



National Environmental Satellite,  
Data, and Information Service

April 3, 2025

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

NOAA CoastWatch Satellite Course

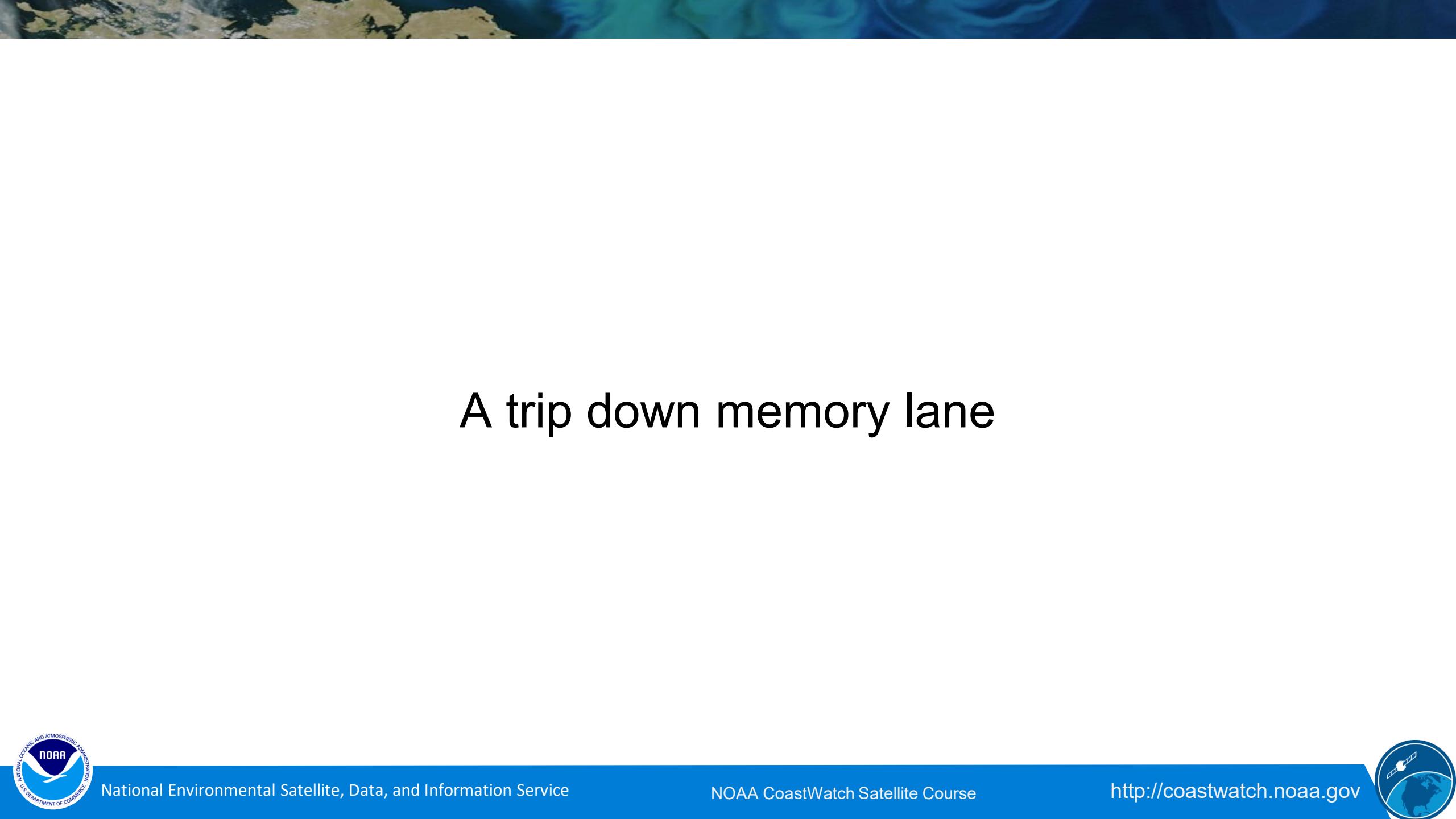
*Viewing and Analyzing Ocean/Coastal Events and Water Quality Using Satellites*

Jonathan Sherman<sup>1,2</sup>

<sup>1</sup> NOAA/NESDIS Center for Satellite Applications and Research

<sup>2</sup> Global Science & Technology Inc.





# A trip down memory lane





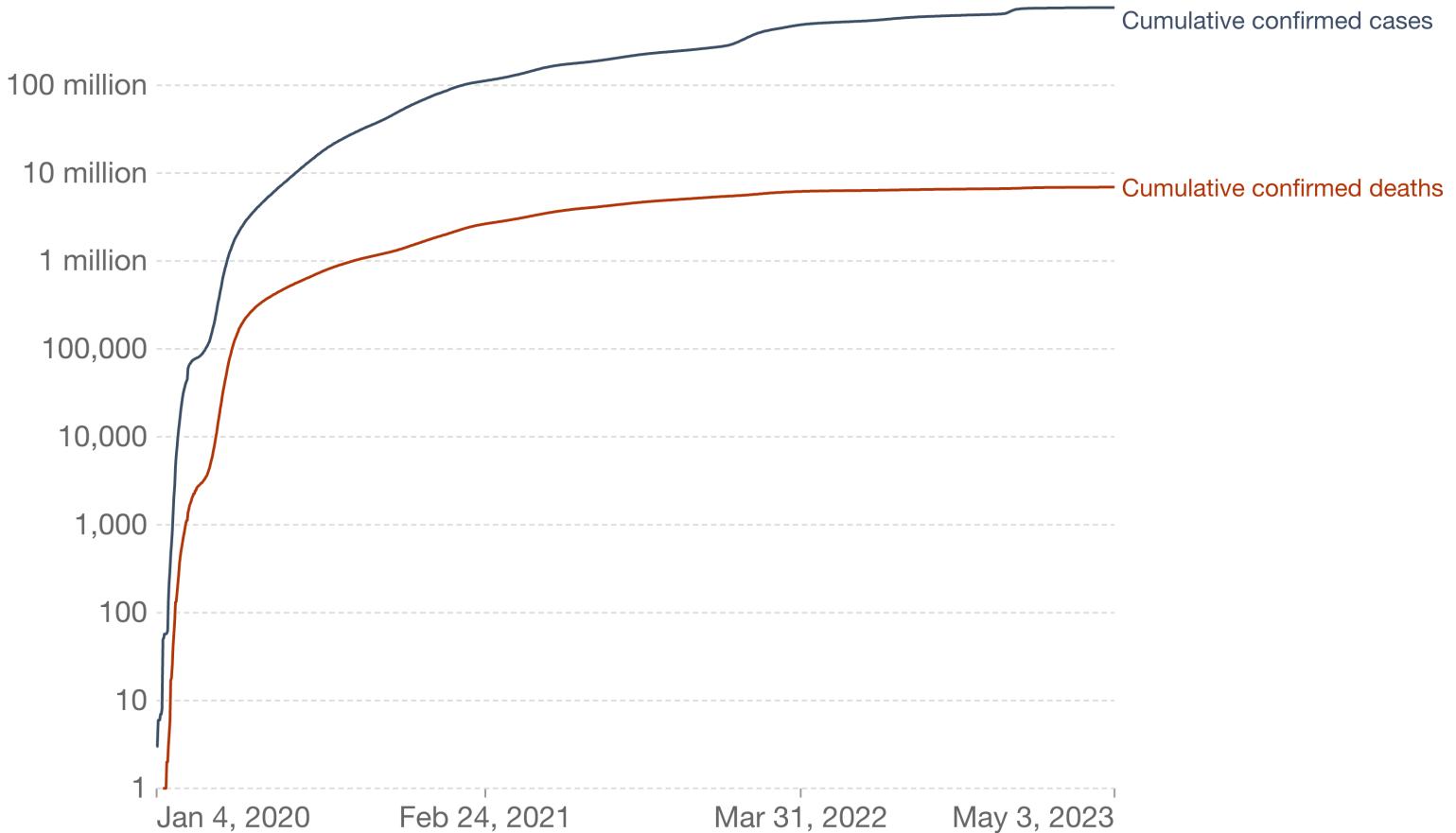
# COVID-19 had far-reaching impacts on society

Cumulative confirmed COVID-19 cases and deaths, World

Limited testing and challenges in the attribution of cause of death mean the confirmed case and death counts may not reflect the true counts.

Our World  
in Data

- Death toll in the millions



Source: WHO COVID-19 Dashboard

OurWorldInData.org/coronavirus • CC BY



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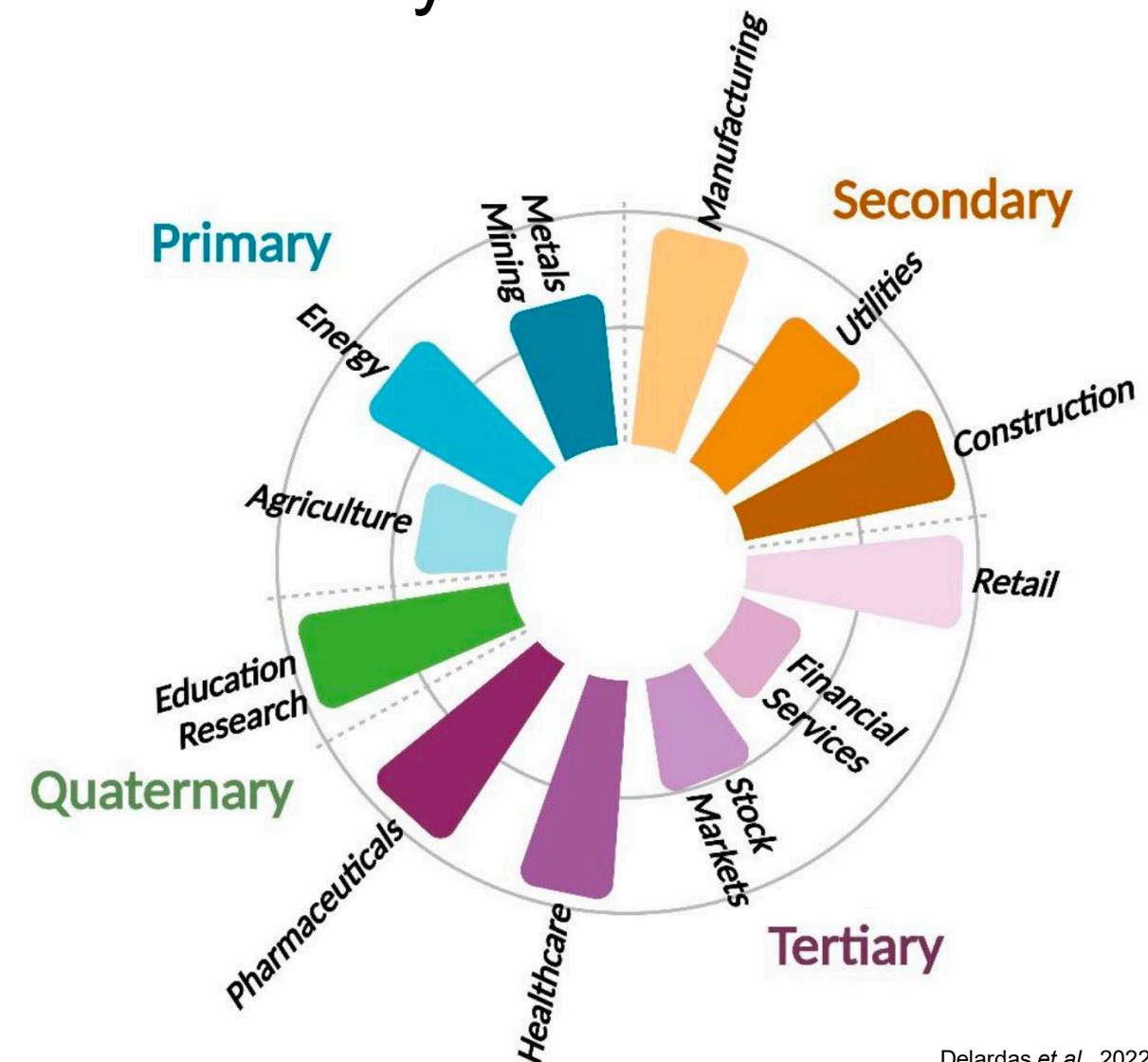
<http://coastwatch.noaa.gov>





# COVID-19 had far-reaching impacts on society

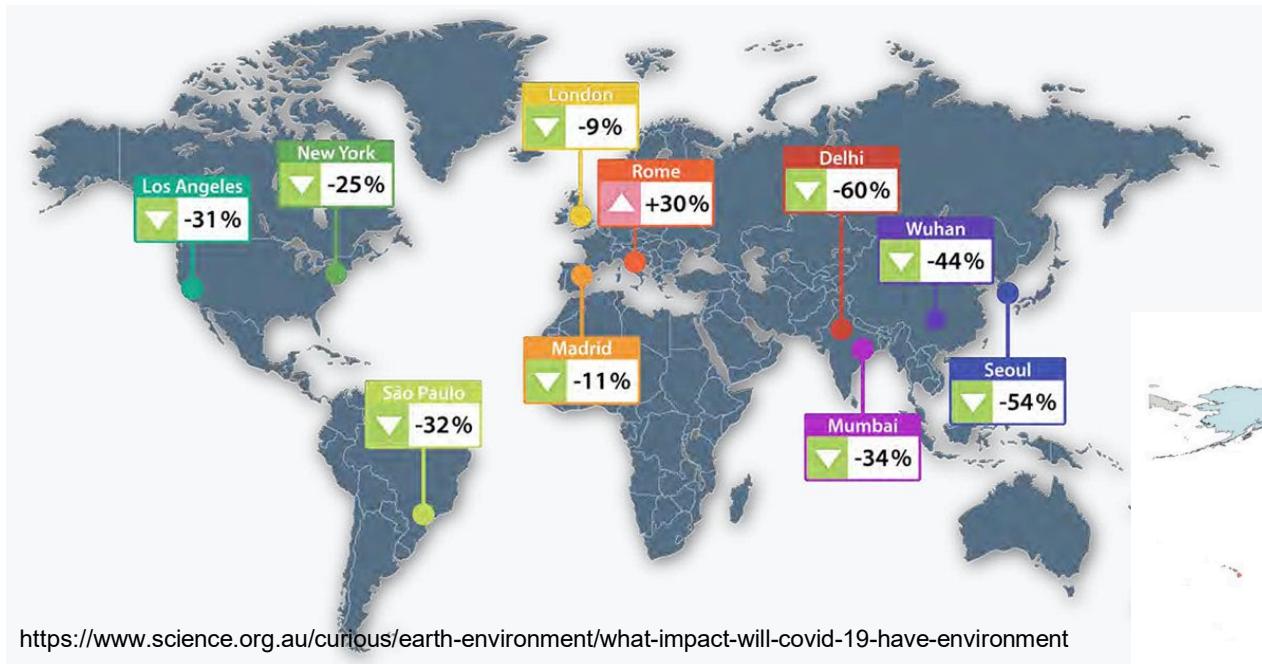
- Death toll in the millions
- The pandemic has also shaken-up the socio-economic order on a global scale



Delardas et.al., 2022

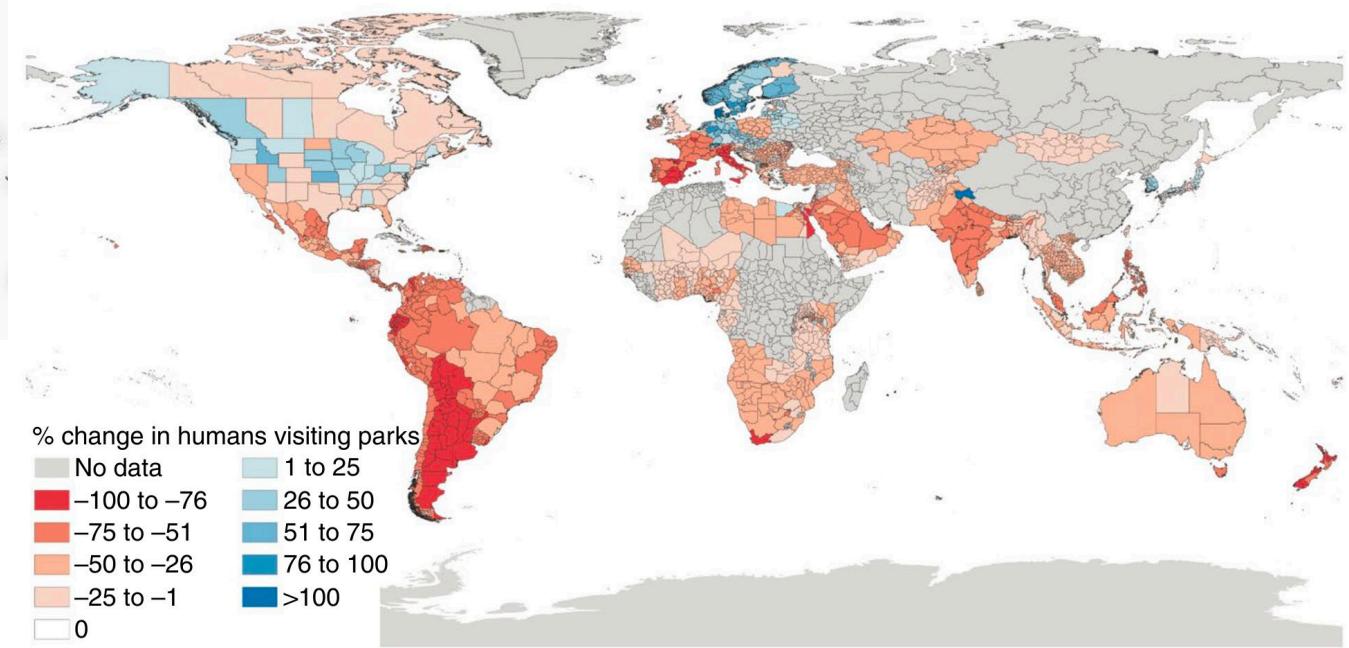


Measures imposed to limit COVID-19 transmission during the different stages of the pandemic changed the degree of anthropogenic pressure across the biosphere.



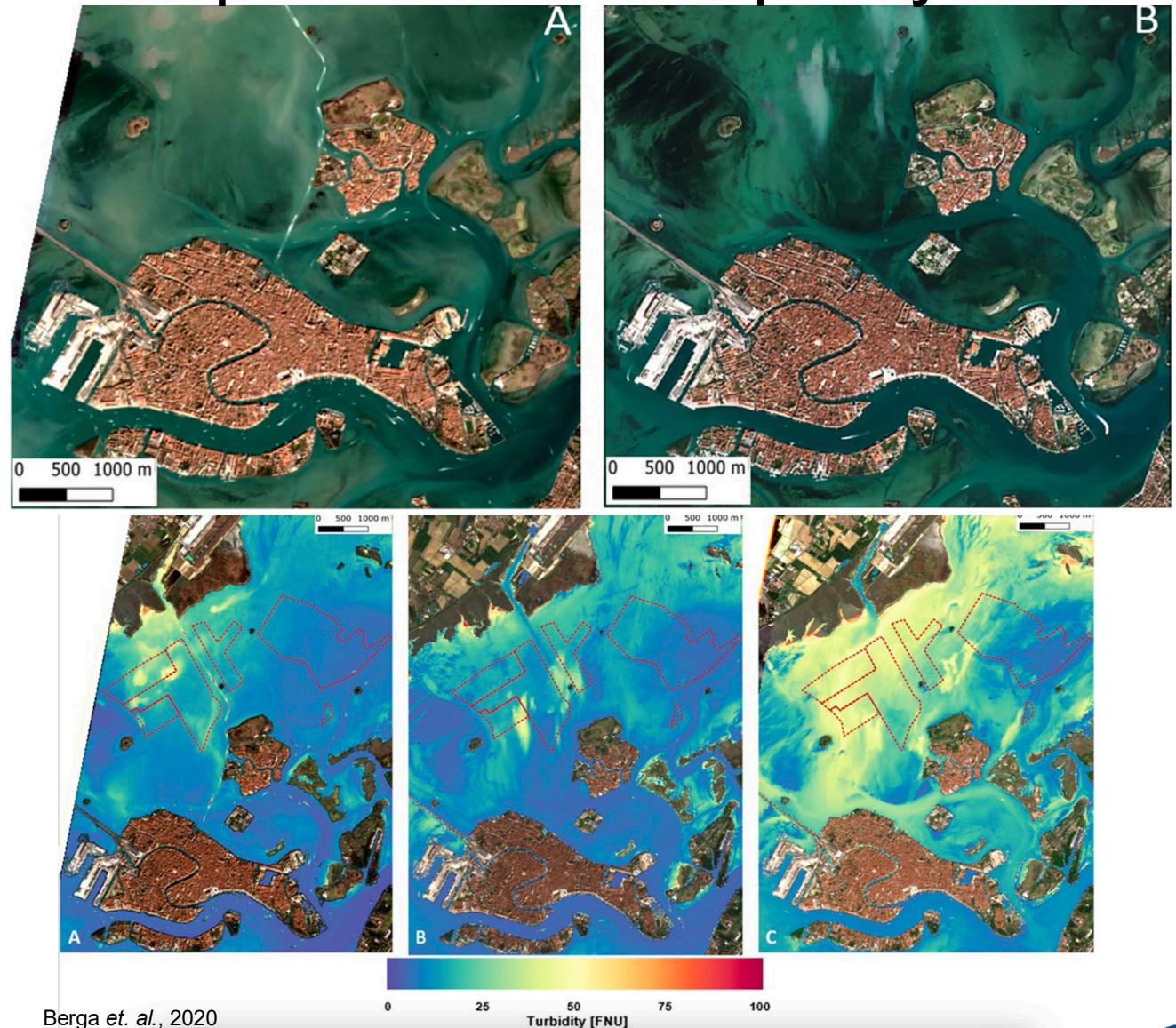
% Change in PM<sub>2.5</sub>

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



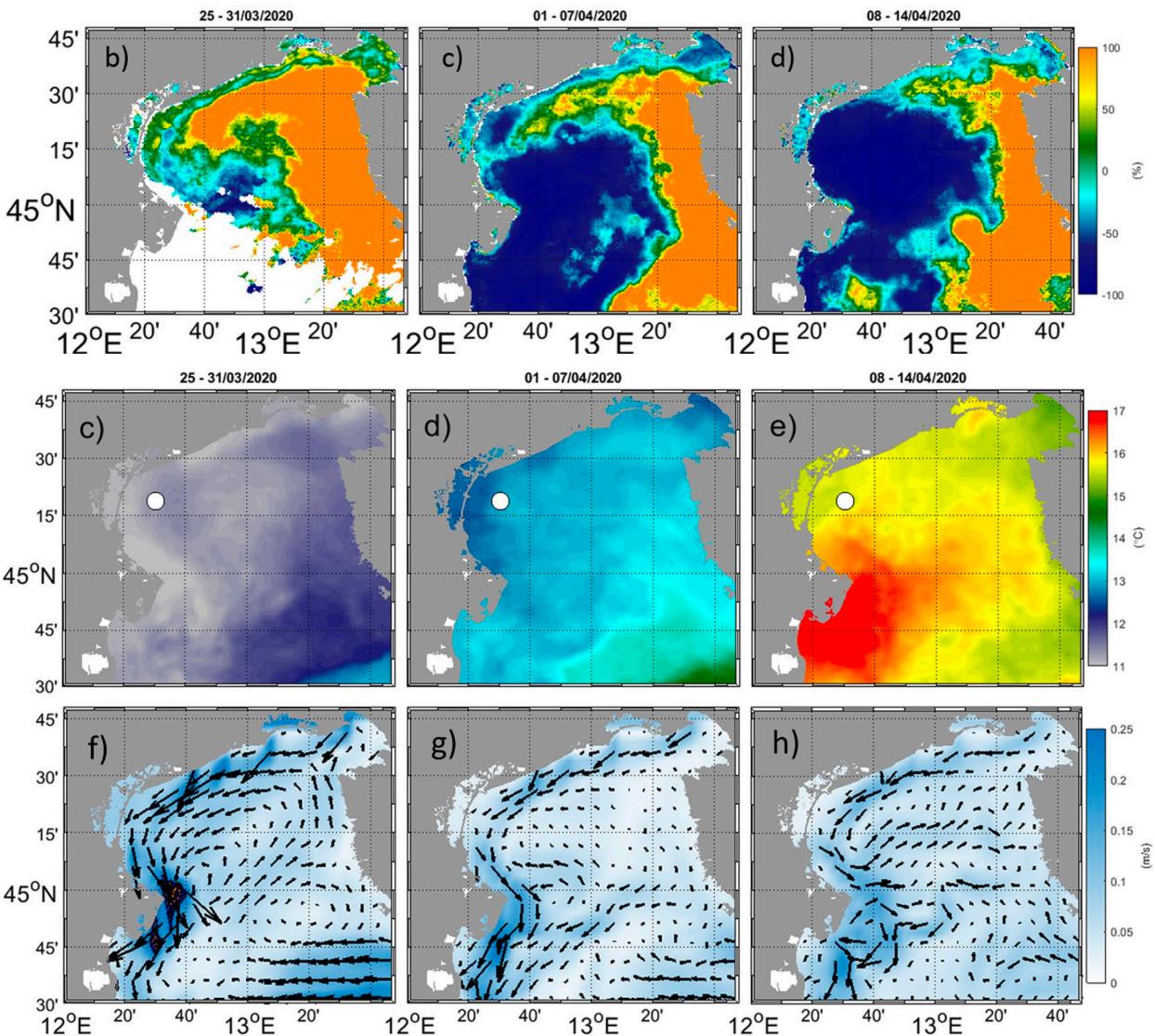
# Studies on COVID-19 shutdown impacts on water quality

- 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



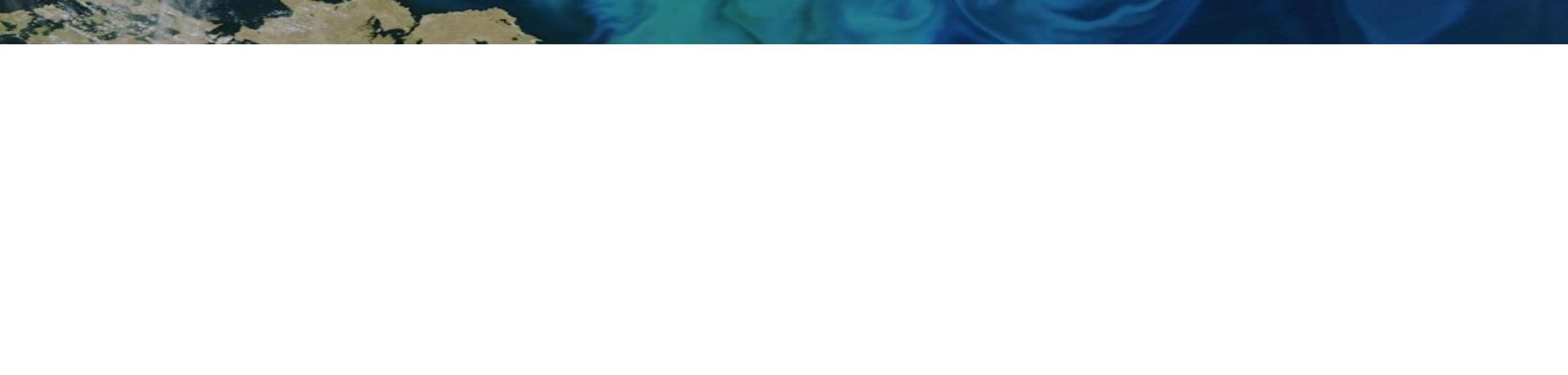
# Studies on COVID-19 shutdown impacts on water quality

- 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 to a combination of meteo-oceanographic and hydrological conditions.



Berga *et. al.*, 2022





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





5/10/23, 12:23 PM

New York City Region Is Now an Epicenter of the Coronavirus Pandemic - The New York Times

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

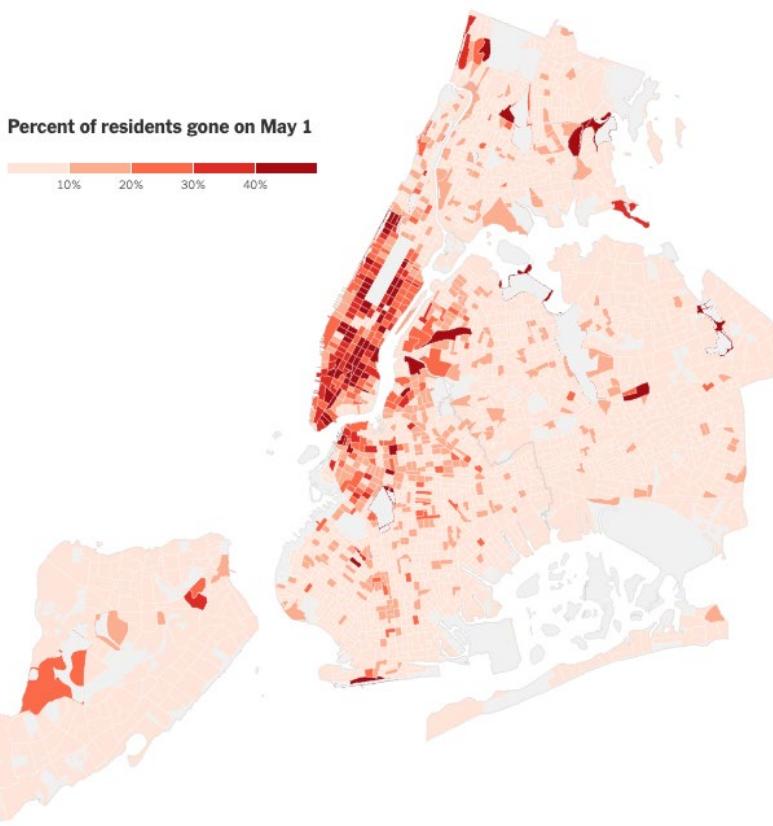
Three weeks after its first coronavirus infection was discovered, the New York City region reached an alarming milestone on Sunday: It now accounts for roughly 5 percent of the world's confirmed cases, making it an epicenter of the pandemic and increasing pressure on officials to take more drastic measures.

The New York Times

The Upshot

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

By Kevin Quealy May 15, 2020



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. © Deseret Labs



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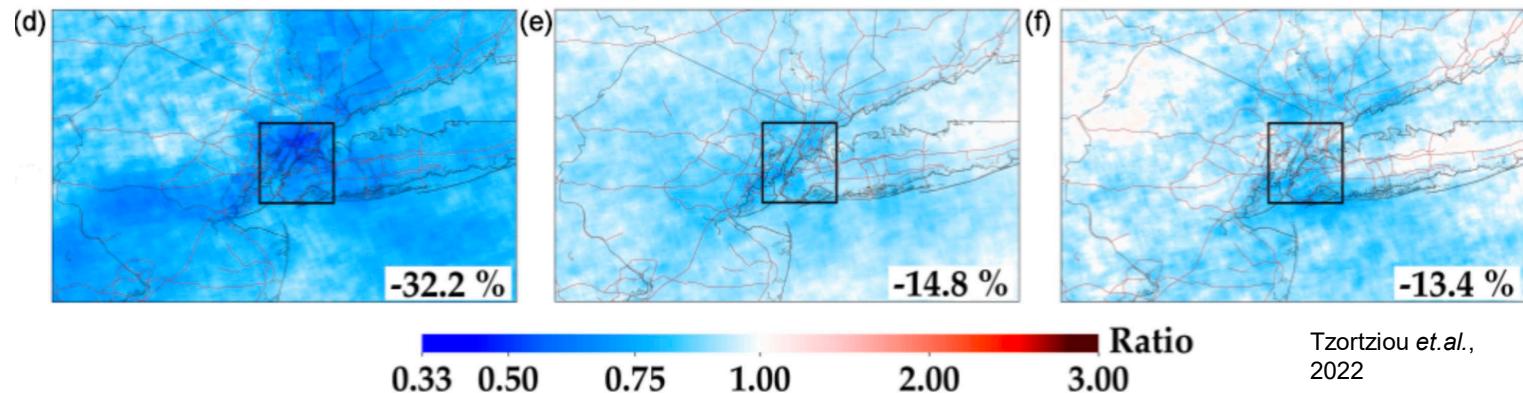
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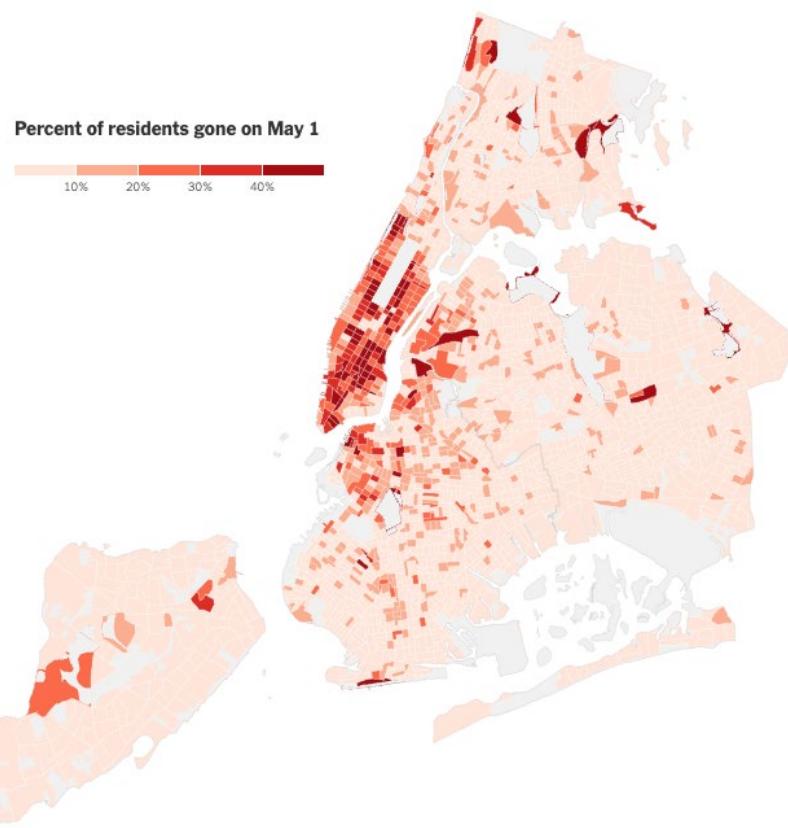


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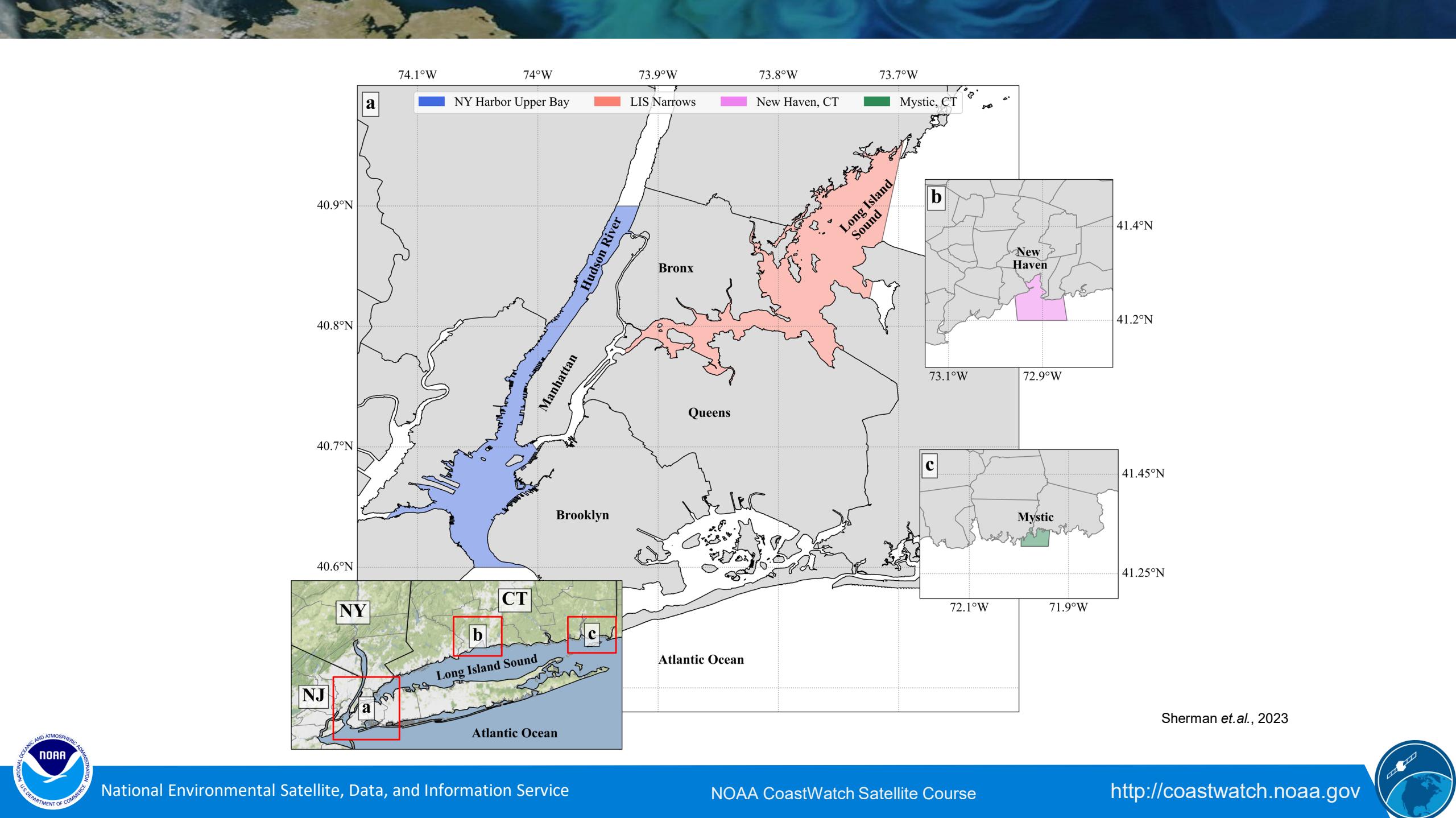


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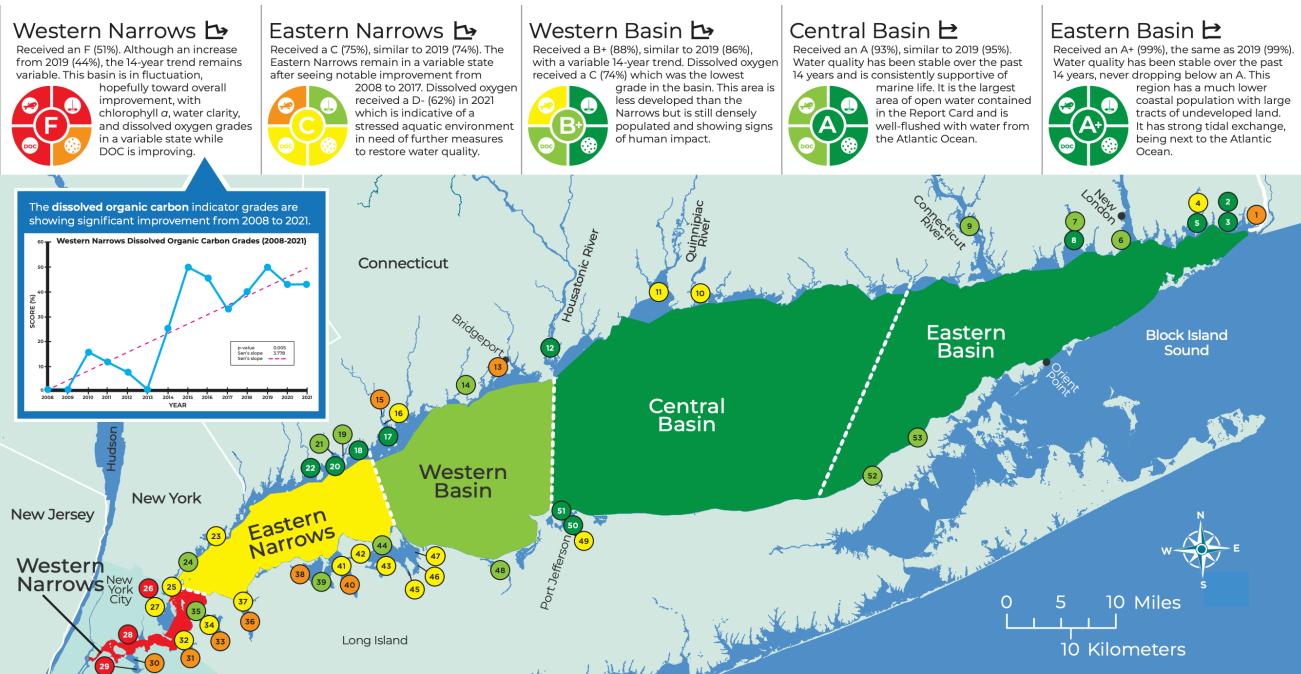
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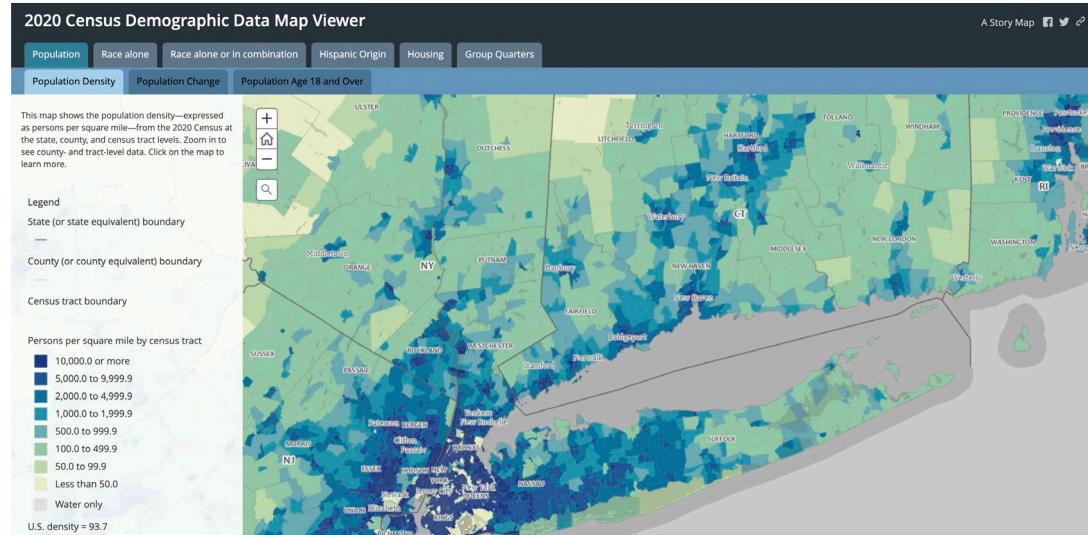




Taillie et.al., 2022



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

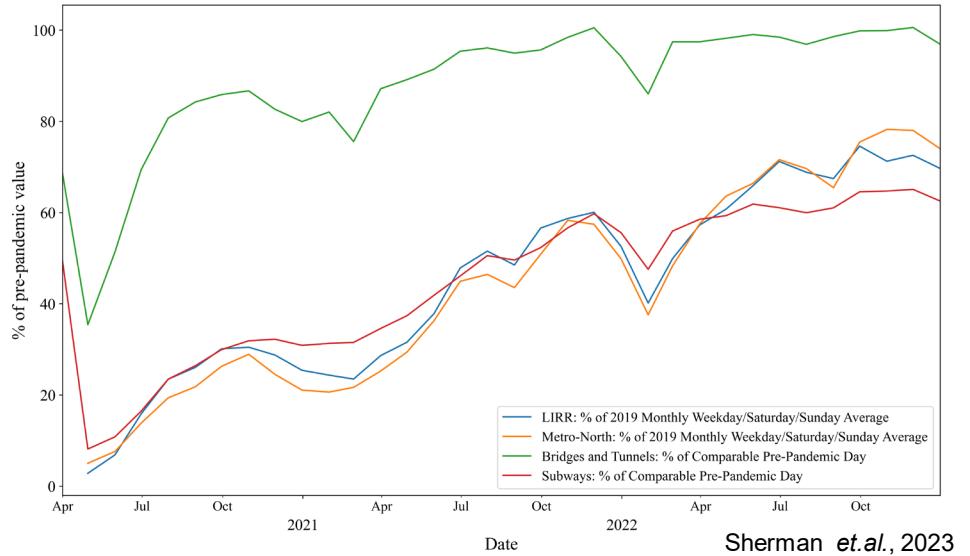
- Evaluate short- and long-term trends in
  - Water turbidity (Nechad *et. al.*, 2009)
  - aCDOM(300) (Cao and Tzortziou, 2022)
  - Chl-a (Sherman *et. al.*, 2023)

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

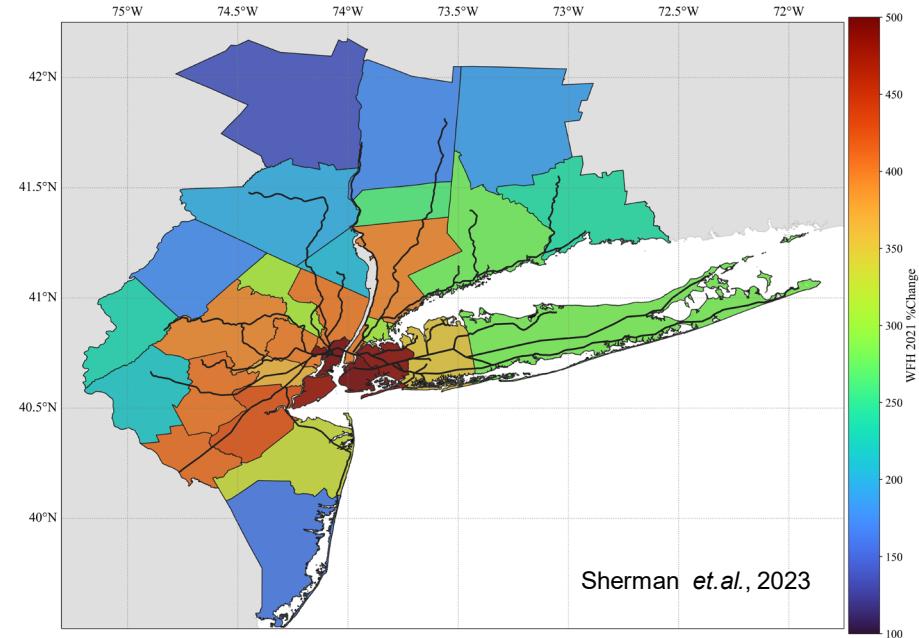


# Changes in human mobility

- 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



Sherman et.al., 2023



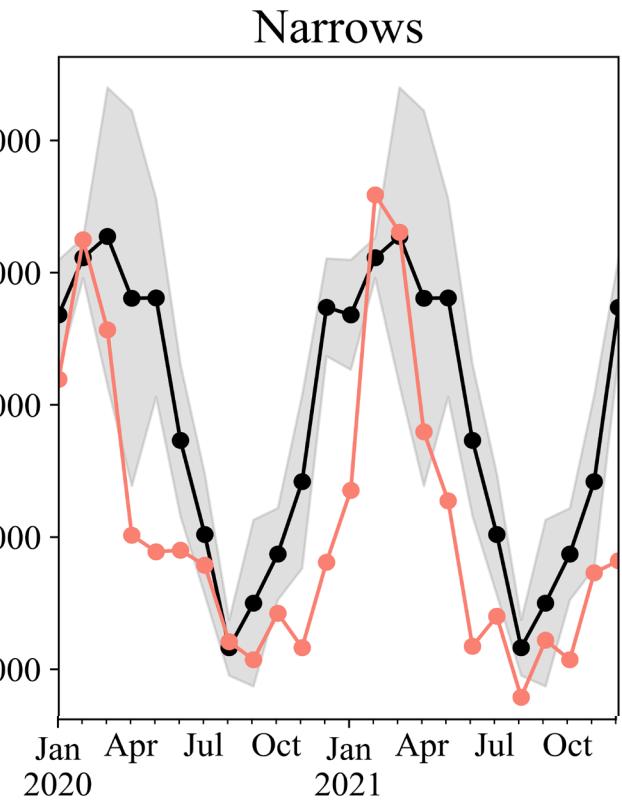
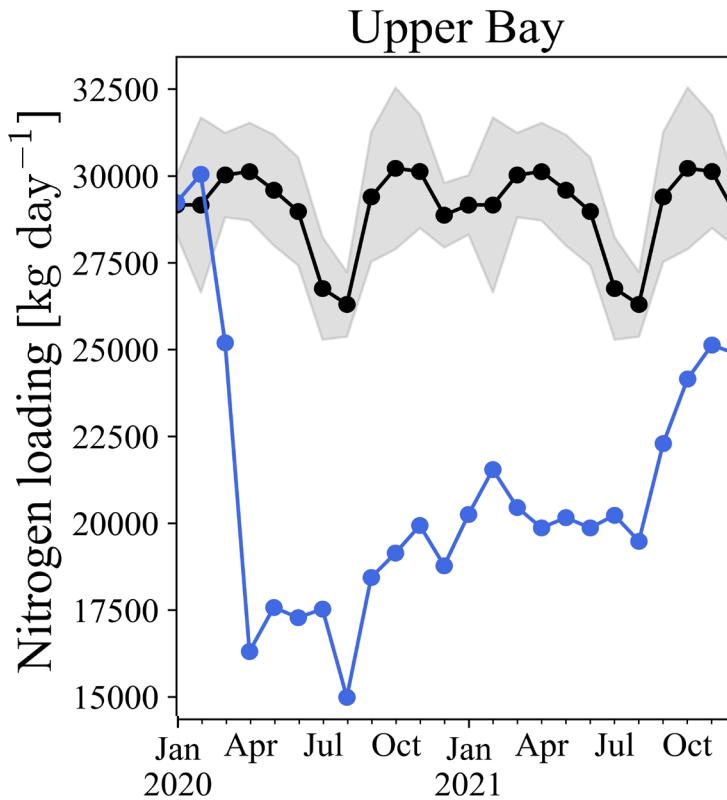
Sherman et.al., 2023



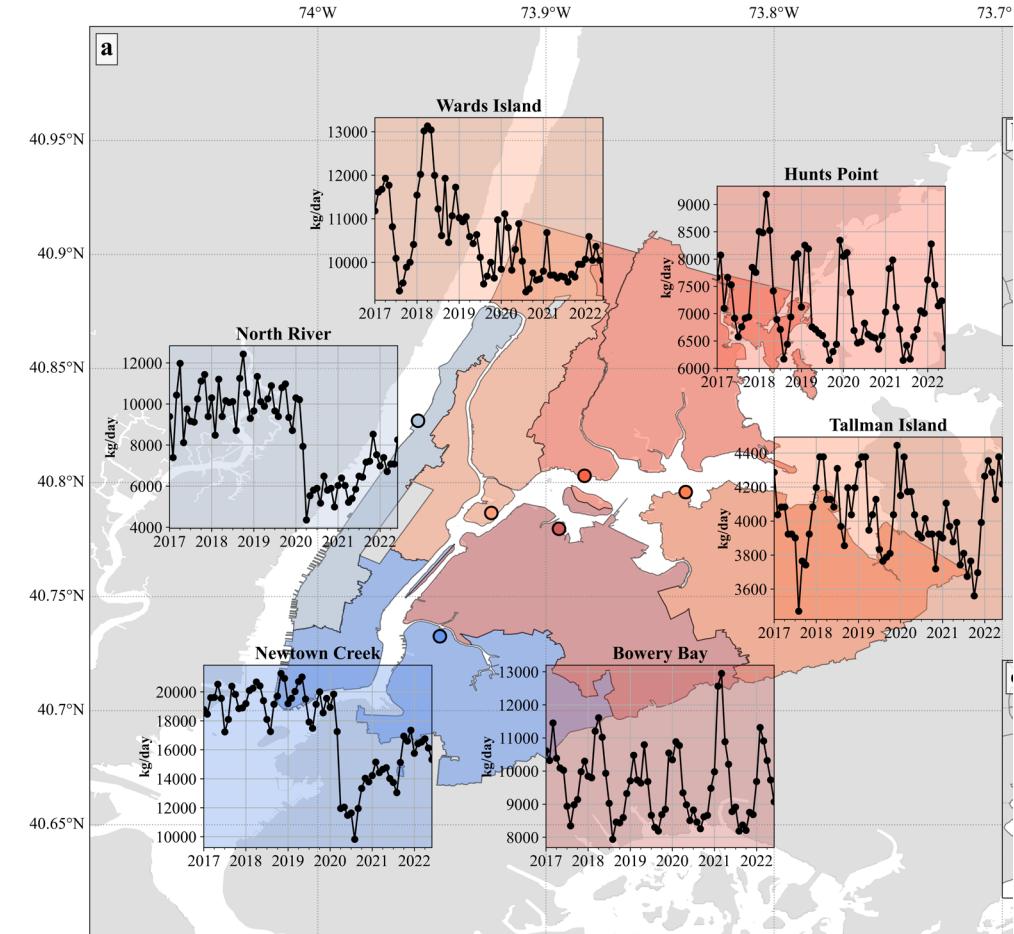


# Trends in nitrogen loading

Two trends emerge past April 2022:



Sherman et.al, 2023



Sherman et.al., 2023



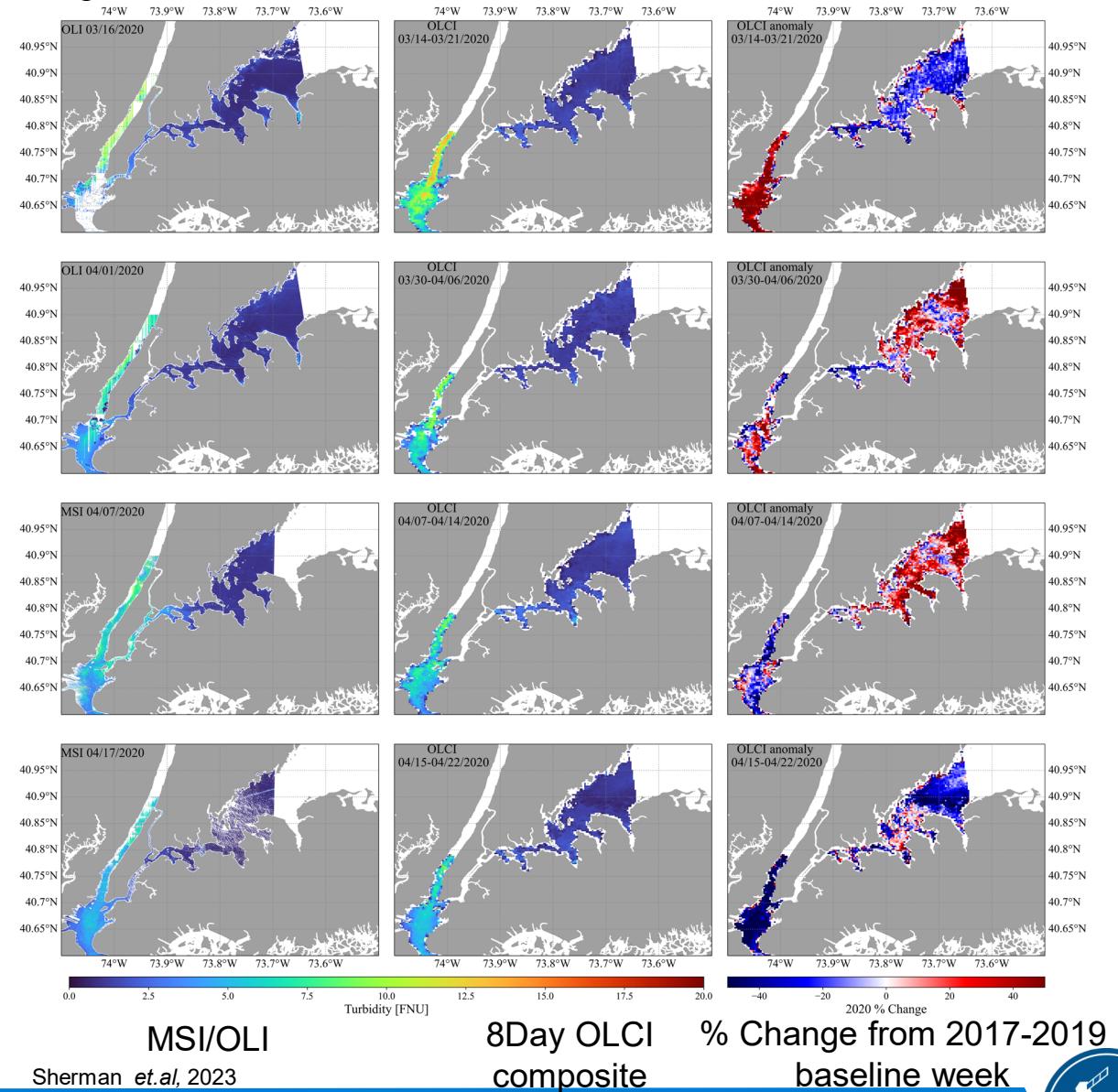
# Short term impacts on water quality Following first lockdown order (March 20<sup>th</sup>)

## Upper Bay:

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

## Narrows:

- Turbidity values remain relatively consistent.
- Change from baseline 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



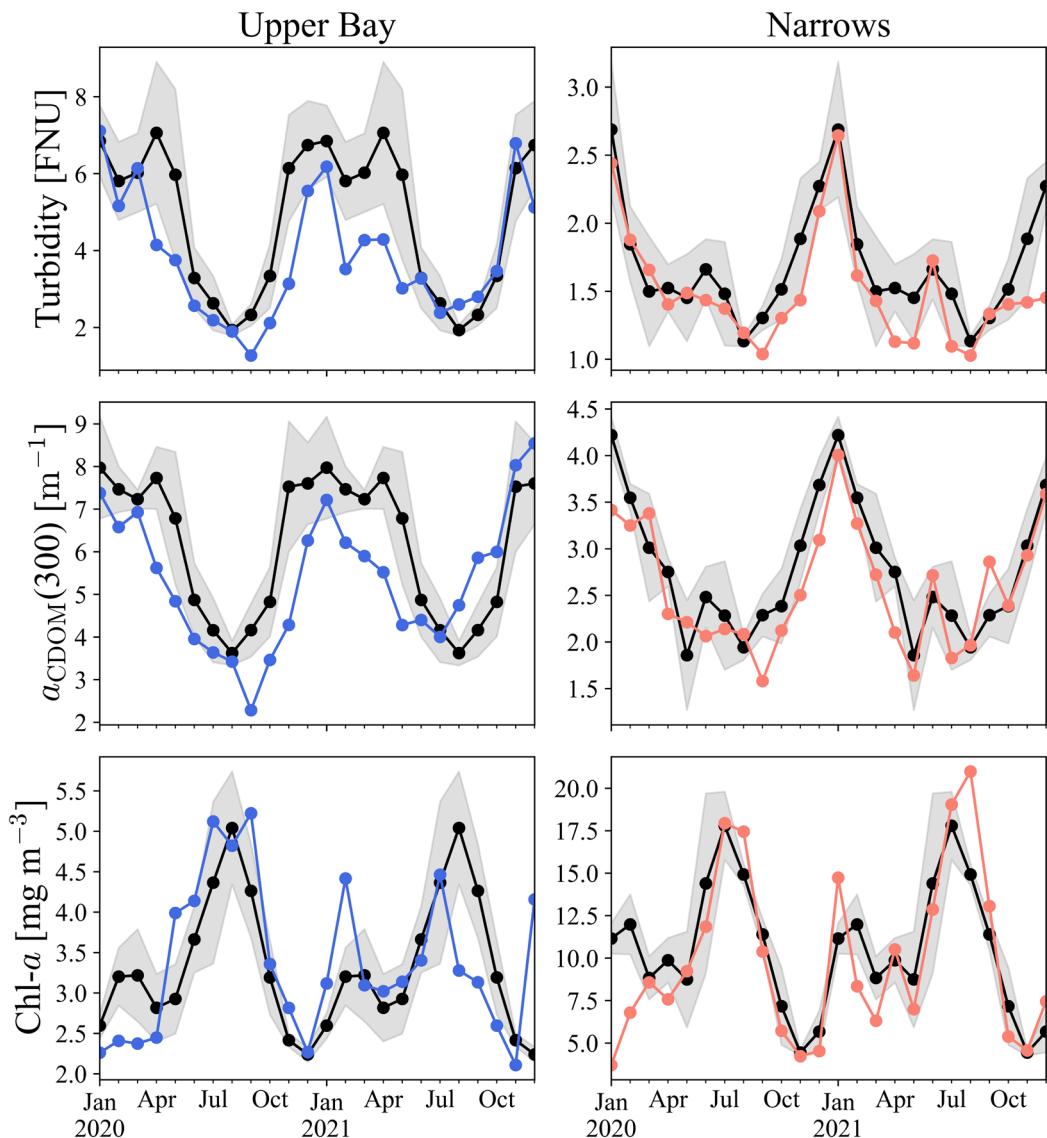
# Long term impacts on water quality

## 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)



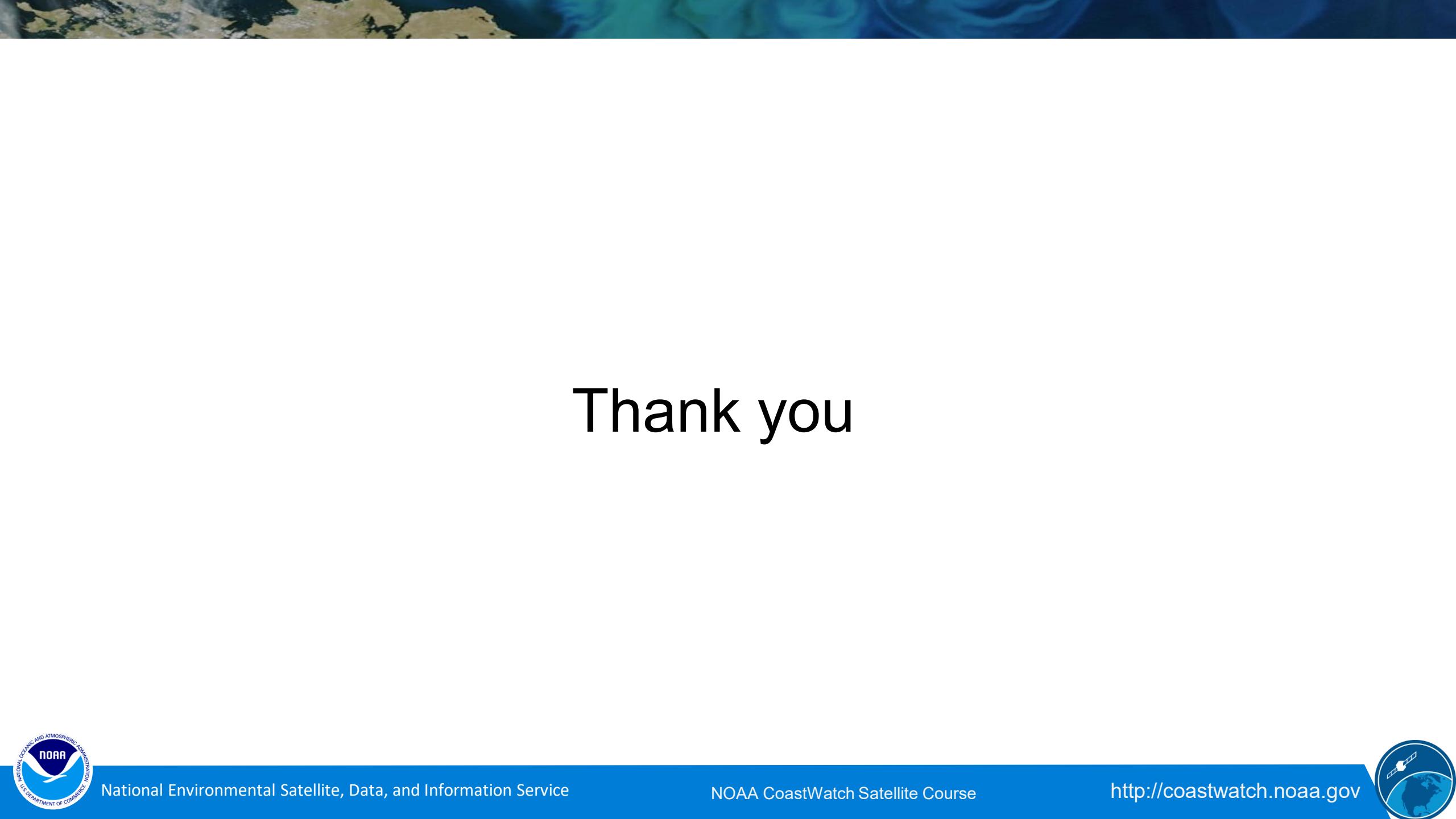
Sherman et.al, 2023



# 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 than average algal 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.





# Thank you



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