Modeling flows and biology in the Delta: Some challenges

Stephen Monismith
Stanford University

What do we use models for?

Evaluation of engineered modifications to system (e.g.):

- Effects of flow regulations on water supply
- Operation of facilities
- Construction of gates/shallow water habitat/runways

Improving understanding of how system works (e.g.):

- Role of tidal mixing in ETM dynamics
- Importance of shoals to phytoplankton blooms
- Variability of residence time inside flooded islands
- Role of transport in recruitment/habitat of organisms in estuary

What models are in use?

1D models

- Fischer Delta Model (DSM1)
- DSM2 (4 Point)/PTM
- Link-node

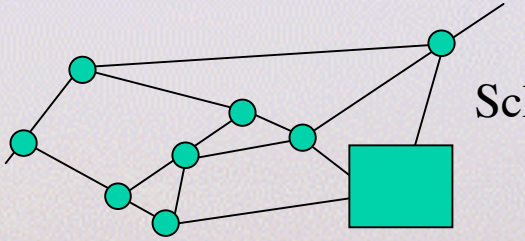
2D models

- RMA (finite element)
- TRIM2D (finite difference)

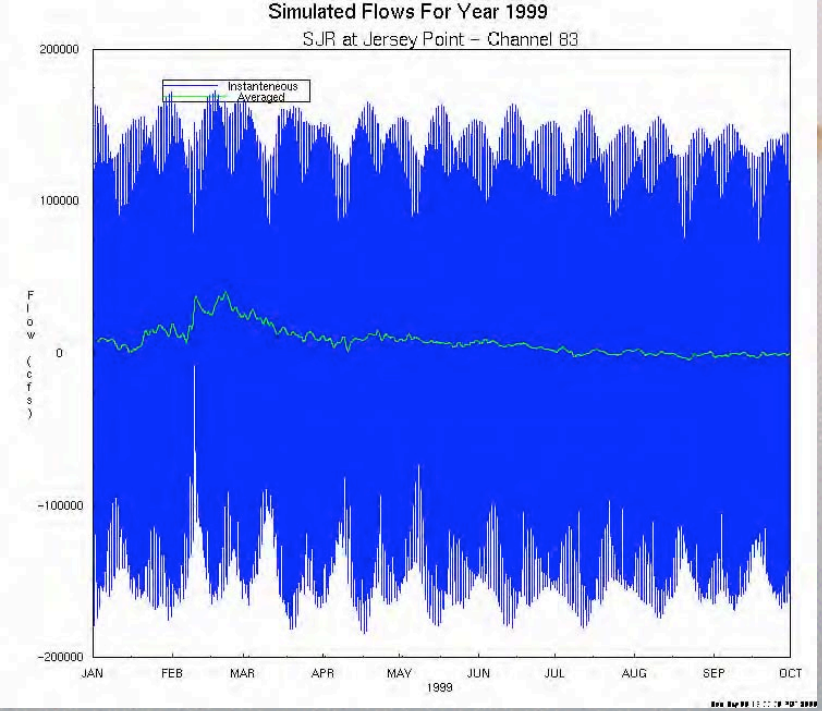
3D models

- RMA
- TRIM3D/SI3D
- UnTRIM (unstructured 3D)/SUNTANS (unstructured 3D)
- ROMS (Regional Ocean Modeling System)
- ECOM

1D Network channel model
(Fischer Delta Model and DSM1/ DSM2)



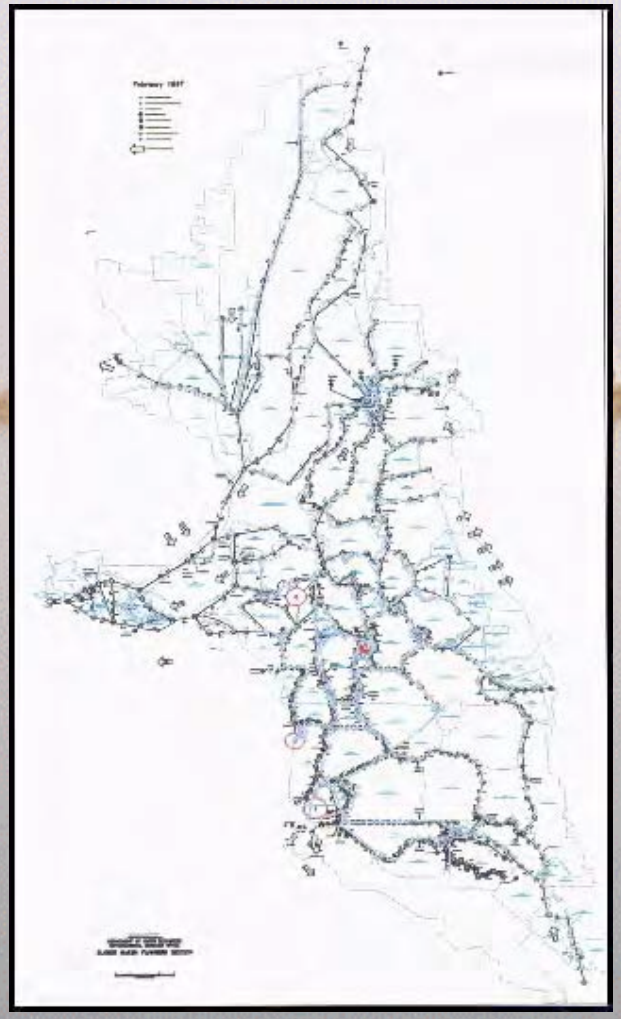
Schematic

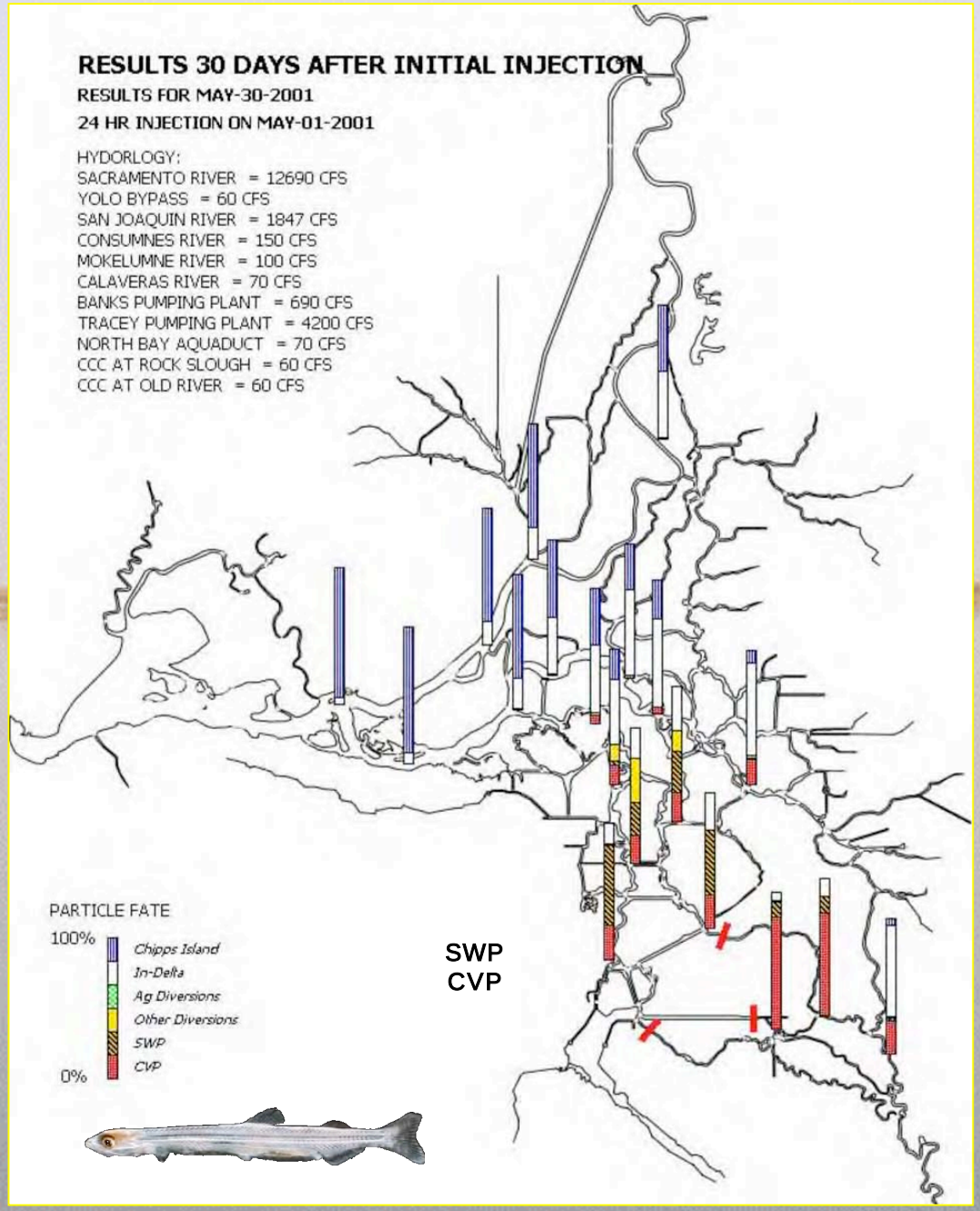


The challenge

From: http://www.iep.water.ca.gov/calfed/dsm1/index.html

The DWR Particle Tracking Model





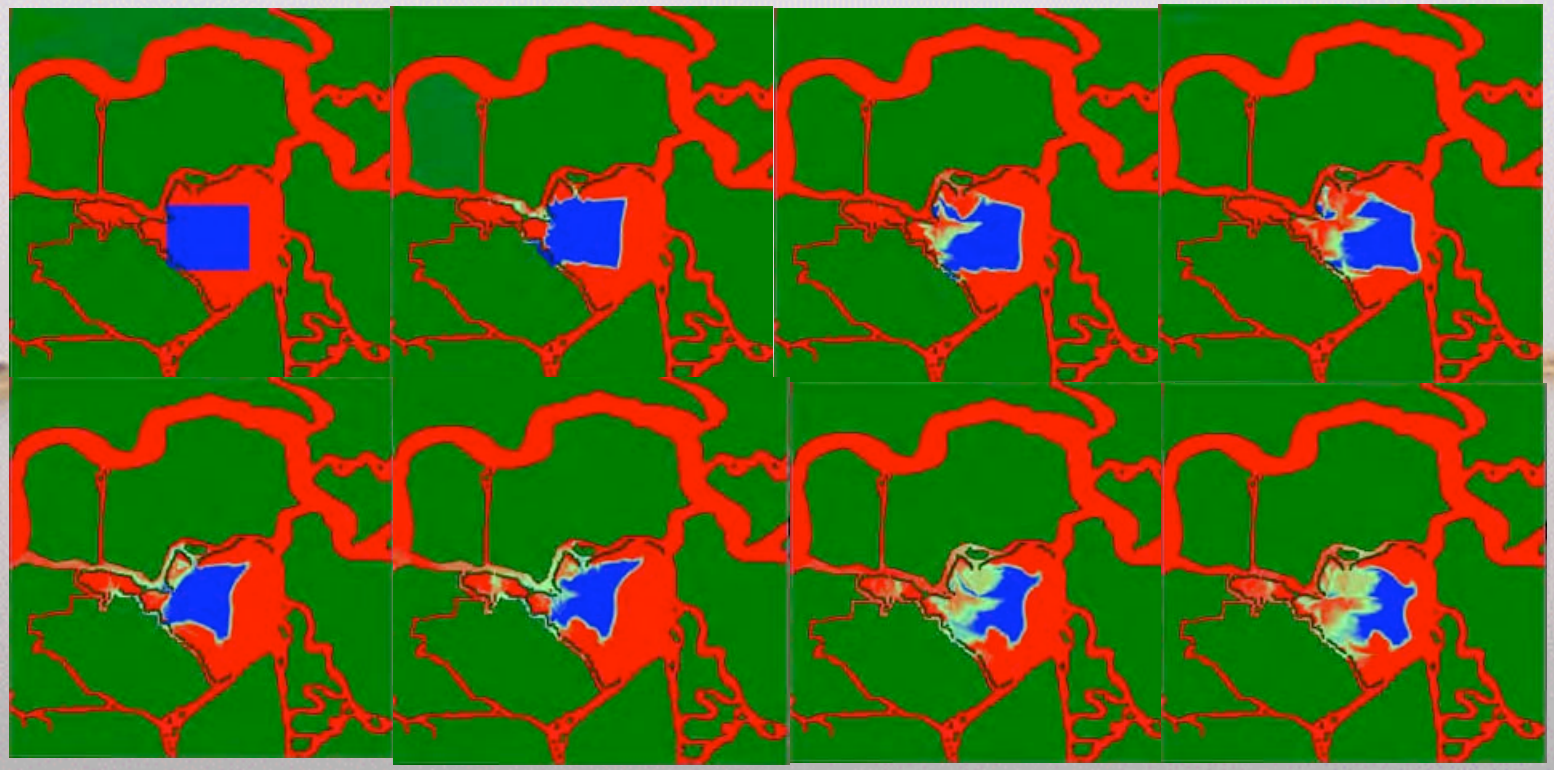
K. Flemming, EWA Review 2004

Montezuma slough

Grizzly Bay

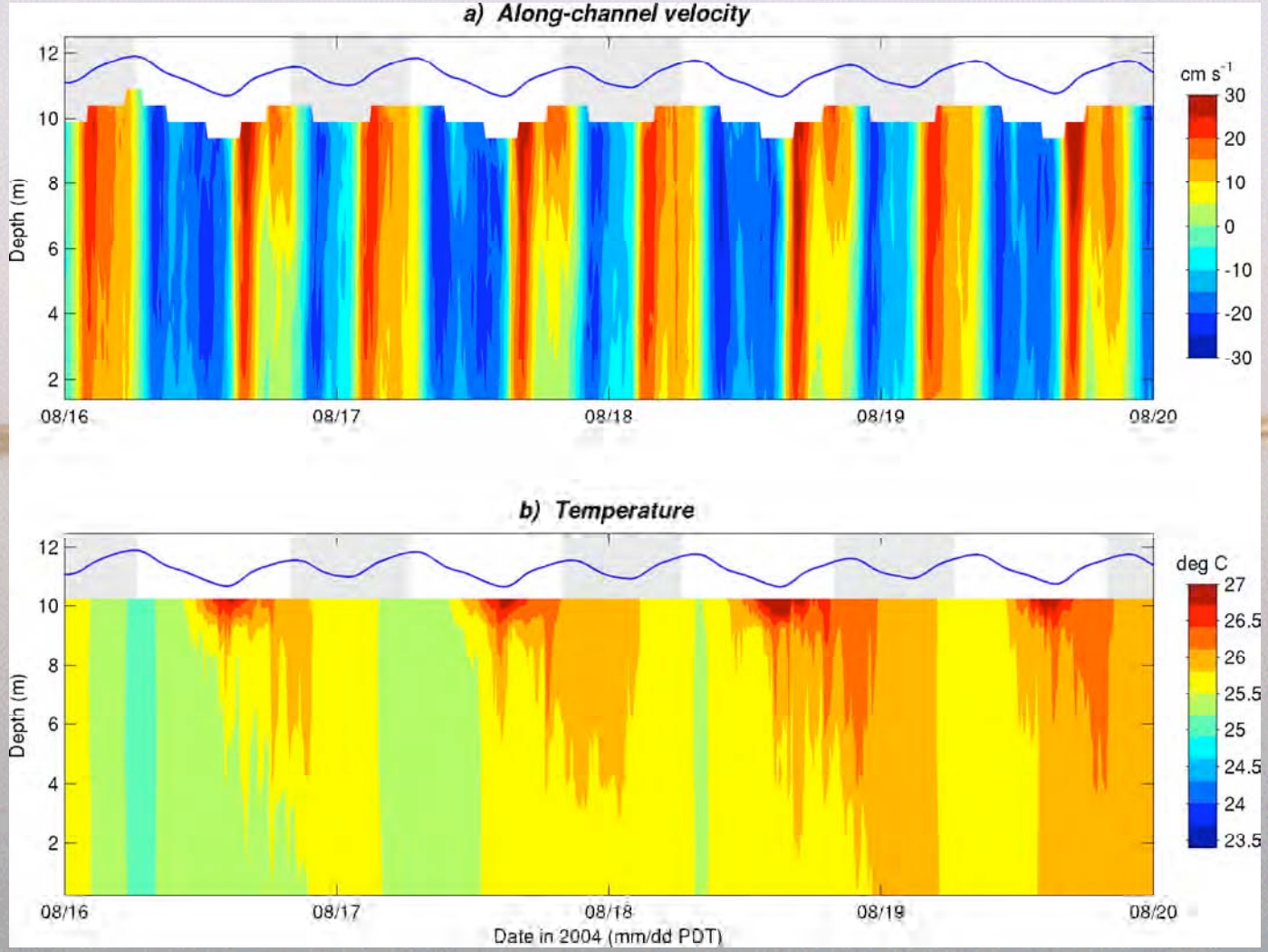
Source: DWR archives

What 2D models can do



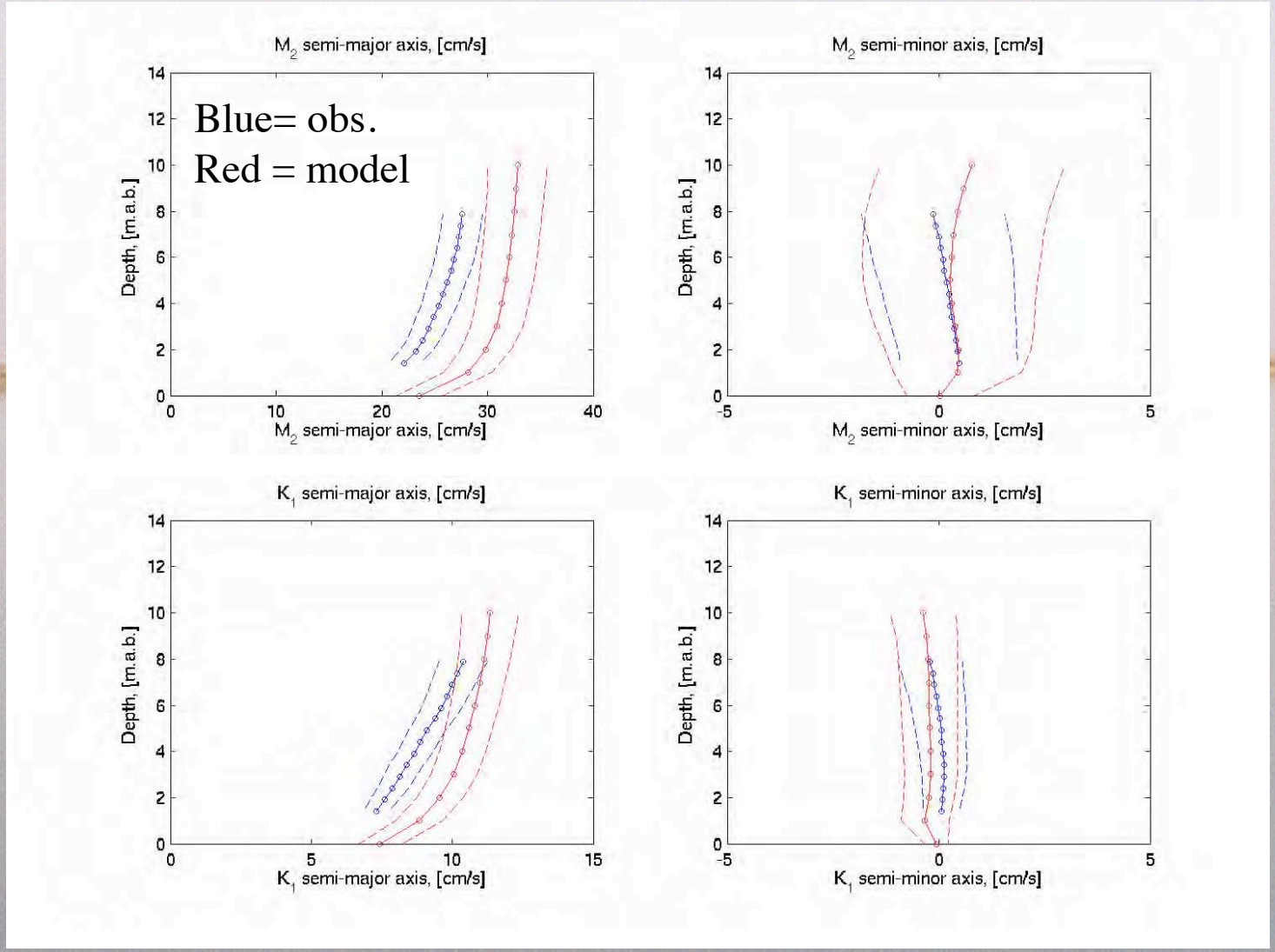
Calculations by N. Monsen (2000)

What 3D models can do: Vertical structure



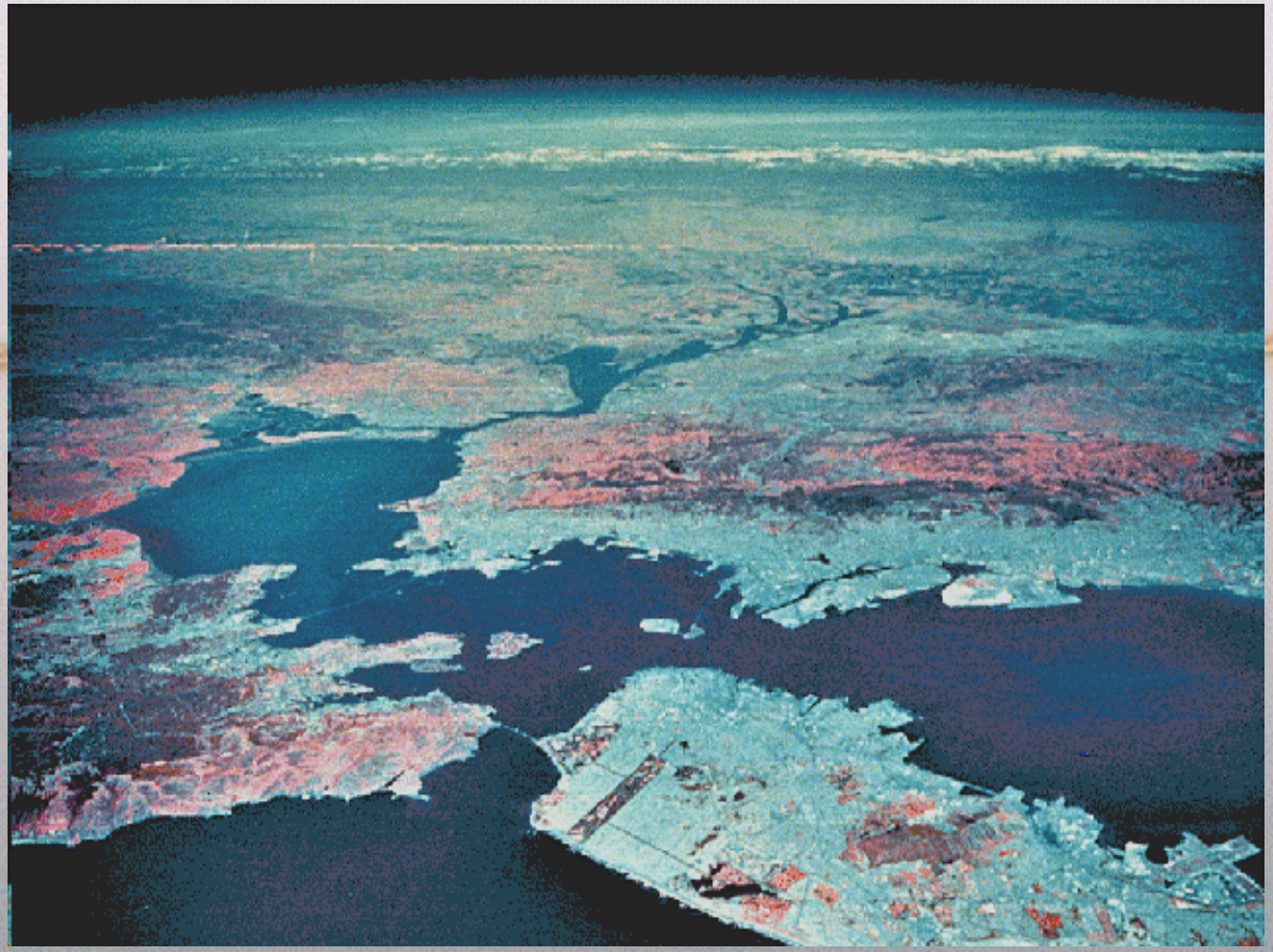
San Joaquin Deep Water Ship Channel (Hench et al unpub.)

Calibration of a 3D model



SI3D - Hench et al (unpub)

Model domain?



Issues with Numerics: Pure advection is tough!

Diagonal advection

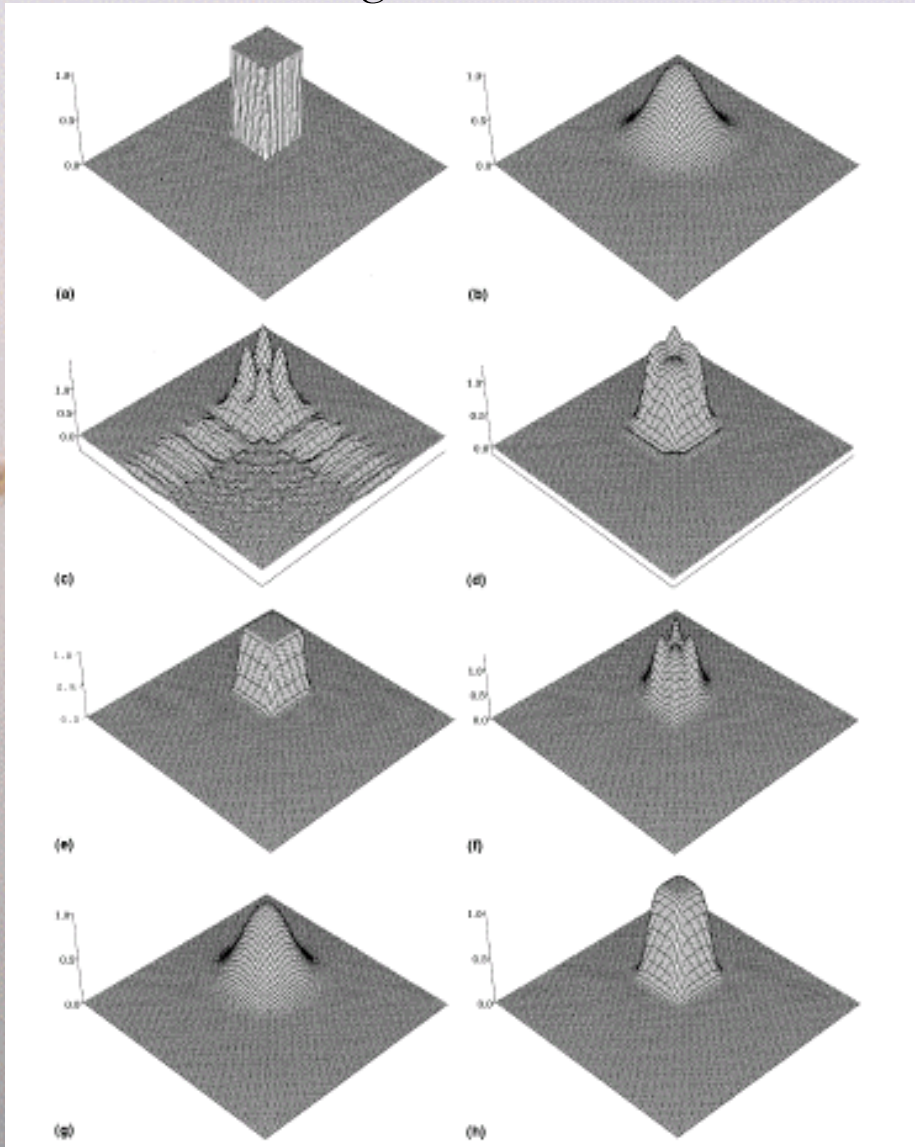


FIG. 1. Final Scalar Field for Diagonal Advection of Square Wave Test Case: (a) Exact Solution; (b) First-Order Upwind; (c) Leapfrog-Central; (d) QUICKEST; (e) LWlim; (f) MPDATA; (g) ELM, Low c; (h) ELM, High c

Rotate a gaussian cone

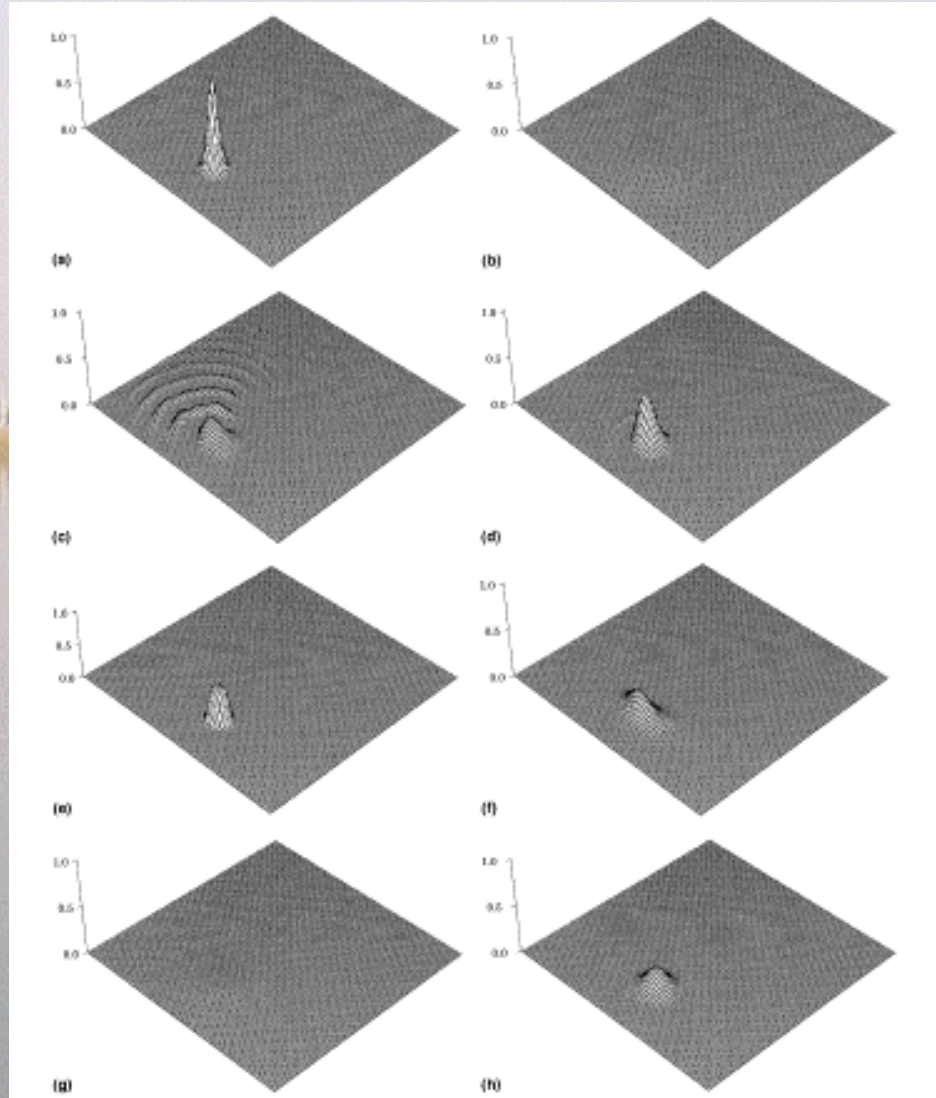
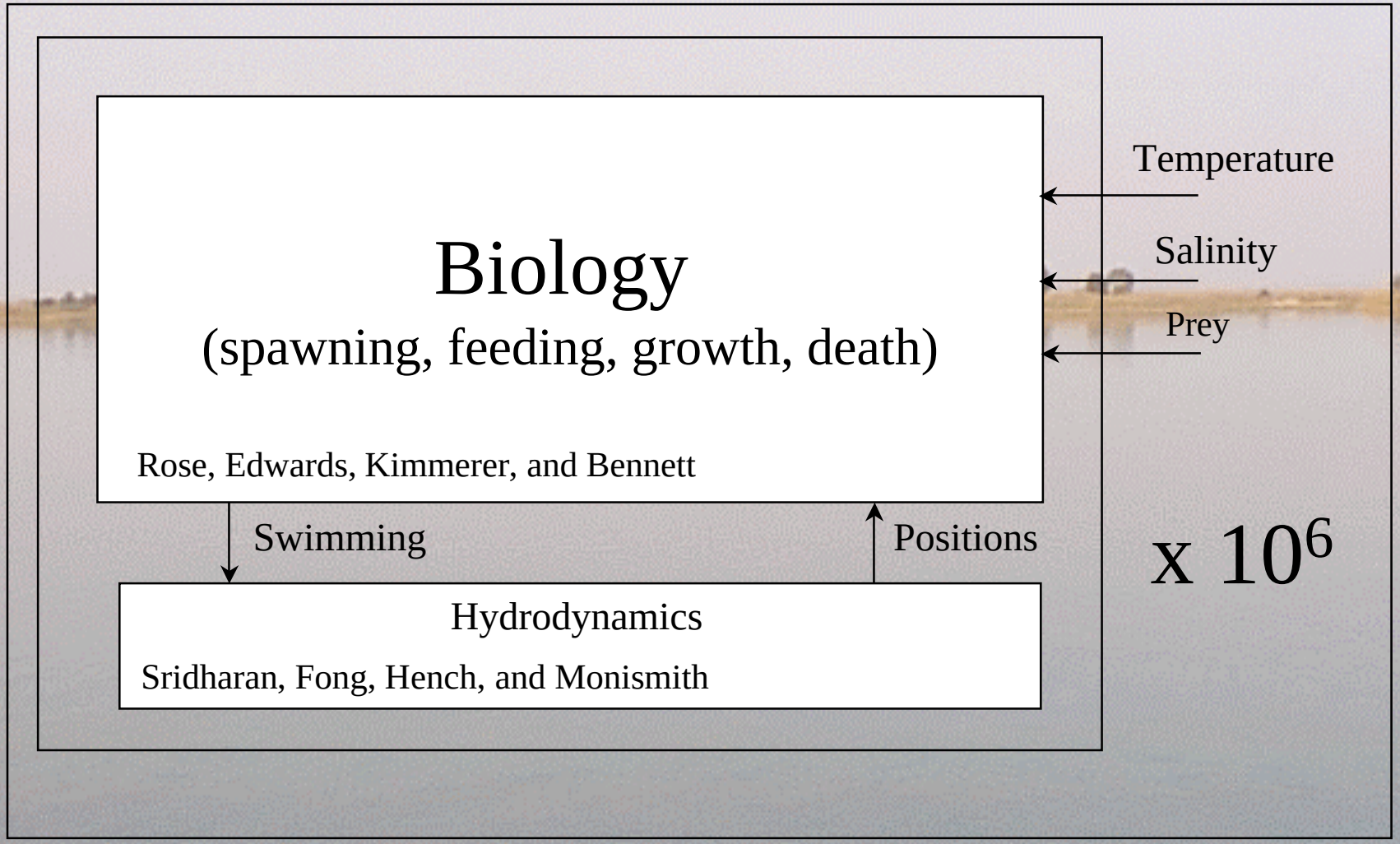


FIG. 2. Final Scalar Field for Rotation of Gaussian Cone Test Case: (a) Exact Solution; (b) First-Order Upwind; (c) Leapfrog-Central; (d) QUICKEST; (e) LWlim; (f) MPDATA; (g) ELM, Low c; (h) ELM, High c

The LSU-SFSU-LSJU Delta Smelt IBM: Goal is to model Delta Smelt population



Physical-Biological Model

Hydrodynamic Model (TRIM3D)

↓

Currents
Eddy diffusivities

↓

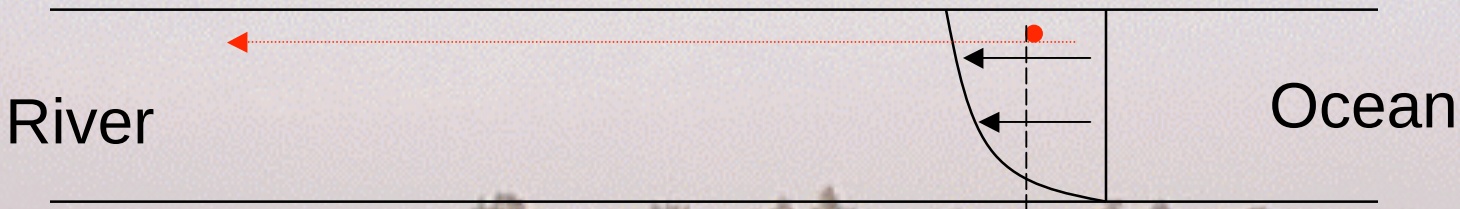
Particle Tracking Model

↓

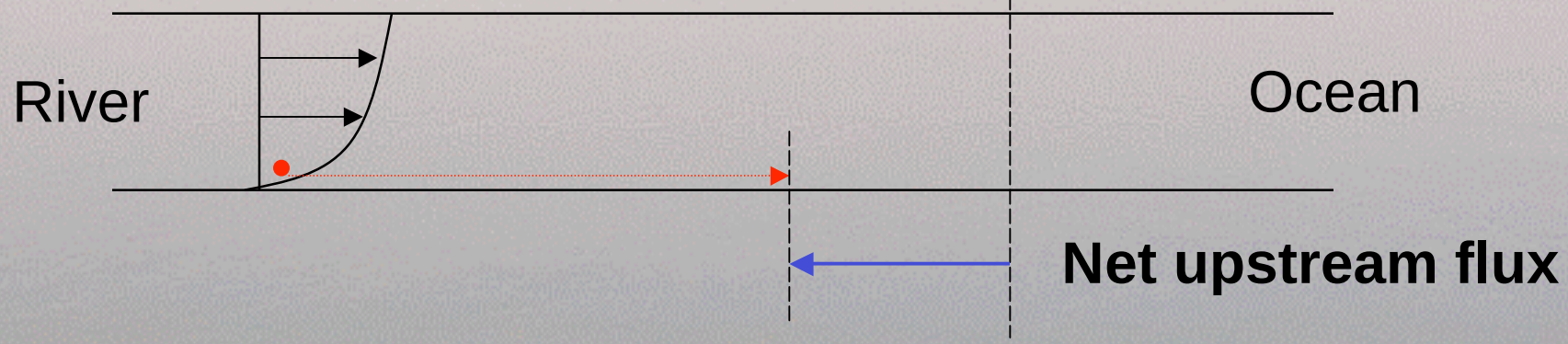
Output: Three-Dimensional Particle Trajectories

Tidal Vertical Migration

Zooplankton swim up on flood



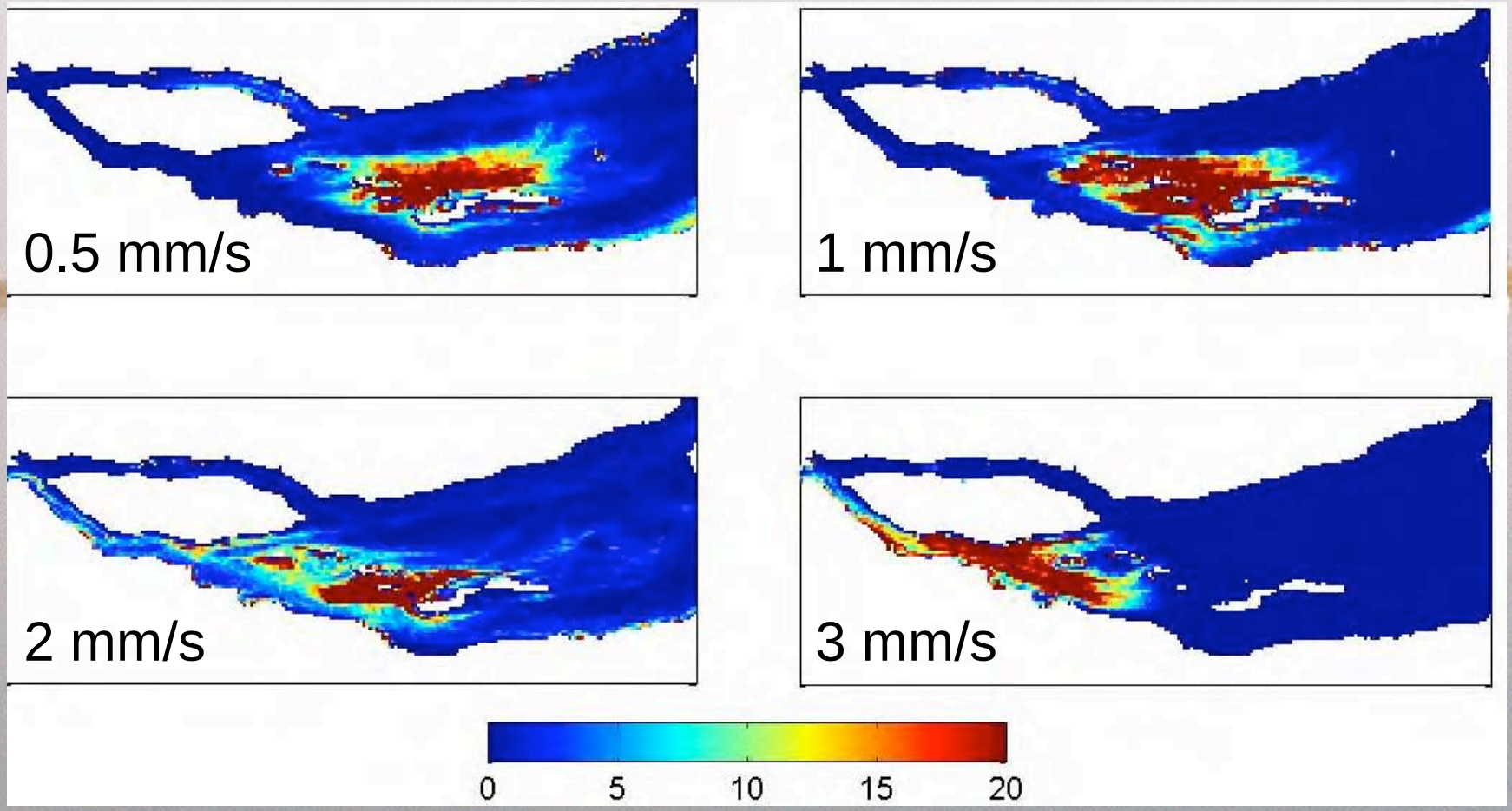
And swim down on ebb



Kimmerer et al., Limnology and Oceanography, 1998

Tidal Vertical Migration: Transport w. behavior in the St. Lawrence estuary

Tidally-average particle distributions



number of particles

Simons et al 2007

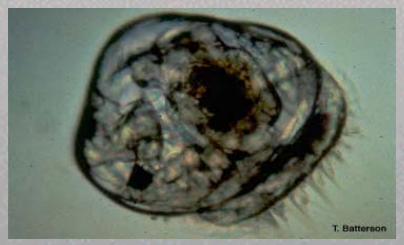
Model Verification: Zebra Mussel Veligers

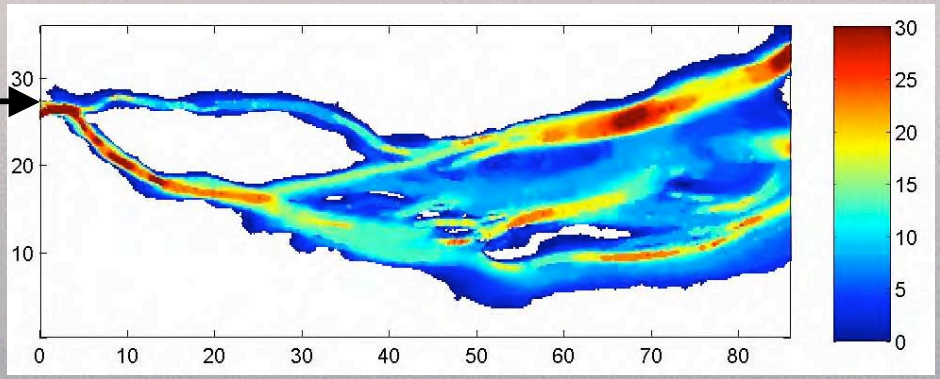
Model Set-up:

- Passive particles (w_b=0, no swimming or sinking speed)
- Mortality: 50% at 5 psu salinity and 100% at 10 psu

Continuous Input from upstream source:

20 particles/time step

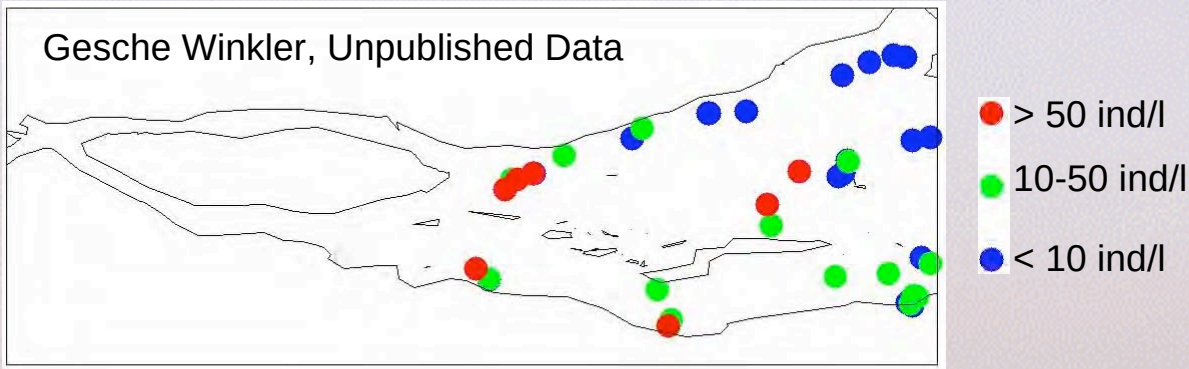




Veliger Spatial Distribution

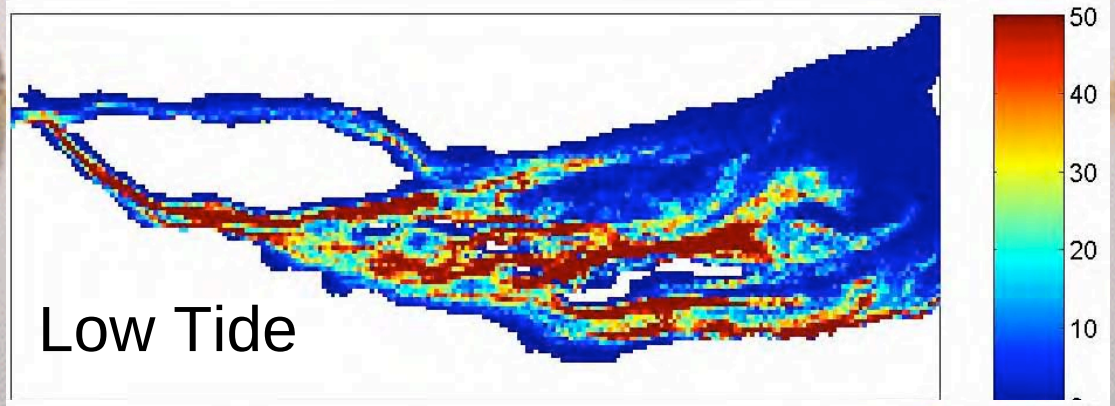
Field Data:

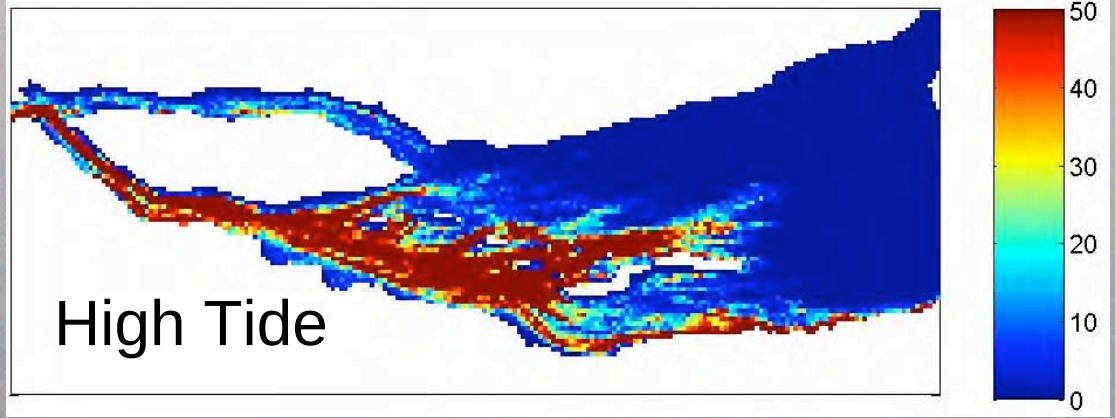
Surface samples
June-August 2000

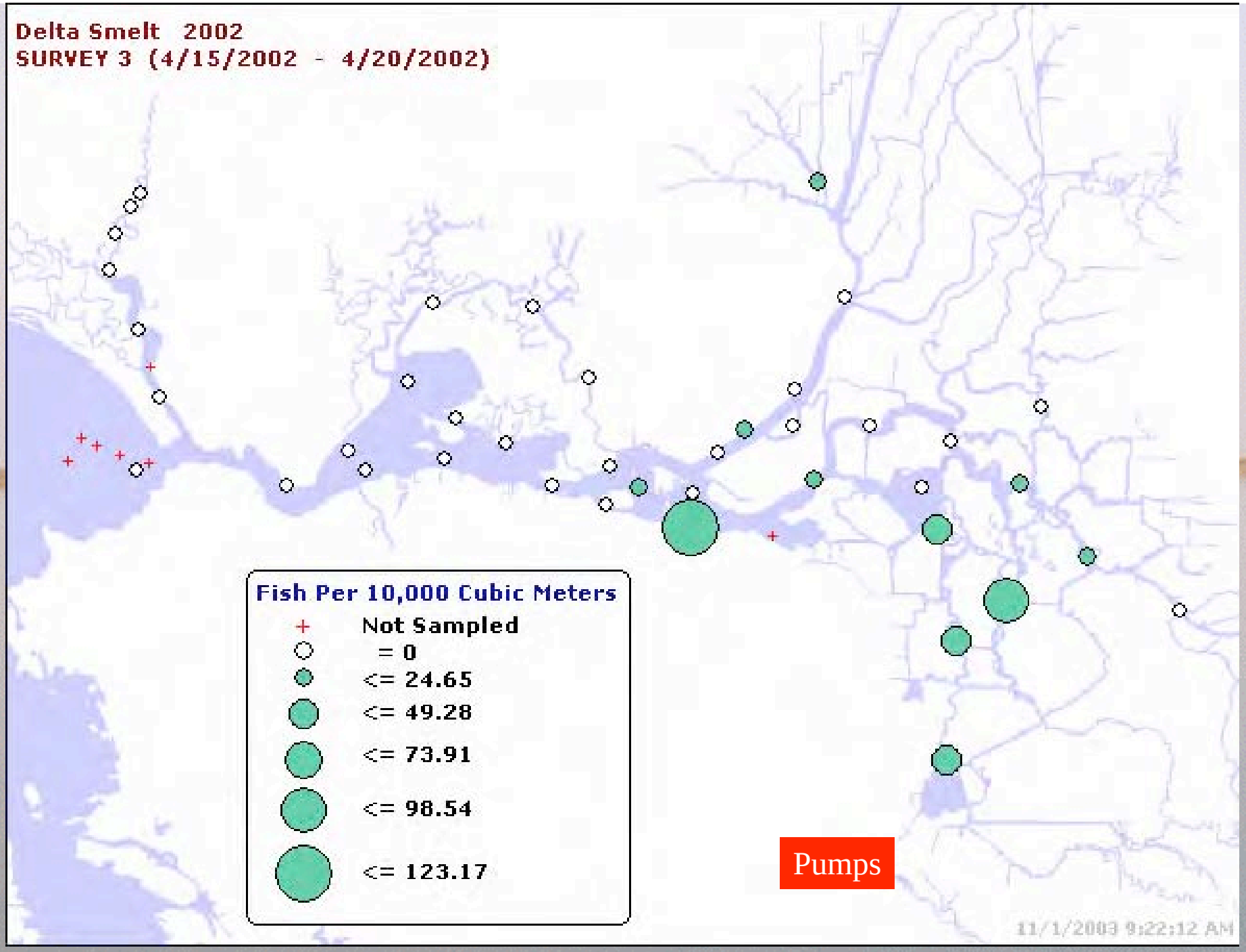


Model Data:

Particle distribution
(total number)






Delta Smelt 2002
SURVEY 3 (4/15/2002 - 4/20/2002)
Fish Per 10,000 Cubic Meters
Not Sampled
= 0
<= 24.65
<= 49.28
<= 73.91
<= 98.54
<= 123.17
Pumps
11/1/2003 9:22:12 AM

Typical Bay/Delta Stakeholder

Summary

Only physics

Physics and biology

Workshop Purposes

- Provide an overview of hydrodynamic and coupled physical-biological modeling in the San Francisco estuary;
- Focus on physical modeling and fish management: how can the various physical models inform fish biologists and managers in the SF estuary?
- Foster public discussion about the models, their applications and limitations, andthe role of the IEP with respect to modeling activities;
- Initiate a review of IEP hydrodynamic modeling activities by the IEP Science Advisory Group (SAG).