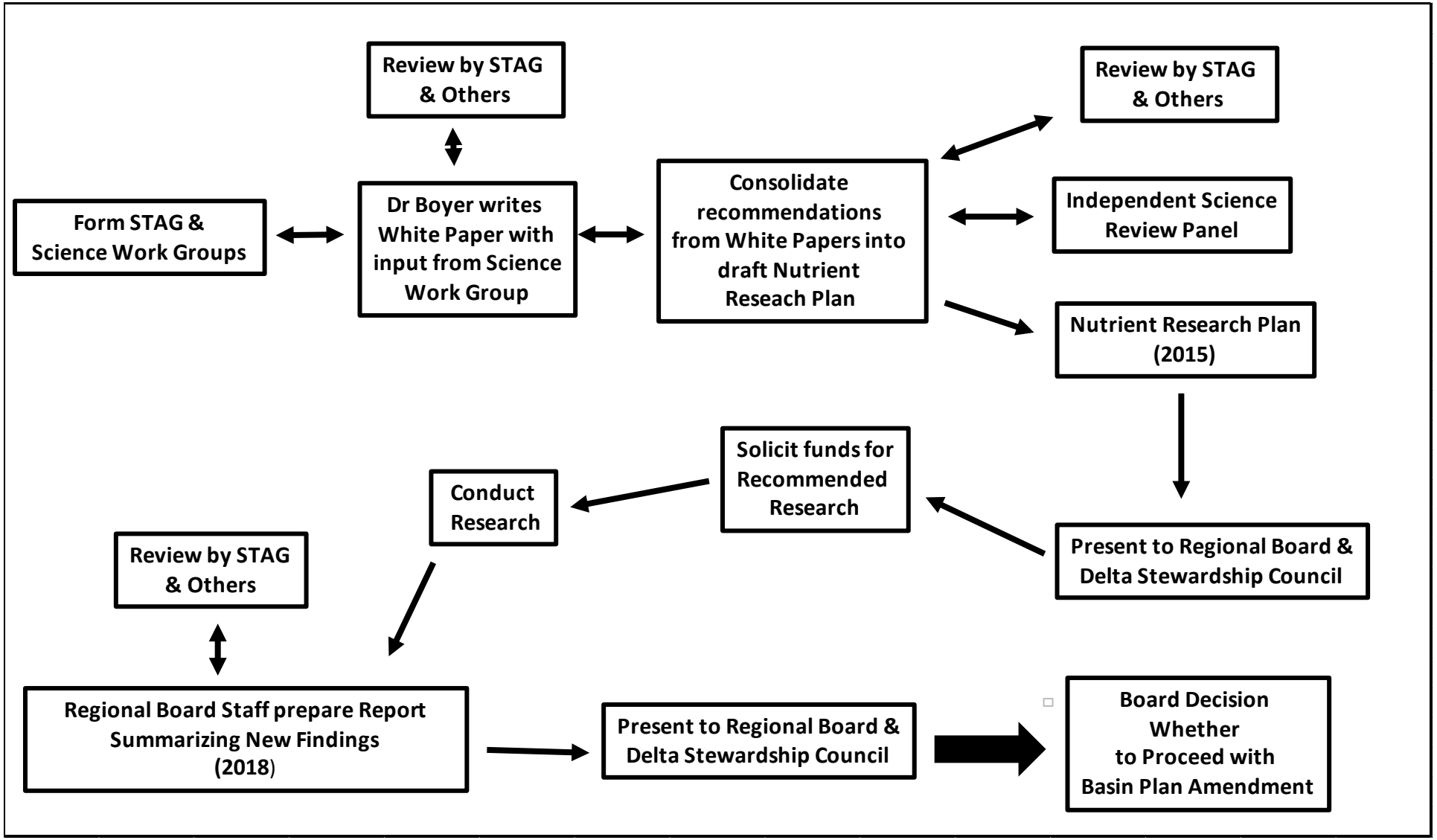
Macrophyte Science Work Group Meeting Agenda

Time	Item	Speaker
10:00 – 10:10	Basic Housekeeping Information 1) Lunch selection (cash only) if you did not bring your own lunch	Christine Joab (Regional Board)
10:10 – 10:30	Introduction, Charge and Meeting Goals 1) Introduce Science Work Group Members 2) Overview of the Charge 3) Review Agenda	Chris Foe (Regional Board) Martha Sutula (SCCWRP) Facilitator
10:30 – 12:00	Presentation of Literature Review Conceptual Model and Findings 1) Discuss review and findings	Katharyn Boyer (SFSU) Martha Sutula (SCCWRP) Facilitator All Science Work Group Members
12:00 – 12:45	Working Lunch	
12:45 – 2:15	Continuation of Feedback on Literature Review 1) Discuss review and findings	Katharyn Boyer (SFSU) Martha Sutula (SCWRP) Facilitator All Science Work Group Members
2:15 –2:30	Break	
2:30 – 3:20	Modeling Discussion 1) Discuss the charge to the Modeling Science Work Group and identify macrophyte modeling questions to inform modeling.	Chris Foe (Regional Board) All Science Work Group Members
3:20 – 4:00	Key Points, Next Steps, and Next Meeting 1) Wrap up discussion with key points 2) Review next steps 3) Discuss next meeting	Martha Sutula (SCCWRP) Facilitator All Science Work Group Members

Macrophyte Science Work Group Meeting
Macrophyte Literature Review

23 April 2015


Review by STAG & Others
Review by STAG & Others
Form STAG & Science Work Groups
Dr Boyer writes White Paper with input from Science Work Group
Consolidate recommendations from White Papers into draft Nutrient Reseach Plan
Independent Science Review Panel
Nutrient Research Plan (2015)
Solicit funds for Recommended Research
Conduct Research
Present to Regional Board & Delta Stewardship Council
Review by STAG & Others
Regional Board Staff prepare Report Summarizing New Findings (2018)
Present to Regional Board & Delta Stewardship Council
Board Decision Whether to Proceed with Basin Plan Amendment

Key Question

- Identify additional studies evaluating the effect of nutrient concentrations, forms or ratios on macrophyte growth rates?

Questions?

Factors Controlling Submersed and Floating Macrophytes in the Delta

Kathy Boyer[1] and Martha Sutula[2]
[1]Romberg Tiburon Center, San Francisco State University
[2]Southern California Coastal Water Research Project

Key Questions:

1) How do SAV and FAV support or adversely affect ecosystem services and related beneficial uses?

2) What is known about the spatial and temporal trends of this vegetation in the Delta?

3) What is the relative importance of nutrients and organic matter accumulation versus other factors in promoting observed trends in SAV and FAV in the Delta?

4) What are the key data gaps and recommended future studies?

Key Question:
What is known about the spatial and temporal trends of this vegetation in the Delta?

(and how did we use this information to focus our review)

Aquatic vegetation found in the Delta:

Table 2.1. Submersed and floating vegetation in the Sacramento-San Joaquin Delta. N = Native, I = Introduced. * Indicates the most abundant introduced and native species, on which this review is focused.

Species	Common name	Submersed/ Floating	N/I
Cabomba caroliniana	Carolina fanwort	Submersed	I
*Egeria densa**	Brazilian waterweed	Submersed[1]	I
*Eichhornia crassipes**	Water hyacinth	Floating	I
Limnobium laevigatum	South American sponge plant	Floating	I
Ludwigia hexapetala	Uruguay water primrose	Floating	I
Ludwigia peploides	Water primrose	Floating	I[2]
Myriophyllum spicatum	Eurasian watermilfoil	Submersed	I
Potamogeton crispus	Crisped or curly-leaf pondweed	Submersed	I
Azolla sp.	Water fern	Floating	N
*Ceratophyllum demersum**	Coontail	Submersed[3]	N
Elodea canadensis	Common waterweed	Submersed	N
Hydrocotyle umbellata	Marsh pennywort	Floating	N
Lemna sp.	Duckweed	Floating	N
Potamogeton foliosus	Leafy pondweed	Submersed	N
Potamogeton nodosus	Long-leaf or American pondweed	Submersed[4]	N
Ruppia maritima	Widgeongrass	Submersed	N
Stuckenia sp.*	Sago and fine-leaf pondweed (+ hybrids?)	Submersed	N

1 *E. densa* is typically rooted but fragments can form floating mats.
2 There is confusion over the identification of native and non-native species of water primrose; this species has been designated as introduced in this review as it has by other authors (e.g., Khanna et al. 2012).
3 *C. demersum* is the one submersed species that is not rooted in the sediment; it often attaches to other plants.
4 *P. nodous* is rooted in the sediment but its leaves float at the surface of the water.

Review focused on four species:

Review focused on four species:

- Submersed
- Typically rooted, but can form detached mats of fragments
- Reproduction entirely vegetative in introduced range
- Throughout Delta in areas of moderate and low flow, along the margins of larger sloughs, in protected areas such as smaller sloughs and breached islands (e.g., Sherman Lake, Franks Tract)
- Present year round
- More than 2000 hectares
- Major subject of control efforts (but only 2% of Delta included)
- Local control effective (spring better), yet expansion

Review focused on four species:

- Free-floating
- Reproduction vegetative as well as sexual (many seeds)
- Throughout Delta in calm waters, but rafts through open waters during windy periods, found along channel edges with more stable flow conditions, or in narrow channels or low flow basins (e.g., marinas, breached island interiors)
- Water depth alone does not limit
- ~200 hectares (1% of Delta)
- Past reports say control effective, but recent large expansion

Review focused on four species:

- Submersed
- Not rooted, free-floating beneath water or can attach to other plants
- Most frequently encountered native species
- Abundant in the west and central Delta in areas of low flow
- Often occurs along with other species
- No Delta-wide estimate of acreage
- Greater abundance in fall indicated by limited studies

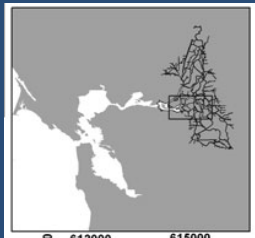
Review focused on four species:

- Submersed
- Primarily vegetative reproduction (rhizome extension)
- *S. pectinata* and *filiformis*? Hybrids?
- Large beds in the west Delta (e.g., Sherman Lake) and along shoals and island shores in open Suisun Bay, in sloughs interior to islands and the Suisun Marsh, present throughout Delta
- Second most frequently found native
- ~350 hectares in Delta and 200 in Suisun
- Expanding during drought
- Largely senescent in winter

Studies evaluating relative abundance

Number of detections, relative frequency (in percent) from point samples, area (ha) and percent cover of the submersed aquatic plant species detected in the Sacramento-San Joaquin River Delta (waterways area is 639.89 ha)

Scientific name	Code	Status	Fall 2007			Summer 2008		
			Detections (%)	Area (ha)	% cover	Detections (%)	Area (ha)	% cover
Egeria densa	EGDE	Non-native	339 (89)	382.49	59.77	300 (69)	99.64	15.6
Cabomba caroliniana	CACA	Non-native	1 (0.3)	NA	NA	36 (8)	1.41	0.2
Myriophyllum spicatum	MYSP	Non-native	32 (8)	68.03	10.6	78 (18)	20.4	3.2
Potamogeton crispus	POCR	Non-native	52 (14)	50.8	7.9	53 (12)	10.03	1.6
Total			424	382.9	59.8	467	174.08	27.2
Ceratophyllum demersum	CEDE	Native	107 (28)	283.77	44.3	180 (41)	59.14	9.2
Potamogeton nodosus	PONO	Native	1 (0.3)	NA	NA	10 (2)	6.04	0.9
Elodea canadensis	ELCA	Native	19 (5)	34.28	5.36	10 (2)	18.29	2.9
Stuckenia spp.	STSPP	Native	24 (6)	73.02	11.4	32 (7)	69.84	10.9
Total			151	294.29	45.9	232	157.04	24.5
Total submersed species			575	388.35	60.7	699	239.6	37.4



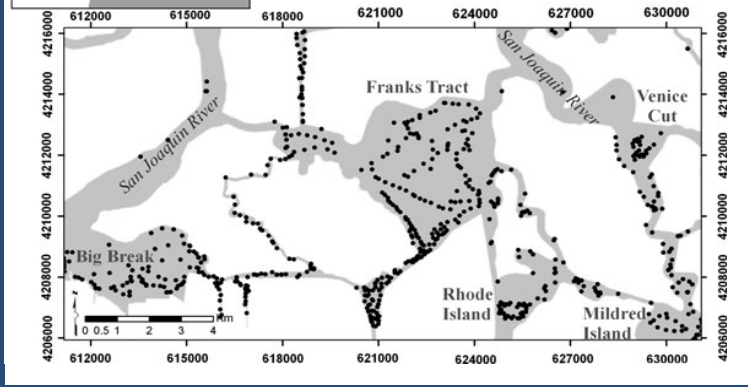
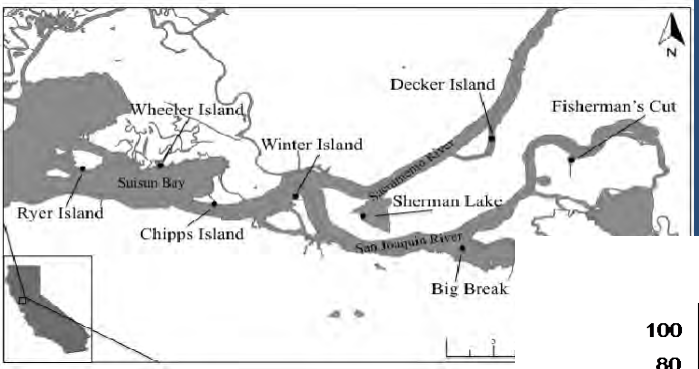
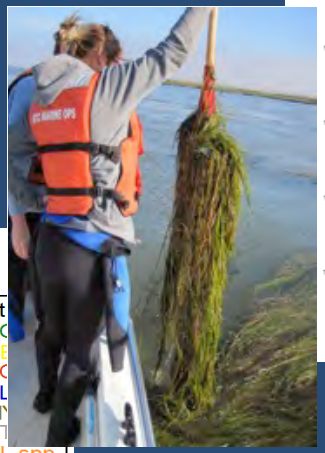
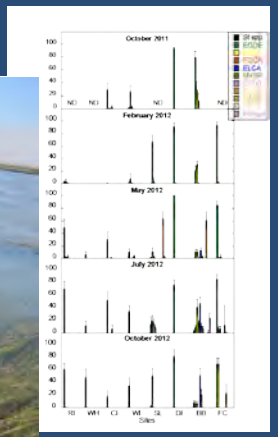


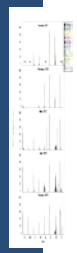
Table 1 from Santos et al. 2011

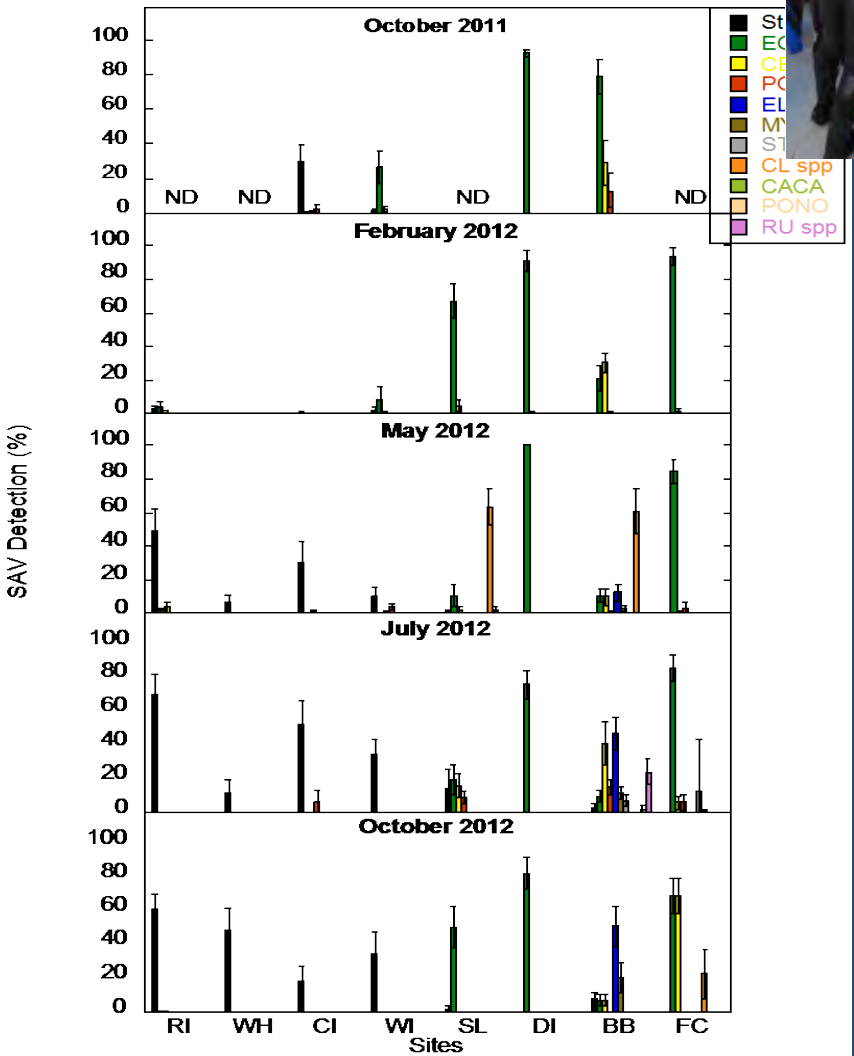
Studies evaluating relative abundance











From Boyer et al. 2013

These were one-off studies of relative abundance…

Periodic mapping using remote sensing very helpful

Important advances in remote sensing:
aerial imagery, hyperspectral imagery
(Ustin, Khanna, Santos work)

But –
- inability to distinguish submersed invaders from each other
- Inability to detect small patches of *Stuckenia*, mixed assemblages
- Confusion in western Delta (algae on *Egeria*, *Myriophyllum*)

Key Question: How do SAV and FAV support or adversely affect ecosystem services and related beneficial uses?

Aquatic vegetation can have many values

- carbon storage
- uptake of nutrients
- oxygenation of waters
- trophic support through direct consumption by grazers or contributions to the detrital food web
- provision of surfaces for algal and invertebrate attachment (also providing trophic support)
- predation refuge for small fish

But…
Excessive biomass, or loss of native species functions reduce values

One conceptual model: loss of beneficial uses to native fish

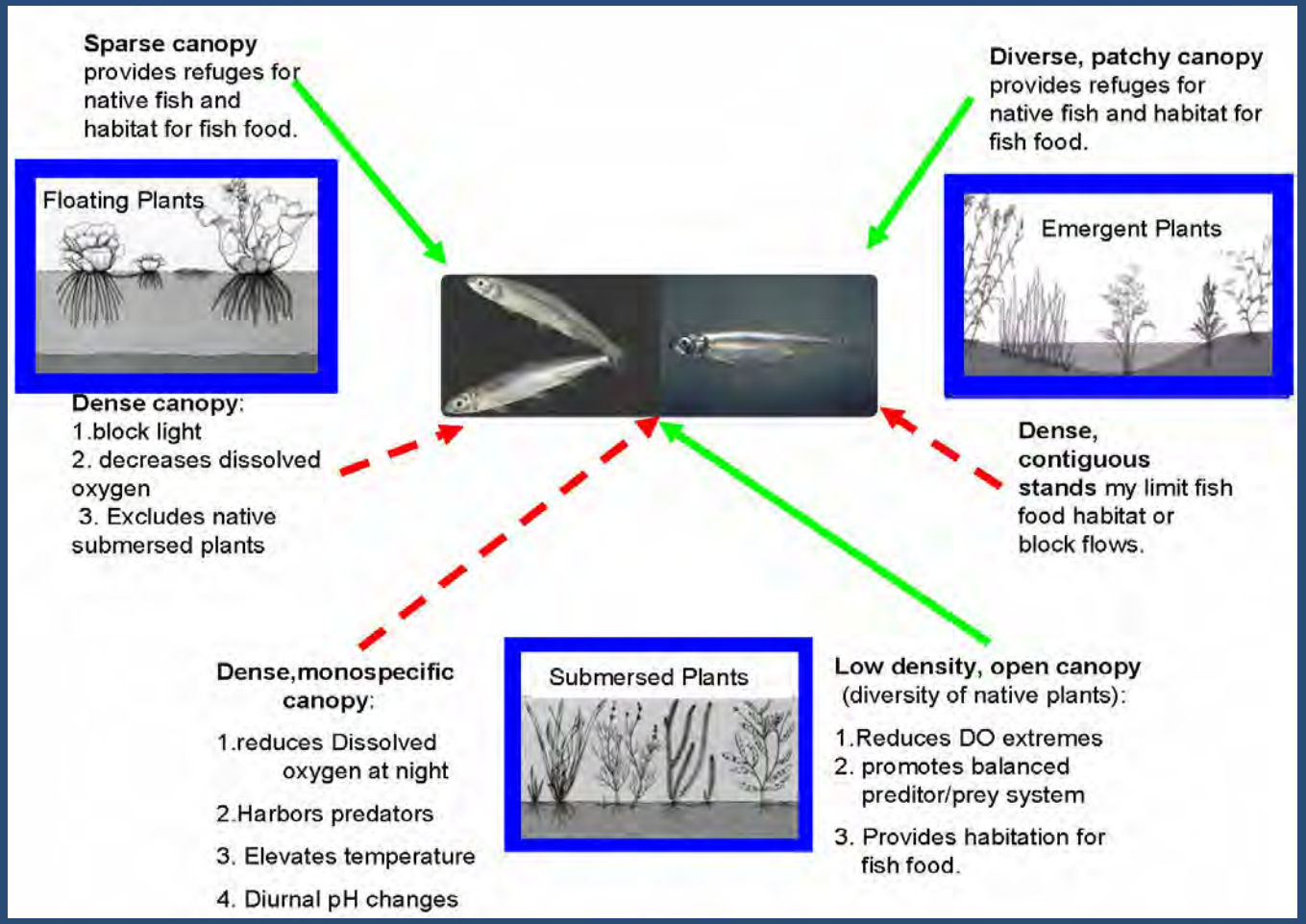
Invasive SAV, *Egeria densa*:

- Dense, reduces turbidity
- Shadowy, non-native predator refuge
- Negative effects on native fish

Native SAV, *Stuckenia* sp.:

- Open canopy, turbid
- Visual refuge from predators
- Ample food resources
- Positive effects on native fish

DRERIP conceptual model: loss of beneficial uses



Arrows show direction and primary effect caused by interaction of each “ecological type” of aquatic plant on fish (red, dashed = negative effect, green, solid = positive effect. From Anderson 2008

Other adverse effects of excessive, invasive aquatic vegetation

- Sediment organic matter accumulation = eutrophication (increased rate of organic matter supply in an ecosystem, Nixon 1995)

  - re-mineralizable nutrient source
  - oxygen drawdown
  - increased availability of P under low O_2

  (counter to widely accepted belief that Delta not eutrophic as measured by algal biomass accumulation)

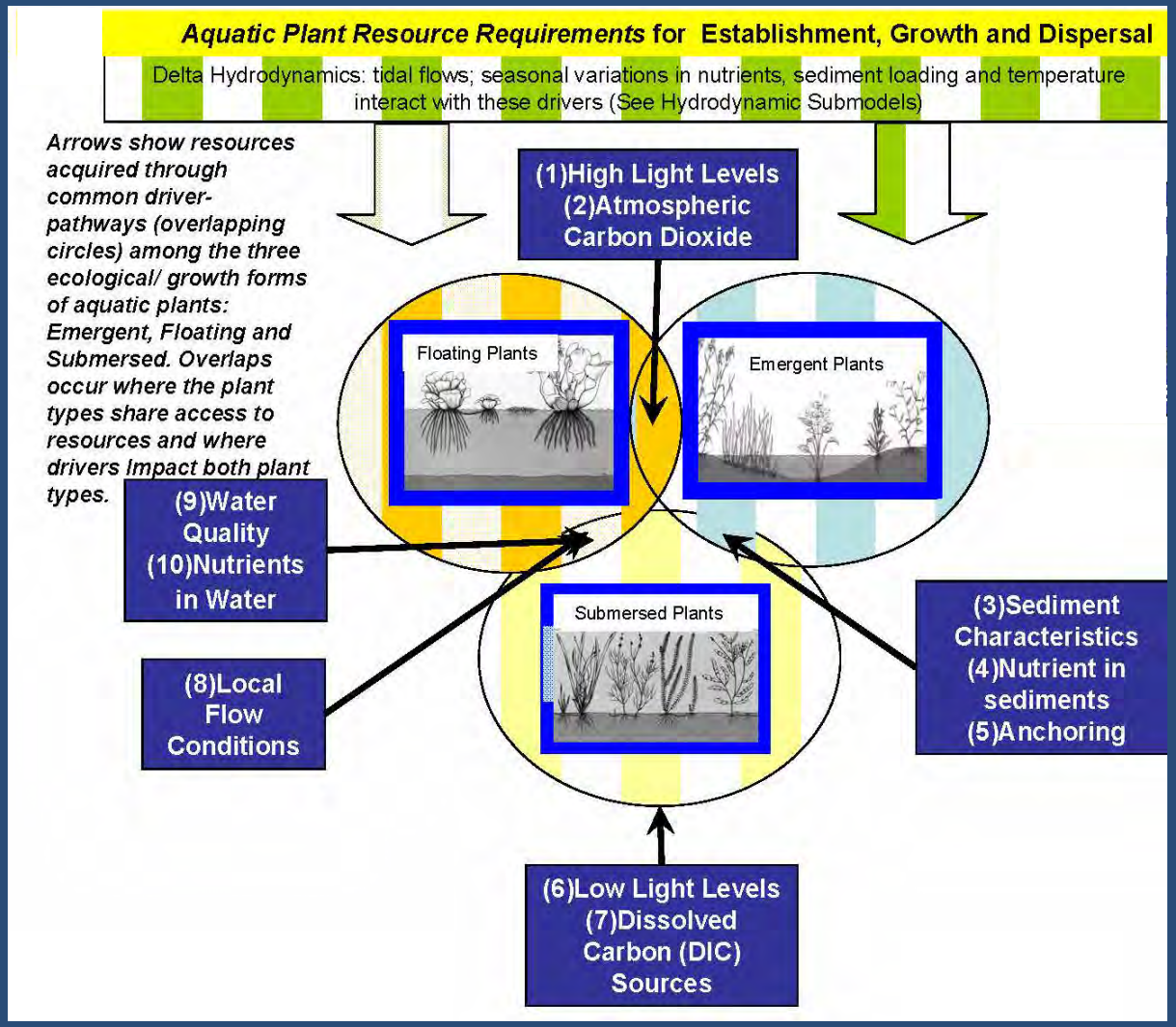
- Impediments to navigation and industry

- Visual impacts

Key Question: What is the relative importance of nutrients and organic matter accumulation versus other factors in promoting observed trends in SAV and FAV in the Delta?

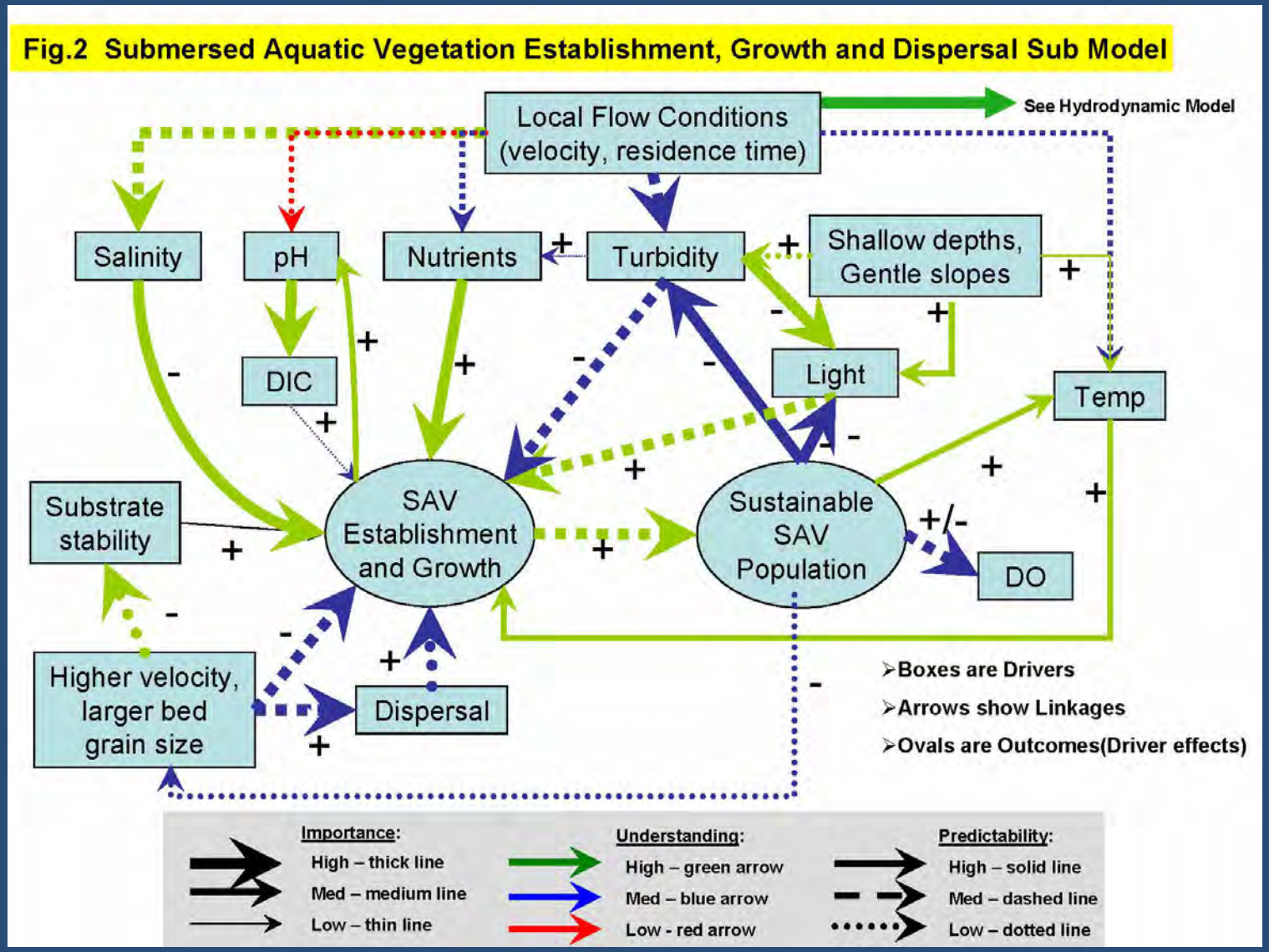
Today, focus on *Egeria* and Water Hyacinth

DRERIP conceptual model: SAV and FAV needs



From Anderson 2008

DRERIP conceptual model: SAV



From Anderson 2008

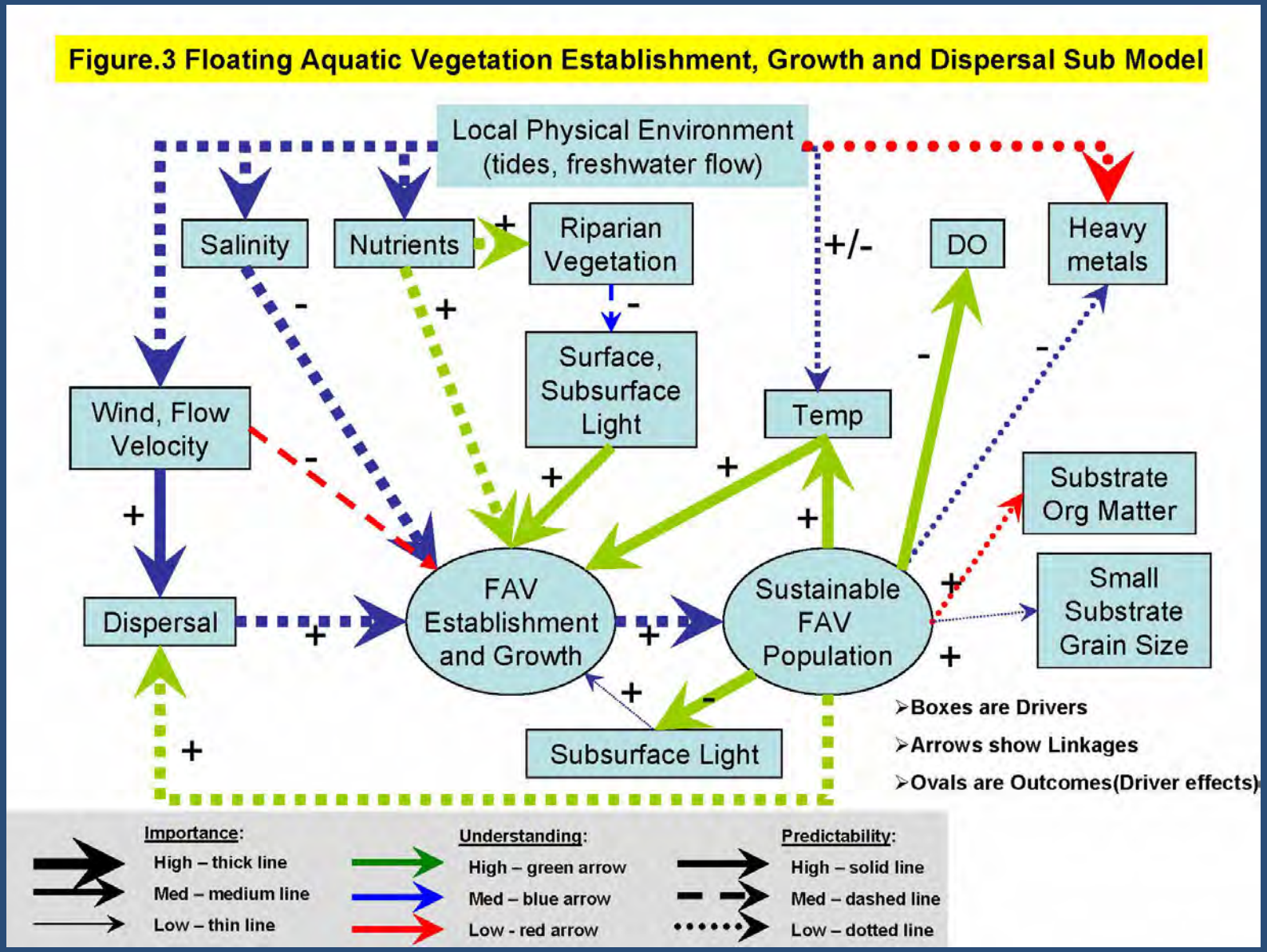
Egeria: Nutrients versus other factors?

Light – important, expected to increase (pos. effect)
Salinity – important, expected to increase (neg. effect)
Temperature – 30 degrees C had neg. effect
DIC – as CO_2 declines, can use bicarbonate efficiently
Competition – shaded by water hyacinth, outcompetes *Stuckenia*

Nutrients – certainly very important to plant growth
- no local experiments
- experiments in other regions: very mixed results
- water column and sediment access
- possible preference for NH_4

Organic matter accumulation – big black box
- unknown relative contribution of re-mineralized nutrients versus “new” in water column

DRERIP conceptual model: FAV



From Anderson 2008

Water Hyacinth: Nutrients versus other factors?

Light – not limiting at surface
Salinity – important, expected to increase (neg. effect)
Temperature – likes it warm
Competition – shades other species
Flow – washed out at higher flows, but aids dispersal

Nutrients – certainly very important to plant growth
- no local experiments
- experiments in other regions: strong effects of N and P
- water column access only

Organic matter accumulation –a black box here, also
- despite water column access, unknown relative contribution of re-mineralized nutrients versus “new”

Recommendation 1: Implement Routine Monitoring of Invasive Floating and Submersed Aquatic Vegetation

Routine monitoring needed to assess trends over time and to support ecosystem modeling of the Delta

Remotely-sensed areal coverage PLUS field-based transects

Early actions:

1) Develop workplan to lay out the key indicators and cost estimates required for monitoring

2) Use existing remote sensing data to estimate areal coverage spatially and over time

Recommendation 2: Develop a Biogeochemical Model of the Delta, focused on Nutrient and Organic Carbon Fate and Transport

Quantify compartments of nutrient and carbon storage (i.e. water, sediment, plant biomass, etc.) and fluxes or exchanges between compartments at varying seasonal and spatial scales.

Determine if management of “new” nutrients can be effective in controlling floating and SAV relative to recycled sources

Early Actions:

1) Examine existing models

2) Determine data requirements, develop implementation strategy

3) Conduct special studies and other monitoring to support model development (e.g., quantify N, P, and organic carbon associated with ecosystem compartments as well as uptake, release and flux rates.)

Recommendation 3. Investigate Control Strategies for Both *E. densa* and *E. crassipes* Including, Among Other Strategies, Mechanical Removal

While monitoring, modeling and special studies are underway, conduct research to determine more effective removal strategies

Early Actions:

1) Conducting literature review of control strategies to identify potential measures that may be useful in the Delta

2) Fund research projects that pilot these strategies

Macrophyte Science Work Group Meeting
--Linked Water Quality Hydrodynamic Models--

23 April 2015

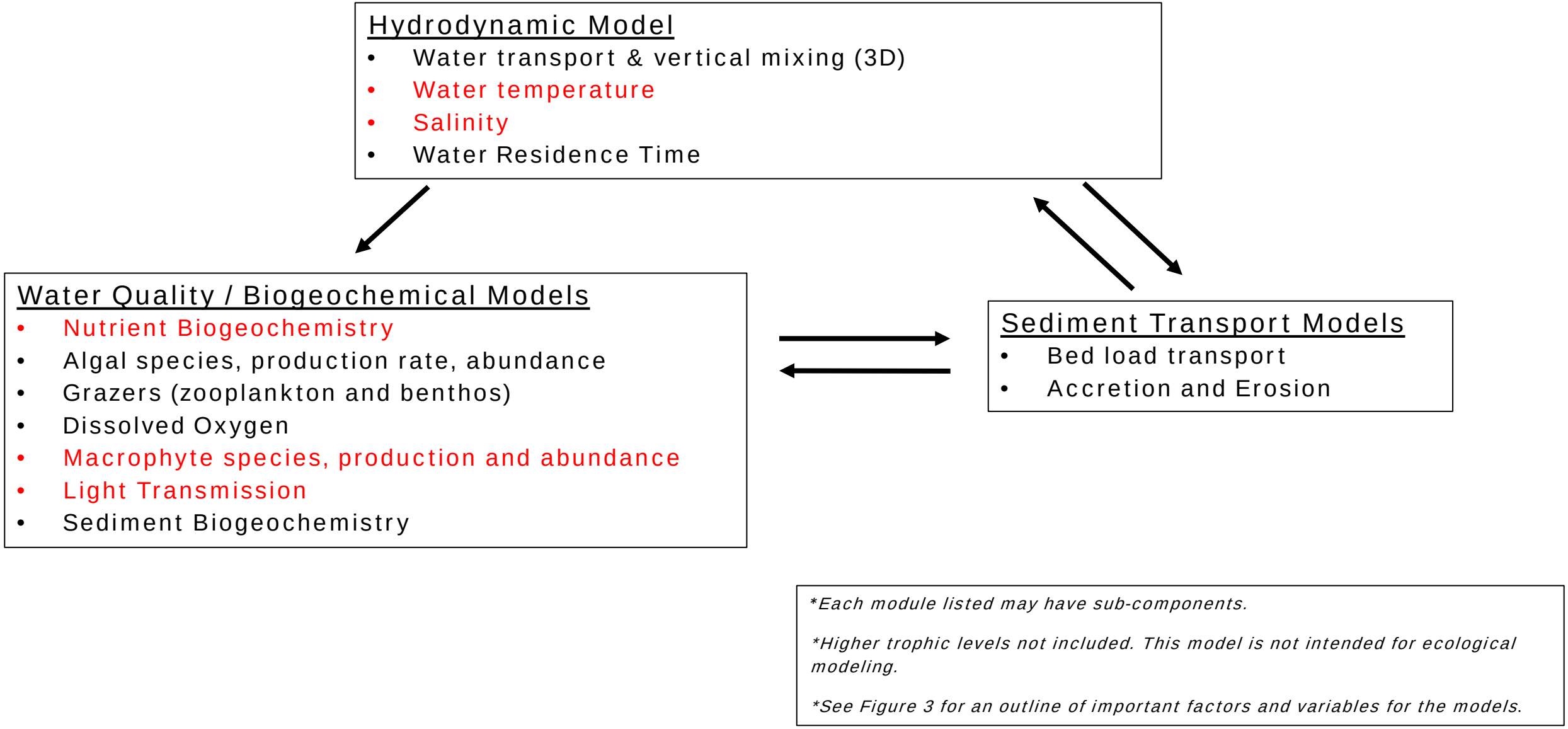


Figure 2. Preliminary framework for the hydrodynamic, water quality/biogeochemical, and sediment transport models and sub-models needed to inform nutrient-related questions. Others researchers may use the model to investigate non-nutrient related issues.

Current Nutrient Sources, Hydrodynamic Transport and Rates of Transformation	
1	What are the main sources and loads of nutrients to the Delta now?
2	How much do nutrient loads from known sources contribute to ambient nutrient concentrations in different sections of the Delta by season?
3	Do the models indicate that all the major sources of nutrients to the Bay are accurately being measured?
4	What are the important processes that transport and transform nutrients in the Delta and what are the rates at which these processes occur?
Which Factors are Most Important	
4	What are the main factors* affecting: • The algal biomass and primary production rates; • The algal species composition; • The distribution and abundance of macrophyte species; • The magnitude and frequency of cyanobacteria and diatom blooms. • How does the relative importance of these factors vary with space & time?
Effects of Nutrient Load Reductions	
5	After the already permitted reductions in nutrient loads from NPDES dischargers have been implemented: a) What will be the main sources of nutrients in the Delta? b) What will be the new ambient nutrient concentrations in different sections of the Delta in each season? c) How much will nutrient loads from known sources contribute to ambient nutrient concentrations in different sections of the Delta by season?

6	After the already permitted reductions in nutrient loads from NPDES dischargers have been implemented, what changes are expected for: • The algal biomass and primary production rates; • The algal species composition; • The distribution and abundance of macrophyte species; • The magnitude and frequency of cyanobacterial and diatom blooms. • How will these changes vary with space and time?
	Effects of Long-Term Climate and Hydrology Changes
7	What effect will predicted climate change, changes in Delta hydrology, and wetland restoration have on the following effects (1) under current nutrient loads and (2) under a future predicted nutrient load scenario: • The algal biomass and primary production rates; • The algal species composition; • The distribution and abundance of macrophyte species; and • The magnitude and frequency of cyanobacterial and diatom blooms?

Questions?