


Pelagic *Sargassum* in the tropical Atlantic: A basin-scale dispersal event driven by anomalous physical forcing that led to a new “normal” for the biology of the Atlantic

Libby Johns and co-authors

PIRATA24/TAV presentation May 11, 2021




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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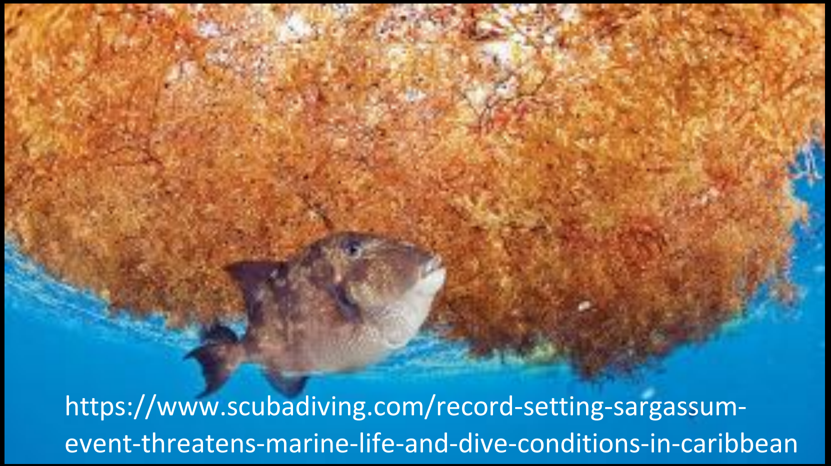
Benefits and hazards of Sargassum mats and inundations

Starting in 2011, coastal areas of the Caribbean Sea and tropical Atlantic Ocean began to experience extraordinary yearly accumulations of pelagic *Sargassum* brown alga. Prior to 2011, historical reports placed large quantities of pelagic *Sargassum* primarily in the Gulf of Mexico and the Sargasso Sea.

The ecological importance of pelagic *Sargassum* rafts and mats as habitat for hundreds of species – invertebrates and fish – has long been known.

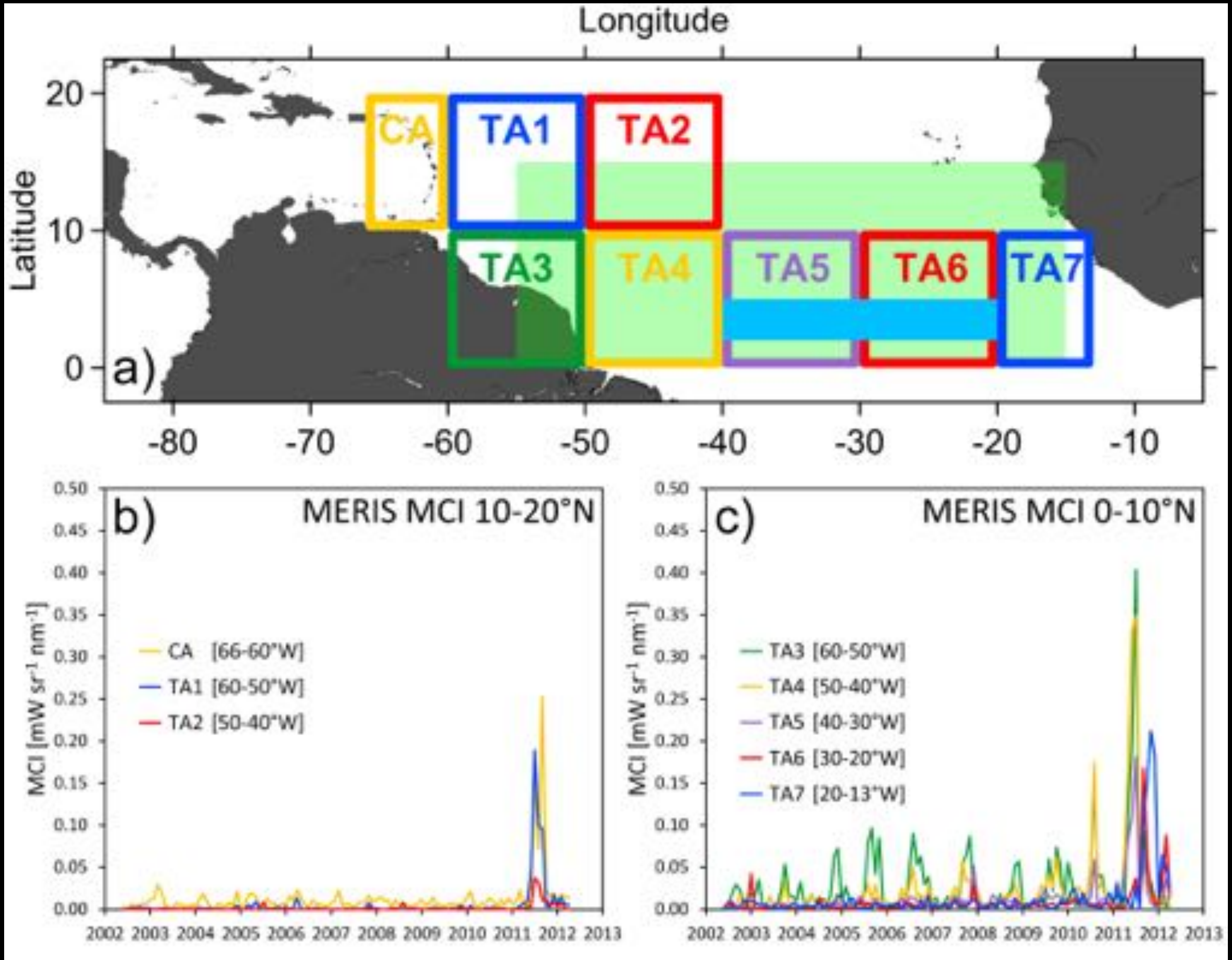
However, beached or nearshore accumulations of *Sargassum* can also have detrimental effects. They can affect nesting areas for turtles, and large inundations of *Sargassum* can negatively impact **negatively impact human health, seagrass beds, coral reef areas, commercial and recreational fishing efforts, and tourism.**

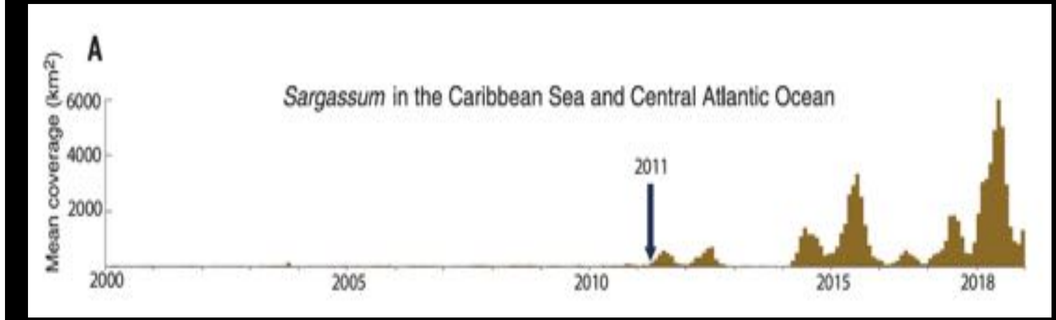


https://www.scubadiving.com/record-setting-sargassum-event-threatens-marine-life-and-dive-conditions-in-caribbean

https://www.businessinsider.com/nasa-satellites-reveal-huge-algae-bloom-in-the-caribbean-2019-7

What triggered the sudden Sargassum event in the tropical Atlantic in 2011?





Wang et al. (2019)

Johns et al. (2020), adapted from data published in Gower et al.

In short…

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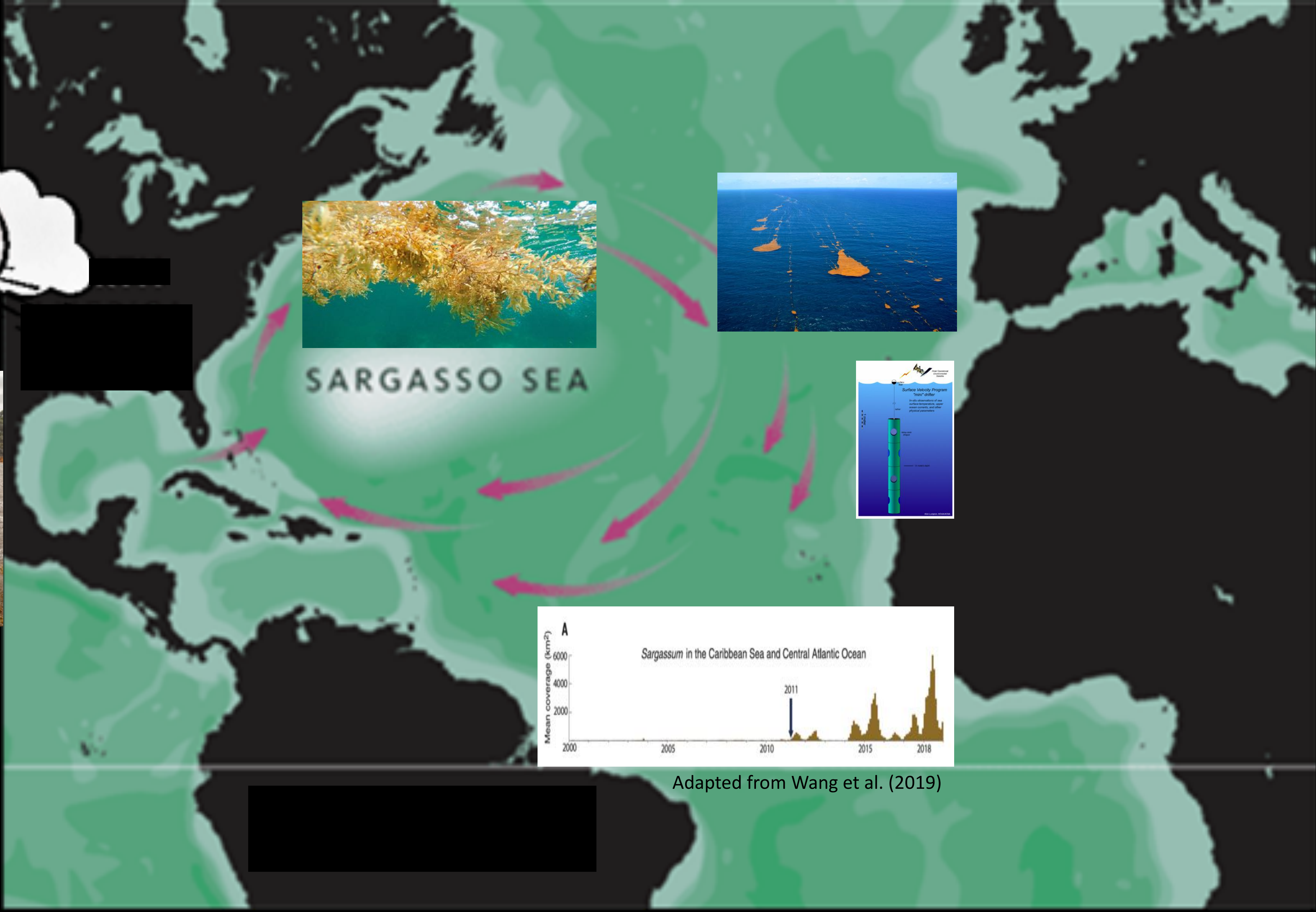

Adapted from Wang et al. (2019)

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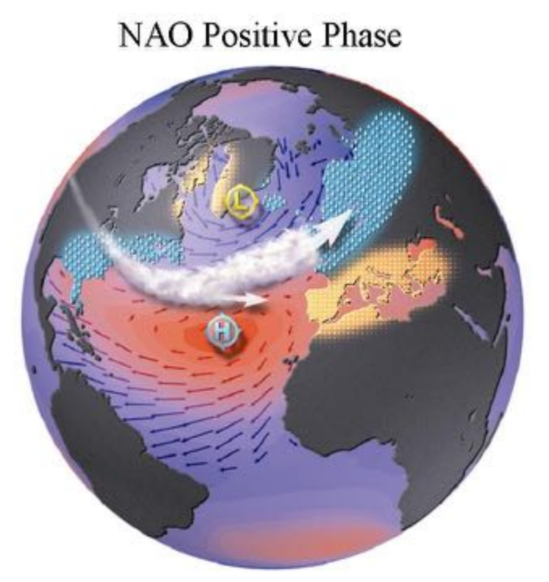
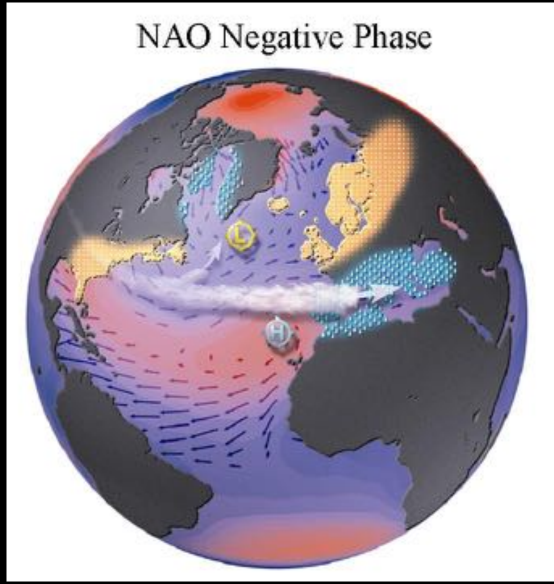
The North Atlantic Oscillation (NAO)

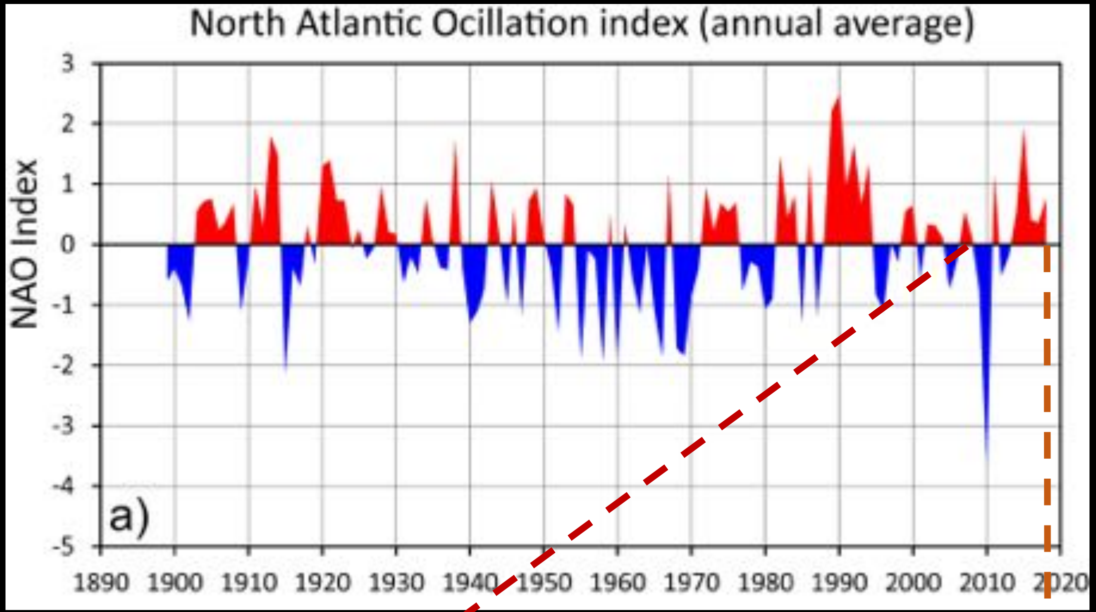


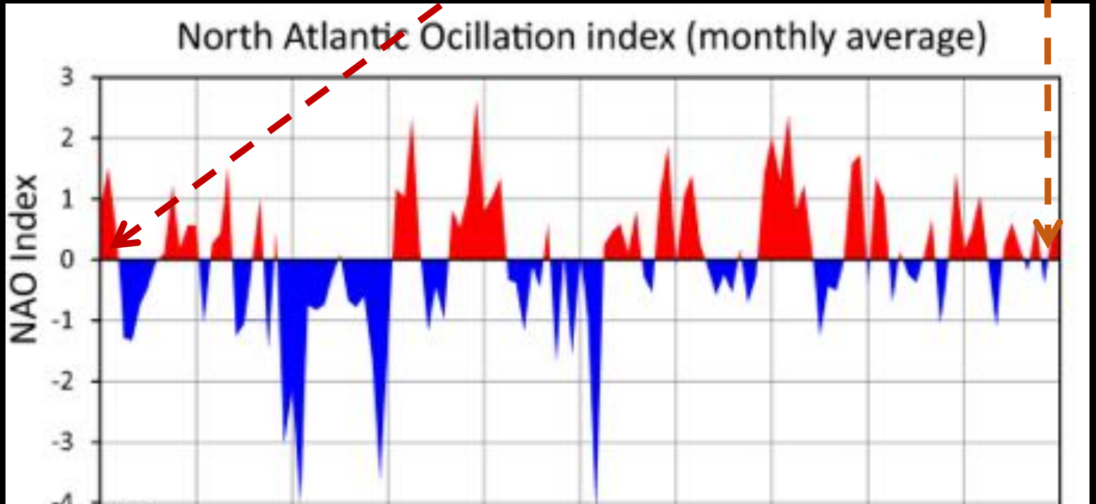


https://www.ldeo.columbia.edu/res/pi/NAO/

The NAO is a periodic change in atmospheric pressure between Iceland and Portugal that affects the strength of the prevailing winds —the westerlies— over the North Atlantic Ocean.

The negative NAO of winter 2009-2010 was the strongest such event since at least 1890!

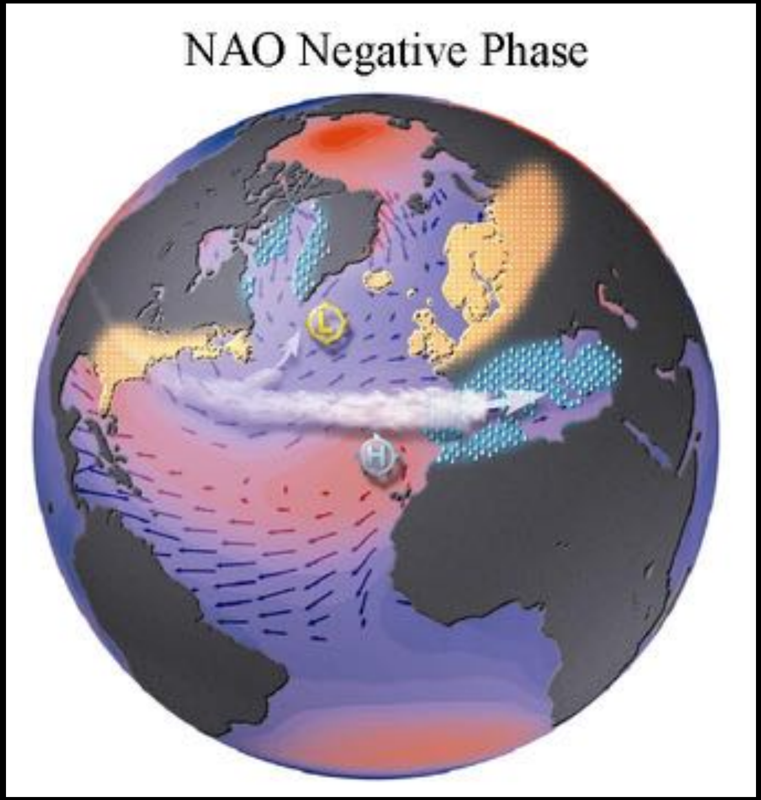




Johns et al. (2020) *Prog. in Oceanogr.*, https://doi.org/10.1016/j.pocean.2020.102269

The wind fields

(NCEP/NCAR reanalysis climatological winds)



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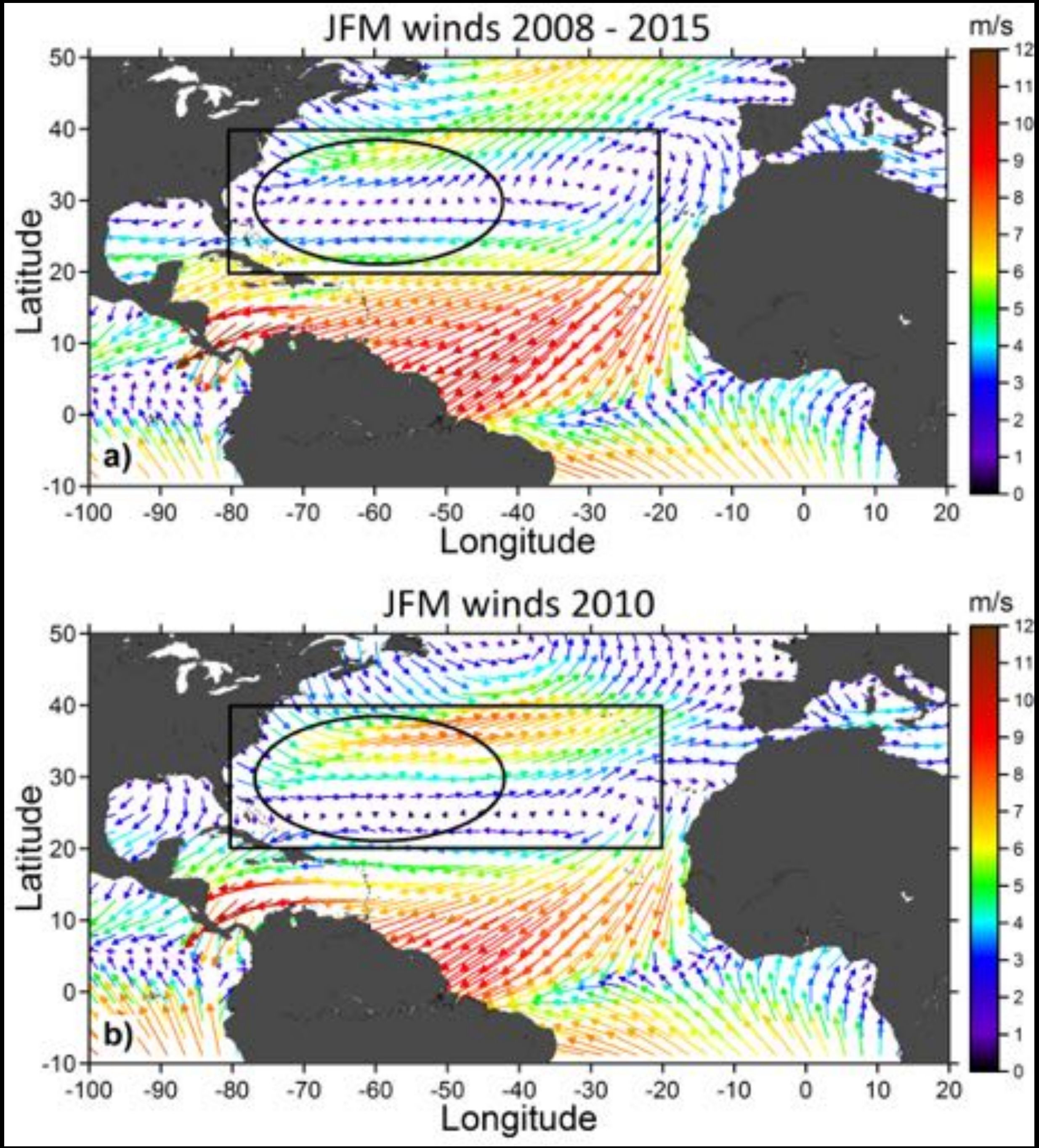
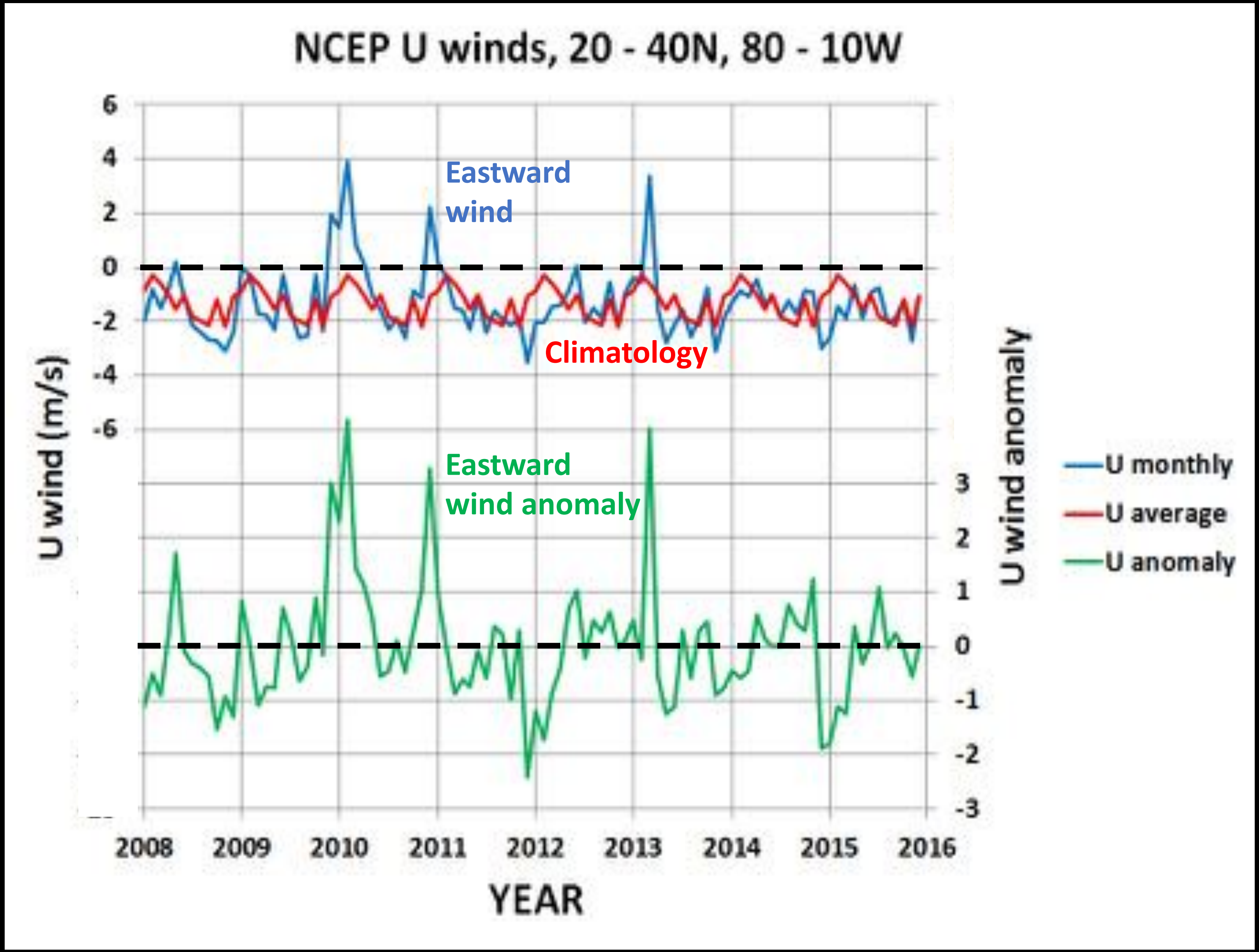


Johns et al. (2020) *Prog. in Oceanogr.*, https://doi.org/10.1016/j.pocean.2020.102269

A closer look at the winds

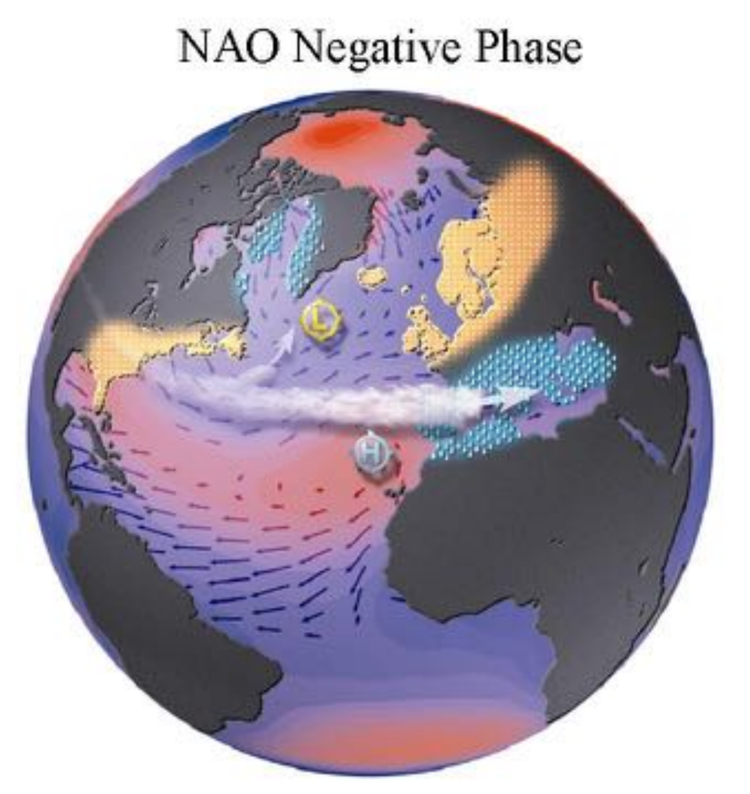
Eastward NCEP winds averaged over a 20 to 40°N, 80 to 20°W box. The climatology (red), monthly (blue), and anomaly (green) values are shown.

Note the reversal of the normally westward winds during the negative NAO periods in early 2010, late 2010, and March 2013.

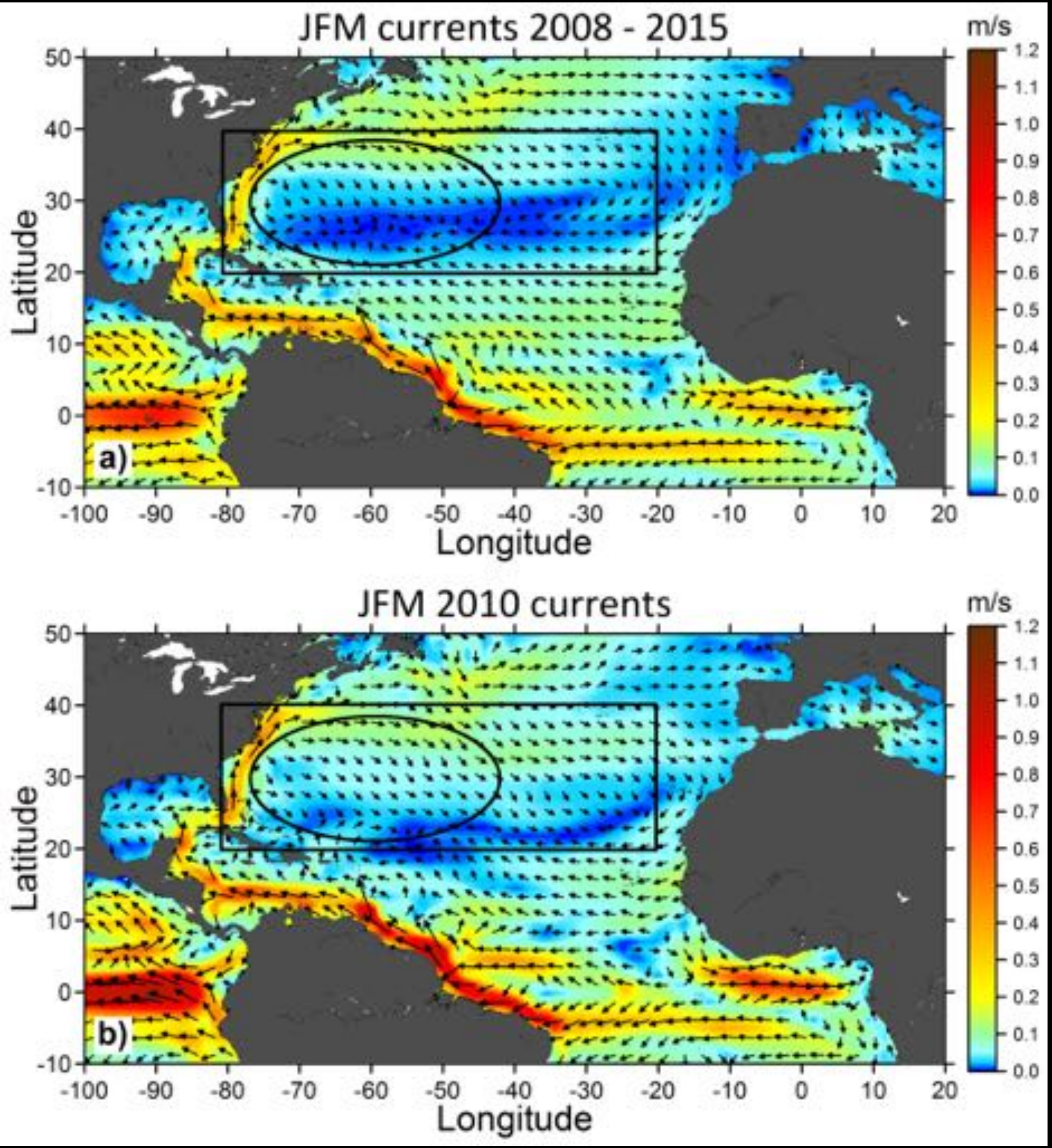


The surface current fields

(NCEP/GODAS reanalysis climatological surface currents)



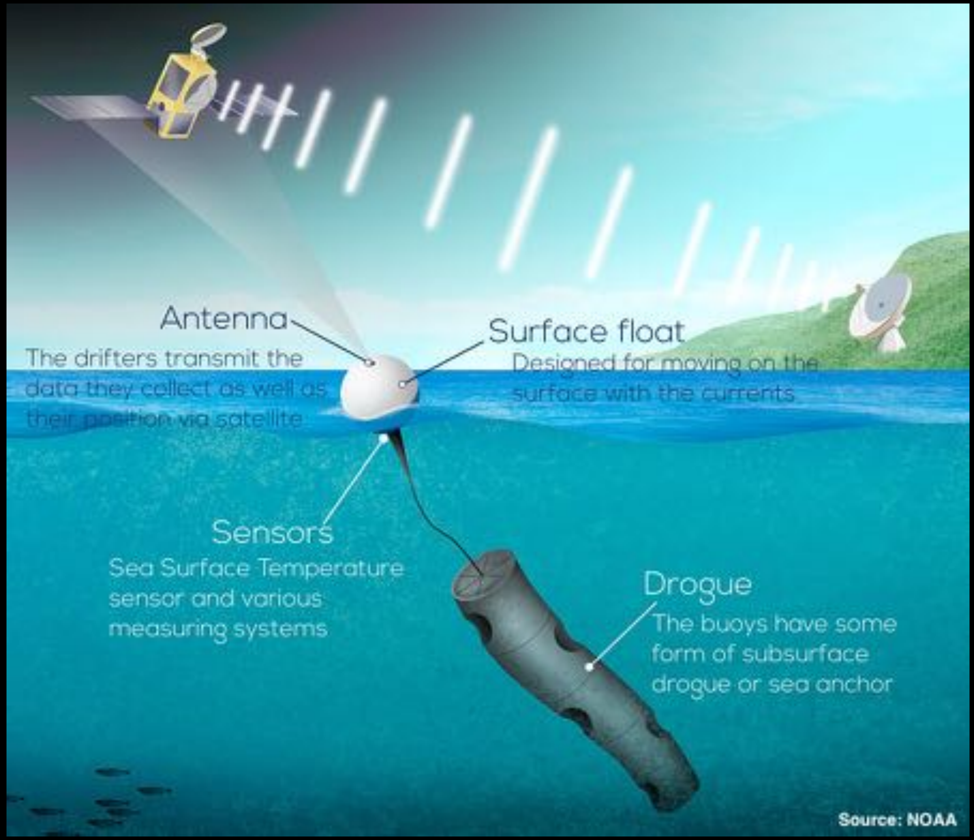
https://www.ldeo.columbia.edu/res/pi/NAO/

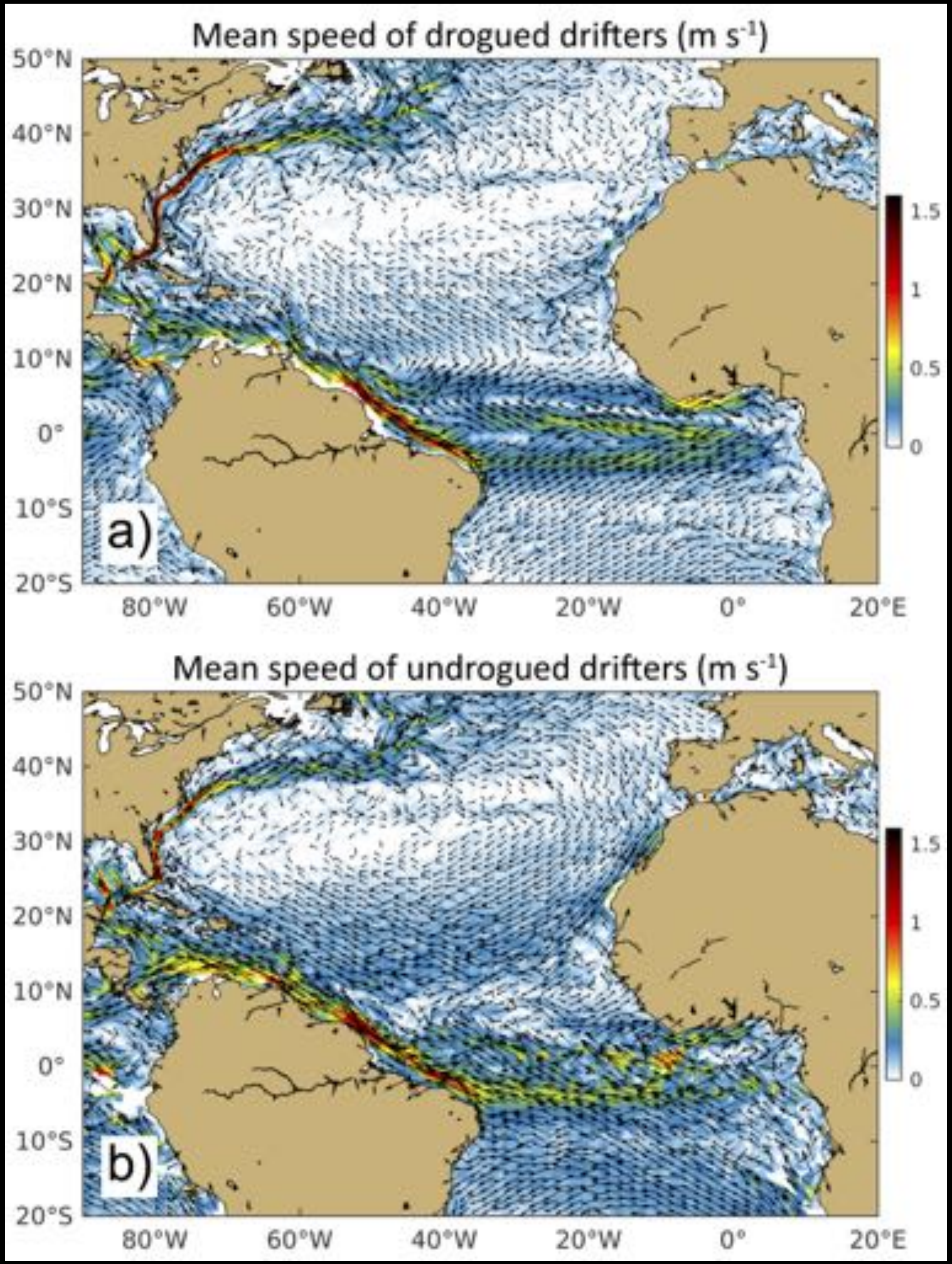


Johns et al. (2020) *Prog. in Oceanogr.*, https://doi.org/10.1016/j.pocean.2020.102269

Surface Drifters

https://www.aoml.noaa.gov/phod/gdp/





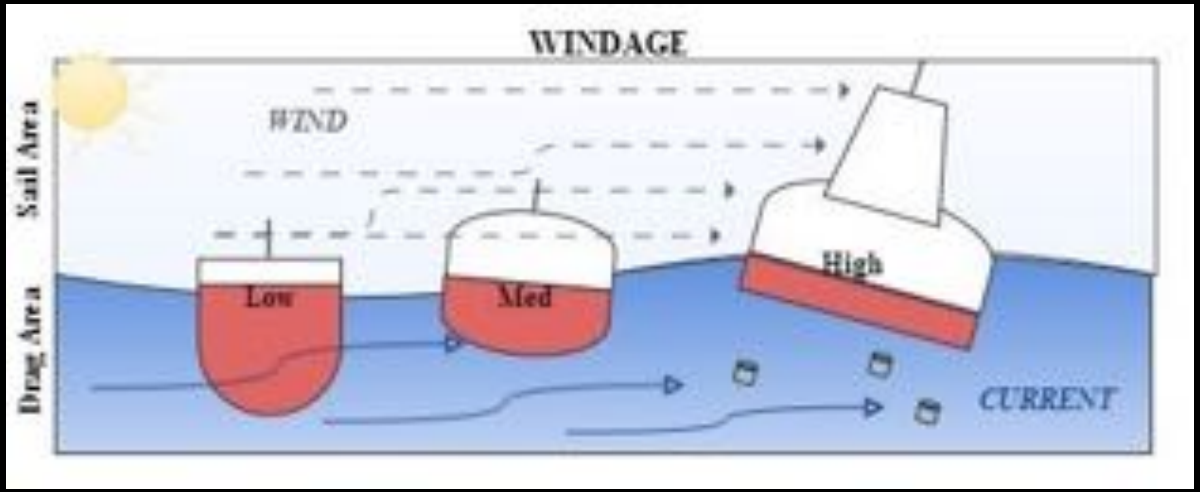
Johns et al. (2020) *Prog. in Oceanogr.*, https://doi.org/10.1016/j.pocean.2020.102269

Climatological circulation patterns based on (a) drogued drifter data, and (b) undrogued data are shown at right. Data were averaged over the period 1979 through July 2018.

The role of windage

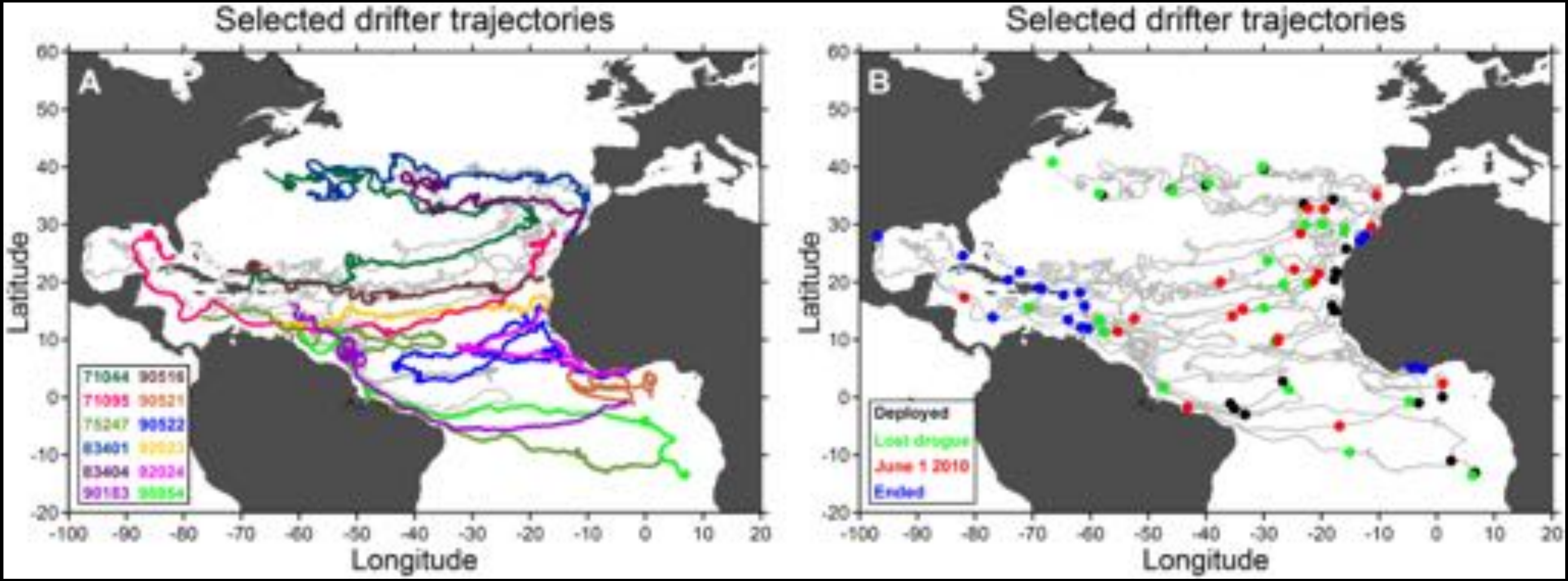
Windage is the additional, wind-induced drift of material floating at the free surface resulting from direct wind forcing on the sea surface, as well as on floating or partially-submerged objects.

Windage is likely to influence *Sargassum* similarly to undrogued drifters, and indeed recent empirical studies using simulated *Sargassum* have been able to confirm this. Windage provides a surface wind speed “boost” of 1 to 3% to the surface currents.



https://sites.uw.edu/coasst/2014/11/26/what-determines-the-path-of-marine-debris-through-the-ocean/

National Geographic

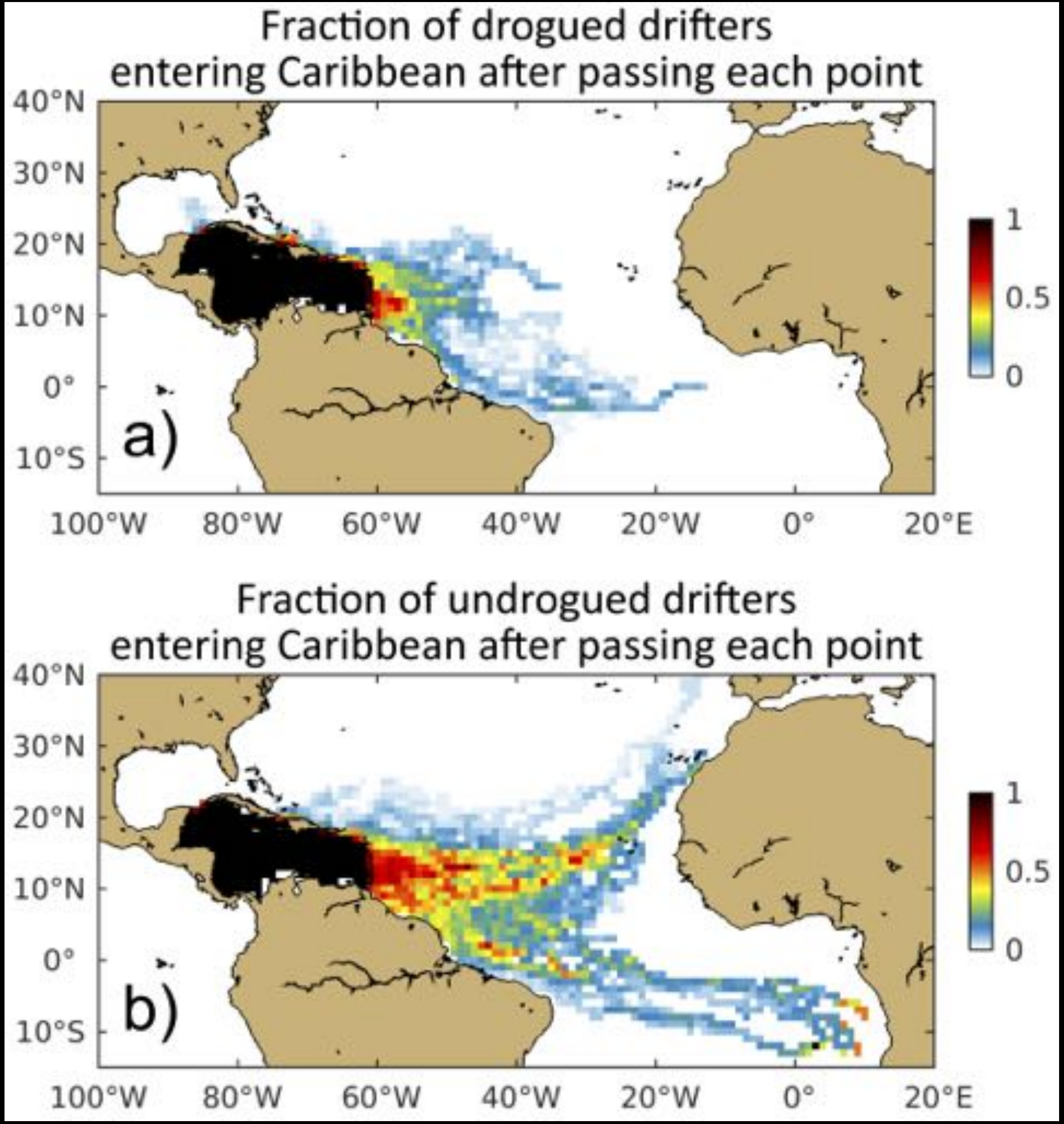


Drifter trajectories from the NOAA Global Drifter Program show pathways from the Sargasso Sea to grounding in the various areas where the *Sargassum* inundations occurred in 2011.

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

Pathways into the Caribbean from a statistical drifter model

The conclusion of previous studies was that the *Sargassum* that began invading the tropical Atlantic in spring 2011 could not have come from the Sargasso Sea because they relied only on drogued drifter data (top panel), but the undrogued drifter data (bottom panel) reveals that there are two distinct pathways into the Caribbean. The NAO wind event that moved *Sargassum* over to the far northeastern Atlantic allowed it to follow the northern path.

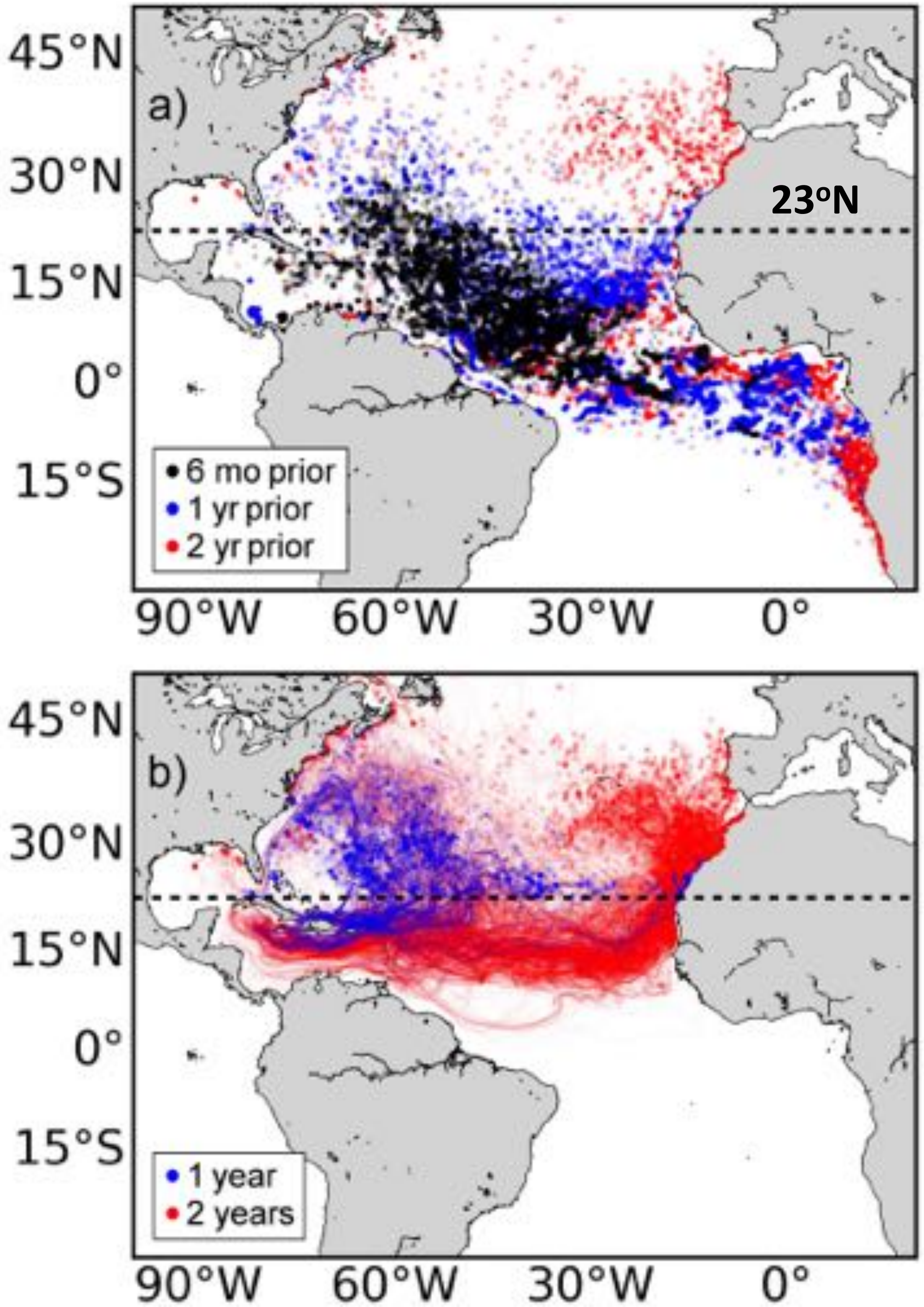


HYCOM model results

The HYCOM model was run with 1% windage in order to best simulate the movement of *Sargassum*.

Particles were released in spring 2011 at random locations in the Caribbean at 5-day intervals and backtracked for 6 months, 1 year, and 2 years (upper panel).

(b) The full trajectories of only those particles originating in the North Atlantic (> 23ºN) are shown in the lower panel. There are two primary routes, a western route through the Greater Antilles (blue), and an eastern route from the Sargasso Sea and Gibraltar to the tropical Atlantic and Lesser Antilles (red).

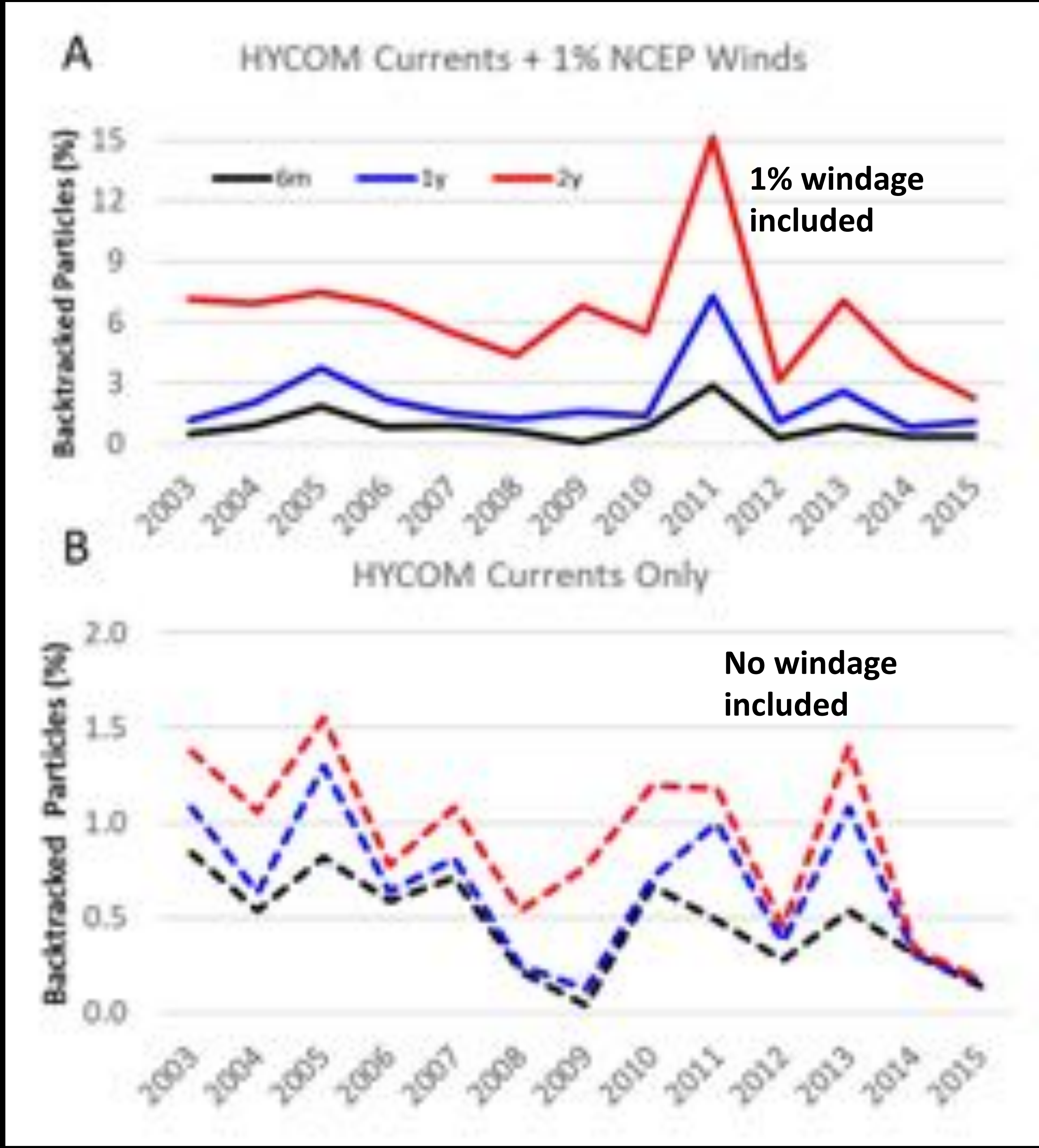


Johns et al. (2020) *Prog. in Oceanogr.*, https://doi.org/10.1016/j.pocean.2020.102269

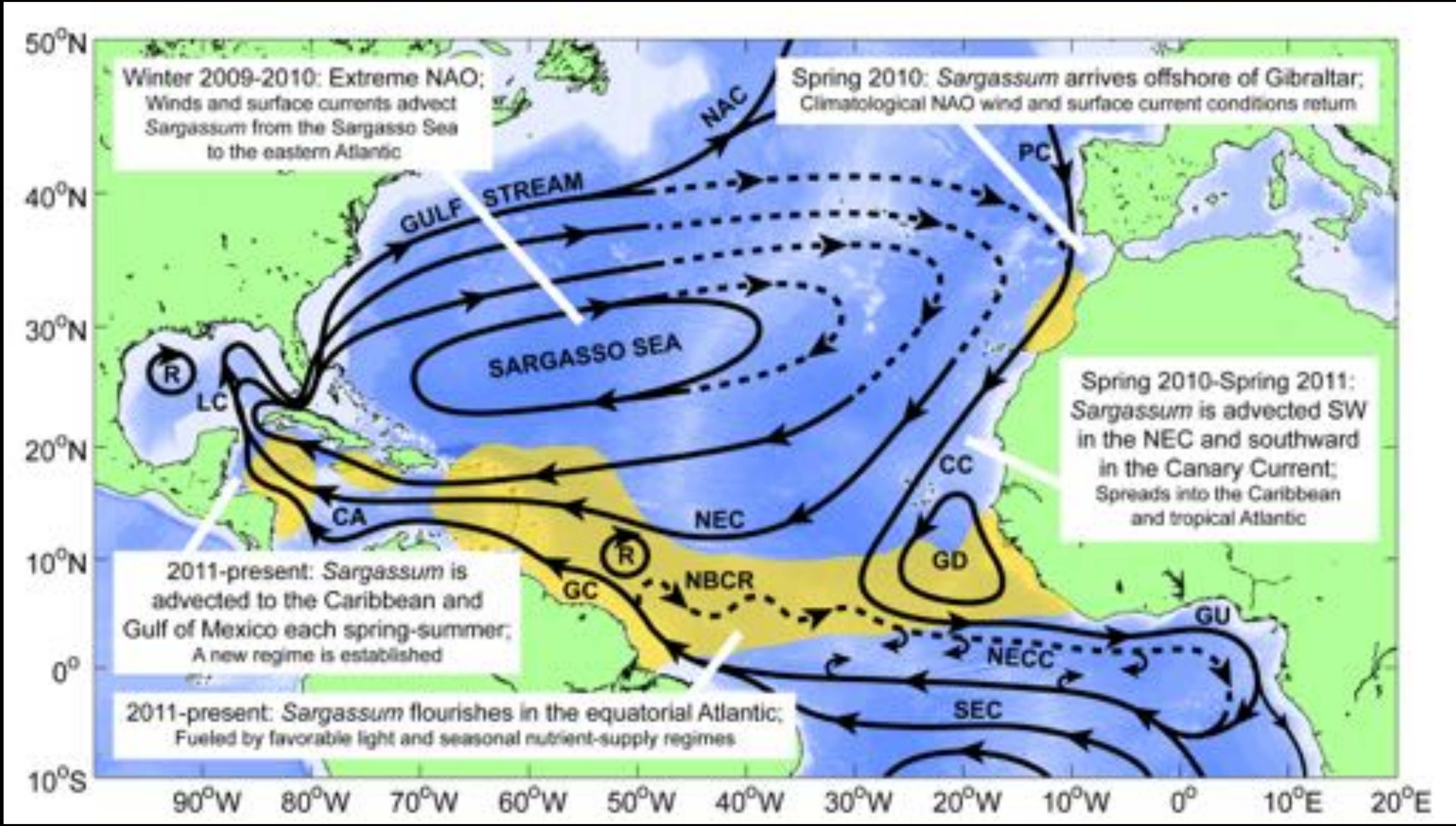
Interannual variability in the HYCOM backtracking model results from the previous slide

Both panels show the percentage of particles released in the Caribbean Sea in April-July that originated in the North Atlantic (> 23°N). Note the change of scale of the vertical axis between the two panels.

Not only is there a dramatic increase in North Atlantic input to the Caribbean for all years when windage is taken into consideration (a), but there is also a dramatic increase in the percentage of particles that reached the Caribbean from the north in 2011, from 1% to 15%.



Graphical Summary



Summary

- **The extreme winds associated with the negative NAO during winter 2009-2010 caused** an unprecedented long-distance dispersal (LDD) of *Sargassum* from the Sargasso Sea, arriving **to the tropical Atlantic and Caribbean Sea by spring of 2011.**

- This event triggered a biosphere “tipping point” that caused basin-scale ecosystem changes in the tropical Atlantic and Caribbean.

- A new, persistent tropical *Sargassum* population is now established, supported by wind convergence aggregation, surface currents, and mixed layer dynamics in the equatorial and tropical Atlantic.

Thank you!

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