A deteção por satélite da cor do oceano (continuação)
Exemplos de Aplicações

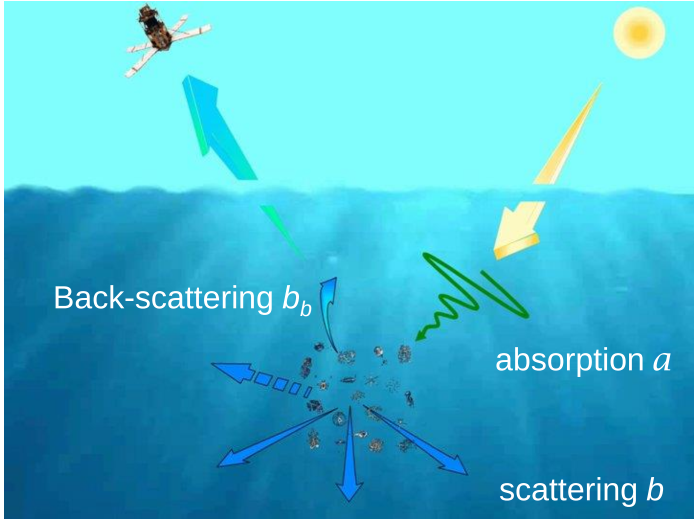
Vanda Brotas

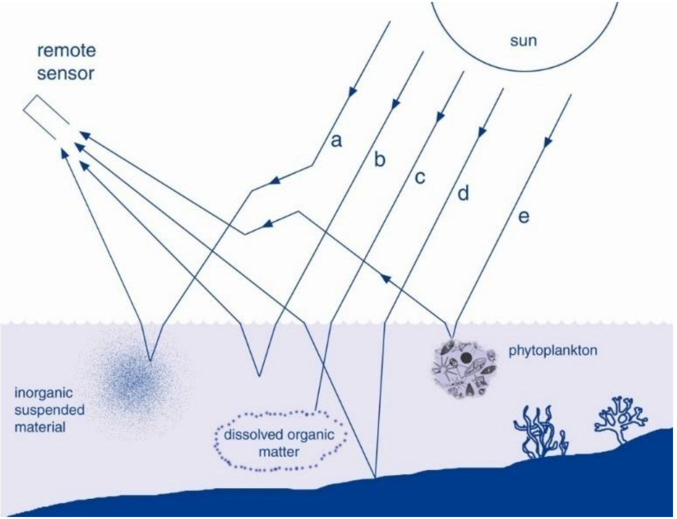
26 de Novembro 2020

Lecture Outline

- Link with previous lectures
- Ocean Colour Applications
- Knowledge about phytoplankton global distribution – practical lecture of 12 Nov.
- Phytoplankton and climate change
- Bloom Phenology
- Phenology and Fisheries
- Harmful Algal Blooms (HABs), how remote sensing can help?

Principles of Ocean Colour Radiometry
Factors affecting remote sensing reflectance





Light photons are absorbed or scattered

Reflectances provide information on phytoplankton concentration, suspended matter, and CDOM (coloured dissolved organic matter)

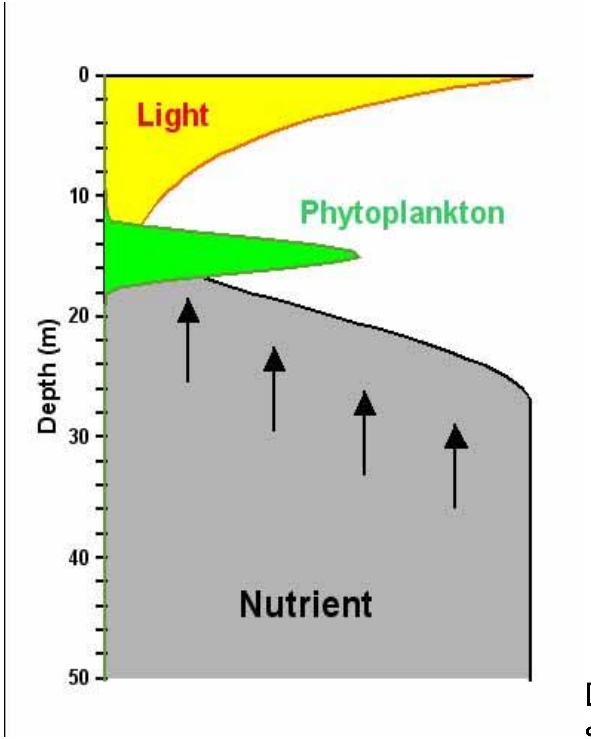
Aula dia 19 nov

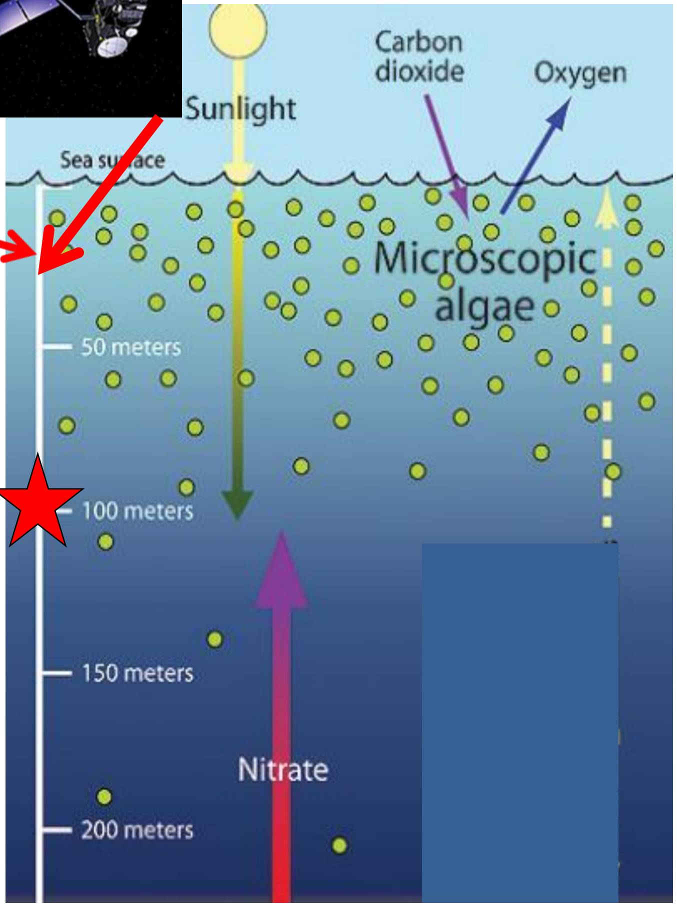
Principles of Ocean Colour Radiometry

How deep do satellites “see”?

100M/ 4.6 = 21M

DCM





Disadvantages of RS, aula 12 nov. Signal from satélites is limited to 1st optical depth

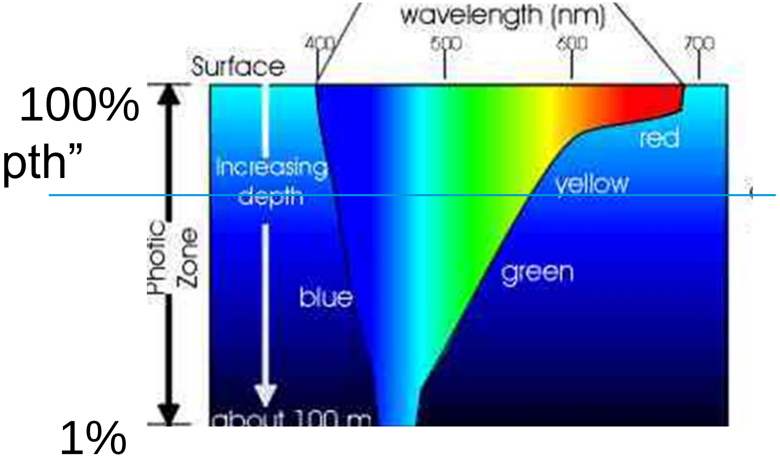
How deep do satellites "see"? First optical depth

Z_{eu} :Depth of Euphotic Zone

Z_{90}, ou Z_{opt} : "First Optical Depth" = where ~90% of the radiance originates

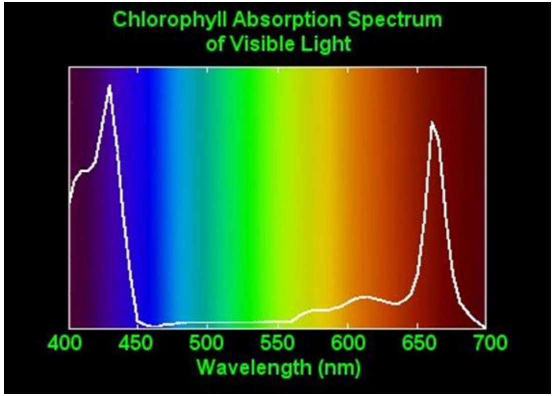
$Z_{opt}=Z_{eu}/4.6$

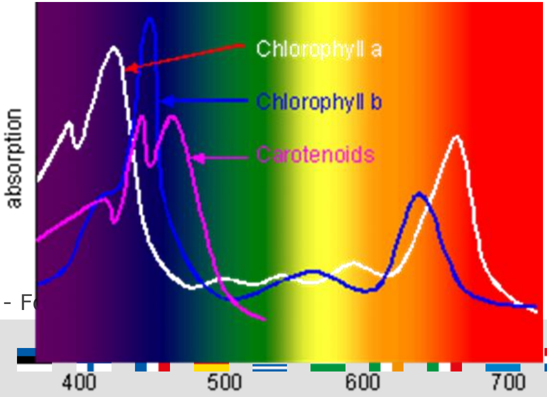
"First Optical Depth"

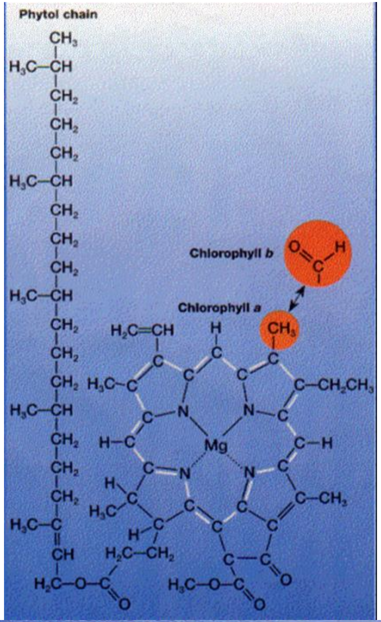


OBJ-1: Phytoplankton is constituted by microscopic cells with different pigments content

- Chorophyll a: universal pigment in all algal classes.
- Other chlorophylls, many carotenoids

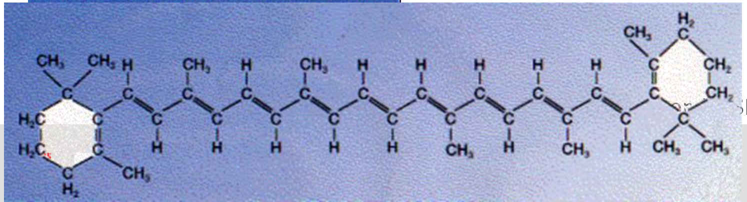






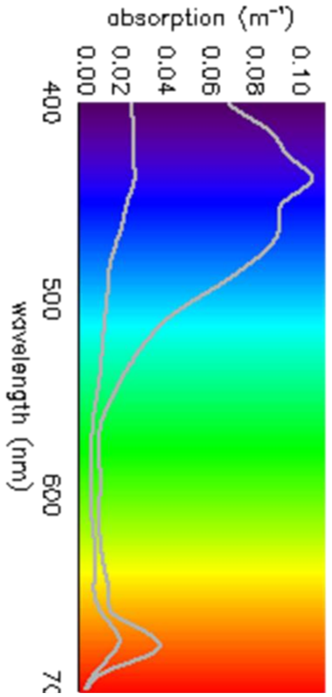
Chlorophylls

Carotenoides



SENTINEL 3

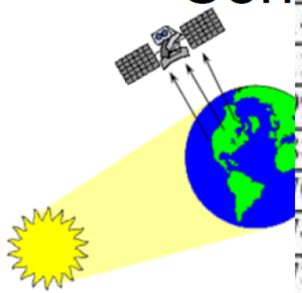
OLCI – bandas



Yellow: additional bands in relation to MERIS

Band #	λ center	Width	Lmin	Lref	Lsat	SNR
	nm	nm	W/(m².sr.µm)	W/(m².sr.µm)	W/(m².sr.µm)	
Oa1	400	15	21.60	62.95	413.5	2188
Oa2	412.5	10	25.93	74.14	501.3	2061
Oa3	442.5	10	23.96	65.61	466.1	1811
Oa4	490	10	19.78	[illegible]	[illegible]	541
Oa5	510	10	17.45	[illegible]	[illegible]	488
Oa6	560	10	12.73	[illegible]	[illegible]	280
Oa7	620	10	8.86	[illegible]	[illegible]	97
Oa8	665	10	7.12	[illegible]	[illegible]	83
Oa9	673.75	7.5	6.87	[illegible]	[illegible]	07
Oa10	681.25	7.5	6.65	[illegible]	[illegible]	45
Oa11	708.75	10	5.66	[illegible]	[illegible]	85
Oa12	753.75	7.5	4.70	[illegible]	[illegible]	05
Oa13	761.25	2.5	2.53	[illegible]	[illegible]	32
Oa14	764.375	3.75	3.00	[illegible]	[illegible]	05
Oa15	767.5	2.5	3.27	[illegible]	[illegible]	30
Oa16	778.75	15	4.22	[illegible]	[illegible]	12
Oa17	865	20	2.88	[illegible]	[illegible]	66
Oa18	885	10	2.80	[illegible]	[illegible]	95
Oa19	900	10	2.05	4.73	237.6	308
Oa20	940	20	0.94	2.39	171.7	203
Oa21	1020	40	1.81	3.86	163.7	152

Sen



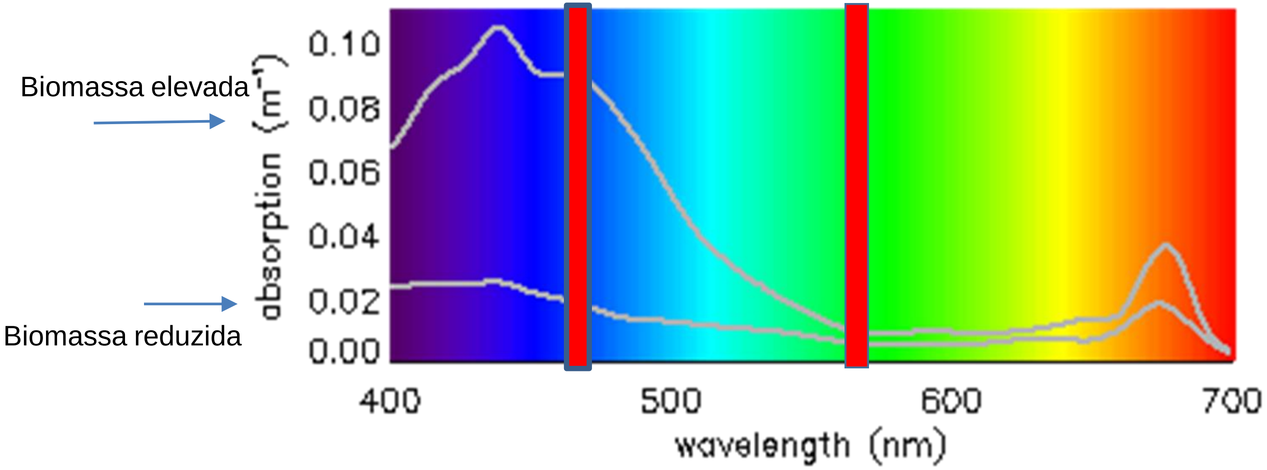
Passive Sensors

- They only receive radition
- Source of Radiation is the sun
- Radiation received in the sensor may result from emission, reflection or may scattered.

https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci/overview/heritage

BASE TEÓRICA DA COR DO OCEANO

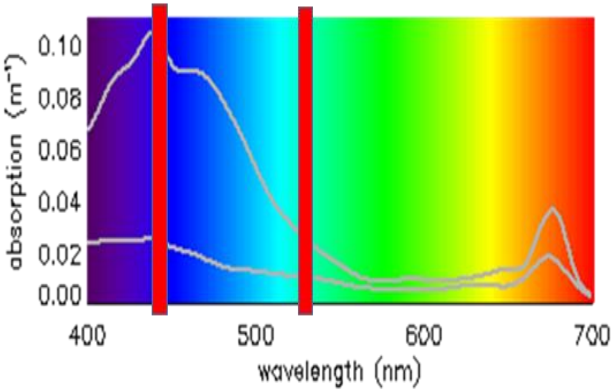
- Absorção da luz pelos pigmentos resulta em espectros de absorção proporcionais à sua concentração. O que é a base da deteção remota da Cor.
- Quanto maior a Absorção, menor a reflexão. Sensor de cor do satélite mede a reflectância.



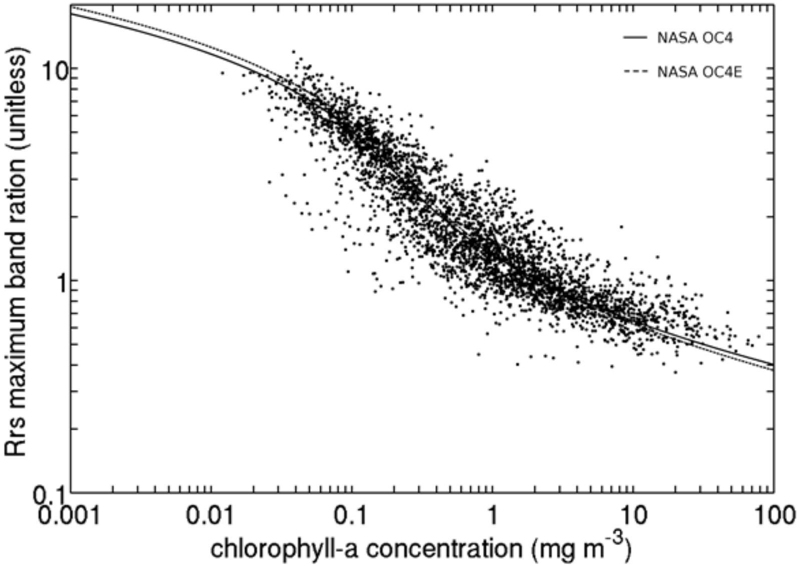
Chla algorithms, blue/green bands ratio

High biomass

Low biomass



Remote-sensing reflectance maximum band ratio ([443,490,510]/555 as a function of chlorophyll-a concentration.



NASA OC4 and OC4E v64 operational standard algorithms, http://oceancolor.gsfc.nasa.gov/cms/atbd/chlor_a).

Right Figure from Valente et al 2016, Earth Syst. Sci. Data, 8, 235-252, doi:10.5194/essd-8-235-2016.

Nasa Ocean Color site – para saber mais

https://oceancolor.gsfc.nasa.gov/atbd/chlor_a/

Inputs:
Rrs at 2-4 wavelengths between 440 and 670nm
Outputs:
chlor_a, concentration of chlorophyll *a* in mg/m^{-3}

This algorithm returns the near-surface concentration of chlorophyll-a (chlor_a) in mg m-3, calculated using an empirical relationship derived from in situ measurements of chlor_a and remote sensing reflectances (Rrs) in the blue-to-green region of the visible spectrum.

Aplicações Cor do Oceano
Ocean Colour Applications

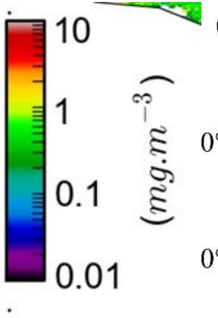
- Conhecimento sobre o oceano, distribuição da biomassa fitoplâncton – aula TP de dia 12 Nov.
- Knowledge about phytoplankton global distribution – practical lecture of 12 Nov.

Phytoplankton from Space: Global picture

Remote sense of Ocean Colour

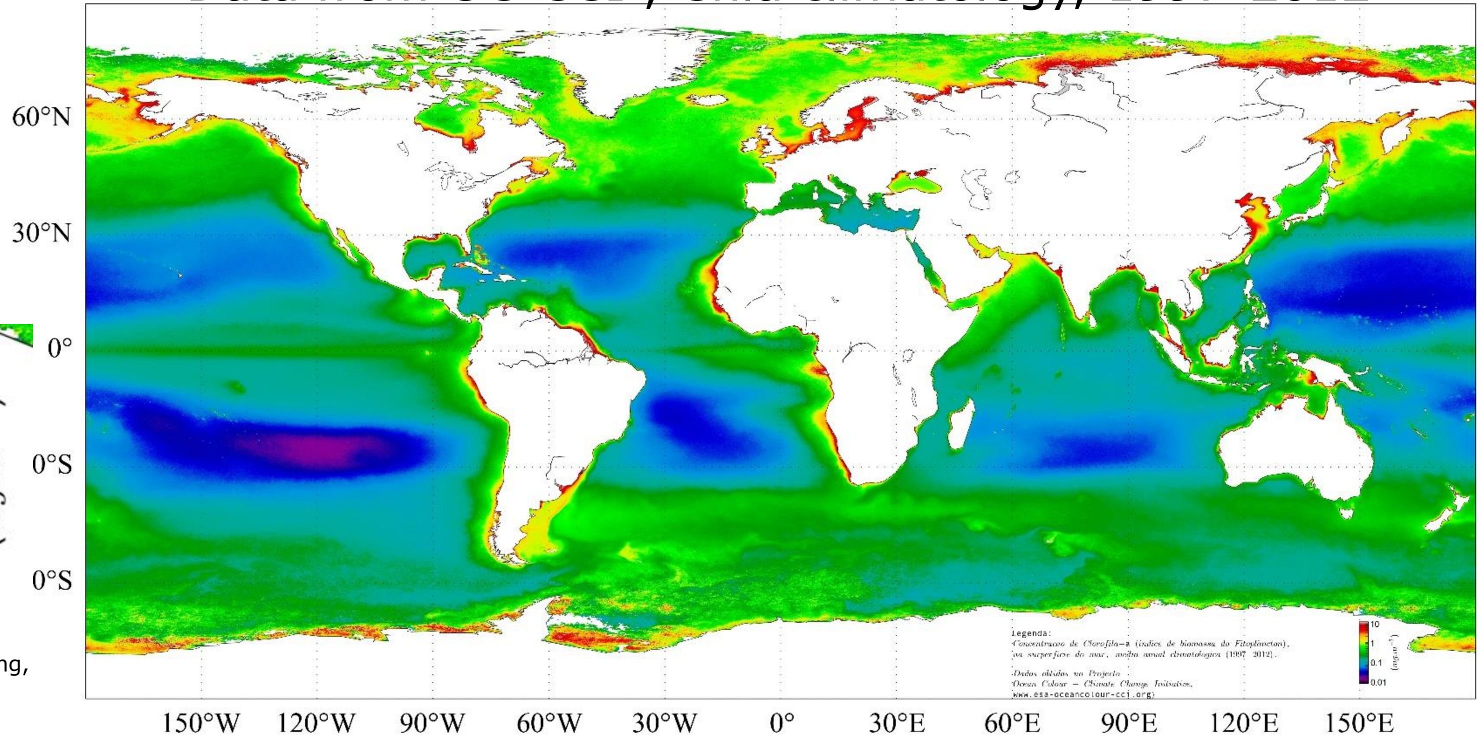
Most used product:

Chlorophyll a concentration



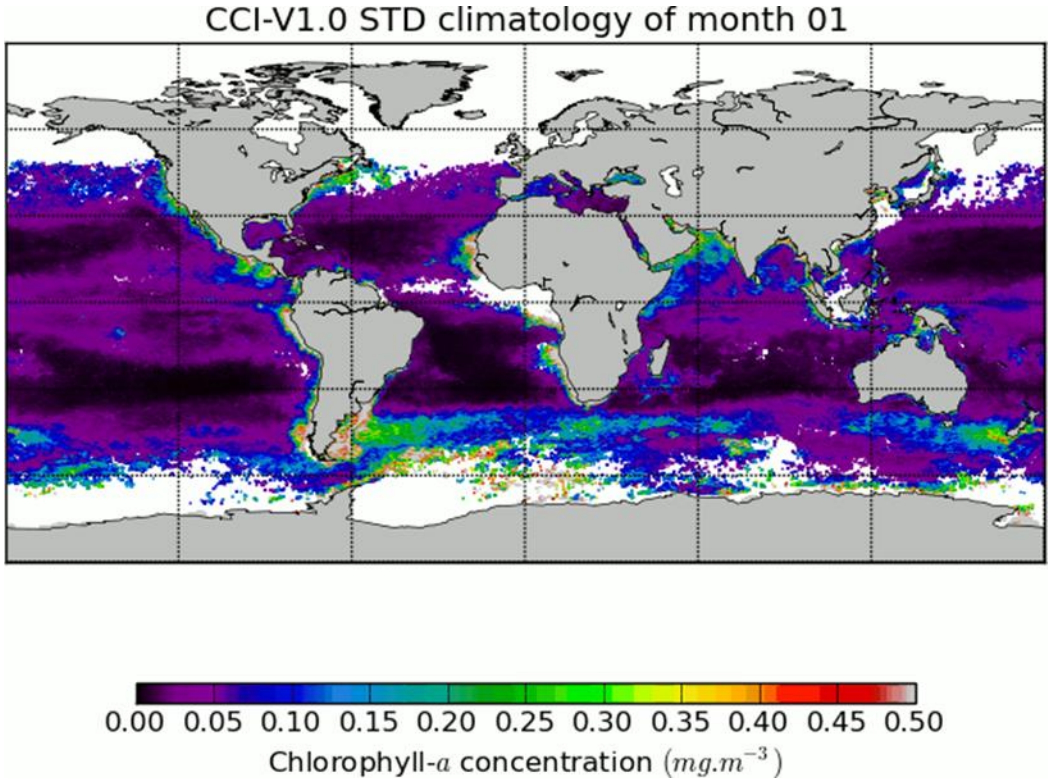
Couto et al, 2016. Int J Remote Sensing, 37:18, 4337-4355

Data from OC-CCI , Chla climatology, 1997-2012



Incertitude? It is key to know the incertitude

Animation of standard deviation (STD) of monthly variability (with climatological values). Regions with higher STD are regions where higher interannual (from 1997 to 2012) variability was registered. It is clear the high variability in higher latitudes, and reduced variability in the centre of the gyres.



Phytoplankton and climate change
Is Phytoplankton biomass increasing or decreasing?

Essential Climate Variables (ECV):

- Atmospheric Group: Cloud, Ozone, Aerosol, GHG
- Ocean Group: Sea Level, Sea Ice (TBC) SST, **Ocean Colour**
- Land Group: Glaciers, Landcover, Fire

Ocean Colour is a ECV

Polémica na Nature
Controversial issue

Archive > Volume 472 > Issue 7342 > Brief Communications Arising > Article

ARTICLE PREVIEW

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NATURE | BRIEF COMMUNICATION ARISING

previous article next article

Is there a decline in marine phytoplankton?

Abigail McQuatters-Gollop, Philip C. Reid, Martin Edwards, Peter H. Burkill, Claudia Castellani, Sonia Batten, Winfried Gieskes, Doug Beare, Robert R. Bidigare, Erica Head, Rod Johnson, Mati Kahru, J. Anthony Koslow & Angelica Pena

Affiliations | Corresponding author

Nature **472**, E6–E7 (14 April 2011) | doi:10.1038/nature09950
Received 31 August 2010 | Accepted 01 February 2011 | Published online 13 April 2011
Article (July, 2010)
Brief Communication Arising (April, 2011)

ARISING FROM D. G. Boyce, M. R. Lewis & B. Worm *Nature* **466**, 591–596 (2010); Boyce *et al.* reply

Phytoplankton account for approximately 50% of global primary production, form the trophic base of nearly all marine ecosystems, are fundamental in trophic energy transfer and have key roles in climate regulation, carbon sequestration and oxygen production. Boyce *et al.*[1] compiled a chlorophyll index by combining *in situ* chlorophyll and Secchi disk depth measurements that spanned a more than 100-year time period and showed a decrease in marine phytoplankton biomass of approximately 1% of the global median per

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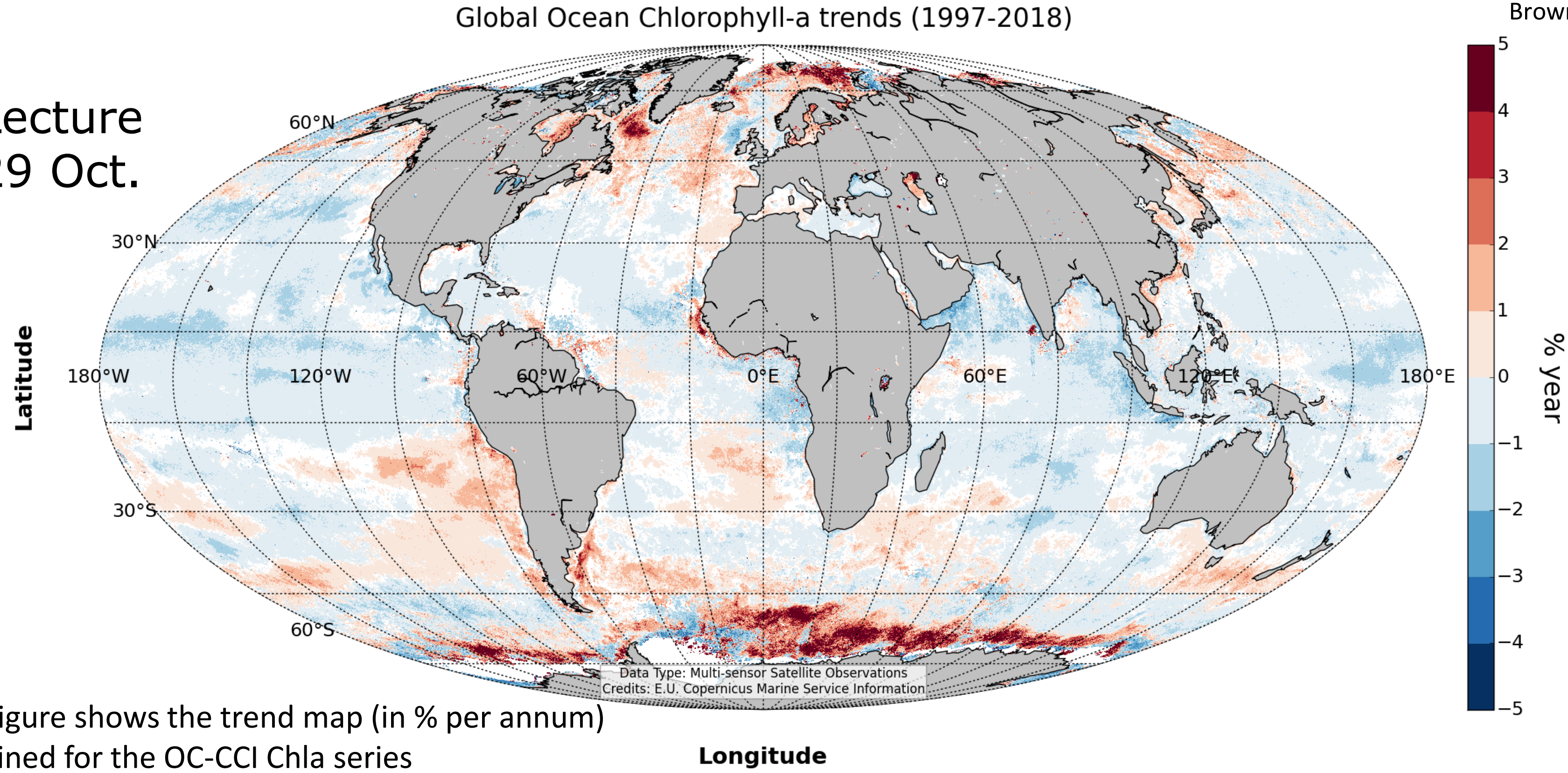
OC-CCI Project

Global chlorophyll trend analysis shows an increasing trend in high latitudes and a decreasing trend in tropical areas

Blue: decrease
Brown: increase

Lecture 29 Oct.



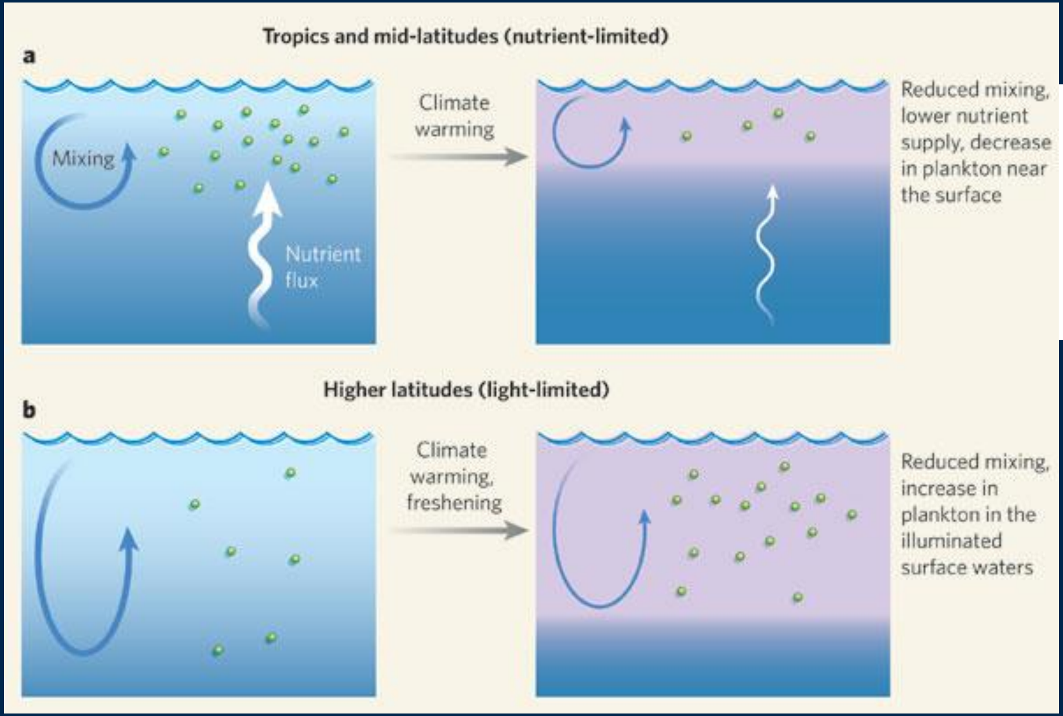
the figure shows the trend map (in % per annum) obtained for the OC-CCI Chla series

Only statistically significant ($p < .05$) trends are shown

Sathyendranath et al(2018). Copernicus Marine Service Ocean State Report, sec. 1.5 Ocean Colour, Journal of Operational Oceanography, 11, S33-S36. DOI: [10.1080/1755876X.2018.1489208.](10.1080/1755876X.2018.1489208.)

Possíveis efeitos do aquecimento global na biosfera

- O aumento da temperatura superficial do oceano tem diferentes efeitos dependendo da região.



OCEANOGRAPHY

Plankton in a warmer world

Scott C. Doney

Satellite data show that phytoplankton biomass and growth generally decline as the oceans' surface waters warm up. Is this trend, seen over the past decade, a harbinger of the future for marine ecosystems?

(In Nature 7Dec 2006)

Bloom Phenology

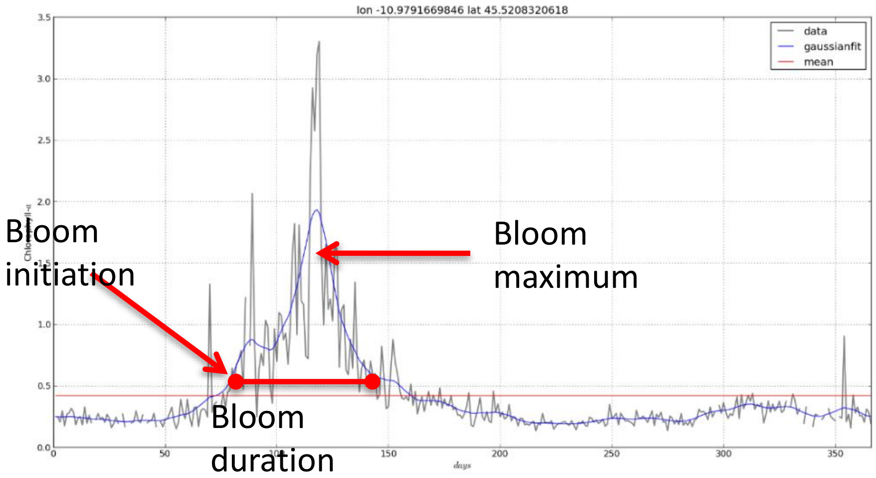
- Used for climate studies. Is Phytoplankton biomass changing due to climate change?
- Links with trophic chain, fisheries
- Link with HABs detection and prevention

Phenology of phytoplankton blooms: Finding Patterns and Anomalies

Table 8.1 Ecological indicators of the pelagic ocean that can be derived fro radiometry (Platt and Sathyendranath, 2008).

Indicator	Label	Dimensions
Initiation of spring bloom	b_i	[T]
Amplitude of spring bloom	b_a	$[ML^{-3}]$
Timing of spring maximum	b_t	[T]
Duration of spring bloom	b_d	[T]
Total production in spring bloom	b_p	$[ML^{-2}]$
Annual phytoplankton production	P_Y	$[ML^{-2}]$
Generalised phytoplankton loss rate	L	$[ML^{-3}T^{-1}]$
Integrated phytoplankton loss	L_T	$[ML^{-3}]$
Annual-scale f-ratio	f	Dimensionless
Spatial variance in biomass field	σ_B^2	$[M^2L^{-6}]$
Spatial variance in production field	σ_P^2	$[M^2L^{-4}]$
Phytoplankton functional types	NA	NA
Delineation of biogeochemical provinces	NA	NA
Phytoplankton size structure	s	Dimensionless

IOCCG 7



Example for latitude 45N , off the Iberia coast

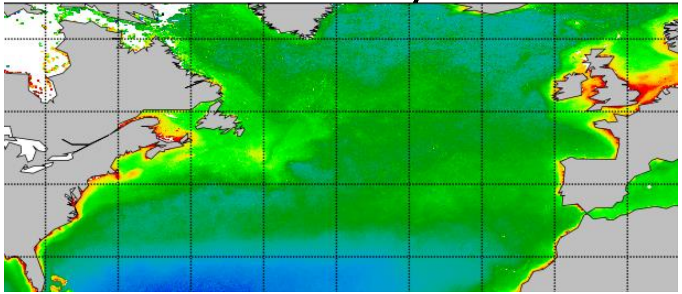
10 years average (2002 – 2012) calculated for each day. MERIS (300 m resolution)

How is marine biodiversity changing?

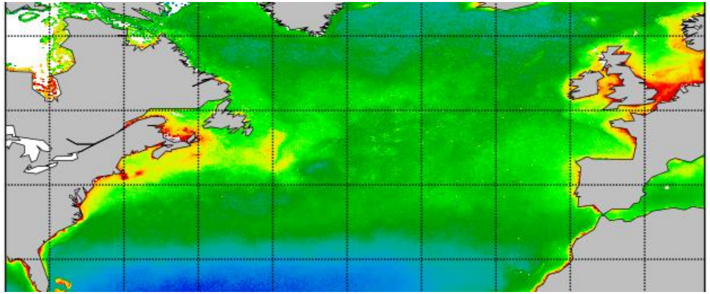
Changing in time
Phenology

A sequence of 4 images of Chla showing the evolution of the Spring bloom in North Atlantic, February – May, climatological averages 1997-2012

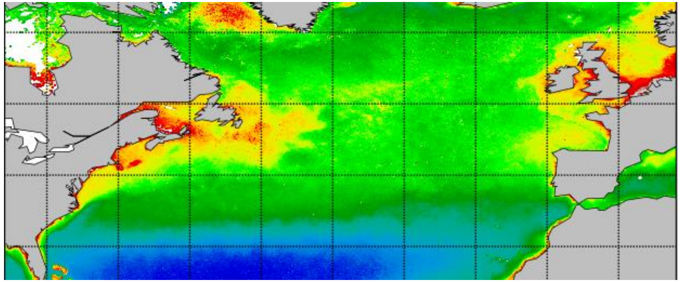
February



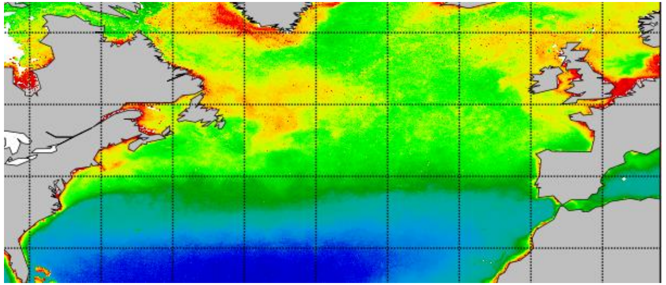
March



April

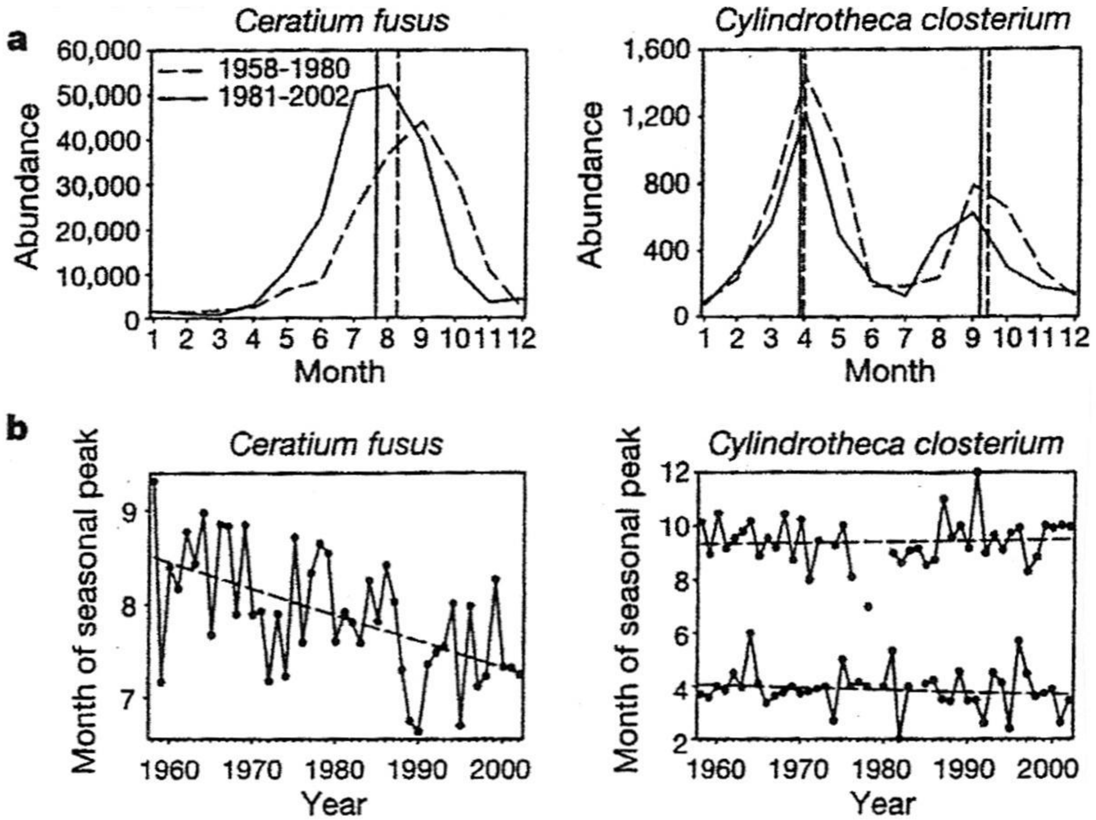


May

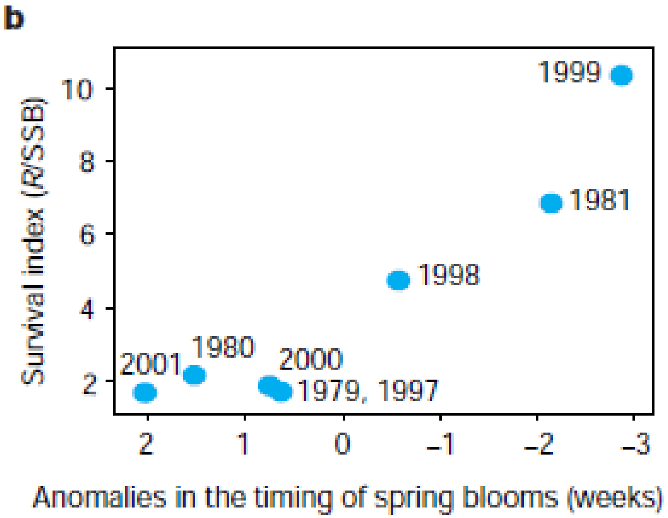


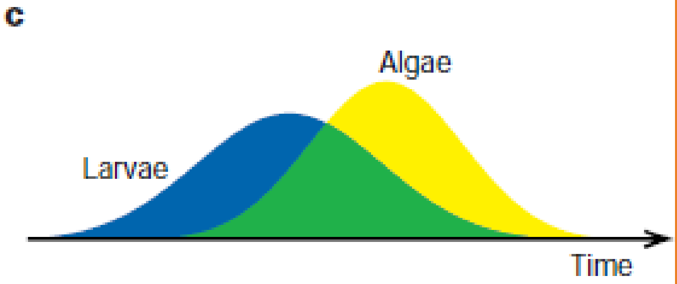
Changes in bloom phenology of 4 species

Alterações no clima mudam a fenologia?



Alterações na fenologia podem ter impacto na cadeia trófica





b) Relação entre taxa de sobrevivência das larvas de peixes e anomalias do bloom de Fitoplancton

c) Azul, nº de larvas, amarelo
Biomassa do Fitoplancton
Quando há interseção, verde
As larvas têm mais comida
E maior capacidade de
Sobreviver.
Estas larvas sofrem menor
Predação, dado que crescem
Depressa e ficam menos visíveis
Se há grande concentração de
Células de Fitoplancton

Platt et al, Nature 2003,
Spring algal bloom and larval fish survival
423:398-399

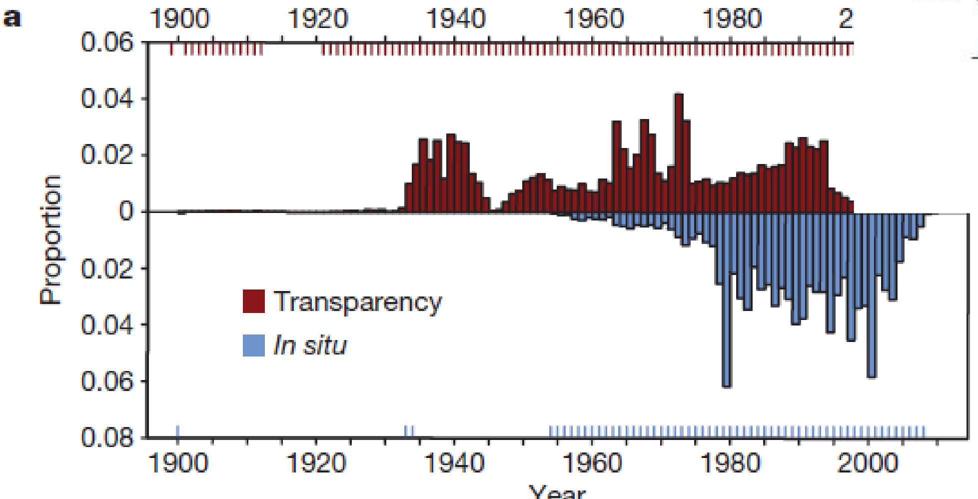
Fitoplancton está a diminuir?

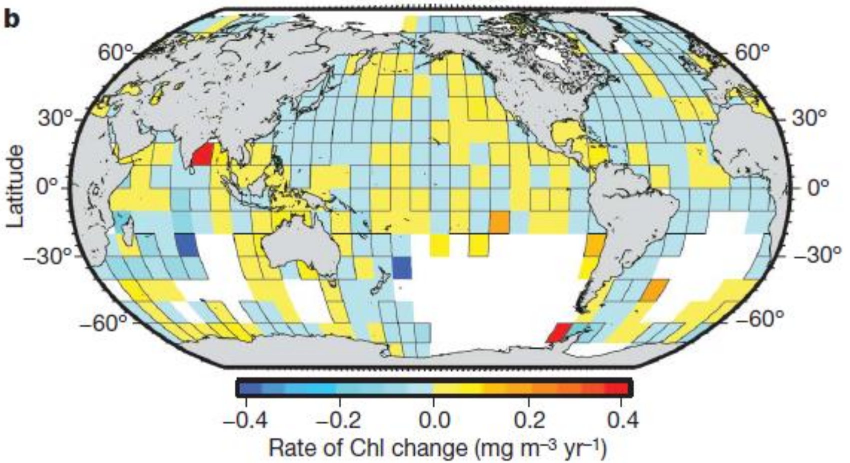
ARTICLES

Global phytoplankton decline over the past century

Daniel G. Boyce[1], Marlon R. Lewis[2] & Boris Worm[1]

Dados antigos de Transparencia da água
Combinados com Dados mais recentes de
Deteção remota





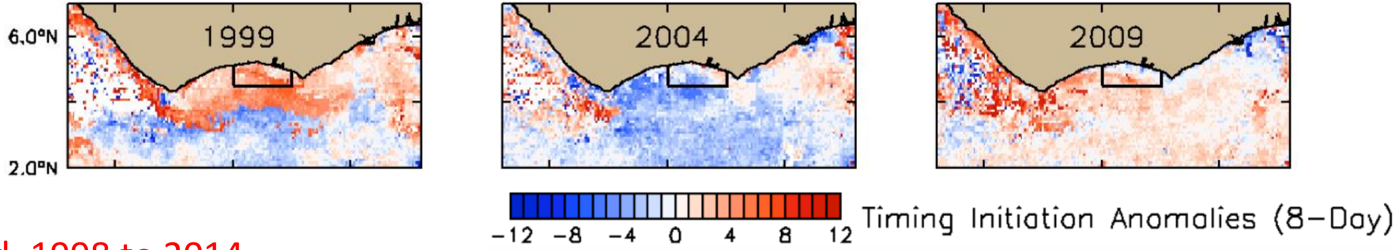
A azul, zonas onde Chla diminuiu
Amarelo e Vermelho, onde Chla aumentou

Desde 1899

Phenology and Fisheries

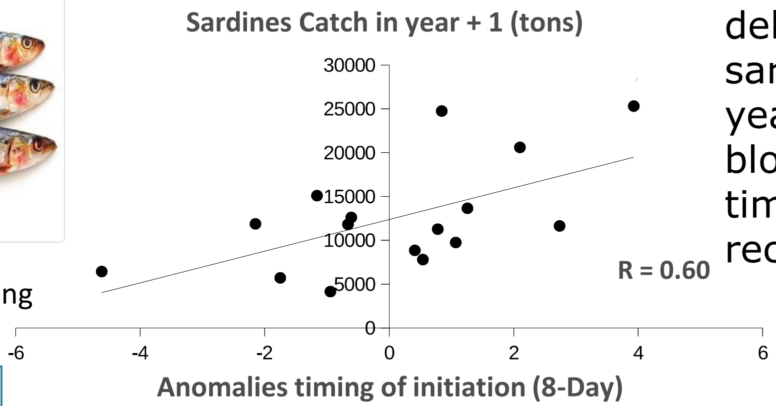
Sardine Catch as a function of Timing of Phytoplankton bloom

Ivory Coast, Gulf of Guinea



Time period: 1998 to 2014
Study based on OC-CCI data v3.0

Kassi, Racault, Mobio, Platt, Sathyendranath, Raitsos, Biophysical drivers of *Sardinella aurita* in Ivorian waters: Applications from remote-sensing observations and GIS



When the bloom initiation is delayed (positive anomalies) the sardines catch in the following year (t+1) are higher. A late bloom appears to be better timing for the larval survival and recruitment;

PML Plymouth Marine Laboratory

pogo

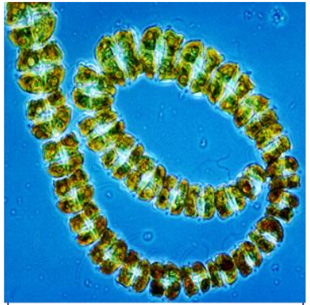
Harmful Algal Blooms (HABs), how remote sensing can help?

Ocean Colour applications: Harmful algal blooms

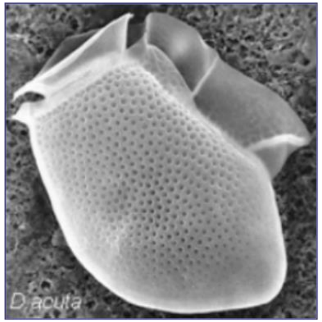
July 2014, Cascais

Photos Luisa Damaso & Marta Pimentel

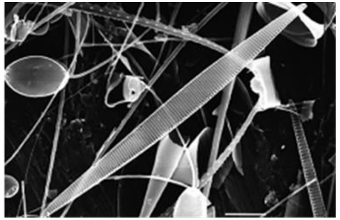
Harmful Algal Blooms (HABs) brief introduction



Dinofagellate
Gymnodinium catenatum

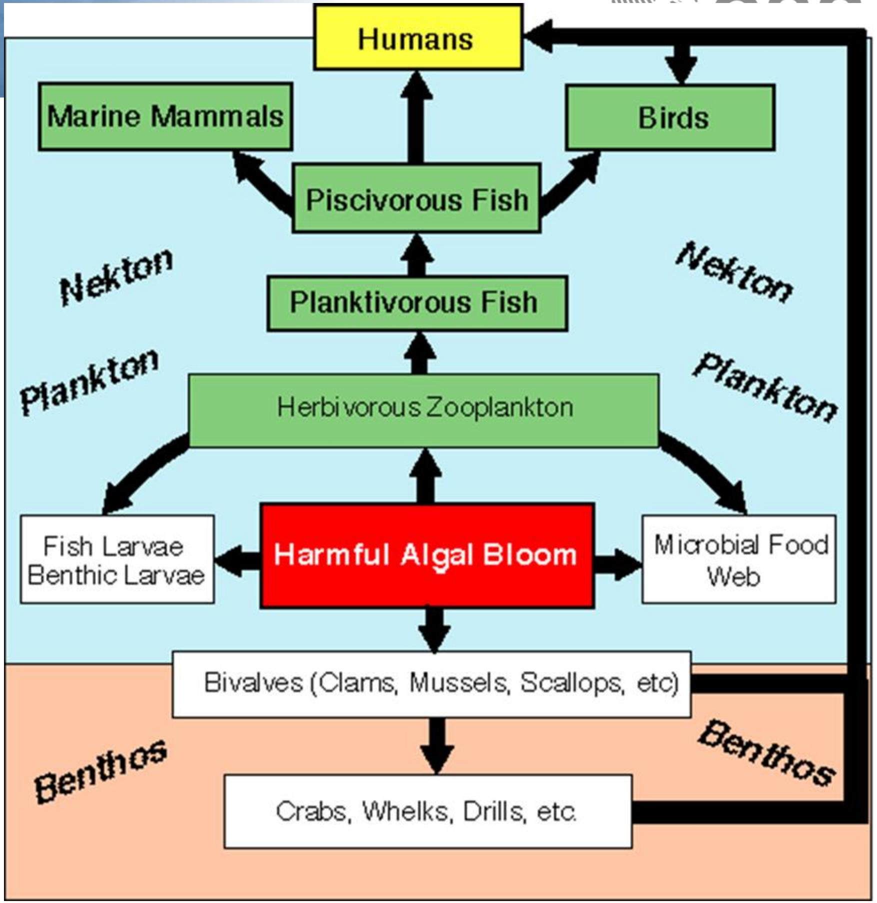


Dinoflagellate
Dinophysis acuta



Pseudo-nitzschia australis
Diatom

Toxic species
Occurring frequently off Iberian coast



South coast of Portugal, Algarve: Aug. 2004
Dinoflagellate *Lingulodinium polyedrum*

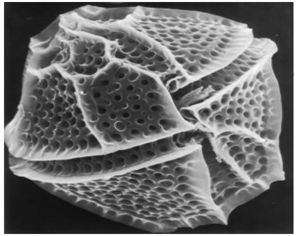


Photo Alexandra Cunha

Example of a bloom

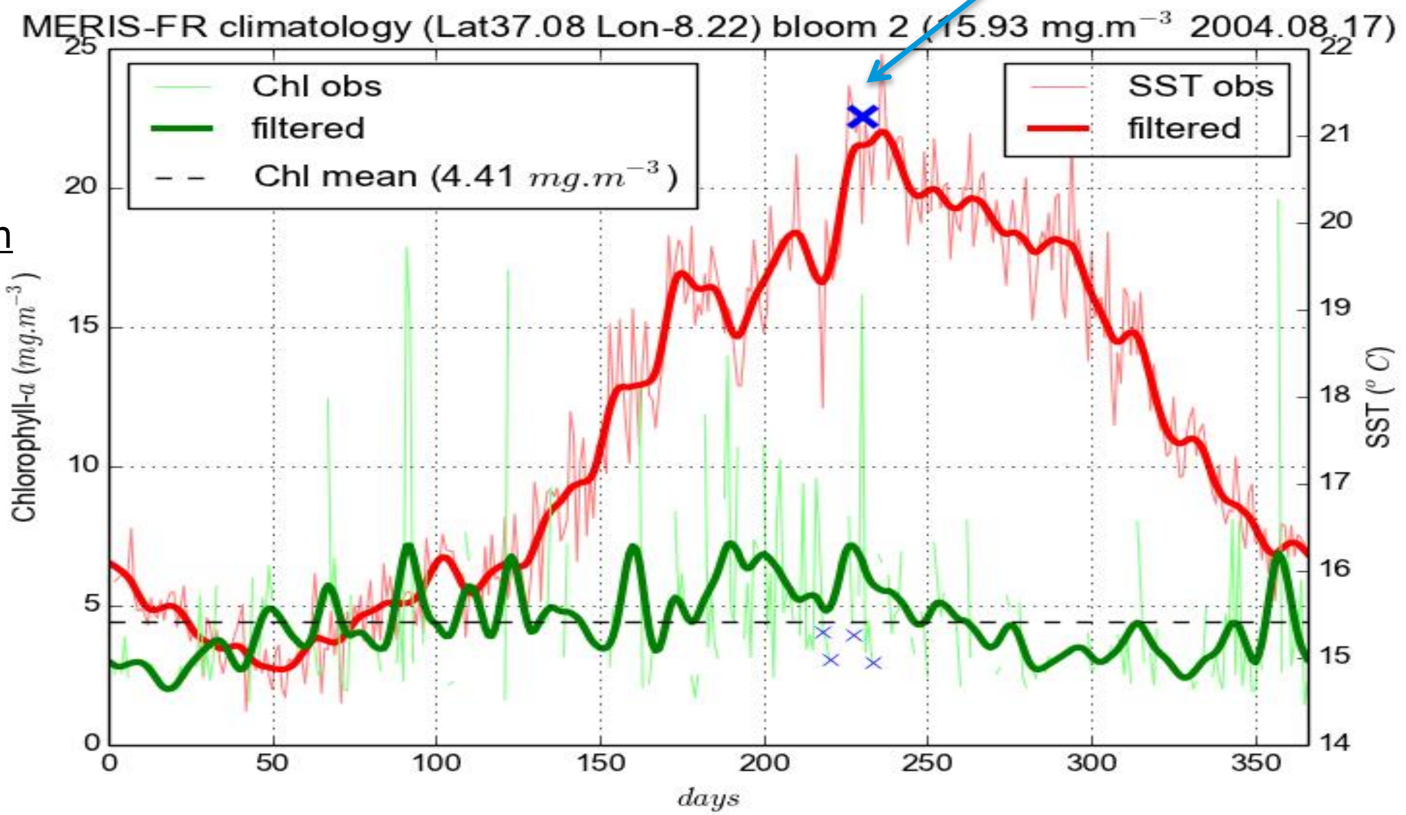
Cell concentration: $1x10^6$ cells /L

Chla estimated for Lingulodinium cells 12-20 µg /L

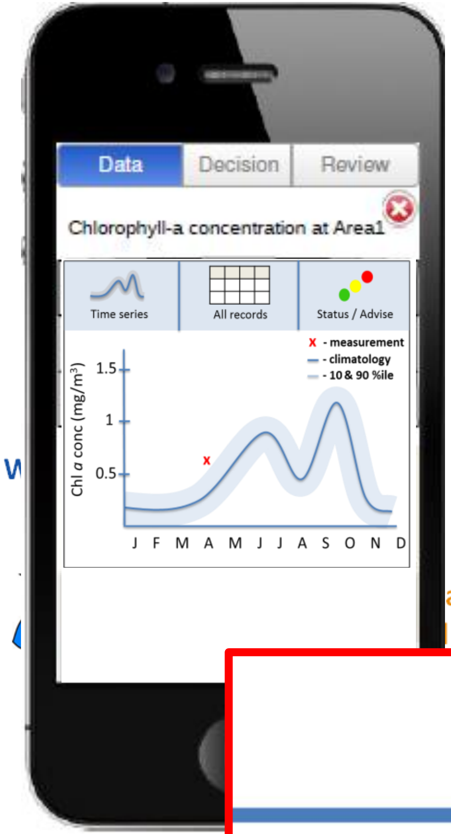
Phenology for Alvor, Algarve, and comparison with observed bloom

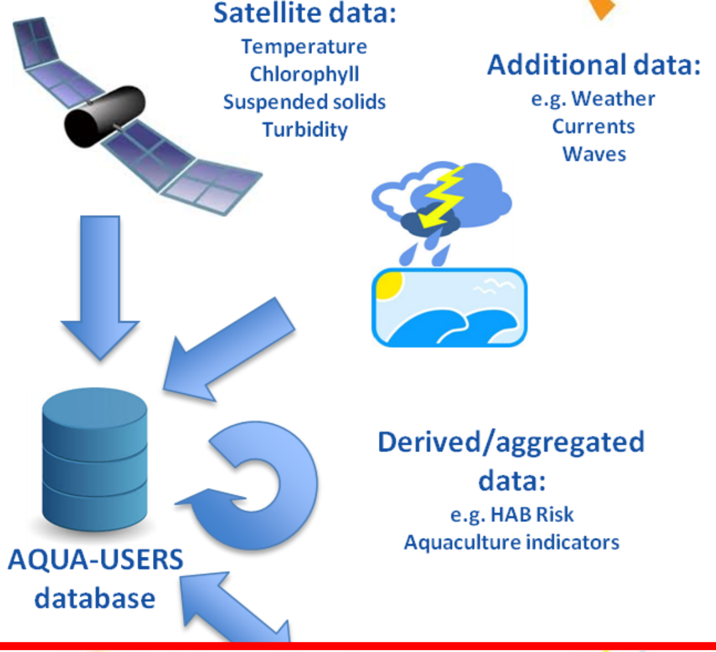
Using
MERIS
Full resolution

Good spatial
Resolution
Is crucial for
HABs
detection



Aquaculture daily decision support





International Ocean Colour Science Meeting 2017

Ocean Color data in a tool to support Aquaculture management

Sá, C.[1]; Couto, A.B.[1]; Brito, A.C.[1]; Brotas, V.[1]; Eleveld, M.[2]; Dale, T[3]; Poser, K.[4]; Laanen, M.[5]

See also Poster Session 2

IPMA UAlg CIMA UNIVERSIDADE DO ALGARVE CENTRO DE INVESTIGAÇÃO MARINHA E AMBIENTAL FCT Fundação para a Ciência e a Tecnologia

Estudo da resposta da biomassa fitoplanctónica durante um episódio de afloramento utilizando a deteção remota e dados in situ no âmbito do Projeto HabWave

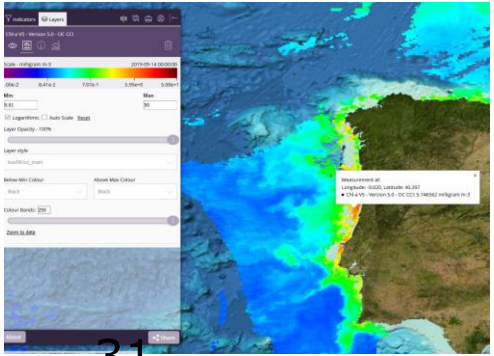
Ocean Colour Summer School
financiado pela FCT

Pedro Nunes

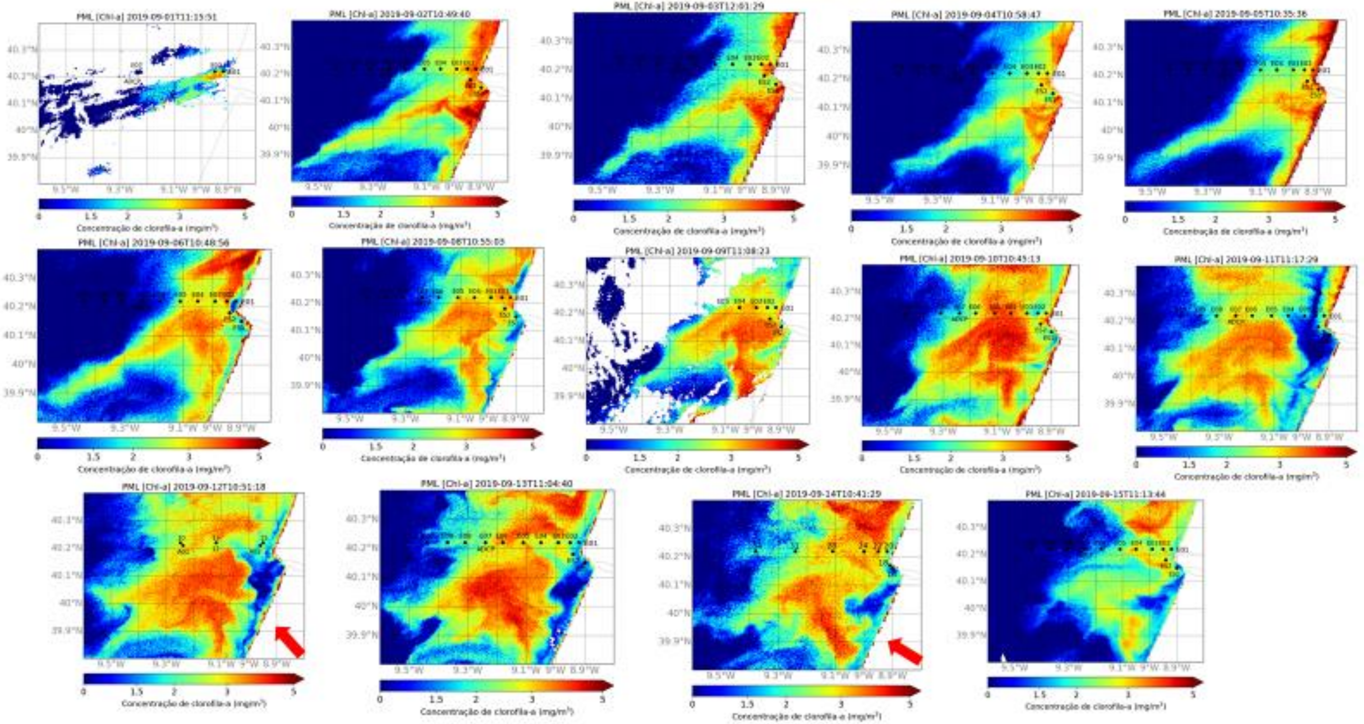
Orientadores: Dr. Paulo Oliveira e Prof.ª Dra.

- Tema tese aluno Pedro Nunes,
- Ciências do mar 2020/2021

Portal cci



Plymouth Marine Laboratory (PML) - https://piscismod.eofrom.space



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