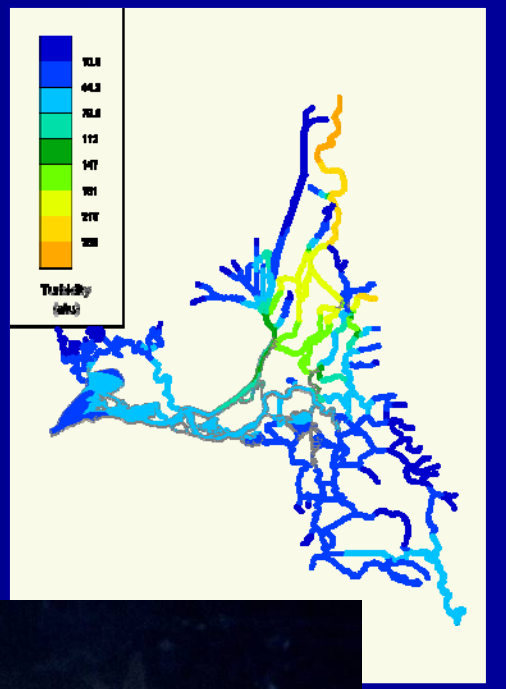
Particle Modeling of Adult Delta Smelt with Behavior based on EC and Turbidity Distributions

John DeGeorge, RMA

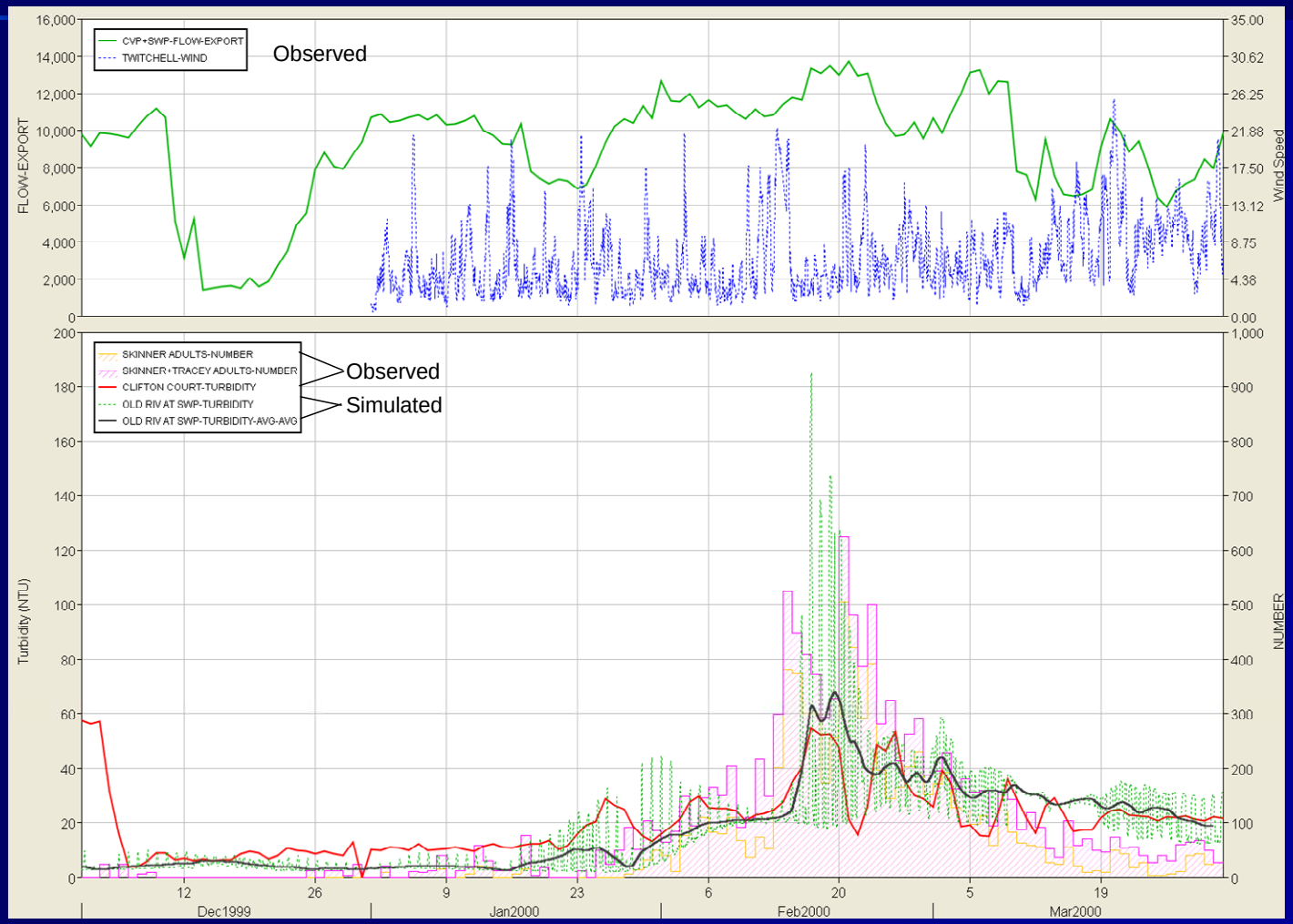
- Turbidity Model
- Adult Delta Smelt Behavior Model for the December-March Spawning Period
- Comparison of Observed and Simulated Adult Delta Smelt Salvage
- Work funded by the Metropolitan Water District under the direction of Curt Schmutte with guidance from Dave Fullerton



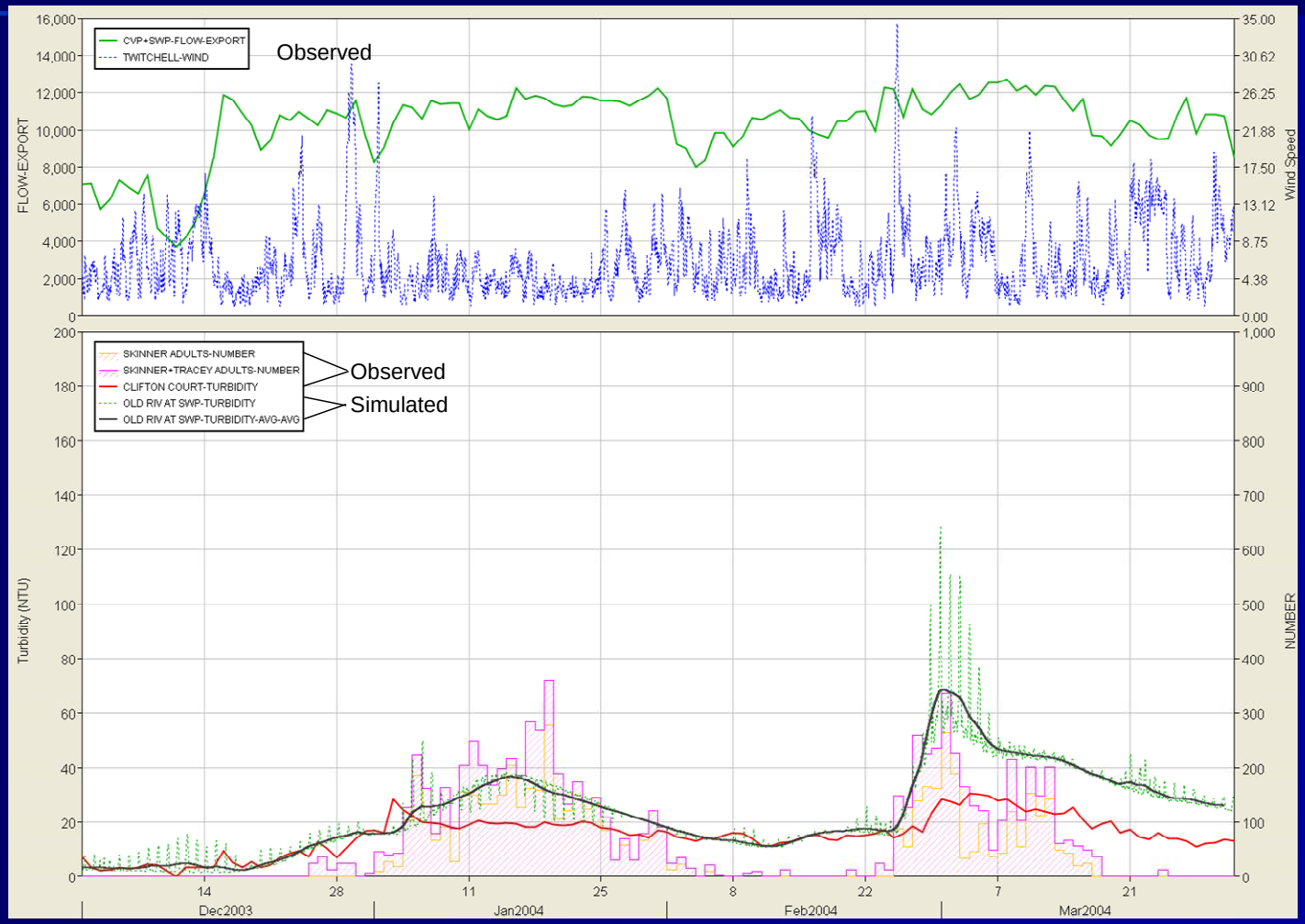
Adult Delta Smelt Behavior Hypothesis

- Adult Delta Smelt salvage at the primary Delta exports appears to correlate with the turbidity distribution particularly during first flush storm events
- Turbidity and Salinity (EC) distributions are primary drivers (or correlated to primary drivers) that impact positioning of Adult Delta Smelt in the system
- Fish can determine which direction leads to “favored water column characteristics” by sensing concentration gradients in the water
- Fish seek “favored” Salinity and Turbidity using a “Surfing” behavior
- Fish distribute throughout the region of “favored” habitat

Turbidity and Salvage, 1999-2000

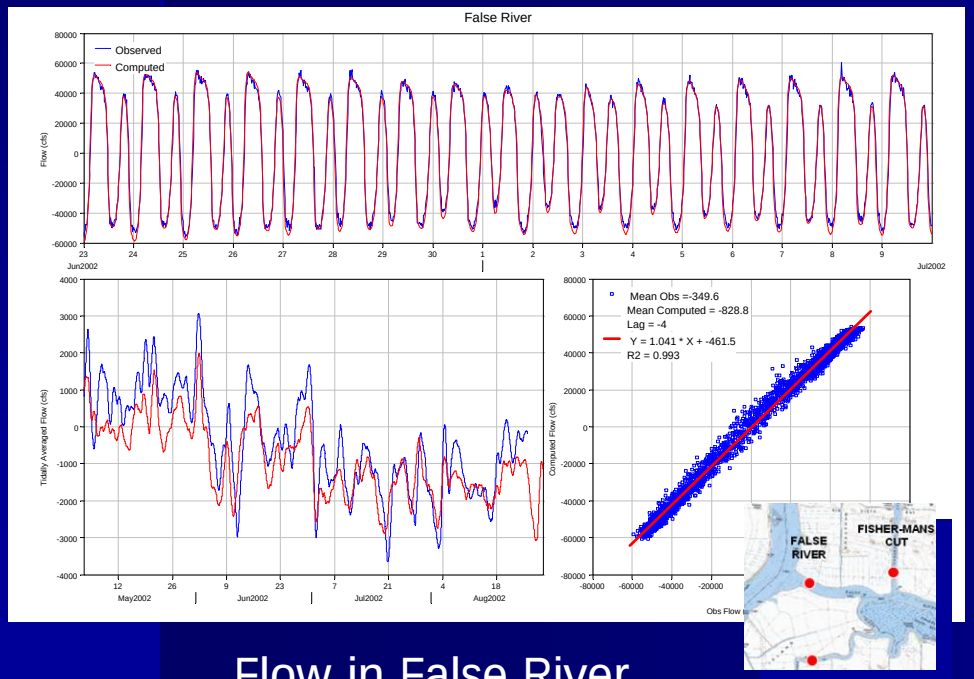


Turbidity and Salvage, 2003-2004

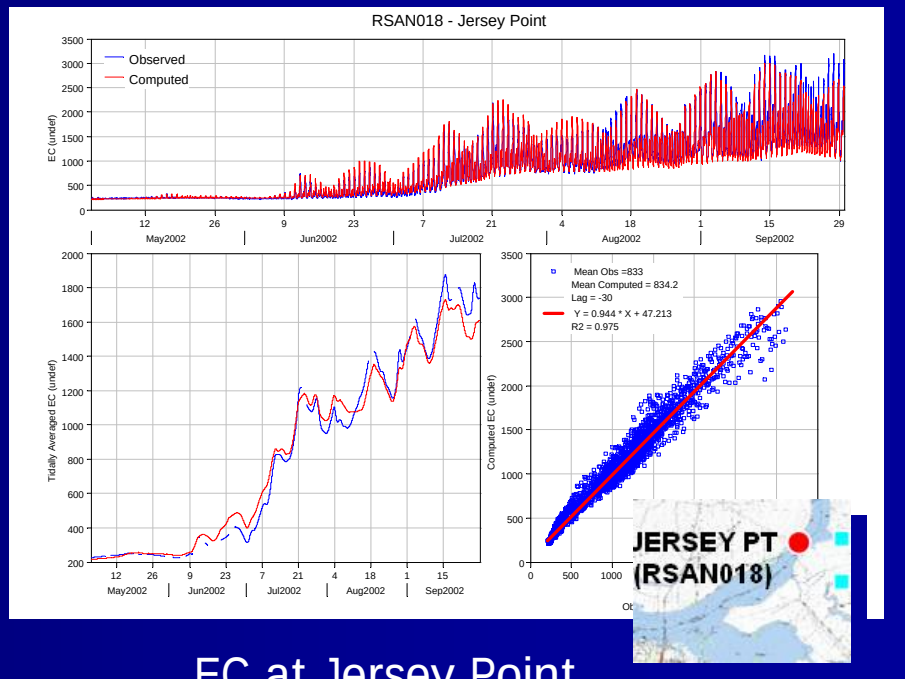


Flow and EC Simulation

- The RMA Bay-Delta Model has been shown to produce good results for Flow and EC throughout the Delta under a wide range of flows (RMA 2002 Calibration Document, 2006 Calibration Updates)



Flow in False River



EC at Jersey Point

Turbidity Simulation

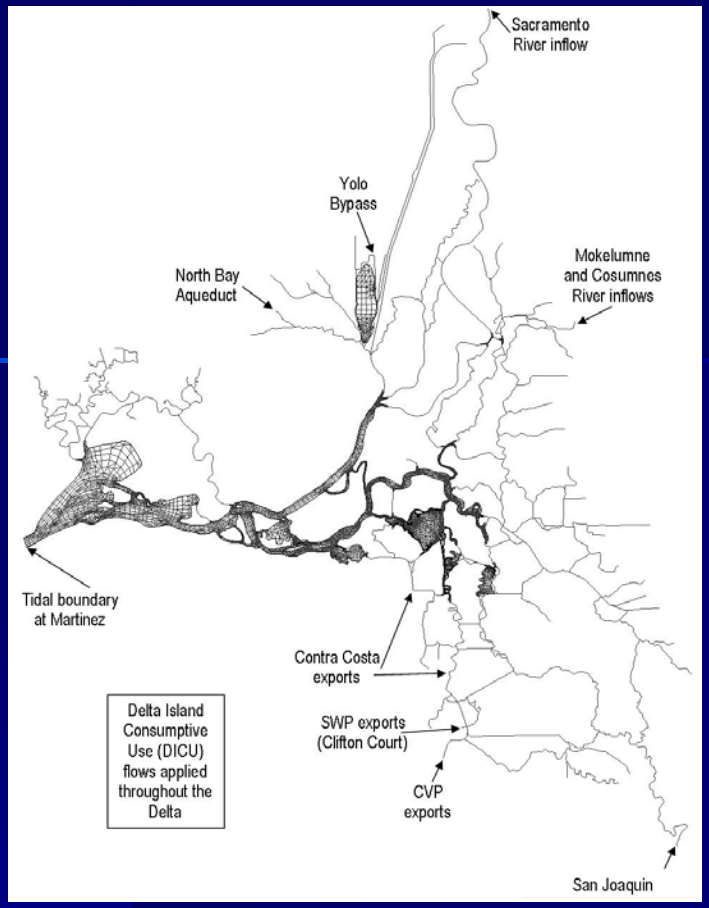
- Simulation of Turbidity is a new use of the model
  - Limited turbidity observations for inflow locations
  - Limited in Delta observations for model calibration/validation
  - How important is settling and resuspension in the system?
  - How do Delta Island return flows impact turbidity?

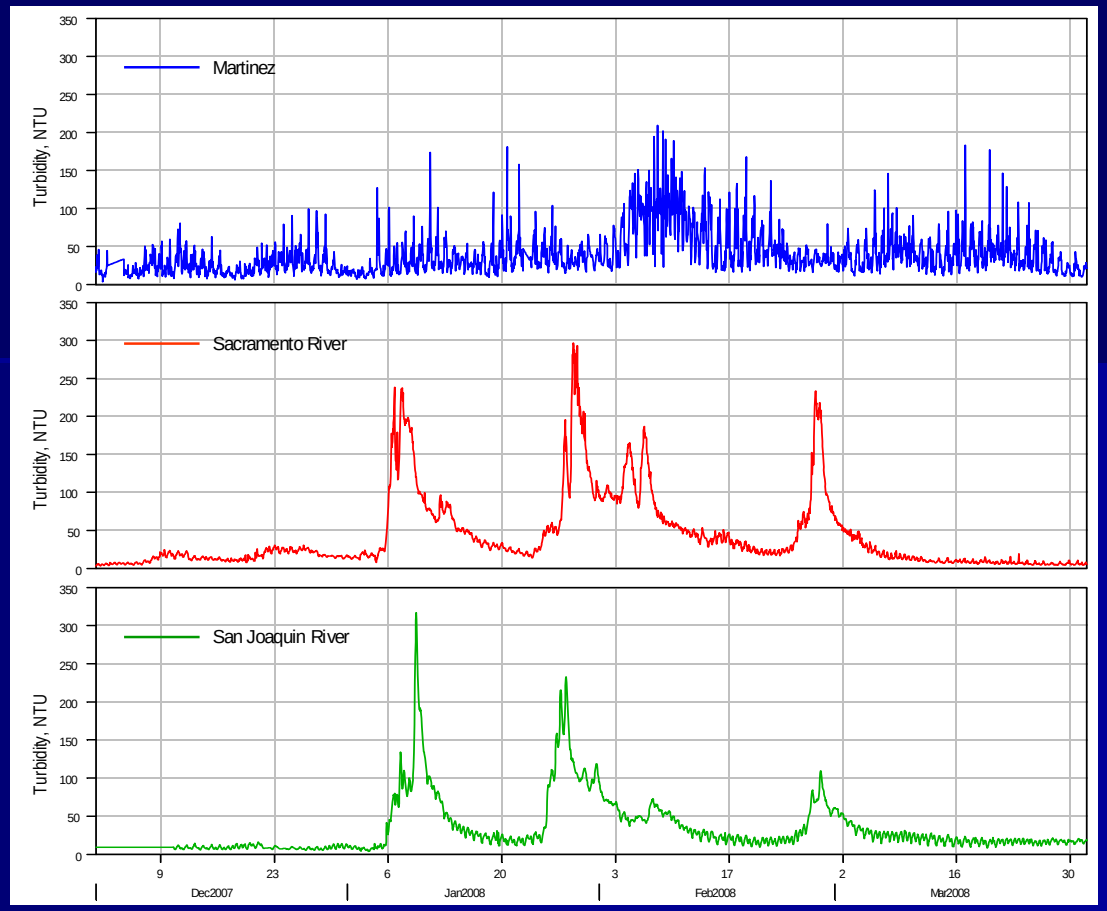
Turbidity Simulation

Turbidity was simulated for the period of December 2007-March 2008

- This is the period with the most reliable and complete boundary condition data (although we still need more data)
- The model was calibrated by introducing an exponential decay of -0.05/day to represent settling (no consideration of sediment grain size)
- Results show good overall agreement with observed data and highlight times and locations where wind resuspension is important

- Turbidity was then simulated using the calibrated decay coefficient for earlier years to drive the smelt particle tracking model

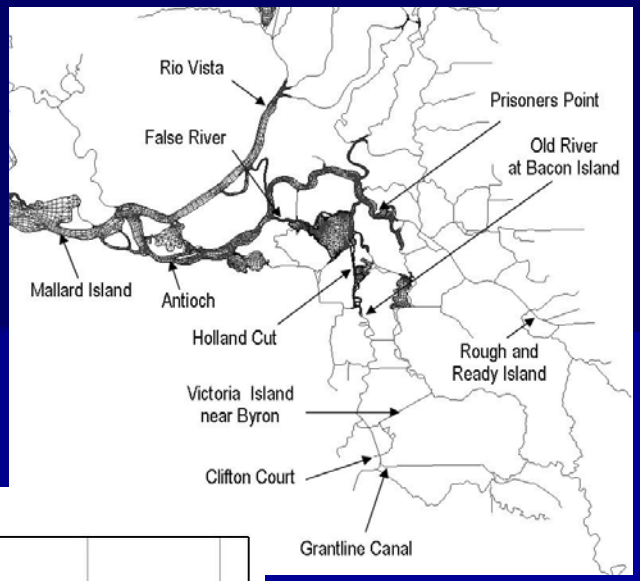


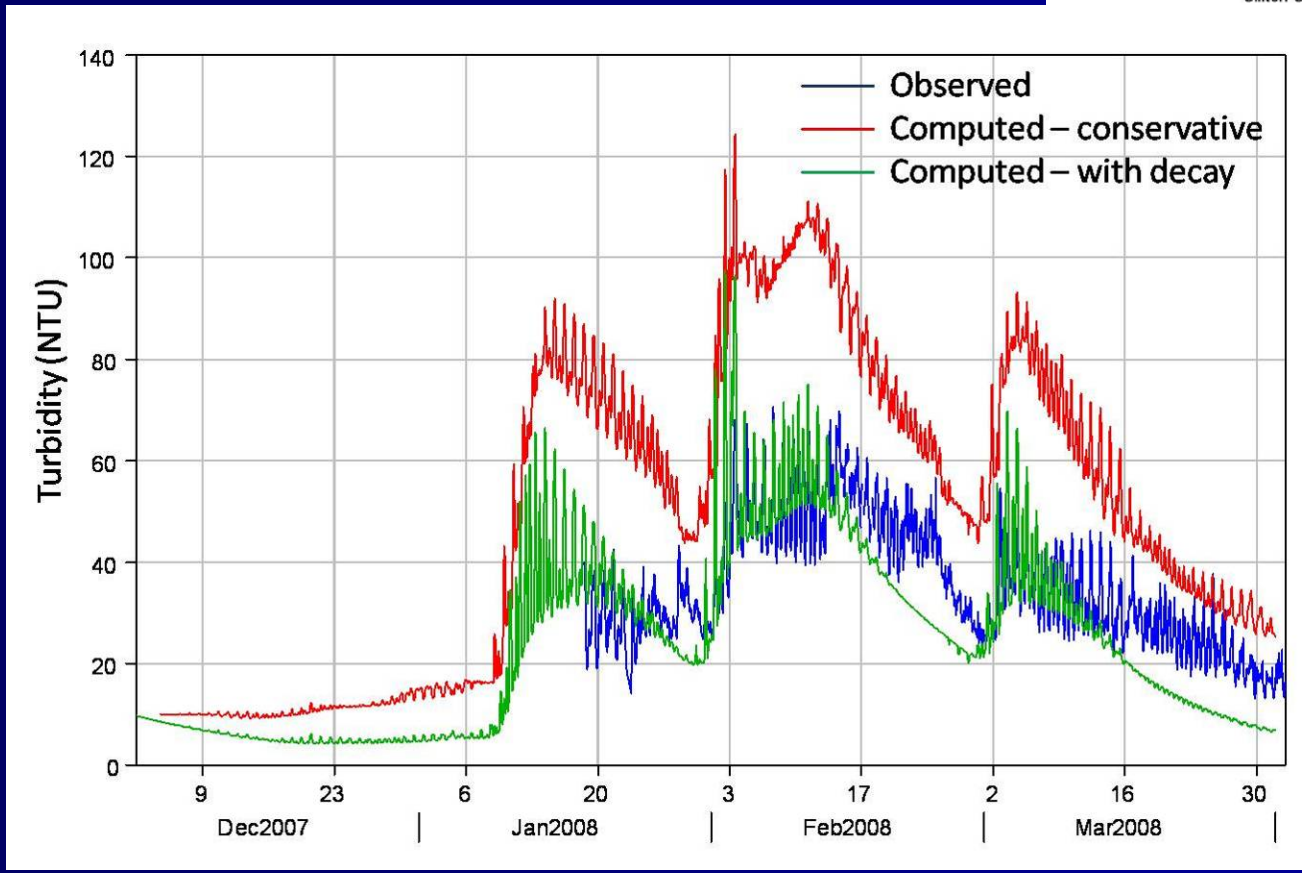


Model Input Locations	BC type	Data Source	Monitoring Location	BC type	Data Source	Monitoring Location
Martinez	Tidal elevation	NOAA	Martinez	Turbidity	CDEC	Martinez
Sacramento River	Inflow	USGS	Sacramento River at Freeport	Turbidity	CDEC	Sacramento River at Hood
San Joaquin River	Inflow	USGS	San Joaquin River at Vernalis	Turbidity	CDEC	San Joaquin River at Mossdale
Yolo Bypass	Inflow	CDEC	Yolo Bypass at Lisbon	Turbidity	CDEC	Sacramento River at Hood
Cosumnes River	Inflow	CDEC	Cosumnes River at Michigan Bar	Turbidity	CDEC	Sacramento River at Hood
Mokelumne River	Inflow	CDEC	Camanche Reservoir Outflow	Turbidity	CDEC	Sacramento River at Hood
Calaveras	Inflow	CDEC	Mormon Slough at Bellota	Turbidity	CDEC	No boundary condition applied - set at ambient

2007 Turbidity Results

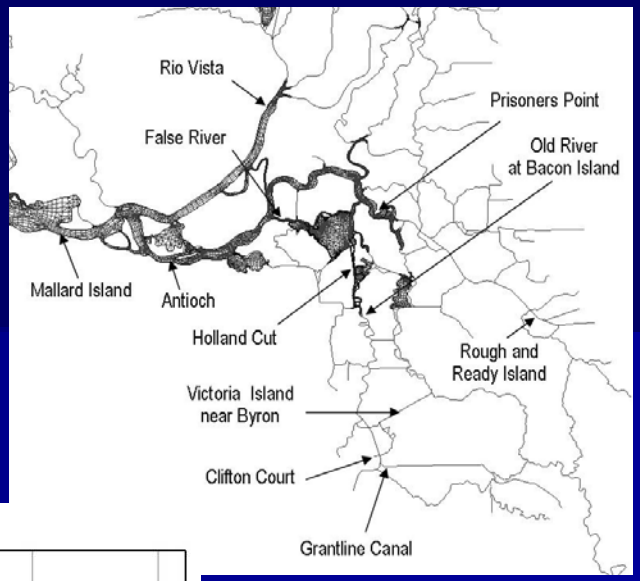
- Antioch

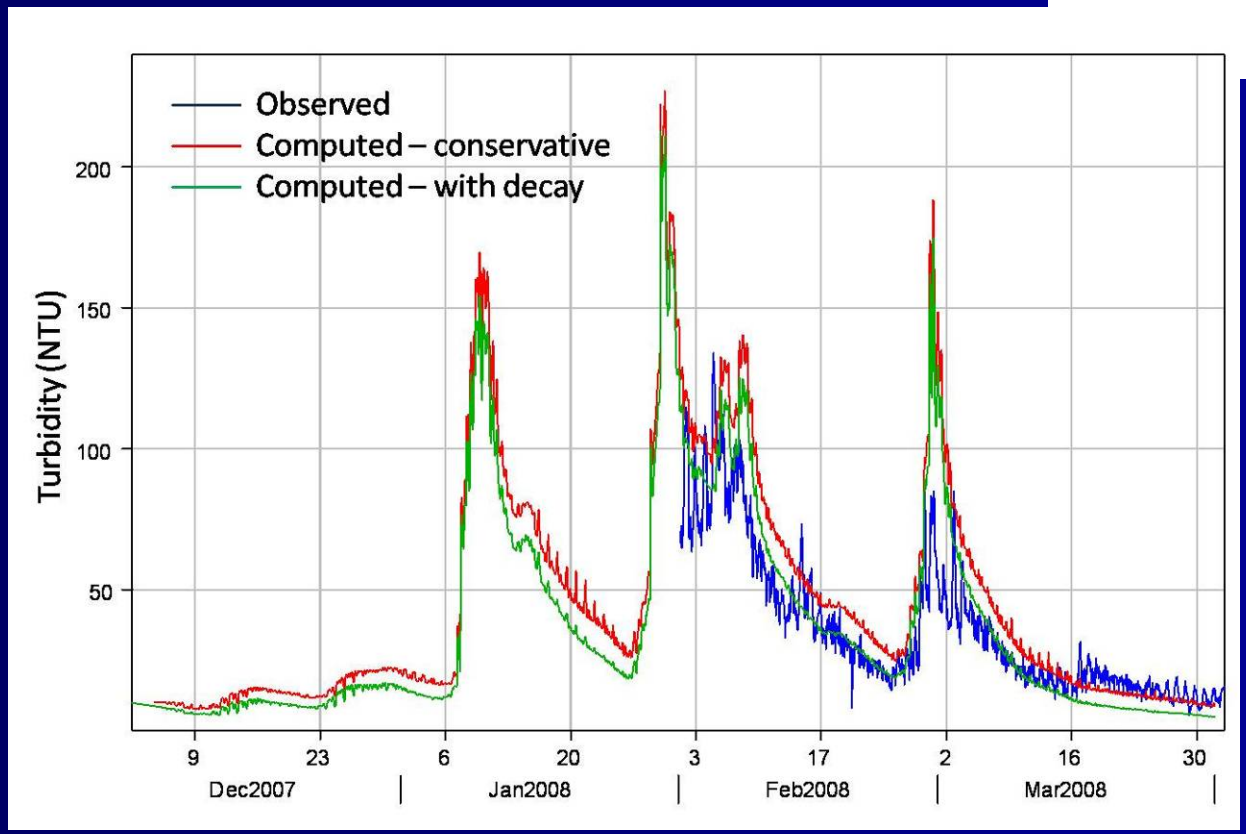




2007 Turbidity Results

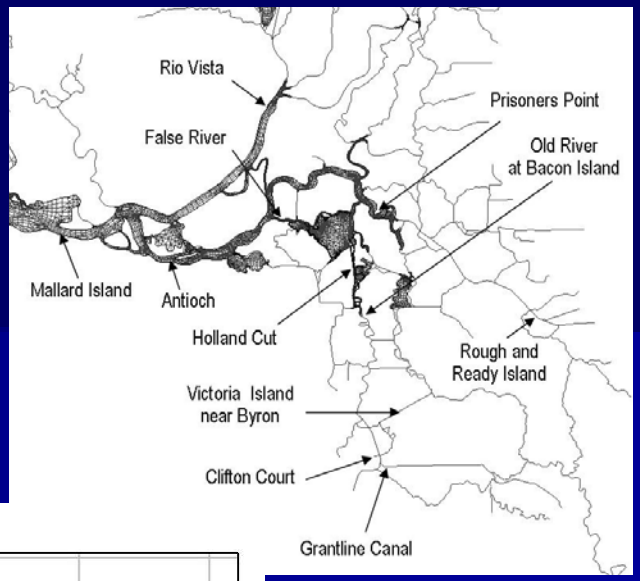
- Rio Vista

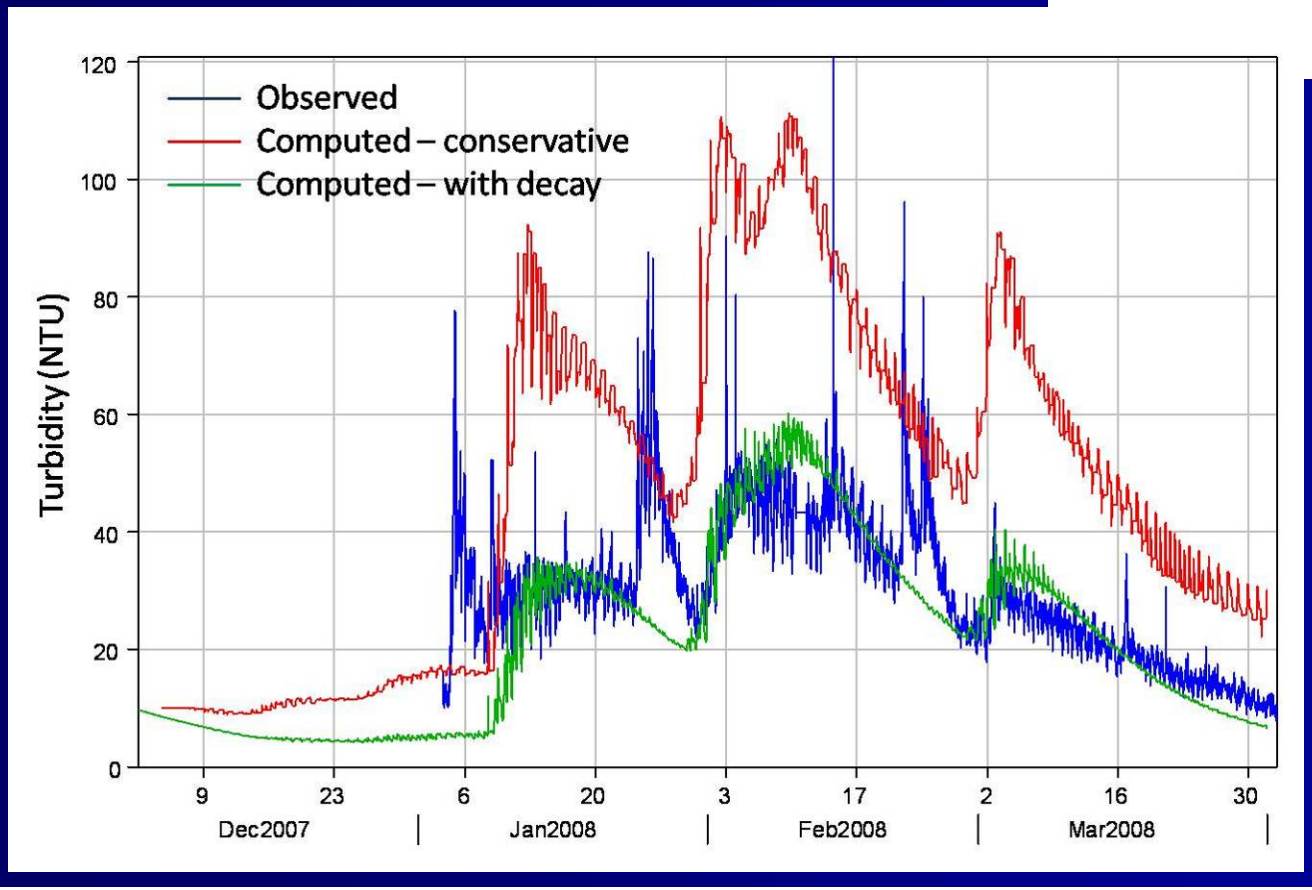




2007 Turbidity Results

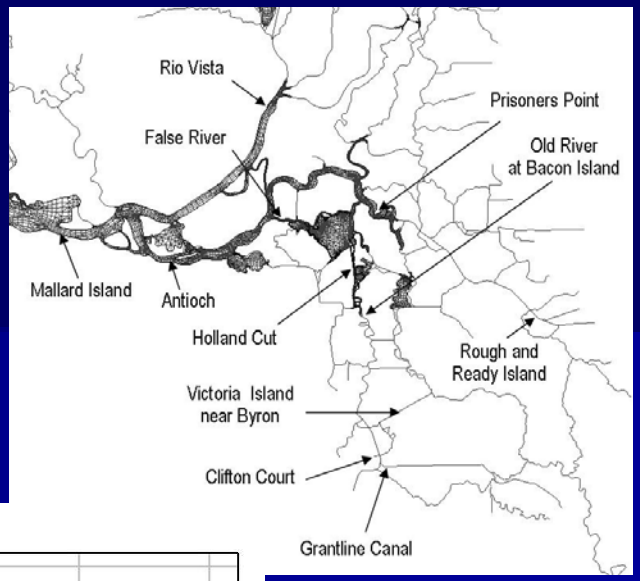
- False River

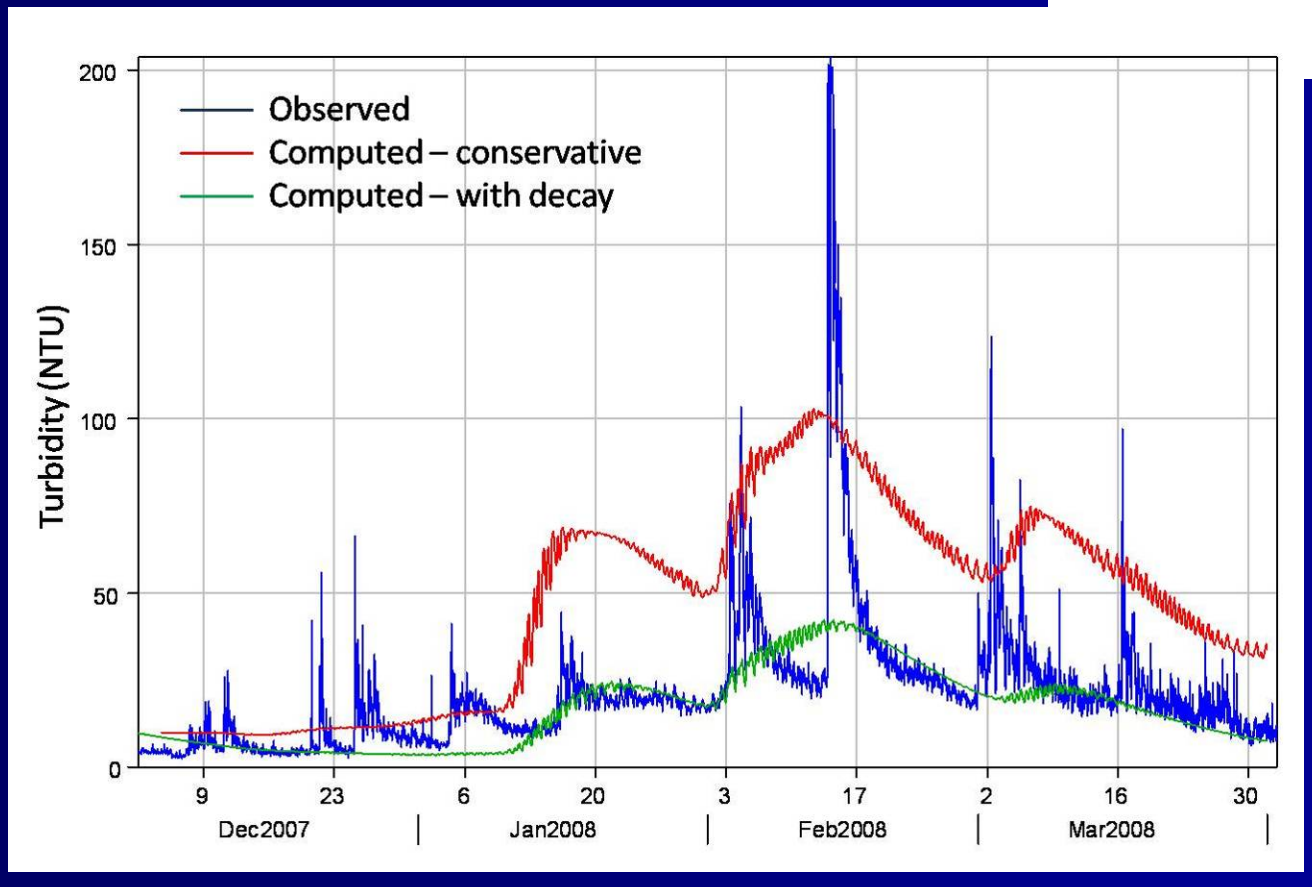




2007 Turbidity Results

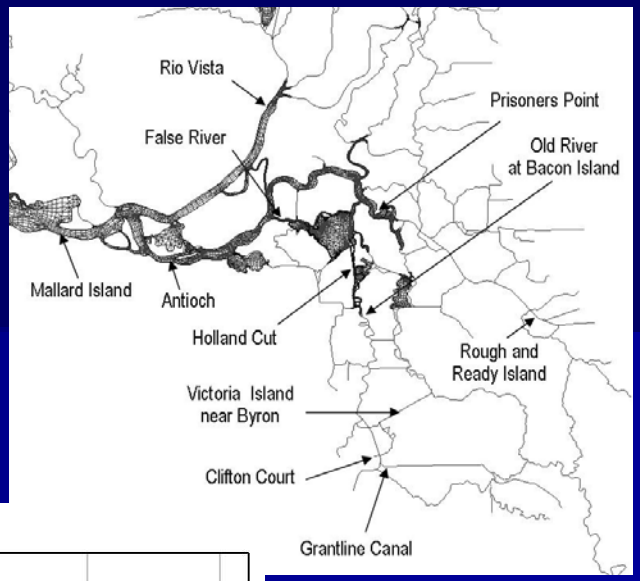
- Holland Cut

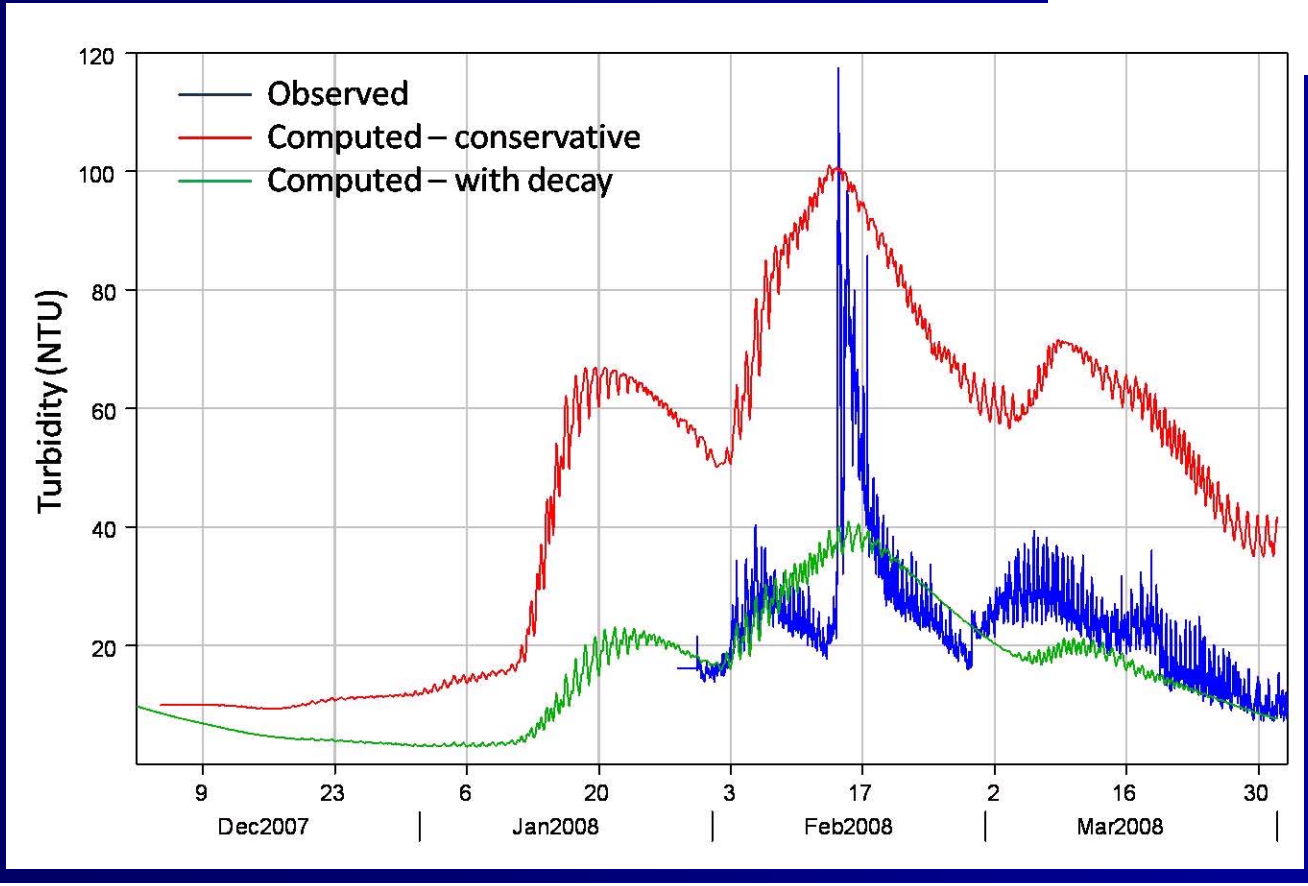




2007 Turbidity Results

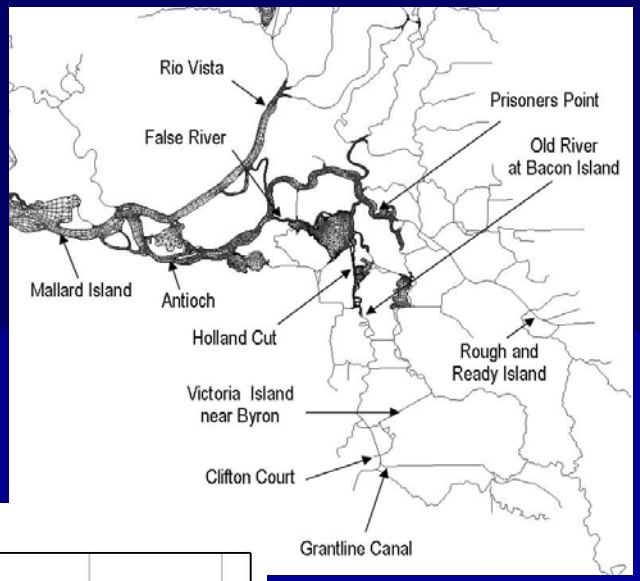
- Old River at Bacon Island

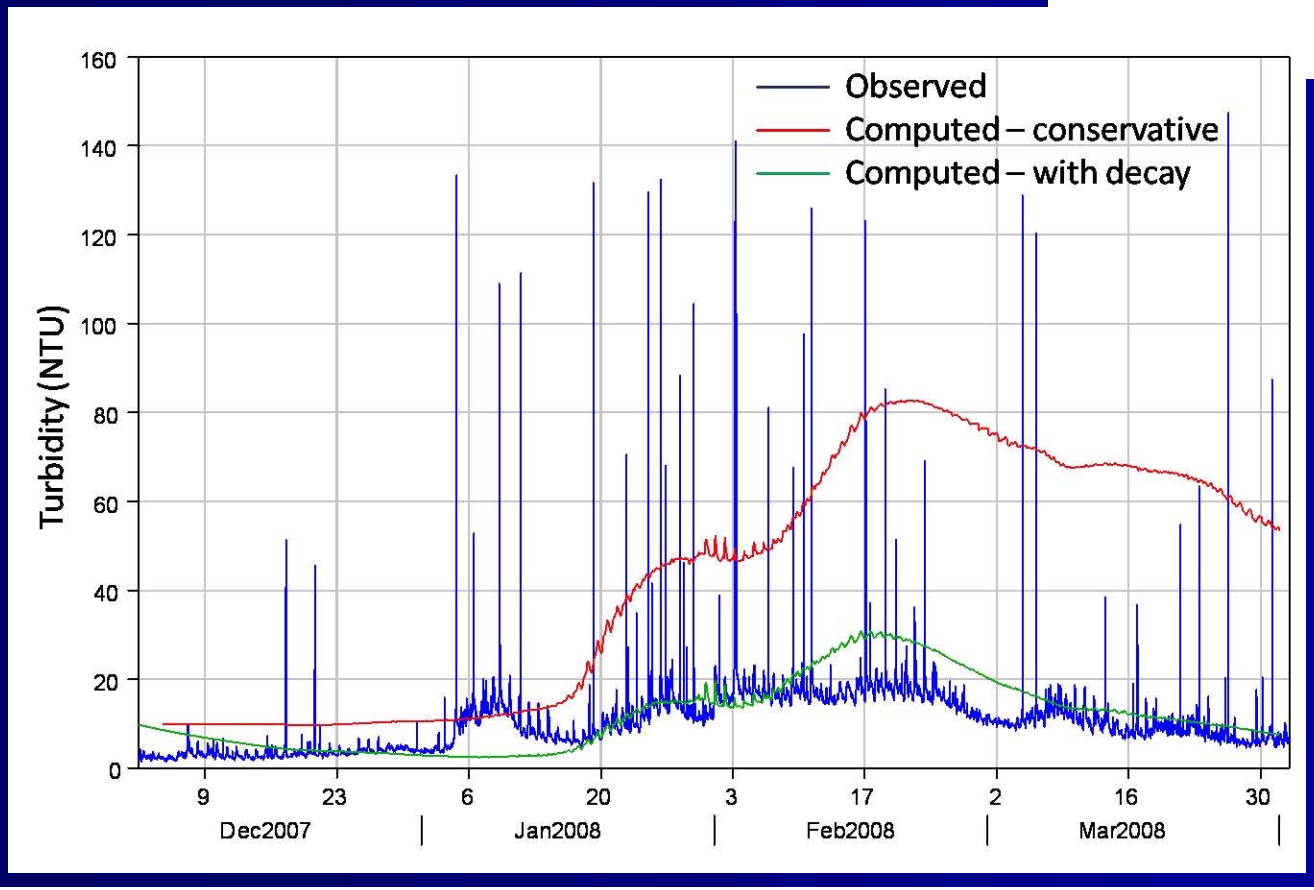




2007 Turbidity Results

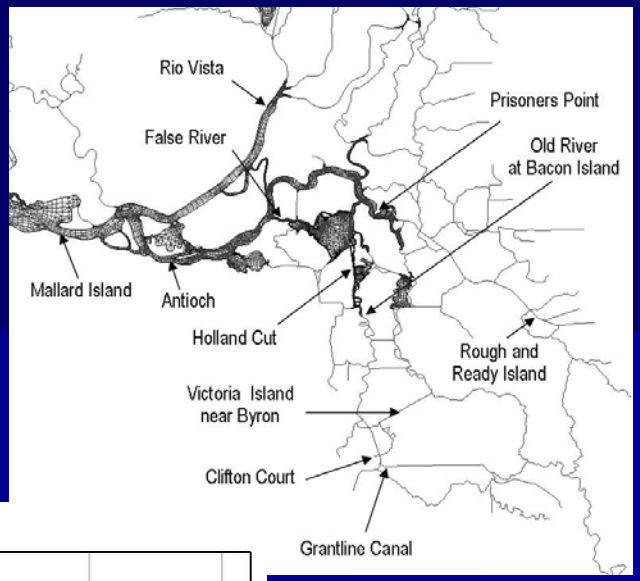
- Victoria Island near Byron

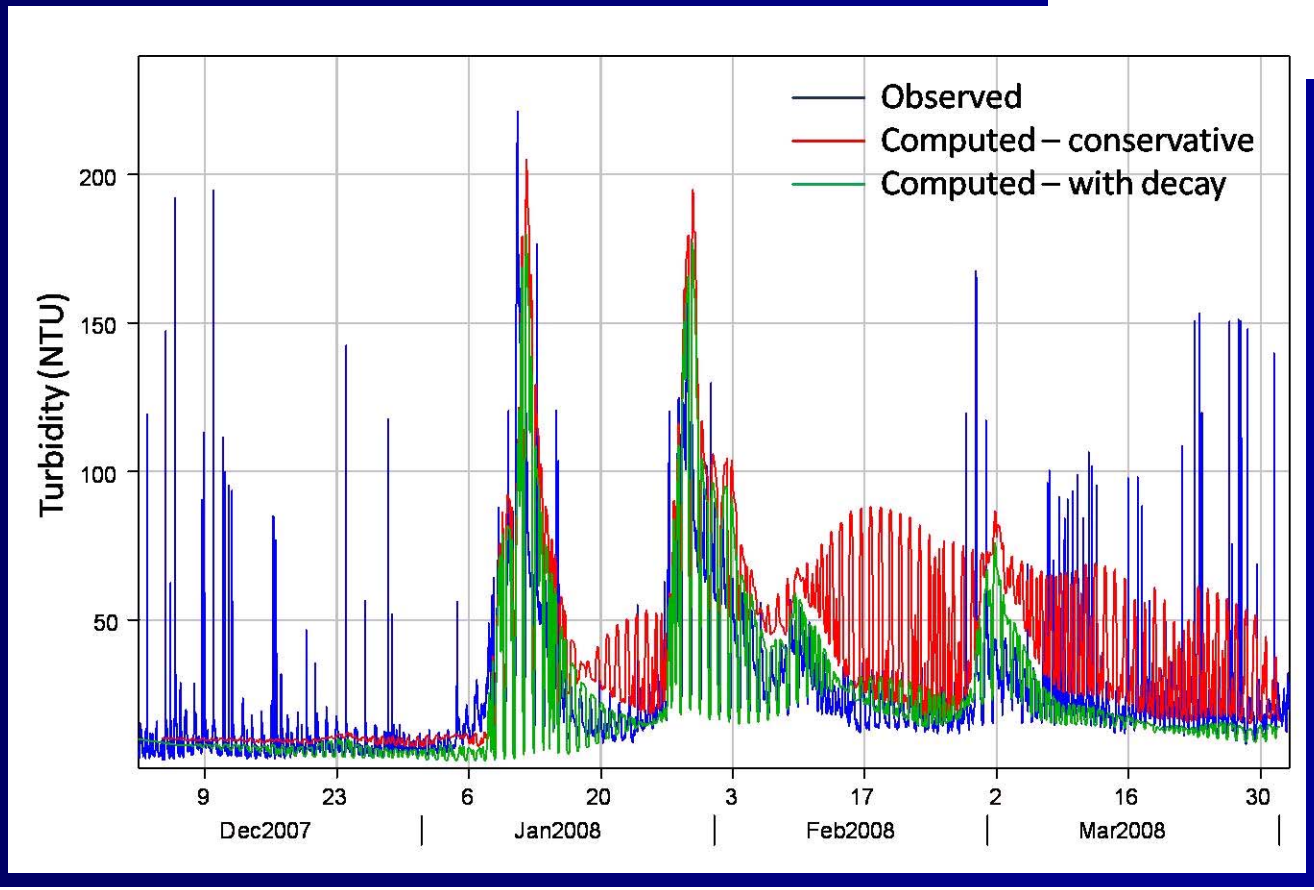




2007 Turbidity Results

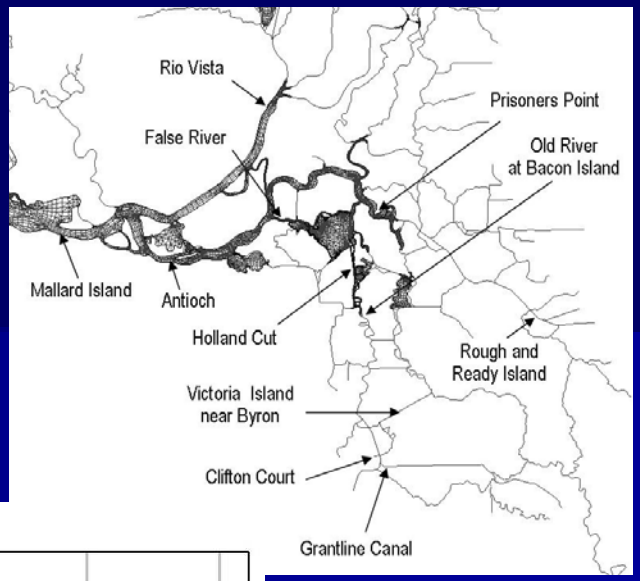
- Grantline Canal

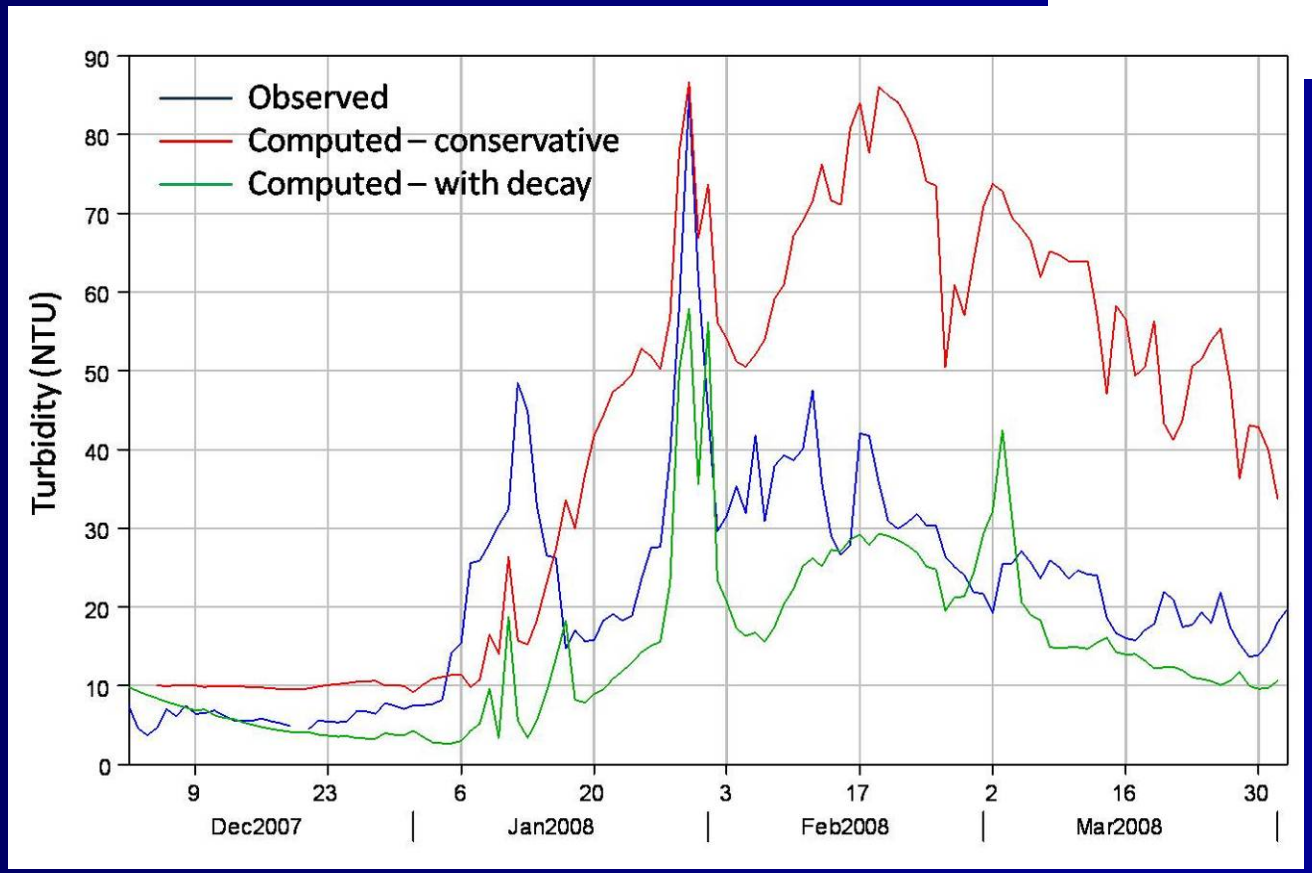




2007 Turbidity Results

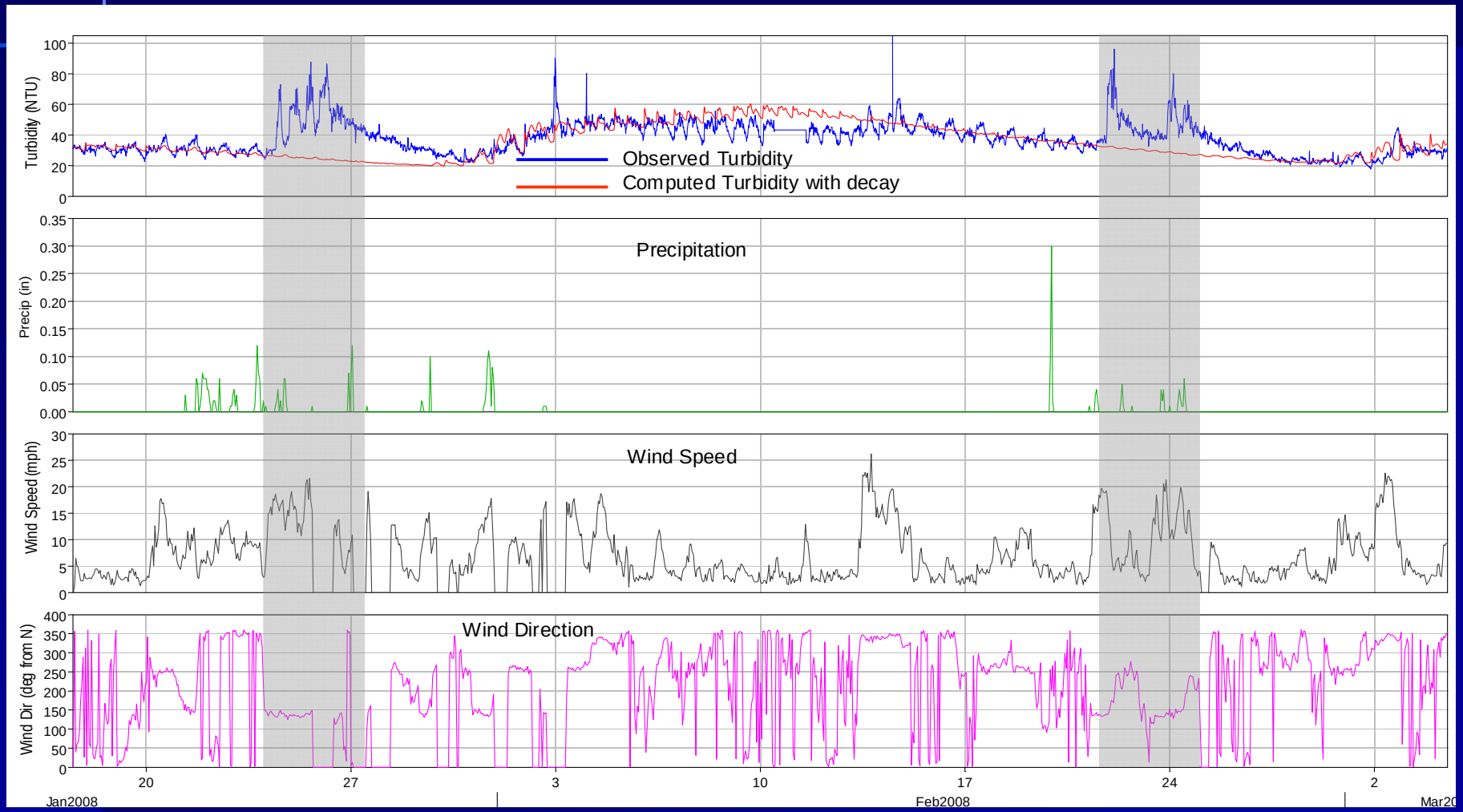
- Clifton Court



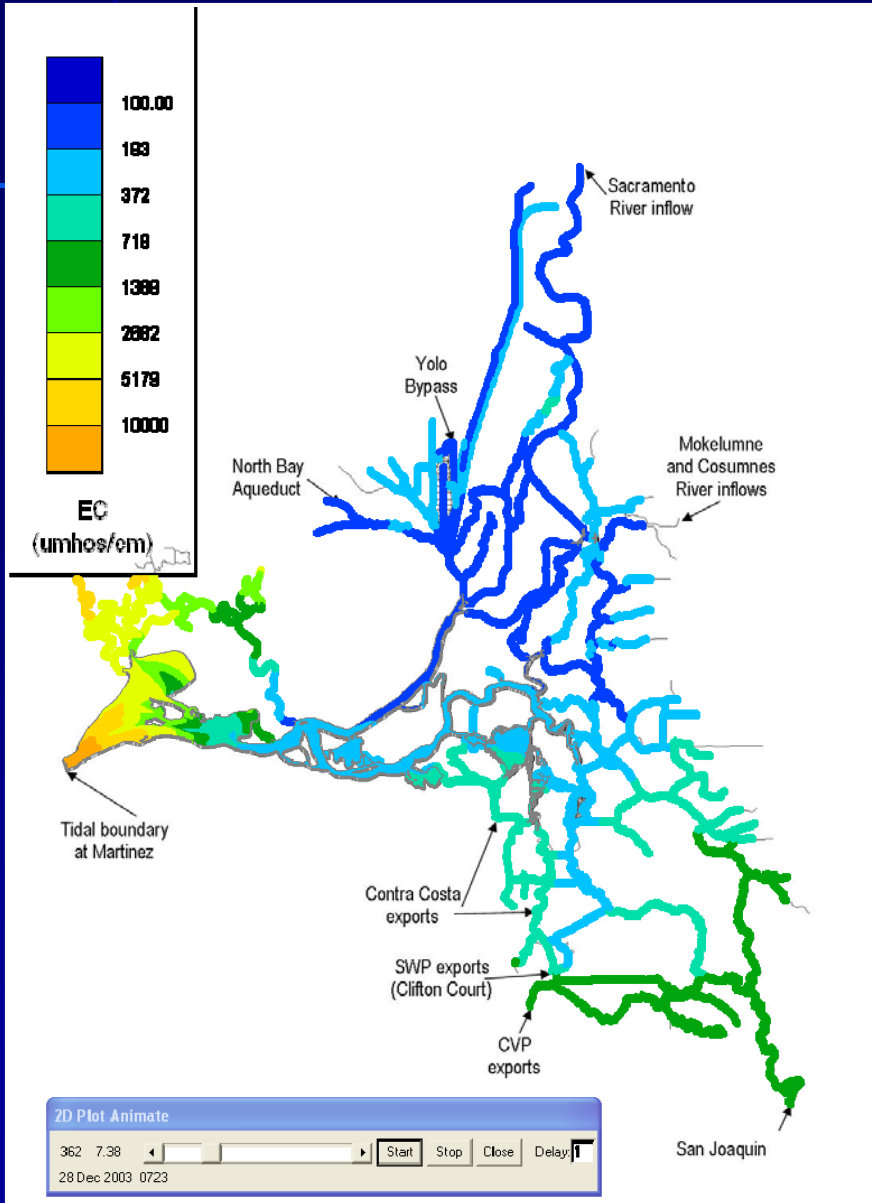


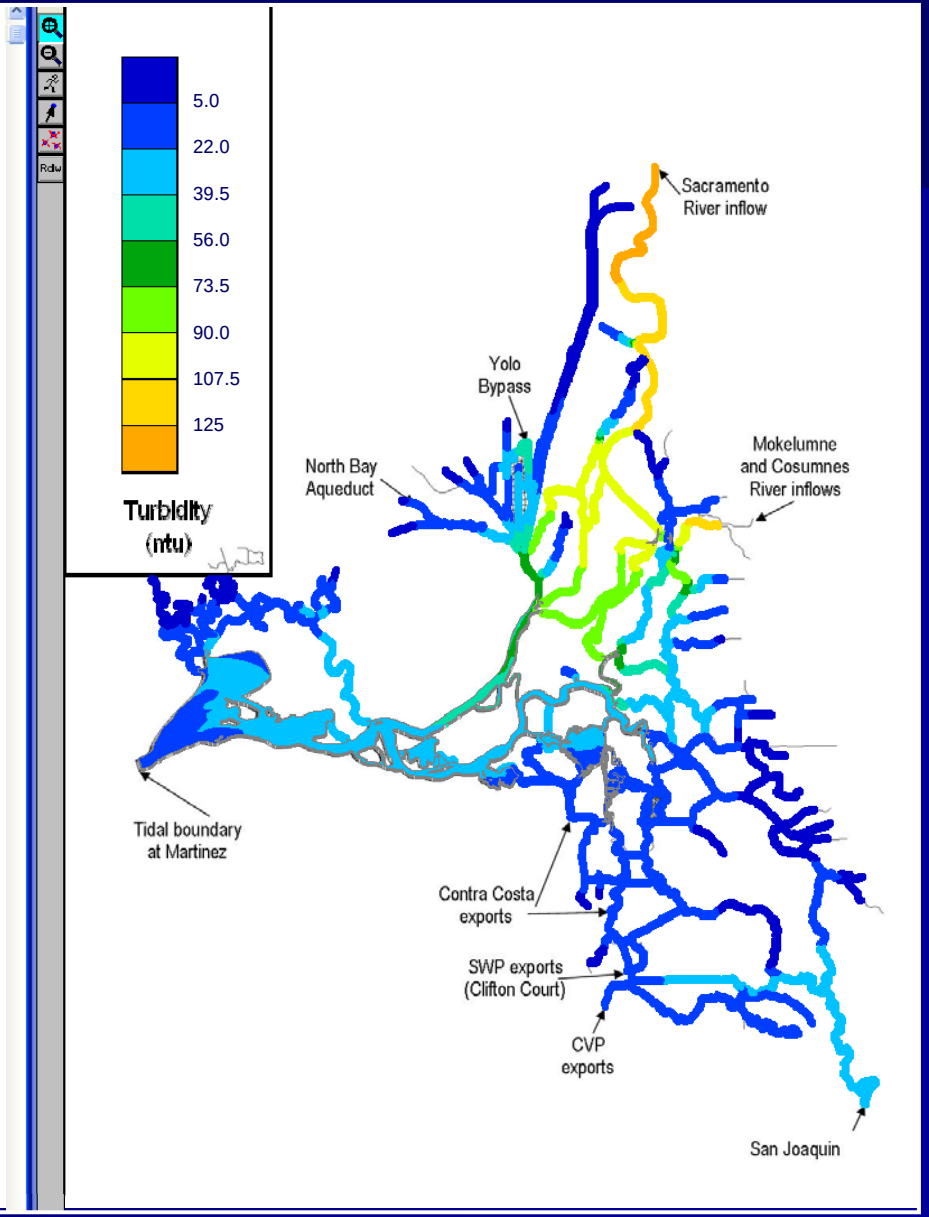
Wind and Resuspension – False River

local spikes in observed turbidity appear to relate to high wind events in a particular direction

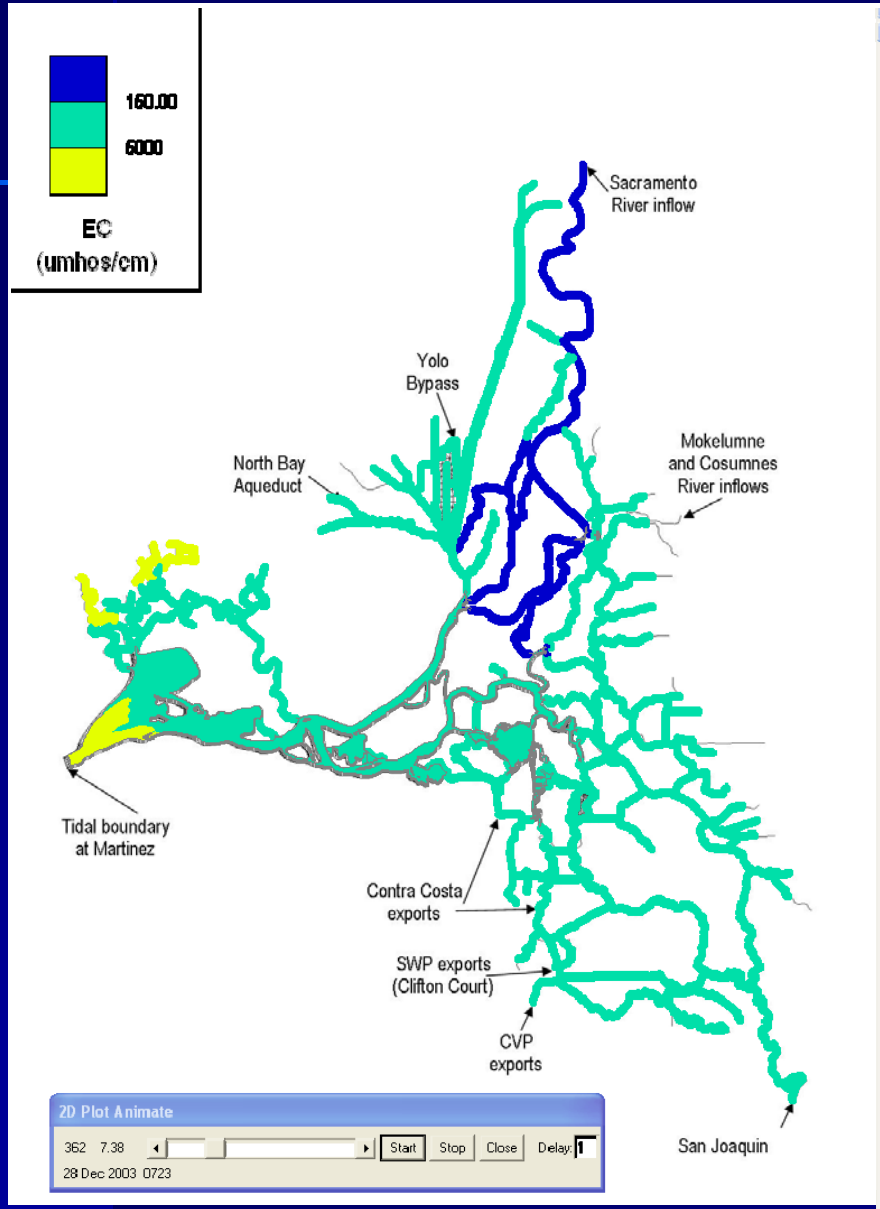


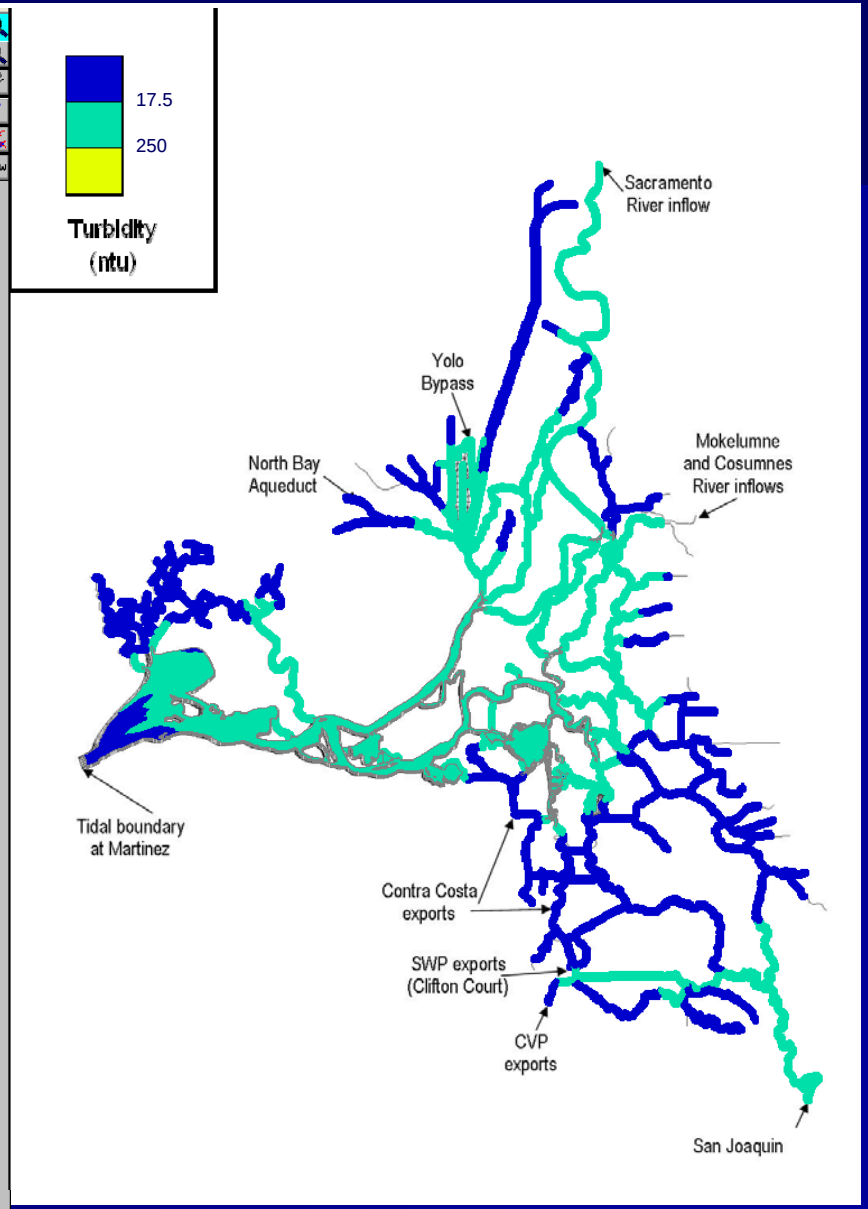
EC and Turbidity Distribution



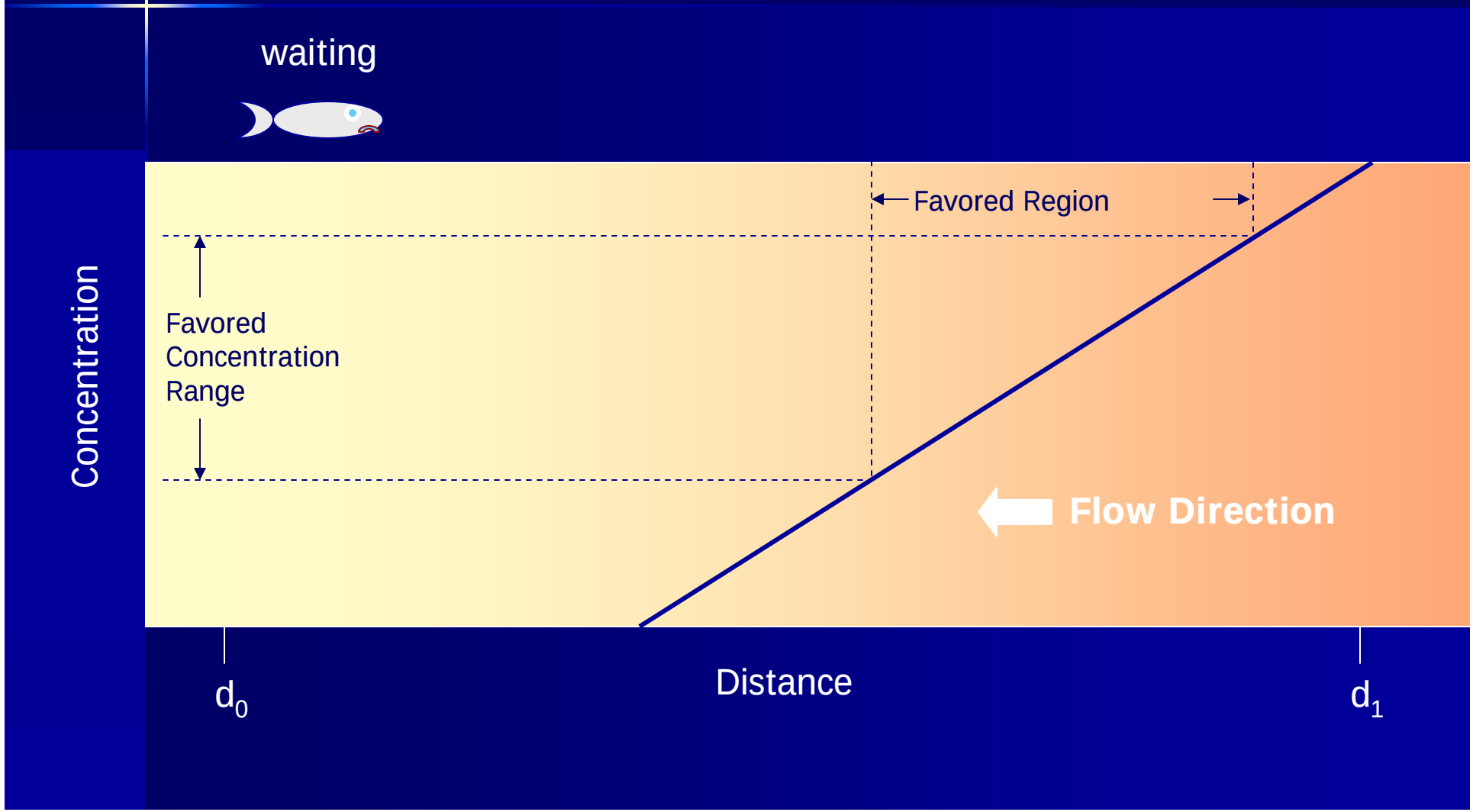


EC and Turbidity "Favored" Range

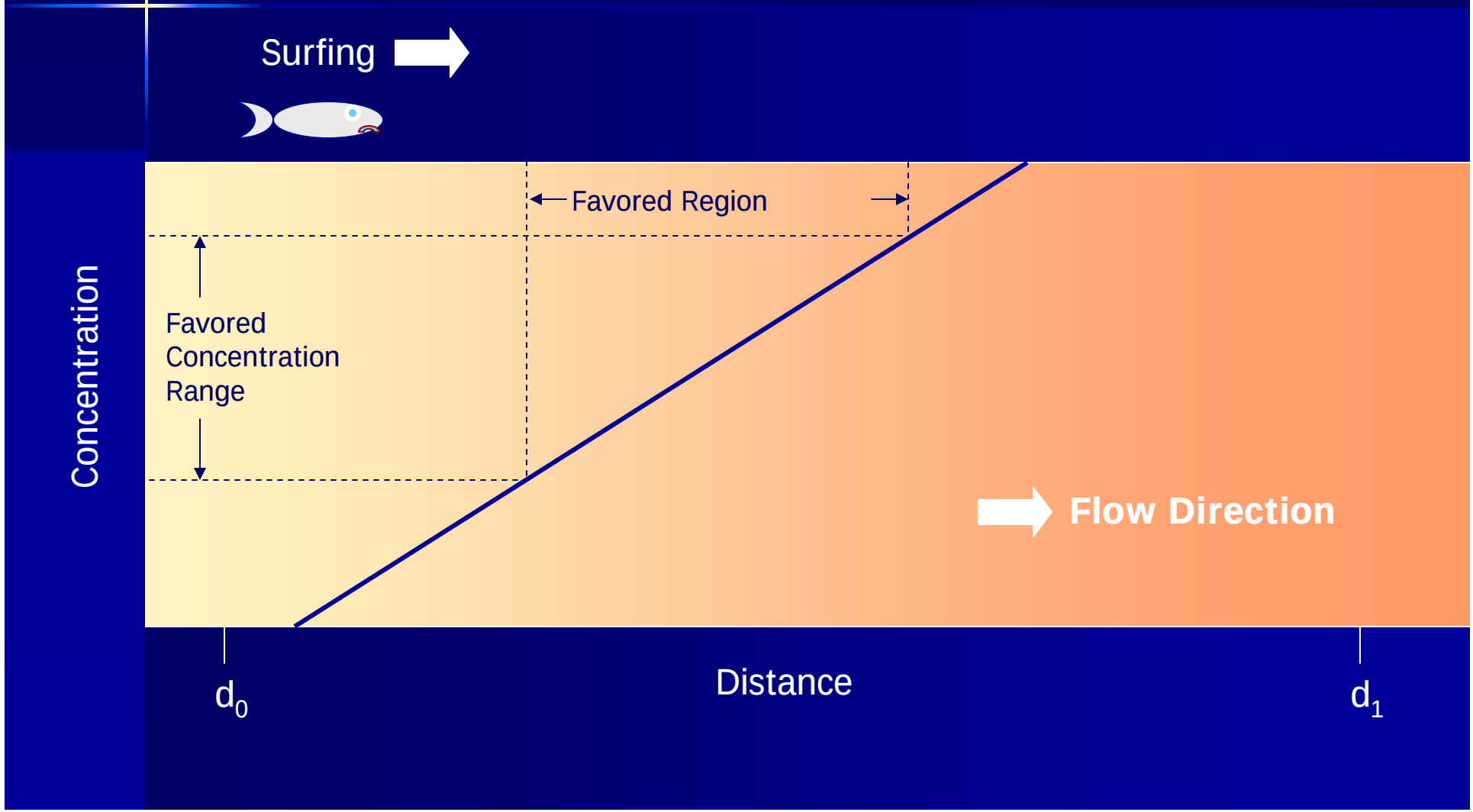




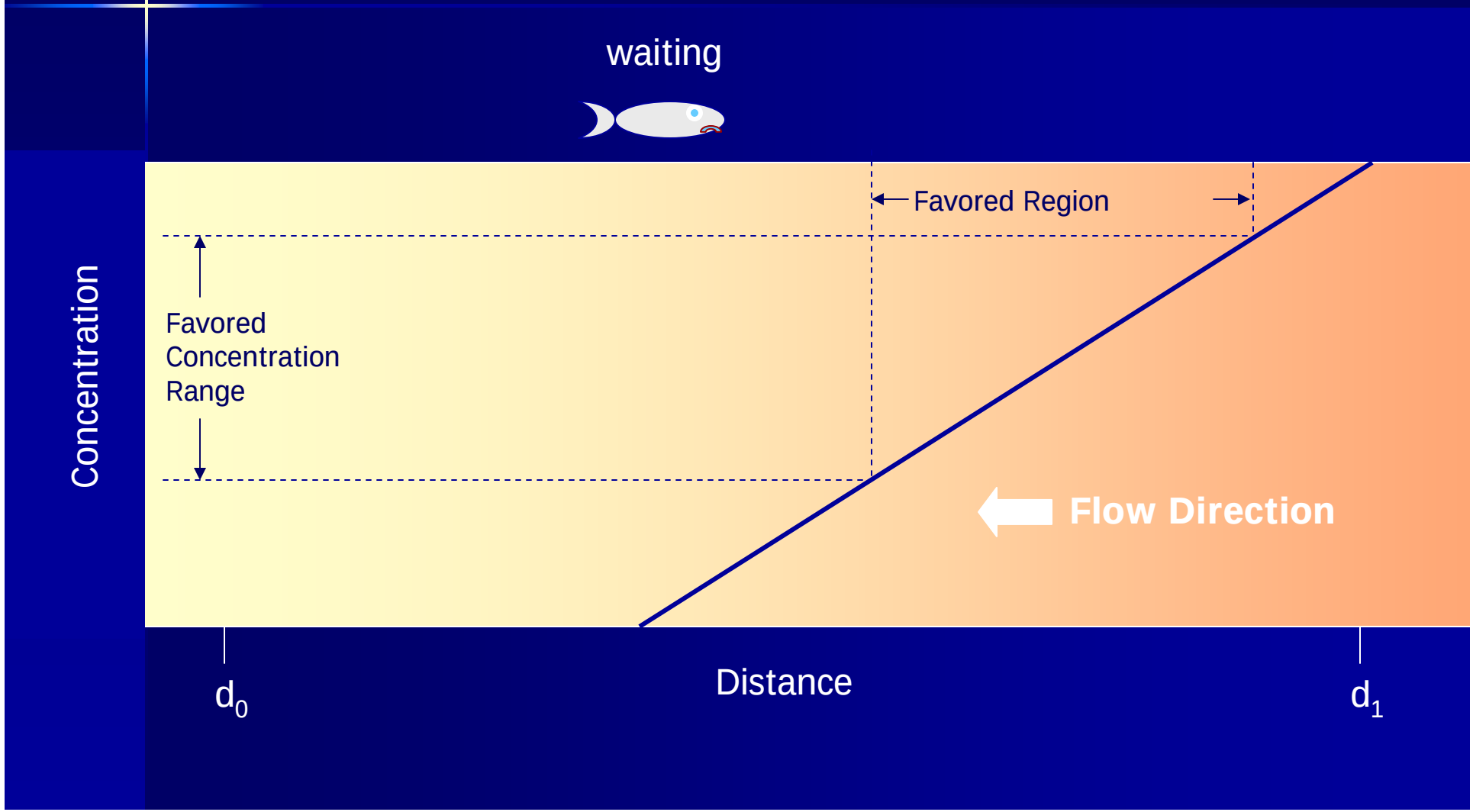
The Surfing Behavior Algorithm



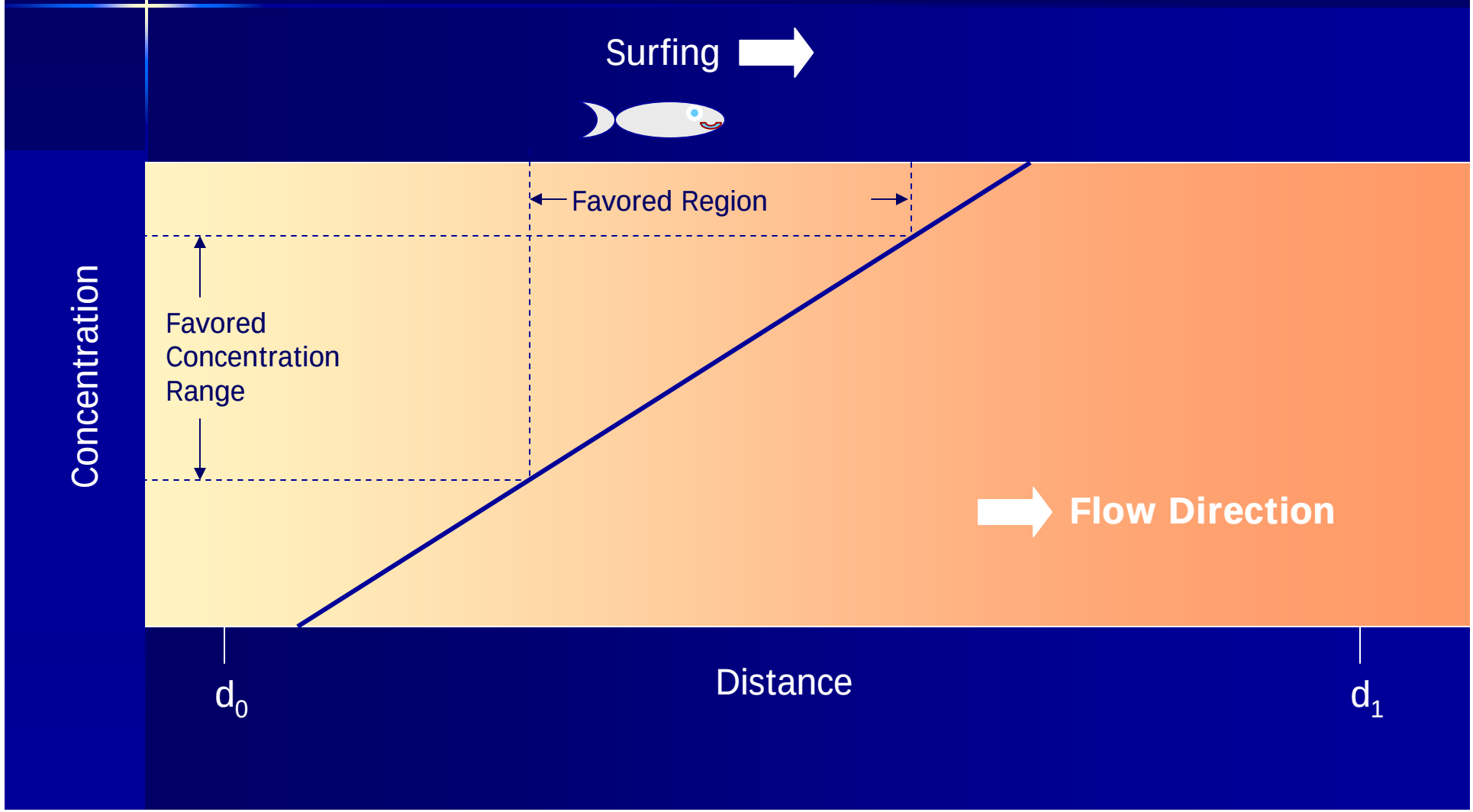
The Surfing Behavior Algorithm



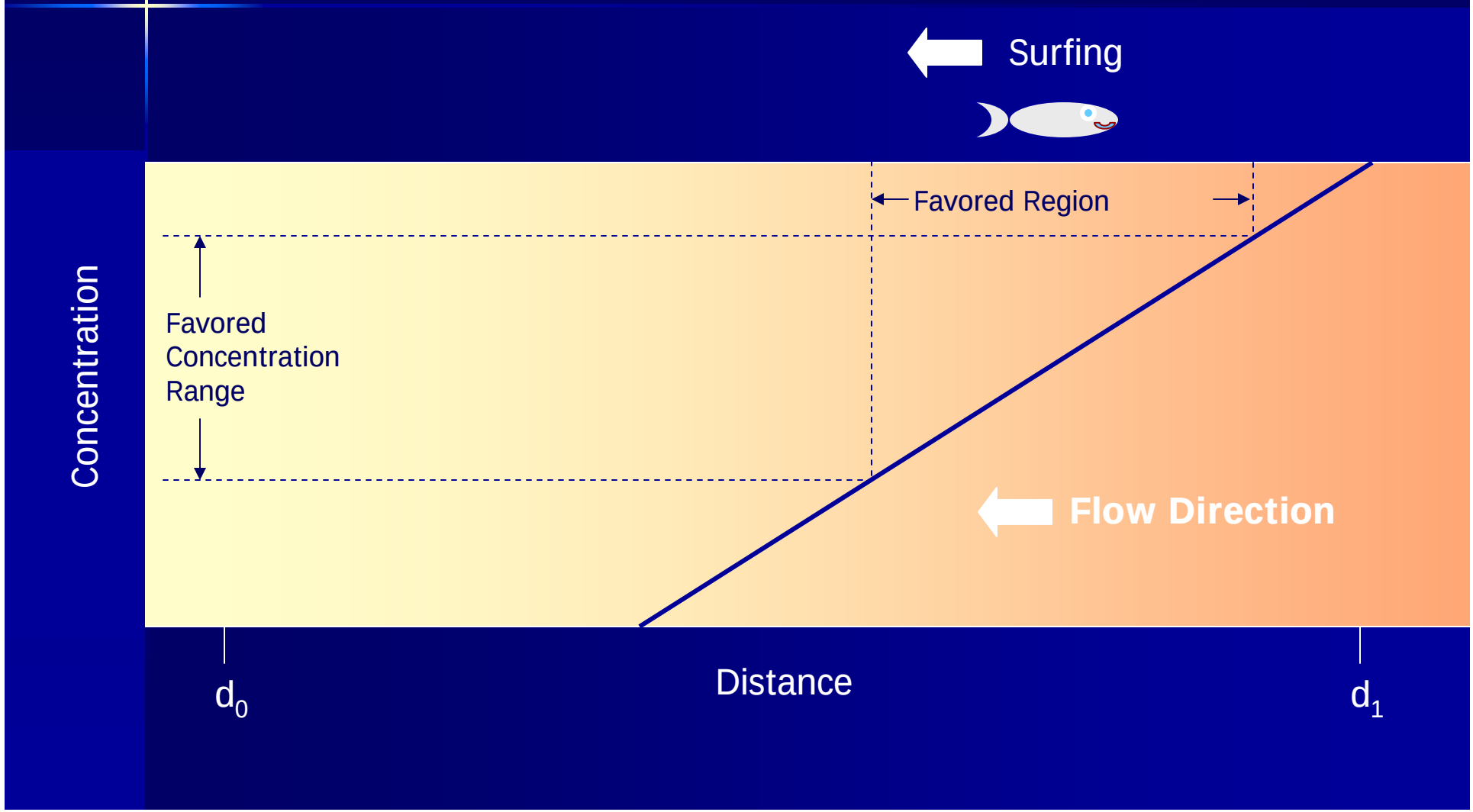
The Surfing Behavior Algorithm



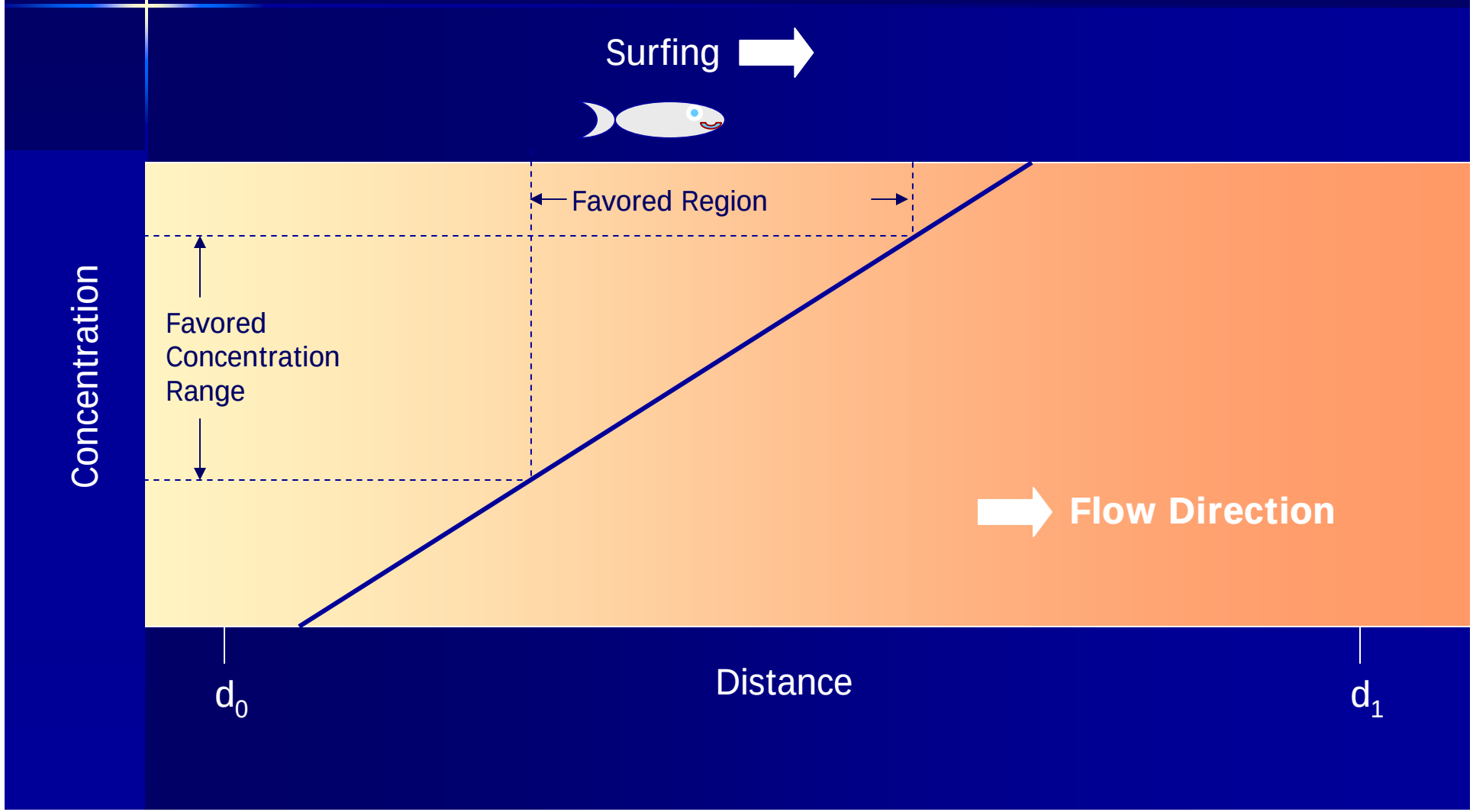
The Surfing Behavior Algorithm



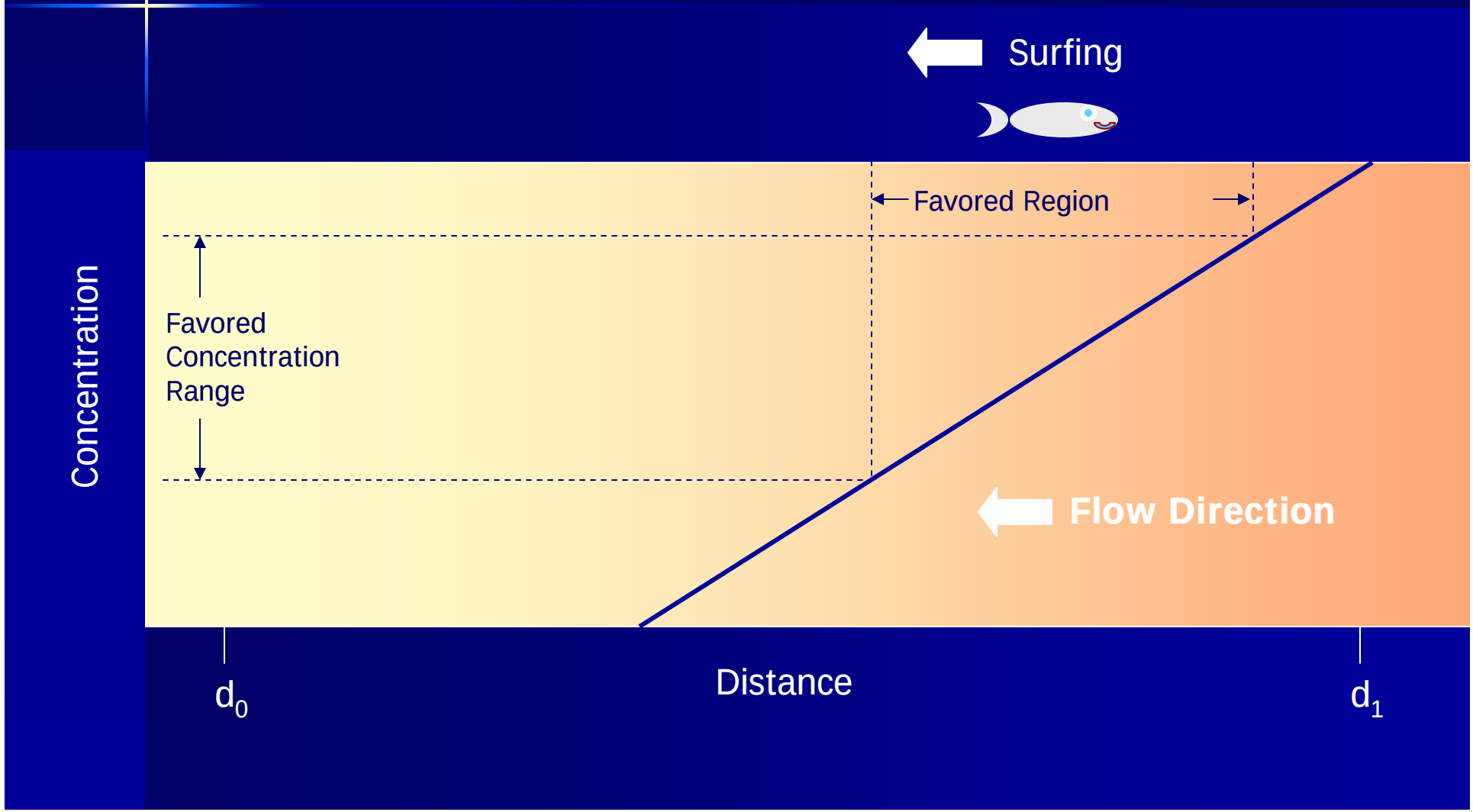
The Surfing Behavior Algorithm



The Surfing Behavior Algorithm



The Surfing Behavior Algorithm



Behavior Model Parameters

Maximum EC	1000 μmhos/cm
Minimum Turbidity	16 NTU
Turbidity Gradient Limit	0.0001 NTU/m
Desired minimum EC	150 μmhos/cm
Move with tide velocity Factor	1.2
Resist tide velocity factor	0.0
Additional Dispersion within region of acceptable EC and Turbidity	
Longitudinal Dispersion Factor	75 (m2/s)
Transverse Dispersion	2 (m2/s)

2003-2004 Boundary Flow and Turbidity

Particles Colored According to Behavior Algorithm State

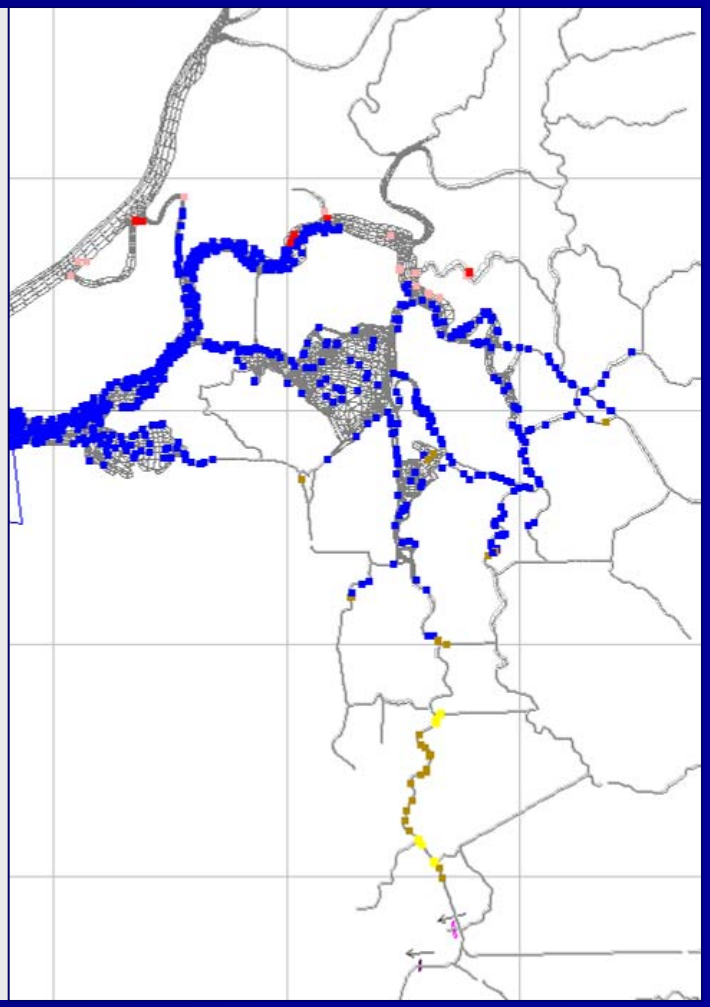
- blue – within all ranges

- red - below min reqd EC waiting
- pink - below min reqd EC surfing
- dark green - above max reqd EC waiting
- light green - above max reqd EC surfing

- dark orange - below min Turb waiting
- light orange - below min Turb surfing
- dark yellow - above max Turb waiting
- light yellow - above max Turb surfing

- dark magenta – below min desired EC waiting
- light magenta – below min desired EC surfing
- dark cyan – above max desired EC waiting
- light cyan – above max desired EC surfing

- dark gray – below gradient limit



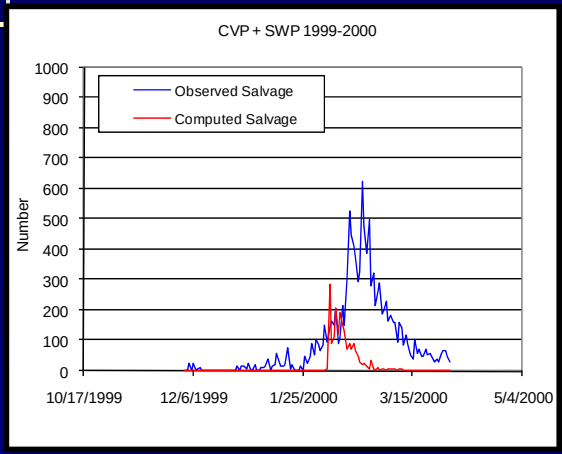
Comparison to Observed Adult Salvage

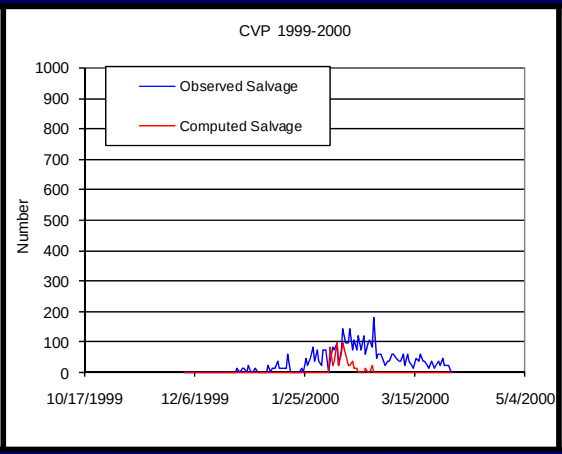
- Predicted salvage was computed by scaling up the total entrainment by the ratio of total estimated adult population to the number of particles released and then correcting for estimated pre-screen losses and screen efficiency

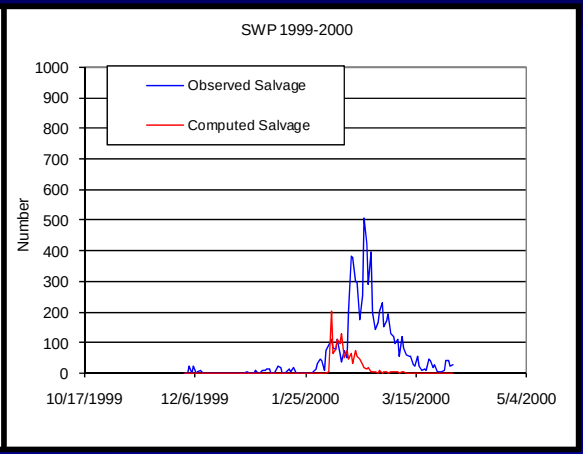
Year	Total Delta Population (Average of Survey 1 and 2) Estimated by Rick Sitts (MWD)
1999-2000	not available, estimated to be 1,000,000
2001-2002	1,355,000
2002-2003	992,000
2003-2004	1,212,000

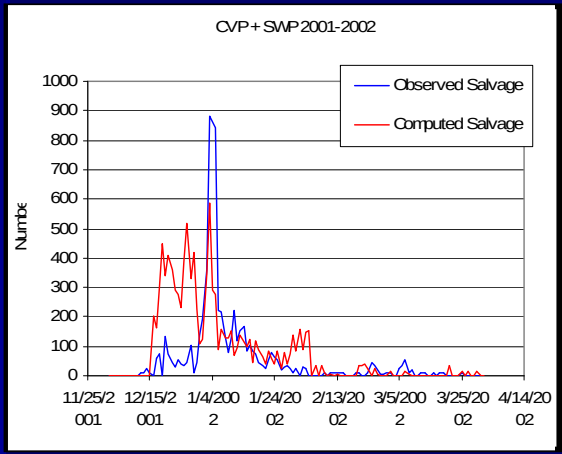
Facility	Pre-Screen Loss	Screen Efficiency	Salvage Factor	Source
Skinner	75%	13%	(1.0-0.75)*0.13=0.0325	Kimmerer, 2008
Banks	15%	14.2%	(1.0-0.15)*0.142=0.1207	Bowen

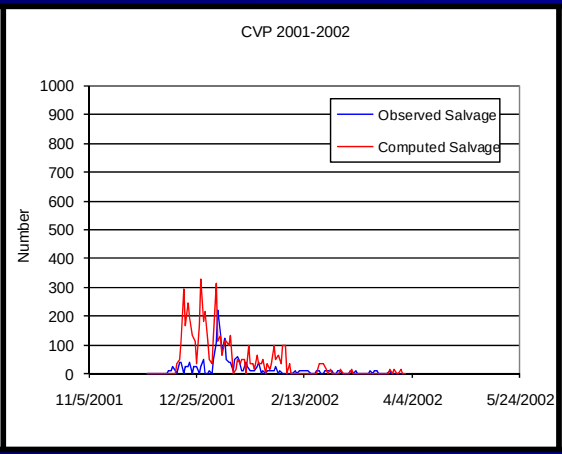
Comparison to Observed Adult Salvage

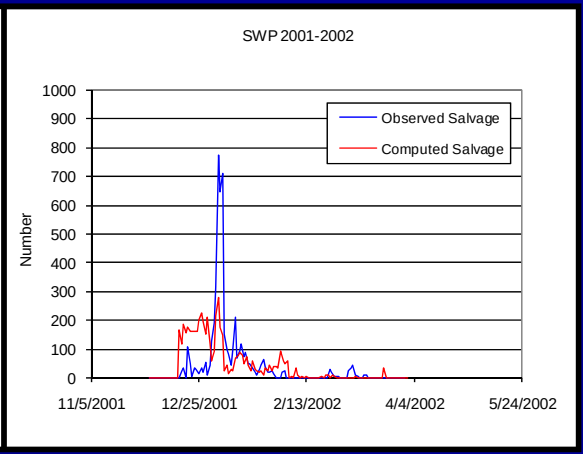




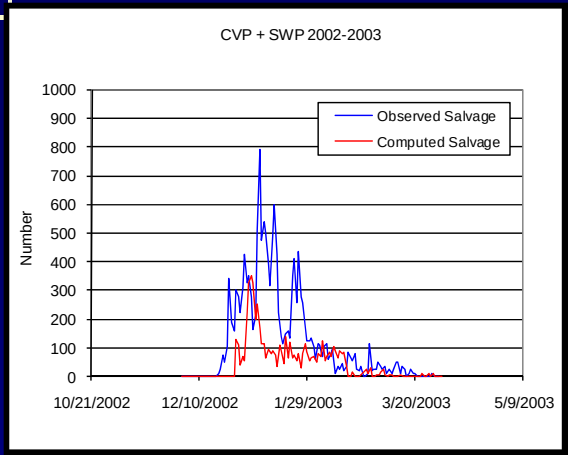


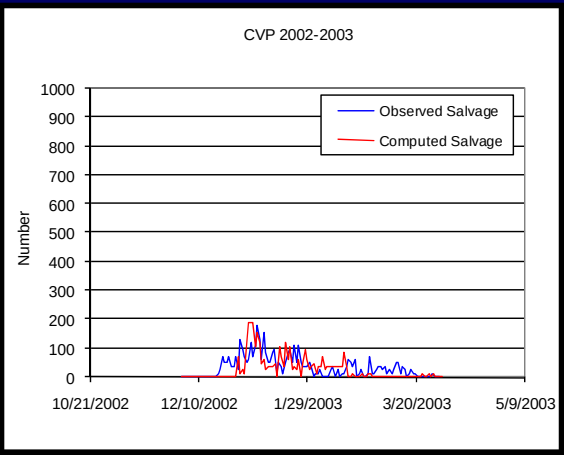


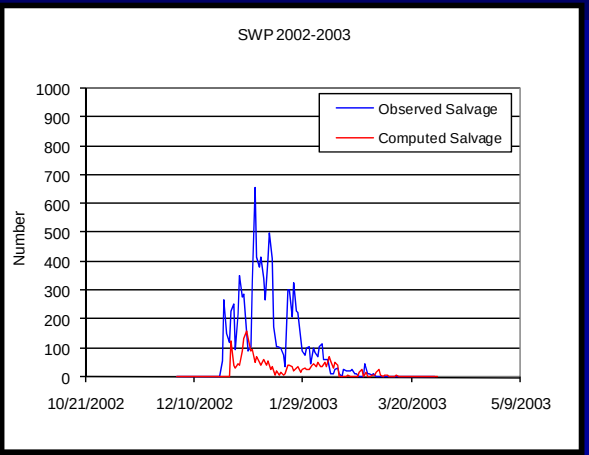


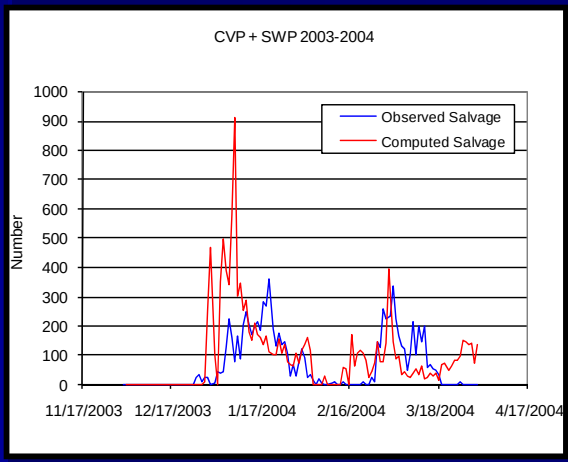


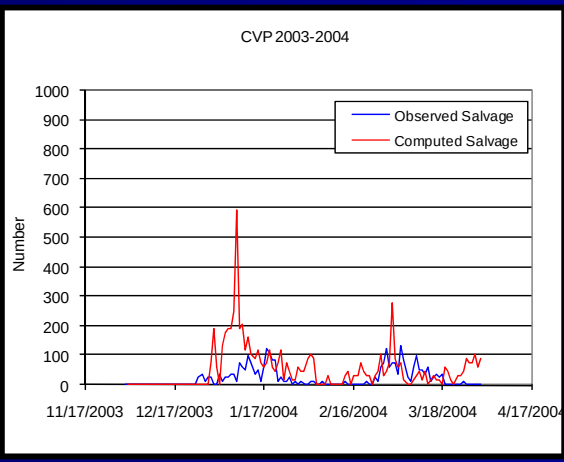
Comparison to Observed Adult Salvage

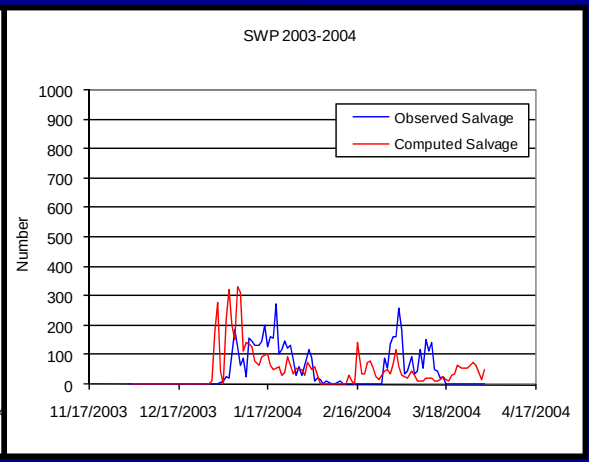












Future Improvements for the Adult Delta Smelt Model

- Improvement of the turbidity model
  - Complete turbidity boundary conditions as if/when they become available
  - Improved representation of Delta Island return flow turbidity
  - Wind driven resuspension
  - Full sediment transport modeling
- Improved algorithm for exploration within region of acceptable water quality – currently experimenting with random tidal surfing based on a “run and tumble” algorithm
- Refined calibration/validation considering additional years
- Comparison of in-Delta distributions based on Kodiak trawl surveys

Acknowledgements

Work funded by the Metropolitan Water District under the direction of Curt Schmutte

Dave Fullerton, MWD, provided the initial concept for behavior algorithm and compilation of observed salvage.

Rick Sitts, MWD, provided estimates of adult population based on Kodiak trawl surveys

Edward Gross provided assistance with conversion of predicted entrainment to salvage

Contact Information

John DeGeorge

Resource Management Associates

707 864-2950

jfdegeorge@rmanet.com