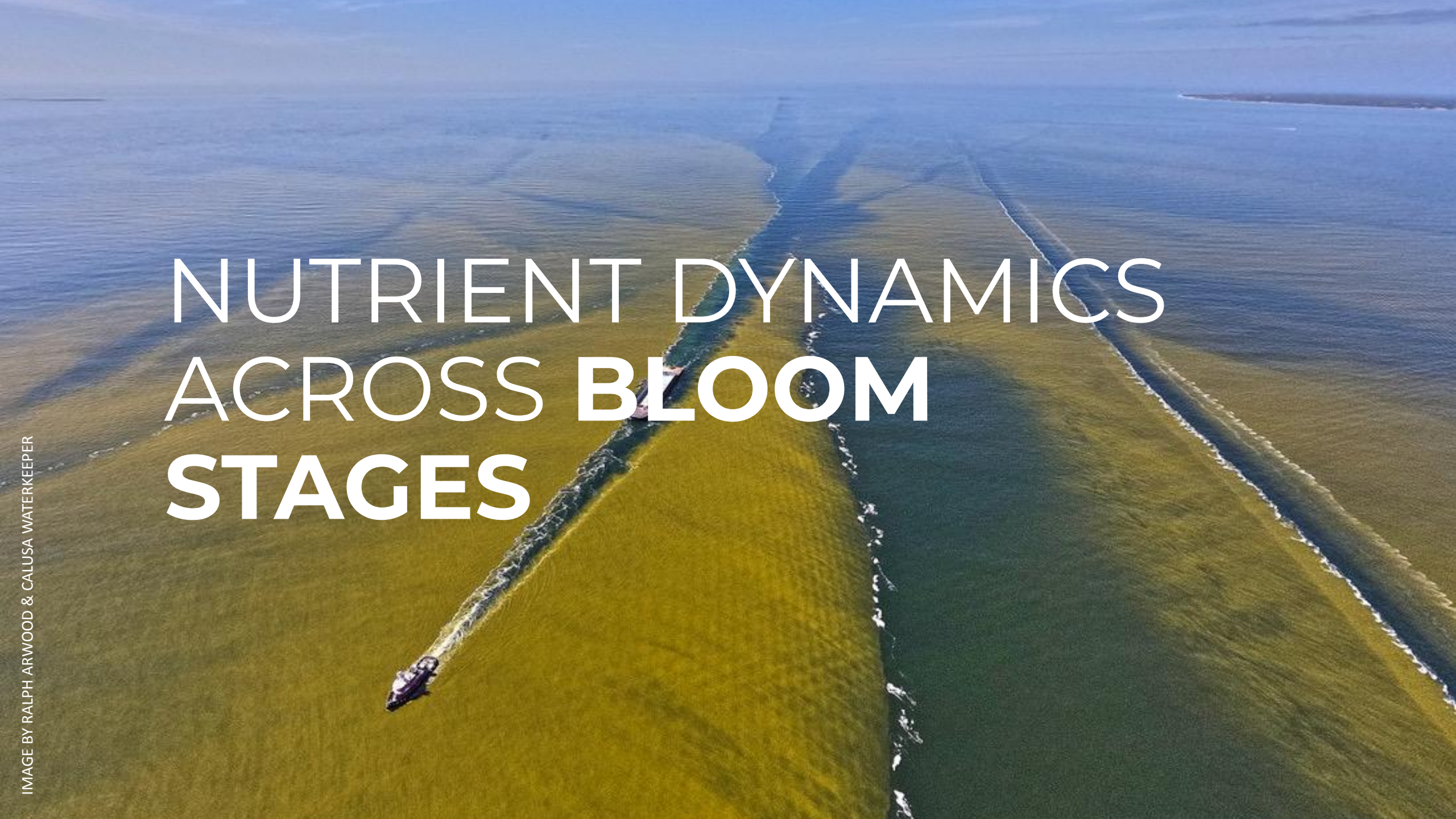


NUTRIENT DYNAMICS ACROSS **BLOOM STAGES**

IMAGE BY RALPH ARWOOD & CALUSA WATERKEEPER

West Florida Shelf nutrient and isotopic monitoring

Angela Knapp

Professor

Oceanography Dept., TAMU College Station, TX

IMAGE BY NOAA-NCCOS

HABs want to be where the nutrients are…

Select Harmful Algae Species:
Karenia brevis

Select Date Range:

From: 2020-01-01
To: 2024-01-31

Select Predefined Condition:
None

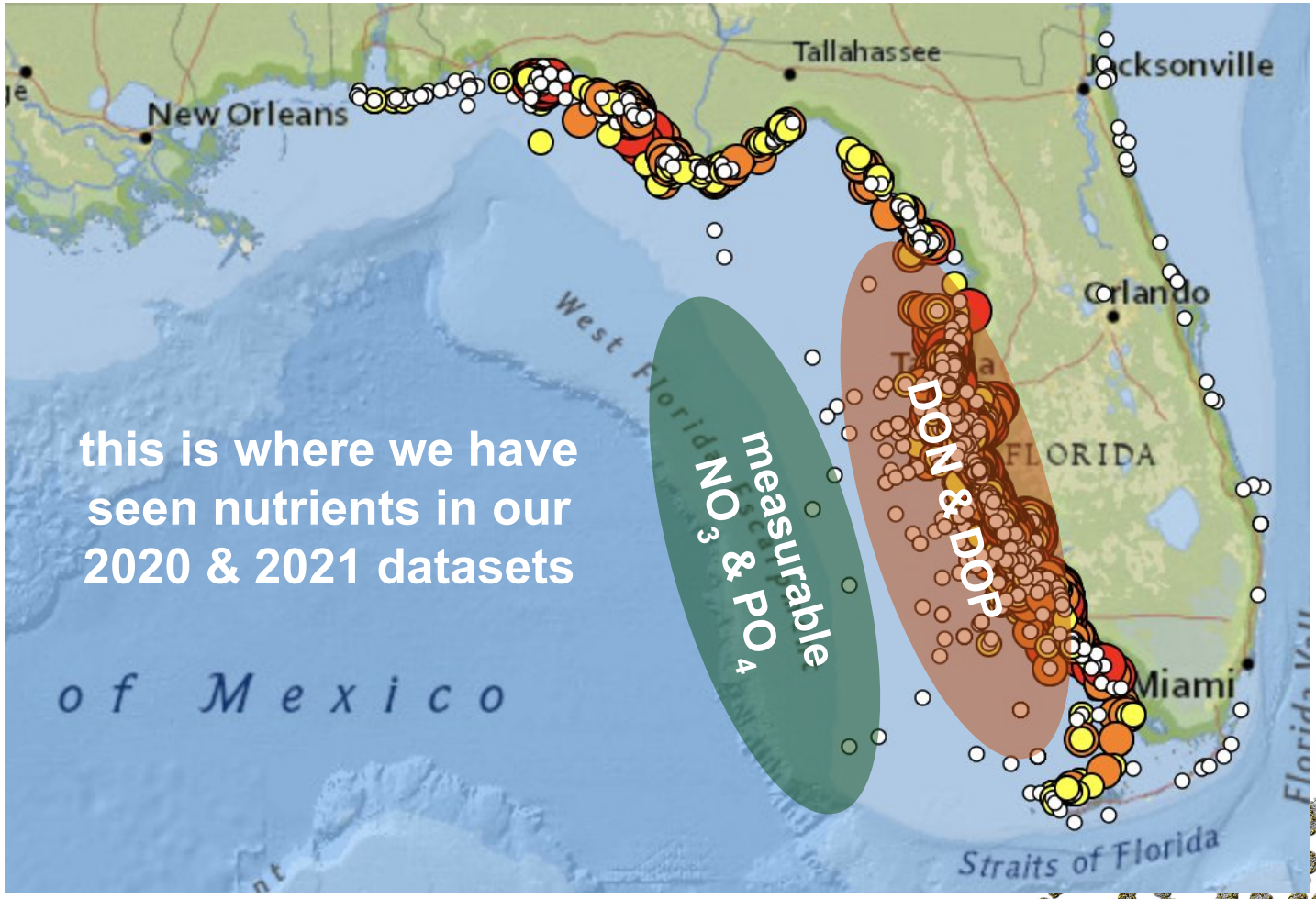
Search Database

Exclude "Not Observed" Reports (X)

Click on any of the displayed analysis points to get additional information.

Classification of Report Values:

- x Not Observed
- Very Low (1 - 10,000 cells/L)
- Low (10,000 - 100,000 cells/L)
- Medium (100,000 - 1,000,000 cells/L)
- High (1,000,000+ cells/L)



NOAA HABSOS

IMAGE BY NOAA-NCCOS

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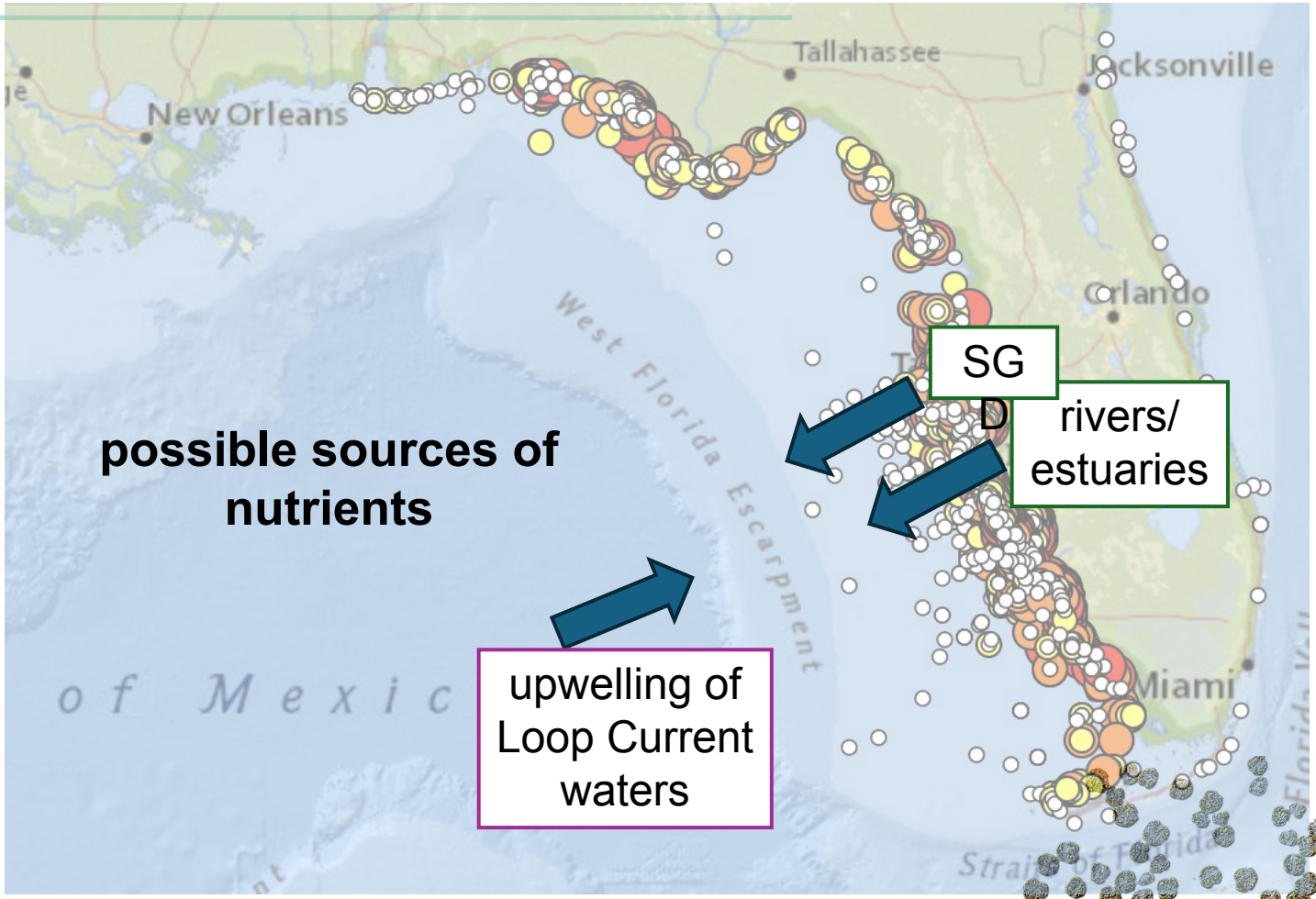


NOAA HABSOS

IMAGE BY NOAA-NCCOS

Goal:

- Evaluate the potential for inorganic and especially organic nutrients to support *K. brevis* blooms on West FL Shelf

- Use changes in nutrient concentration and isotopic composition, and correlated geochemical signatures, to identify the source of nutrients supporting *K. brevis*

IMAGE BY NOAA-NCCOS

Trichodesmium spp. as N source?

- Does biological di-nitrogen fixation provide N for *K. brevis*?

IMAGE BY NOAA-NCCOS

[DON] and [dFe]: Tricho related?

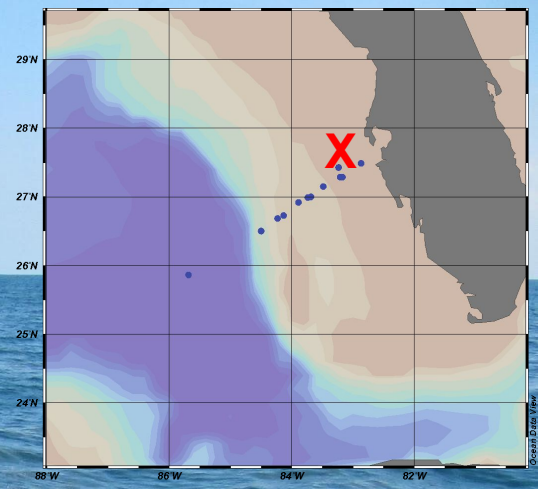


IMAGE BY NOAA-NCCOS

Does high, near-shore [DON] come from *Trichodesmium*?

How much N_2 fixation does it take to raise DON in a 20 m water column 12 µM (i.e., from 5 to 17 µM)?

5000 µmol N m^{-2} d^{-1} * 1 day * 20 m = 0.25 µM N

5000 µmol N m^{-2} d^{-1} * **20 days** * 20 m = 5 µM N

…Maybe we can't do this by N_2 fixation alone?

Inorganic nutrients as the source?

- Rivers, estuaries?
- Upwelling?

IMAGE BY NOAA-NCCOS

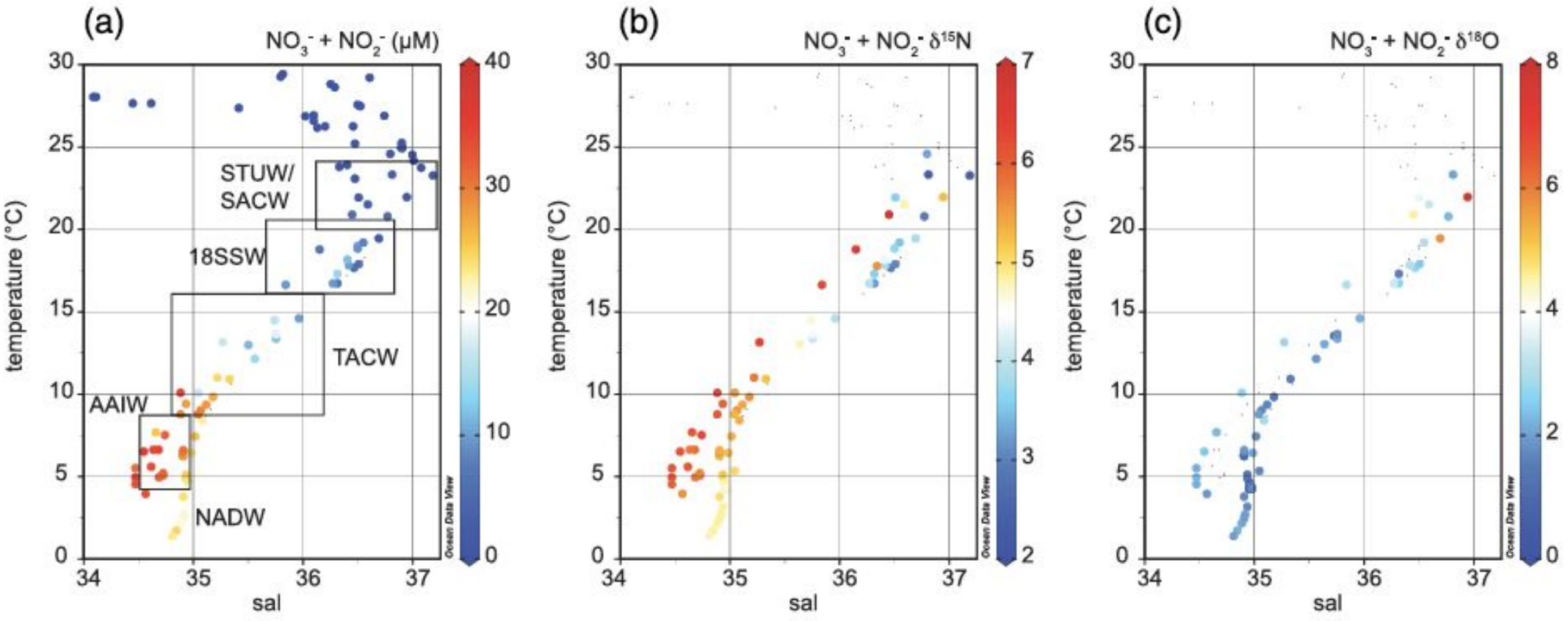
Inorganic nutrients as the source?

- Rivers, estuaries?
  - Inorganic nutrients don’t make it out of estuaries to WFS
  - Biofilter within rivers, estuaries
  - Lots of observational, modeling work to support this, including specifically around the Gulf (e.g., Sharples et al., 2017, Izett & Fennel, 2018, Howe et al., 2020, Mellett & Buck, 2020)

IMAGE BY NOAA-NCCOS

How to identify source of nutrients:

-NO_3+NO_2 $\delta^{15}N$ is unique and well-defined on density surfaces; **newly nitrified NO_3^- is isotopically distinct!**



Howe et al., 2020, JGR, Knapp et al., 2021, J. Plankton Res.

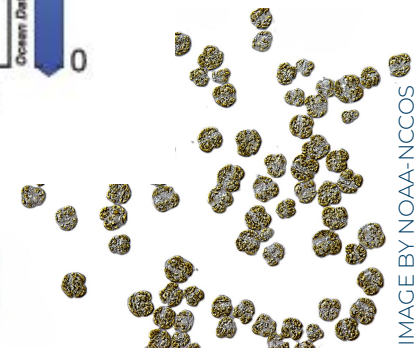


IMAGE BY NOAA-NCCOS

Organic nutrients as the source?

Methods matter! *Wet chemical oxidation of DON to NO_3^-, followed by "denitrifier" $\delta^{15}N$ analysis; cannot do this by high temperature combustion of TDN/DON*

IMAGE BY NOAA-NCCOS

Sources of DON on the WFS

1. Loop Current water: 4 to 5µM, $\delta^{15}N$: 4‰ DON (Knapp et al., 2005, 2011, 2021)

2. Submarine Groundwater Discharge: high conc. >20µM, $\delta^{15}N$: 2±1‰ DON (Knapp, unpublished)

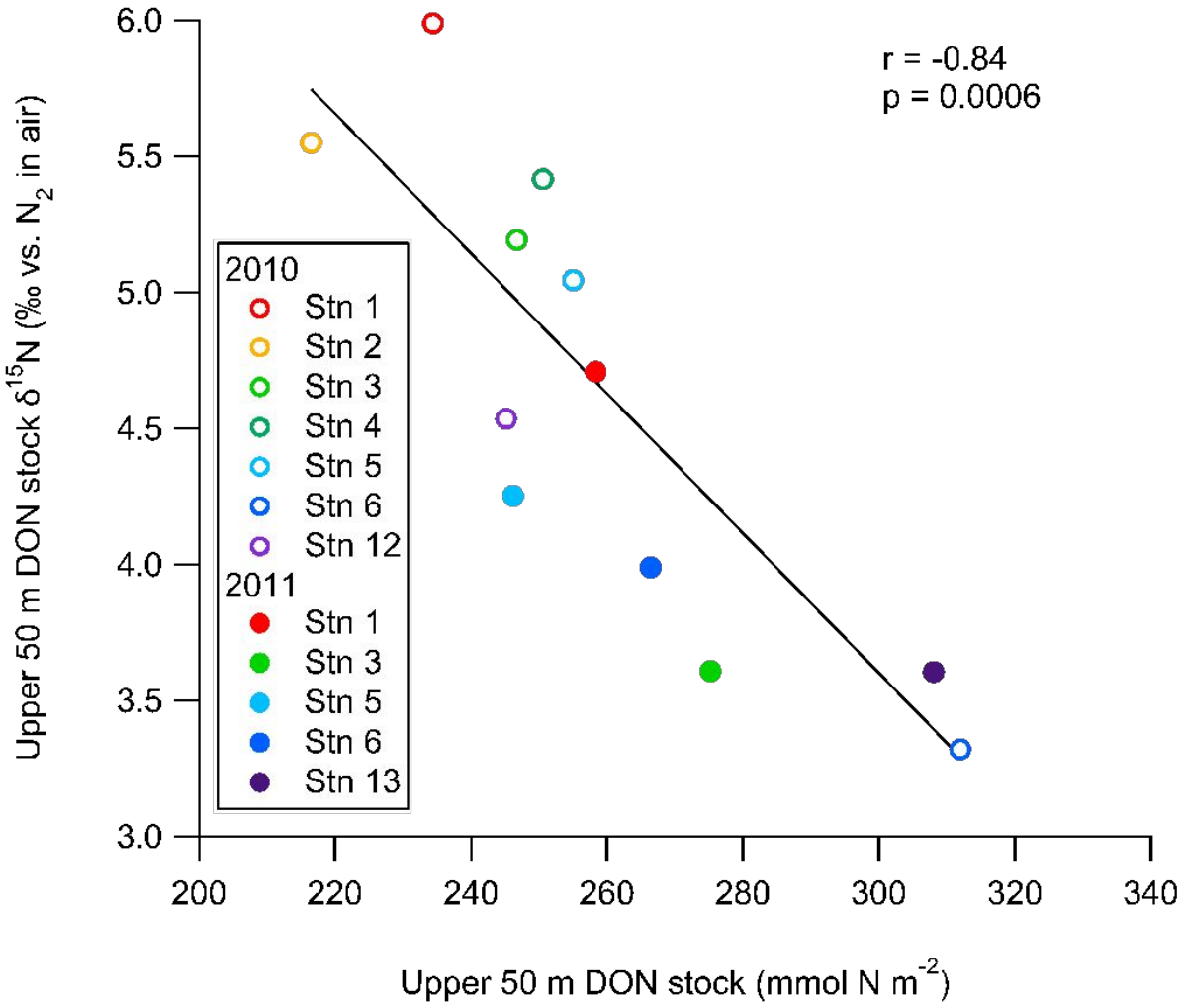
3. N_2 fixation: ↑[DON], ↓ $\delta^{15}N$ DON values ~ -1‰ (Hoering and Ford, 1960; Minigawa and Wada, 1986; Carpenter et al., 1997)

4. Consumption of DON: ↓[DON], ↑ DON $\delta^{15}N$ (Knapp et al., 2018; Zhang et al., 2020)

IMAGE BY NOAA-NCCOS

How to evaluate role of organic nutrients:

-Look for [DON] decrease with associated DON $\delta^{15}N$ increase



First time DON consumption with an isotope effect was observed; ETSP

- Subsequently confirmed in other regions w/ productivity gradients

Knapp et al., 2018, Global Biogeochemical Cycles

IMAGE BY NOAA-NCCOS

Complimentary work: $2.3 million, 7-PI, NSF – "STING" project

1) SGD is the dominant source of bioavailable DON, dFe, and Fe-binding ligands on the WFS

2) Alleviation of dFe stress by SGD inputs changes the dominant *Trichodesmium* species and increases N_2 fixation rates on the WFS

3) dFe-stressed diazotroph populations modify DON and dFe concentration, isotopic, and chemical composition, as well as Fe-binding ligand abundance and composition, on the WFS

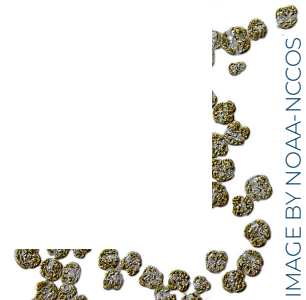
Complimentary work: $2.3 million, 7-PI, NSF – "STING" project

-Quarterly characterization of geochemistry in SGD, rivers, estuaries to quantify elemental fluxes;

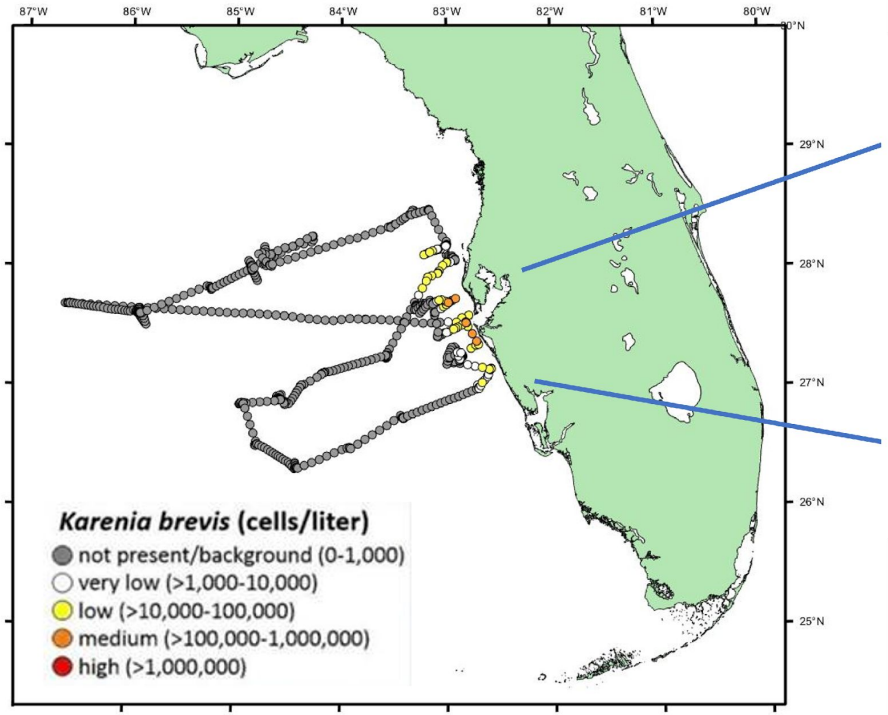
-two cross-shelf cruises: Feb/Mar and July 2023

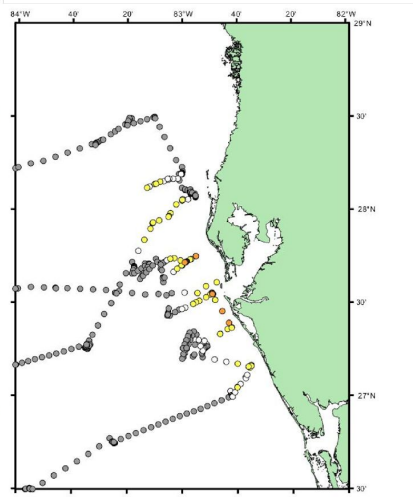
- Link geochemistry (nutrients, metals, radium, organic matter composition) to C, N_2 fixation rates, *Trichodesmium* spp., phyto species and their abundance, gene expression

- Use this info to interpret data from FWC cruises



Significant *Karenia brevis* bloom Feb/Mar 2023; [chl] ≥6 µg L^{-1}





FFWC
Imaging
Flow
Cytobot
Data

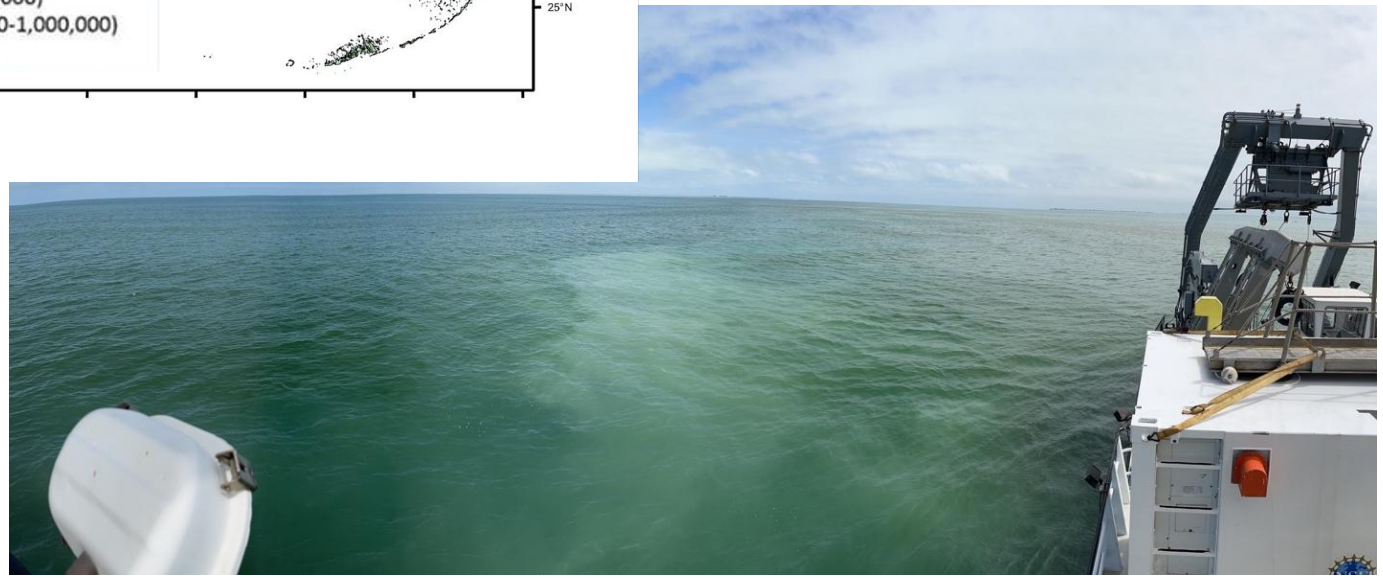


IMAGE BY NOAA-NCCOS

SUMMARY

-Need to measure BOTH inorganic (rarely present) and organic nutrients

-$\delta^{15}N$ of NO_3^-+NO_2^- and DON can be used as tracers of source (including upwelling of Loop Current water, rivers, SGD, nitrification) and, together with concentration data, biological consumption

-*K. brevis* needs P, Fe in addition to N! SGD has all, and lots of it; should see distinct stoichiometries for consumption; **upwelling favorable winds as mechanism?**

IMAGE BY NOAA-NCCOS

ACKNOWLEDGEMENTS

Dr. Chelsie Bowman, postdoc; FFWC-FWRI; Kate Hubbard, Julie Koester

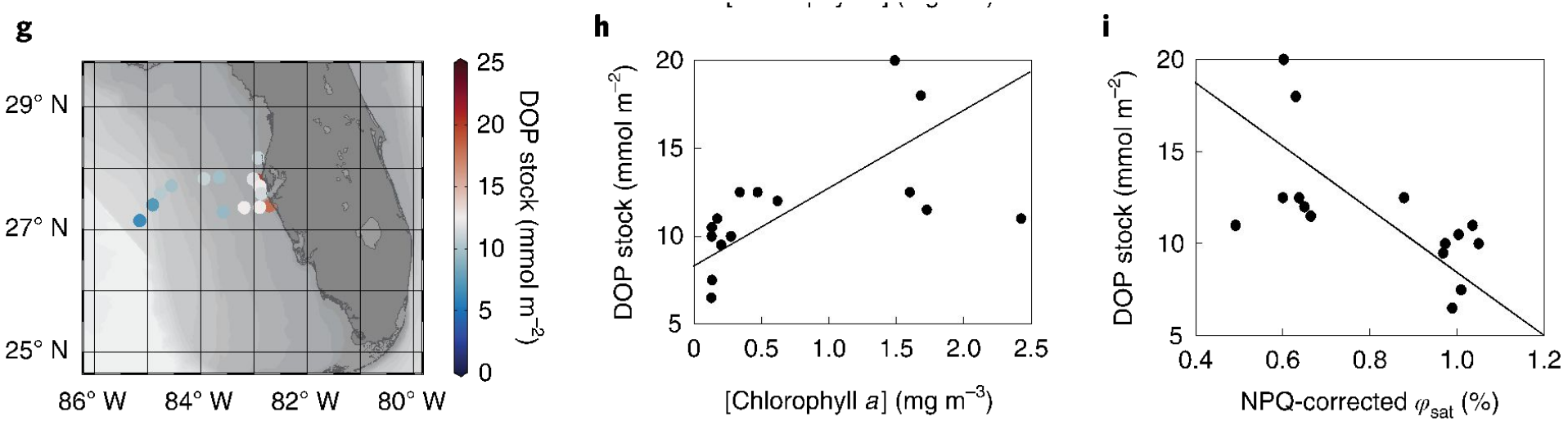
NSF-Chemical Oceanography; Rene Boiteaeu (U. Minn.), Kristen Buck (OSU), Dreux Chappell (USF), Tim Conway (USF), Chris Smith (USGS-St. Pete), Joe Tamborski (ODU), Eric Webb (USC)

IMAGE BY NOAA-NCCOS

How to evaluate role of organic nutrients:

-Look for [DOP] decrease with correlated [DON] decrease, DON $\delta^{15}N$ increase

WFS is a unique region globally as net source of DOP to ocean! Likely an SGD source

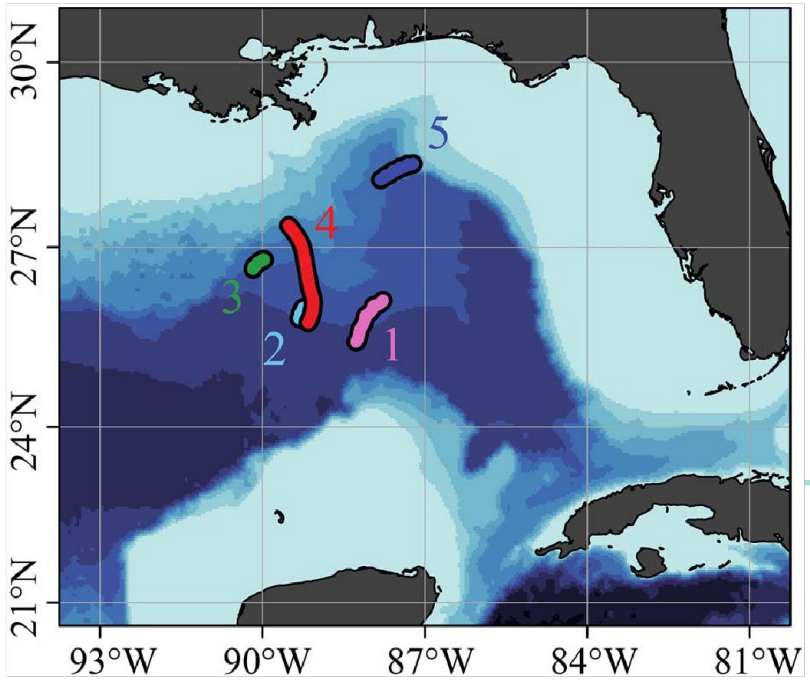


Liang, Letscher, and Knapp, 2022, Nature Geosciences

IMAGE BY NOAA-NCCOS

How to identify source of nutrients:

-If inorganic, look at NO_3+NO_2 $\delta^{15}N$; unique on density surfaces



Knapp et al., 2021, J. Plankton Res.

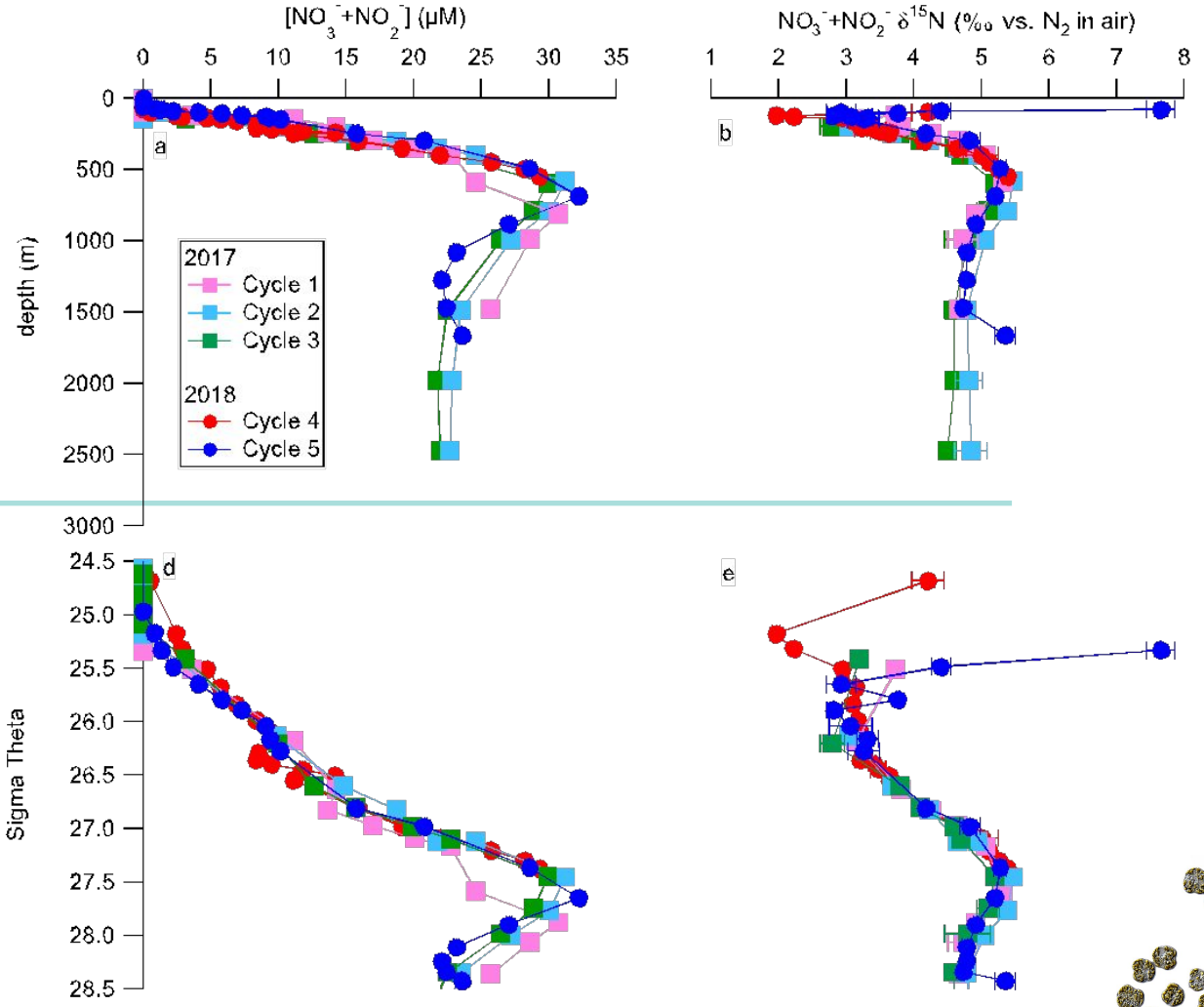


IMAGE BY NOAA-NCCOS

How to identify source of nutrients:

-Compare [DON], DON $\delta^{15}N$ from "Loop Current" with that measured on WFS

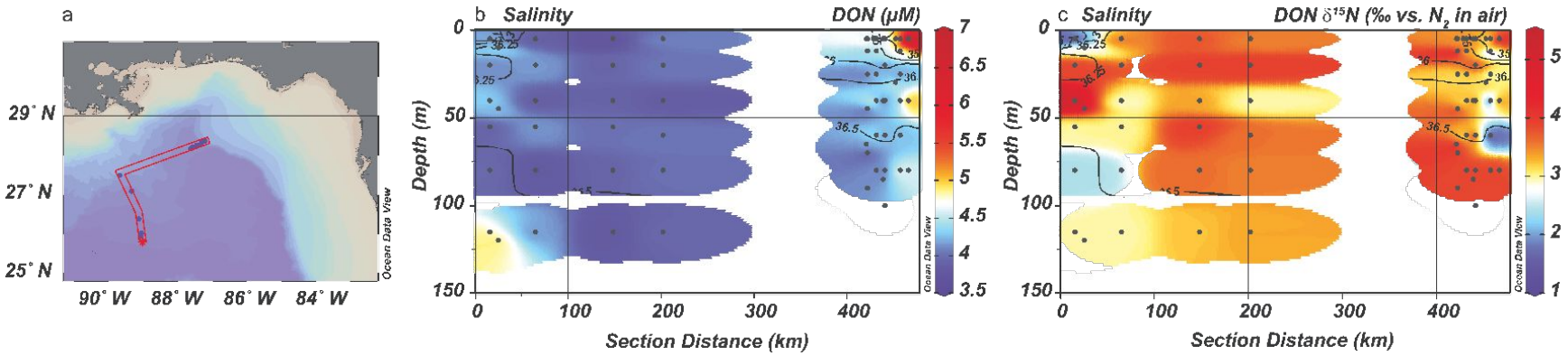
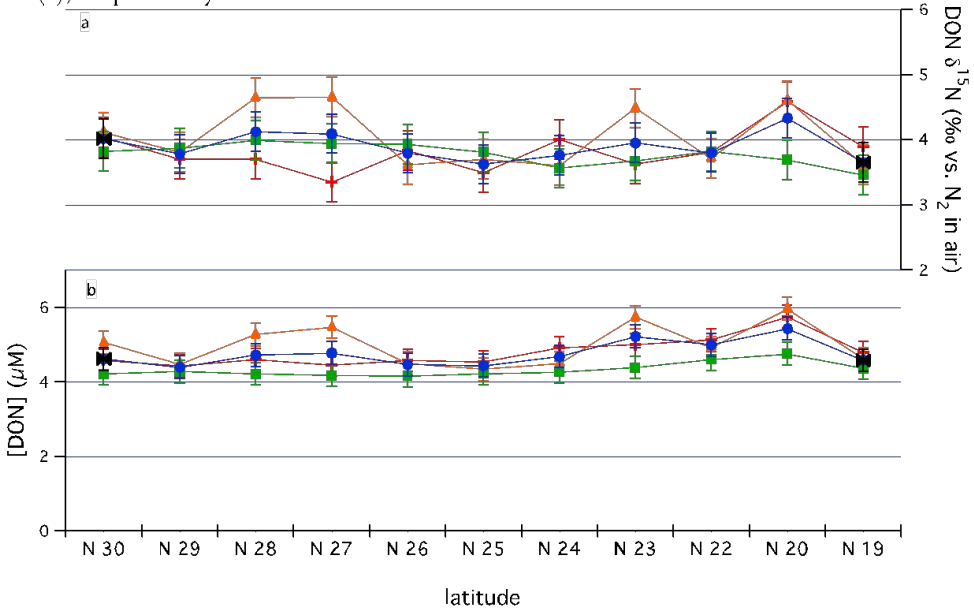


Fig. 4. Location of sampling during the 2018 cruise (a) with concentration (b) and $\delta^{15}N$ (c) of DON in the upper 150 m. Cross-section begins at southwest end and finishes at northeast end of transect. Salinity contours overlay DON concentration and $\delta^{15}N$ color contours in panels (b) and (c), respectively.



Atlantic [DON]: 4.0 ± 0.5 μM

Atlantic DON $\delta^{15}N$: 4.0 ± 0.5‰

Knapp et al., 2005, GBC

Knapp et al., 2011, GBC

Knapp et al., 2021, JPR

IMAGE BY NOAA-NCCOS