


Mechanism for the Recurrence of Pelagic Sargassum in the Tropical Atlantic: Biological Consequences of Mid-Ocean Surface Aggregation and Nutrient Supply Processes

Frank Muller-Karger, Libby Johns, Cisco Werner, Rick Lumpkin, Nathan Putman, Ryan Smith, Digna Rueda-Roa, Chuanmin Hu, Mengqiu Wang, Maureen T. Brooks, Lewis J. Gramer

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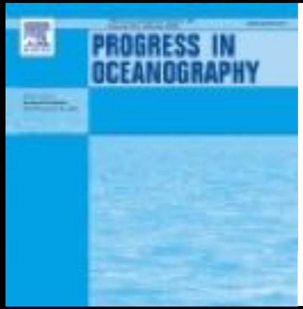
Marine Biodiversity Observation Network




Outline



The establishment of a pelagic *Sargassum* population in the tropical Atlantic: Biological consequences of a basin-scale long distance dispersal event

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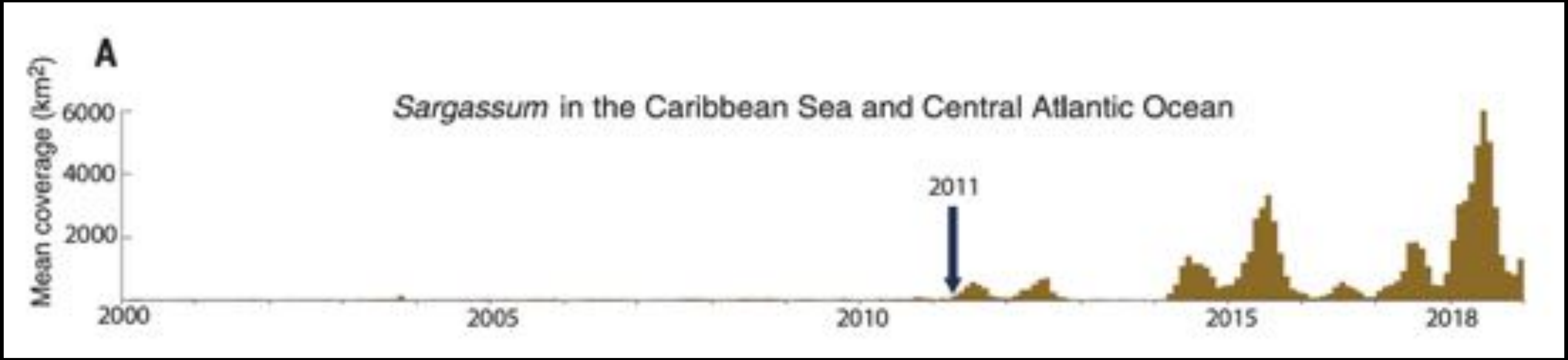
- Background
- Sustained growth and recurring inundations
- **<u>Recommendations</u>: research on bloom mechanisms <u>to improve forecasting</u>**

Time series of *Sargassum* cover in the tropical Atlantic

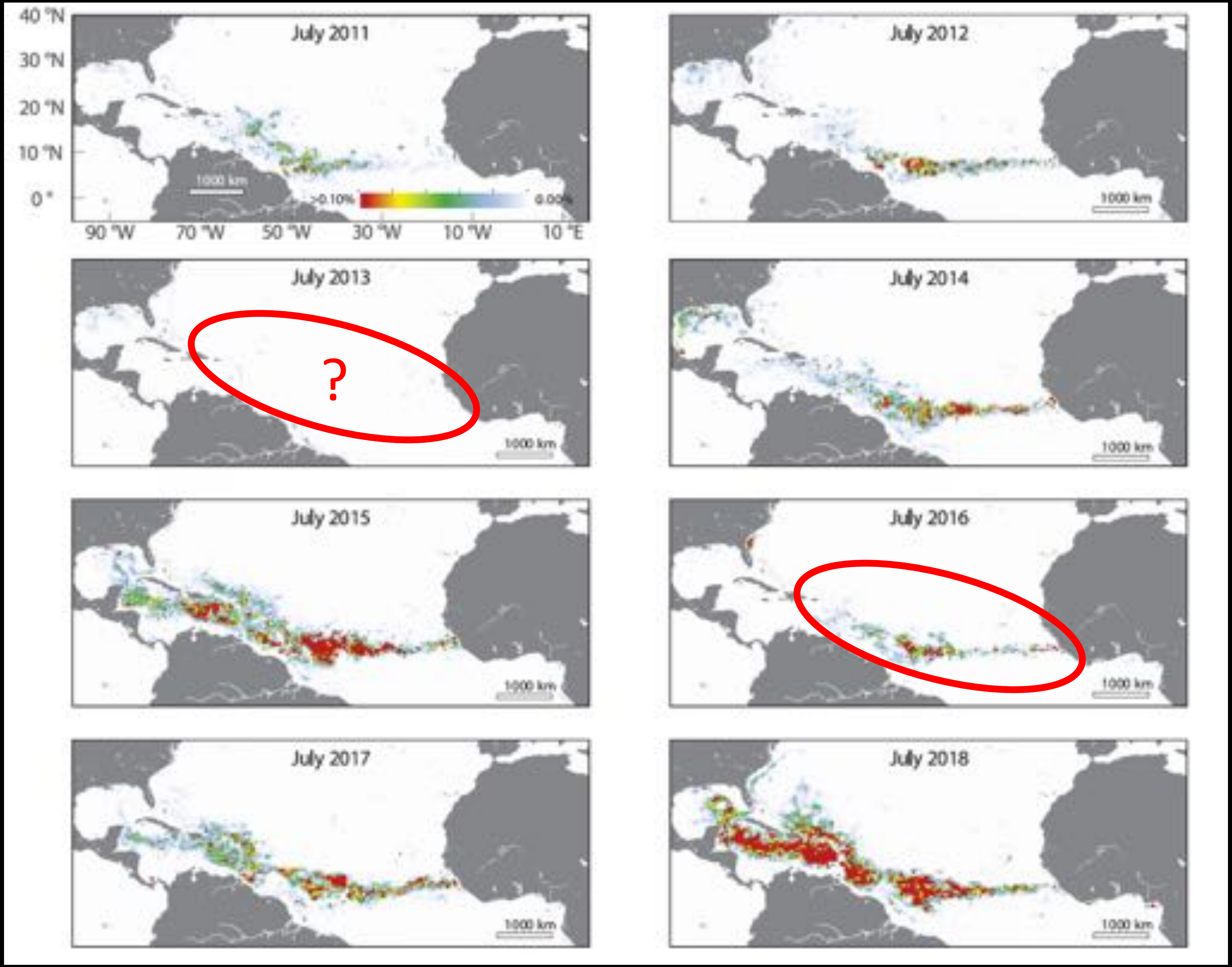


Wang et al. Science (2019)

Interannual variability

- Monthly mean *Sargassum* density for the month of July from 2011 to 2018.
- The GASB* is observed in all years except 2013.

*Great Atlantic *Sargassum* Belt



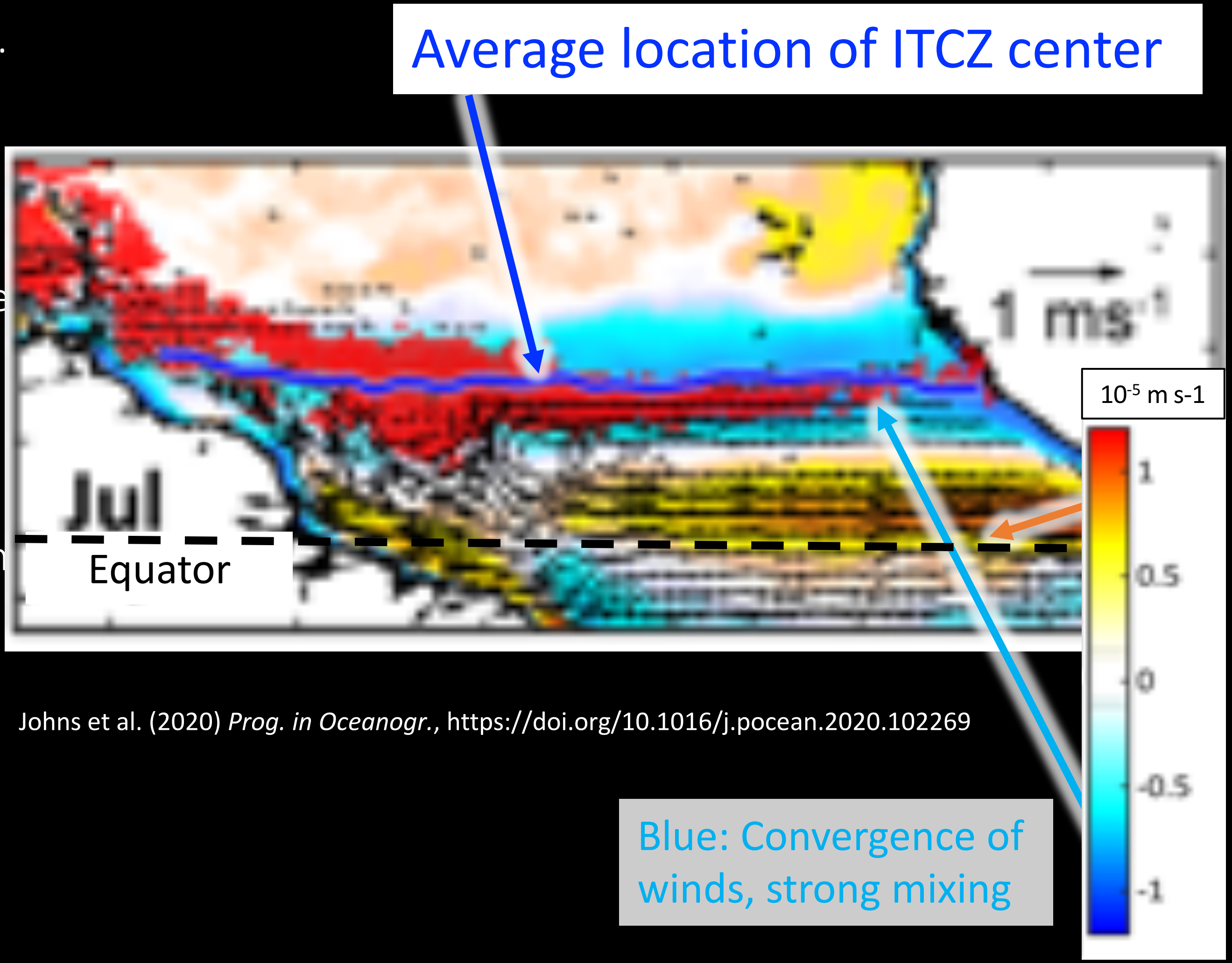
Wang et al. Science (2019)

What fuels the recurrence of the blooms and what determines their seasonality?

Sargassum patches aggregate in windrows along the ITCZ.

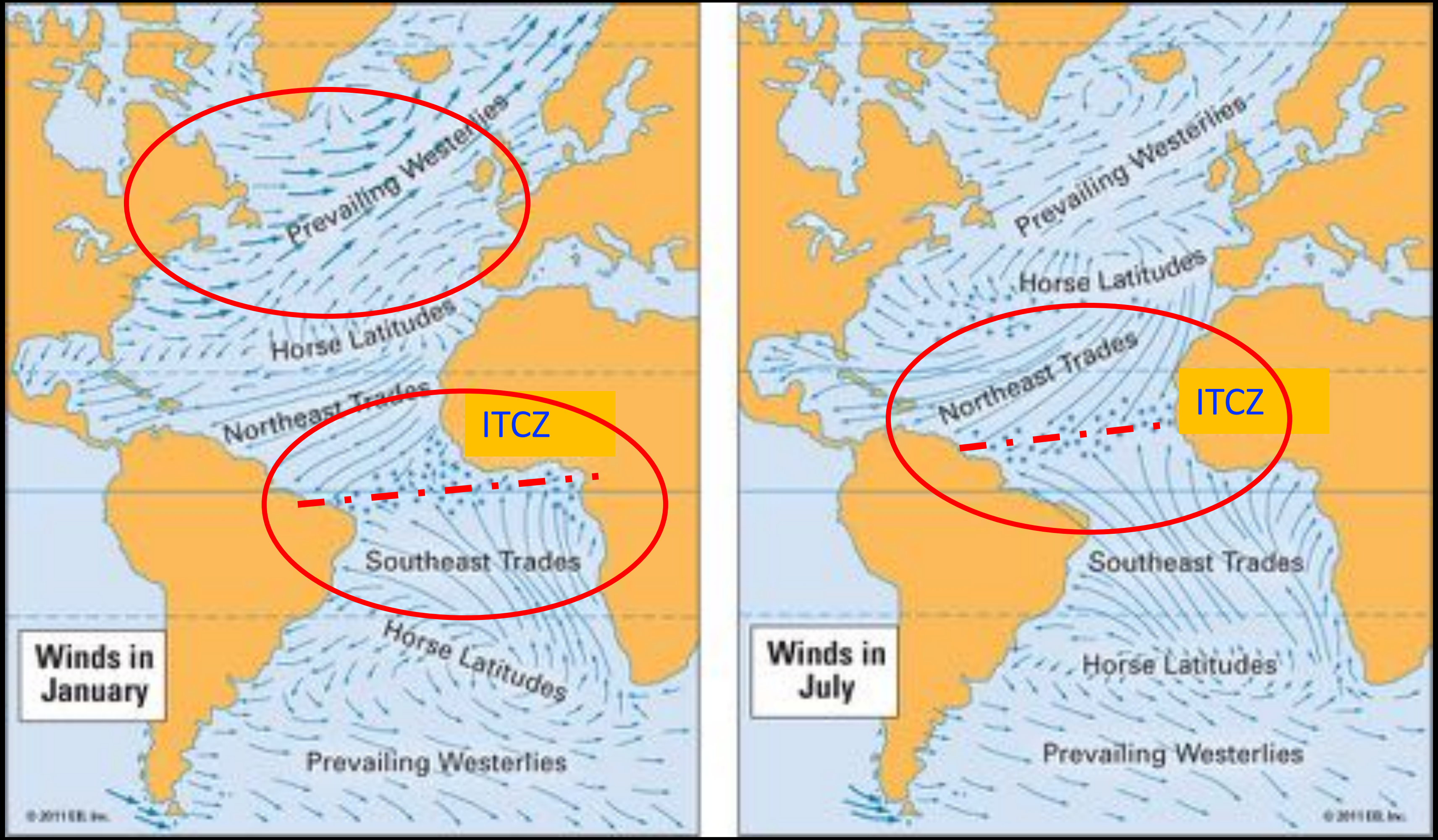
Patches and windrows are exposed to high sunlight and open-ocean upward flux of nutrients due to eddy and wind-driven mixing in the central tropical Atlantic (Johns e al. (2020):

- During the northern spring and summer, the *Sargassum* drifts north with the ITCZ, and large portions are advected into the eastern Caribbean Sea.
- If wind mixing is strong and the mixed layer is deeper than ~50–60m in the southern tropical Atlantic, the *Sargassum* will bloom and form a massive windrow.



Johns et al. (2020) *Prog. in Oceanogr.*, https://doi.org/10.1016/j.pocean.2020.102269

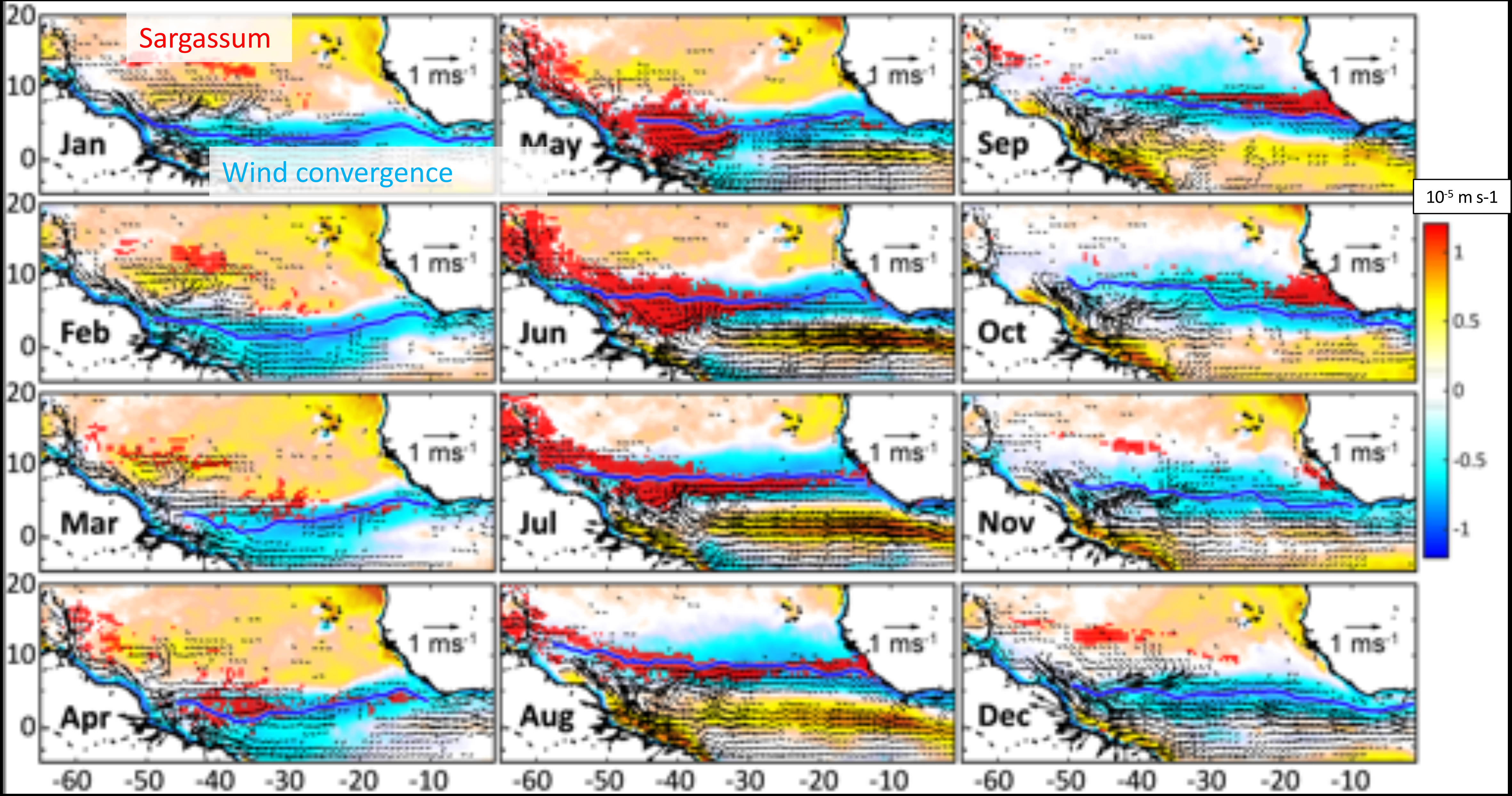
Physical setting: prevailing winds and the ITCZ (Inter-Tropical Convergence Zone)



Encyclopædia Britannica, Inc.

Taylor et al. Ecosystem responses in the southern Caribbean Sea to global climate change, *PNAS*, 2012; https://doi.org/10.1073/pnas.1207514109

Seasonal Dynamics (monthly averages 2010-2018)



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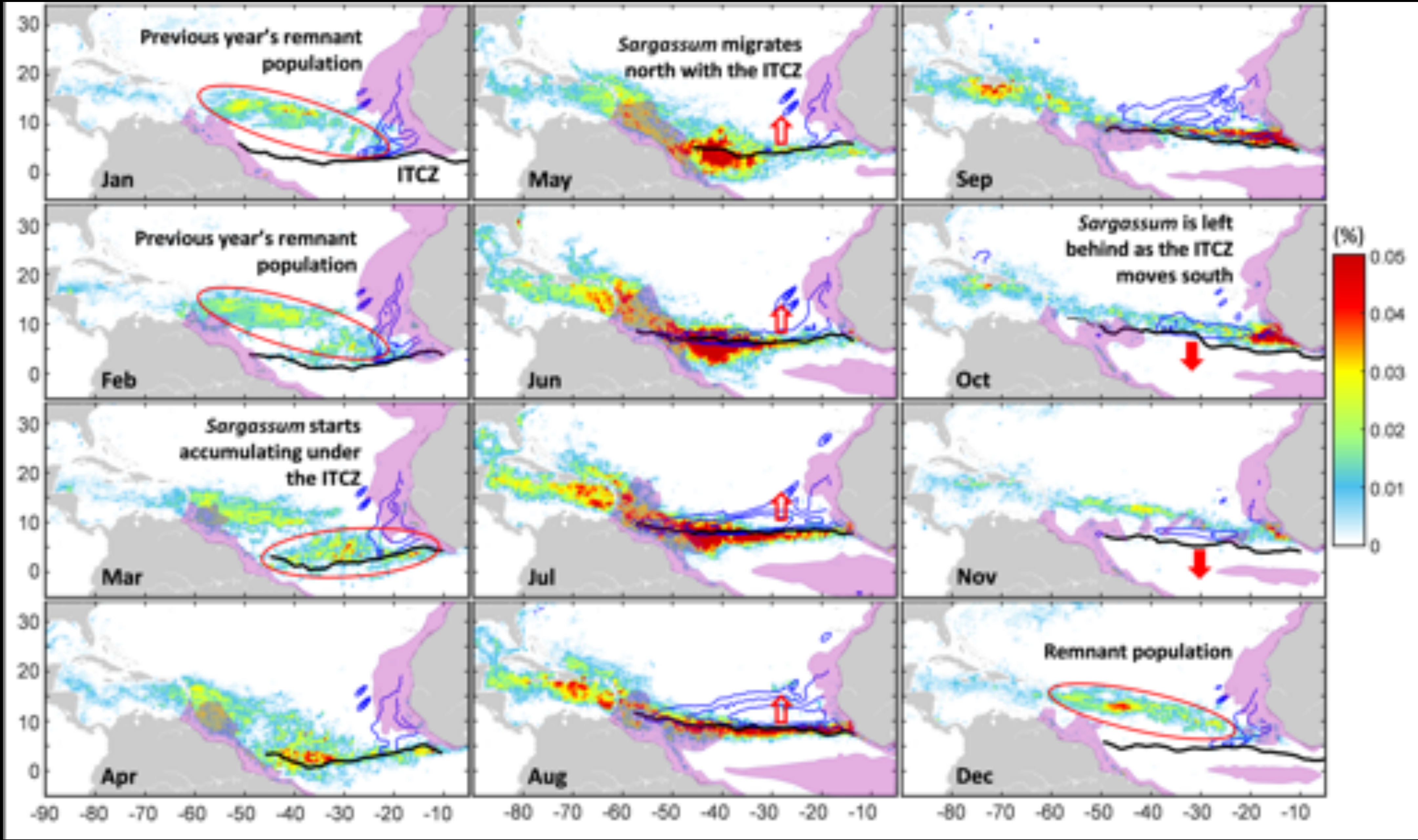

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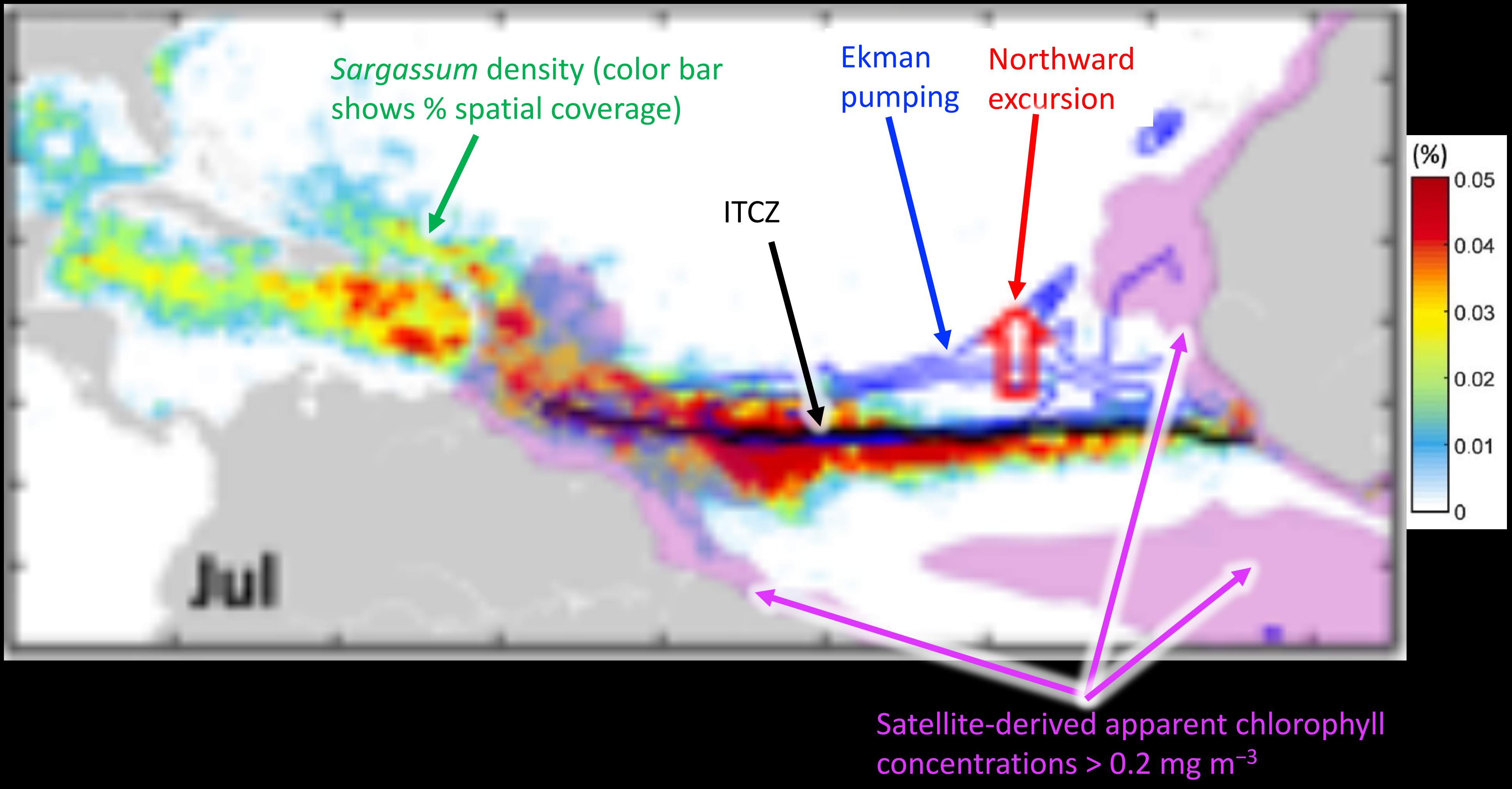

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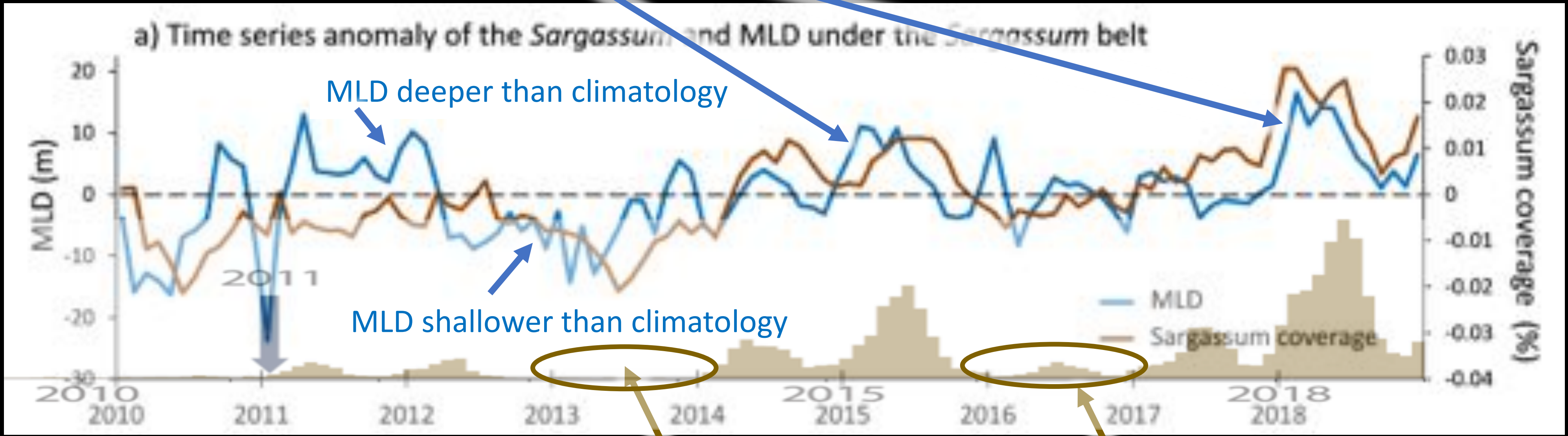
Mixed layer and nutrient dynamics

- The most intense *Sargassum* blooms were observed when the deepest MLD (and strongest trade winds) were observed.



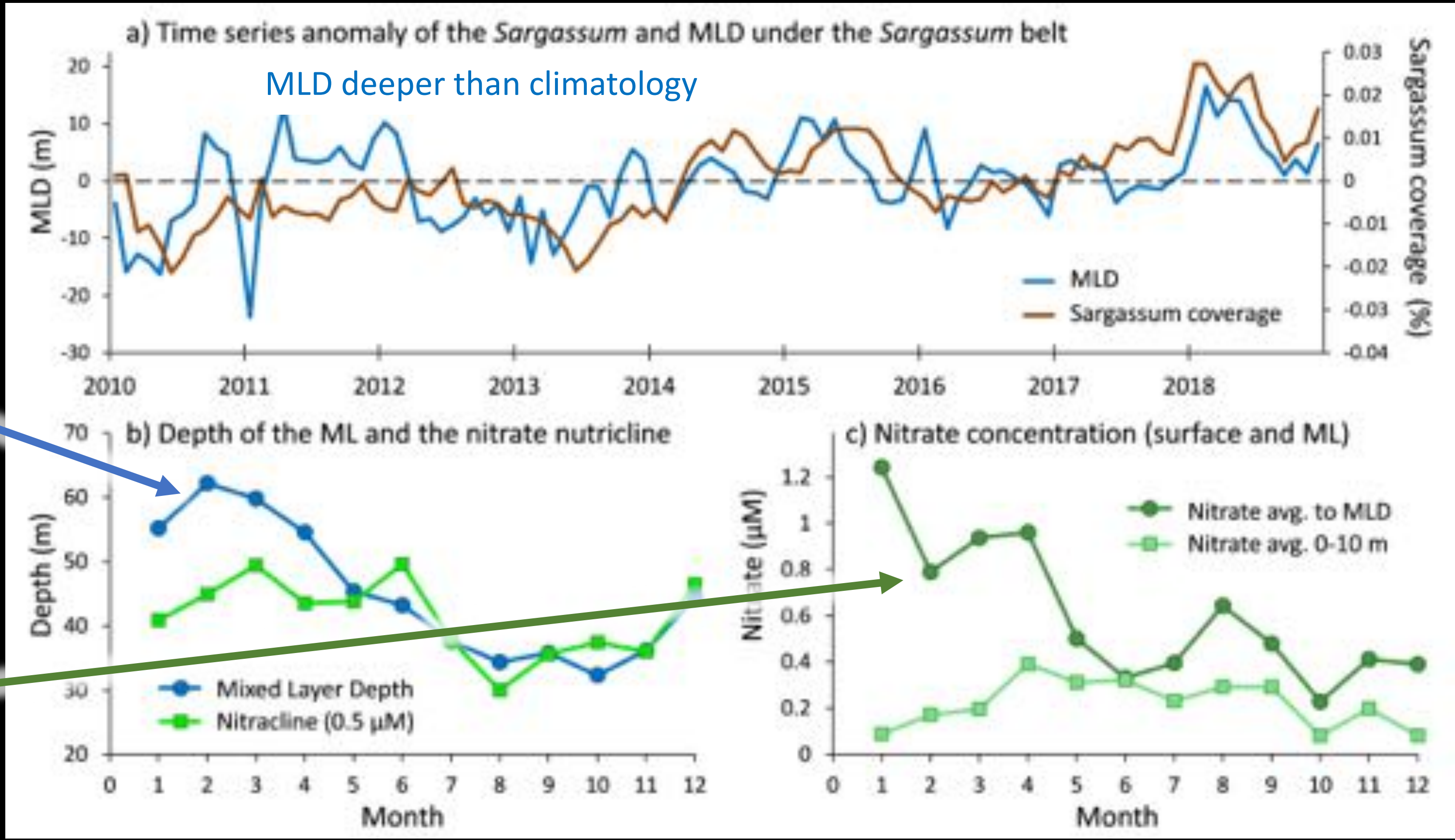
- When the MLD remained shallow relative to the climatology during October to December (2012 and 2015), the bloom the following year was absent (as in 2013), or smaller and delayed (as in 2016). Indeed, the MLD was shallower than normal for several months in 2012–2013, before a minimum in *Sargassum* was observed in 2013.

Johns et al. (2020) *Prog. in Oceanogr.*, https://doi.org/10.1016/j.pocean.2020.102269
Wang et al. Science (2019)

Mixed layer and nutrient dynamics

The MLD can be deep enough so that nutrients are available to the large accumulation of the *Sargassum* in the equatorial Atlantic.

- The seasonal variability of the MLD under the *Sargassum* belt tends to be deeper than or similar to the nitrate nutricline.
- Nitrate averaged within the MLD was usually higher than the nitrate concentration averaged over the first 10m of the surface.



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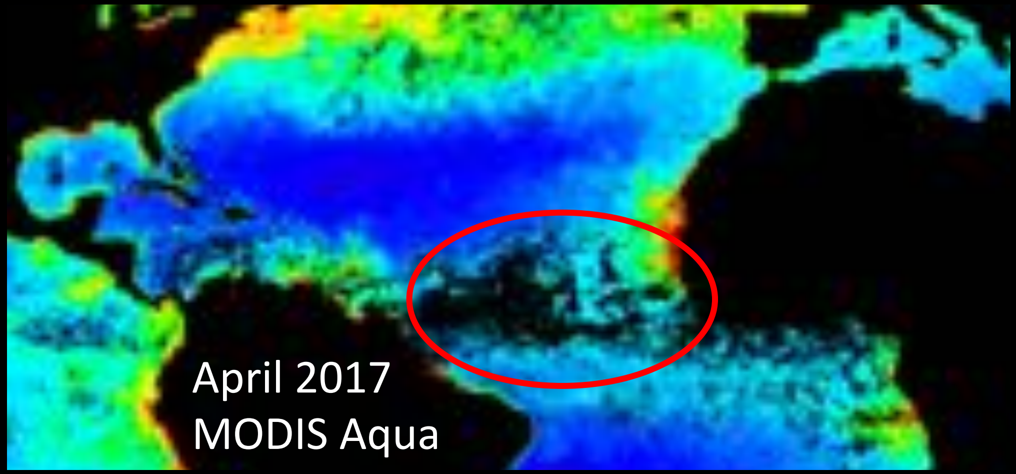
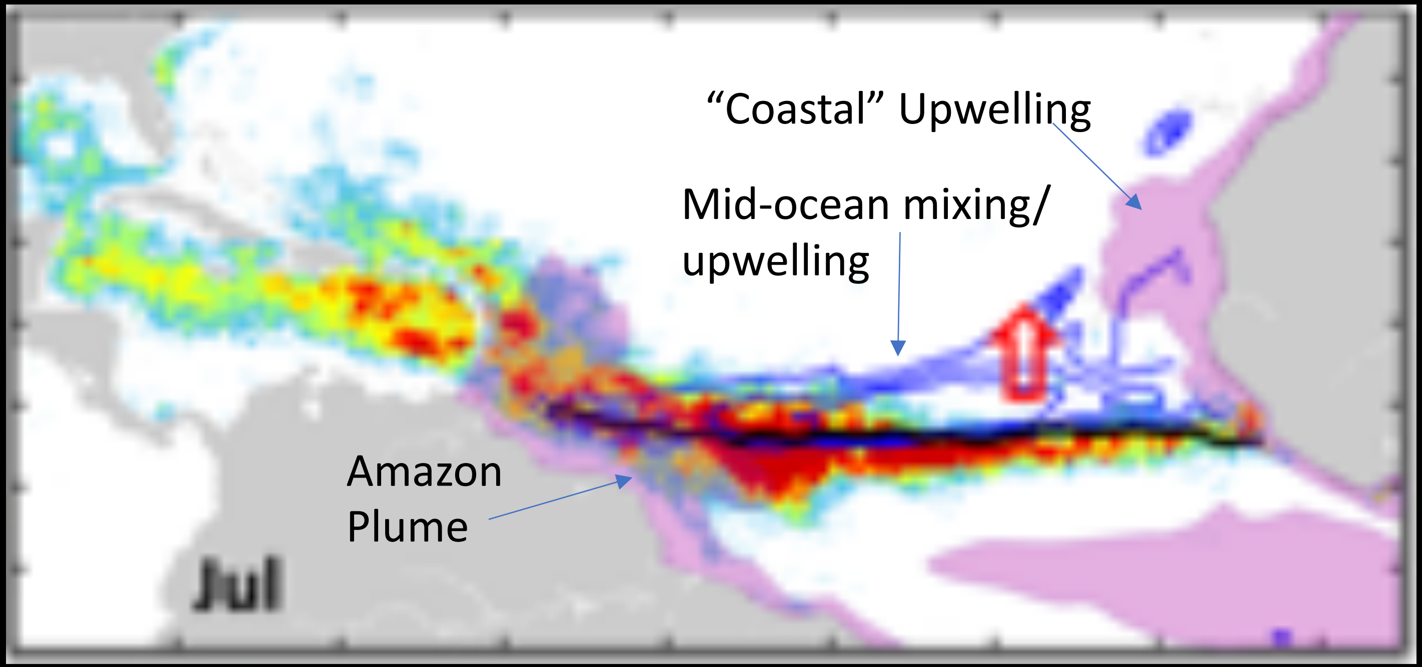
Ideas for Research

- Remote sensing: we have not fully used these data
  - Multiple datasets (wind, ocean color to study chl-a/blooming, etc.)

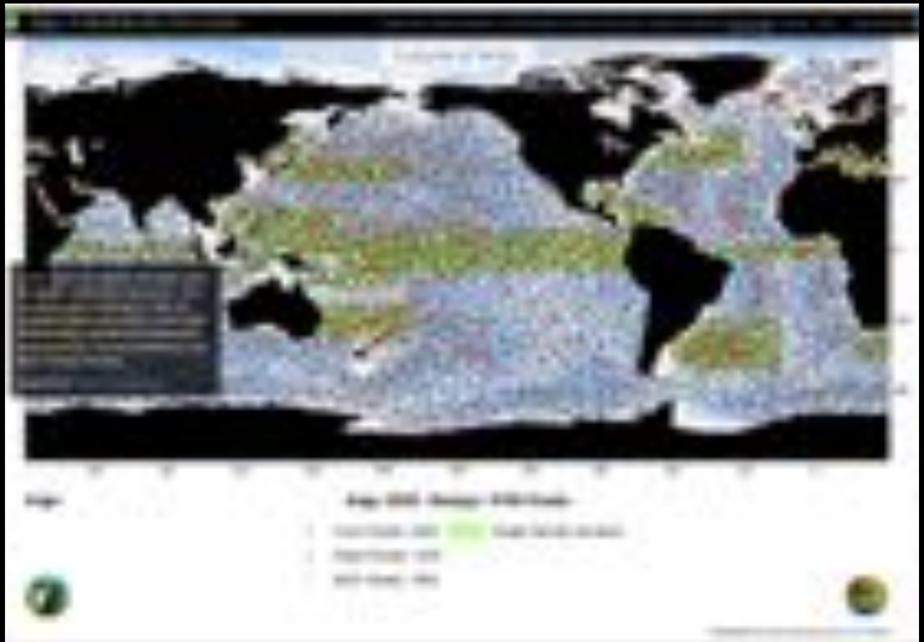


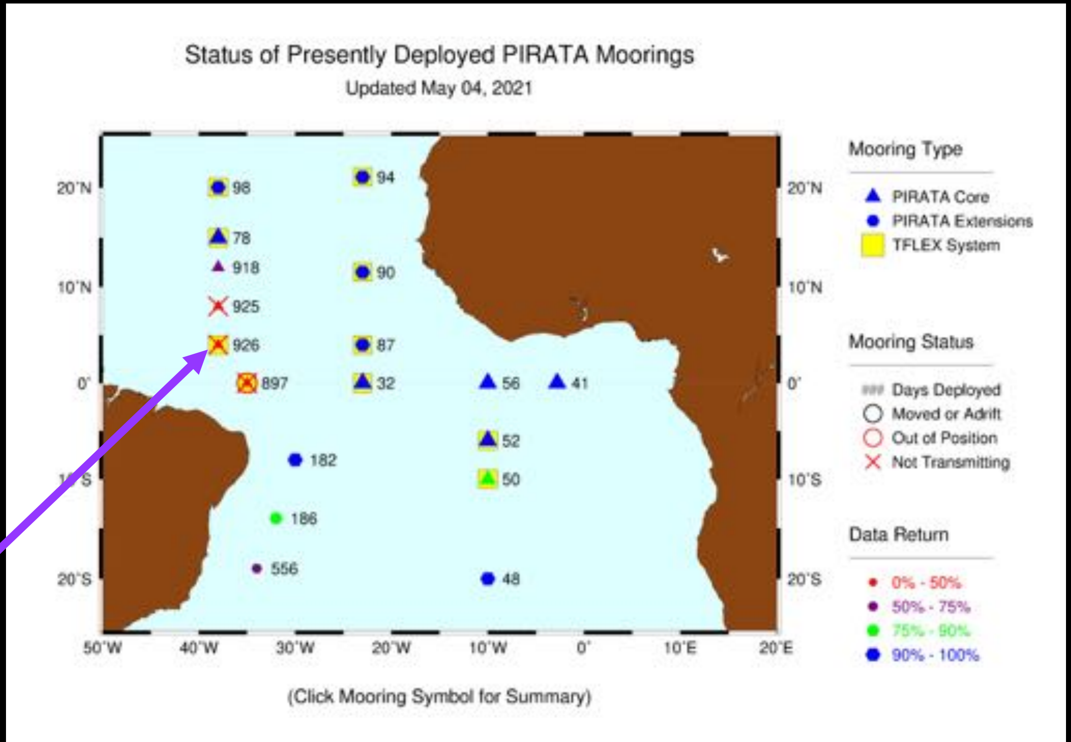
- Models:
  - ECCO
  - Eddy mixing/turbulence
  - Statistical or dynamic nutrient-driven model of Sargassum blooming?



Ideas for Research

- Field data:
  - Argo floats (+BGC Argo):
    - Detect changes in buoy behavior? (vertical motions in buoys)
    - Variability in thermocline / nutricline (BGC Argo)





[PIRATA Mooring Status (noaa.gov)](https://www.pmel.noaa.gov/tao/drupal/disdel/)

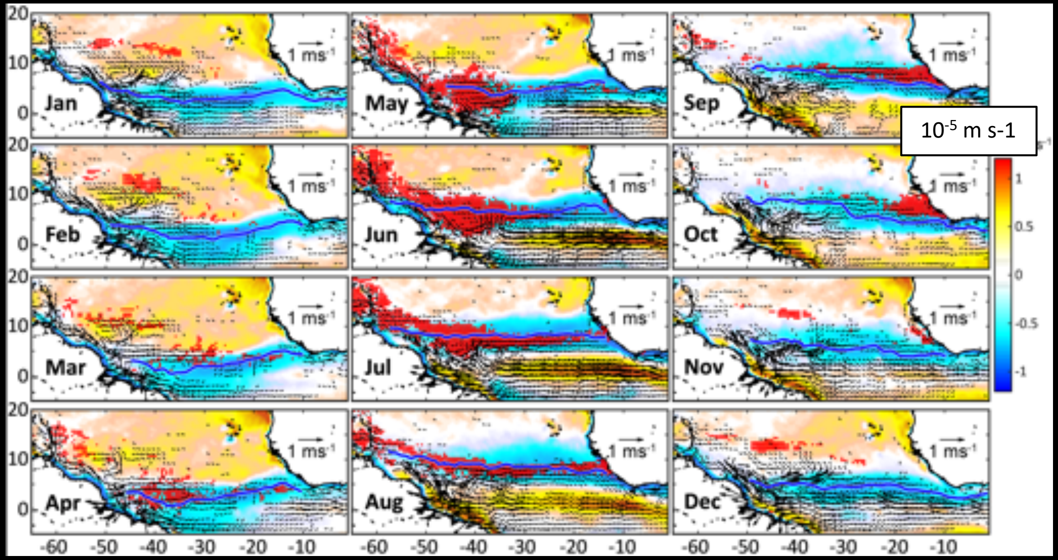
  - PIRATA array: examine hydrography and current profiles
    - The 4N,38W mooring has not transmitted ~ 2+years
  - Analyze data from dedicated cruises, gliders to measure vertical fluxes
    - (Argo servicing, AMT, etc) https://www.aoml.noaa.gov/phod/pne/cruises.php

Data: https://www.pmel.noaa.gov/tao/drupal/disdel/

Ideas for Research

Goal: Improve forecasts of bloom intensity

- Test hypothesis: Role of seasonal vertical mixing due to eddy turbulence, wind mixing, Ekman Pumping associated with ITCZ and changing subsurface thermocline structure



Remarks on seasonal offshore nutrient inputs to surface

- upward eddy diffusion
- entrainment due to mixed layer deepening by winds/convergence
- positive Ekman pumping (open-ocean upwelling) due to the wind stress curl
- Amazon River plume (W Atlantic, NECC)
- Data:
  - PIRATA, Argo float, satellite data, World Ocean Database, cruise of opportunity

(Photo by Alain Brin, Blue Glass Photography.)

Ideas for Research

- Impacts on ecosystems and people:
  - Surface ocean
  - Coastal
  - Deep ocean

Baker et al. (2017) lots of Sargassum found on bottom at ~5,000 m in transect ~10N across the Atlantic
https://www.sciencedirect.com/science/article/pii/S0967064516304283?via%3Dihub

Thank you!

https://www.nytimes.com/es/2019/08/16/espanol/america-latina/sargazo-playas-mexico.html

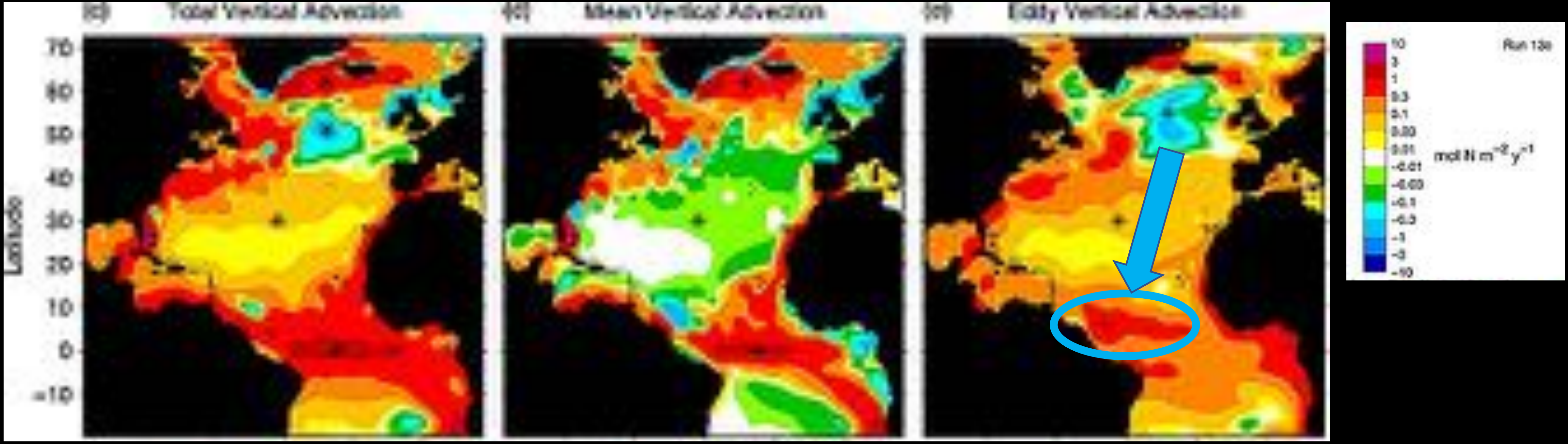
https://www.sportfishingmag.com/sargassum-and-mahi/

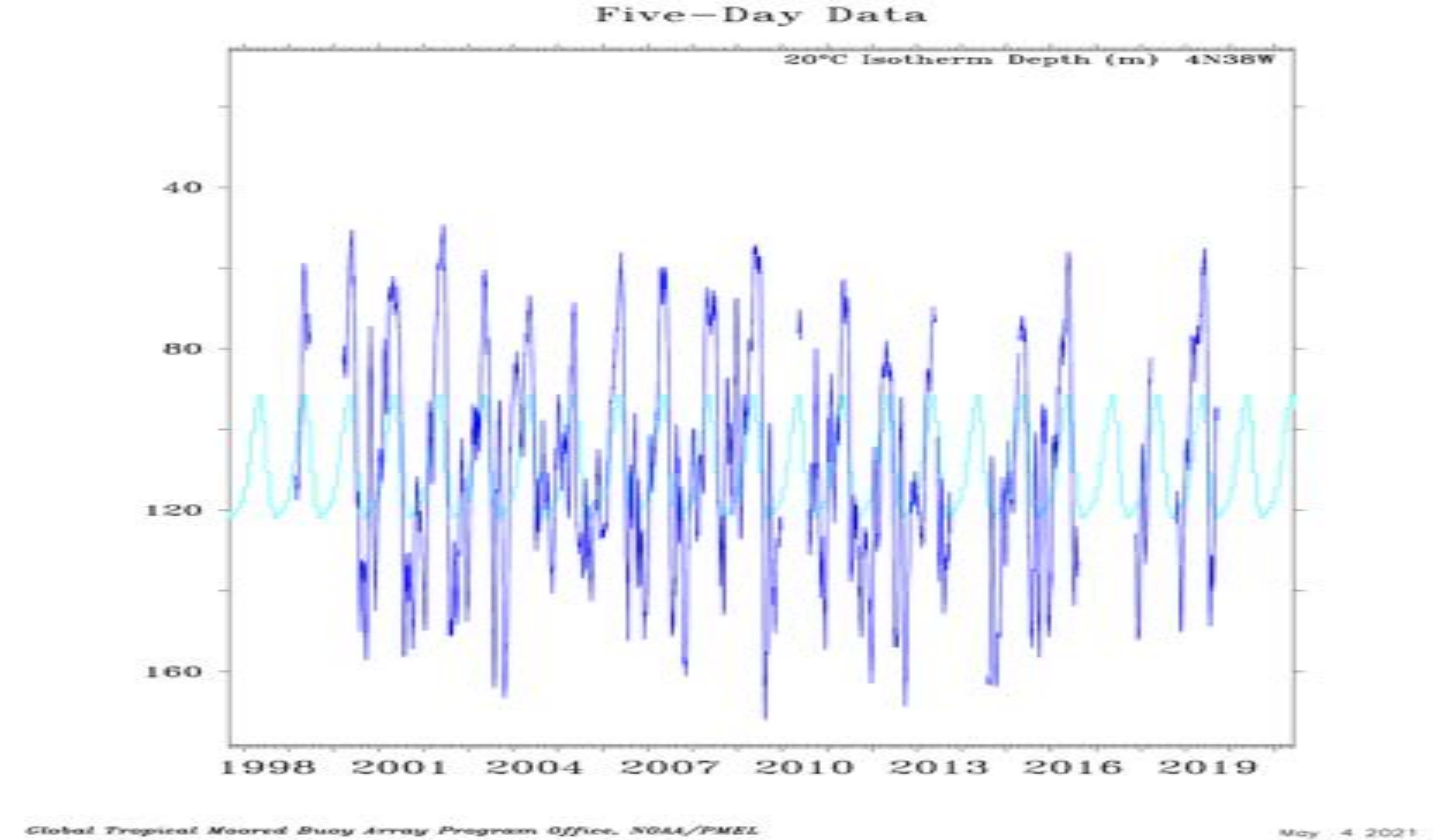
Near-equatorial offshore nutrient sources

- Vertical diffusive flux is enhanced throughout this region owing to high nitrate at the base of the euphotic zone.
- Causes:
  - wind-driven upwelling
  - Eddy-driven vertical advection
  - Wind-driven vertical pumping

Eddy-driven sources and sinks of nutrients in the upper ocean: Results from a 0.1° resolution model of the North Atlantic

McGillicuddy et al. (2003) Global Biogeochemical Cycles,
DOI: 10.1029/2002GB001987





Five-Day Data
20°C Isotherm Depth (m) 4N38W
40
80
120
160
1998
2001
2004
2007
2010
2013
2016
2019
Global Tropical Moored Buoy Array Program Office, NOAA/PMEL
May 4 2021