# Deciphering the water quality impacts of COVID-19 human mobility shifts in estuaries surrounding New York City

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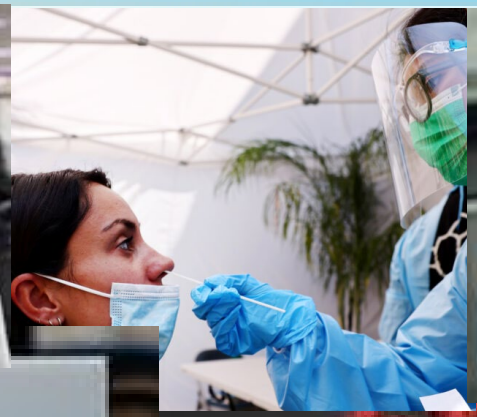
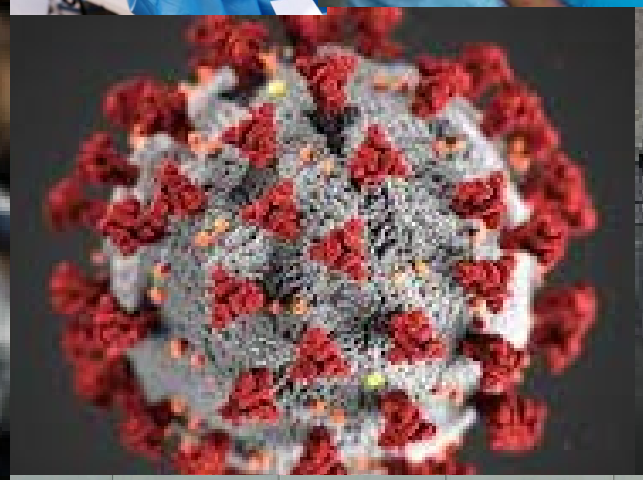
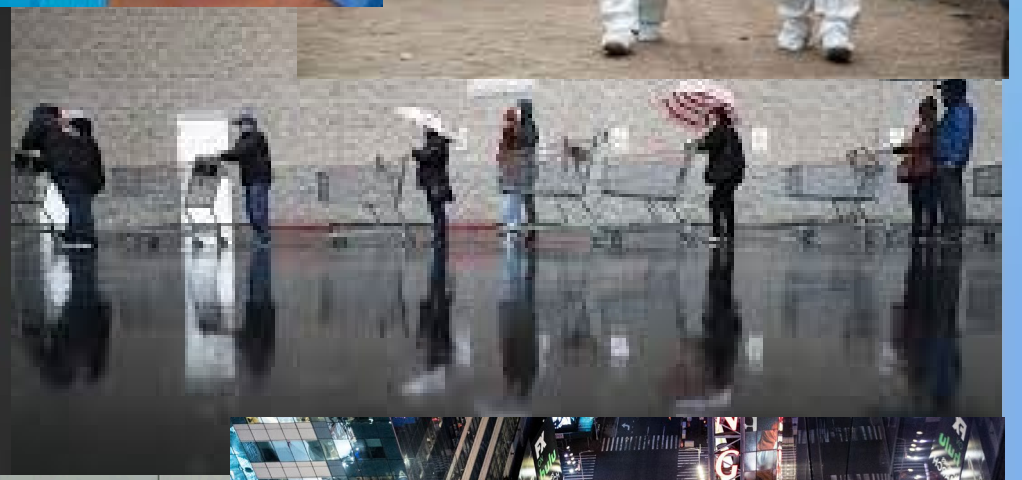



PLEASE STAY
AN ANDEAN CONDOR'S
WINSPAN DISTANCE APART
6 + FEET

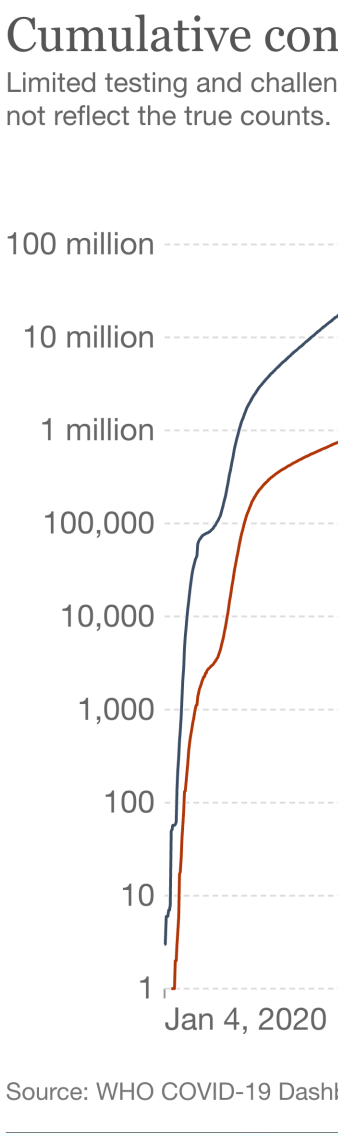


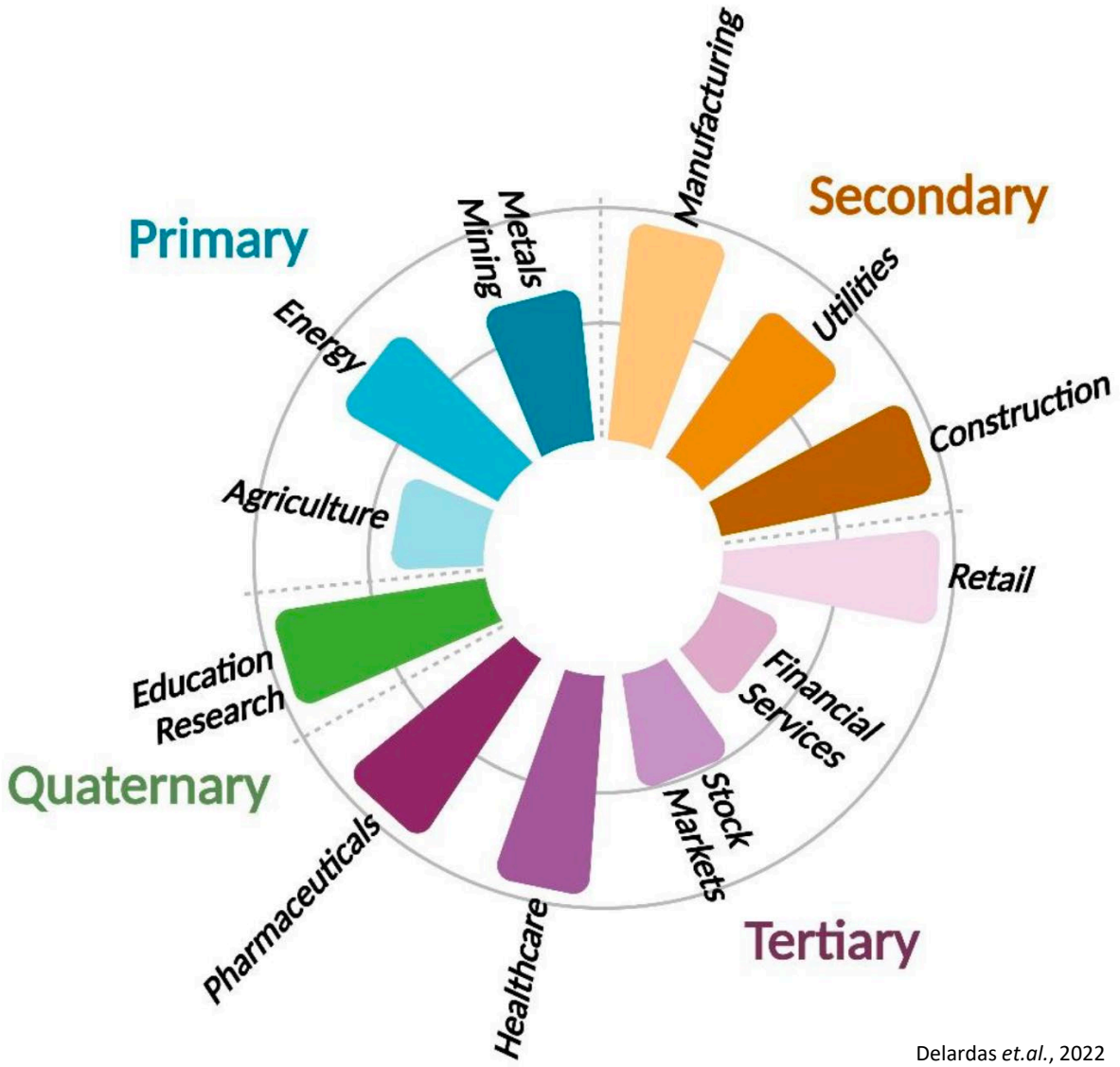



AT LEAST
6 FEET

# COVID-19 had far-reaching impacts on society

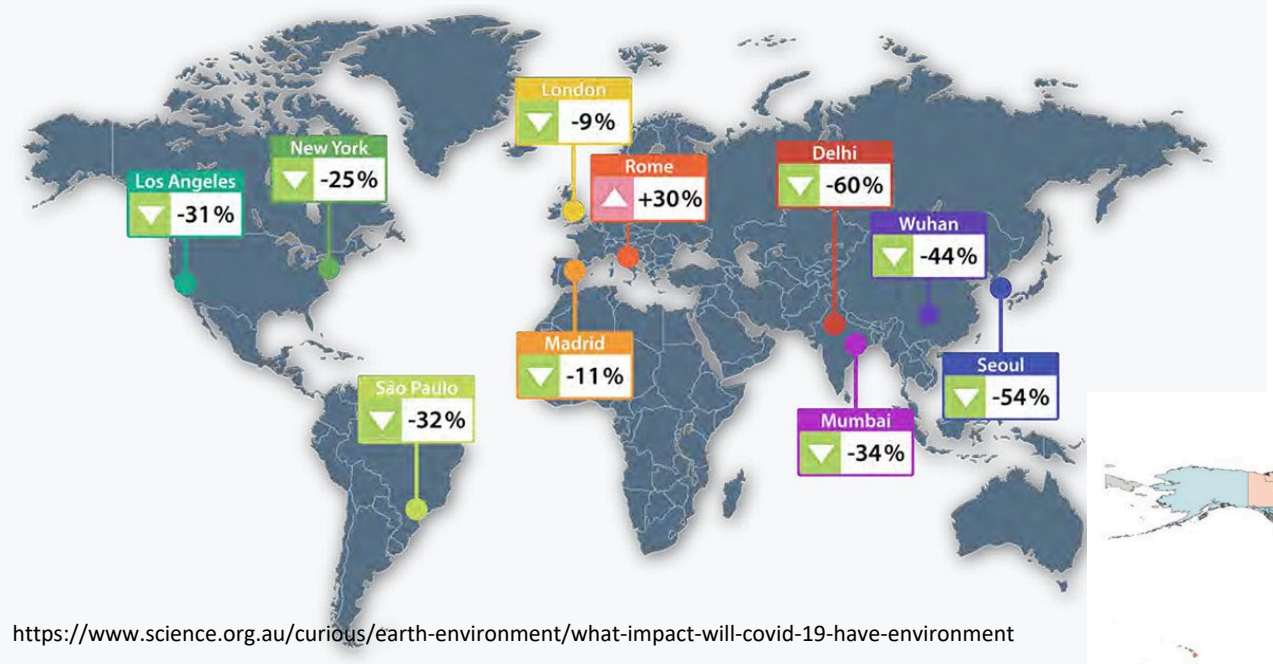
- Death toll > 1,000,000 (with some estimating the true number is far greater)
- The pandemic has also shaken-up the socio-economic order on a global scale




Delardas *et.al.*, 2022

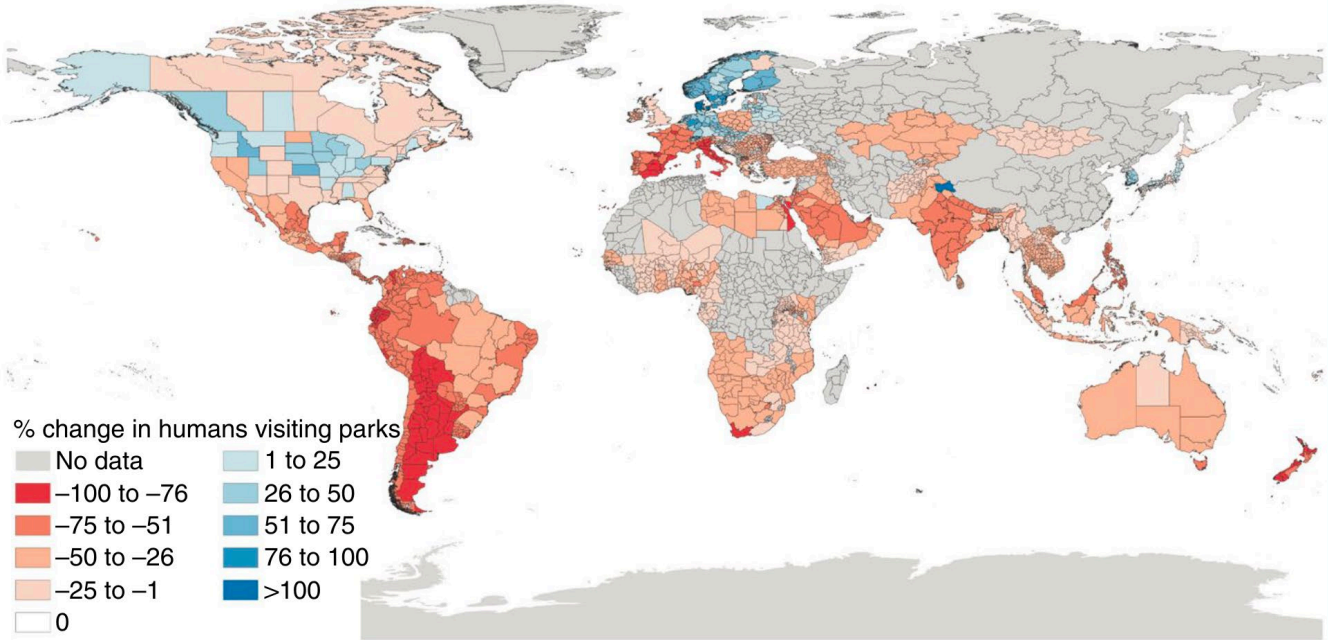
# Measures imposed to limit COVID-19 transmission during the different stages of the pandemic changed the degree of anthropogenic pressure across the biosphere.




https://www.science.org.au/curious/earth-environment/what-impact-will-covid-19-have-environment

% Change in $PM_{2.5}$

% Change in visits to outdoor locales (local and national parks, beaches etc.)



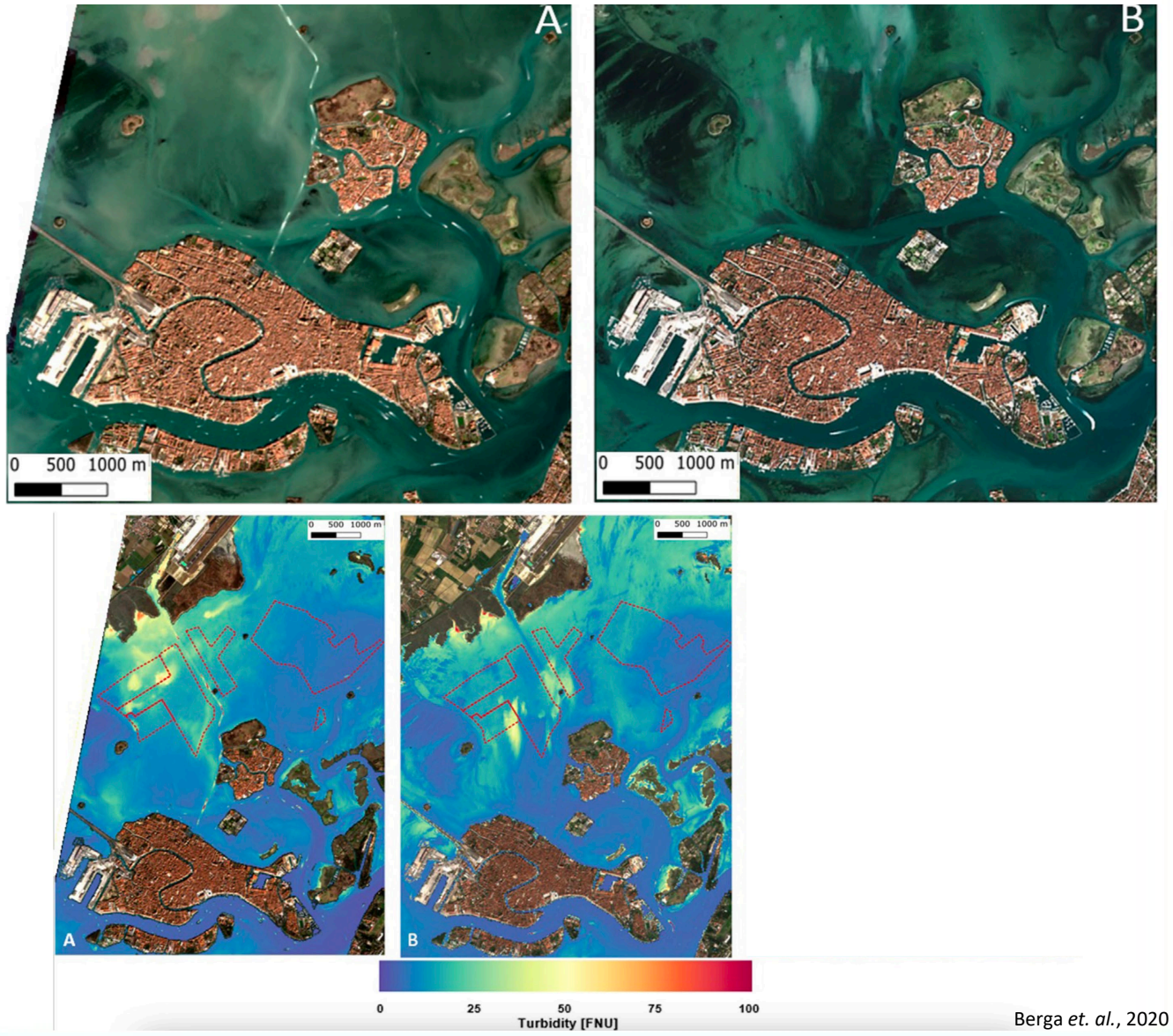

Rutz *et.al.*, 2020 (using with data complied form the Google COVID-19 Community Mobility Reports)

# Previous studies on COVID-19 shutdown impacts on water quality

- Decreased vessel traffic and associated wakes led to increased water clarity following shutdown

- However,  the impact was ephemeral, with environmental forcing (strong winds) greatly increasing turbidity later in April

- Similar results were observed in other regions, including, Belize, Rivers across China and several location in India amongst a few



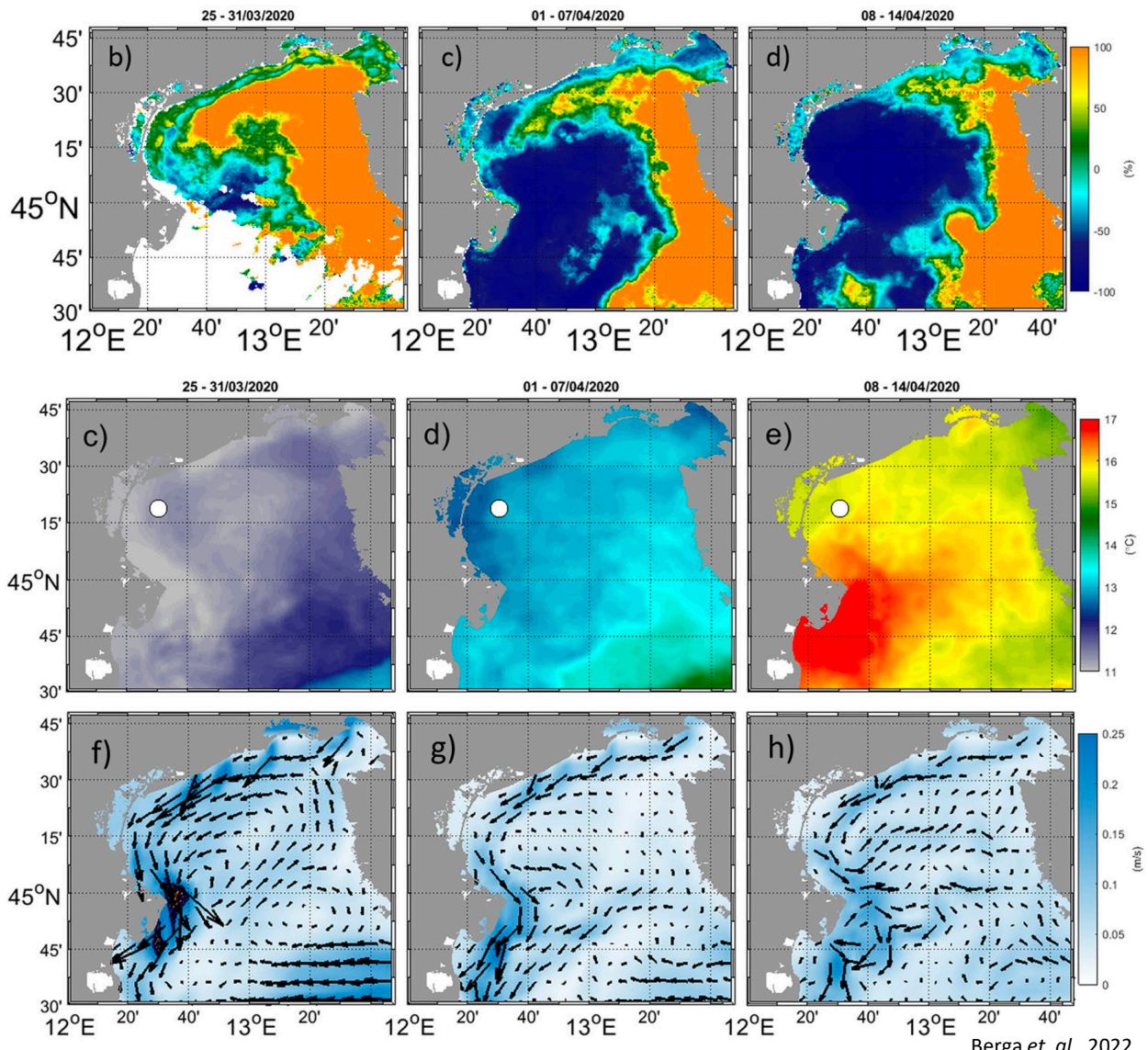

Berga *et. al.*, 2020

MSI true color in the Lagoon of Venice pre- and post- lockdown

# Previous studies on COVID-19 shutdown impacts on water quality

- On the other hand, several studies found found little to no measurable impact of COVID-19 on water quality parameters

- Berga *et. al.*, (2022) showed that anomalously low Chla in the North Adriatic Sea in April 2020 was due toa combination of meteo-oceanographic and hydrological conditions.




Berga *et. al.*, 2022

The main weakness in most of these studies are the limited temporal scale of impacts assessed, primarily focusing on March-April

Here, we investigated the extent to which COVID-19 related restrictions in the NYC metro region **during the height of the pandemic in 2020** and the following return to "new-normal" **throughout 2021** impacted water quality in surrounding estuaries

The New York Times https://www.nytimes.com/2020/03/22/nyregion/Coronavirus-new-York-epicenter.html

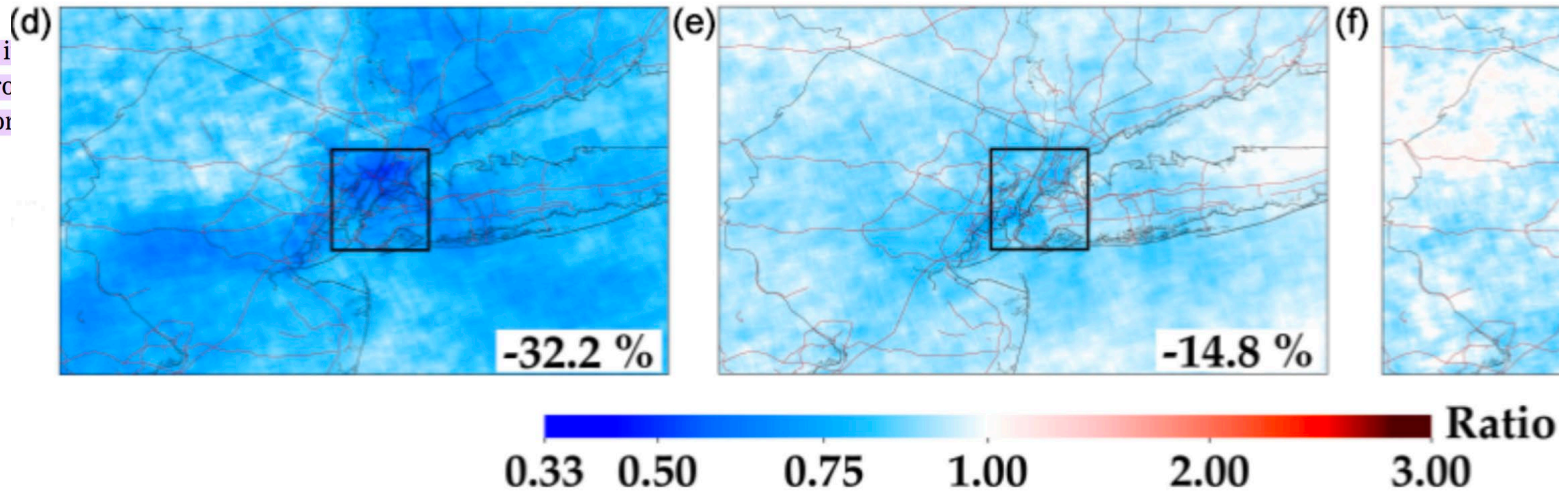
# *New York City Region Is Now an Epicenter of the Coronavirus Pandemic*

The city and its suburbs account for roughly 5 percent of global cases, forcing officials to take urgent steps to stem the outbreak.

By Jesse McKinley

March 22, 2020

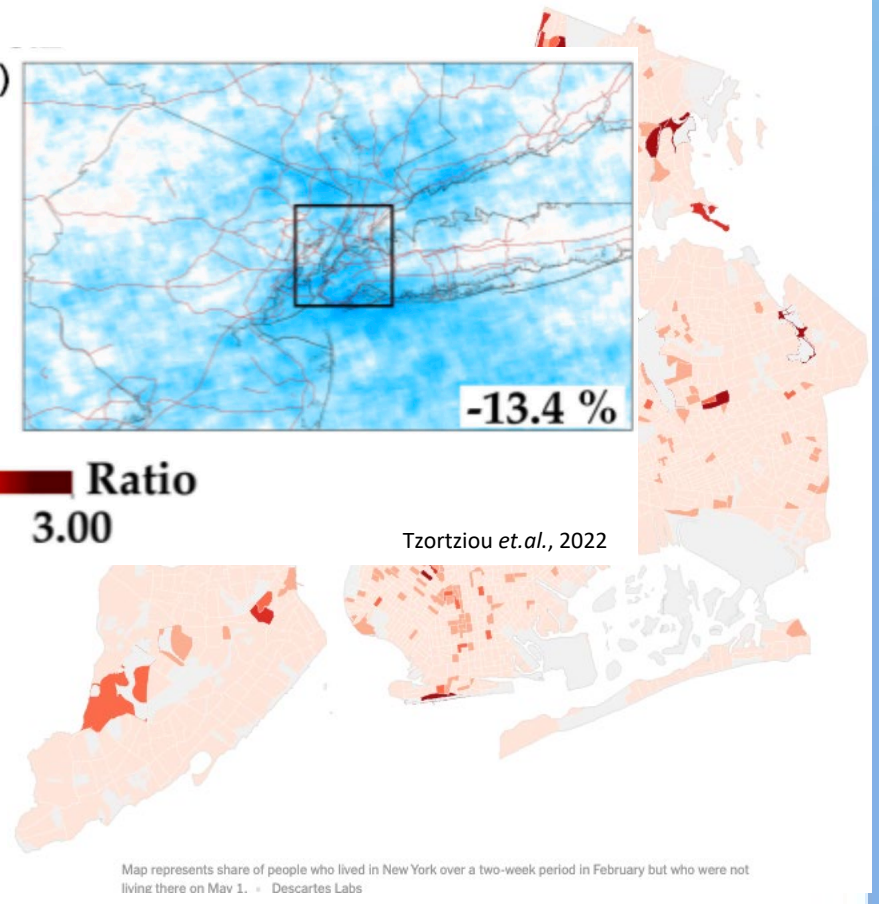
Three weeks after i
now accounts for rc
officials to take mor




The New York Times
TheUpshot

# The Richest Neighborhoods Emptied Out Most as Coronavirus Hit New York City

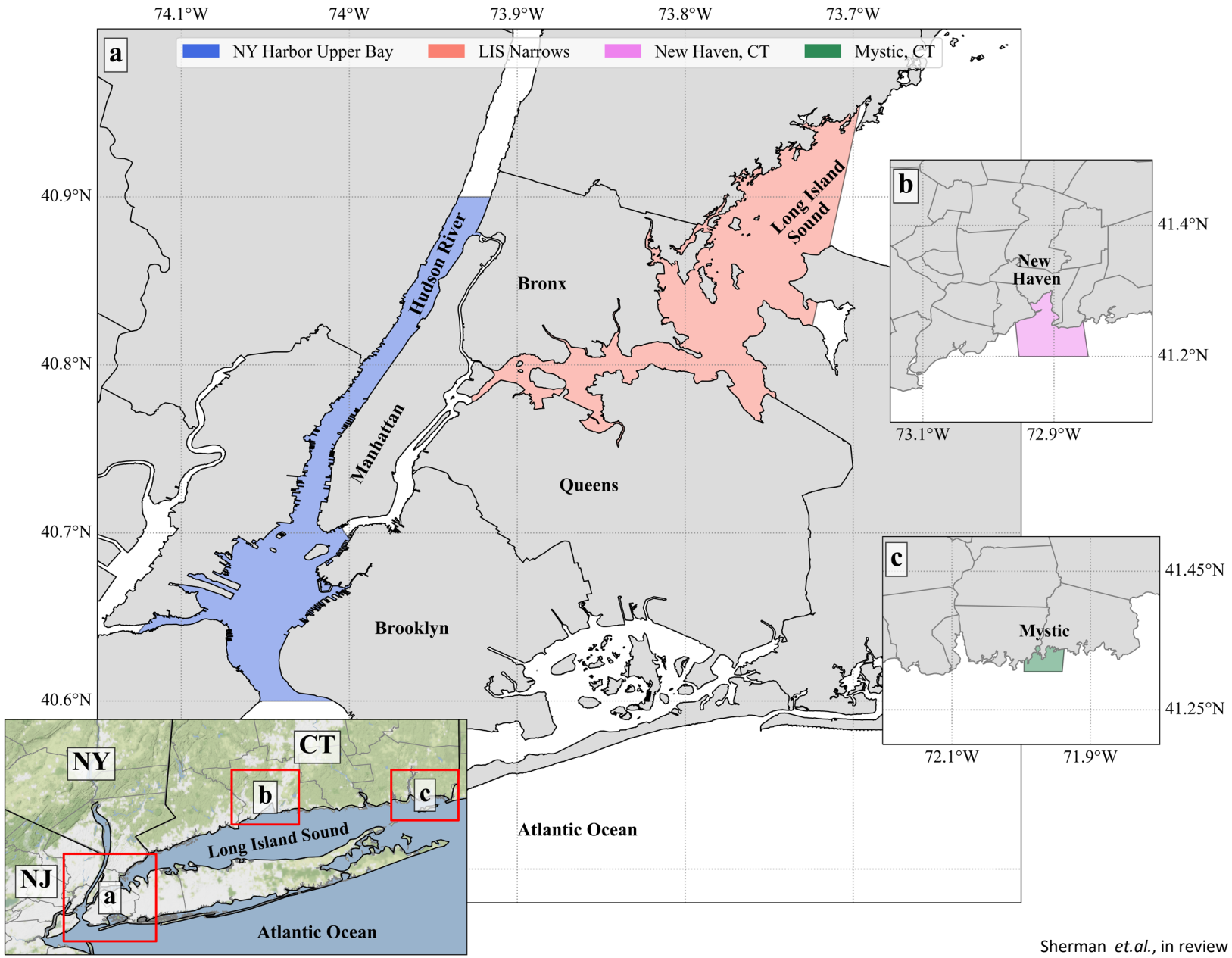
By Kevin Quealy May 15, 2020



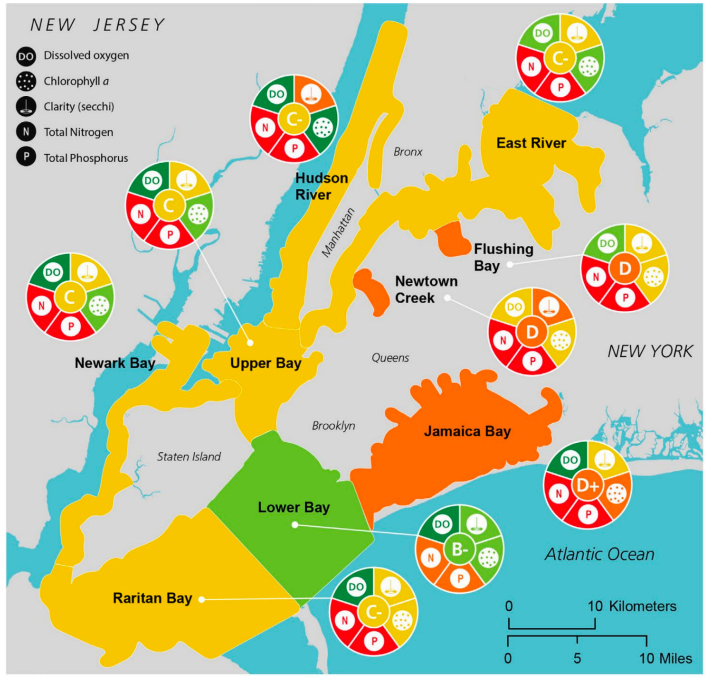
Tzortziou *et.al.*, 2022

Map represents share of people who lived in New York over a two-week period in February but who were not living there on May 1. • Descartes Labs

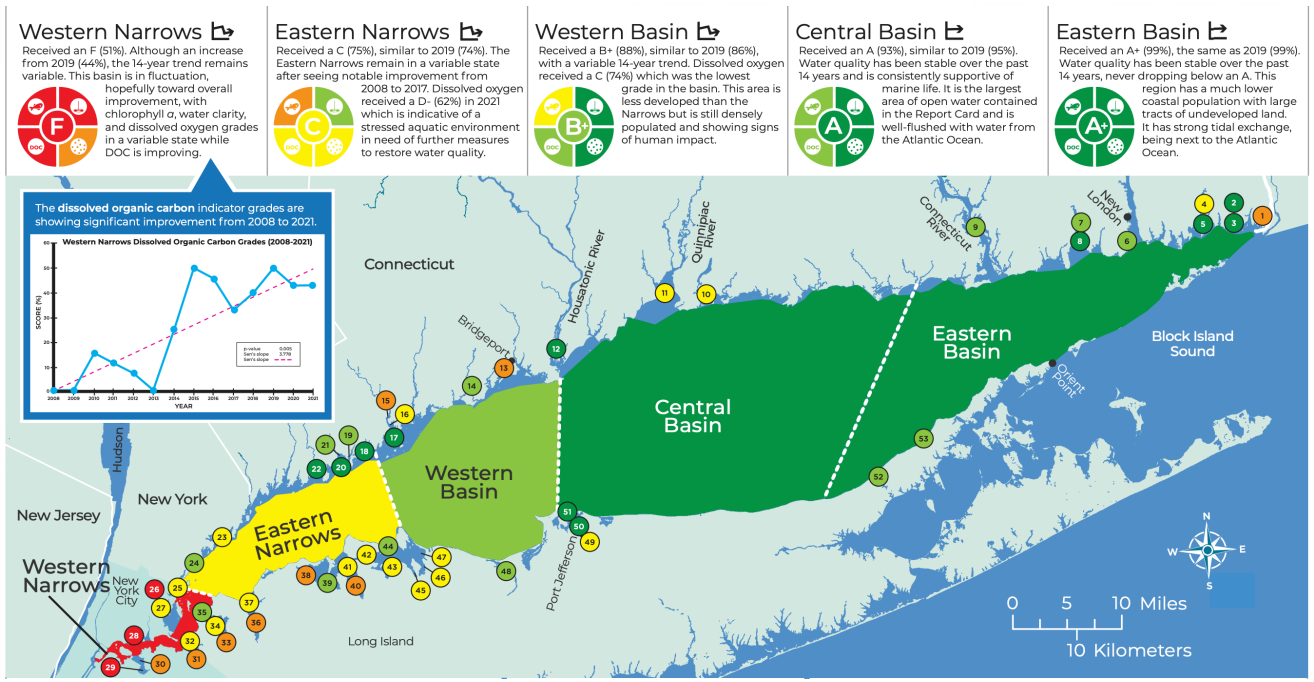
# The Study Region



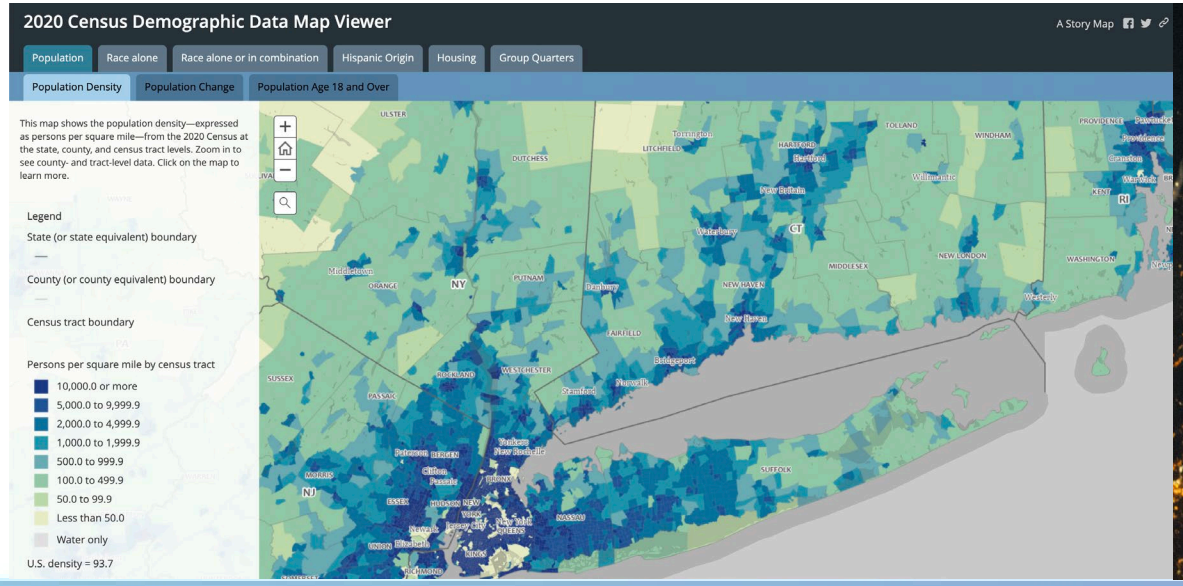

Sherman *et.al.*, in review

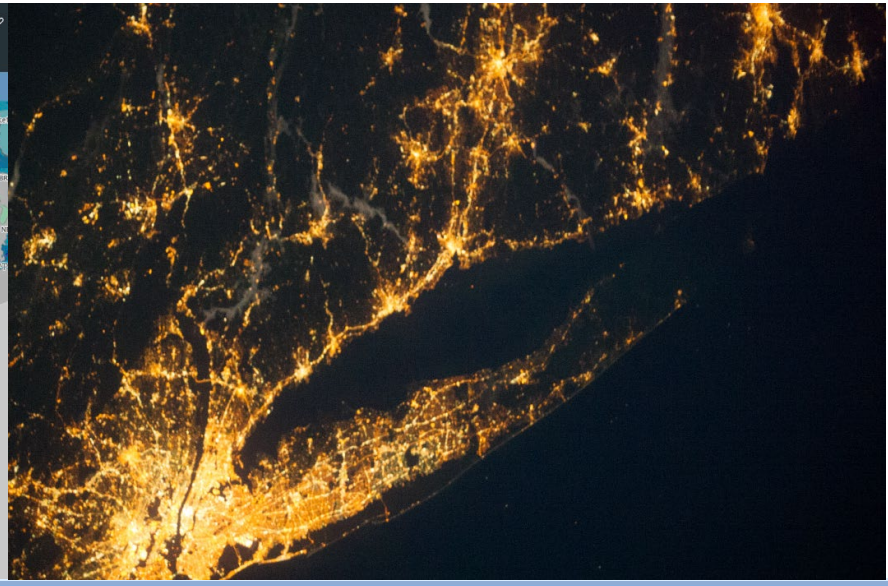



Taillie *et.al.*, 2022




Save the Sound 2022 report card



# Assessing human mobility anthropogenic pressure and Regional meteorology

**Human Mobility**

- Trends in mass transit ridership (data published by NYC MTA)
- Trends in work-from-home (data from the U.S. Census Bureau's annual American Community Survey

**Anthropogenic pressure**

- Trends in wastewater discharge, with focus on Nitrogen loading (data from NYC-DEP, CT DEEP and EPA)

**Regional meteorology**

- Meteorological data, with focus on precipitation from NOAA’s Applied Climate Information System

# Assessing water quality from remote sensing platforms

**OLCI, OLI, and MSI**

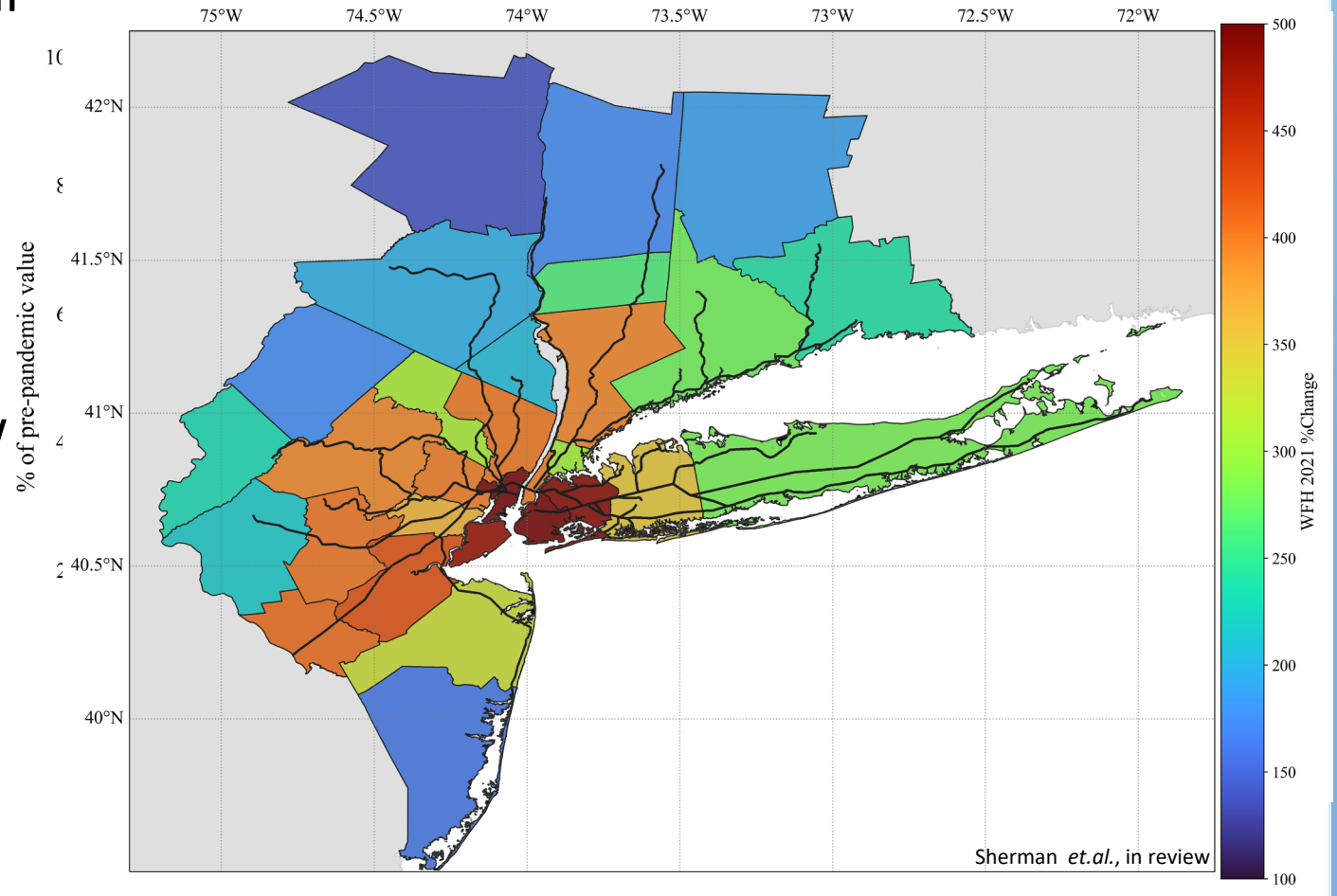
- Evaluate short- and long-term trends in
  - Water turbidity (Nechad *et. al,*.2009)
  - aCDOM(300) (Cao and Tzortziou, 2022)
  - Chl-a (Sherman *et. al.,* 2023)

Changes in human mobility, environmental conditions, nitrogen loading, and water quality for 2020 and 2021 were compared to a 2017-2019 baseline

$$\% \text{ change} = \frac{X_{2020 \text{ or } 2021} - X_{2017\text{-}2019}}{X_{2017\text{-}2019}} * 100$$

# Trends in human mobility

- Significant decrease in April 2020 in all mods of transportation
- Steady increase, with minor dips during COVID resurgence waves
- By end of 2022, values still 40% below pre-pandemic values
- Preferential use of private vehicles
- In 2021, work from home is up 400% in the NYC Metro core

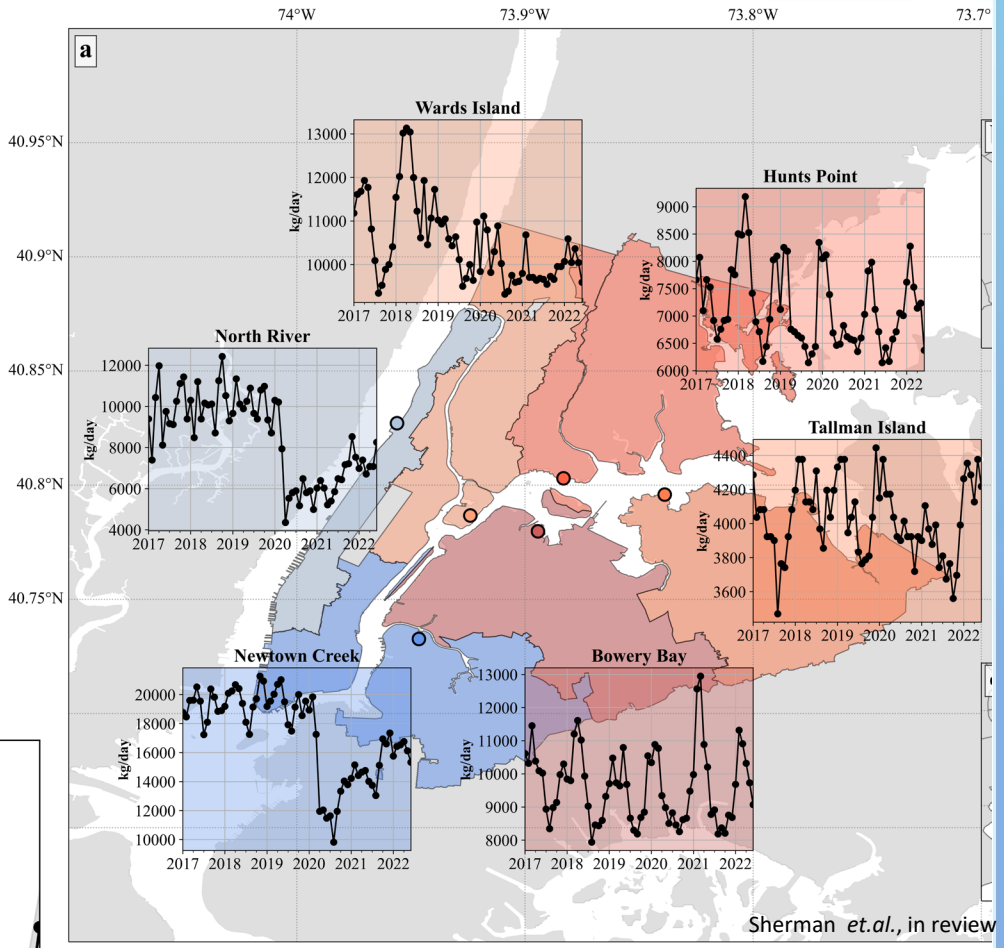


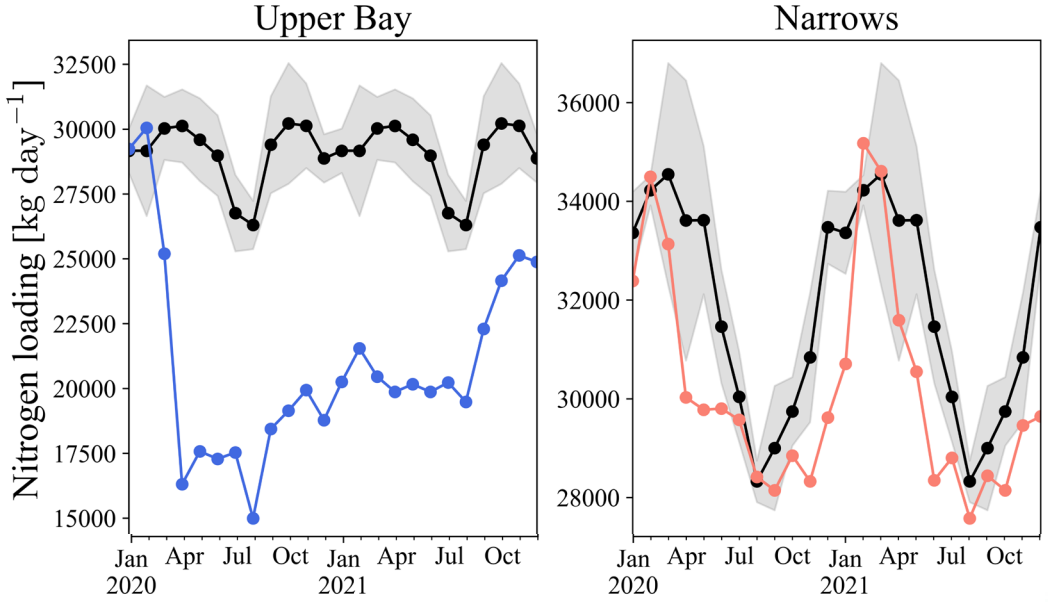
# Trends in nitrogen loading

Two trends emerge past April 2022:

- In facilities serving West and Lower Manhattan and discharge into Upper Bay.

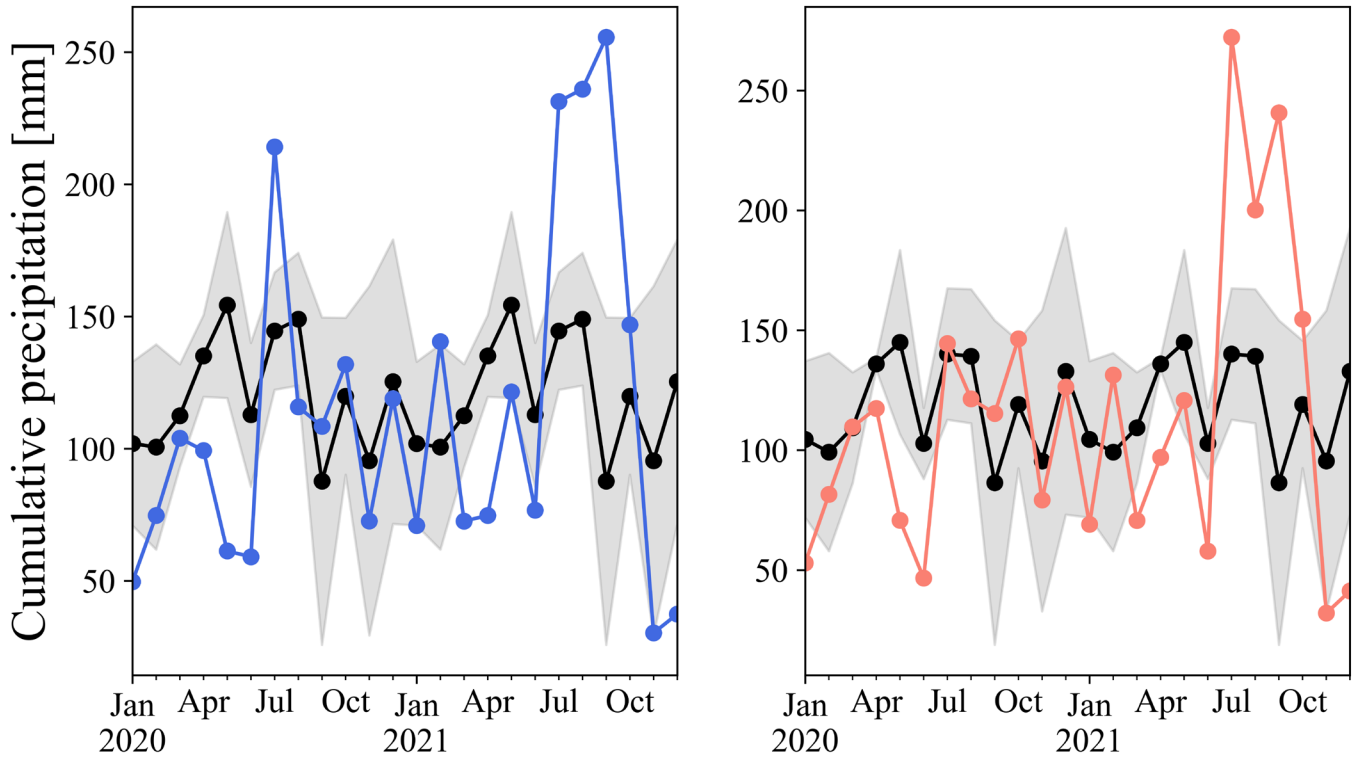
- In the outer boroughs large decreases in April-May but past that minor changes that track seasonal cycle. These discharge into the Narrows




Sherman *et.al.*, in review

# Trends in precipitation




In general, 2020 and 2021 were relatively drier years. Evident summer storms in July 2020 and Aug-Sep 2021 (Hurricanes Henri and Ida). Seasonal trend agrees overall.

# Short term impacts on water quality Following first lockdown order (March 20th)

**Upper Bay:**

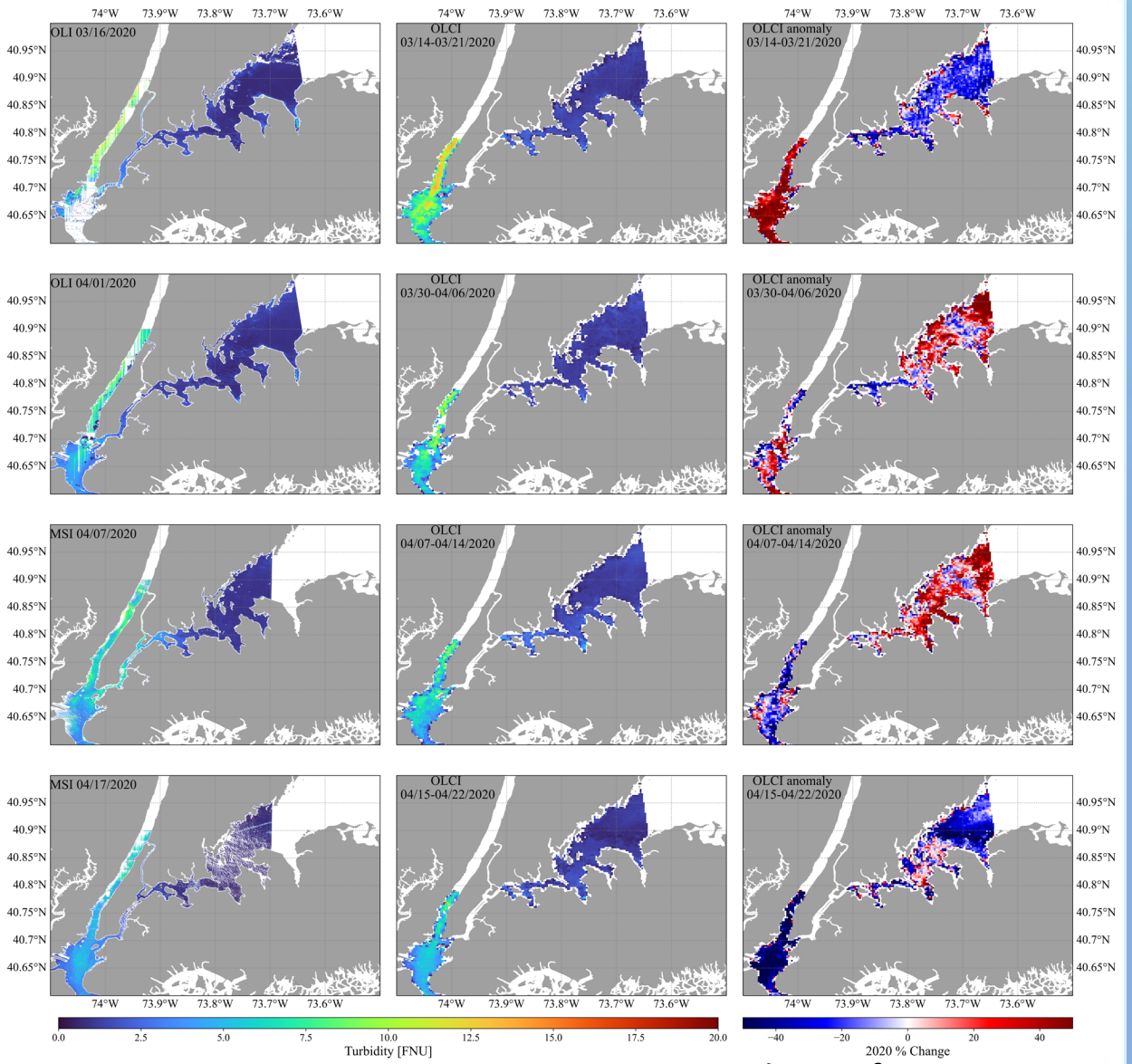
- Turbidity decreases
- Transition from above the baseline to below it

**Narrows:**

- Turbidity values remain relatively consistent.
- Change from bassline has no trend

- $a_{CDOM}(300)$ follows a similar trend as turbidity between the regions

- Chla in both regions was below the baseline into April




MSI/OLI

8Day OLCI composite

% Change from 2017-2019 baseline week

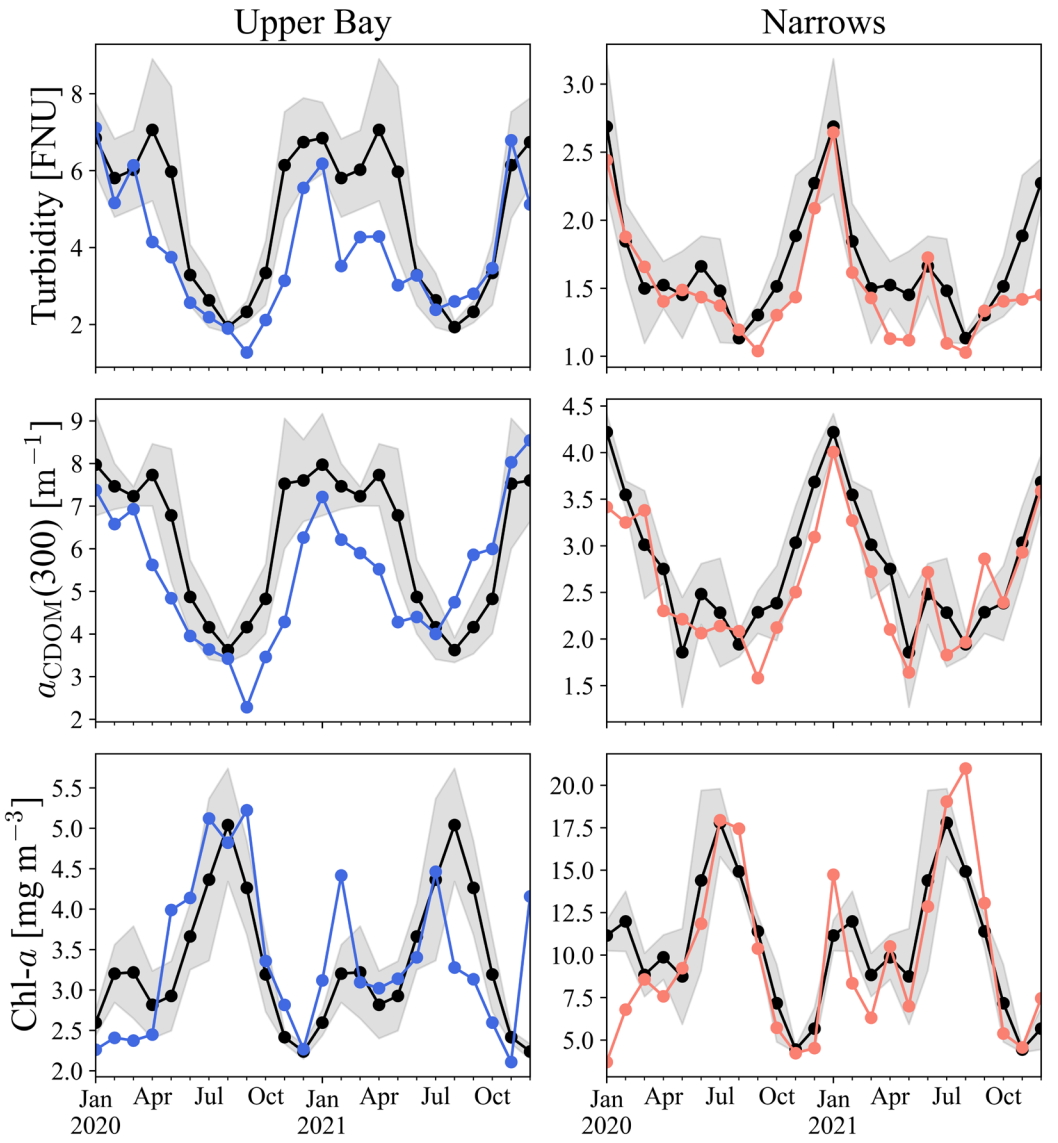
# Long term impacts on water quality

**Turbidity and $a_{CDOM}(300)$:**

- 2020/21 seasonal cycle consistent with baseline cycle in both regions.
- In Upper Bay values remain below the range of seasonal variability. In Narrow departure is smaller in magnitude.
- Note Aug 2021 when turbidity is above baseline for the first time

**Chla**

- Inverse relationship, particularly in the Upper Bay. Largest positive anomalies associated with most negative turbidity anomalies (e.g., Sep 20, Feb 21)



# Conclusions

- Ocean color remote sensing provided an opportunity to monitor the impacts of COVID-19 over space and time

- COVID-19 drastically changed anthropogenic pressure, primarily in Manhattan's heavily trafficked regions.

- Nitrogen loading into the Upper Bay drastically decreased in response, leading to generally lower turbidity and CDOM in the water concurrent with larger then average agal blooms.

- Conversely, in the more residential boroughs anthropogenic pressure remained more consistent, leading to minor changes in nitrogen loading and as a result less impact on water quality in the Narrows.

- This study highlights the potential benefits for water quality with additional wastewater treatment improvements.

# Acknowledgements

## Co-authors

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# Questions?