

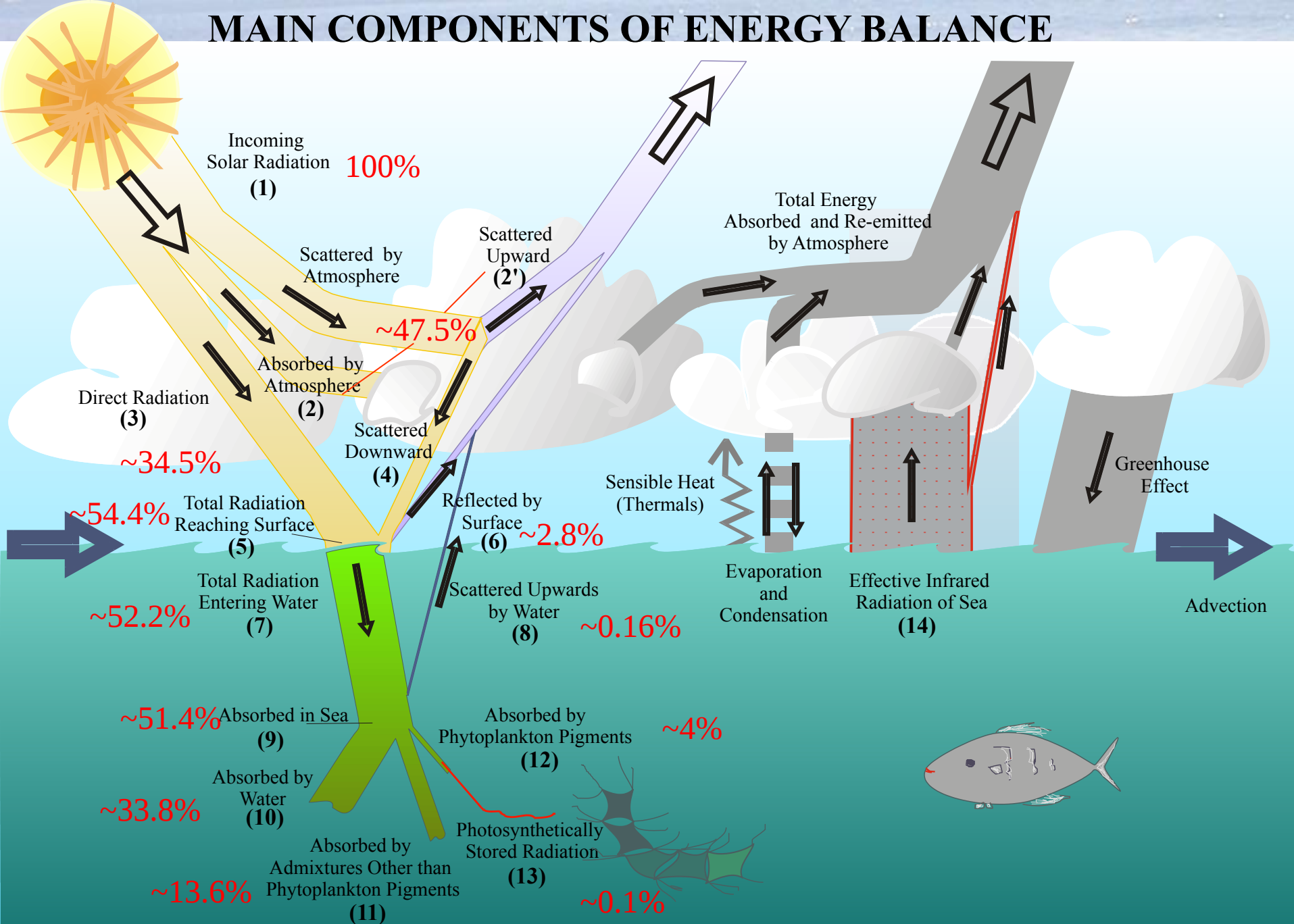
Introduction to bio-physics

Joanna Stoń-Egiert

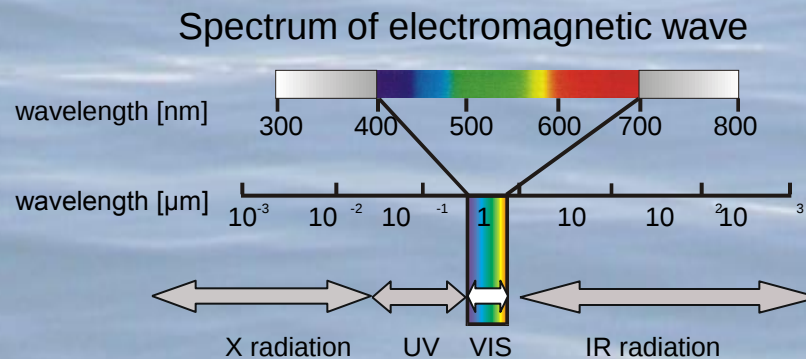
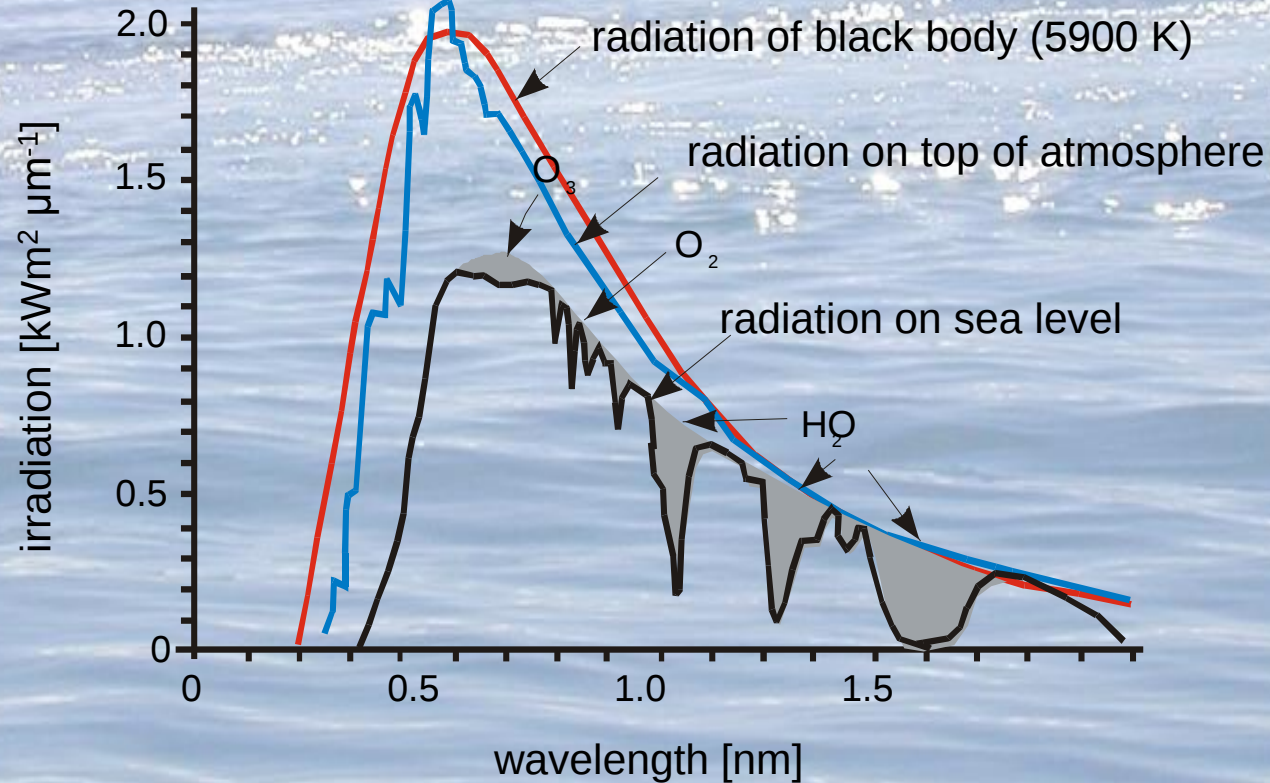


Biophysics Laboratory
Institute of Oceanology
Polish Academy of Science

MAIN COMPONENTS OF ENERGY BALANCE

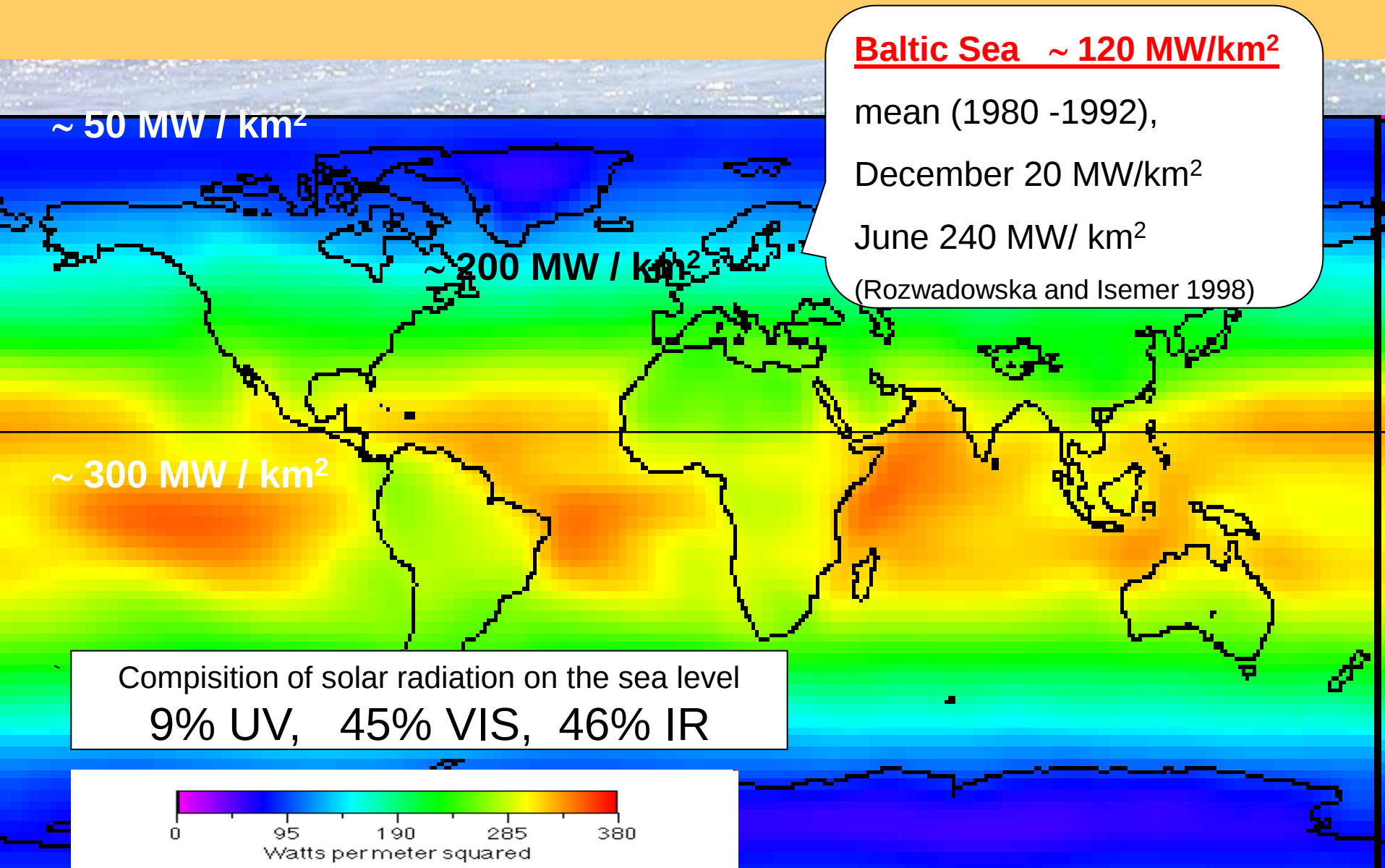


Sun light – the source of energy reaching the Earth



Sun light – the source of energy reaching the Earth

Average radiation power absorbed on the Earth

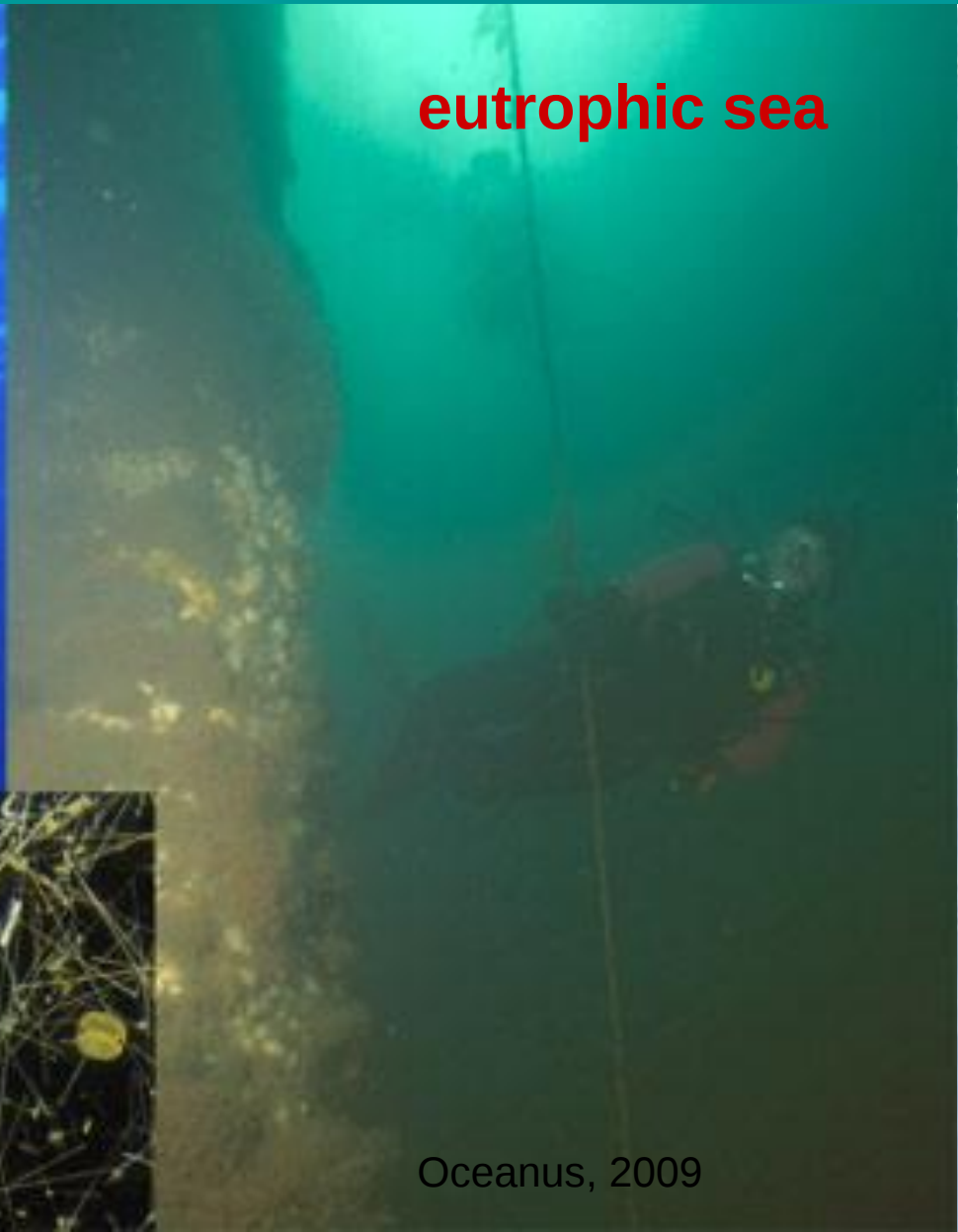


(Image created by the CoVis Greenhouse Effect Visualizer)

Light penetration into the sea deep

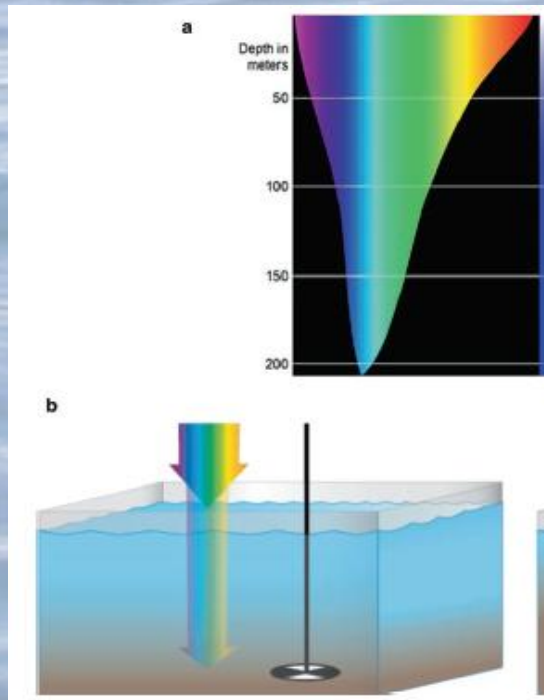
oligotrophic sea

eutrophic sea

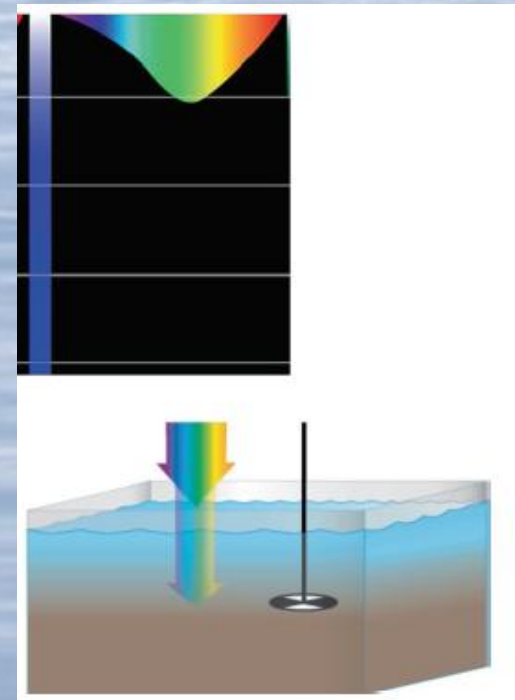


Transmission of light in different waters (400-700nm)

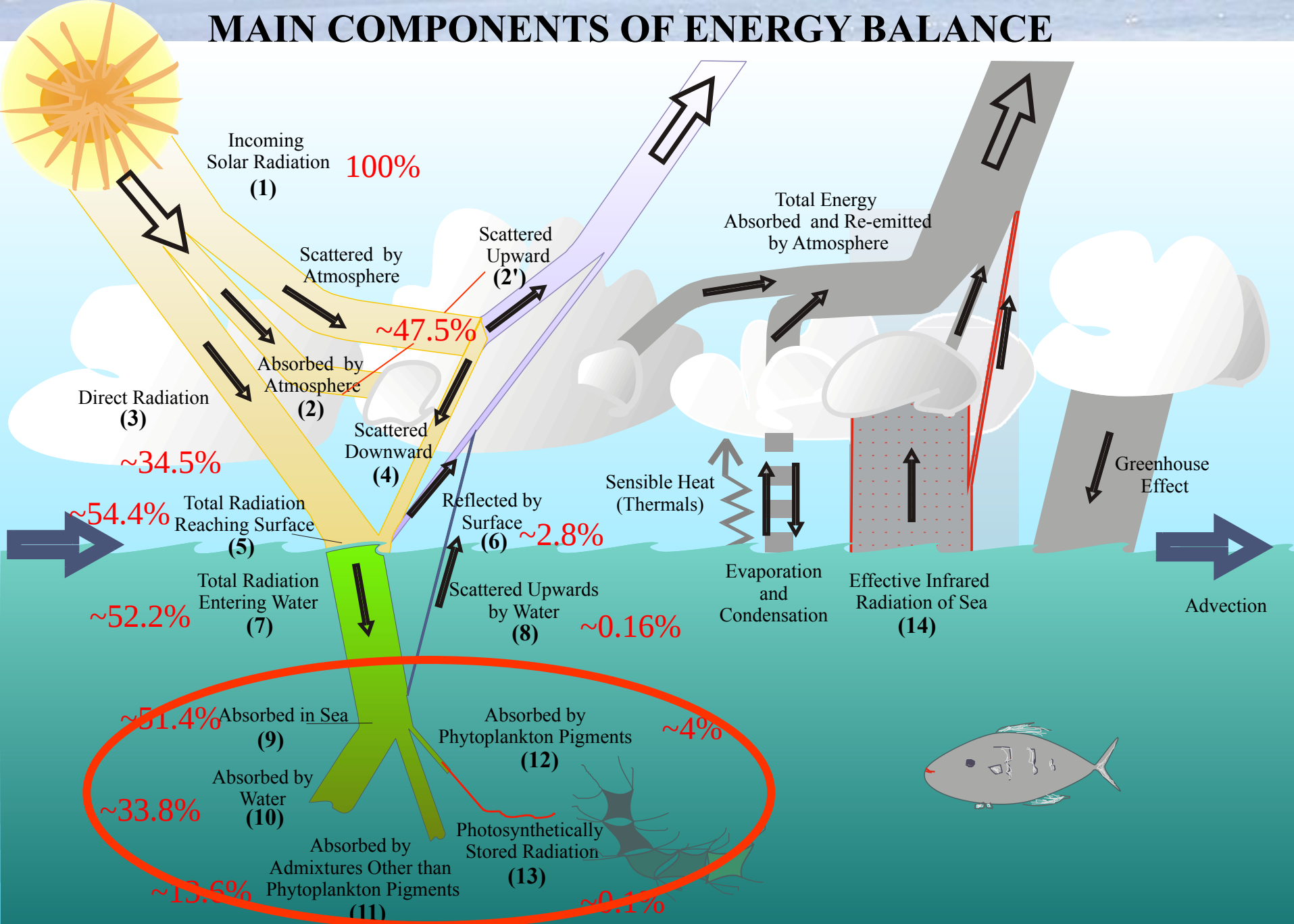
Open oligotrophic waters



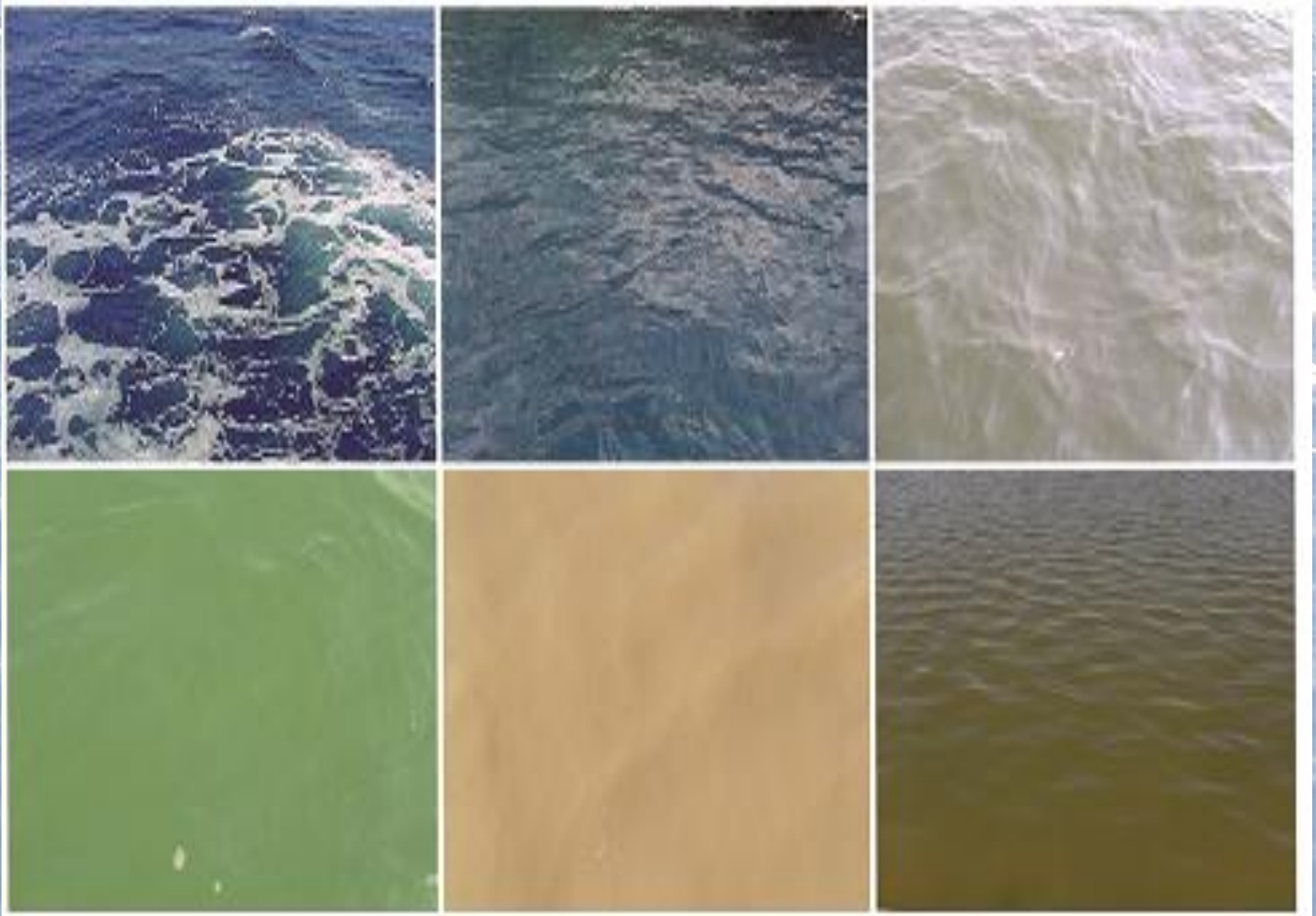
Eutrophic coastal waters



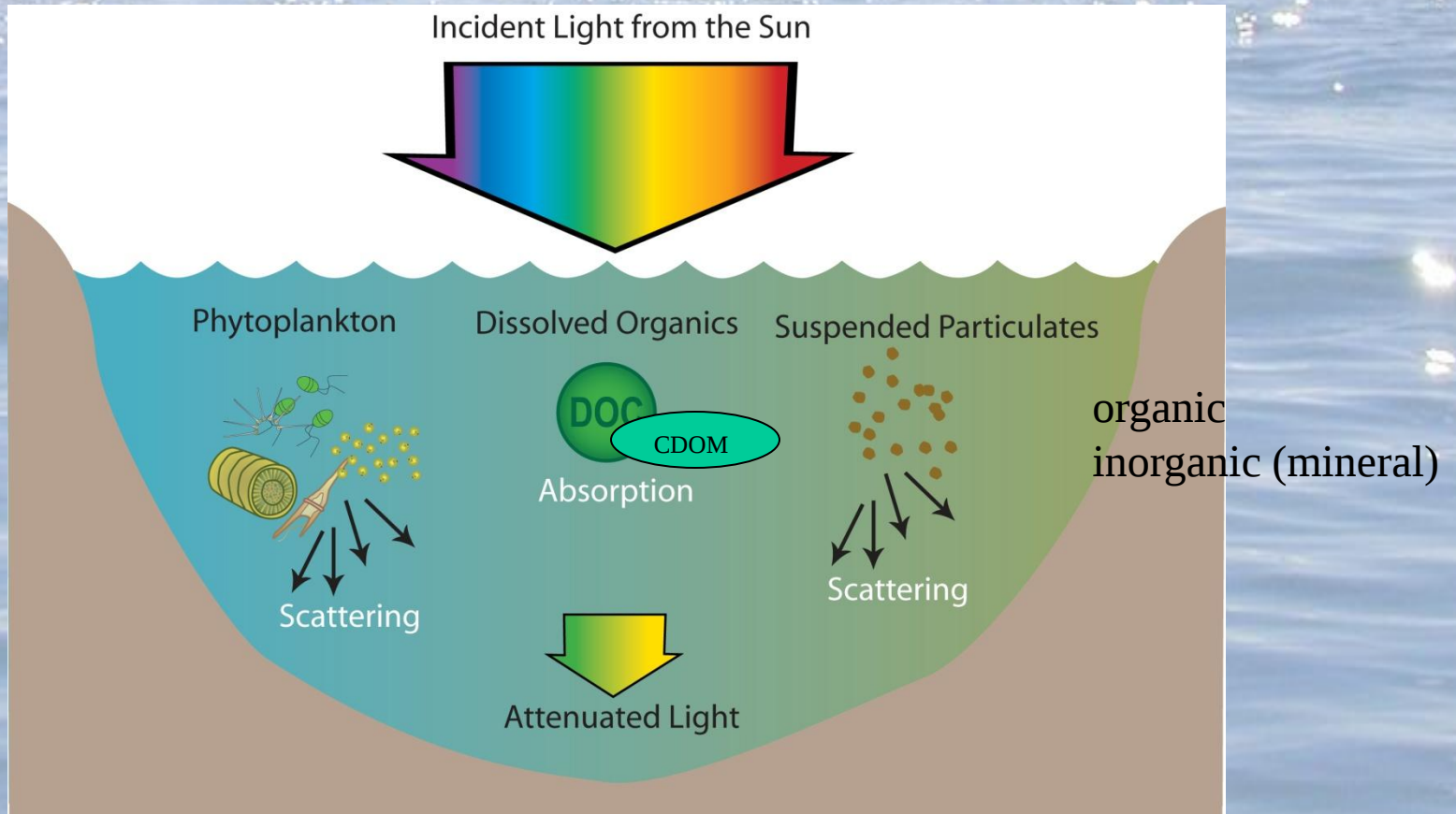
MAIN COMPONENTS OF ENERGY BALANCE



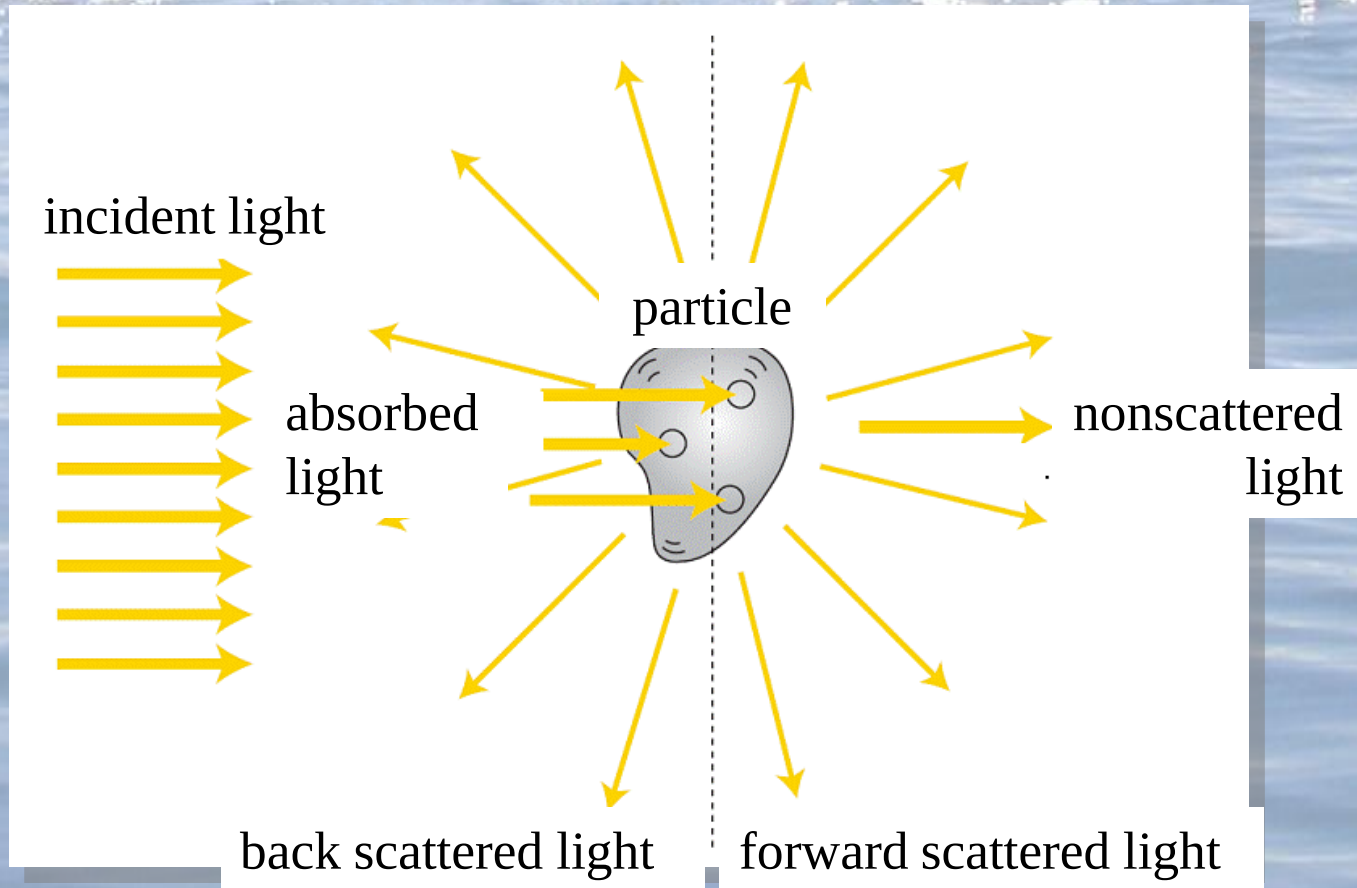
Water colour



Main components influence on light distribution



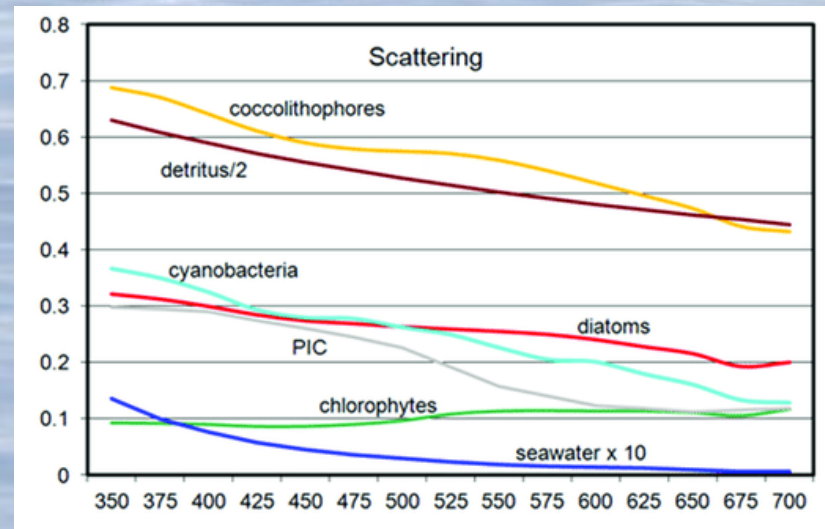
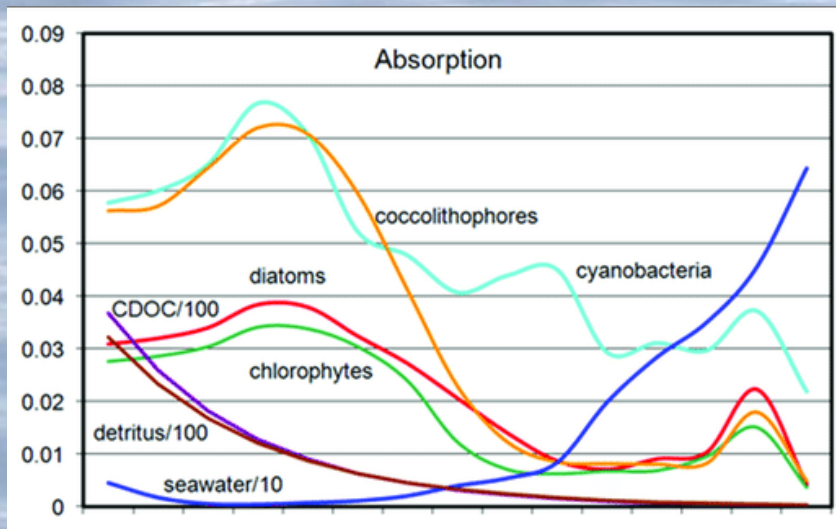
The interaction of light with the environment



Processes: absorption + scattering = attenuation of light

Interaction of light with sea components

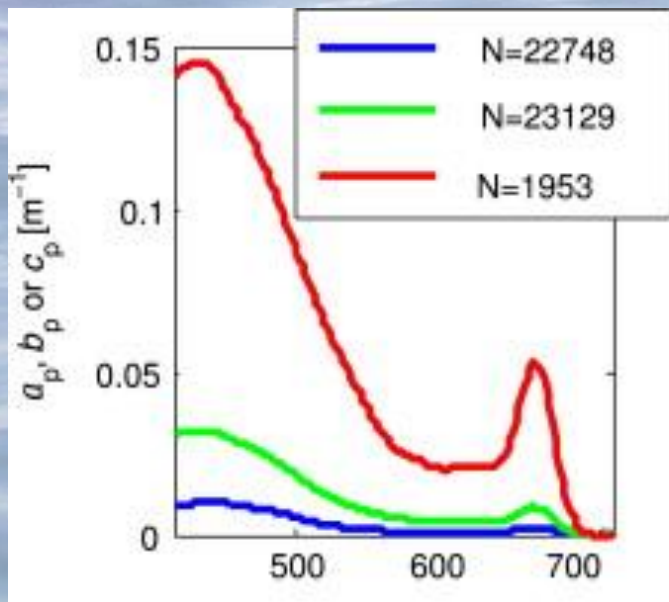
m^{-1} (water, detritus, and CDOC);
 $\text{m}^2 \text{mg chl}^{-1}$ (phytoplankton chlorophyll);
 $\text{m}^2 \text{mg}^{-1}$ (PIC)



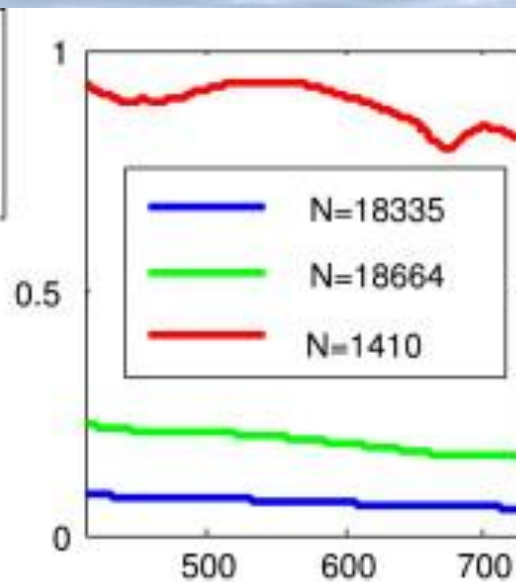
Gregg WW and Rousseaux CS (2017) Simulating PACE Global Ocean Radiances. *Front. Mar. Sci.* 4:60. doi: 10.3389/fmars.2017.00060

Averaged spectra of absorption, scattering and attenuation for different chlorophyll ranges

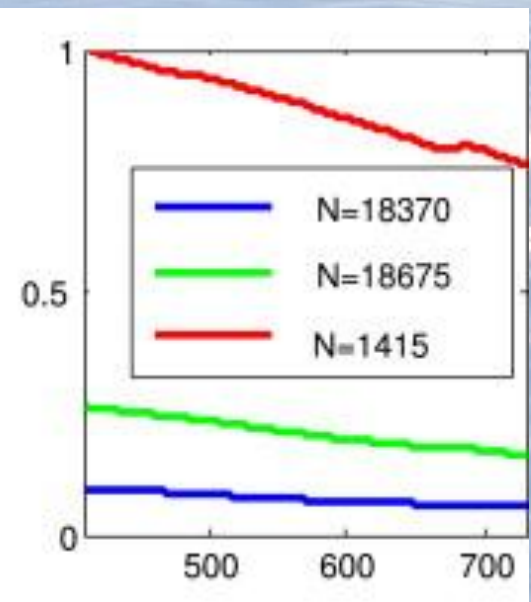
absorption



scattering



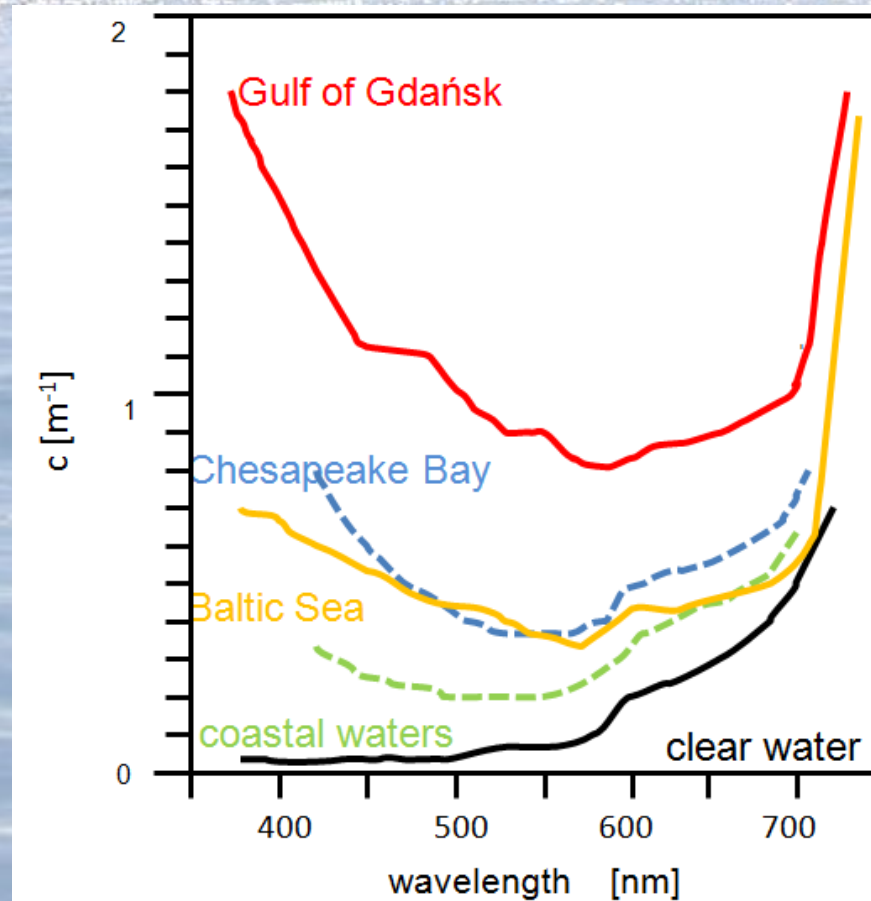
attenuation



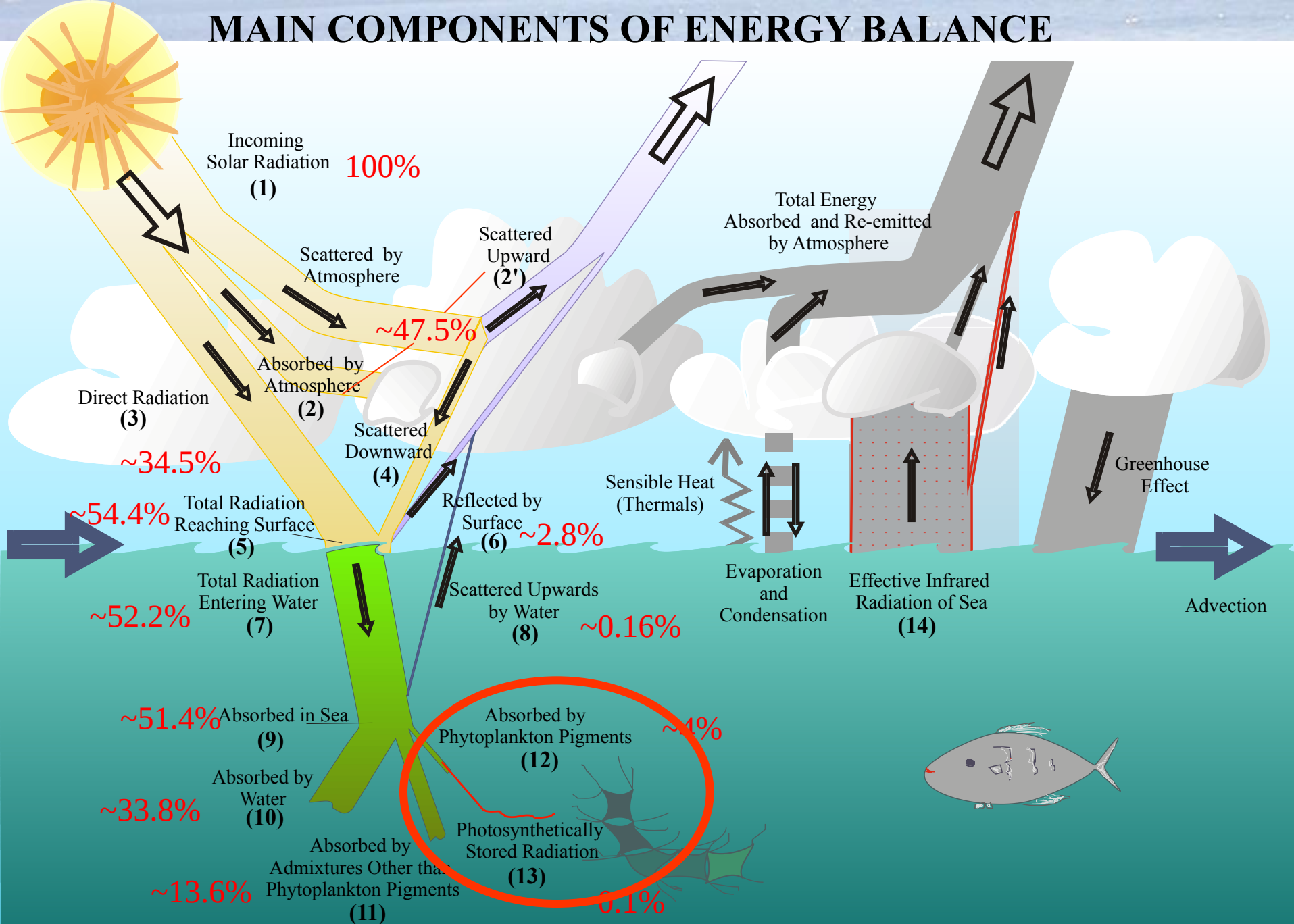
$\text{Ca} < 0.1$, $0.1 < \text{Ca} < 1$, $1 < \text{Ca}$

N - number of spectra

Attenuation coefficient in different waters

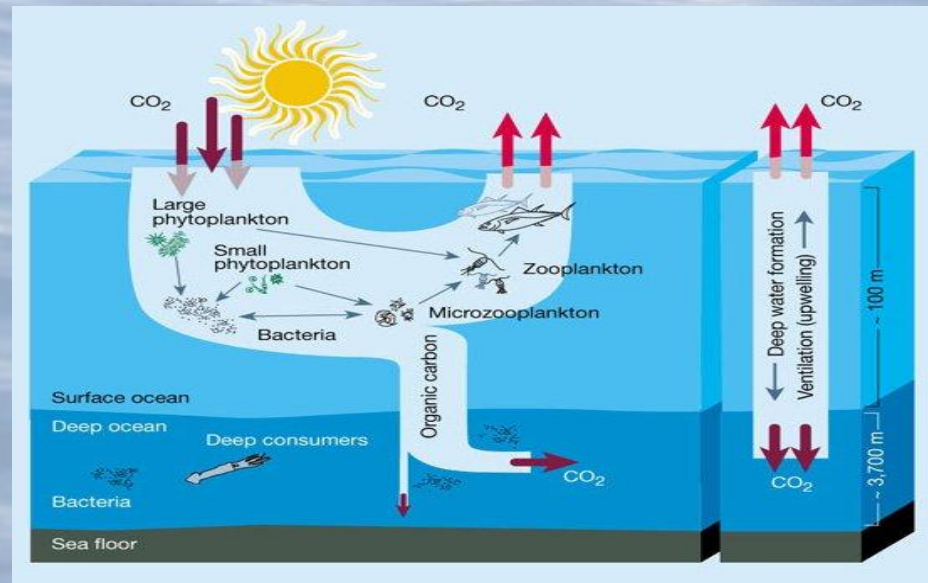
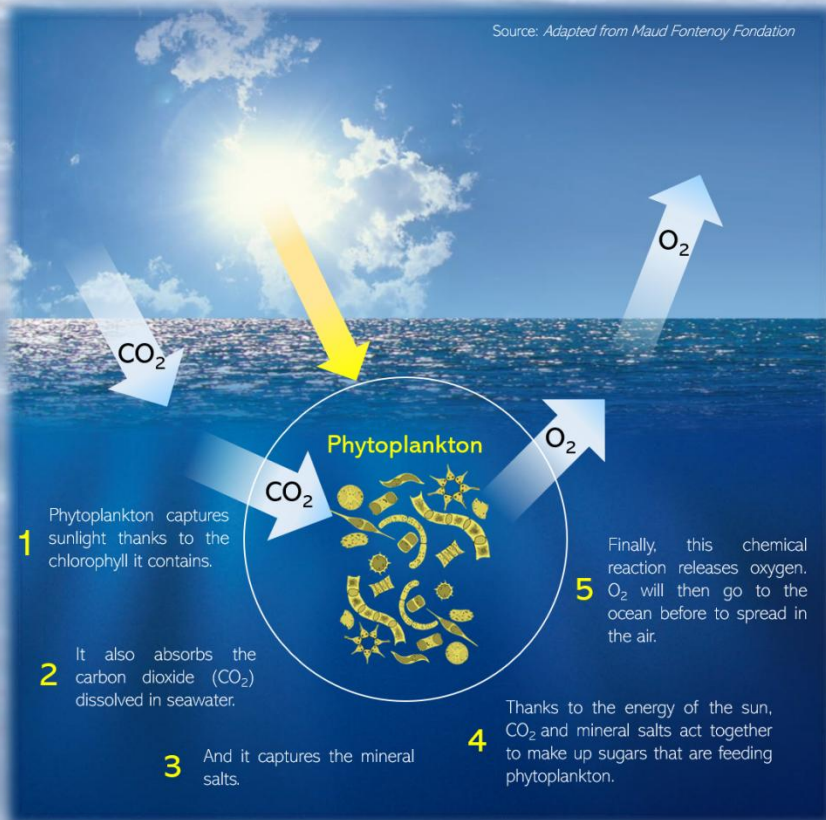
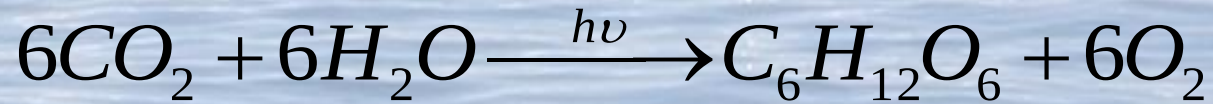


MAIN COMPONENTS OF ENERGY BALANCE



Photosynthesis

is a process used by plants and other organisms to convert light energy into chemical energy that, through cellular respiration, can later be released to fuel the organism's metabolic activities.



Photosynthesis



Primary production

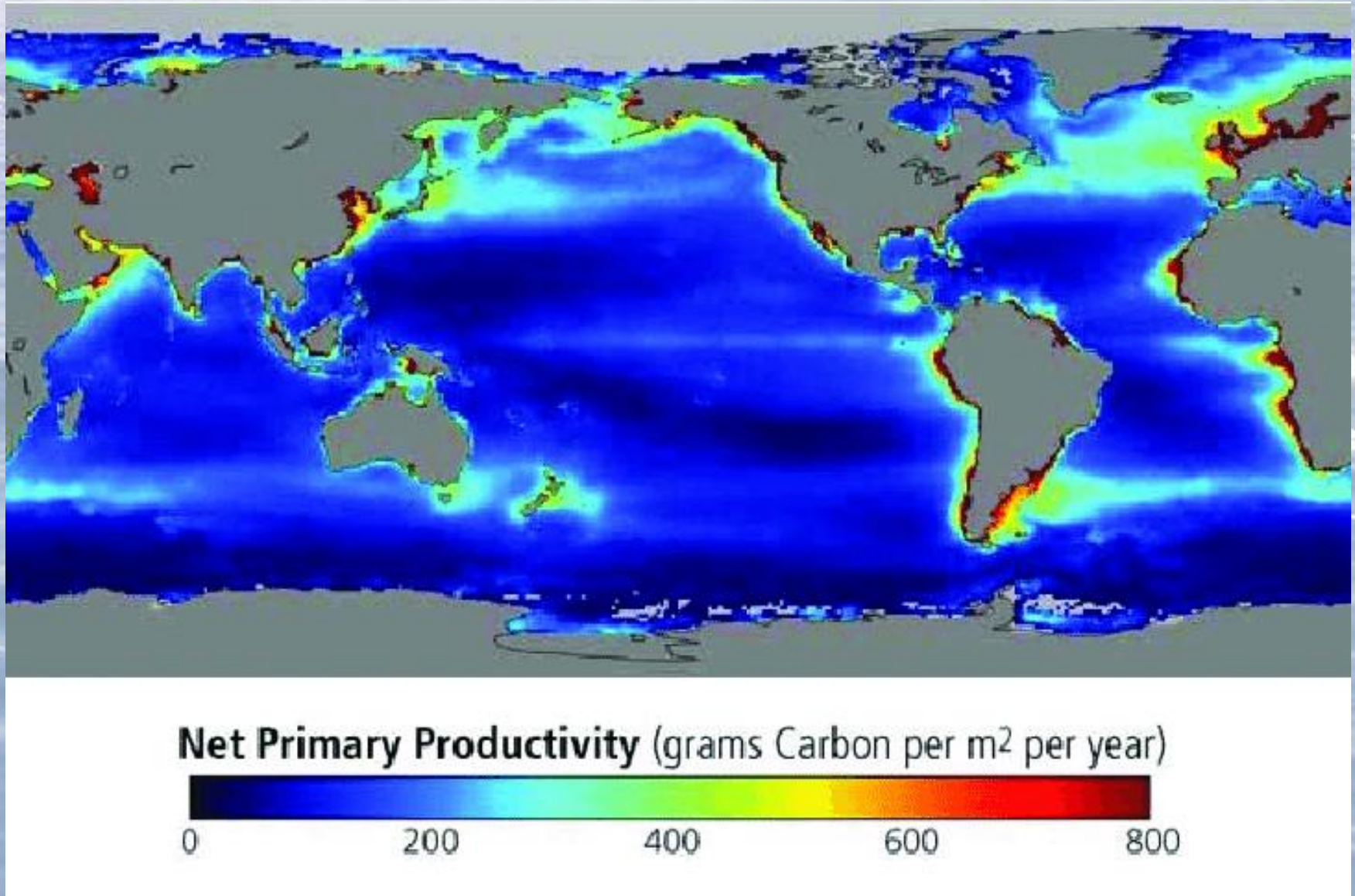
ecological importance

The main process in Earth Biosphere responsible for supplying ecosystems with energy. Phytoplankton – first link in trophic chain

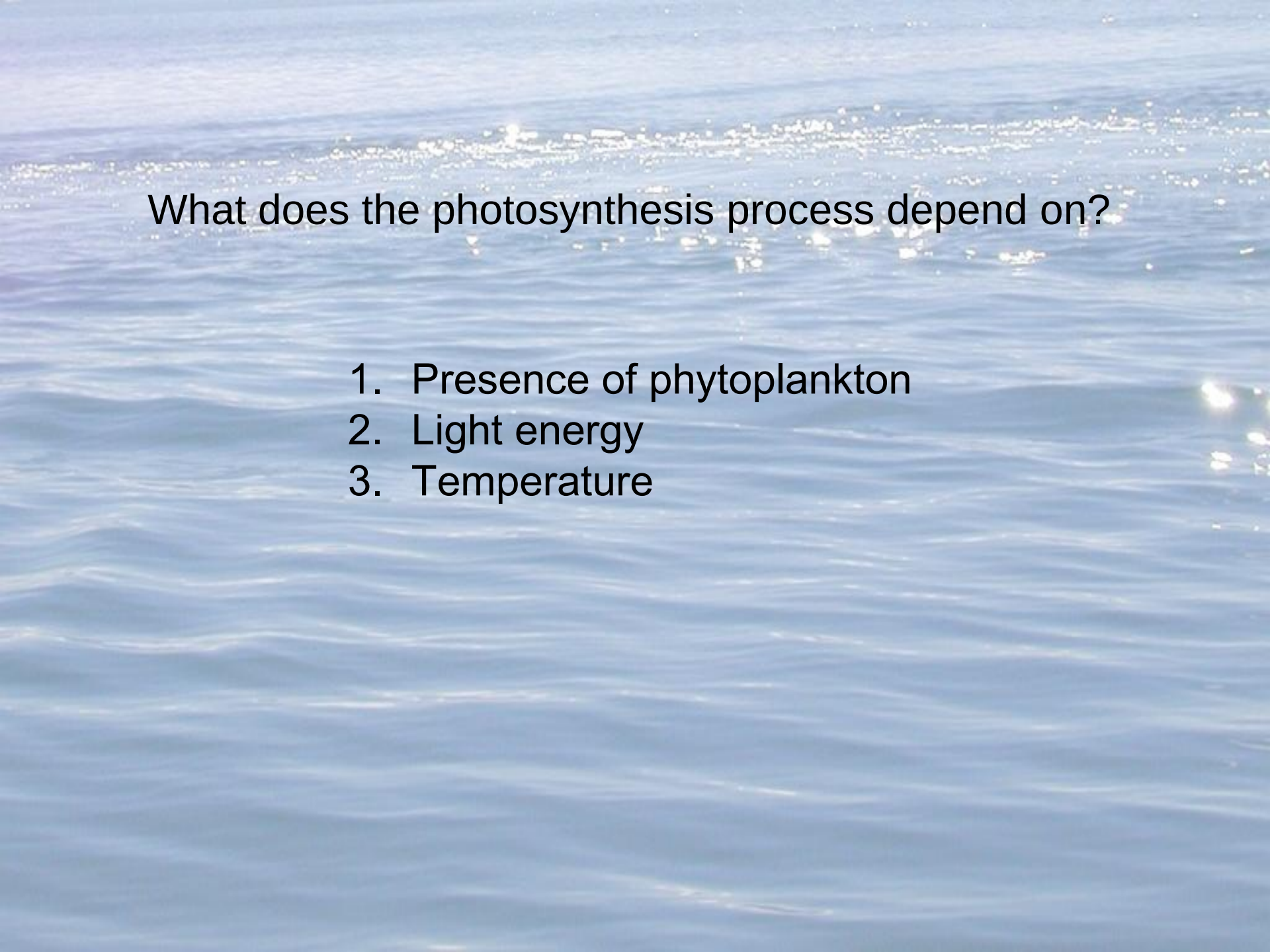
climatology importance

Carbon cycle and oxygen balance in nature – responsible for greenhouse effect in atmosphere

Global primary production in the oceans



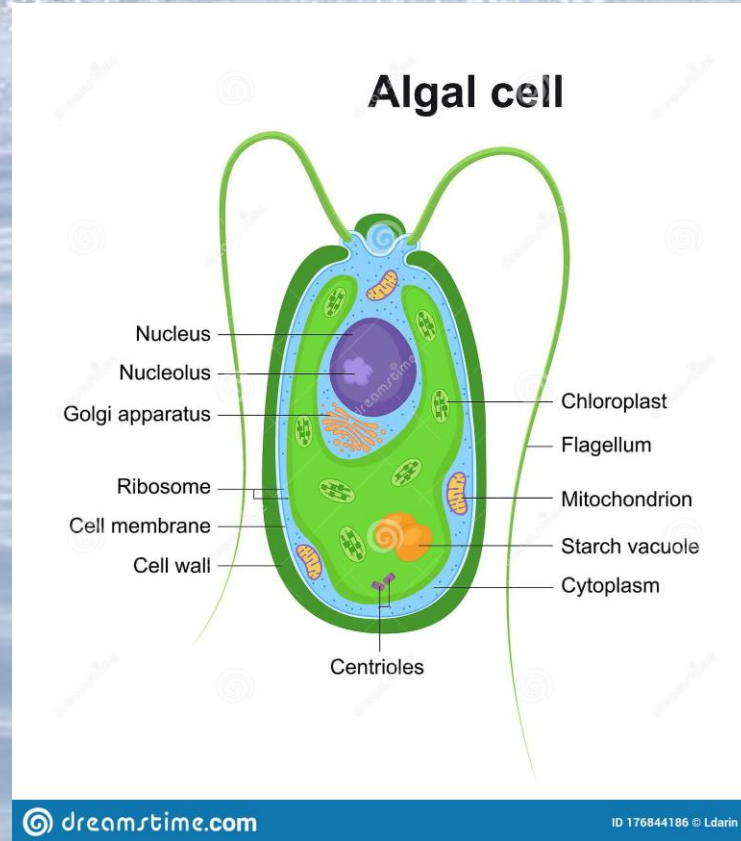
Source: earthobservatory.nasa.gov



What does the photosynthesis process depend on?

1. Presence of phytoplankton
2. Light energy
3. Temperature

Energy absorbers – pigments in phytoplankton cells



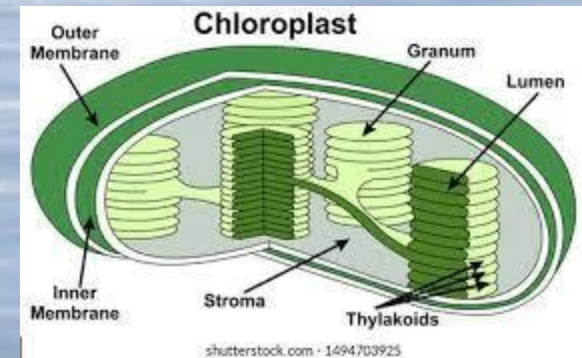
Composition of organic matter in chloroplast

protein - 50% (weight)

lipids - 30 - 50%

pigments- 2 -10%

Parsons et al. 1977



- pigments create macromolecular complex with a few types of protein
- pigment-protein complexes are organized in photosynthetic units – photosystems I and II, located in thylakoid membrane in a heterogeneous and asymmetric manner

Division and structure of pigments

More than 650

Phytoplankton pigments

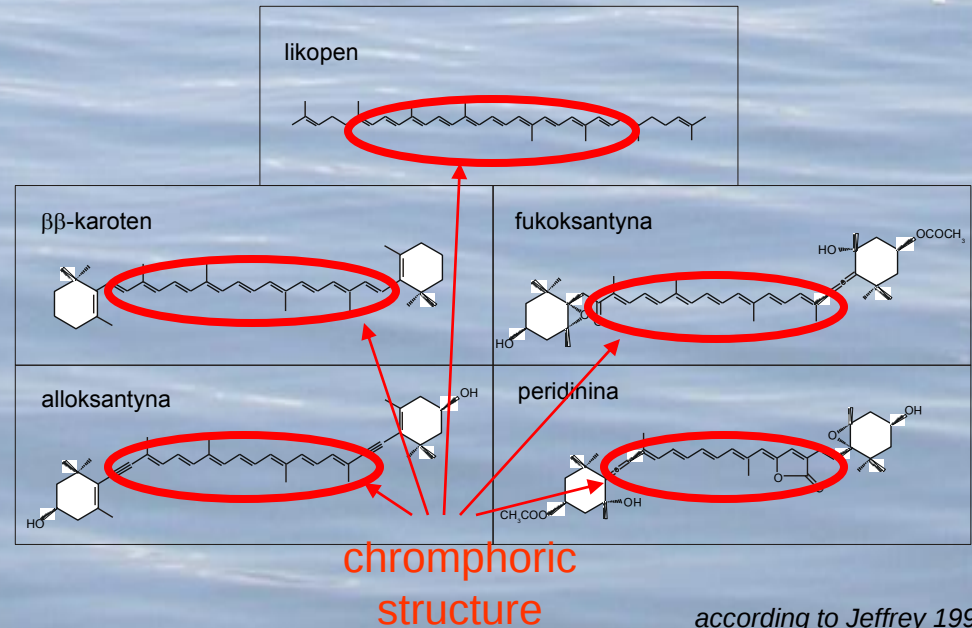
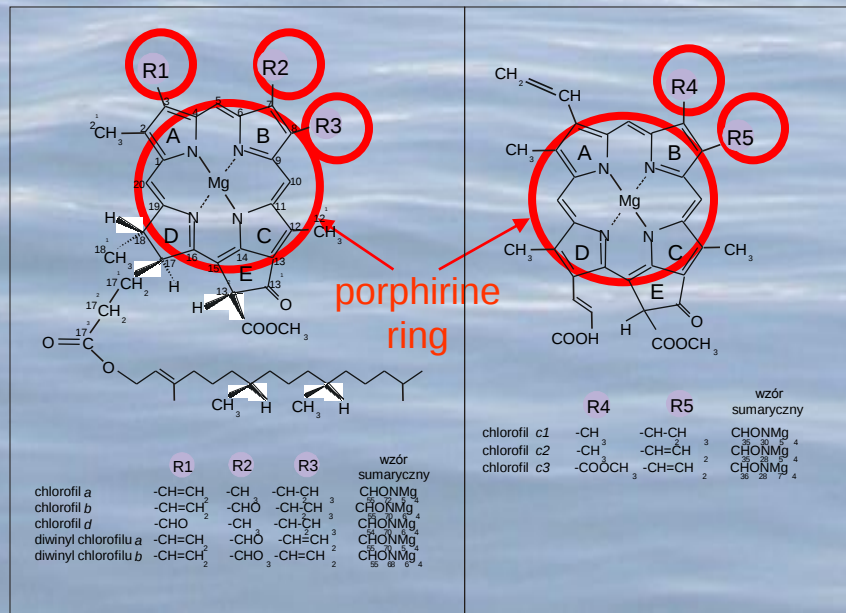
→ {
phycobilins
mycosporines

chlorophylls:
a, b, c1, c2, c3

carotenoids:
carotenes $C_{40}H_{56}$
xanthophylls $C_{40}H_{56}O_{1-8}$

Example of chemical structure of pigments

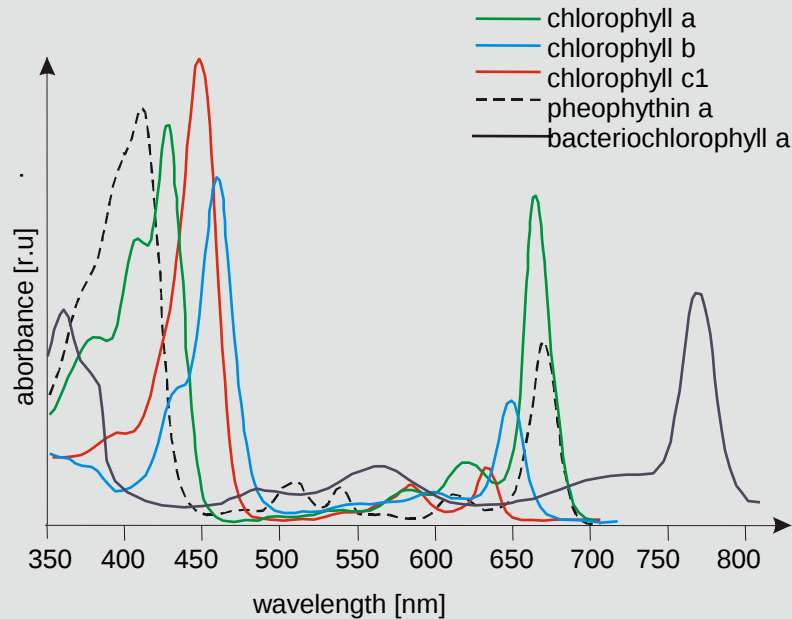
substituents



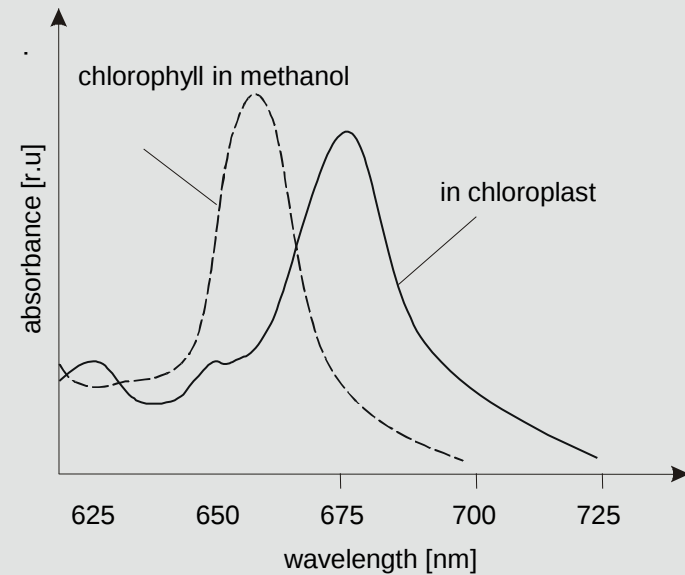
Main properties of pigments

- absorption of sunlight in VIS range (350 - 700 nm)

Chlorophylls absorption spectrum



- 100% acetone - chlorophyll a, b, pheophytin a
- diethyl ether - chlorophyll c1

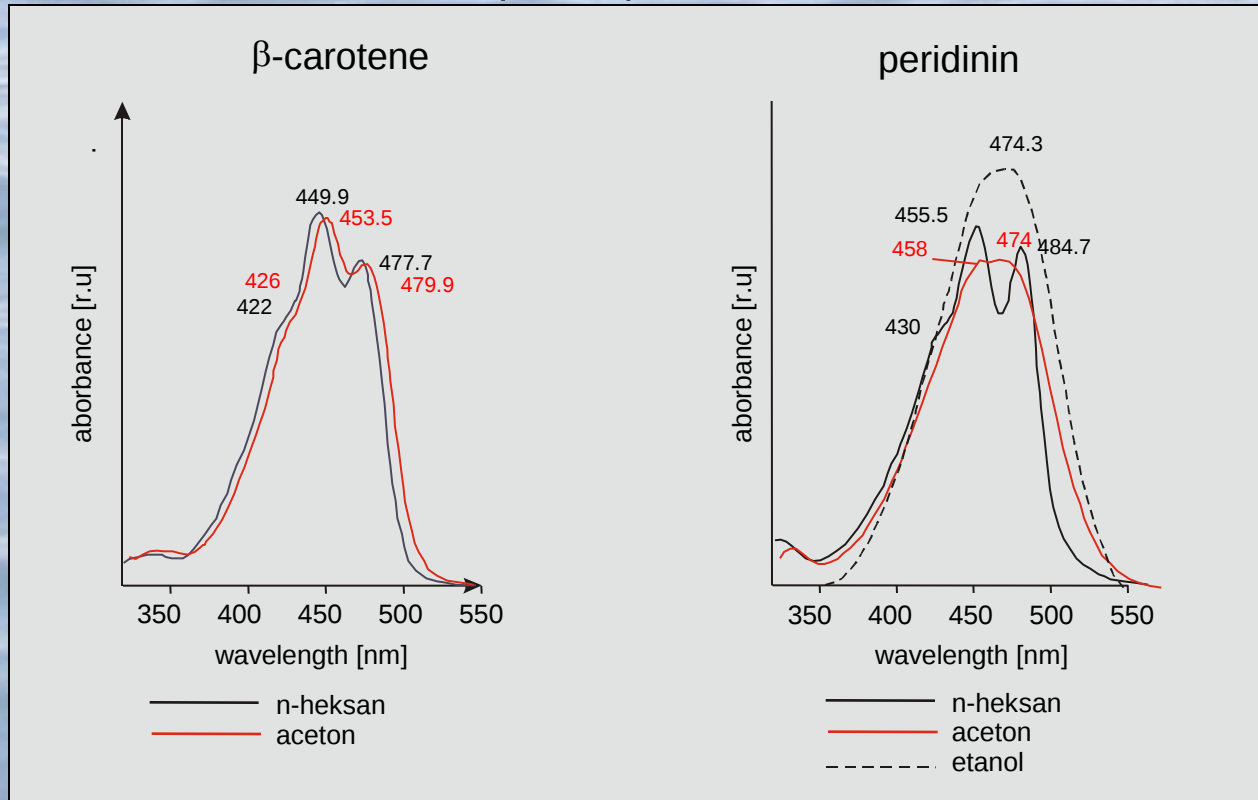


Differences in absorption spectrum in chlorophyll a extract and chlorophyll bounded in pigment-protein complex in chloroplast membrane

Main properties of pigments

- absorption of sunlight in VIS range (350 - 700 nm)

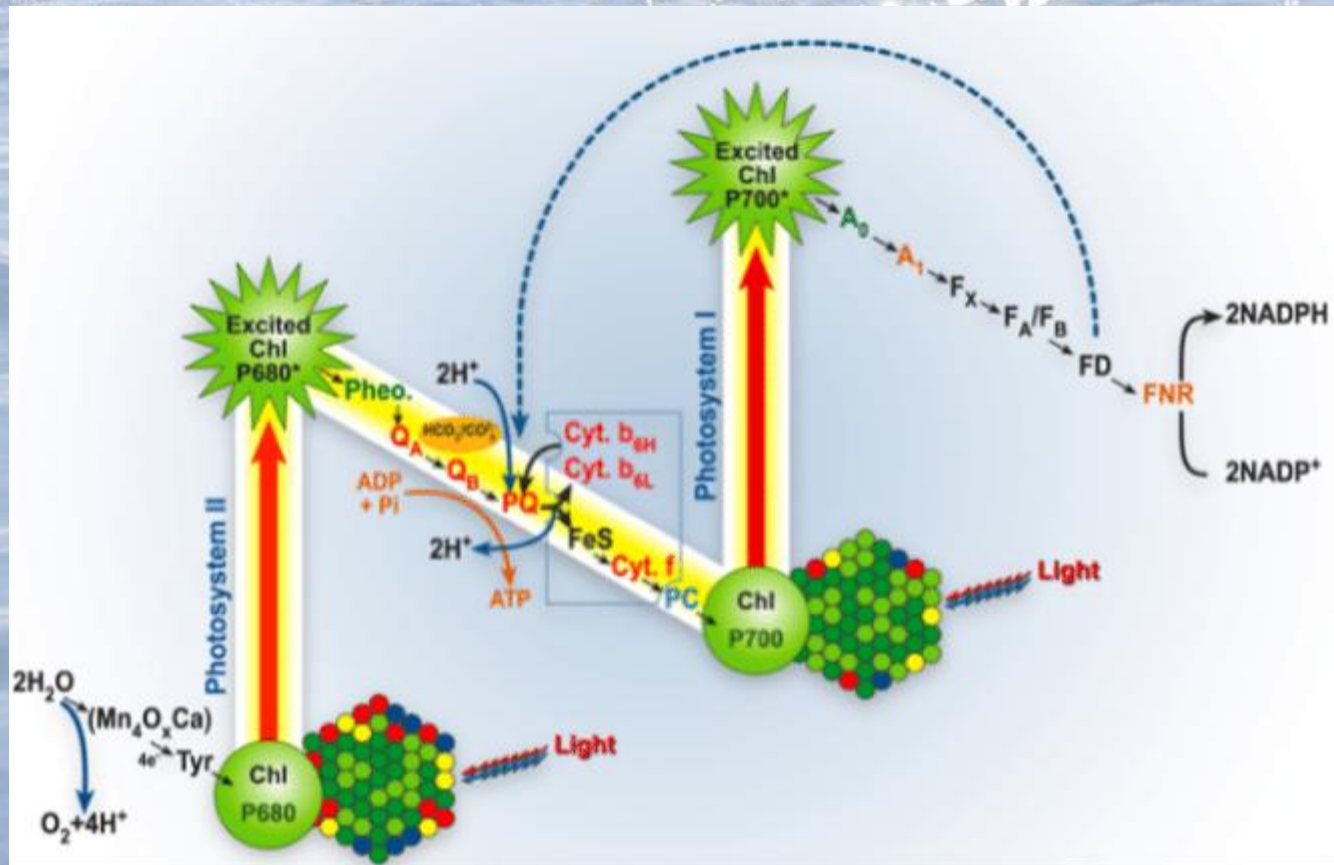
Absorption spectrum of carotenoids



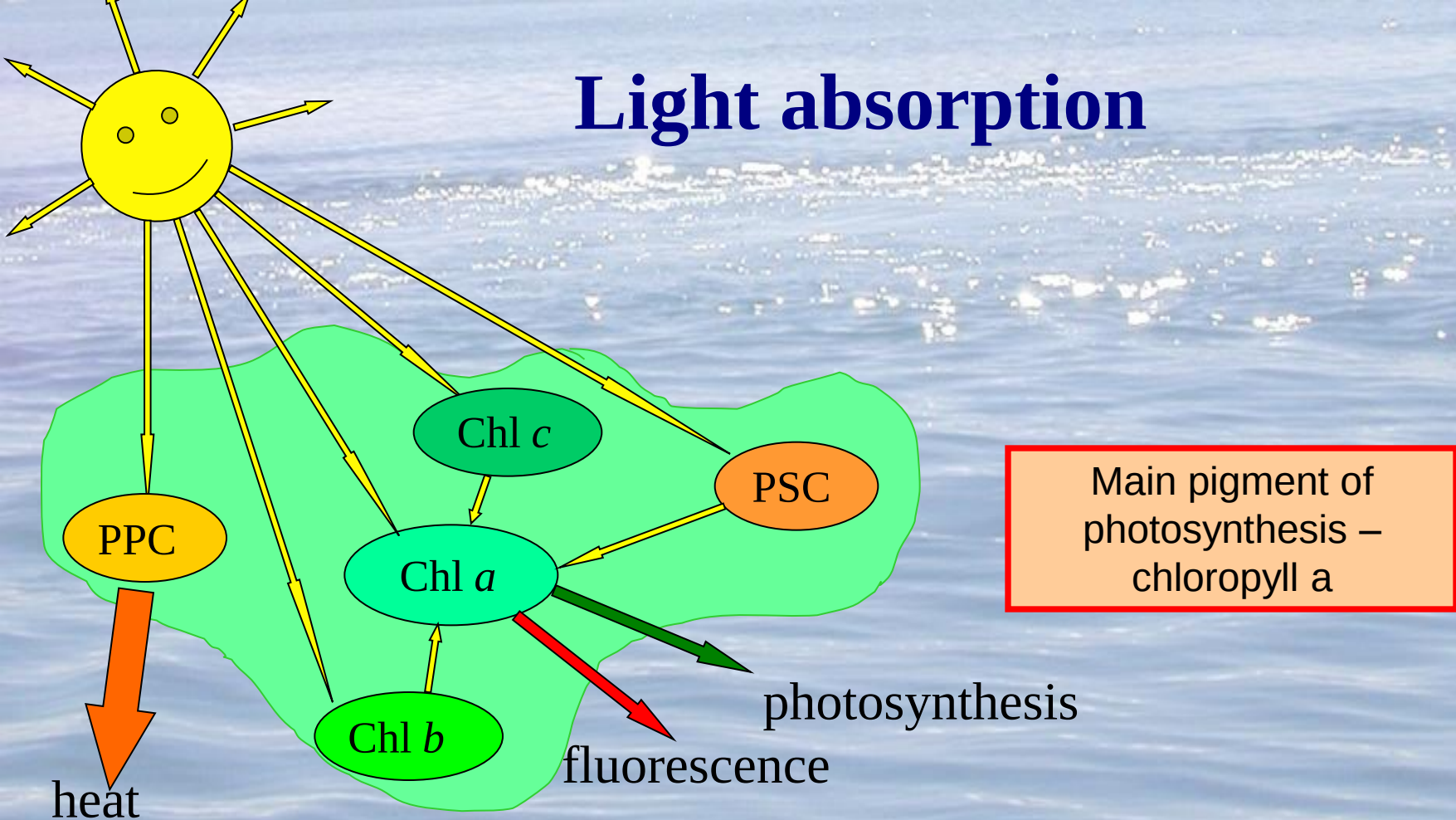
according to Jeffrey et al. 1997

Z-scheme of photosynthesis

describes the oxidation/reduction changes during the light reactions



Light absorption



Photoprotecting pigments (PPC)

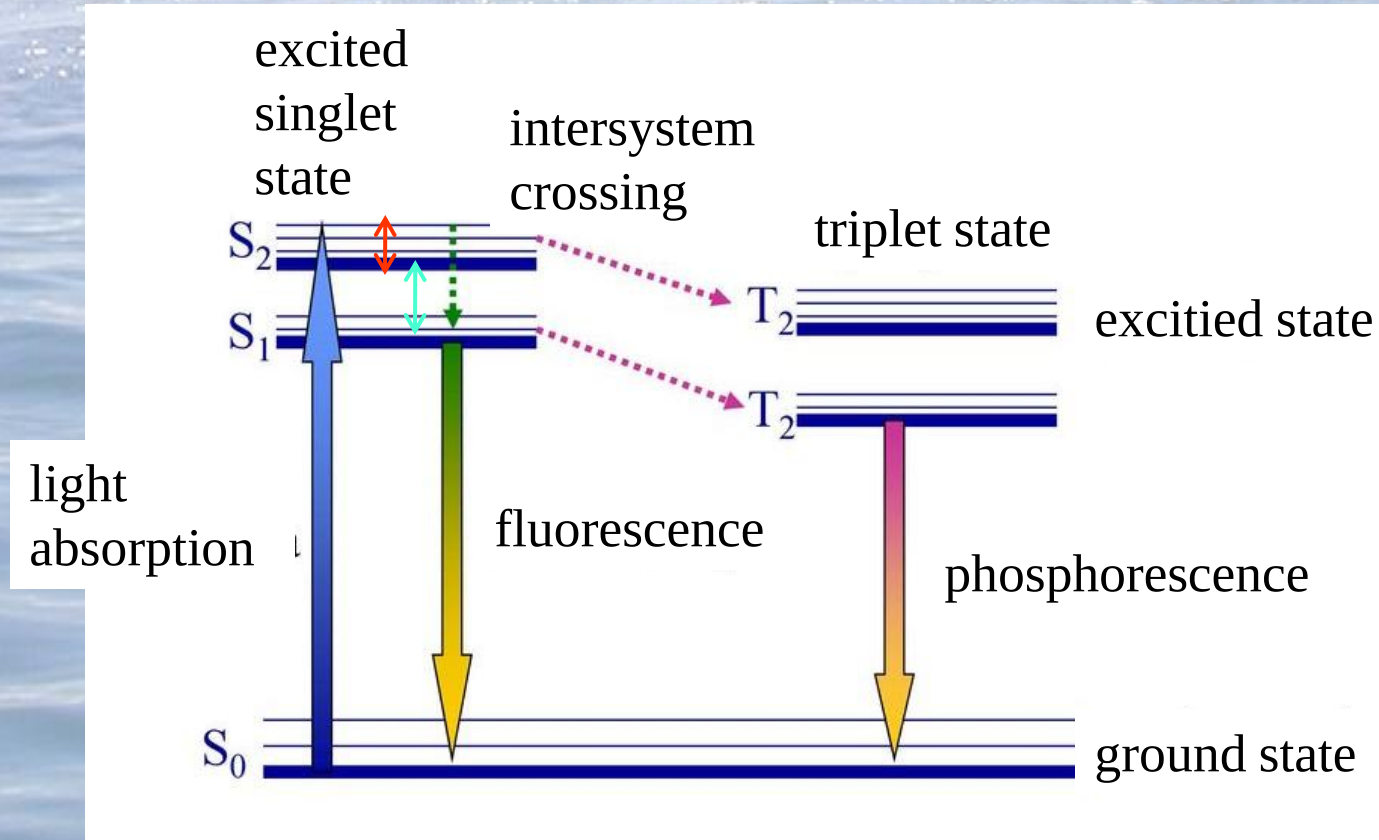
- antioxidant effect - reactions with free radicals,
- suppression of the singlet and triplet states of chlorophyll
- xanthophyll cycle

Photosynthetic pigments (PSC)

- absorption and transfer of some energy to the chlorophyll a molecule (function of the so-called photosynthetic antenna)

Jabłoński diagram

– possible energy transition between molecules

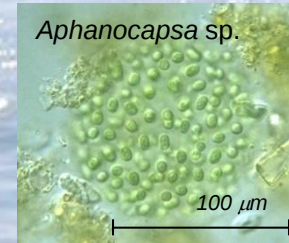


vibration (oscillatory) relaxation

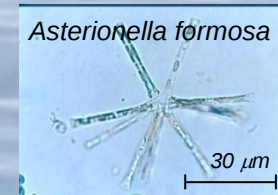
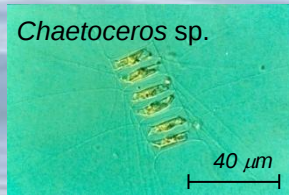


intramolecular conversion

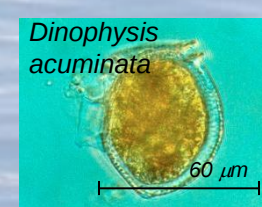
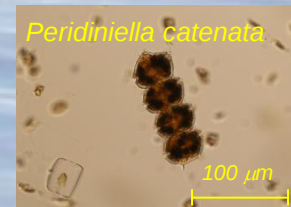
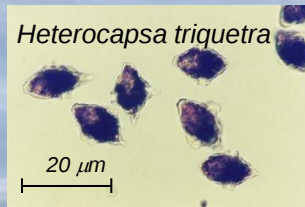
Phytoplankton classes – biotic factor determining pigments composition



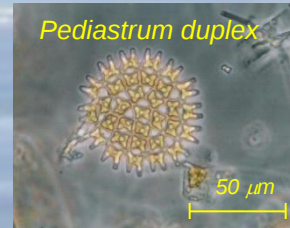
cyjanobacteria



diatoms



dinophytes



chlorophytes

cryptophytes

Phytoplankton pigments

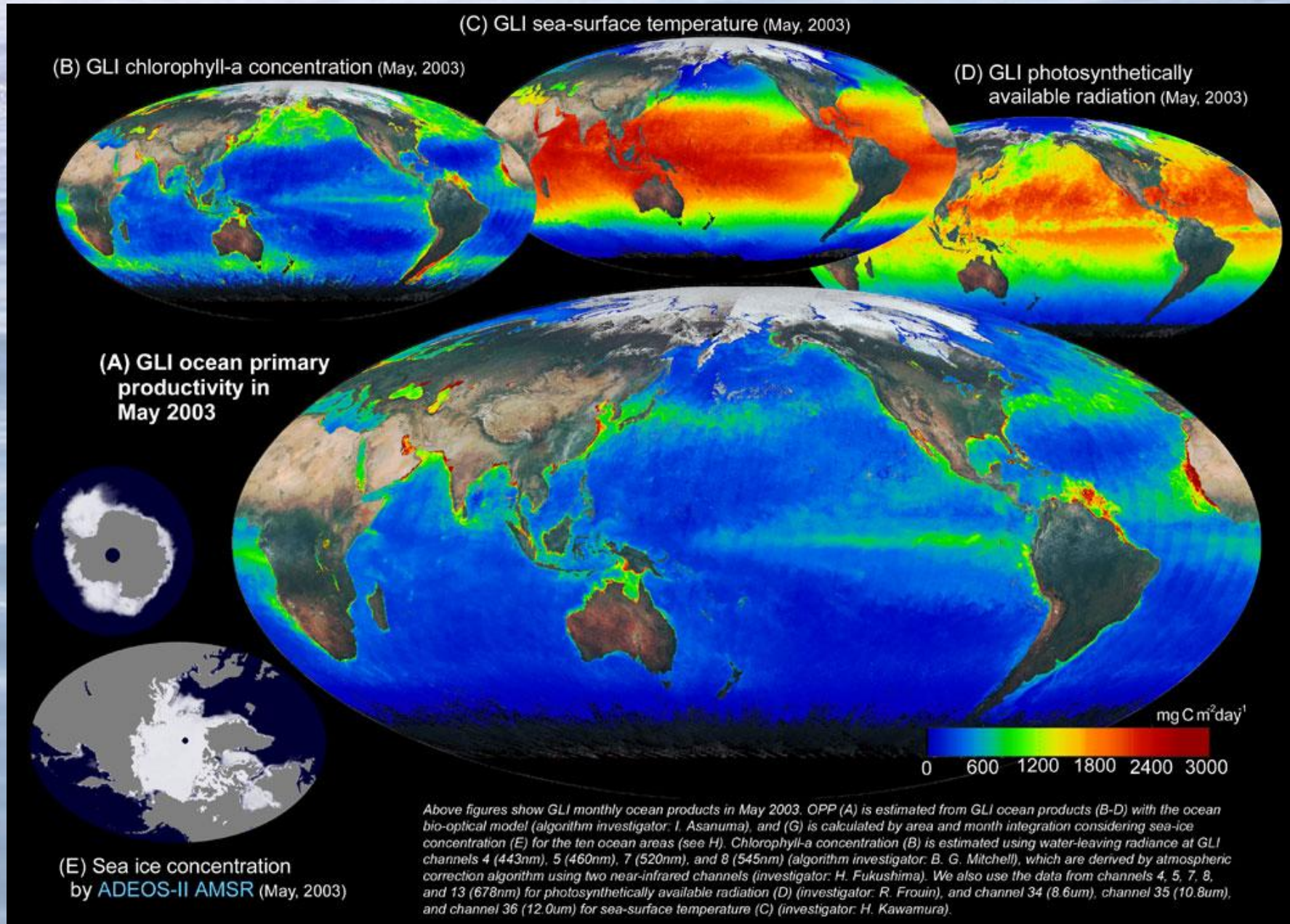
Pigment		Cyanobacteria	Algae classes											
			Prochlorophyceae	Rhodophyceae	Cryptophyceae	Chlorophyceae	Prasinophyceae	Euglenophyceae	Eustigmatophyceae	Bacillariophyceae	Dionophyceae	Prymnesiophyceae	Raphidophyceae	Chrysophyceae
CHLOROPHYLLS	a	●	x	●	●	●	●	●	●	●	●	●	●	●
	b		x			●	●	●			x			
	c1									●	x	●	●	
	c2				●					●	●	●	●	●
	c3											●	●	●
divinyl chlorophyll a	a		●											
divinyl chlorophyll b	b		●											
CAROTENES	α			●	●	●	●	●				●		
	β	●	●			●	●	●	●	●	●	●	●	●
	γ				●									
likopen					●									
PHYCOBILINS	phycocyanin	●		●	●									
	allophycocyanin	●		●										
	phycoerythrin	●		●	●									

- >10% of total pigment amount
- 1 – 10%
- < 1%
- x – pigment noted occasionally

Pigment		Aglae classes												
		Cyanobacteria	Prochlorophyceae	Rhodophyceae	Cryptophyceae	Chlorophyceae	Prasinophyceae	Euglenophyceae	Eustigmatophyceae	Bacillariophyceae	Dinophyceae	Prymnesiophyceae	Raphidiophyceae	Chrysophyceae
XANTHOPHYLLS	alloxanthin		x		●									
	antheraxanthin		x			●	●	●						
	astaxanthin					x	x							
	19'but-fucoaxanthin									x	●	●	●	●
	diadinoxanthin							●		●	●	●	●	●
	diatoxanthin							●		●	●	●	●	●
	dinoksanthina										●			
	echinenone	x				x	x	x						
	fucoxanthin								●	x	●	●	●	●
	19'hex-fucoaxanthin									x	●	●		
	canthaxanthin	x				x								
	lutein					●	●							
	monadoxanthin				●									
	neoxanthin					●	●	●						
	peridinin										●			
	prasinioxanthin						●							
	violaxanthin					●	●		●					
	zeaxanthin	●	●	●		●	●		●					

according to Jeffrey and Vesik 1997

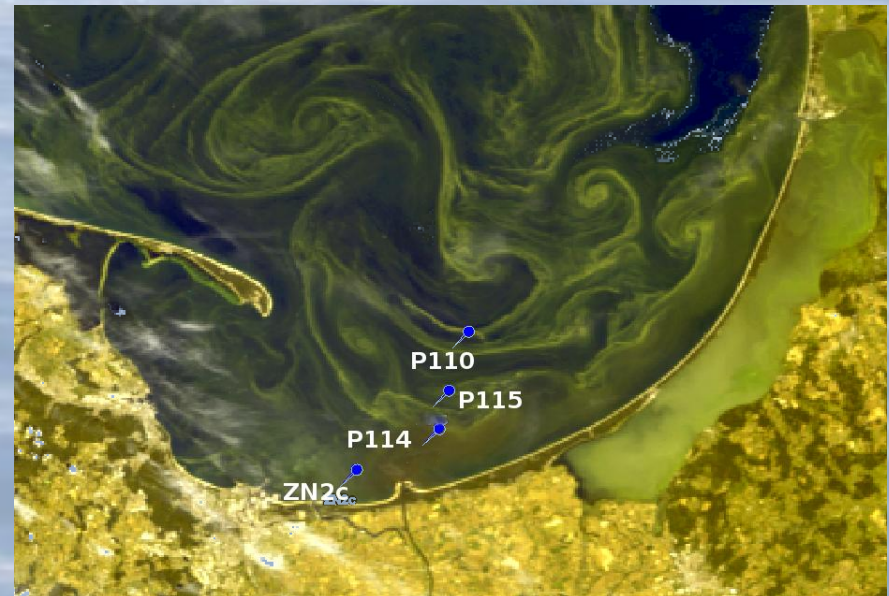
Global primary production in the oceans



13.07.2002 11:00 UTC MODIS, AQUA

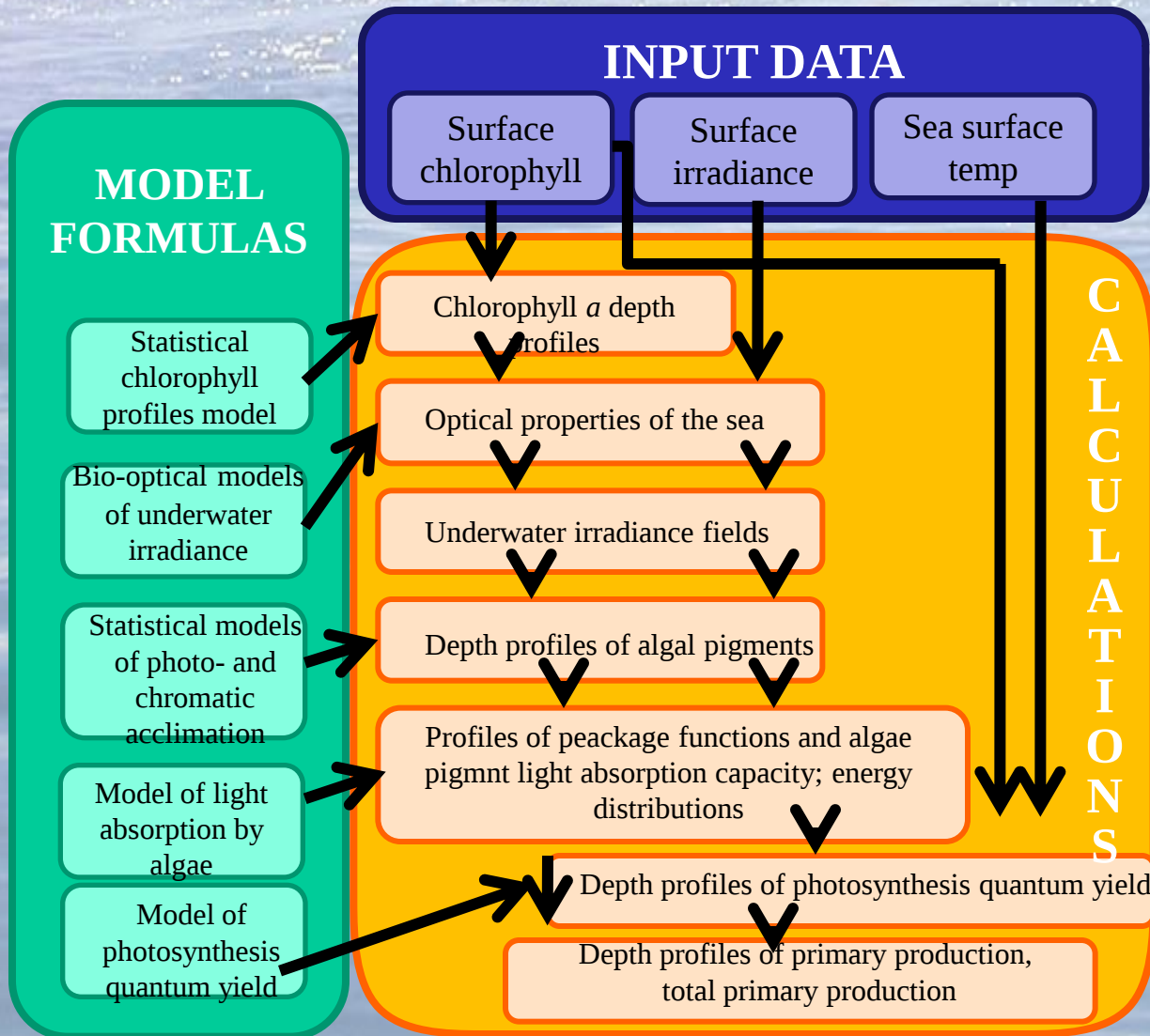


Phytoplankton blooms



DESAMBEM

Development of a satellite method for Baltic ecosystem monitoring



**Model
„Light -
photosynthesis”**

by:

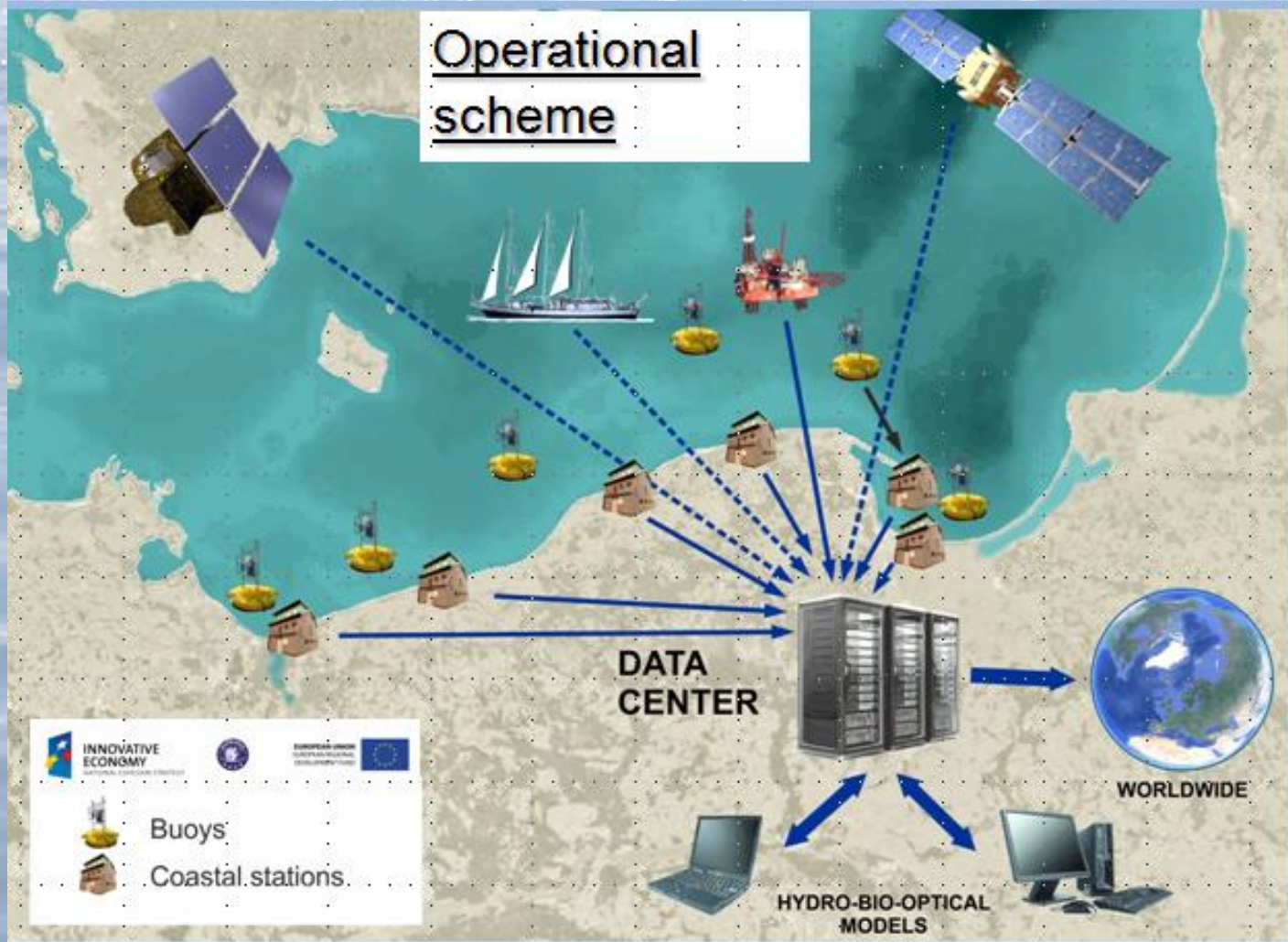
**-IO PAN
-AP in Slupsk**

2002-2005



SatBałtyk

Satellite Environmental Control of Baltic Sea



founded by European Union through European Regional Development Fund (POIG 01.01.02-22-011/09)



Temperature



Cloudiness



Chlorophyll a



Primary production



Solar radiation

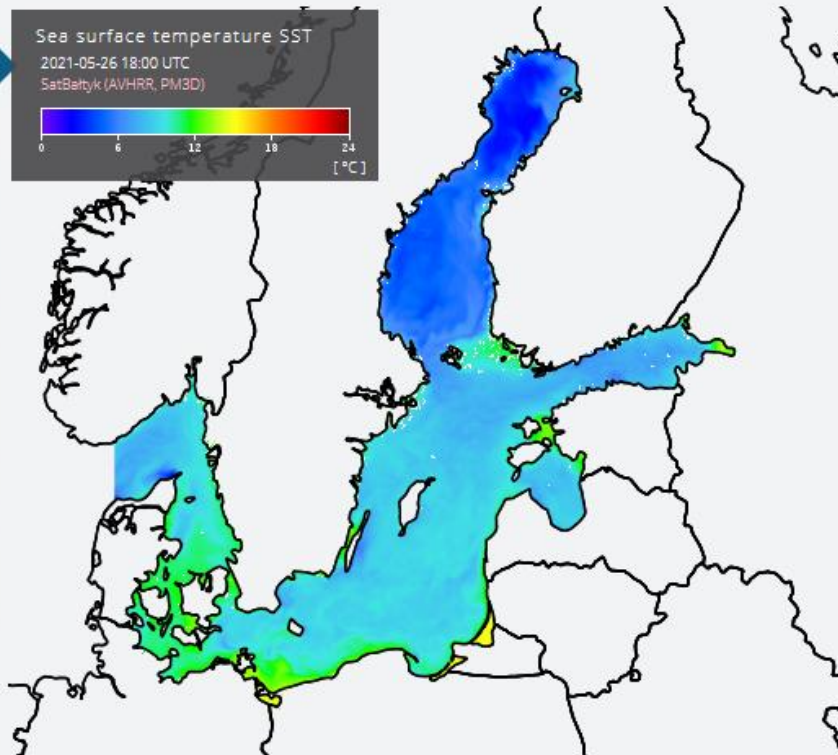
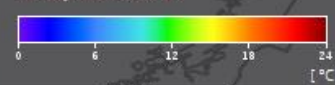


See maps of other parameters

Sea surface temperature SST

2021-05-26 18:00 UTC

SatBaltyk (AVHRR, PM3D)



8.3°C

average water temperature

48.7%

average Baltic cloudiness

2.6 mg/m³

average Baltic chlorophyll a

433.8 mg/m²·d

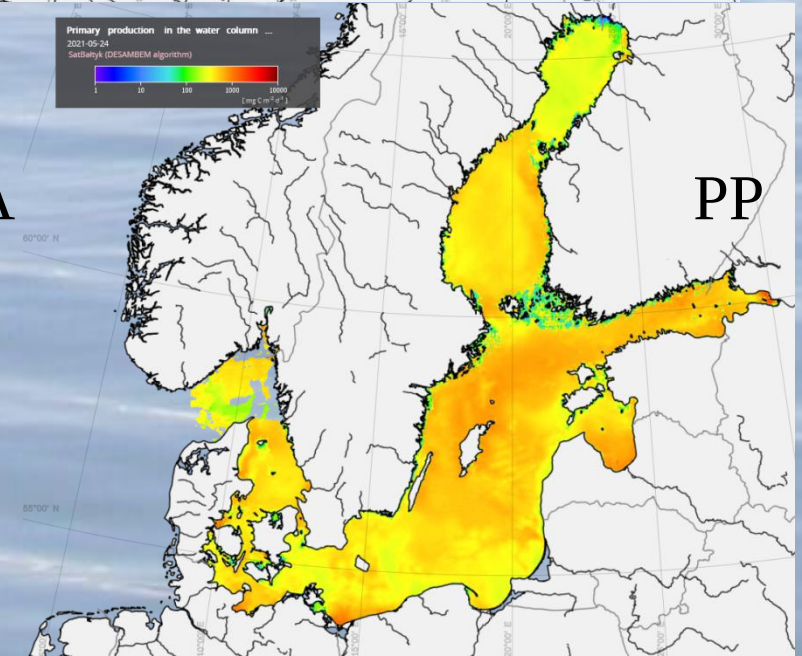
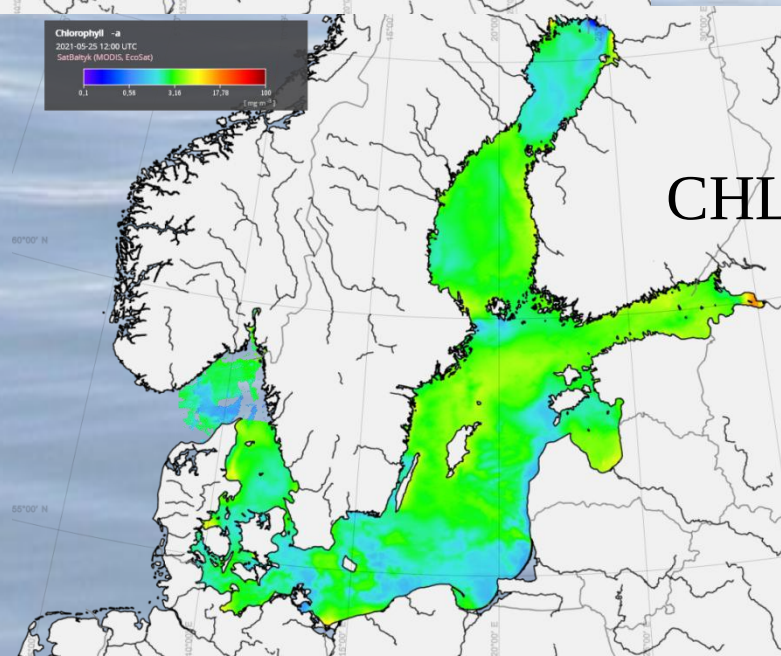
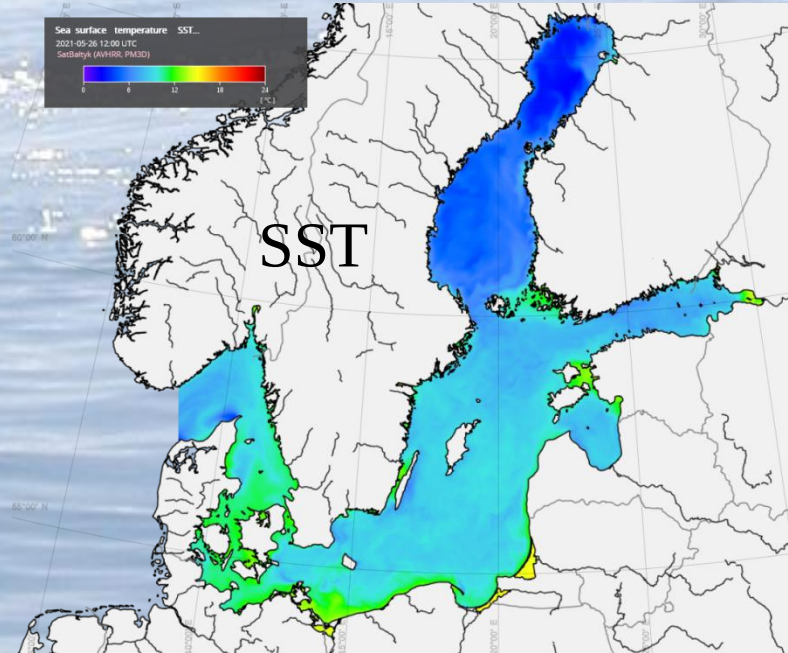
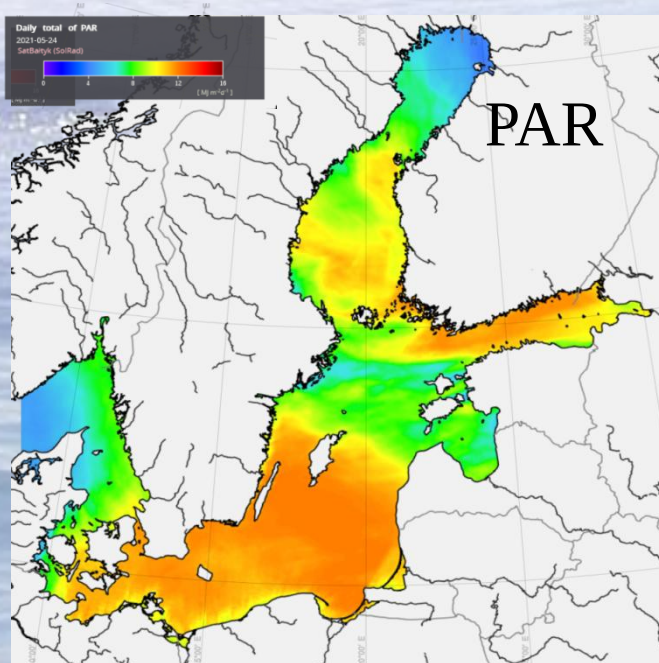
average Baltic primary production

21.99 MJ/m²

Baltic mean daily total

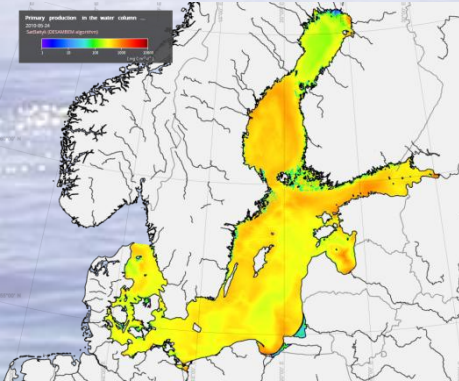
Do you know: photosynthesis is the process which converts carbon dioxide and water into glucose and oxygen with the light energy. The process allows plants grow.

24 May 2021

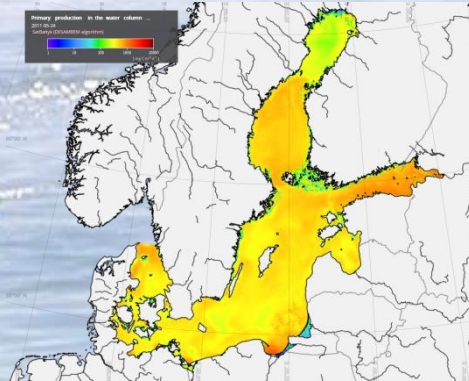


Primary production during last twelve years in May

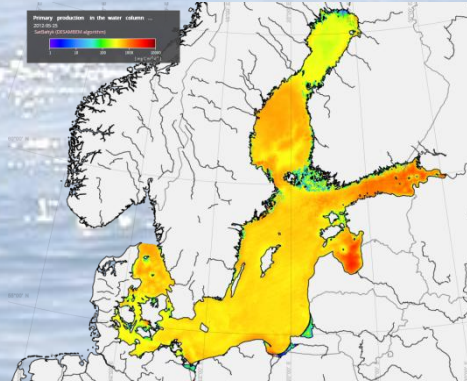
2010



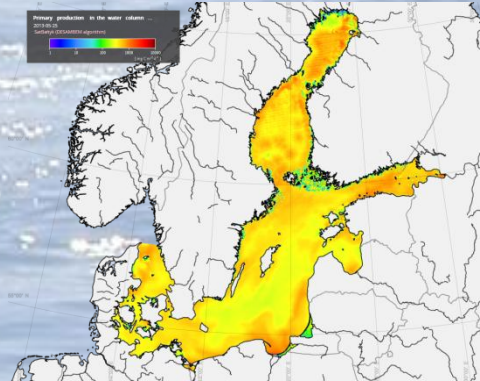
2011



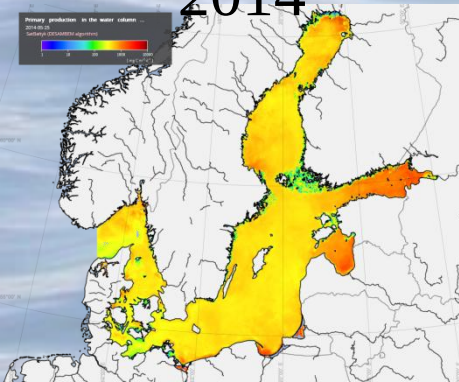
2012



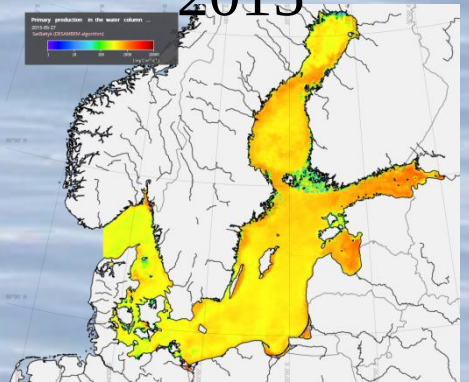
2013



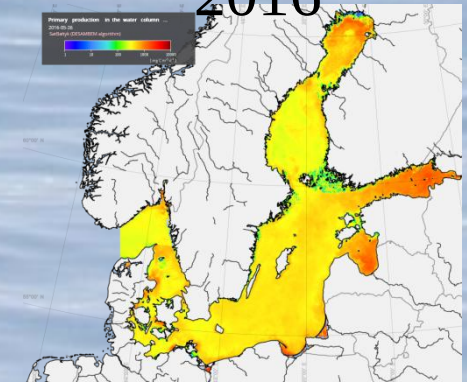
2014



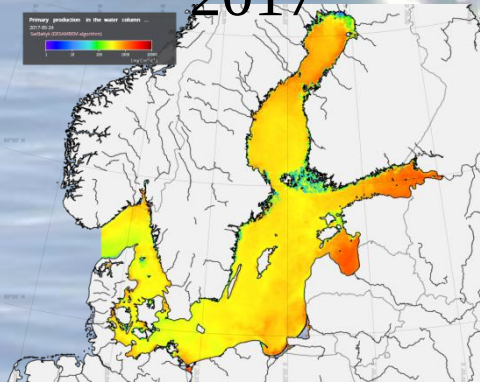
2015



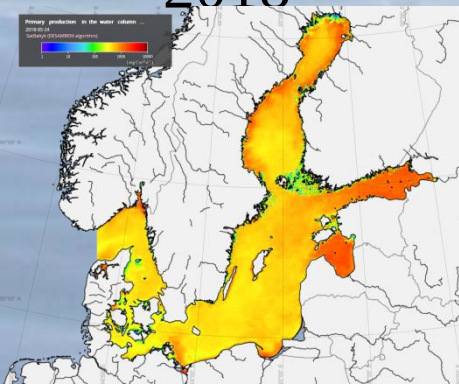
2016



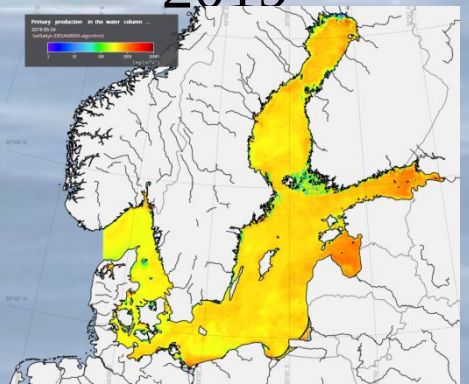
2017



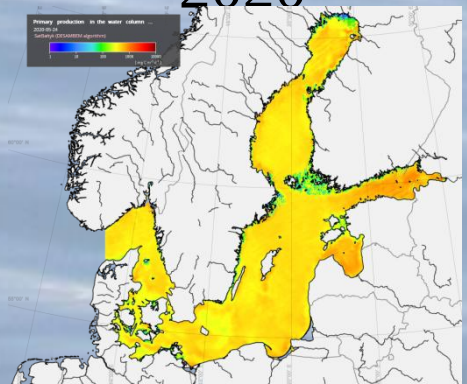
2018



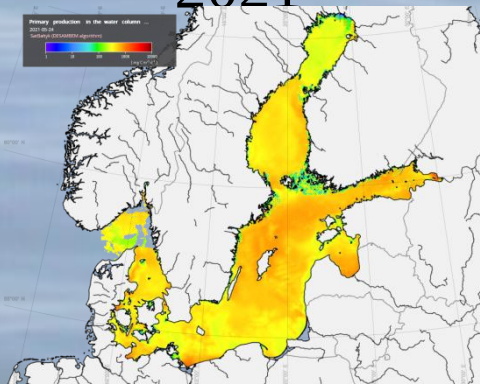
2019



2020

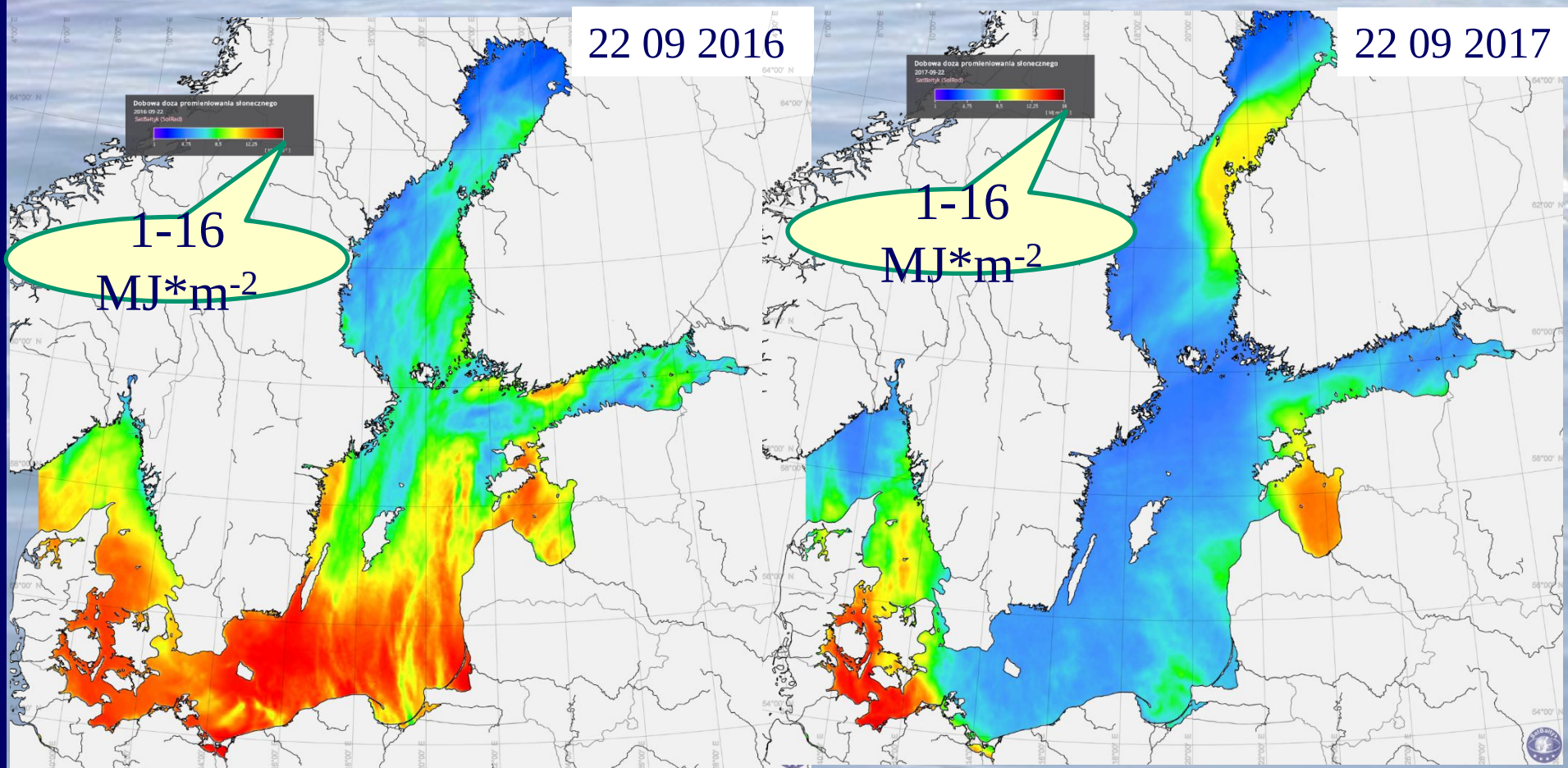


2021



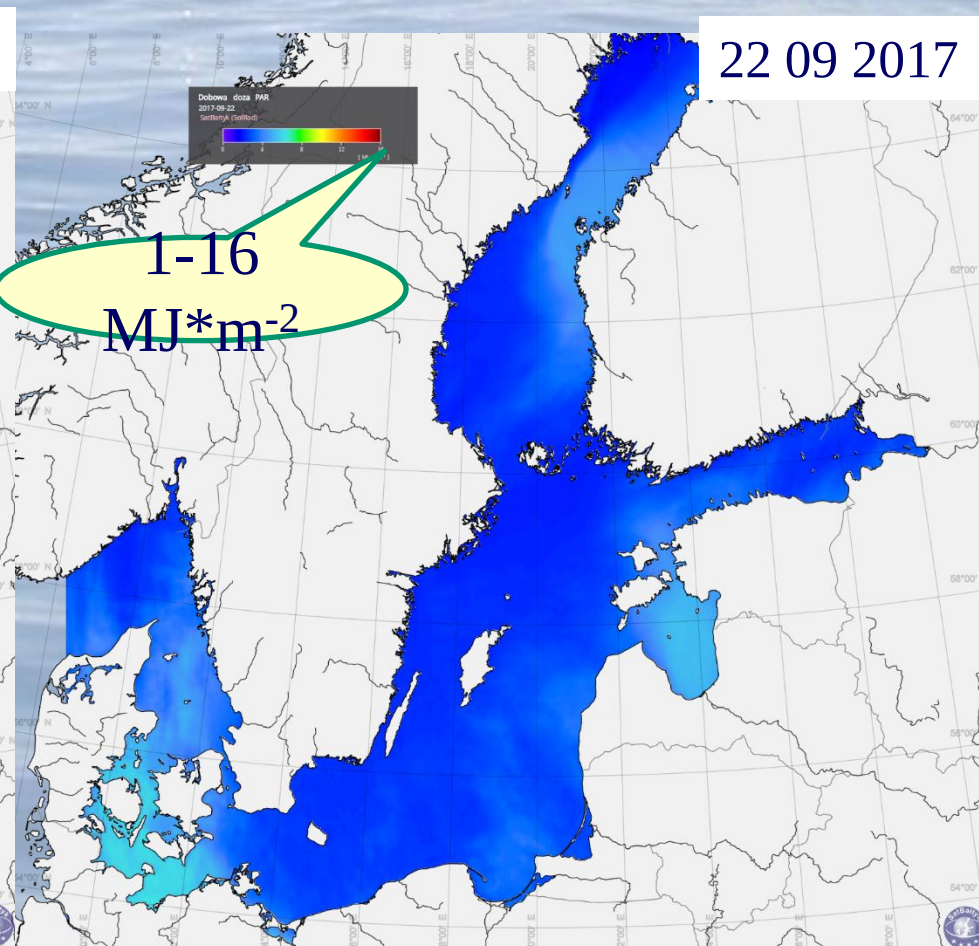
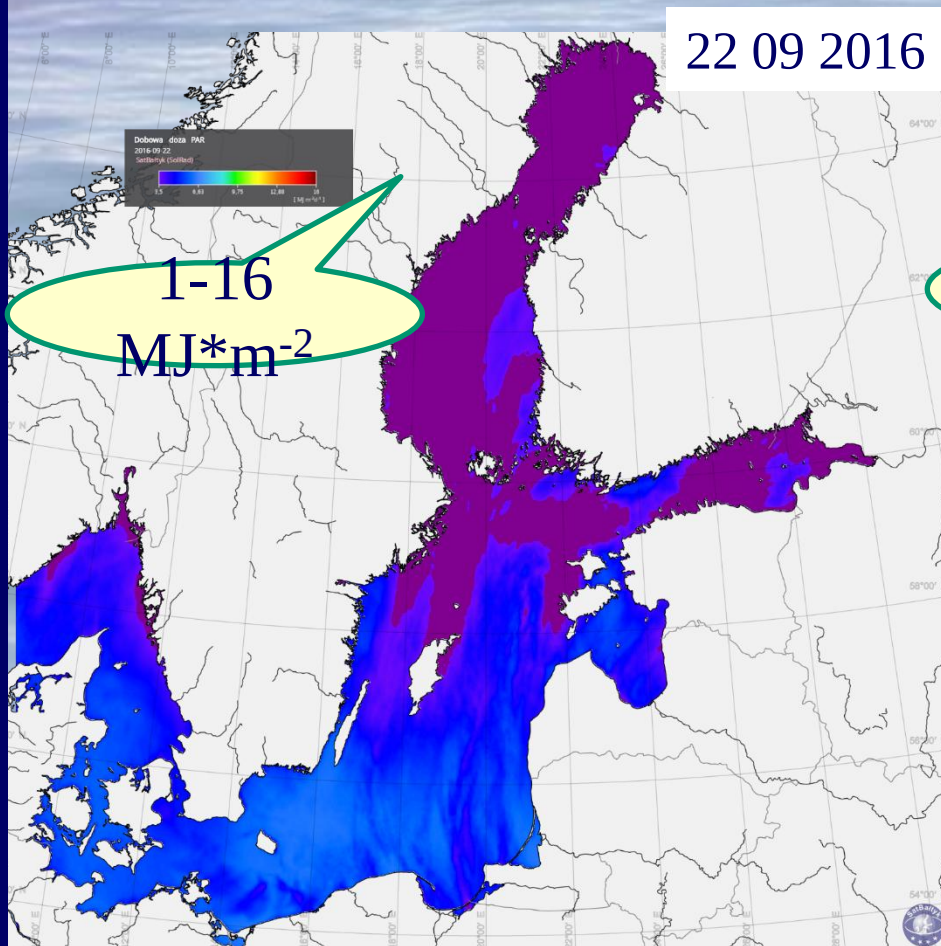


Daily dose of sunlight on sea surface





Daily dose of photosynthetically active radiation PAR



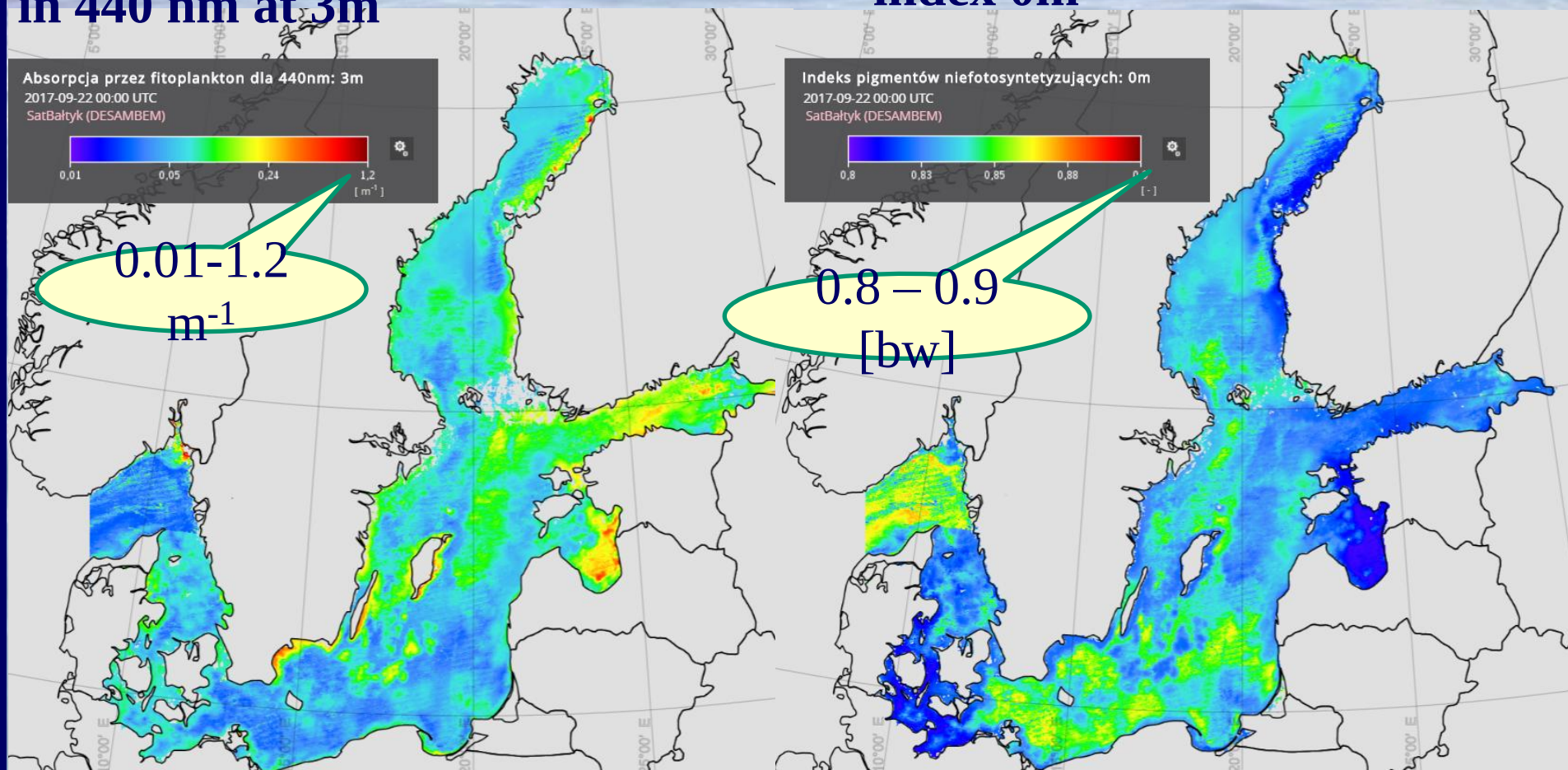


Absorption properties of phytoplankton

22 09 2017

Coefficient of light absorption
in 440 nm at 3m

Non photosynthetic pigment
index 0m





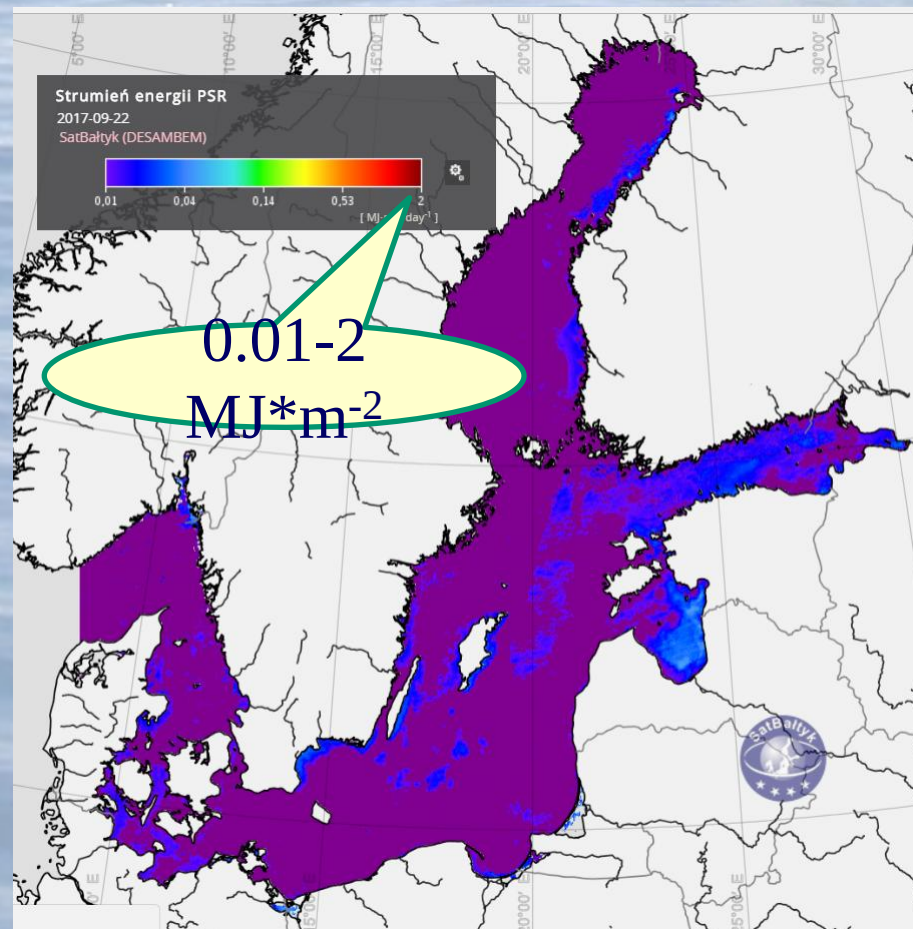
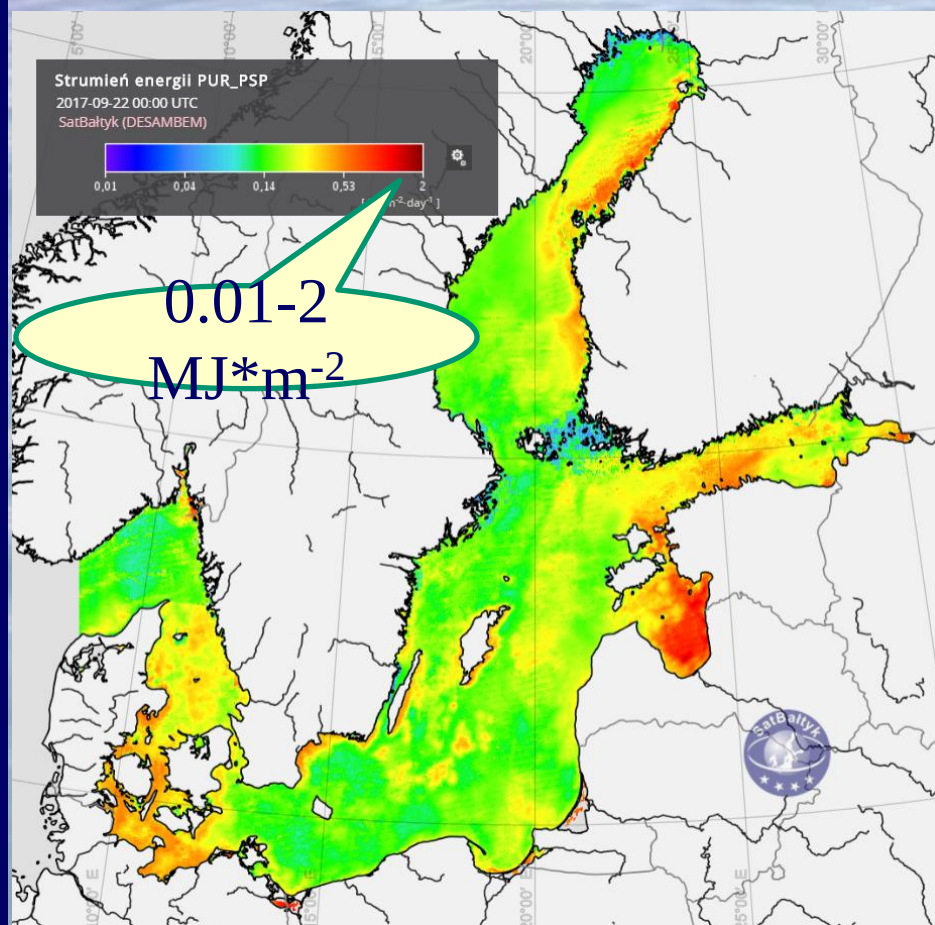
Energy fluxes in photosynthesis

22 09 2017



Energy absorbed by
photosynthetic pigments PUR_{PSP}

Photosynthetically stored
radiation PSR

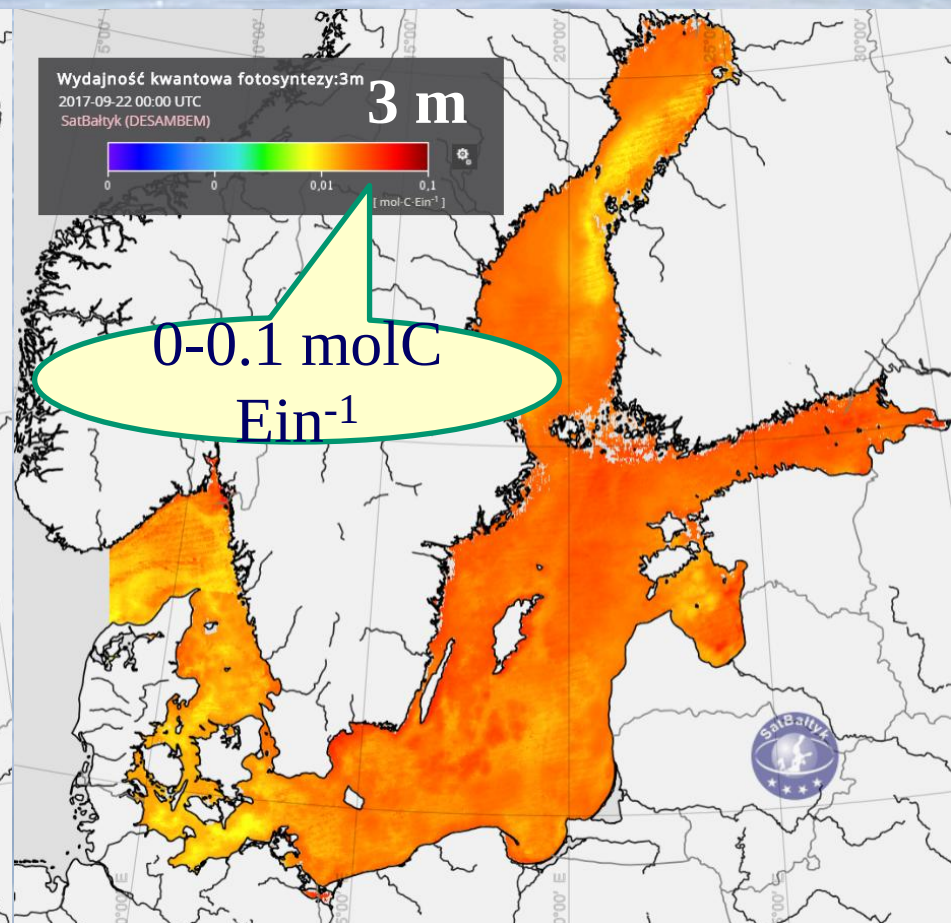
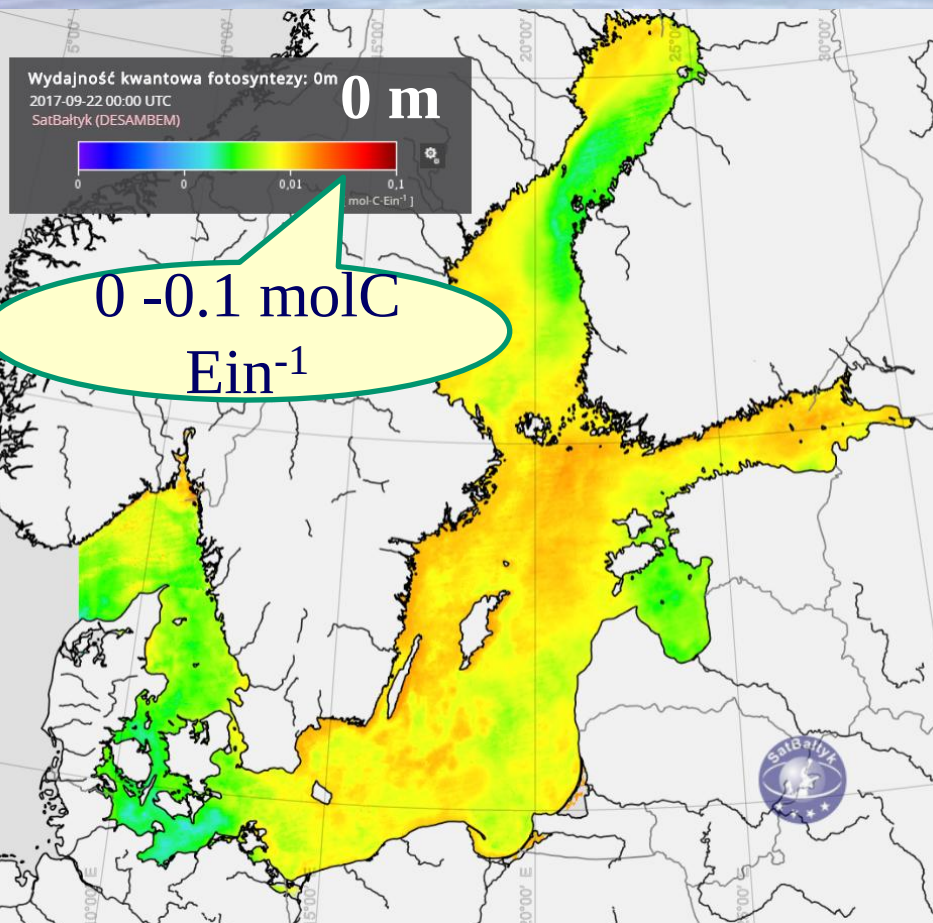




Quantum yield of photosynthesis



22 09 2017





Thank you