# Water Quality and Seagrass Health in the Florida Keys

## How Far We've Come, and How Far We Still Have to Go


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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

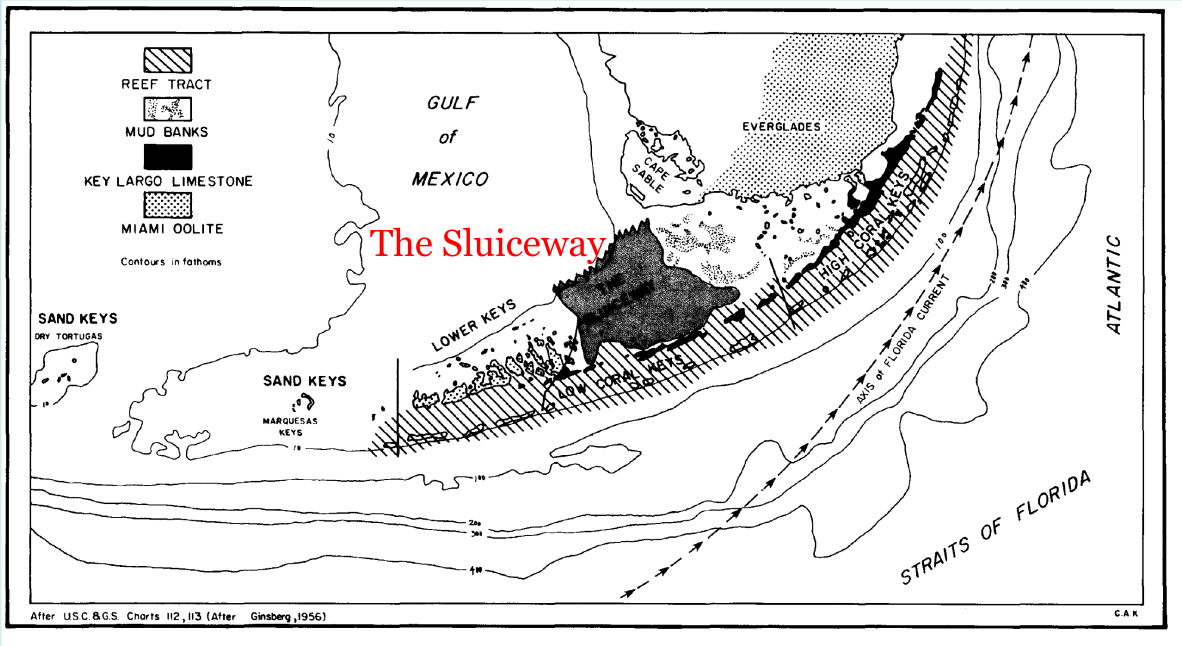
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION · U.S. DEPARTMENT OF COMMERCE · NOAA

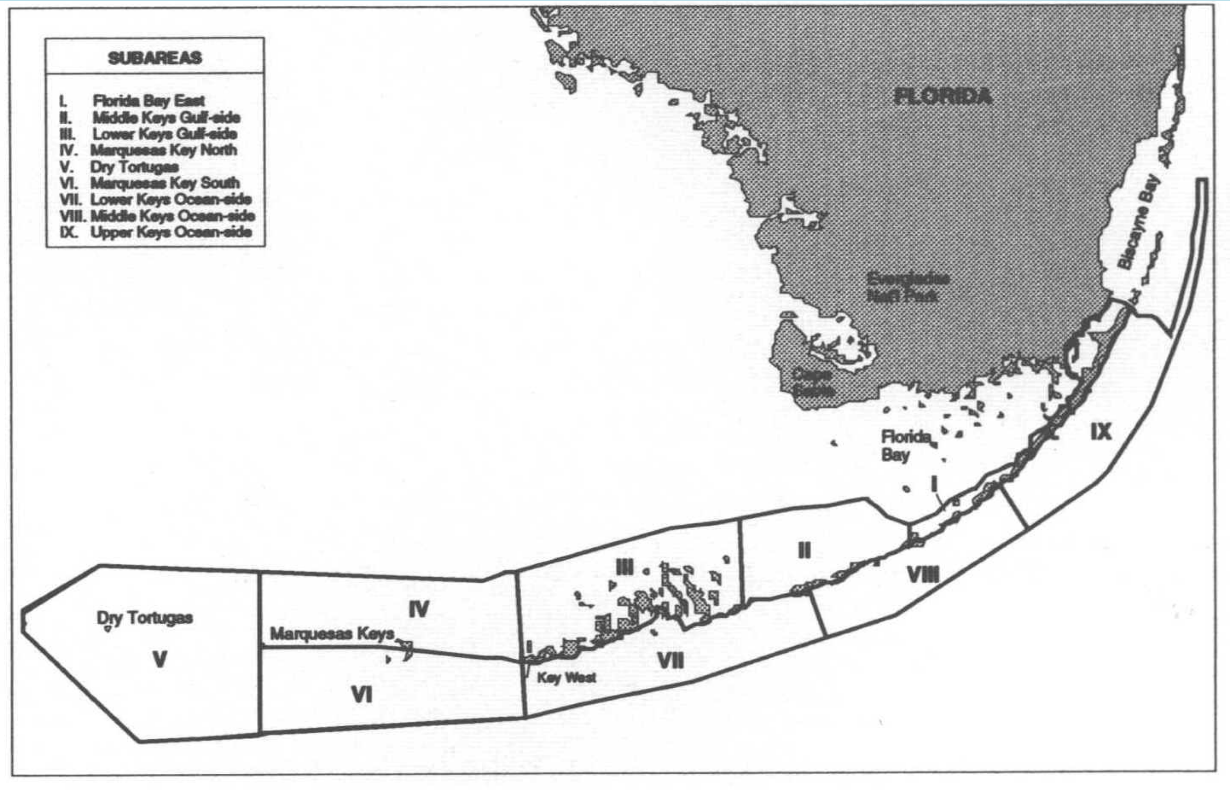
FIU Institute of Environment

# Take home messages

- There were very few water quality data for the Florida Keys prior to the 1980's – If no problems are perceived, there is little support for data collection and monitoring
- Natural history observations informed a general understanding of relative water quality across the Florida Keys seascape
- Seagrass dieoff events in Florida Bay in the late 1980's spurred the creation of systematic monitoring of water quality in the Keys
- Water quality determines seagrass species composition
- Long-term patterns and shorter cycles in water quality drive seagrass abundance
- Continued monitoring is essential to proper stewardship, and automation will generate better data!

# Before the Florida Bay seagrass dieoff in the 1980's, Natural history drove understanding of seascape patterns in water quality

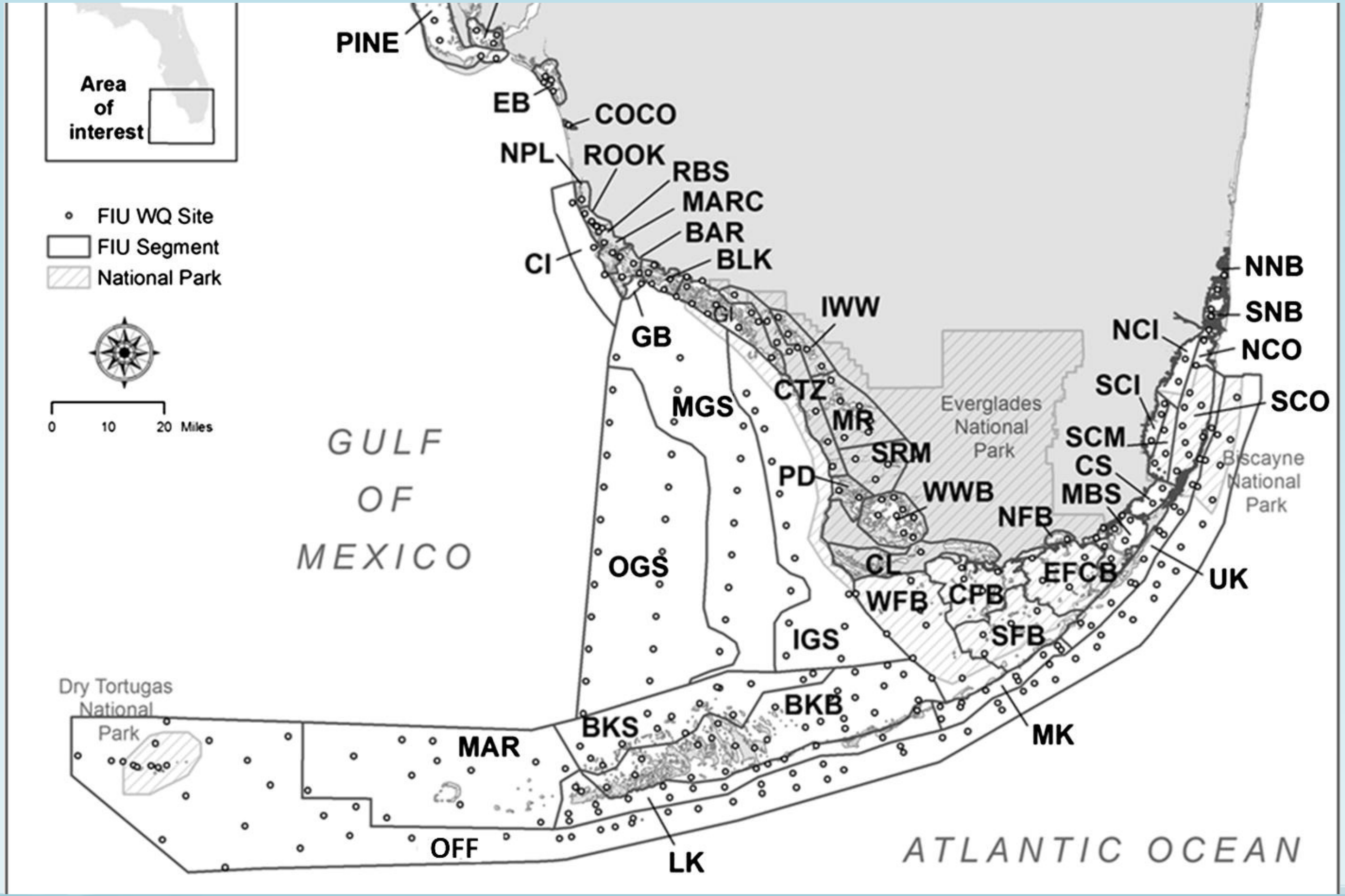


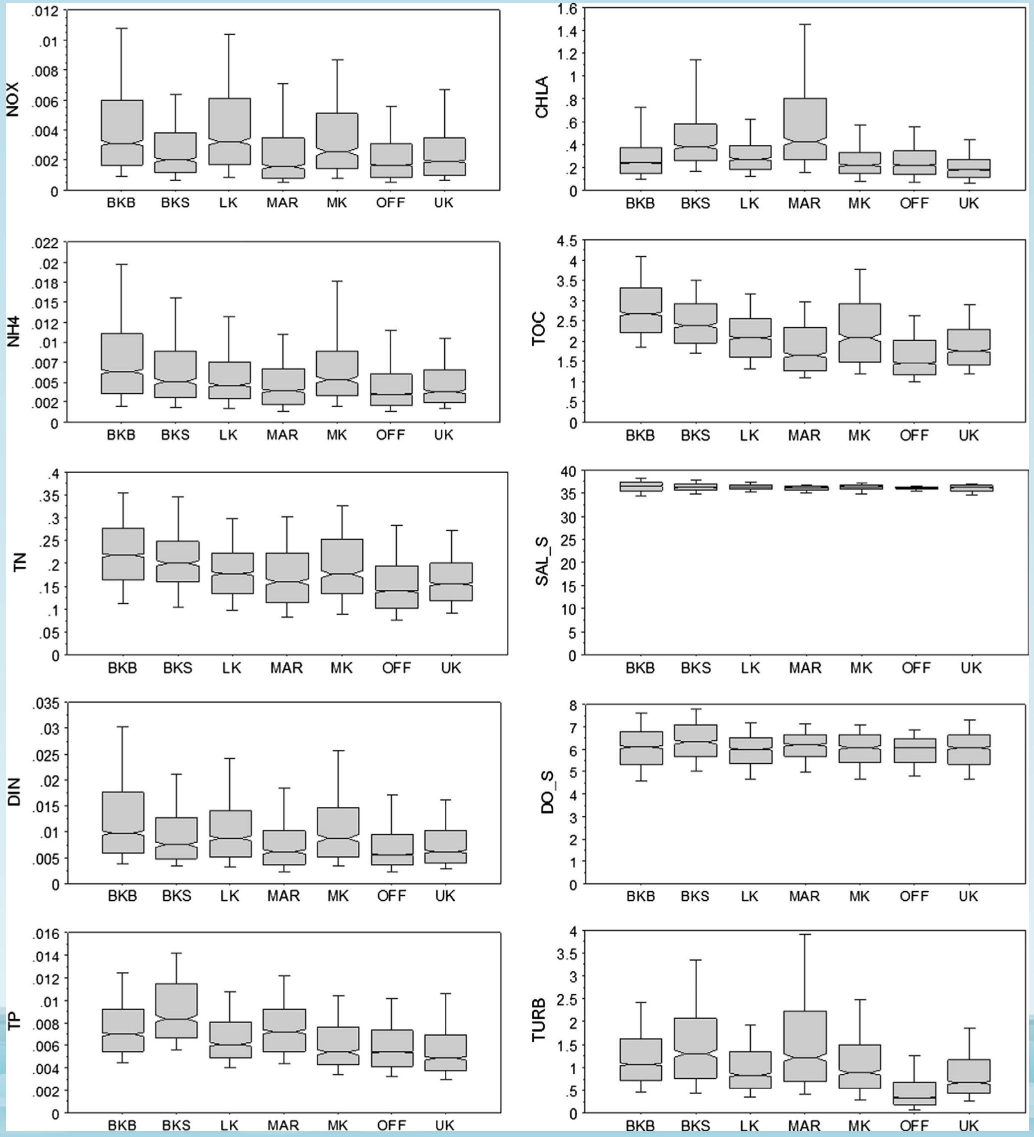




Schomer and Drew 1982 FWS/OBS-82/58.1, Ginsburg 1956, *Bull Am Soc Petrol Geol*

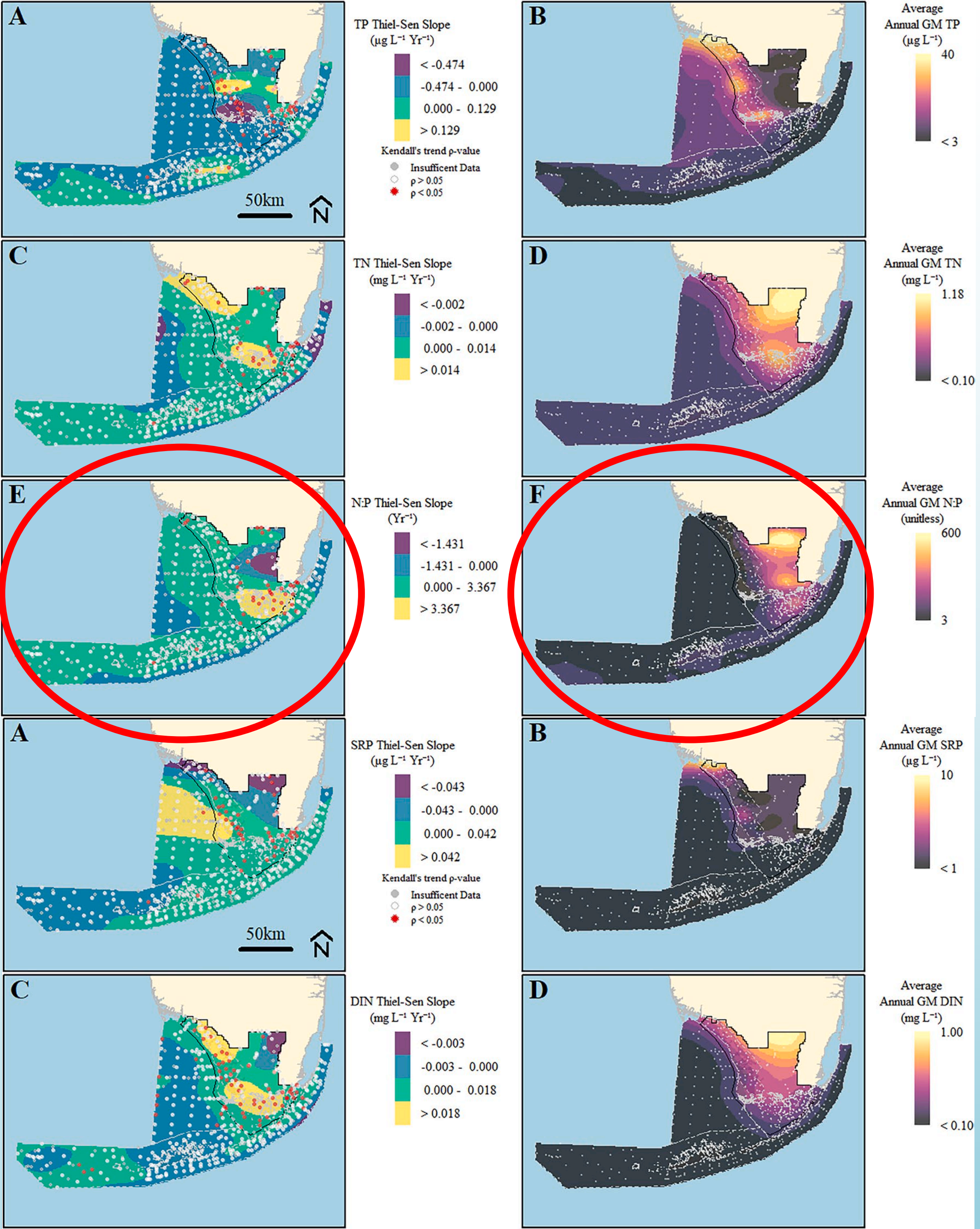
Klein and Orlando 1994 *Bull Mar Sci*

# The Florida Keys is now one of the most water quality data-rich seascapes in the world




Briceño et al 2013 *Mar Poll Bull*



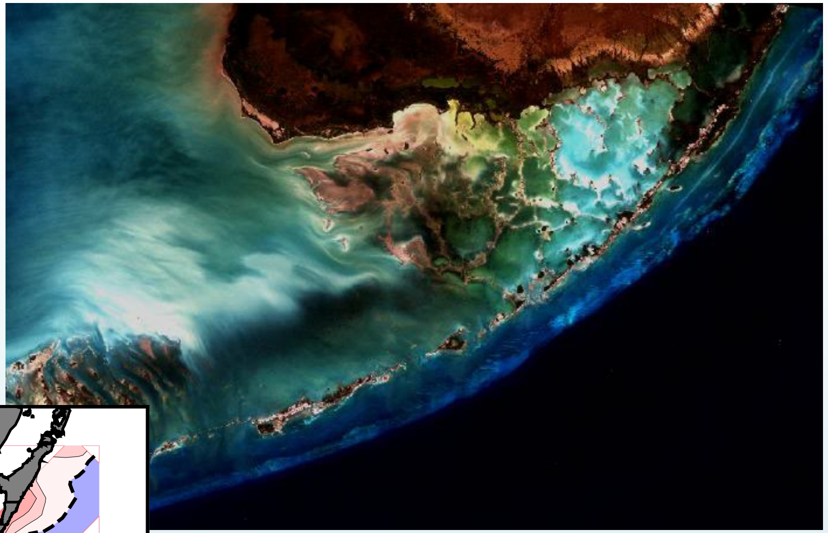

Twenty five year averages and time series records define spatial patterns and trends on the scale of the greater Everglades-Florida Keys ecosystem

Note spatial pattern in N:P mean and trends – N:P is an indicator of relative availability of these two most important plant nutrients for building biomass.

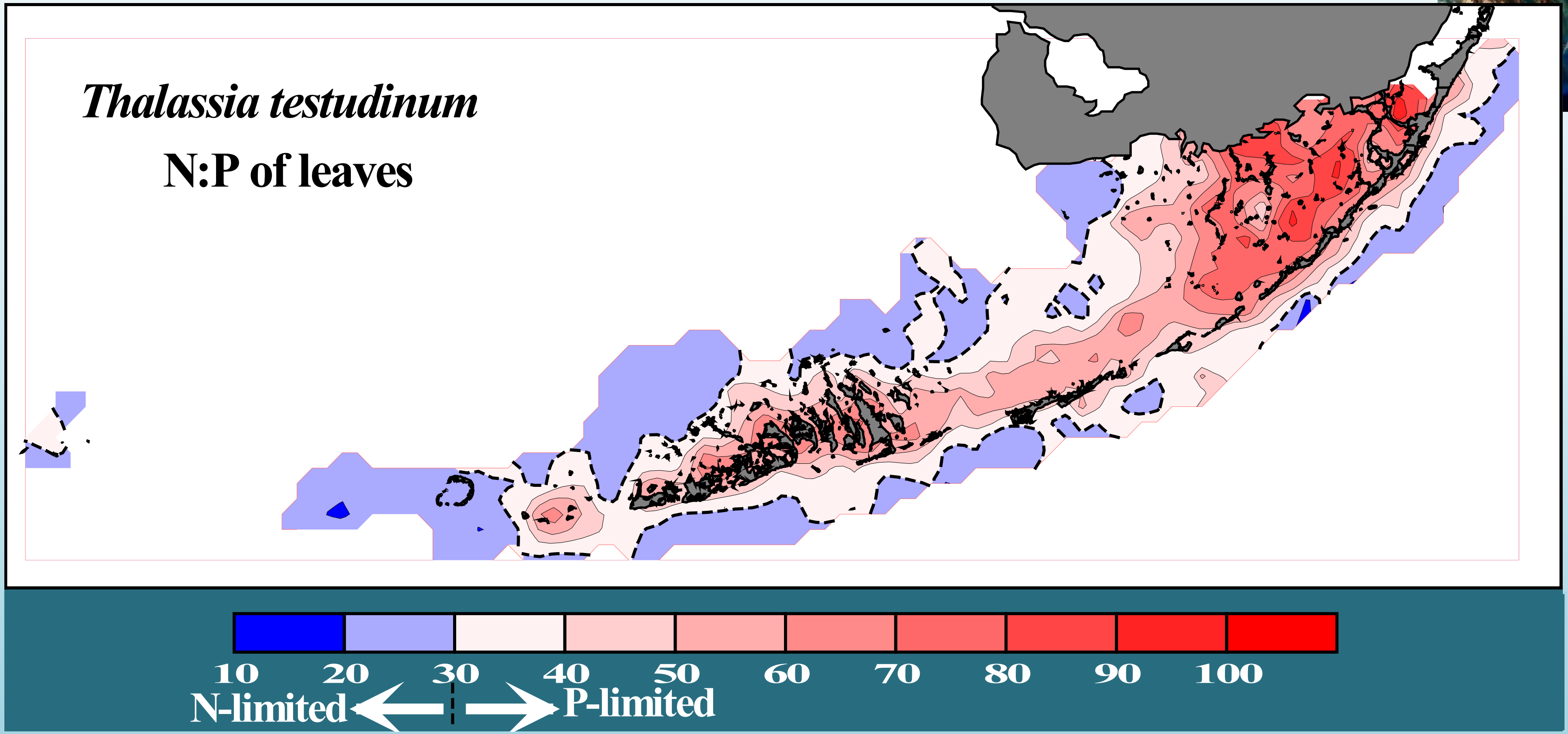
High N:P indicates P-limitation. Lots of N, relative to P, runs off the Everglades into the Keys seascape

Julian et al 2024 *ECSS*

# Seagrass tissue nutrients indicate spatial pattern in relative importance of N anP for controlling biomass of primary producers arosss the seascape



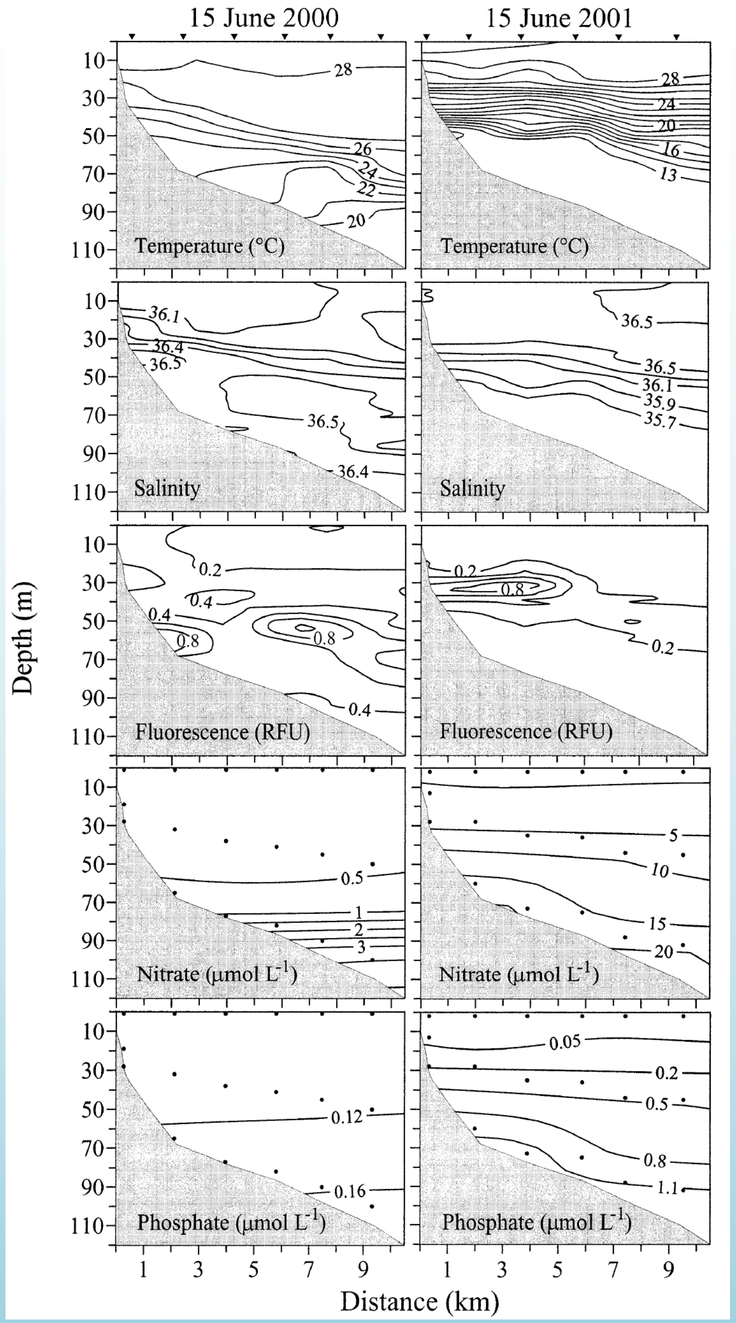
## Seagrass “Redfield Ratio” ≈ 550:30:1 C:N:P




Fourqurean et al 1992 *L&O*, Fourqurean and Zieman 2002 *Biogeochem.*

Upwelling of P-rich deeper waters over the reef tract deliver up to 40-fold more P to the Florida Keys nearshore waters than anthropogenic P sources (Leichter et al 2003 L&O.

This drives N-limitation of benthic primary production near the offshore reef (Ferdie and Fourqurean 2004 *L&O*)

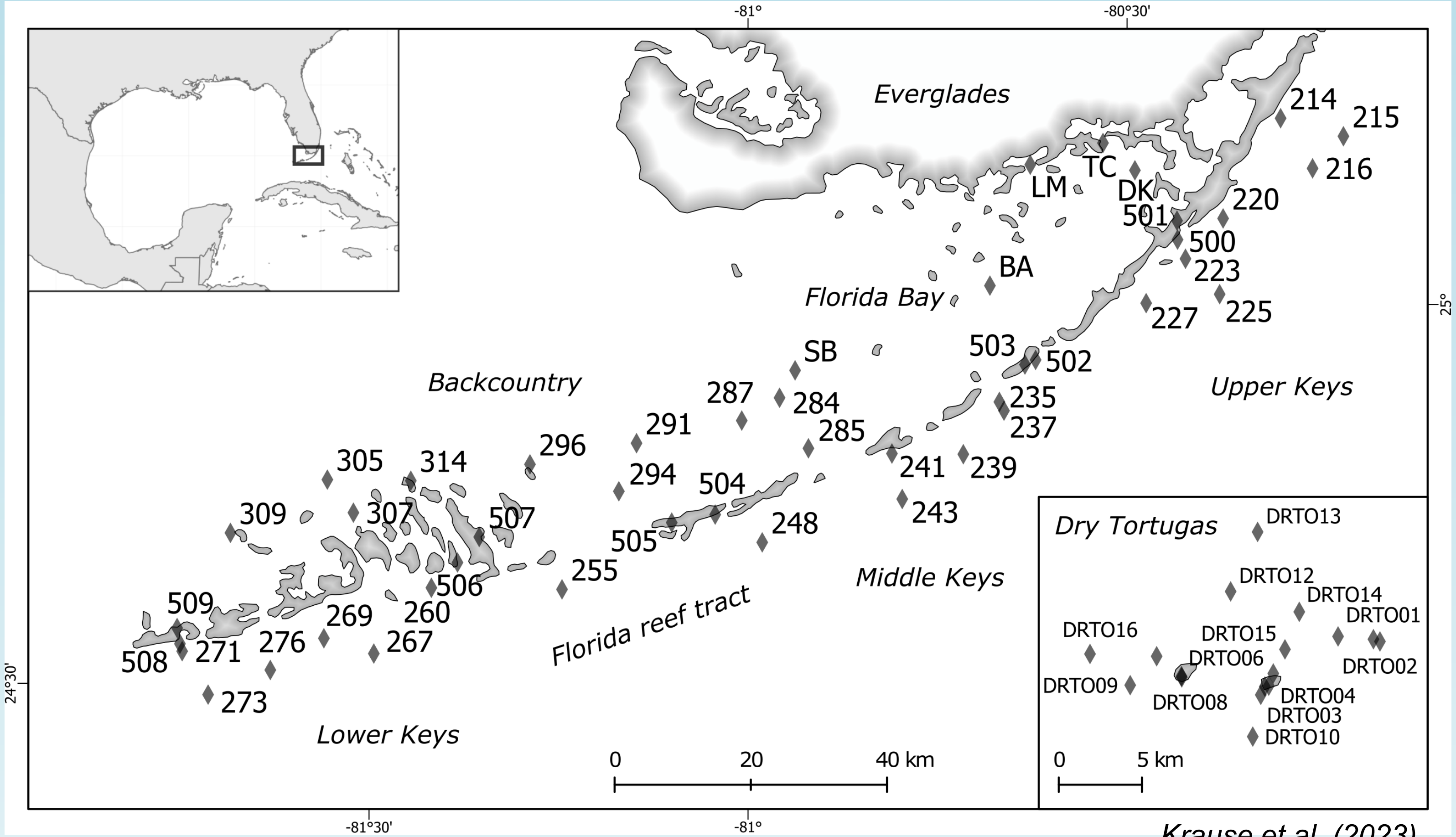



Leichter et al 2003 *L&O*


Benthic
community status
& trends

# Long-term monitoring in the FKNMS and beyond

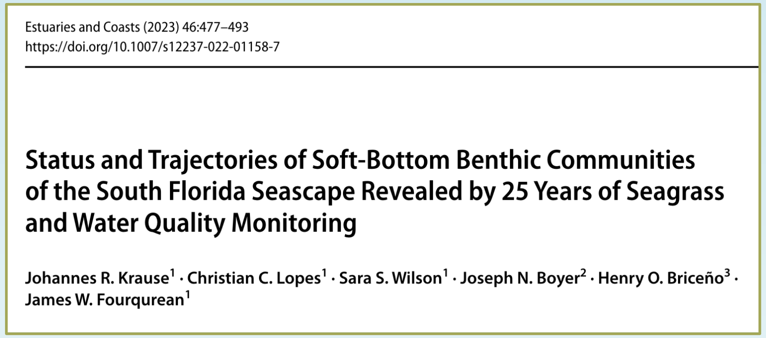
- 40 sites in FKNMS for benthic community monitoring
- Coinciding with water quality monitoring stations
- Integrates into wider network of seagrass monitoring with consistent methodology (Florida Bay, Dry Tortugas)




Krause et al. (2023)

# Synthesis study of 25 years of monitoring data

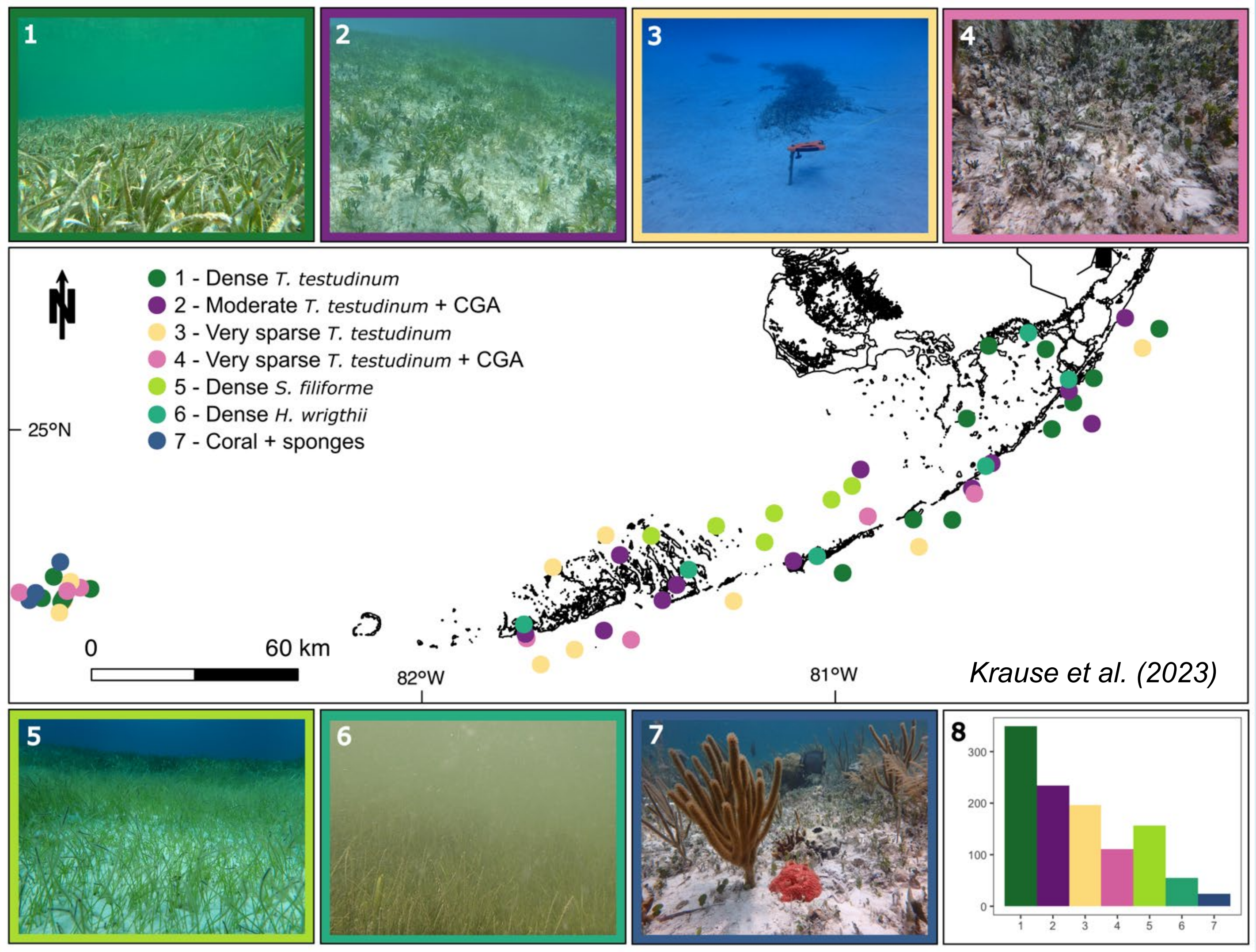
- Identified 7 prevalent benthic community types via cluster analysis
- Described spatial pattern of benthic community distribution
- Identified environmental correlates of benthic community status and trends



Estuaries and Coasts (2023) 46:477–493
https://doi.org/10.1007/s12237-022-01158-7

**Status and Trajectories of Soft-Bottom Benthic Communities of the South Florida Seascape Revealed by 25 Years of Seagrass and Water Quality Monitoring**

Johannes R. Krause[1] · Christian C. Lopes[1] · Sara S. Wilson[1] · Joseph N. Boyer[2] · Henry O. Briceño[3] · James W. Fourqurean[1]




Status & trends

01: MICROBIAL

03: ECOSYSTEMS

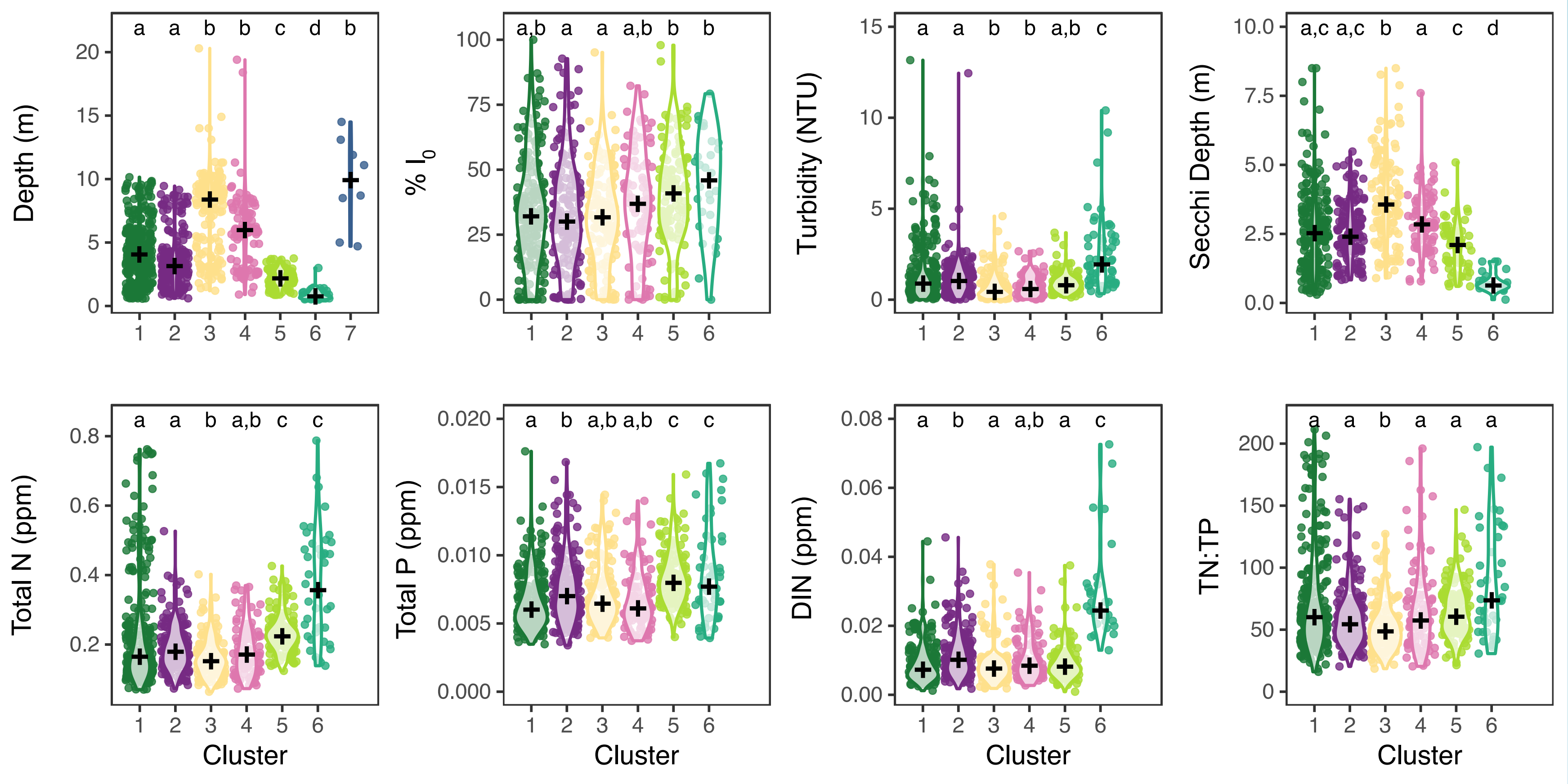
# Synthesis study of 25 years of monitoring data

- Dense Thalassia at 1-10m depth and very low TP

- Dense Syringodium in shallower, higher-nutrient (TN & TP) water

- Dense Halodule at <4 ft depth, highest TN, DIN, TP

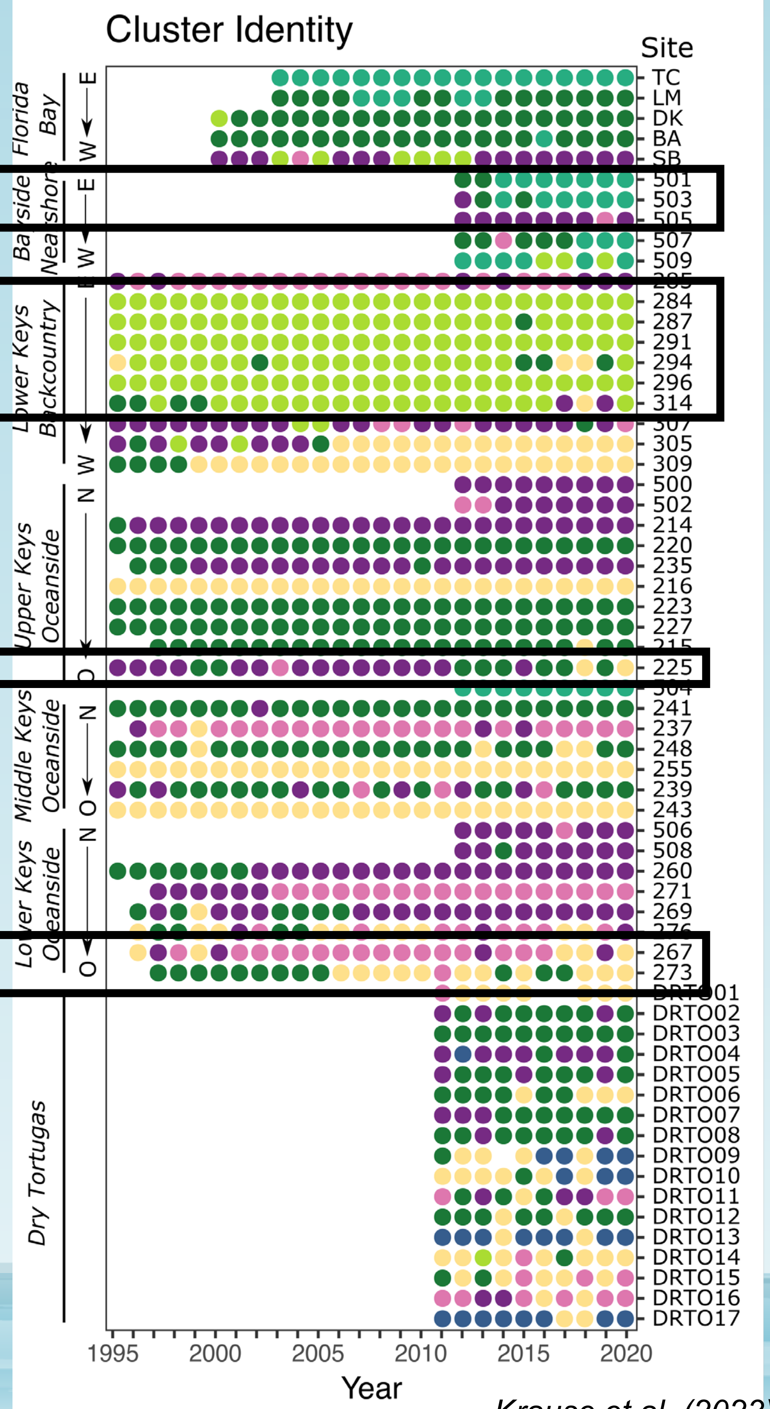
- Patchy, low-density sites in offshore, deepest, lowest TN:TP




*Krause et al. (2023)*

# Benthic community trajectories

- Used clusters to track community change over time
- Overall, stable communities at most sites
- *S. filiforme* meadows most stable
- Least stable communities transition between dominant *T. testudinum* and calcareous green algae
- Some inshore sites change species composition (*T. testudinum* to *H. wrightii*)
- Some offshore sites suddenly lose seagrass cover and do not recover for many years

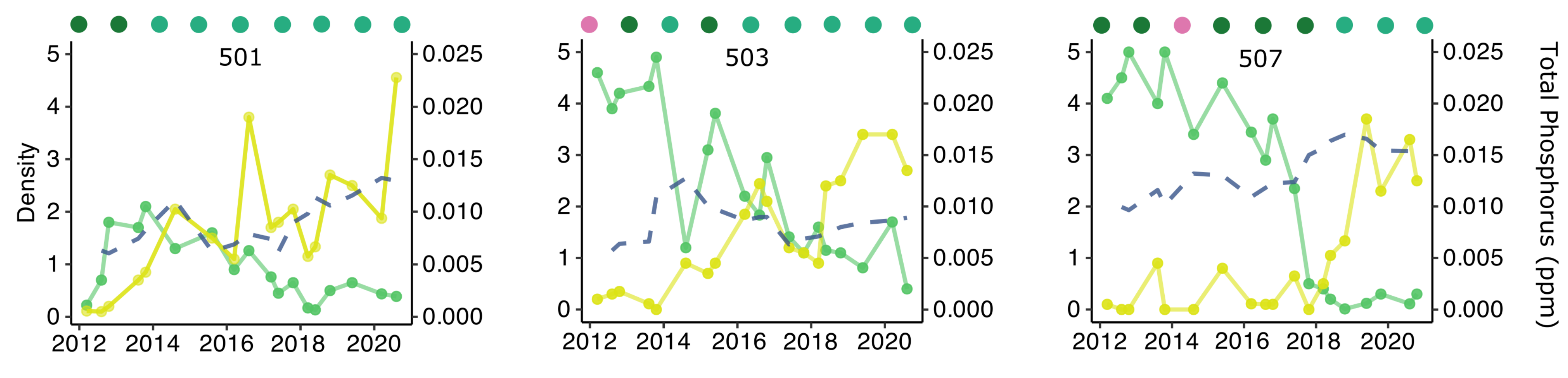



Krause et al. (2023)

Status & trends

01: MICROBIAL

# Nutrient enrichment causes inshore community change




Krause et al. (2023)

- Nutrient enrichment at inshore sites (within 100m of shore)
- Increasing water total phosphorus concentrations (blue dashed)
- Change from climax seagrass *T. testudinum* (green) to fast-growing *H. wrightii* (yellow)

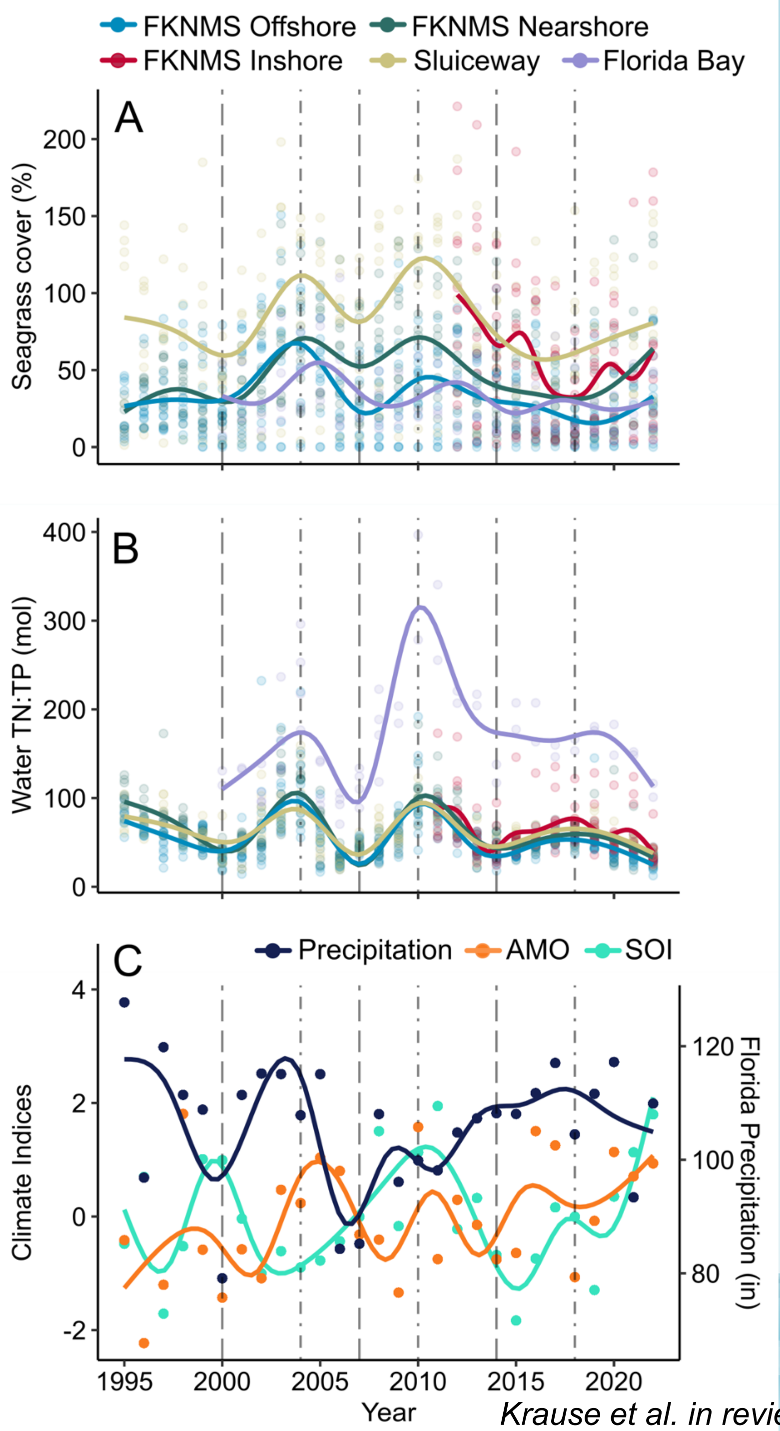
# Benthic community status and trends

- Overall, benthic communities at FKNMS stable over past 25 years
- Spatial pattern in nutrient environment drive benthic community distribution
- Nutrient-enrichment in nearshore waters associated with benthic community shifts to *Halodule* meadows
- Catastrophic, lasting loss of seagrass in FKNMS only after major hurricane passages
- Long-term monitoring needed to track recovery dynamics and learn about resilience of South Florida seagrass meadows


Climate Variability

# Interannual fluctuations

- Oscillating pattern in seagrass abundance
- Mirroring pulses in water TN:TP
- Synchronous pulses throughout FKNMS
- Rainfall pattern in South Florida and climate indices (SOI, AMO) with similar oscillations

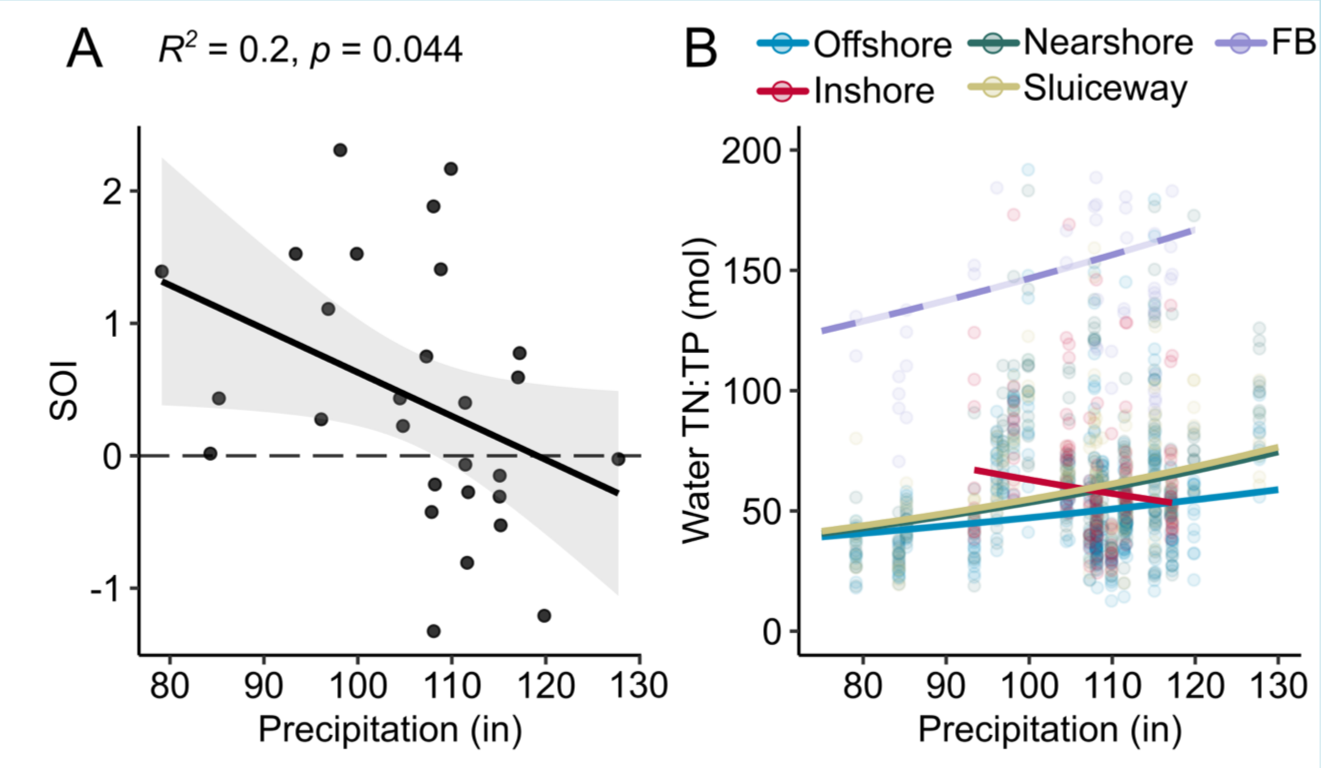



*Krause et al. in review*

**Climate variability**

# Climate drivers of nutrient availability

- Negative SOI (El Niño) with high-rainfall years
- High rainfall years coincide with high TN:TP
  - Potential effects of freshwater on upwelling of nutrient-rich waters (Cherubin & Burgman 2022)
  - Potential increased terrestrial nitrogen inputs from runoff

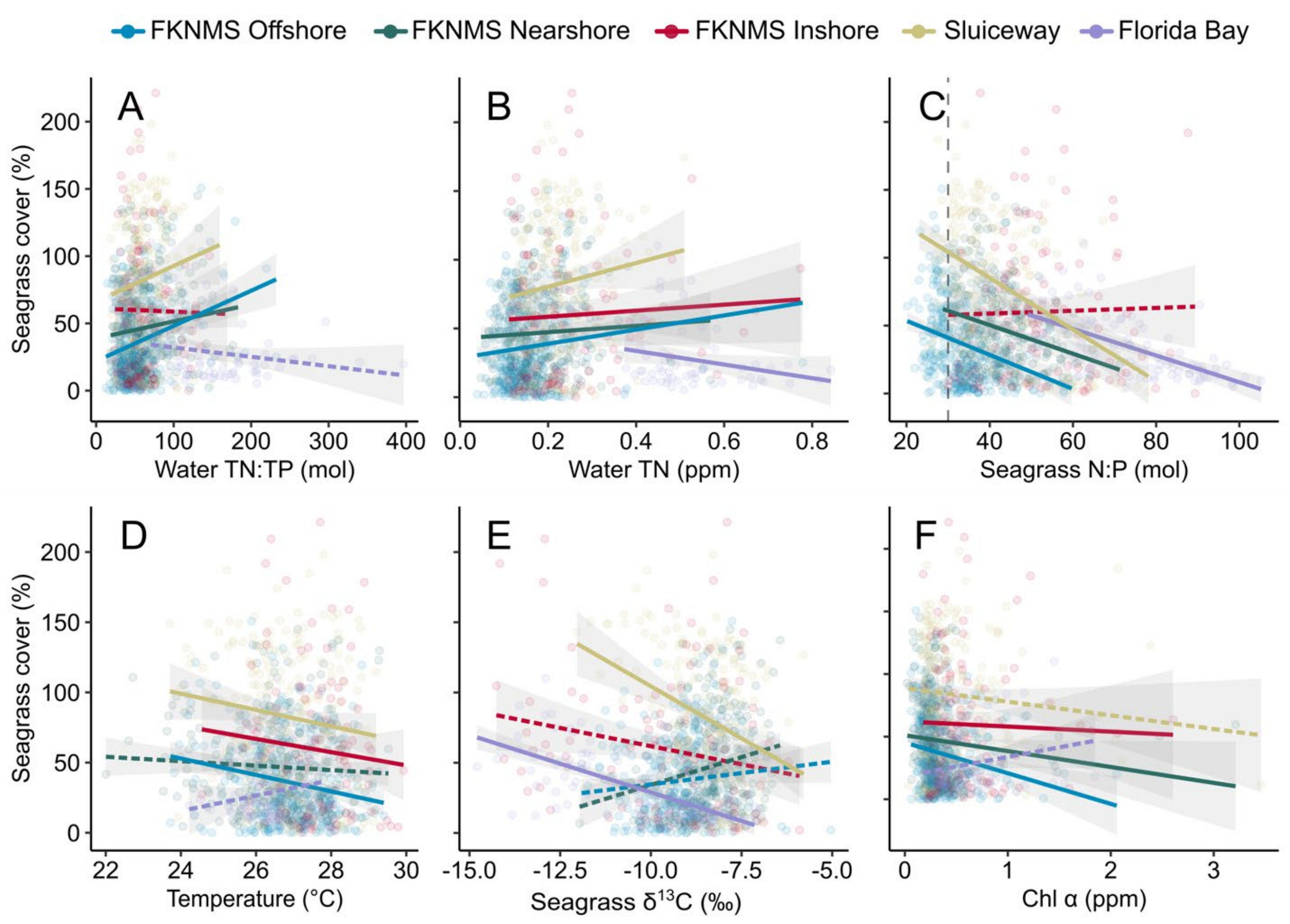



Krause et al. 2025 *L&O*

Climate variability

# Water quality affects seagrass abundance

- Seagrasses abundance affected by relative nutrient availability
- Relationships differ depending on region
- Relatively more TN supports higher seagrass cover in FKNMS backreef and Sluiceway meadows
- Relatively more TP may support higher cover in Florida Bay and Inshore




*Krause et al. 2025 L&O*

**Climate variability**

# Climate variability affects seagrass cover

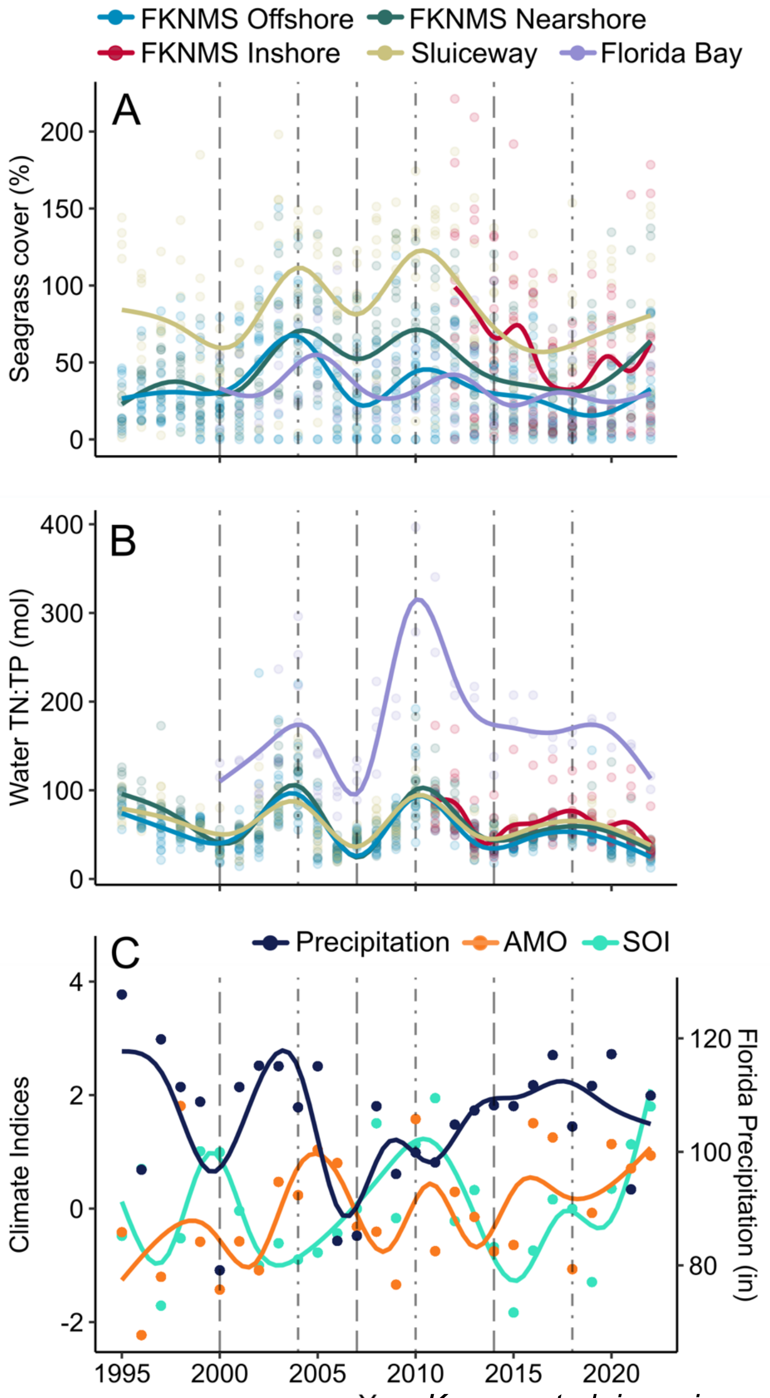
- Coupled long-term seagrass and water quality monitoring allows for analysis of interannual trends in relation to climate drivers

- Relative nutrient availability oscillates in FKNMS, possibly in relation to annual rainfall pattern driven by climate oscillations (ENSO, AMO)

- Higher N availability does not affect Inshore and Florida Bay (P-limited), but backreef meadows are periodically fertilized

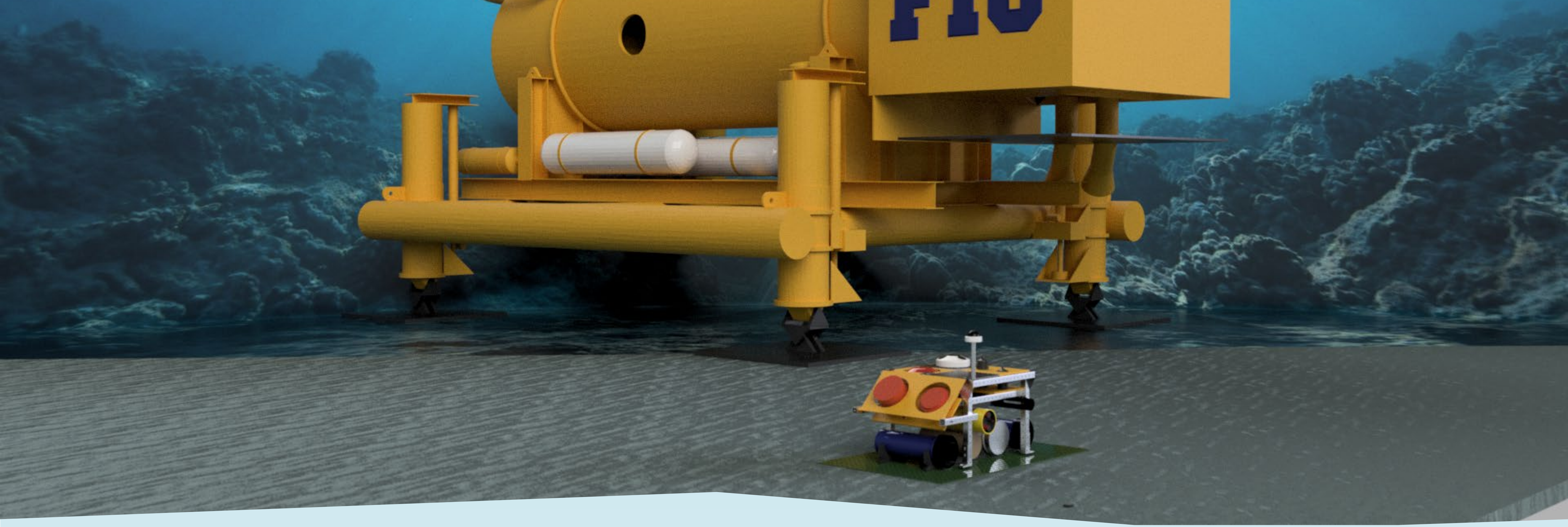
- Nutrient-enrichment effects on seagrass cover are not permanent, at least so far.

- Seagrasses show resilience to pulsed nutrient enrichment (different from press-type that led to species shifts)



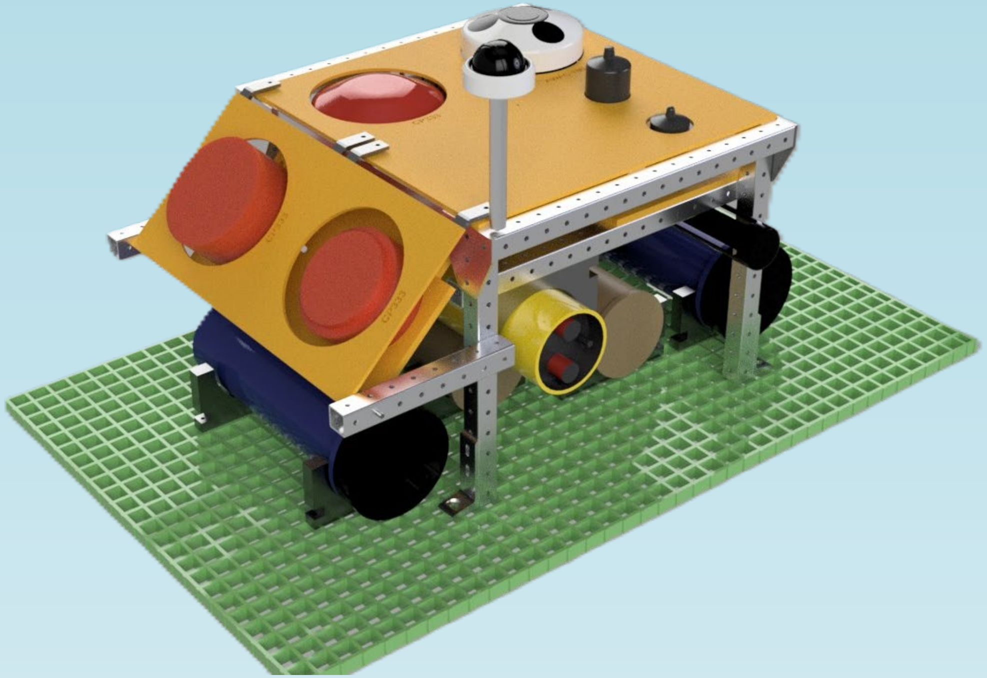

*Krause et al. in review*

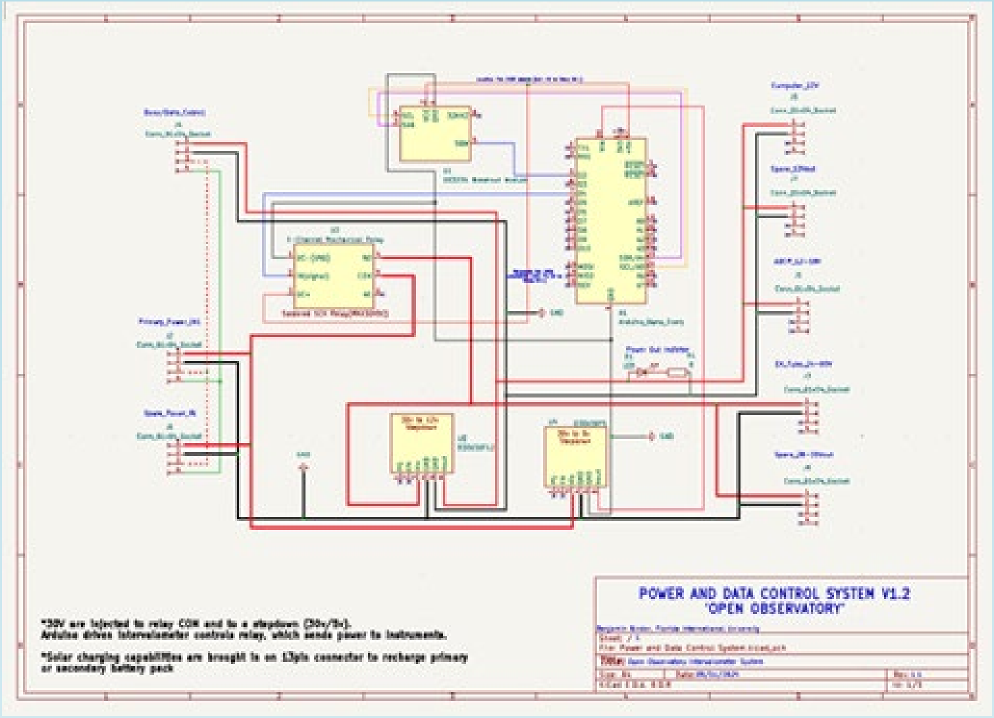
**Climate variability**



# Future of water quality monitoring in the kKeys

We need to keep collecting data!
Replacement of former data stations along the reef tract (FIU-FDEP)
New sensors with new capabilities
Real-time reporting of seascape-wide data via a web portal

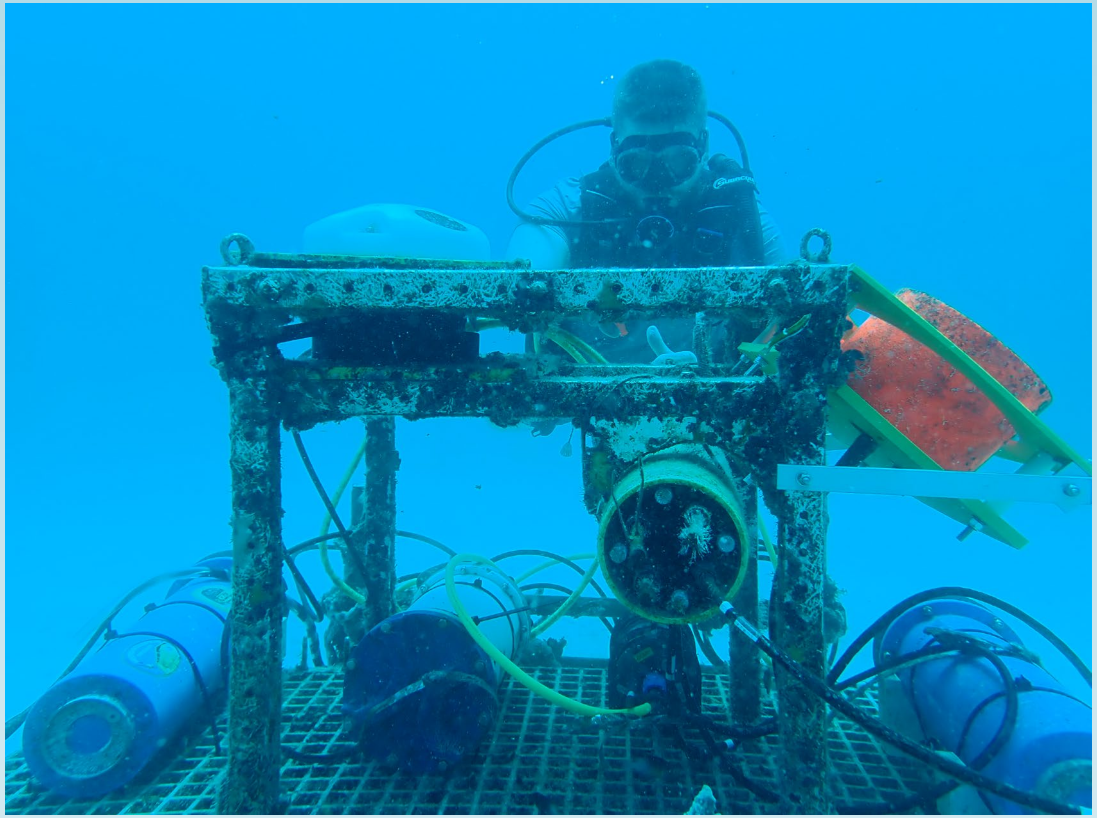





# The Aquarius Observatory

Started as flow charts and matured into real conceptual designs and products.

Consists of paired echosounders, water quality probes, ADCP's, hydrophone, acoustic receiver, custom computers and power controllers.



# The Aquarius Observatory

First prototype was deployed Fall 2024, and two iterations have followed.

Releasing the full suite of software packages, schematics, and design notes to Github by the end of the year.

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# Aquarius 2 is on the way!