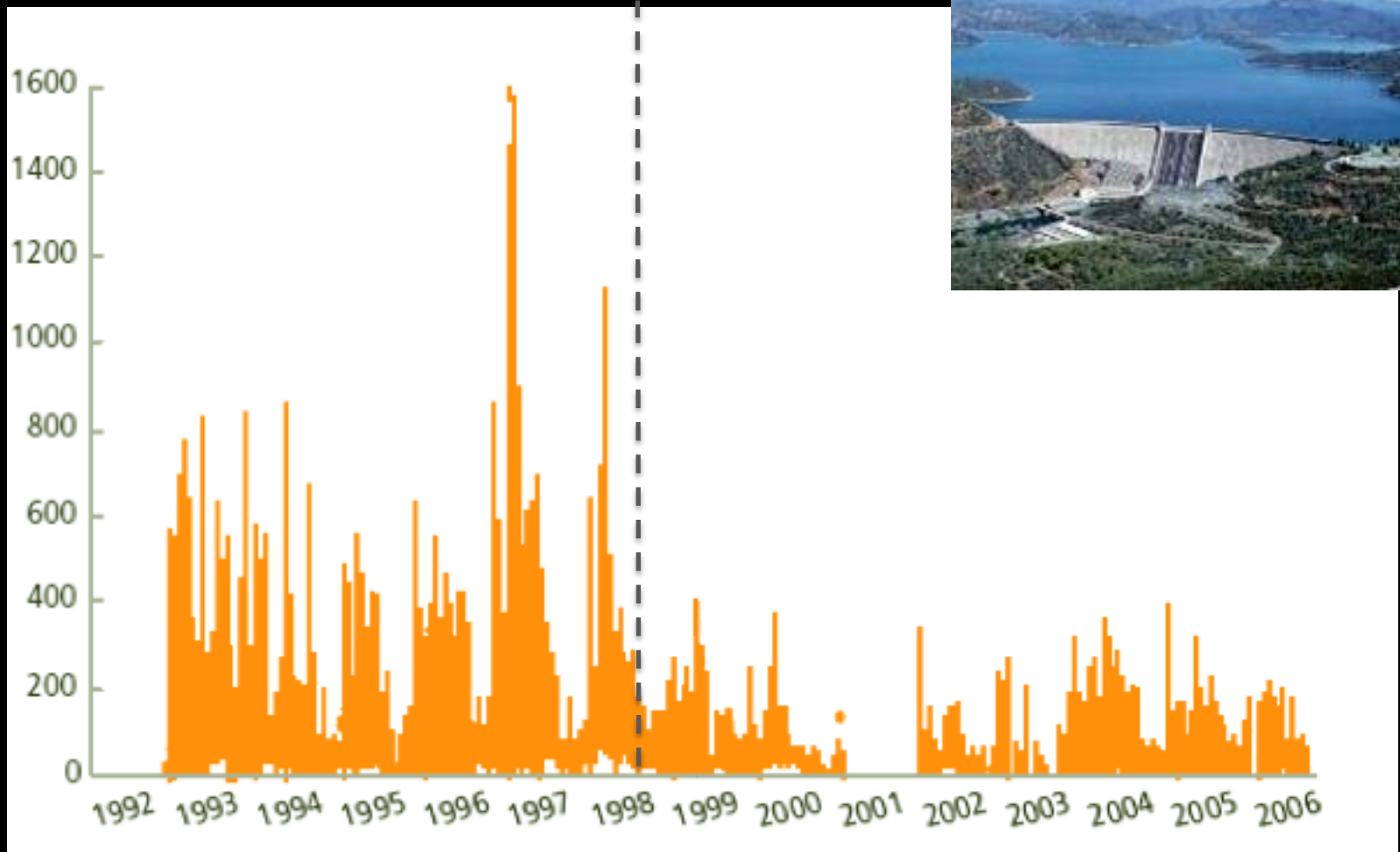
+ 105% chlorophyll
+ 213% June-Oct chlorophyll
- 4% bottom DO



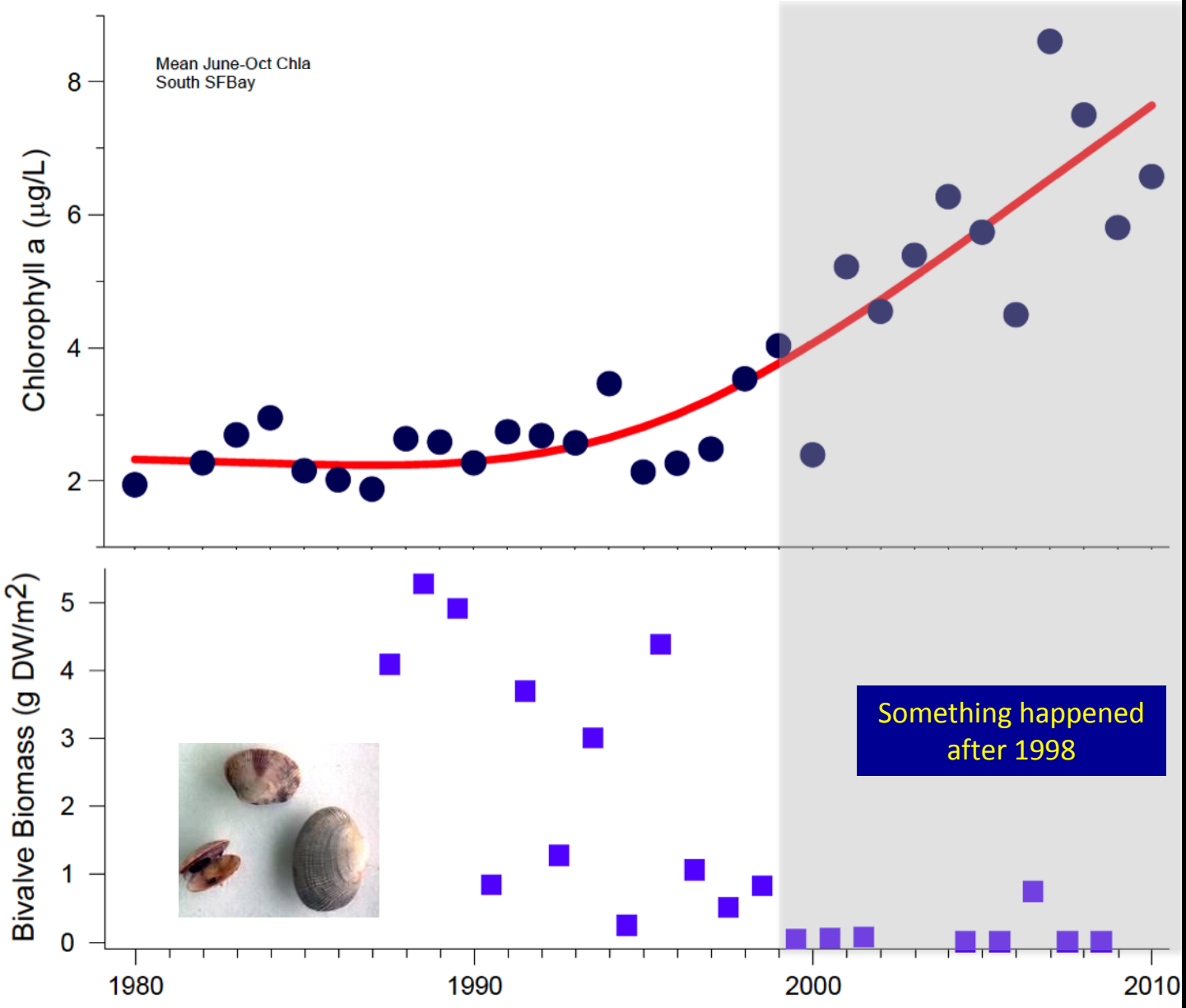
North San Francisco Bay is getting clearer, phytoplankton grow faster



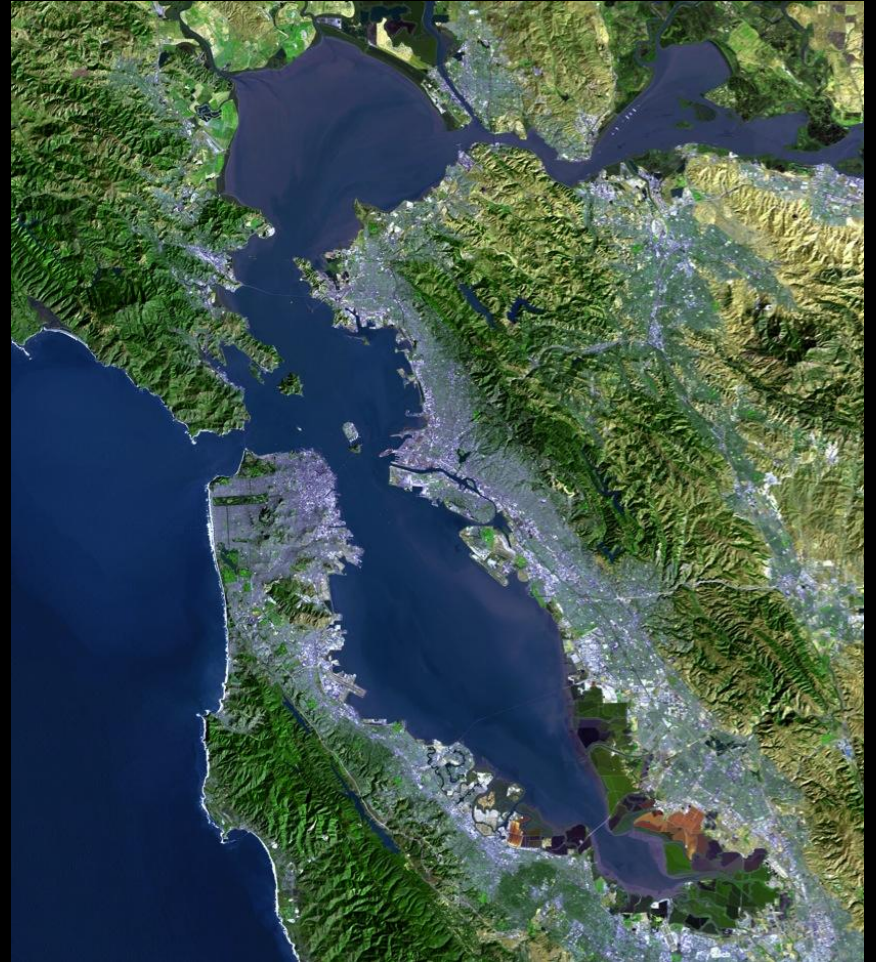
Suspended sediment concentration (mg/L)



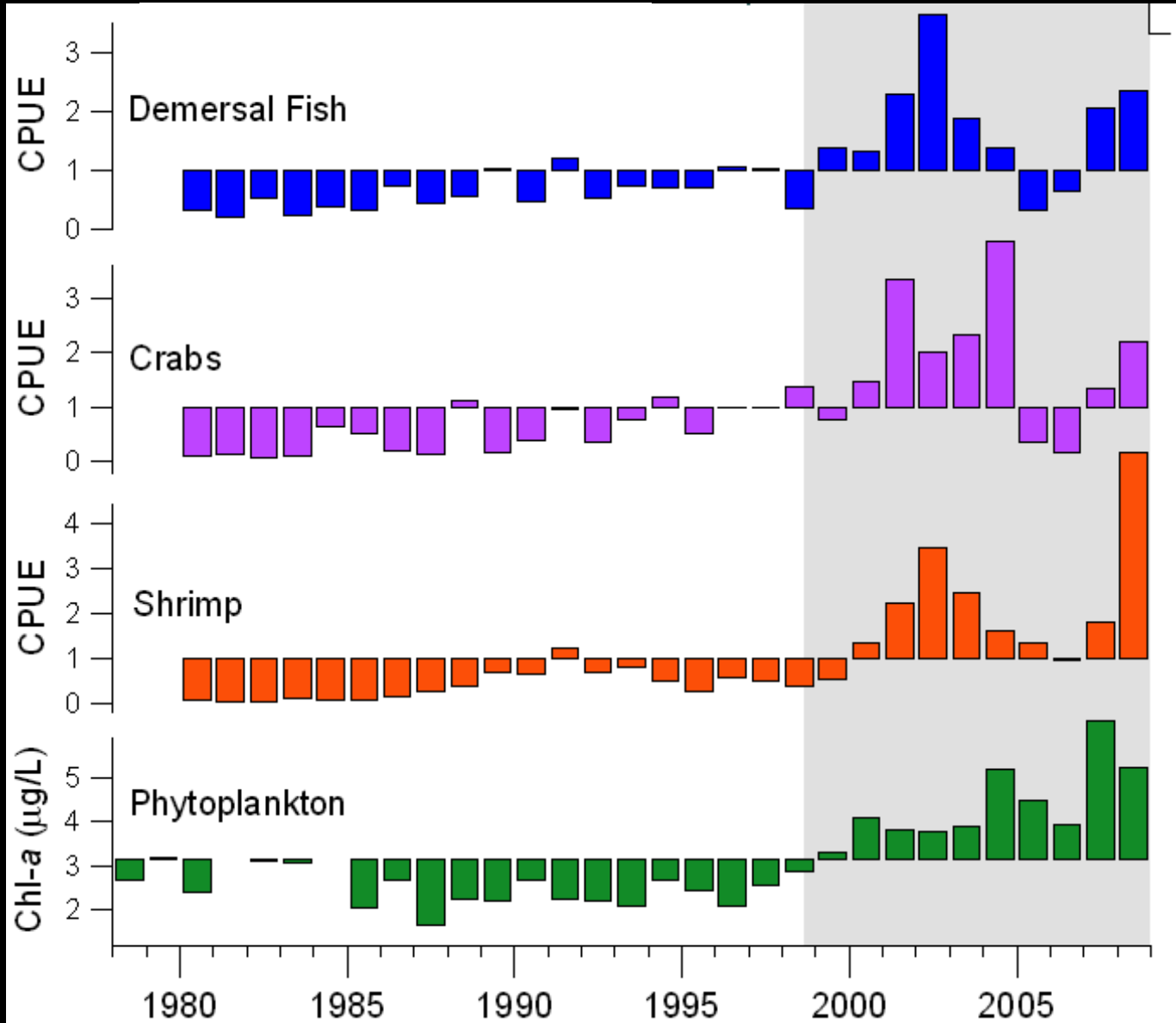
Data from Point San Pablo, mid-depth
Dave Schoellhamer, *Pulse of the Estuary* 2009



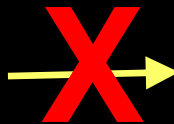
San Francisco Bay is a nursery for marine animals



Record-high numbers of flatfish, crabs, and shrimp



With the decline of the predators at the higher levels, shrimp, crabs and fish?
less phytoplankton biomass is consumed



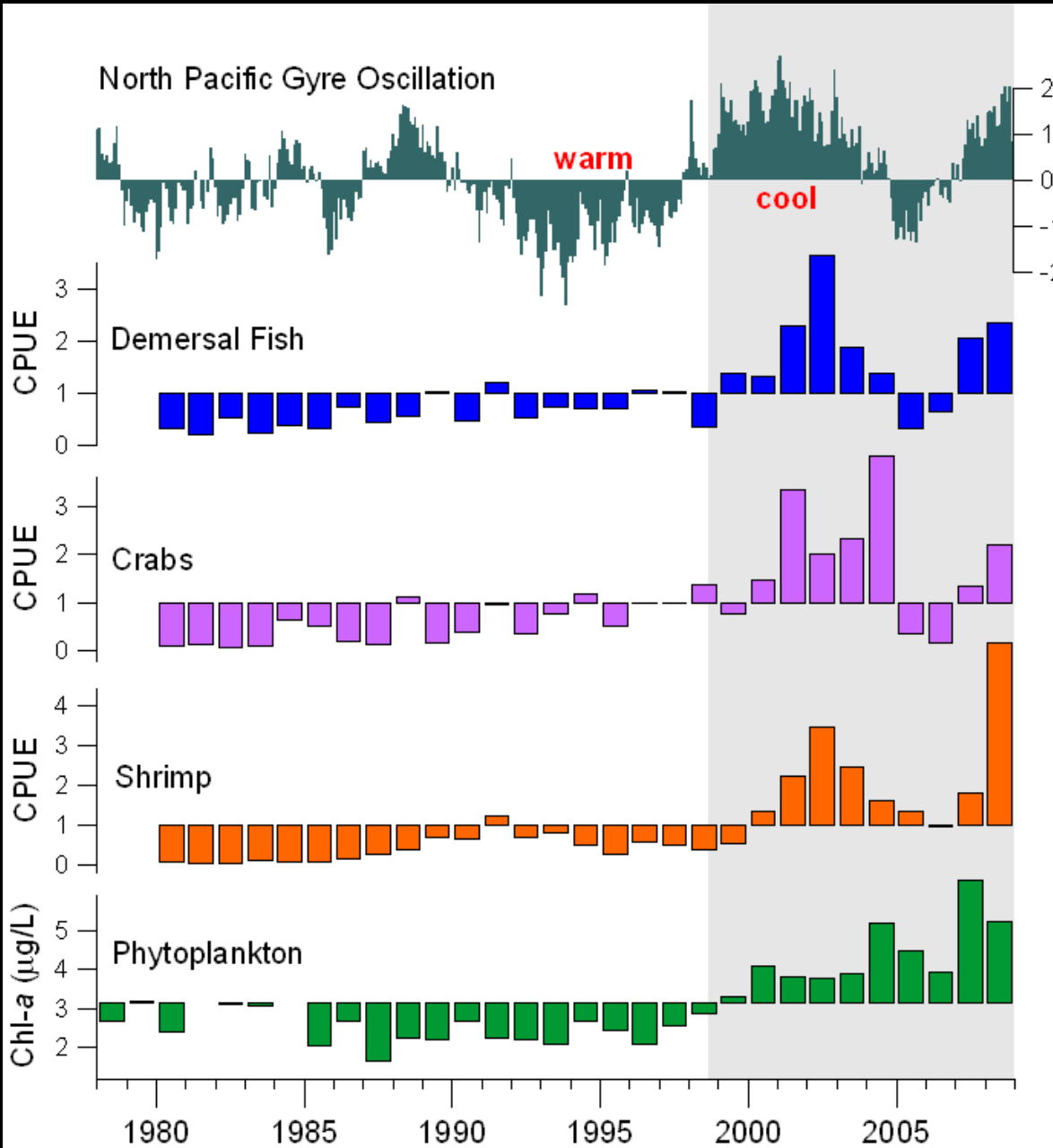
PREDATORS

HERBIVORES

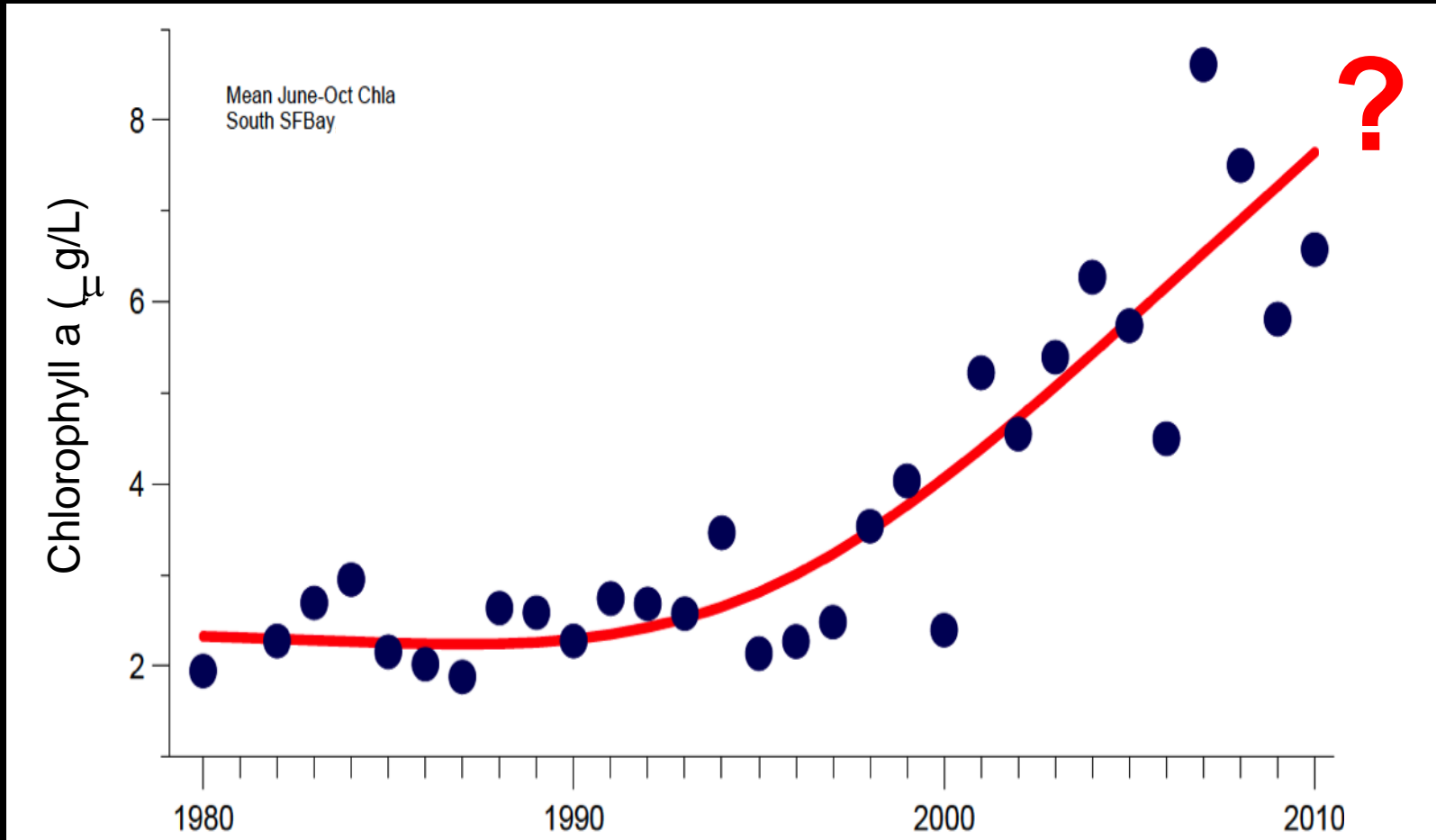
PRIMARY PRODUCERS



1999 Climate Shift

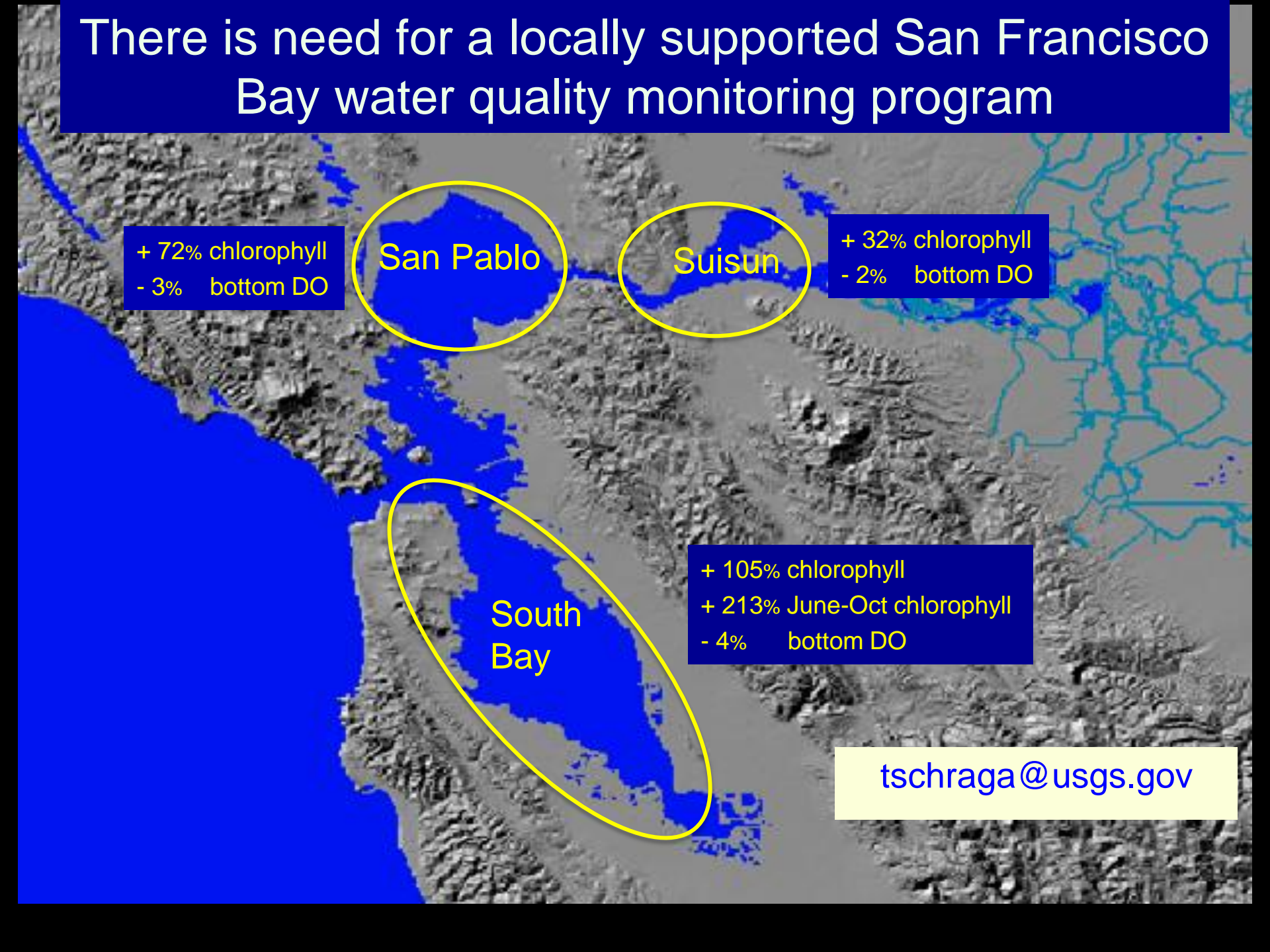


So we have an idea of what happened....
will these trends continue?



Could San Francisco Bay's water quality become impaired by nutrients?

There is need for a locally supported San Francisco Bay water quality monitoring program



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