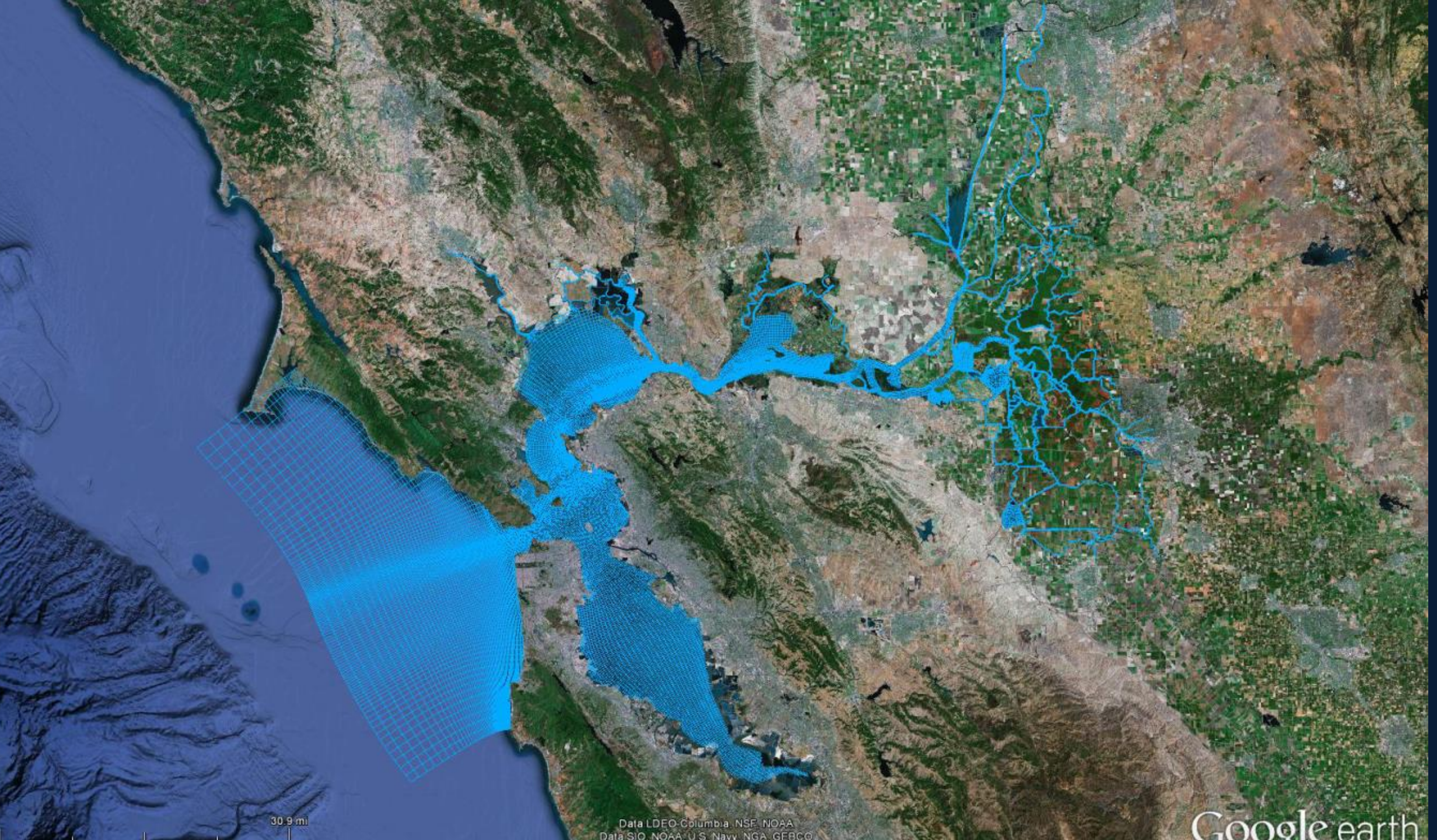
Deltares

Enabling Delta Life

San Francisco Bay Delta Community model

Kees Nederhoff


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**

Deltares USA

Content

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

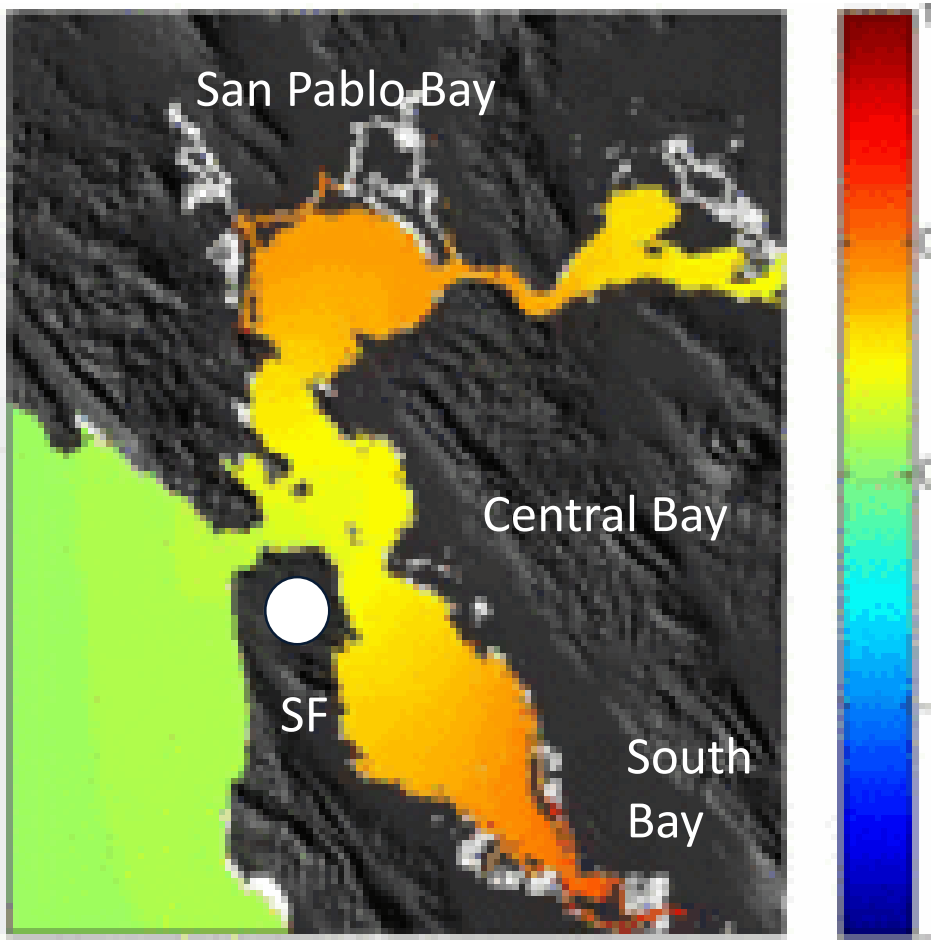
Deltares USA

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:**

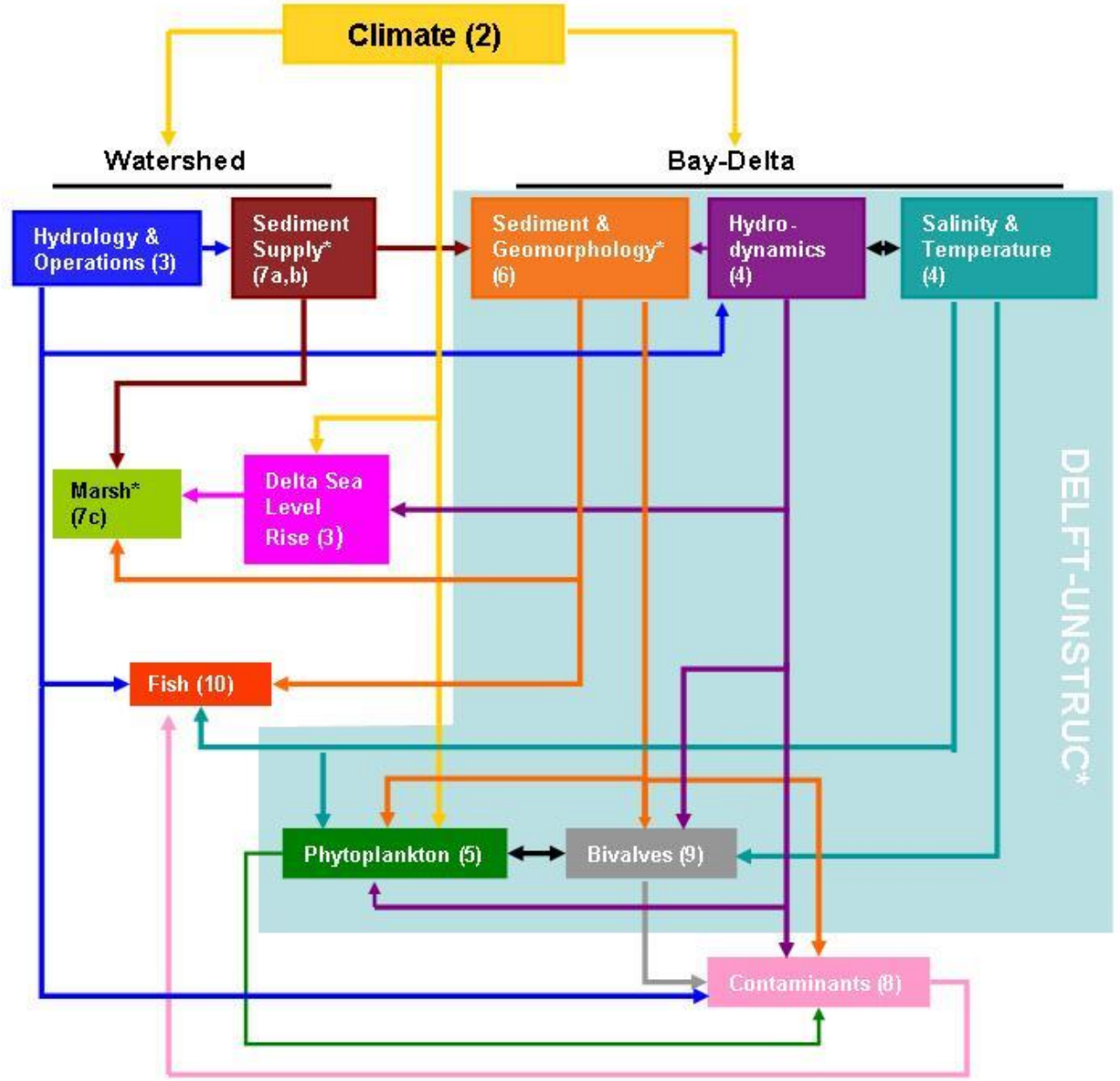
USGS science for a changing world

Deltares Enabling Delta Life

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)



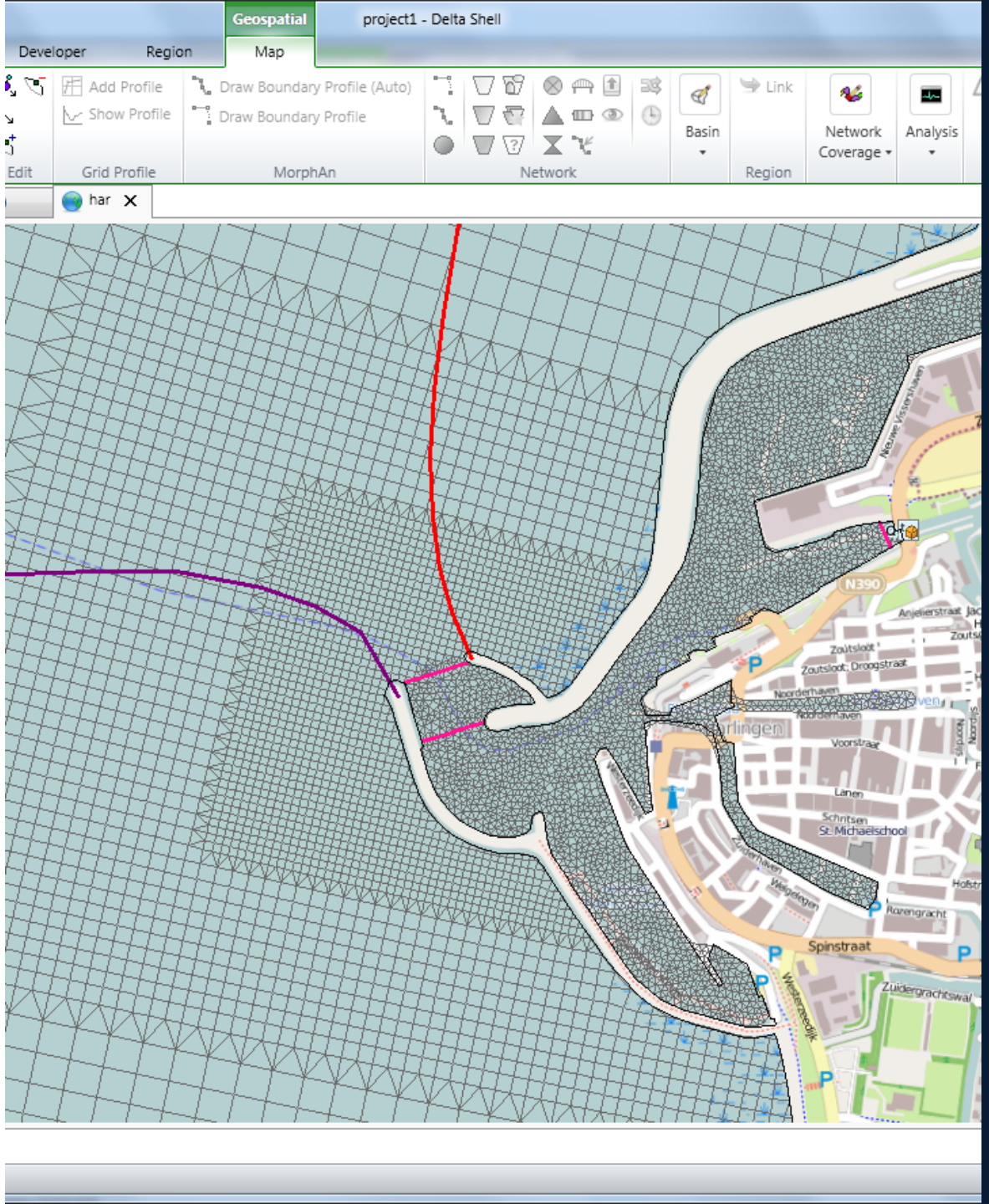
Why Delft3D-FM?

- 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**



Content

1. Background: how did this start?

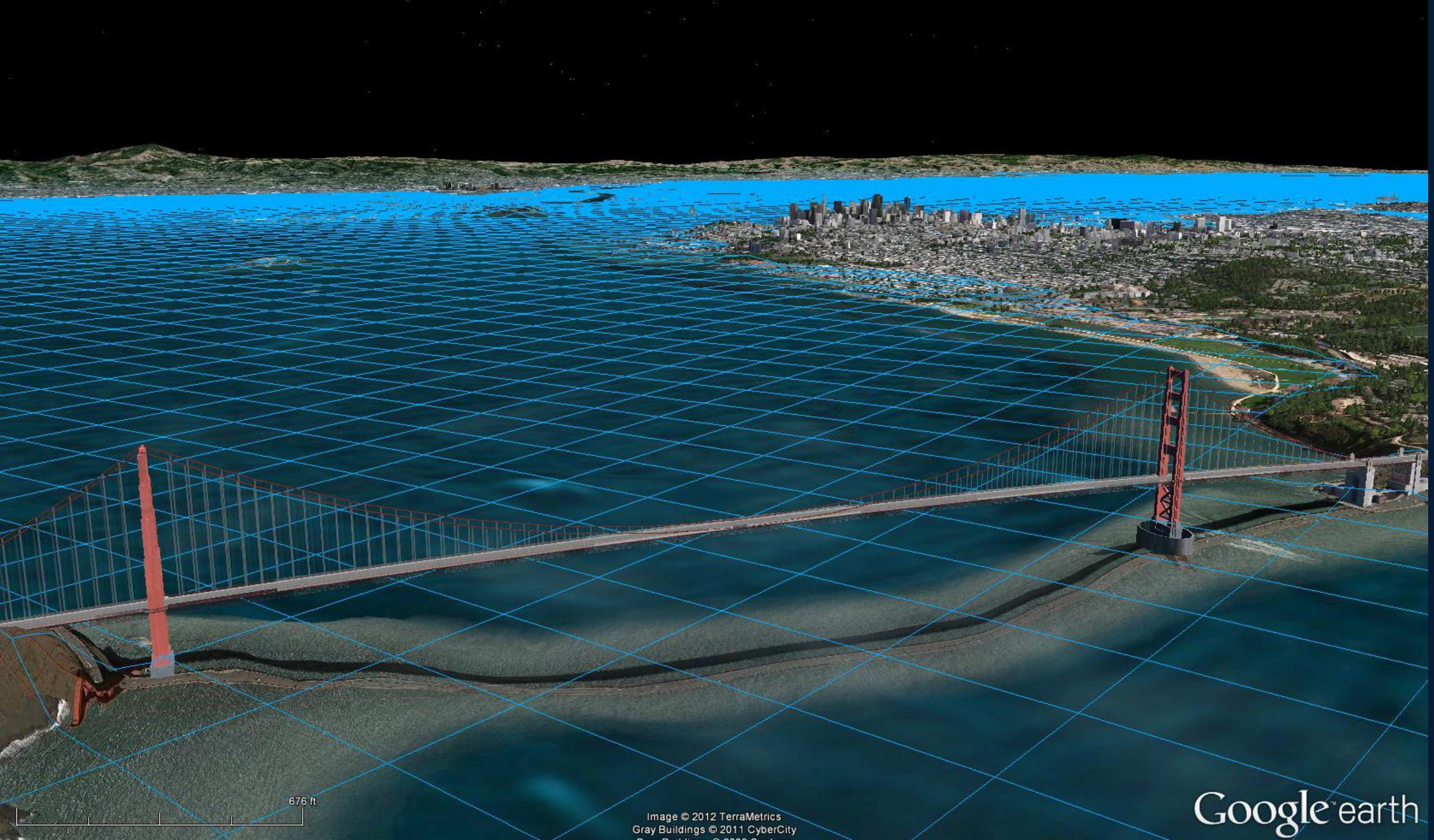
2. **Delft3D-FM model schematization**

3. Community model

4. Applications of a community model
   1. Salt intrustion
   2. Sediment transport

5. Conclusions

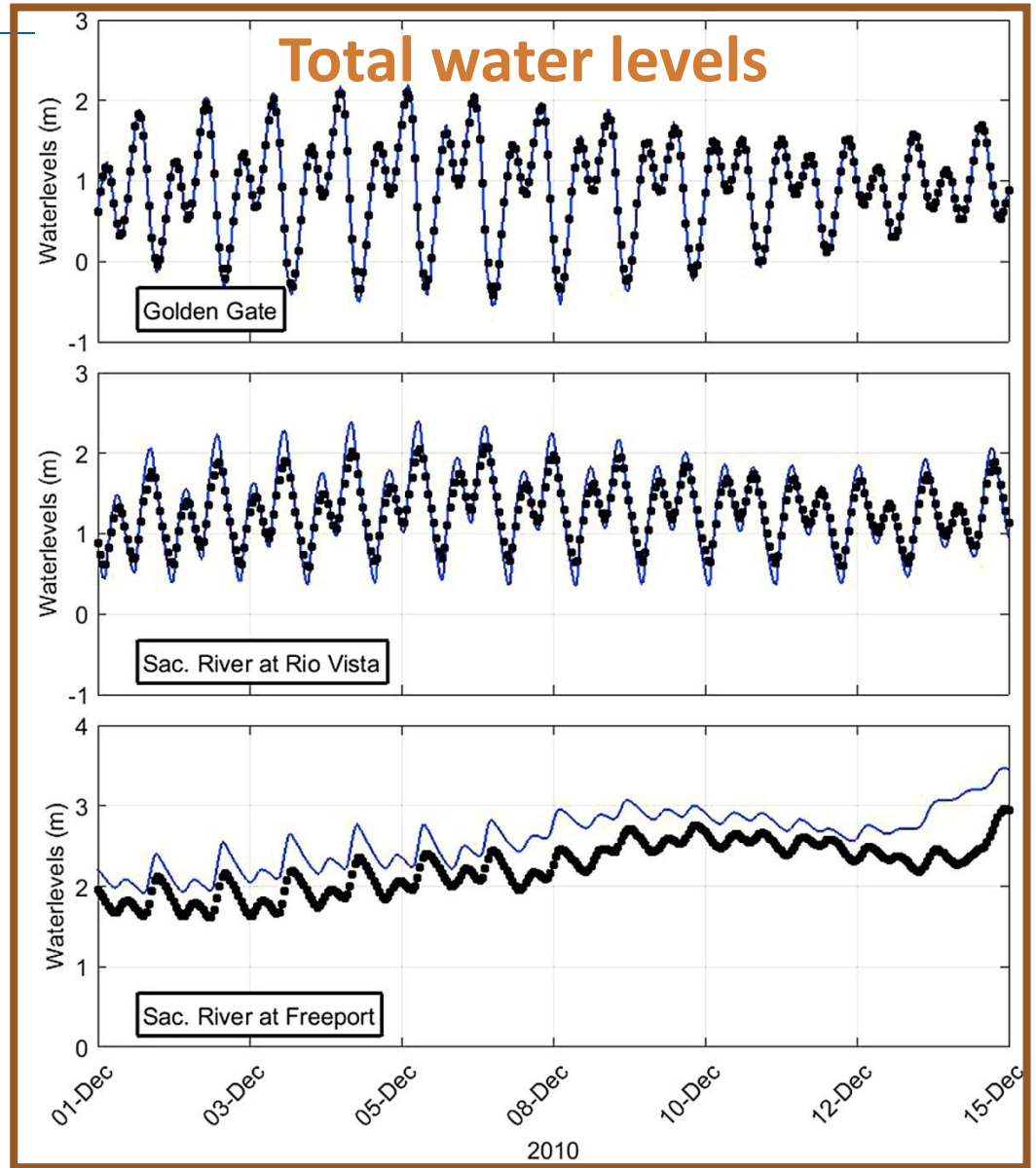
Deltares USA


676 ft
Image © 2012 TerraMetrics
Gray Buildings © 2011 CyberCity
Google earth

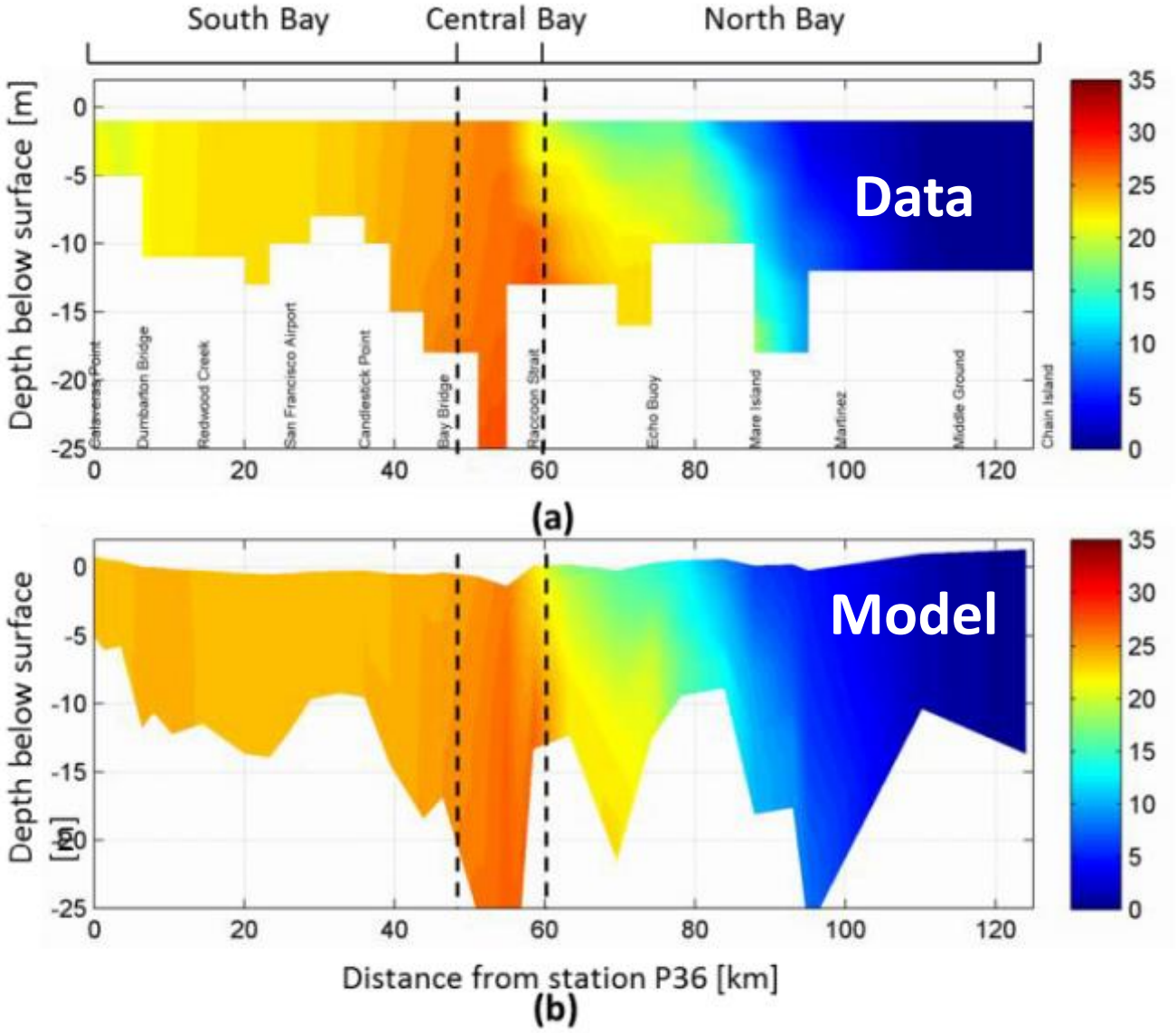

10095 ft
Google earth


10095 ft
Google earth

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



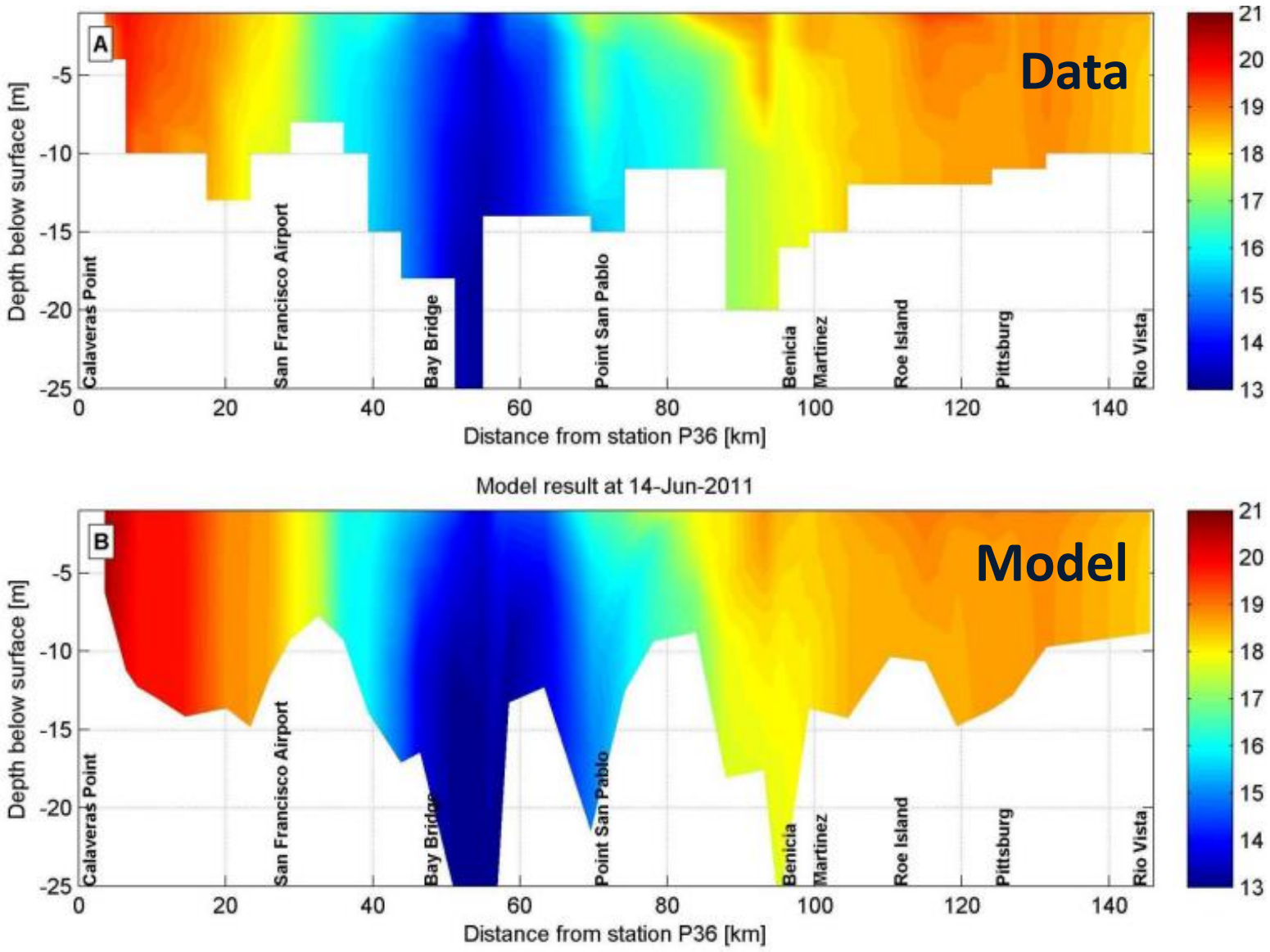
Salinity fields are well reproduced (Pubben, 2017)



- **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)



- 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

Deltares USA

Content

1. Background: how did this start?

2. Delft3D-FM model schematization

3. **Community model**

4. Applications of a community model
    1. Salt intrustion
    2. Sediment transport

5. Conclusions

Deltares USA

Community model from 2014 - onwards

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

- Creative Commons Attribution-Share Alike 4.0 International License

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

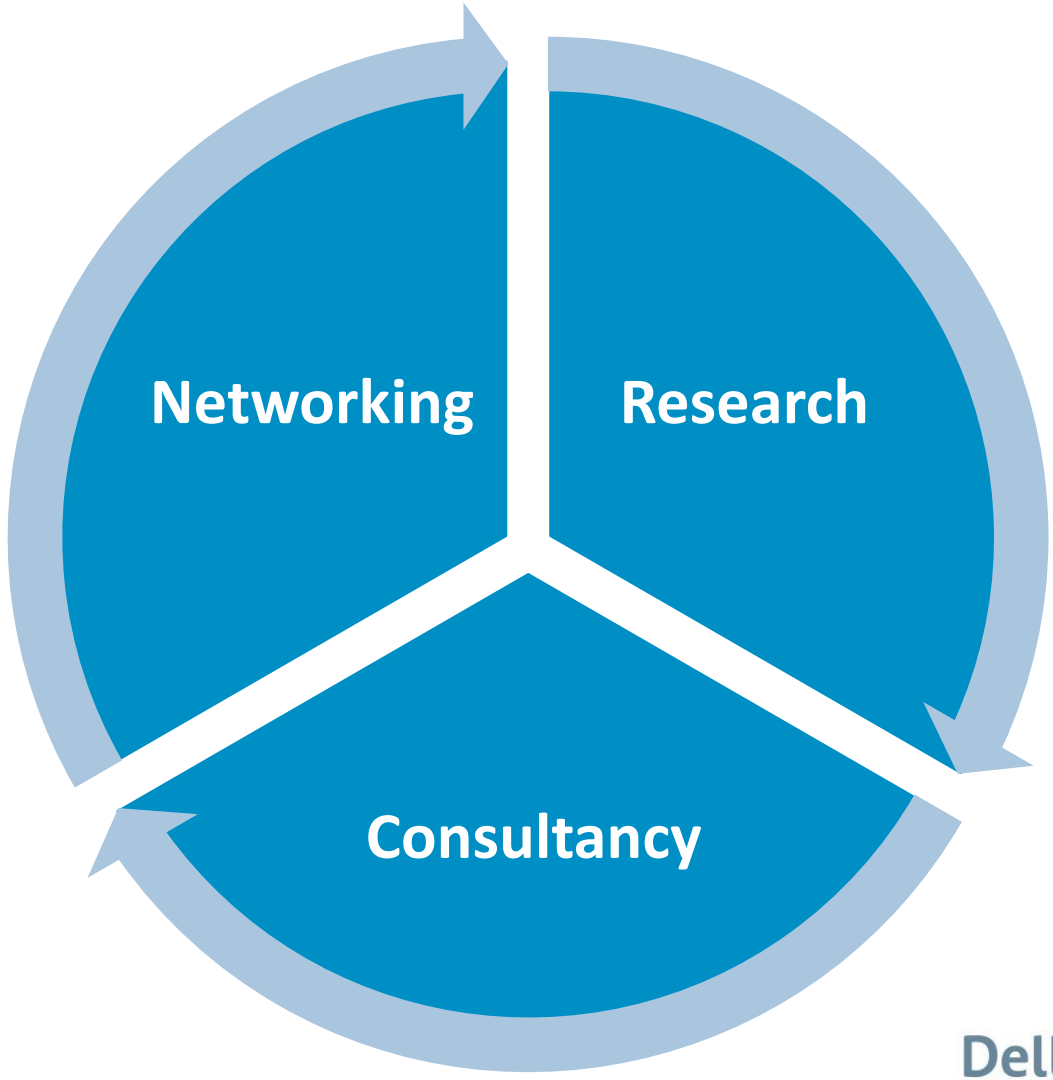
Concept of the community model:

- 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



Deltares USA

Content

1. Background: how did this start?

2. Delft3D-FM model schematization

3. Community model

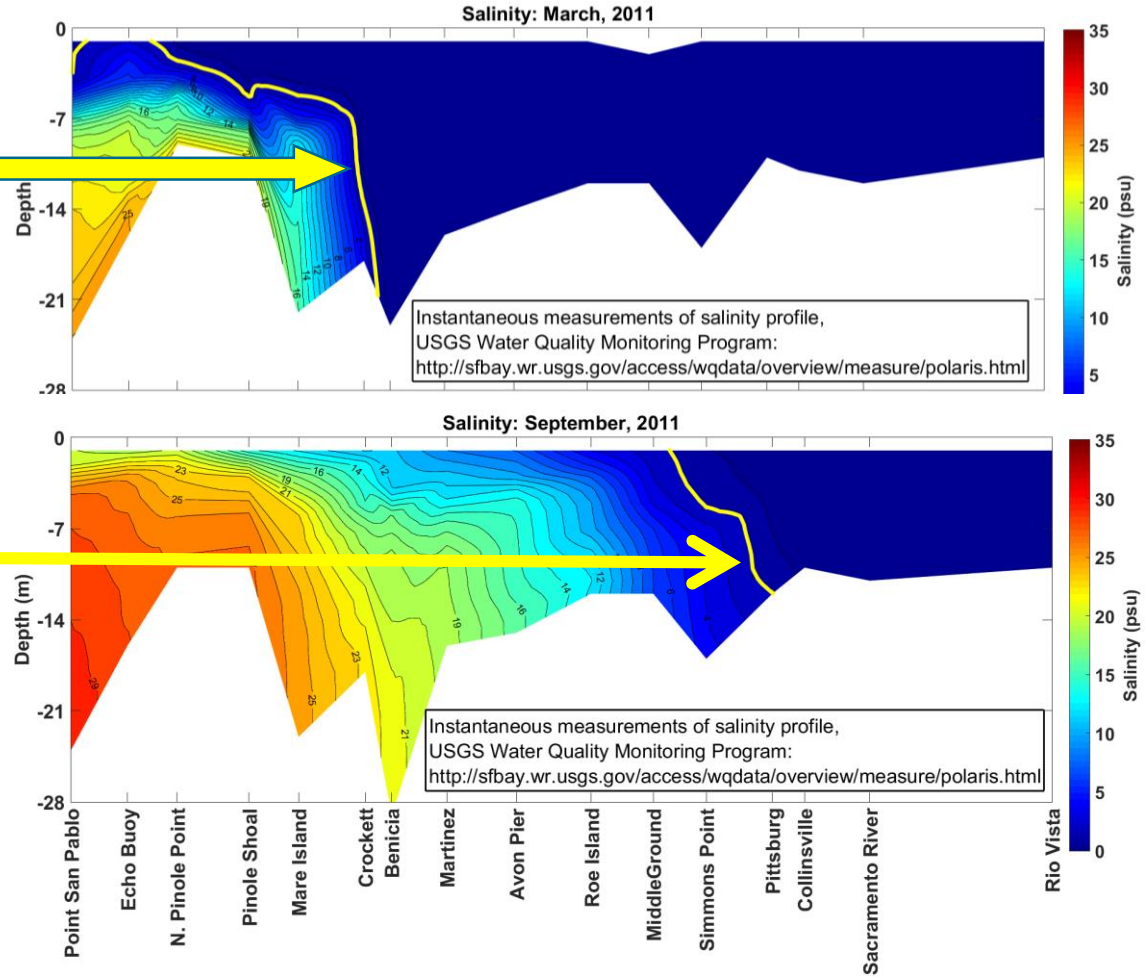
4. **Applications of a community model**
   1. Salt intrustion
   2. Sediment transport

5. Conclusions

Deltares USA

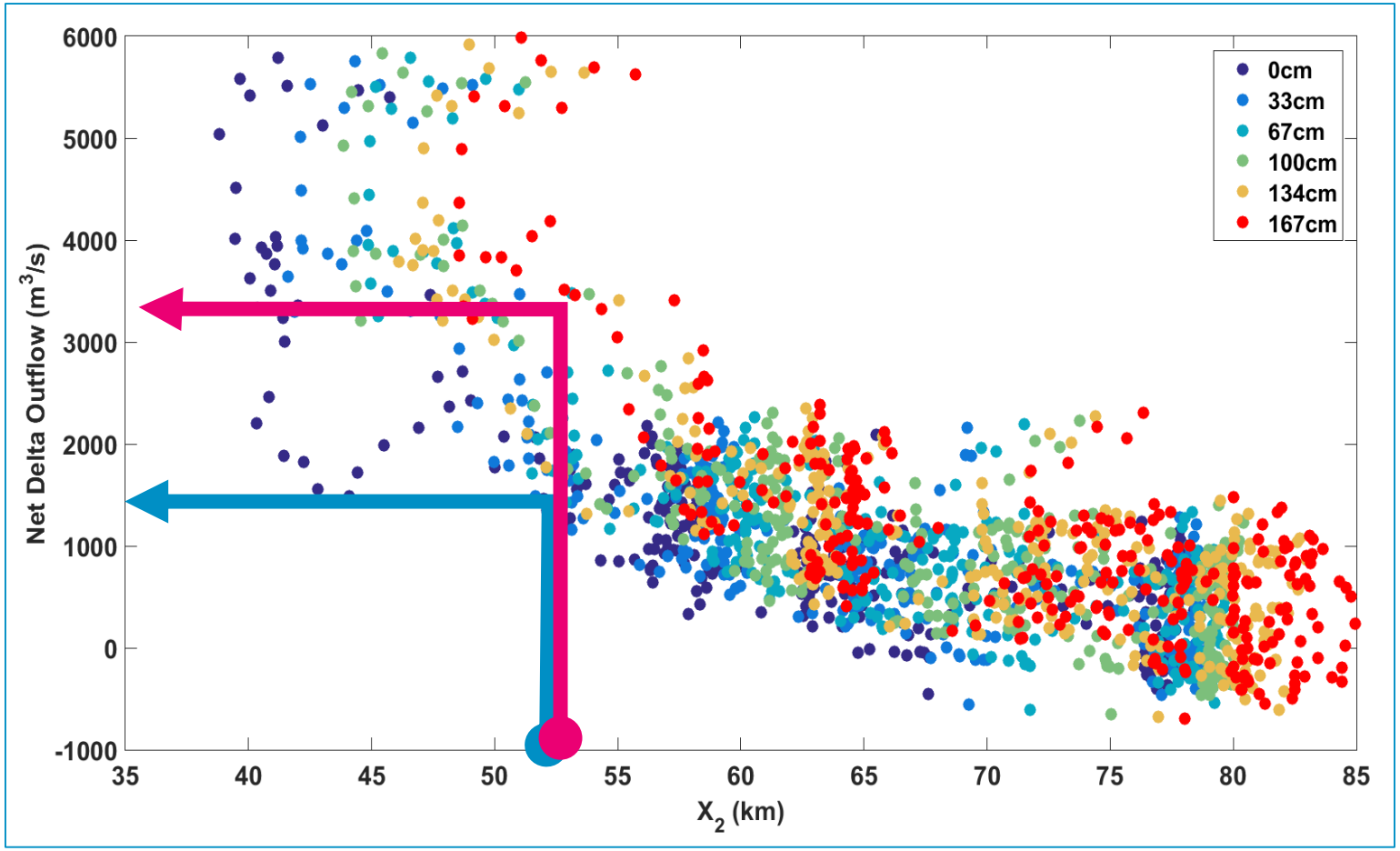
Application: salinity intrusion (work Knowles, Lucas, Martyr-Koller)

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



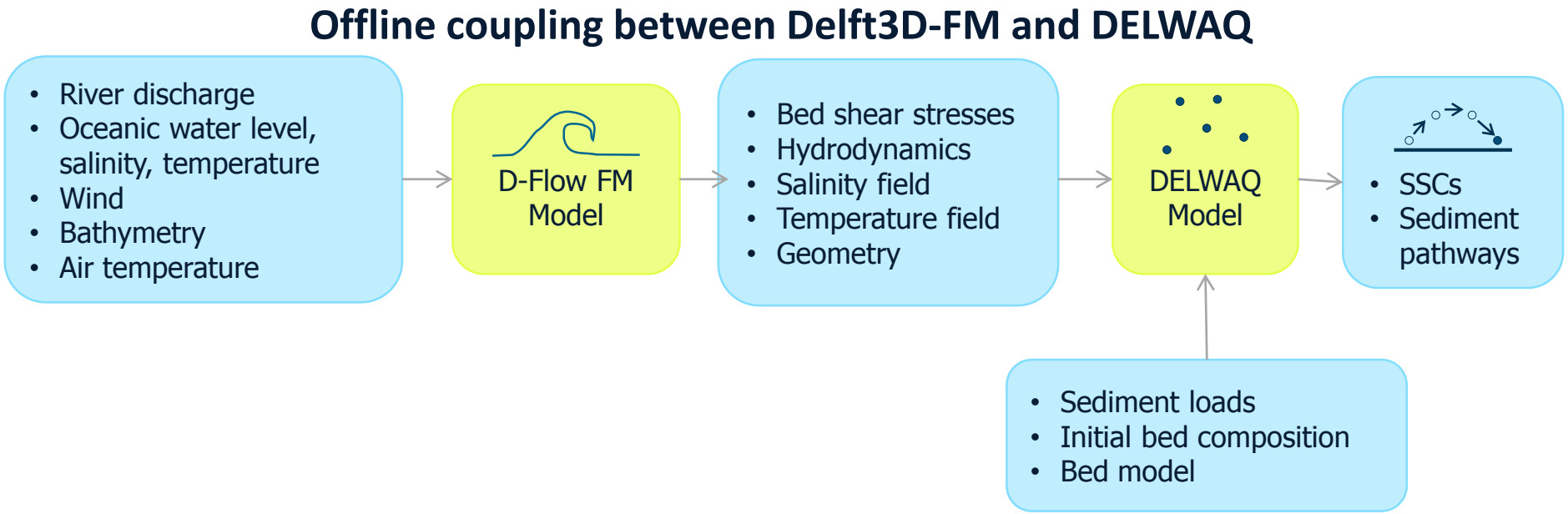
More water will be needed to keep X2 downstream

- **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.



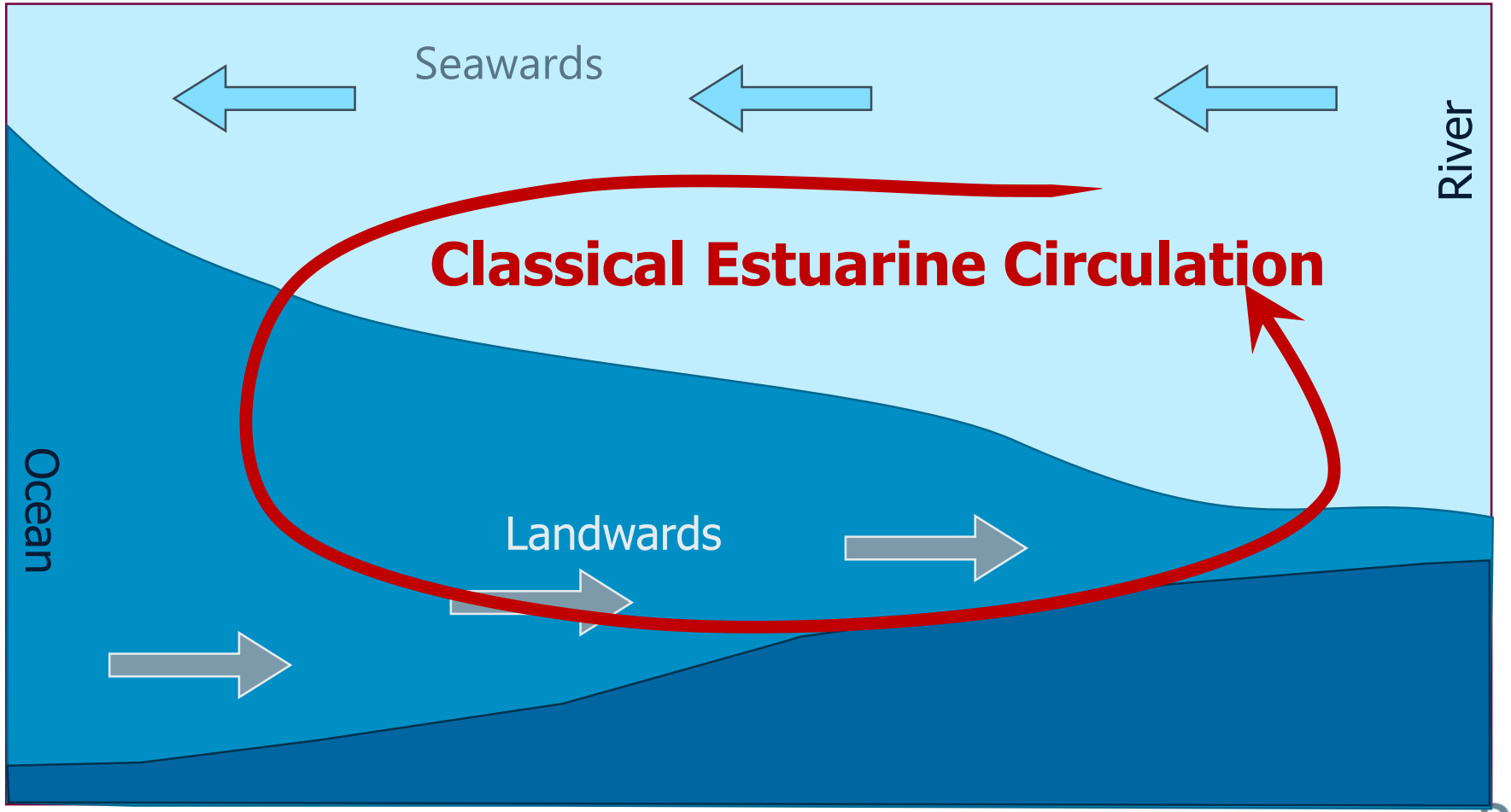
Deltares USA

Application: suspended sediment (work Michelle Gostic)



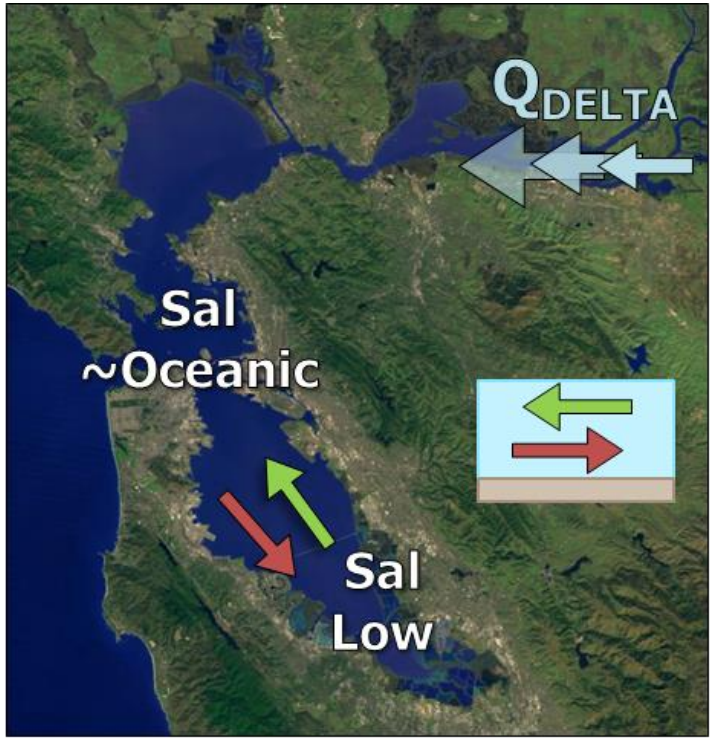
Deltares USA

Ideal estuary “salt wedge” results in estuarine circulation



Deltares USA

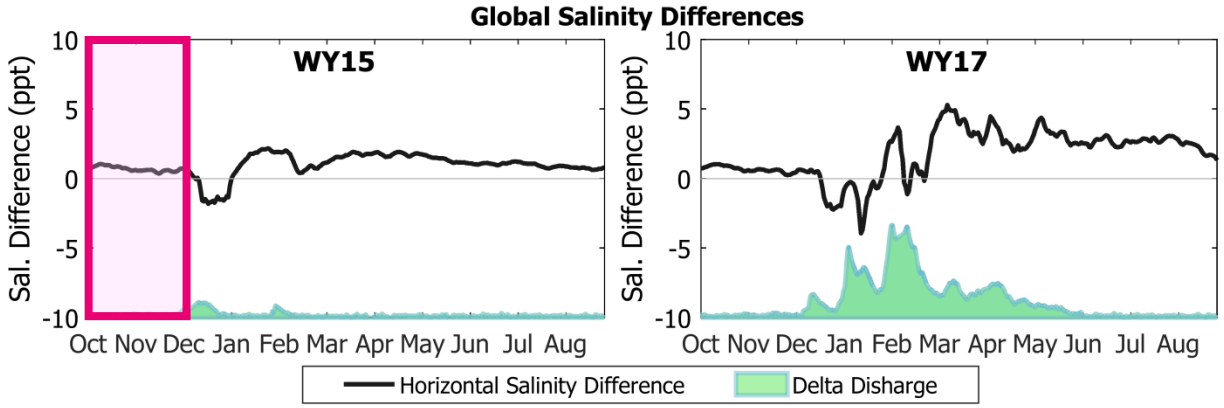
Classical estuarine circulation in South Bay

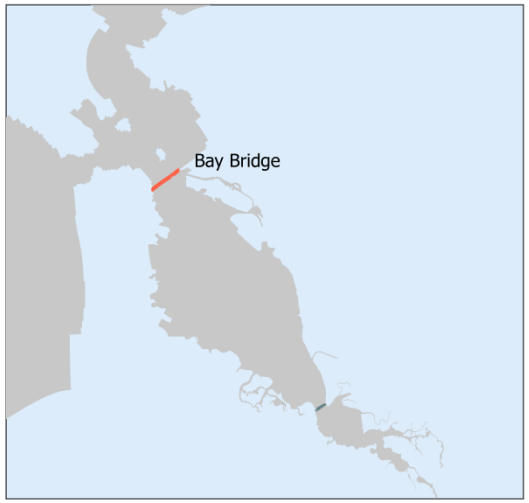


Reducing Delta Discharge SB: Classic Estuarine Circulation

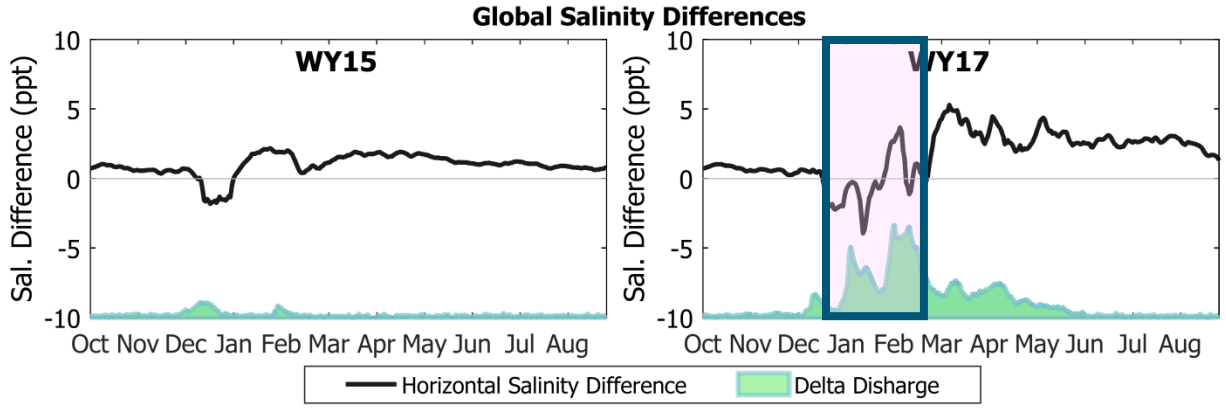
Deltares USA

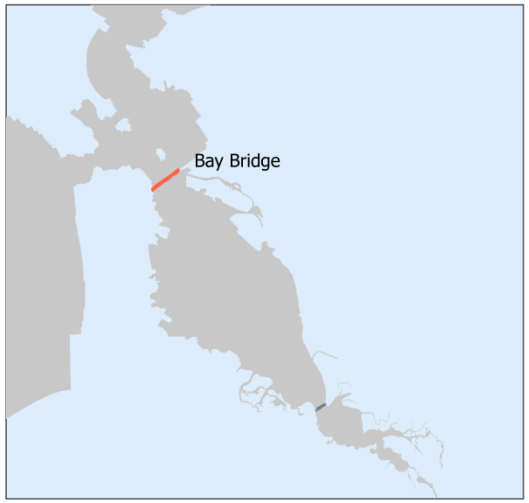
Low delta discharge

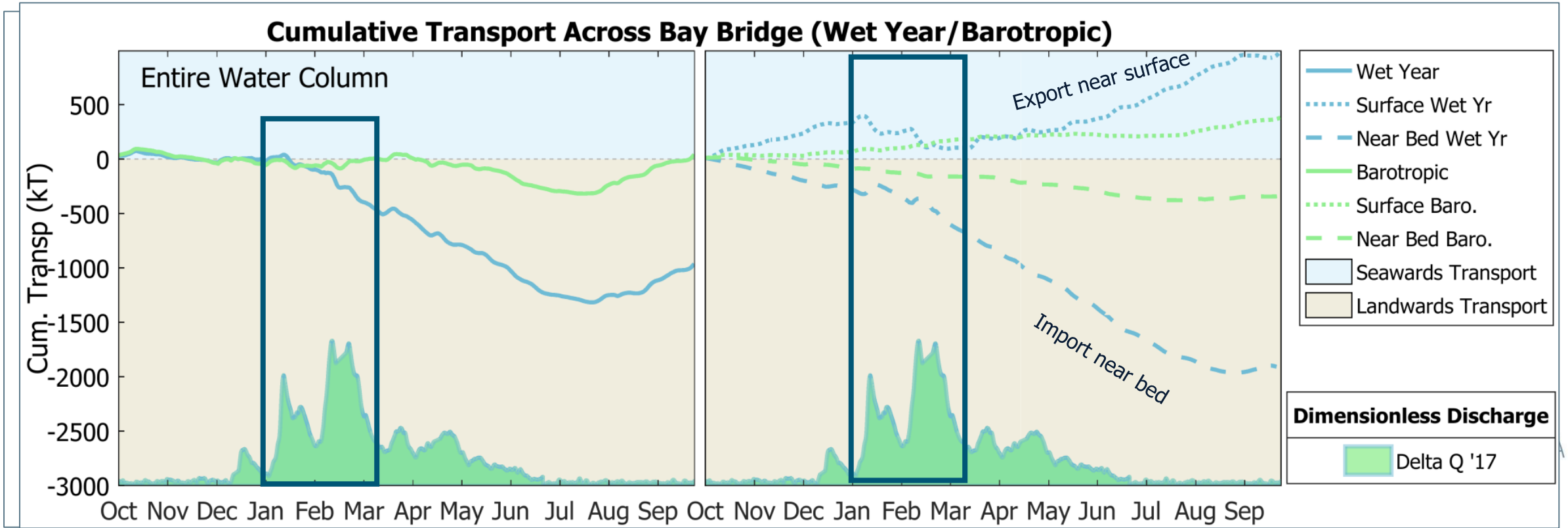




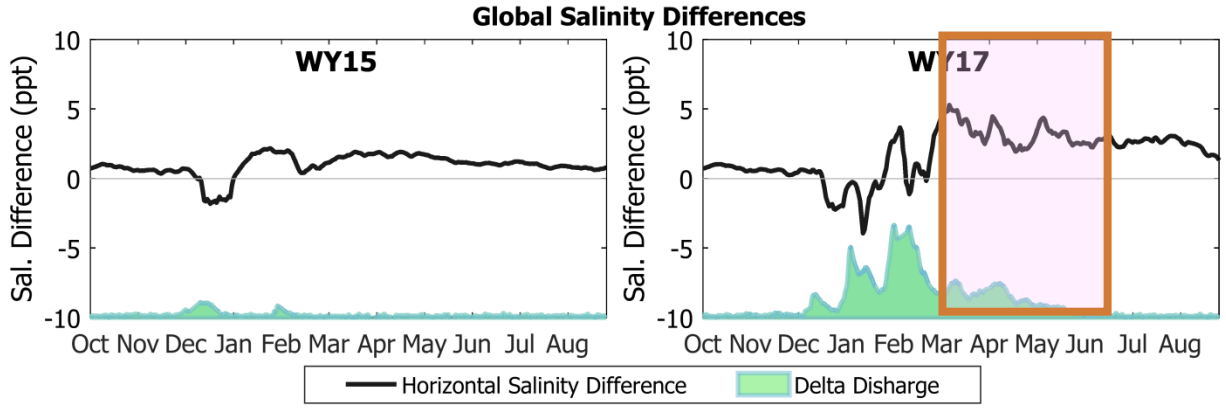
High delta discharge

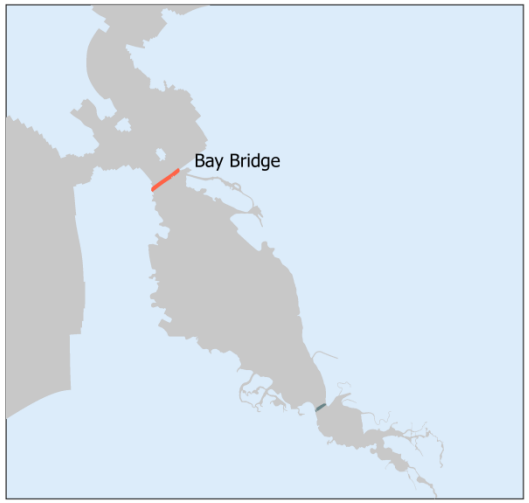


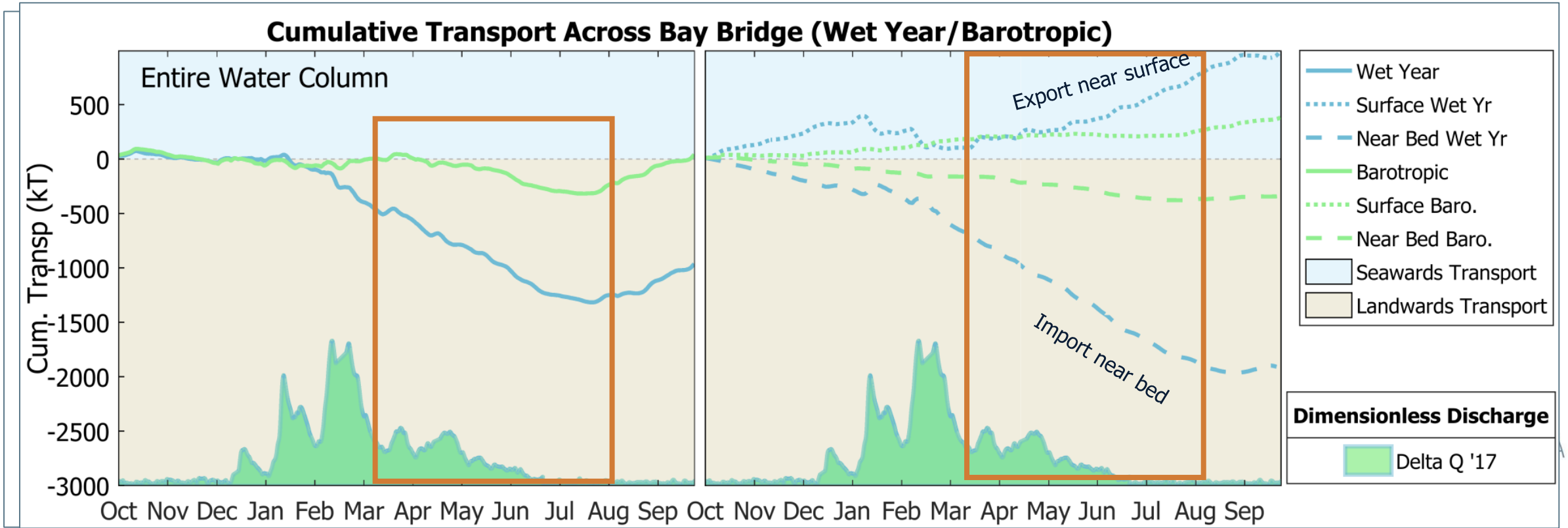




Reduced delta discharge





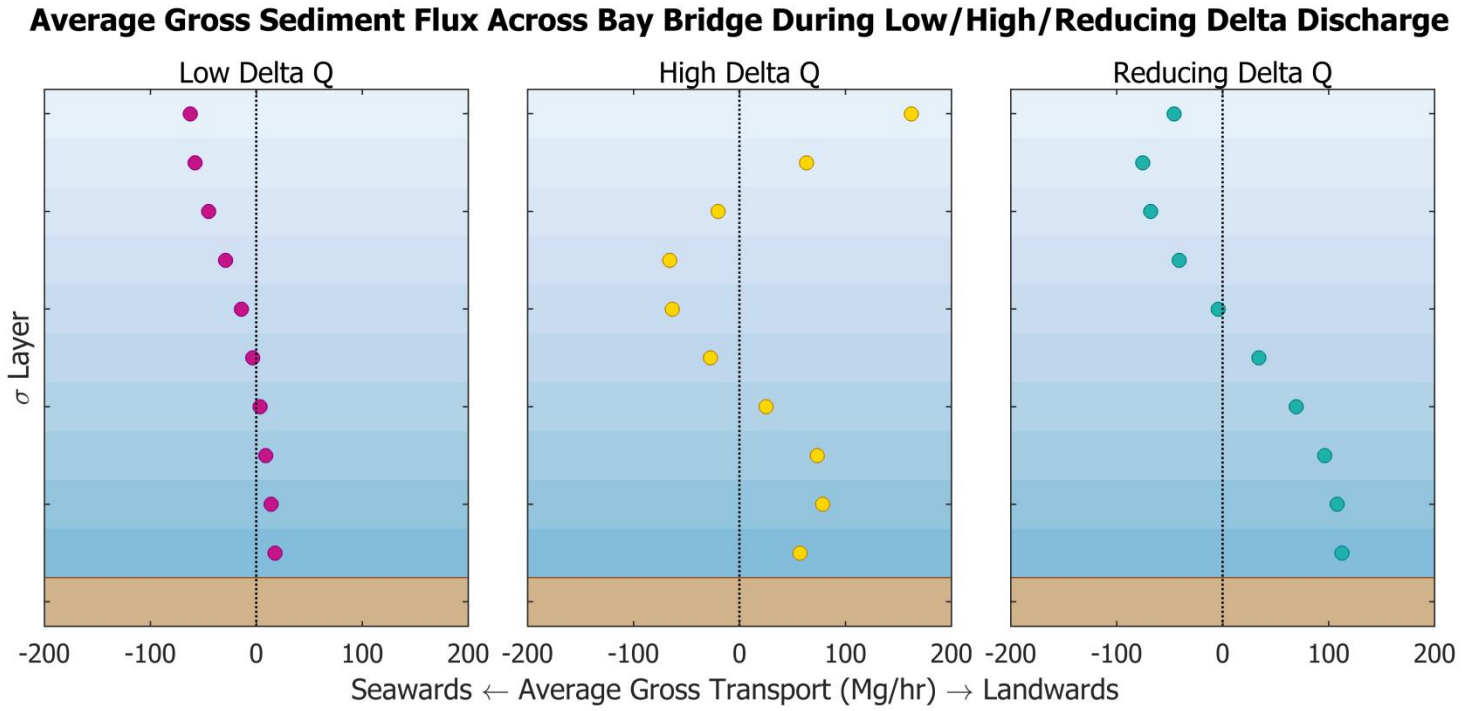


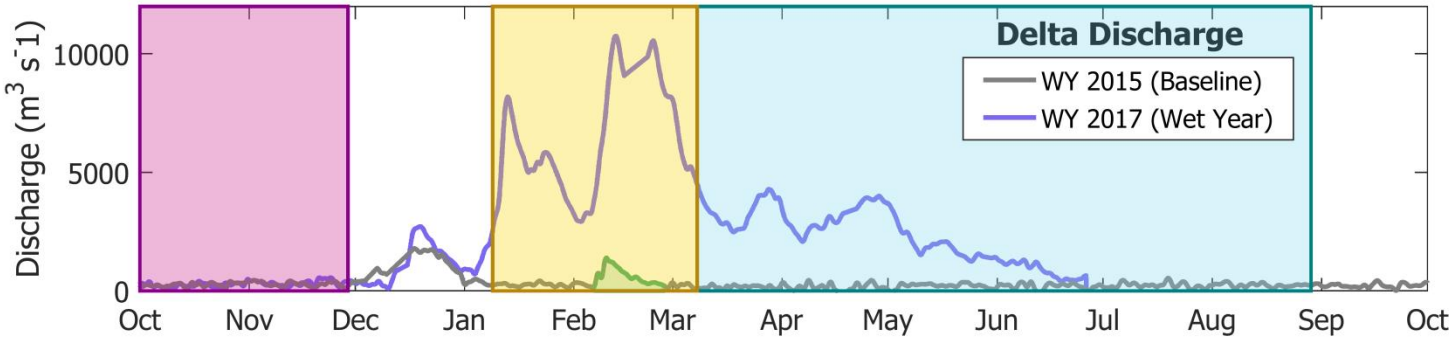
What drives the sediment exchange in the South Bay?

← Net Export

Net Import →

Net Import →





Deltares USA

Content

1. Background: how did this start?

2. Delft3D-FM model schematization

3. Community model

4. Applications of a community model
   1. Salt intrustion
   2. Sediment transport

5. **Conclusions**

Deltares USA

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 USA

Deltares

Enabling Delta Life

The San Francisco Bay Community model

Kees Nederhoff