Nutrients in San Francisco Bay – Charting the Way Forward

- Scientific Background
- Nutrient Strategy
- Proposal to RMP

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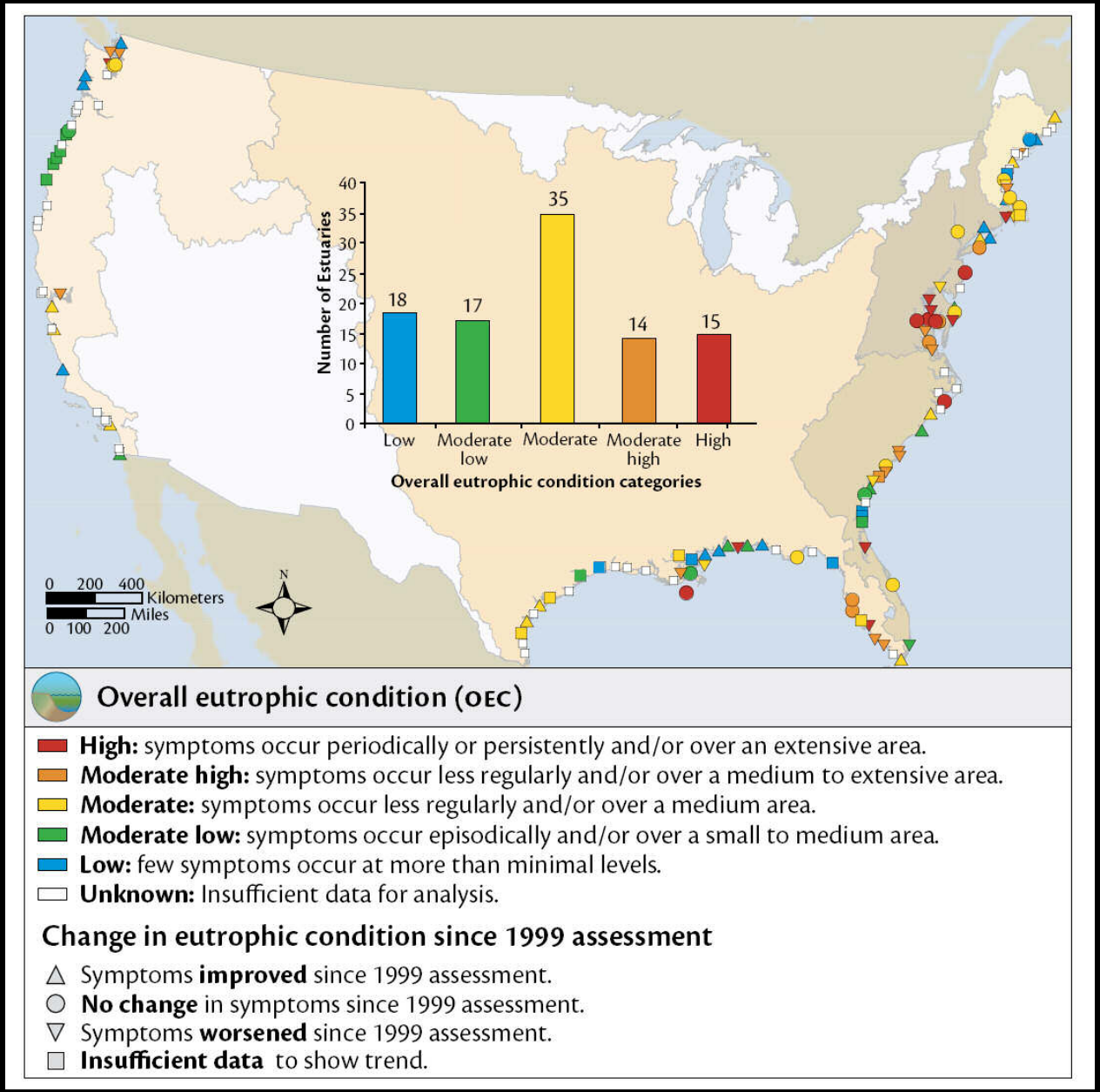
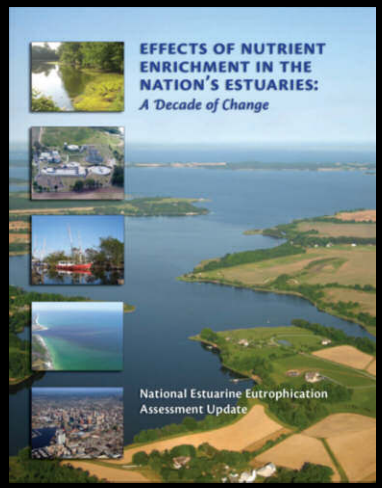
RMP TRC **9/27/2011**

Nutrient loading to estuaries



National and global high priority issue



Bricker et al. 2007

San Francisco Bay

Bay Institute, 1998

San Francisco Bay

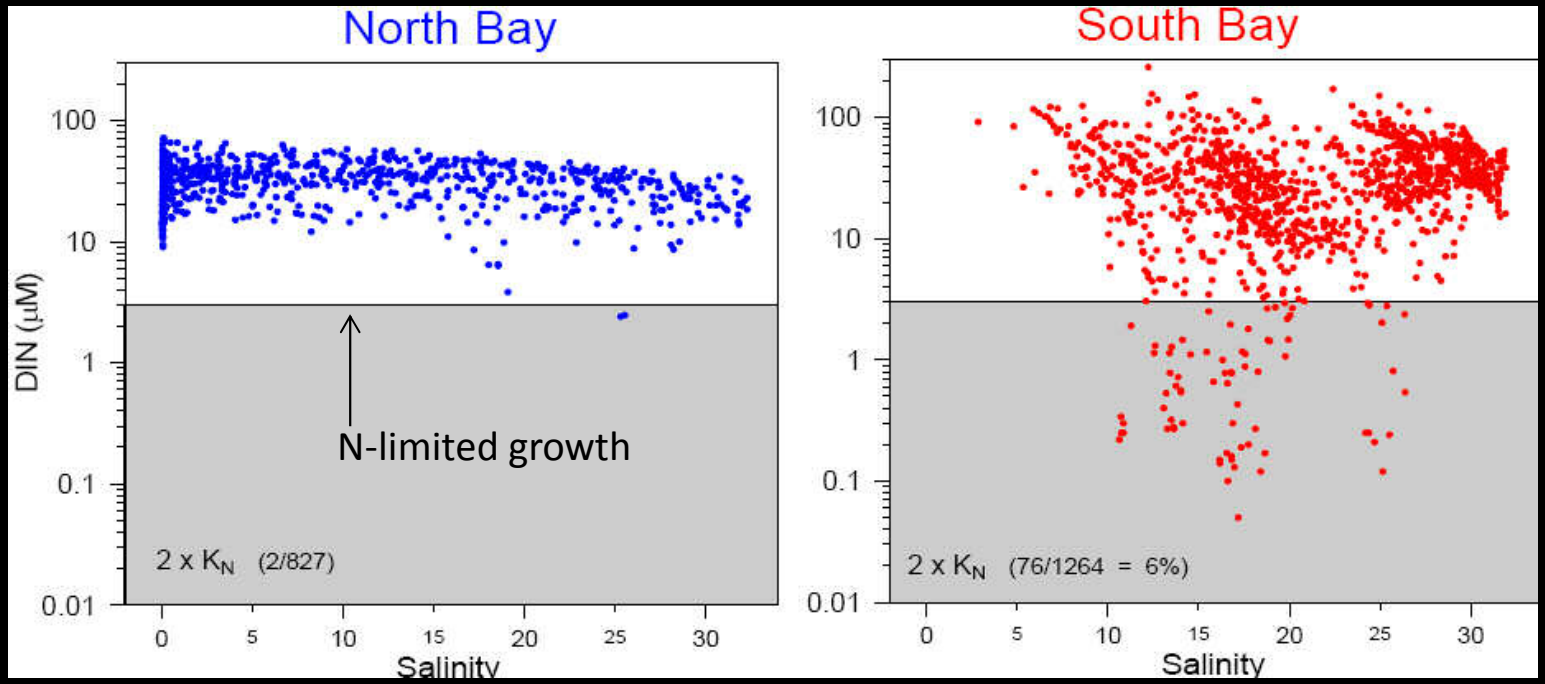
Bay Institute, 1998

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
Barnegat Bay	5	20	< 1
Coastal Bays	2–4	< 5	< 0.5
Florida Bay	10	10	< 1
Pensacola Bay	14	14	< 0.5

National Estuarine Experts Workgroup (2010)

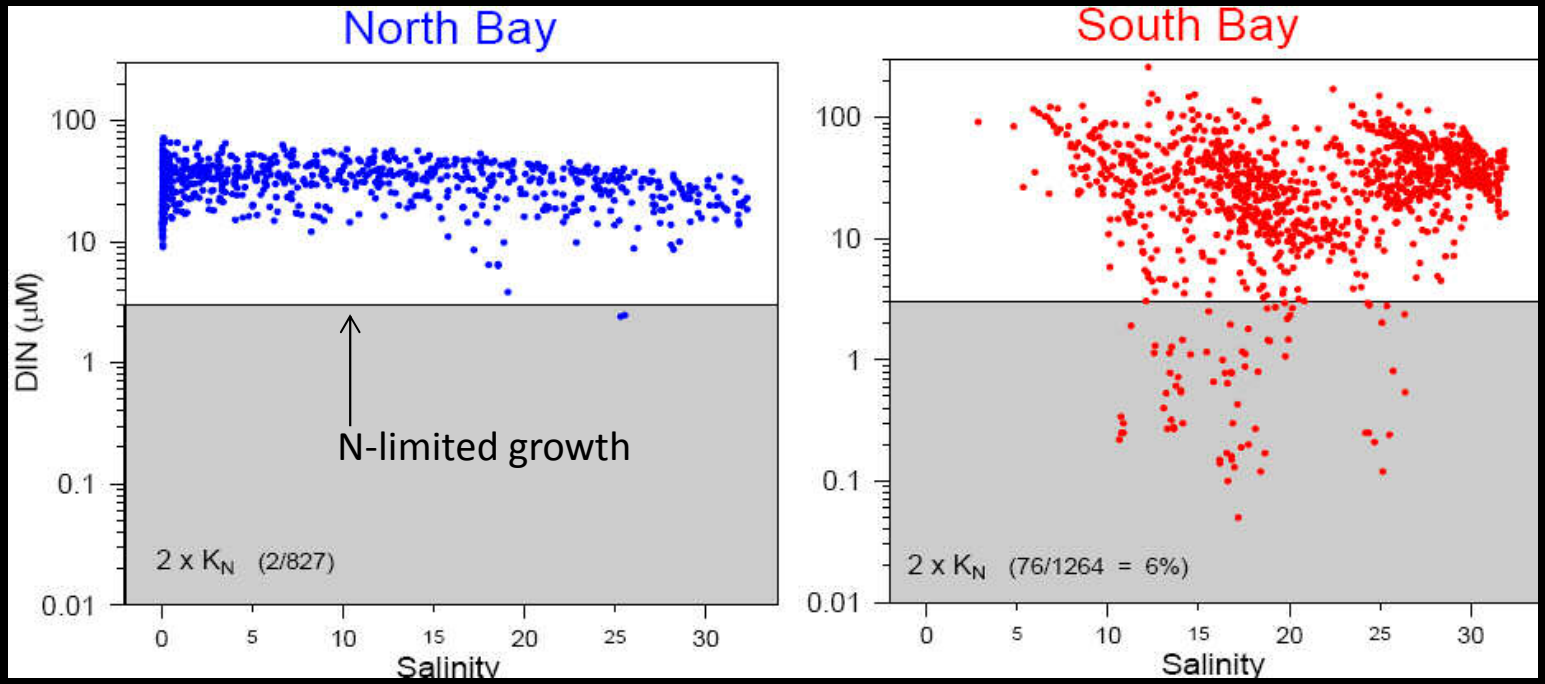
Despite large loadings from diverse sources…

…and relatively high DIN and DIP concentrations



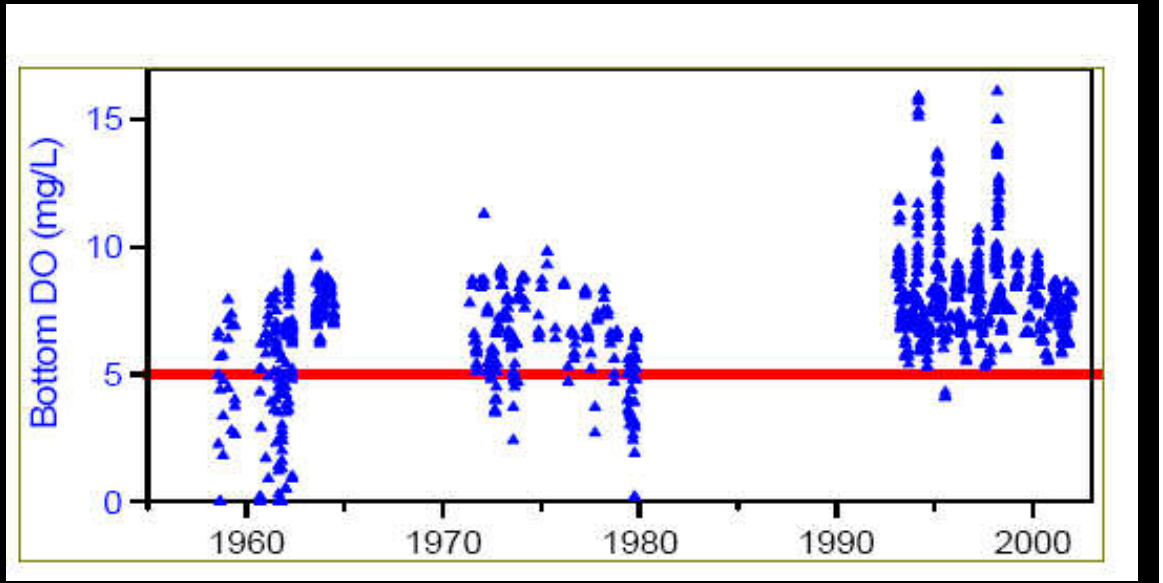
Dugdale and Cloern (2010)

…and relatively high DIN and DIP concentrations,



…historically the Bay has not been suffering obvious "classic" symptoms of eutrophication

(compared to other estuaries with high nutrient loads/concentrations)



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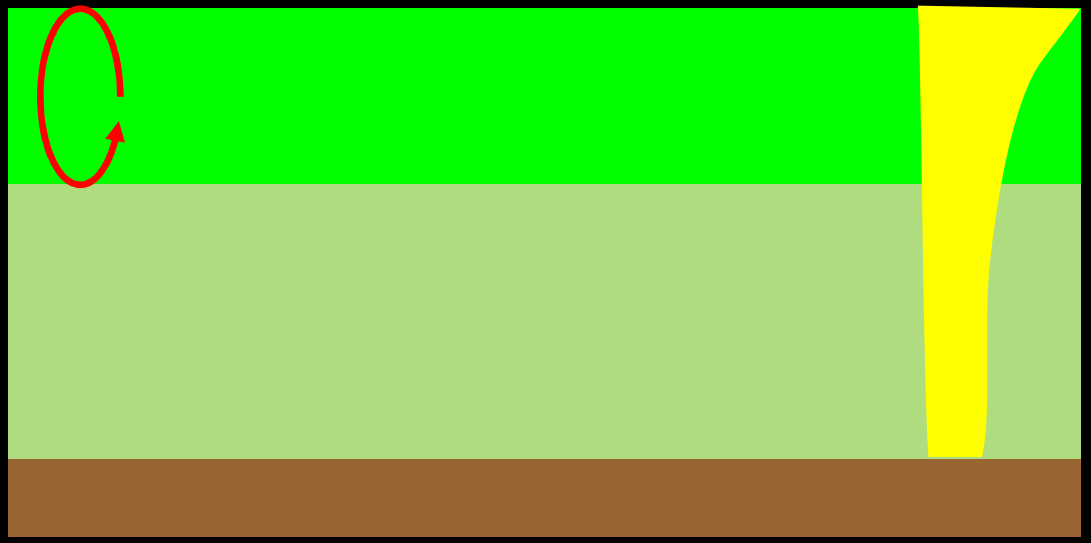
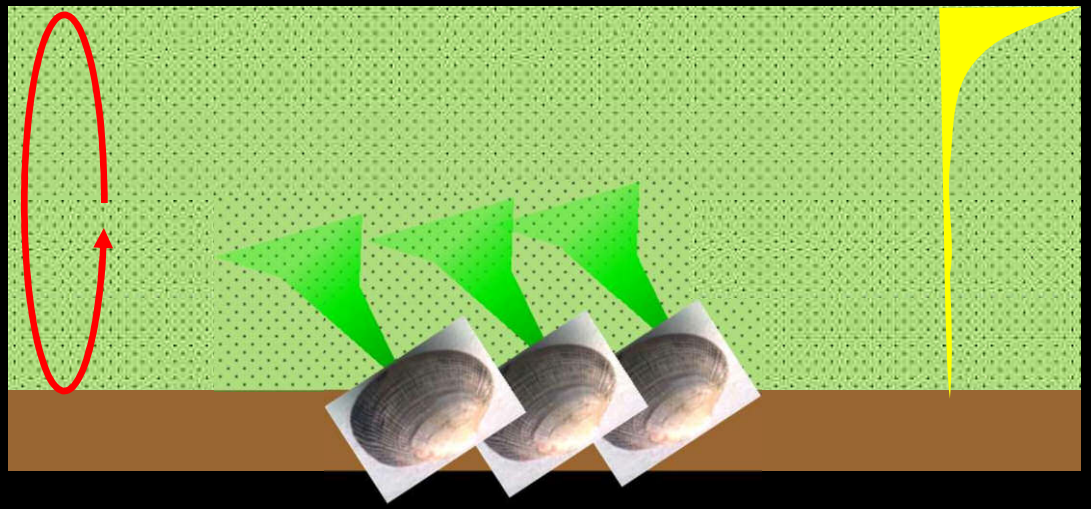


Resilience of San Francisco Bay

1) Strong tidal mixing

2) Filter-feeding clams

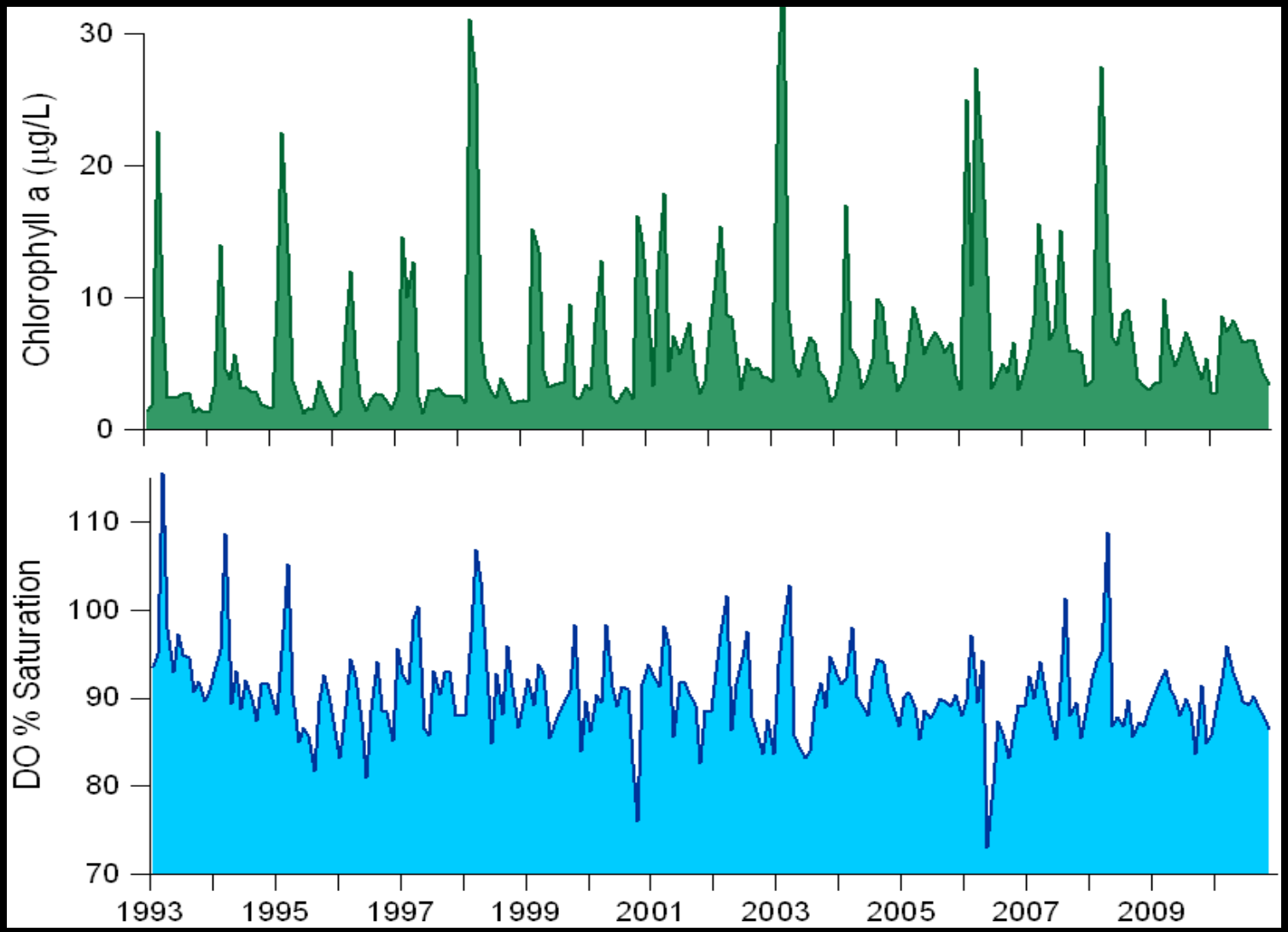
3) High Turbidity



- Relative importance?

- Spatial variation?

South Bay – Evidence that resilience is weakening



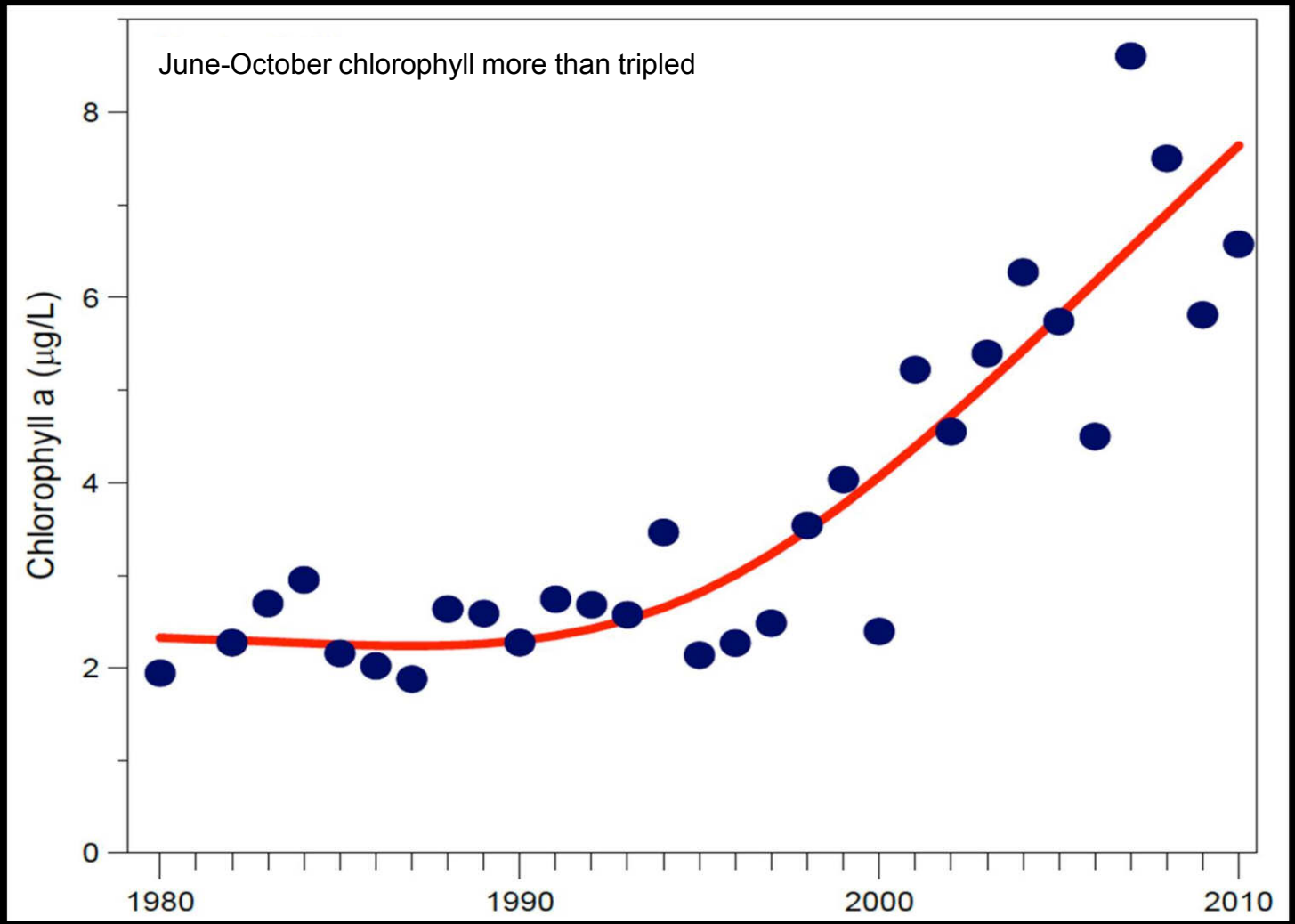
+ 105%

- 4%

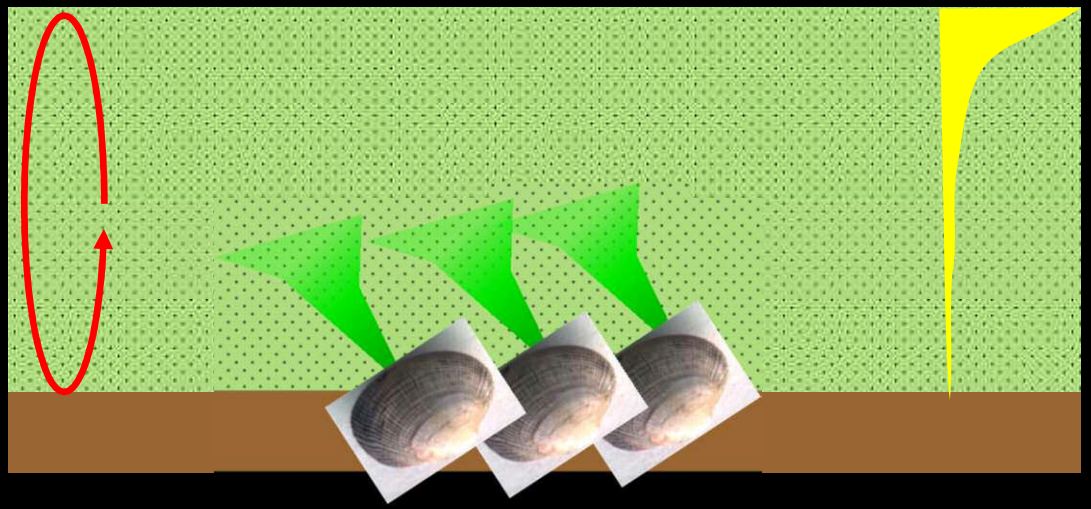
% change = as % of 1988-93 mean

Cloern (2011)

Warm season primary production – 3x increase

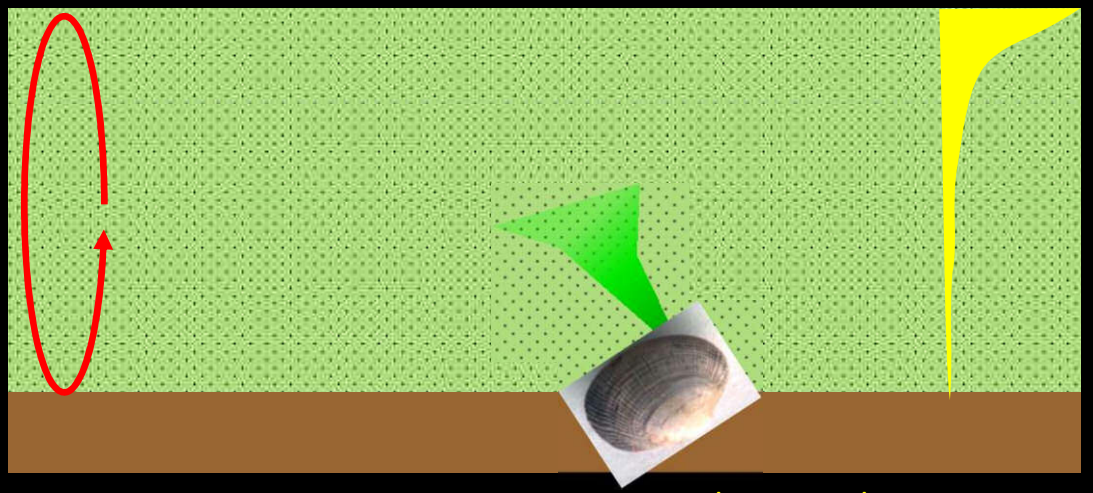


Cloern (2011)



Changing resilience in South Bay

- decreased clam abundance
- higher predator abundance



Cloern et al. 2007, 2010

Differences Between Bay Segments – e.g., Suisun and San Pablo Bays

- Similar trends…Chl-a increasing and O_2 decreasing
  - Cause: (in part) decreased sediment loading (Schoelhammer et al. 20XX)

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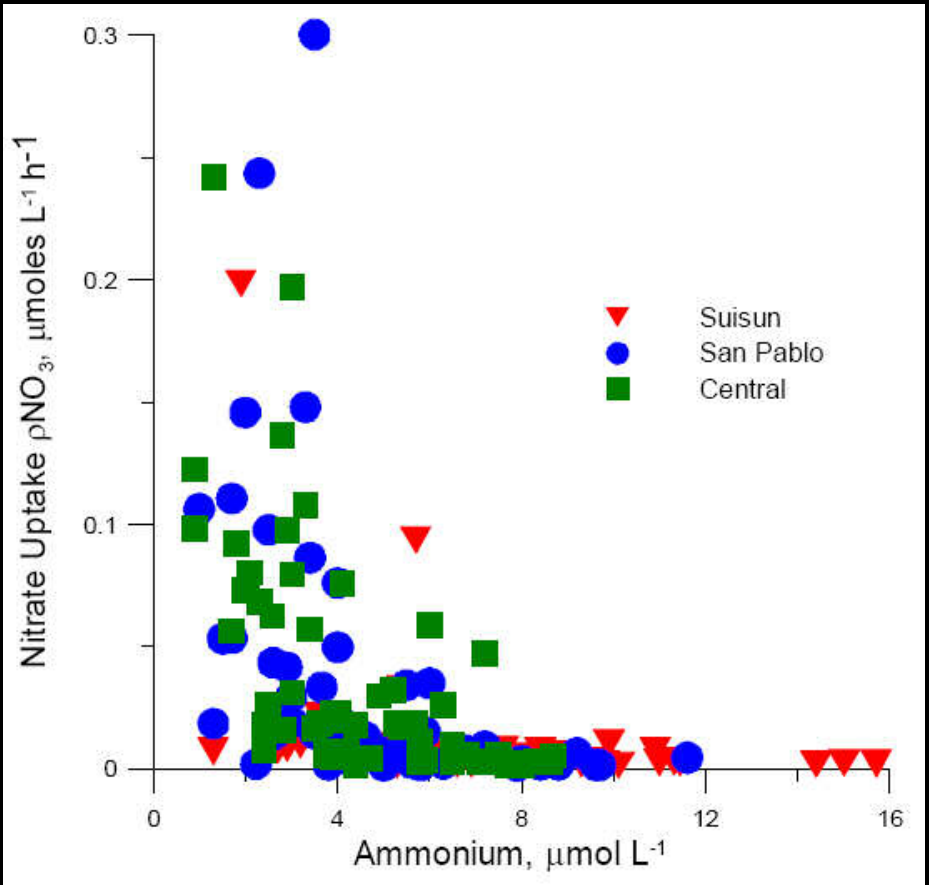

Dugdale and Cloern, 2010

- Too little phytoplankton biomass
  - linkage to POD?
- Causes…
  - clams
  - inhibition of primary production by high NH_4^+

Happening in parallel…

- Statewide and regional moves toward developing nutrient objectives for freshwaters and estuaries

- Nutrient Numeric Endpoint (NNE)
  - narrative objective(s) with numeric guidance for sustaining beneficial uses
  - based on ecological response indicators: e.g., algal biomass, dissolved oxygen
  - models to link response to nutrients and other management controls

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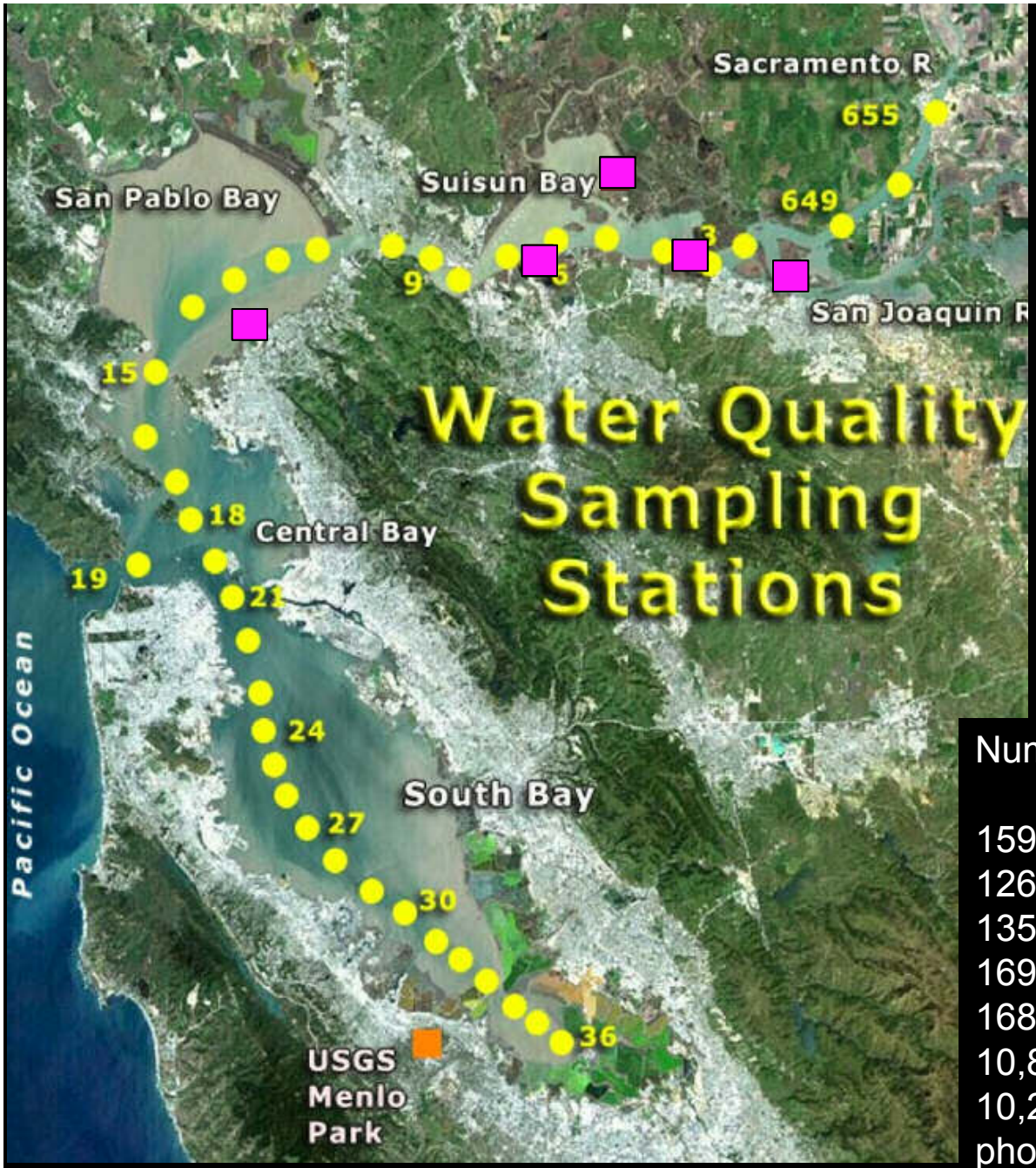
- Uncertain future for USGS monitoring program



IEP
Interagency Ecological Program

+

USGS / RMP
US Geological Survey / Regional Monitoring Program

USGS since 1969

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

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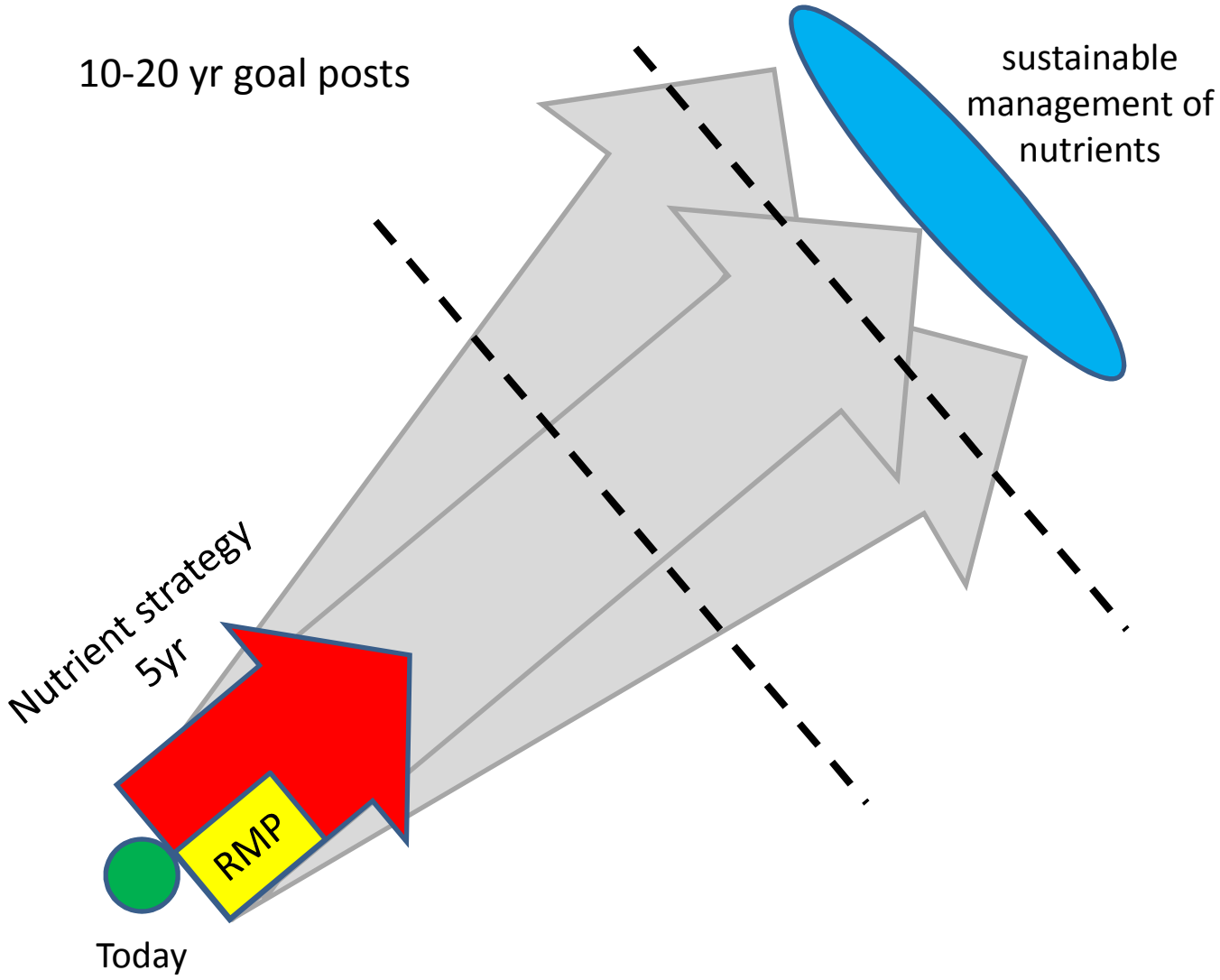
- Workshops/meetings to chart the way forward
  - April 2011, June 2011, September 2011
  - development goals and structure for a nutrient strategy

- *Develop Nutrient Strategy*



Nutrient Strategy:

→draft document, presenting cohesive strategy, broken into bite-size pieces that can be funded by various mechanisms

Key Management Questions

Is there a problem, or are there signs of a problem?

a. Is eutrophication currently, or trending towards, adversely affecting beneficial uses of the Bay?
b. Are beneficial uses in segments of the Bay impaired by any form of nutrients (e.g. ammonium)?

Which sources, pathways, and processes are most important?

a. What is the relative contribution of each loading pathway (POTW, Delta inputs, NPS, etc.)?
b. What are contributions of internal sources and sinks?

What nutrient loads can be assimilated without impairment of beneficial uses?

What is the likelihood that the Bay will be impaired by nutrient overenrichment/eutrophication in the future?

What are appropriate guidelines for identifying a nutrient-related problem?

Principal goals of the 5-year strategy:

1) Synthesize current understanding of nutrient dynamics in the Bay, highlighting what is known and the crucial questions that need to be answered;

2) Implement a monitoring program that supports regular assessments of the Bay;

3) Establish guidelines (water quality objectives; i.e., assessment framework) for eutrophication and other adverse effects of nutrient overenrichment;

4) Quantify nutrient loads to and estimate coarse nutrient budget for the Bay; and

5) Establish a modeling strategy to support decisions regarding nutrient management for the Bay.

Proposal to RMP:

Fund three high-priority projects:

Task 1 Nutrient/Water Quality Conceptual Model and Scenario Building

- $80k in 2012

Task 2 Quantifying External Nutrient Loads and Data Gaps Analysis

- $20k in 2012 and $30k in 2013

Task 3 Management of Nutrient Strategy Development Activities

- $10k in 2012

Task 1 – Main Goals

What problems, or what future scenario(s) , are we most concerned about ?

What information do we need to evaluate these scenarios?

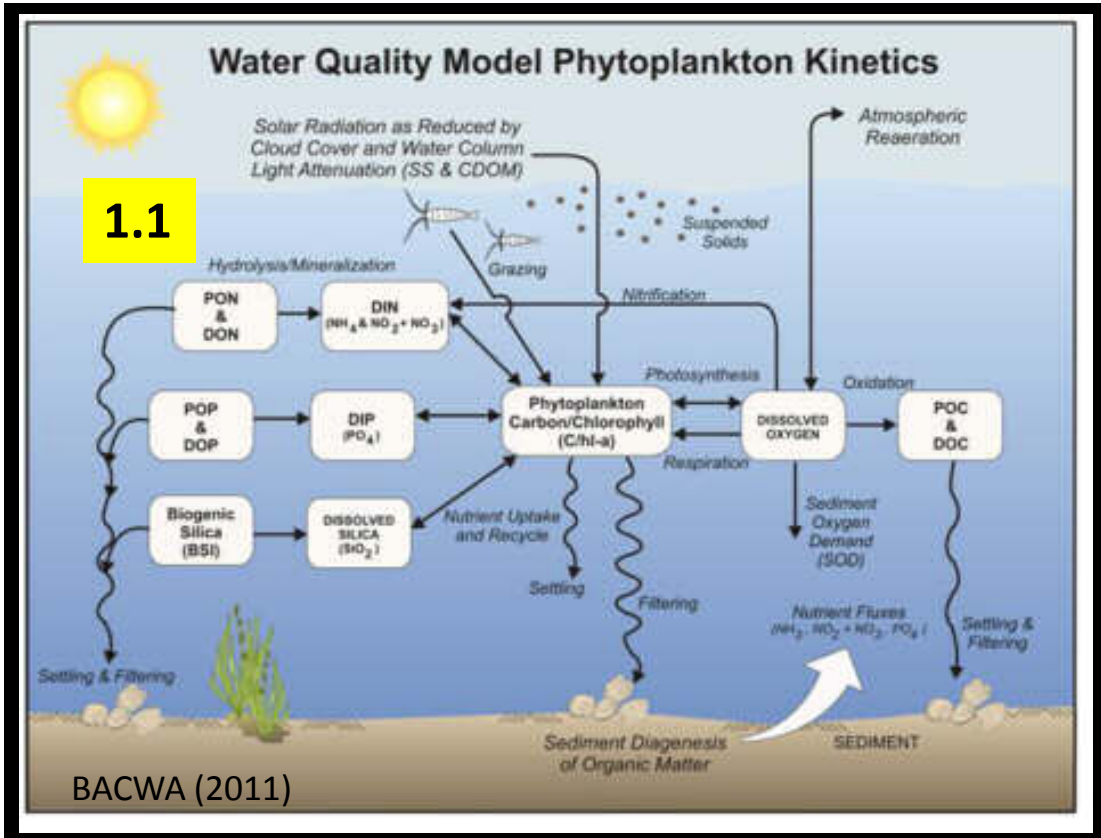
How do we best monitor to detect current problems or onset of future problems?

1) **Develop spatially-explicit (Bay compartments and habitats) conceptual models of nutrient dynamics in the Bay, with clear linkages to indicators of Bay beneficial uses;**

2) **Develop scenarios for future changes to key drivers/factors that influence biological responses to nutrient loads;**

3) **Prioritize scenarios that could be investigated through future modeling efforts, and additional scientific investigations to address critical knowledge gaps; and**

4) **Determine the key elements of a monitoring program that are needed to assess the Bay's current status and to detect changes in that status over time.**



1.2 Scenarios

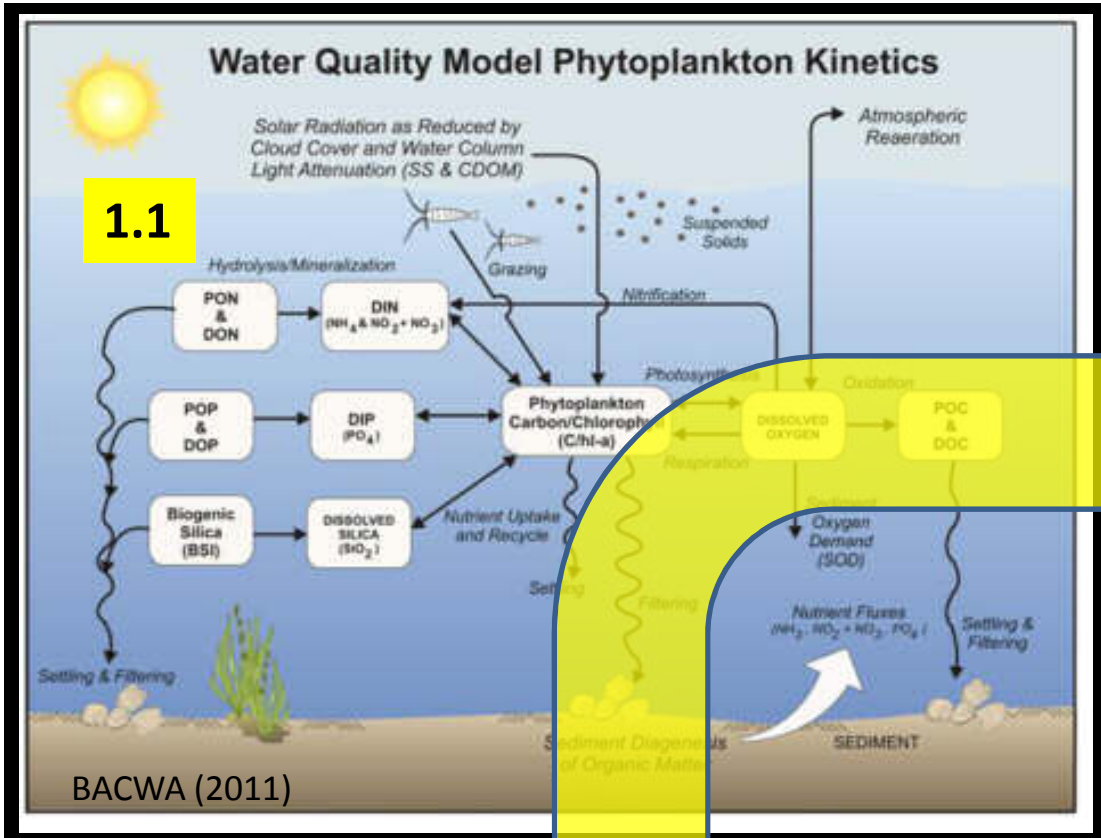
Δ Management forcings

Δ Natural forcings

Alternate future state

e.g.,

- 1% per year decrease in sediment load *(M, N)*
- decrease in NH_4^+ loads from Sacramento *(M)*
- stronger thermal stratification *(N)*
- change in North Pacific Oscillation *(N)*
- increase or decrease in loads from Bay POTW *(M)*



1.2 Scenarios

Δ Management forcings

Δ Natural forcings

Alternate future state

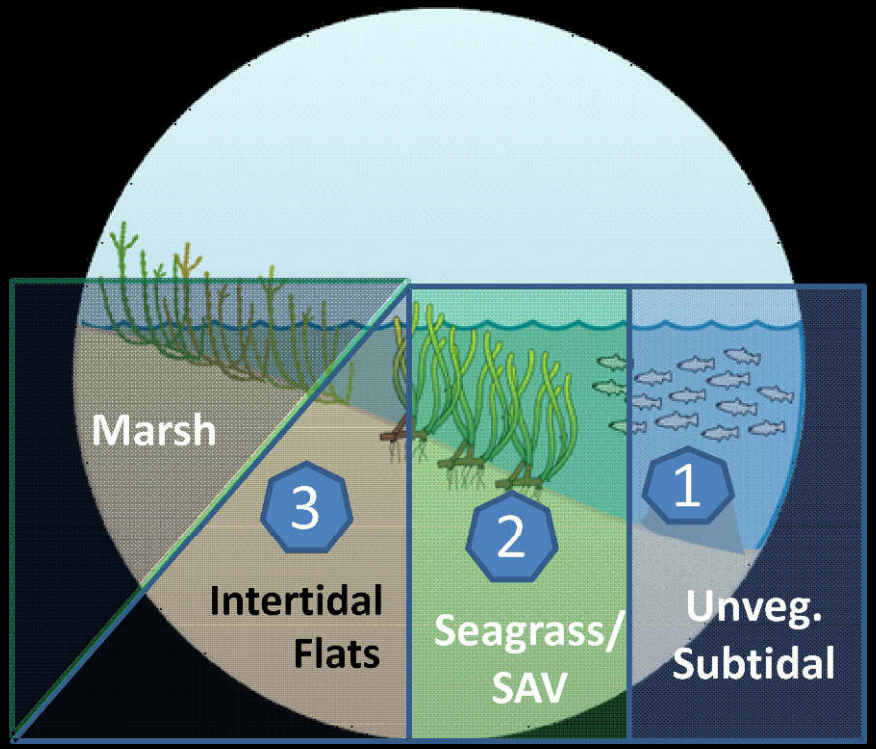
1.2
- Prioritize/rank
- Critical knowledge gaps

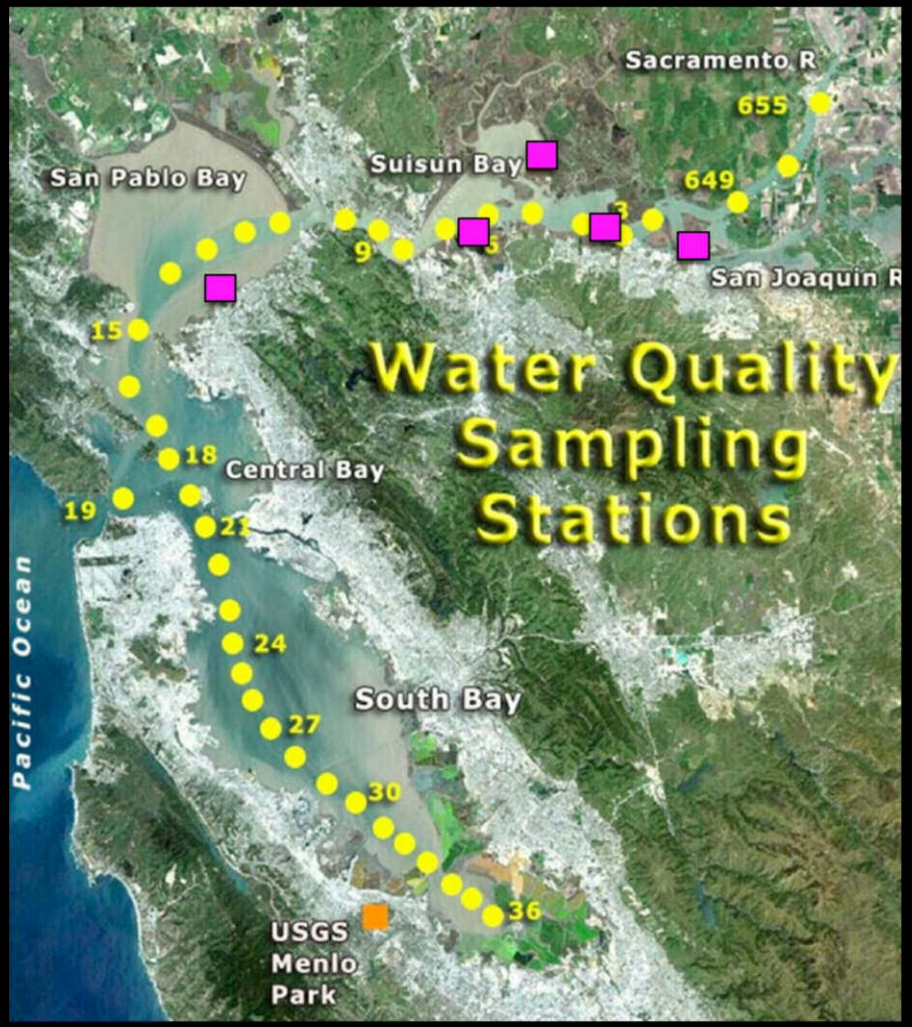
1.3 - 'Consensus' statement on nutrient outlook for the Bay

1.4 - Recommend elements of a monitoring program

Monitoring

- Temporal/spatial resolution
- Key parameters
- Special studies
- Other habitats



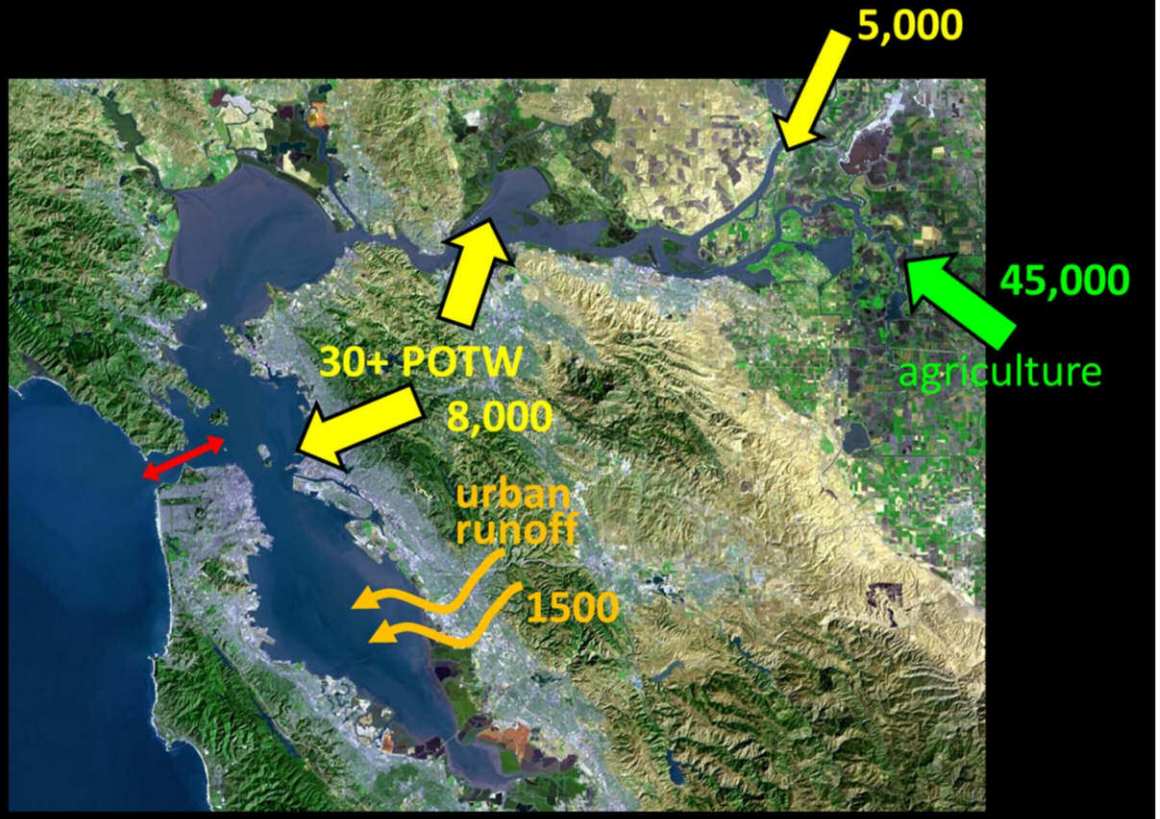


Task 2 – Quantifying External Nutrient Loads and Data Gap Analysis

- only coarse (spatial/temporal) and highly uncertain load estimates are currently available

- basic but critical input to…
  - modeling load-response
  - considering potential effectiveness of load reduction scenarios

<u>Very rough</u>…
DIN-loading estimates



Units = 10^3 tons/yr

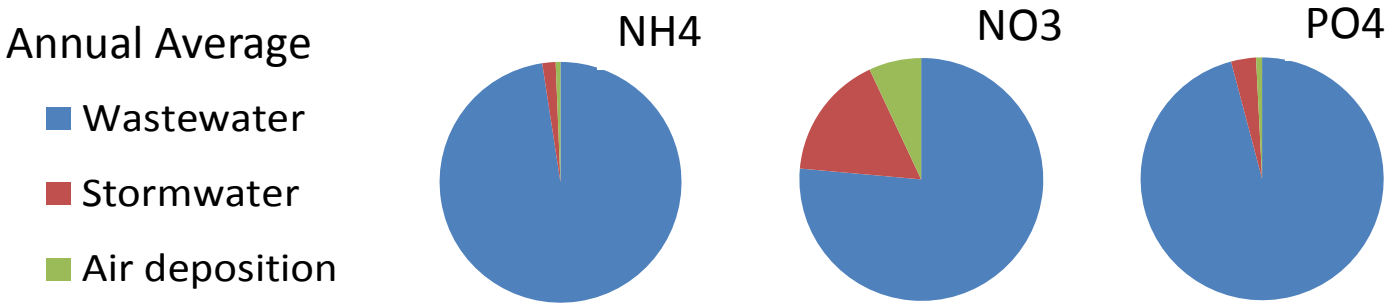
McKee et al., 2011
C. Foe, pers. comm.

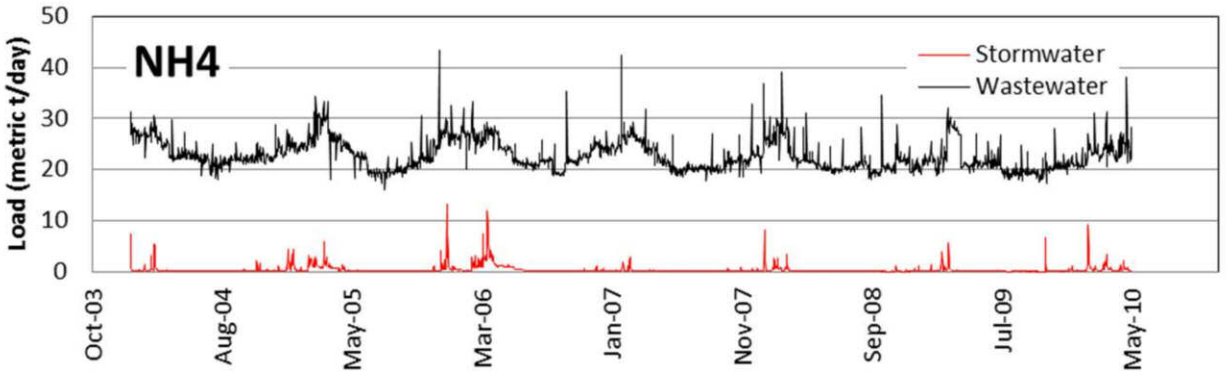
Nutrient load estimates to the South Bay

McKee and Gluchowski (2011)

Key Findings

- Wastewater dominance (occasional stormwater dominance for NO_3^-)
- Pronounced seasonality (up to ±25%)
- Large difference in NH4:NO3:PO4 and concentrations between treatment systems
- Limited data on stormwater concentrations





Nutrient load estimates to the South Bay

McKee and Gluchowski (2011)

Priorities for Task 2:

- Expand to entire Bay

- monthly or seasonally (3)

- Additional consideration of differences in wastewater composition across treatment types, and seasonality of concentrations/loads

- Additional reporting data on flows and nutrient concentrations (?)

- Uncertainty estimates on loads (central value ± confidence interval estimate)

- Key data/knowledge gaps, and recommendations and prioritizations for addressing these gaps

Task 3 – Management of Nutrient Strategy Development Activities

- Only a modest portion of proposed work will be solicited through RMP

- Need for close coordination between RMP-funded work and the larger Nutrient Strategy
  - fund-raising
  - coordinating expert panel meetings and input
  - stakeholder meetings and coordinating stakeholder input