

# Harmful Algal Blooms and Satellite Earth Observation

Dr Marié Smith,  
Coastal Systems and Earth Observation Group, CSIR

**AASA Abalone workshop 15 July 2022**



# CSIR Marine Earth Observation

## Project involvement

### Operational Marine Industry support



Fisheries support



Aquaculture support



Coral Bleaching Monitoring



Water Quality Monitoring

### Research interests

- ✓ Bio optical and radiative transfer modelling
- ✓ Satellite and model product validation
- ✓ Sensor/region specific algorithm & product development
- ✓ Phytoplankton type ID and Harmful Algal Bloom detection
- ✓ Satellite and over-flight campaign sensor validation



H2020 All Atlantic Ocean Sustainable, Profitable and Resilient Aquaculture



South African National Oceans and Coastal Information Management Service



GMES&Africa Marine and Coastal Operations for southern Africa



ESA 4D Atlantic PRIMary-productivity in Upwelling Systems (PRIMUS)



NEOFrontiers Development of new high resolution water quality observation capabilities for coastal and estuarine systems



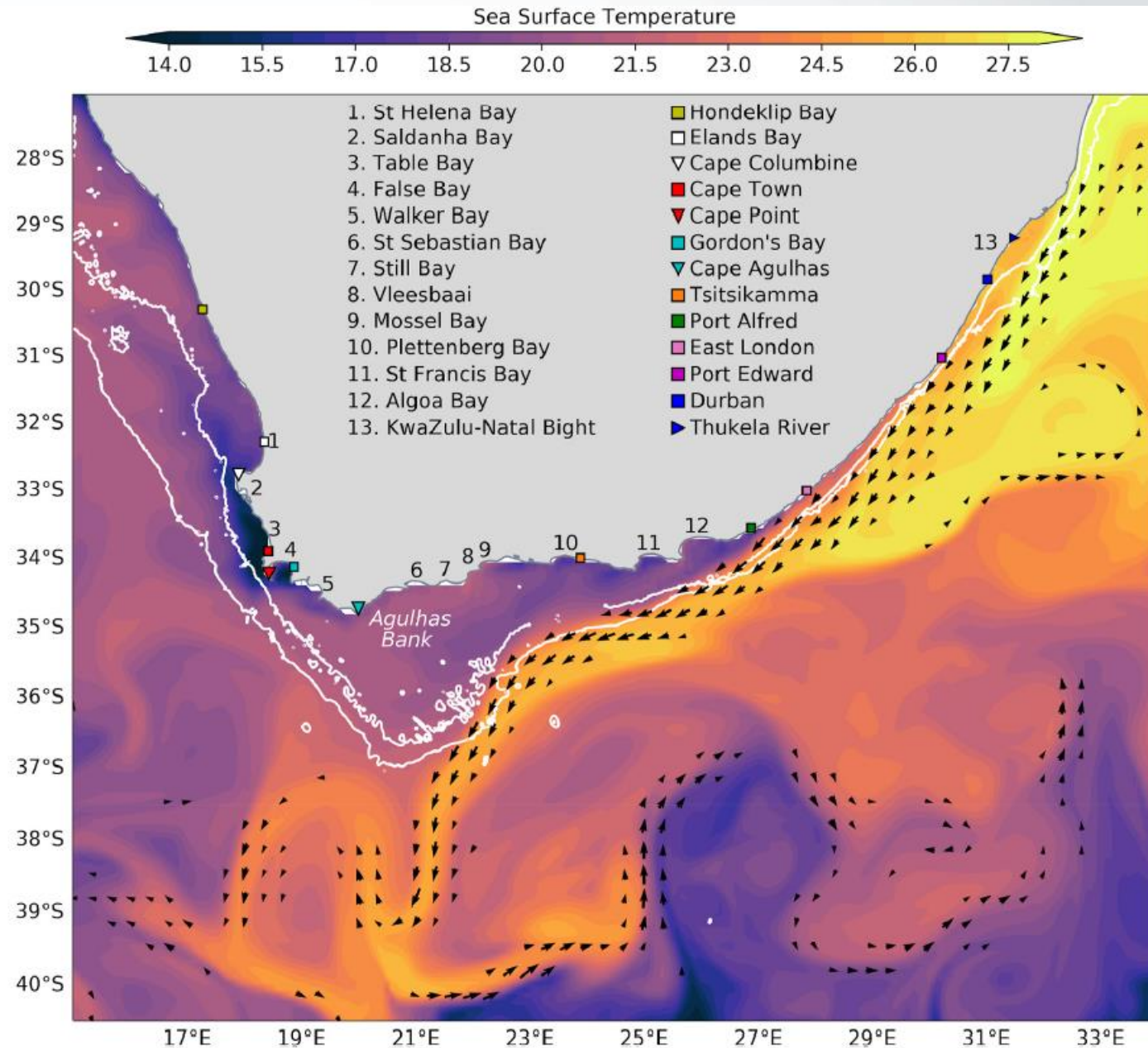
NEOFrontiers Development of New Hyperspectral Capabilities across Aquatic, Atmospheric and Terrestrial Domains



Cyanobacteria and Surface Aquatic Vegetation of the Cape Freshwater Systems (CyanoScape): A Hyperspectral Data Campaign and Analysis

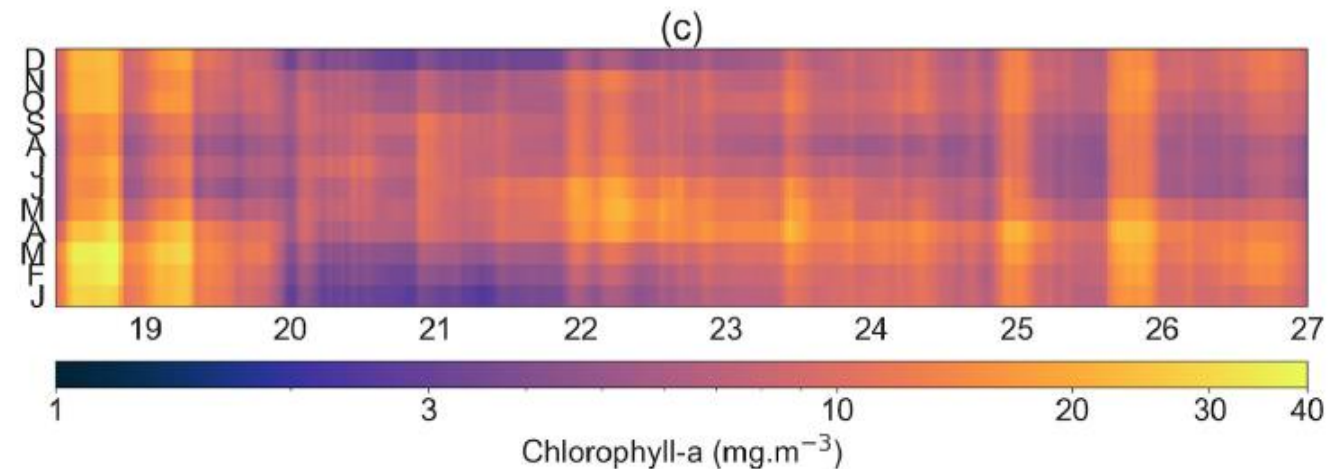
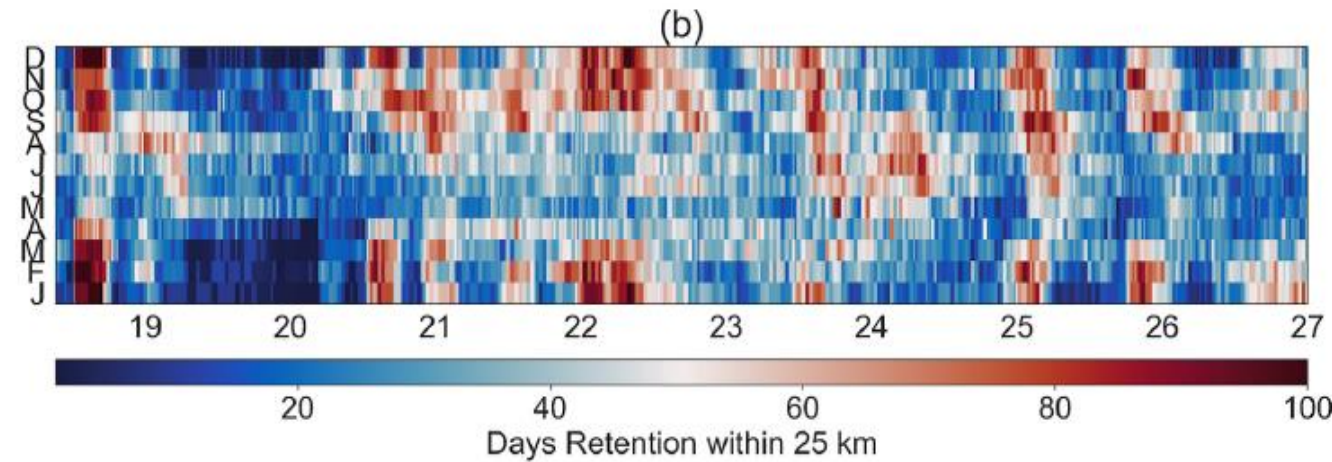
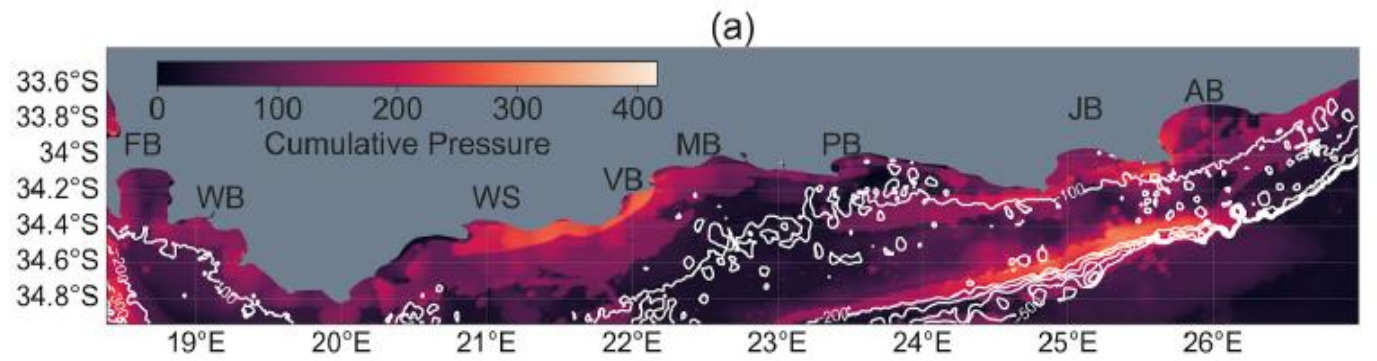
# Environmental overview

- West (and Southwest) coast of South Africa is part of the highly productive Benguela Upwelling System
- Bounded in the south by the warm Agulhas current
- Southwest coast is a region of overlap between the cool-temperate upwelling system and warm-temperate Agulhas region.



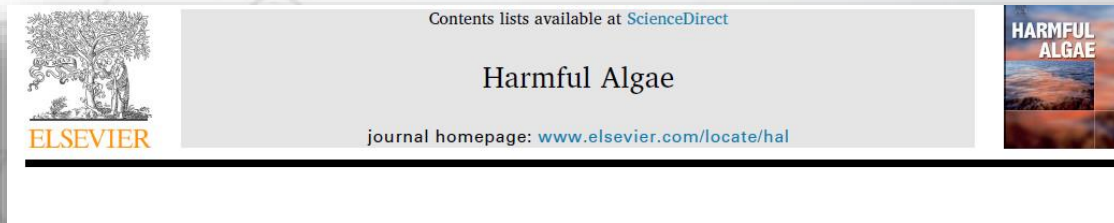
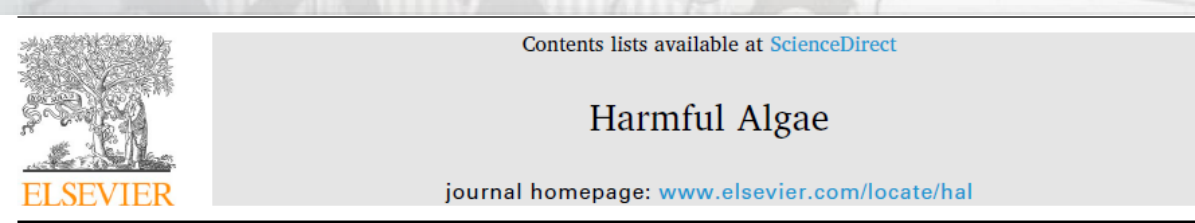
# Environmental overview

- The southern Benguela is in turn divided into the West Coast and the South-West Coast regions owing to a change in coastline orientation at Cape Point
- These biogeographic regions are reflected in both the make-up and frequency of phytoplankton blooms
- Generally the bays are areas of greater coastal retention and phytoplankton biomass (Pfaff et al 2022)



# Harmful Algal Blooms

- Phytoplankton can be harmful due to toxin production, mechanical damage, or high biomass (potentially leading to hypoxic events)
- Can affect both farmed and wild abalone
  - Dinoflagellate *Karenia cristata* resulted in the mortality of 40 tons of wild abalone on the southwest coast
  - Abalone have been affected by Paralytic Shellfish Poisoning (PSP) toxins (*Alexandrium catenella*), through paralysis and inability to produce viable larvae
  - Yessotoxin producing dinoflagellate species *Gonyaulax spinifera* & *Lingulodinium polyedrum* bloom, which affects the epithelial cells and gills



## Harmful algal blooms of the Benguela eastern boundary upwelling system

Grant C. Pitcher<sup>a,b,\*</sup>, Deon C. Louw<sup>c</sup>

<sup>a</sup> Department of Environment, Forestry and Fisheries, Cape Town, South Africa

<sup>b</sup> Department of Biological Sciences, University of Cape Town, Rondebosch, South Africa

<sup>c</sup> National Marine Information and Research Centre, Swakopmund, Namibia

## Devastating farmed abalone mortalities attributed to yessotoxin-producing dinoflagellates

Grant C. Pitcher<sup>a,b,\*</sup>, Charles J. Foord<sup>a</sup>, Brett M. Macey<sup>a,b</sup>, Lisa Mansfield<sup>a</sup>, Anna Mouton<sup>c</sup>, Marie E. Smith<sup>d</sup>, Steven J. Osmond<sup>e</sup>, Lynndal van der Molen<sup>f</sup>

<sup>a</sup> Fisheries Management Branch, Department of Agriculture, Forestry and Fisheries, Cape Town, South Africa

<sup>b</sup> Department of Biological Sciences, University of Cape Town, Cape Town, South Africa

<sup>c</sup> Independent Researcher, Stanford, South Africa

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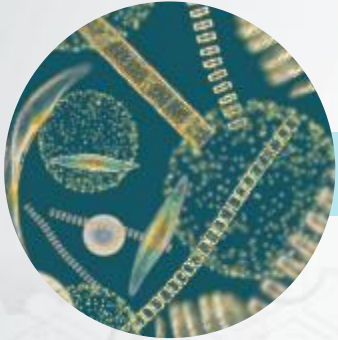
<sup>f</sup> Food and Beverage Laboratory, Aspirata, Cape Town, South Africa



The background is a dark blue gradient with various geometric shapes and patterns. On the left side, there are several interlocking gears of different sizes, some in a lighter blue color and some in a darker blue. There are also hexagonal and circular patterns scattered throughout. The overall aesthetic is technical and modern.

**Why satellite data?**

# What can satellites measure?



*Algal blooms*



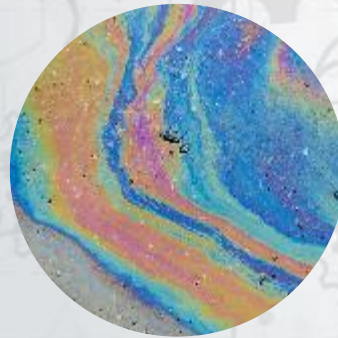
*Floating vegetation*



*Water clarity*



*Suspended sediments*



*Surface oil slicks*



*Sea surface temperature*

# What are some of the limitations?

Satellites cannot directly measure the following parameters :

- x *Nutrients*
- x *Dissolved oxygen*
- x *Pollutants, metals, toxins*
- x *Salinity (at high resolution)*

**Ocean colour satellites cannot :**

- x *measure through clouds*
- x *measure at night*
- x *measure below the surface of the water*
- x *detect very small features*

**Other:**

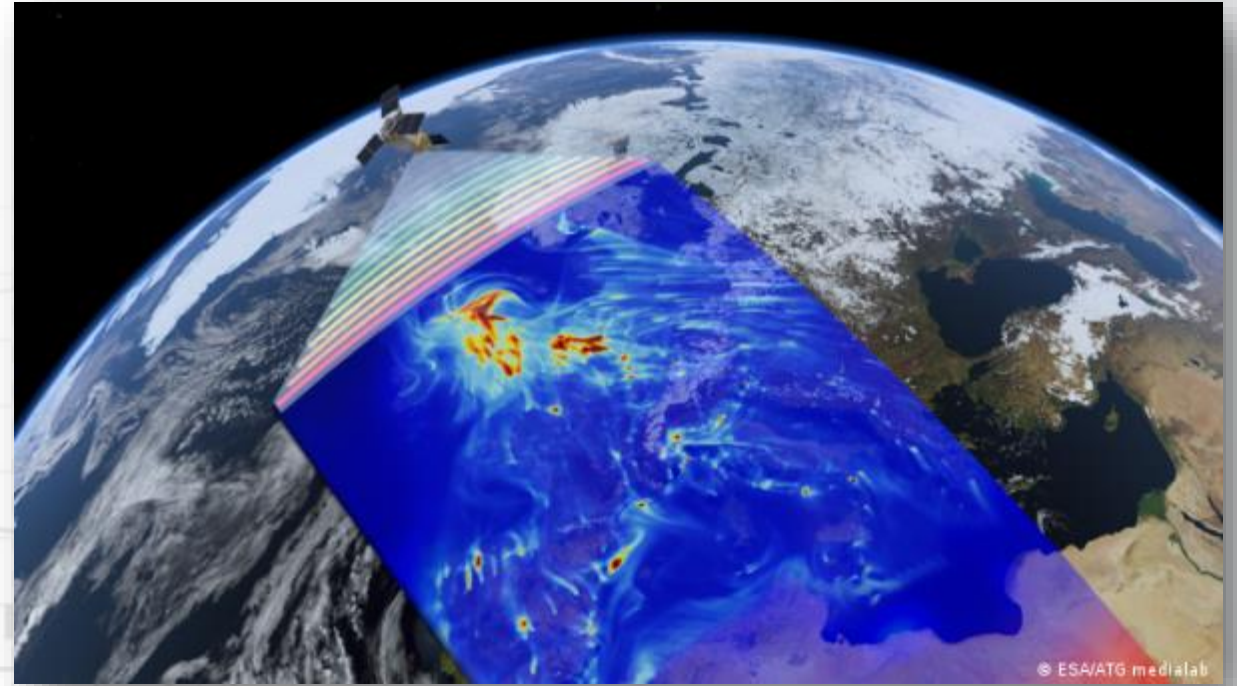
- x *not “point and shoot”*
- x *data not easily used by non-specialists*



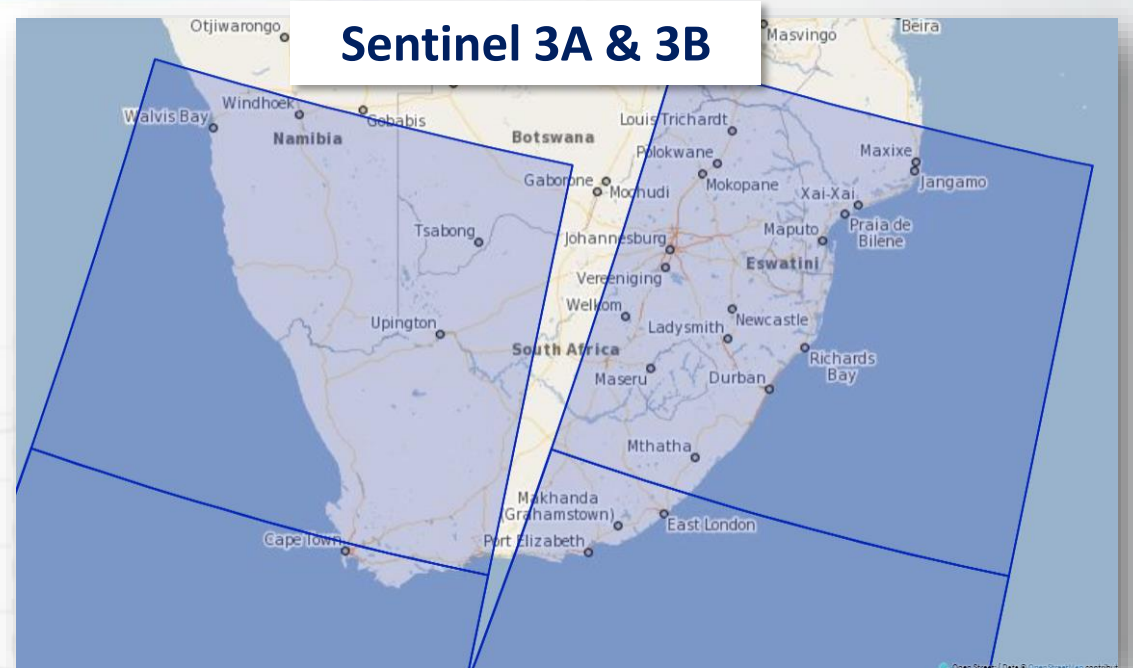
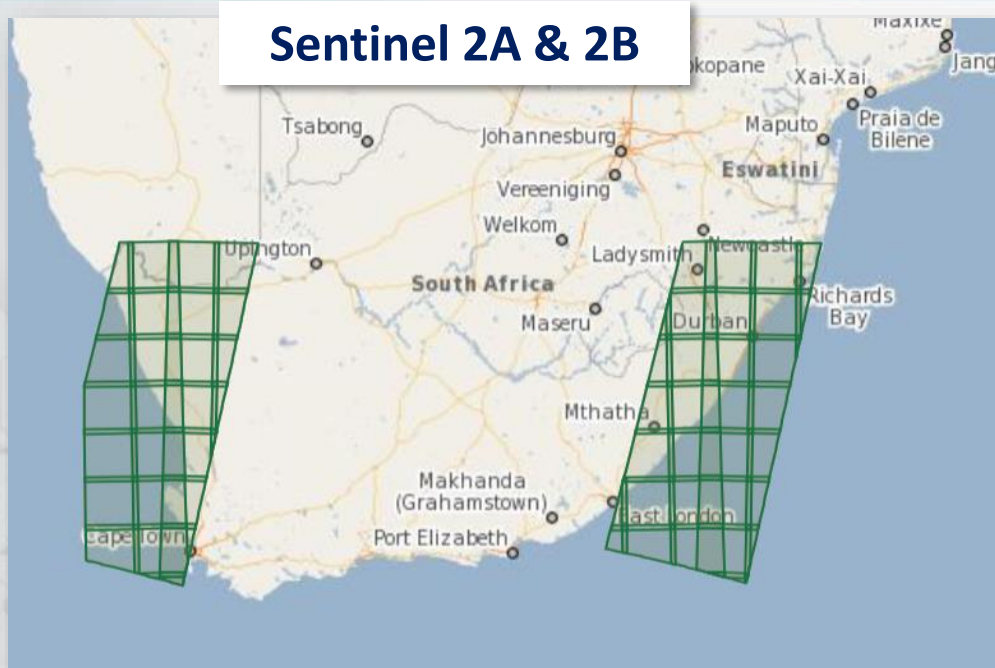


# Why use satellite data?

- Data are freely available
- It's a routine and reliable source of information
- It provides global coverage
- It provides historical coverage
- The combination of *in situ* and satellite information is often the most powerful



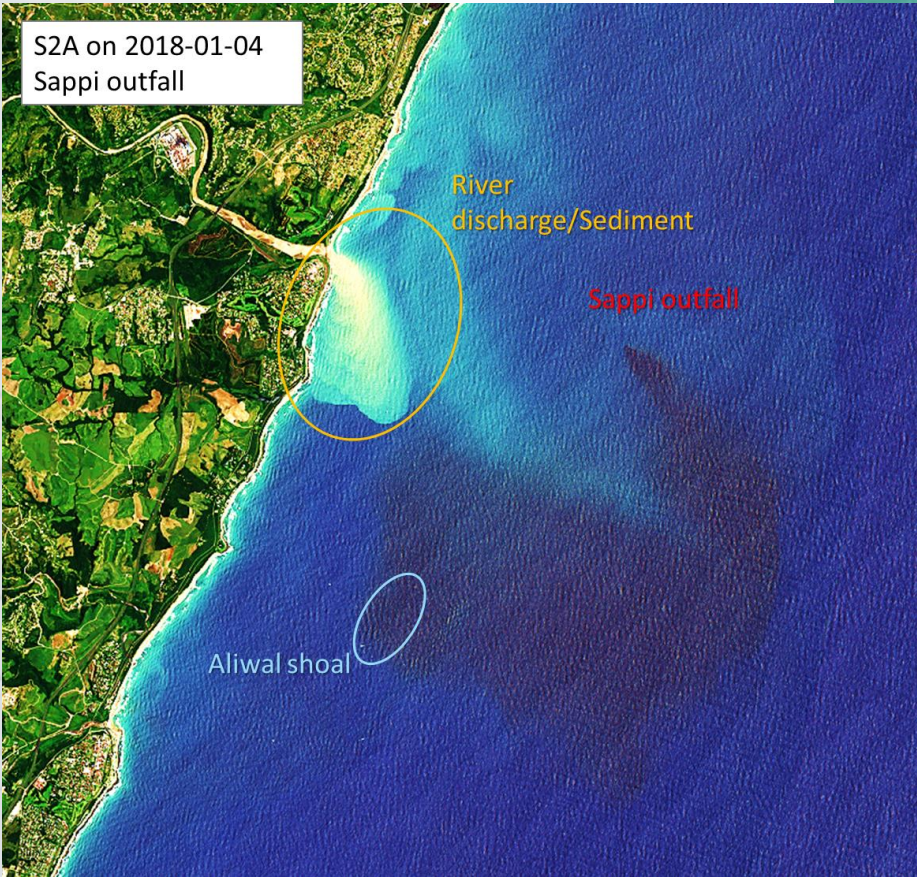
# Satellite coverage & resolution



- Designed for land observation
- Narrow swath
- Higher spatial resolution (10-60m)
- 5-day revisit time

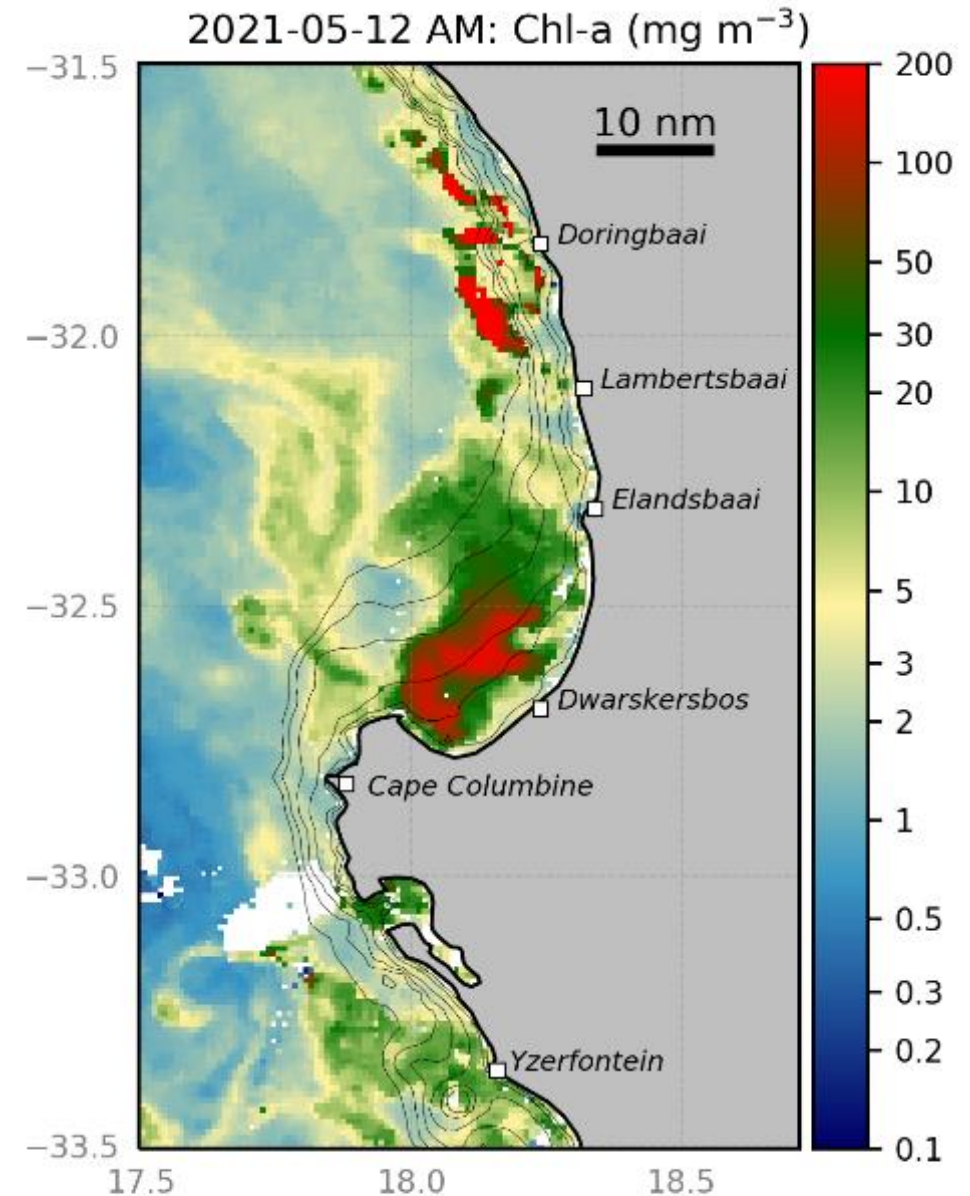
- Specifically designed for marine observation
- Wider swath
- Lower spatial resolution (300m – 1km)
- Daily revisit time

# Visible impacts on ocean colour

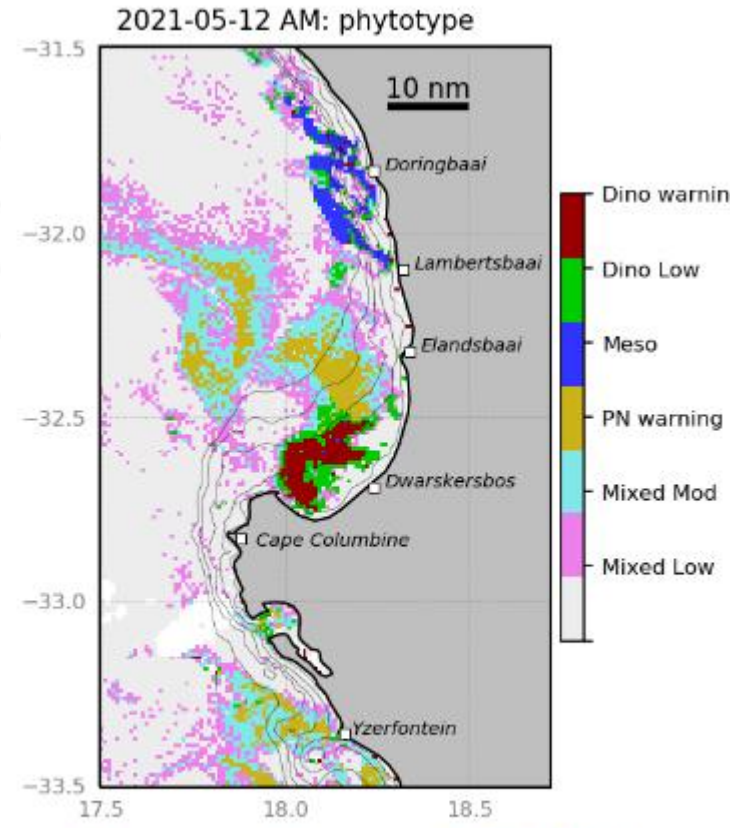
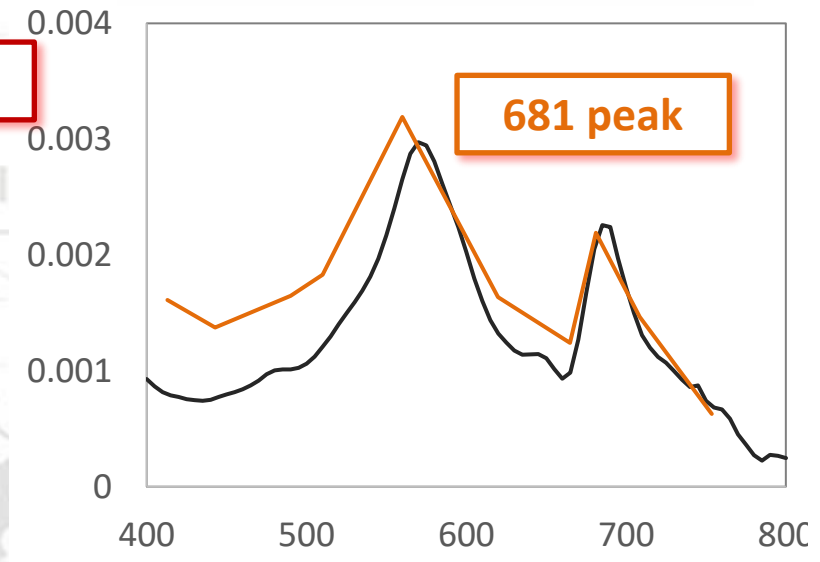
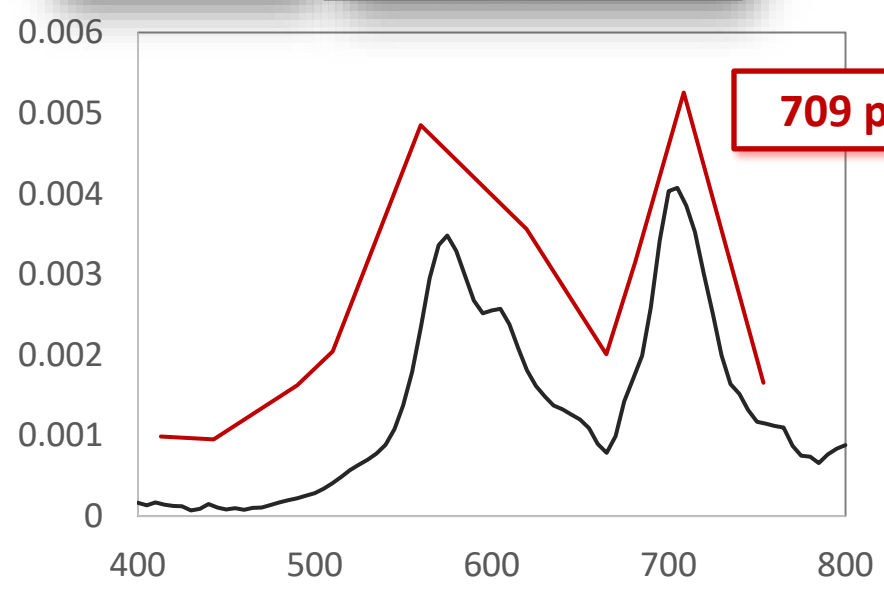
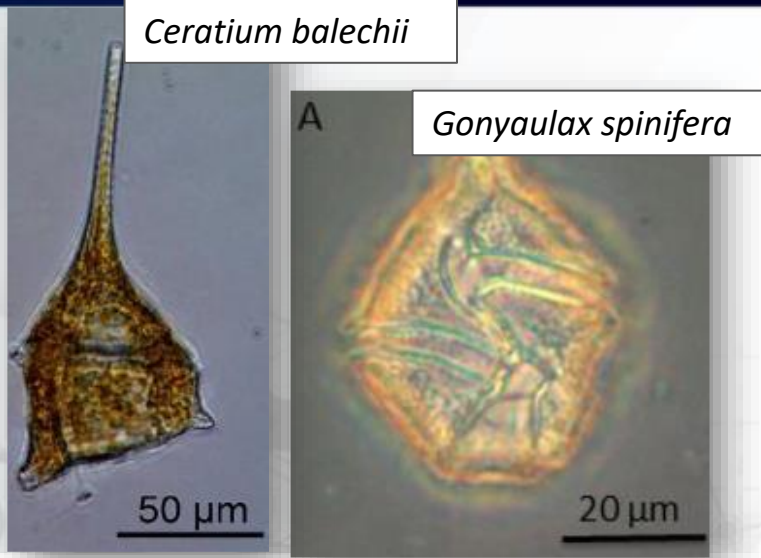
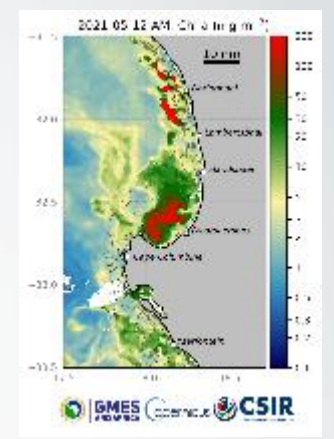


# Phytoplankton monitoring

- Phytoplankton cannot be counted directly from space
- All phytoplankton contain Chlorophyll a (Chl-a) which has a measureable effect on the water leaving reflectance
- Chl-a concentration is used as a proxy for phytoplankton biomass



# HAB detection based on spectral shape



# The 2017 bloom

- Yessotoxin producing dinoflagellate species *Gonyaulax spinifera* & *Lingulodinium polyedrum* bloom
- High biomass dinoflagellate species easily detected from Ocean Colour imagery and Chl-a



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Contents lists available at ScienceDirect

Harmful Algae

journal homepage: [www.elsevier.com/locate/hal](http://www.elsevier.com/locate/hal)



Devastating farmed abalone mortalities attributed to yessotoxin-producing dinoflagellates

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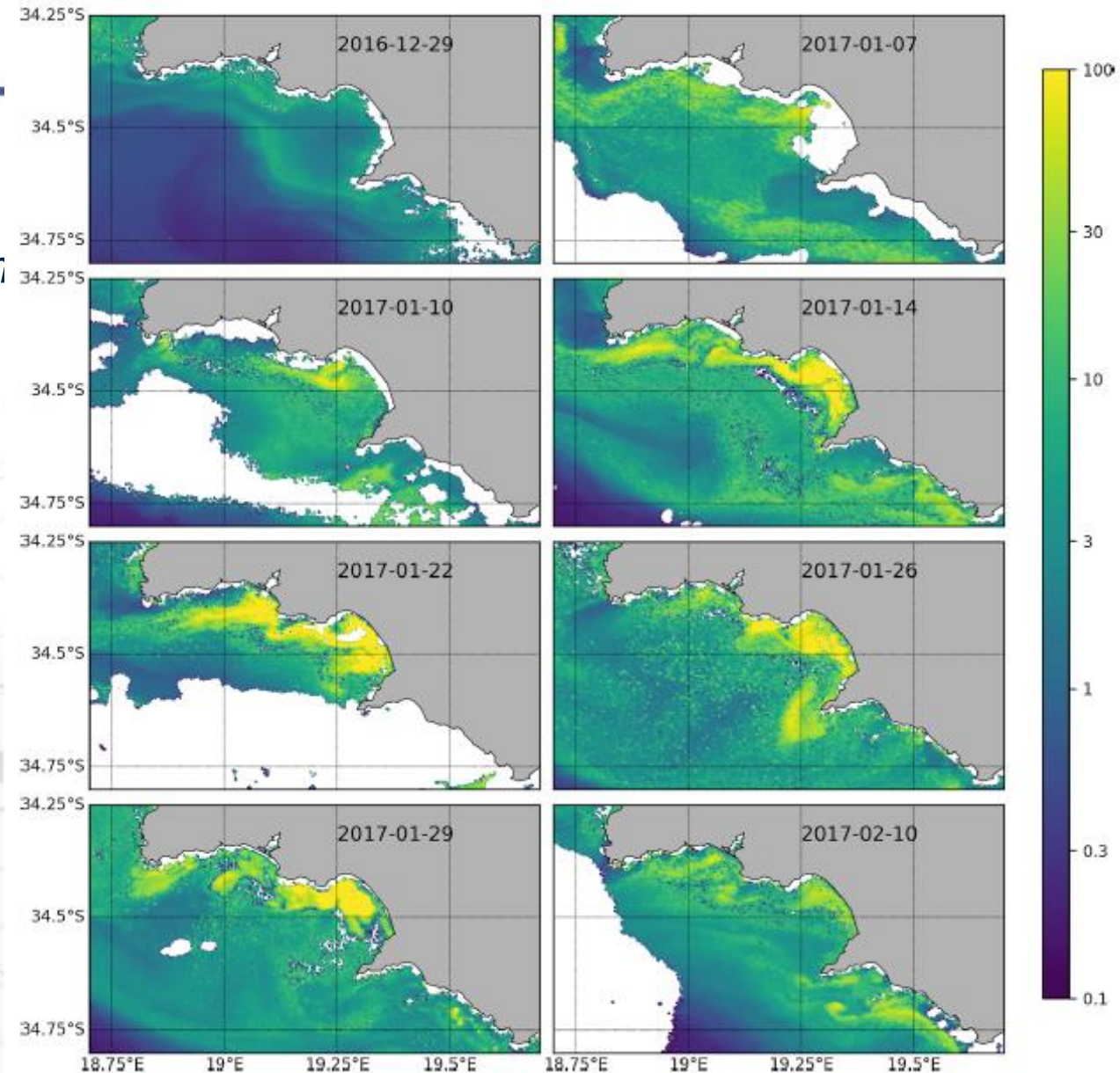
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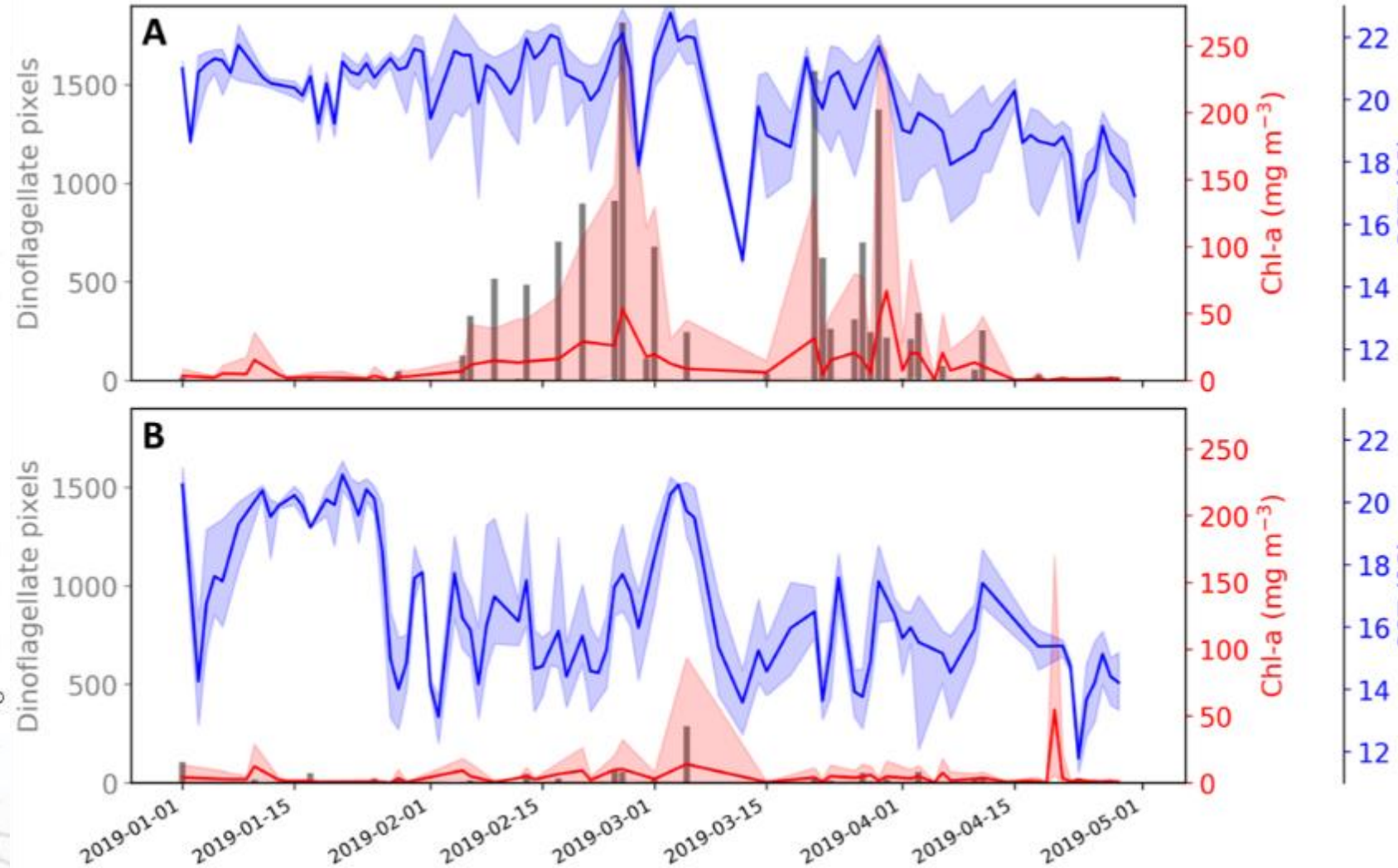
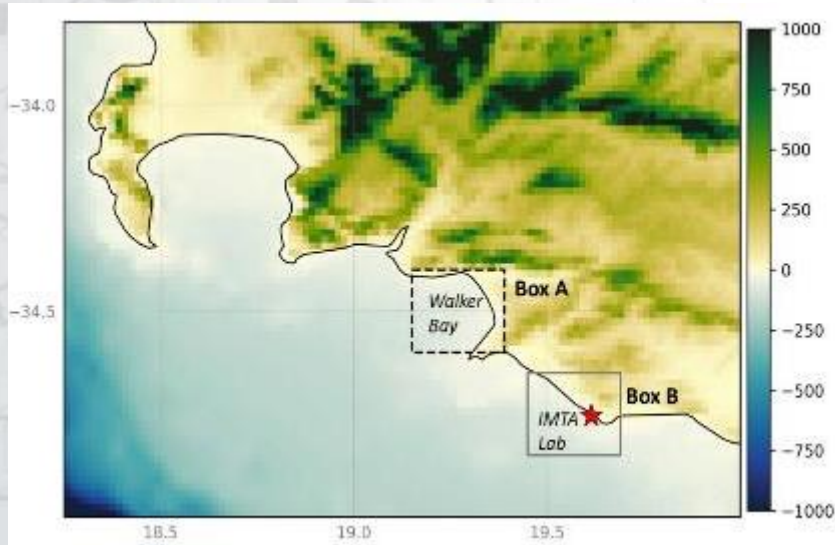
<sup>e</sup> Amanzi Biosecurity, Sandbaai, South Africa

<sup>f</sup> Food and Beverage Laboratory, Aspirata, Cape Town, South Africa



# The 2019 bloom

- Using Chl-a, Temperature and phytoplankton type to inform on regional differences



The background features a complex, layered design. On the left side, there are several interlocking gears of various sizes, some rendered in a lighter blue and others in a darker blue. These gears are set against a backdrop of overlapping, semi-transparent geometric shapes, primarily triangles and polygons, in shades of blue. The overall effect is a sense of mechanical complexity and modern technology.

**Current Tools available to you**



# EO marine service development and delivery

National scale



## National Oceans and Coastal Information Management System (OCIMS) project

Provides decision support for the effective governance of SA's oceans and coasts

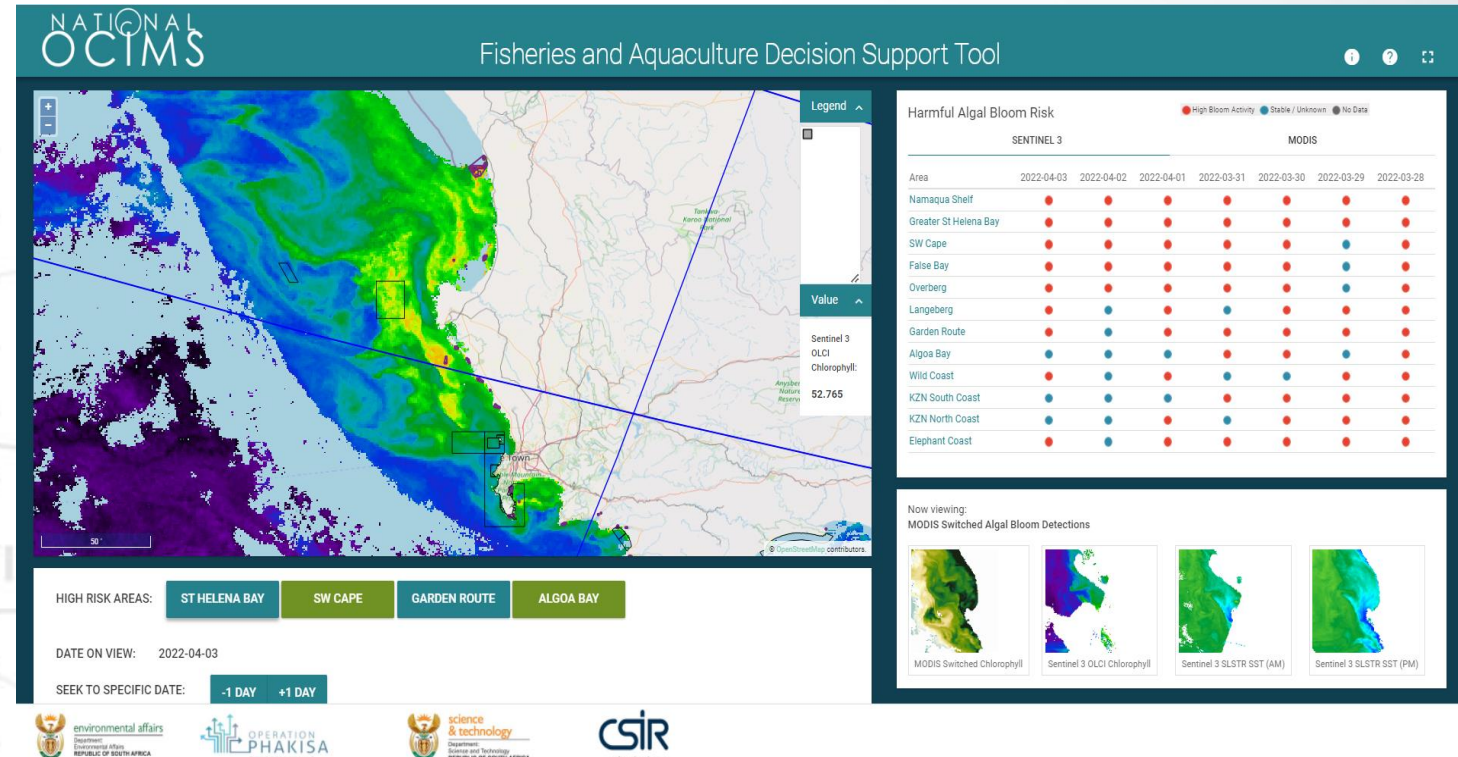
Phase2 of OCIMS runs 2022-2026

# OCIMS Fisheries and Aquaculture Decision Support Tool

## Current features:

- ✓ Map interface
- ✓ Sentinel3 SST [am&pm ]
- ✓ Sentinel3 Chl-a [am]
- ✓ MODIS Chl-a (broken)
- ✓ HAB features (“over-alerting”)
- ✓ HAB alert panel (“over-alerting”)

<https://www.ocims.gov.za/hab/app/>



**Several improvements planned, watch this space!**

# EO marine service development and delivery

## Continental scale



MarCOSIO

●●● MARINE AND COASTAL OPERATIONS  
FOR SOUTHERN AFRICA AND THE INDIAN OCEAN

Used to be known as **MarCOSouth**

One of two Marine Thematic area consortia GMES & Africa programme. Represents the southern African and Indian Ocean partners.

Includes partners from Angola, Namibia, South Africa, Mozambique, Tanzania, Kenya, Madagascar, Seychelles, and Mauritius



# MarCOSIO Aquaculture support service

<https://marcosouth.org/hab/app/#>

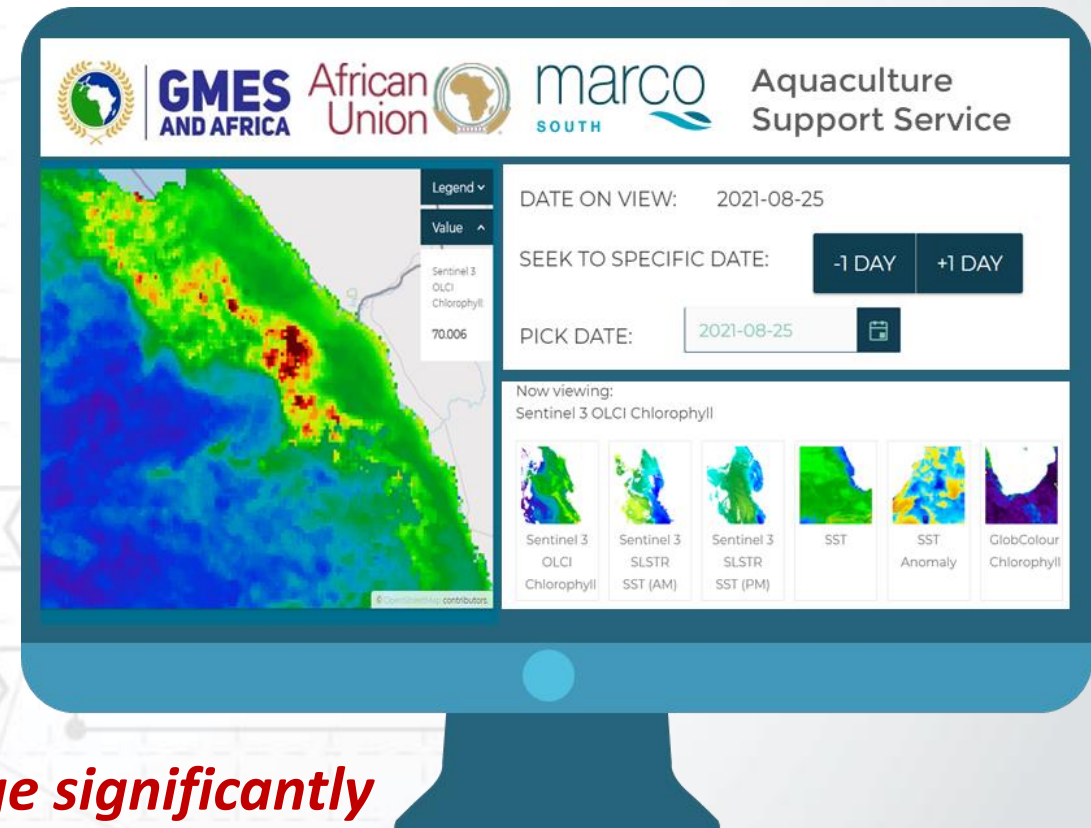


## MarCOSIO

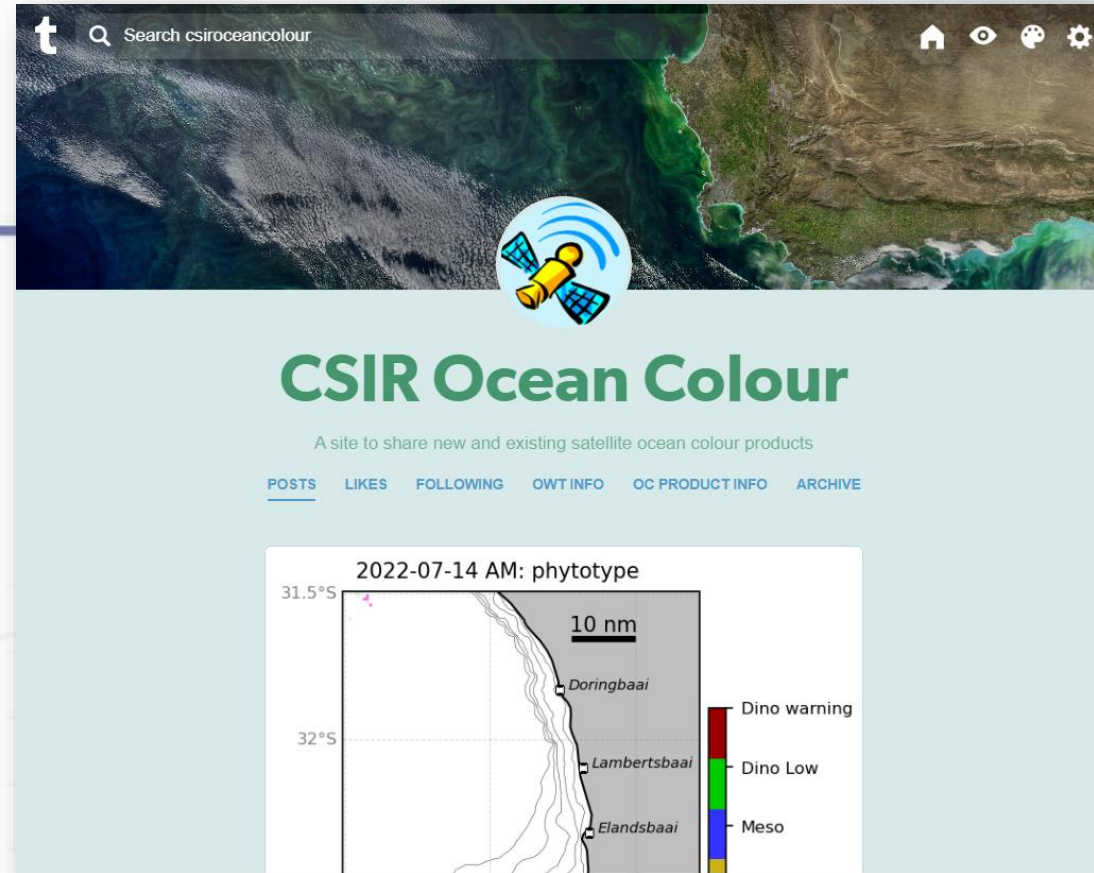
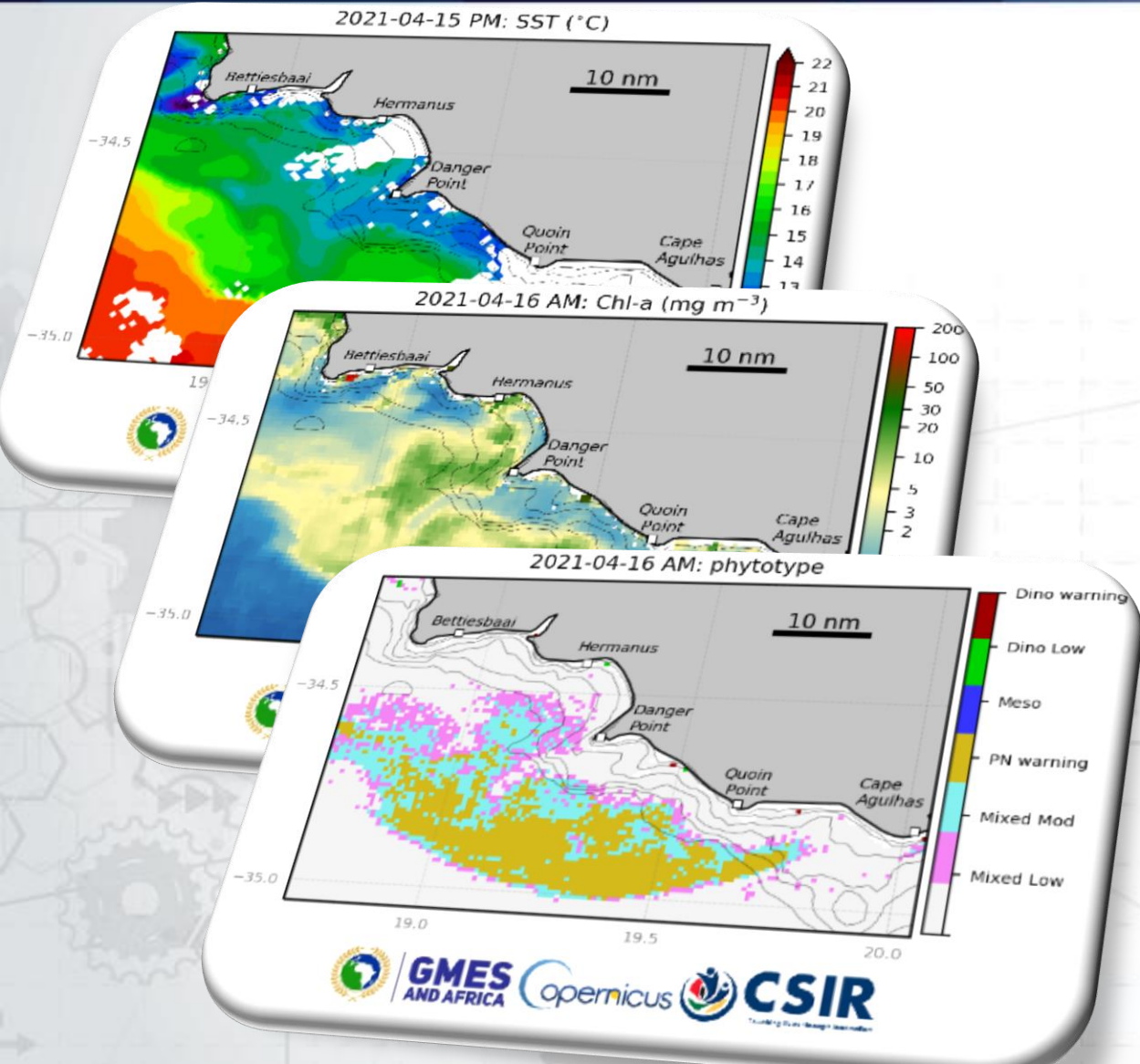
●●● MARINE AND COASTAL OPERATIONS  
FOR SOUTHERN AFRICA AND THE INDIAN OCEAN

### Current features:

- ✓ Web tool with map interface
- ✓ Sentinel 3 SST
  - [am&pm] 1km resolution 3h latency
- ✓ Sentinel 3 Chl-a
  - [am] 1km resolution 3h latency
- ✓ OSTIA SST & anomaly
  - Gap-free 5km resolution 1day latency
- ✓ Globcolor Chl-a
  - Gap-free 4km resolution 2day latency



# The CSIR Ocean Colour Tumblr



Regional maps in png format uploaded daily:

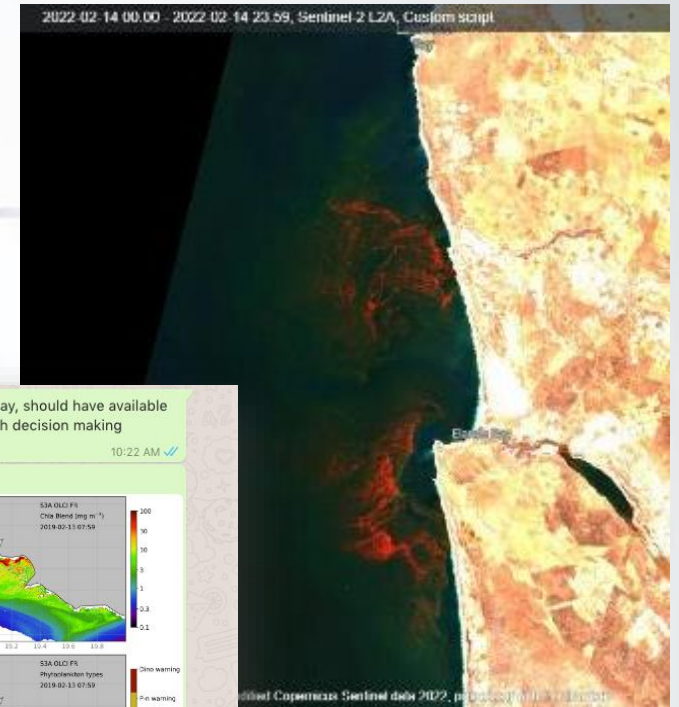
- Sea surface temperature (1km resolution, 2 times a day)
- Chlorophyll a concentration (300m)
- Phytoplankton Type (300m)

<https://csiroceancolour.tumblr.com/>

# Me 😊 – Marie Smith (Ocean Colour Geek)

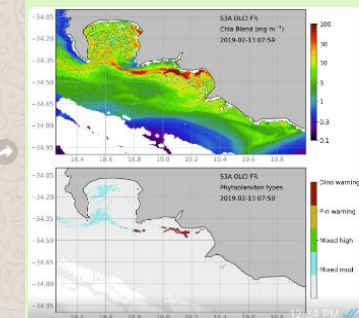
Able to provide near real-time support on regional whatsapp groups or via email

Able to resource satellite imagery not routinely provided through the online services



Hoping for clear pass with Sentinel 3 today, should have available  $\pm 1300$  and will post here if that helps with decision making (hopefully no cloud!) 10:22 AM ✓

Forwarded



The first map is titled 'S3A OLCI FS' and shows a color-coded map of the region with a legend on the right ranging from -0.1 to 200. The second map is titled 'S3A OLCI FS' and shows a color-coded map of the region with a legend on the right ranging from 'Mixed med' to 'Sino warning'.

Sentinel 3 @ 300m from this AM 12:35 PM ✓

Still v high biomass Hermanus & eastwards, Danger Point seems clearer, SE forecast may clear bay further, hopefully more SST data this PM 12:42 PM ✓

Sorry, Hermanus + westwards! 12:51 PM ✓

+27 79 276 2776 ~Sally  
Very helpful image 1:09 PM

+27 79 343 8209 ~Deidre  
All hermanus farms on flow through? All ok for now? 1:38 PM

+27 76 342 4507 ~Lize Schoonbee  
This message was deleted 1:39 PM

+27 79 276 2776 ~Sally  
D huge plumes sitting just in front of sump but being deflected by current. We are still on flow through 1:40 PM

Abagold, Aquion, we are counting from that big section in front of us, SASC took a sample just now. Will send results shortly 1:41 PM

The background features a complex, layered design. On the left side, there are several interlocking gears of various sizes, some rendered in a lighter blue and others in a darker blue. The right side of the background is dominated by large, overlapping geometric shapes, primarily triangles and polygons, in various shades of blue, creating a sense of depth and movement. The overall color palette is monochromatic, ranging from deep navy to bright cerulean.

# **Current and upcoming EO projects**

**and how they could help you**

# Projects



## New Earth Observation Frontiers Program



- 2 year project
- High resolution product development feeding into

NATIONAL  
OCIMS



- 3 year project
- In situ support for BioScape overflight campaign



# Project overview



- NEOFrontiers *Development of New **Hyperspectral Capabilities across Aquatic, Atmospheric and Terrestrial Domains***
- Providing in situ support for the NASA BioScape overflight campaign in end 2023
  - We will be putting the CSIR buoy in Walker Bay during late 2023
- Providing algorithm development support for upcoming hyperspectral satellite missions
  - Better ability to differential between different phytoplankton types
  - So that the satellite products are ready to be integrated into OCIMS

# Project overview



- This is a **two year** (2022-2023) New Earth Observation Frontiers Domain Development Action
- Focusing on developing **high spatial resolution** (10-300m) water quality products
- from **freely available** environmental satellite data
- for the **coastal marine and estuarine** domains of South Africa
- We want to synthesize data products into useful and **intuitive** information and **indicators**, to support the needs of a diverse water quality community





*We could use your input!*

Come chat to me about filling out the 5minute user needs **survey**

- Specific regions needing high resolution monitoring?

Let me know if you want to join the project's **technical advisory group** for email updates on product developments and workshops



### Satellite-based coastal and estuarine water quality monitoring : user needs assessment

Please take a moment to fill in the survey to help us streamline our project product development efforts

Email \*

Valid email

This form is collecting emails. [Change settings](#)

What is your interest in water quality monitoring? Select all that apply

- Aquaculture
- Environmental protection
- Biodiversity and ecosystem health
- Outfalls / pipeline / discharge monitoring
- Maritime safety
- Compliance
- Other..

The background features a complex, layered design. On the left side, there are several interlocking gears of various sizes, some with a mesh-like texture. The rest of the background is composed of overlapping, semi-transparent geometric shapes, primarily triangles and polygons, in various shades of blue, creating a sense of depth and movement.

# Thank you!

[MSmith2@csir.co.za](mailto:MSmith2@csir.co.za)