BIOSCape - Mapping of phytoplankton functional types (PFTs) from space in support of coastal resource management and decision support activities

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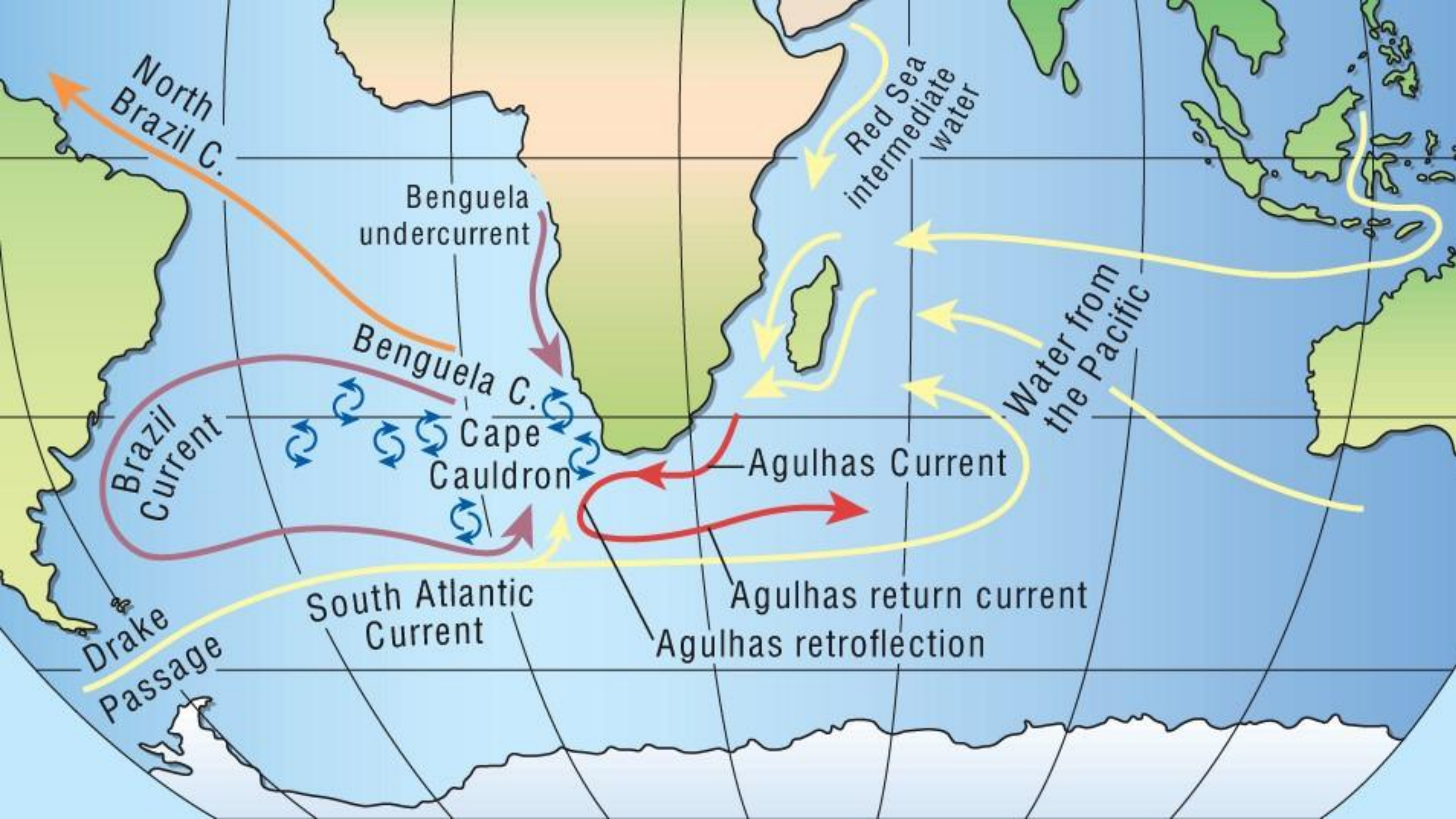

North Brazil C.
Benguela undercurrent
Red Sea intermediate water
Benguela C.
Brazil Current
Cape Cauldron
Agulhas Current
Water from the Pacific
Drake Passage
South Atlantic Current
Agulhas return current
Agulhas retroflection

Harmful Algae Blooms (HABs)

1. Human Health Risks

- Toxin Exposure
- Contaminated Drinking Water
- Seafood Poisoning
- Respiratory Irritation
- Skin Rashes

2. Environmental Damage

- **Hypoxia (Dead Zones)**: Decomposing algal biomass consumes oxygen, creating hypoxic conditions that suffocate aquatic life.
- **Fish Kills**: Toxins and low oxygen levels from blooms can cause mass die-offs of fish and other marine life.
- **Loss of Biodiversity**: HABs can outcompete and displace native species, disrupting entire ecosystems.
- **Habitat Destruction**: Corals, seagrasses, and other vital habitats may be damaged by shading or toxins.
- **Marine Mammals and Birds**: HAB toxins can bioaccumulate up the food chain, affecting top predators.

3. Economic Consequences

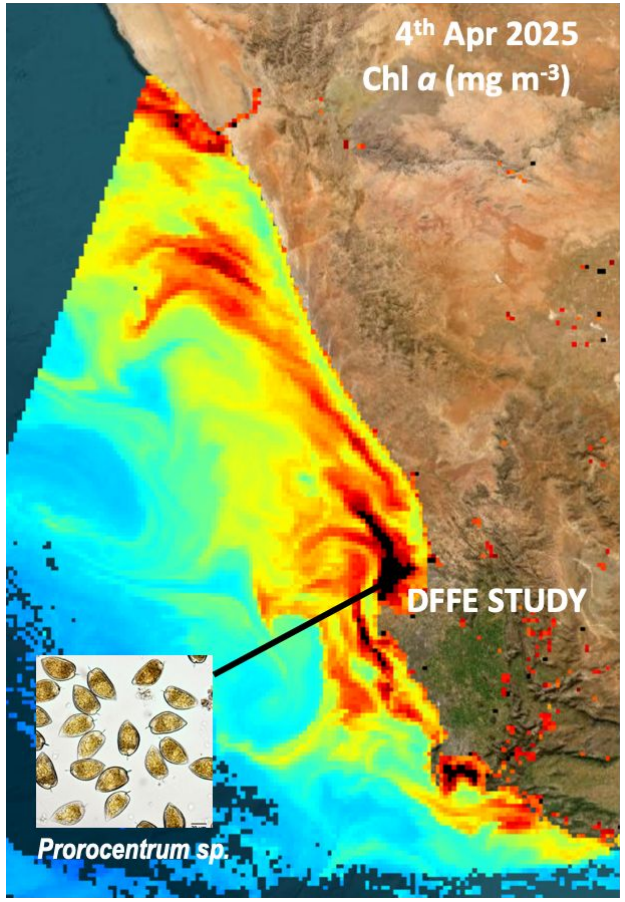
- Fisheries and Aquaculture
- Tourism
- Water Treatment Costs
- Property Value Decline

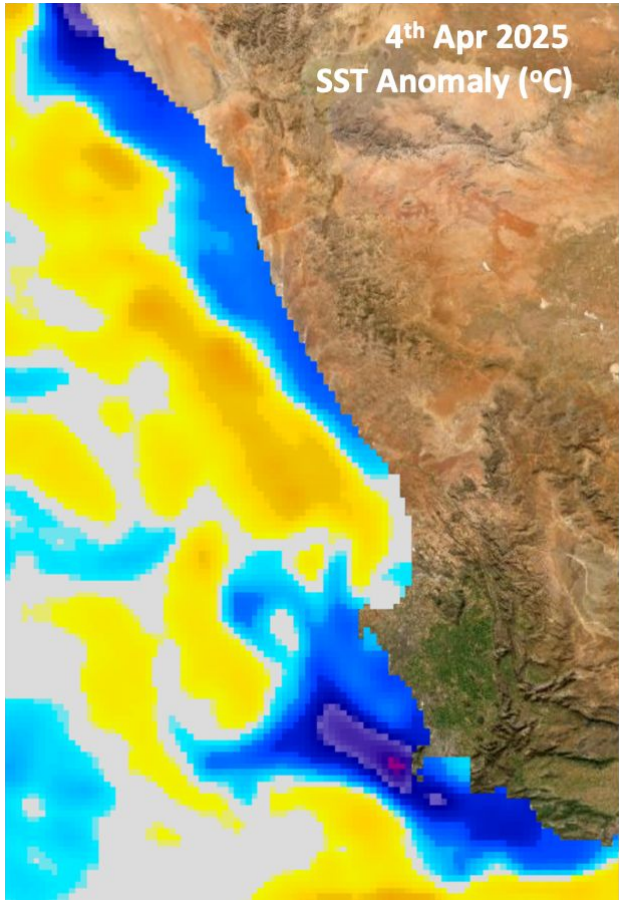




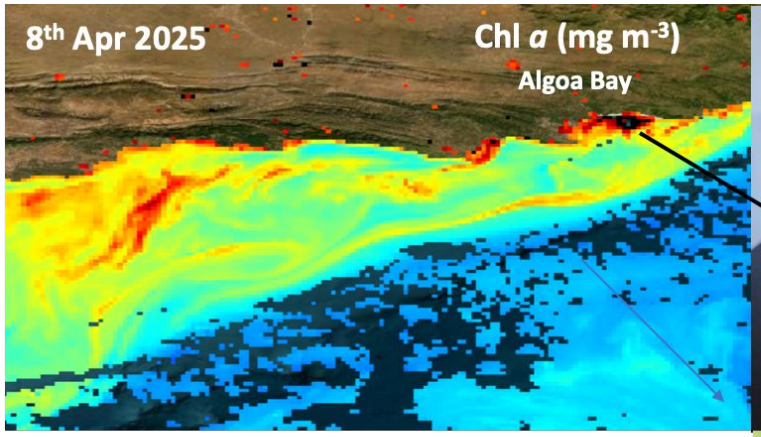
Harmful algal blooms are increasing in frequency and intensity

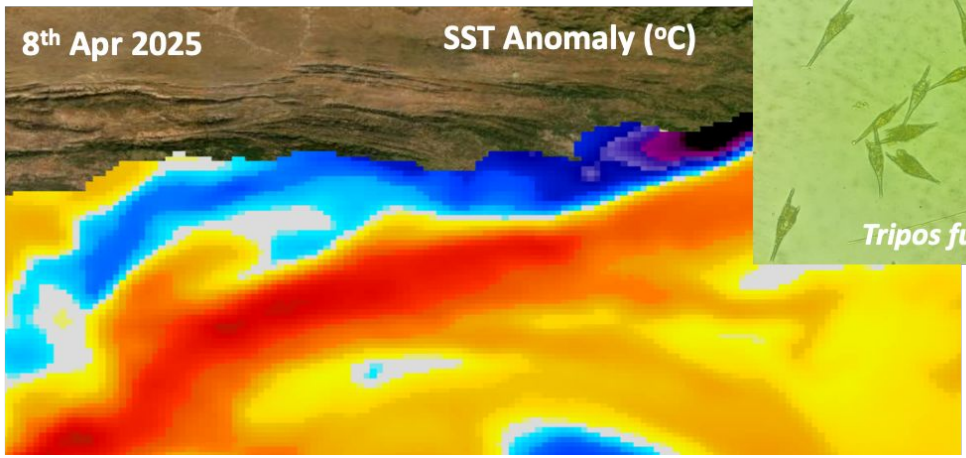
HABs at St Helena Bay





HABs at Algoa Bay





Goal

Develop a hyperspectral radiometric method to map the spatial distribution of **phytoplankton functional types (PFT)** across environmental gradients within these three ecologically distinct but socio-economically vital bays.

St Helena Bay

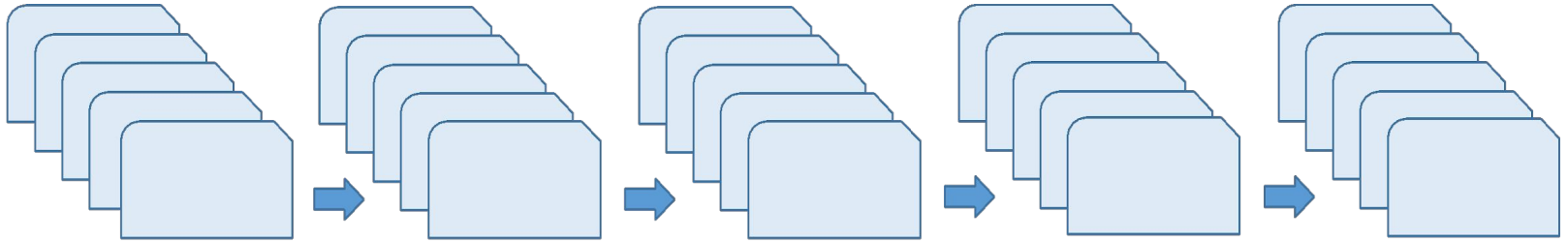
Walker Bay

Algoa Bay

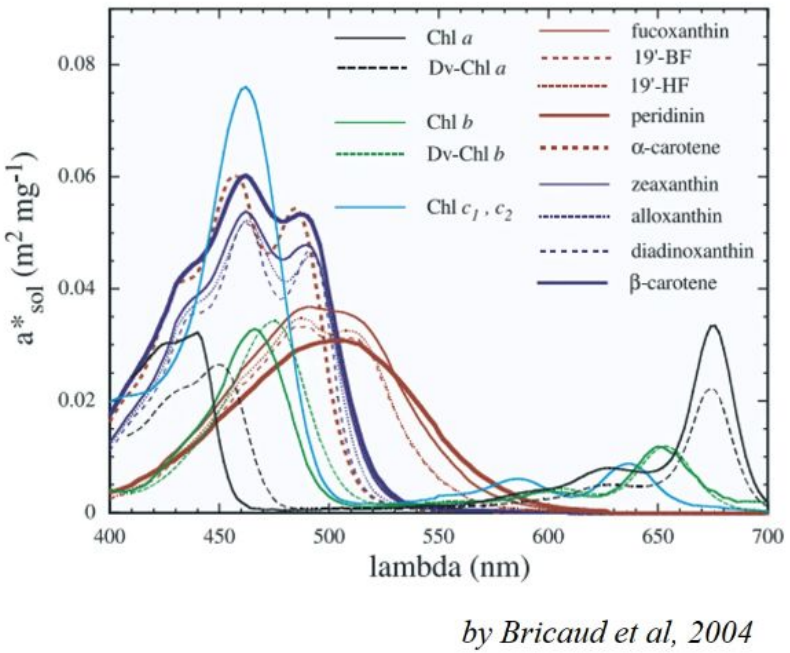
Method

Multi-pigment inversion model (MuPI)

(Wang et al. 2016; Wang, Lee & Mouw, 2017)

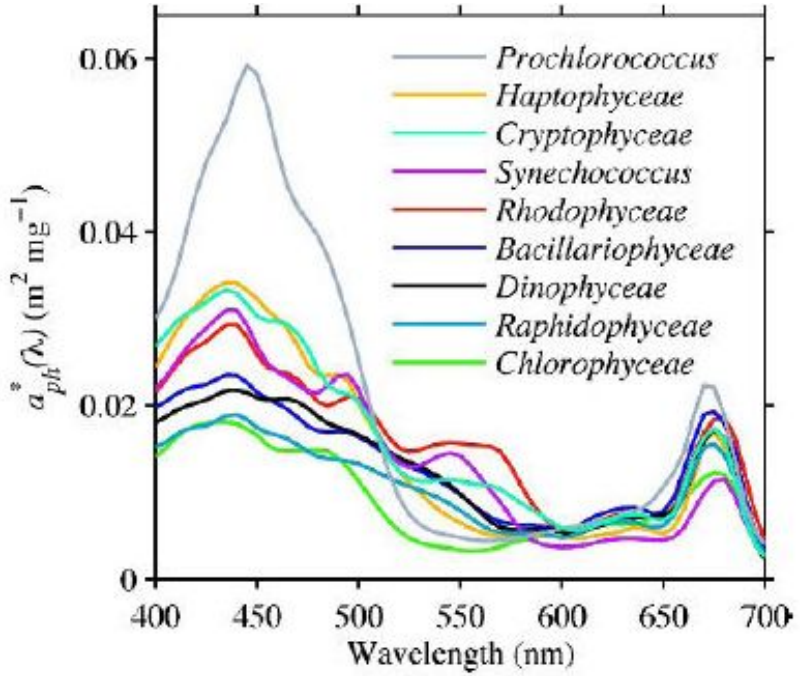


$$R_{rs}(\lambda) = f\left(\frac{b_b}{a_t + b_b}\right) = f\left(\frac{b_{bw} + 0.01\left(c_s - a_{ph}(\lambda)\right)}{\sum_{i=1}^{n} a_{gaus}(\lambda_i)\exp\left[-0.5\left(\frac{\lambda-\lambda_i}{\sigma_i}\right)^2\right] + a_{dg}(\lambda_0)\exp\left(-S(\lambda-\lambda_0)\right) + a_w + b_{bw} + 0.01\left(c_s - a_{ph}(\lambda)\right)}\right)$$

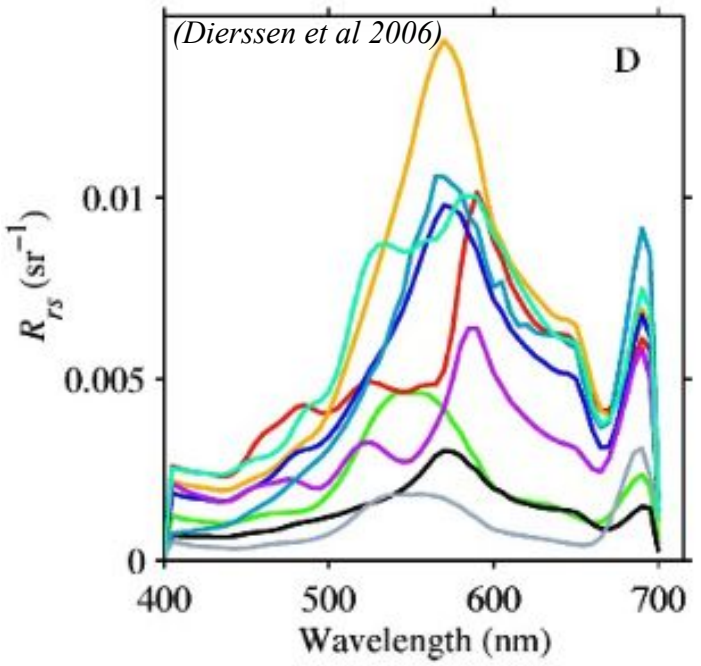


by Bricaud et al, 2004

Absorption of individual Pigments



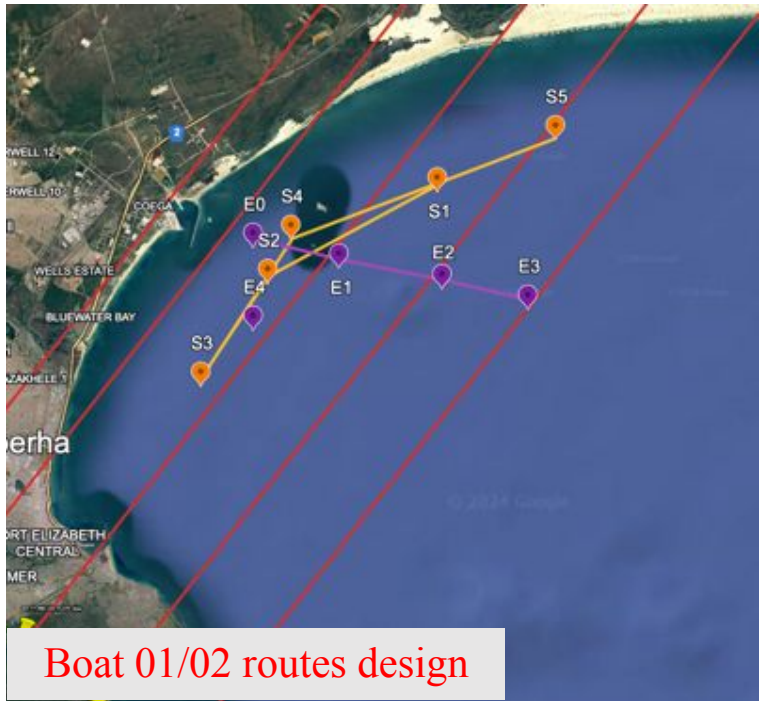
Aph of PFTs



Remote sensing reflectance (Rrs)

Algoa Bay [Oct 25/26th]

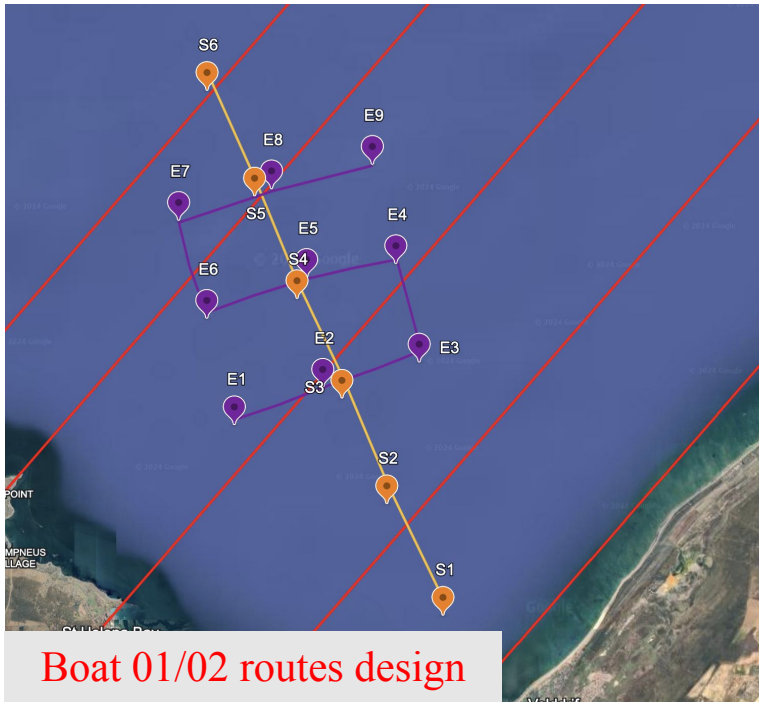
G-III flight routes design



Boat 01/02 routes design

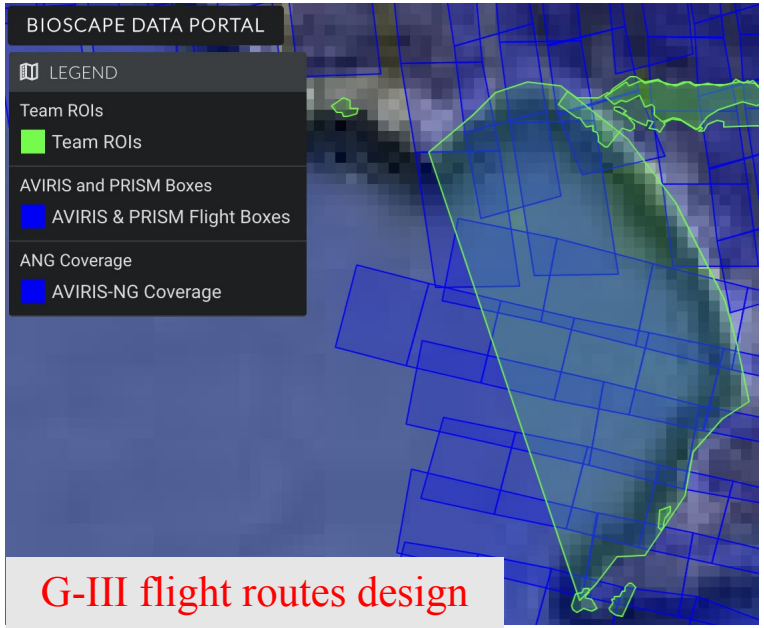
St. Helena Bay [Oct 30/31st]

G-III flight routes design

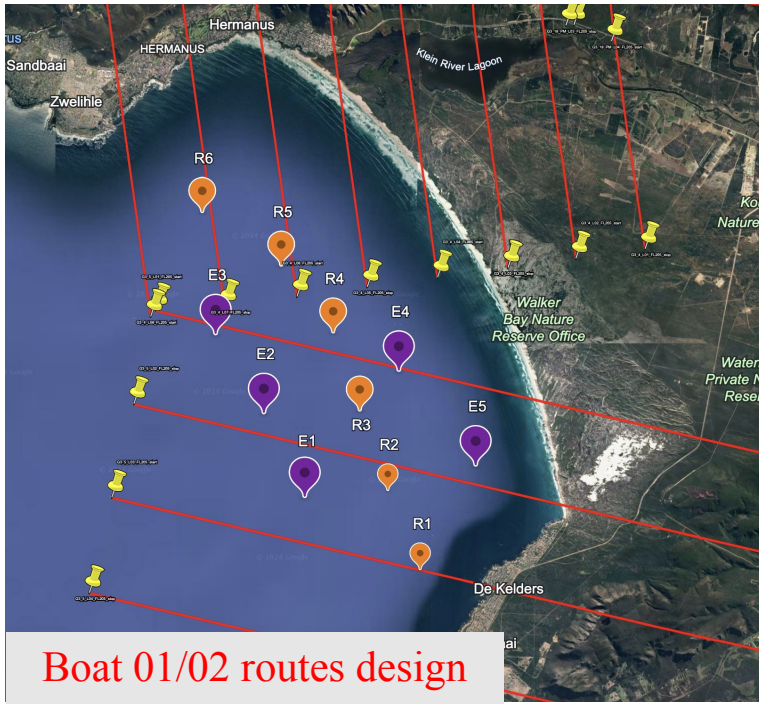


Boat 01/02 routes design

Walker Bay [Nov 08/09th]



G-III flight routes design



Boat 01/02 routes design

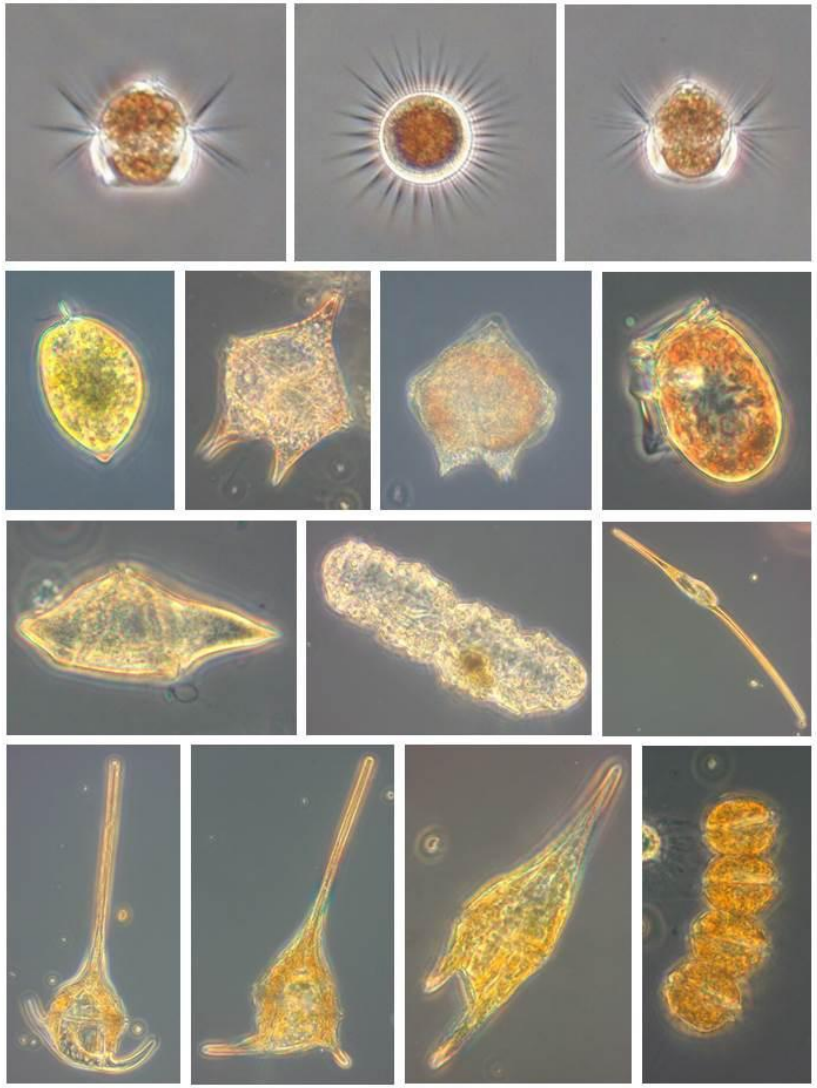
Plankton dominated by:

PFTs from Microscopy

Dinoflagellates

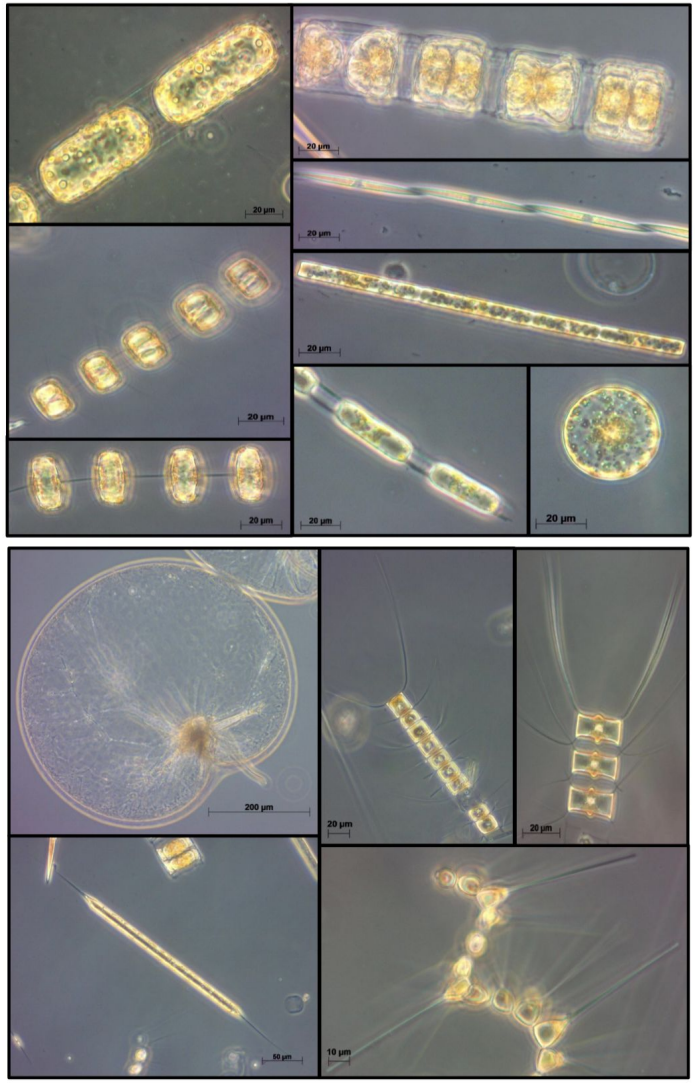
Diatom Plate (Algoa Bay)

photosynthetic ciliate



Plankton (St Helena Bay)

Noctiluca scintillans



Plankton (Walker Bay)

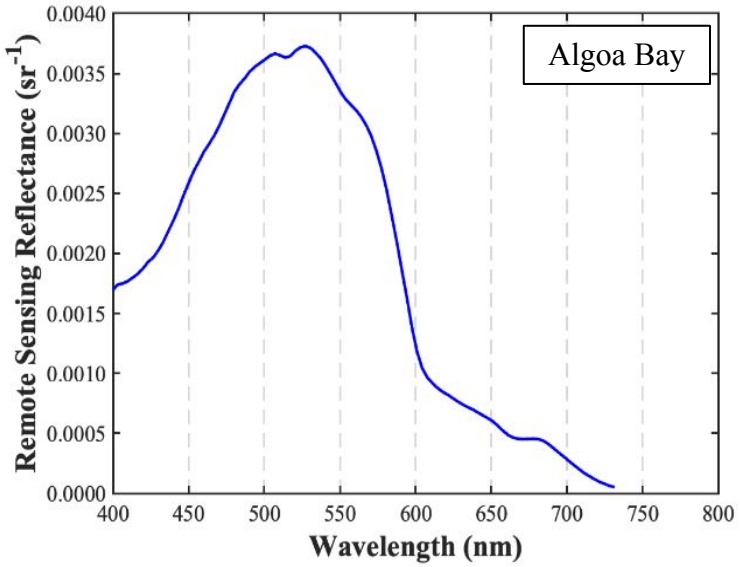
Primary Productivity of three bays

Algoa Bay **St. Helena Bay** **Walker Bay**

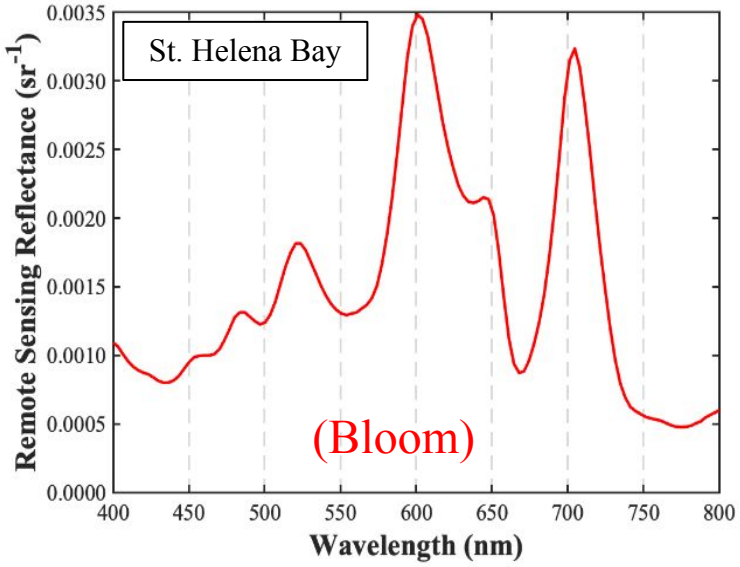
COMPARISON OF BAY PRODUCTIVTY
as depicted by incremental changes in dissolved oxygen at 3, 8 and 14 m depth

Representative hyperspectral Rrs

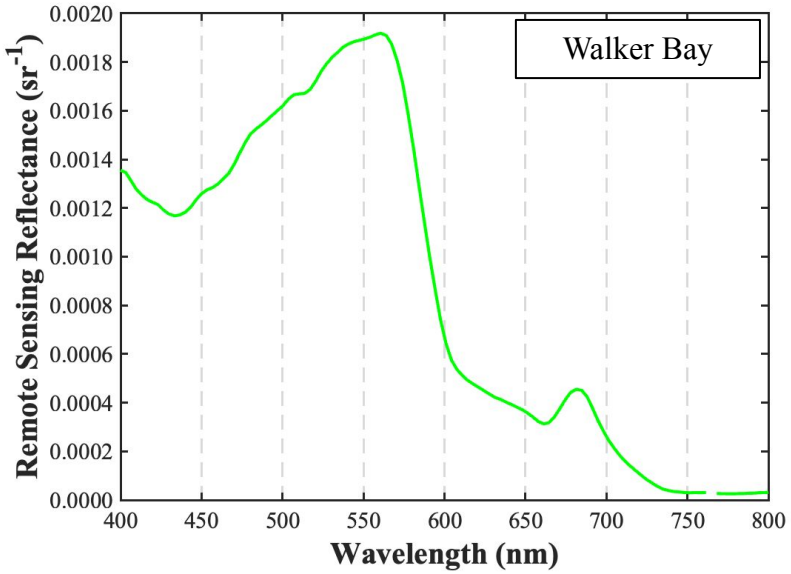
Algoa Bay



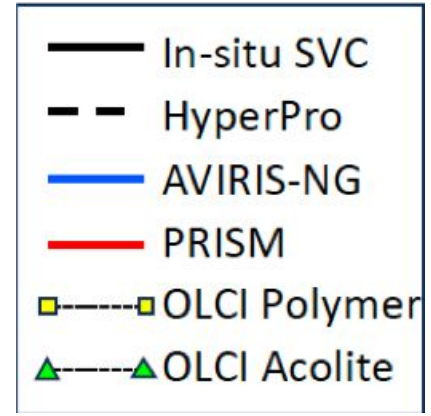
St. Helena Bay



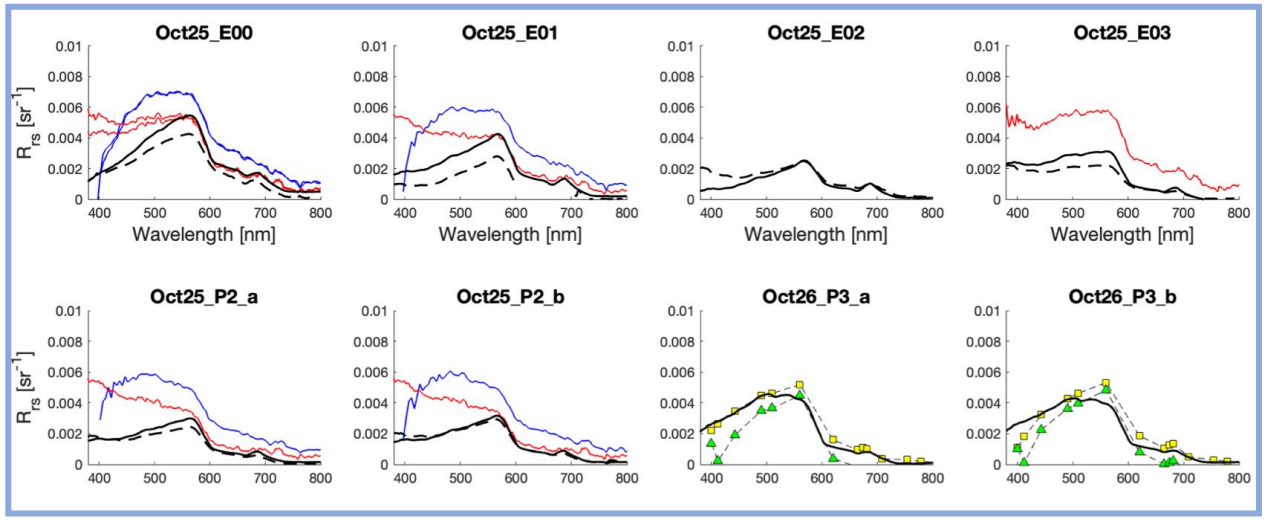
Walker Bay



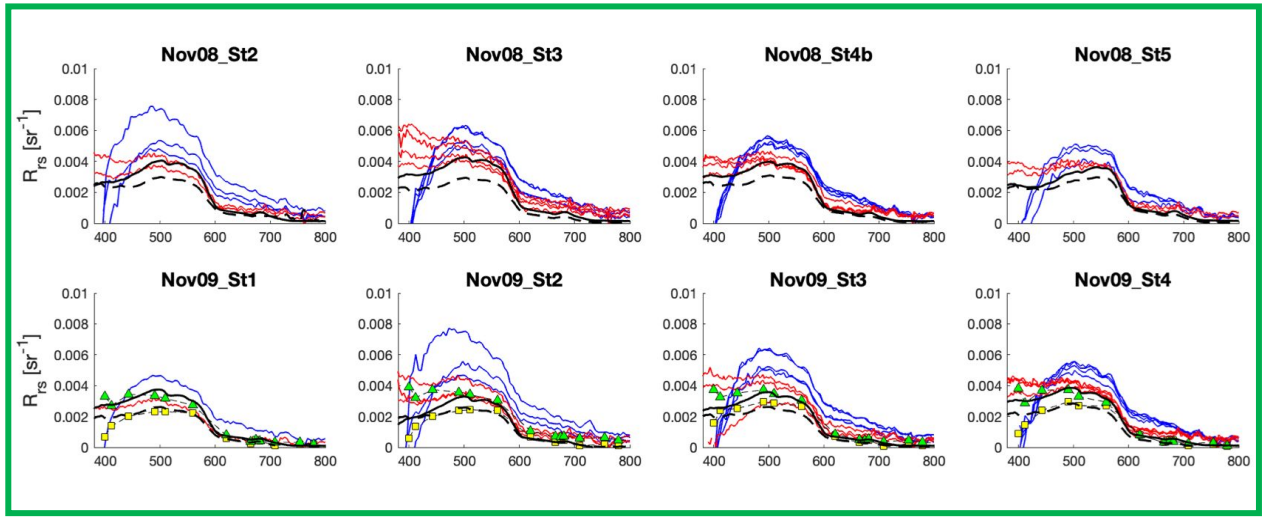
Comparison of hyperspectral Rrs



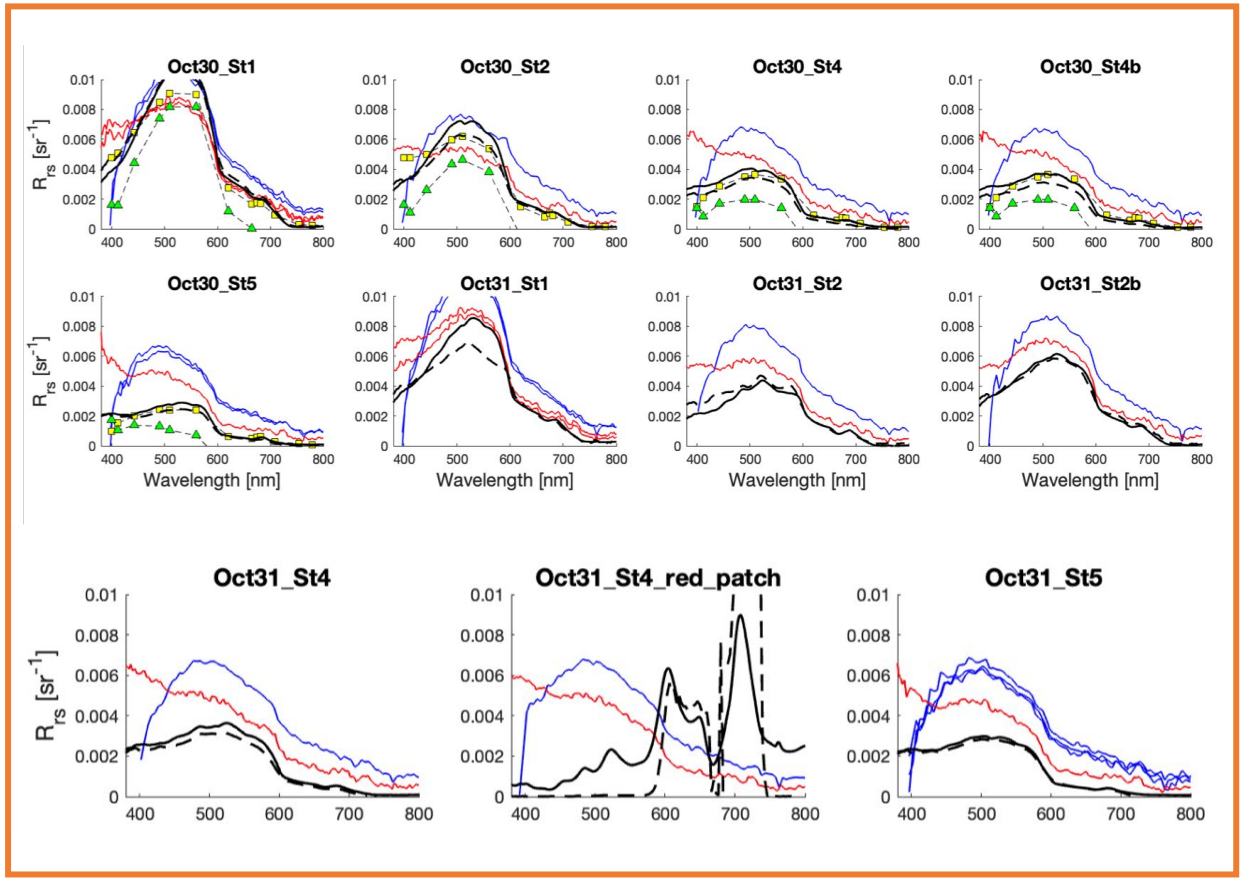
Algoa Bay



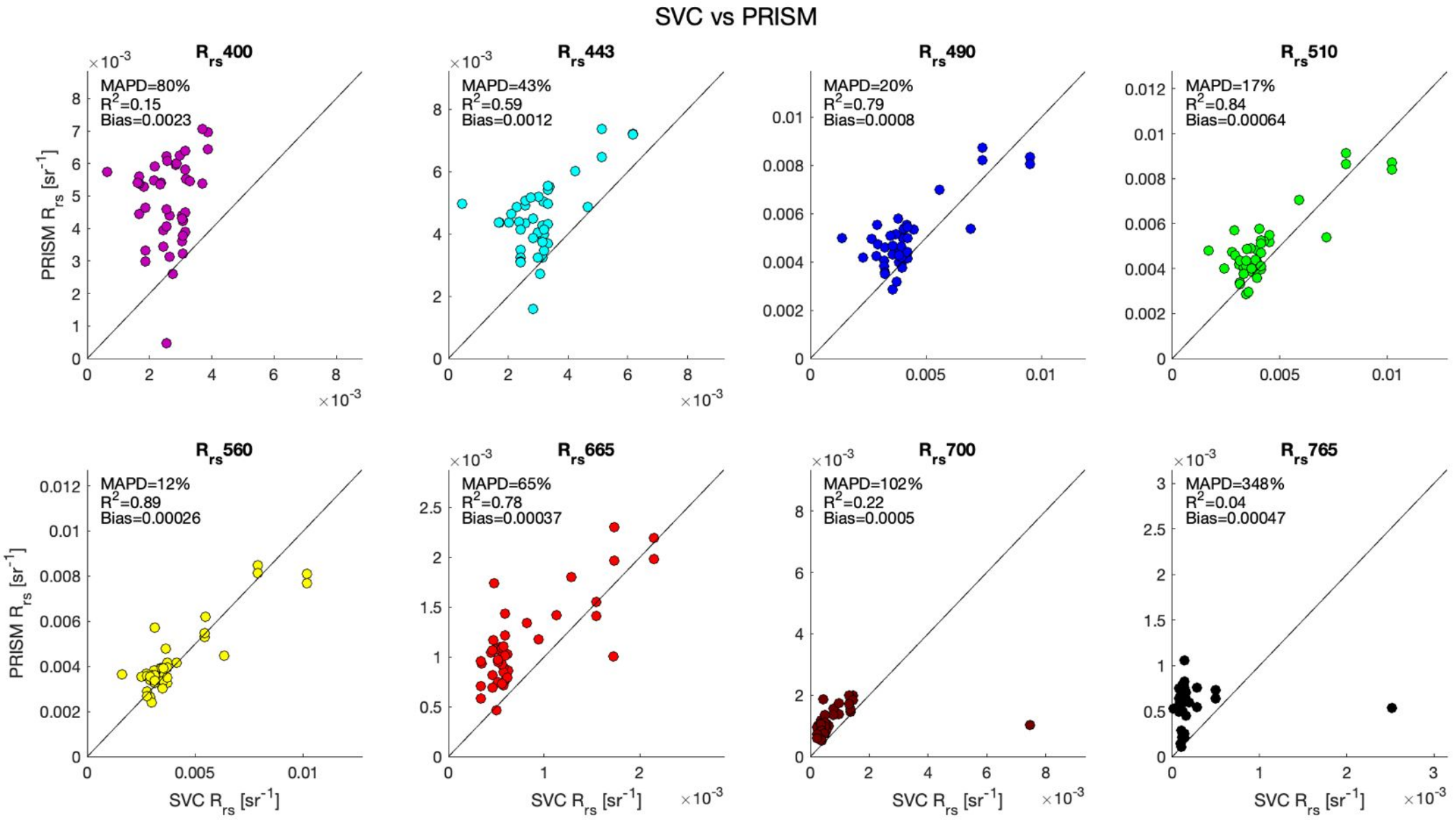
Walker Bay



St. Helena Bay

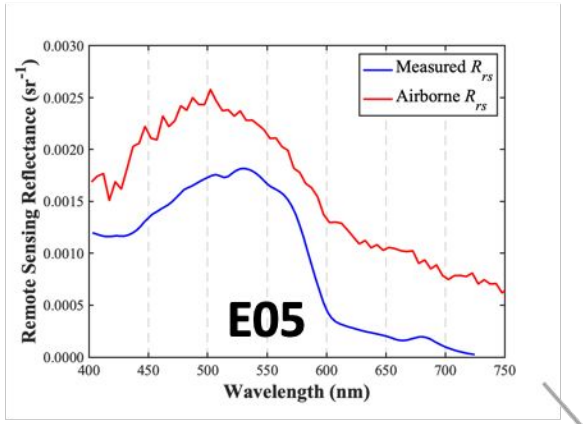


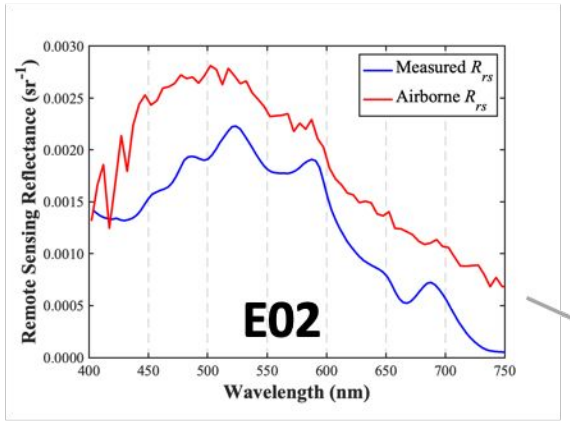
Comparison of hyperspectral Rrs

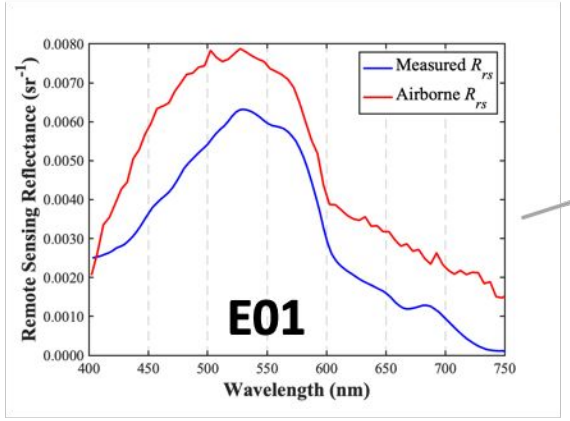


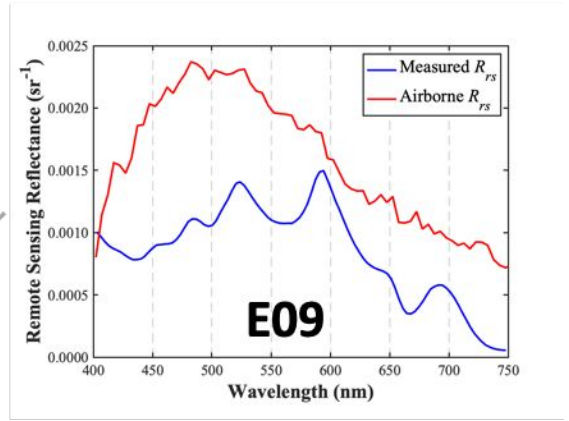
BIOSCape AVIRIS-NG image

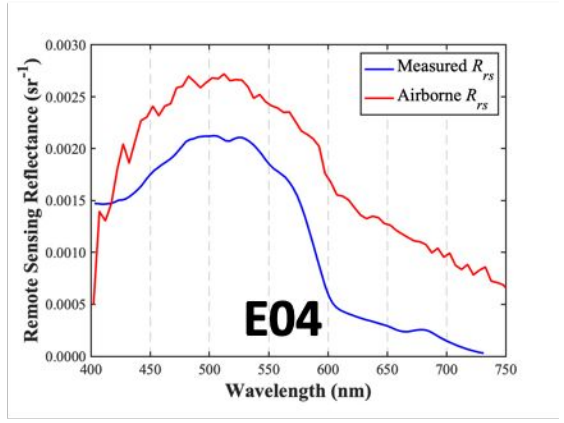
Oct 31st 2023 St. Helena Bay

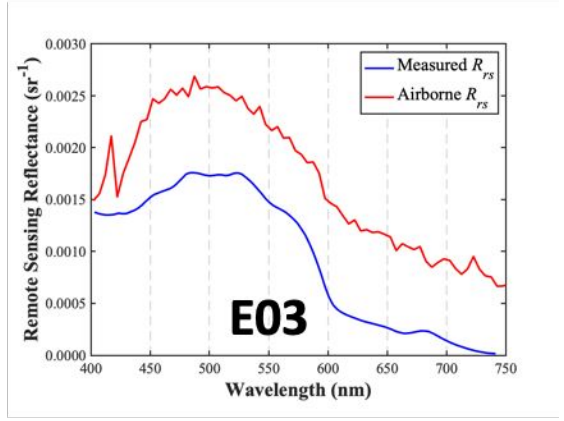


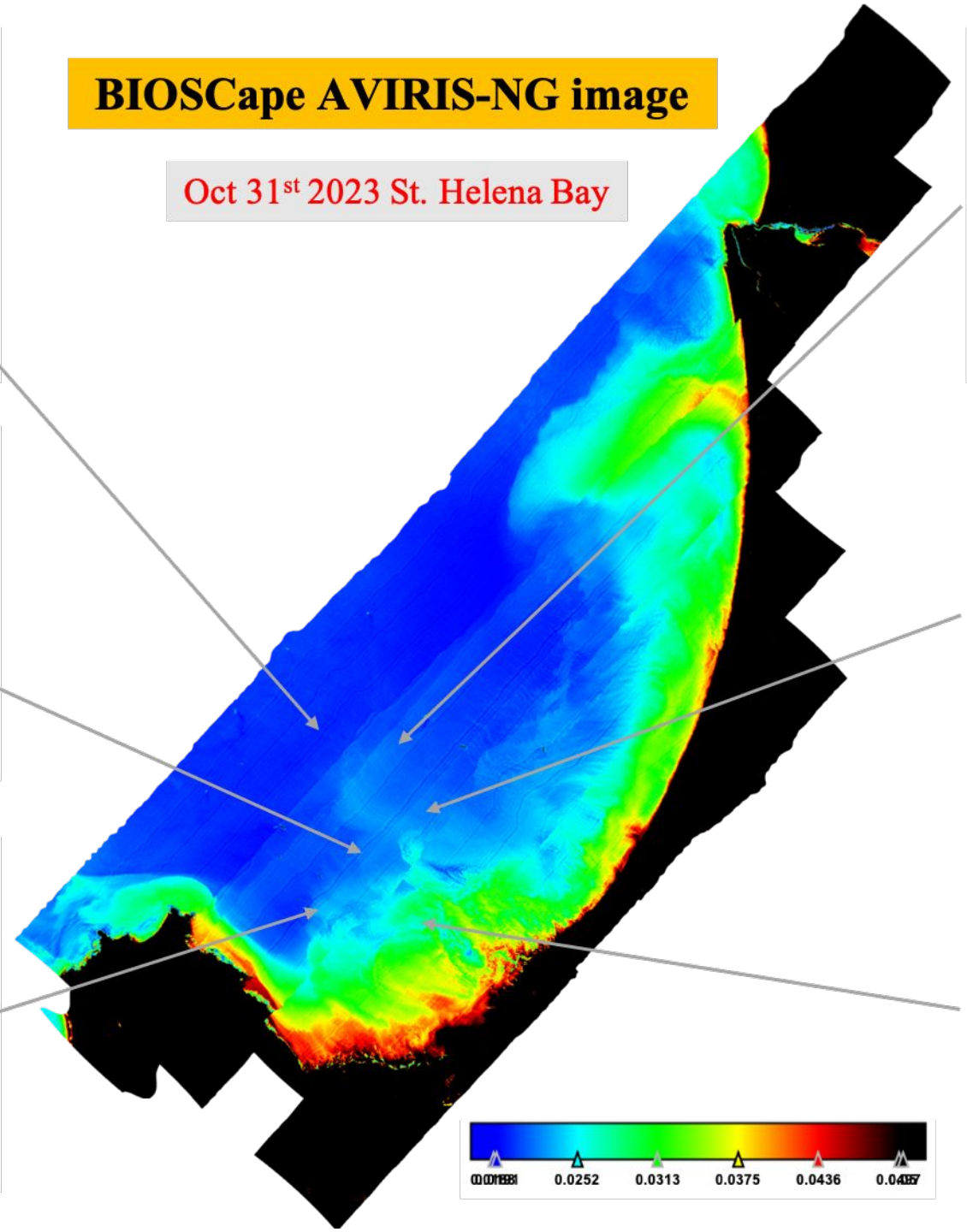






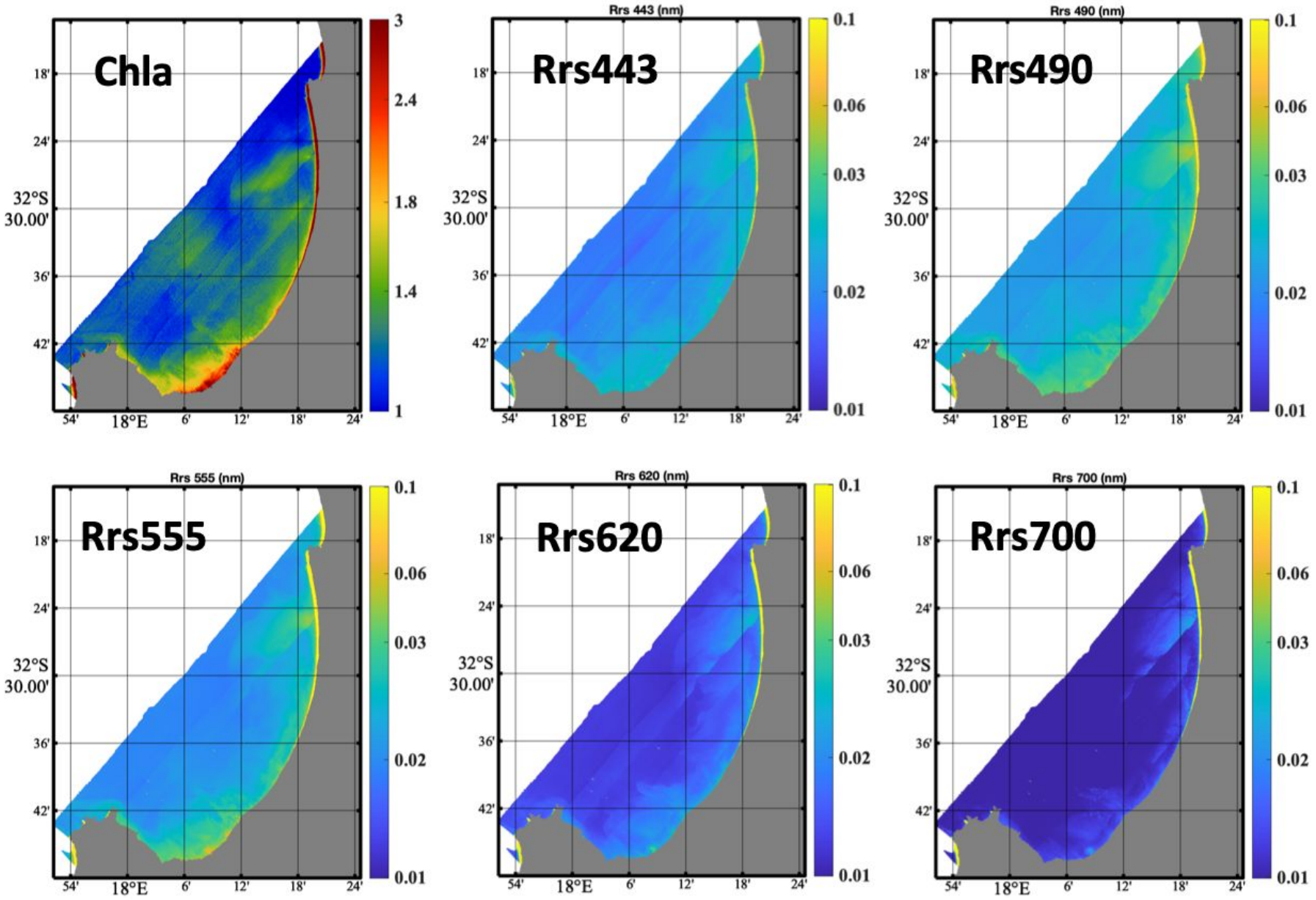






BIOSCape AVIRIS-NG image

Oct 31st 2023 St. Helena Bay



MuPI model results in St. Helena Bay

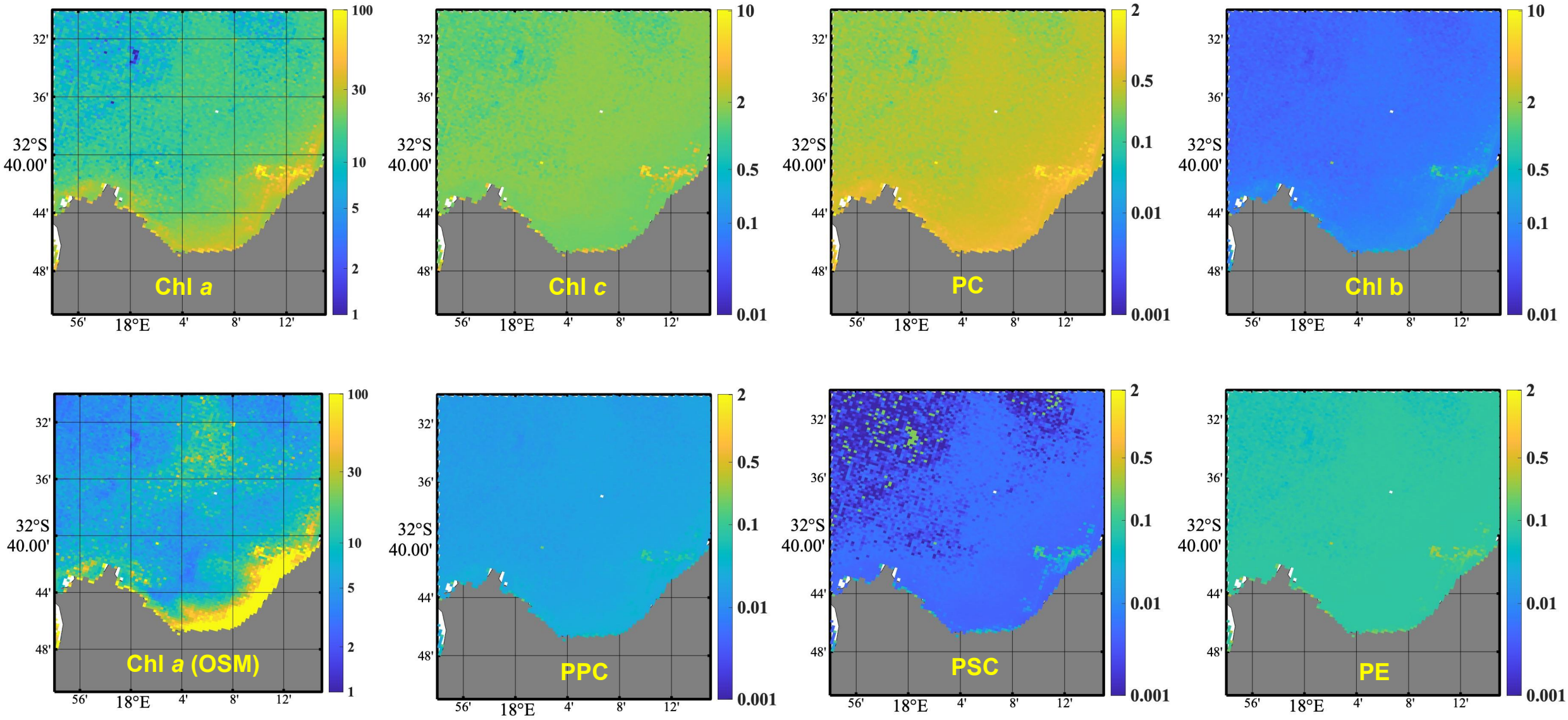
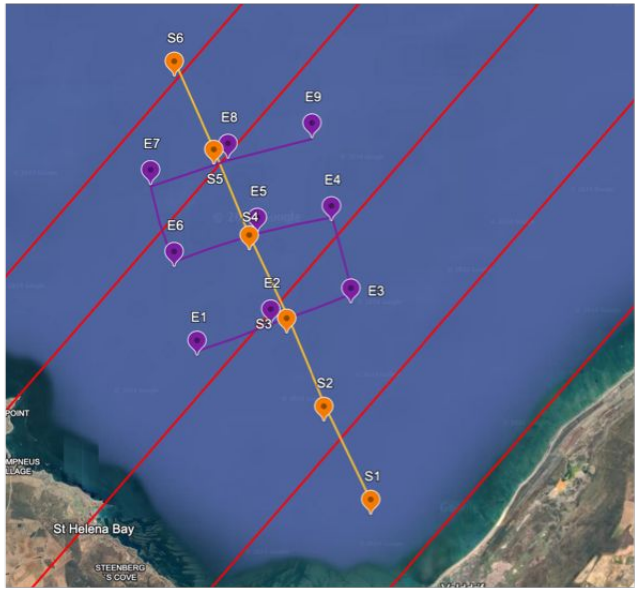
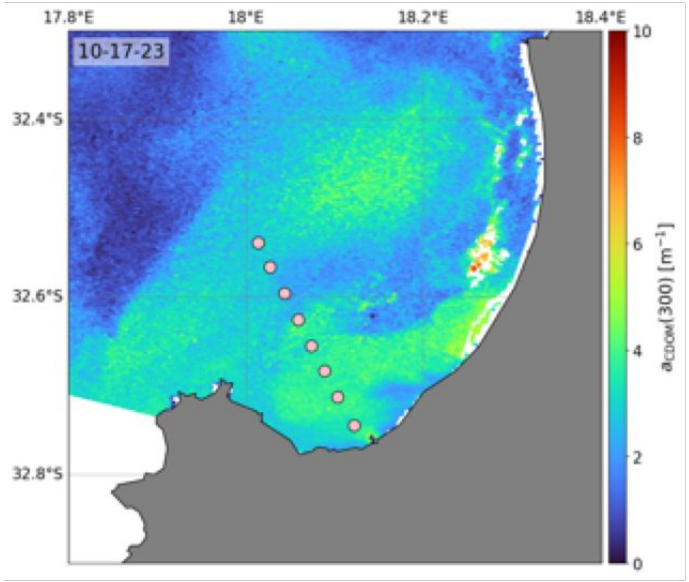


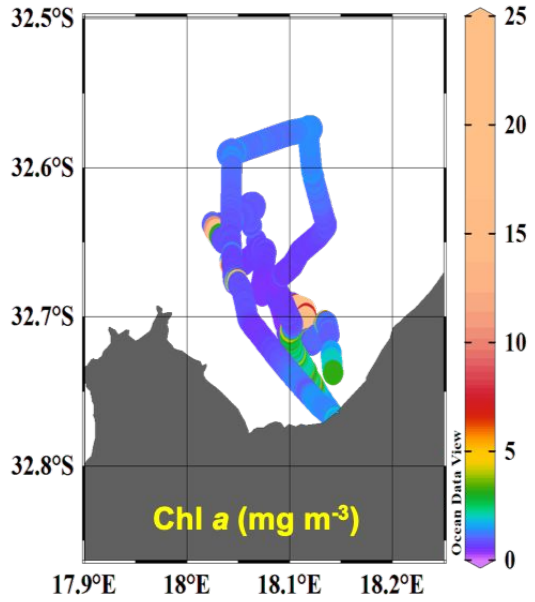
Fig. Pigment (Chl a, Chl b, Chl c, Phycocyanin (PC), Phycoerythrin (PE) < Photoprotective Carotenoid (PPC), Photosynthetic Carotenoids (PSC) concentrations from OLCI

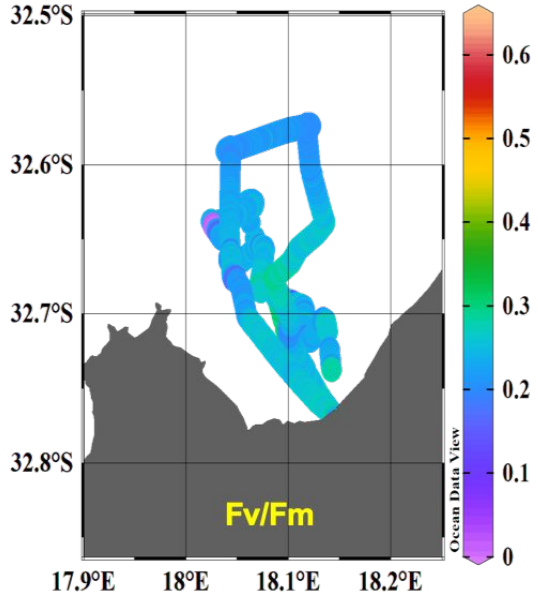
Field measurements in St. Helena Bay

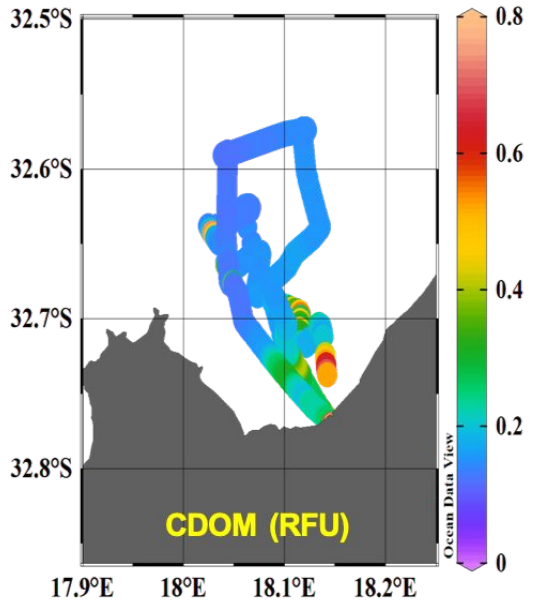
ciliate *Mesodinium* sp

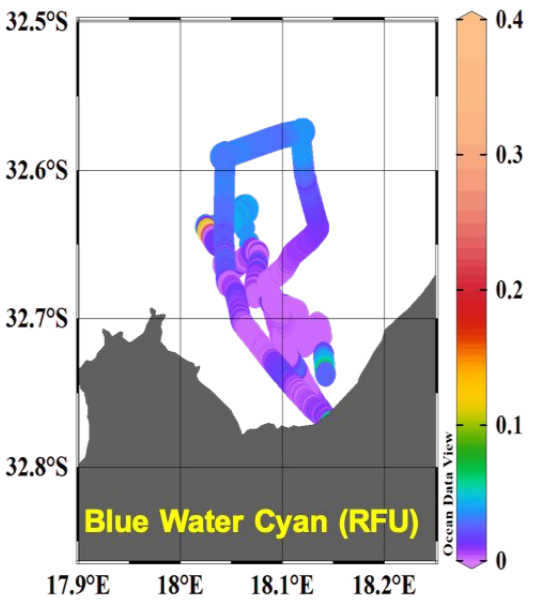


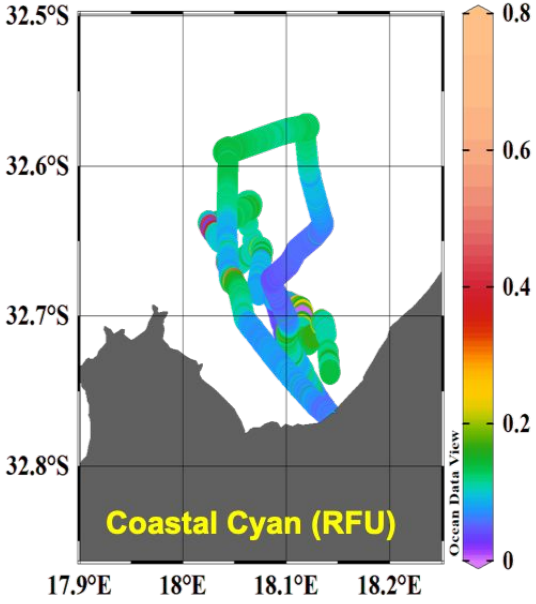


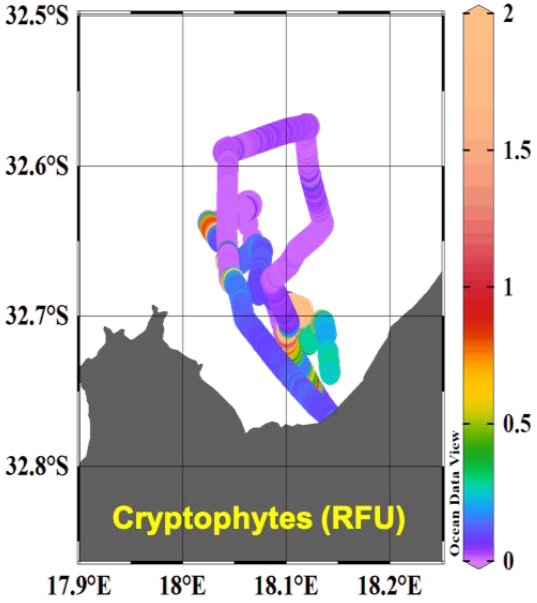












PFTs from MuPI model (satellites)

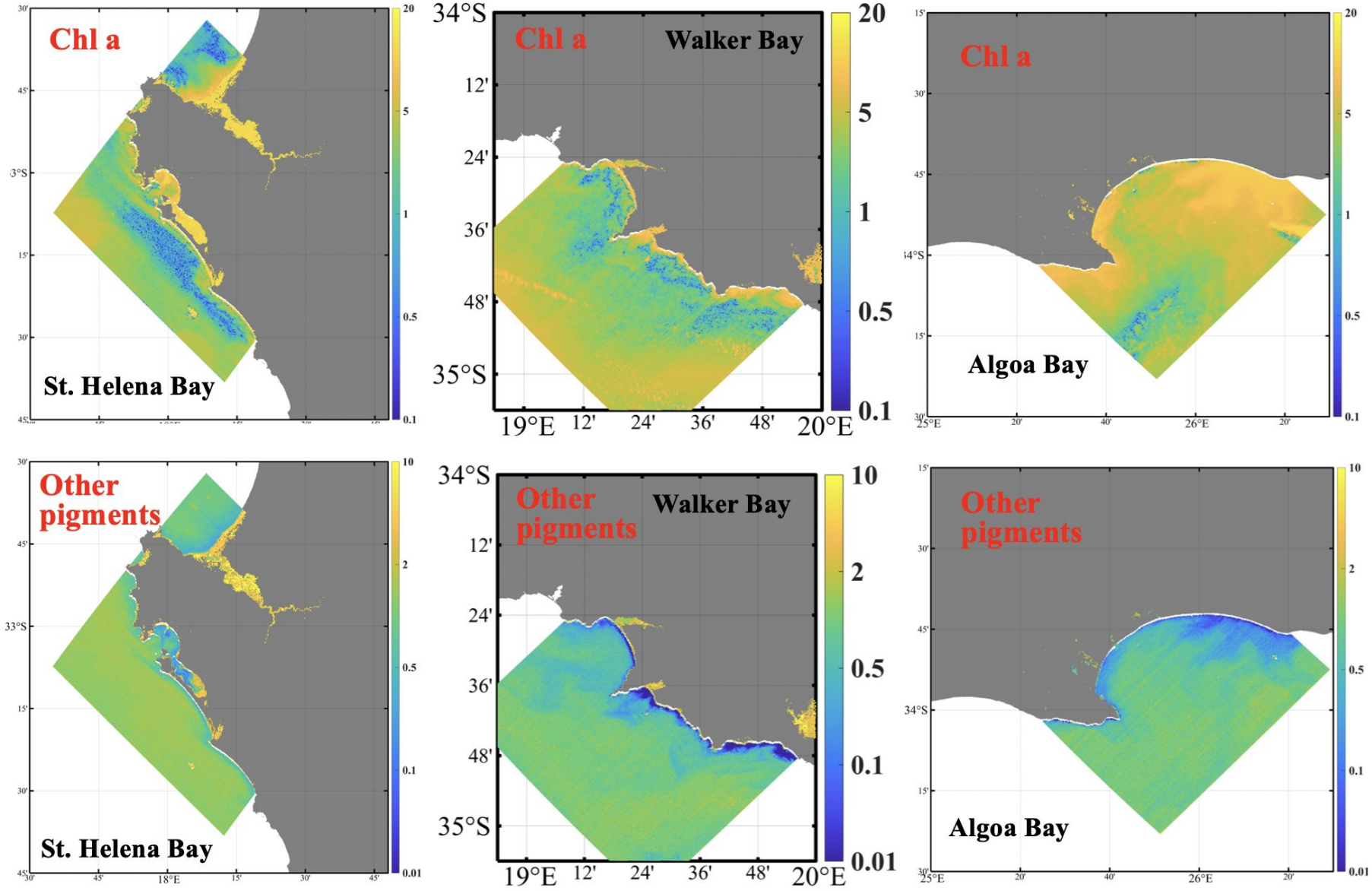
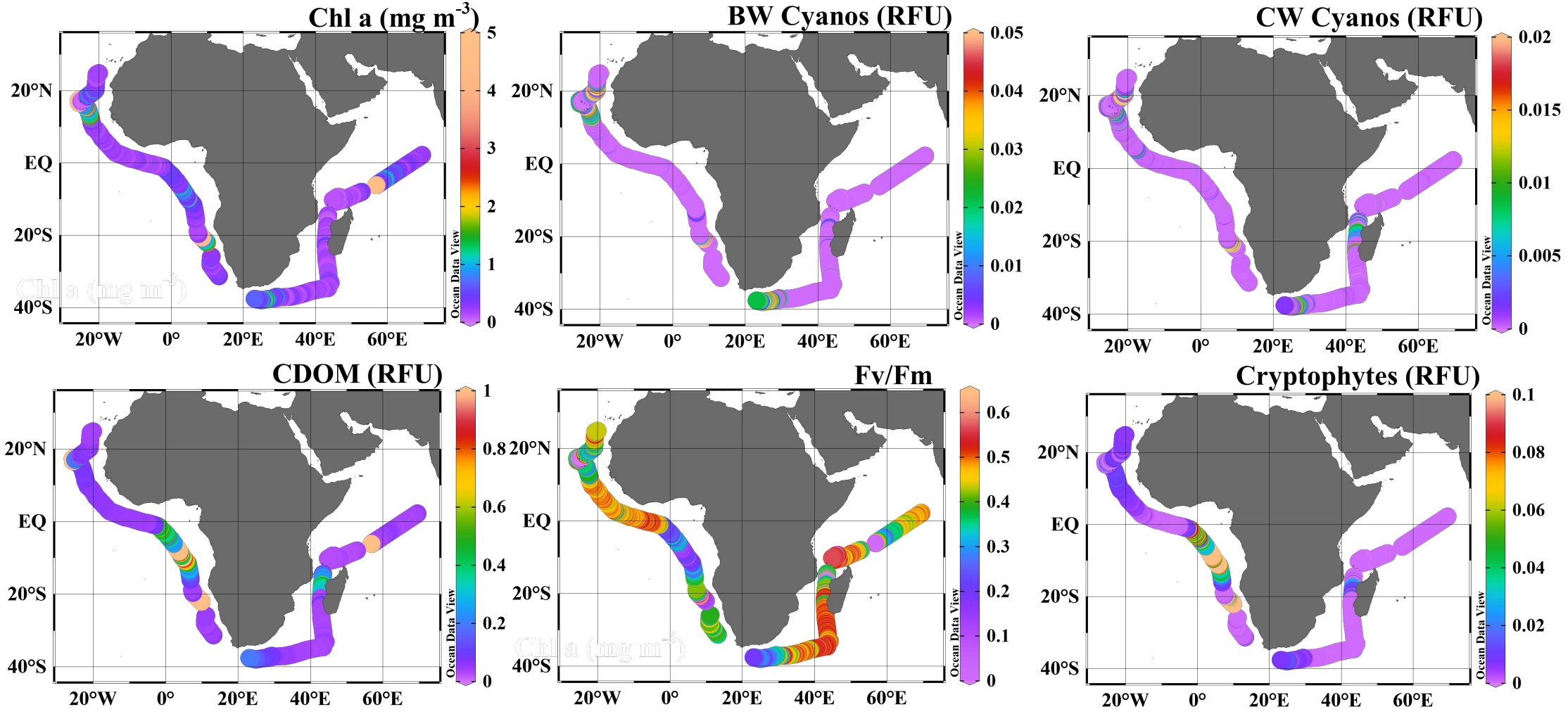


Fig. Chla and other pigments concentrations from EMIT for three bays.

Application to PACE-OCI

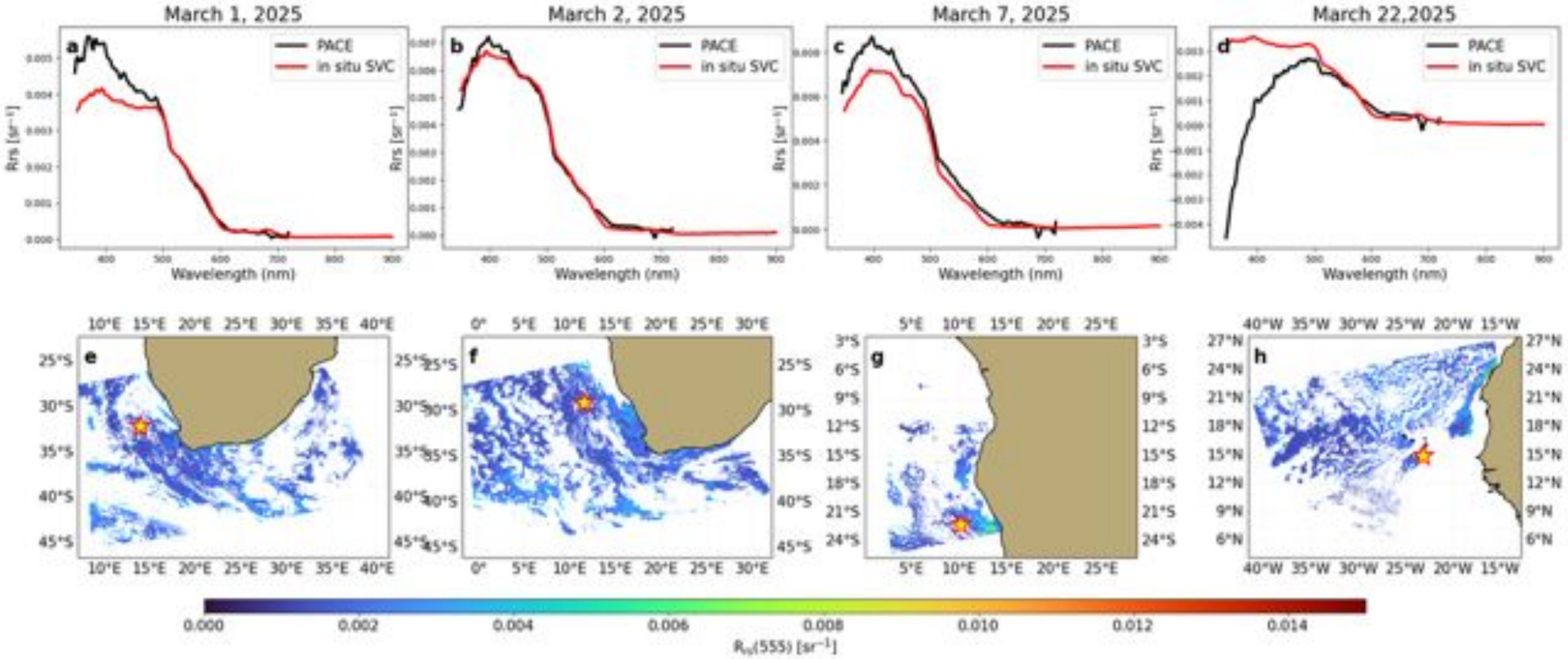
measured biology parameters

PACE-PVST MEASUREMENTS around Africa ON R/V OCEANX (6TH JAN – 9TH APRIL 2025)



Application to PACE-OCI

Comparison of hyperspectral Rrs from PACE & in situ SVC



Application to PACE-OCI

PFTs from MuPI model (PACE)

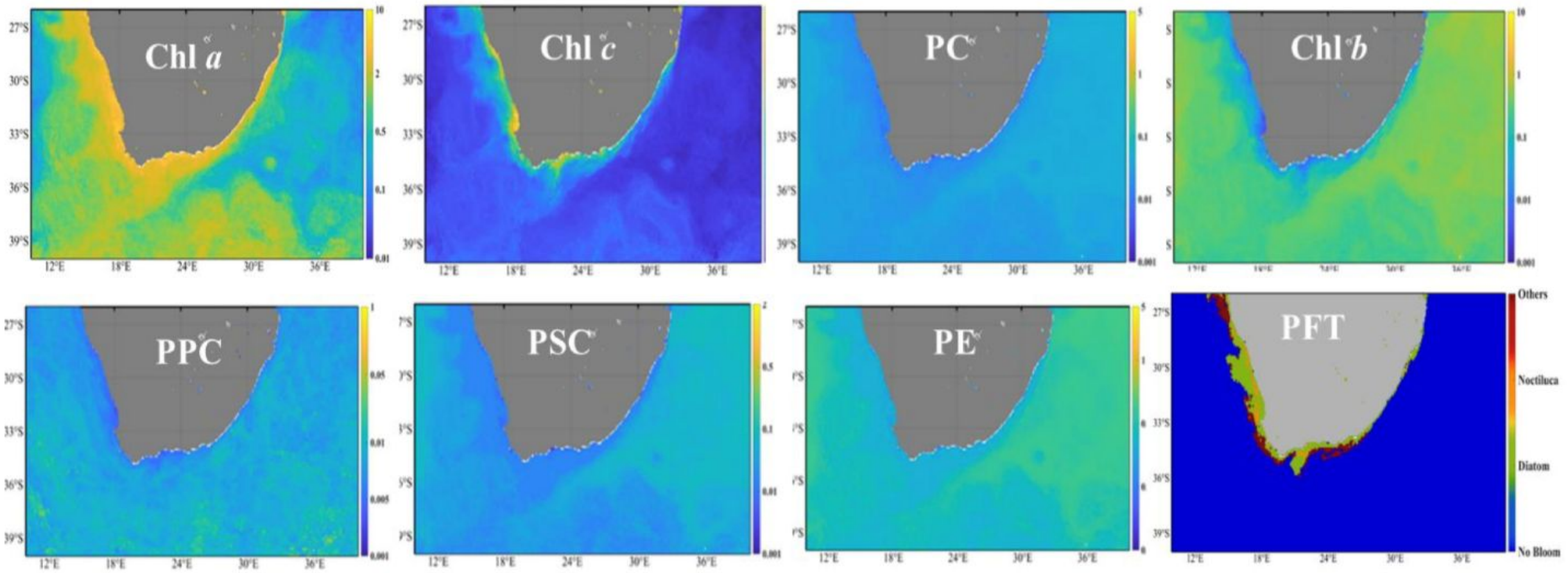


Fig. Pigment (Chl a, Chl b, Chl c, Phycocyanin (PC), Phycoerythrin (PE) < Photoprotective Carotenoid (PPC), Photosynthetic Carotenoids (PSC) concentrations from PACE

BIOSCape - Mapping of phytoplankton functional types (PFTs) from space in support of coastal resource management and decision support activities

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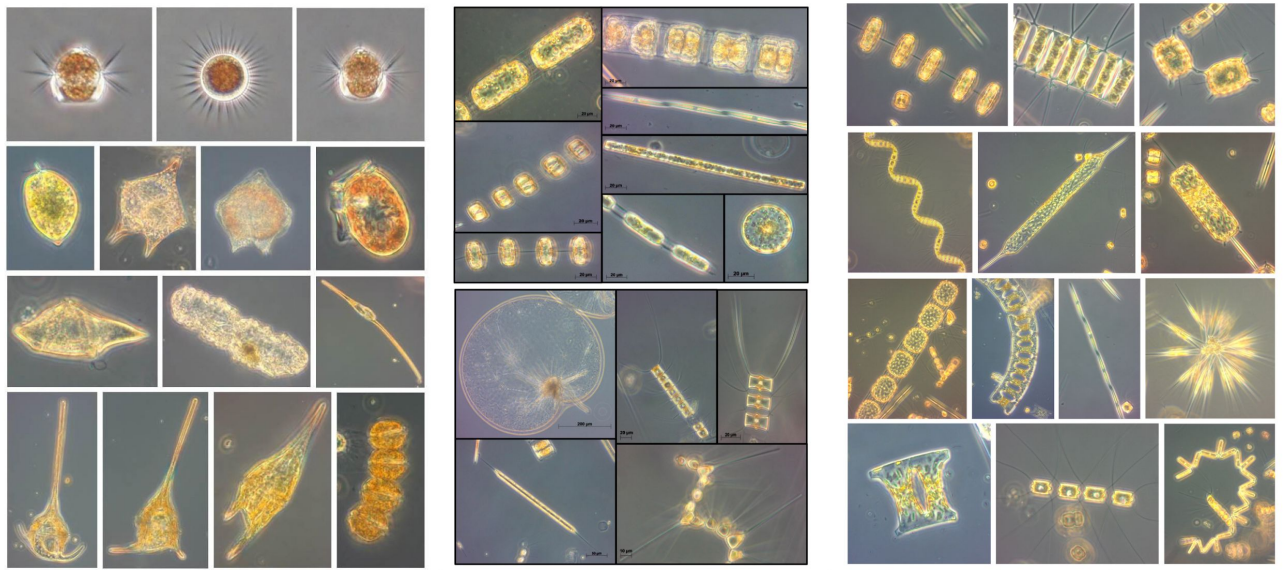
1 Lamont Doherty Earth Observatory at Columbia University, New York, USA; 2 Dept. of Agriculture, Fisheries and Forestry, Cape Town, SA3 Institute for Coastal and Marine Research, Nelson Mandela University, Gqeberha, SA; & 4 African Environmental Observation Network, Elwandle Node, Gqeberha, SA

PFTs from Microscopy

Plankton dominated by:

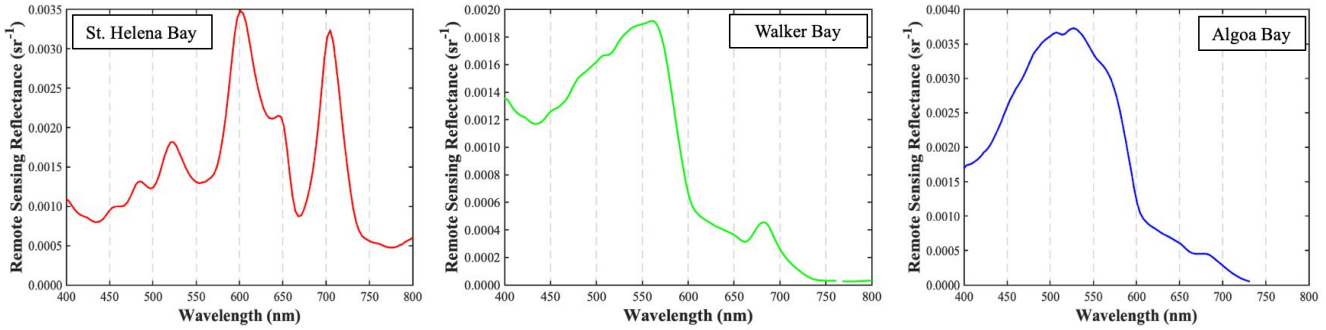
1) photosynthetic ciliate
2) Noctiluca scintillans
3) dinoflagellates

Plankton (St Helena Bay) | **Plankton (Walker Bay)** | **Diatom Plate (Algoa Bay)**



Representative hyperspectral Rrs for MuPI

Combined SVC/SBA/Gybe



Hyperspectral datasets from AVRIS/PRISM

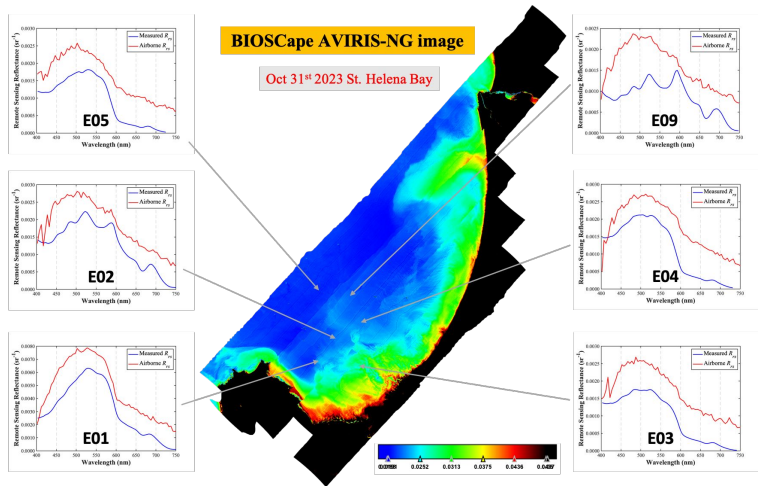


Fig. Comparison of Rrs from in-situ & AVIRIS at St Helena bay.

PFTs from MuPI model (satellites)

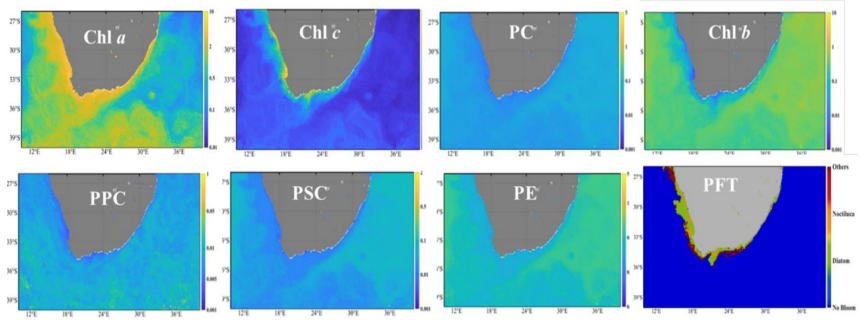


Fig. Pigment (Chla, Chlb, Chlc, Phycocyanin (PC), Phycoerythrin (PE) < Photoprotective Carotenoid (PPC), Photosynthetic Carotenoids (PSC) concentrations from PACE