Waste from Space:

Characterizing Wastewater in the Tijuana River Estuary using Laboratory, In Situ, and EMIT Satellite Spectroscopy

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SDSU

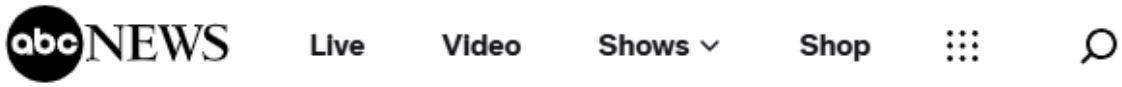
JPL

Jet Propulsion Laboratory

US-Mexico border: 100 billion gallons of toxic sewage creating a 'public health crisis'

Researchers found harmful bacteria, viruses and more in water samples.

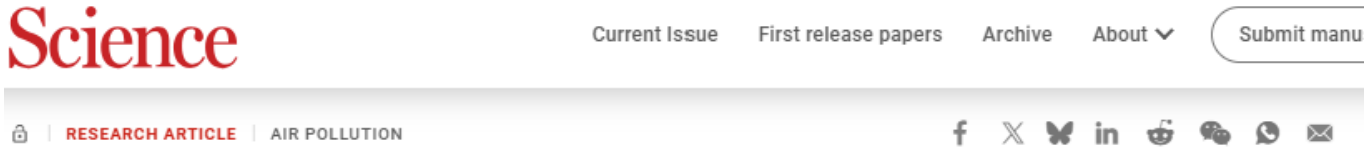
By Leah Sarnoff
February 20, 2024, 6:01 PM



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Heavily polluted Tijuana River drives regional air quality crisis

BENJAMIN RICO, KELLEY C. BARSANTI, WILLIAM C. PORTER, KAROLINA CYSNEIROS DE CARVALHO, PAULA STIGLER-GRANADOS, AND KIMBERLY A. PRATHER

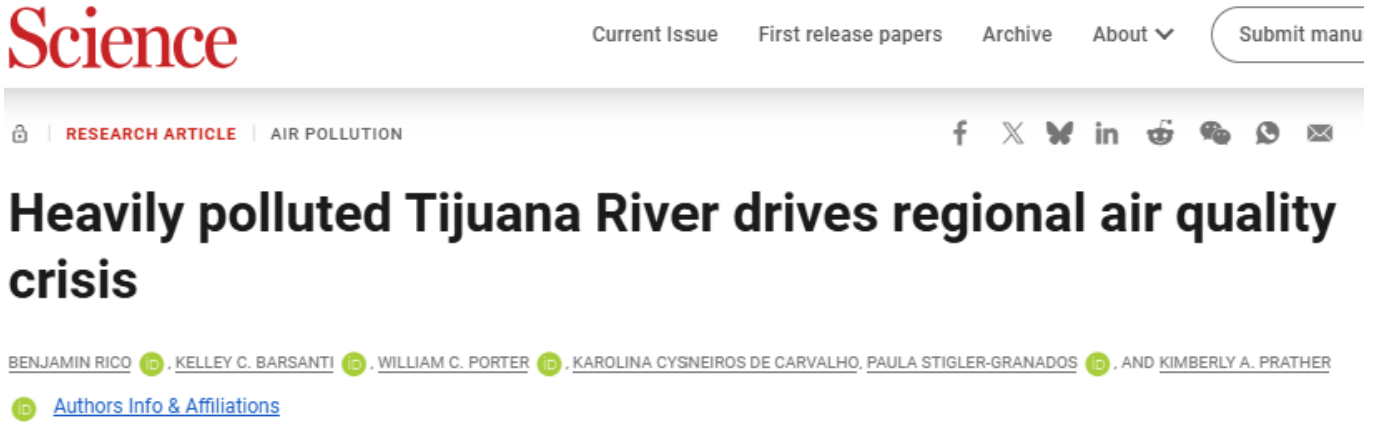
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Traditional sampling methods are spatially and temporally limited.

- TRE Water quality monitoring typically conducted via grab sampling, fluorometry, and stationary sondes.



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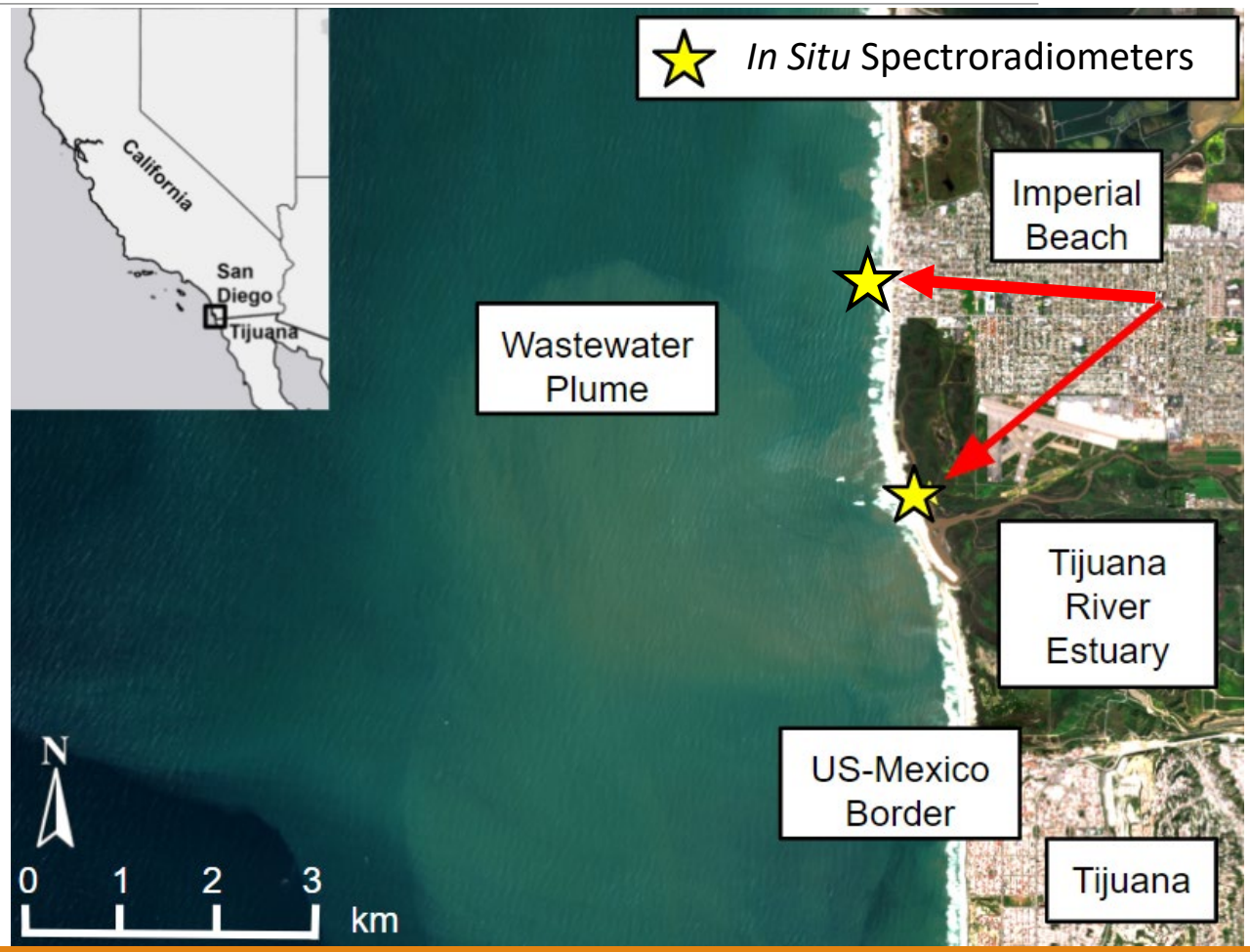
- TRE Water quality monitoring typically conducted via grab sampling, fluorometry, and stationary sondes.

- Current methods are limited spatially (sondes) or temporally (grab sampling).

Satellite remote sensing can increase spatiotemporal coverage

Previous studies classify plume and presence and type (stormwater runoff, wastewater discharge).

- DiGiacomo et al. 2004, Gierarch et al., 2016, Ayad et al. 2020,

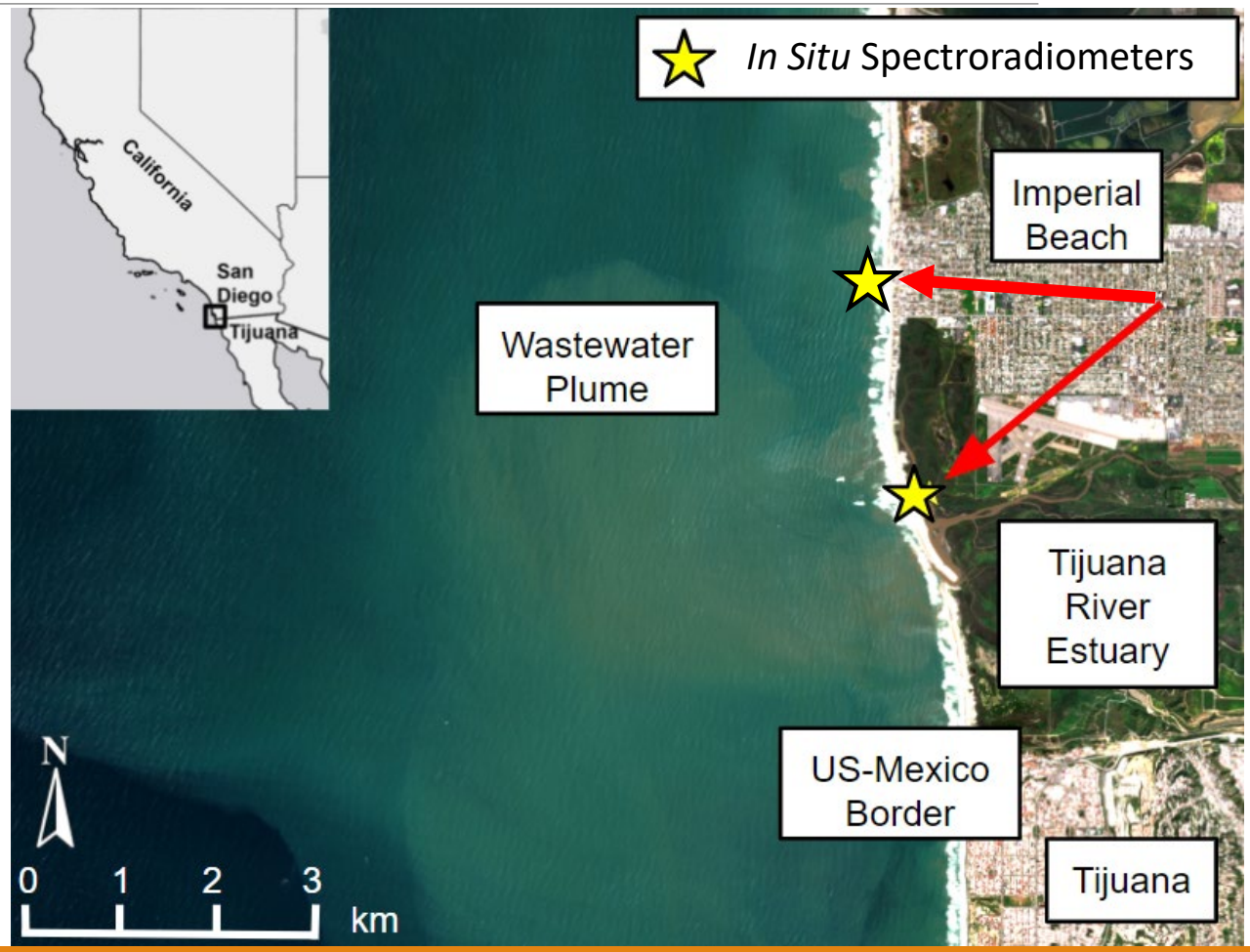


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Bacterial concentrations and other water quality parameters (WQPs) have not yet been remotely retrieved.



Scrivner et al., 2025, STOTEN

True Color Image from Sentinel 2a, 24 March 2023.

Research Objectives

1) What spectral features exist in pure and mixed Tijuana River wastewater?

2) With what strength do these features correlate with paired water quality measurements?

3) Are these features present *in situ* or in satellite imagery?

Methods

U.S. Environmental Protection Agency



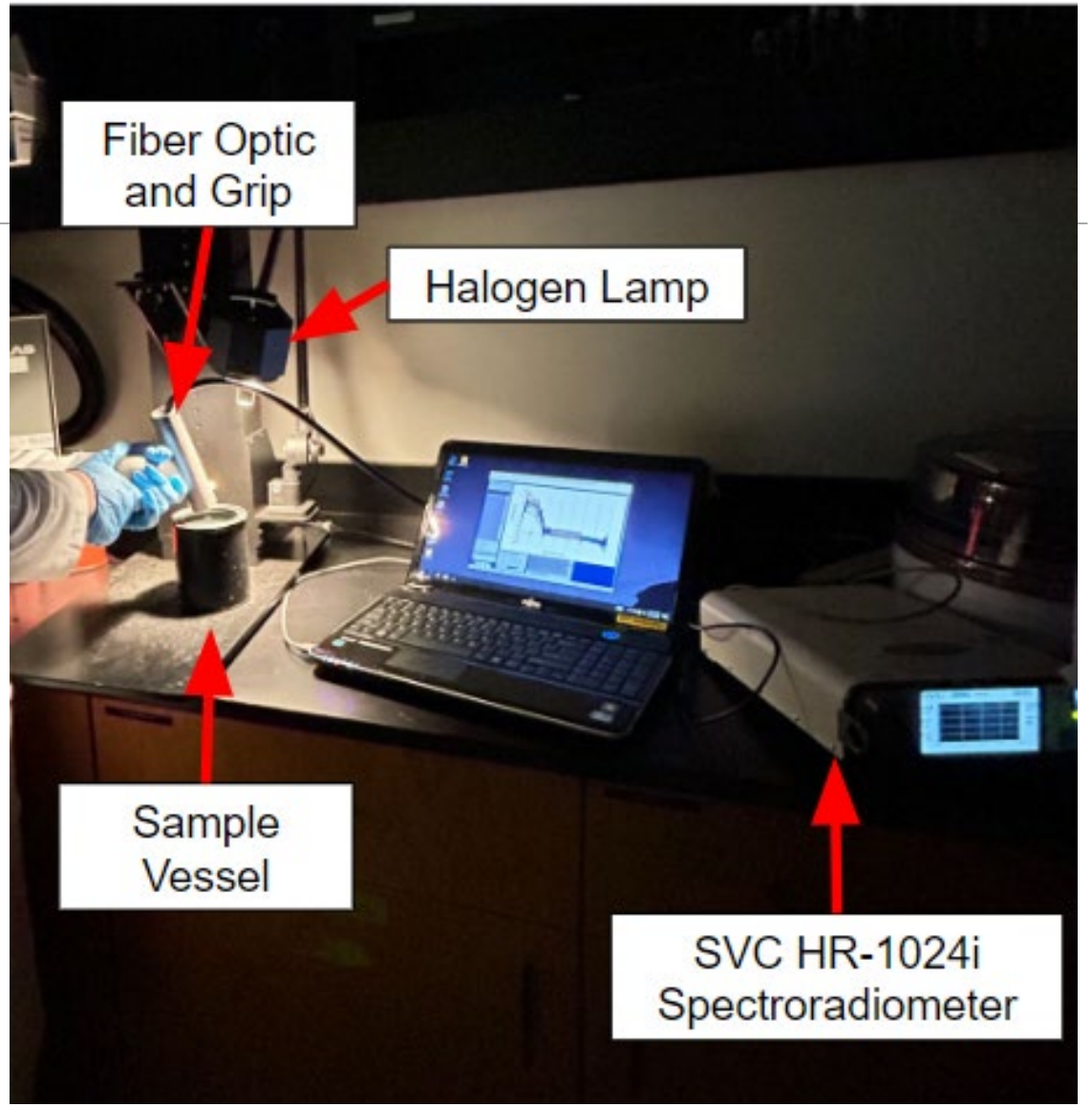
U.S. Environmental Protection Agency



Wastewater Addition Experiment

Varying dilutions of WW-SW were prepared.

Reflectance measurements made using Spectra Vista Corporation™ (SVC) HR-1024i spectroradiometer.



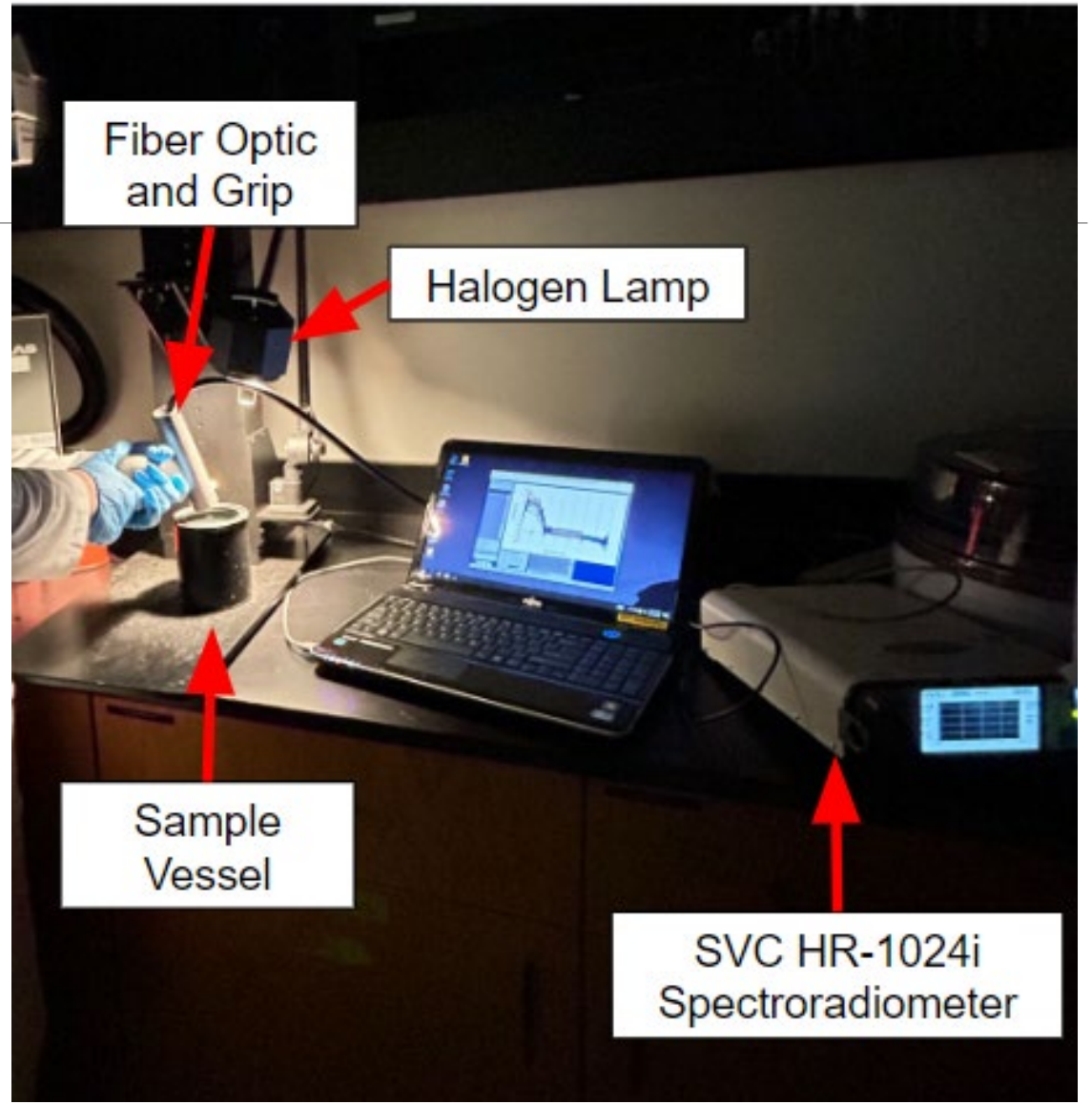
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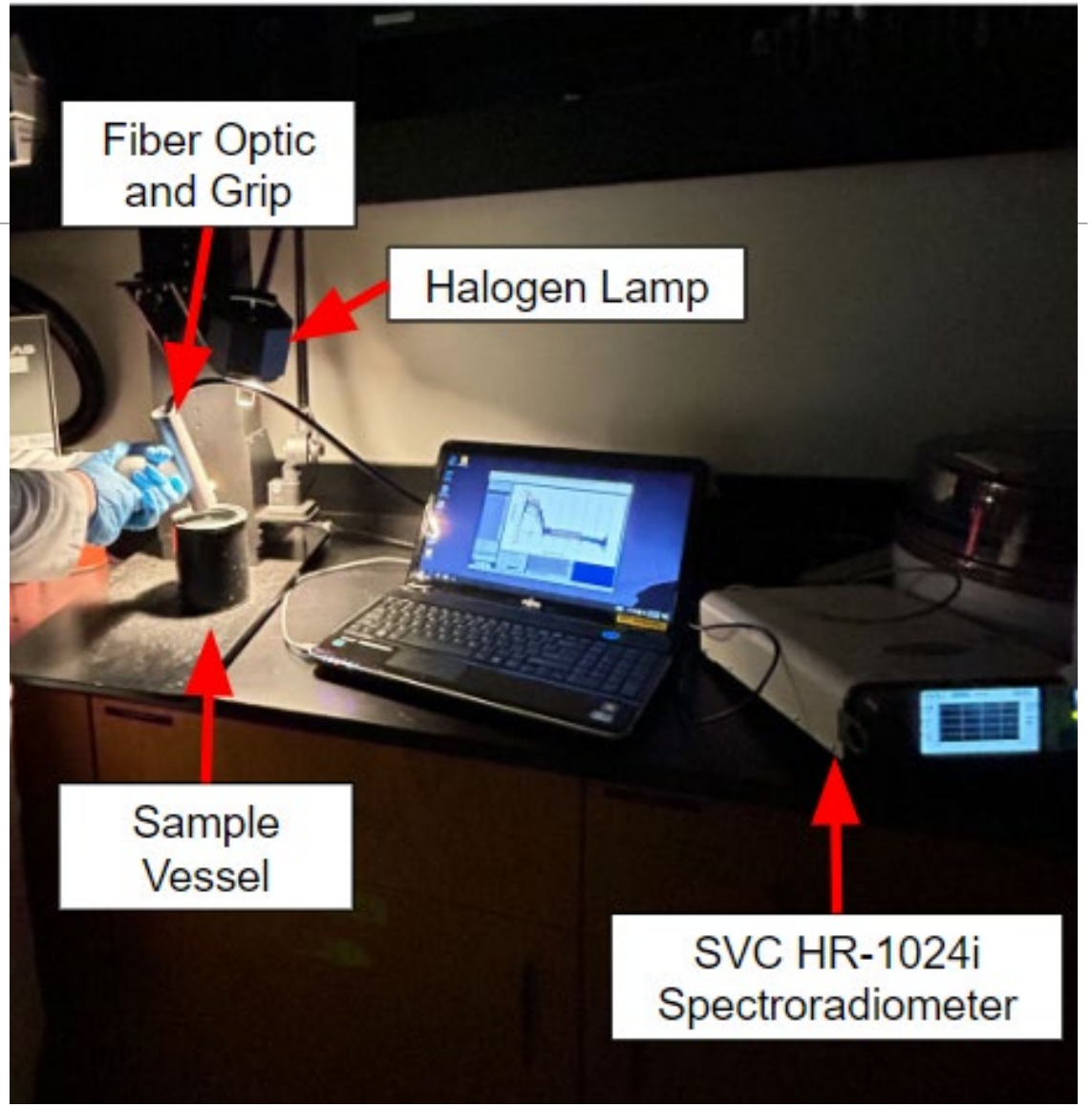
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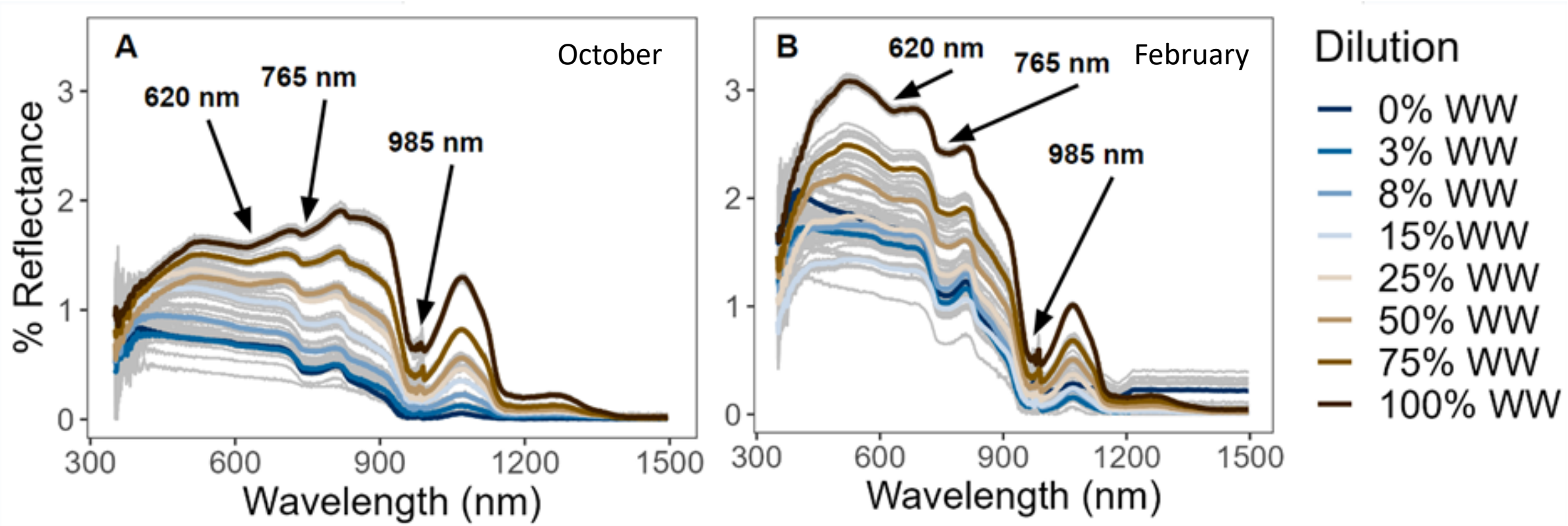
Challenging laboratory constraints due to hazardous nature of untreated wastewater and limited sample volume.

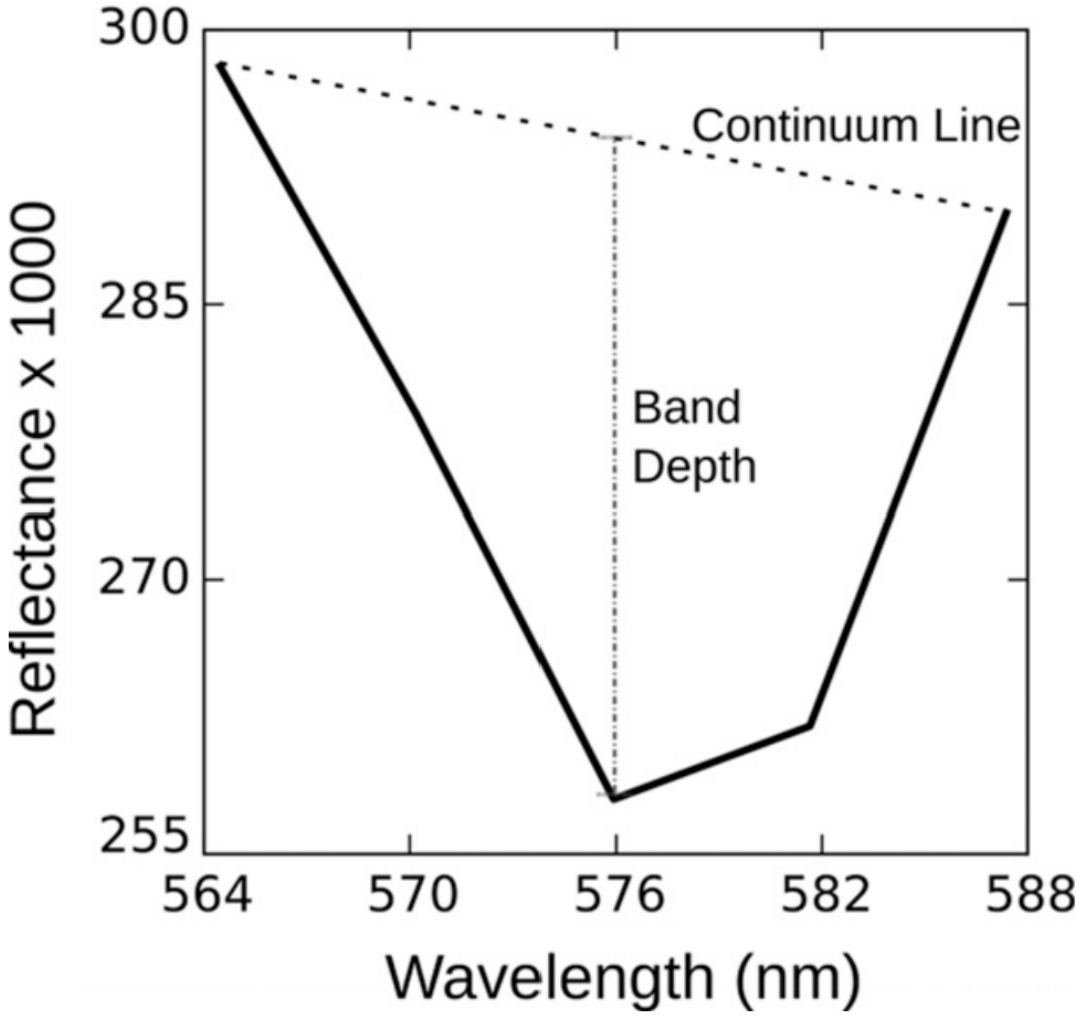


Scrivner et al., 2025, STOTEN

Results

As % WW increases, 620 nm absorption increases



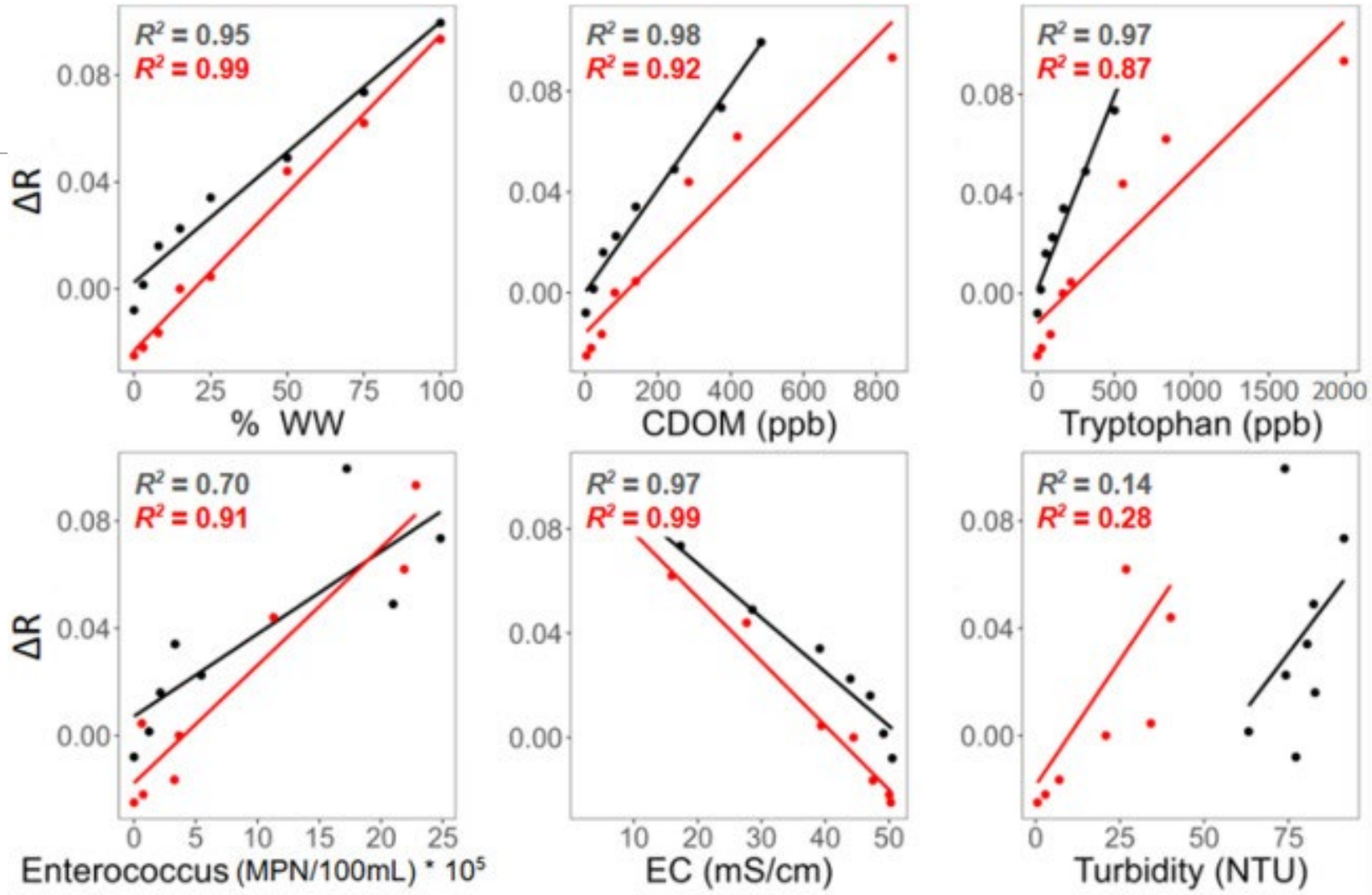


620 nm absorption quantified using band depths.

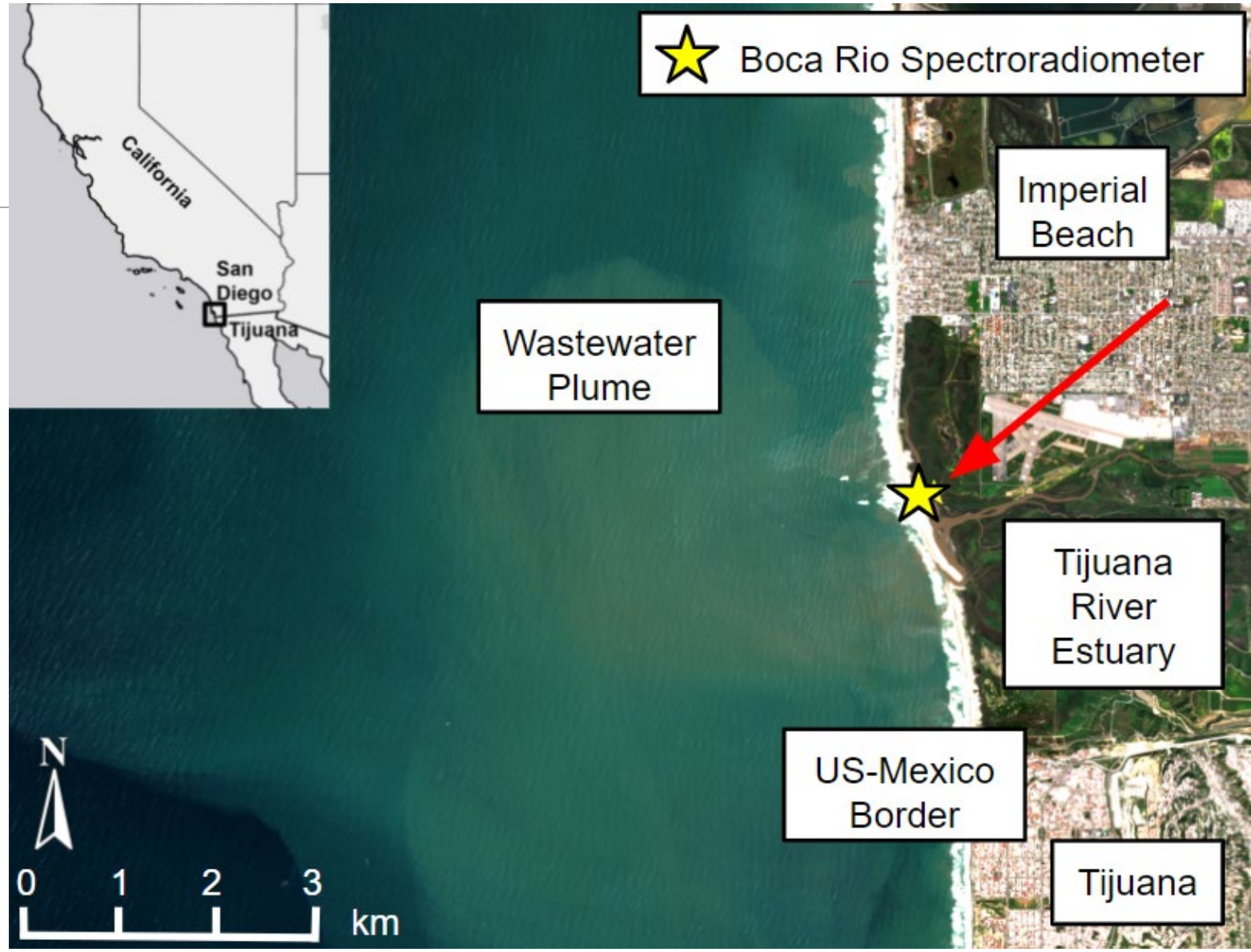
Dierssen et al., 2015, PNAS

— October 2023
— February 2024

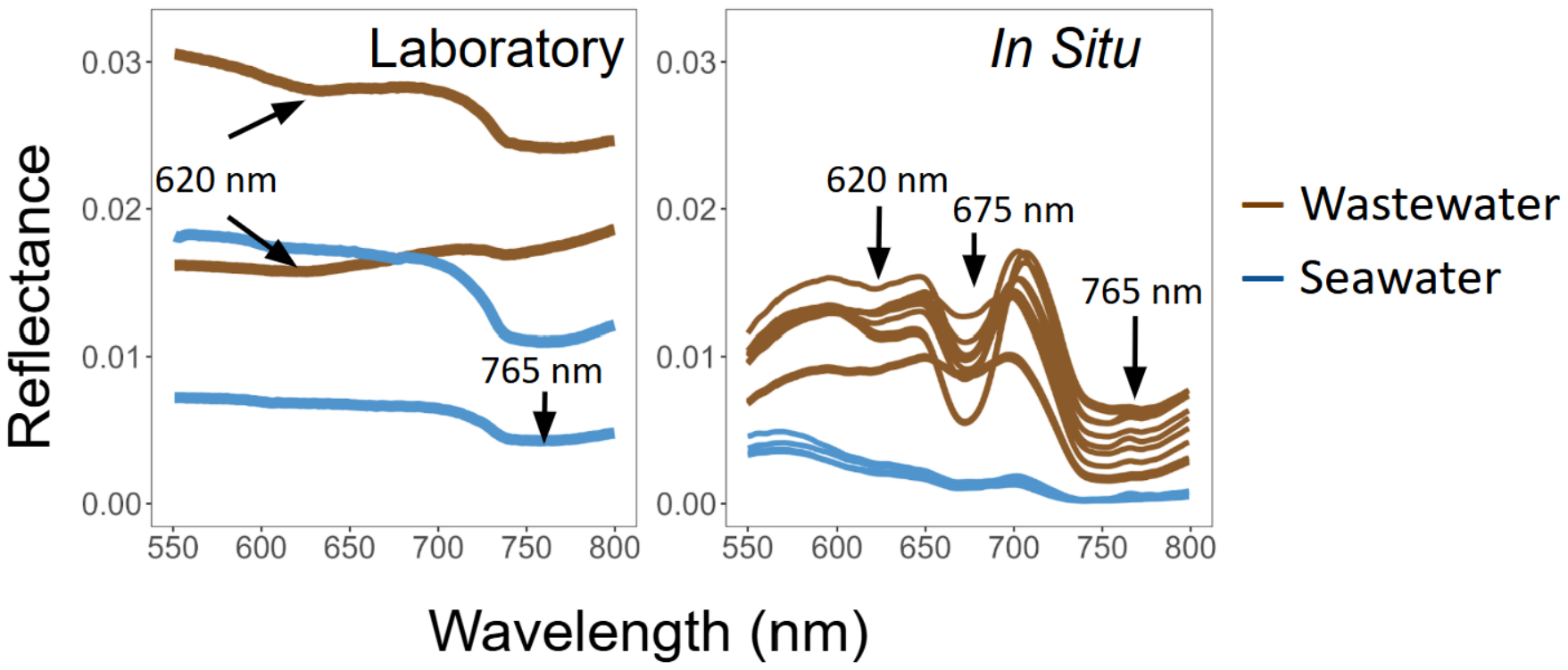
Water quality parameters were highly correlated with 620 nm band depths.



In situ spectroradiometer deployed in the Tijuana River Estuary



620 nm feature is present *in situ* under high volumetric wastewater discharge.

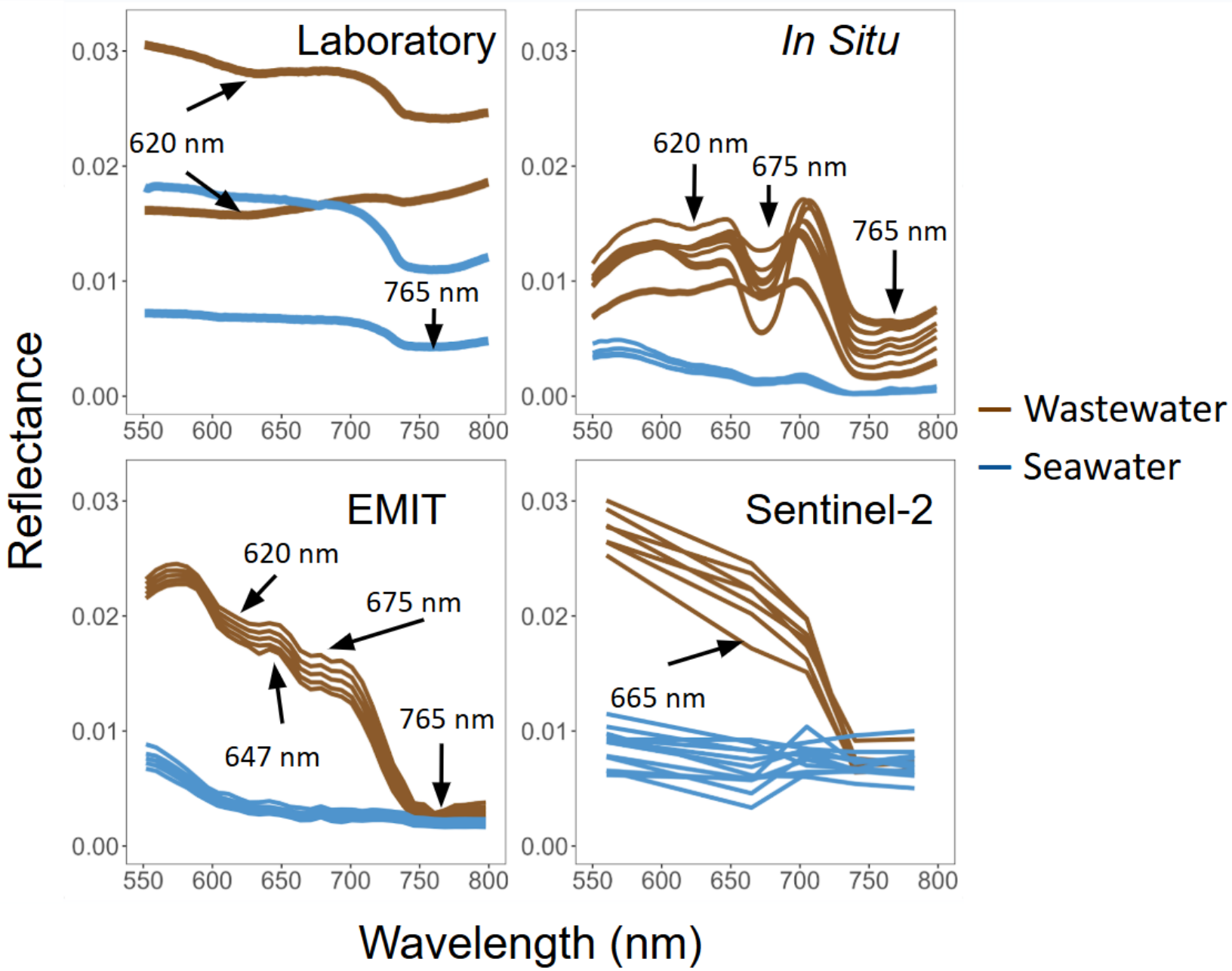


High wastewater discharge:

1.68×10^6 m^3 from 10:00 25 March 2023 to 15:45 26 March 2023

Low wastewater discharge:

0 m^3 from 10:00 to 12:15 02 July 2023).

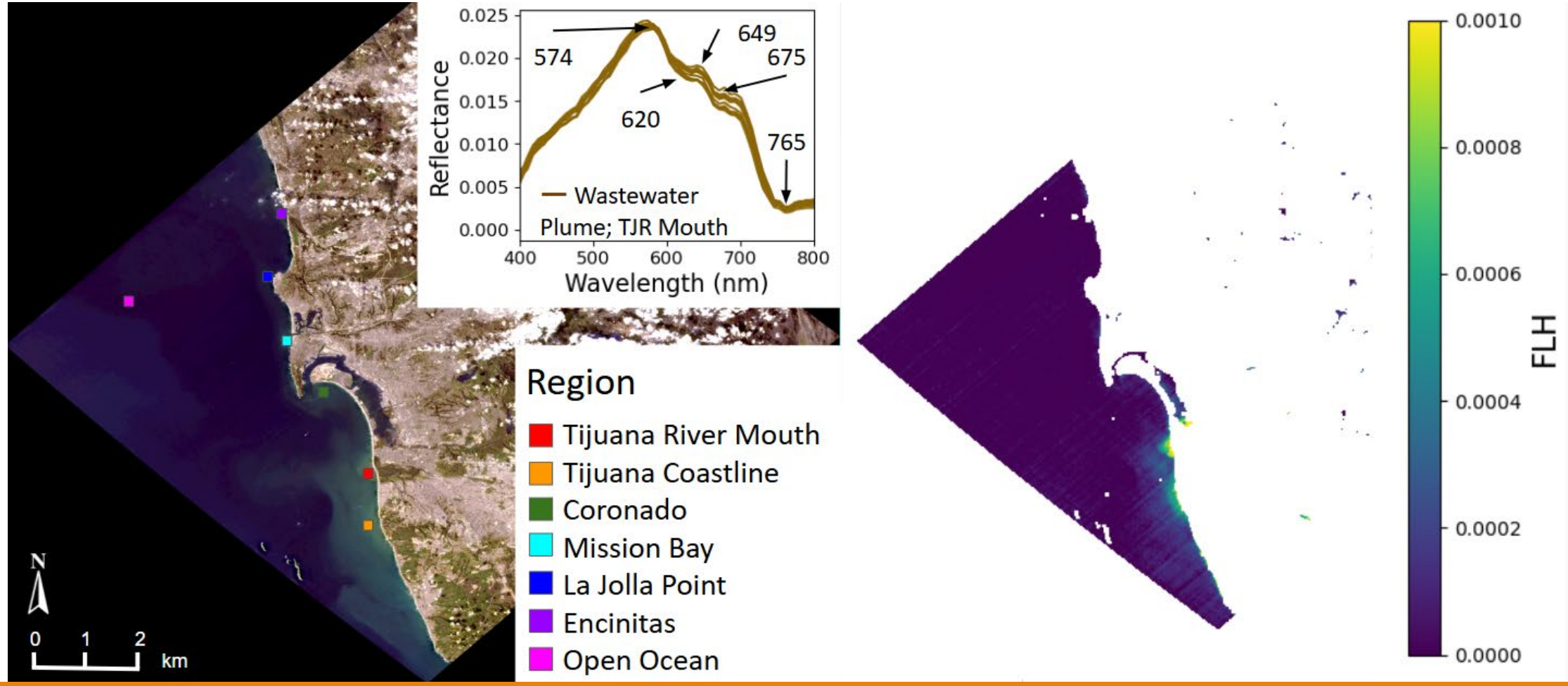


620 nm feature present *in situ* and in EMIT hyperspectral satellite imagery.

Scrivner et al., 2025, STOTEN

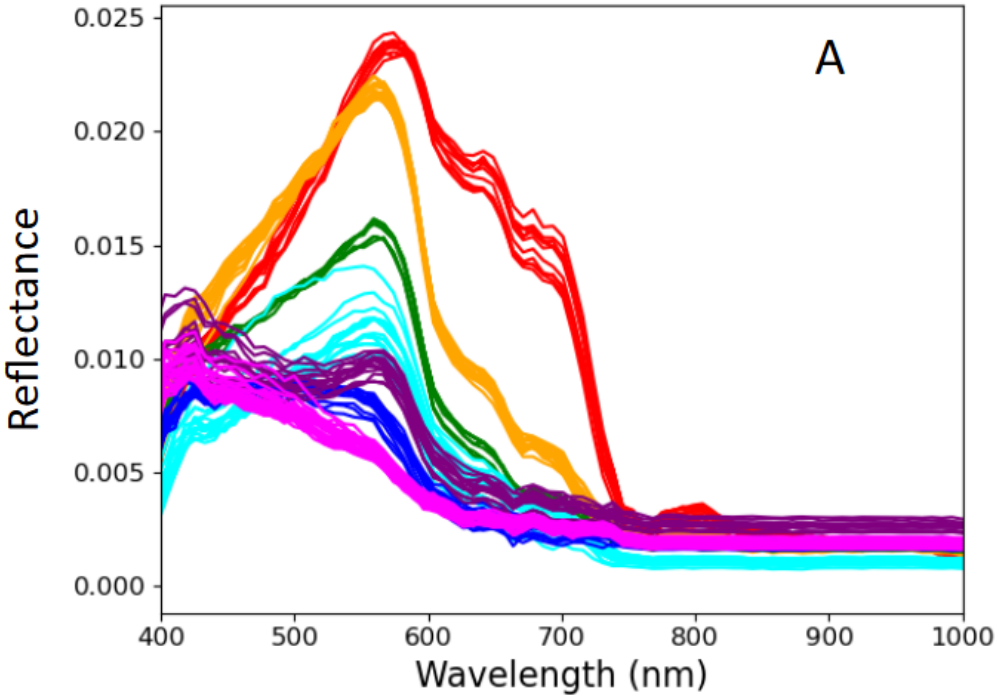
EMIT Image acquired 25 March 2023

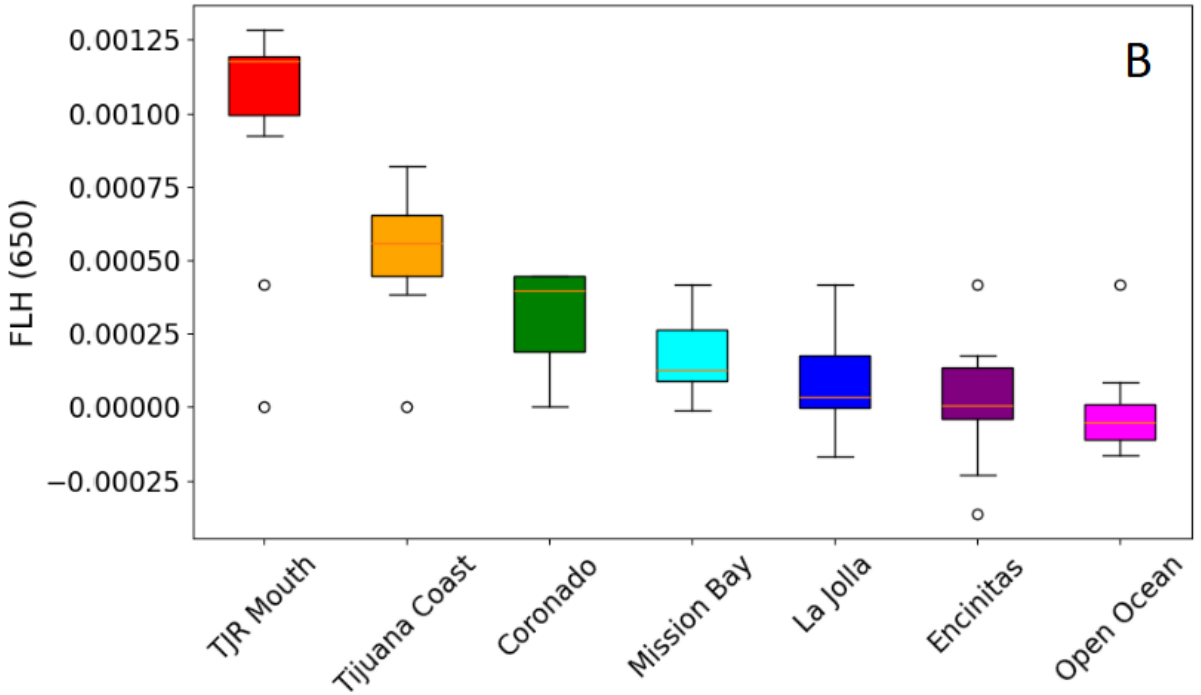
Fluorescence Line Height at 650 nm more closely traces Tijuana River wastewater.



Scrivner et al., 2025 , STOTEN

Fluorescence Line Height at 650 nm more closely traces Tijuana River wastewater.





Scrivner et al., 2025 , STOTEN

Discussion

Results Summary

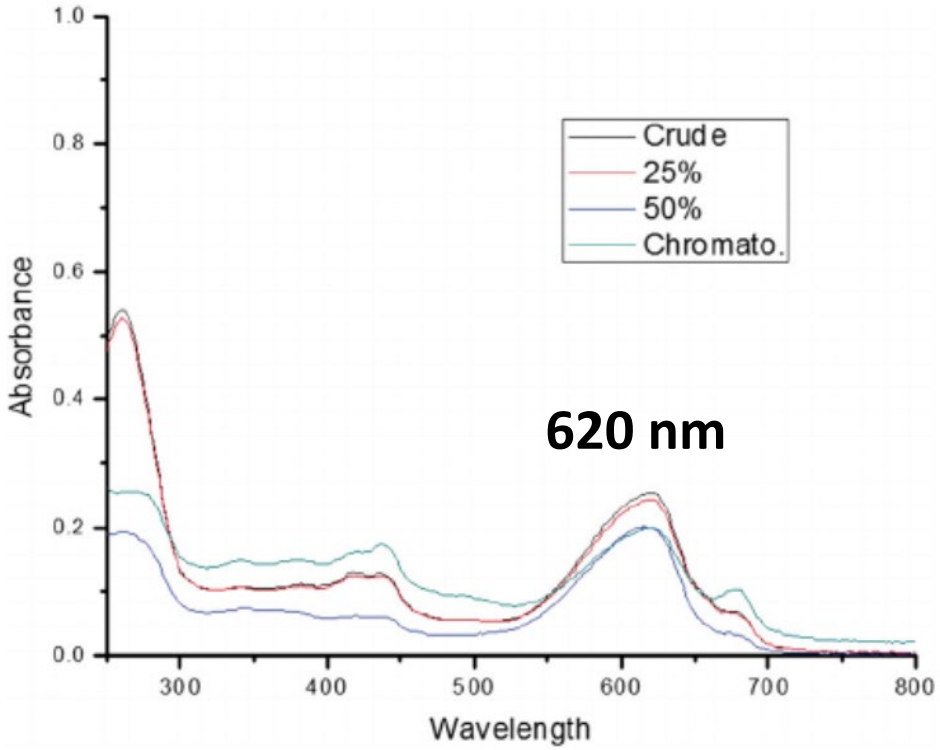
620 nm absorption:

1) increases under high wastewater conditions,
2) has high correlation with water quality parameters,
3) present *in situ* and in hyperspectral imagery

We present one of the earliest applications of EMIT for water quality applications.

Phycocyanin – absorbs at 620 nm, fluoresces at 650 nm

- Phycocyanin characteristically absorbs at 620 nm.
- Accessory pigment found in inland cyanobacteria.
- Commonly found or even employed in secondary wastewater management.



Absorption spectra of purified phycocyanin. Figure credit: *Paswan et al., 2015*

Future Applications

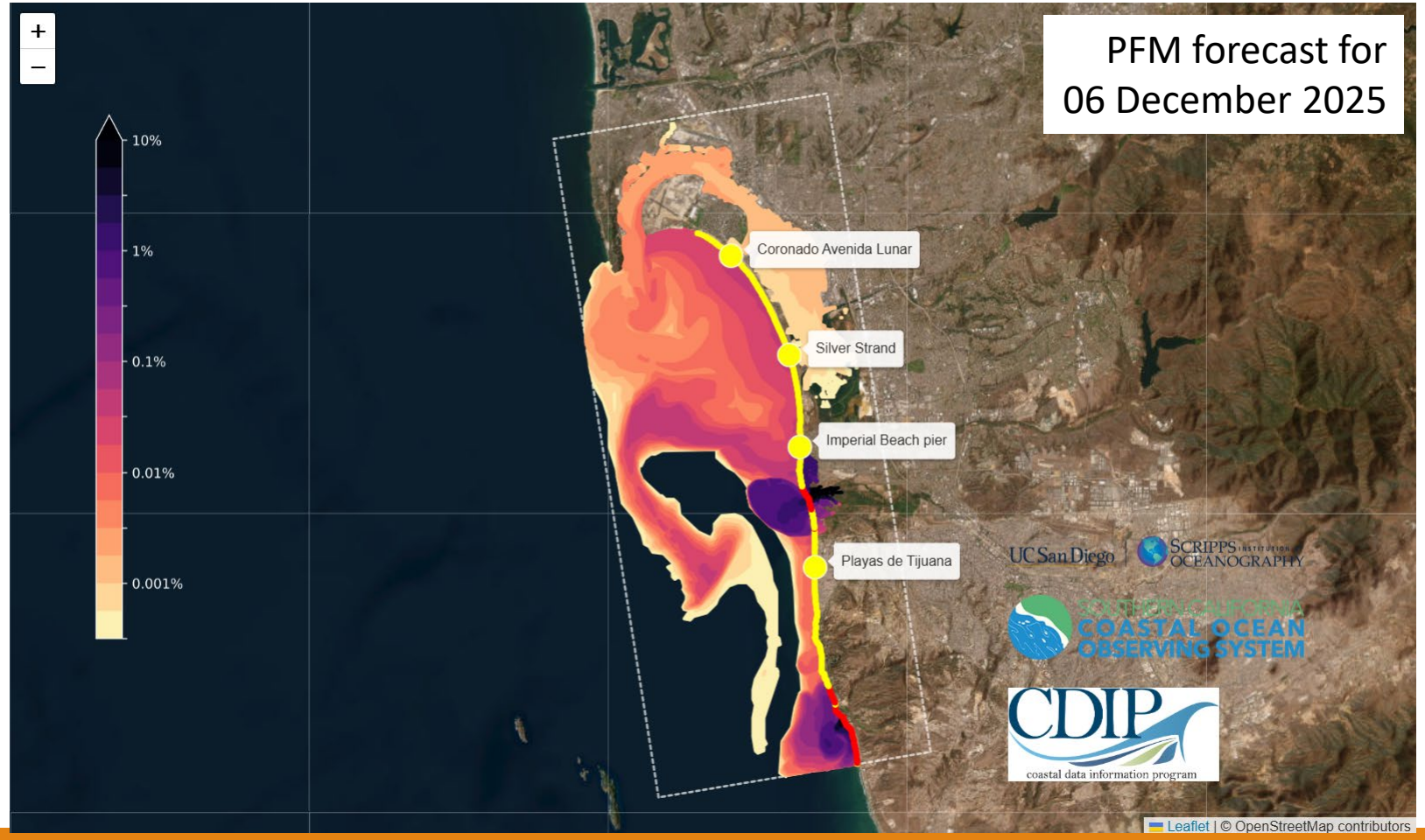
- Major recent policy change (September, 2024) resulted in redirection of discharge from Tijuana River Estuary to Punta Bandera outfall in Mexico. How does wastewater composition compare?

Future Applications

- Major recent policy change (September, 2024) resulted in near-complete redirection of discharge from Tijuana River Estuary to Punta Bandera outfall in Mexico. How does wastewater composition compare?

- Operationalize remote sensing retrievals of wastewater content in the TJR.
  - Continued wastewater addition experiments
  - HPLC pigment and absorption analyses: is phycocyanin the source of the 620 nm feature?

Comparisons with the San Diego/ Tijuana Pathogen Forecast Model (PFM)



Recently debuted PFM forecasts "swimmer risk" as a function of % wastewater concentration.

What synergies exist between the PFM and the 620 nm feature?

Fedderson et al., 2021, GeoHealth

Future Applications

- EMIT is a promising water quality sensor

  - Underscores need for SBG, GLIMR, future missions.

- Is this feature present in similar wastewater contaminated aquatic systems?

Acknowledgments

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Thanks!
Questions?

