GEOHAB Global Ecology and Oceanography of Harmful Algal Blooms

IOCCG International Ocean Colour Coordinating Group

Comparison of MERIS FR Products in Application to Harmful Algal Blooms in Four Marine Ecosystems.

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CoastColour User Consultation Meeting, Lisbon, October 2011

IOCCG/GEOHAB Working Group
Aims and Key considerations

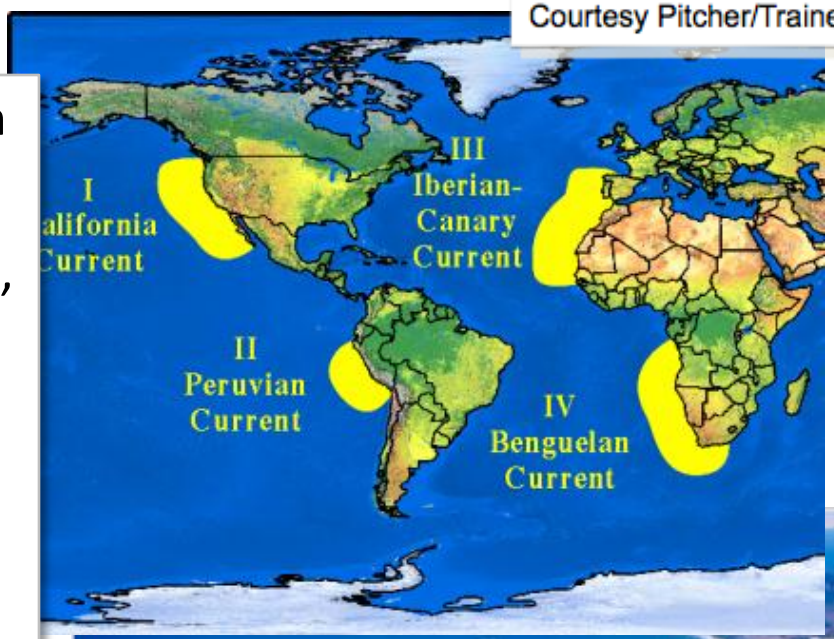
Improve communication between the ocean colour and HAB scientific communities

=> Inform HAB community about **options**, **benefits** and **limitations** of available techniques

=> Inform OC community of the HAB **types**, **methods**, **ecosystem-specific contextualisation**

Resource should **address the needs** of non-specialist

=> approachable "**consumers guide**" to ocean colour based HAB methods



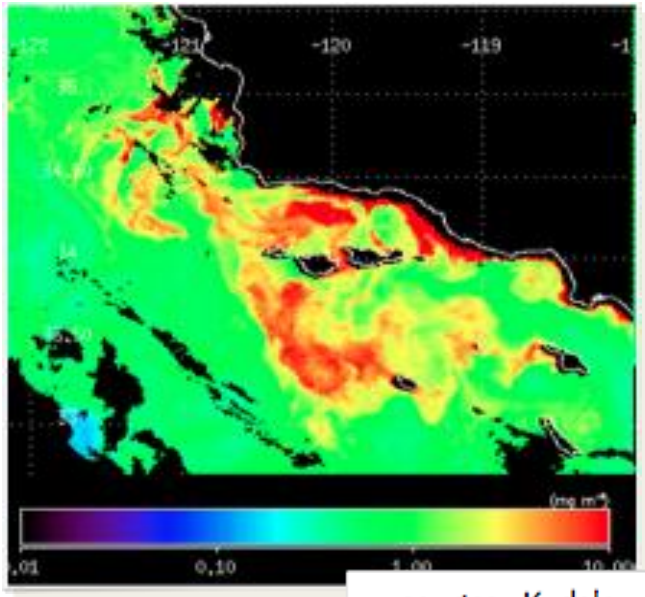
IOCCG/GEOHAB Working Group
HABs and Ocean Colour

Ecological & regional contextualisation of OC techniques and products important for effective HAB application

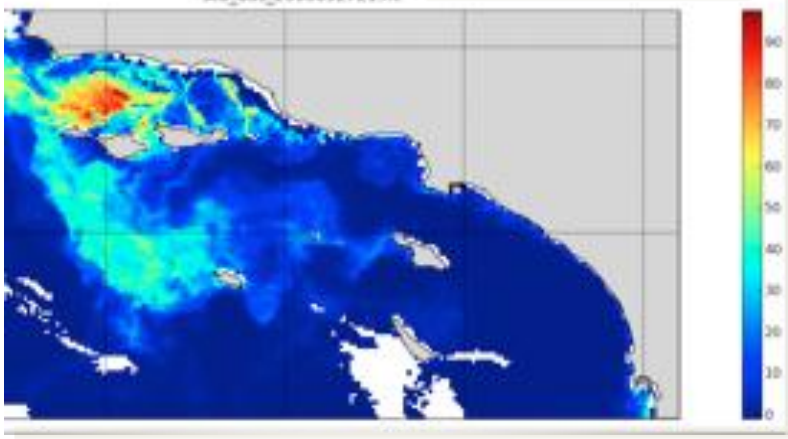
Comparative ecosystem approach **helps classify OC techniques** with regard to organism types, impacts, distribution and ecosystem function

HAB WG currently using **MERIS** and **MODIS** "standard" algorithms, C2R, GIOP variants, fuzzy logic classifier, and regionally specific where available (California Domoic Acid, St Lawrence eco-classifier, Benguela size)

Not comparing all algorithms for all areas, rather **show examples** of both sub- and optimal algorithms for bloom/ecosystem types.



courtesy Kudela



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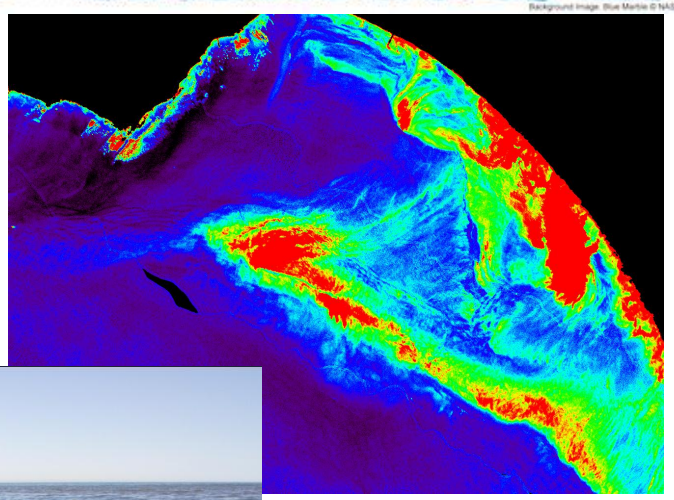
HABs and CoastColour

WG assessing performance & applicability of many OC products for variety of HAB case studies in many **CoastColour Champion User sites**

Output from WG (monograph & special issue) can **showcase CoastColour achievements** to a broad community

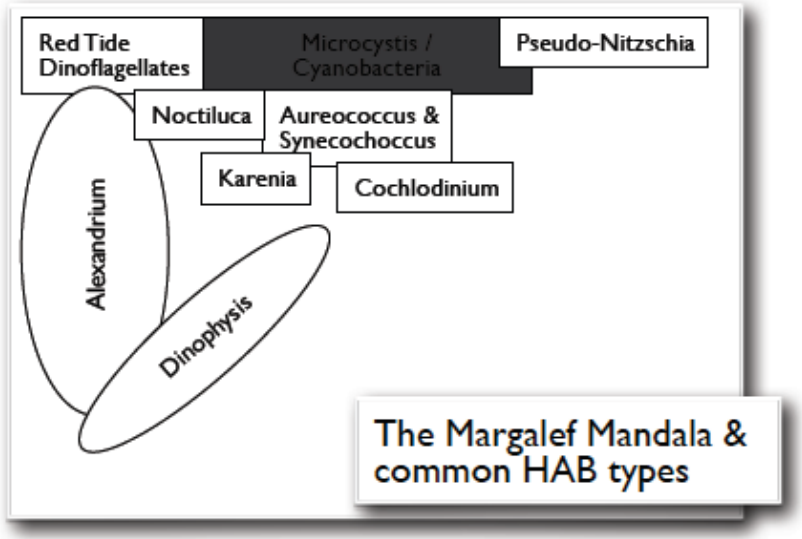
MERIS FR in many ways an **optimised sensor** for HAB detection:

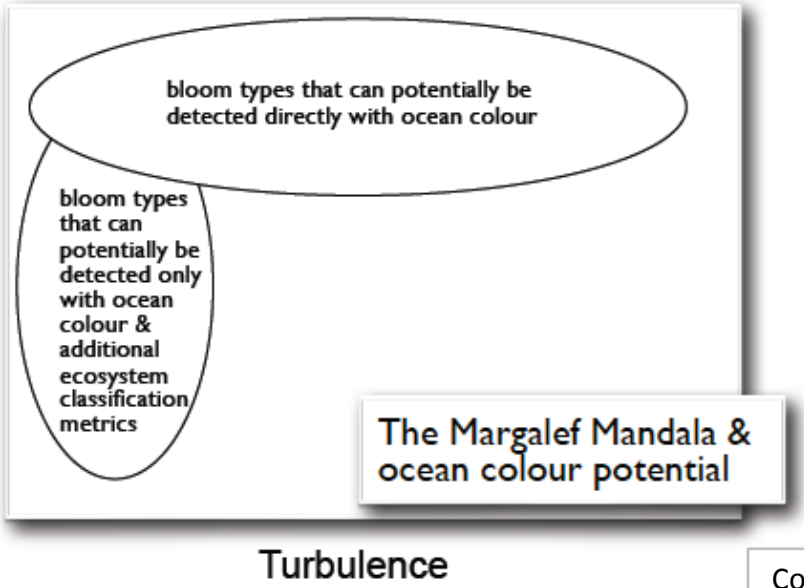
- Spatial resolution
- 709 nm band
- advanced processing options



courtesy: Cheriton/Kudela

HABs and Ocean Colour
The Ecosystem Perspective



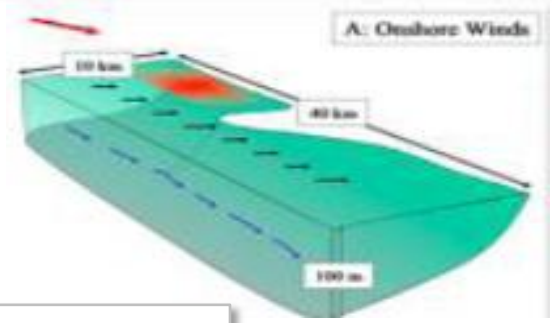


The Margalef mandala

Common way to characterise the **ecological niche** in which different algal species are likely to thrive

Only **high nutrient-demand/biomass** blooms likely to be directly detectable using Ocean Colour (regardless of algorithm type or technique)

Ocean Colour as part of a **multi-parameter ecosystem classification**, can potentially help detect some other bloom types



Courtesy S. Bernard

Focus of this study:
Two types of harmful algal blooms

Dinoflagellates
***Alexandrium*, *Cochlodinium*, *Prorocentrum* spp.**

- Prefers stratification, warmer water & low wind
  e.g. estuaries, bays

- Can contain Saxitoxins
- Paralytic, Diarrhetic shellfish poisoning

⇒ paralyze muscles, diarrhea

- St. Lawrence, Chesapeake bay, California

Diatoms
***Pseudo-Nitzschia* spp.**

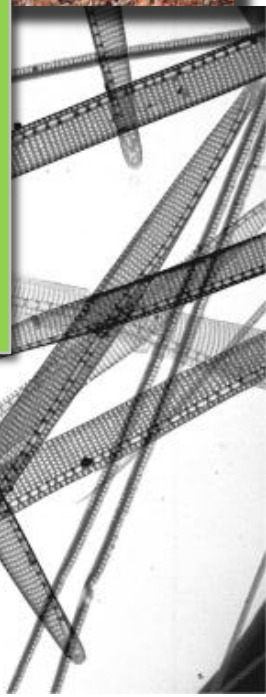
- Prefers high turbulence, high nutrients & cold temps
  e.g. dynamic upwelling areas

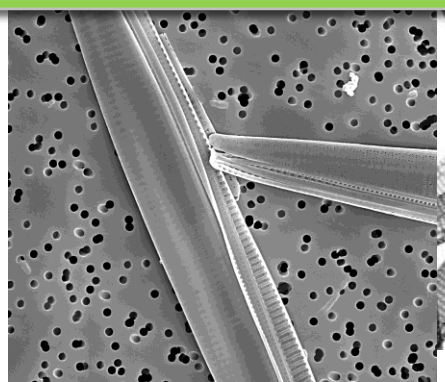
- Can produce domoic acid
- Amnesic shellfish poisoning

⇒ neurotoxin, brain damage

- Benguela, California

Jeong et al. (2004)



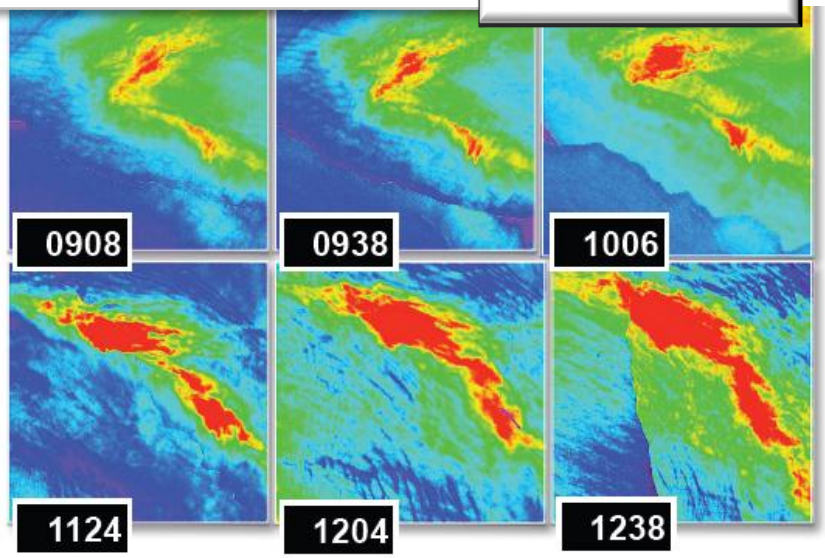


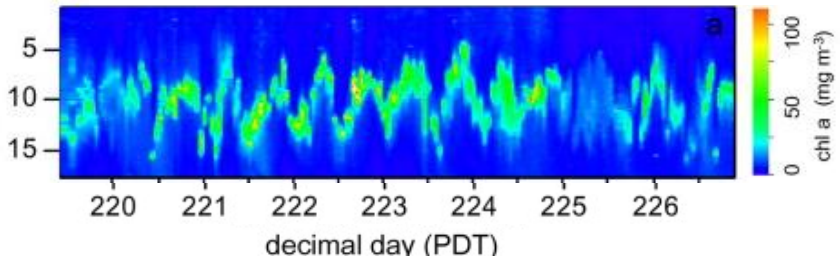
Challenges of using Ocean Colour remote sensing for HAB detection

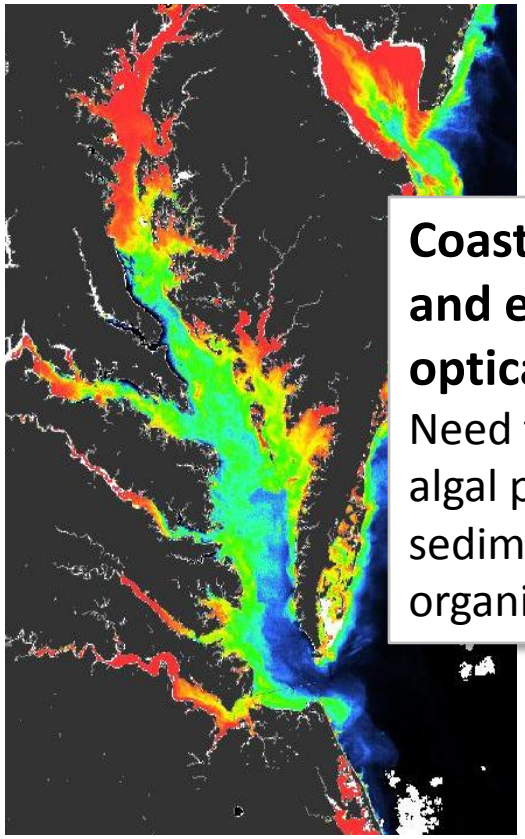
Stratification of blooms & motility

Example: migrating high biomass (>500 mg m^{-3}) dinoflagellate blooms in Monterey bay

Courtesy Raphe Kudela







Coastal embayments and estuaries optically complex

Need to account for algal properties, sediments and dissolved organics

Not all HABs harmful at high biomass

A. tamarense toxic at only 10^3 cell L^{-1}

Case Study: Fjords & Embayments

Bloom of *Cochlodinium polykrikoides* in the Chesapeake Bay

August & September 2007

- Dinoflagellate

- Tends to bloom in mid August following heavy rains

- Causes massive blooms, leading to fish kills and low dissolved oxygen

- *In situ* Chl-a concs reached > 350 µg L^{-1}

- Bloom first detected in situ ~ 11Aug following heavy rains. It dissipated then returned several days later

Photo by K. Matsuoka

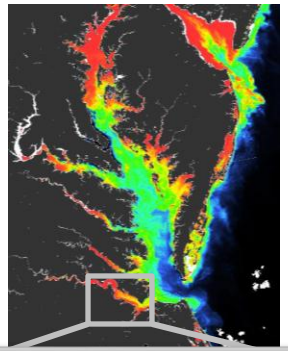
Photo by S. Earley

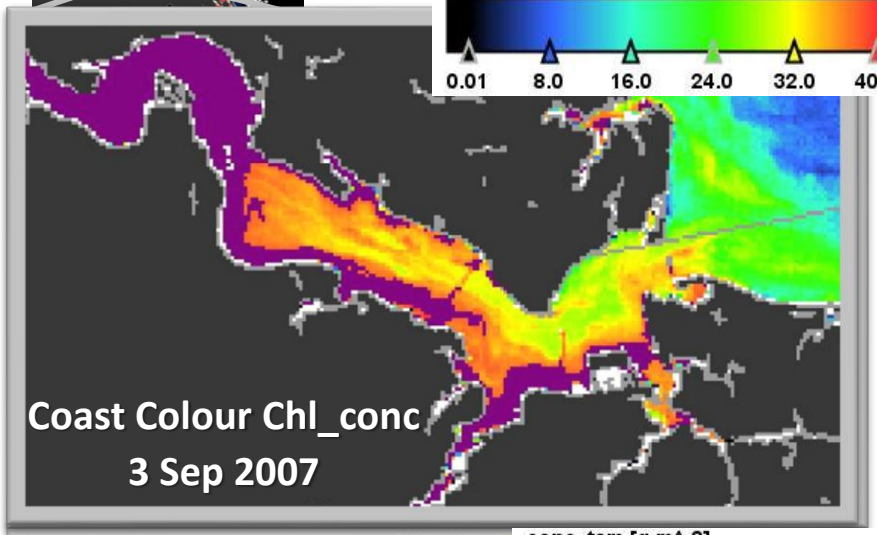
Courtesy Pat Glibert

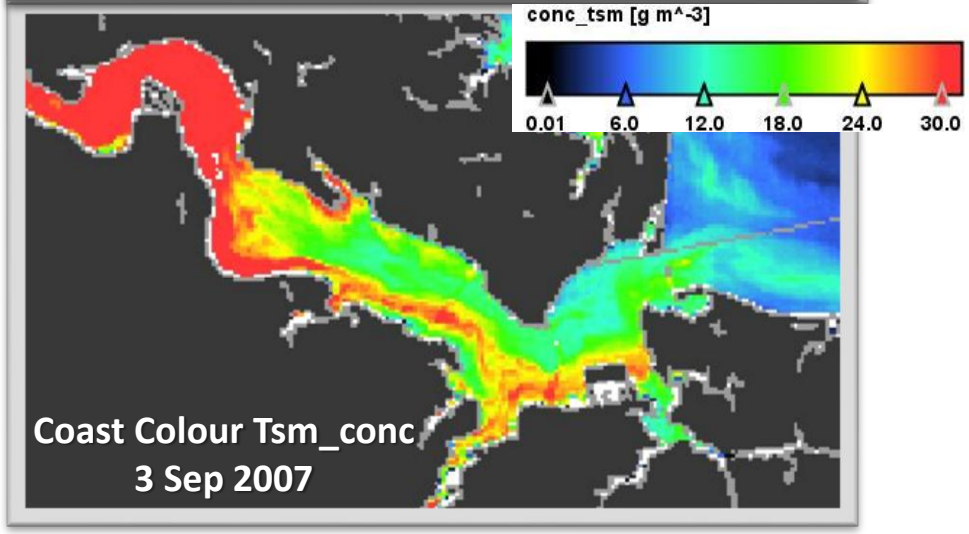
Case Study: Fjords & Embayments

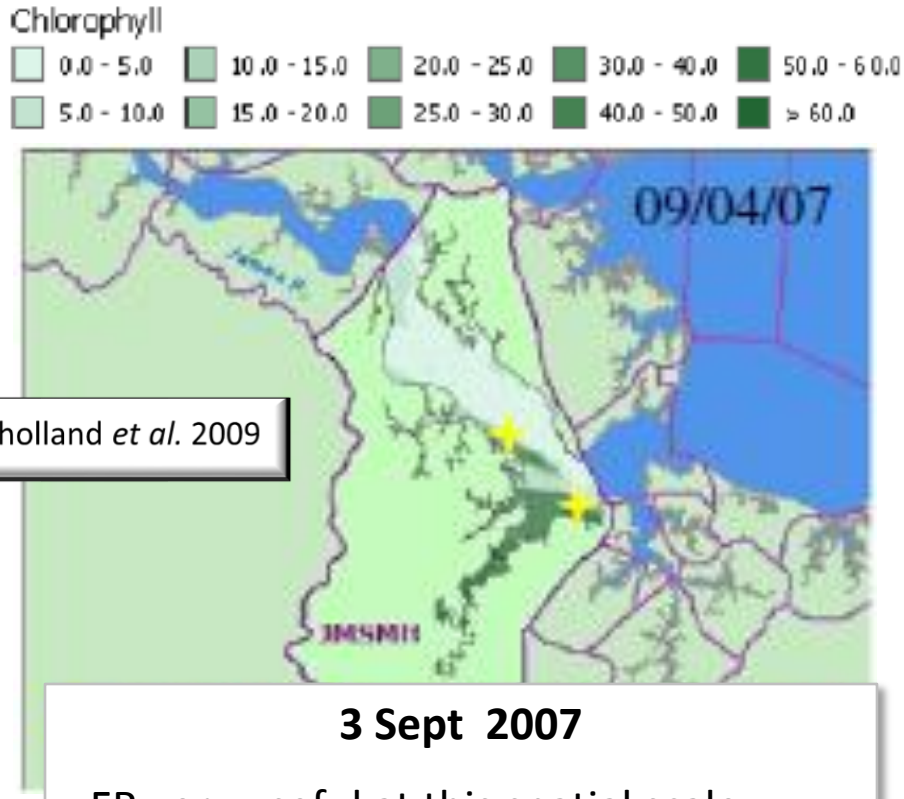
Bloom of *Cochlodinium polykrikoides* in the Chesapeake Bay

August & September 2007









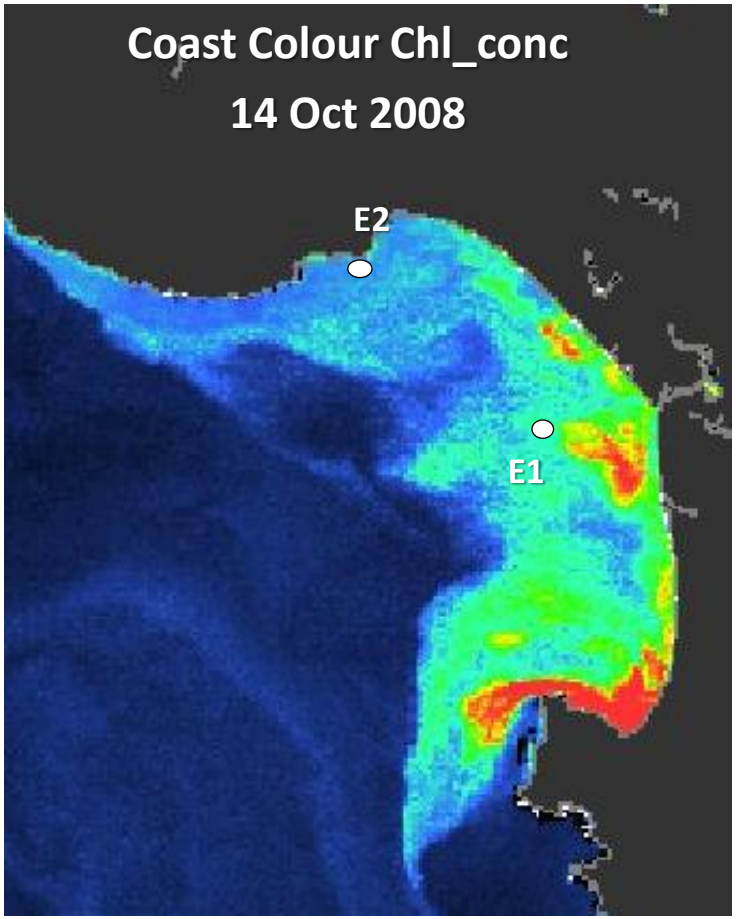
Mulholland *et al.* 2009

3 Sept 2007

- FR very useful at this spatial scale
- CC overestimates in most areas
- purple represents flag for “spectrum out of training range”
- Highlights difficulties of coastal zone

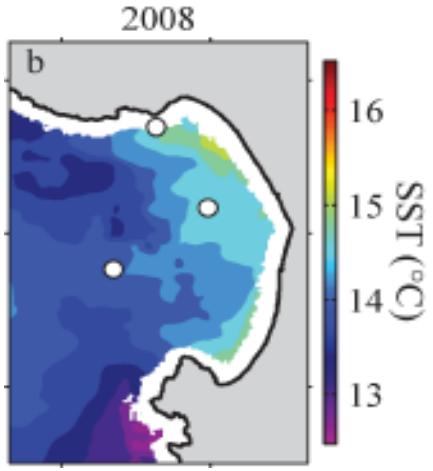
Case Study: Dynamic upwelling system

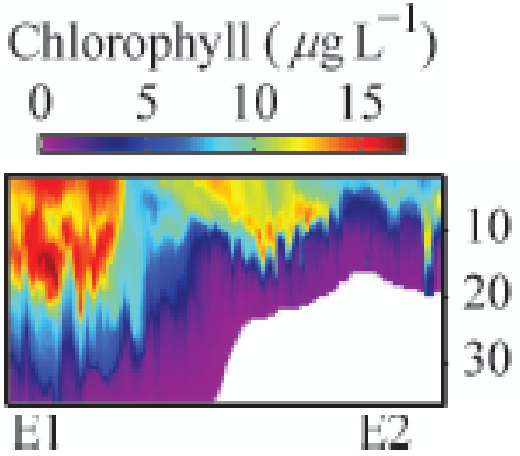
Bloom of *Pseudo-nitzschia* spp. in Monterey Bay
October 2008

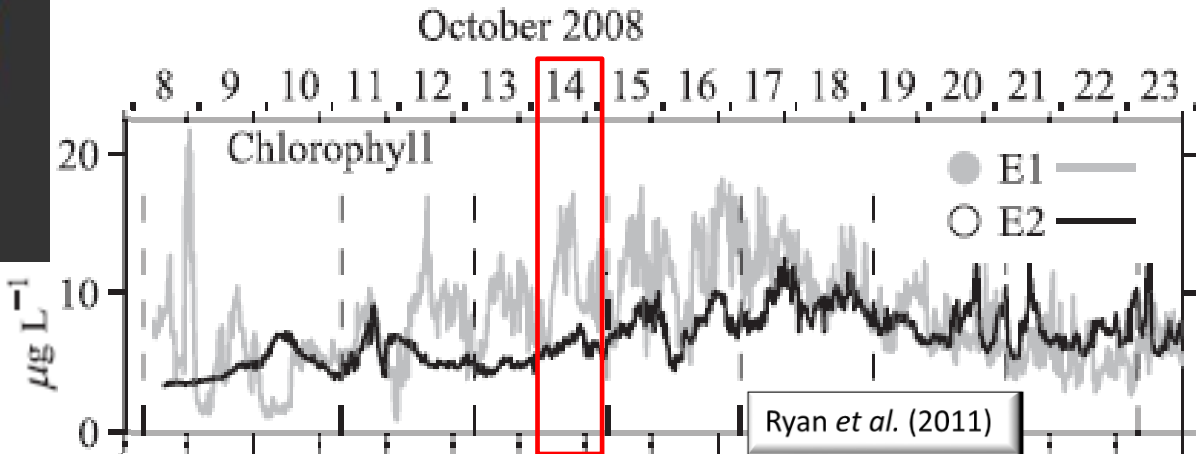


14 Oct 2008

- strong wind and turbulent conditions (diatoms)
- Blooms of *P. australis* & *P. multiseries* at both stations
- CC chl product performs well in surface waters



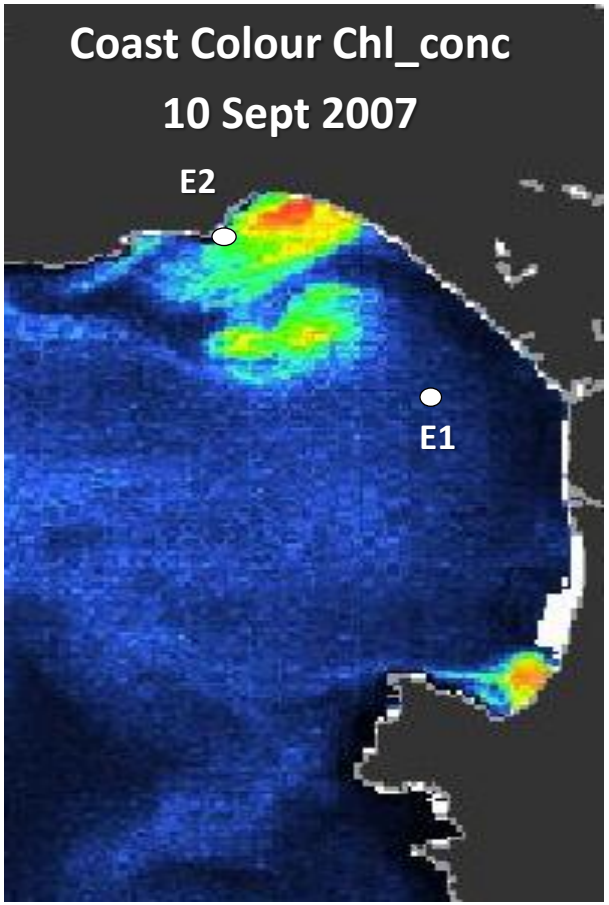




Case Study: Dynamic upwelling system

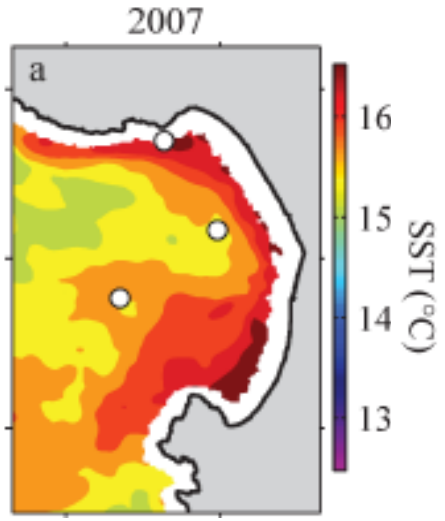
Presence of *Alexandrium catanella* in Monterey Bay

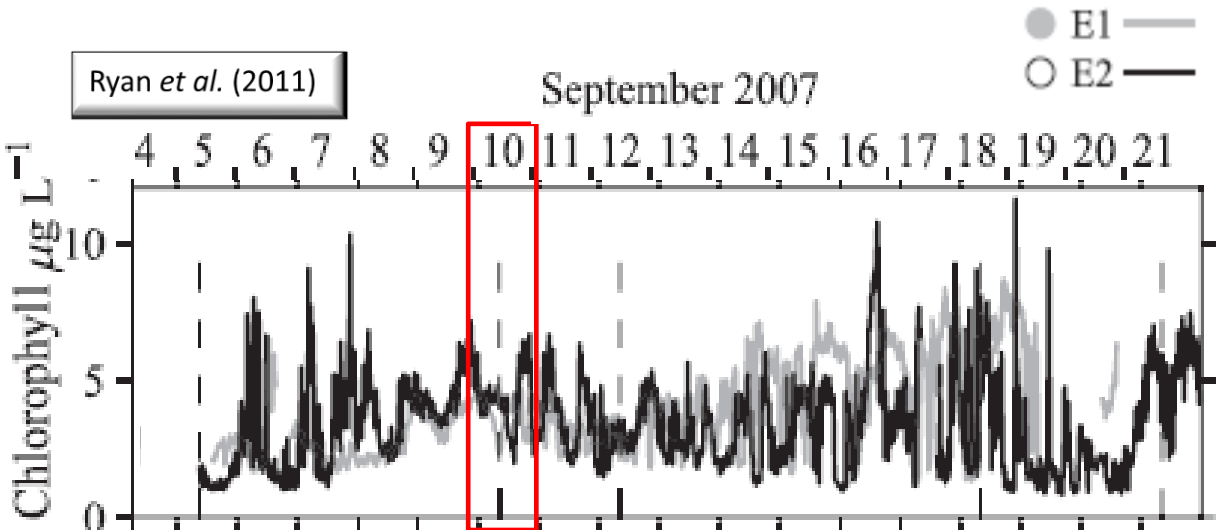
September 2007



10 Sept 2007

- less wind, warmer temps (dinoflagellates)
- tend to form subsurface thin layers
- can be difficult to examine blooms with OC imagery





Case Study: Fjords & Embayments

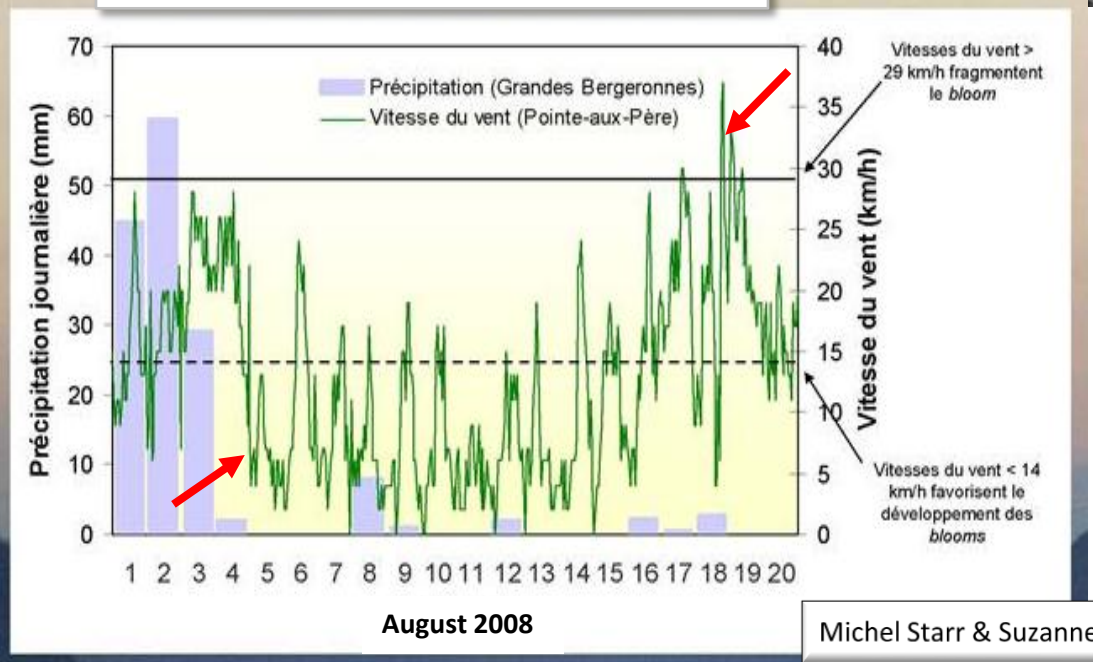
Bloom of *Alexandrium tamarense* in the St. Lawrence Estuary

August 2008

Environmental preferences

- Temperatures rel. high
- Salinity rel. low (estuaries, river outflows)
- Strong stratification
- Low turbulence (motile)
- Increased humic substances

M Starr - 15 August 2008 – Ste-Flavie



August 2008 bloom

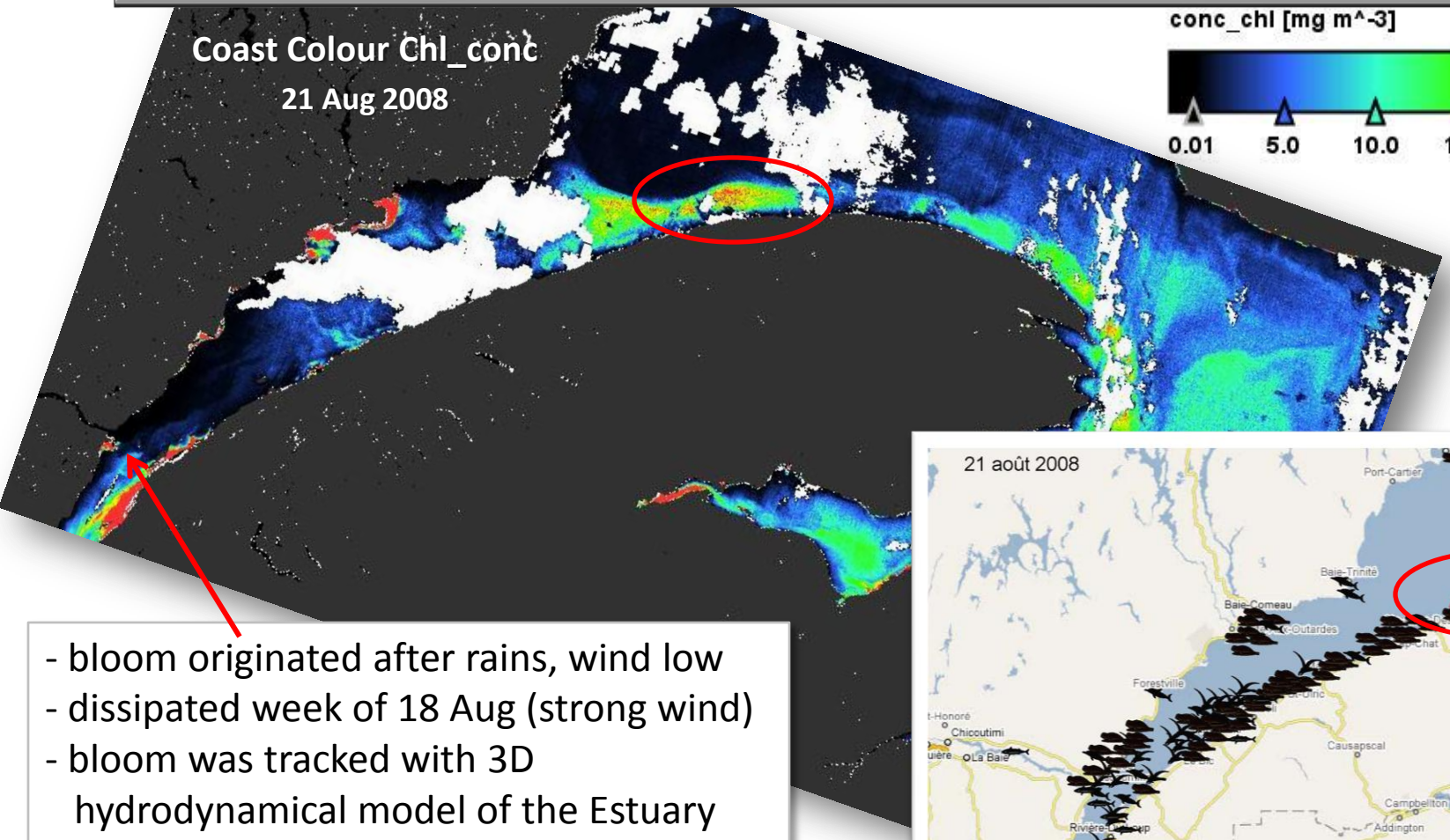
- 600 km^2 in size
- Lasted about 3 weeks
- Strong stratification
- mortalities (whales, seals, birds, fish)

Michel Starr & Suzanne Roy

Case Study: Fjords & Embayments

Bloom of *Alexandrium tamarense* in the St. Lawrence Estuary

21 August 2008



- bloom originated after rains, wind low
- dissipated week of 18 Aug (strong wind)
- bloom was tracked with 3D hydrodynamical model of the Estuary and Gulf of St. Lawrence

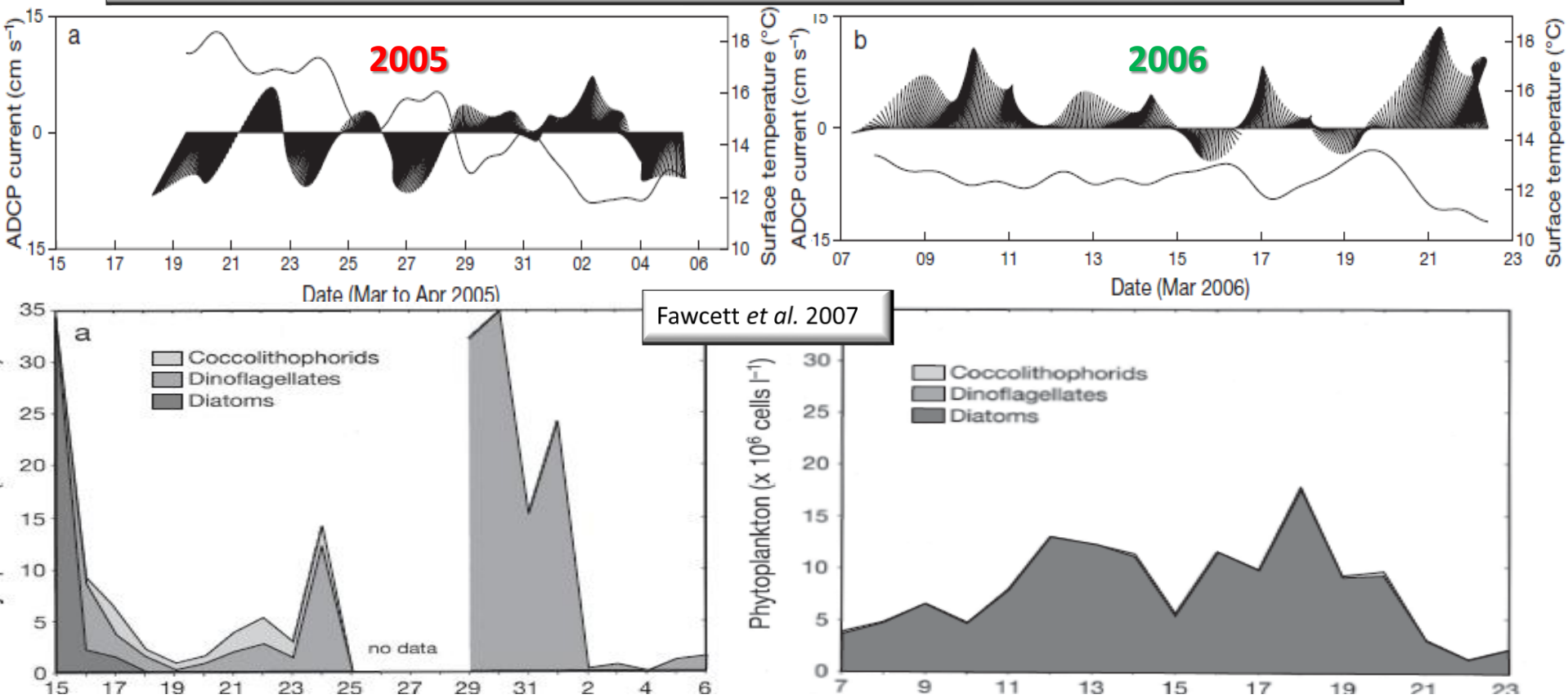
(used atmospheric and hydrologic forcing)

Michel Starr & Suzanne Roy

Case Study: Dynamic upwelling system

HABs in the Benguela

March 2005 & 2006



Fawcett *et al.* 2007

-Weaker winds & wind reversals
- higher temps

⇒**Dinoflagellates**

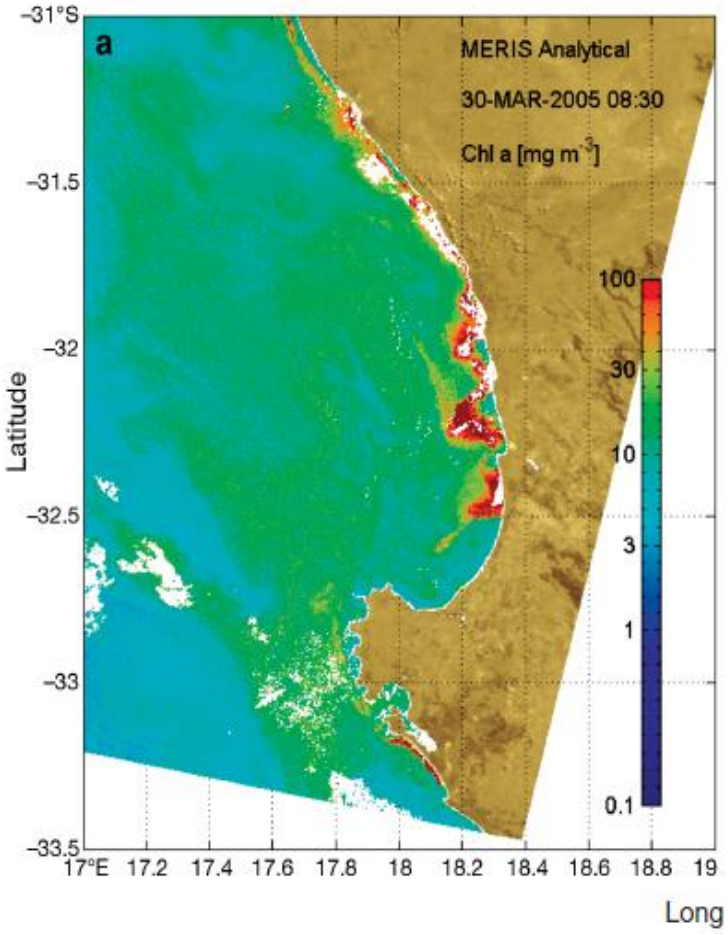
- Upwelling-favourable winds & fewer reversals
- lower temps

⇒ **Diatoms**

Case Study: Dynamic upwelling system

Blooms of *Prorocentrum triestinum* in the Benguela

March 2005

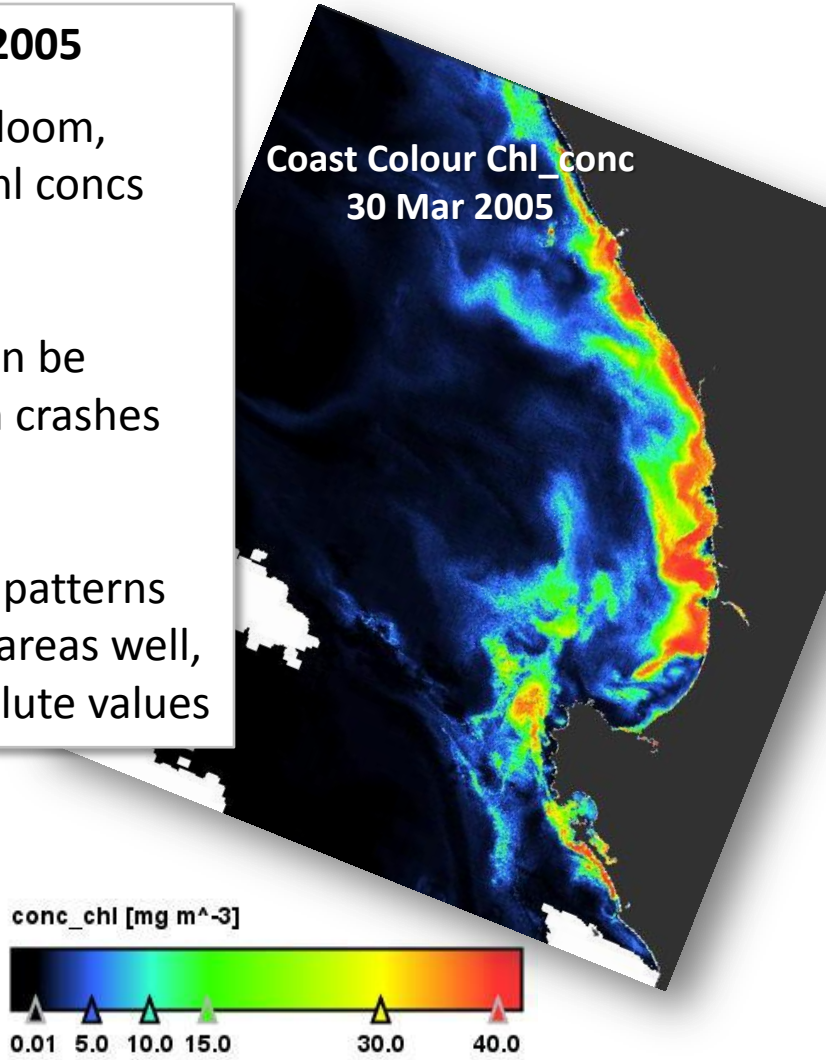


30 March 2005

Dinoflagellate bloom, relatively high Chl concs (±150 mg m^{-3})

Not toxin, but can be harmful if bloom crashes
⇒Anoxic event

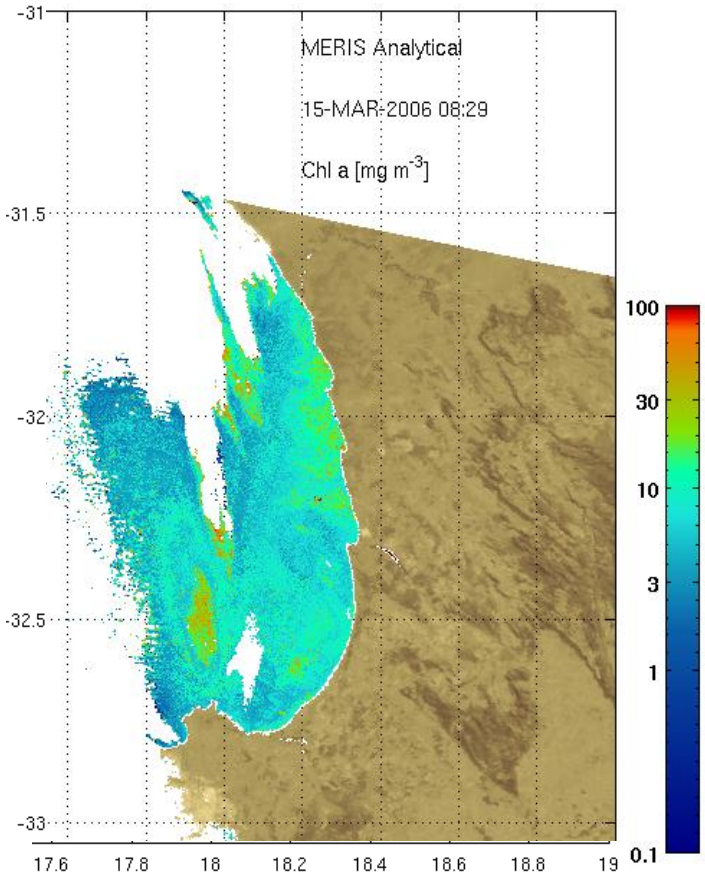
CC distinguishes patterns of high biomass areas well, but not the absolute values



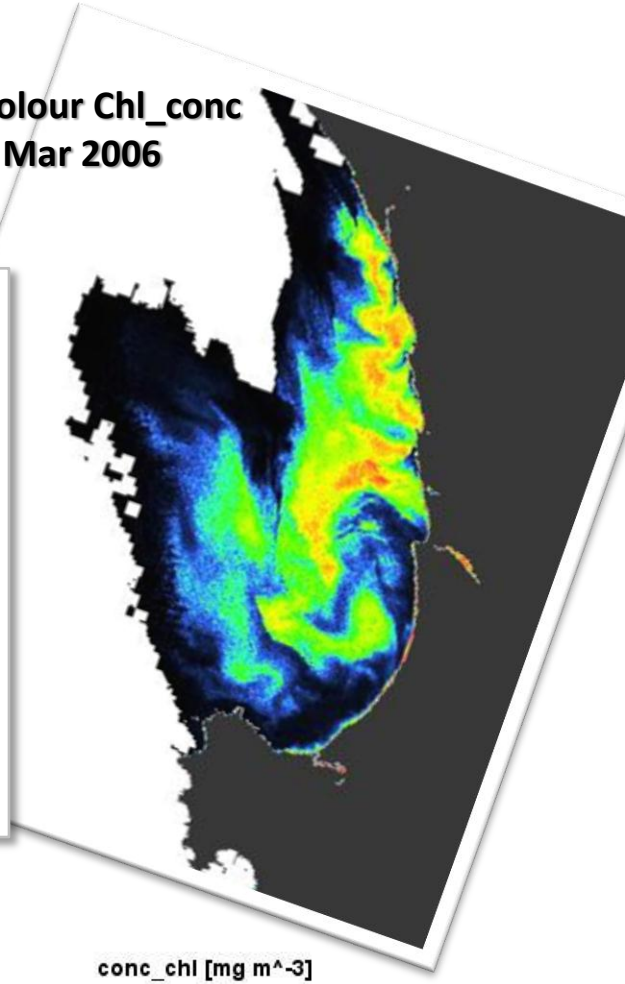
Case Study: Dynamic upwelling system

Blooms of *Pseudo-nitzschia* in the Benguela

March 2006



Coast Colour Chl_conc
15 Mar 2006



15 March 2006

Diatom bloom

Relatively low Chl concs for a Benguela bloom (±30 mg m^{-3})

CC distinguishes higher biomass areas well

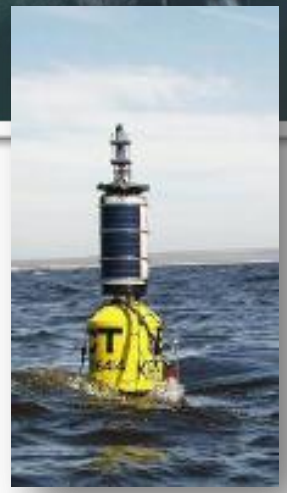
Conclusions

Effective HAB detection, monitoring and analysis requires an appreciation of the **sizable uncertainties** associated with ocean colour applications in the optically complex coastal zone

Observation systems need to be mindful of the **suitability** of available ocean colour techniques for HAB application to different ecosystems

FR optimal for HAB detection

Plans for HAB working group:
- Monograph – can **showcase** CoastColour data
- Case studies – will have *in situ* and reflectance data available for a more comprehensive OC product **comparison**



Thank you

HAB working group
August 2010

References

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