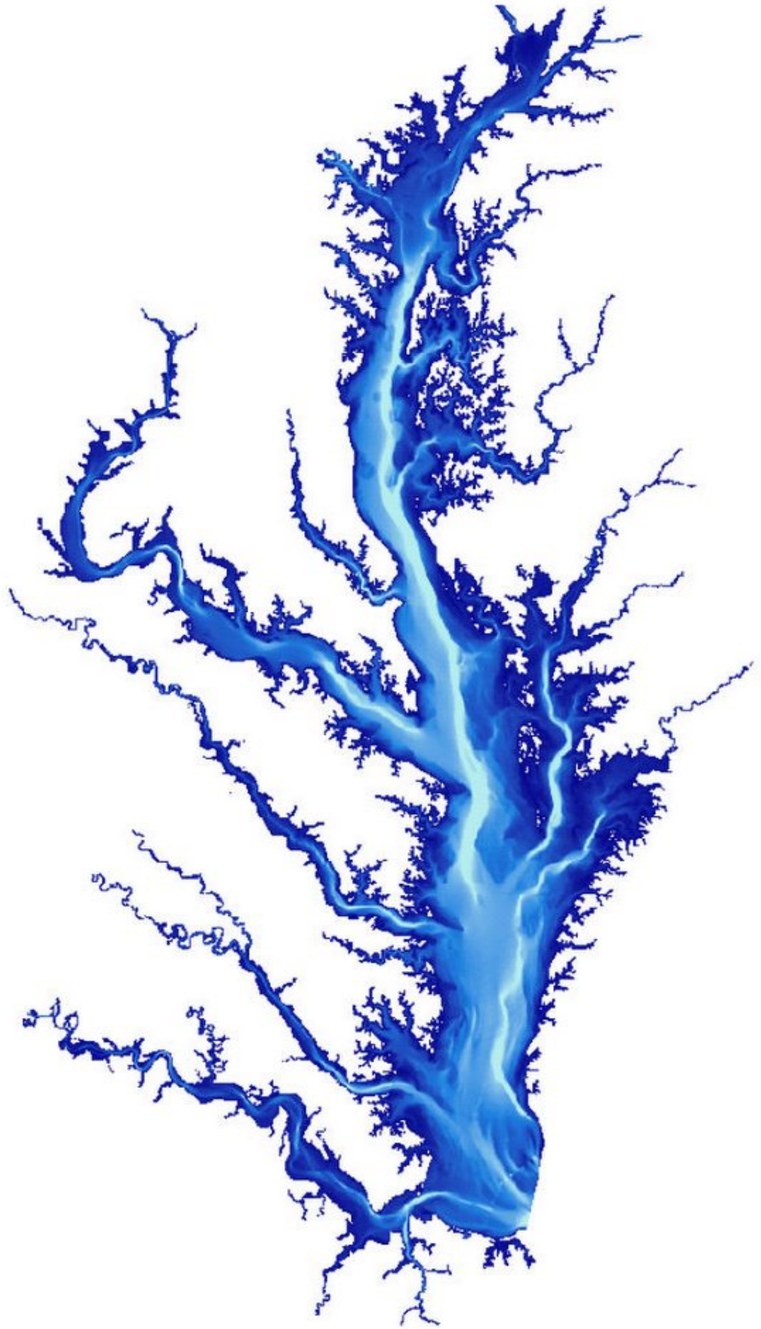
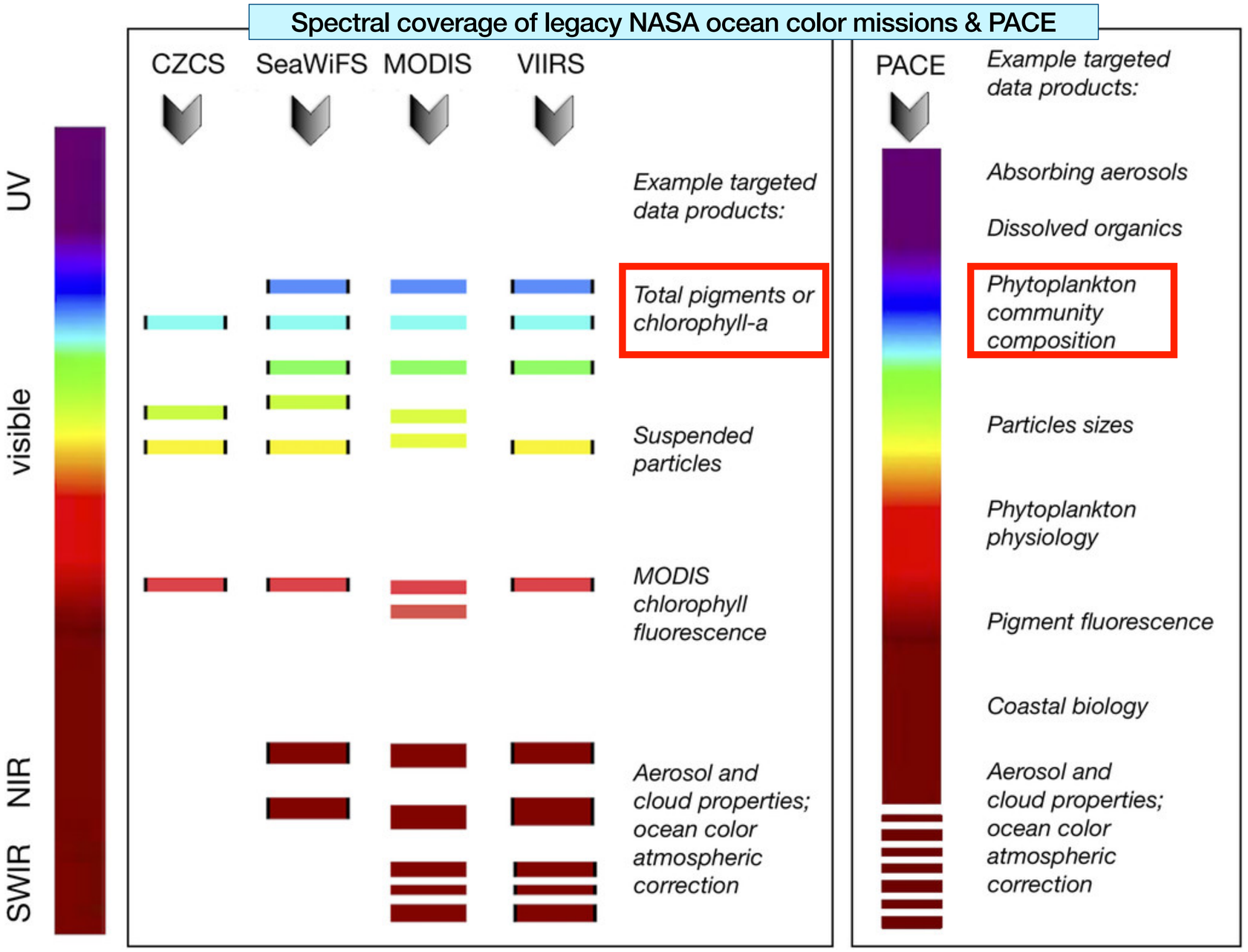


Identification of phytoplankton groups in the Chesapeake Bay & potential applications to regional HAB monitoring

Virginia Annual HAB Task Force Meeting
January 15, 2021

Morgaine McKibben
NASA Postdoctoral Program Fellow
Universities Space Research Association
NASA Goddard Space Flight Center - Applied Sciences
morgaine.mckibben@nasa.gov

Motivation: Upcoming hyperspectral, satellite-based monitoring



PACE

~2023 launch
1-2 day repeat
1 km resolution

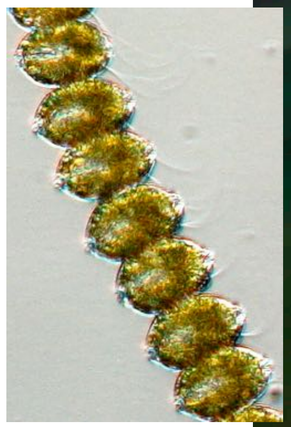
Need regional-scale research to develop tools that leverage hyperspectral PACE observations

- ✓ Engaging end users prior to launch
- ✓ Advancing coastal/estuarine satellite observations
- ✓ Enhanced identification & monitoring of harmful algal blooms from space

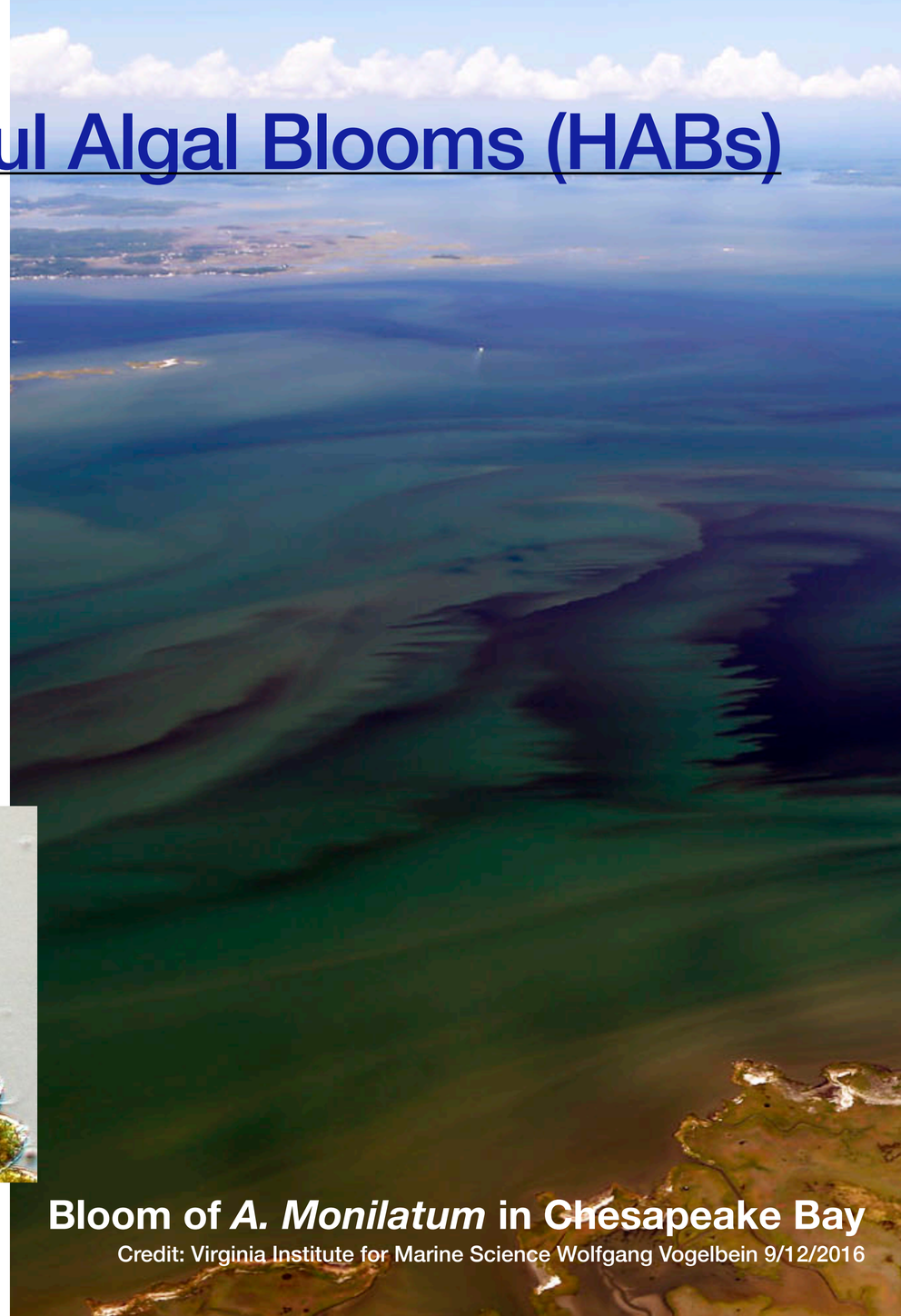
Motivation: Chesapeake Bay & Harmful Algal Blooms (HABs)

Chesapeake a good candidate for developing new coastal satellite monitoring tools:

- ✓ HABs in Chesapeake impact lucrative fisheries, public health, recreation
- ✓ High *in situ* data density: HAB & water quality monitoring
- ✓ **Need for satellite-based HAB monitoring tools**
- ✓ Established relationships: NASA-GSFC Applied Sciences Chesapeake Interagency Meetings (monthly) & ongoing efforts with
  - Maryland Dept of Natural Resources
  - Maryland Dept of Environment
  - Virginia Dept of Health
  - Chesapeake Bay Program
  - NOAA, USGS
  - Several others…



HAB species: Alexandrium Monilatum
Credit: VIMS



Bloom of *A. Monilatum* in Chesapeake Bay
Credit: Virginia Institute for Marine Science Wolfgang Vogelbein 9/12/2016

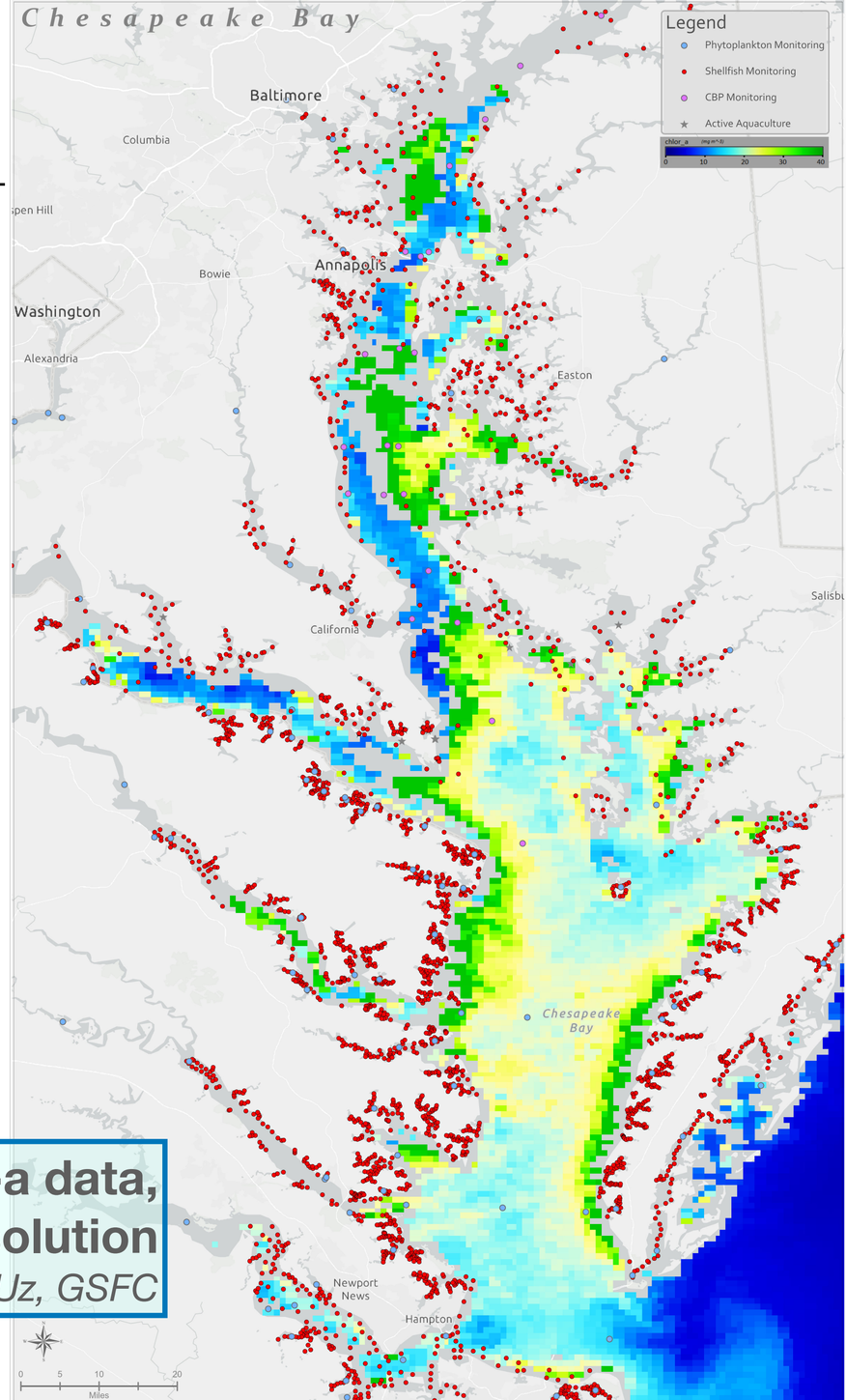
Research Goal

- **Using hyperspectral information can we reliably identify phytoplankton groups in the Chesapeake Bay?**

- **How can this information be applied to enhance HAB monitoring in the region?**

- Results:

  ✓ Lay a foundation for improved HAB monitoring with hyperspectral information (satellite, field based) in the Chesapeake Bay



MODIS 1km Chl-a data, anticipated OCI resolution

Credit: Stephanie Uz, GSFC

Primer: Aquatic optics

Class A

Class B

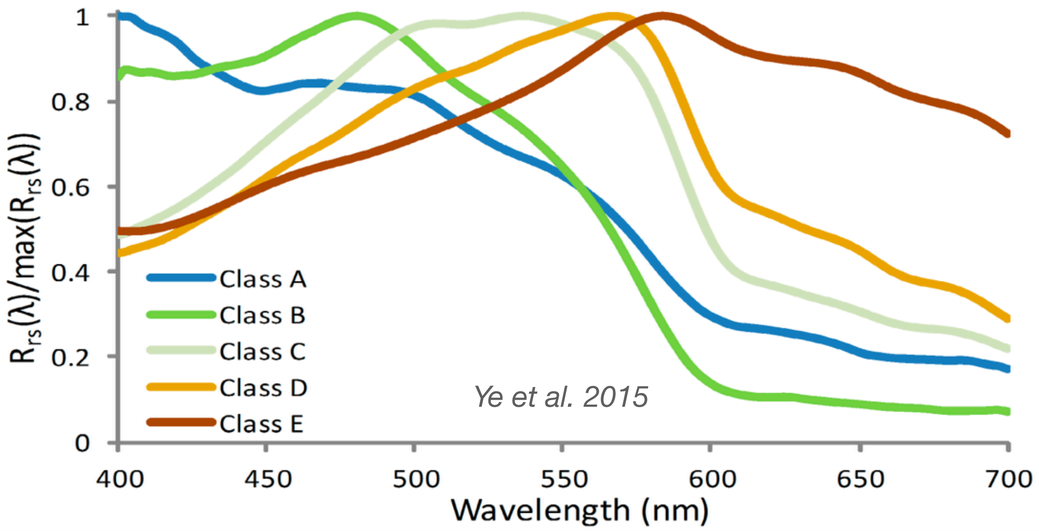
Class C

Class D

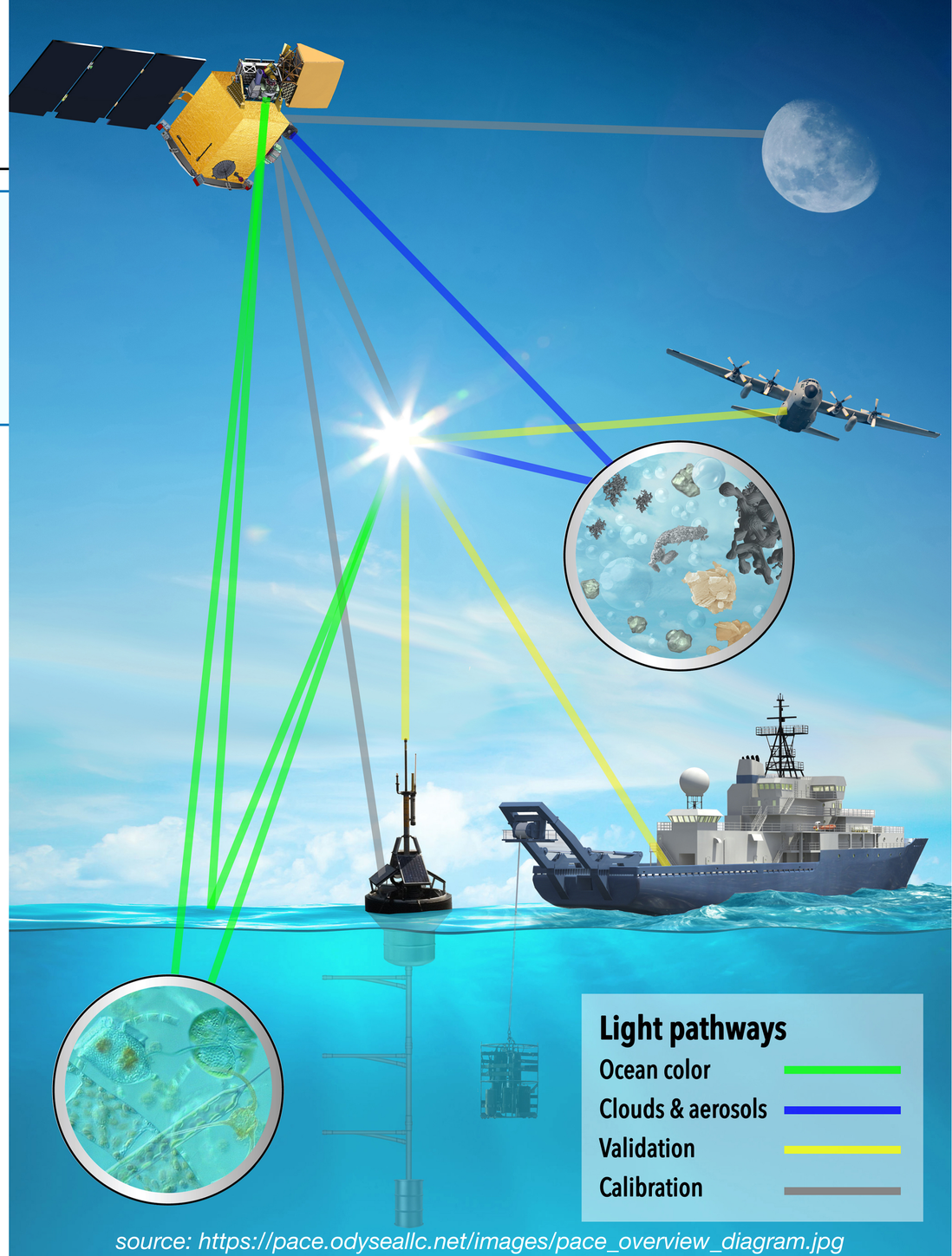
Class E

In water constituents can be deduced using optical measurements, radiative transfer theory & associated radiative transfer equations:

the color of the water can tell us what's in it



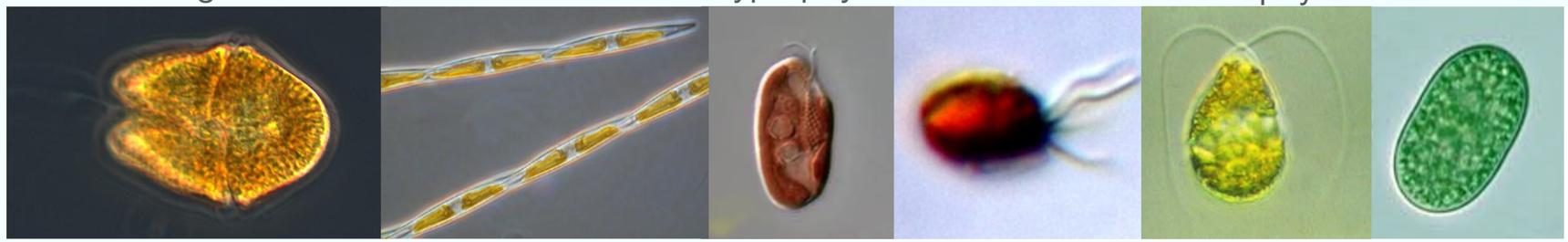
Variability in coastal **ocean color** as seen by the eye (squares on left) and by measures of **remote sensing reflectance (R_{rs})**



source: https://pace.oceansciences.org/images/pace_overview_diagram.jpg

Approach: PHYDOTax, **PHY**toplankton **D**etection with **O**ptics

Phytoplankton functional types (class-level) identified from remote sensing reflectance (Palacios et al. 2012)

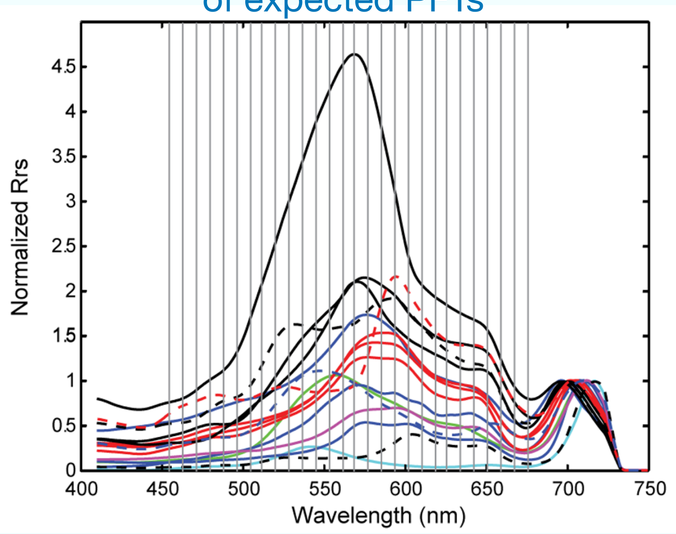


Lab measurements of phytoplankton cultures

Optical modeling

R_{rs} Signature Library

modeled spectra representative of expected PFTs



Adapted from slide contributed by S. Palacios, CSU Monterey Bay

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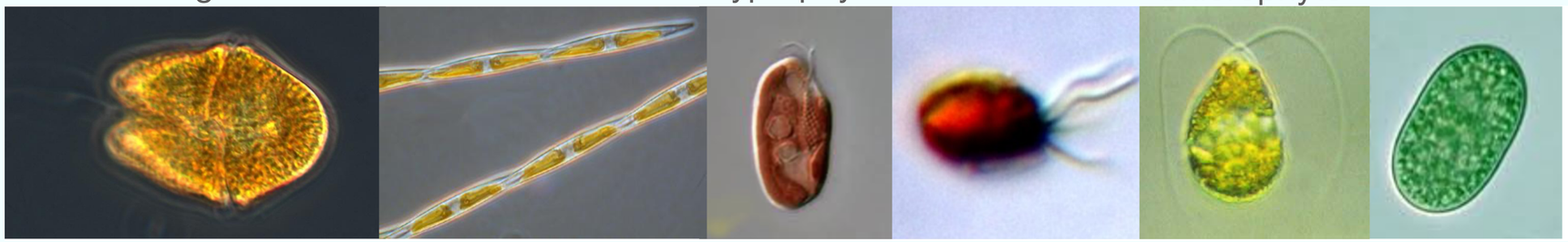
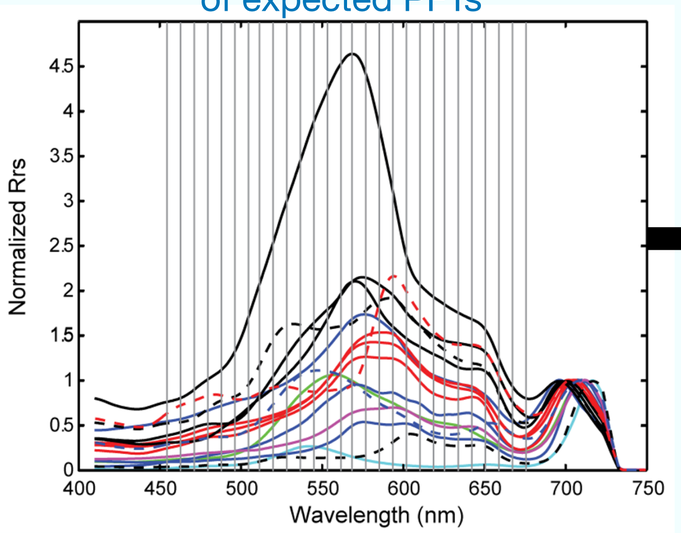


R_{rs} Signature Library

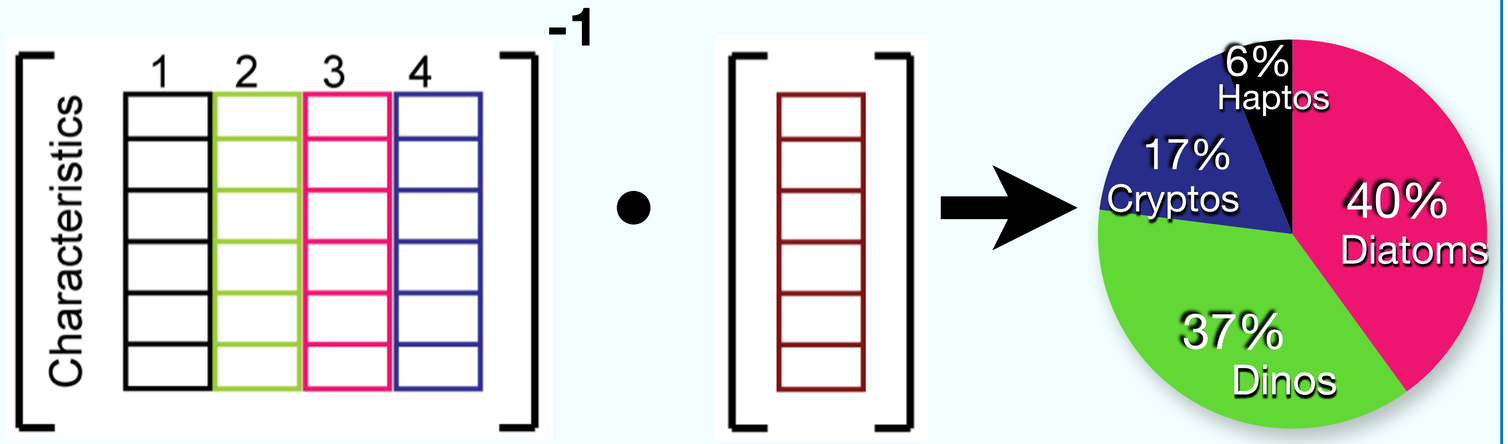
modeled spectra representative of expected PFTs



R_{rs} Signature Library "KNOWN"

R_{rs} measurement "UNKNOWN"

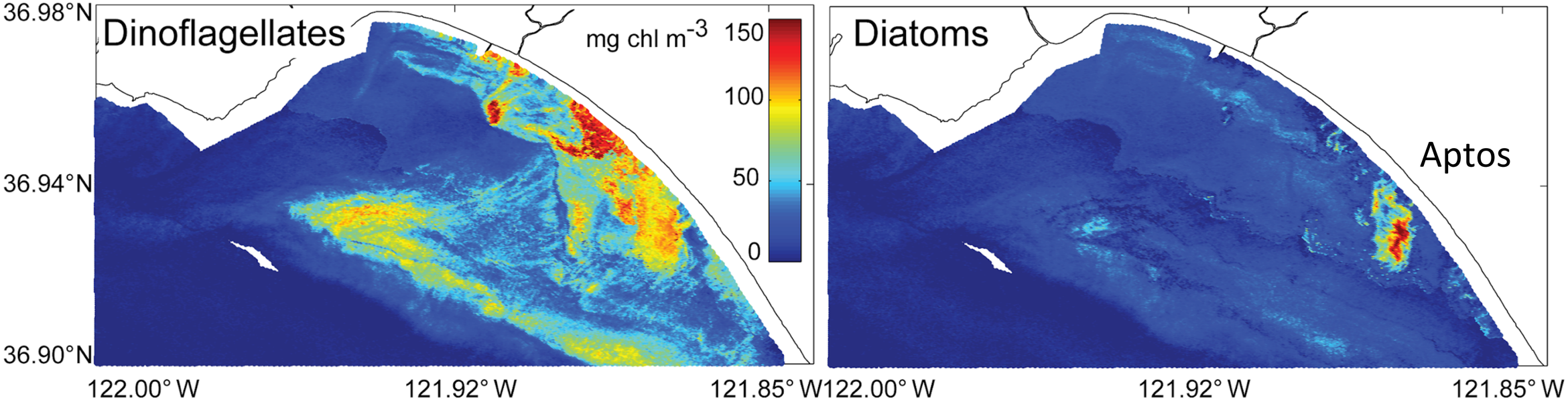
Percent of Total Chl-a



Inverse matrix-based decomposition algorithm

Adapted from slide contributed by S. Palacios, CSU Monterey Bay

Approach: PHYDOTax, **PH**ytoplankton **D**etection with **O**ptics



First developed & tested in the Monterey Bay, California (Palacios et al. 2012):

- Successfully distinguished 7 phytoplankton classes (diatom, dinoflagellate, haptophyte, cryptophyte, chlorophyte, cyanophyte & “unidentified pico-eukaryotes”
- First to differentiate dinoflagellates from diatoms using ocean color data
- Development of library, testing on current/past sensors (airborne & satellite), expanded regions etc. is ongoing

Hyperspectral PFT identification in the Chesapeake Bay

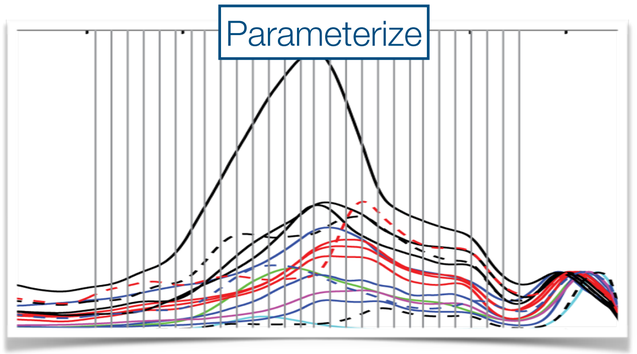
Research Questions

Objective 1: Most robust approach for Chesapeake Bay R_{rs} Signature Library?

- Representative phytoplankton groups?
- How to represent other optically-active components? (e.g. sediment, colored dissolved organic matter)

Objectives 2 & 3: Does it work? Quantitative evaluation of algorithm output.

Objective 3: Practical applications in the context of HAB monitoring?



Objective 3: Evaluation & application in the context of HAB monitoring

Compare phytoplankton classes from satellite imagery to available *in situ* monitoring datasets

- Match-up satellite, airborne imagery + with *in situ* data (quantitative evaluation)
- Retrospective match up of HAB/water quality monitoring data with algorithm output from different *in situ, hyperspectral data* (e.g. discrete/Hypergun, time series/AERONET-OC)

Potomac River & Chesapeake Bay from Space https://oceancolor.gsfc.nasa.gov

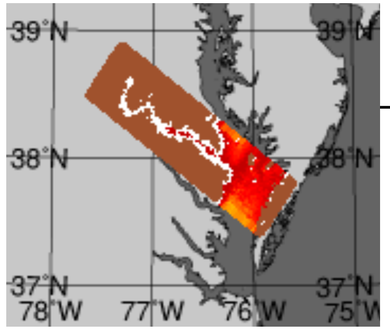
https://ciglr.seas.umich.edu/

https://aeronet.gsfc.nasa.gov

Applications to HAB monitoring efforts:

- Is useful info from past HAB events captured?
- Complimentary to *in situ* monitoring efforts and existing regional satellite products?
- Communicate regularly with state agencies, NOAA,etc.

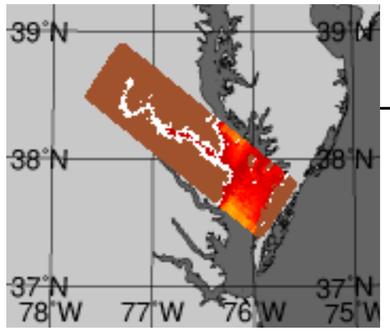
Mouth of Chesapeake Bay from Space https://oceancolor.gsfc.nasa.gov



Example of Applied Usage: Satellite imagery

HICO Imagery: Potomac River, July 30 2014

True Color

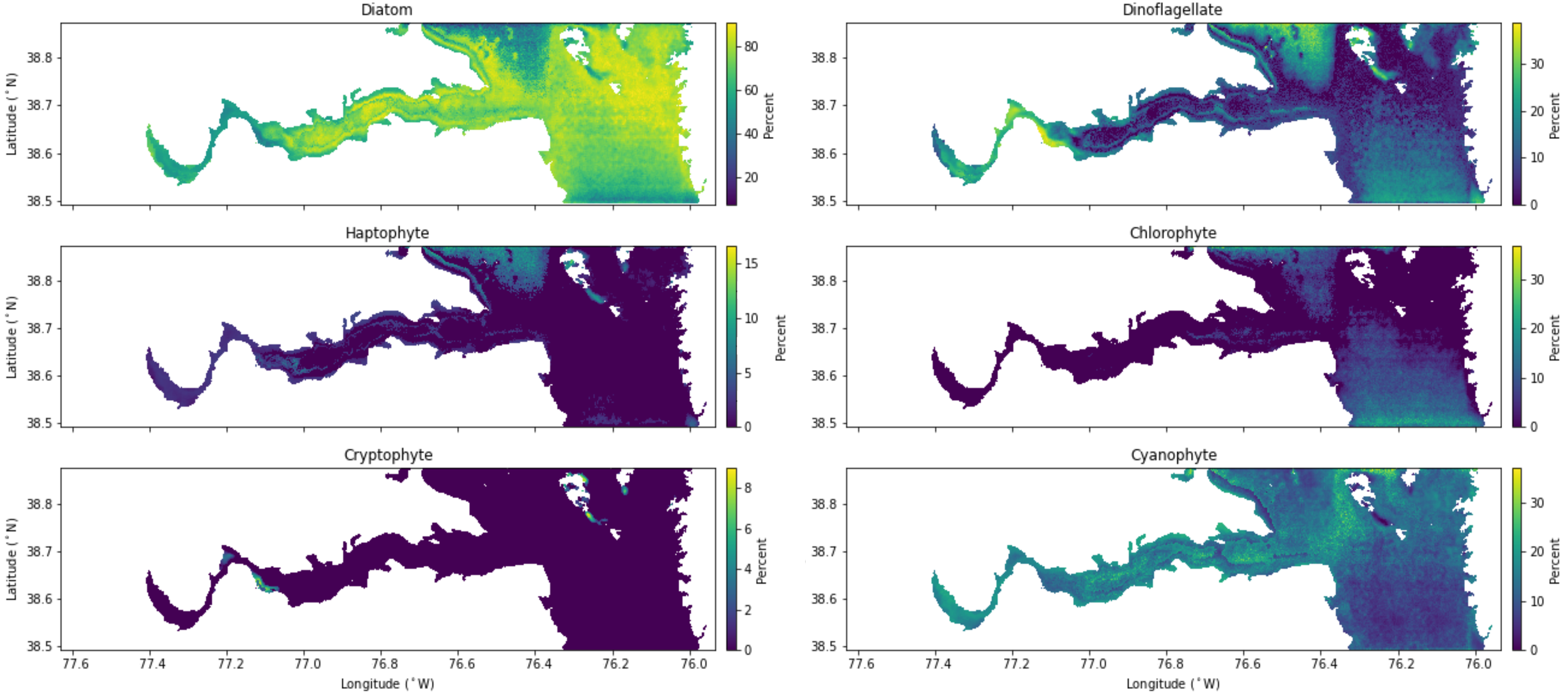


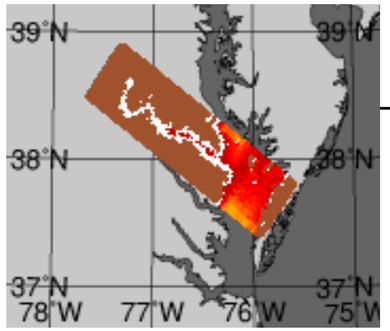
Example of Applied Usage: Satellite imagery

HICO Imagery: Potomac River, July 30 2014

Colors = Percent Phytoplankton Class of Total Community

(Note: L3 R_{rs} data; standard atm corr; no L2 flags; Monterey Bay R_{rs} Signature Library)





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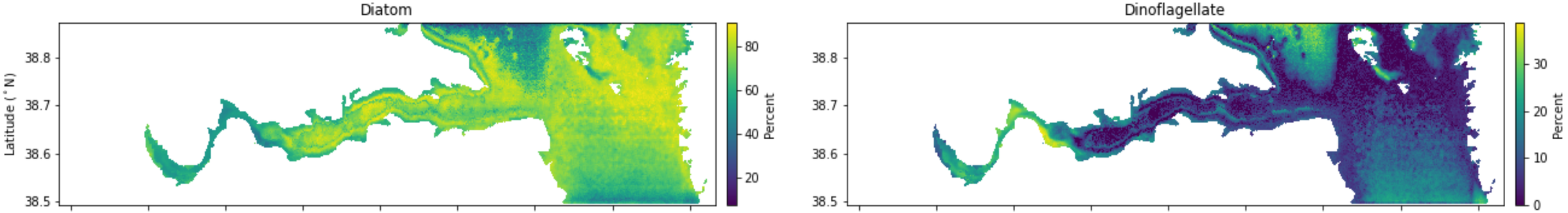
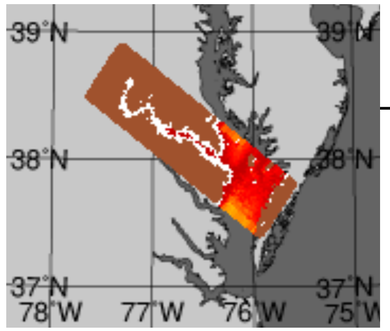


- **Diatoms are dominant bloom producers, periodic dinoflagellate blooms** (e.g. Kemp et al. 2005, Marshall et al., 2005 & 2009)
- **HABs of concern with respect to PFTs: dinoflagellates, cyanobacteria** (e.g. Wolny et al. 2020)

With Satellite Imagery:

- **Monitoring:** Track dinoflagellate bloom initiation and movement over time remotely
- **Adaptive sampling:** Observe spatial extent of bloom, spend more resources sampling in high dinoflagellate bloom areas



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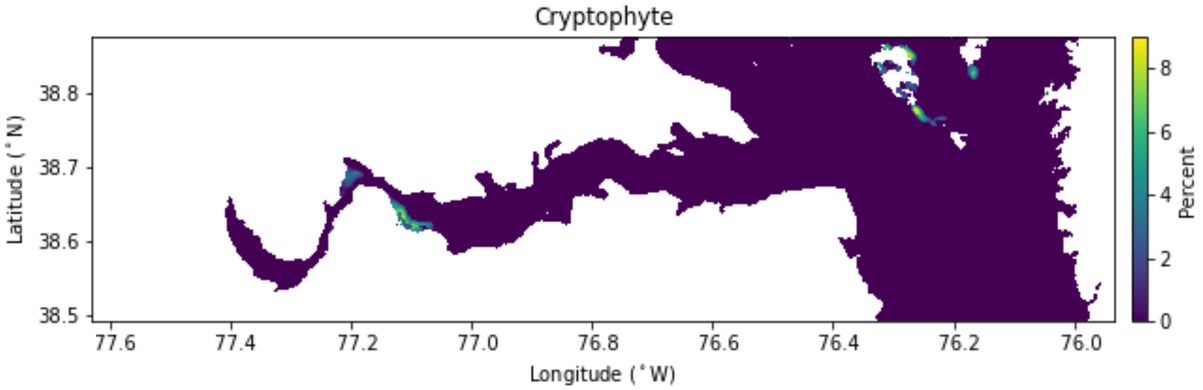
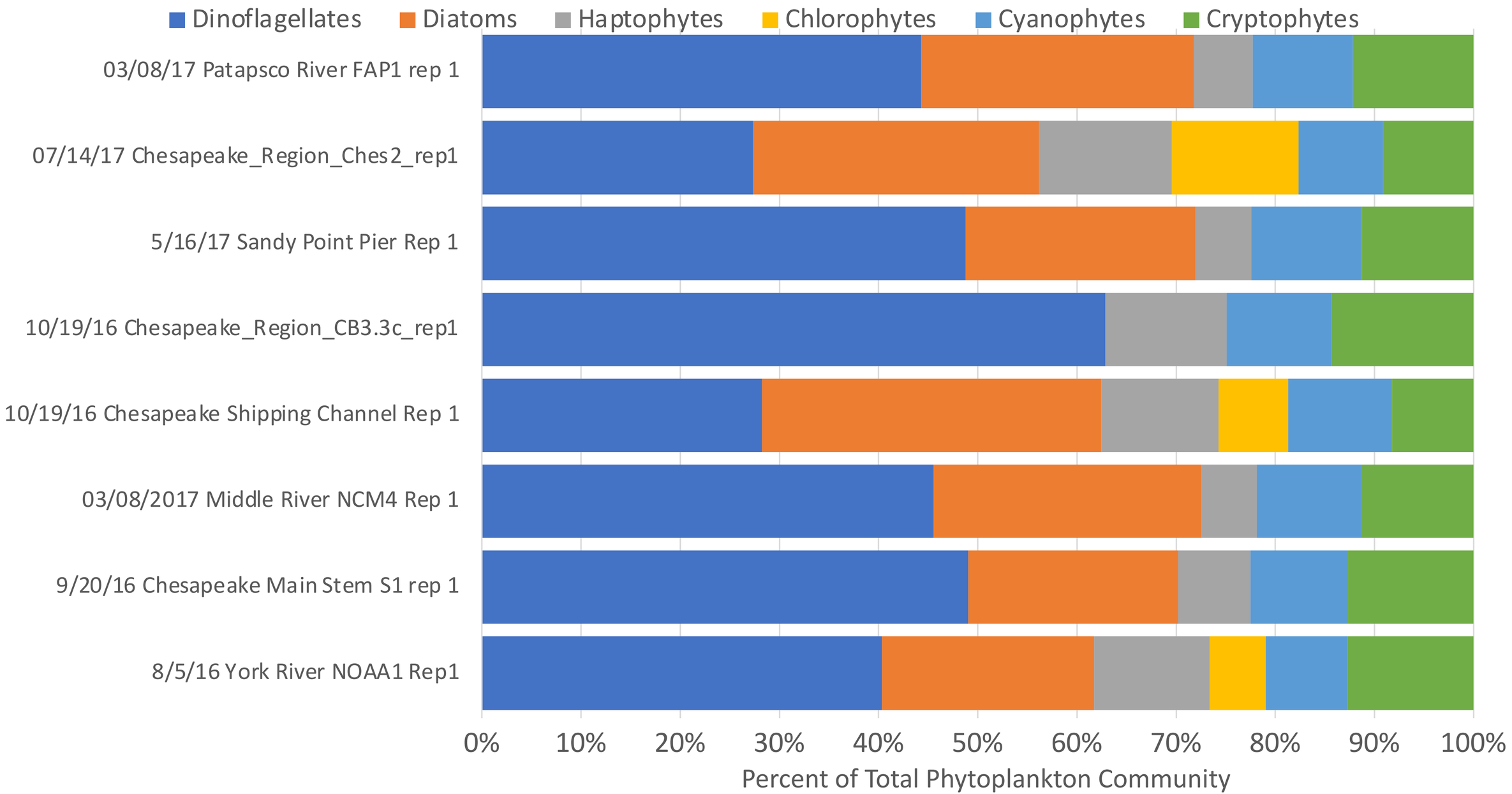


If we can reliably track cryptophyte abundance, does it provide useful information for hetero/mixotrophic HABs?

Sample PHYDOTax Output: Hypergun

Hypergun data from Shelly Tomlinson/NOAA



Summary

Optical identification of phytoplankton groups in the Chesapeake Bay & applications to regional HAB monitoring

Anticipated Outcomes:

Applications to augmenting HAB monitoring in the Chesapeake Bay using hyperspectral information

How reliable will these applications be given the challenges of “optically complex” estuarine waters

morgaine.mckibben@nasa.gov