

Deltares

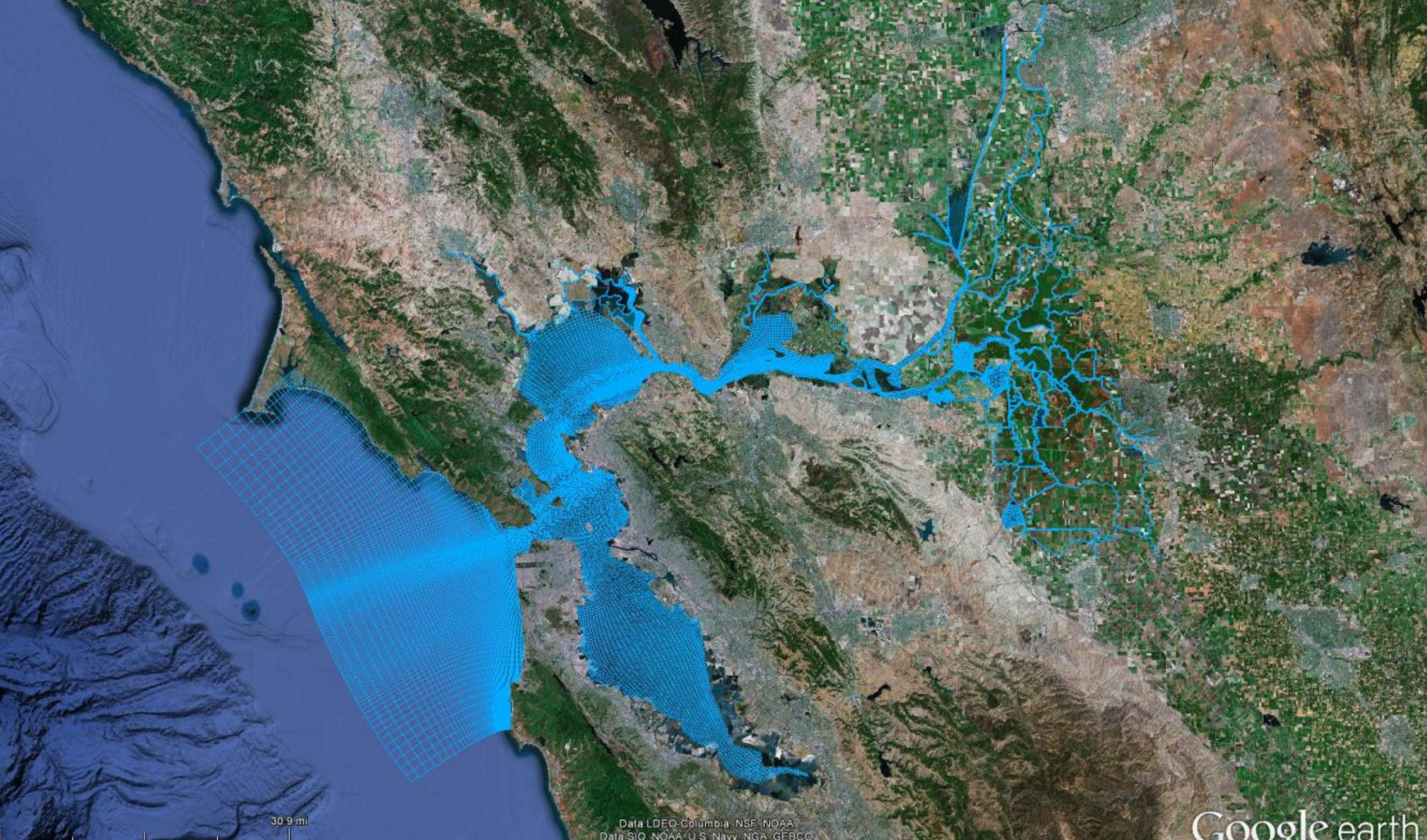
Enabling Delta Life



San Francisco Bay Delta Community model

Kees Nederhoff

Deltares – 'Enabling Delta Life'



30.9 mi

Data LDEO-Columbia, NSF, NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google earth



Content

1. **Background:** how did this start?
2. Delft3D-FM **model schematization**
3. **Community model**
4. **Applications of a community model**
 1. Salt intrusion
 2. Sediment transport
5. **Conclusions**

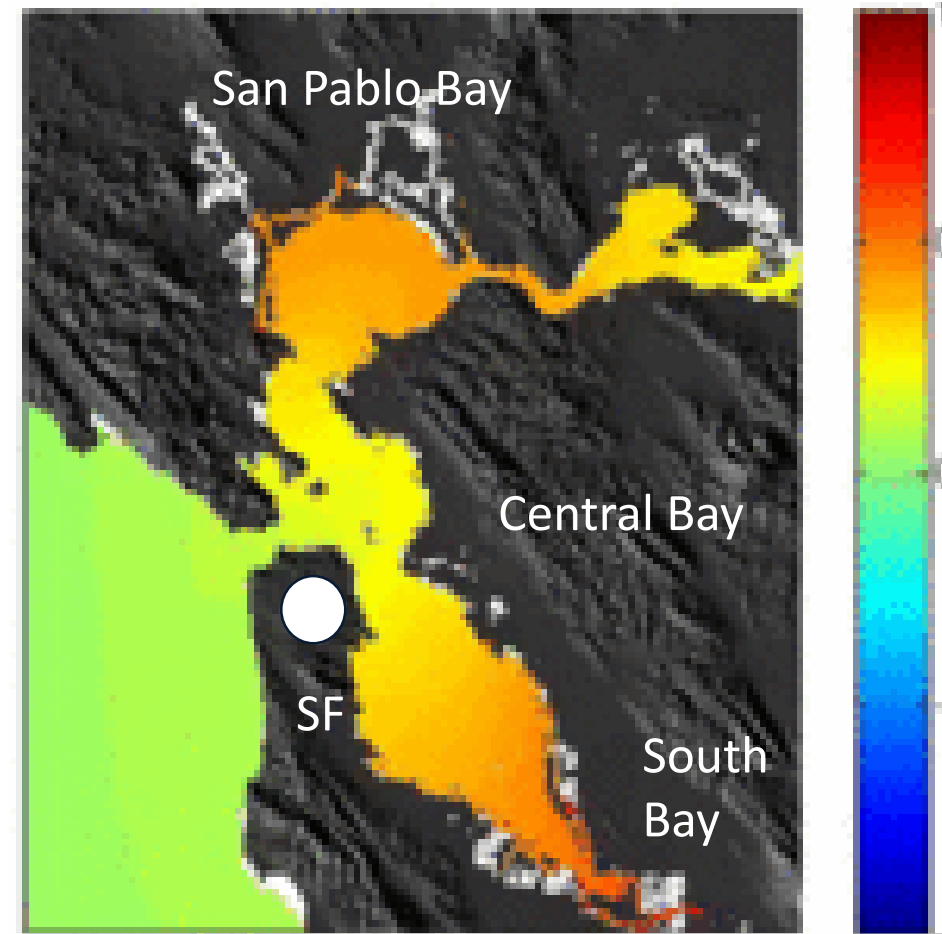
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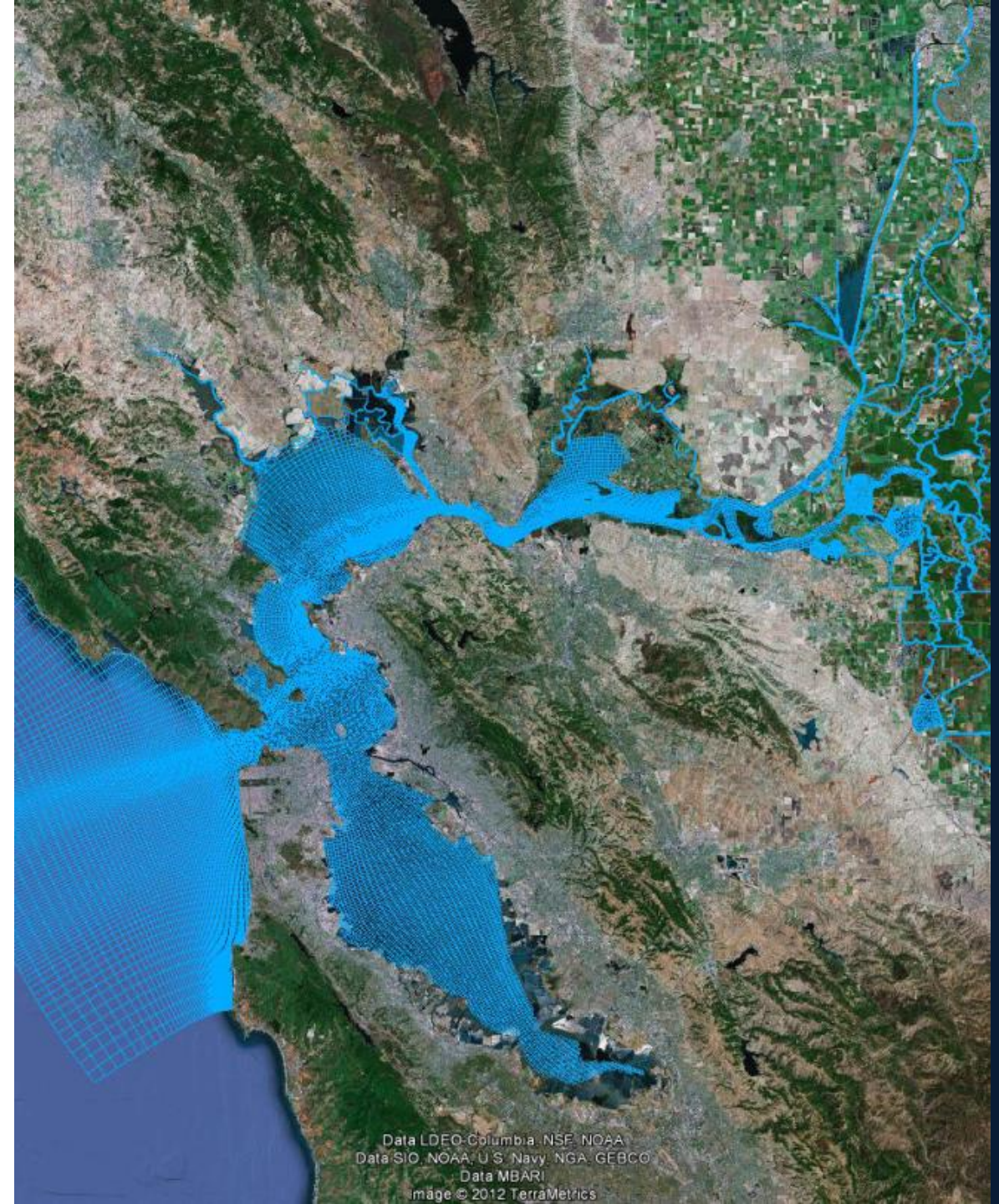
History: San Francisco Bay Basic Tide Model

- **Delft3D modelling** of San Francisco Bay Delta goes back to **2006**
- **First community model:** basic tide model (2013).
<https://www.usgs.gov/media/files/san-francisco-bay-basic-tide-model>
- Developed with the primary aim of **assessing water level fluctuations and flow conditions** in the vicinity of the Golden Gate (Elias and Hansen 2013).



Background project

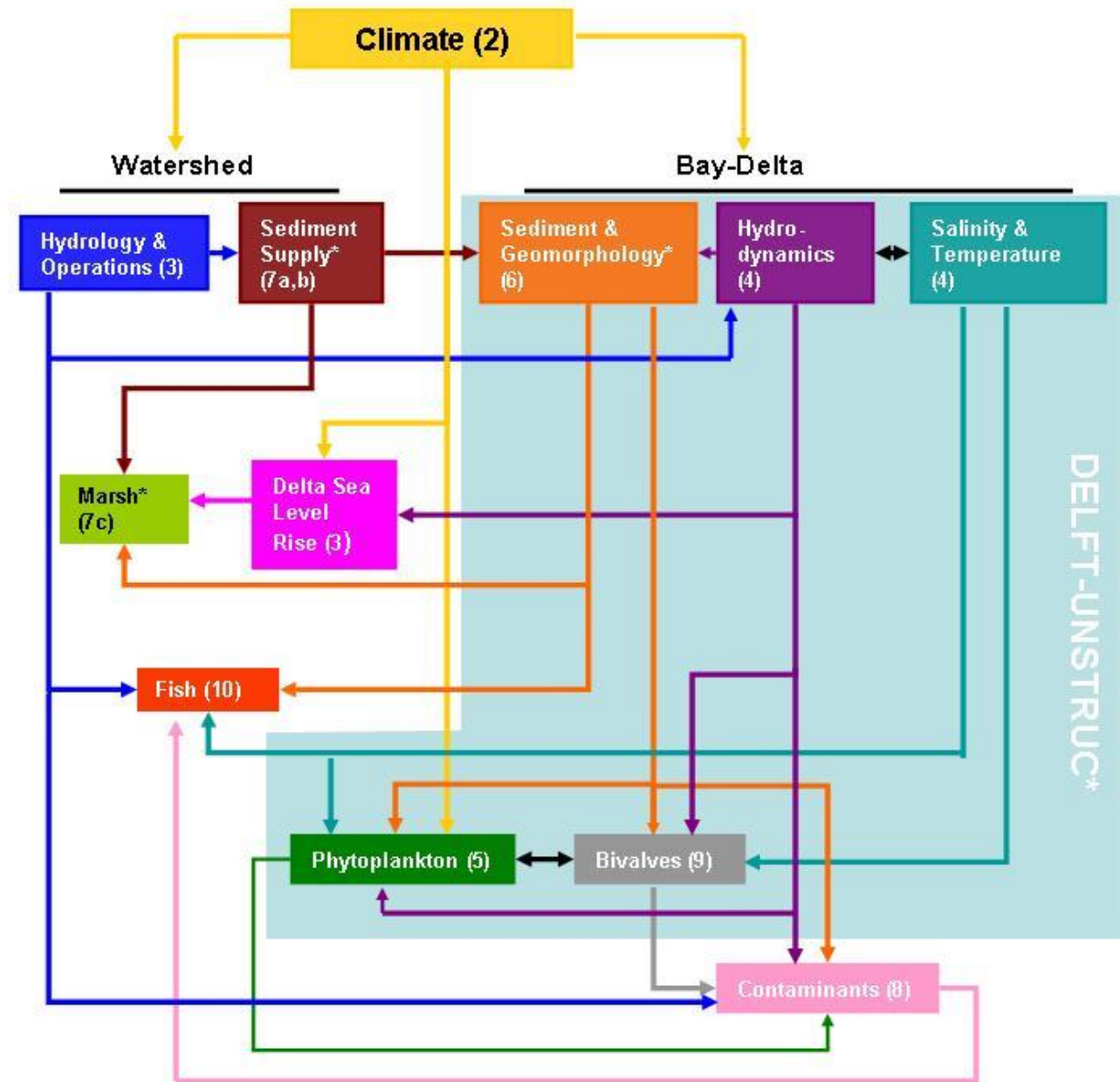
- **CASCaDE II: Computational Assessments of Scenarios of Change for the Delta Ecosystem**
 - URL: <http://cascade.wr.usgs.gov/>
- **Goal:** Impact of *climate change* scenarios on San Francisco Bay-Delta eco-system
- **Funding:** 8 MUSD funded by CalFed and USGS (2011-2016)
- **Partners:**



Data LDEO-Columbia, NSF, NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Data MBARI
Image © 2012 TerraMetrics

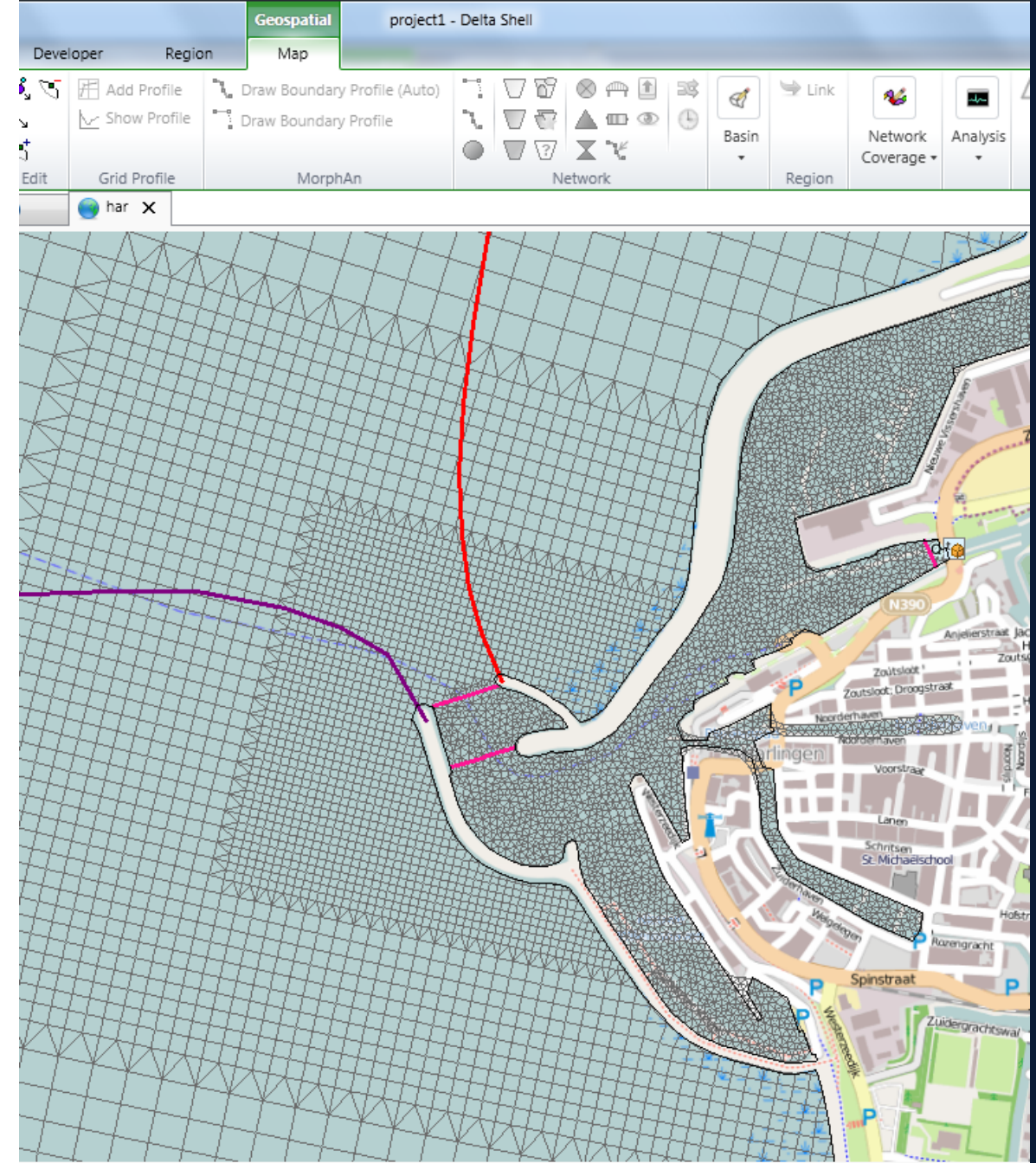
Approach CASCADE II

- The long-term view is developed through simulations with **linked models** to project changes under a range of plausible scenarios of climate change and Delta configurational changes.
- Central in CASCADE:** Delft3D-FM 3D model of San Francisco Bay Delta (SFBD)



Why Delft3D-FM?

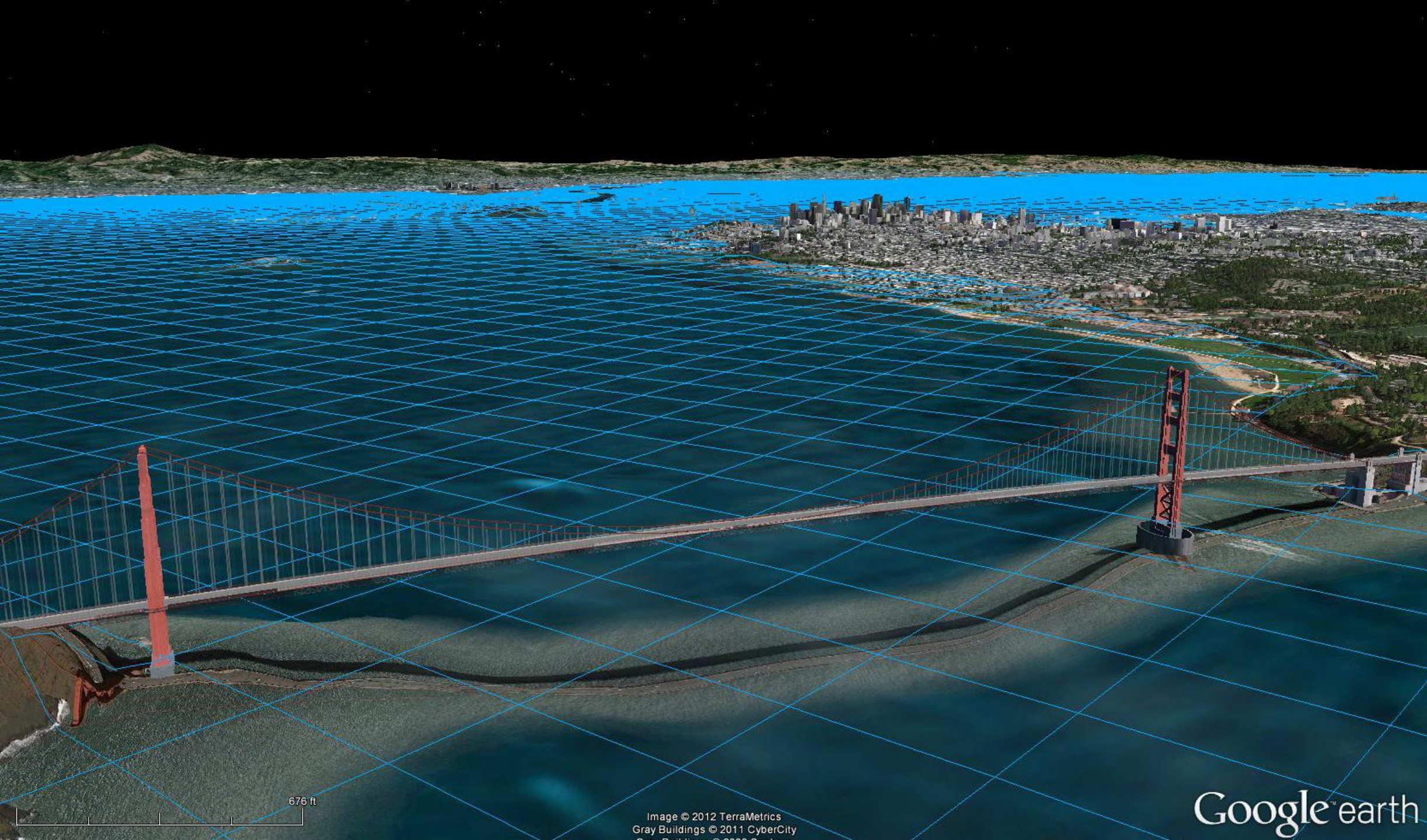
- The software's **unstructured** grid framework to create a single model domain of the Bay-Delta's highly complex geometry and perform year-long simulations at relatively low computational cost;
- Unique **momentum conservation** scheme which can be applied in 1D channels, 2D overland flows, and 3D stratified flows;
- 3D numerics supporting salinity and temperature dynamics; a **loosely-coupled framework** to sediment, water-quality, phytoplankton, and habitat suitability models;
- D-Flow FM is released as **open-source software**



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676 ft

Image © 2012 TerraMetrics
Gray Buildings © 2011 CyberCity
2012

Google™ earth



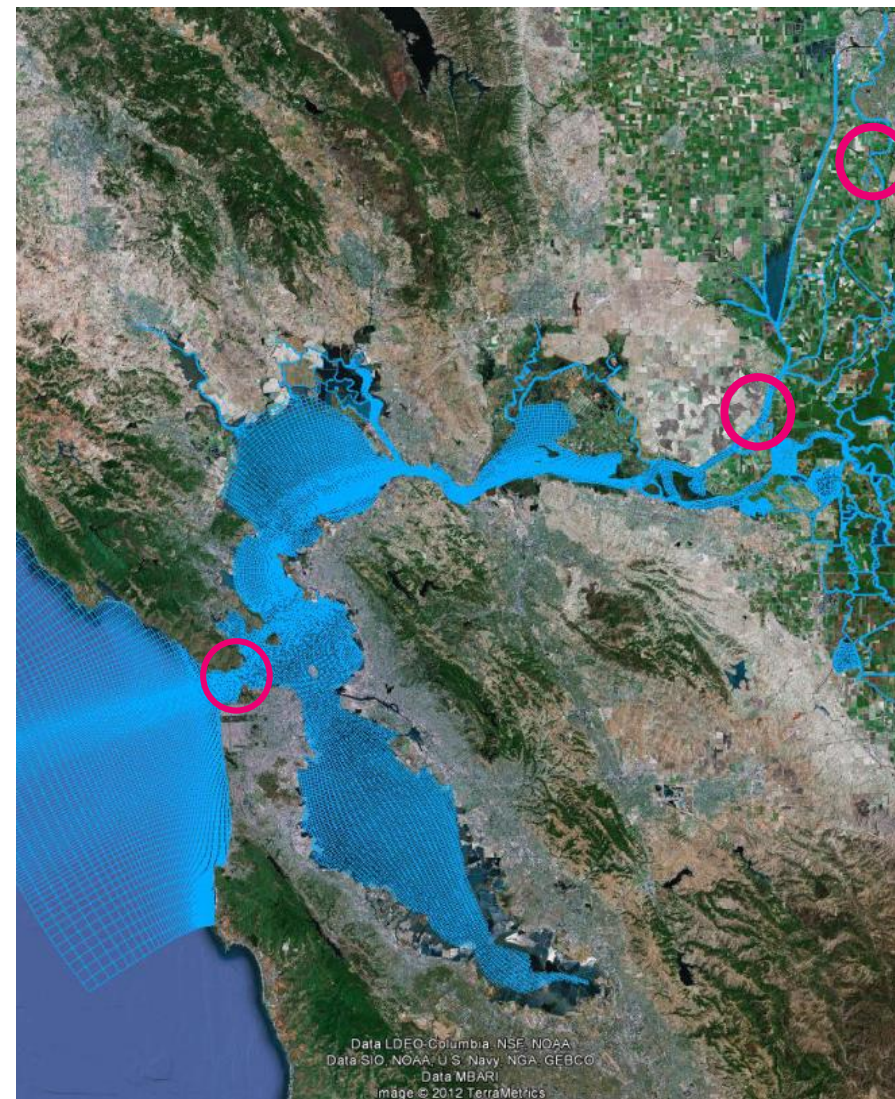
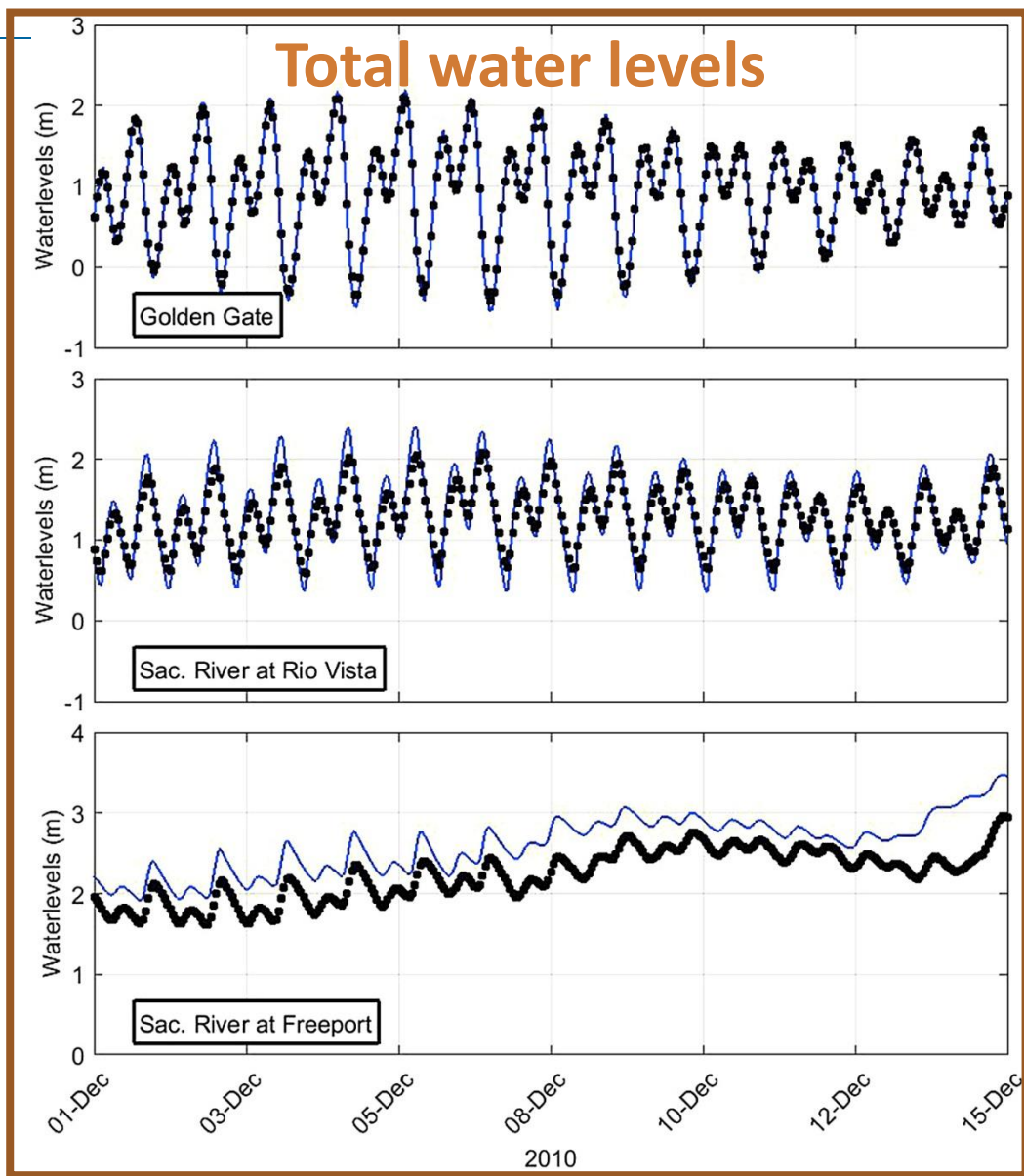
10095 ft

Google earth

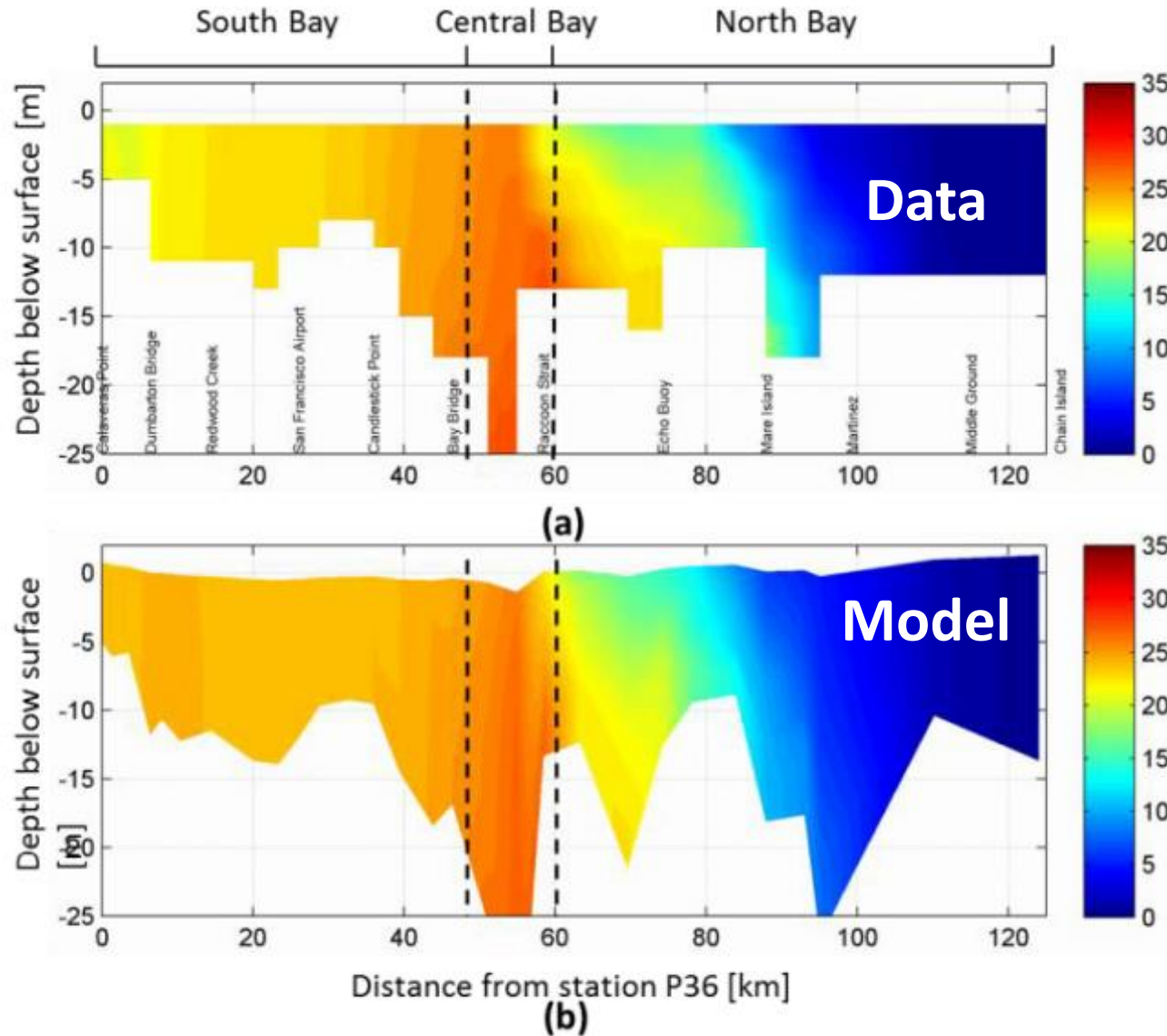




Model calibrated and validated (Martyr-Koller et al., 2017)

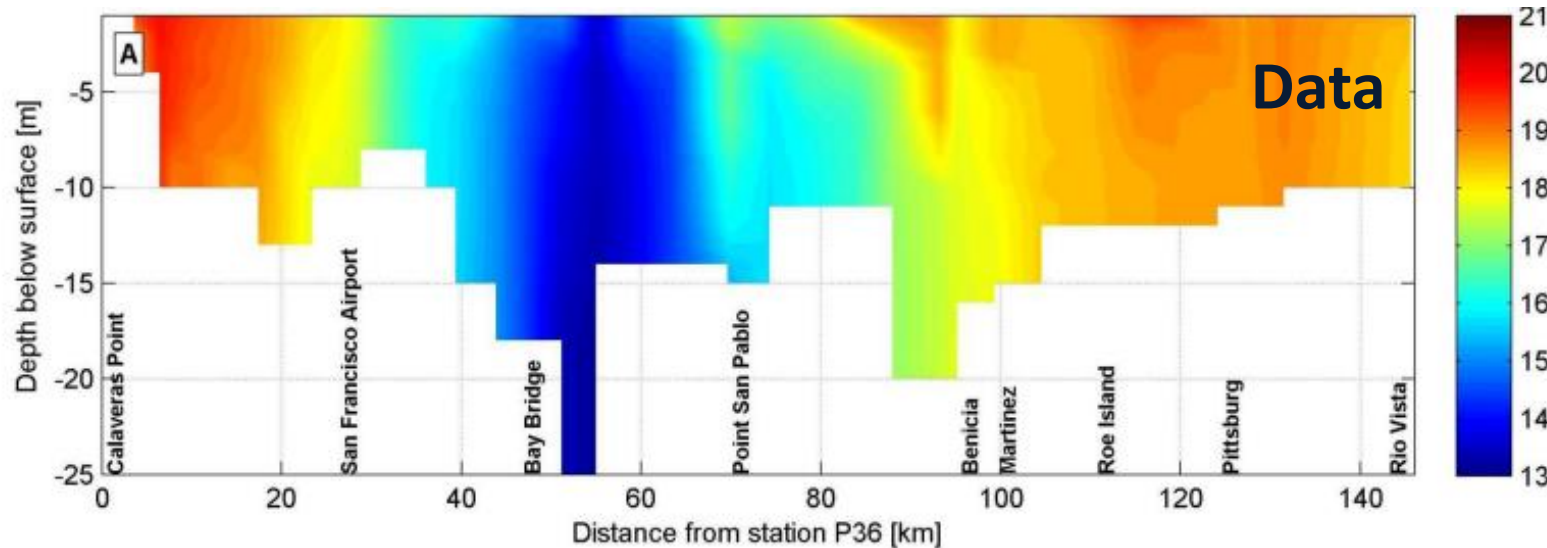


Salinity fields are well reproduced (Pubben, 2017)

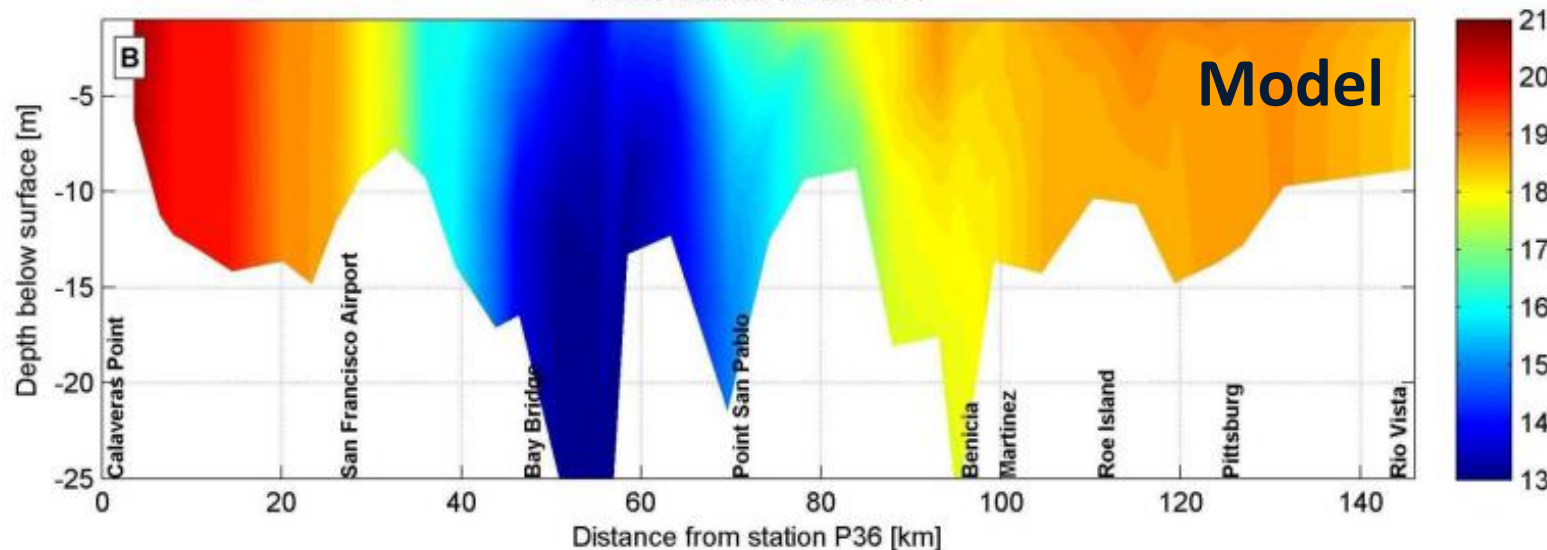


- **Full details paper:** “Application of an unstructured 3D finite numerical model to flows and salinity dynamics in the San Francisco Bay-Delta’ by R.C. Martyr-Koller, H.W.J. Kernkamp, A. van Dam, M. van der Wegen, L.V. Lucas, N. Knowles, B.Jaffe and T.A. Fregoso.
- **Master thesis:** “3D Mixing patterns in San Francisco South Bay” by Silvia Pubben

Temperature dynamics are also well reproduced (Vroom et al., 2017)



Model result at 14-Jun-2011



- Same **Polaris cruise** as previous slide
- **Full details paper:** “What Determines Water Temperature Dynamics in the San Francisco Bay-Delta System?” by J. Vroom M. van der Wegen R. C. Martyr-Koller L. V. Lucas

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Community model from 2014 - onwards

- Community model is available online: <http://www.d3d-baydelta.org/>

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- “Our vision is to support the development of a open source , open access, web-based infrastructure around the SFBDD ”



The screenshot shows the homepage of the San Francisco Bay Delta Community Model website. The header features a blue silhouette of the San Francisco skyline above the title "San Francisco Bay Delta Community Model". Below the title is a navigation bar with links: Home, Demo, Downloads, Model Spec, Development Framework, and Parties Involved. The main content area displays a satellite map of the San Francisco Bay-Delta region with a blue grid overlay. A text box on the map reads "The grid on a Google Earth base map". Below the map, a paragraph describes the complexity of the San Francisco Bay-Delta system and the need for integrated modeling tools. Another paragraph states that the website provides a platform for the availability and continuous development of a process-based, hydrodynamic surface water flow model applying the Deltares Delft3D FM (flexible mesh) software. A bulleted list details the model's capabilities: flow (including salinity and temperature), sediment transport (sand and mud transport, suspended sediment concentration, turbidity, morphodynamics), water quality (including turbidity, phytoplankton, nutrients, and contaminants), and eco-systems (habitat indicators). At the bottom, a link is provided for a Delft3D curvilinear grid model for the Bay Delta.

The San Francisco Bay Delta Community Model

Home Demo Downloads Model Spec Development Framework Parties Involved

The grid on a Google Earth base map

The San Francisco Bay-Delta system is complex in its physical and environmental dynamics. Modeling tools that integrate hydrodynamics and water quality dynamics are essential to unravel the governing processes on various spatial and temporal scales and assess potential developments due to climate change and adapting management strategies. There is a need for open access, publicly available, integrated modeling platforms to facilitate and enhance interdisciplinary and interagency scientific communication, collaboration, and understanding.

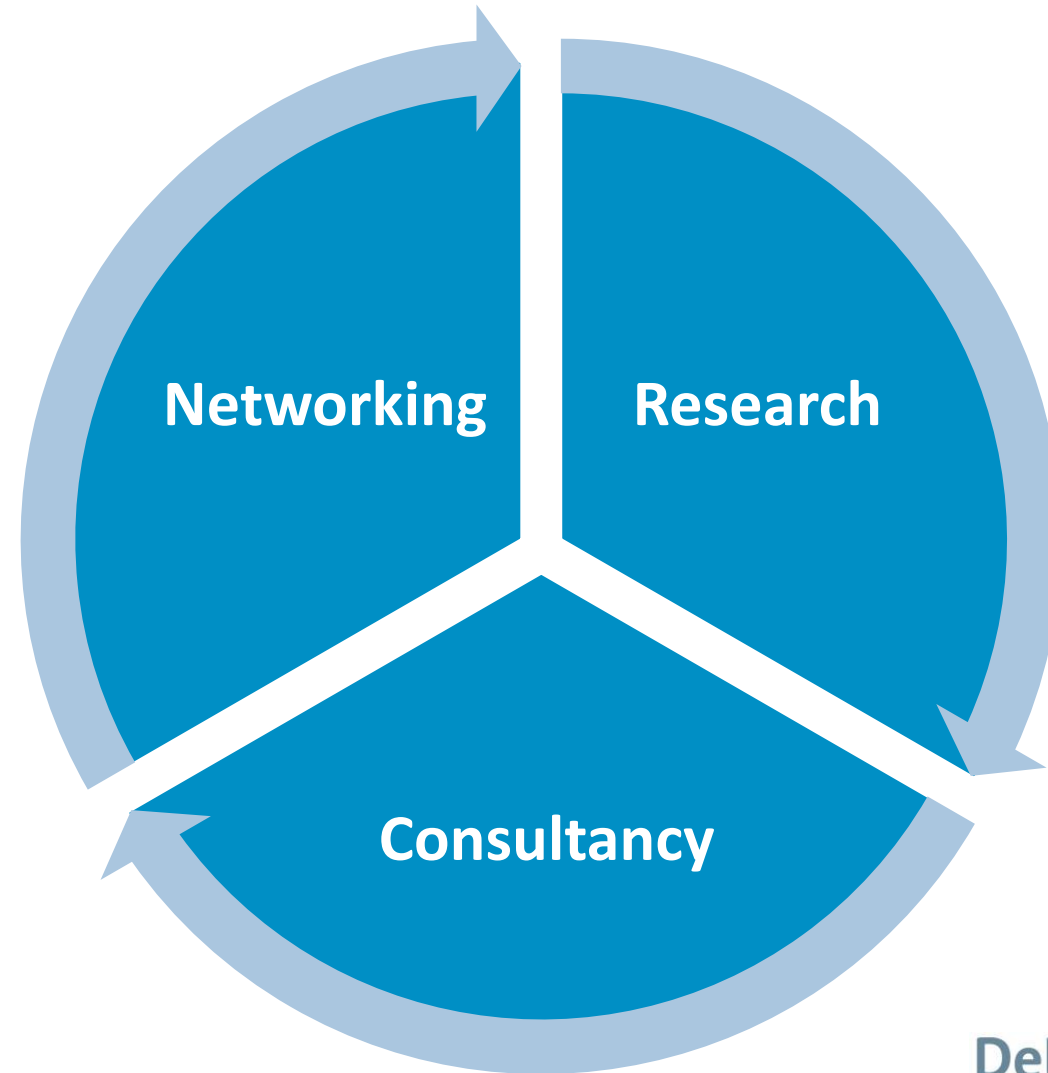
This website provides a platform for availability and continuous development of a process-based, hydrodynamic surface water flow model applying the [Deltares Delft3D FM \(flexible mesh\)](#) software describing the San Francisco Bay-Delta system. The domain covers an area from Point Reyes up to the tidal limits near Sacramento and Vernalis. A high resolution mesh ultimately allows for detailed computations of

- flow (including salinity and temperature)
- sediment transport (sand and mud transport, suspended sediment concentration, turbidity, morphodynamics)
- water quality (including turbidity, phytoplankton, nutrients, and contaminants) and
- eco-systems (habitat indicators)

A Delft3D curvilinear grid model for the Bay Delta is available at http://walrus.wr.usgs.gov/coastal_processes/sfbaycoastalsys/SFBay_model/.

Concept of the community model:

- The community model concept sets standard for strong linkage of hydraulics to water quality by integrating all environmental aspects.
- **Research** : Open-source and open-access developments + Scientific feedback and progress
- **Consultancy**: Scientific basis for sound consultancy
- **Networking**: Involvement of several institutes & continuous building with multiple discipline and parties



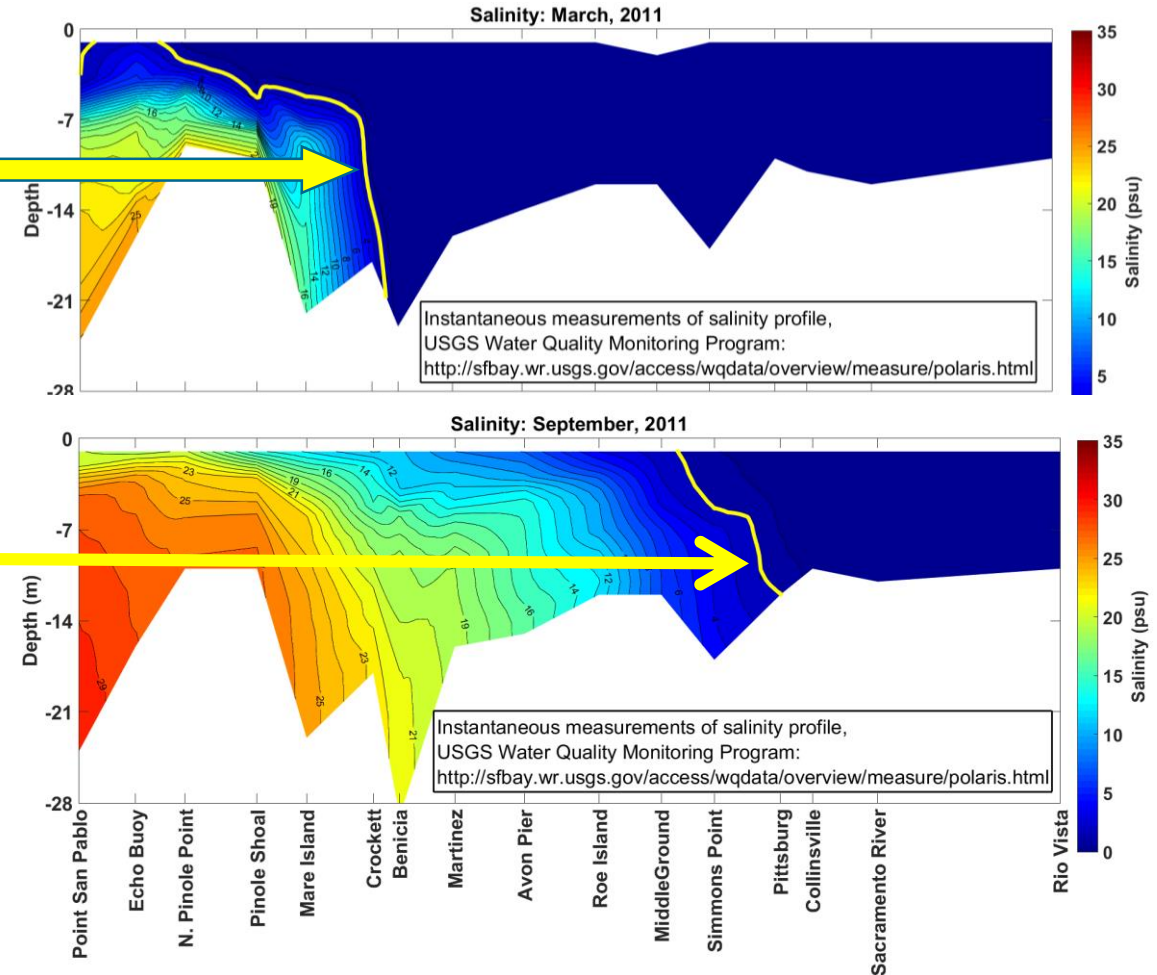
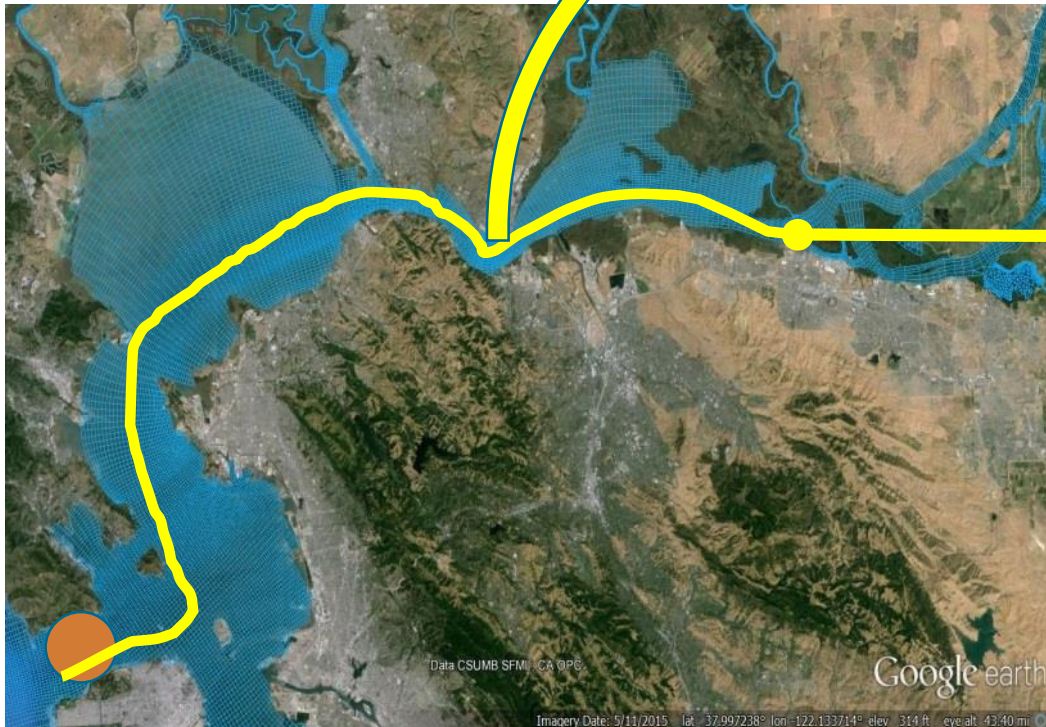
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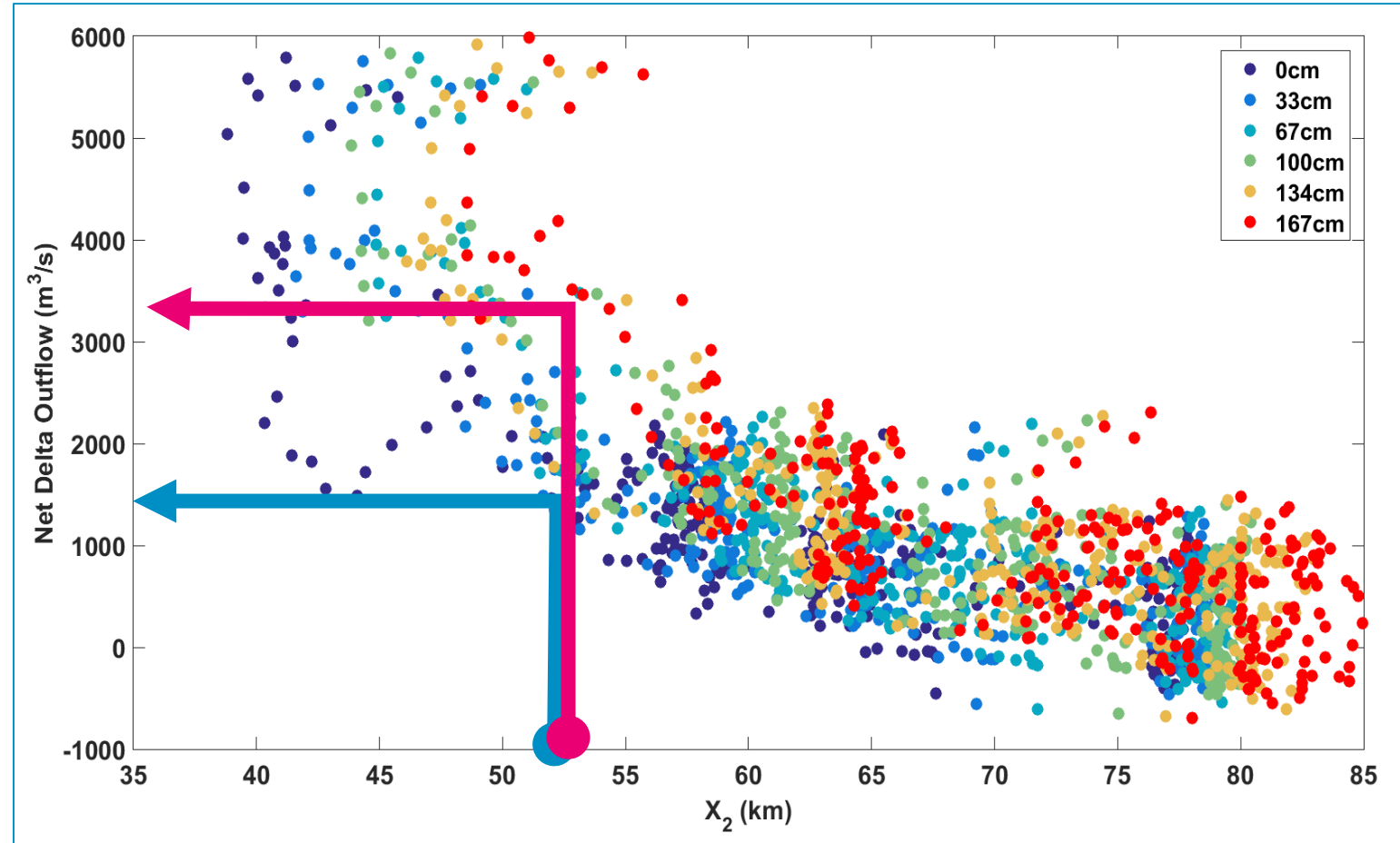
Application: salinity intrusion (work Knowles, Lucas, Martyr-Koller)

- **X2 definition:** the distance from Golden Gate Bridge to the daily 2 psu isohaline near the bottom of the water column.



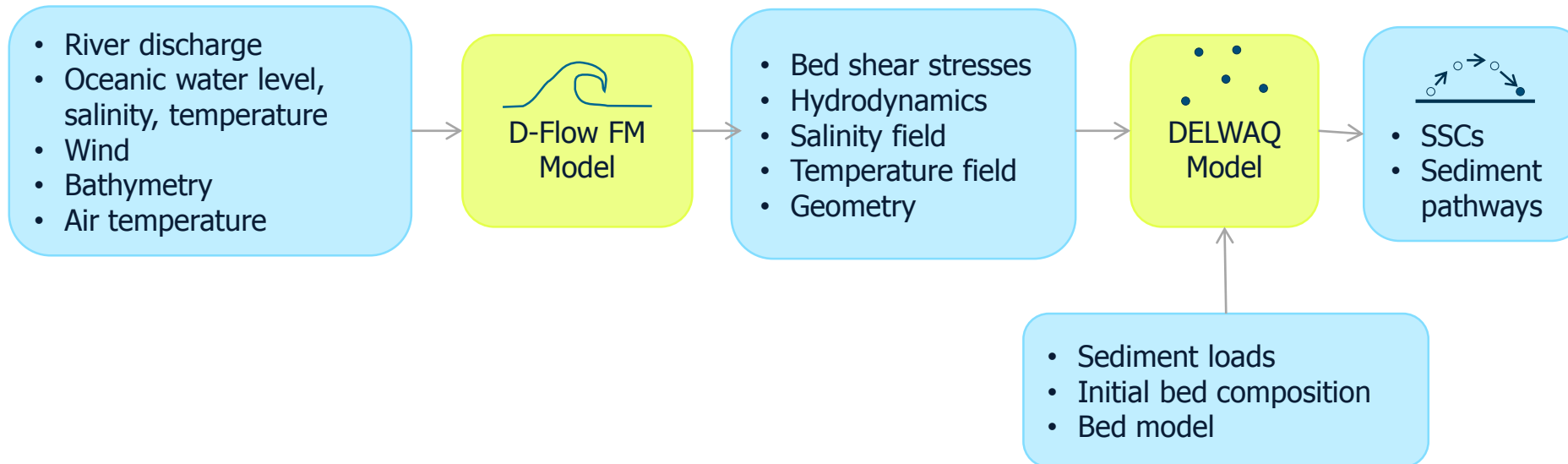
More water will be needed to keep X2 downstream

- For a desired X2, e.g. 55 km:
- **Current** day needs ~ 1500 m³/s of freshwater.
- **SLR=167cm** needs at least twice that amount of freshwater.

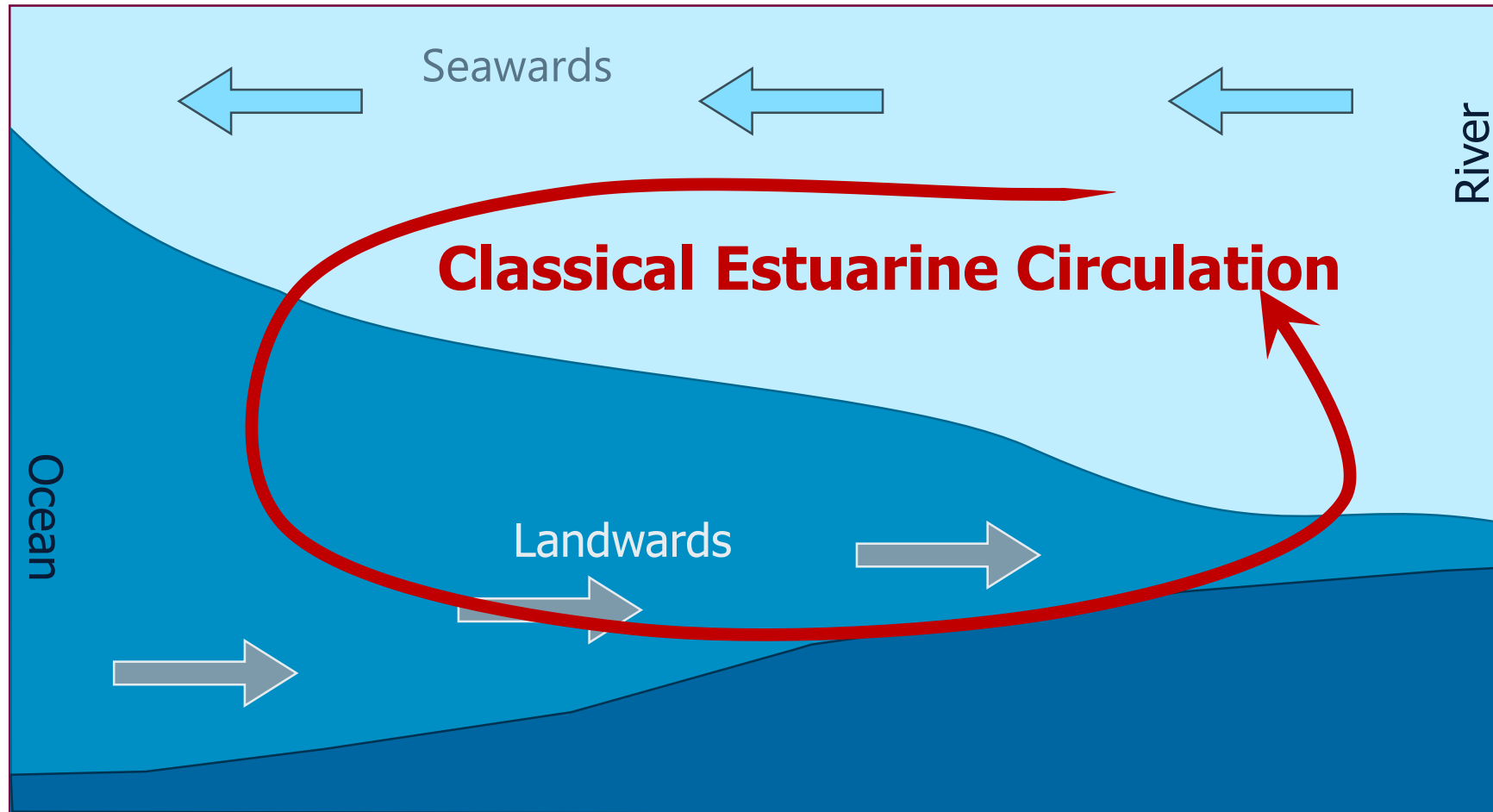


Application: suspended sediment (work Michelle Gostic)

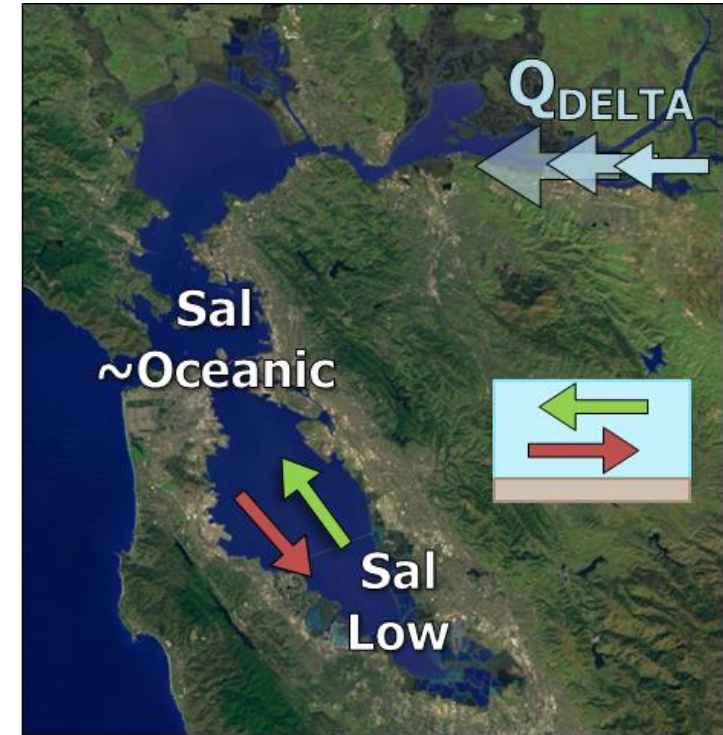
Offline coupling between Delft3D-FM and DELWAQ



Ideal estuary “salt wedge” results in estuarine circulation

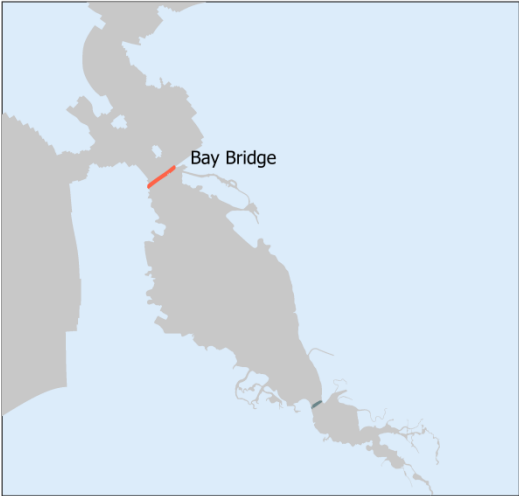
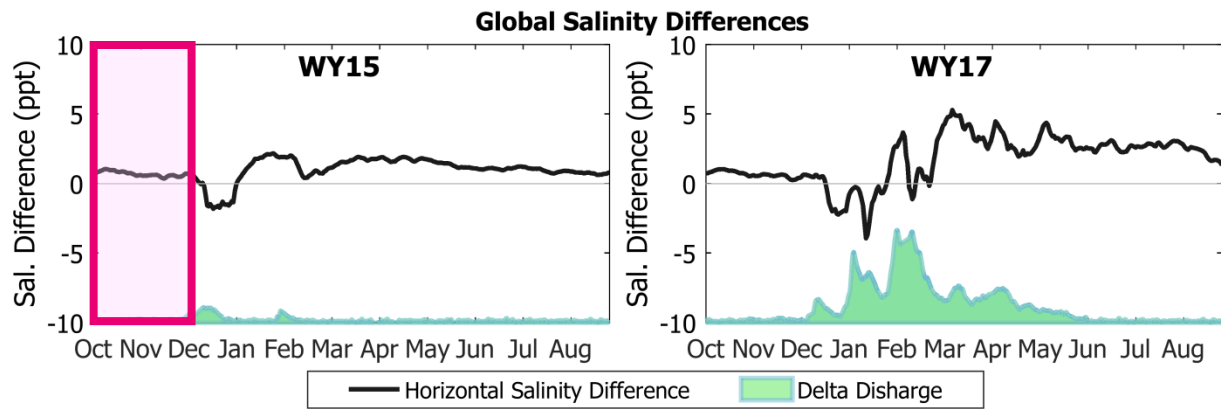


Classical estuarine circulation in South Bay

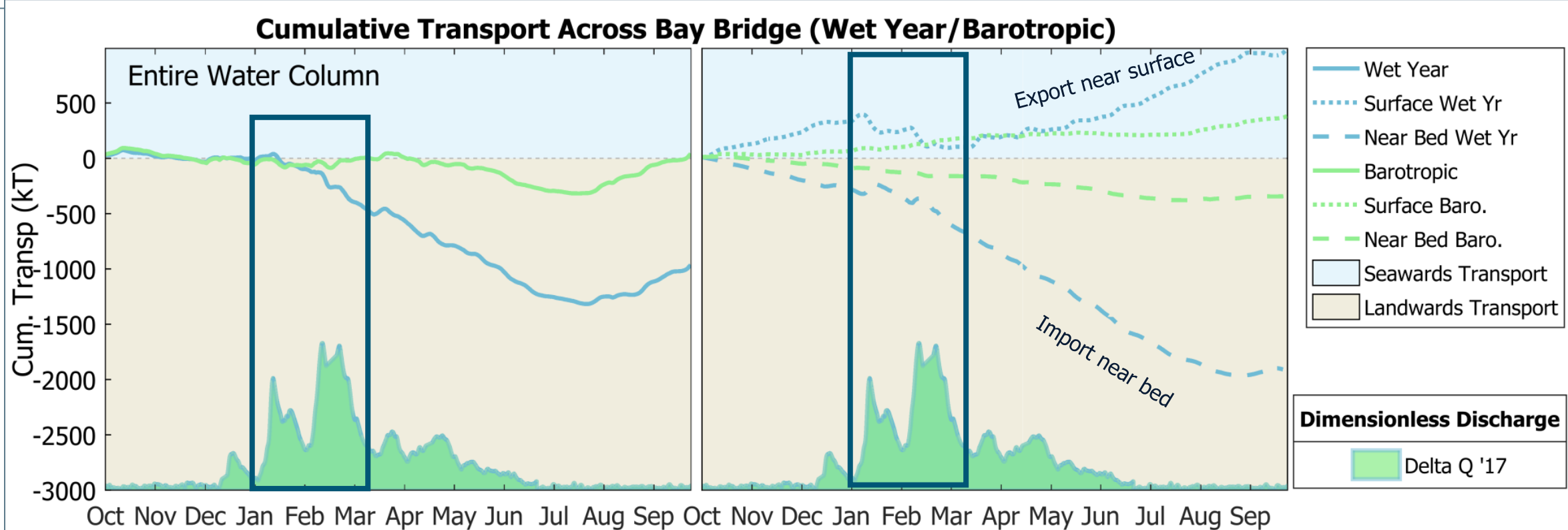
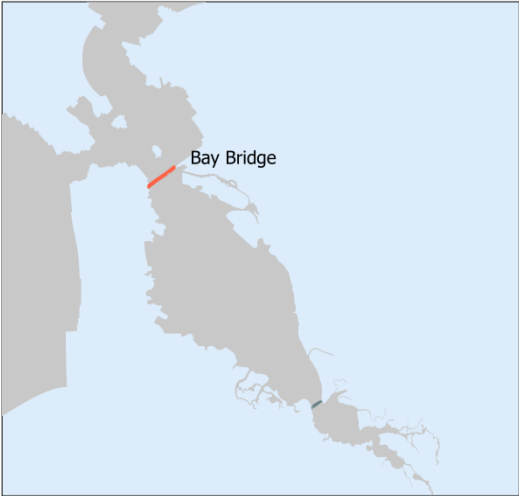
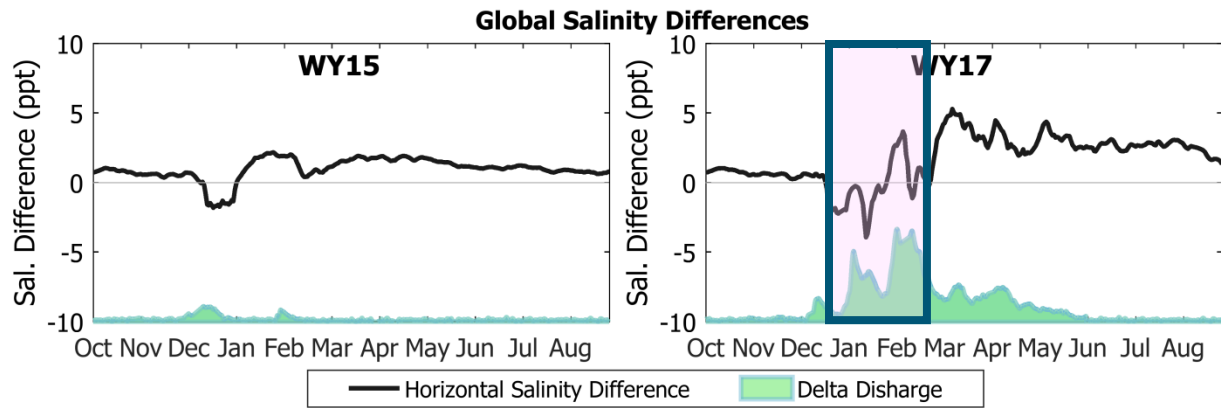


**Reducing Delta Discharge
SB: Classic Estuarine
Circulation**

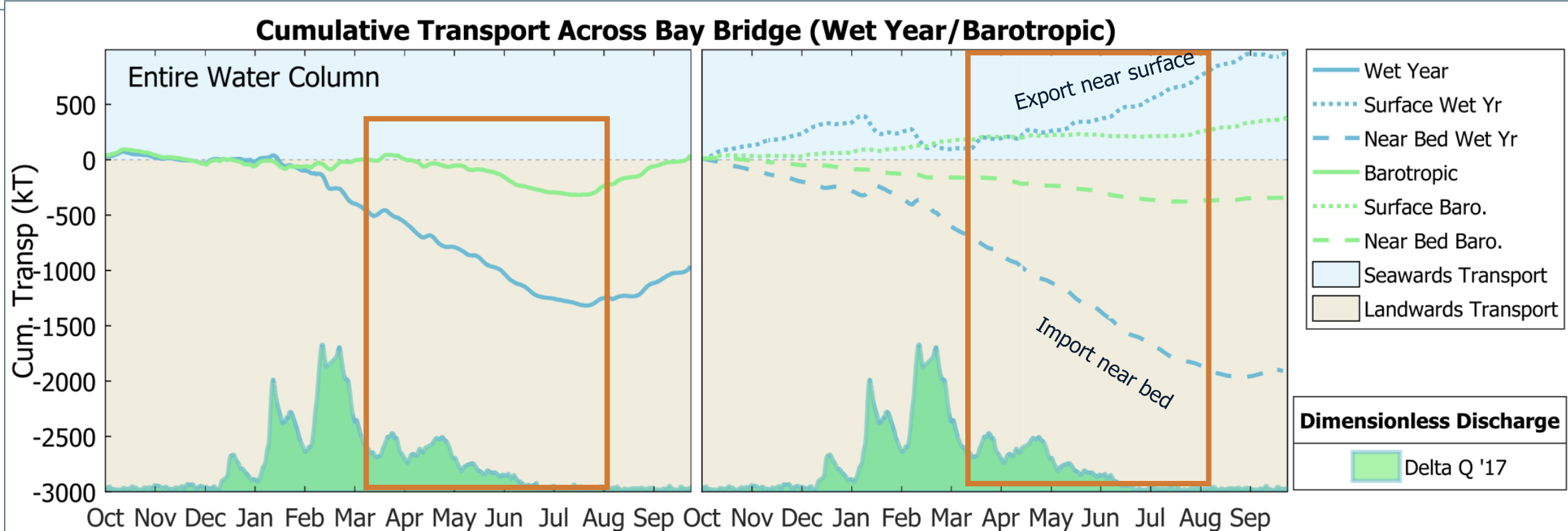
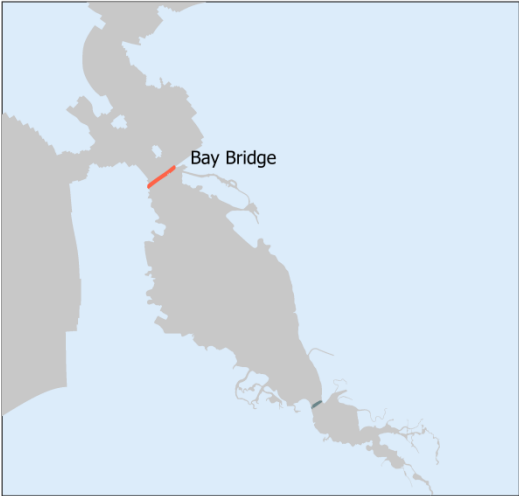
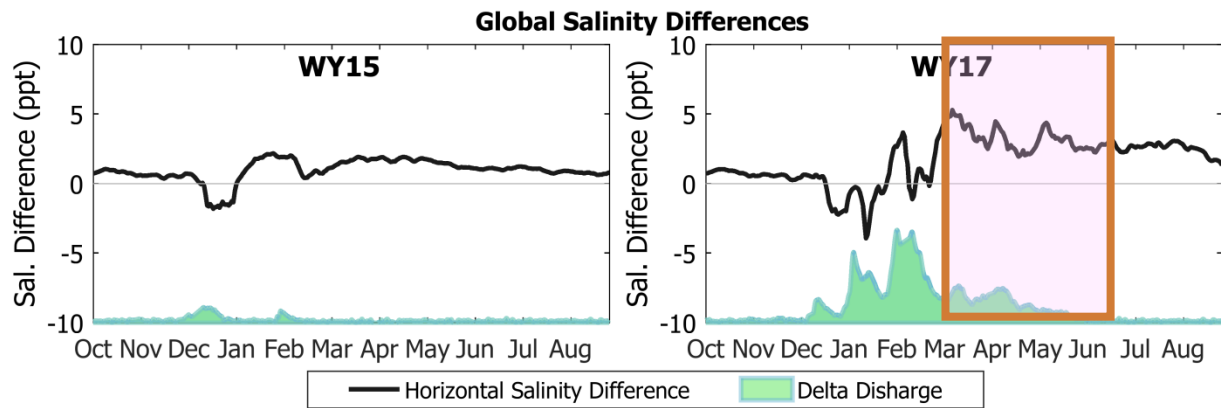
Low delta discharge



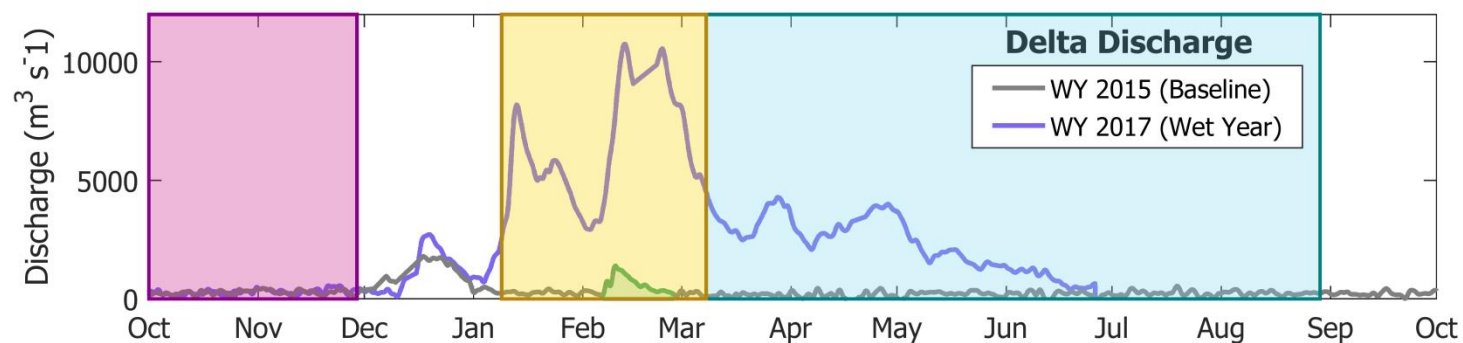
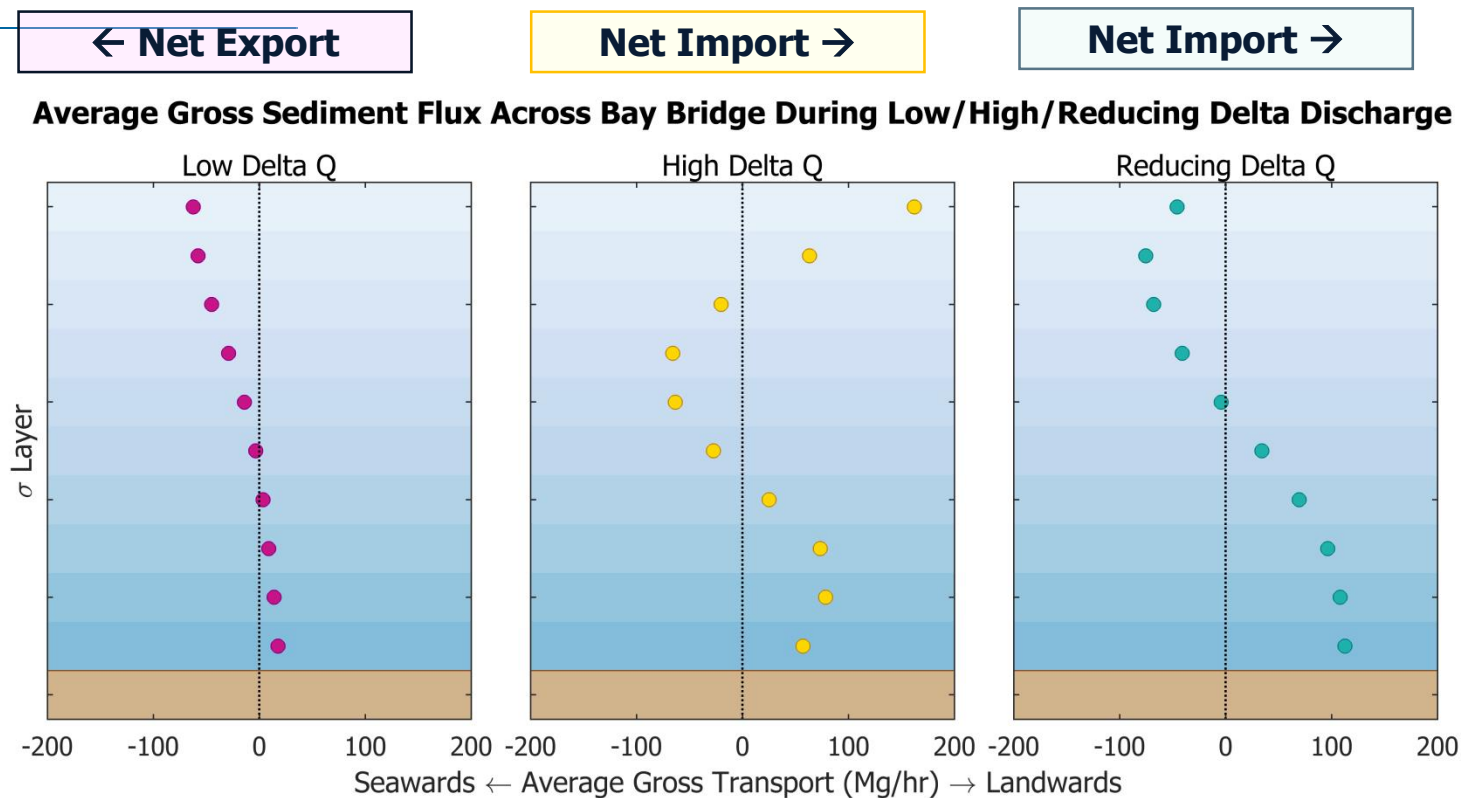
High delta discharge



Reduced delta discharge



What drives the sediment exchange in the South Bay?



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Conclusions

- **CASCADE II** was a large research project with Deltares and the USGS to focused on the impact of climate change scenarios on San Francisco Bay-Delta eco-system
- A **3D Delft3D-FM** model of the entire San Francisco Bay-Delta was created, calibrated and validated. The unstructured grid framework made it possible to include highly complex geometry and perform year-long simulations at relatively low computational cost.
- Model schematizations are shared as **community model** to support networking, science and consultancy.
- **Applications** of the community model range from
 - **Salt intrusion:** sea level rise will increase salinity intrusion in SF Bay-Delta and more freshwater is needed to keep salt downstream which poses challenges in dry conditions.
 - **Sediment transport:** Delft3D-FM coupling with DELWAQ made it possible to unravel sediment exchange processes in South Bay

Deltares

Enabling Delta Life



The San Francisco Bay Community model

Kees Nederhoff

Deltares – 'Enabling Delta Life'