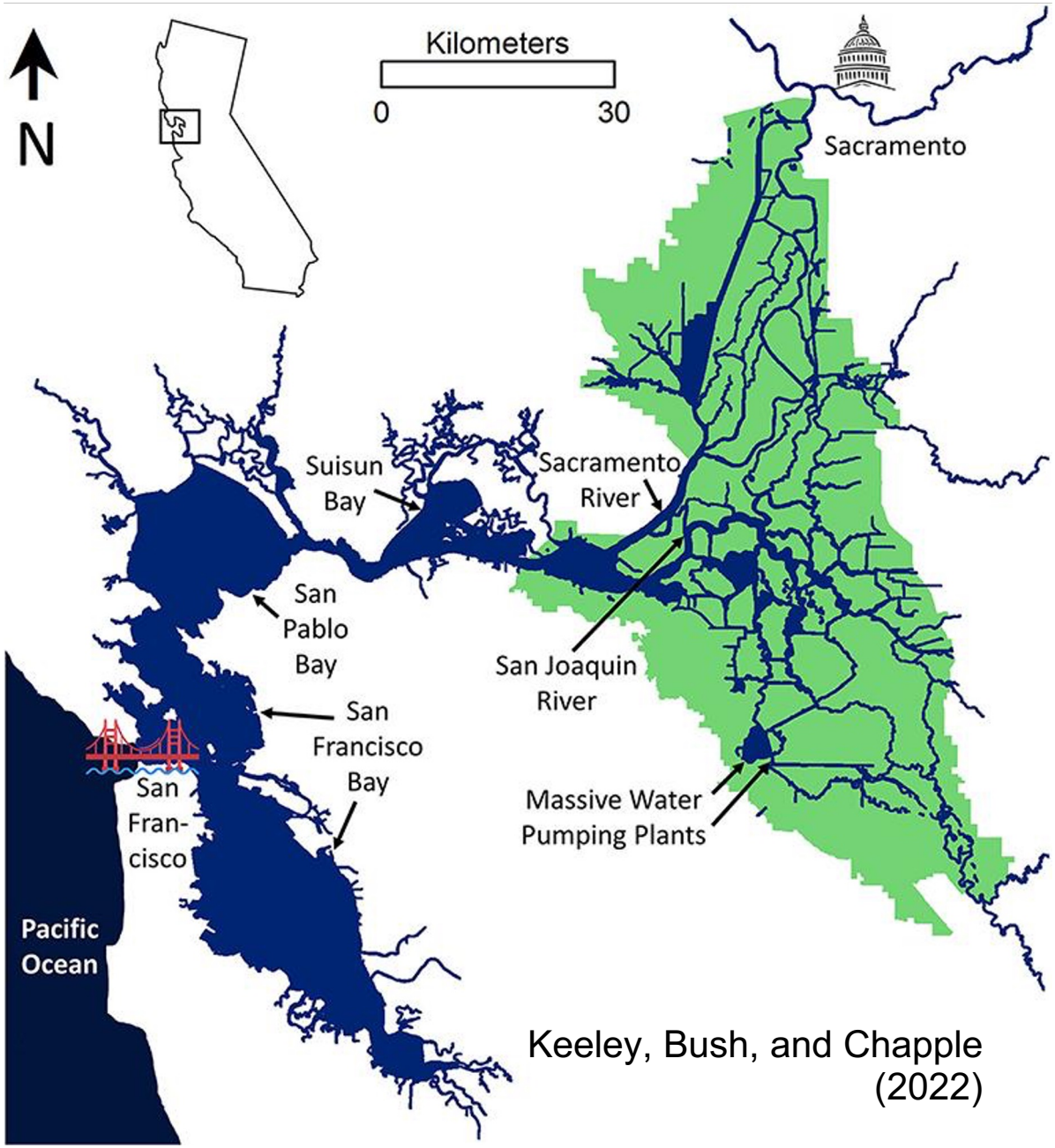
Water Temperatures in the Bay-Delta

Christiana Ade*, Sam Bashevkin*, Kelly Luis, Brian Mahardja, Dain Kim, Rebecca Gustine, Cassandra Nickles, Christine Lee

*Presenting authors

The Bay-Delta

- Watershed is 40% of the land and 33% of the total runoff in California
- Heavy hydrological modification upstream (dams and diversions) and in the estuary (channelization, export pumps)
- Several endangered and threatened fish species
- Ongoing threats from water demands and climate change



Keeley, Bush, and Chapple (2022)

Water temperatures

- Several endangered species (Chinook Salmon, Delta Smelt) are challenged by current temperature conditions
- Water temperature is a key variable
  - Metabolism
  - Predation
  - Thermal stress
  - Development rates
  - Reproductive timing
  - Climate change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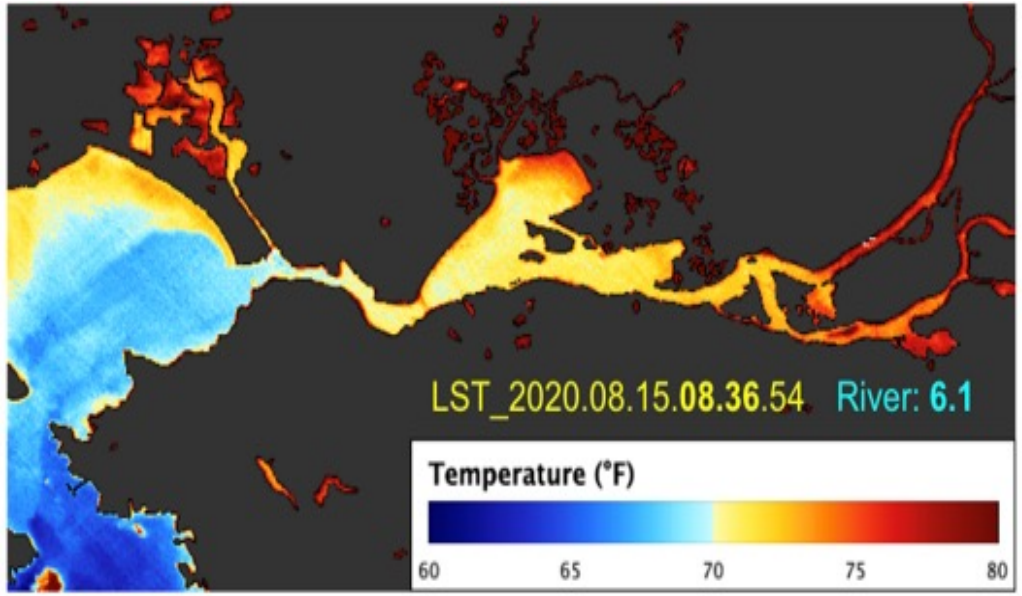
Jeffery R. Cordell, University of

Overall approaches for water temperatures

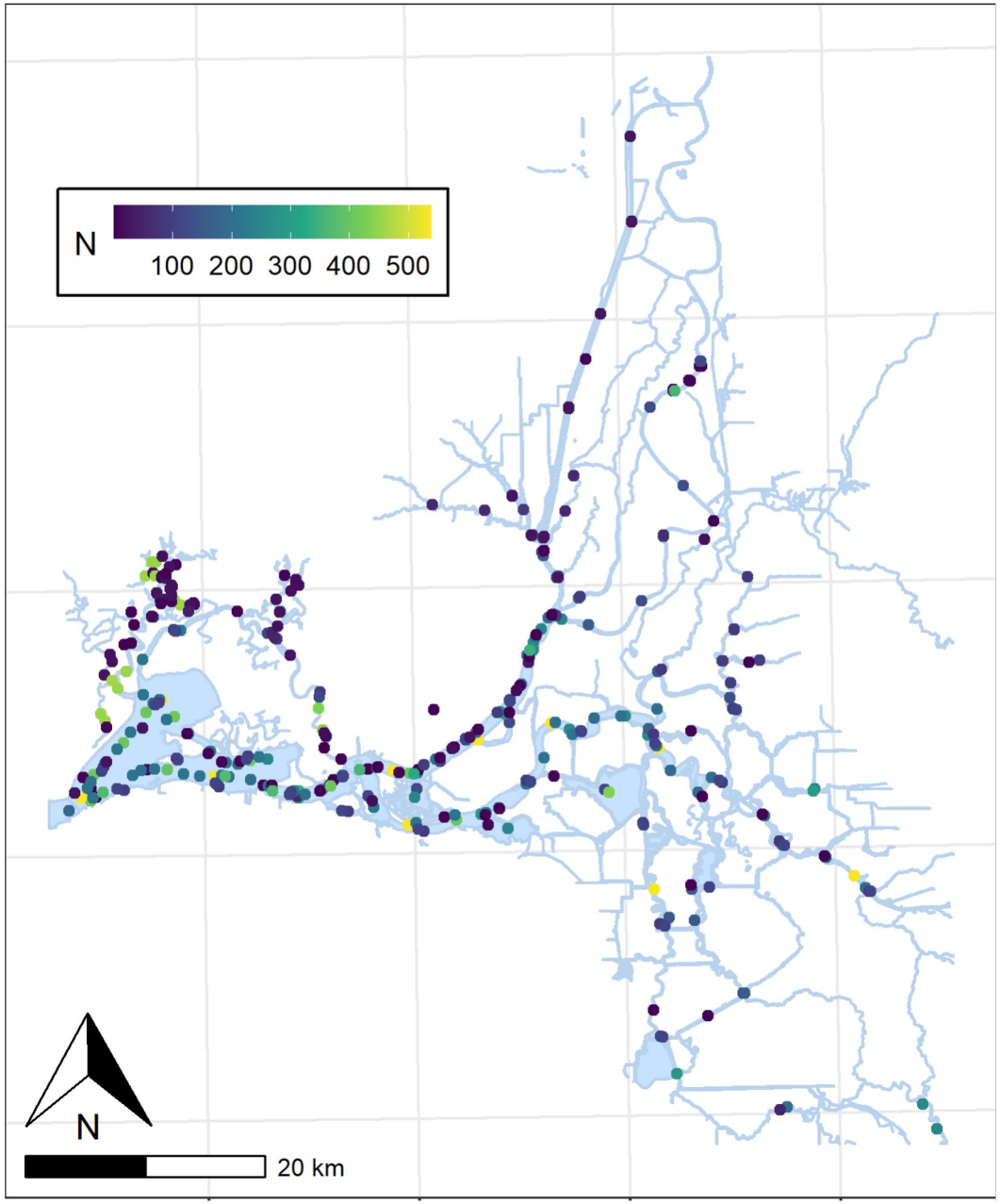
- In Situ
  - Fixed location sondes
  - Boat-based discrete monitoring
- Remote sensing



Leveraging discrete surveys

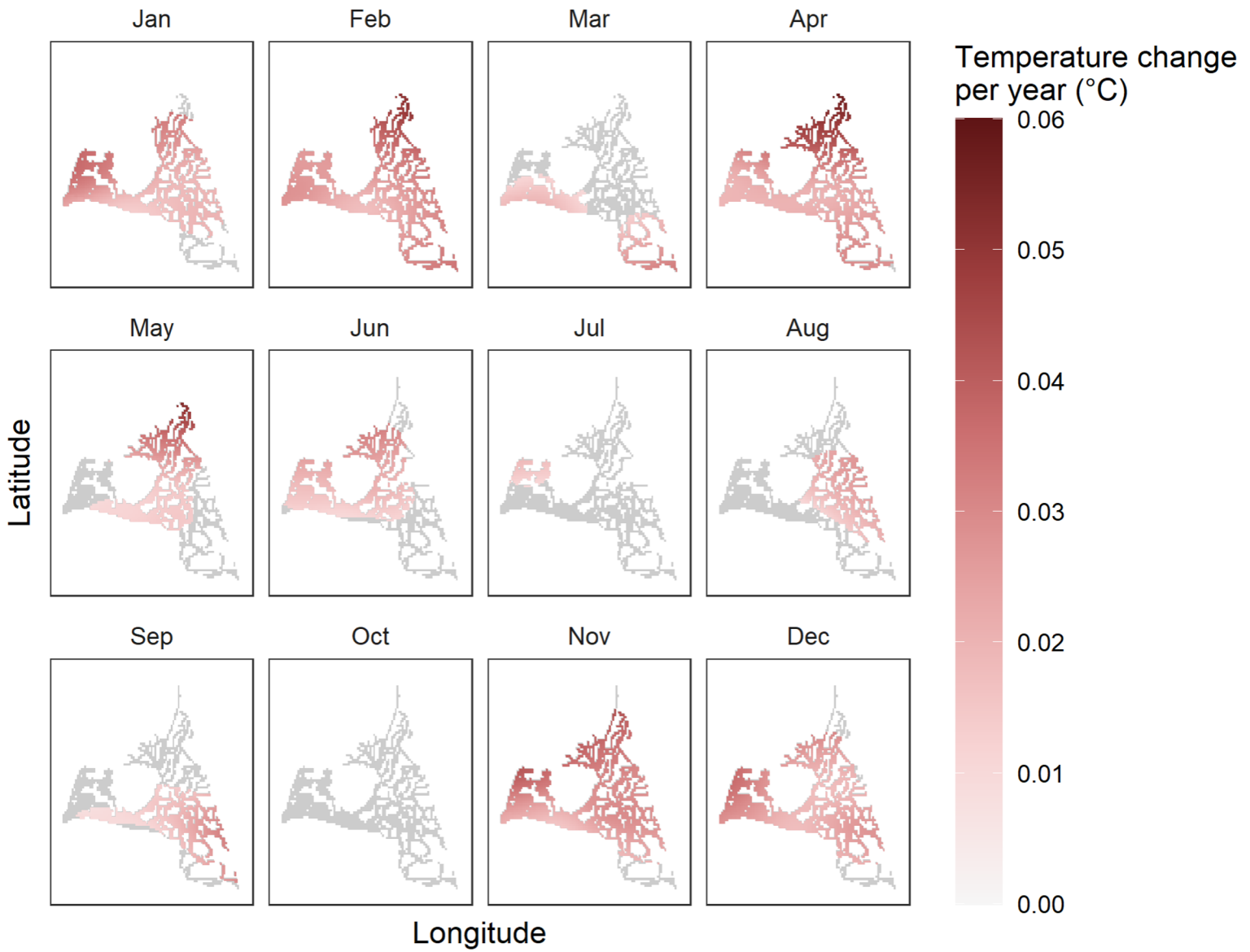
- 59,634 temperature records 1969 – 2020
- 405 unique locations
- 9 water quality and fish monitoring surveys

- Generalized additive models with spatio-seasonal smooths



Water temperature has increased 0.017 °C/year over 50 years

- Fastest warming in the North
- Widespread warming in Nov, Dec, Jan, Feb, and Apr

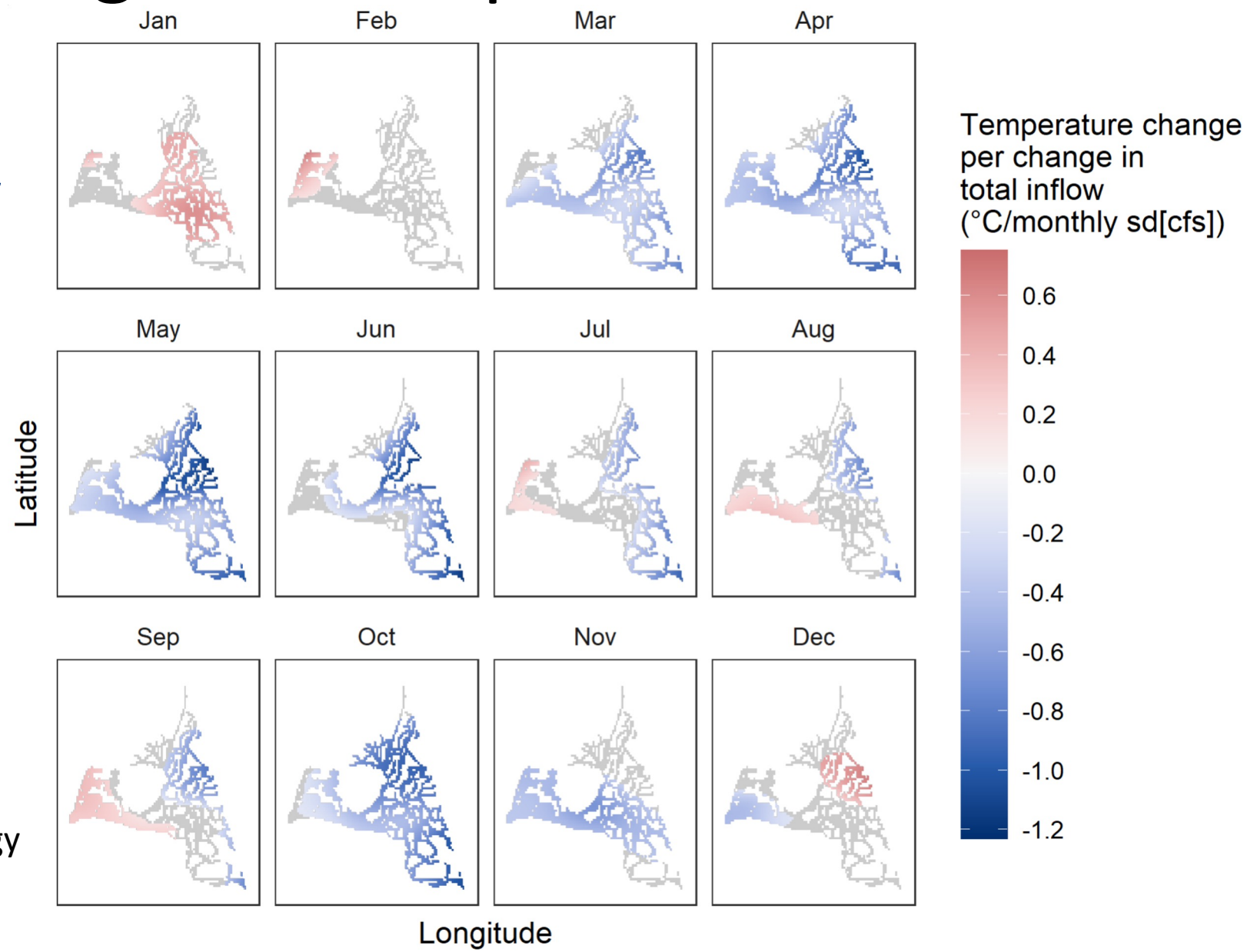


Bashevkin, Mahardja, and Brown (2022), Limnology and Oceanography

Predominantly negative temp-inflow relationship

- **Negative** temperature-inflow relationships
  - Higher inflow = **cooler** water
  - Most common
- **Positive** temperature-inflow relationships
  - Higher inflow = **warmer** water
  - Occurs during winter and downstream in the summer

Bashevkin and Mahardja (2022), Limnology and Oceanography

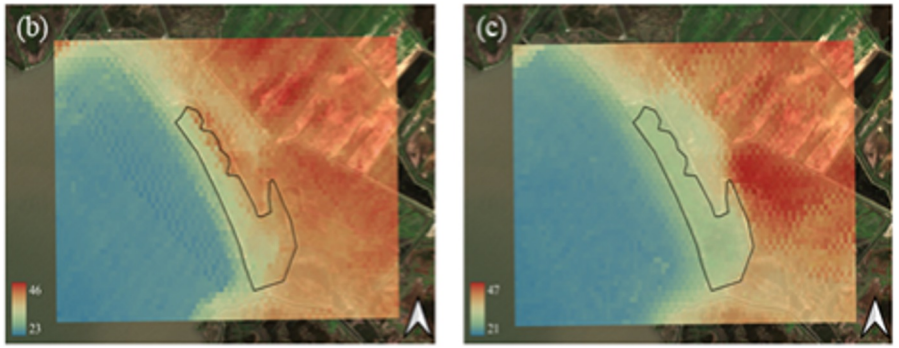


Benefits and limitations of in situ data

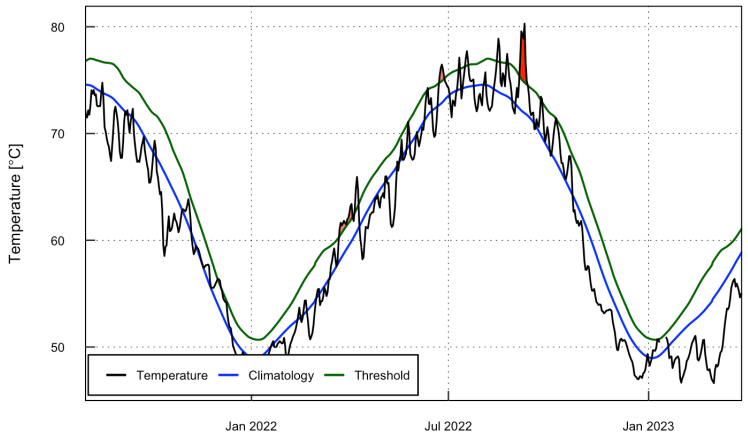
- Benefits
  - Accuracy
  - Fewer weather limitations
  - Can sample any channel size or depth
  - High temporal frequency at fixed locations
  - Historical record
  - High spatial resolution

- Limitations
  - Limited spatial coverage
  - Requires foresight and advanced planning of sampling design
  - Logistical challenges such as crew safety, vandalism, maintenance

Extending Bay-Delta applications with ECOSTRESS



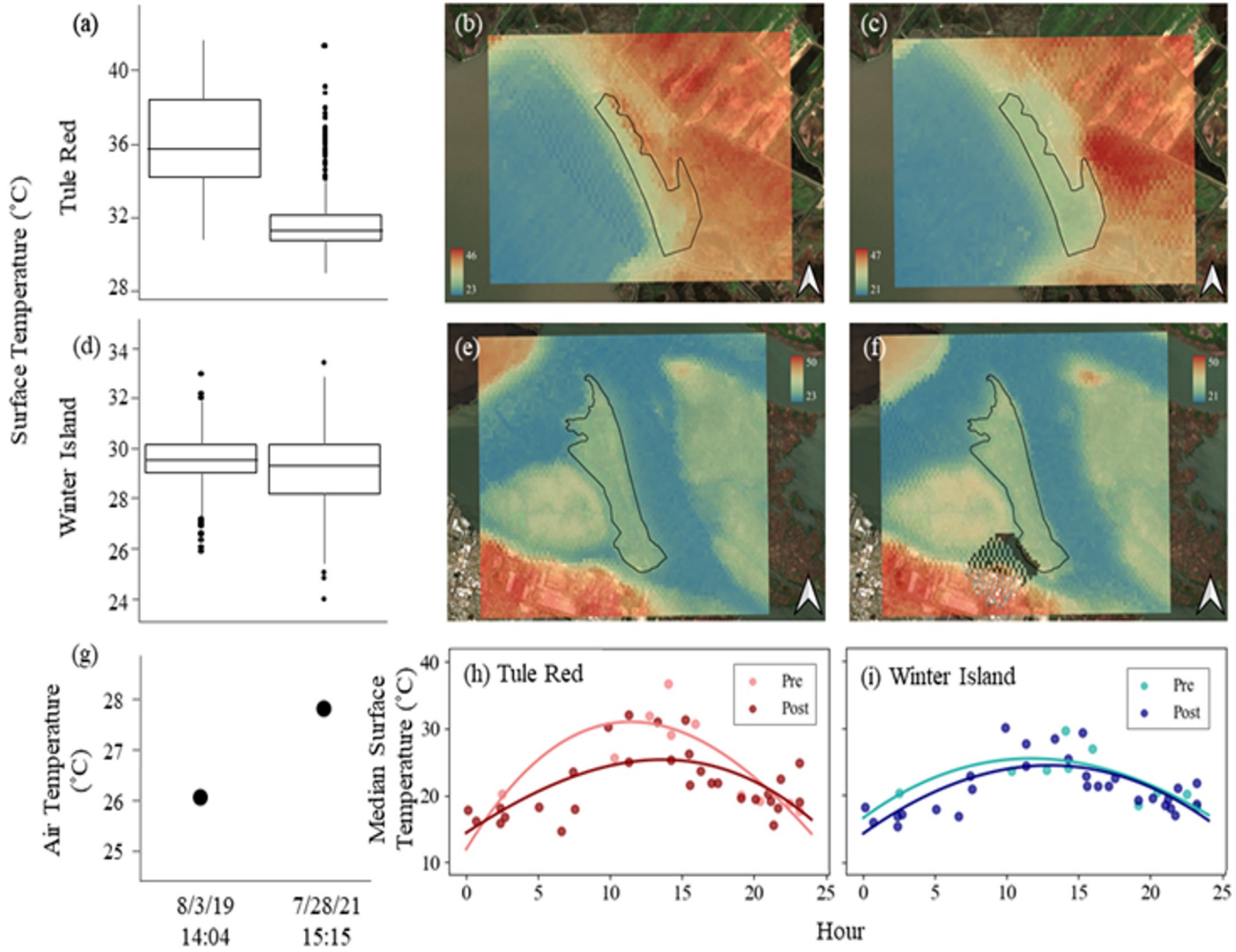
1) Wetland restoration efforts



2) Aquatic heatwaves

Detected Wetland Restoration Effects

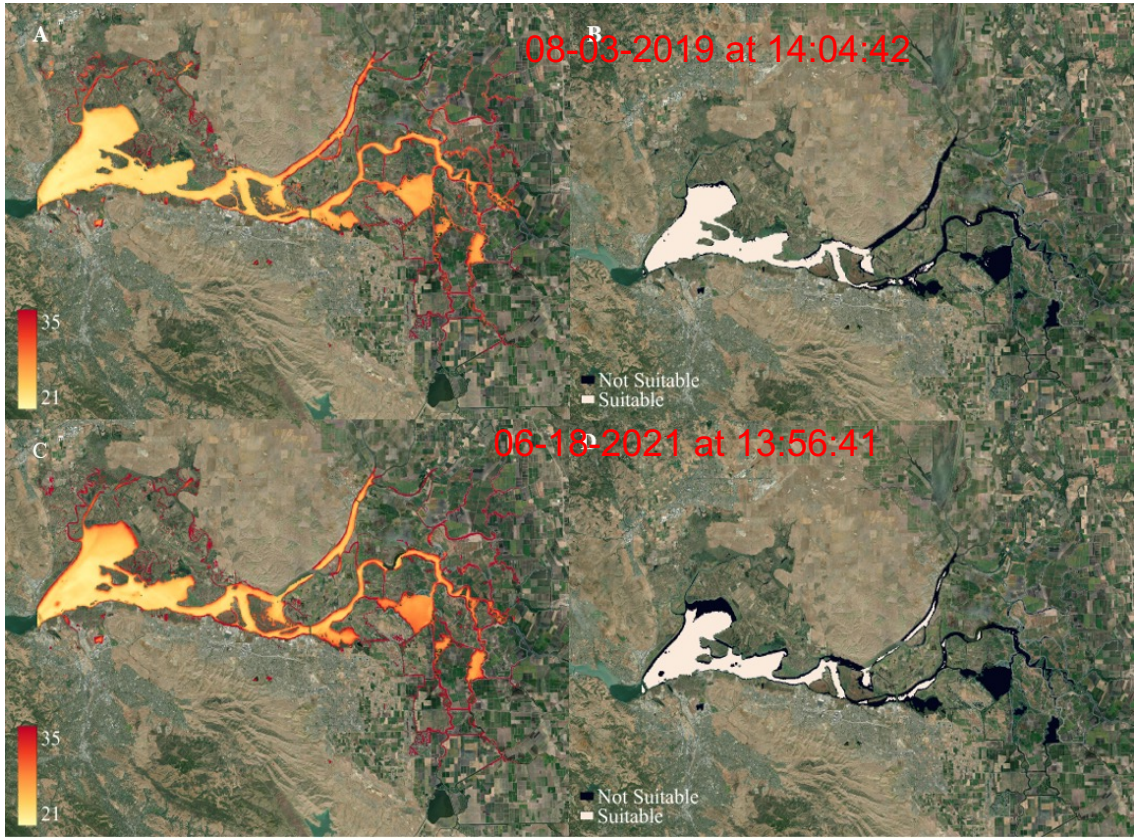
- At similar tidal stages, decrease in surface water temperature at both restoration sites after restoration
- At Tule Red, the median surface water temperature decreased 5.4 ◦C
- At Winter Island, the median surface water temperature decreased by about 0.3 ◦C



(Gustine et al., 2023) *in JGR: Biogeosciences*

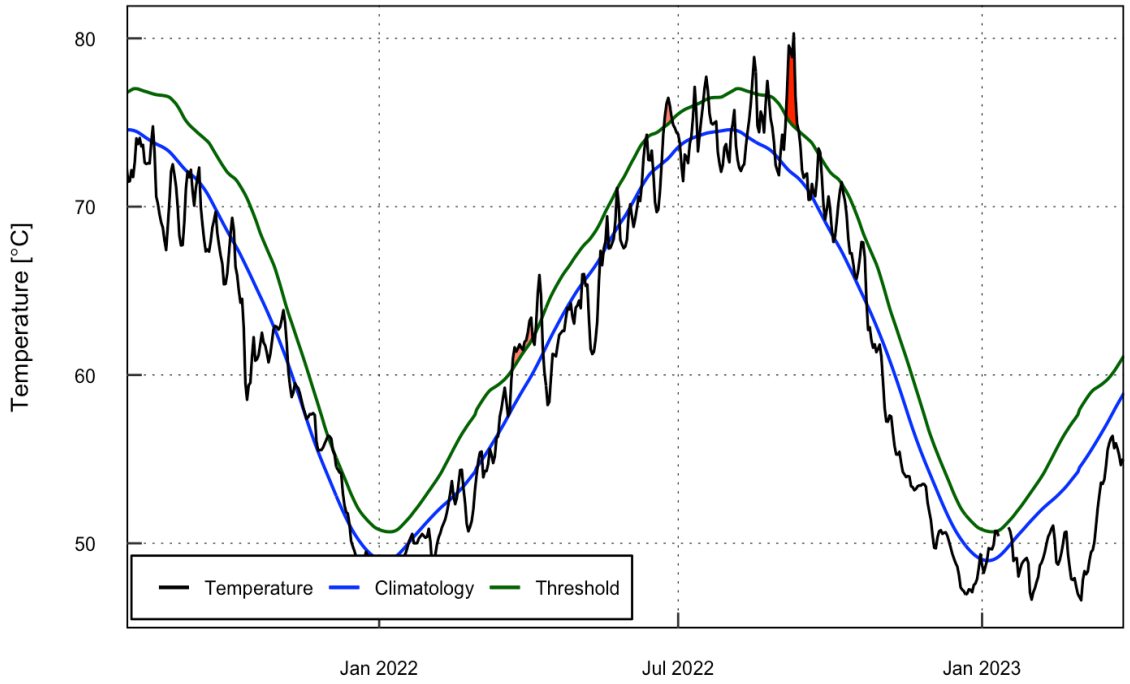
Spatial differences in Smelt Habitat suitability

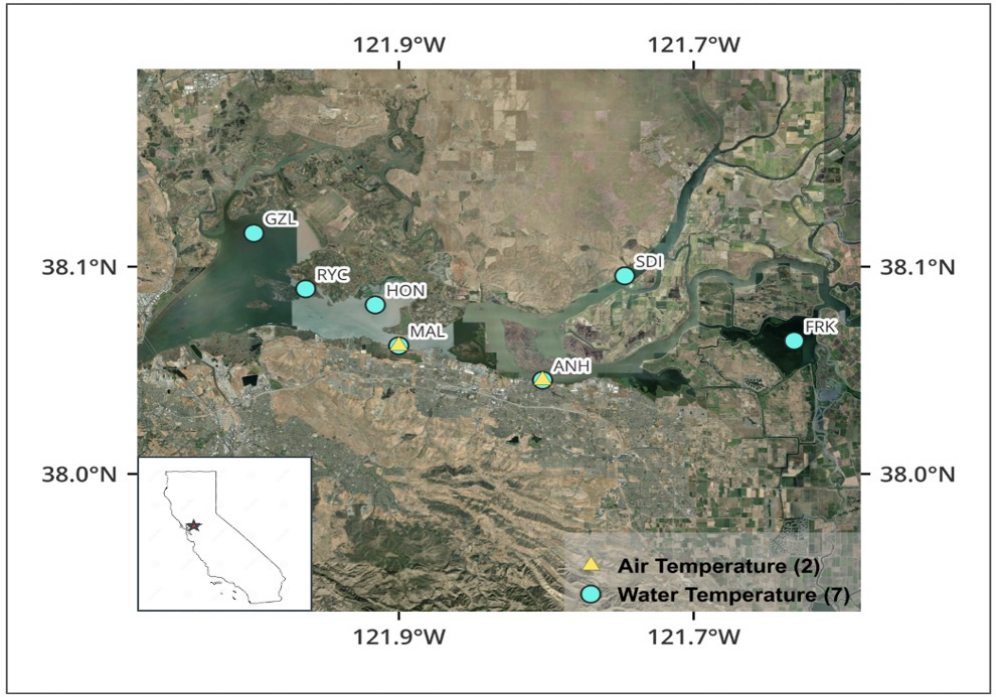
- Eastern part of the Bay Delta had the worst habitat suitability (likely due to channel size and less of a cool water influence from the ocean/tides)
- Highlights key areas for potential restoration efforts—areas that retained suitable habitat during certain hours that are also within Delta Smelt Habitat
- Miday hours had less suitable habitat across ecoregions



(Gustine et al., 2023) *in JGR: Biogeosciences*

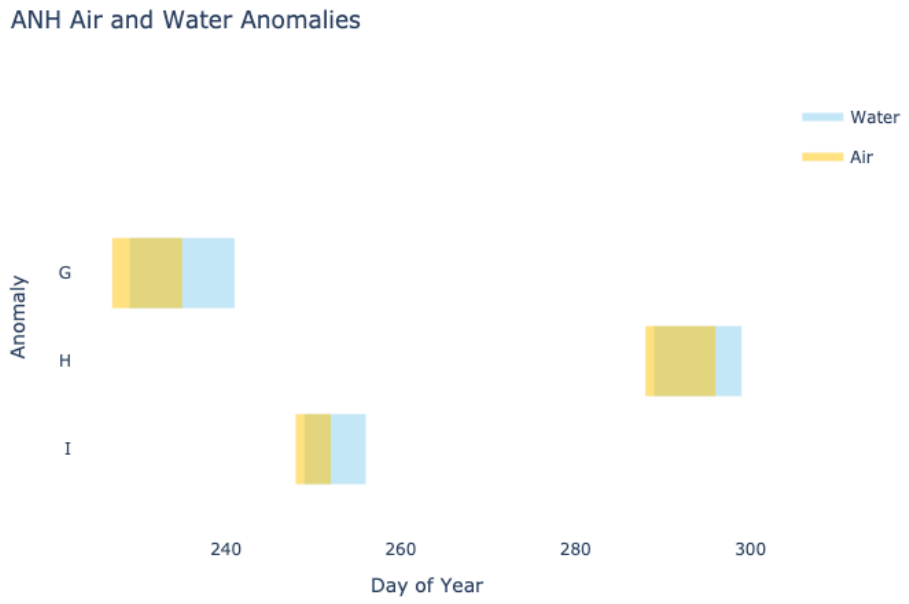
Heatwave detection with joint air and water in-situ data

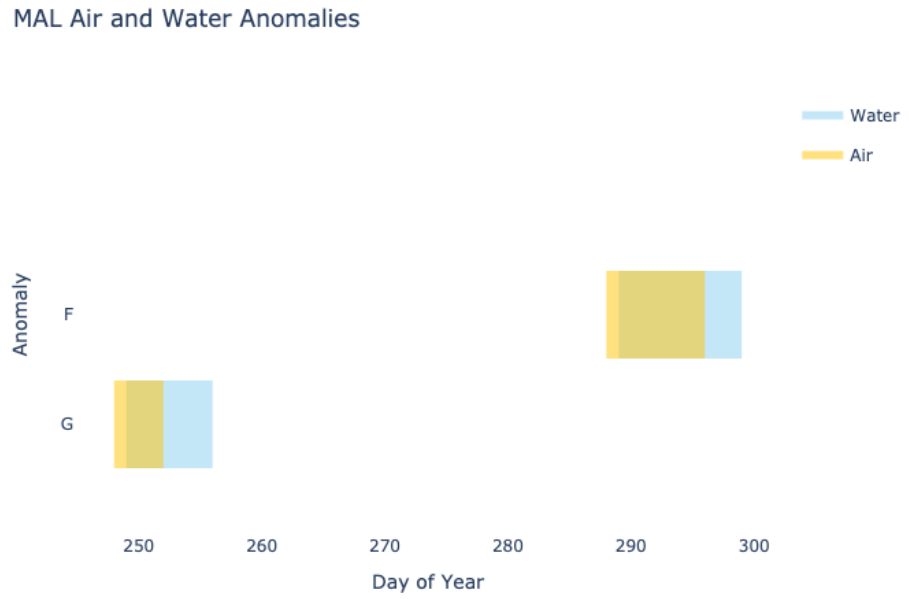




Climatology Period: 2015-06-19 – 2023-03-28
Threshold: 90th percentile
Five consecutive days above the threshold ⇒ “anomaly”

Water heatwaves last longer and are more frequent

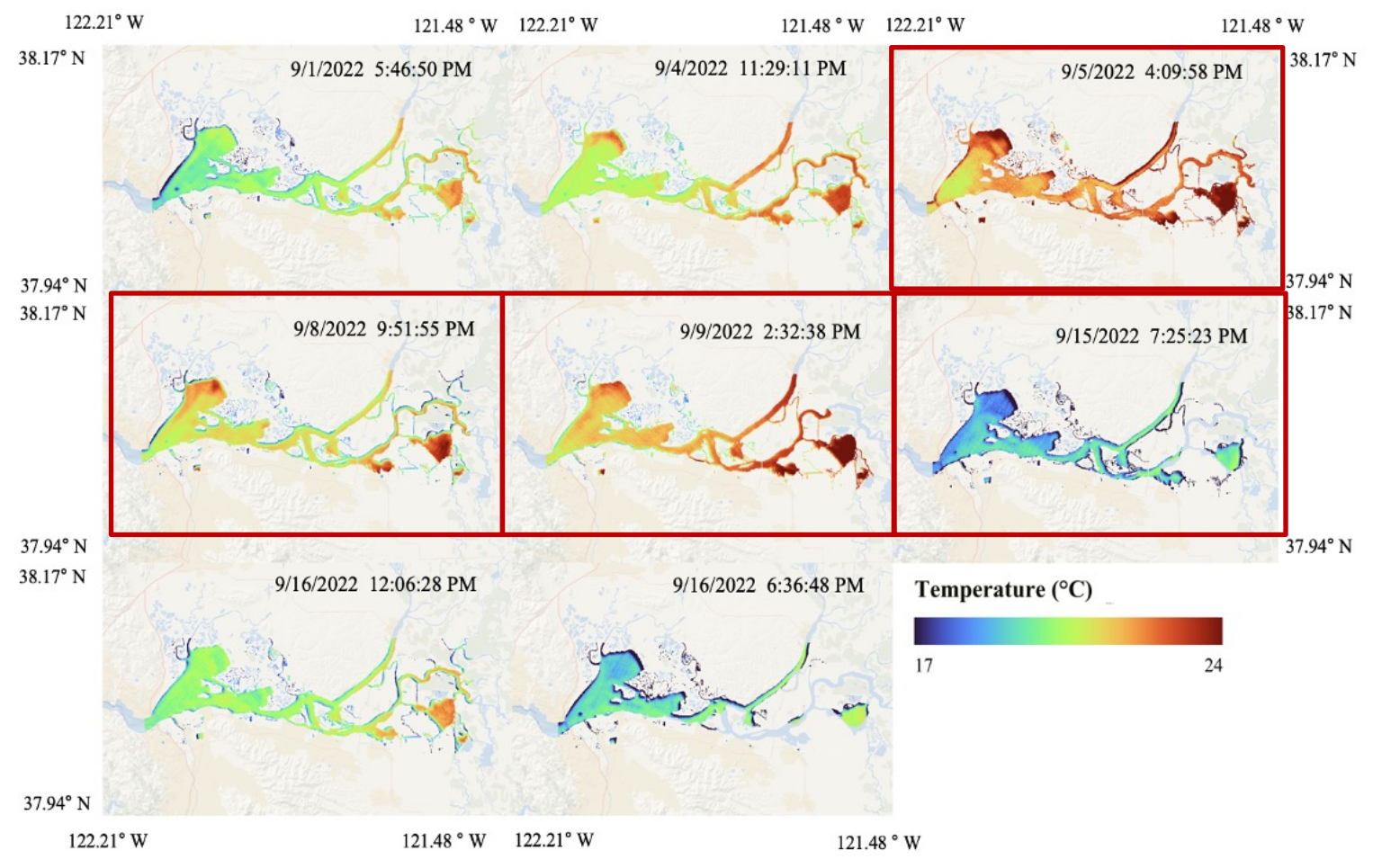




ANH	Air Temperature						Water Temperature					
Anomaly	Start Date	End Date	Duration	Intensity (mean)	Intensity (max)	Intensity (cum)	Start Date	End Date	Duration	Intensity (mean)	Intensity (max)	Intensity (cum)
G	8/14/20	8/22/20	9	13.27	20.44	119.44	8/16/20	8/28/20	13	3.51	4.51	45.67
H	10/14/20	10/22/20	9	9.82	15.47	88.36	10/15/20	10/25/20	11	3.90	4.68	42.87
I	9/5/22	9/9/22	5	13.16	15.38	65.80	9/6/22	9/13/22	8	3.34	4.04	26.73

MAL	Air Temperature						Water Temperature					
Anomaly	Start Date	End Date	Duration	Intensity (mean, °C)	Intensity (max)	Intensity (cum)	Start Date	End Date	Duration	Intensity (mean, °C)	Intensity (max)	Intensity (cum)
F	10/14/20	10/22/20	9	10.37	16.28	93.36	10/15/20	10/25/20	11	3.82	4.71	42.04
G	9/5/22	9/9/22	5	16.05	20.72	80.25	9/6/22	9/13/22	8	3.20	3.93	25.58

ECOSTRESS fills in spatial gaps



- Red boarder indicates images taken during one of the heatwave events
- We see certain areas that are hot spots (e.g lake like environments in the eastern side)
- Would like community feedback for addressing difference in image timing

Remote sensing applications

- Tidal wetland cooling effect (Enright et al. 2013, Gustine et al. 2023)
  - Also could look at turbidity
- Suitability indices for harmful algal blooms based on residence time and temperature
- Temperature dynamics in the tributaries
- Yolo Bypass floodplain temperatures to inform salmon bioenergetics