National Aeronautics and Space Administration

San Francisco Bay Delta Water Resources

Utilizing NASA and ESA Earth Observations to Monitor Turbidity Distribution in the San Francisco Bay-Delta

Katherine Cavanaugh (Project Lead)

Leah Kucera

Molly Spater

NASA Jet Propulsion Laboratory

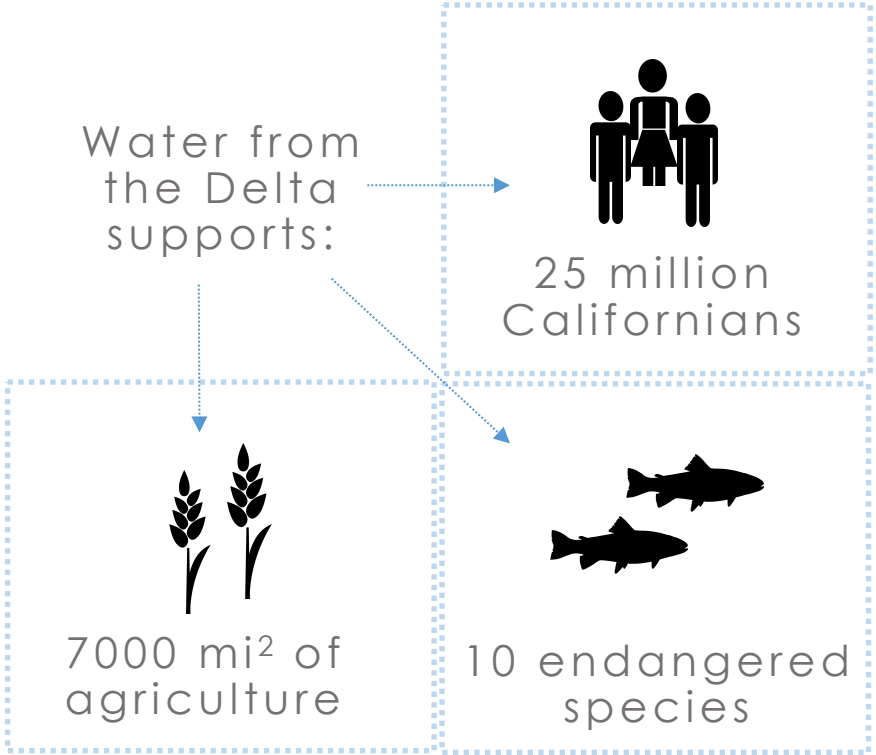
2017 Summer

Overview

- Community Concerns
- Partners
- Objectives
- Study Area & Period
- Methodology
- Results & Limitations
- Conclusion & Future Work

Image: Wikimedia

Community Concerns



- Increased demand for Bay-Delta water resources
- Agricultural and municipal water comes at the expense of the Delta smelt
- Demand for turbidity data in areas not monitored by *in situ* stations

Partners

Metropolitan Water District of California (MWD)

- Largest distributor of treated drinking water in the United States
- Supply water to 19 million people in Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura Counties.
- Support research efforts to balance water resource needs with proper ecosystem functioning

Image: Oregon Environmental Council

Partners

34 North

- Application and Software Development
- Graphic and user experience design
- Provide MWD with website and data analysis and visualization support

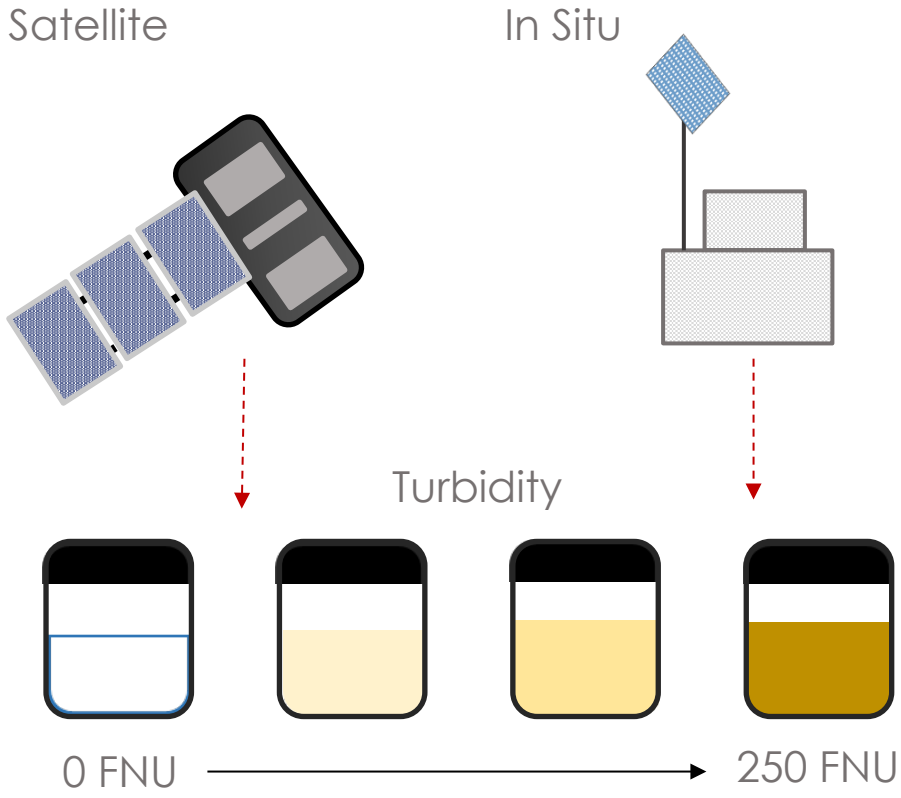
Anchor QEA

- Planning, Cleanup, Development and Restoration efforts
- Focus on aquatic landscapes
- Provide MWD with turbidity modelling within the Bay Delta

Image: Oregon Environmental Council

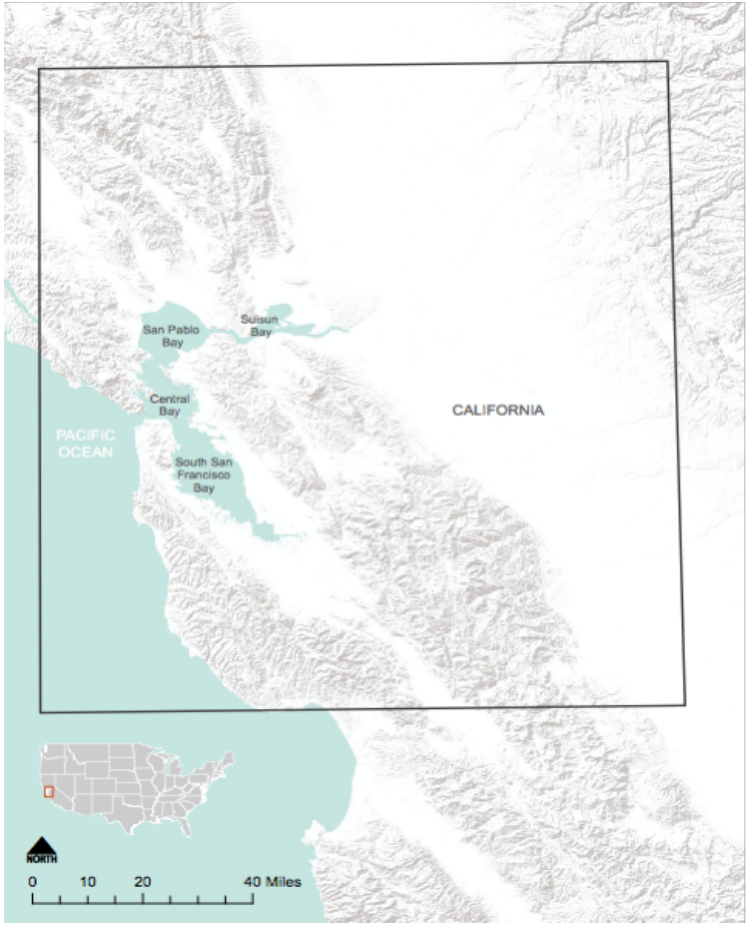
Objectives

- Support the development of MWD's turbidity model by providing satellite data for validation
- Compare turbidity values derived from Landsat 8, Sentinel-2, Sentinel 3
- Explore the interchangeable use of satellite data and *in situ* data for model validation



Study Area

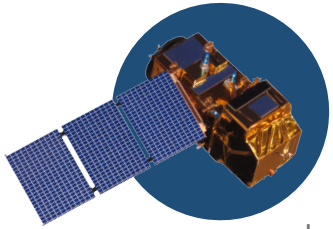
- Western portion of the Bay Delta Watershed
  - San Pablo Bay
  - Central Bay
  - South Bay
  - Suisun Bay
  - Tributaries of the Sacramento and San Joaquin Rivers



Study Period

Sentinel-2

January 2016 — Present

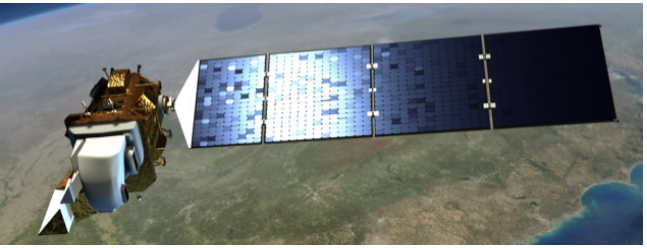


Landsat 8

April 2013 — Present

Image: NASA/ESA, Oregon Environmental Council

Satellites & Sensors Used



Landsat 8:

- Launched February 11, 2013
- 16 day orbit
- 30 m resolution
- Operational Land Imager (OLI)

Sentinel-2:

- Launched June 23, 2015
- 10 day orbit
- 10 - 20 m resolution
- Multispectral Imager (MSI)

Sentinel-3:

- Launched February 16, 2016
- 2 - 4 day orbit
- 300 m resolution
- Ocean and Land Colour Instrument (OLCI)

Images: NASA, ESA

Methodology

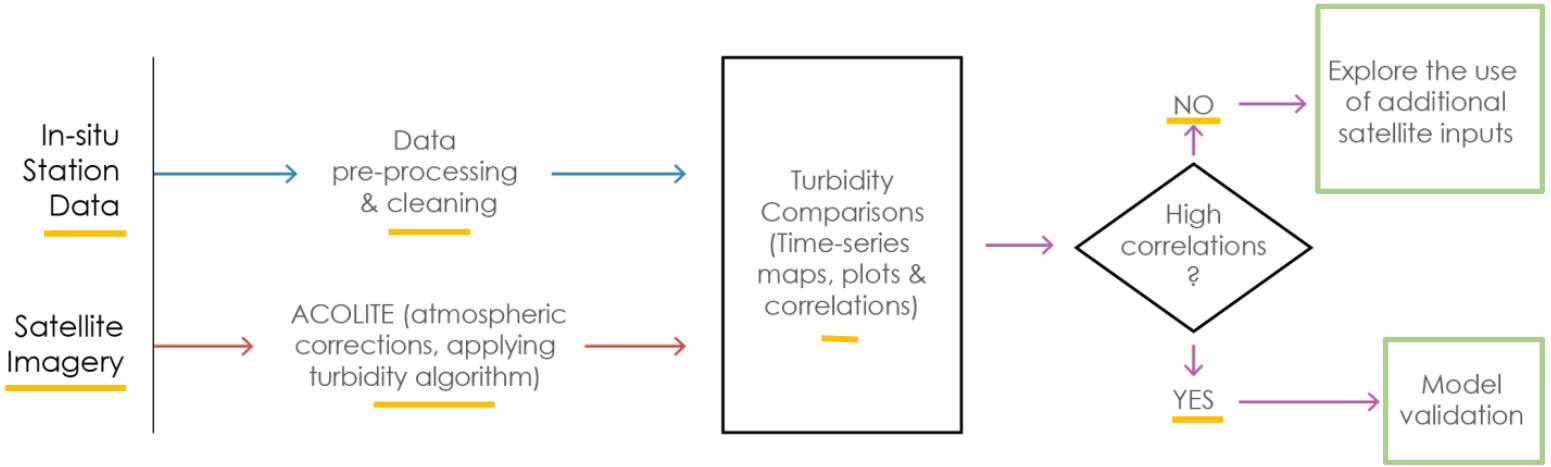
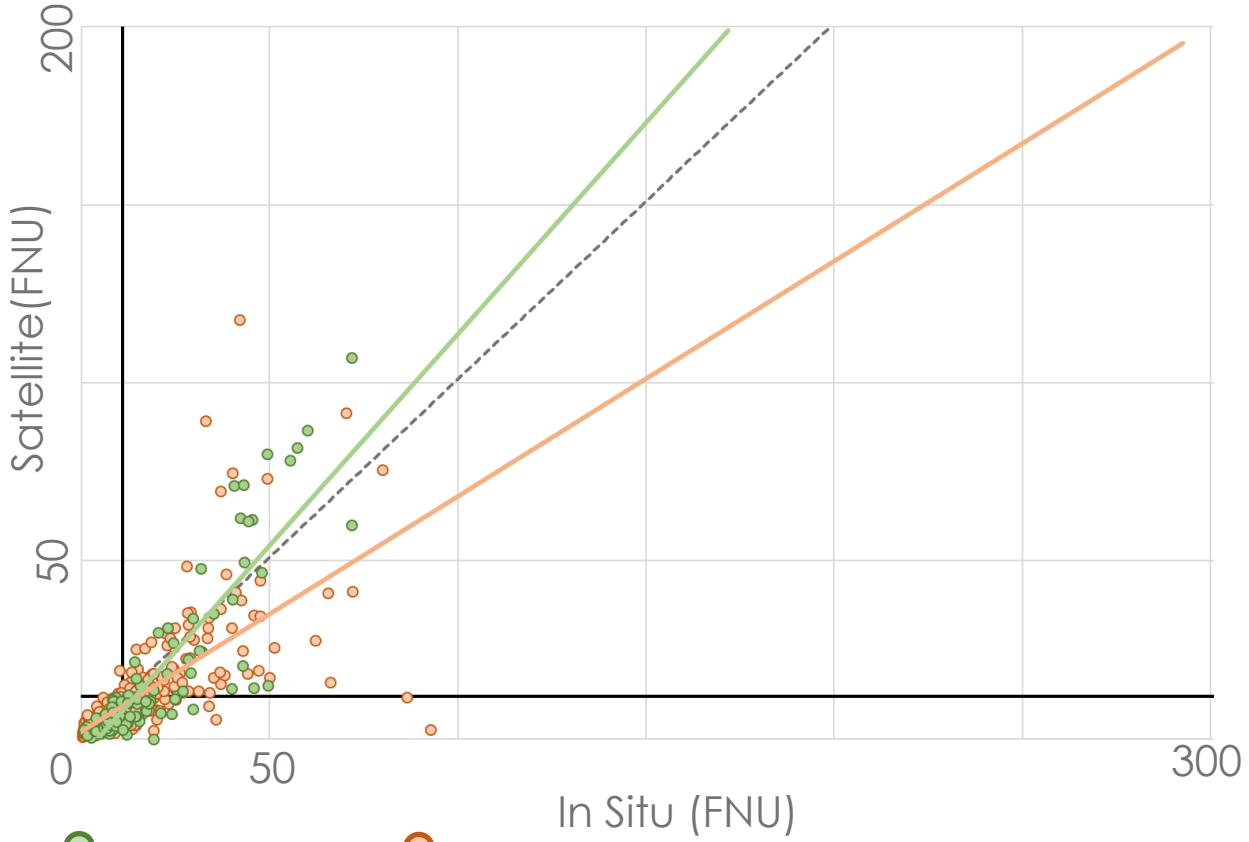


Image: Oregon Environmental Council

Results: Landsat 8 vs Sentinel-2

- Landsat 8 ~ In Situ:
  $r^2 = 0.474$
  y= 0.6604x + 1.4888

- Sentinel-2 ~ In Situ:
  $r^2 = 0.767$
  y= 1.187x – 6.1963



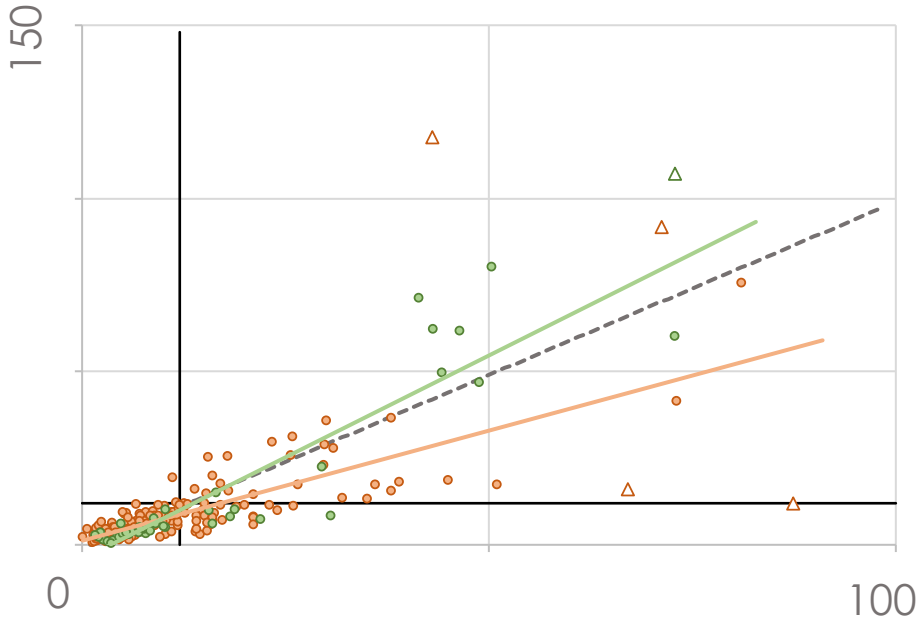
* Without North and South Bay

Results: Landsat 8 vs Sentinel-2

Tributaries

Landsat 8: $r^2 = 0.71$ $y = 0.6359x + 1.1669$

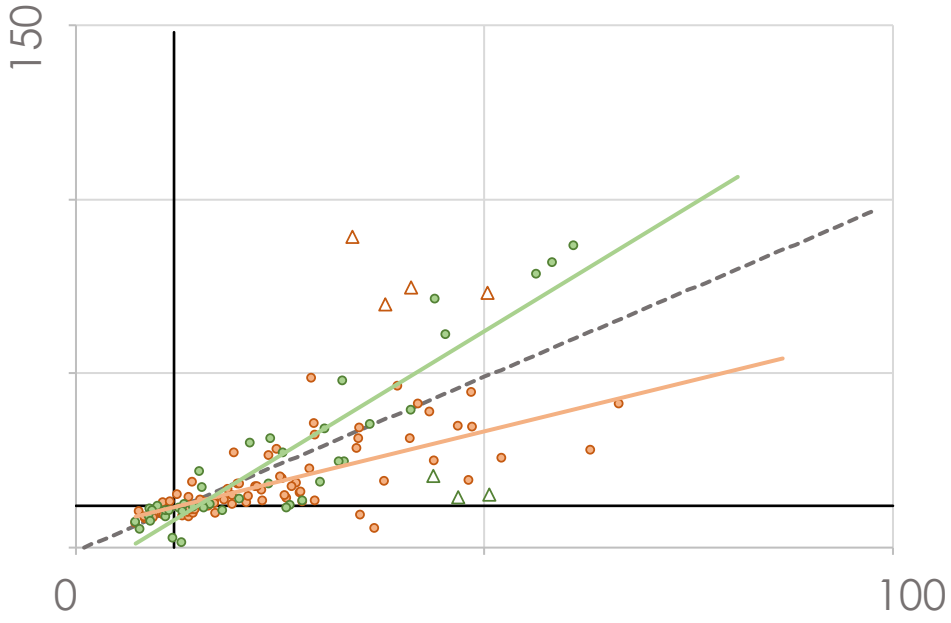
Sentinel-2: $r^2 = 0.83$ $y = 1.1757x – 4.1283$



Suisun Bay

Landsat 8: $r^2 = 0.53$ $y = 0.5731x + 4.7338$

Sentinel-2: $r^2 = 0.86$ $y = 1.429x – 9.2892$

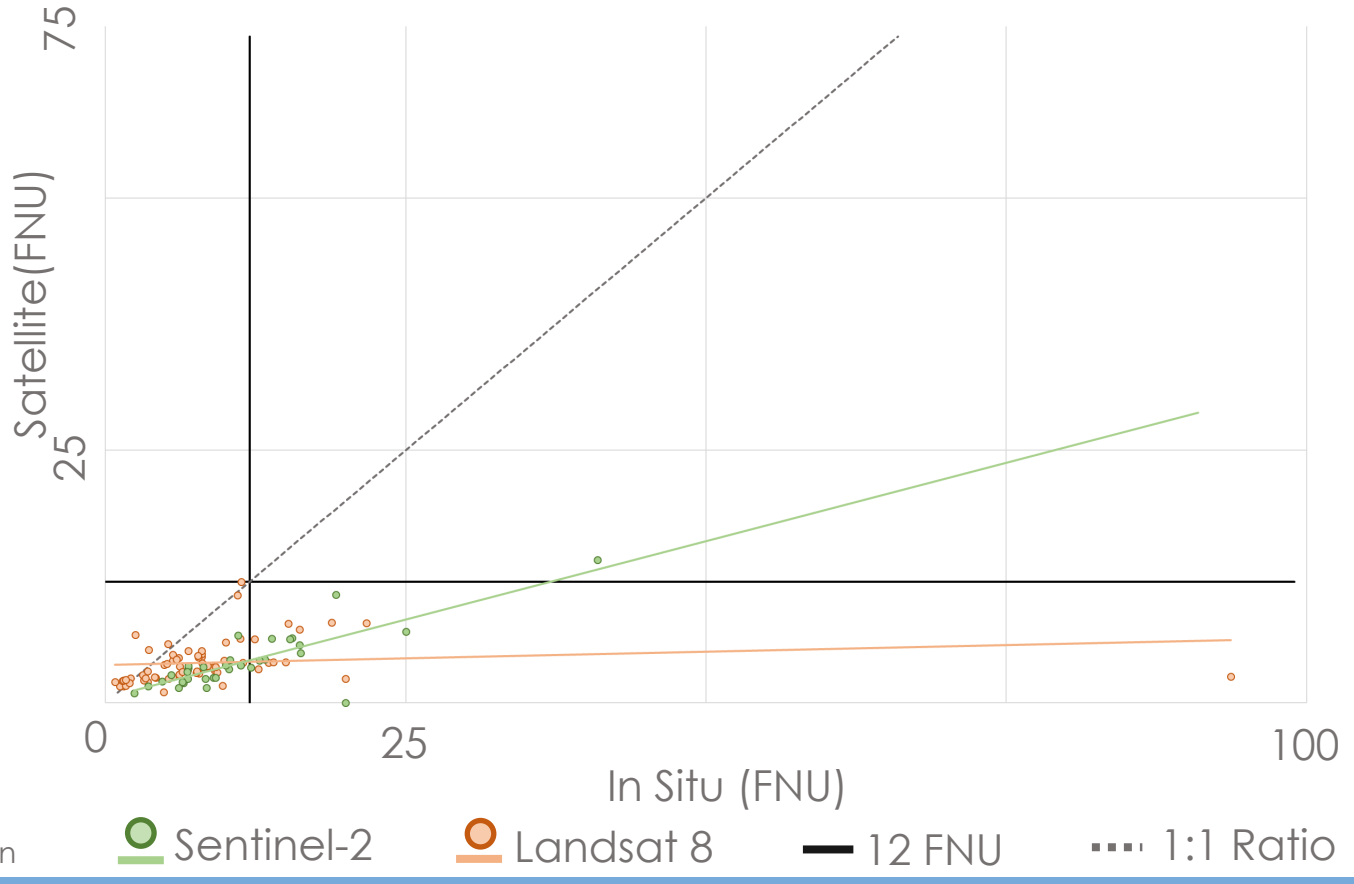


Sentinel-2 Landsat 8 S2 Outlier L8 Outlier 12 FNU 1:1 Ratio

Results – Clifton Court Forebay

- Landsat 8 ~ In Situ:
  $r^2 = 0.0209$
  y= 0.0259x + 3.7599
- Sentinel-2 ~ In Situ:
  $r^2 = 0.6541$
  y= 0.3104x + 0.4832

Image: Marianne Muegenburg Cothern



Limitations

- Data availability due to temporal resolution
- T. Dogliotti turbidity algorithm is global rather than regional
- In Situ monitoring sites are shoreline

Image: Maven

Conclusions

- The accuracy of Sentinel-2 and Landsat 8 derived turbidity varies regionally, but is a promising method for filling in data gaps between in situ monitoring sites

- The relative strength of correlations between both satellites and in situ data might allow incorporation of both in models to allow for greater temporal coverage

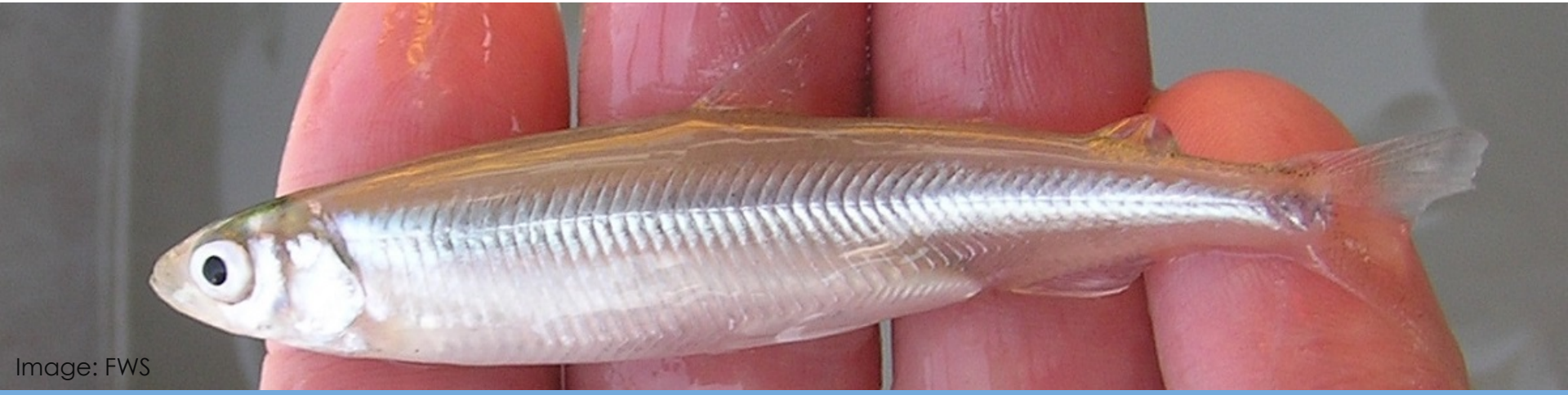


Image: FWS

Future Work

- San Fransisco Bay Delta Water Resources II – Fall 2017
  - Evaluate water quality through the use of hyperspectral imagery (AVIRIS and PRISM)
- San Fransisco Bay Delta Water Resources III – Spring 2018
  - Evaluate the benefits of hyperspectral vs. multispectral for water quality monitoring

Image: Wikimedia

Acknowledgements

We'd like to thank our partners at the MWD - David Fullerton, Russ Ryan, and Sean Acuna - for their input and guidance. We'd also like to thank Amye Osti and David Osti from 34 North, and Michael McWilliams of Anchor QEA.

We'd like to thank our science advisors - Michelle Gierach and Christine Lee - for their continued support and encouragement throughout the term.

We'd like to thank Ben Holt & the whole Summer DEVELOP team for the opportunity and the completion of a great term!

Image: Oregon Environmental Council

This material is based upon work supported by NASA through contract NNL16AA05C and cooperative agreement NNX14AB60A. Any mention of a commercial product, service, or activity in this material does not constitute NASA endorsement. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration and partner organizations.