NASA Earth Science perspective and public health:

global to local efforts to inform Chesapeake Bay resource managers

Stephanie Schollaert Uz
Applied Sciences Manager
Goddard Space Flight Center

NASA EARTH FLEET

OPERATING & FUTURE THROUGH 2023

SWOT (CNES)
LANDSAT-9 (USGS)
SENTINEL-6 Michael Freilich/B (ESA)
TROPICS (6)
GEOCARB
NISAR (ISRO)
MAIA
TSIS-2
TEMPO
PREFIRE (2)
PACE (NSO)
GLIMR
ICESAT-2
GRACE-FO (2) (DLR)
CYGNSS (8)
NISTAR, EPIC (DSCOVR/NOAA)
CLOUDSAT (CSA)
TERRA (JAXA, CSA)
AQUA (JAXA, AEB)
AURA (NSO, FMI, UKSA)
CALIPSO (CNES)
GPM (JAXA)
LANDSAT 7 (USGS)
LANDSAT 8 (USGS)
OCO-2
SMAP
SUOMI NPP (NOAA) (JAXA)

ISS INSTRUMENTS

EMIT
CLARREO-PF
GEDI
SAGE III
OCO-3
TSIS-1
ECOSTRESS
LIS

JPSS-2, 3 & 4 INSTRUMENTS

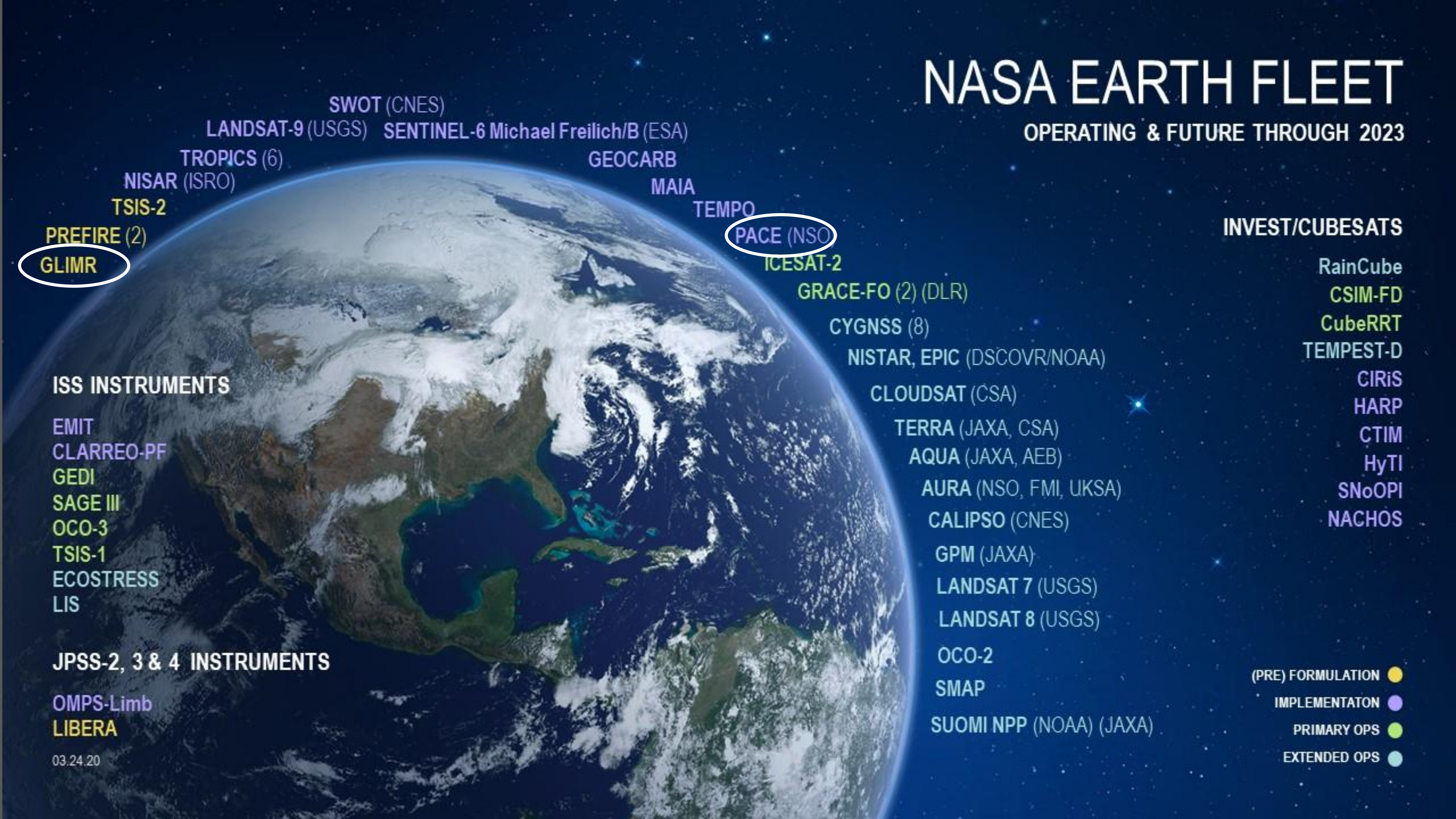
OMPS-Limb
LIBERA

INVEST/CUBESATS

RainCube
CSIM-FD
CubeRRT
TEMPEST-D
CIRiS
HARP
CTIM
HyTI
SNoOPI
NACHOS

(PRE) FORMULATION
IMPLEMENTATON
PRIMARY OPS
EXTENDED OPS

03.24.20


NASA EARTH FLEET
OPERATING & FUTURE THROUGH 2023
SWOT (CNES)
LANDSAT-9 (USGS)
SENTINEL-6 Michael Freilich/B (ESA)
TROPICS (6)
GEOCARB
NISAR (ISRO)
MAIA
TSIS-2
TEMPO
PREFIRE (2)
PACE (NSO)
GLIMR
ICESAT-2
GRACE-FO (2) (DLR)
CYGNSS (8)
NISTAR, EPIC (DSCOVR/NOAA)
CLOUDSAT (CSA)
TERRA (JAXA, CSA)
AQUA (JAXA, AEB)
AURA (NSO, FMI, UKSA)
CALIPSO (CNES)
GPM (JAXA)
LANDSAT 7 (USGS)
LANDSAT 8 (USGS)
OCO-2
SMAP
SUOMI NPP (NOAA) (JAXA)
ISS INSTRUMENTS
EMIT
CLARREO-PF
GEDI
SAGE III
OCO-3
TSIS-1
ECOSTRESS
LIS
JPSS-2, 3 & 4 INSTRUMENTS
OMPS-Limb
LIBERA
03.24.20
INVEST/CUBESATS
RainCube
CSIM-FD
CubeRRT
TEMPEST-D
CIRiS
HARP
CTIM
HyTI
SNoOPI
NACHOS
(PRE) FORMULATION
IMPLEMENTATON
PRIMARY OPS
EXTENDED OPS

Planned for Launch in 2023

Plankton,
Aerosol, Cloud,
ocean Ecosystem
(PACE)

PACE

2022

Understand and quantify global biogeochemical cycling and ecosystem function in response to anthropogenic and natural environmental variability and change

Four Designated Observable Studies Underway

2017-2027 Decadal Survey for Earth Science & Applications from Space:

Surface Biology and Geology (SBG)

Aerosols, Clouds, Convection and Precipitation (A-CCP)

Mass Change (MC)

Surface Deformation and Change (SDC)

Mission Study on Surface Biology and Geology

SBG Science and Applications Objectives from the 5 Decadal Survey Panels

Flows of energy, carbon, water, and nutrients sustaining the life cycle of terrestrial and marine ecosystems

Variability of the land surface and the fluxes of water, energy and momentum

Composition and temperature of volcanic products immediately following eruptions

Snow accumulation, melt, and spectral albedo

Inventory the world's volcanos and geology of exposed land surfaces

The global carbon cycle and associated climate and ecosystem impacts

Monthly terrestrial CO_2 fluxes at 100 km scale

Land and water use effects, surface temperatures, evapotranspiration

Functional traits and diversity of terrestrial and aquatic vegetation

Water balance from headwaters to the continent

What color is the ocean (or Bay)?

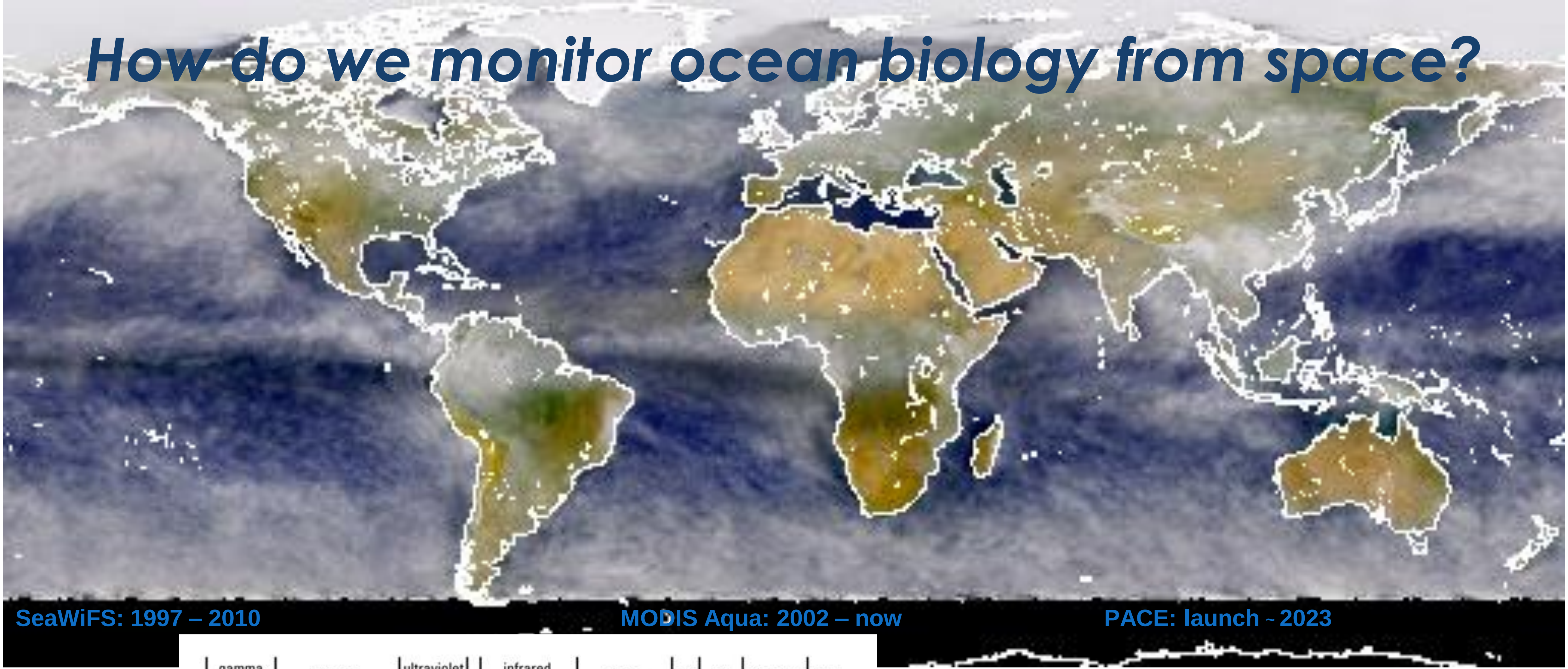
What color is the ocean (or Bay)?

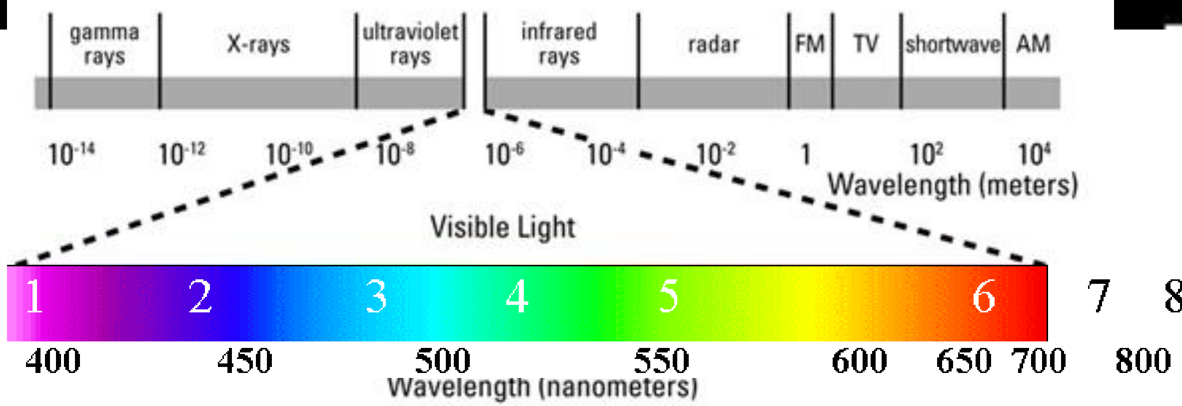
What color is the ocean (or Bay)?

Phytoplankton make a difference!

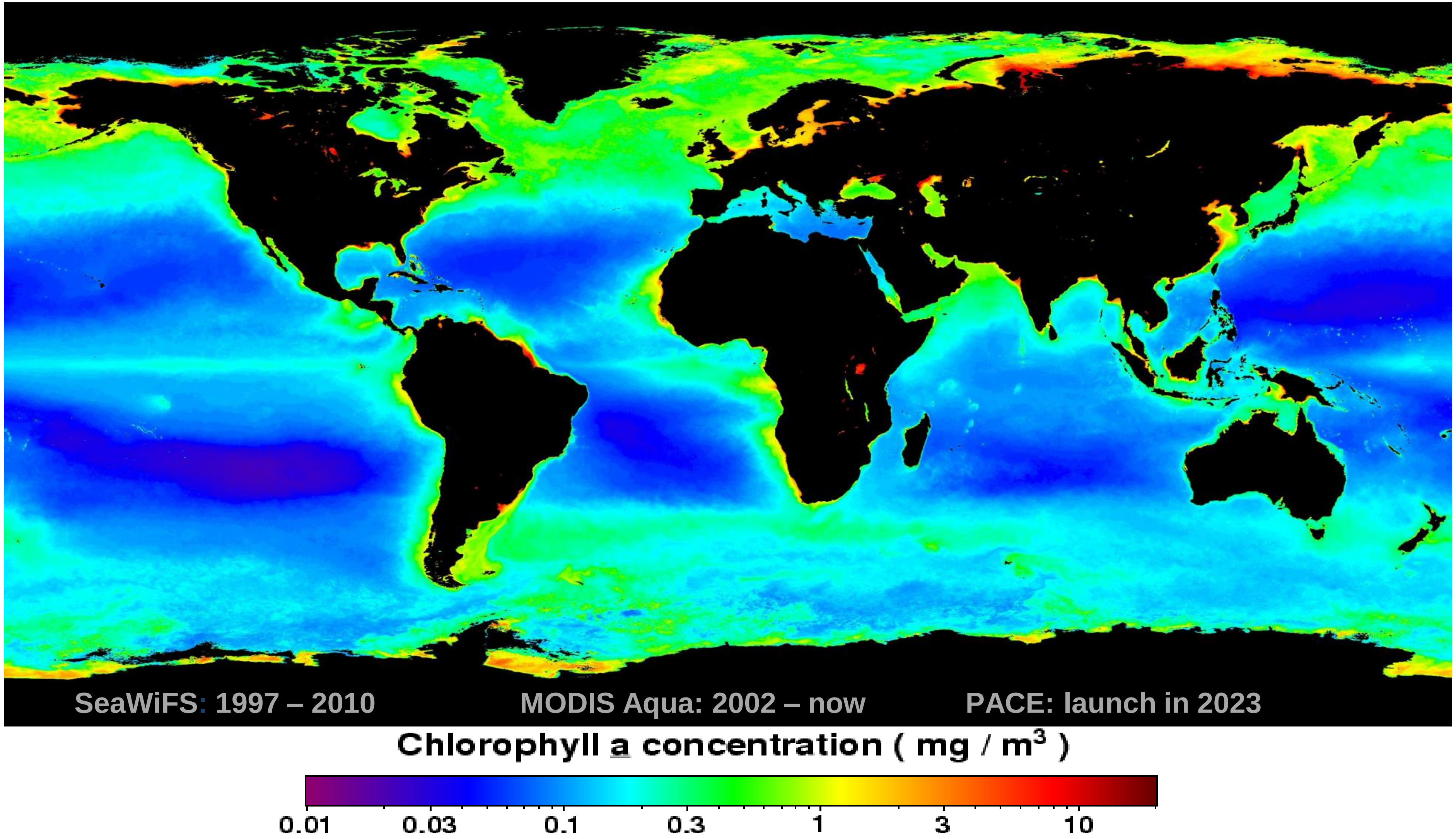
Satellite image of the Black Sea and Eastern Mediterranean Sea

How do we monitor ocean biology from space?





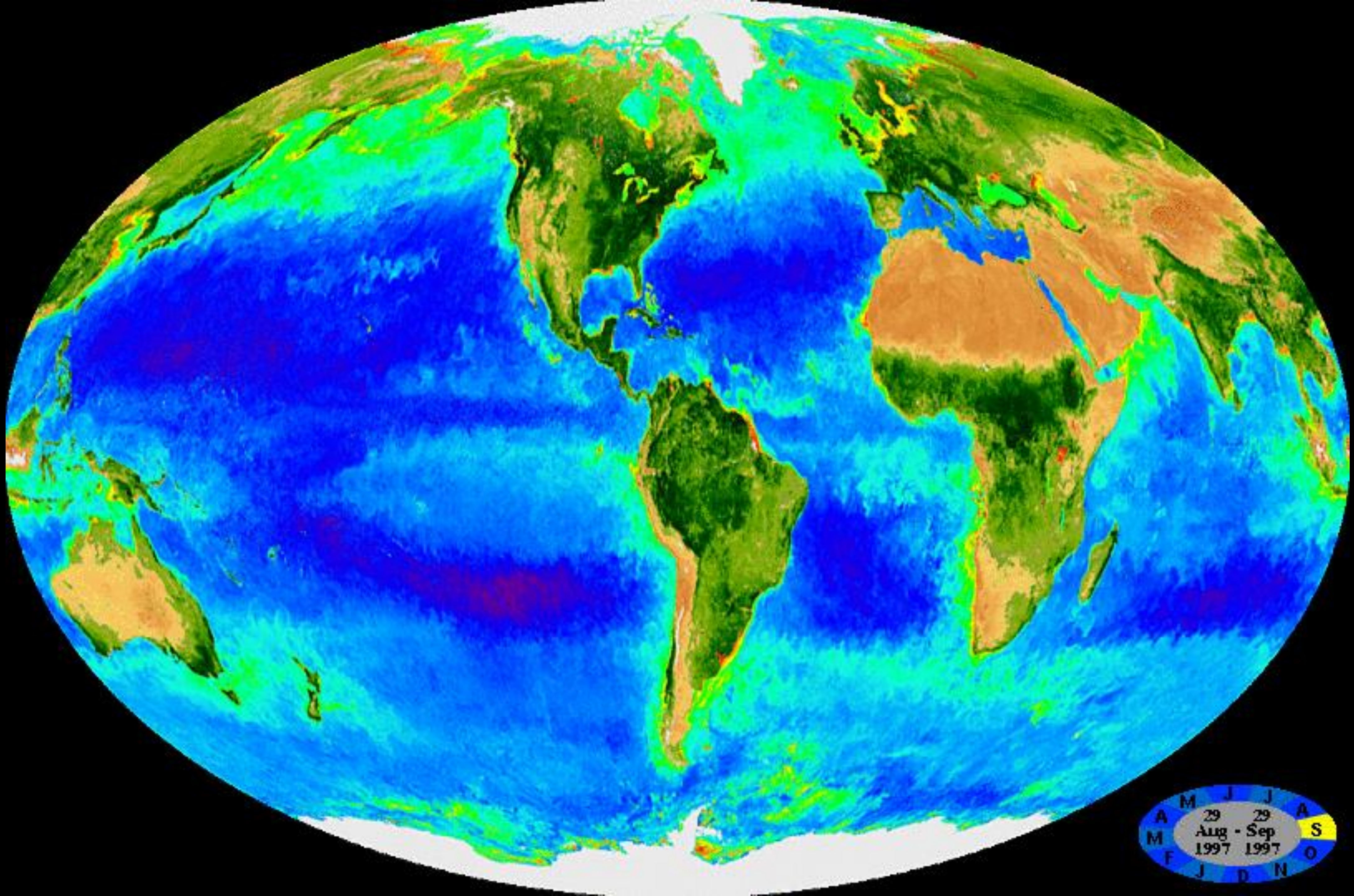
- Importance of atmospheric correction
- Satellite see 90% atmosphere, 10% ocean
- Bio-optics uses ratios of visible bands (e.g. green/blue)



Chlorophyll-a pigment used to identify:

Ecological provinces, physical-biological interaction, phenology, net primary production

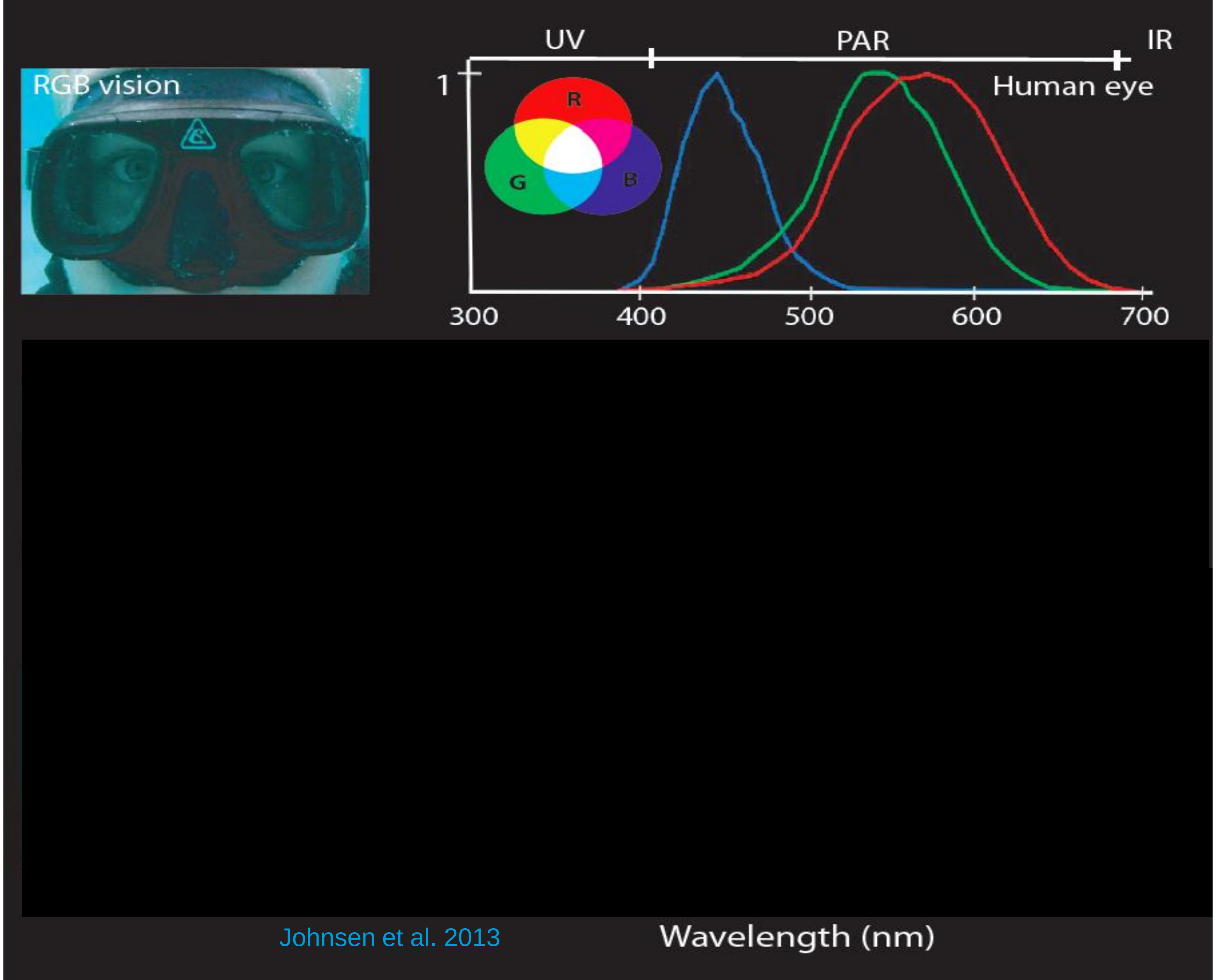
Future goals: phytoplankton community composition, biogeochemical cycling


M
J
J
A
A
S
M
O
F
J
D
N
29 Aug 1997 - 29 Sep 1997

Constituents in water that enhance backscattering of light

- Whitecaps & Foam
- Sea Ice
- Floating Vegetation
- Floating Plastics etc..
- Bubbles
- Cyanobacteria, Trichodesmium, Red Tides
- Sediment (turbid water)
- Calcite (PIC): Coccoliths
- Seafloor (Optically Shallow)

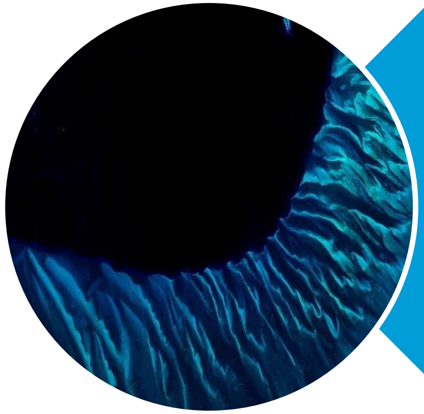
What is hyperspectral?



Higher spectral resolution (hyperspectral) applications

Biogeochemical modeling	• species composition • nutrient cycling • export of carbon, nitrogen, etc…
Ecological indicators	• hypoxia • eutrophication • informed monitoring and assessment
Ecological processes	• primary producers • DMS producers • trophic dynamics & food web efficiency
Global change	• distributional shifts • phenology shifts • changing trophic interactions
Fisheries	• finding fish • locations/monitoring for aquaculture • shellfish food safety
Harmful Algal Blooms(HABS) and human health	• detecting types of blooms • finding probabilistic conditions for toxin production • warnings to public
Environmental reporting	• meeting thresholds • species ID • detecting anomalies

Trade-offs in Satellite Technology



Trade-off spatially

- More narrow spectral bands → Larger bins or pixels
- Few broad spectral bands → Smaller pixel

Trade-off temporally

- Larger pixel → More frequent revisit
- Smaller pixel → Less frequent revisit

Digital Globe, Planet, etc.	• High spatial <1 m • Low spectral (RGB uncalibrated) • Low temporal
Landsat OLI/Sentinel 2	• Medium spatial (10-30 m), Global coastal • Low spectral (3 channels) • Low temporal (10-16 day revisit, but glint issues)
MODIS, PACE Ocean Color	• Low spatial (500-1000 m), Global • High spectral (5 nm bands) • Medium temporal (3-5 day revisit)
Geostationary	• Medium spatial (30 m), Regional • High spectral (5 nm bands) • High temporal (Hourly)
Aircraft and Drones	• High spatial (1-10 m) Local • High spectral (5 nm bands) • High temporal possibility depending on cost

Applied Science Working Groups at Goddard

Connecting societal challenges to our basic and applied research to improve life on Earth

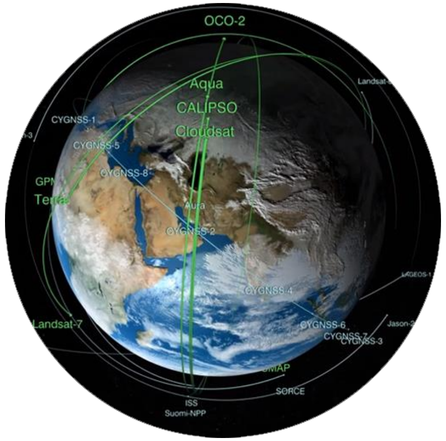
Disasters

Air Pollution

Climate & Health

Chesapeake Bay

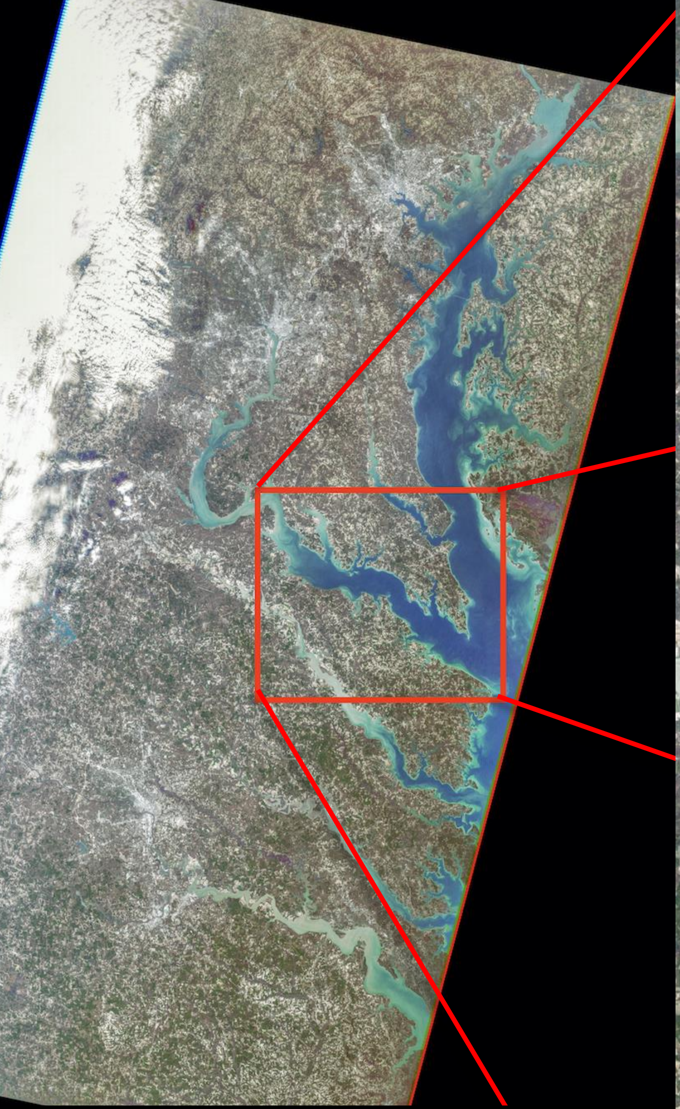
Food Security

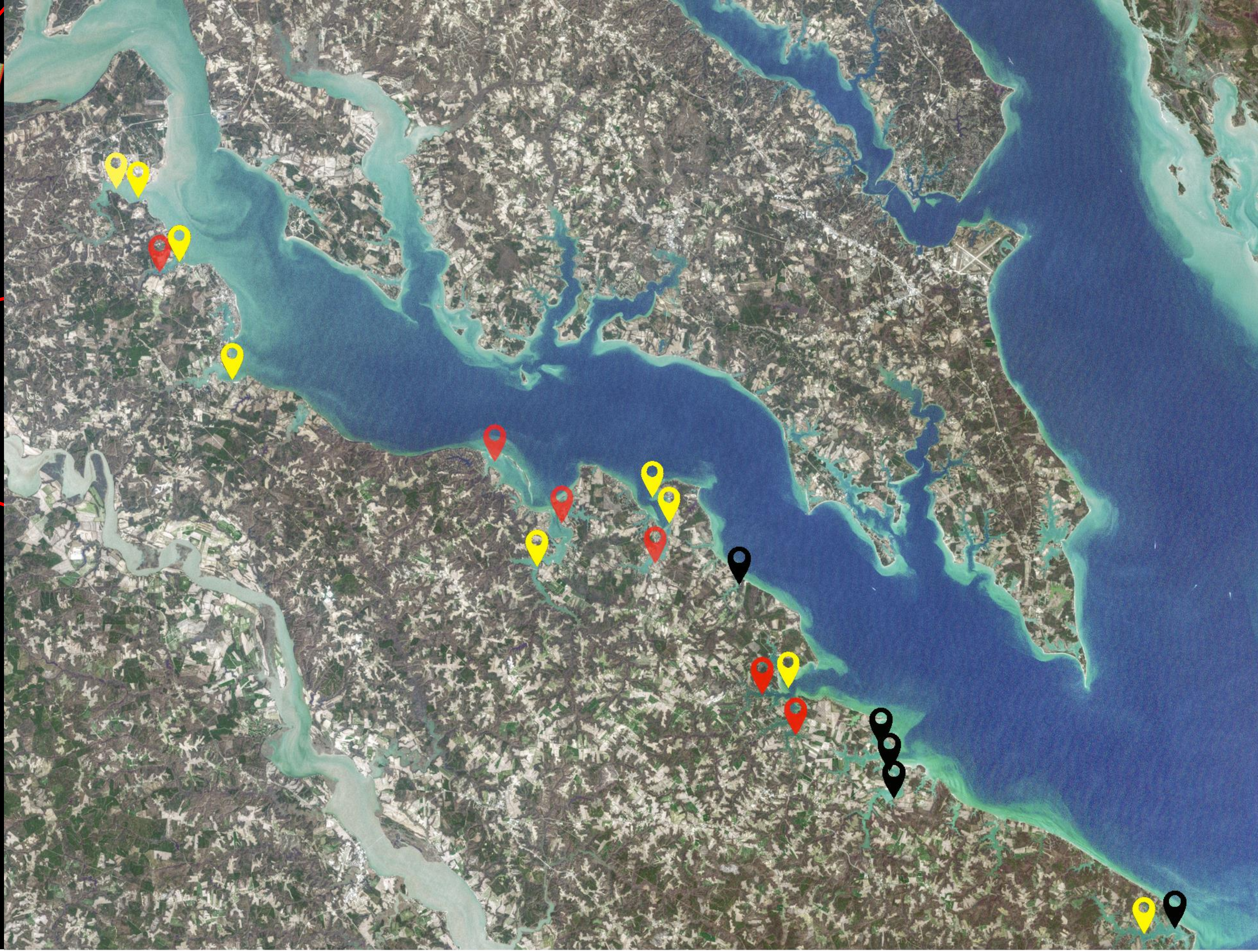


New Satellites

Satellite applications in the Chesapeake Bay:

- harmful algal blooms, water-borne pathogens
- nutrients, water clarity
- dissolved oxygen (i.e. dead zone)

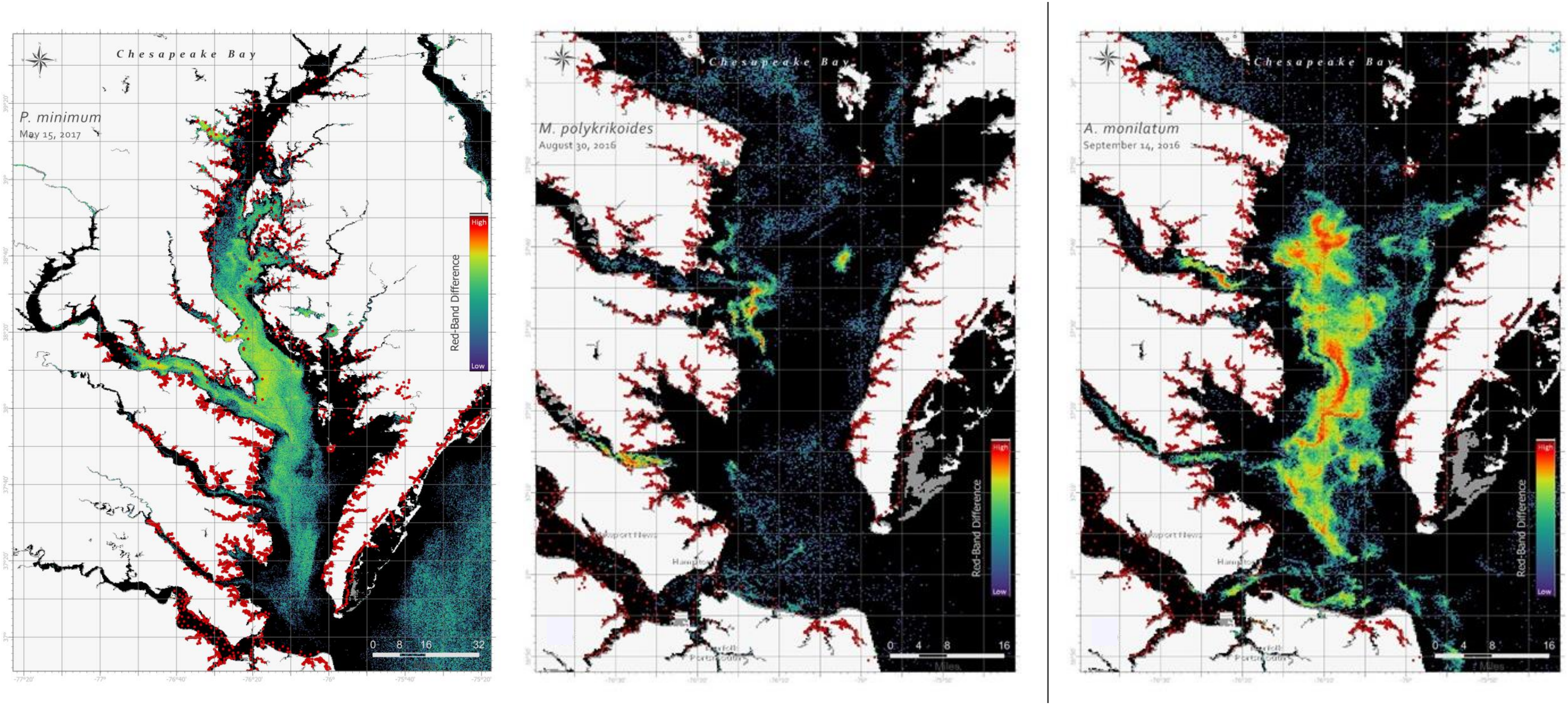




Landsat 7 scene, February 26, 2002

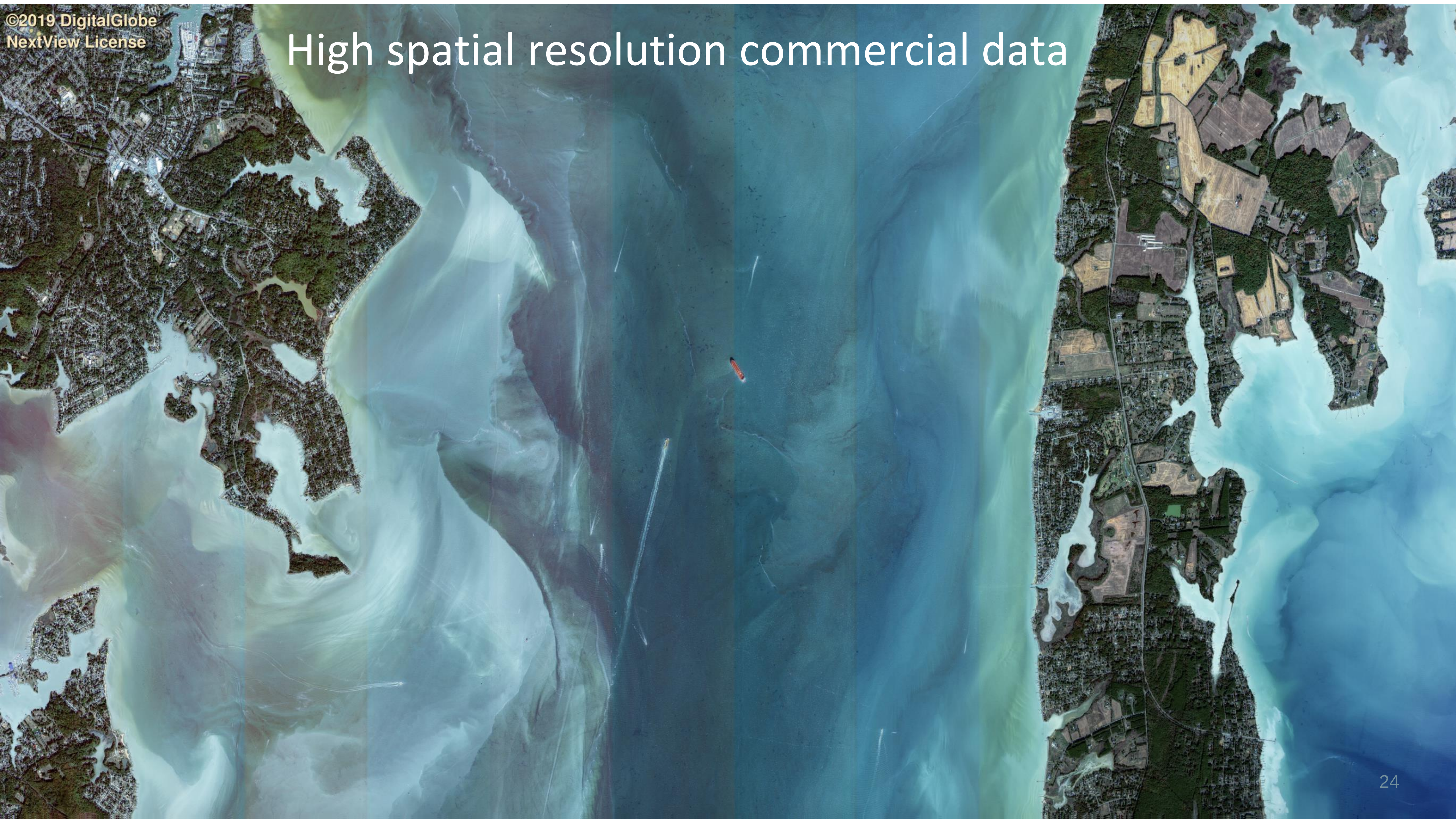
Dinophysis acuminata by VIMS/VDEQ:
low (black) < 10,000 cells L^{-1}
medium (yellow) 10,000 – 50,000 cells
high (red) > 50,000 cells L^{-1}

Harmful Algal Bloom detection in the Chesapeake Bay



Wolny, J.L., M.C. Tomlinson, S. Schollaert Uz, T.A. Egerton, J.R. McKay, A. Meredith, K.S. Reece, G.P. Scott, and. R.P. Stumpf, 2020, Current and Future Remote Sensing of Harmful Algal Blooms in the Chesapeake Bay to Support the Shellfish Industry, *Front. Mar. Sci., doi:10.3389/fmars.2020.00337*

High spatial resolution commercial data



Chesapeake Bay water quality

Working with Maryland Dept of Environment shellfish unit, UMD, NOAA, USDA-ARS to combine sampling of biology, chemistry, physics with optical measurements (in water, above water, satellite)

Photo credit: John 'Rusty' McKay/MDE

Aquaculture is a growing industry world-wide

Elevated fecal coliform runoff causes shellfish bed closures

Remote sensing may provide early warning of harmful algal blooms and polluted run-off

Remotely sensed optical techniques are being explored

Developing AI for water quality

Chesapeake Bay phytoplankton classes

Phytoplankton have diverse roles in the marine ecosystem and carbon cycle.
Next: how can they be distinguished by their color?