CASCaDE
Computational Assessments of Scenarios of Change for the Delta Ecosystem

Noah Knowles presenting for the CASCaDE Team

Photo: Francis Parchaso, USGS
CASCaDE: Linked modeling framework to evaluate Delta responses to multiple forces of change

- >30 scientists
- 4 USGS Offices
- 4 Universities
- **Cooperators:** Deltares, DWR, USBR
- Funded by USGS, Delta Science Program
CASCaDE 1
(2006-2010)
Primary Forcing: Climate

CASCaDE 2
(2011-present)
Forcing: Climate + Physical configuration
(and refined, expanded modeling capabilities)

Projected Evolution of California’s San Francisco Bay-Delta-River System in a Century of Climate Change
James E. Cloern1, Noah Knowles1, Larry R. Brown2, Daniel Cayan3, Michael D. Dettinger3, Tara L. Morgan2, David H. Schoellhamer1, Mark T. Stacey4, Mick van der Wegen5, R. Wayne Wagner6, Alan D. Jassby5

Available through cascade.wr.usgs.gov
Physical Configuration Scenarios

Multiple Flooded Islands

1100 miles of fragile levees currently protect subsided Delta “islands”.

Alternative Conveyance

The proposed twin tunnels would ship water from the Sacramento River under the Delta, with the intent to end fish-harming reverse flows caused by the current operation of water export pumps.

Also possibly: Ecosystem Restoration
Translation of daily, 100-year climate scenarios to the Delta

Global climate model outputs are downscaled to provide atmospheric forcing. These outputs drive models of watershed hydrology and management. GCM outputs are also downscaled to provide oceanic forcing (water levels).
Hydrodynamic Model: DFLOW-FM

Deltarres: Arthur van Dam, Sander van der Pijl, Herman Kernkamp
UNESCO-IHE: Mick van der Wegen, Fernanda Achete, Ali Dastgheib, Johan Reyns, Dano Roelvink
UCSD: Rose Martyr, John Helly
USGS: Bruce Jaffe, Theresa Fregoso, Noah Knowles, Lisa Lucas
Bathymetry grid

(Mick van der Wegen, Bruce Jaffe, Theresa Fregoso)
In progress: Seamless Bathy-Topo (LIDAR) grid
(Mick, Bruce, Theresa)
red line: level in river
blue line: level in island
levee height is 1 m

Levee Overtopping & Filling of an Island

Courtesy Mick van der Wegen, UNESCO-IHE
SDSC’s “Gordon” Supercomputer

“...can process data-intensive problems about 10 times faster than other supercomputers because it employs massive amounts of flash-based memory...”

UCSD—Rose Martyr, John Helly
Deltares—Arthur van Dam, Sander van der Pijl
USGS-NRP—Noah Knowles)
Bay-Delta Suspended Sediment and Geomorphology

UNESCO-IHE (Delft):
Mick van der Wegen, Fernanda Achete-Minikowski, Dano Roelvink

USGS-CMG (Santa Cruz): Bruce Jaffe

Purpose: To project future suspended sediment concentrations and long-term changes in geomorphology
How might phytoplankton biomass and productivity in the Delta change in response to changing climate & physical configuration?

**Inputs:** solar irradiance, turbidity, clam grazing rates, zooplankton grazing rates, velocity/stage/turbulent diffusivity, flow & temp @ boundaries

**Outputs:** algal biomass to clam, contaminant, fish models
Phytoplankton properly talking to hydrodynamics...

In progress: incorporation of grazing...stay tuned
Non-native Bivalves

J. Thompson, F. Parchaso (USGS-NRP), T. Troost (Deltares)

Q: How will clam grazing rates change? (←→ phytoplankton model)

Q: How will distributions and biomass change? (→ contaminant model)

DEB (Dynamic Energy Budget) Model

An energetics model grows the bivalves and a population model estimates bivalve biomass distribution.

Phytoplankton Model

Contaminant Model
Biodynamic Model (Lee et al.)

\[
[Se]_{\text{organism}} = \frac{uptake_{\text{water}} + uptake_{\text{food}}}{\text{efflux} + \text{growth}}
\]

How does Se bioaccumulation in the clam and its predators vary with:

- hydrology (e.g. source water contributions, residence time)
- Delta configuration
- suspended sediment
- phytoplankton dynamics

Terms of equation depend on:
- phytoplankton biomass
- phytoplankton species
- temperature
- dissolved Se concen.
- dissolved Se species
- hydrology
- hydrodynamics
- point/distributed loads
- turbidity
- geochemistry
- nutrients
- other grazers
- organisms species
- physiology

Biomonitor: Potamocorbula amurensis

Selenium (EPA priority pollutant)

Robin Stewart (USGS-NRP)
S. Luoma (UC Davis)
Physical habitat defined by:
- salinity
- temperature
- turbidity

CASCaDE 1:
- Climate change has all 3 habitat parameters heading in the wrong direction for Delta smelt!
Physical habitat defined by:
- salinity
- water temperature
- turbidity

CASCaDE 1:
- Climate change has all 3 habitat parameters heading in the wrong direction for Delta smelt!
- Not yet an integrated, spatially explicit habitat analysis

CASCaDE 2:
- Integrated, spatially detailed estimates of habitat areas using overlap of continuous salinity, turbidity, and temperature
- Infrastructural + climate change
CASCaDE is an interdisciplinary modeling effort aimed at helping illuminate plausible futures for the Delta ecosystem as a function of changing climate and physical infrastructure. It takes:

- decades of data and knowledge building
- a (good-sized) village
- generous colleagues who like working together!
- $$$ (Thanks, USGS-PES & Delta Science Program!)