Nutrient Science and Management Strategy For San Francisco Bay

David Senn
San Francisco Estuary Institute
davids@sfei.org

Outline

- Background: Nutrients in SFB

- Nutrient Strategy at a Glance

- Overview and Approach

- Details of Work Elements

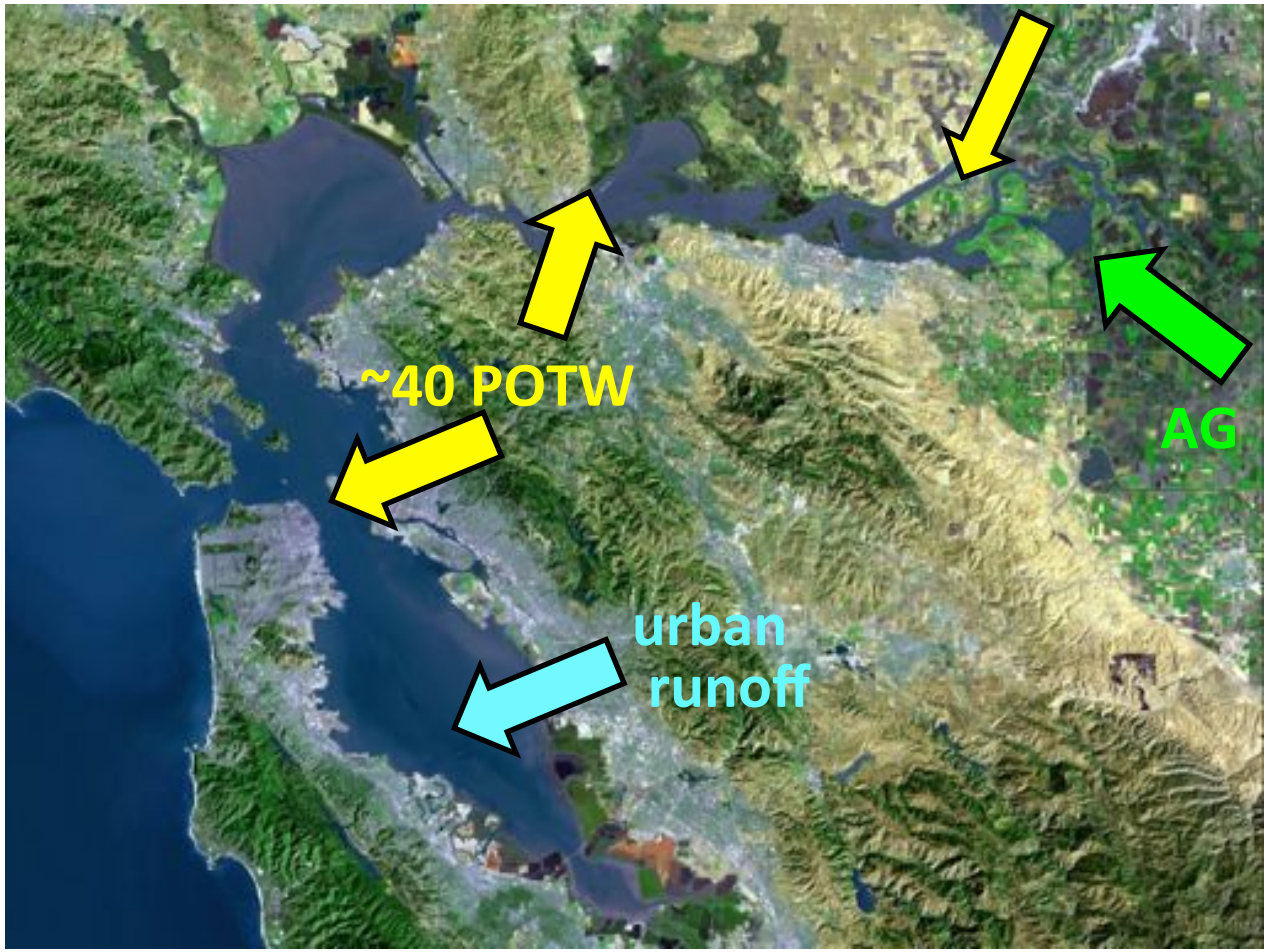
Input from stakeholders…

- Right work elements and tasks identified?

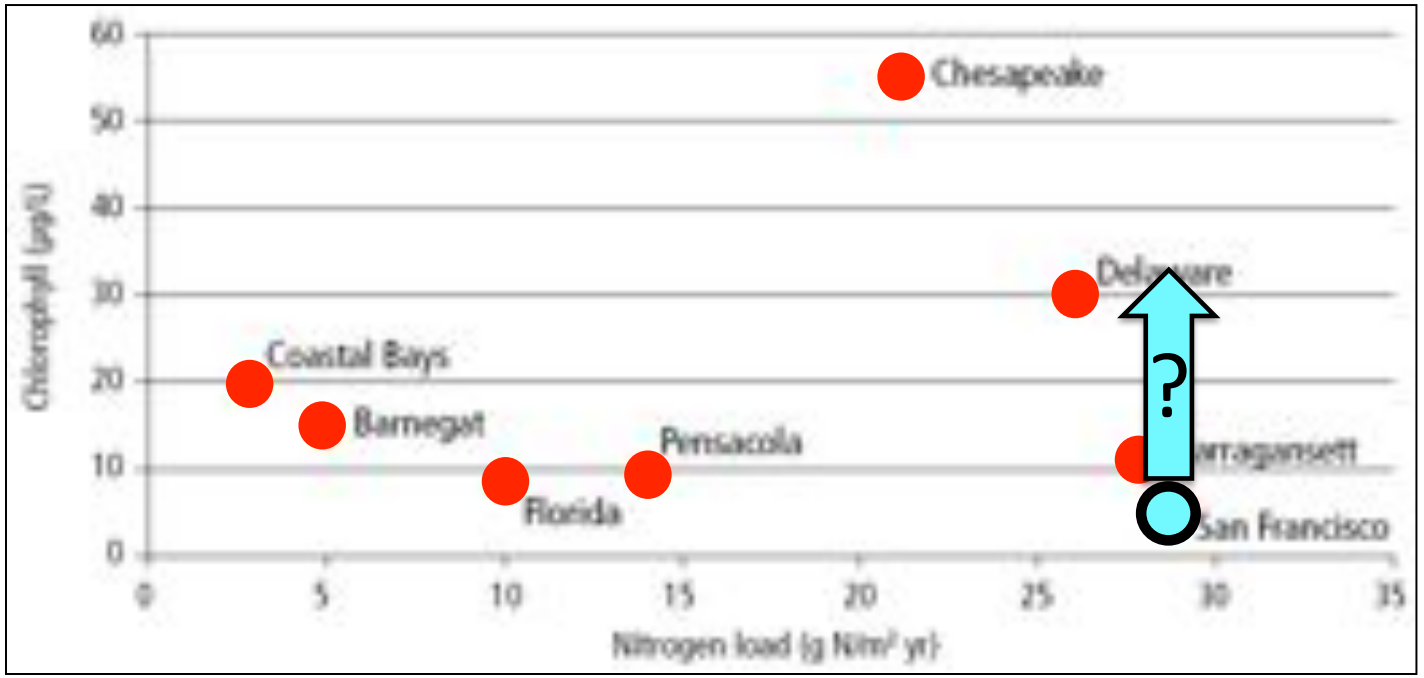
- Questions/comments about process?

- Other?

San Francisco Bay - Large nutrient loads…



San Francisco Bay Paradox



National Estuarine Experts Workgroup (2010)

Resilience of San Francisco Bay

1) High turbidity

2) Strong tidal mixing

3) Filter-feeding clams

} Subject to change?

Need for a Bay-Wide Nutrient Strategy

- Consensus among scientific community: Bay conditions are changing
  - *increasing chl-a, harmful algal blooms, other roles of NH_4^+ (?)*
- Nutrient objectives on the horizon: Nutrient Numeric Endpoint (NNE)
- No regionally-administered water quality monitoring program
  - *uncertain future for USGS research program*
- Numerous entities engaged in nutrient-related work
  - *aligning goals = leveraging resources*
- Draft Nutrient Strategy – RMP Nutrient Workgroup (Sep 2011)

Key Management Questions

Is there a nutrient problem, and how is it defined?

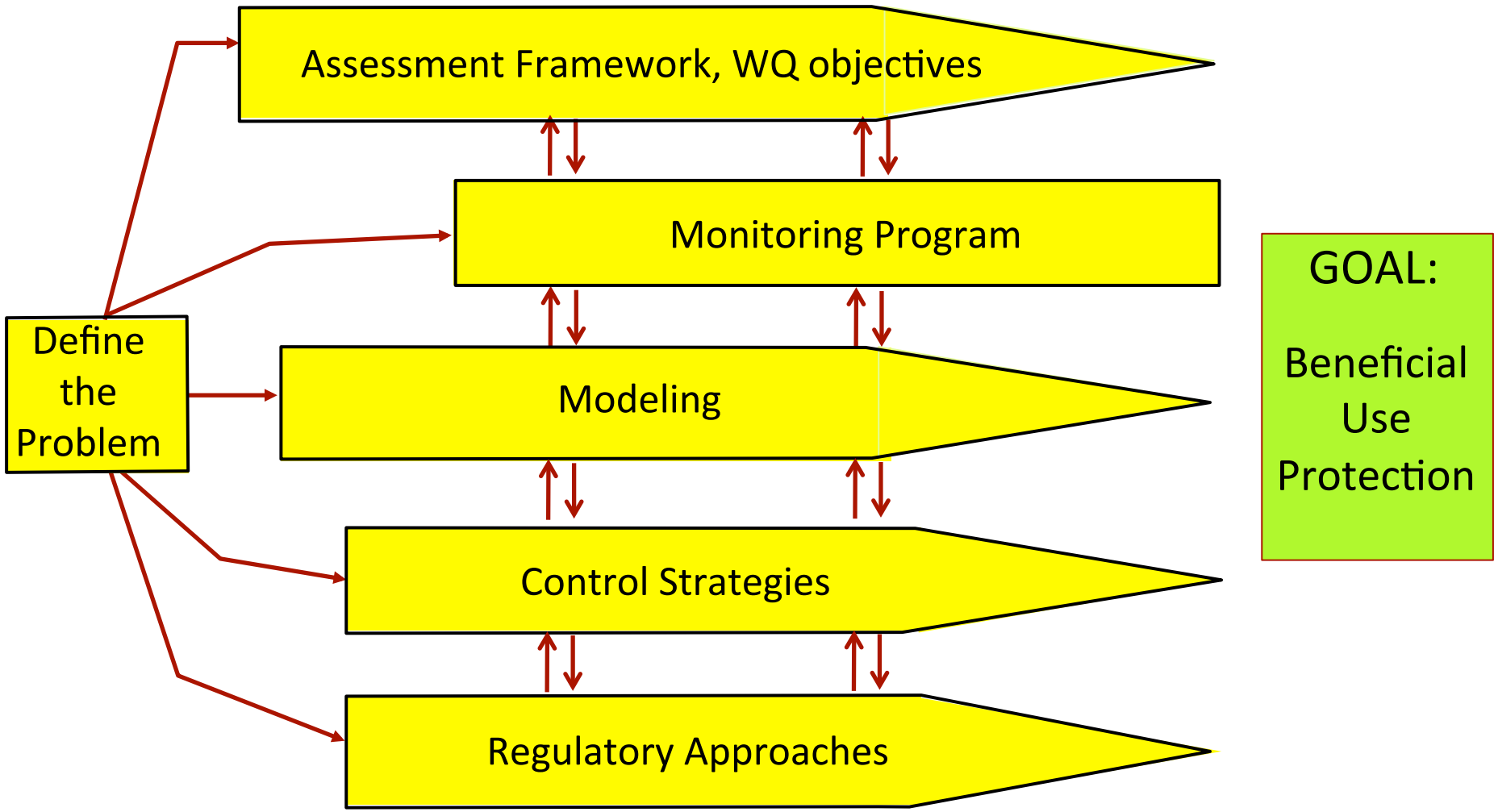
- *Now? Future? Under what scenarios?*
- *In which Bay segments/habitats?*

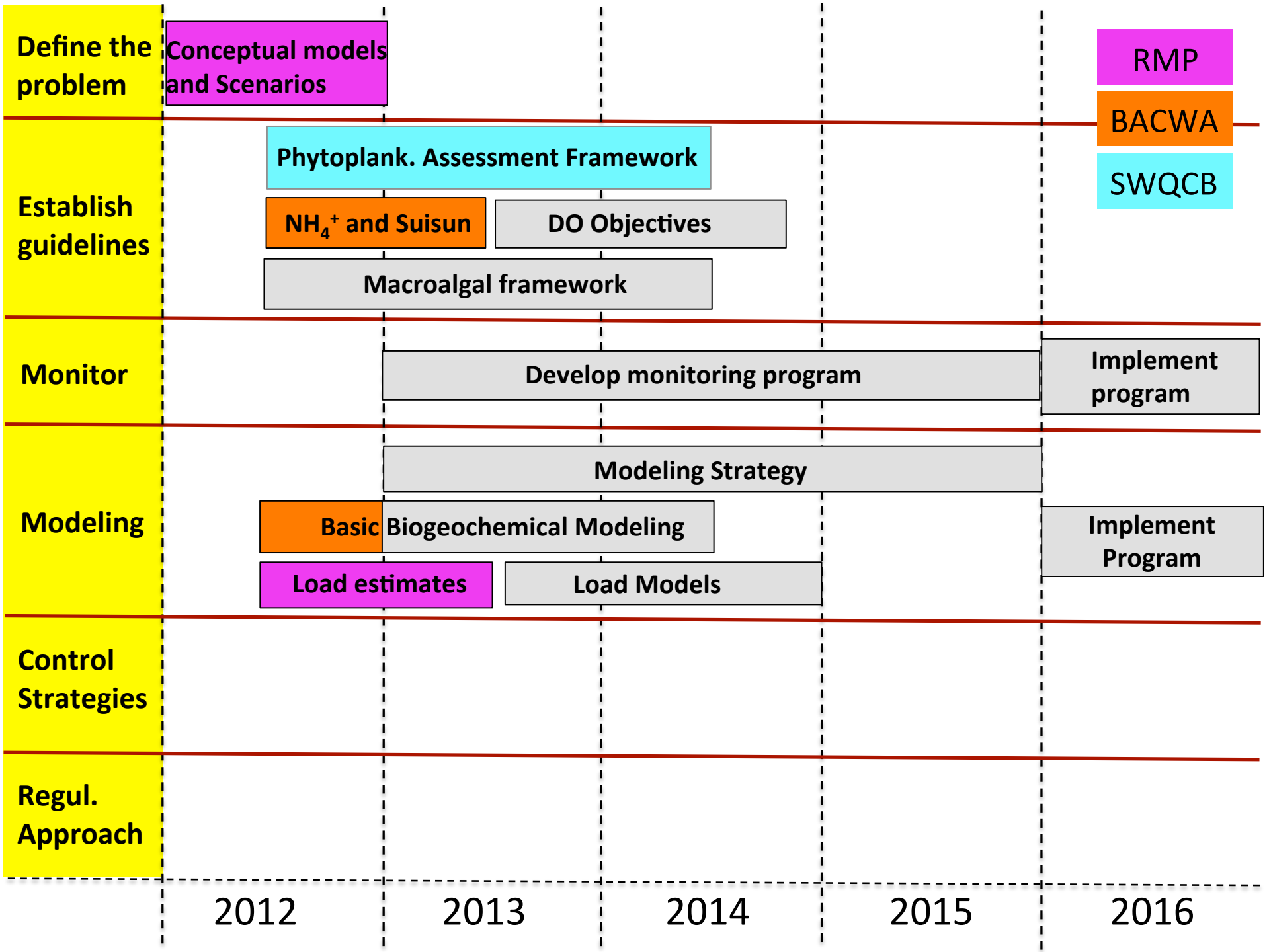
Most important sources, pathways, and processes?

What loads can be assimilated without impairing beneficial uses?

What are appropriate guidelines for identifying a problem?

Draft Nutrient Strategy

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RMP
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Establish guidelines
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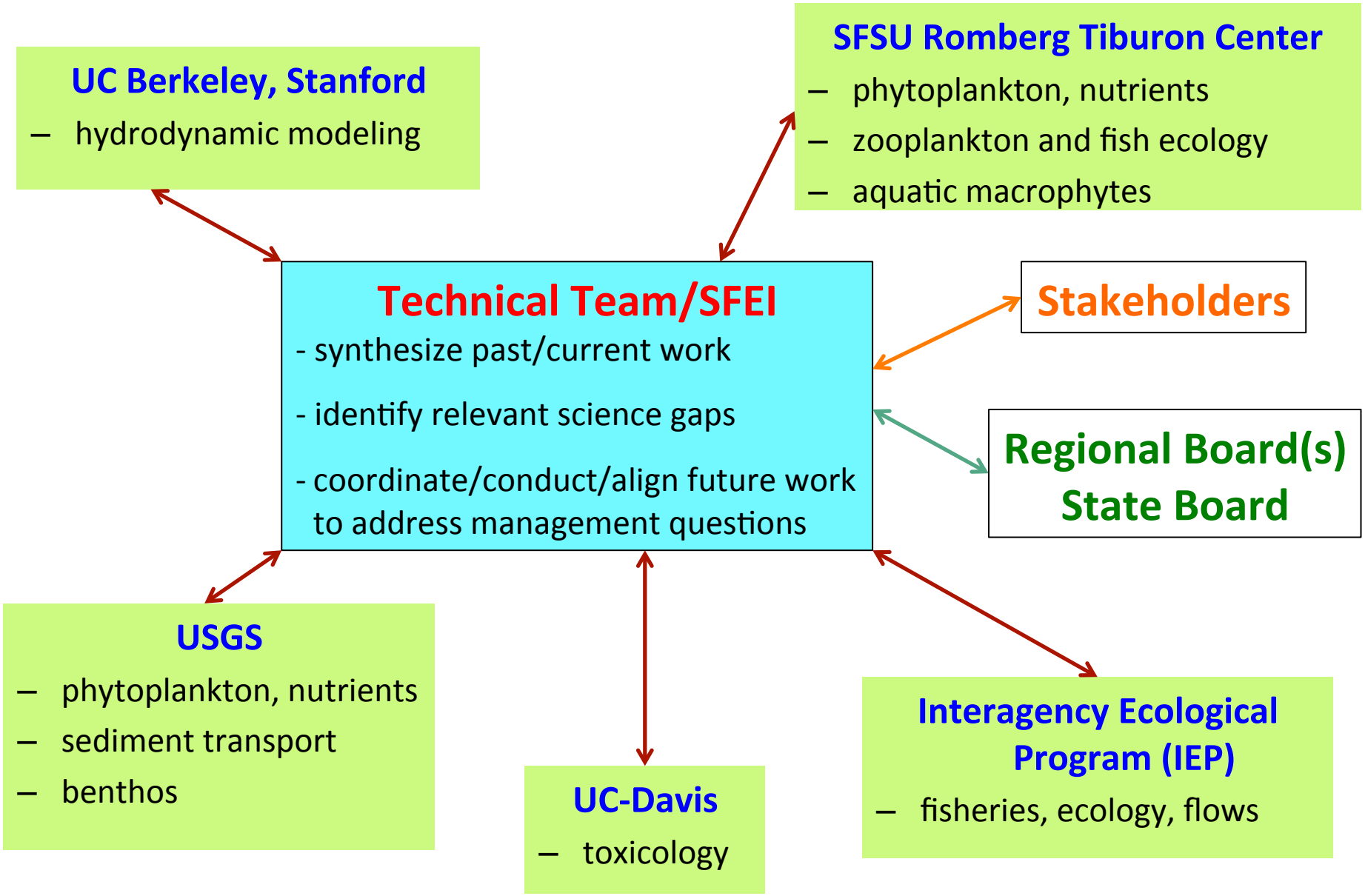
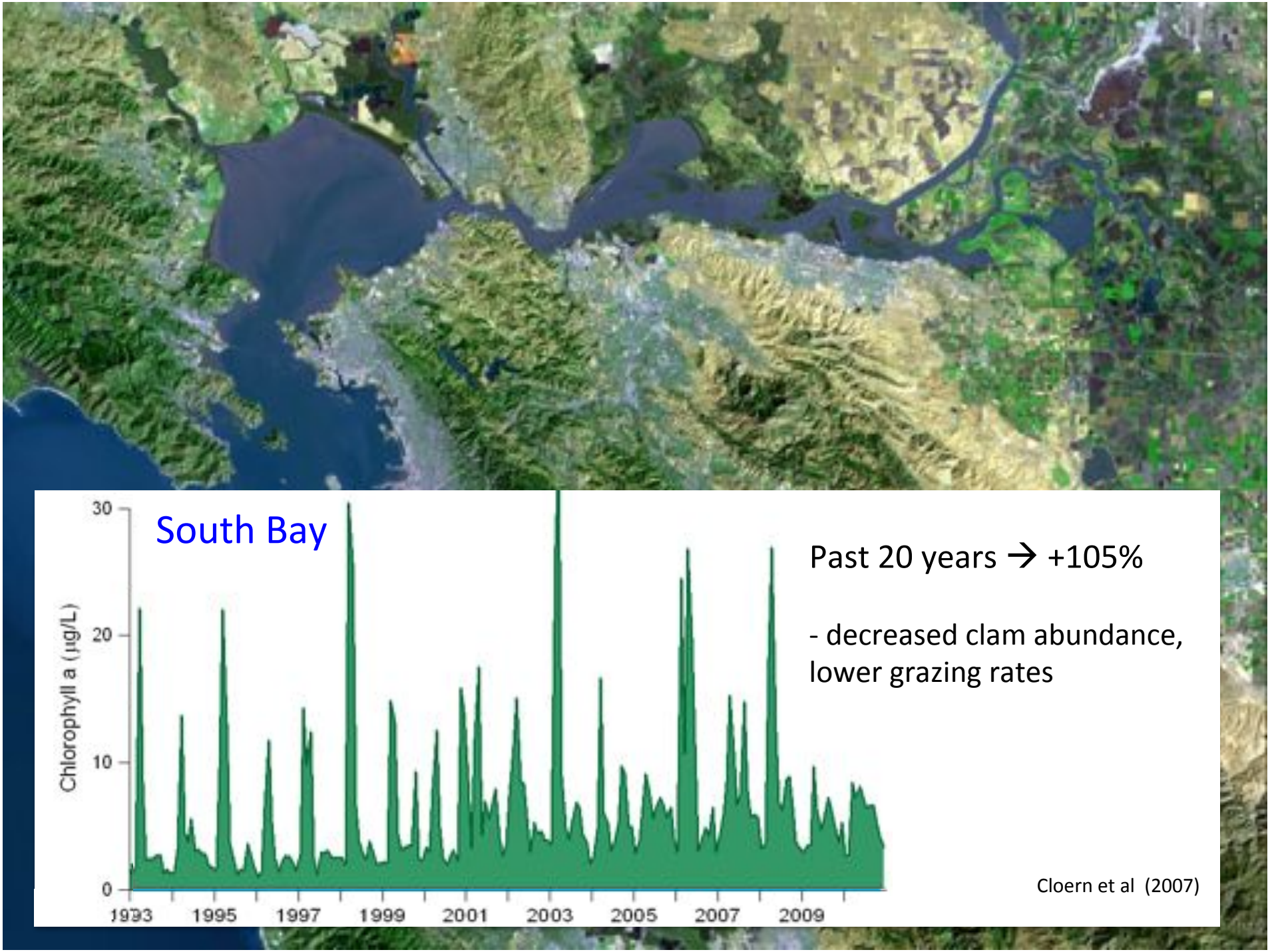
Strong Bay/Delta Research Community



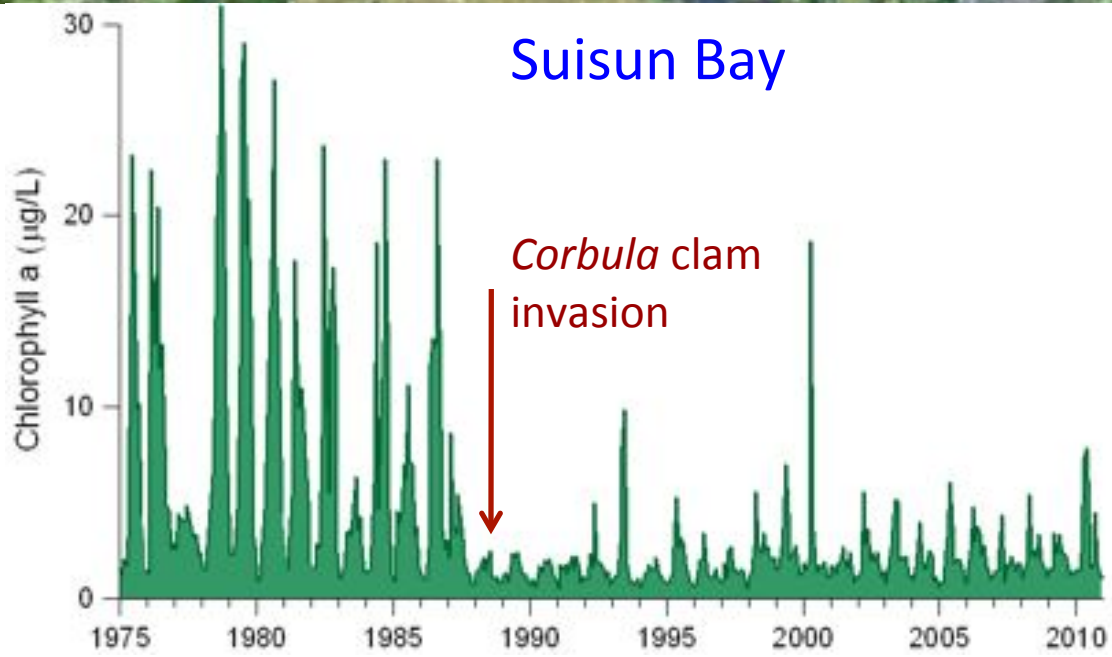

South Bay
Chlorophyll a (µg/L)
30
20
10
0
1993
1995
1997
1999
2001
2003
2005
2007
2009
Past 20 years → +105%
- decreased clam abundance, lower grazing rates
Cloern et al (2007)

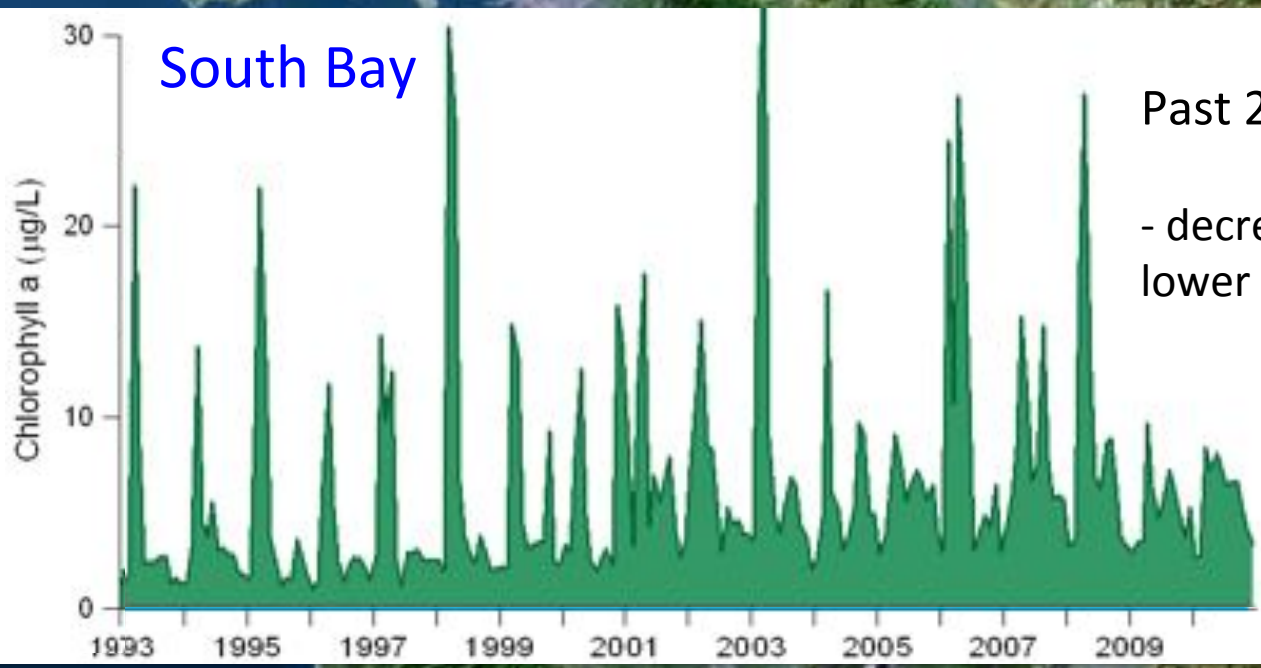
- low Chl-a → food limitation

- Past 20 yrs → +32%

Source: J. Cloern, USGS

- NH_4^+ impacts
  - impairing primary production?
  - toxicity to copepods?





Past 20 years → +105%

- decreased clam abundance, lower grazing rates

Cloern et al (2007)

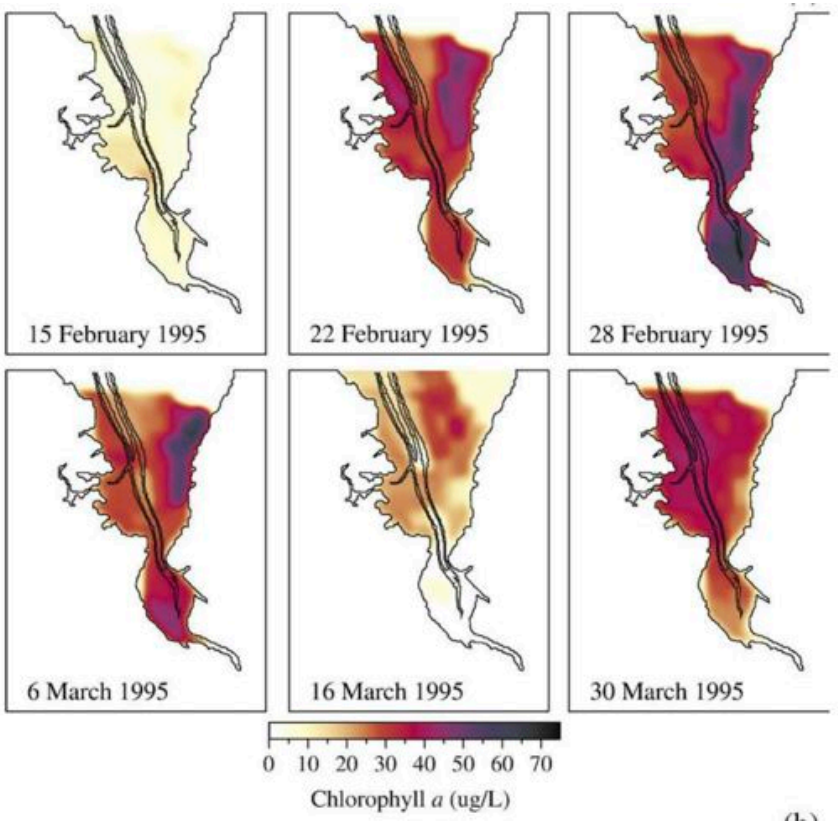
Bloom formation: South Bay

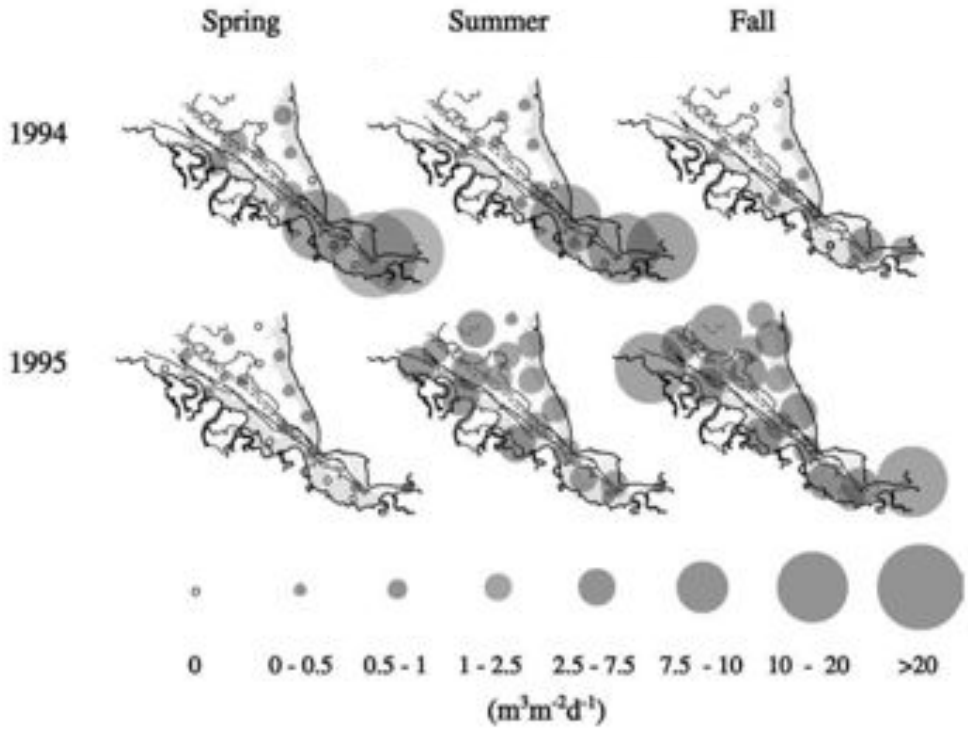
Physics and Benthos

- light limitation

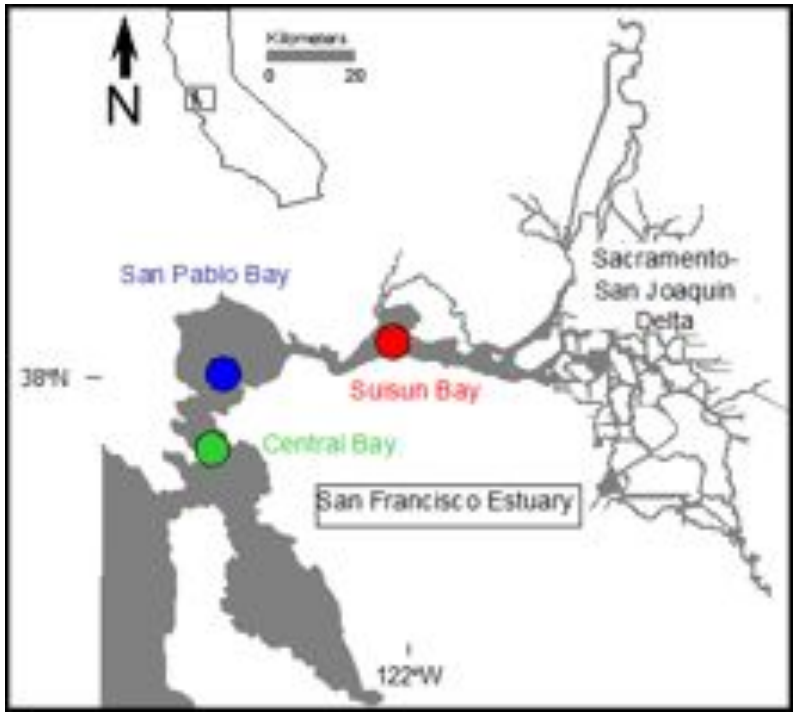
- lateral exchange
  - light-rich shoals
  - light-poor deep subtidal

- seasonal/interannual variations in clam abundance

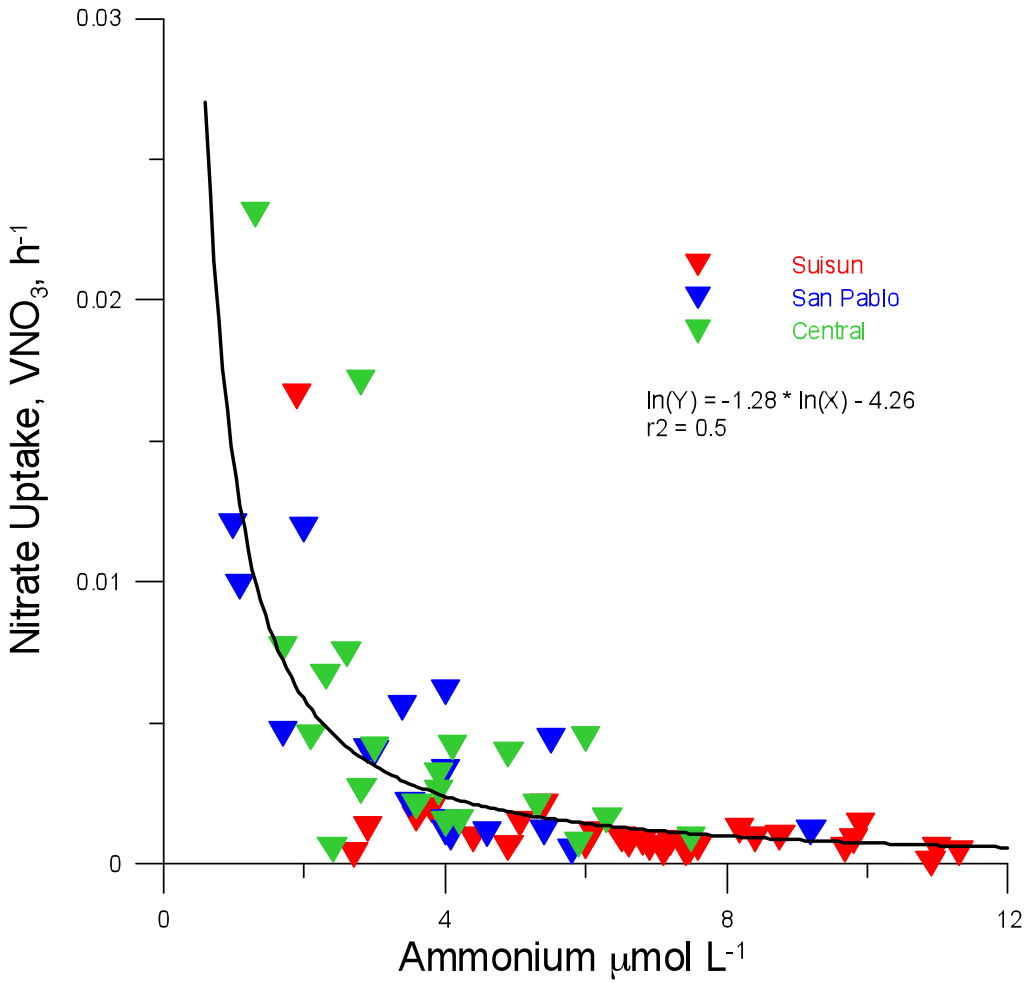




Thompson et al. 2008
Lucas et al., 2008



Evidence of NH4 inhibiting NO3 uptake



Dugdale et al., 2007

Suisun Bay Study (2010-2012)

Objectives:

- Determine if NH4, copper and/or pesticides cause inhibition of primary production (laboratory study – TIE)

- Determine if NH4 conc, specific nutrient ratios, or nitrogen uptake rates are related to a lower rate of primary production (field study)

Researchers/Funding: Region 2, SFSU-RTC, SWAMP, Water Contractors, Central Contra Costa Sanitation District

Other Suisun/Delta Nutrient Studies

Microcystis in the Delta (2011-2014; Parker et al., SFSU-RTC)

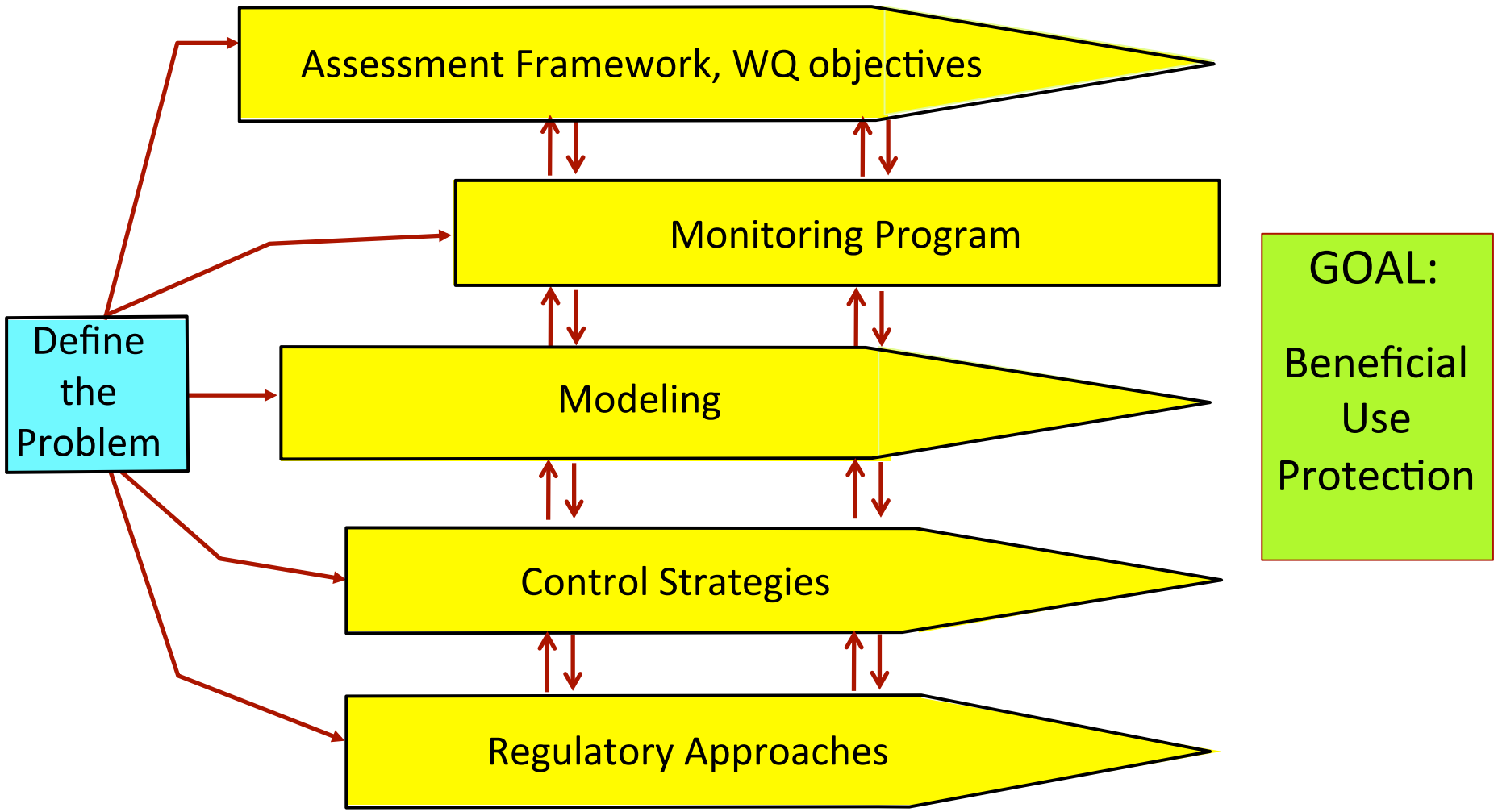
Goal: Determine environmental conditions leading to Microcystis blooms, their toxicity, and their impact on the pelagic food web

Effect of nutrient forms/ratios and light availability on Delta lower food web (2011-2014; Glibert et al. U-Maryland)

Goal: Test the relationship between phytoplankton community composition/production and N and P ratios and chemical form, and light availability

Sediment flux study (2011-2014; Glibert and Cornwell, U-Maryland)

Draft Nutrient Strategy



Problem Definition: Conceptual Models, Scenarios

(2012) RMP

What current problems, or future scenarios, are most concerning?

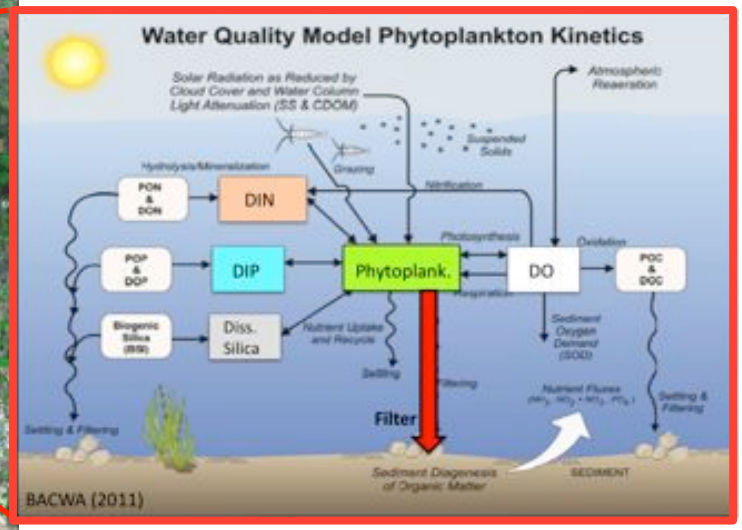
What information do we need to evaluate these problems/scenarios?

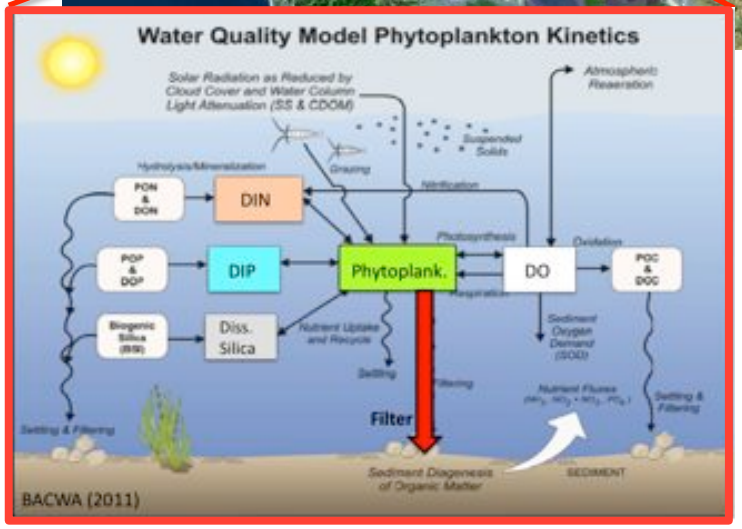
How do we detect current problems or the onset of future problems?

Problem Definition: Conceptual Models, Scenarios

Example Scenarios

- 1% per year decrease in sediment load
- decreased clam abundance
- changing nutrient loads, NH4:NO3, N:P:Si
- drought conditions
- climate change effects

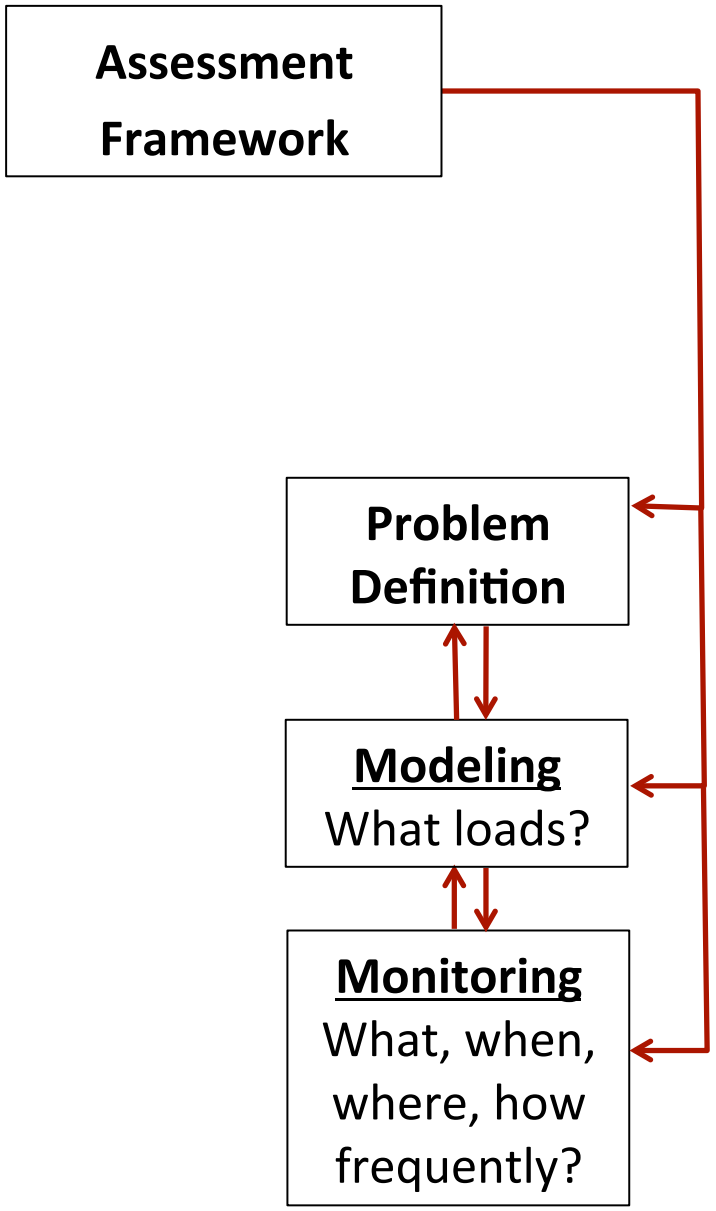




Outcomes

- 'Consensus' statement on nutrient outlook for the Bay
- Critical knowledge gaps and science plan
- Feedback to assessment framework
- Monitoring/Modeling recommendations

Where does the CM fit in overall?



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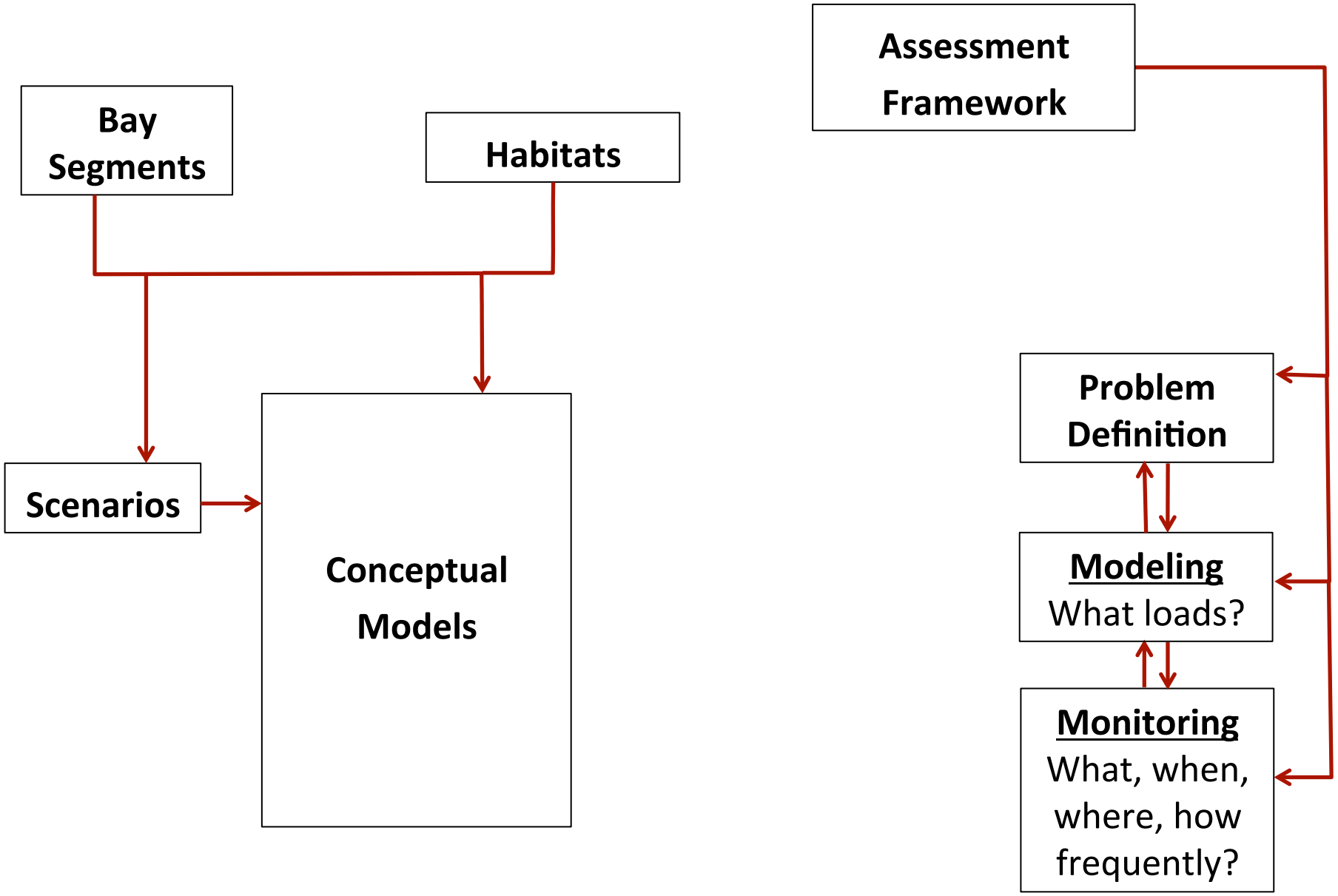

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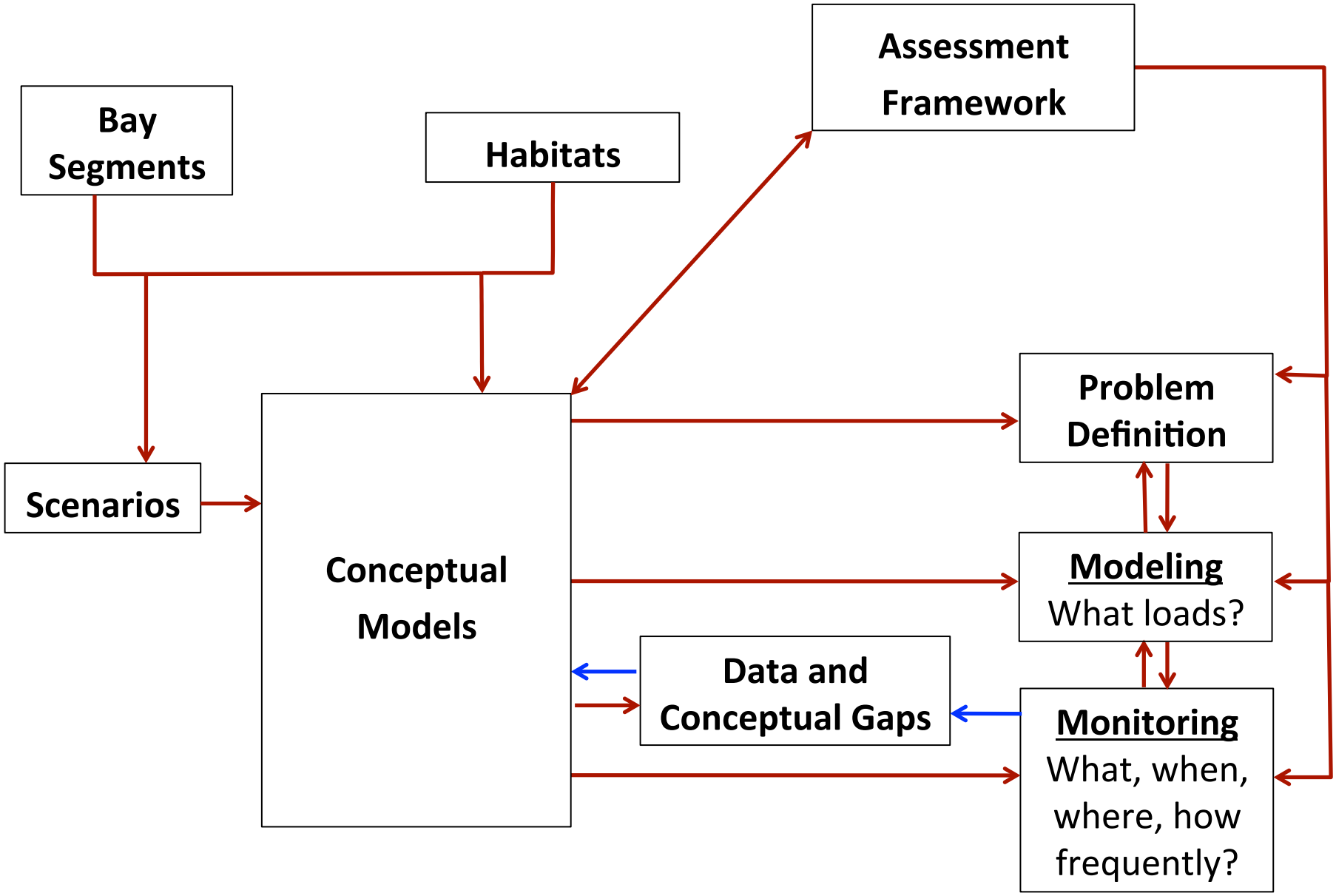
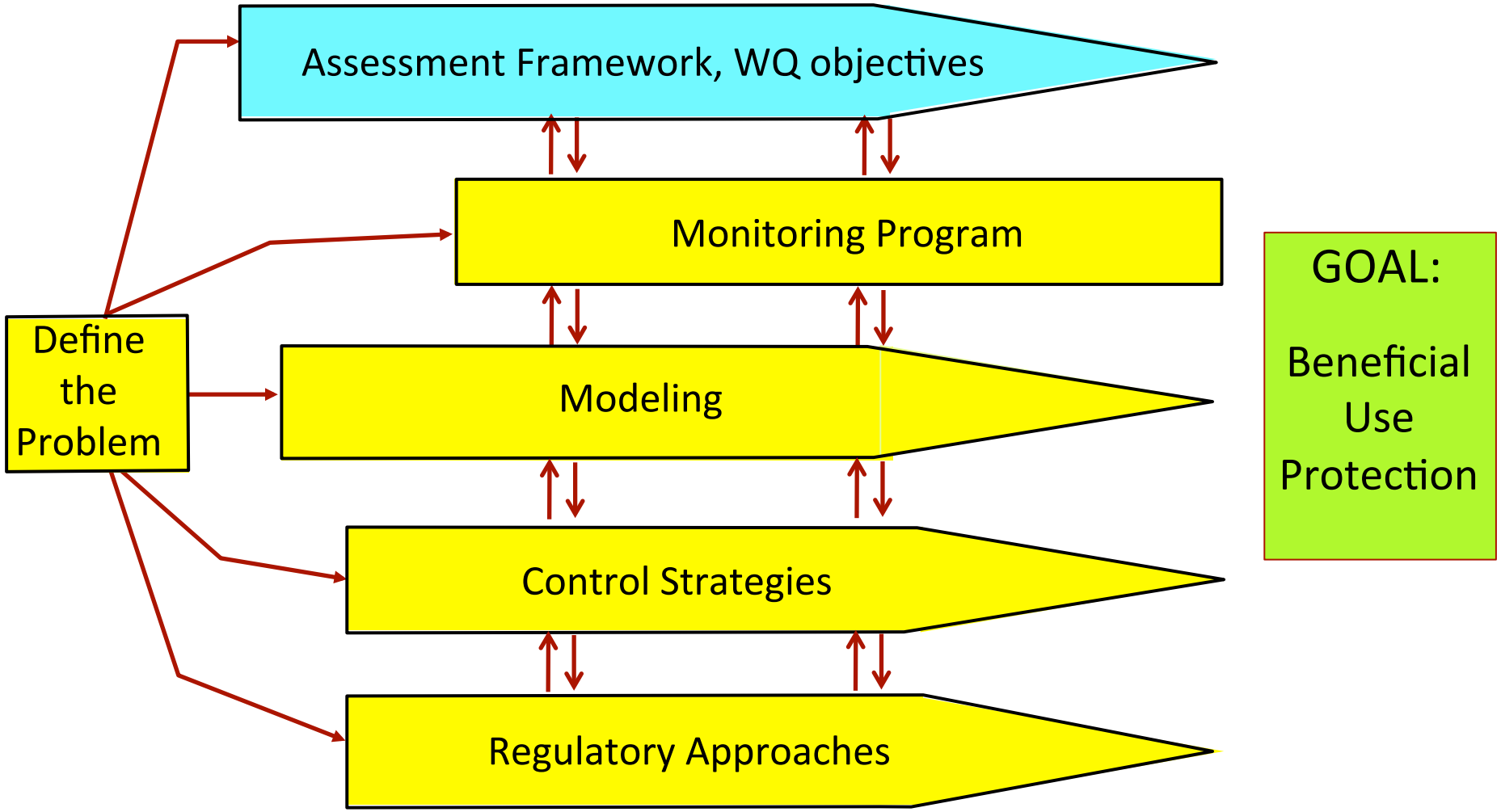


Draft Nutrient Strategy



Phytoplankton Assessment Framework

SWRCB

(2012-2013)

Phytoplankton: leading candidate indicator for assessment of Bay eutrophication

What are the precise measures of phytoplankton that we need to assess ? Biomass ? Assemblage? Harmful algal species?

What are the appropriate thresholds for regulatory action?

What kind of monitoring data are needed to make an assessment?

Phytoplankton Assessment Framework

SWRCB

(2012-2013)

Phytoplankton: leading candidate indicator for assessment of Bay eutrophication

<u>Outcomes</u>

- Transparent decision framework to determine whether regulatory action is required

- Numeric targets that can be used to inform decisions on load allocations

Suisun Bay: evaluating potential impacts of nutrients and NH_4^+

(2012-2015)

Complex management questions

- Pelagic Organism Decline (POD)
- Phytoplankton and zooplankton
  - Decreased abundance
  - Different community composition
- Potential links to nutrients, with specific focus on NH_4^+

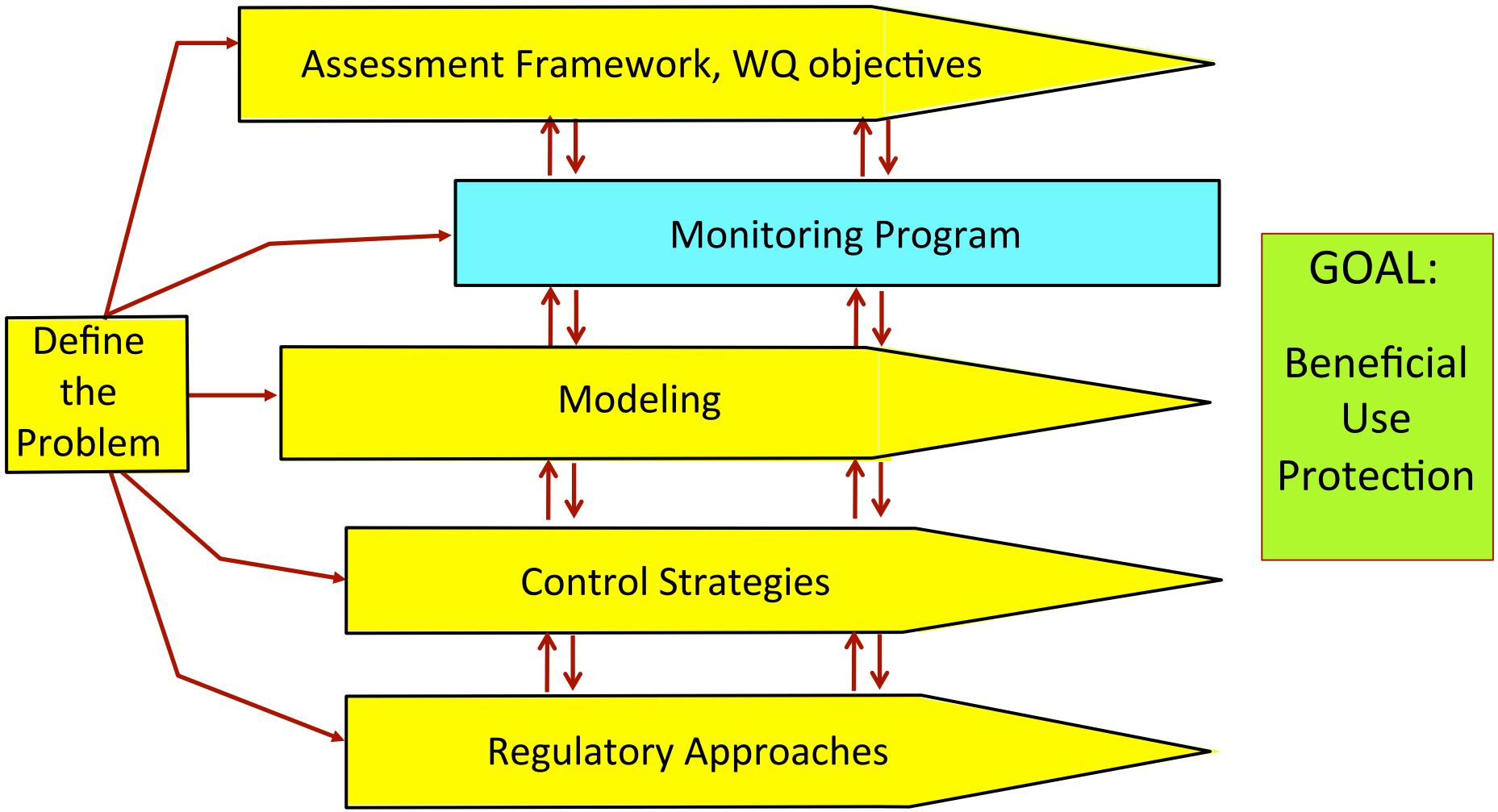
Suisun Bay: evaluating potential impacts of nutrients and NH_4^+

(2012-2015)

Outcomes

- Synthesis – Nutrient/NH_4^+ role in…
  - *altered phytoplankton community composition?*
  - *low primary production rates?*
  - *copepod toxicity*
- Data gaps and future studies

Draft Nutrient Strategy



1969-present

- monthly sampling

- research studies

- RMP support
  -1993-present

● USGS

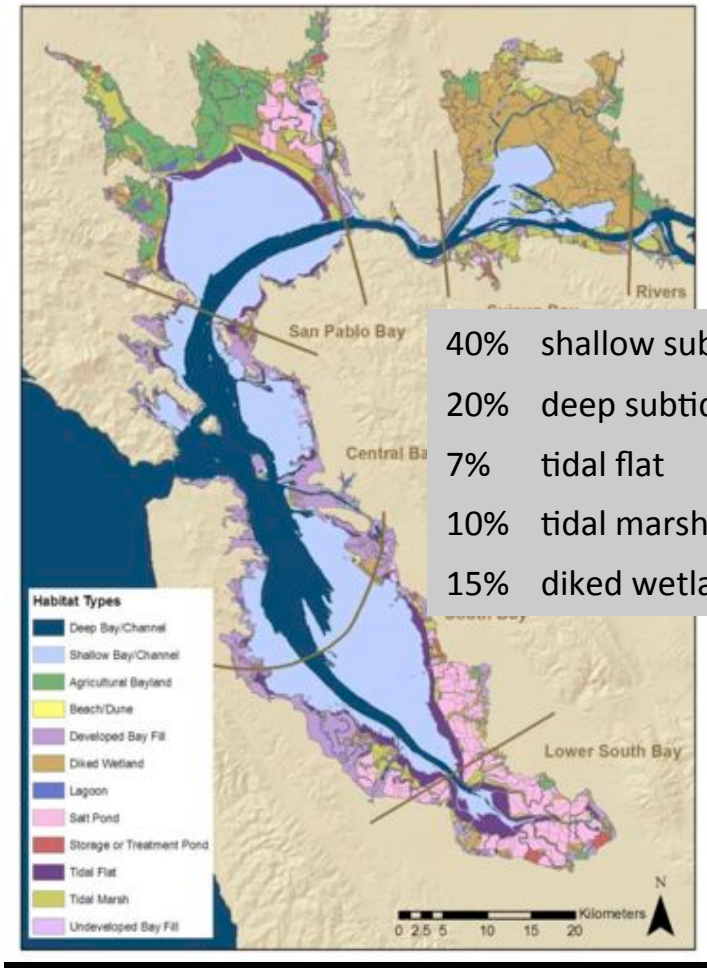
■ IEP

Next Generation…

"Regular" Monitoring

- identify optimal spacing along spine

- complement with moored sensors



40%	shallow subtidal
20%	deep subtidal
7%	tidal flat
10%	tidal marsh
15%	diked wetland

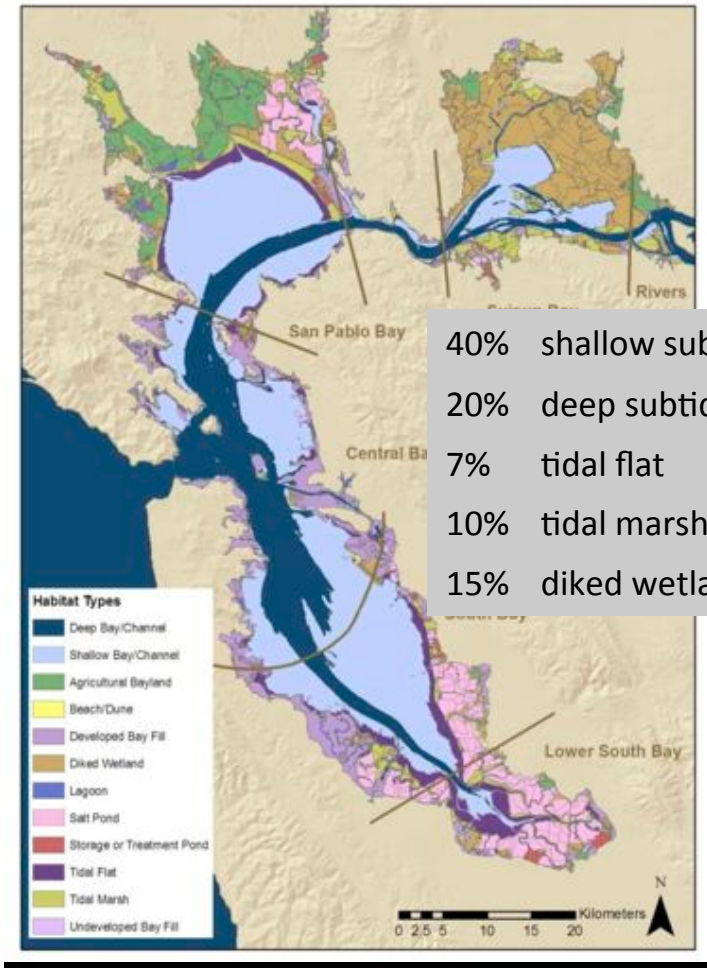
Next Generation…

"Regular" Monitoring

- identify optimal spacing along spine
- complement with moored sensors
- lateral transects

Special studies

- processes, internal cycling
- focus sites/habitats
- exchange across Golden Gate



40%	shallow subtidal
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Parameters

- *Chemical/biological*
  - salinity, T, PAR, nutrients, DO
  - chl-a, phytotoxins
  - phytoplankton composition
  - zooplankton abundance/composition
  - benthos
- *Processes*
  - growth/uptake kinetics
  - denitr., nitrif., oxygen demand
- *Physical*
  - velocities/exchange (ADVs)

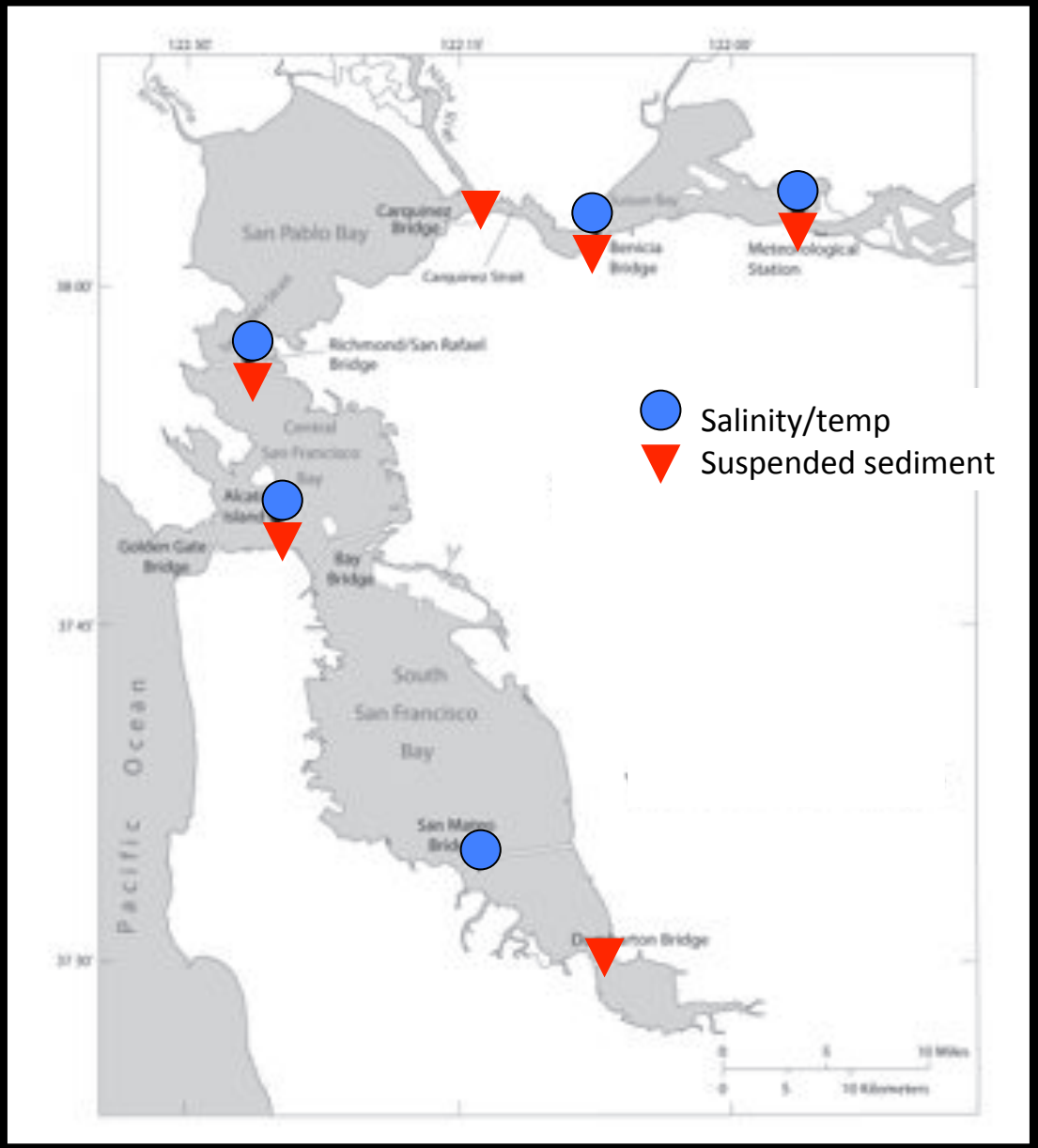
Continuous monitoring

Suspended sediment

- 15 minute interval
- 1991-present
- Funding: RMP & USACE

Salinity/T:

- 15 minute interval
- 1989-present
- Funding: IEP & DWR, USGS



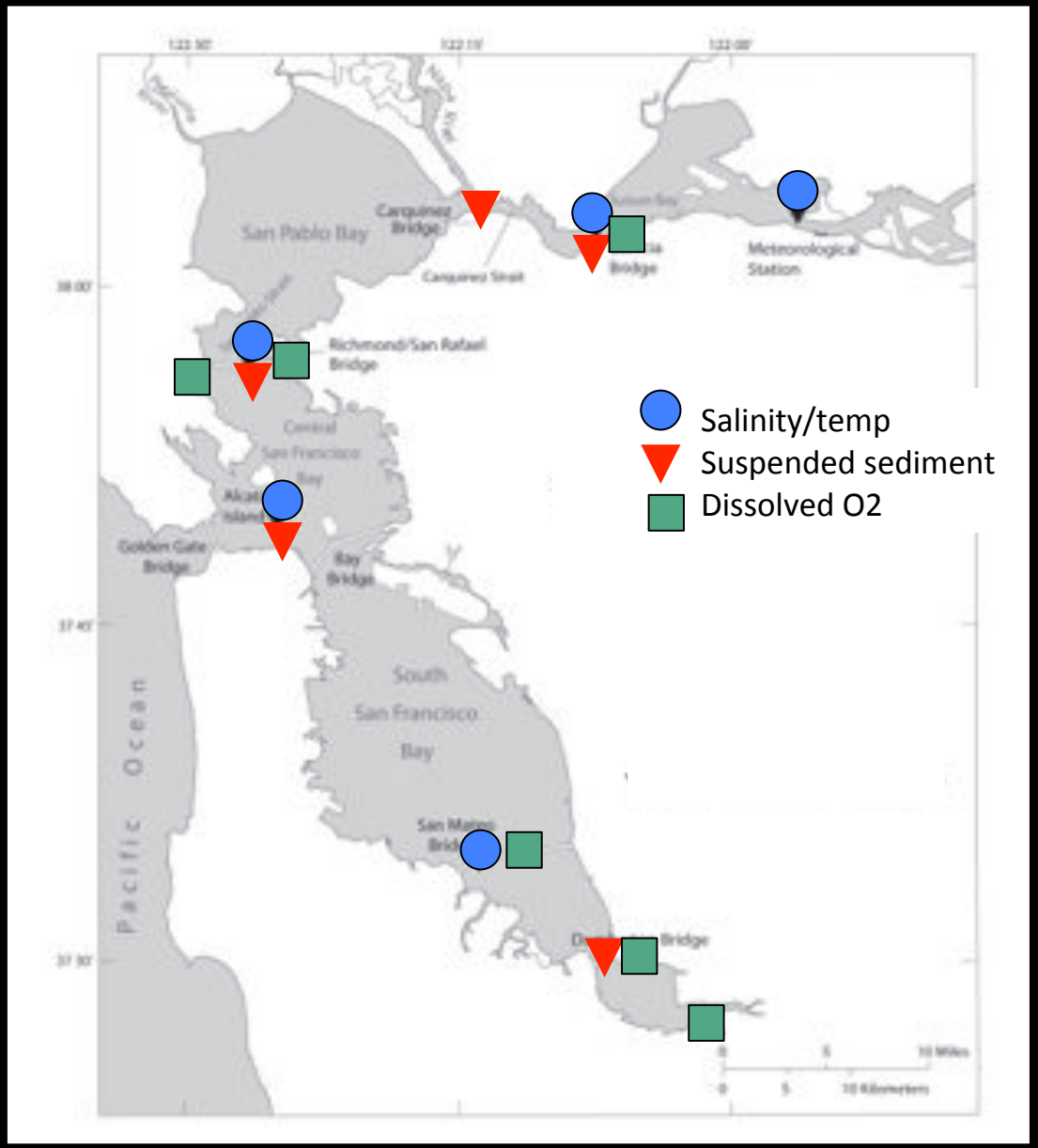
Continuous monitoring

Dissolved Oxygen

- on the horizon…

What else??

- chl-a ?
- nutrients ?
- flow cytometry ?



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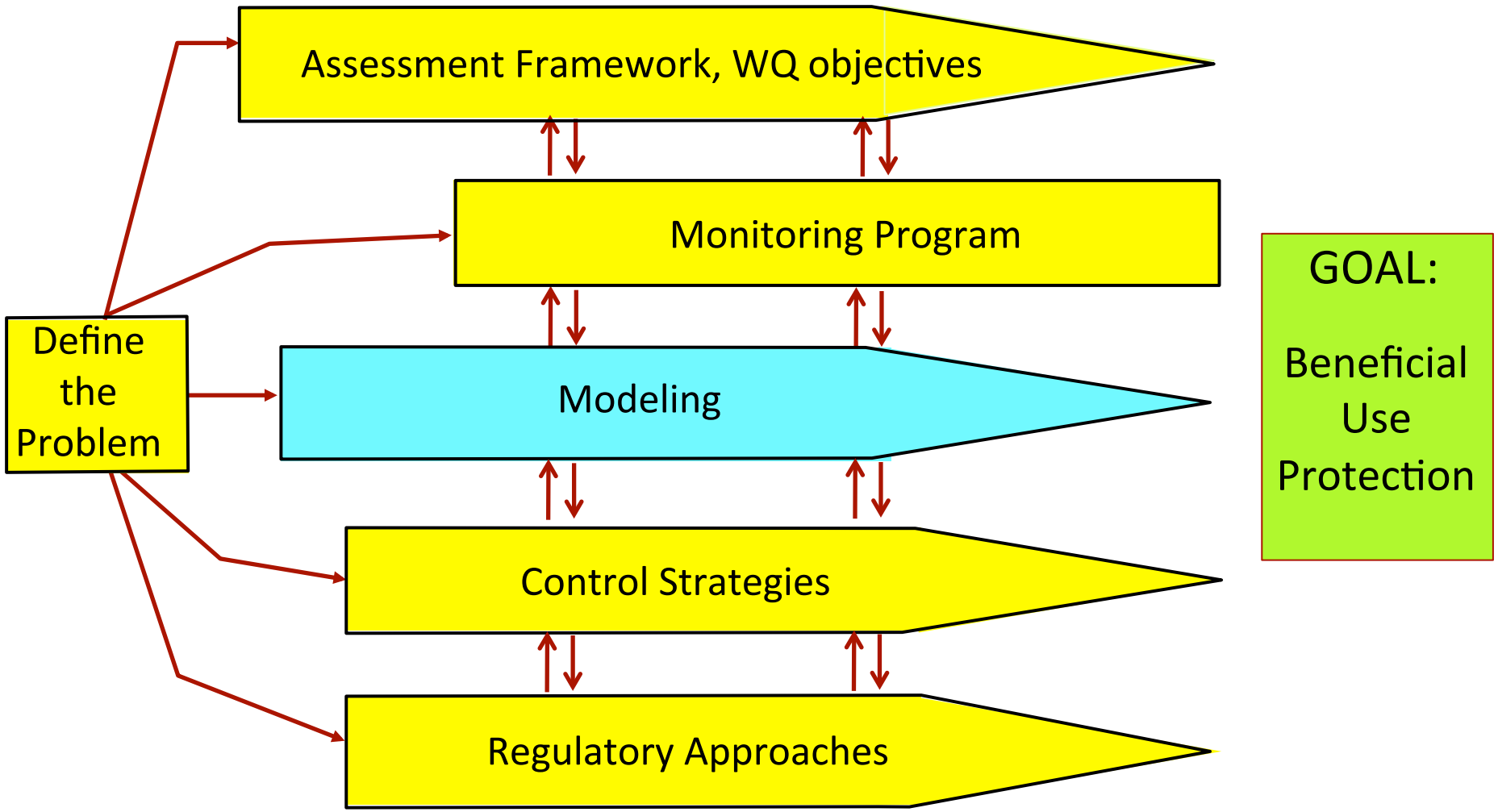
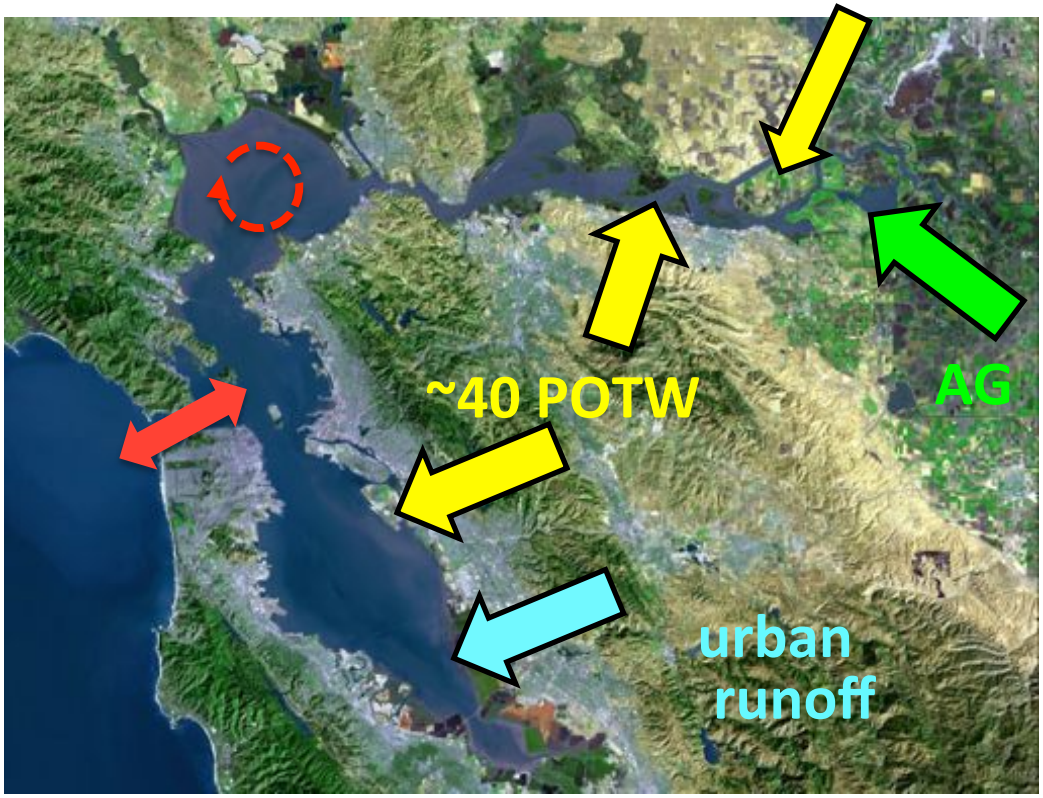


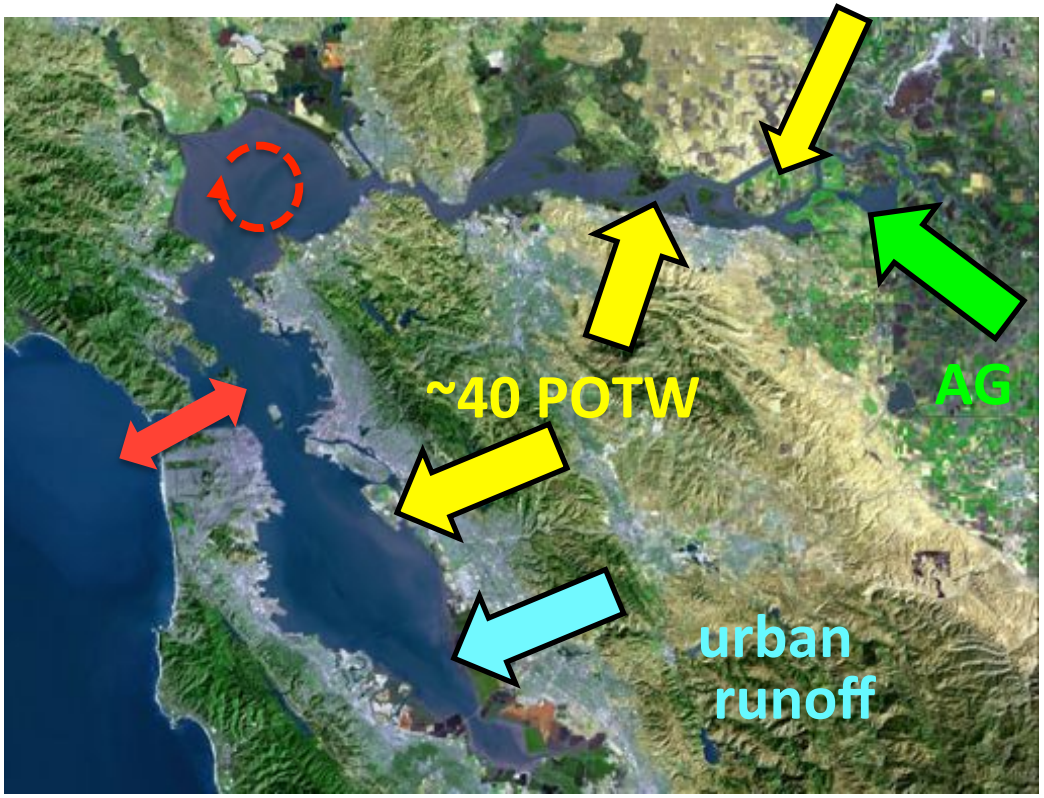
Assess Nutrient Loads to the Bay

(2012-2013) RMP



- Assess major nutrient loads (and composition)
- Characterize variations in space and time
- Identify major uncertainties and data gaps, future work

Assess Nutrient Loads to the Bay



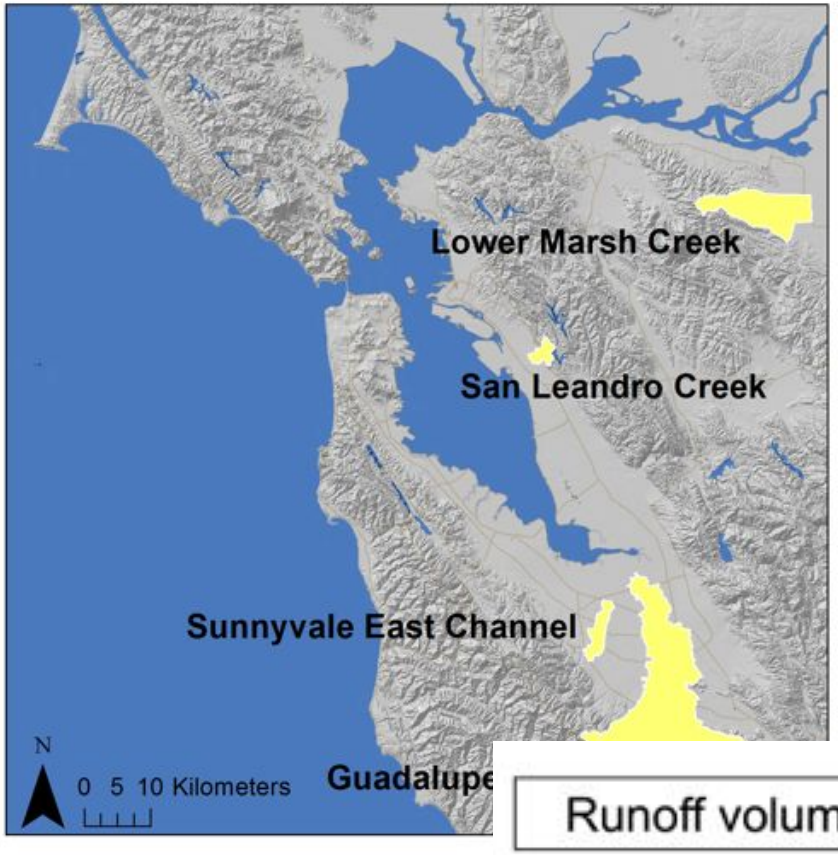
Very Rough Numbers

	Tons DIN/yr
Bay POTWs	18,000
SacRegional	5,000
Sac+SJ Rivers (Agriculture*)	5,000
Urban runoff**	1,000

- *Space/time will be important (Bay segments)*
- *POTW effluent characterization*
- *Urban runoff contribution, and Delta inflow*

*Kratzer et al. (2011)

**Gluchowski and McKee (2011)



Current Studies: nutrients

- 4 watersheds in 2012, 4 storms
- 4-6 watersheds in 2013-2014
- contaminants, flow, turbidity
- Added:
  -NO3, NO2, NH4, PO4, TN, TP

Runoff volume* x Concentration = Load

Developing GIS-based "spreadsheet" Regional model

Lent and McKee (2011)

Funding: RMP and BASMAA

Bay/Delta Modeling

- Engaged and top-notch Bay/Delta modeling community

- Multiple platforms, multiple actors, and multiple funders
    - 1D, 2D, 3D
    - Delft3D, UnTRIM, SUNTANS, EFDC
    - limited agreement on “the best model”

- *Strengths*: hydrodynamics and sediment transport

- *Weaknesses*: water quality (nutrients, phytoplankton, D.O.) and contaminant models

Modeling Needs for Nutrient Management

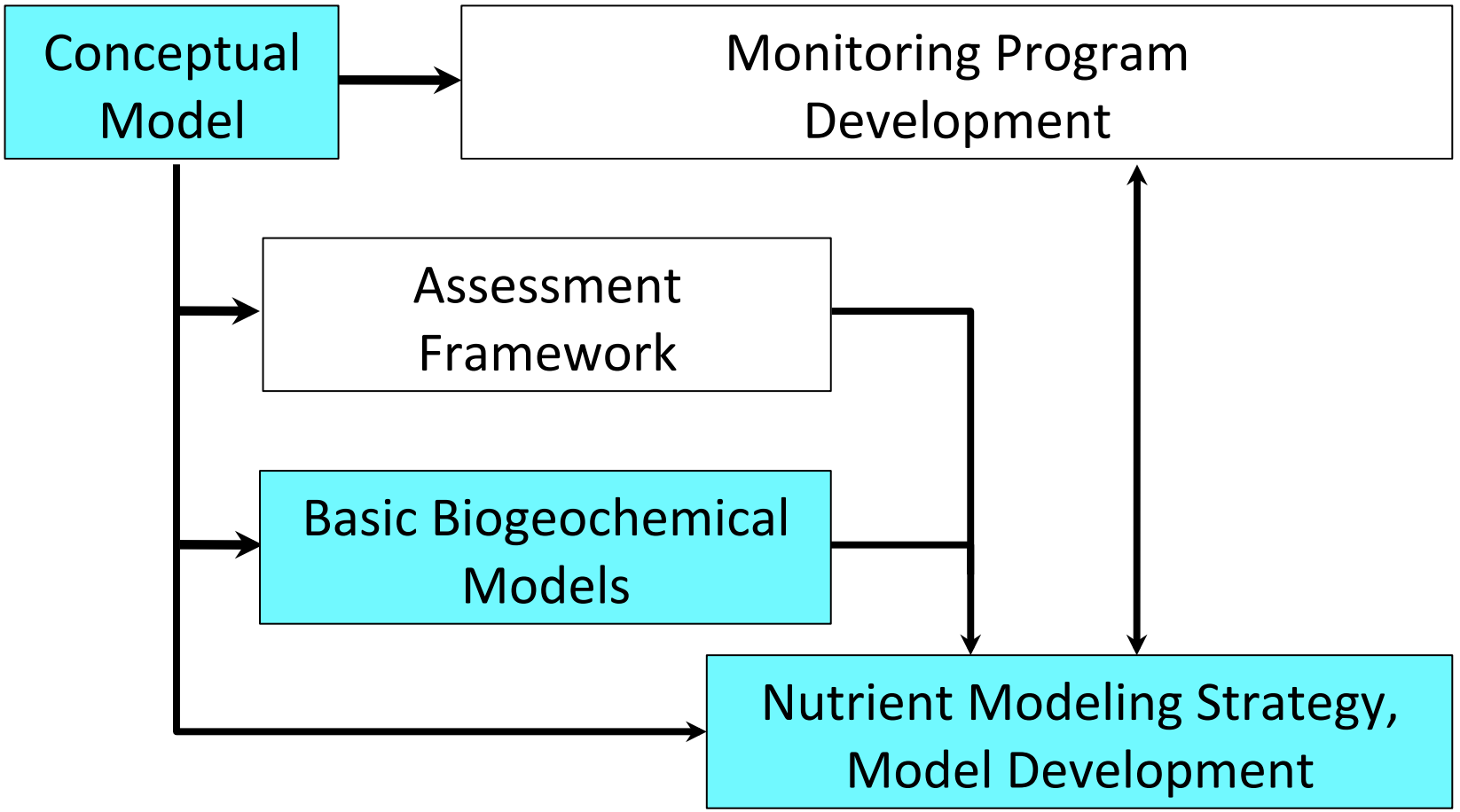
- Goldilocks hydrodynamic model
    - *sufficiently complex, but useable by non-developers*
    - *open-source*

- Development of a WQ/phytoplankton model

- Coupling with coastal ocean model (ROMS)
    - *upwelling and exchange across Golden Gate*

- Compatible (to extent possible) with needs for other contaminants

Staged Approach:



Biogeochemical Models: Suisun Bay, South Bay

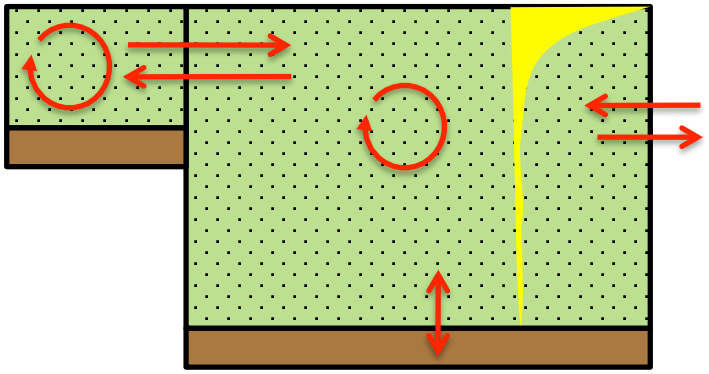
BACWA

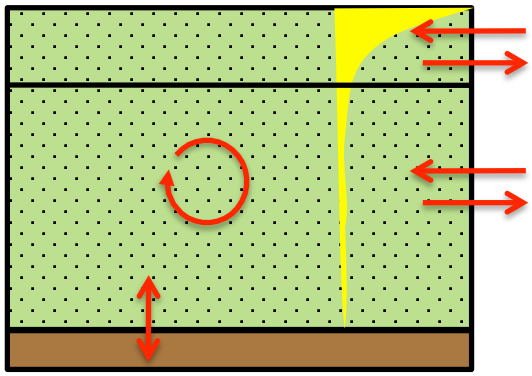
(2012-2014)

- Quantitative data synthesis and nutrient budgets
- Assess relative importance of key processes/drivers
- Sensitivity analysis, identify critical uncertainties and data gaps
- Characterize system response (e.g., chl, O_2) under future scenarios

Biogeochemical Models: Suisun Bay, South Bay

BACWA

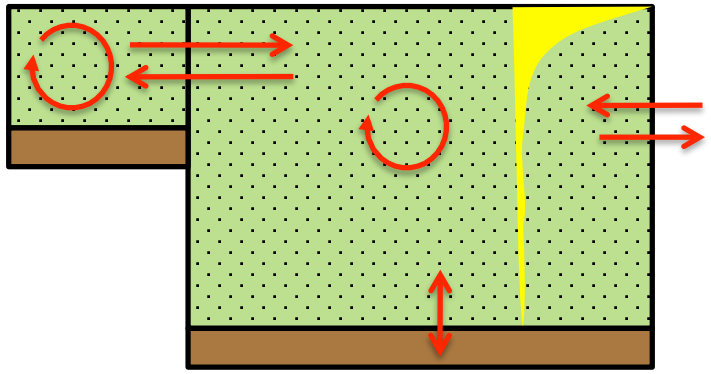


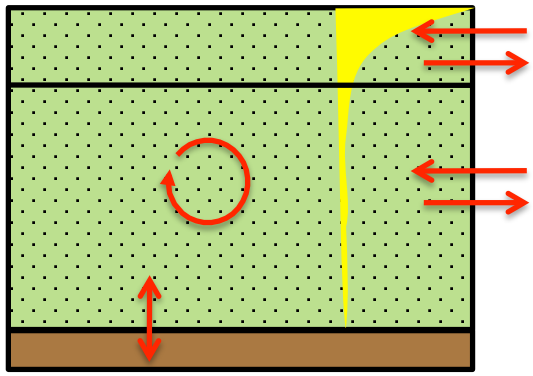


- flow, tidal exchange (t_{res})
- light limitation
- benthic grazing
- potential inhibition of PP by NH_4^+
- budgets: transformations, sources, and sinks

Biogeochemical Models: Suisun Bay, South Bay

BACWA





Outcomes

- Key inputs to advanced modeling
- Relative importance of processes
- Uncertainty/sensitivity analysis
- Knowledge/data gaps
  → field studies, monitoring
- Narrowing scenarios of concern

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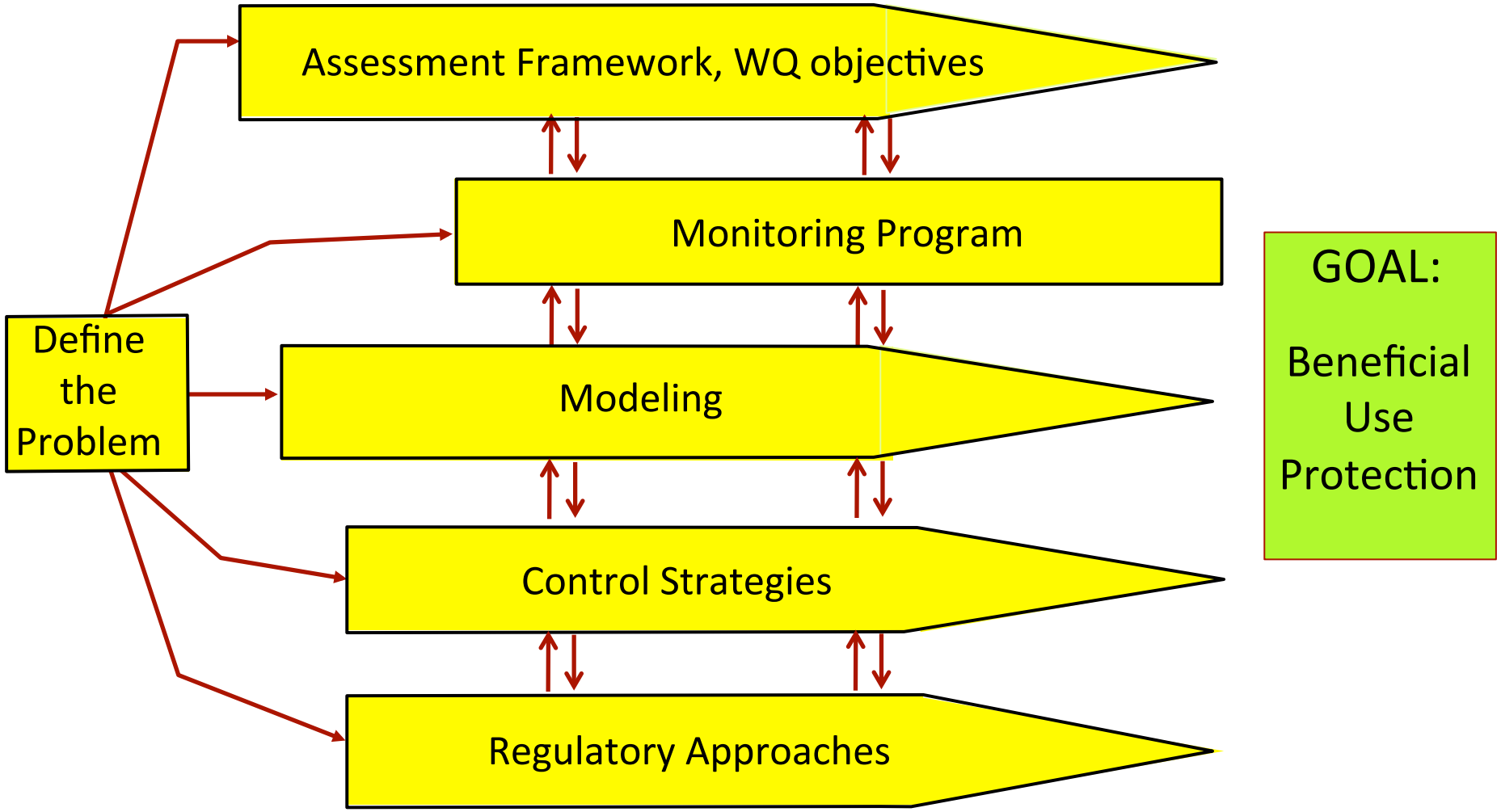
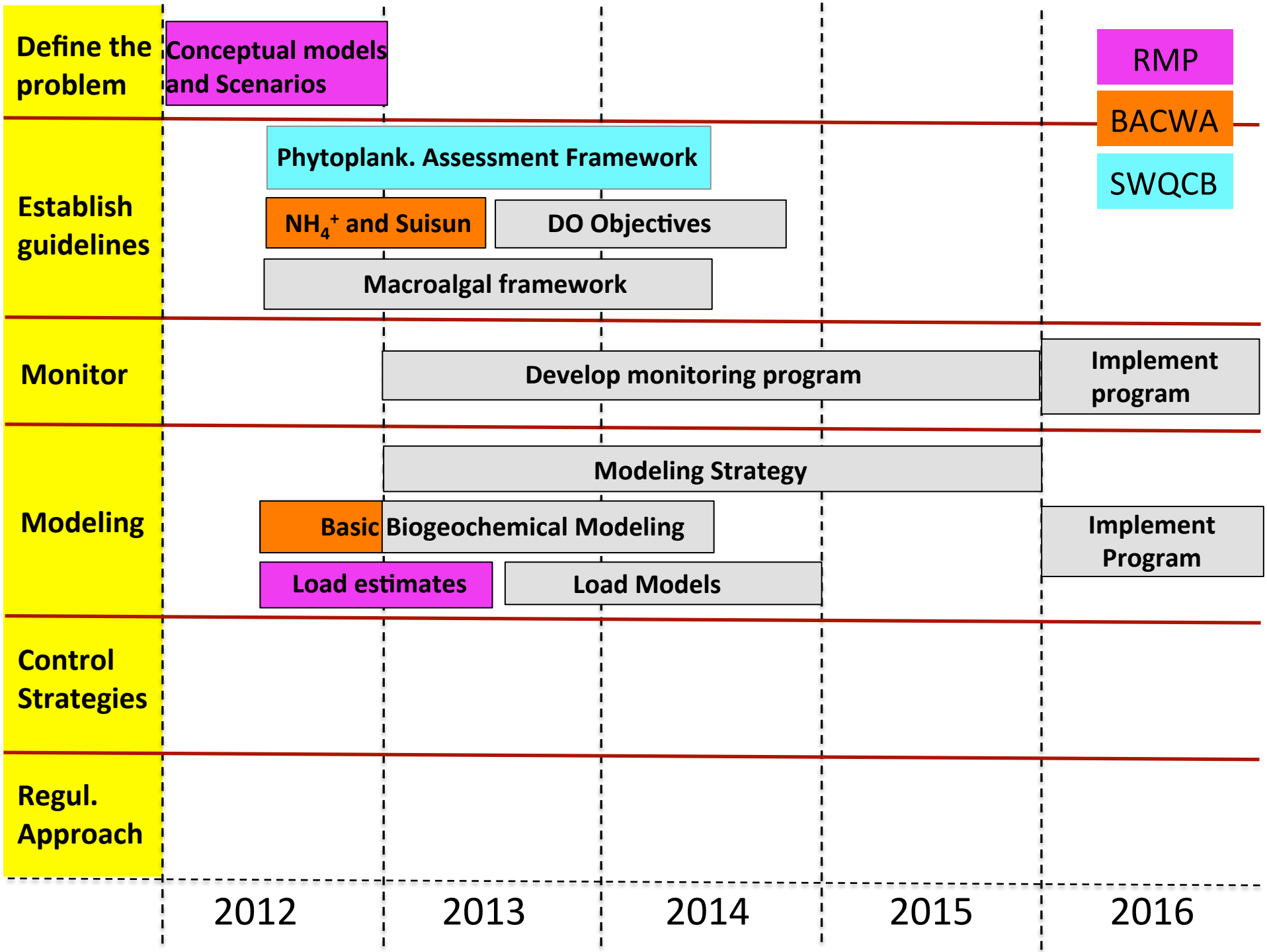
Draft Nutrient Strategy (March 2011)

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#1 – Define the Problem

Goals: **Funding**

1) Conceptual models of nutrient dynamics ☒
   - Bay segments, habitats
   - beneficial uses, indicators, monitoring, modeling

2) Explore scenarios for future changes to key drivers ☒

3) Identify critical knowledge/data gaps/studies ☒ ☐

4) Identify major elements for monitoring ☒ ☐

5) Develop consensus problem statement ☒

#2 – Establish Guidelines

Goal: Develop approaches and recommend guidelines for assessment of beneficial use attainment/impairment

Tasks:	**Funding**
2.1 Phytoplankton NNE Assessment Framework	☒ ☐
2.2 Evaluate need for ammonium objectives	☒ ☐
2.3 Review dissolved oxygen objectives and existing data	☒ ☐
2.4 Macroalgal NNE assessment framework	☐ ☐

#3 – Monitoring Program

Goal: Develop and implement a Bay-wide nutrient/water quality status and trends monitoring program

Tasks: **Funding**

3.1 Develop monitoring program

3.1.a Recommend elements of core program ☐☐

3.1.b Develop Work Plan and QAPP ☐☐

3.1.c Identify special studies ☐☐

3.2 Implement Bay monitoring program ☐☐

#4 – Modeling Program

Goal: Develop/implement a modeling program to inform nutrient management decisions

Tasks:	**Funding**
4.1 External sources	
4.1.a Synthesize existing data, uncertainties/gaps	☒ ☐
4.1.b Load modeling approaches	☐ ☐
4.1.c Load monitoring plan	☐ ☐
4.2 Modeling load-response	
4.2.a Basic biogeochemical models: Suisun/South Bay	☒ ☐
4.2.b Review existing hydrodynamic/WQ platforms	☐ ☐
4.3 Develop modeling strategy	☐ ☐
4.4 Implement modeling strategy	☐ ☐

#5 – Control Strategies

Goal: Explore the various approaches available (e.g., technological) for reducing nutrient loads to the Bay.

Tasks	**Funding**
5.1 Develop work elements	☒
5.x,y,z	☐

#6 – Regulatory Approaches

Goal: Analyze the potential approaches to regulating nutrients, and consider their applicability to the San Francisco Bay setting

	Funding
6.1 Develop work elements	☒
6.x,y,z	☐

Nutrients in San Francisco Bay

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Overview

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Nutrients - With increased Bay water clarity, controls on nutrient concentrations may become necessary to prevent excessive phytoplankton growth (Pulse of the Estuary 2009)

Nutrients, such as phosphorus and nitrogen, are chemicals that plants and animals need to grow and survive. When too many nutrients make their way into waters, they can create conditions that are harmful for fish, crabs, and other underwater life.

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Events

March

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
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18	19	20	21	22	23	24
25	26	27	28	29	30	31

Next steps…

- Work with core group to incorporate feedback and revise
  - *SAG Technical Subcommittee?*

- Prioritize projects and timeline

- Develop funding plan

- Detailed work plans and scopes of work

Schedule:

Final Strategy: Nov 2012

Input from stakeholders…

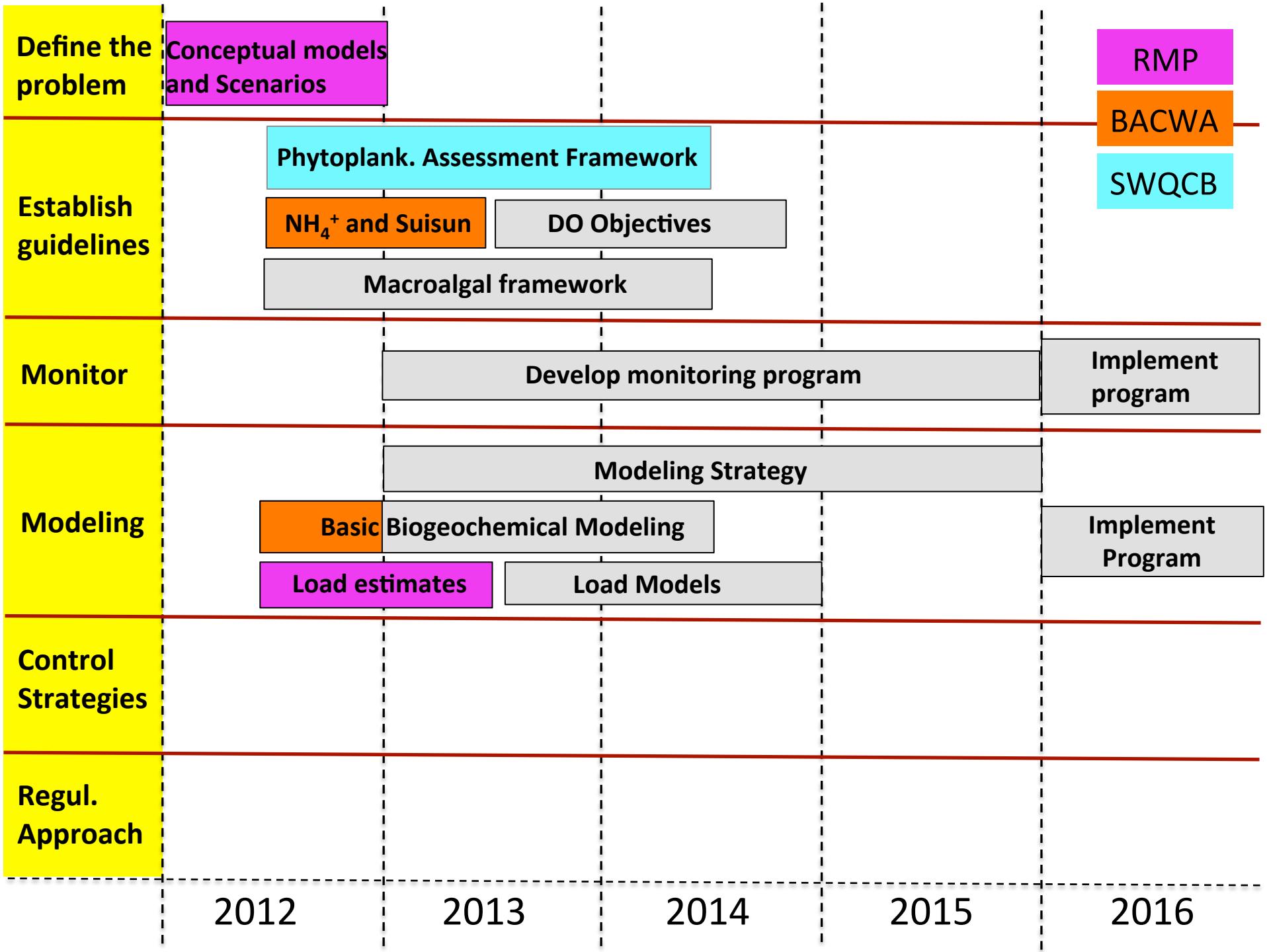
- Right work elements and tasks
- Questions/comments about process?
- Other?

Other opportunities for input…

- 2+ more stakeholder meetings in 2012

- Email comments on draft nutrient strategy:

  davids@sfei.org


Define the problem
Conceptual models and Scenarios
RMP
BACWA
SWQCB
Establish guidelines
Phytoplank. Assessment Framework
NH_4^+ and Suisun
DO Objectives
Macroalgal framework
Monitor
Develop monitoring program
Implement program
Modeling
Modeling Strategy
Basic Biogeochemical Modeling
Implement Program
Load estimates
Load Models
Control Strategies
Regul. Approach
2012
2013
2014
2015
2016

Problem Definition: Conceptual Models, Scenarios

Approach

- Start with two (extreme) Bay segments, and develop approach
    - South of Dumbarton Bridge
    - Suisun Bay

Budget, funding, schedule

- Regional Monitoring Program: $80k
- Draft Report: October 2012
- Final Report: December 2012