Bigelow | Laboratory for Ocean Sciences

Ocean color remote sensing of zooplankton

Detecting swarms of Calanus in the western North Atlantic

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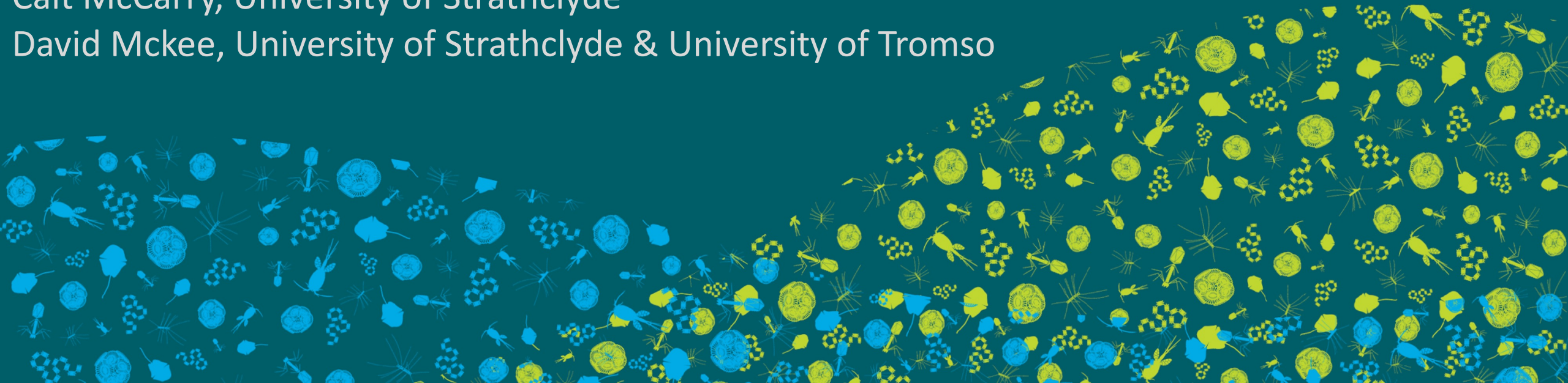
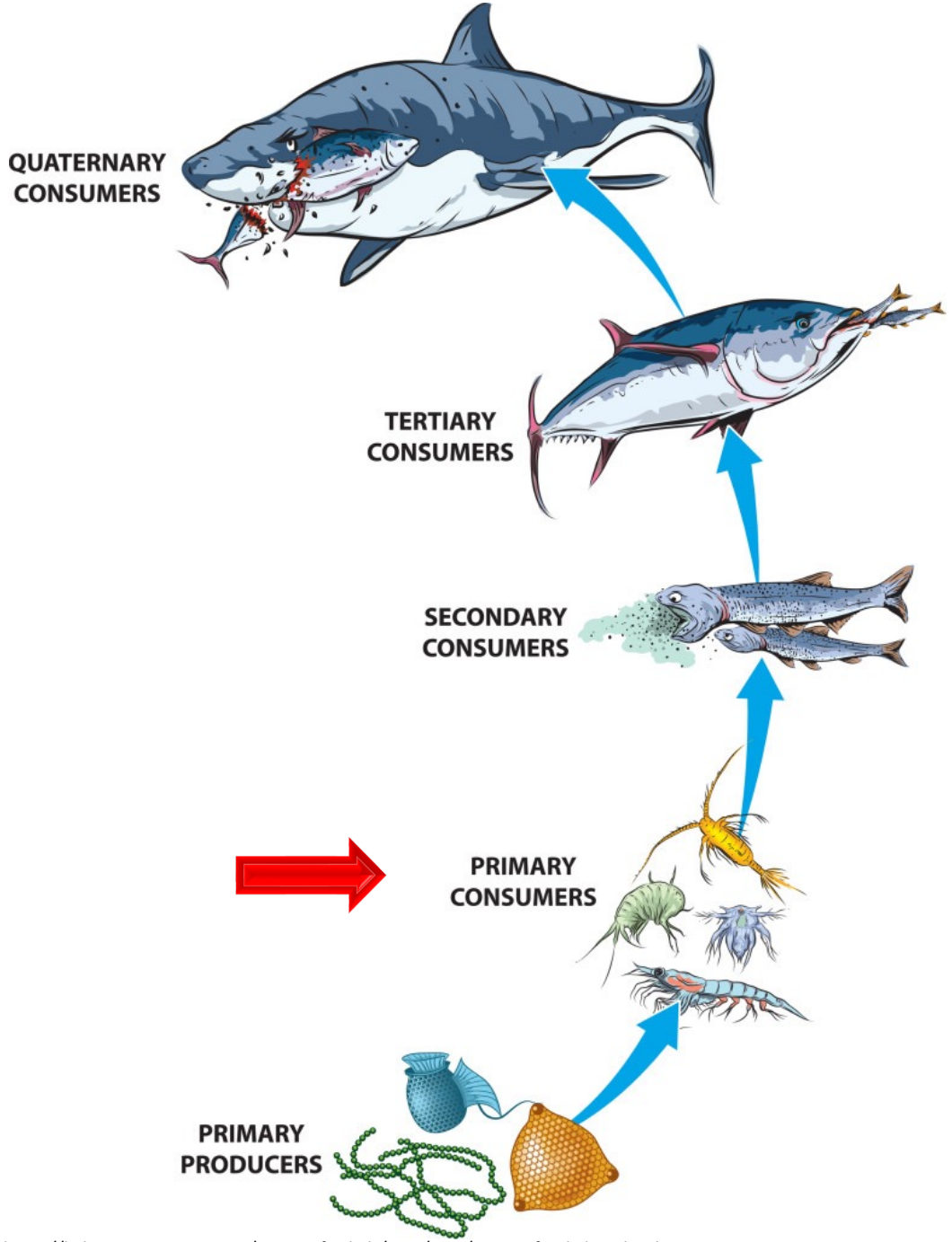
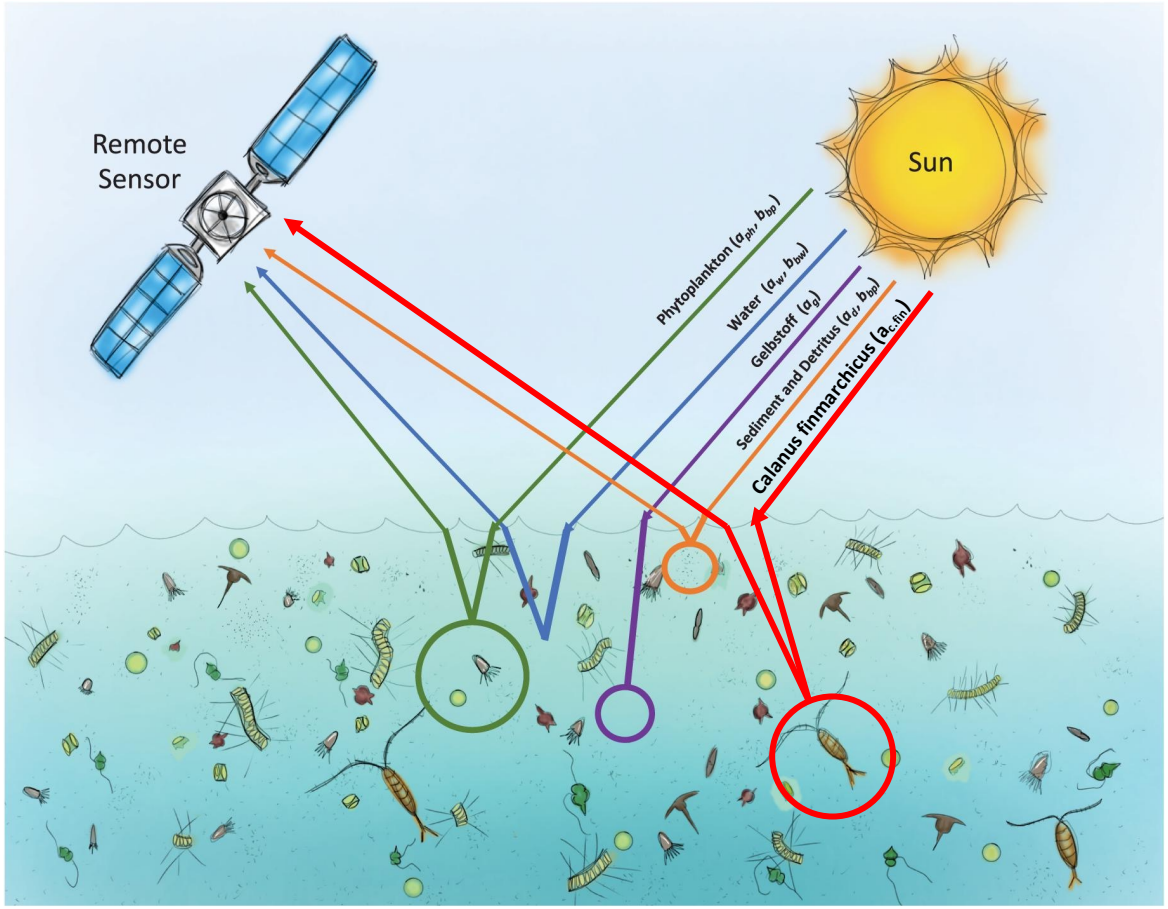




Source: https://kidspressmagazine.com/science-for-kids/misc/misc/marine-food-chain.html

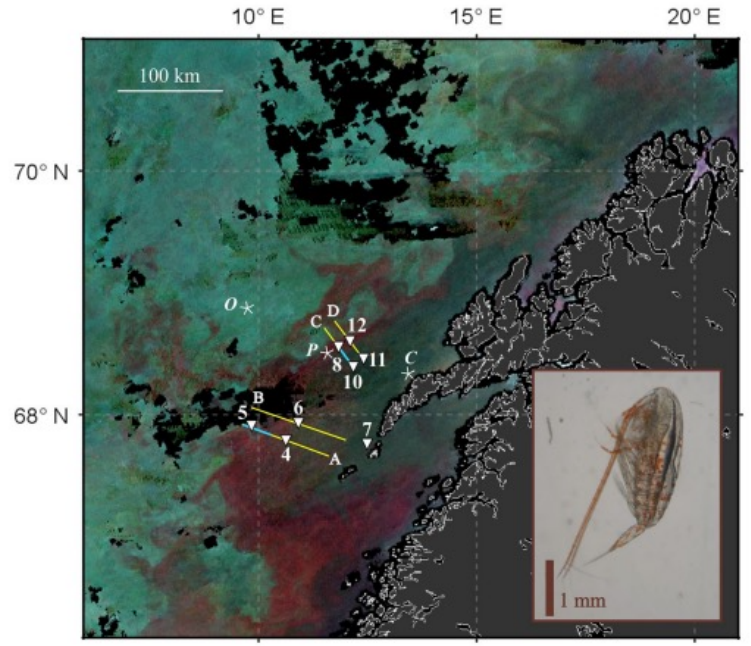
Zooplankton Remote sensing



Modified from Menden-Deuer et al. (2021)

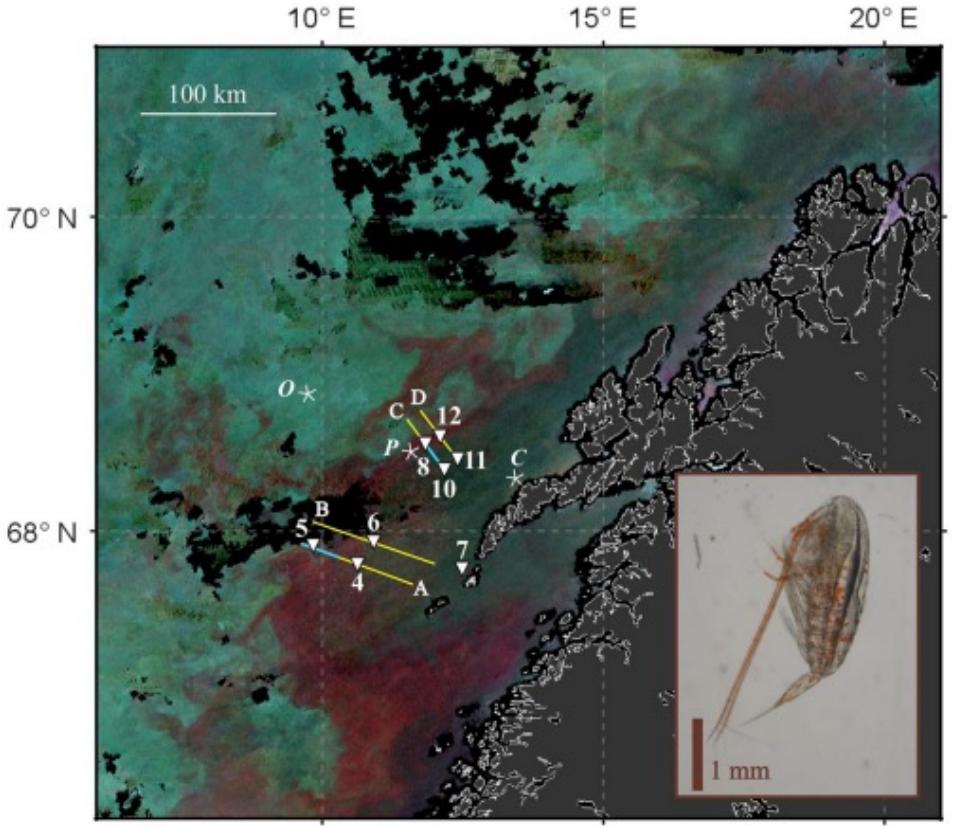
Calanus finmarchicus

What do copepods look like from space?



(Basedow et al., 2019)

Remote sensing of Zooplankton swarms



enhanced RGB (eRGB) satellite image shows the high abundances of C. finmarchicus in the off Norwegian Coast. (Basedow et al., 2019)

SCIENTIFIC REPORTS

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Remote sensing of zooplankton swarms

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Zooplankton provide the key link between primary production and higher levels of the marine food web and they play an important role in mediating carbon sequestration in the ocean. All commercially harvested fish species depend on zooplankton populations. However, spatio-temporal distributions of zooplankton are notoriously difficult to quantify from ships. We know that zooplankton can form large aggregations that visibly change the color of the sea, but the scale and mechanisms producing these features are poorly known. Here we show that large surface patches (>1000 km²) of the red colored copepod *Calanus finmarchicus* can be identified from satellite observations of ocean color. Such observations provide the most comprehensive view of the distribution of a zooplankton species to date, and alter our understanding of the behavior of this key zooplankton species. Moreover, our findings suggest that high concentrations of astaxanthin-rich zooplankton can degrade the performance of standard blue-green reflectance ratio algorithms in operational use for retrieving chlorophyll concentrations from ocean color remote sensing.

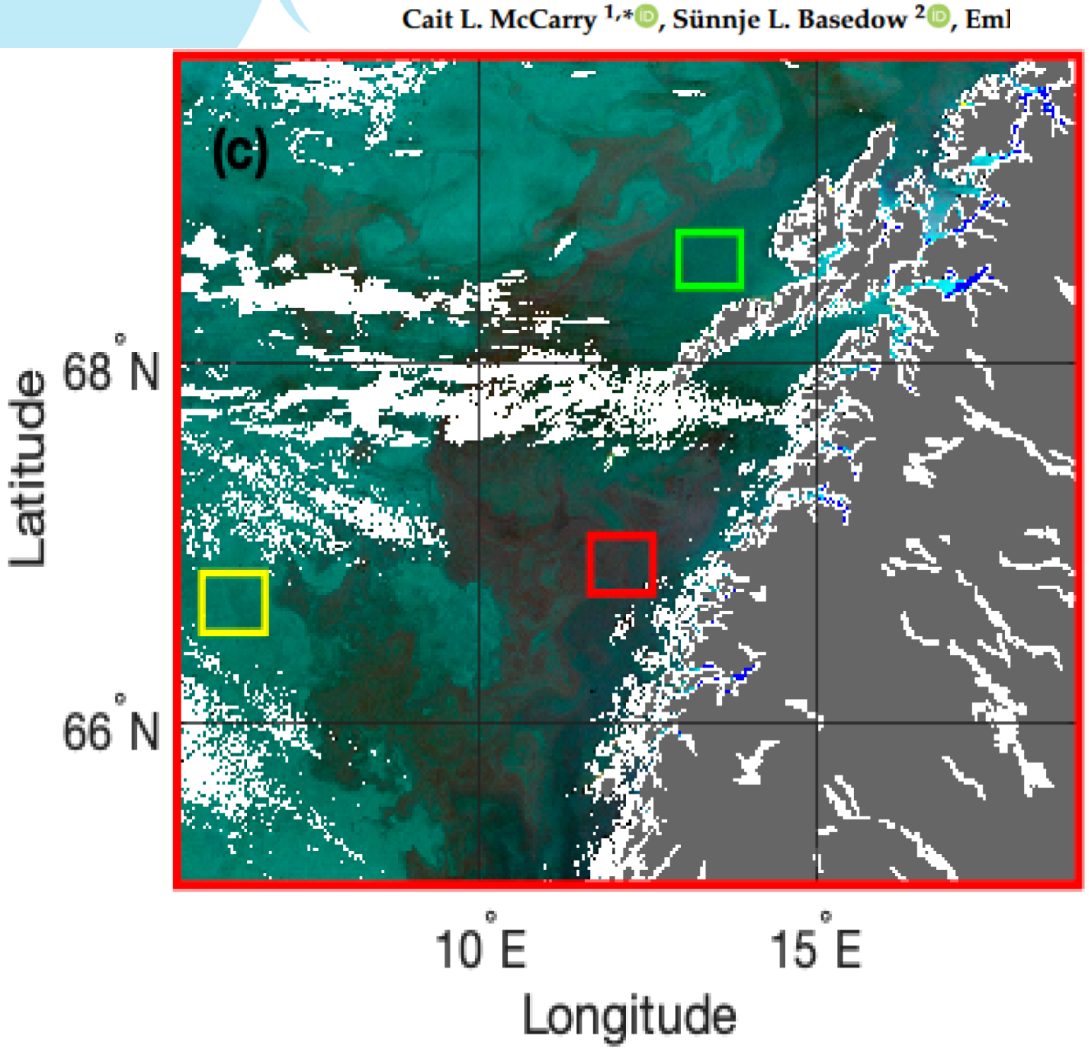
remote sensing

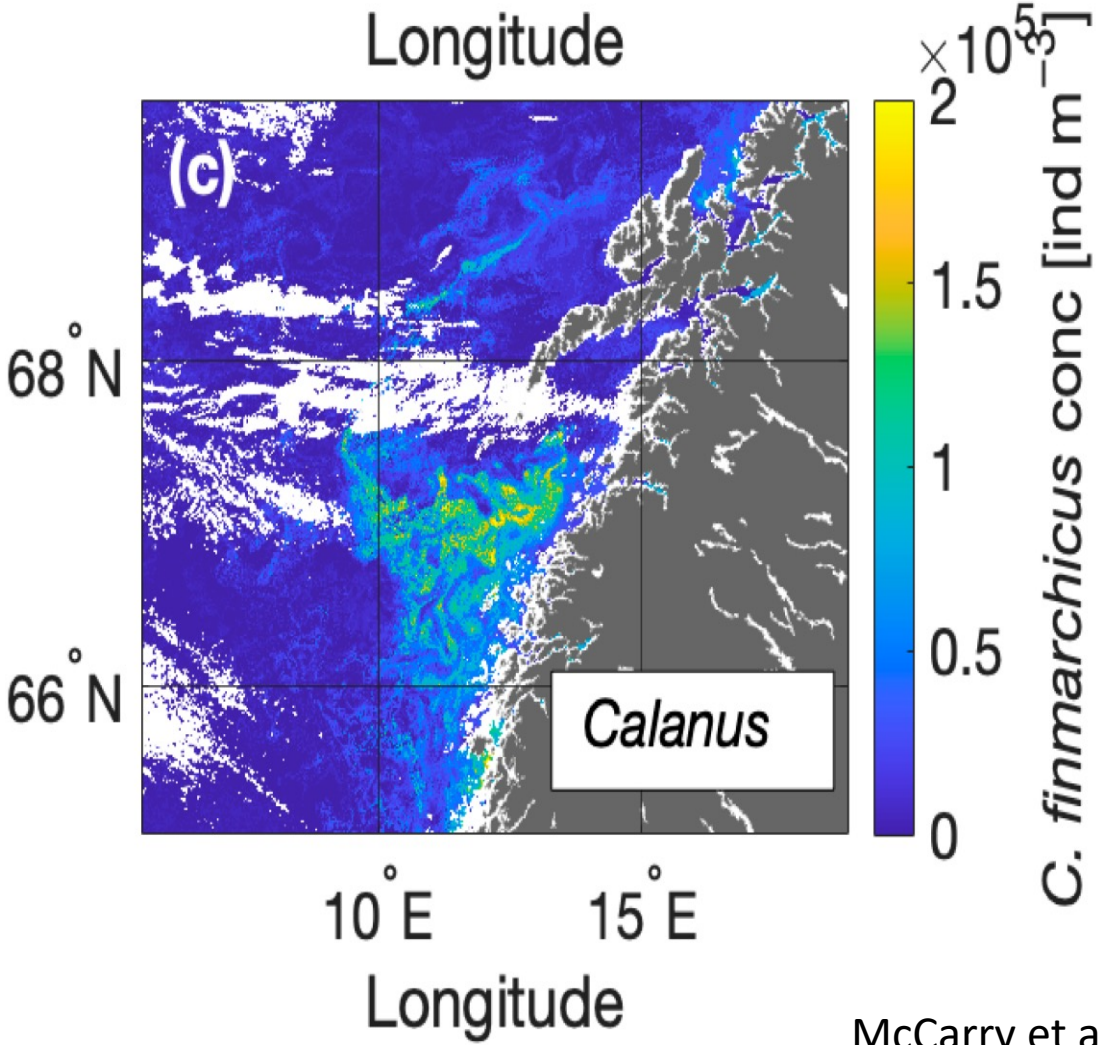
MDPI

Article

Estimating Surface Concentrations of *Calanus finmarchicus* Using Standardised Satellite-Derived Enhanced RGB Imagery

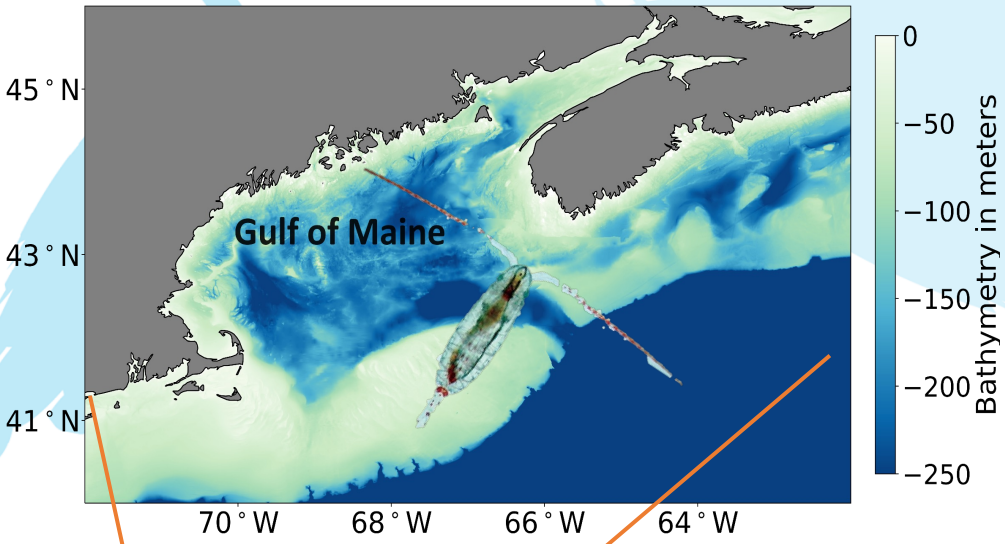
Cait L. McCarry [1,*], Sünnje L. Basedow [2], Eml

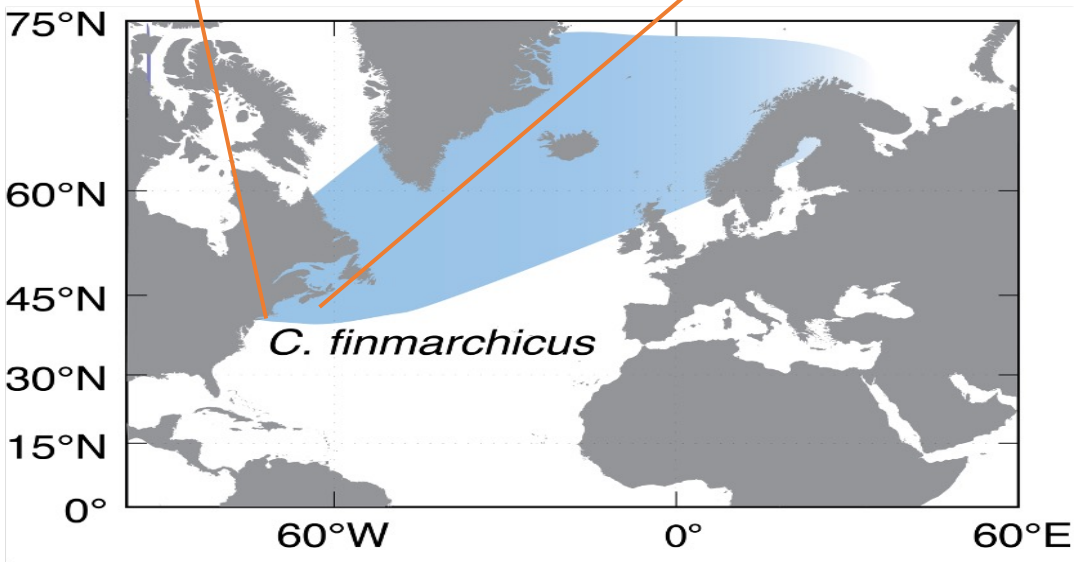


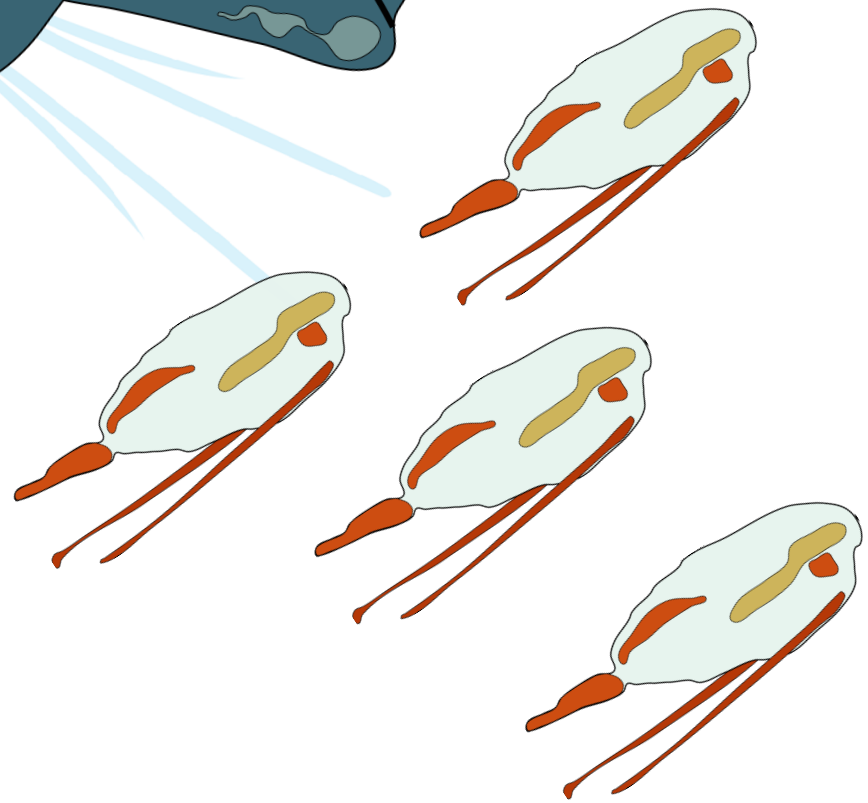


McCarry et al. (2023)

Calanus in the Gulf of Maine (GoM)







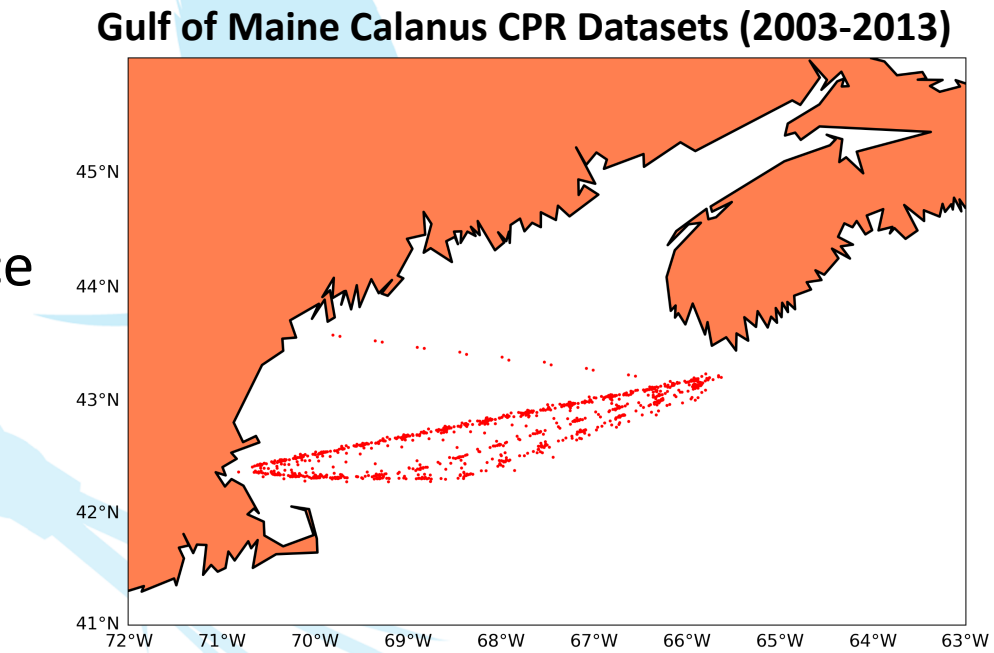
Subarctic distribution of the planktonic copepod, Calanus finmarchicus. Inset: photograph of the lipid-rich C. finmarchicus Stage CV, favored prey of the North Atlantic right whale.

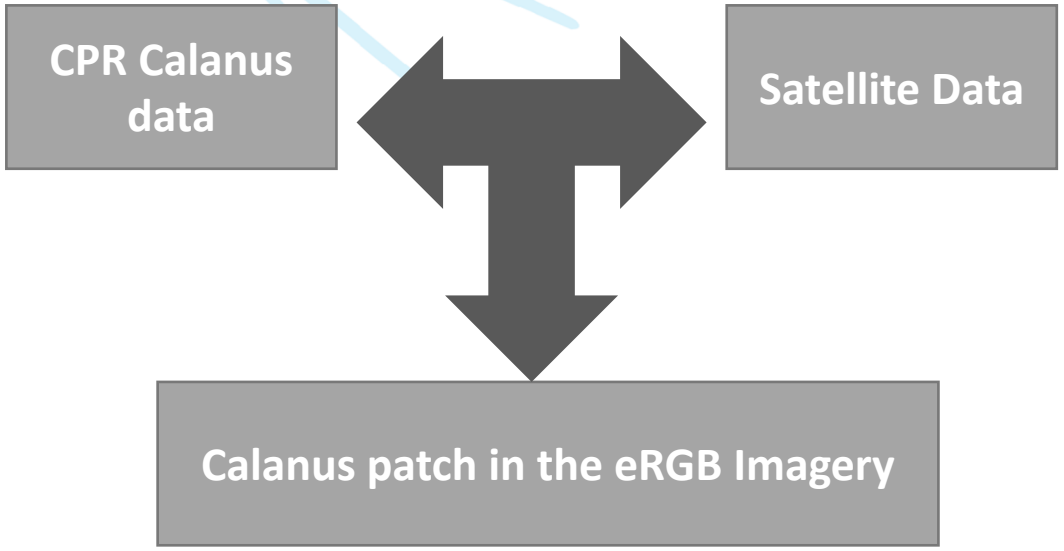
Source: The Marine Biodiversity Observing Network (MBON)

Detecting Calanus in the Gulf of Maine

To verify the presence of surface patches in eRGB satellite imagery as Calanus, we utilized in situ surface abundance data of Calanus from the Continuous Plankton Recorder (CPR) collected in the GoM, sourced from a CPR database maintained by NOAA (National Oceanic and Atmospheric Administration).

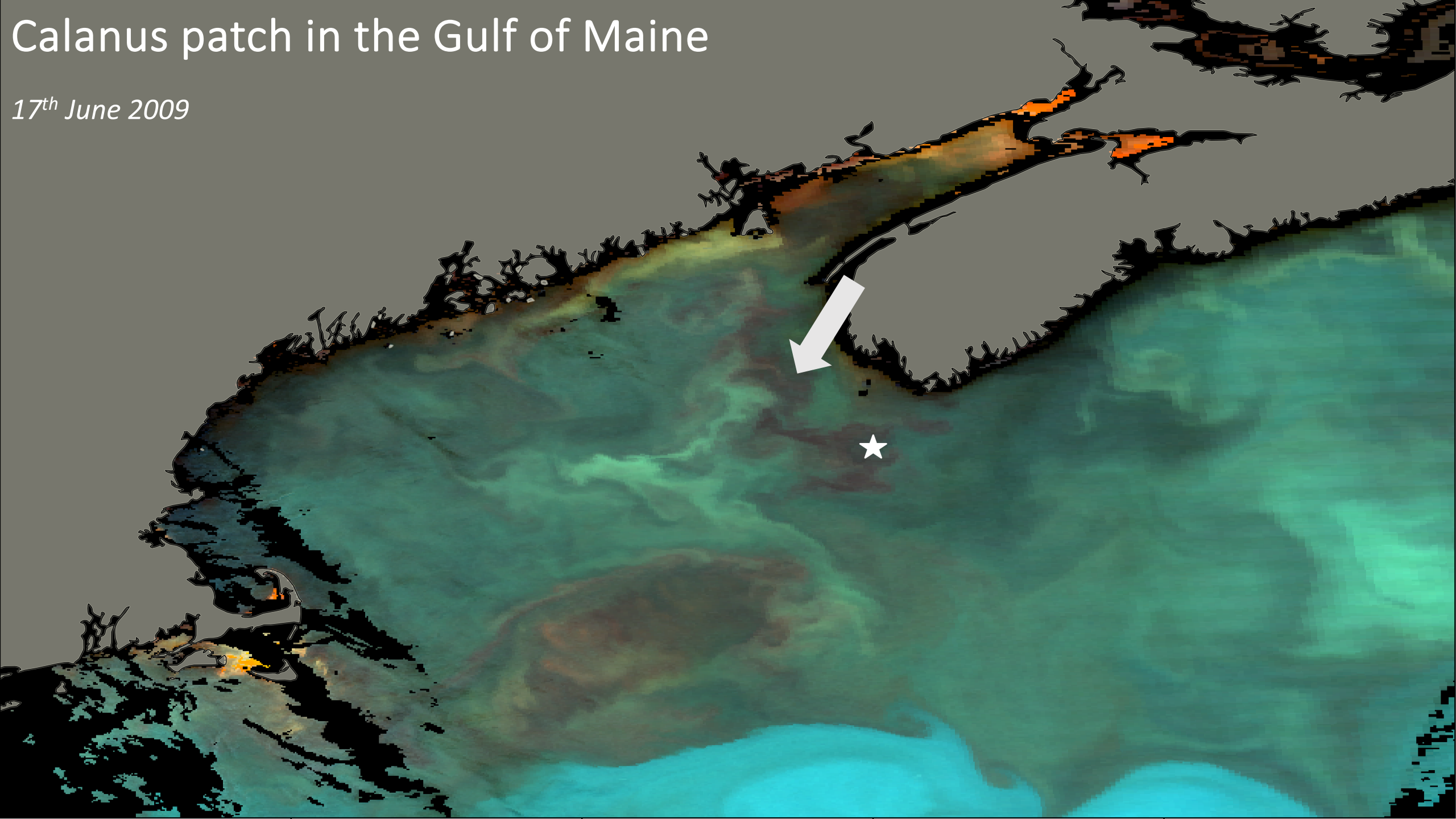
The initial identification of Calanus patch in eRGB satellite imagery involved comparing in-situ CPR Calanus and eRGB satellite data from 2003 to 2013. This timeframe was selected due to the overlap of data availability from both CPR and MODIS Aqua satellite data.





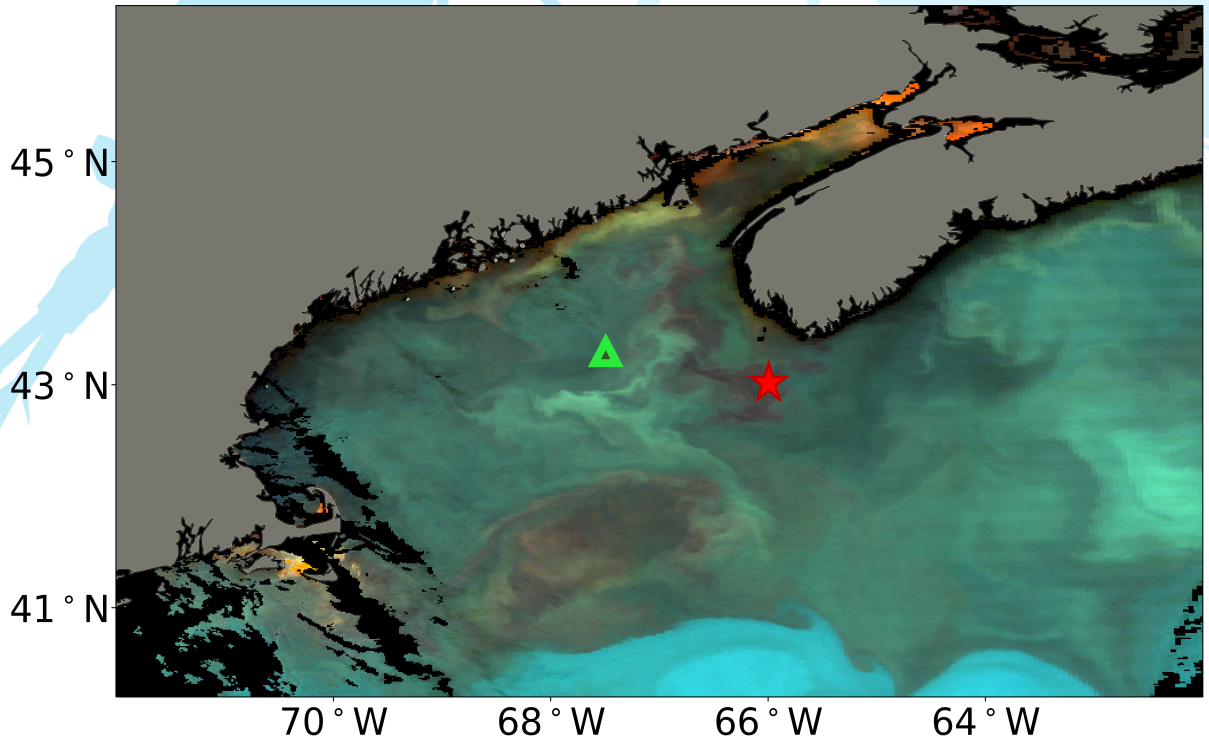
Calanus patch in the Gulf of Maine

17th June 2009

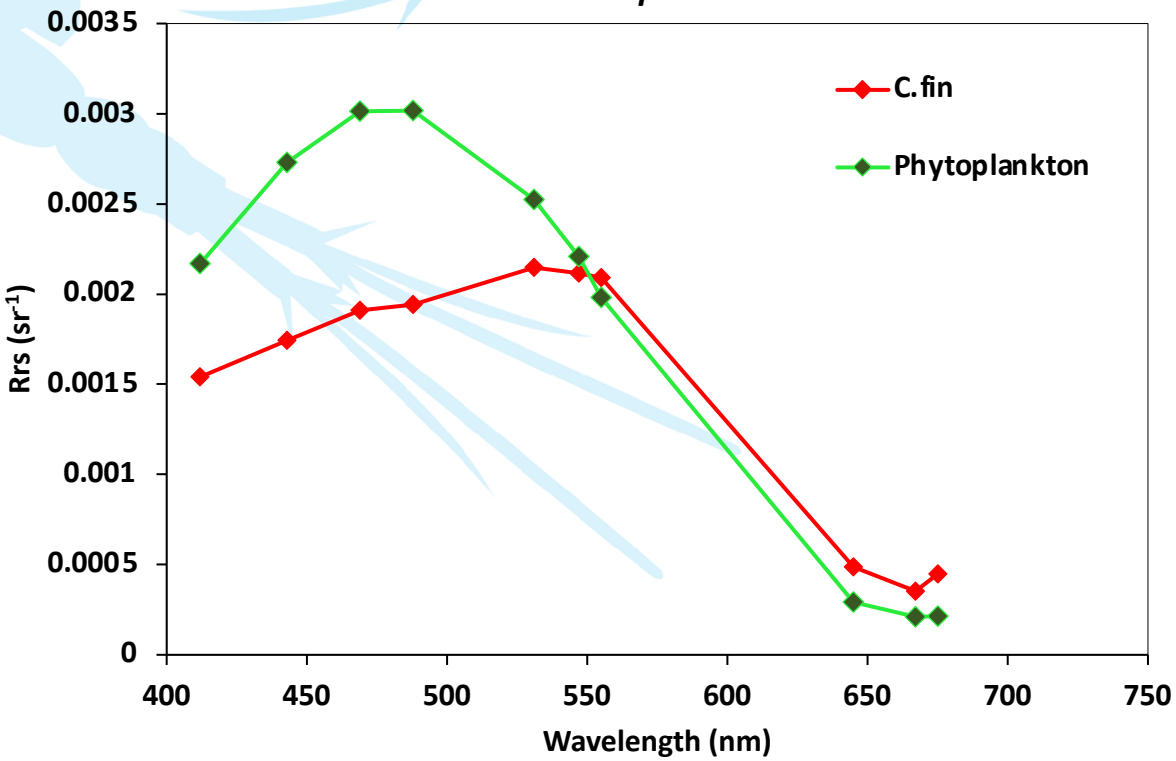


Calanus in the Gulf of Maine

enhanced RGB image



Ocean color spectra



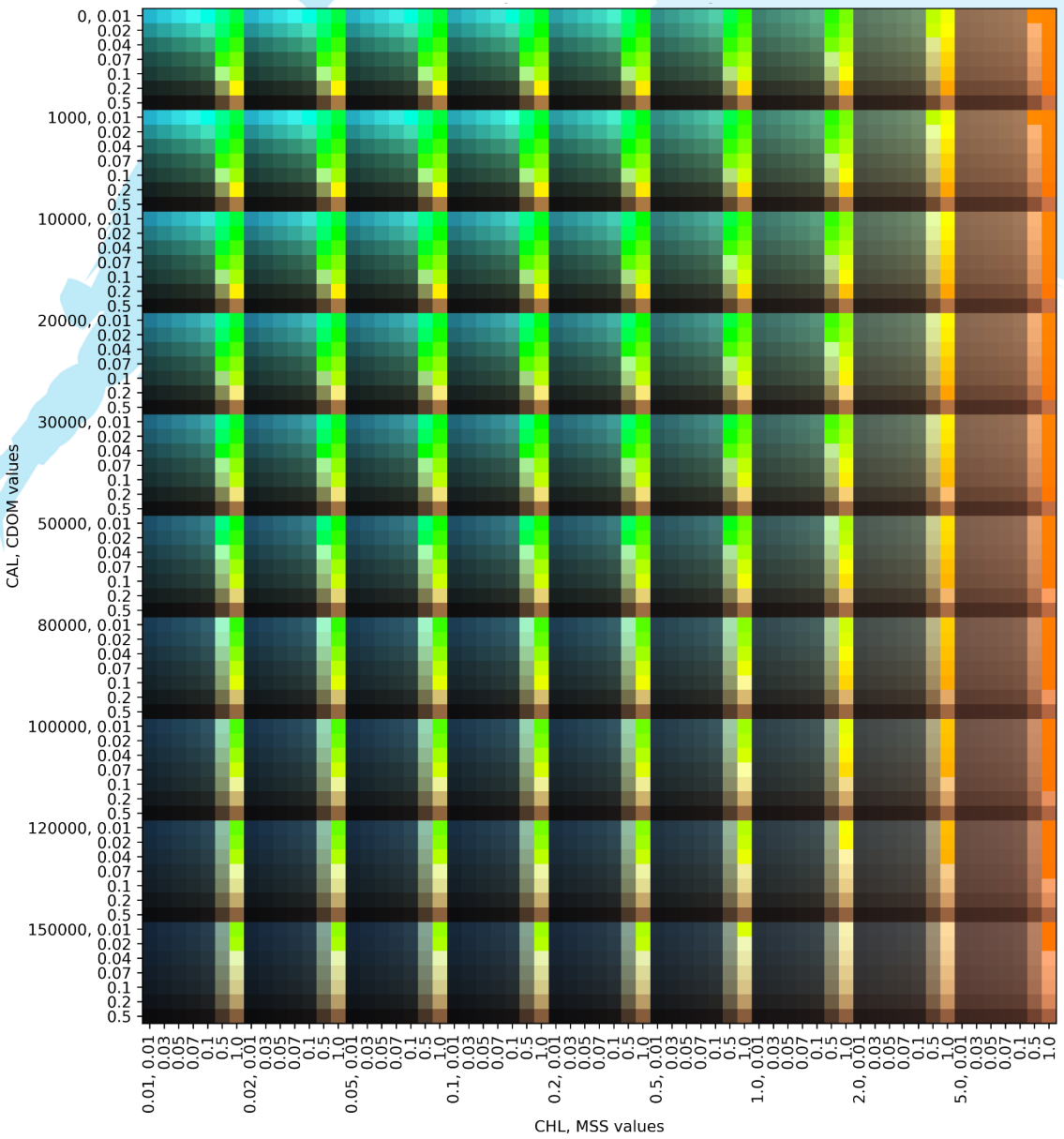
MODIS Aqua L2 enhanced RGB image from 17th June 2009.

★ The GoM insitu surface Calanus data records high concentrations of Calanus on this specific date (*17th June 2009)*, corresponding to the satellite imagery showing a red Calanus patch.

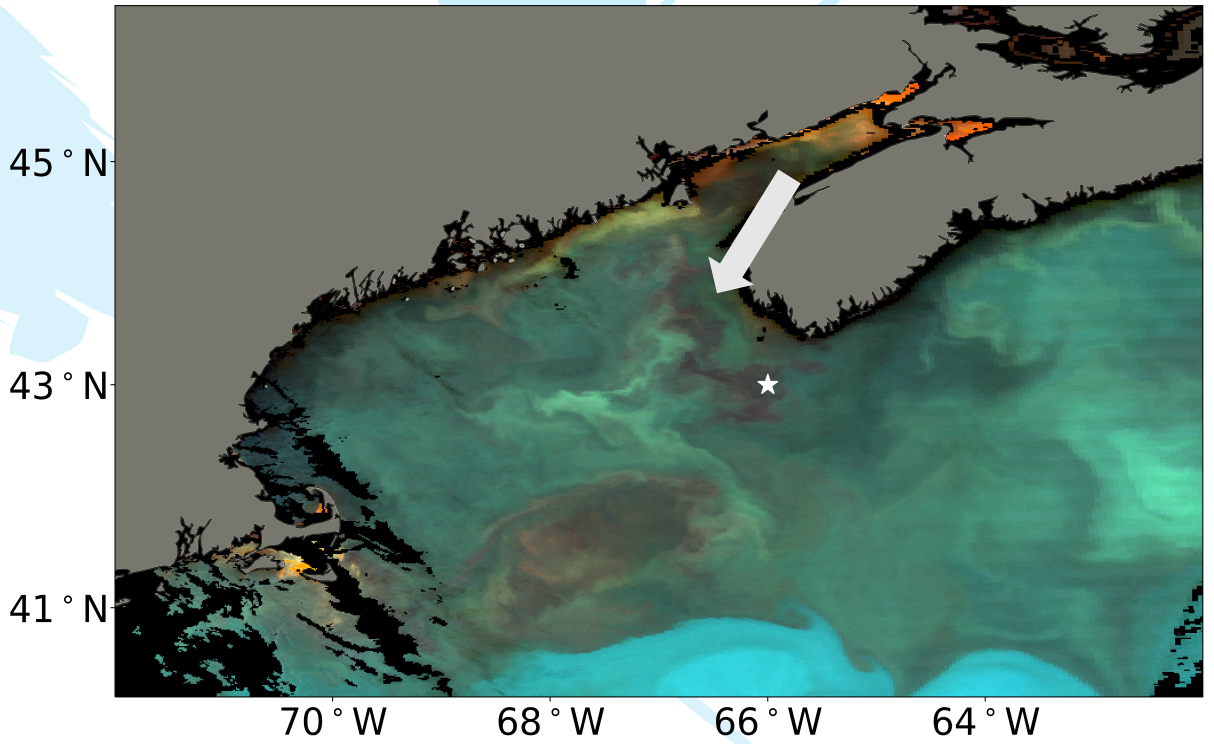
C.fin = Calanus finmarchicus

eRGB Color Matching method

eRGB Color Table from LUT



eRGB Imagery



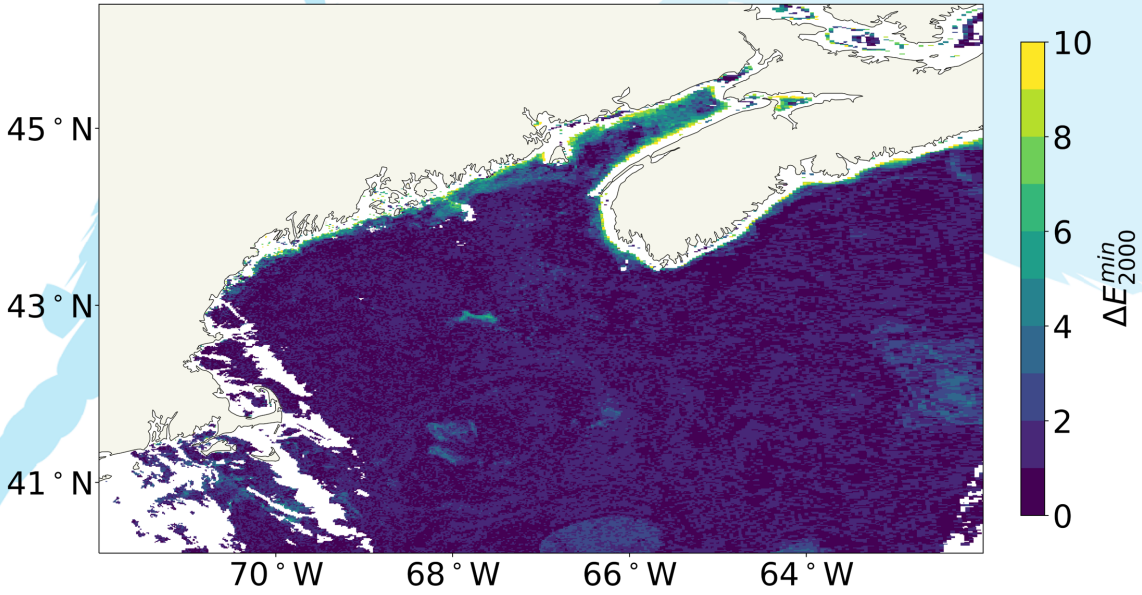
DeltaE calculates color differences between LUT RGBs and Satellite RGBs (Rrs 555, Rrs 488 and Rrs 443)

DeltaE minimum gives the anomaly map of minimum color difference between
the LUT RGBs and satellite RGBs.

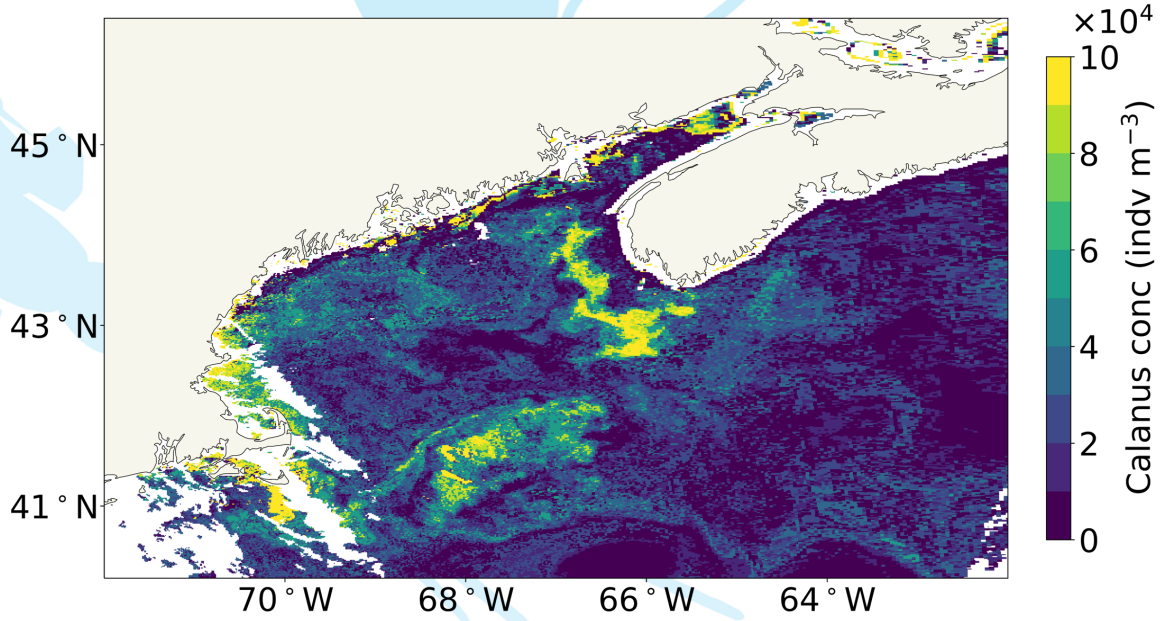
Indexing is created based on the position of the minimum value in the arrays.

Estimated Calanus concentration

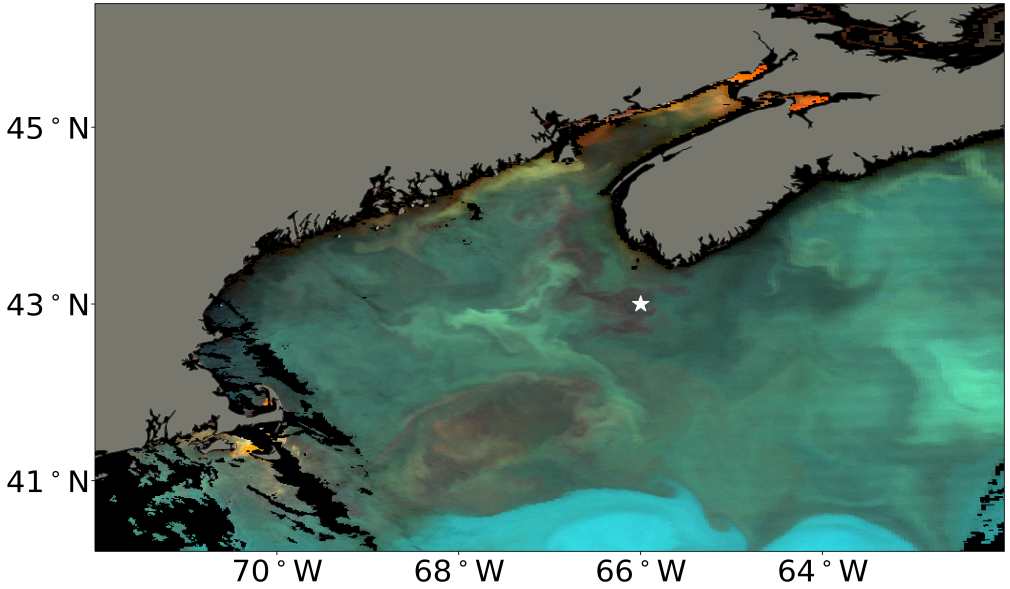
DeltaE min Anomaly Map



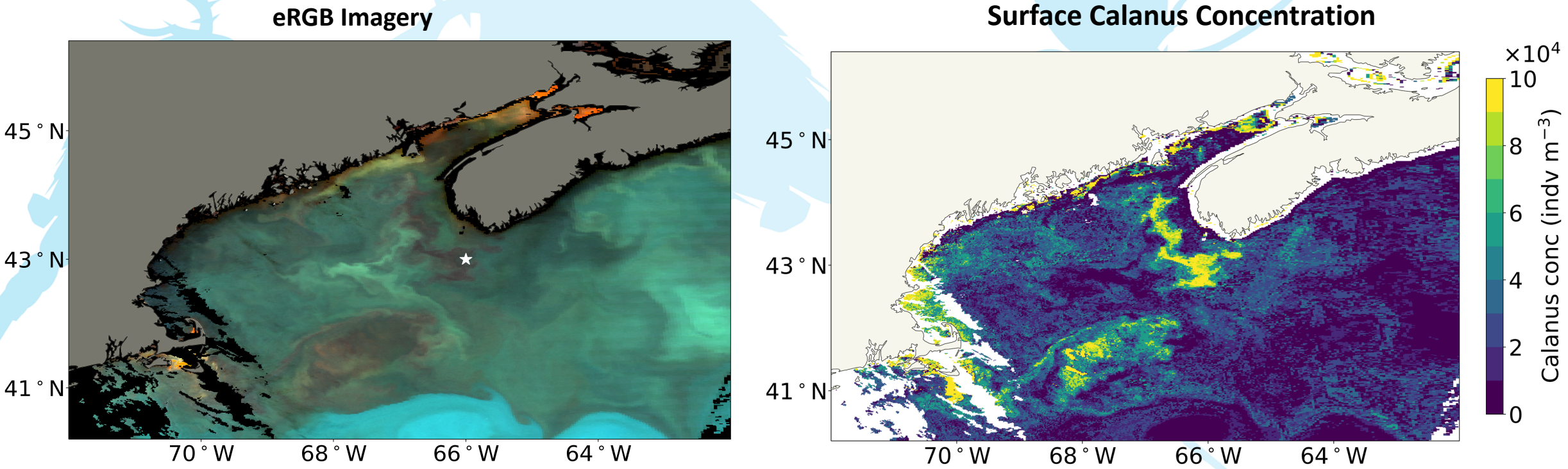
Surface Calanus Concentration



eRGB Imagery



Estimated surface Calanus concentration

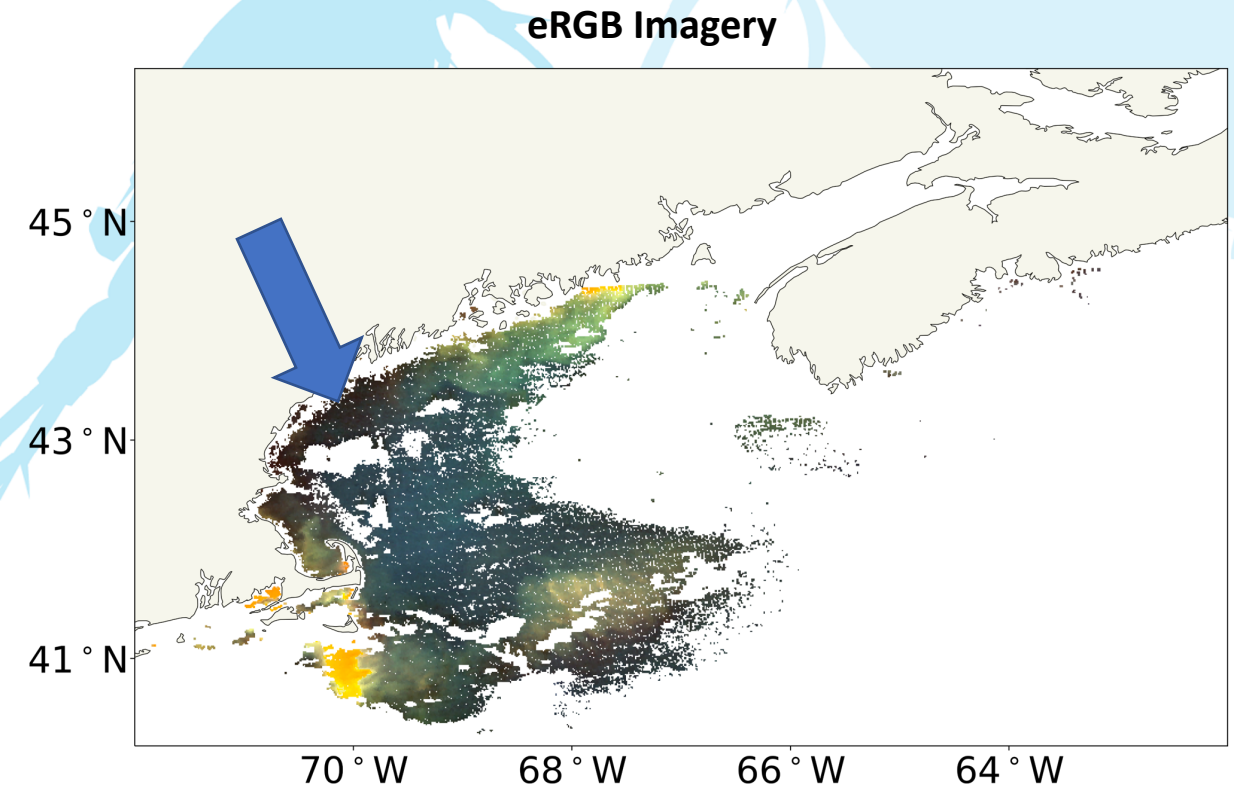


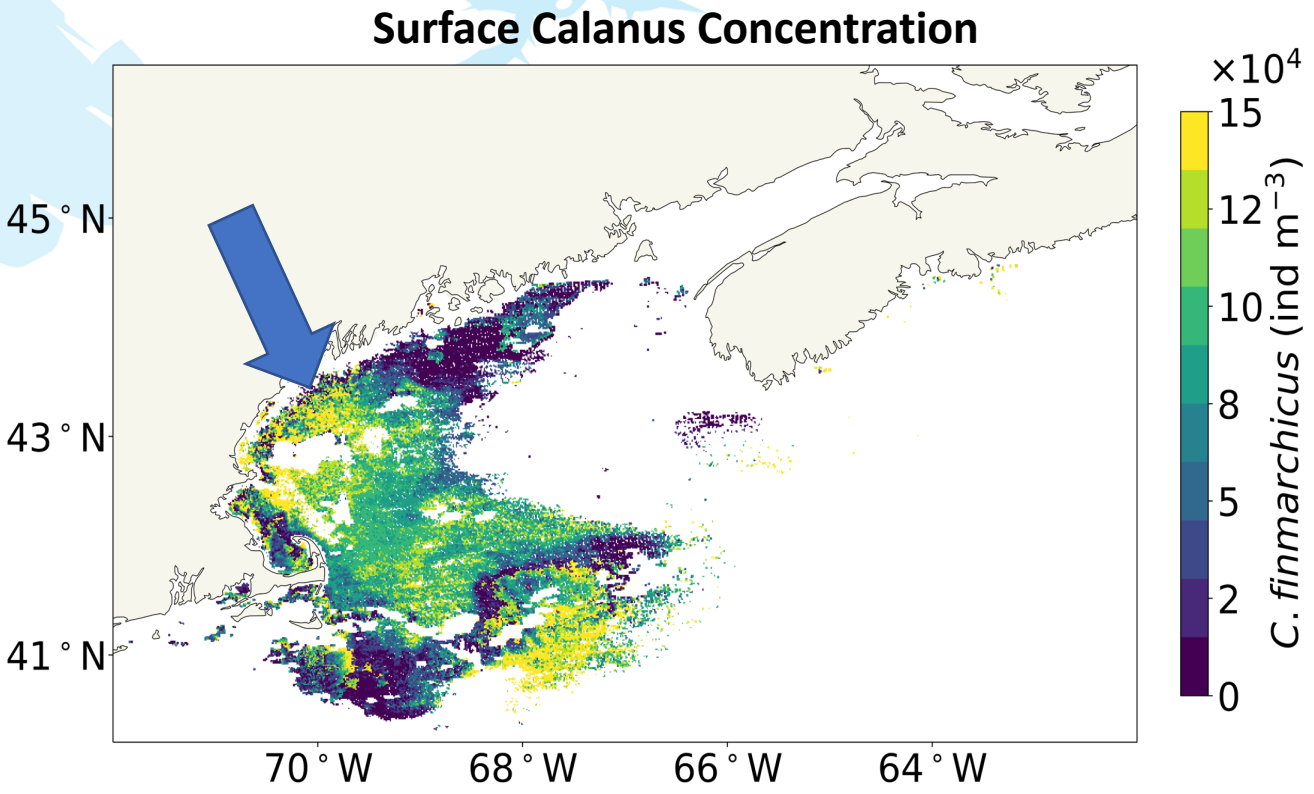
McCarry et al. (2023) Calanus estimating approach which was developed for the off coast Norwegian Sea has been applied on the optically complex GoM waters to estimate Calanus concentration. This is the example figures shows the enhance RGB imagery in the left and the estimated Calanus concentration in the right on June 17 2009.

*The Gulf of Maine is optically complex due to factors such as sediment input from rivers, phytoplankton blooms, and organic matter accumulation. These elements affect light penetration and scattering, making it challenging to accurately measure optical water properties.

Factors affecting the Calanus estimation

Case 1

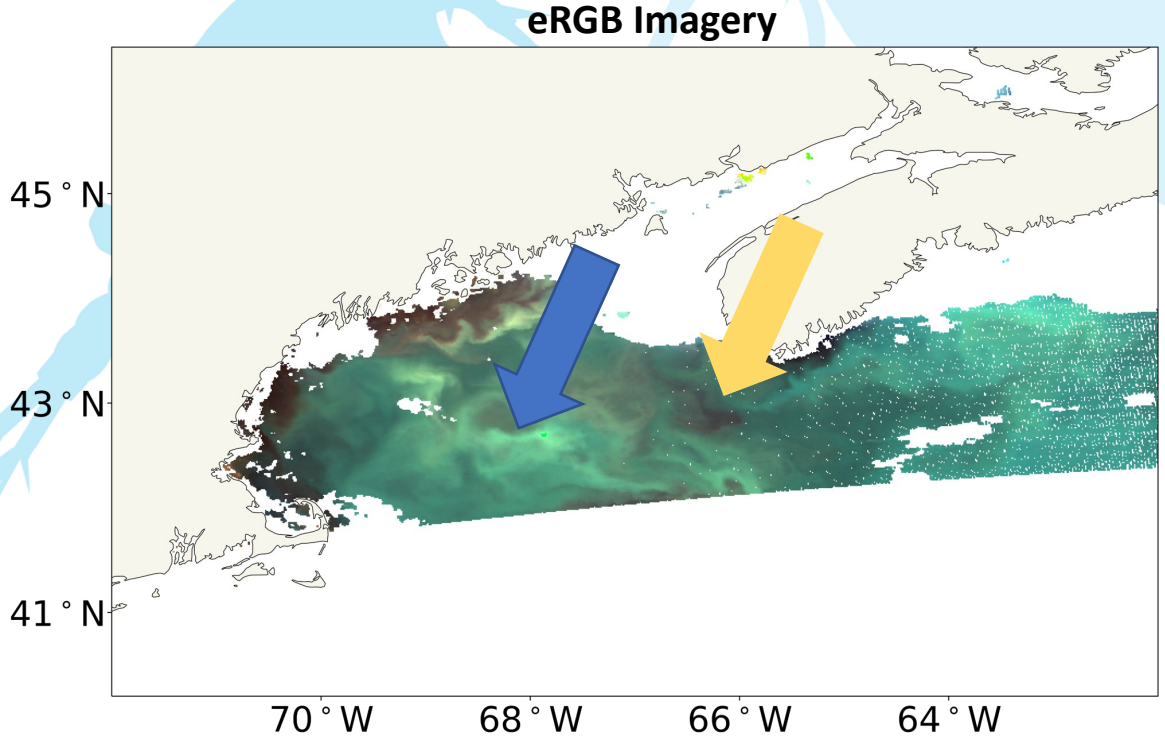


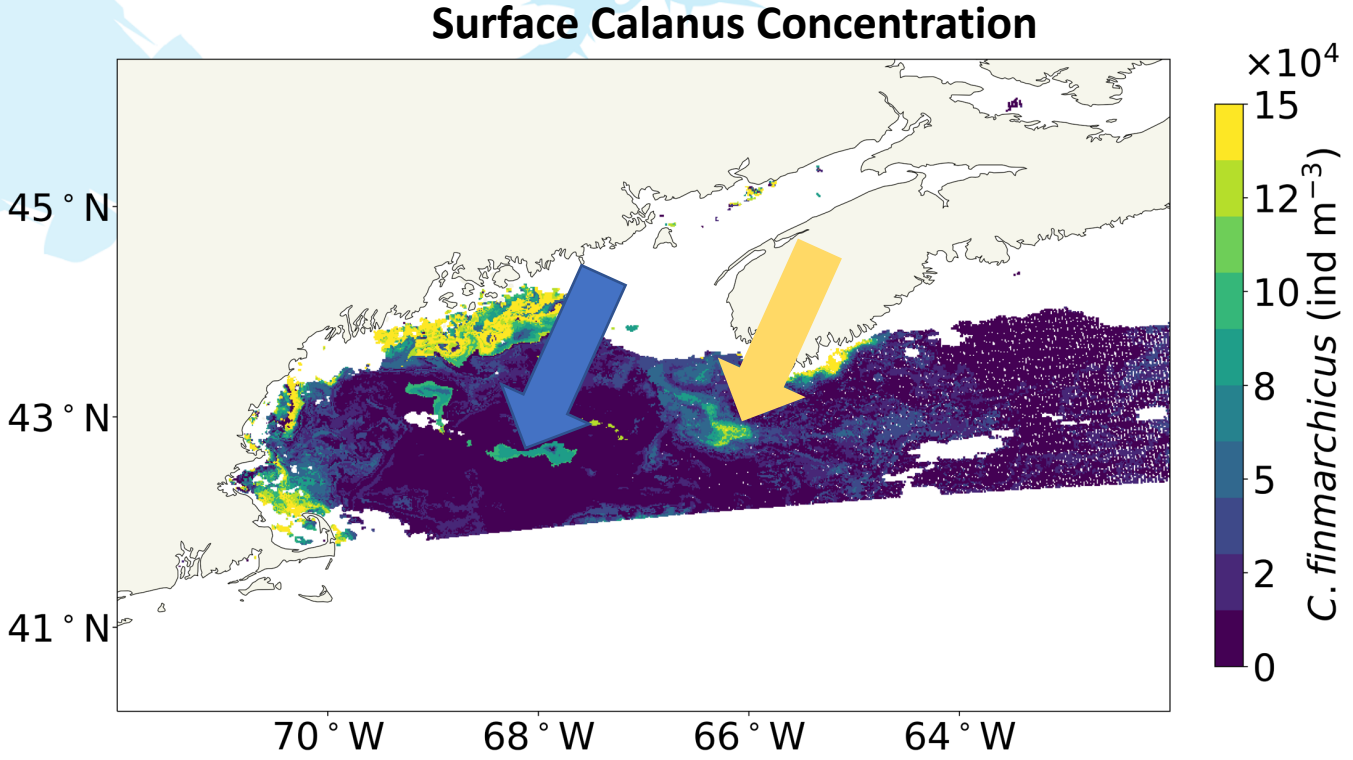


November 21 2017

Factors affecting the Calanus estimation

Case 2

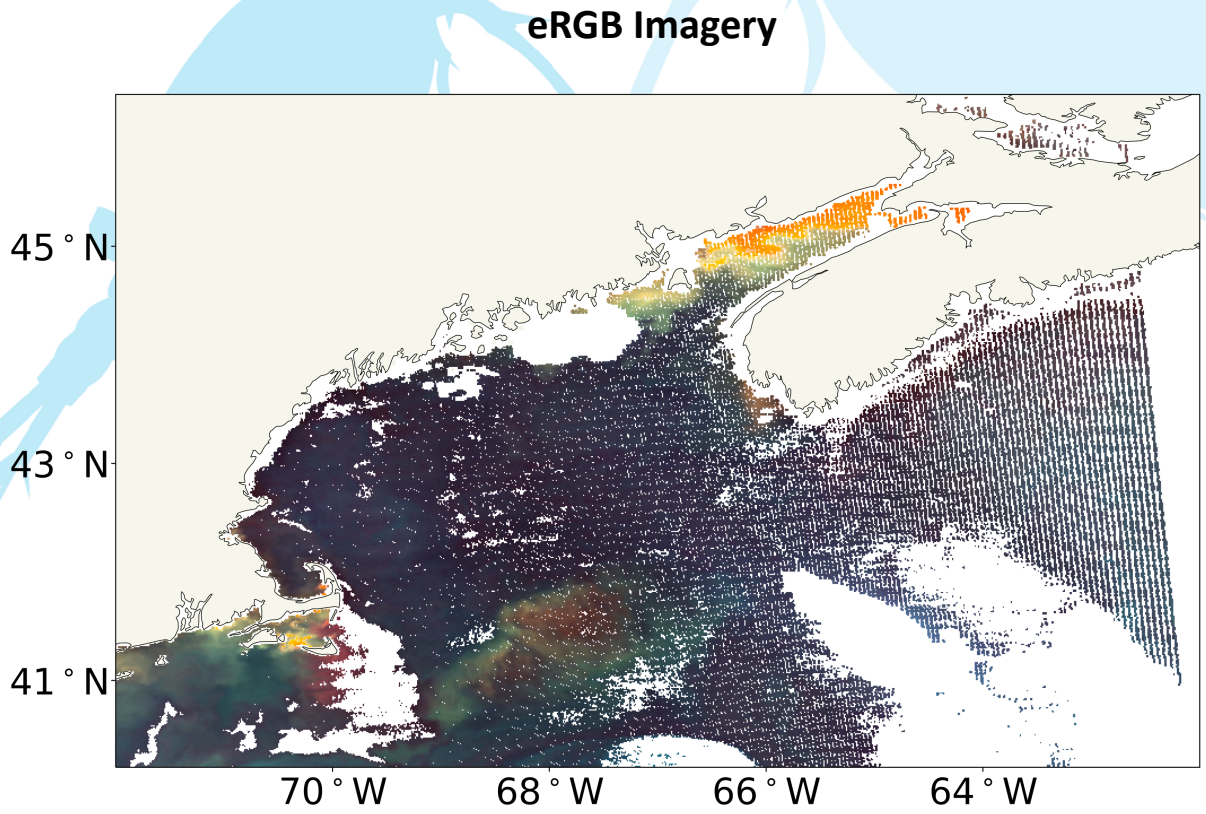


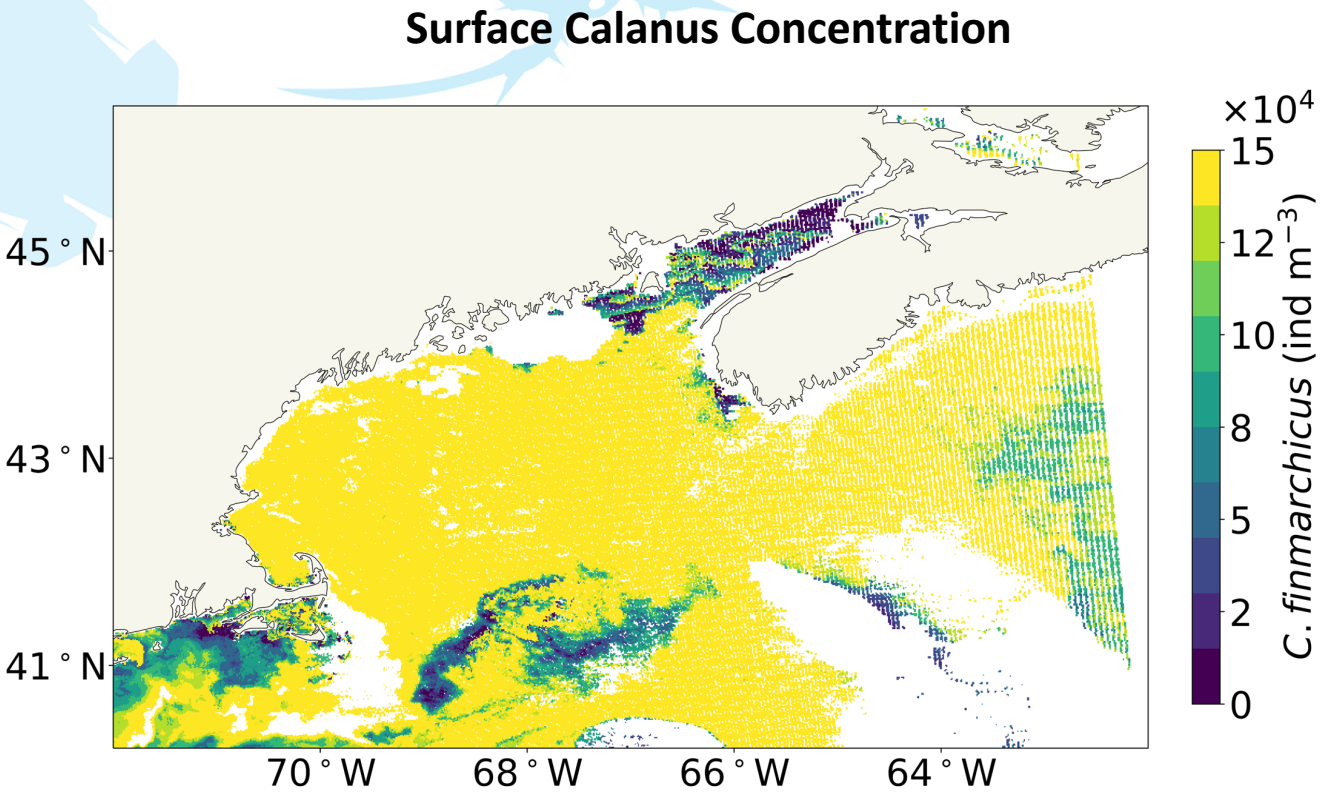


July 05 2009

Factors affecting the Calanus estimation

Case 3





April 13 2023

In summary

- This study highlights the potential of detecting Astaxanthin-rich surface Calanus concentration in the Gulf of Maine.
- Underscores the importance of considering optically active zooplankton when evaluating the optical properties of ocean waters.
- Estimating surface concentrations of Calanus in the Gulf of Maine by this approach demonstrates both effectiveness of, and factors influencing the method, especially in optically complex waters.
- We’re refining the current Calanus estimation method considering the factors affecting the Calanus estimation before the technique can be routinely applied in optically complex waters.

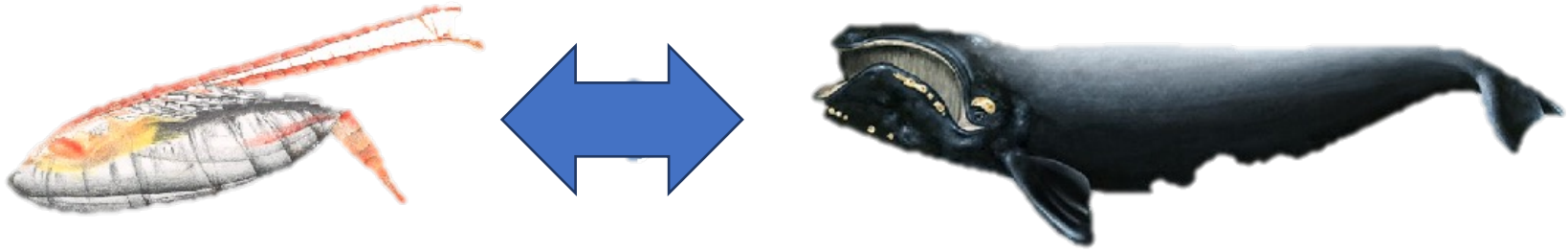
Next Steps…

- Refining the optical anomaly to improve the surface Calanus estimates in the optically complex waters.

- Improving the Astaxanthin-based approach further to understand the relationship between Astaxanthin concentration and other zooplankton populations.

- Improving Calanus quantification could involve using full spectral signatures beyond RGB bands. The PACE mission's global hyperspectral data could enhance methods for quantifying optically active zooplankton.

- Utilizing ocean color remote sensing to detect the surface abundance of Calanus in the GoM could facilitate tracking North Atlantic Right Whale (NARW) migration pattern.



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