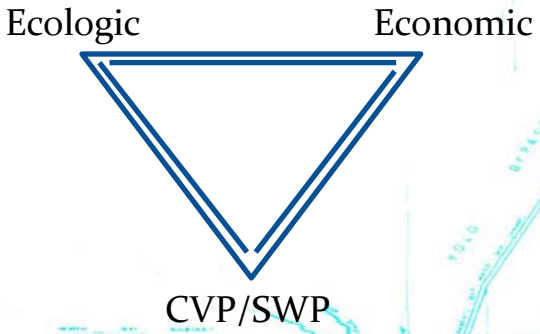
Unifying aquatic science for adaptive management of the Sacramento-San Joaquin Delta

Erwin Van Nieuwenhuyse, Ph.D.
Bureau of Reclamation
Bay-Delta Office, Sacramento CA

Delta Science Program Brown Bag Series
Park Tower Building, 2nd Floor Conference Center
March 5, 2013

Policy challenge: achieve co-equal goals



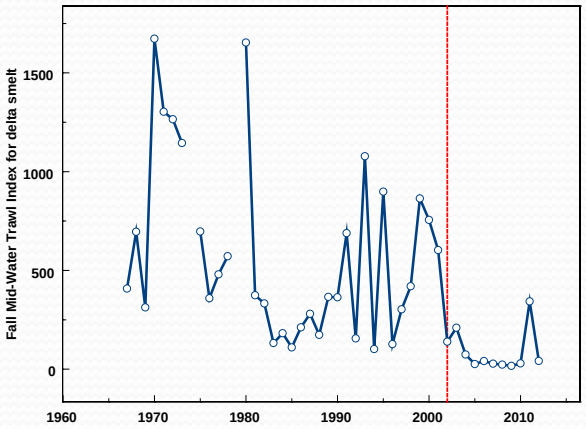
- **1992 Central Valley Project Improvement Act (CVPIA)**
- **1995 Bay-Delta Accord (CALFED)**
- **2009 Delta Reform Act (BDCP)**

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Delta is hub of CA water supply and home to ESA-listed fish populations

Regulatory challenge: integrate two biological opinions

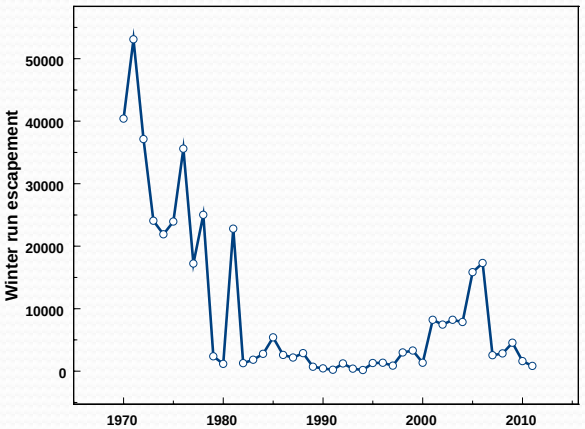
- 2008 BiOp Fish and Wildlife Service (smelt)
- 2009 BiOp National Marine Fisheries Service (smolt)



Delta smelt

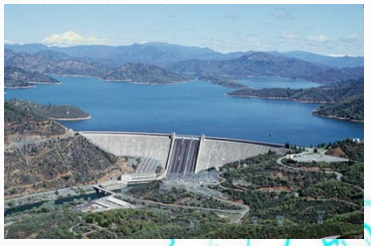
Smelt Salmon

CVP/SWP



Winter run

Operational challenge: store/open/pump



Shasta Dam

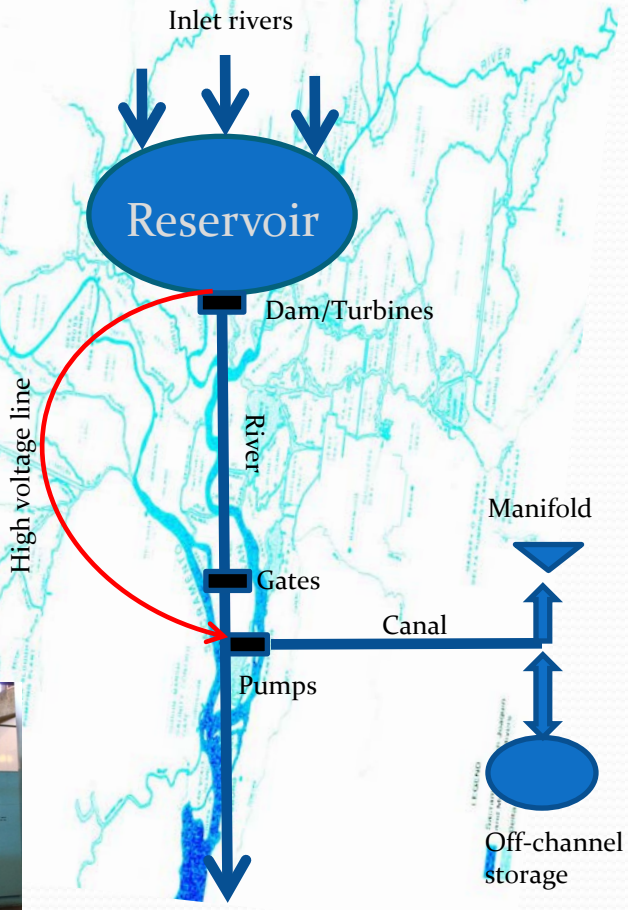
DCC gates

CVP pumping plant

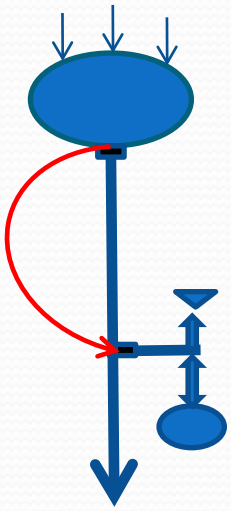
Oroville Dam

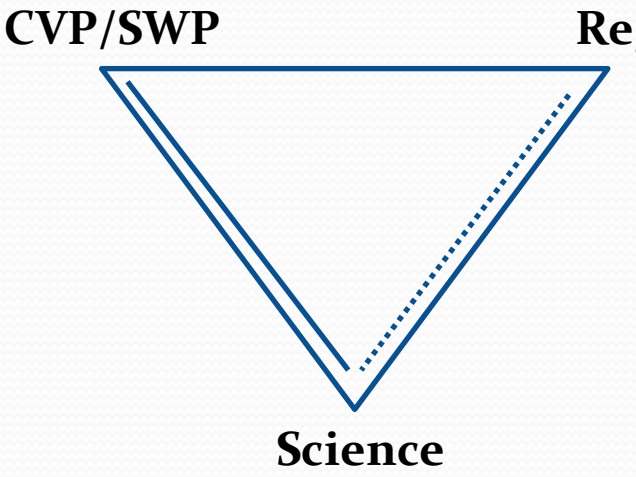
Mendota Pool

San Luis Reservoir



Solution: Integrated adaptive management



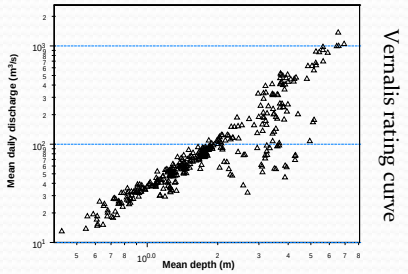


Science = Theory + Experiment

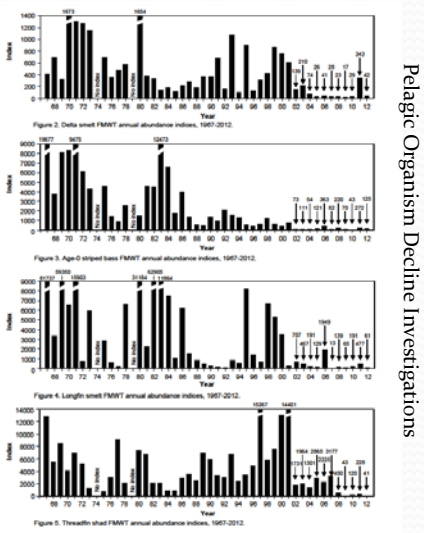
- Independent
- Best available
- Integrated

Integrated AM requires unified science

...but most science does not seek unity



Vernalis rating curve



Pelagic Organism Decline Investigations

Integration — Explanation

Prediction

Seek predictive power

Prediction — Integration

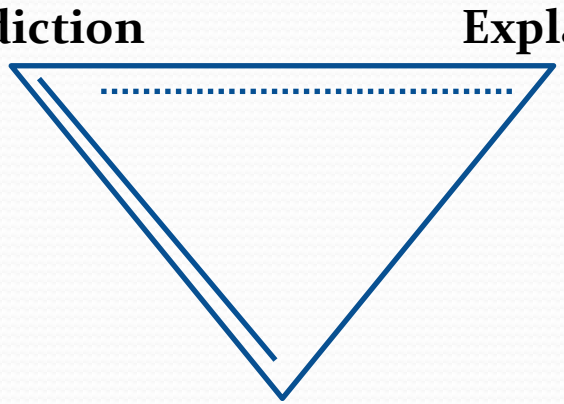
Explanation

Seek understanding

Solution: Reverse science priorities

Unity > Prediction > Understanding

Science advances toward unity and simplicity (p.148).



...only a synthetic, integrated, analytical approach to understanding the effects of suites of environmental factors on the ecosystem and its components is likely to provide important insights that can lead to enhancement of the Delta and its species.

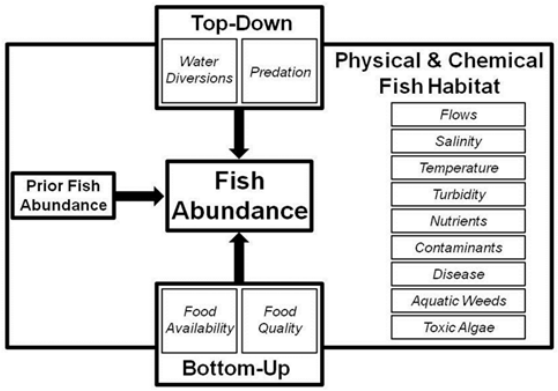
Poincare, Henri. 1913. The Foundations of Science, The Scientific Press, Lancaster, PA. 1946 edition.

National Academy of Sciences 2012. Sustainable Water and Environmental Management in the California Bay-Delta (p.6)

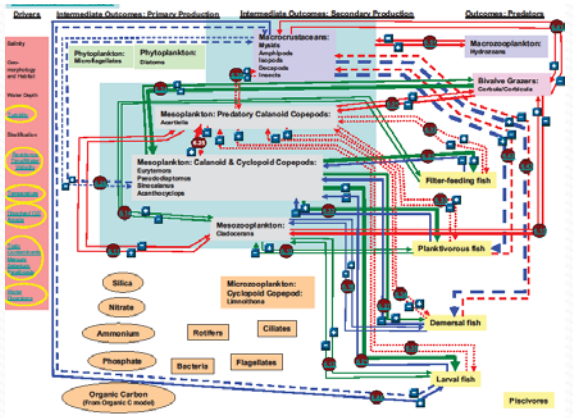
OUTLINE

- **Unifying conceptual model**
- **Unifying adaptive management decision**
- **Unifying adaptive management experiment to get us started**

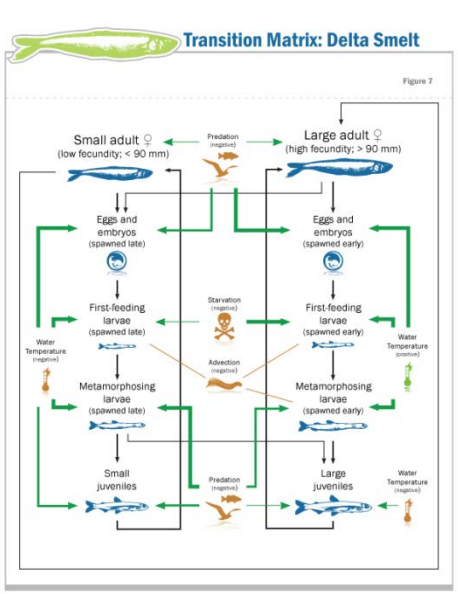
I: Conceptual model (theory)



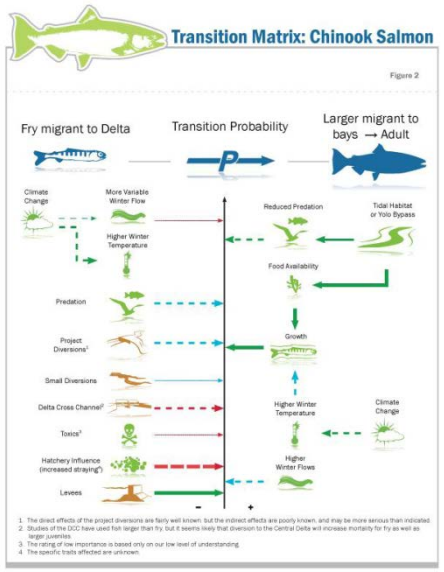
Pelagic organism decline



DRERIP- aquatic food web



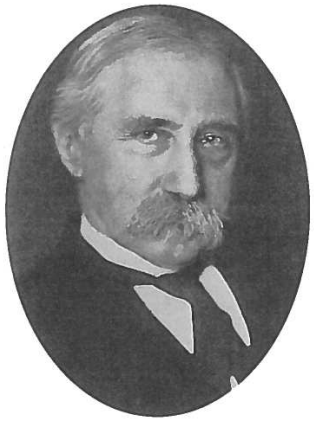
DRERIP-delta smelt



DRERIP-Chinook salmon

Stephen A. Forbes (1844 – 1930)

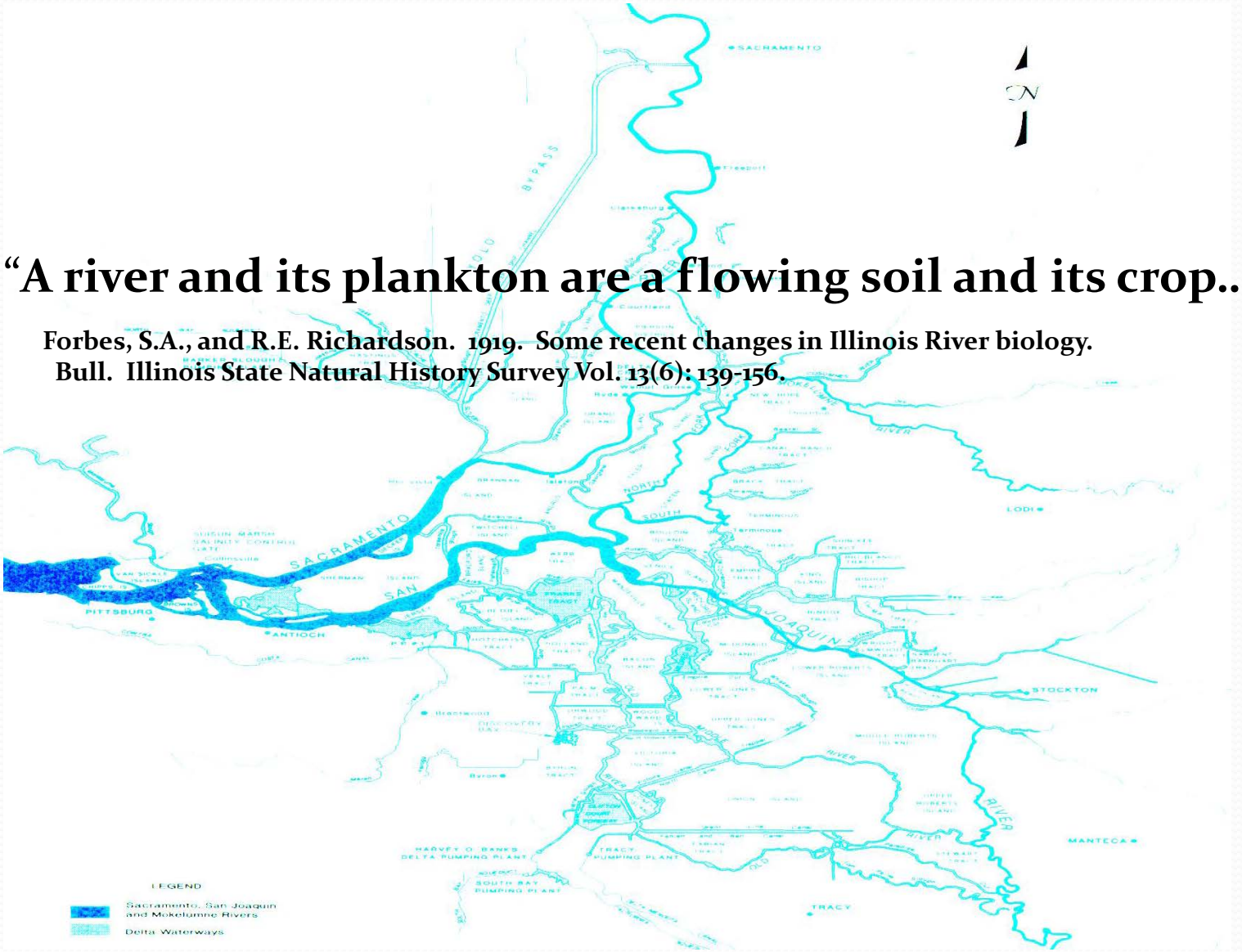
1880



1915

1921

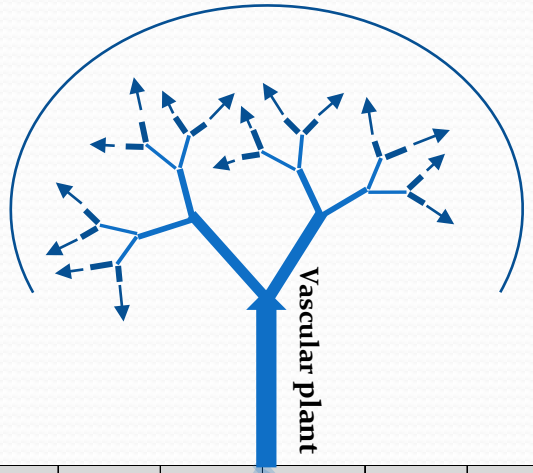
Father of American ecology

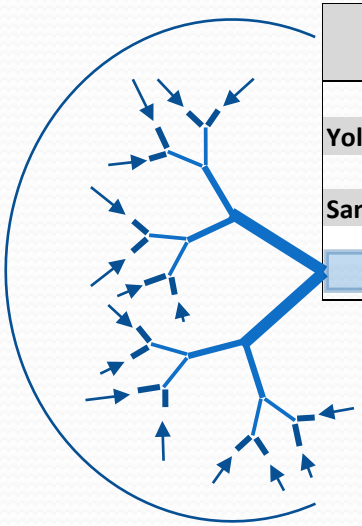


"A river and its plankton are a flowing soil and its crop…"

Forbes, S.A., and R.E. Richardson. 1919. Some recent changes in Illinois River biology. Bull. Illinois State Natural History Survey Vol. 13(6): 139-156.

San Joaquin R is a flowing soil



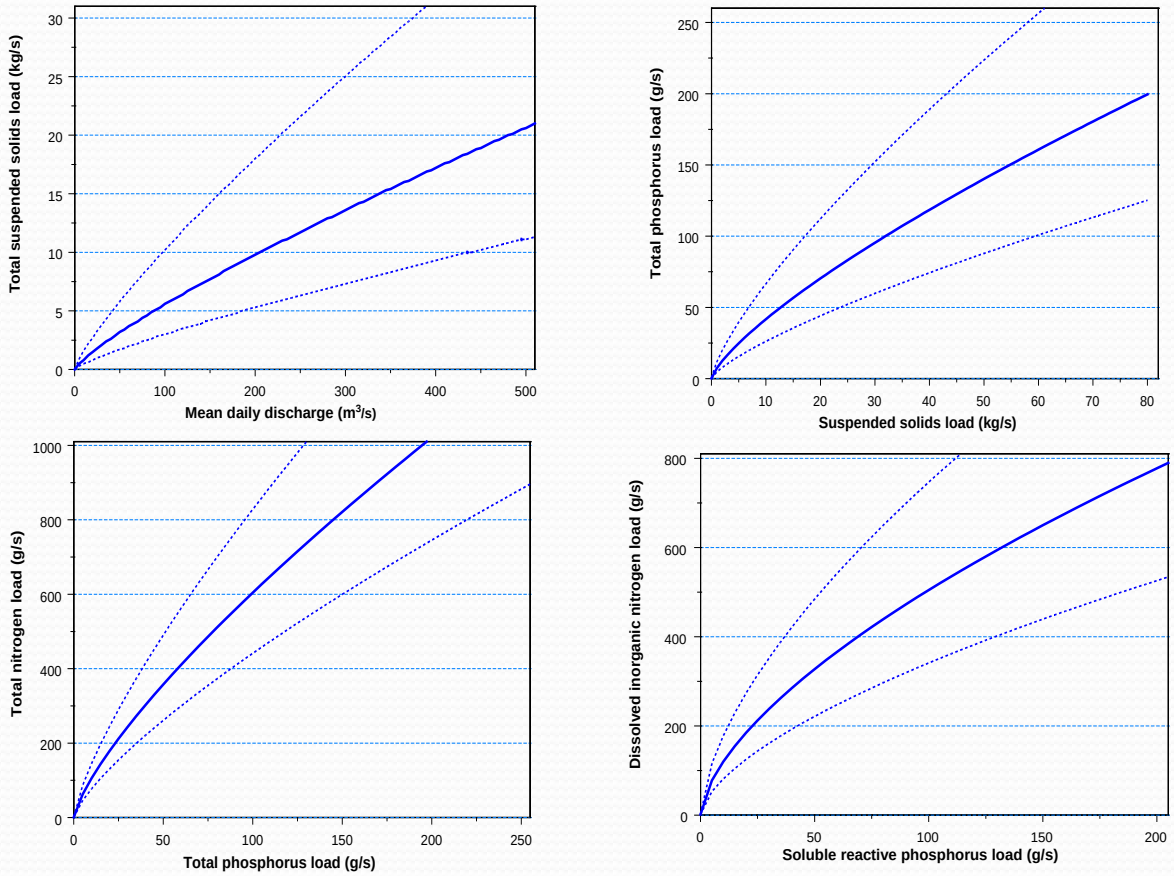


System	Area km^2	Depth m	Flow m^3/s	Time d	TSS kg/m^3	%Org %	TP kg/m^3	TN kg/m^3	N:P
Yolo silt loam in corn	*5,000*	1.0	50	4	2600	2.4	1.04	3.12	3
San Joaquin R, Vernalis	*19,000*	2.7	50	14	0.05	15	0.0003	0.003	10

Nutrient supply and turbidity → **Phytoplankton production**

Source: Professor Randy Dahlgren (UC-Davis), unpublished data for 2003

Flowing soils supply nutrients



Suspended solids, phosphorus and nitrogen loads, San Joaquin River near Vernalis, 1969-2011

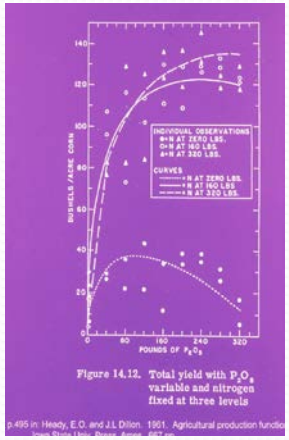
Data: IEP Environmental Monitoring Program (n ~ 500 obs)

Phytoplankton use nutrients to produce a crop

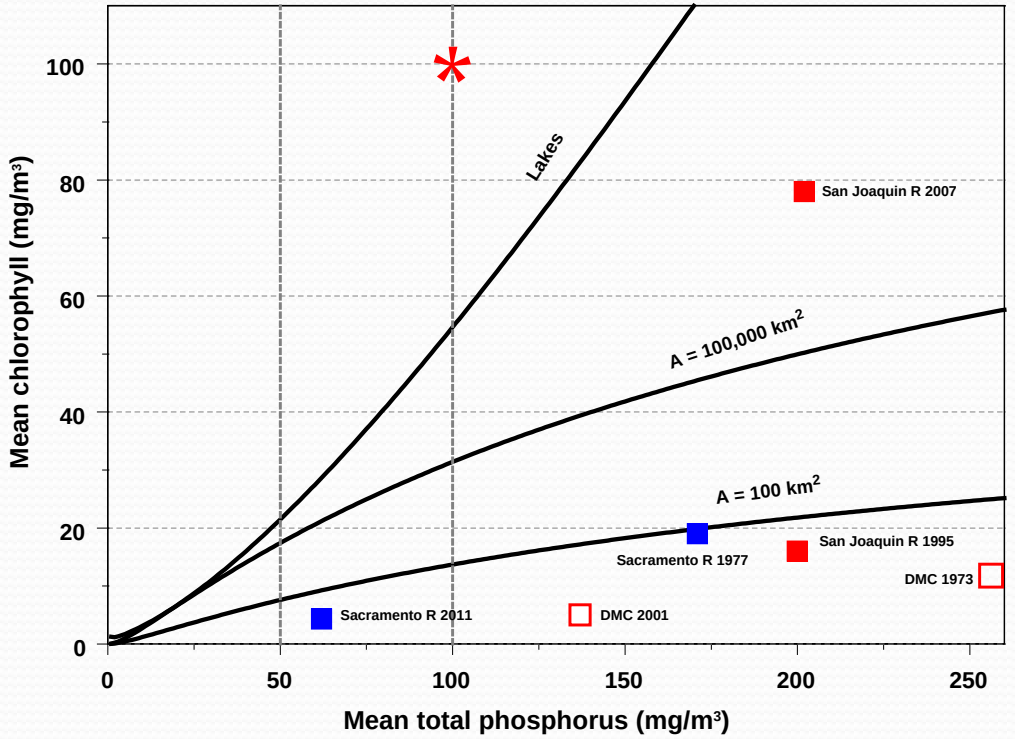
Non-vascular plant crop

Cyclotella sp.

Vascular plant crop



Zea mays

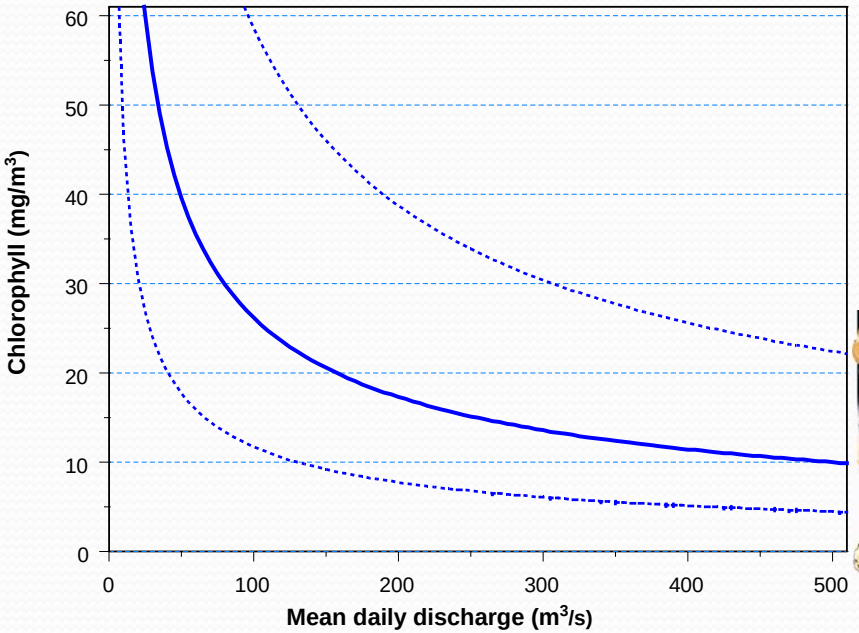


Van Nieuwenhuyse, E.E., and J.R. Jones. 1996. Phosphorus-chlorophyll relationship in temperate streams and its variation with stream catchment area. Can. J. Fish. Aquat. Sci. 53: 99-105.

Heady, E.O., and J. Dillon. 1961. Agricultural production functions. Iowa State University Press, Ames, Iowa.

Washout, settling and grazing remove plankton

$$NPP = Q_{chl}\rightarrow + Q_{chl}\downarrow$$



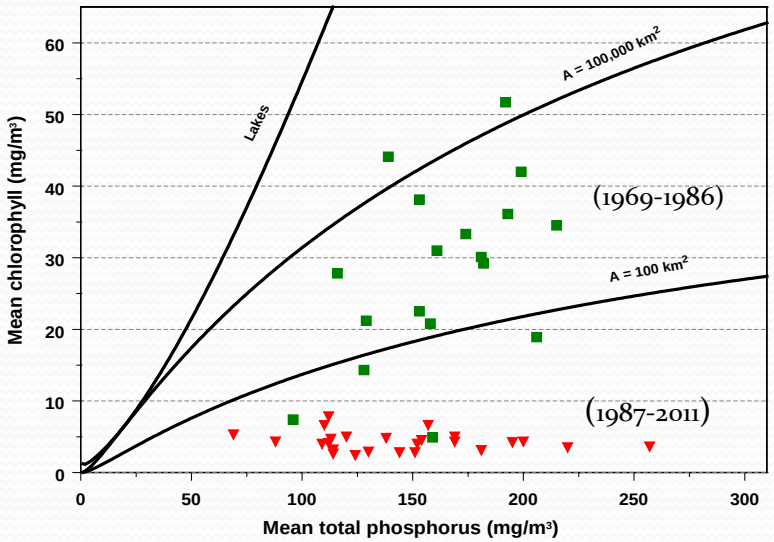
Ocean

Inverse relationship between flow and chlorophyll concentration, San Joaquin River near Vernalis, 1969-2011

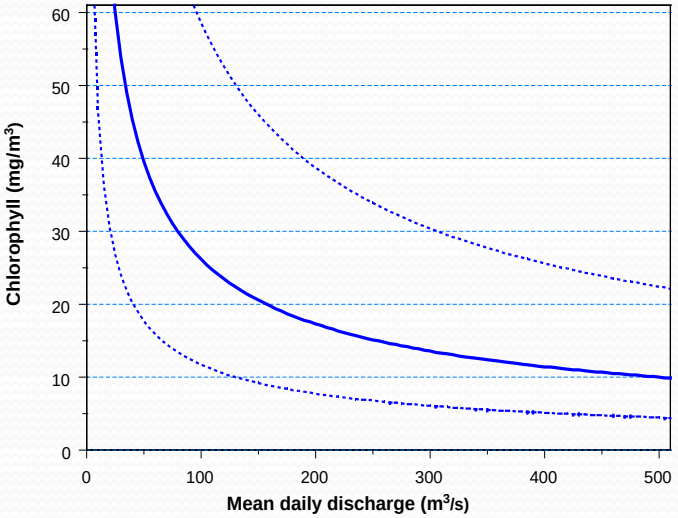
Data: IEP Environmental Monitoring Program (n ~ 500 obs)

Abrupt increase in Chl loss to grazing, Suisun Bay, 1986

Suisun Bay before and after *Potamocorbula amurensis*

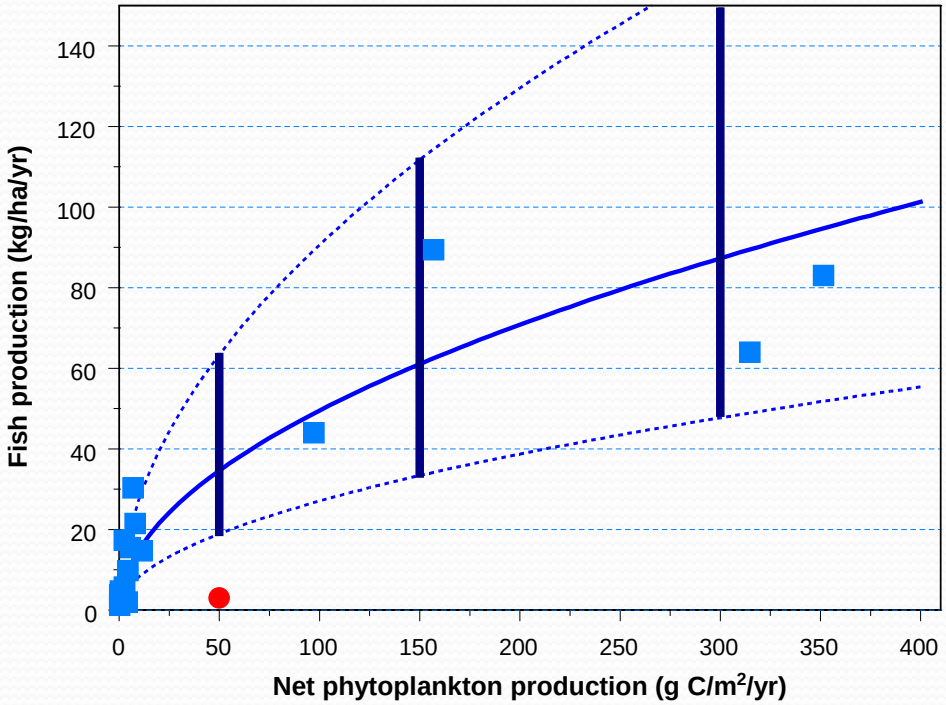


Chlorophyll washout curve, San Joaquin R, Vernalis



Data: Reclamation (1969-1974) and IEP Environmental Monitoring Program (>1974)

Plankton production supports fish production

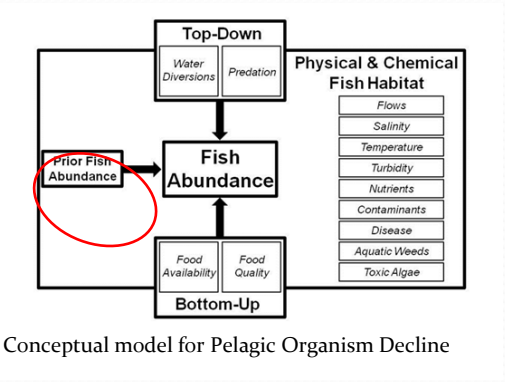


Downing, J.A., C. Plante, and S. Lalonde. 1990. Fish production correlated with primary productivity, not the morphoedaphic index. Can. J. Fish. Aquat. Sci. 47: 1929-1936.

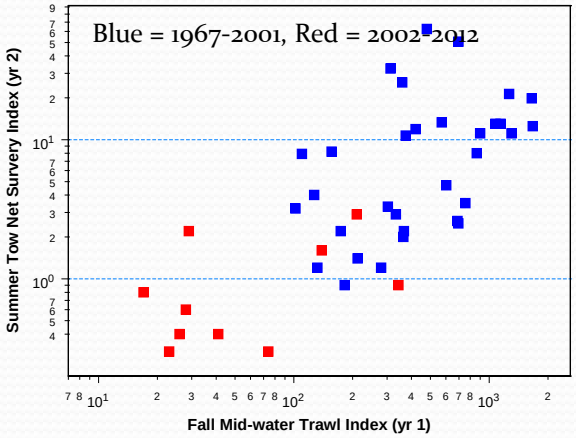
Delta fish production estimate (red dot, 3 kg/ha/yr) = mean annual CVP/SWP expanded salvage for 1981-2011 divided by area of Delta (24,561 ha). Assumes mean fish weight of 6 g (preliminary value, Bob Fujimura, California Department of Fish and Game, pers. comm., 10/4/12)

Net phytoplankton production (50 gC/m²/yr) = gross production divided by 2 (Jassby 2008)

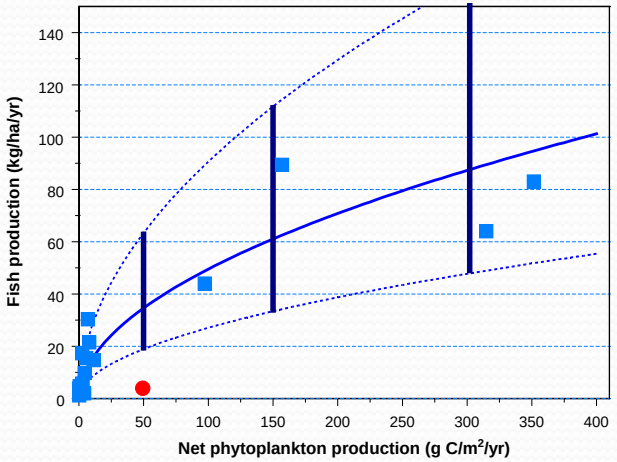
Flowing soil approach is statistically superior

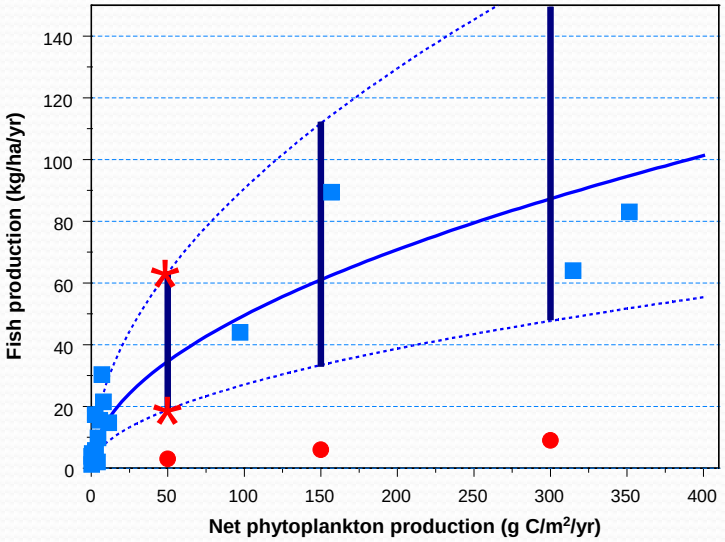


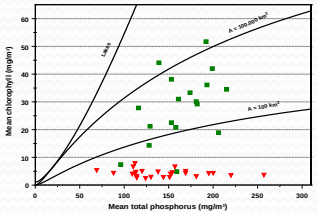
Conceptual model for Pelagic Organism Decline



We are dealing with random variables







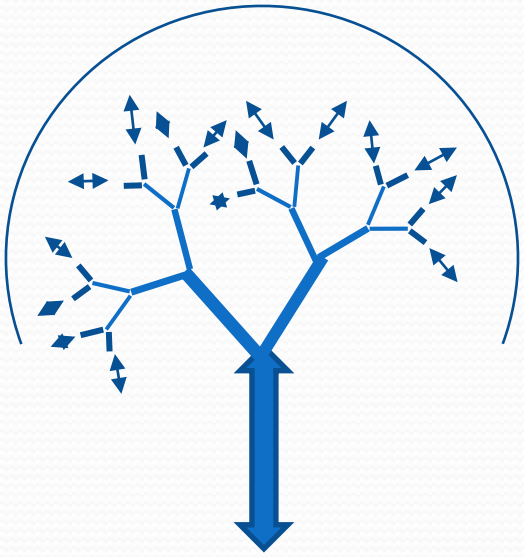
Reduce fish loss

- Minimize take
- Reduce entrainment
- Reduce stranding
- Reduce predation by non-native species
- (Reduce competition with non-native species)
- (Reduce ocean fishing pressure)

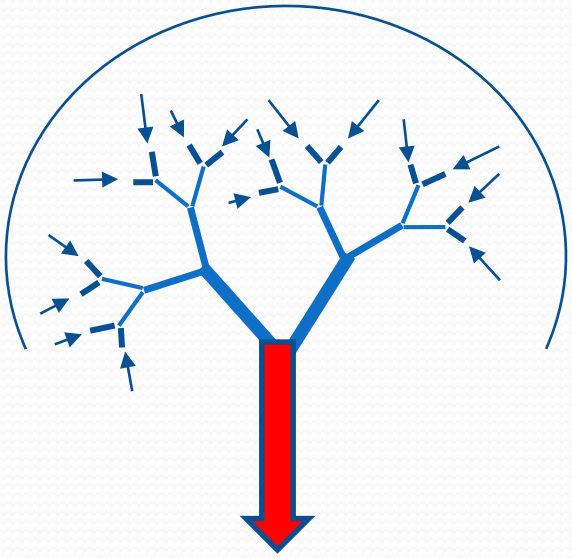
Acoustic tag studies

Non-physical barrier

II: Adaptive management decision



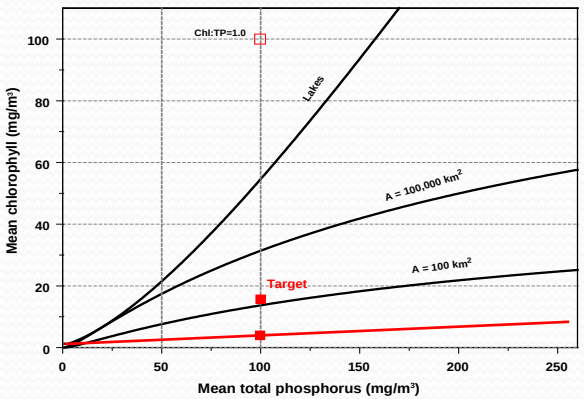
Tidal wetland of indecision with many mouths

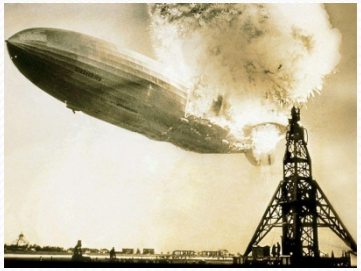


Unified network of decisions that lead to one mouth

Tripling plankton crop production will double Delta fish production

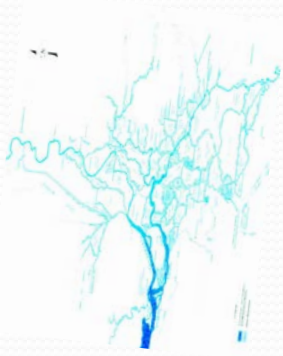
NPP tripling goal for the Delta catchment



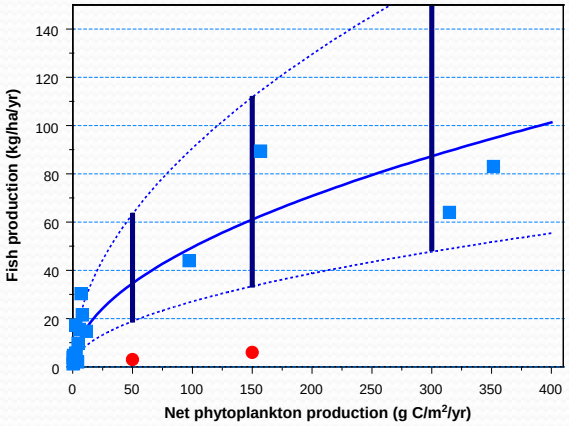


1 H = 2.3 TJ = 600 m^3 of H_2O

(1 TJ = 10^{12} Joules)



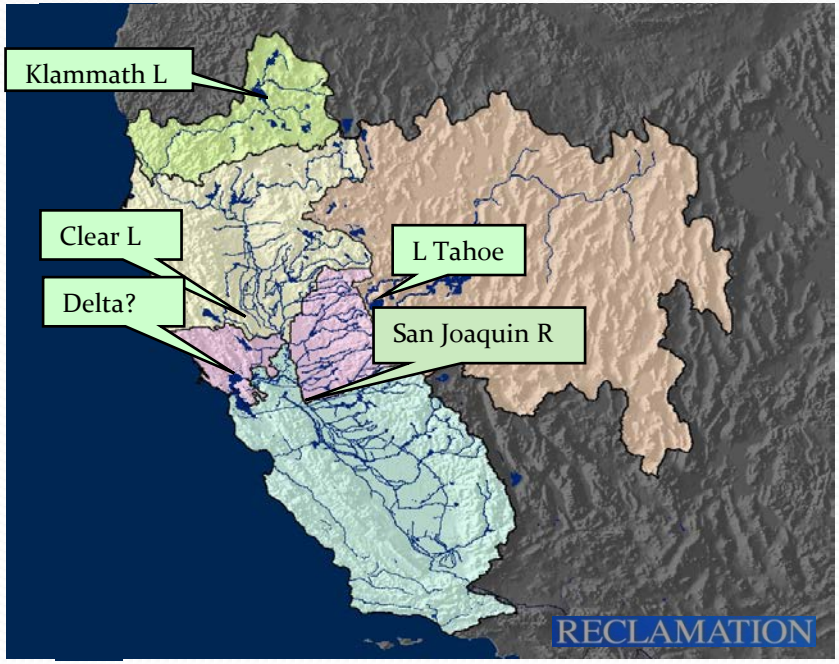
Delta Chl = 5 mg/m^3 = 13 TJ



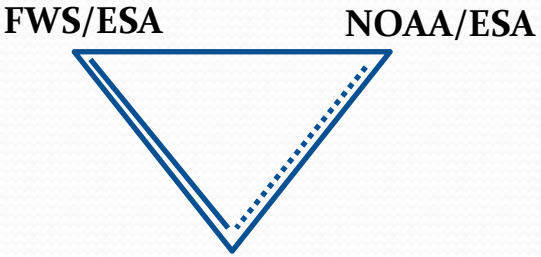
Increase plankton production

- Operate reservoir outlets to mimic springs (processing mode)
- Pump hardest when flows are highest (throughput mode)
- Reduce through-Delta flow (late-spring, summer)
- Fund upstream de-reclamation to boost plankton input to Delta
- (Add nutrients where limiting)
- (Reduce clam grazing)

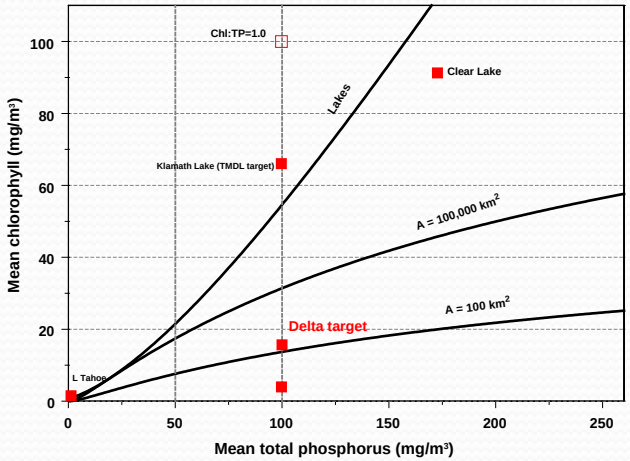
Inverted TMDL for an inverted Delta



Nutrient-phytoplankton TMDLs in MP region

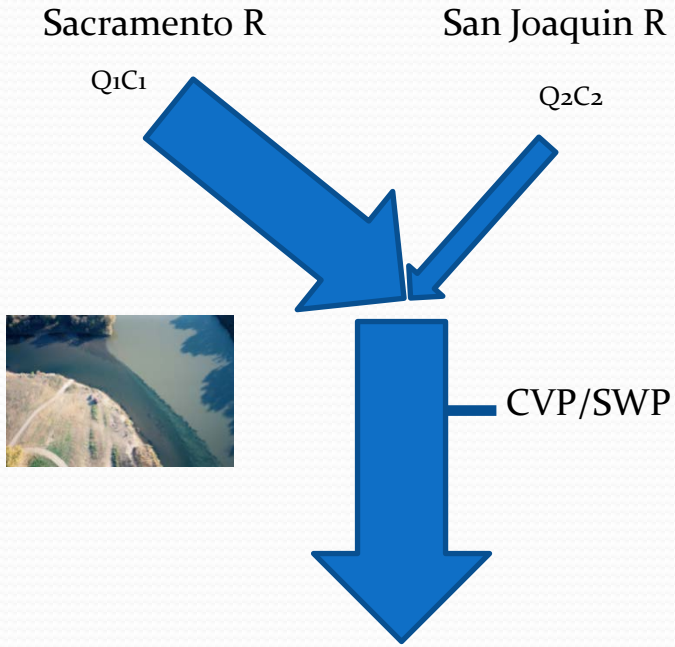


Start with flowing soil



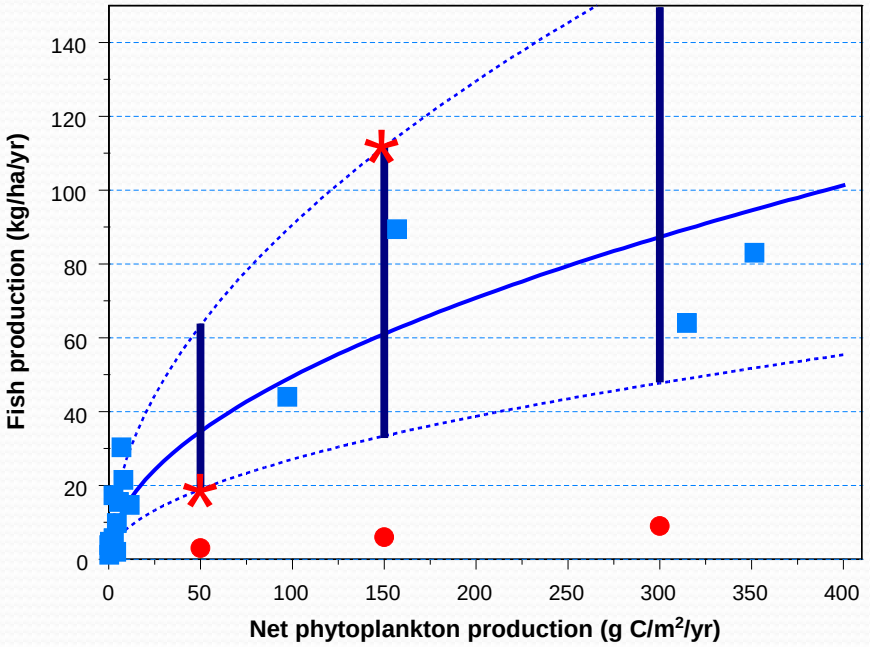
Performance measures

For the flowing soil



$C_3 = (Q_1C_1 + Q_2C_2)/(Q_1+Q_2)$

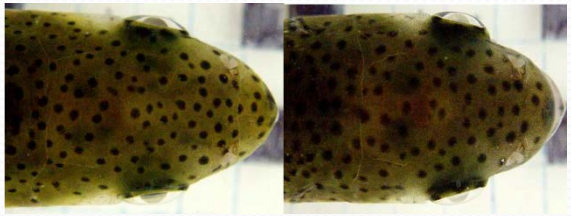
For the fish community

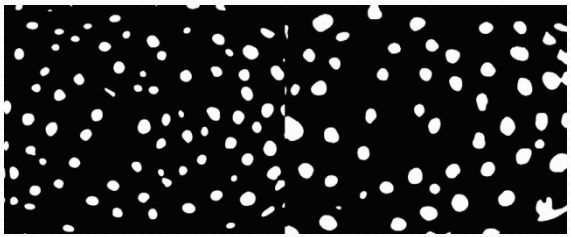


Make CVP/SWP part of aquatic science infrastructure

Provide an actuarial-grade estimate of absolute fish abundance for all species

Photographic identification of individuals





Merz et al. 2012. N. Amer. J. Fish. Mgmt. 32: 806-816

Salmonid hatchery

Coded wire tagging trailer

Rotary screw traps

IEP trawls

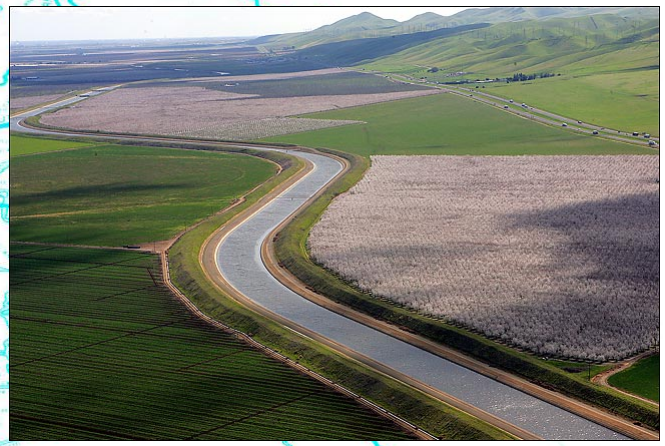
Tracy Fish Rescue Facility

III: Adaptive management experiment

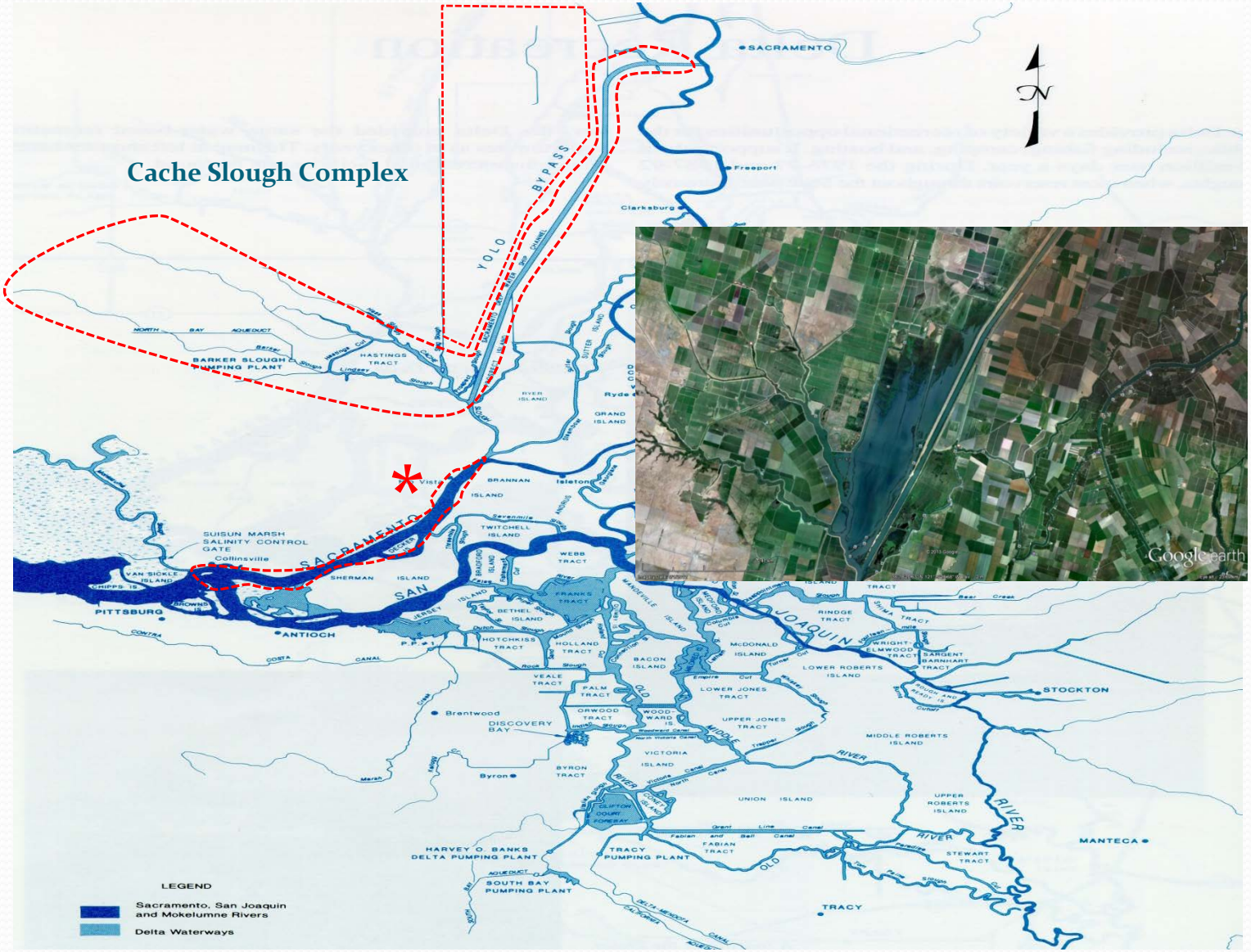
"It is not only space but time also that is now lacking, since the river now hurries its burden downward at a rate more rapid than it did before it was shut out from so large a part of its valley."

Lower Sacramento R

"...free access of fishes to the ponds, lakes and marshes naturally connected with a stream is a matter of the highest importance."

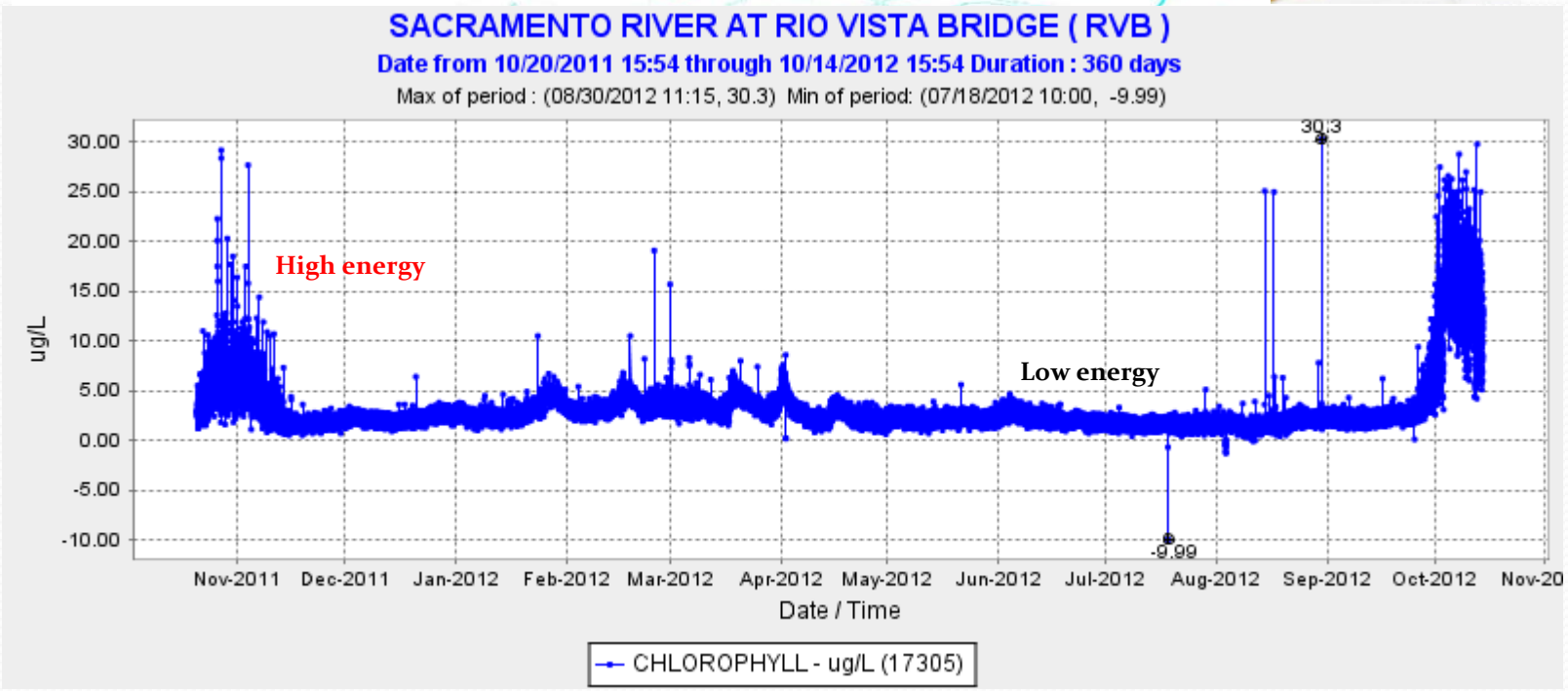


Delta-Mendota Canal

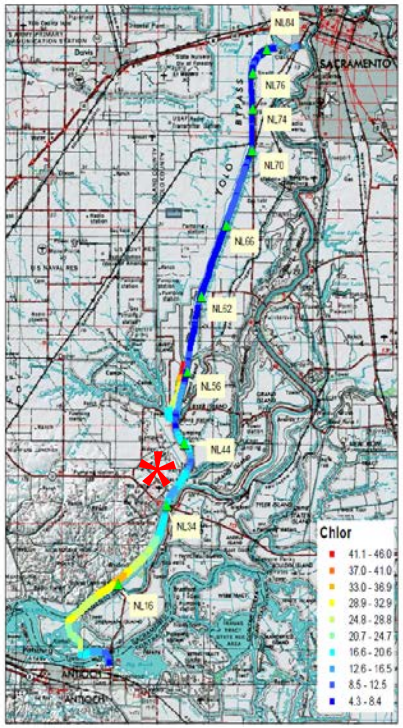


Map: Delta Atlas, California Department of Water Resources

Fall diatom blooms in the lower Sacramento River



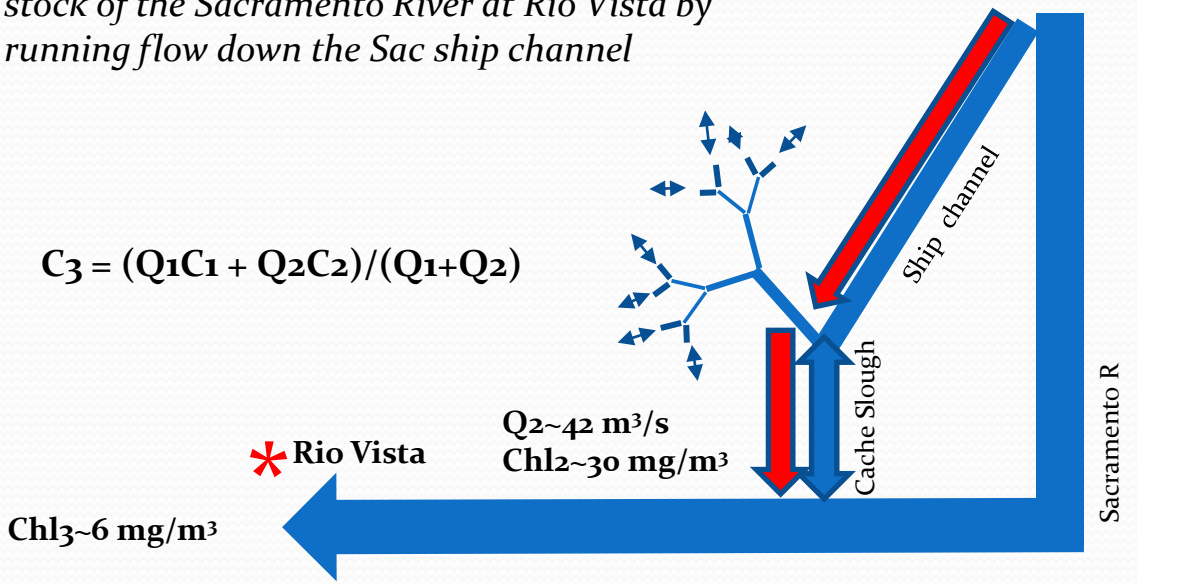
Continuous flurometer readings-October 9, 2012

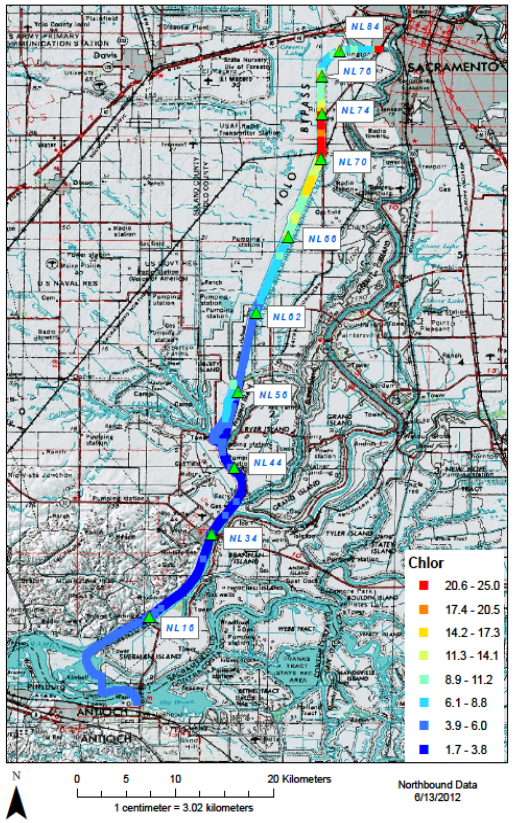


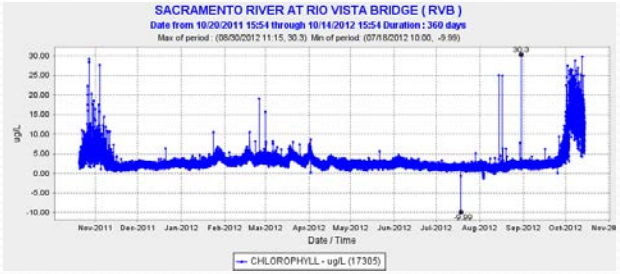
Southbound (10/9/12)

UAME-1: *double the phytoplankton standing stock of the Sacramento River at Rio Vista by running flow down the Sac ship channel*

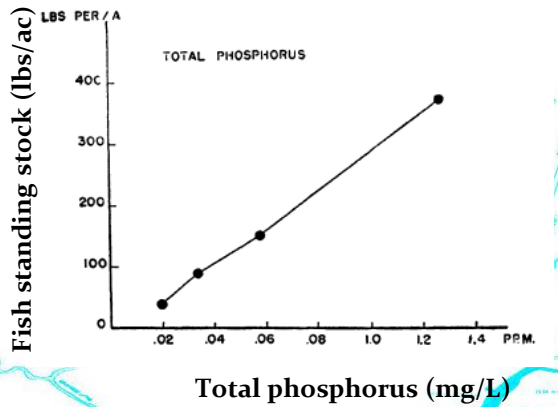
$C_3 = (Q_1C_1 + Q_2C_2)/(Q_1+Q_2)$







Sometimes it really *is* that simple

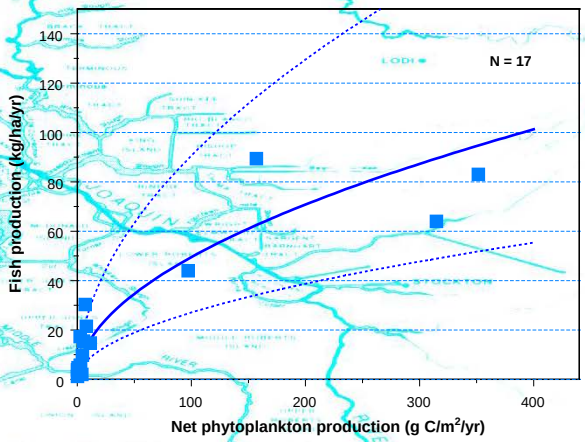


Fish standing stock (lbs/ac)

Total phosphorus (mg/L)

Moyle, J.B. 1956. Relationships between the chemistry of Minnesota surface waters and wildlife management. J. Wildl. Mgmt. 20(3): 303-320.

Sometimes the simple is obscured by the complex...p.131



$(\sqrt{N})$

All physics is statistical physics.
(Schrodinger, Erwin 194x. What is life?)

Downing, J.A., C. Plante, and S. Lalonde. 1990. Fish production correlated with primary productivity, not the morphoedaphic index. Can. J. Fish. Aquat. Sci. 47: 1929-1936.

Unified science for integrated management

Proposed approach

•Emphasis on unity-integration
•One conceptual model (flowing soil)
•One prediction, with SE
•One decision: *triple plankton production*
•One unifying AM experiment (ship channel)

•**Two integrated science programs (IEP+)**

Program splits itself to embrace obstacle

Present approach

•Emphasis on mechanistic understanding
•Many conceptual models (DRERIP)
•Many *possible futures*
•Two BiOps*: multiple RPA actions*
•Testing multiple hypotheses

•**One coordinated science program (IEP)**

Program tries to split obstacle

Which approach is more likely to succeed?

Questions