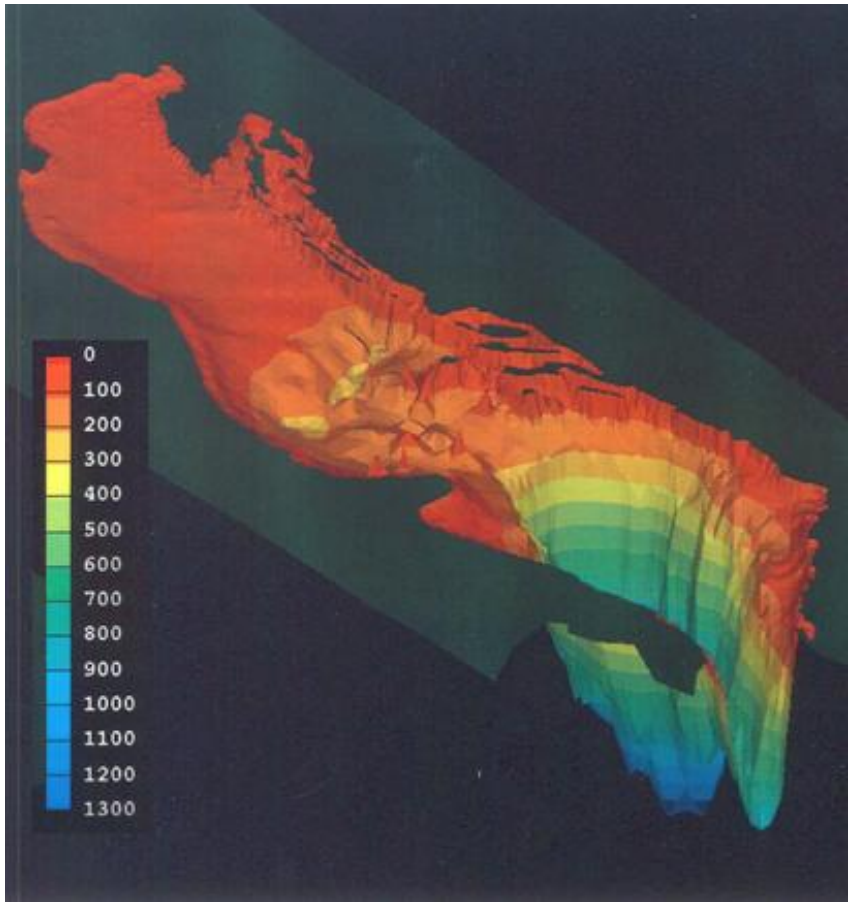
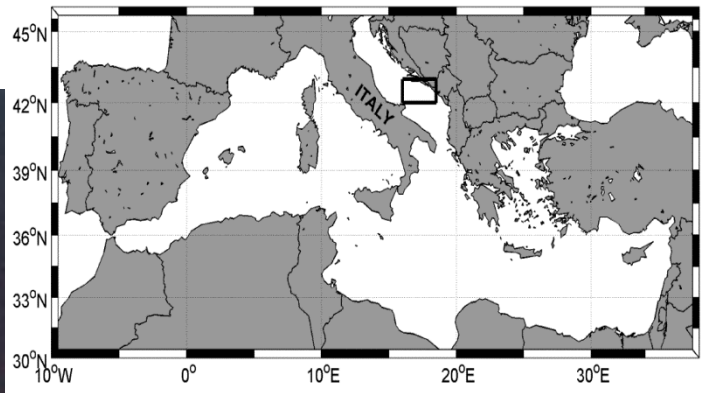
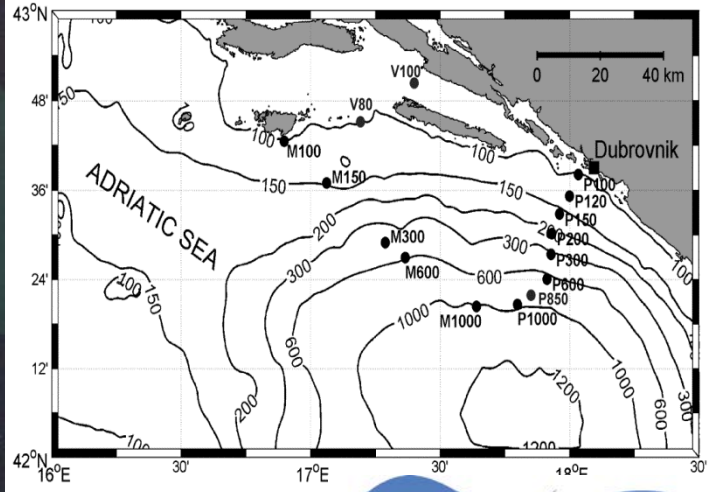
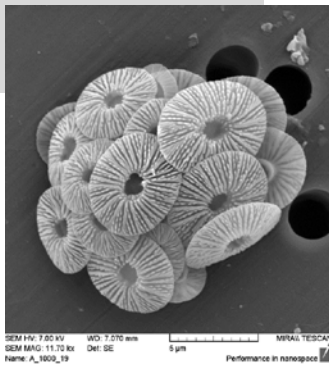
BIOTA cruises in the Adriatic Sea
Bio-tracing Adriatic Water Masses

hrzz
Hrvatska zaklada za znanost

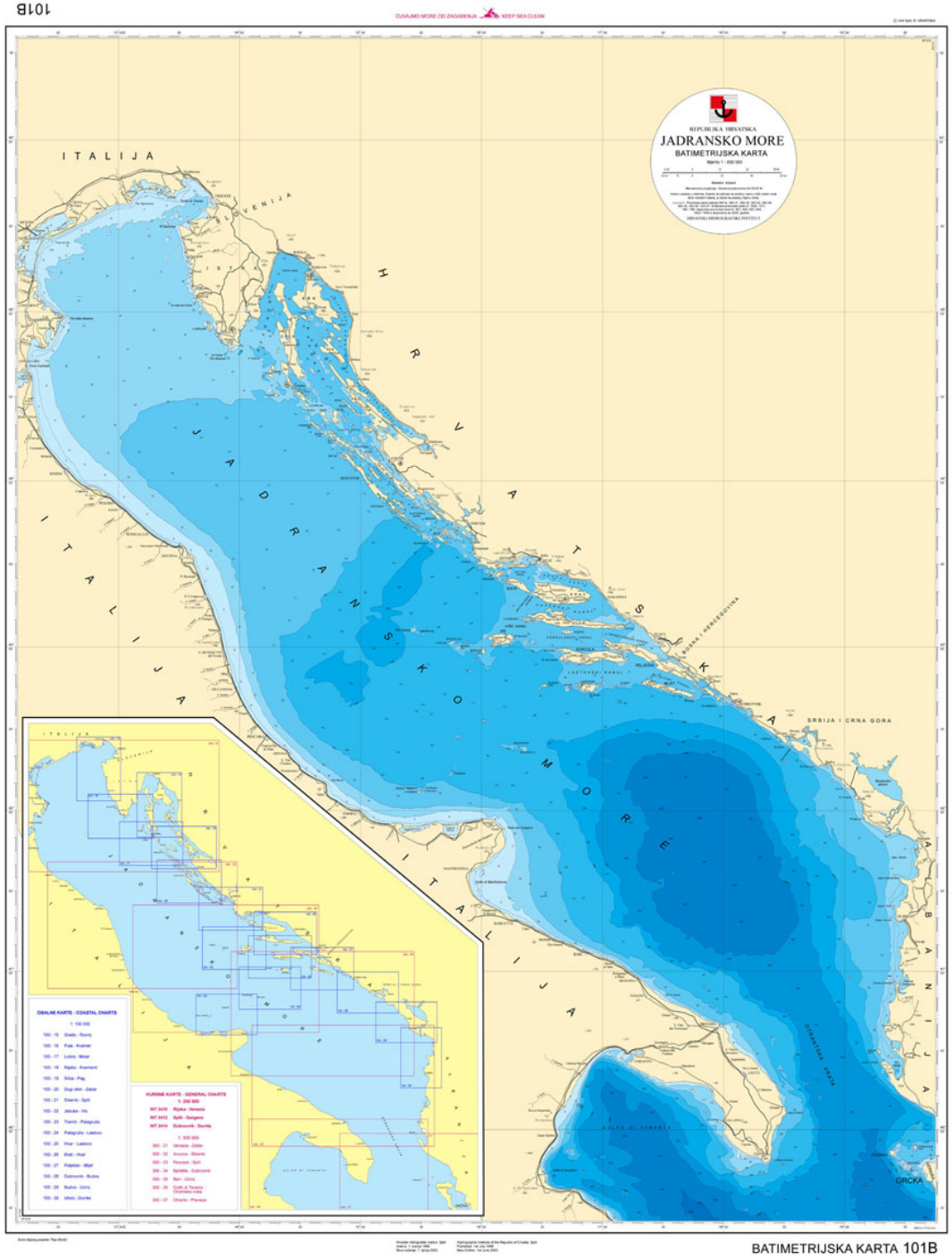






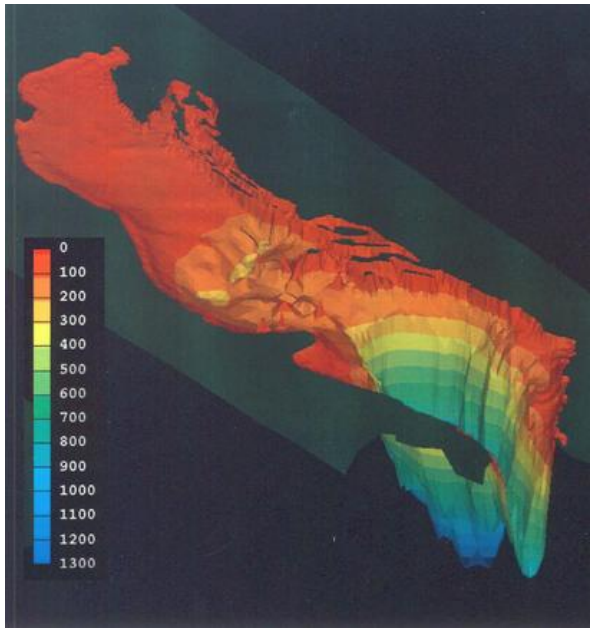


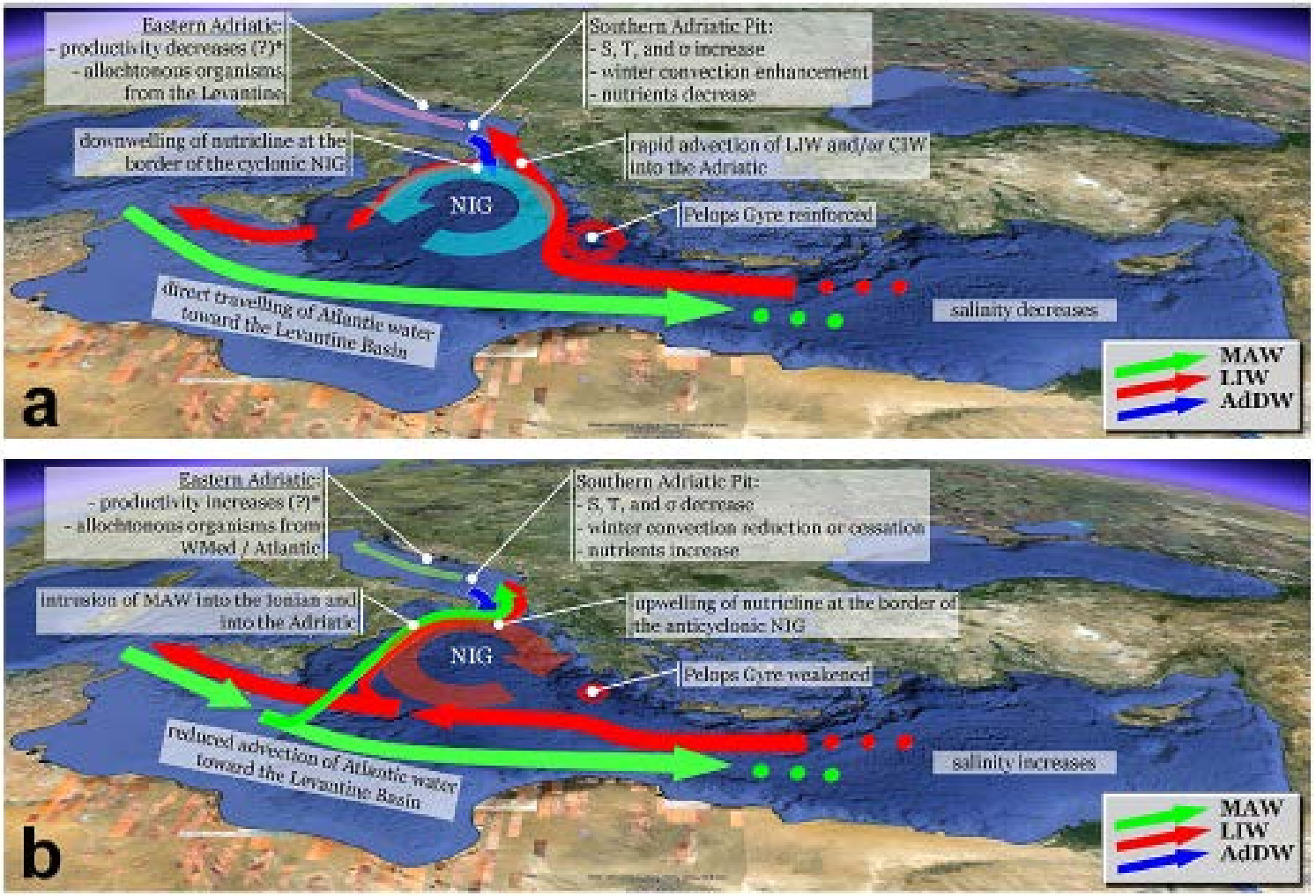
BIOTA



BATIMETRIJSKA KARTA 101B

- Surface area 138 600 km^2 i volume 35 000 km^3
- **Northern Adriatic** (15 m Trst-Venecija)
- **Middle Adriatic, Jabuka pit** (270 m)
- **Southern Adriatic, Southern Adriatic pit** (1200 m)
- Otrant (780 m), water exchange with Ionian sea
- The most northern Mediterane





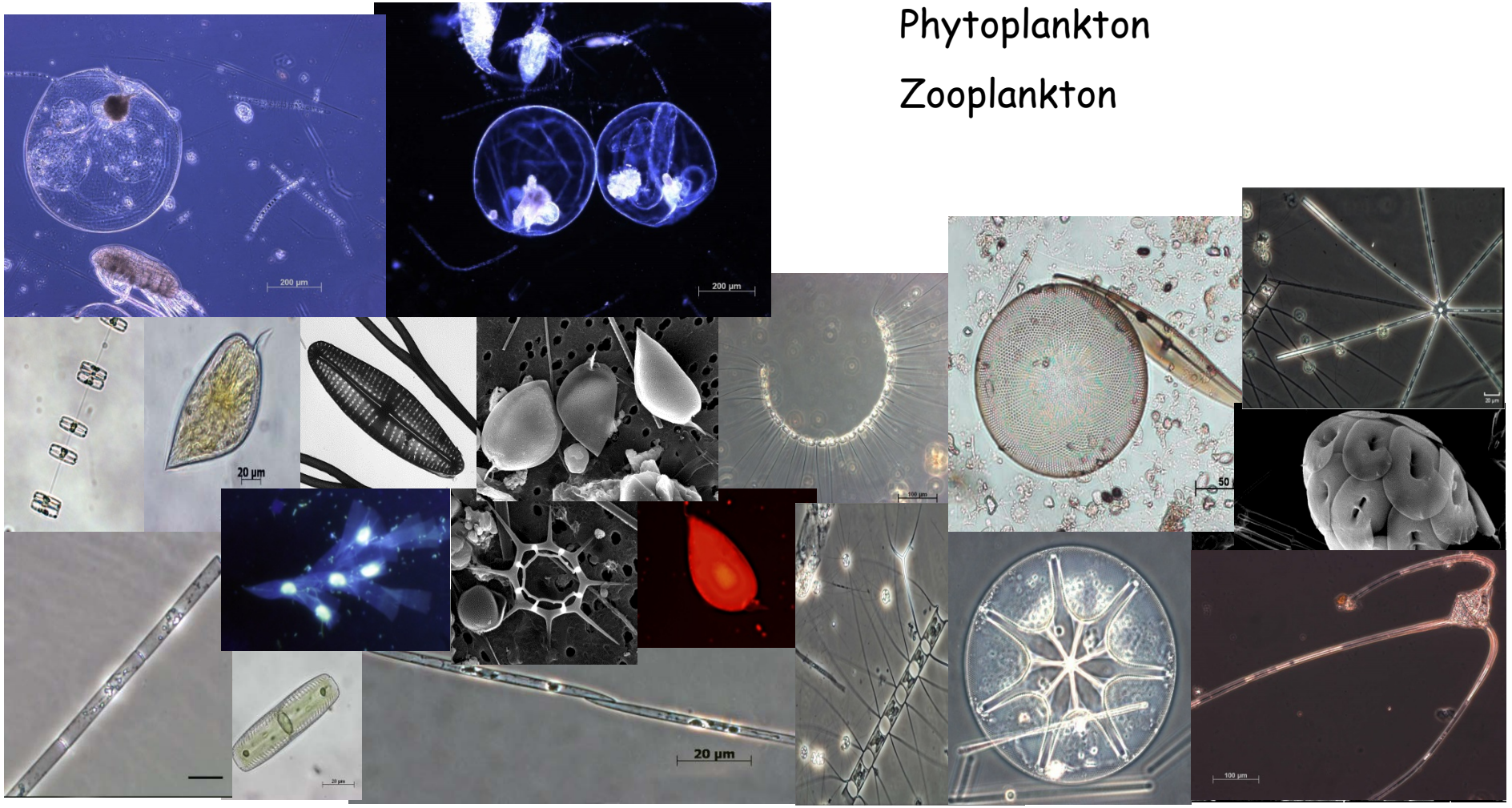
Civitarese, et al 2010, Biogeosciences

Table 2. Biological records and changes in NIG circulation.

Date	Organism (type)	NIG circulation	Remarks
1982	Schedophilus medusophagus (fish)	?	Present in the WMed. Reported in the central Adriatic (Onofri, 1986).
end of 1980's	Copepod community (mesozooplankton)	reversal from cyclonic to anticyclonic	Changes of the entire copepod community in the Gulf of Trieste (Conversi et al., 2009)
1993	Desmopterus papilio (gastropode)	anticyclonic	Common in the Atlantic and found in the open South Adriatic, off Dubrovnik (Batistić et al., 2004)
1993	Pelagobia longicirrata (polychete)	anticyclonic	Common in the tropical Atlantic and found in the open South Adriatic (Batistić et al., 2004)
1995	Muggiaea atlantica (hydrozoan)	anticyclonic	Typical of the WMed. It was reported for the first time in 1995 in the coastal southeastern (Gamulin and Krsinic, 2000), and central Adriatic (Batistić, 2007), then invaded the North Adriatic (Kršinić and Njire, 2001)
end of 1990's	Total copepod, in particular Paracalanus parvus (mesozooplankton)	reversal from anticyclonic to cyclonic	Changes in the abundance of some species (Conversi et al., 2009)
2002	Siganus rivulatus (fish)	cyclonic	Lessepsian migrator, recorded in the South Adriatic (Dulčić and Pallaoro, 2004)
2006	Fistularia commersonni (fish)	cyclonic	Lessepsian migrator, caught off the coastal waters in South Adriatic (Dulčić et al., 2007)
2006	Thysanoteuthis rhombus (cephalopode)	cyclonic	Considered a "slow swimmer" (Marčić et al., 2008), it was introduced in the North Adriatic probably from the Levantine basin
2007	Therapon theraps (fish)	cyclonic	Lessepsian migrator. Captured off Piran, Slovenia (Lipej et al., 2008)

Plankton

Plankton – organisms dipersed in the water column, passivley driven by water currents

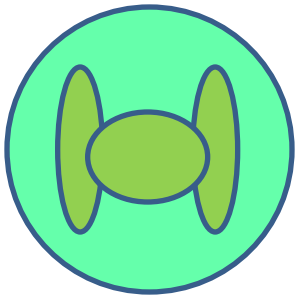


Phytoplankton

Zooplankton

- 71% oceans
- 66% open ocean

- ASSUMPTION (by R. Andersen, modified by S. Bosak)



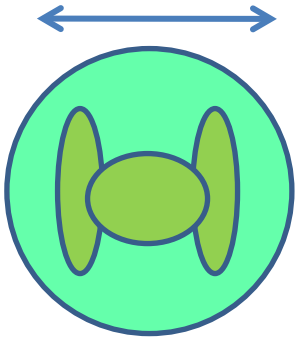
~ 10^6 cells per 1L

Photosynthetic layer = 100 m

Ocean surface area = 3.6 x 10^8 km^2

THEN…

There is **10^{25}** cells in ocean!!!!

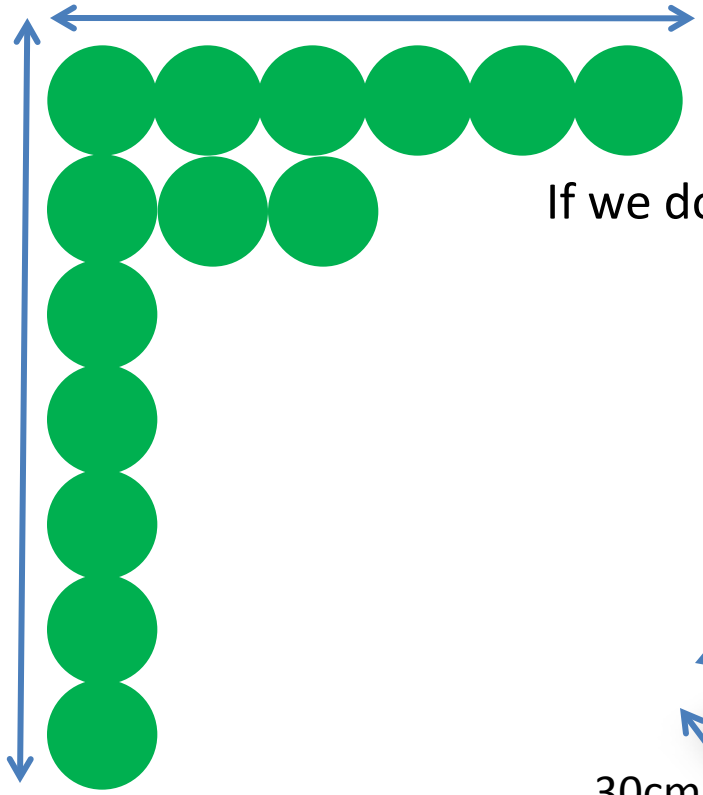


10^{25} cells

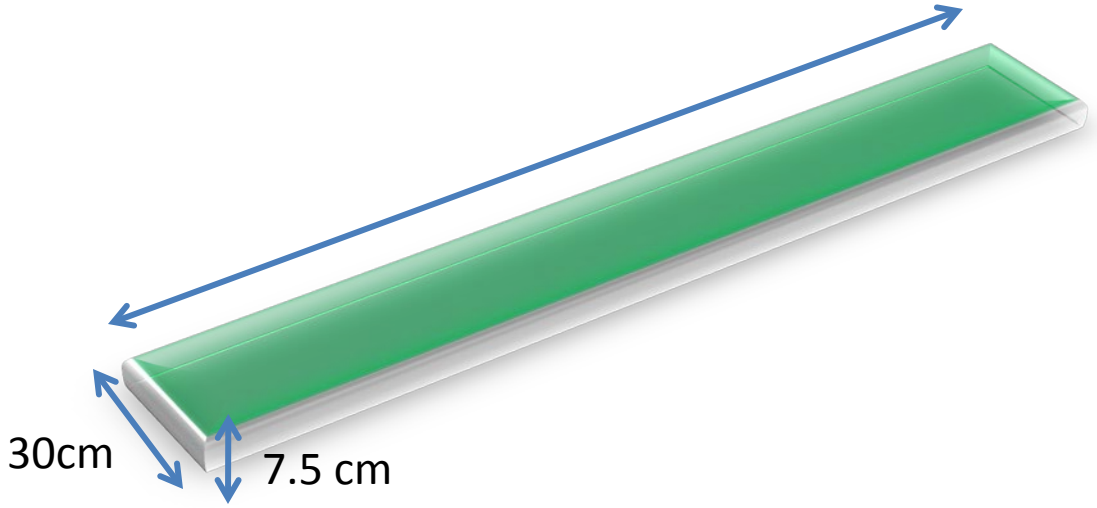
Average diameter 2 µm

- THEN…

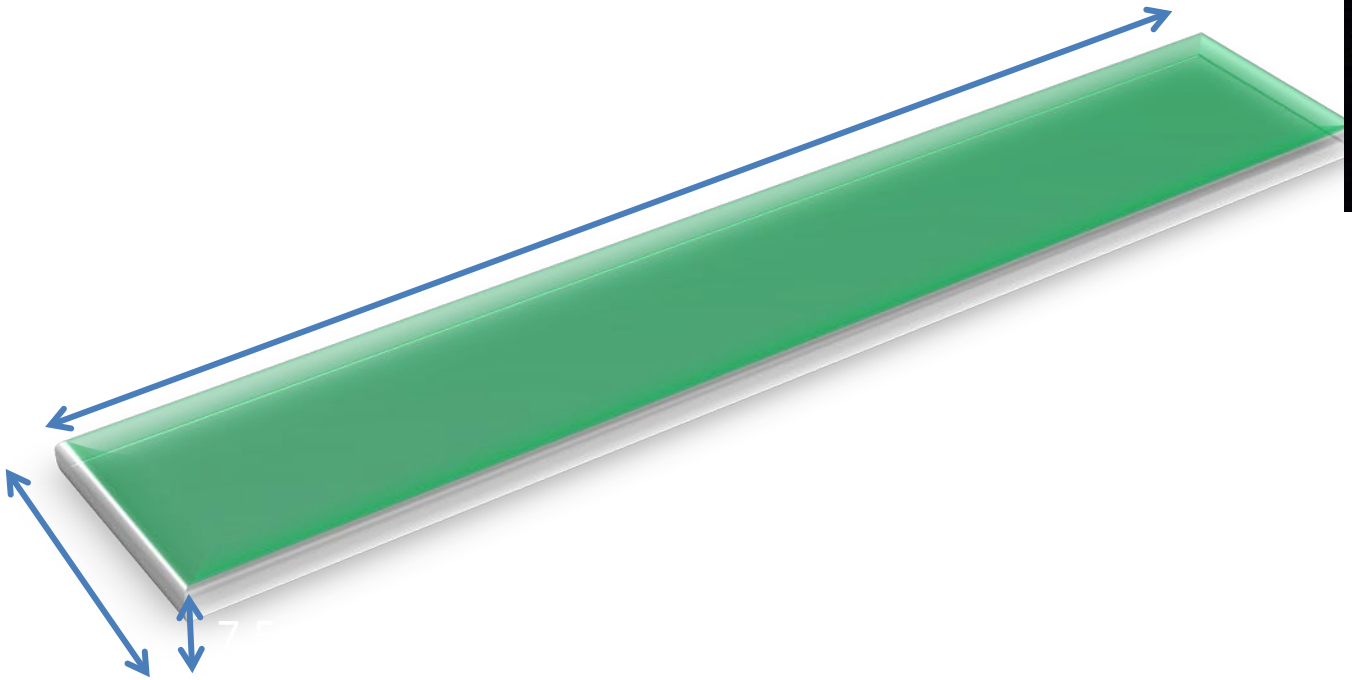
If we would have all the cells in a line, the lenght would be from the earth to te moon and back **10 miliard times !!!!**



If we do it in 2D…

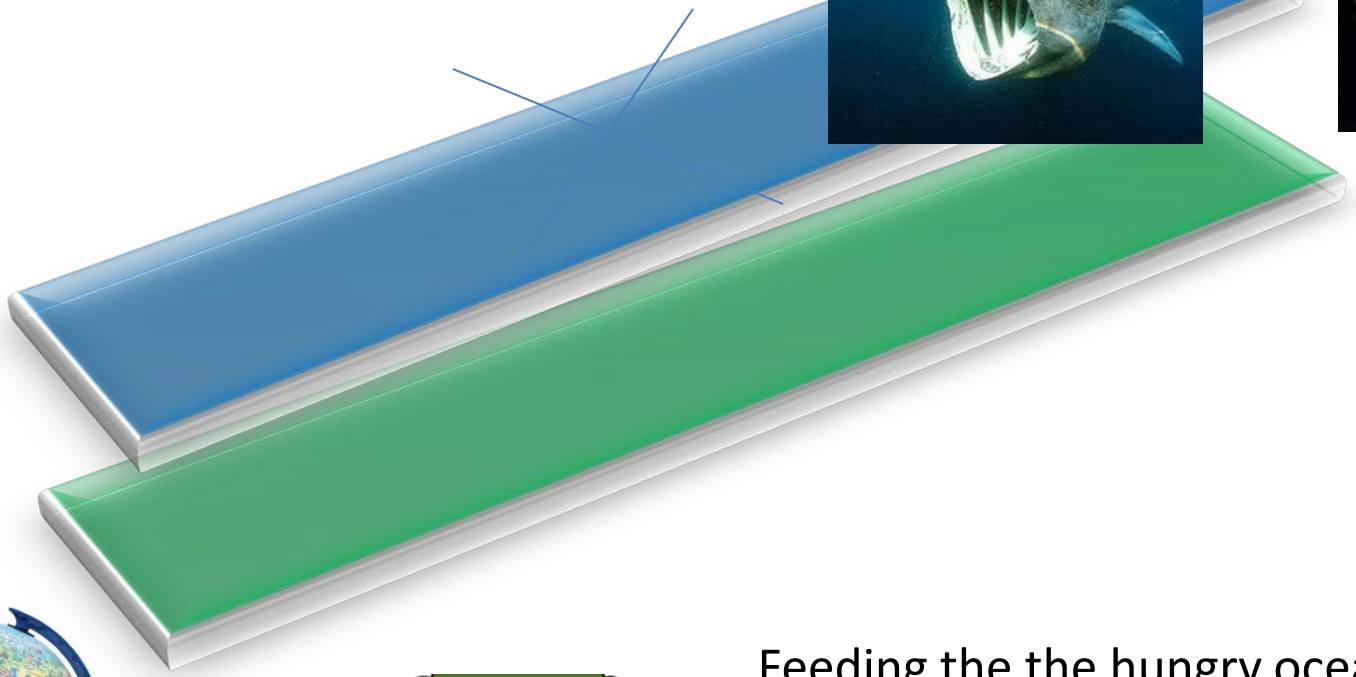


7.5 cm x 30 cm x 400 000 km!!!!



Distance from Earth to Moon!!!!

1 board gets eaten every day!!! Eaten by predators – ciliates, zooplankton, fish, whales…



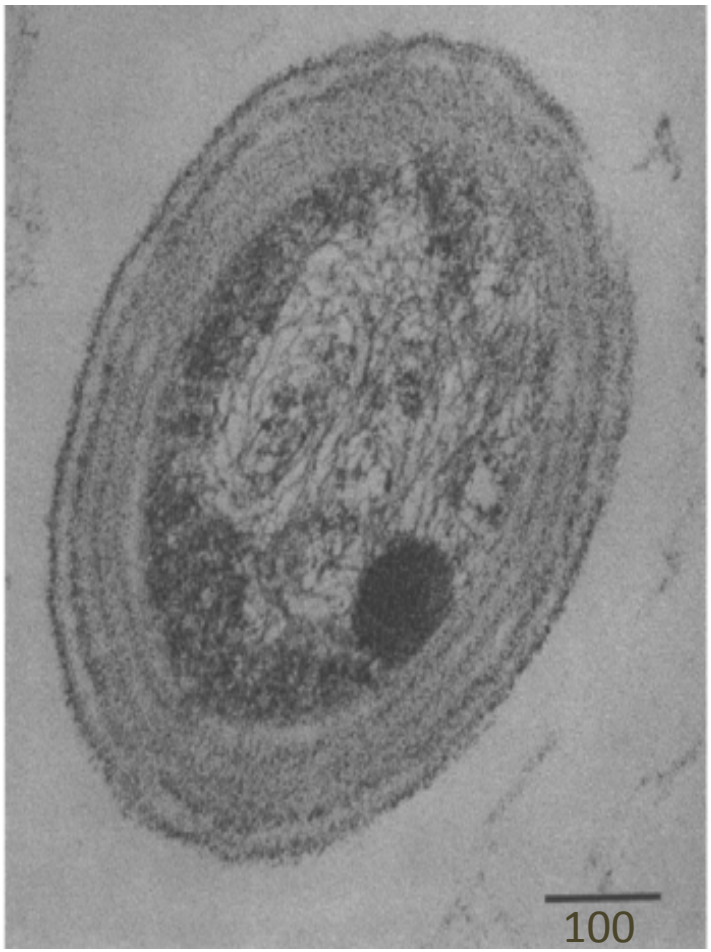
Feeding the the hungry ocean!!

Marine ecosystems much more sensitive from terestrial

Picoplankton - oligotrophy

Cyanobacteria - *Prochlorococcus* & *Synechococcus* i picoeukariotes

Sallie W. Chisholm
(Massachusetts Institute
of Technology, USA)



[cell size: 0.5 – 0.7 µm]

Electron micrograph of a thin section of *P. marinus* (strain CCMP-1375; Chilsom et al., 1992).

Kingdom: Bacteria
Phylum: Cyanobacteria
Order: Synechococcales
Family: Synechococcaceae
Genus: *Prochlorococcus*
Species: ***marinus***

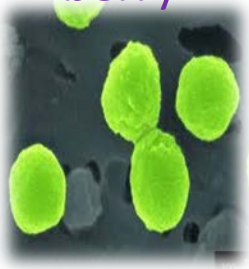
Prochlorococcus

Chilsom et al., 1992

Gr. pref. ***Pro*** = before (primitive)

Gr. adj ***chloros*** = green

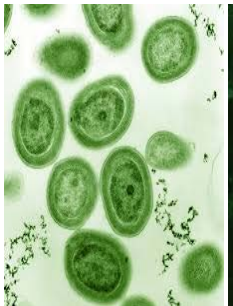
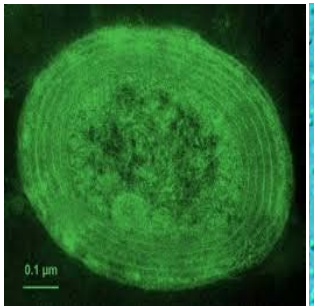
Gr. noun ***coccus*** = berry

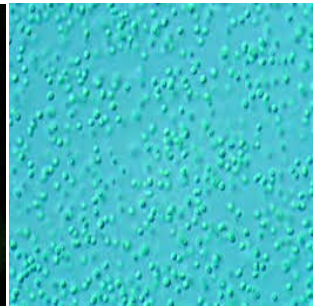


"Little greens"

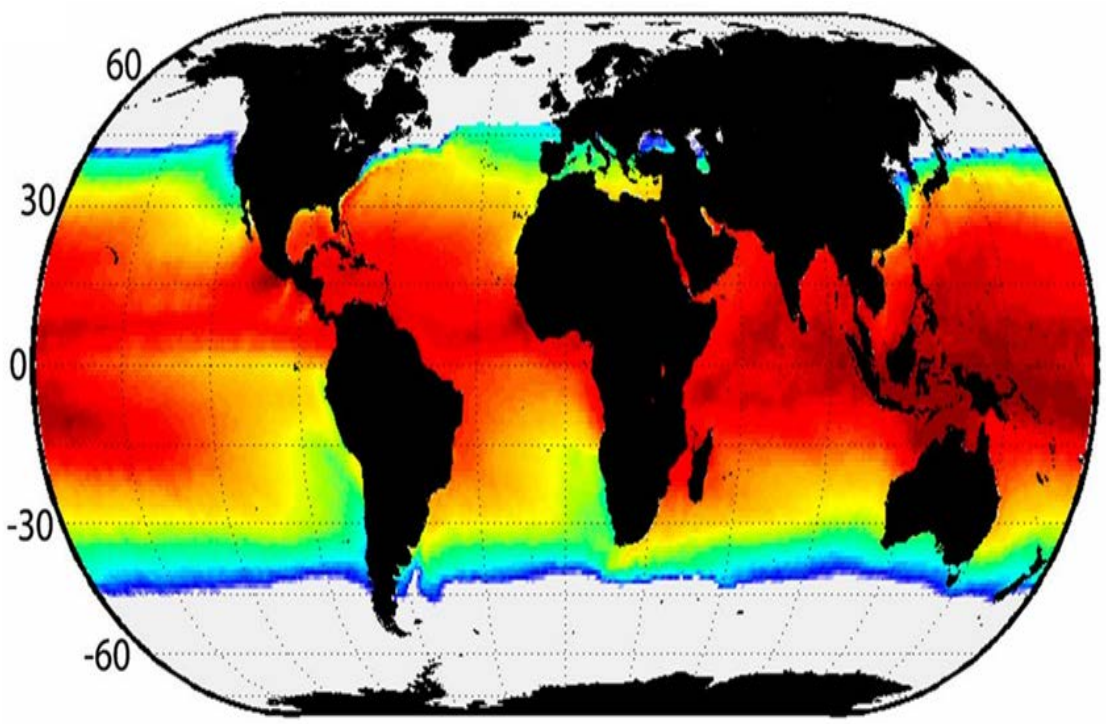
“Mighty” *Prochlorococcus*

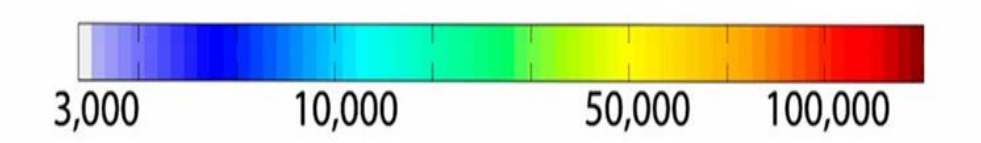
- ✓ Seawater microbial picoplanktonic organism discovered 25 years ago
- ✓ **Present in trillions**: annual mean global abundance of *Prochlorococcus* in the world oceans reaches 2.9 ± 0.1 × 10^{27} cells (oligotrophic environment)
- ✓ Accounts for **20% of total oxygen production on Earth** → “lungs” of the ocean
- ✓ **DOMINANT** and **TINIEST** photosynthetic organism on Earth



Global distribution of *Prochlorococcus*



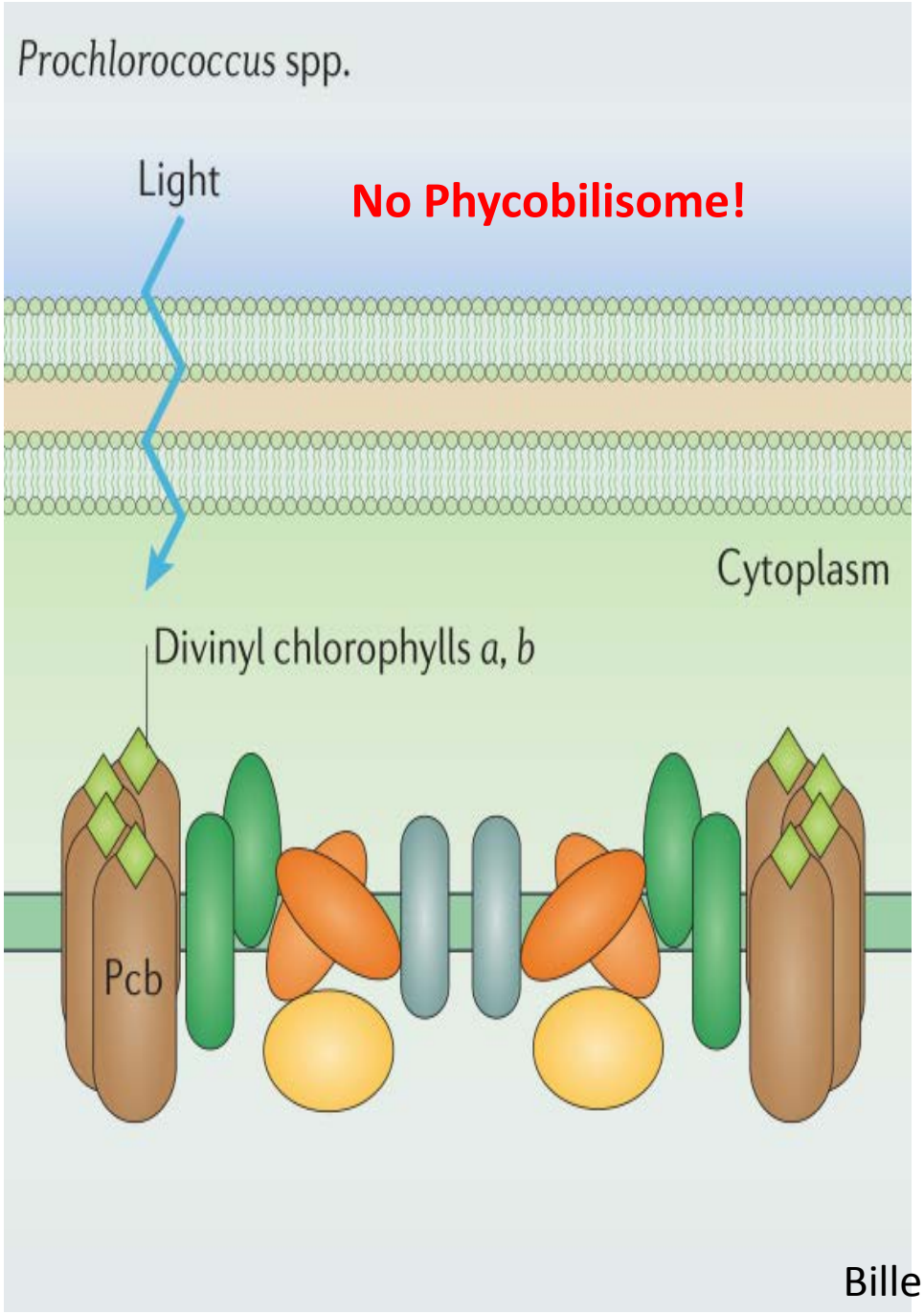


Abundance [cells mL^{-1}]

- ✓ **between 40°N and 40°S → warmer oligotrophic oceans**
- ✓ from the surface up to depth of 200 m

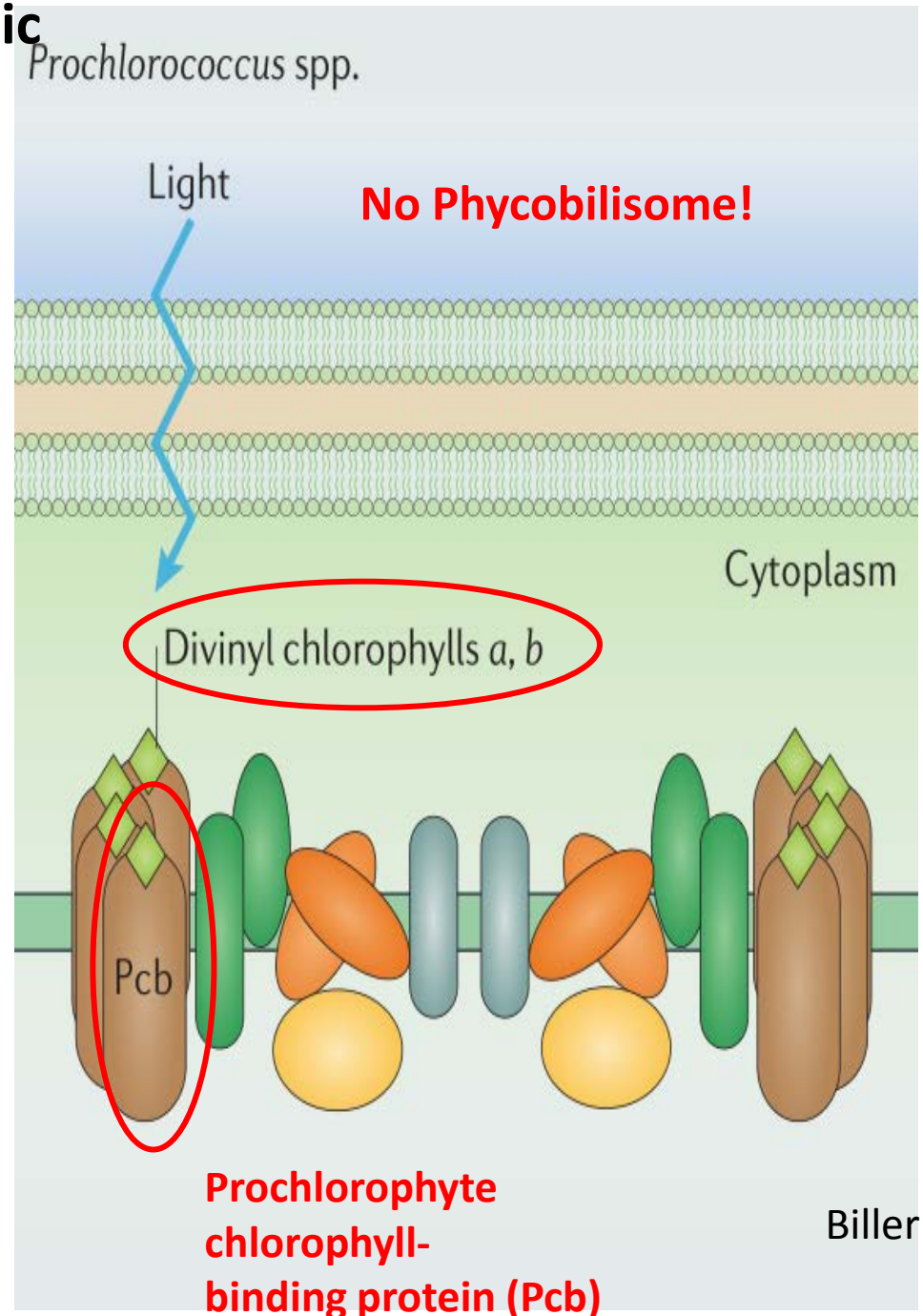
Flombaum et al., P*NAS*

Photosynthetic apparatus:



Biller et al., *Nature Reviews*

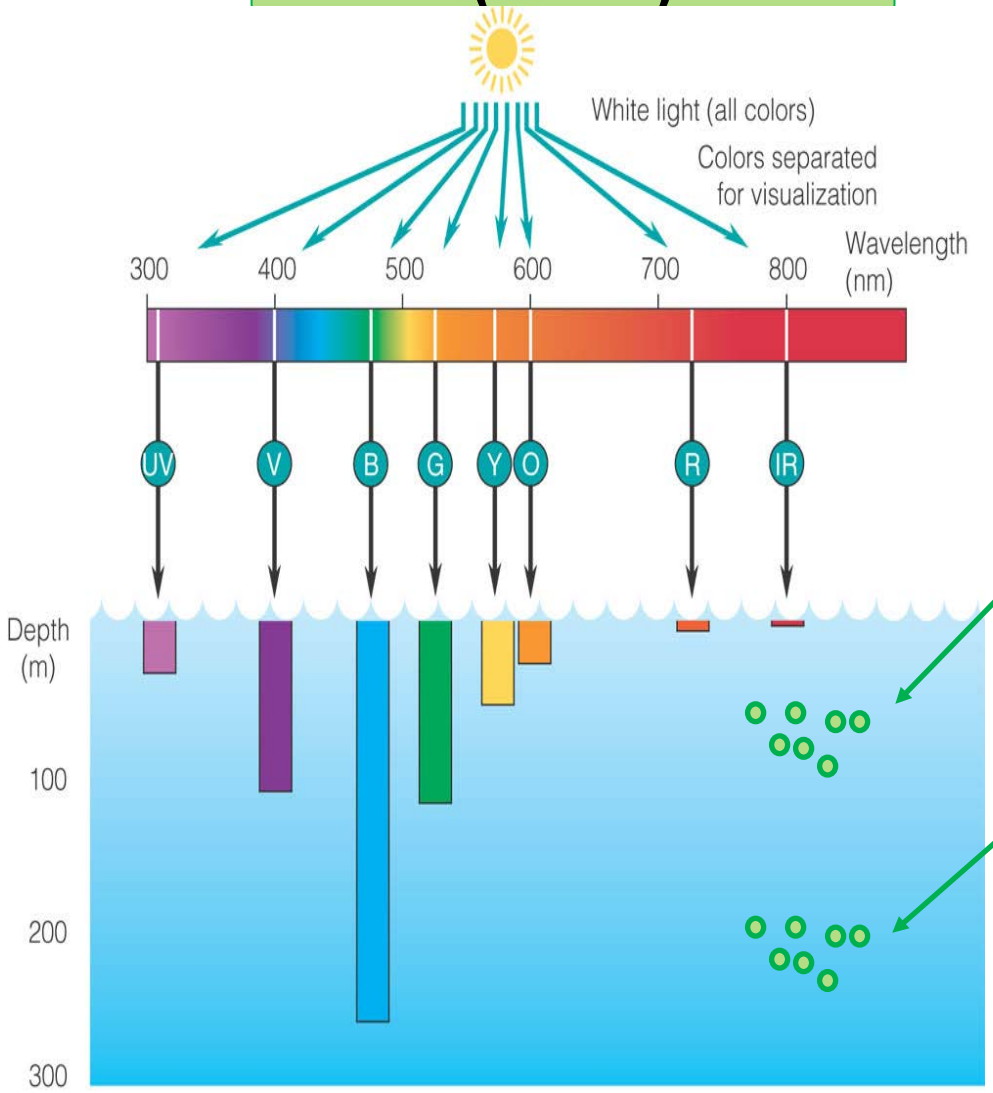
Photosynthetic apparatus:



Biller et al., *Nature Reviews Microbiology*, 2015

Pigments: divinyl chlorophyll *a* (Chl a2)

divinyl chlorophyll *b* (Chl b2) → ratio Chl b2/a2



Prochlorococcus Ecotypes:

HL = "*high light*" [25 – 100 m depth]

→low Chl b2/a2

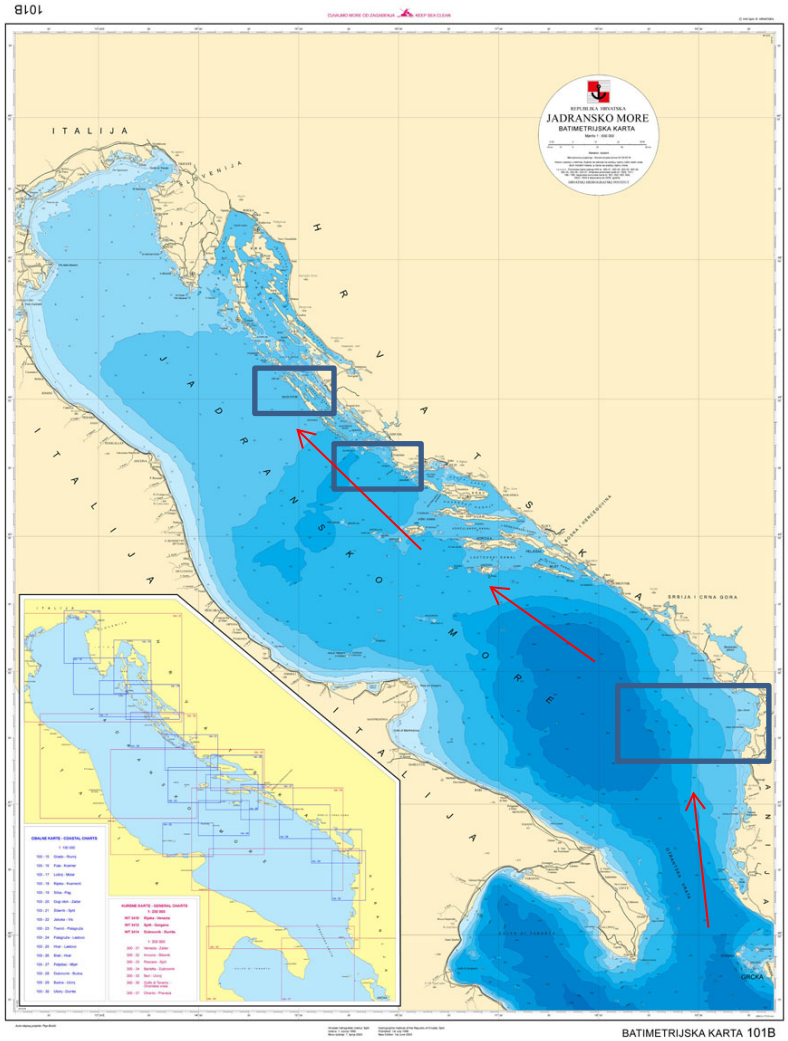
LL = "*low light*" [80 – 200 m depth]

→ high Chl b2/a2

light requirements, nitrogen and phosphorus utilization, copper, and virus sensitivity

Biomarker pigment divinyl chlorophyll *a* as a tracer of water masses?

Maja Mejdandžić[1], Hrvoje Mihanović[2], Tina Šilović[3], Jorijntje Henderiks[4], Luka Šupraha[5], Dorotea Polović[1], Sunčica Bosak[1], Ivana Bošnjak[1], Ivona Cetinić[6], Goran Olujić[7], Zrinka Ljubešić[1]



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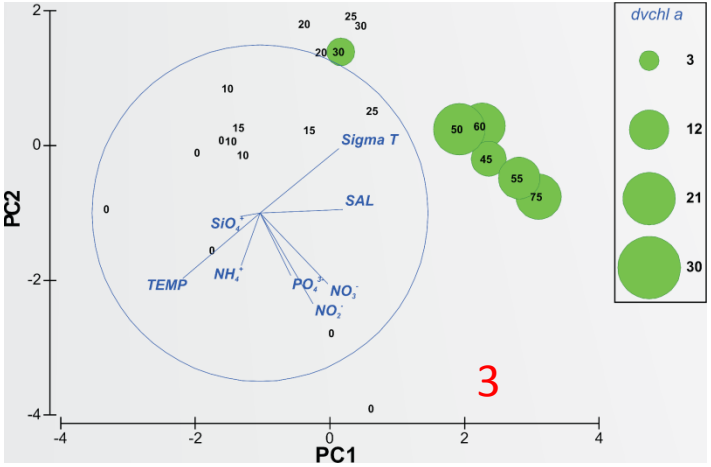
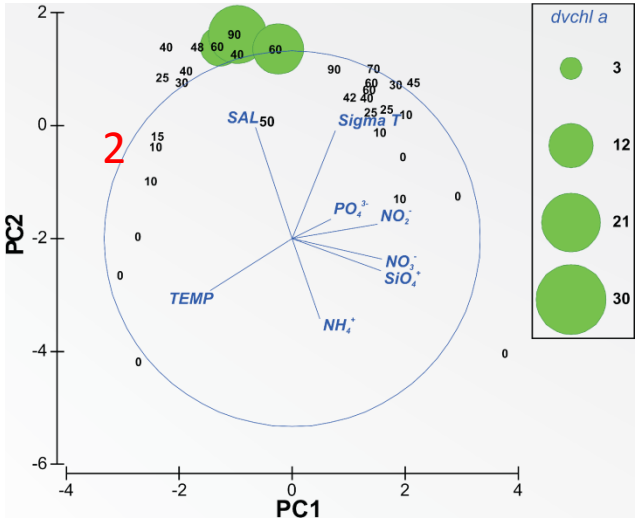
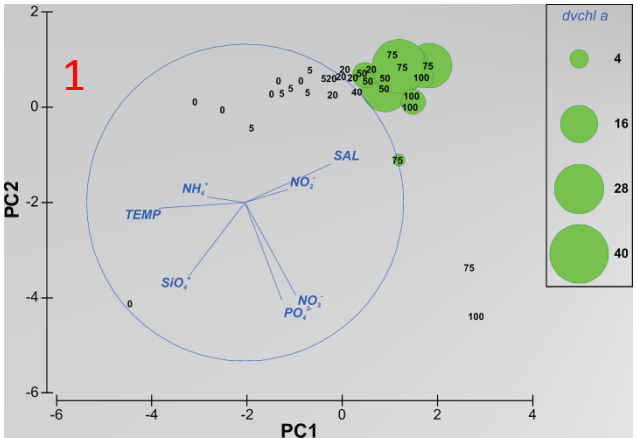
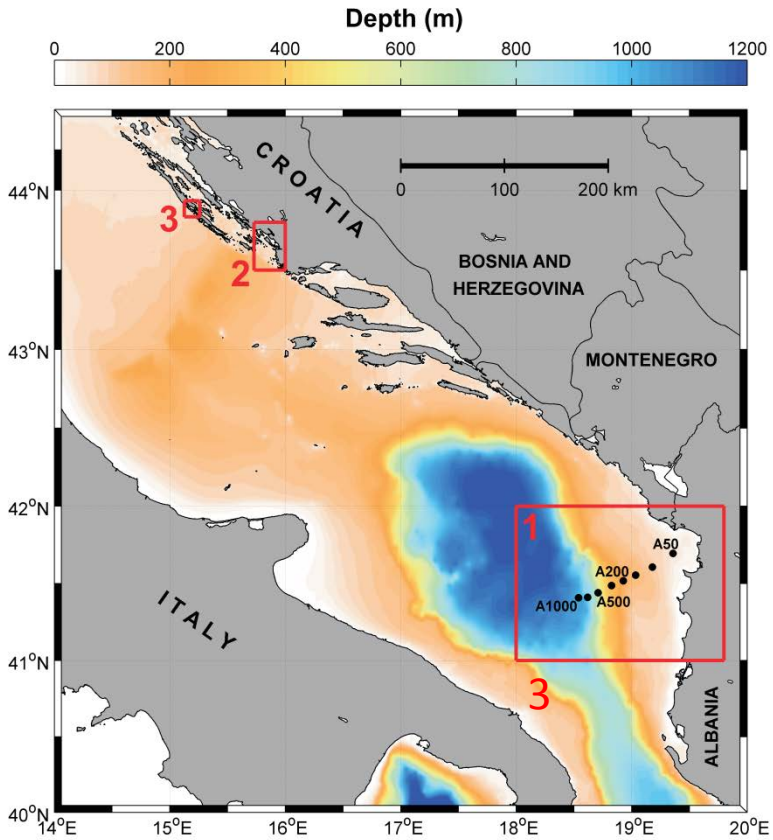
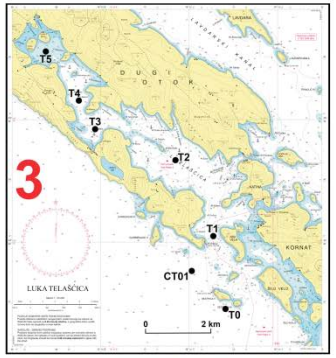
[1] University of Zagreb, Faculty of Science,
[2]Institute for Oceanography and Fisheries
[3]Center for Marine Research, Ruđer Bošković Institute
[4] CEES, Dept. of Biosciences, University of Oslo,
[5]Department of Earth Sciences, Paleobiology Programme, Uppsala University
[6] University of Maine, Ira C. Darling Marine Center,
[7]Hydrographic Institute of the Republic of Croatia

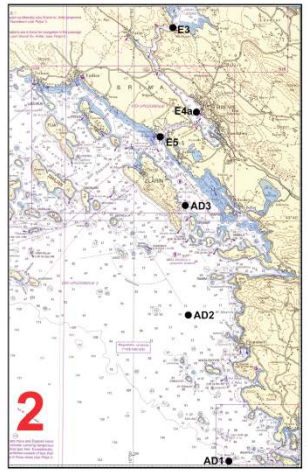

dvchl a
3
12
21
30
Sigma T
SAL
SiO4+
TEMP
NH4+
PO43-
NO3-
NO2-
PC1
PC2
3

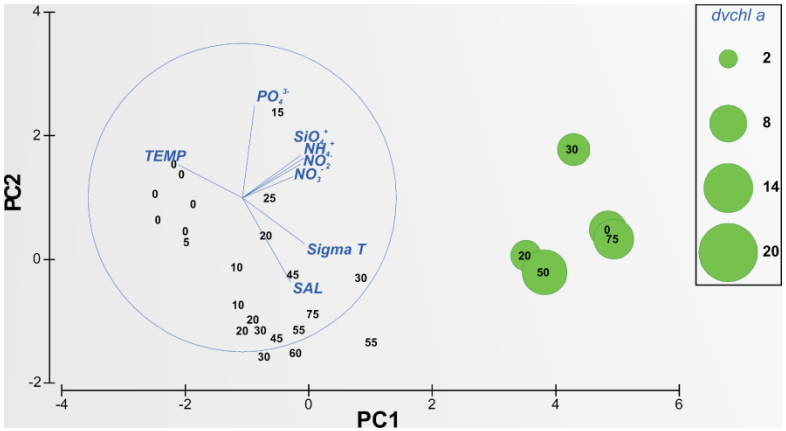

dvchl a
3
12
21
30
SAL
Sigma T
PO43-
NO2-
NO3-
SiO4+
TEMP
NH4+
PC1
PC2
2

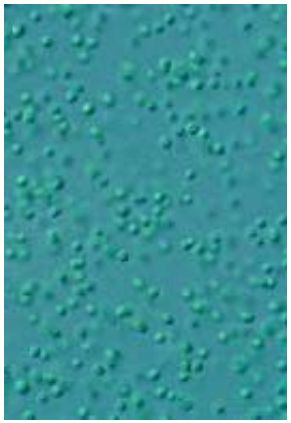

dvchl a
4
16
28
40
1
SAL
NH4+
NO2-
TEMP
SiO4+
NO3-
PO43-
PC1
PC2

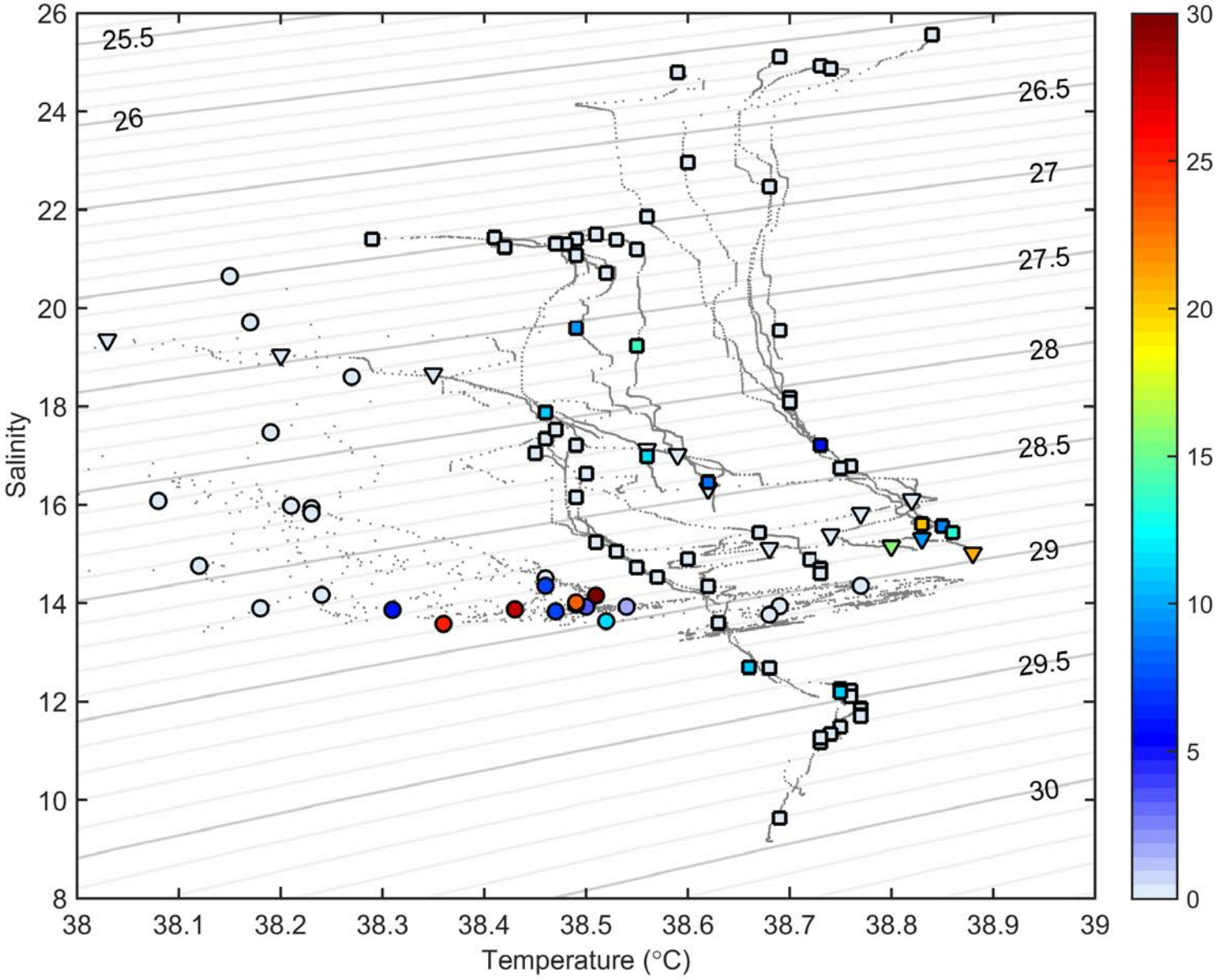

Depth (m)
0
200
400
600
800
1000
1200
CROATIA
BOSNIA AND
HERZEGOVINA
MONTENEGRO
ITALY
ALBANIA
0
100
200 km
44°N
43°N
42°N
41°N
40°N
14°E
15°E
16°E
17°E
18°E
19°E
20°E
1
2
3
A50
A200
A500
A1000


T5
T4
T3
T2
T1
T0
CT01
LUKA TELAŠĆICA
KORNAT
0
2 km
3


E3
E4a
E5
AD3
AD2
AD1
2


dvchl a
2
8
14
20
PO43-
SiO4+
NH4+
NO2-
NO3-
TEMP
Sigma T
SAL
PC1
PC2



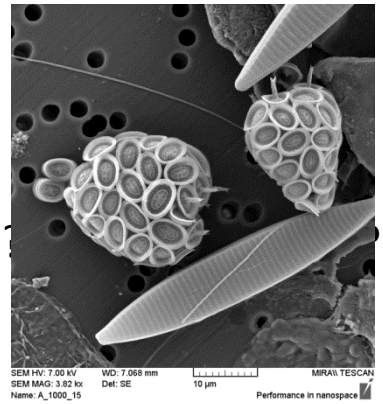

Salinity
Temperature (°C)
25.5
26
26.5
27
27.5
28
28.5
29
29.5
30
26
24
22
20
18
16
14
12
10
8
38
38.1
38.2
38.3
38.4
38.5
38.6
38.7
38.8
38.9
39
30
25
20
15
10
5
0

Global distribution of specific phytoplankton species is a response to the ecological parameters (eg. temperature, available light, nutrients, etc)

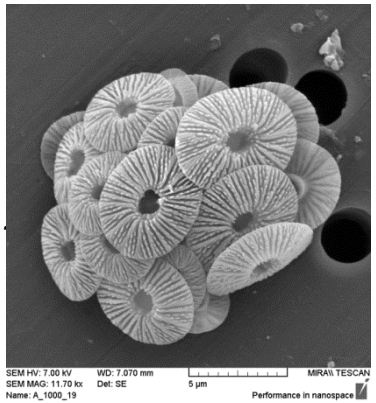
Water masses are characterized by specific values of tempearture and salinity

BIOINDICATORS

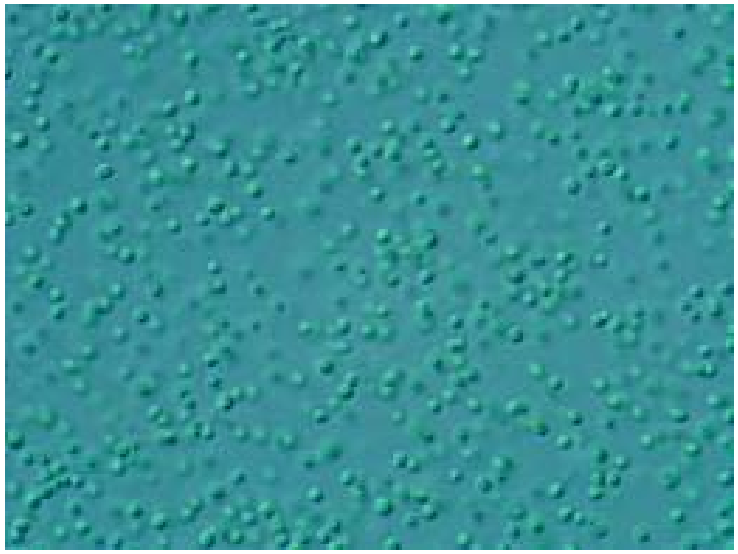
??????????????



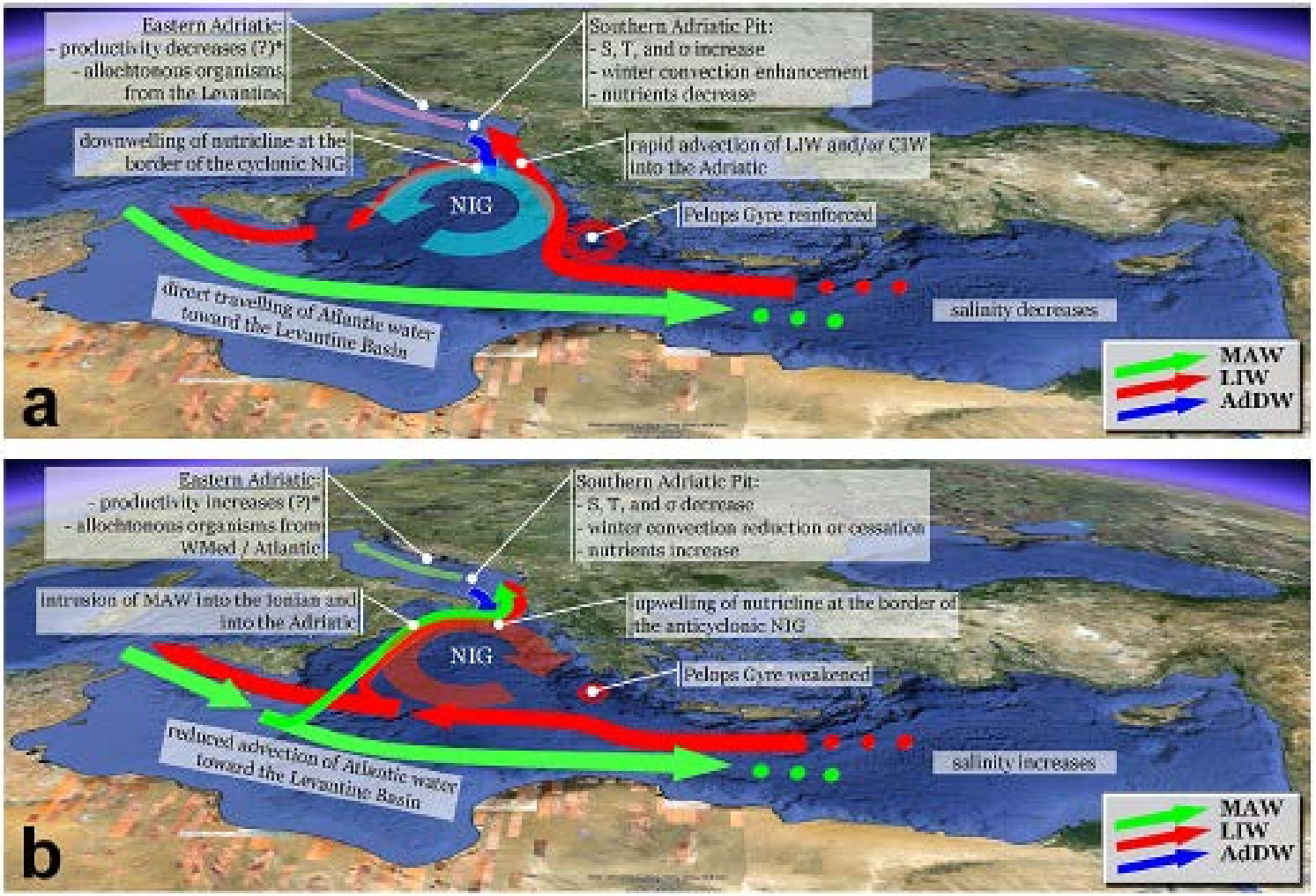
??????????????



Prokaryote *Prochlorococcus*



Coccolithophore : *Emiliania huxleyi i/ili Gephyrocapsa oceanica*



Civitarese, et al 2010, Biogeosciences

Mediterranean Sea

LIW = Levantine Intermediate Water

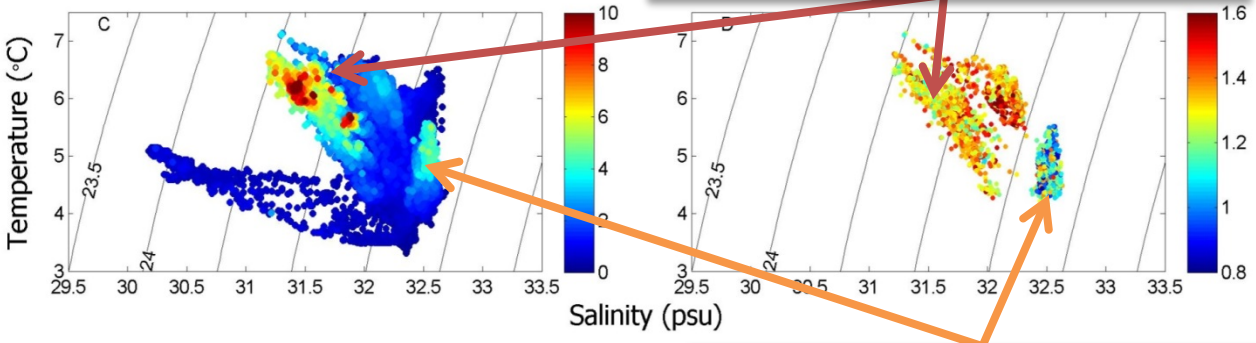
NAdDW = North Adriatic Dense Water

AdDW = Adriatic Dense Water

- ✓ Recent studies: detection of tropical or subtropical species → influence of global warming! (Coll et al., 2010; Lejeusne et al., 2009; Mella-Flores, 2012)
- ✓ **<u>Southern Adriatic</u>** = hot spot for climate change investigations

1. Bio-optics

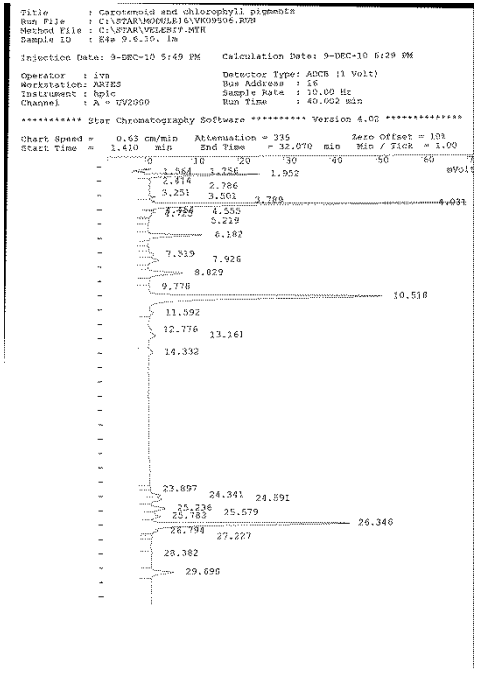
Phytoplankton population 1
Higher backscattering



Phytoplankton population 2
Lower backscattering

4. Biomarkers

HPLC

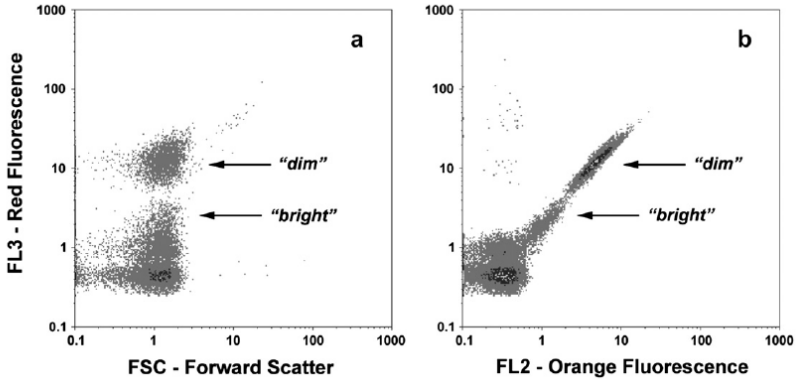


3. Zooplankton

LM

2. Phytoplankton

a) LM, SEM
b) Flow cytometry
a) Molecular identification

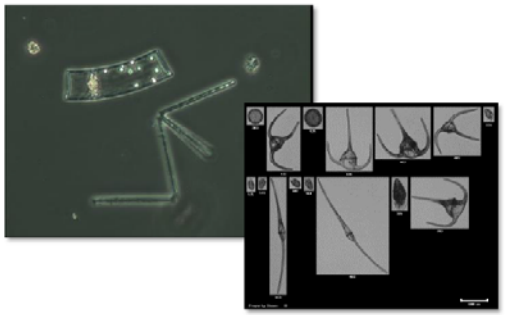


Measuring phytoplankton

- Molecular tools
  - 18s and 16s rRNA

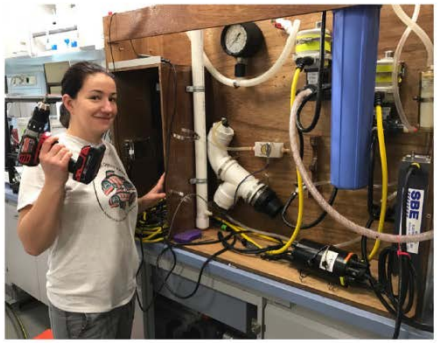
Imagery

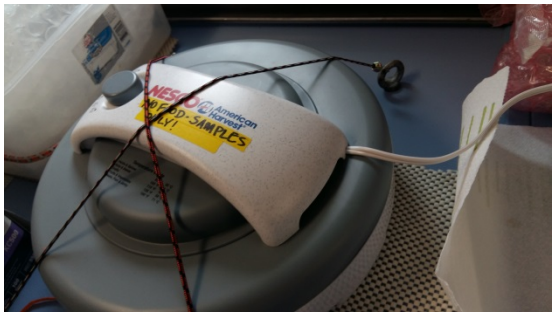
- Continuously + vertical profiles on the station
  - Flowcam, Imaging flow cytobot, Holographic (3-D) camera, classical microscopy
  - Calculation of Carbon

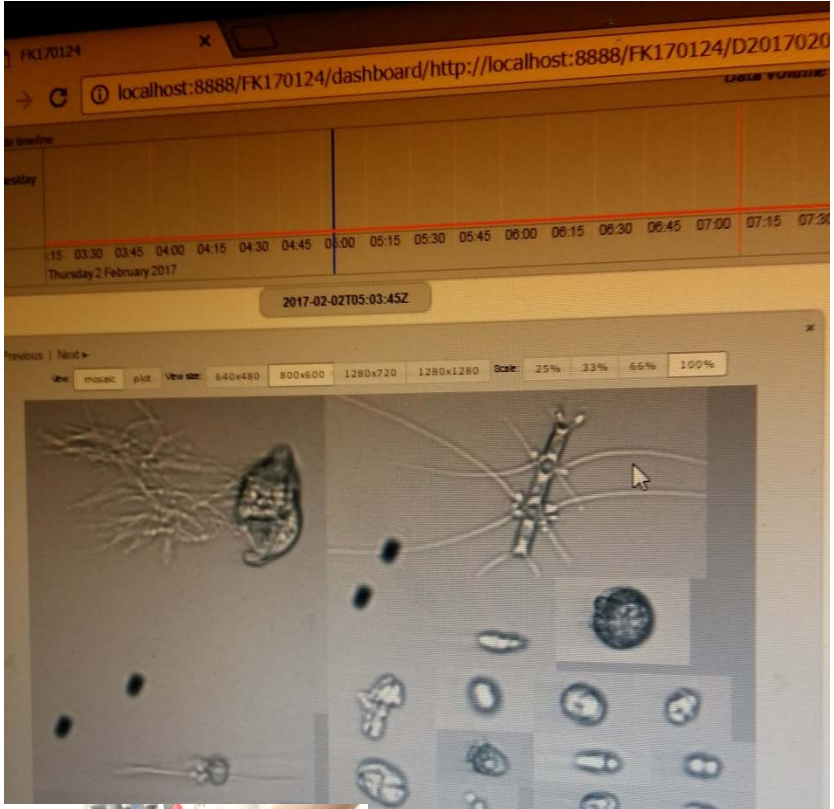


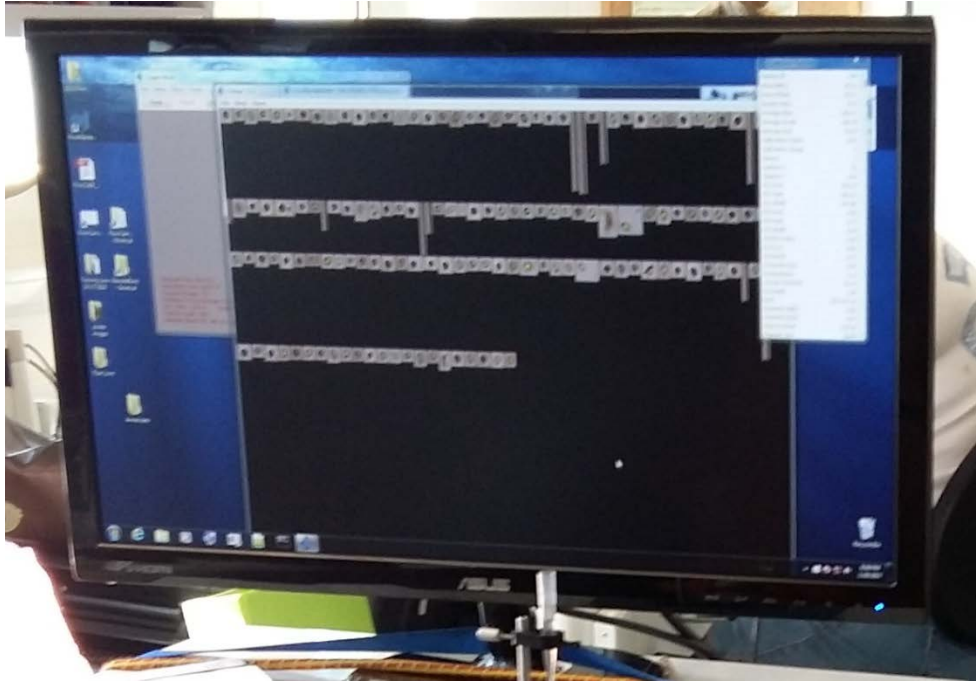
Optical in-line measurments

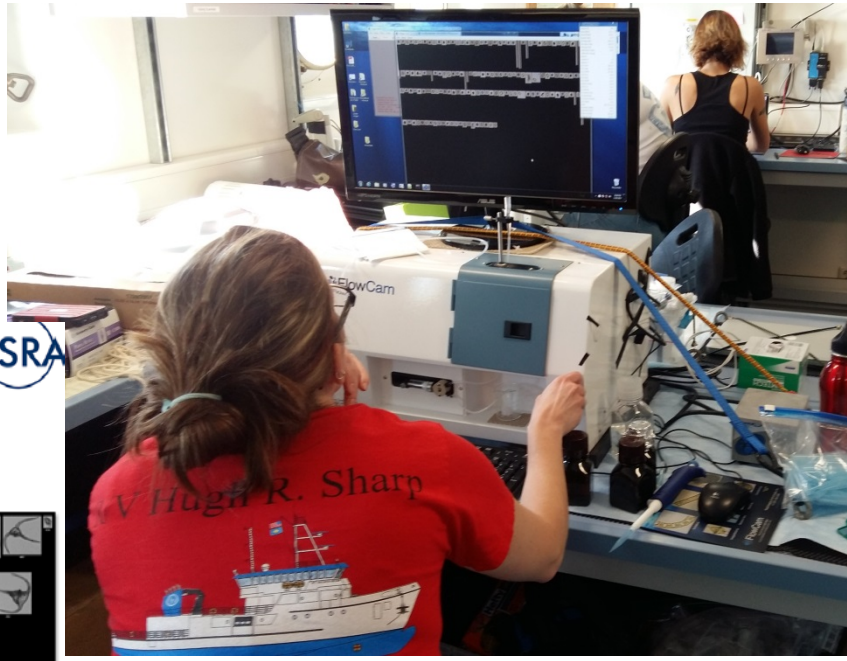
- Interaction of light and particles /phytoplankton
  - Absorption
  - scattering
- Continuous system (wetlab)







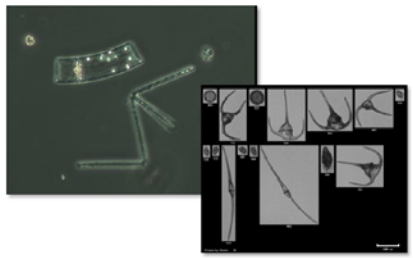




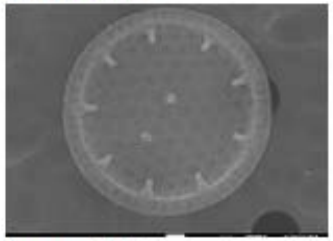
Measuring phytoplankton

Imagery

- Continuously + vertical profiles on the station
  - Flowcam, Imaging flow cytobot, Holographic (3-D) camera, classical microscopy
  - Calculation of Carbon



Diatoms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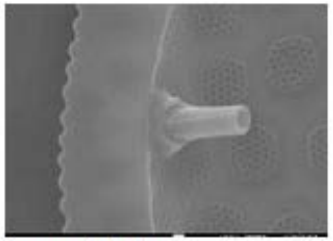
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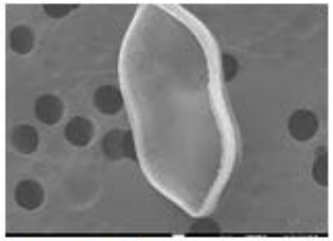
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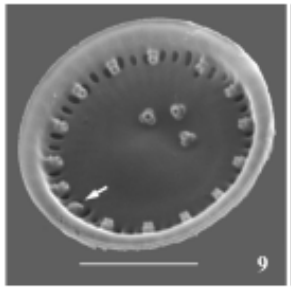

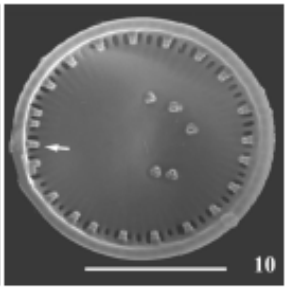

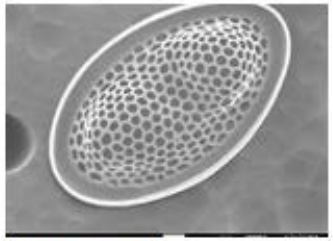
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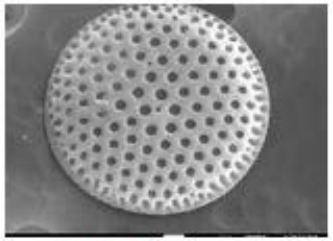
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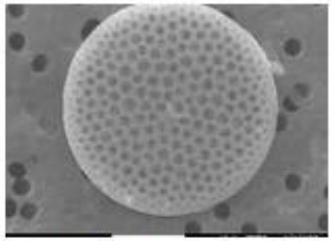
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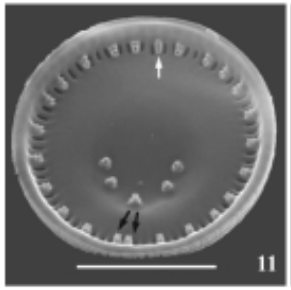

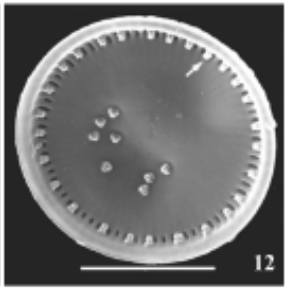

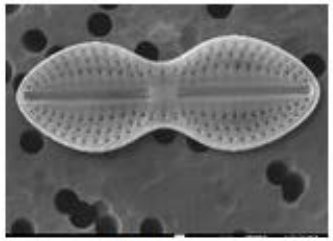
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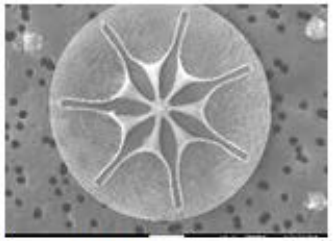
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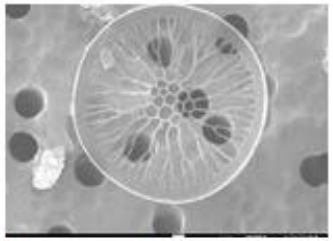
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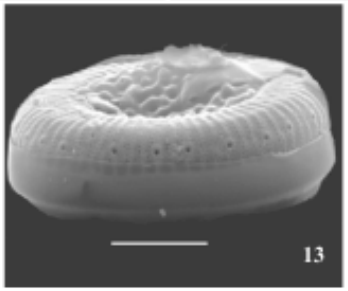
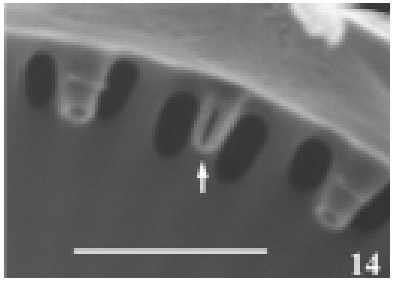
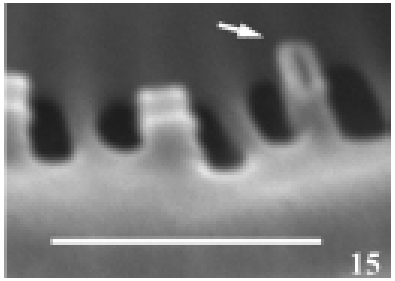
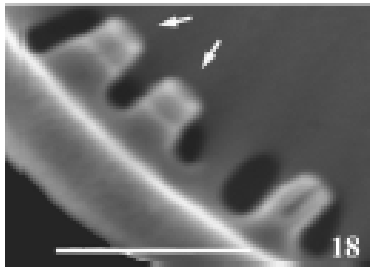
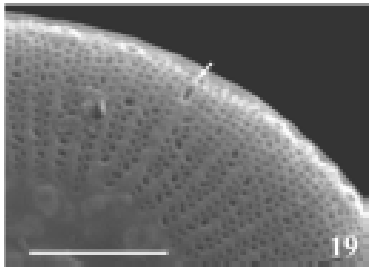


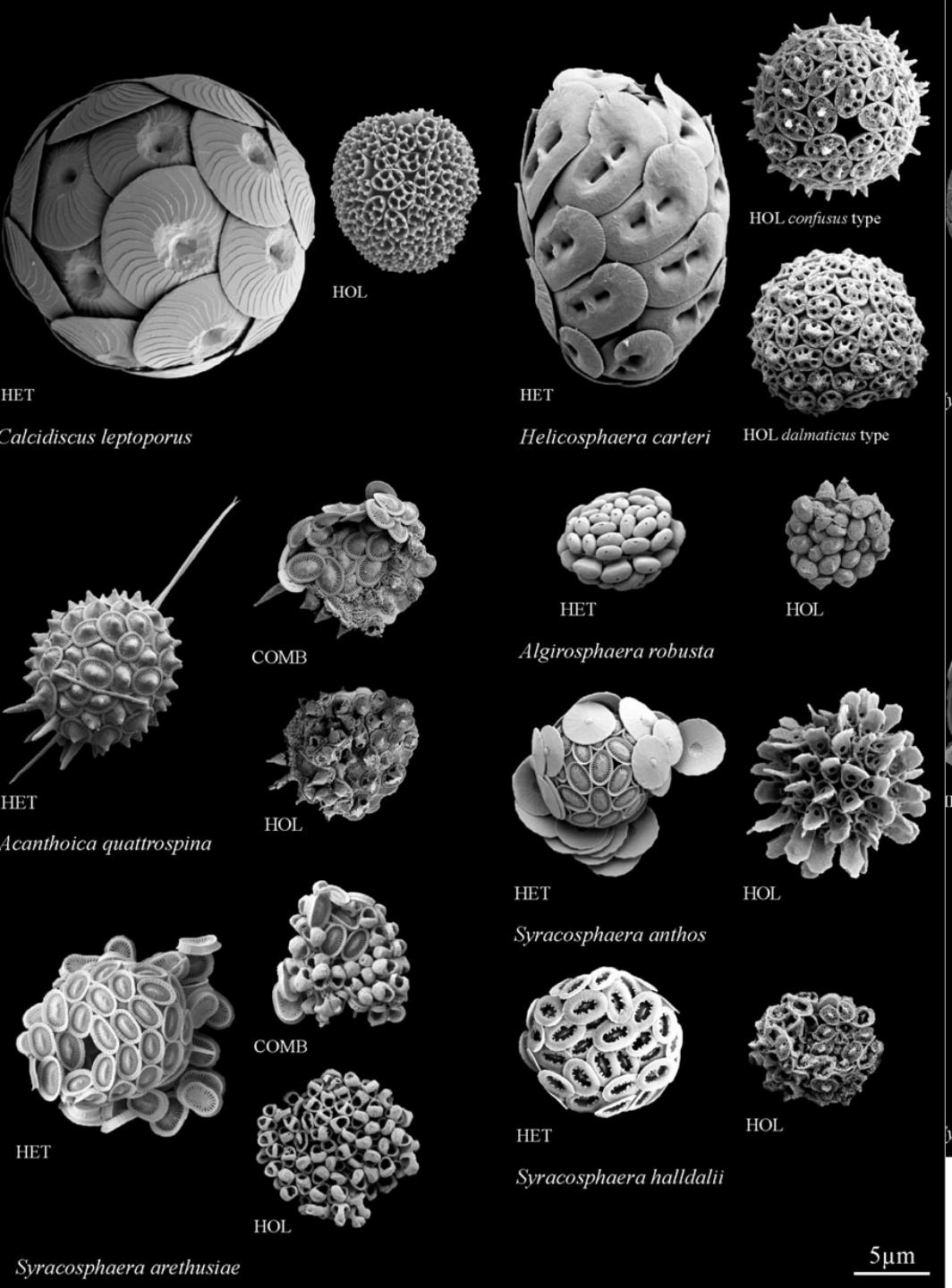


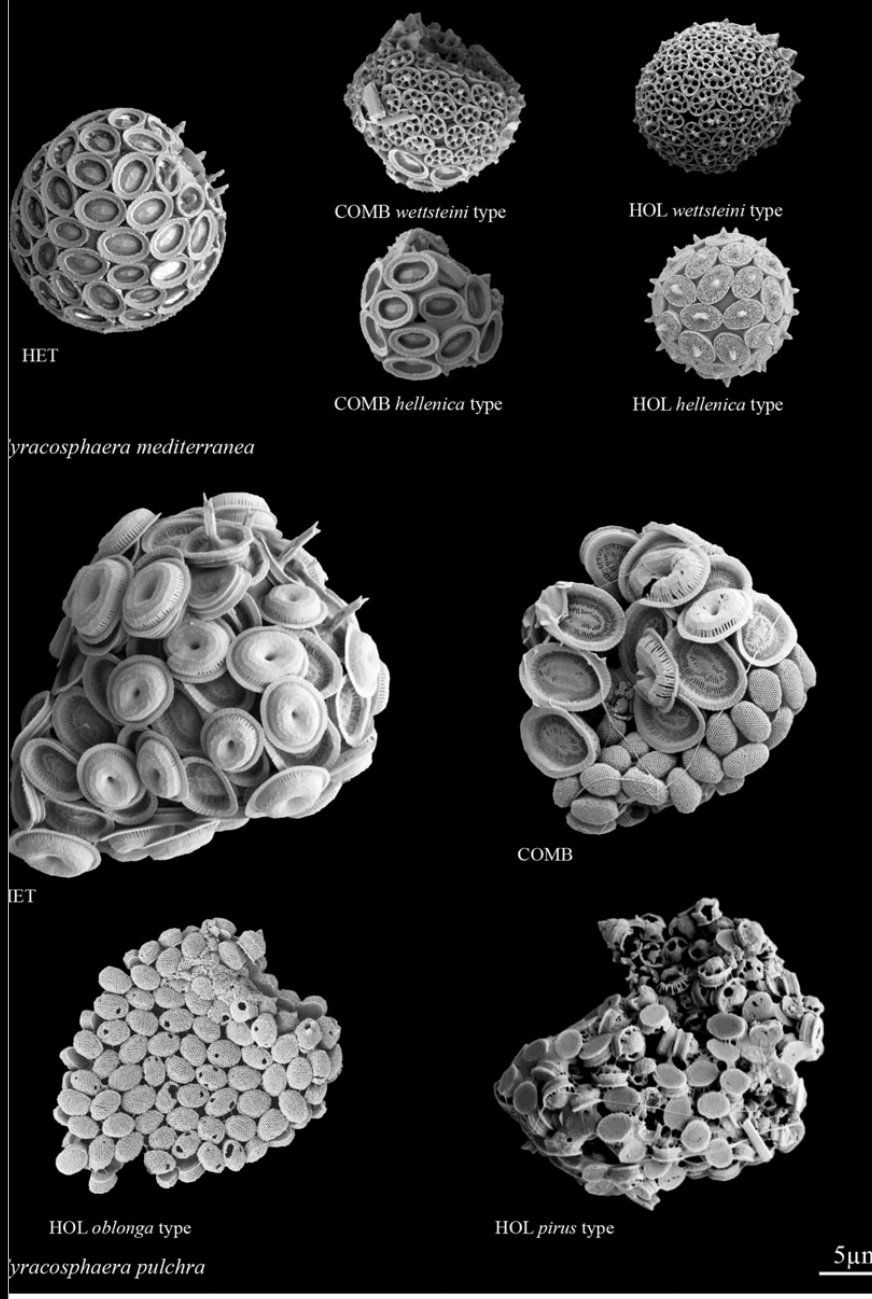




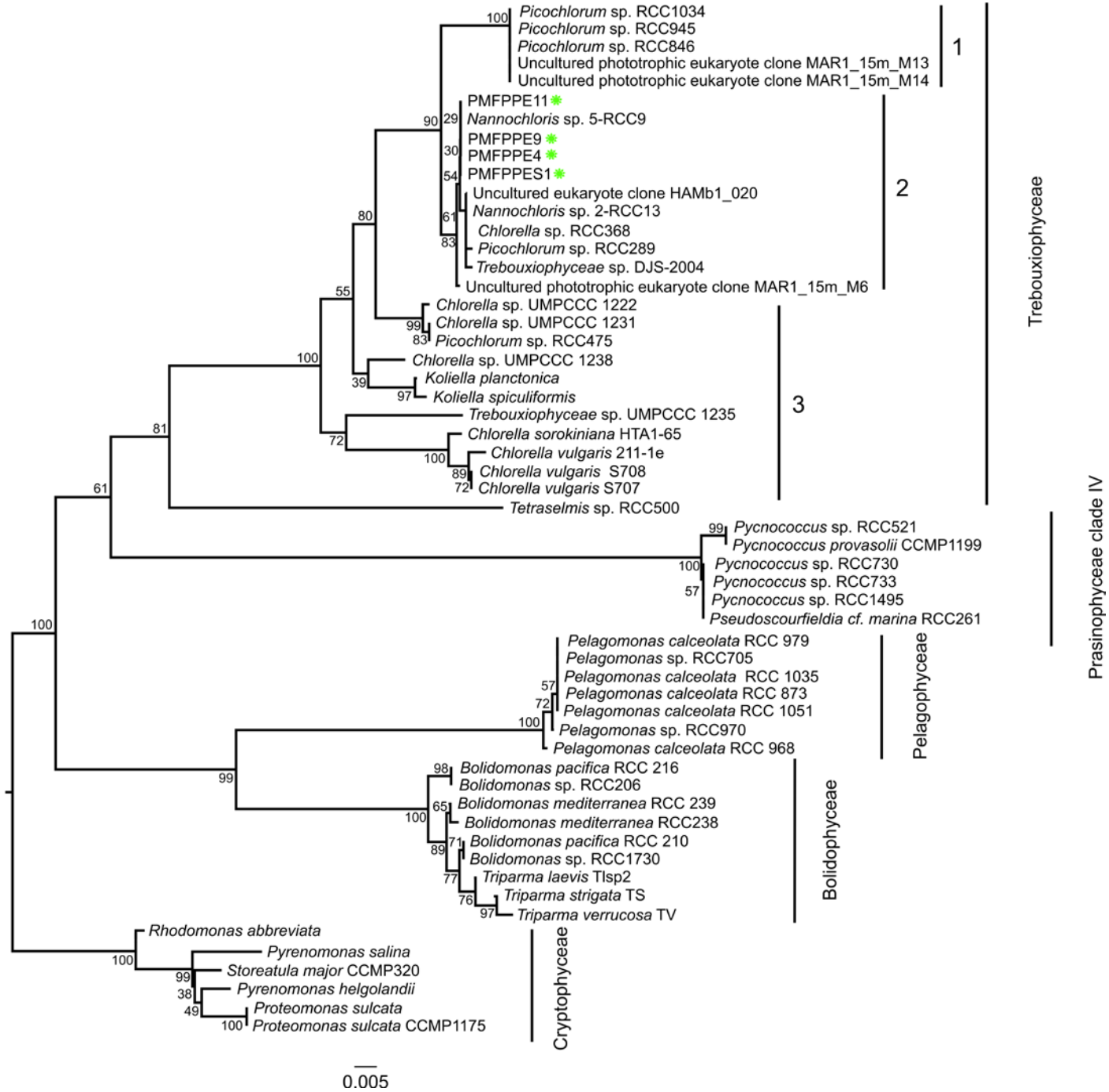


Burić et al 2007, Nova Hedwigia





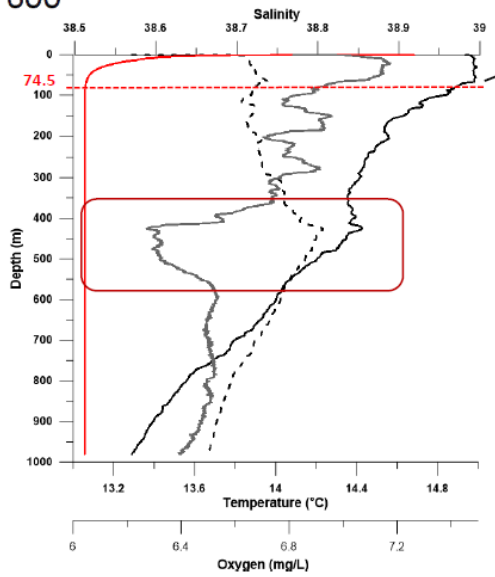
Šupraha et al 2015, JPR


Picochlorum sp. RCC1034
Picochlorum sp. RCC945
Picochlorum sp. RCC846
Uncultured phototrophic eukaryote clone MAR1_15m_M13
Uncultured phototrophic eukaryote clone MAR1_15m_M14
1
PMFPPE11
Nannochloris sp. 5-RCC9
PMFPPE9
PMFPPE4
PMFPPES1
Uncultured eukaryote clone HAMb1_020
Nannochloris sp. 2-RCC13
Chlorella sp. RCC368
Picochlorum sp. RCC289
Trebouxiophyceae sp. DJS-2004
Uncultured phototrophic eukaryote clone MAR1_15m_M6
2
Chlorella sp. UMPCCC 1222
Chlorella sp. UMPCCC 1231
Picochlorum sp. RCC475
Chlorella sp. UMPCCC 1238
Koliella planctonica
Koliella spiculiformis
Trebouxiophyceae sp. UMPCCC 1235
Chlorella sorokiniana HTA1-65
Chlorella vulgaris 211-1e
Chlorella vulgaris S708
Chlorella vulgaris S707
3
Tetraselmis sp. RCC500
Trebouxiophyceae
Pycnococcus sp. RCC521
Pycnococcus provasolii CCMP1199
Pycnococcus sp. RCC730
Pycnococcus sp. RCC733
Pycnococcus sp. RCC1495
Pseudoscourfieldia cf. marina RCC261
Prasinophyceae clade IV
Pelagomonas calceolata RCC 979
Pelagomonas sp. RCC705
Pelagomonas calceolata RCC 1035
Pelagomonas calceolata RCC 873
Pelagomonas calceolata RCC 1051
Pelagomonas sp. RCC970
Pelagomonas calceolata RCC 968
Pelagophyceae
Bolidomonas pacifica RCC 216
Bolidomonas sp. RCC206
Bolidomonas mediterranea RCC 239
Bolidomonas mediterranea RCC238
Bolidomonas pacifica RCC 210
Bolidomonas sp. RCC1730
Triparma laevis Tlsp2
Triparma strigata TS
Triparma verrucosa TV
Bolidophyceae
Rhodomonas abbreviata
Pyrenomonas salina
Storeatula major CCMP320
Pyrenomonas helgolandii
Proteomonas sulcata
Proteomonas sulcata CCMP1175
Cryptophyceae
0.005

Back to Adriatic….

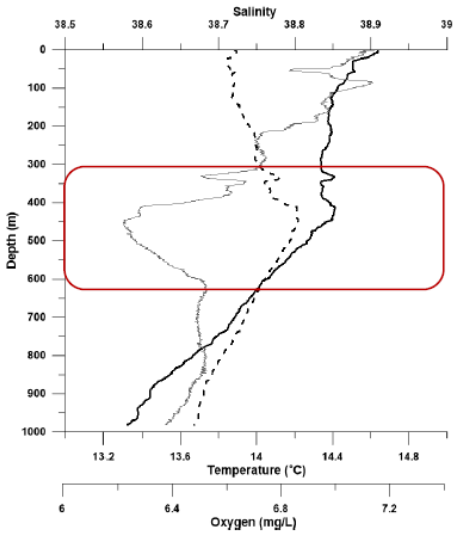
Winter 2015

P600



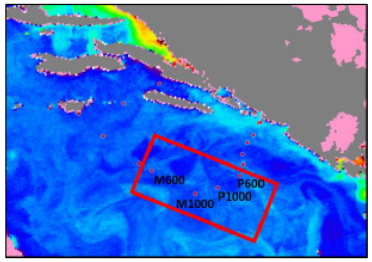
1% of photosynthetically active radiation (PAR)

M1000



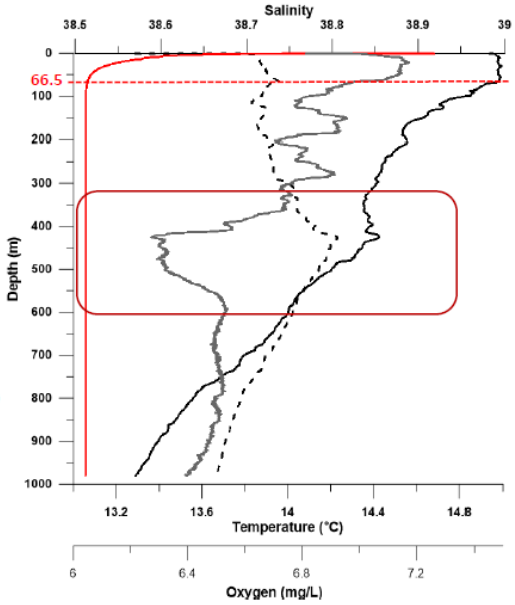
Temperature –
Salinity –
Oxygen
Profiles

Levantine Intermediate Water (LIW)

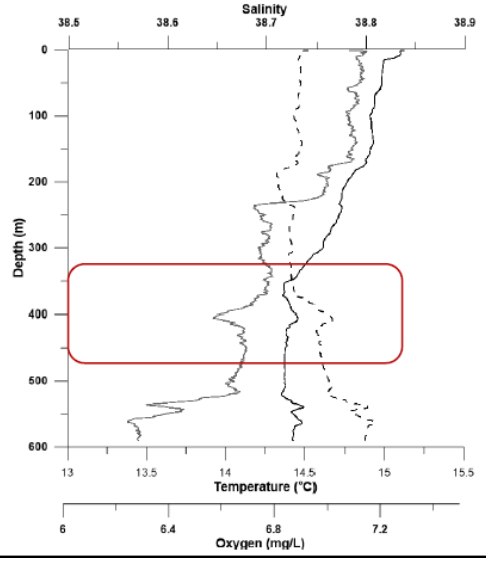


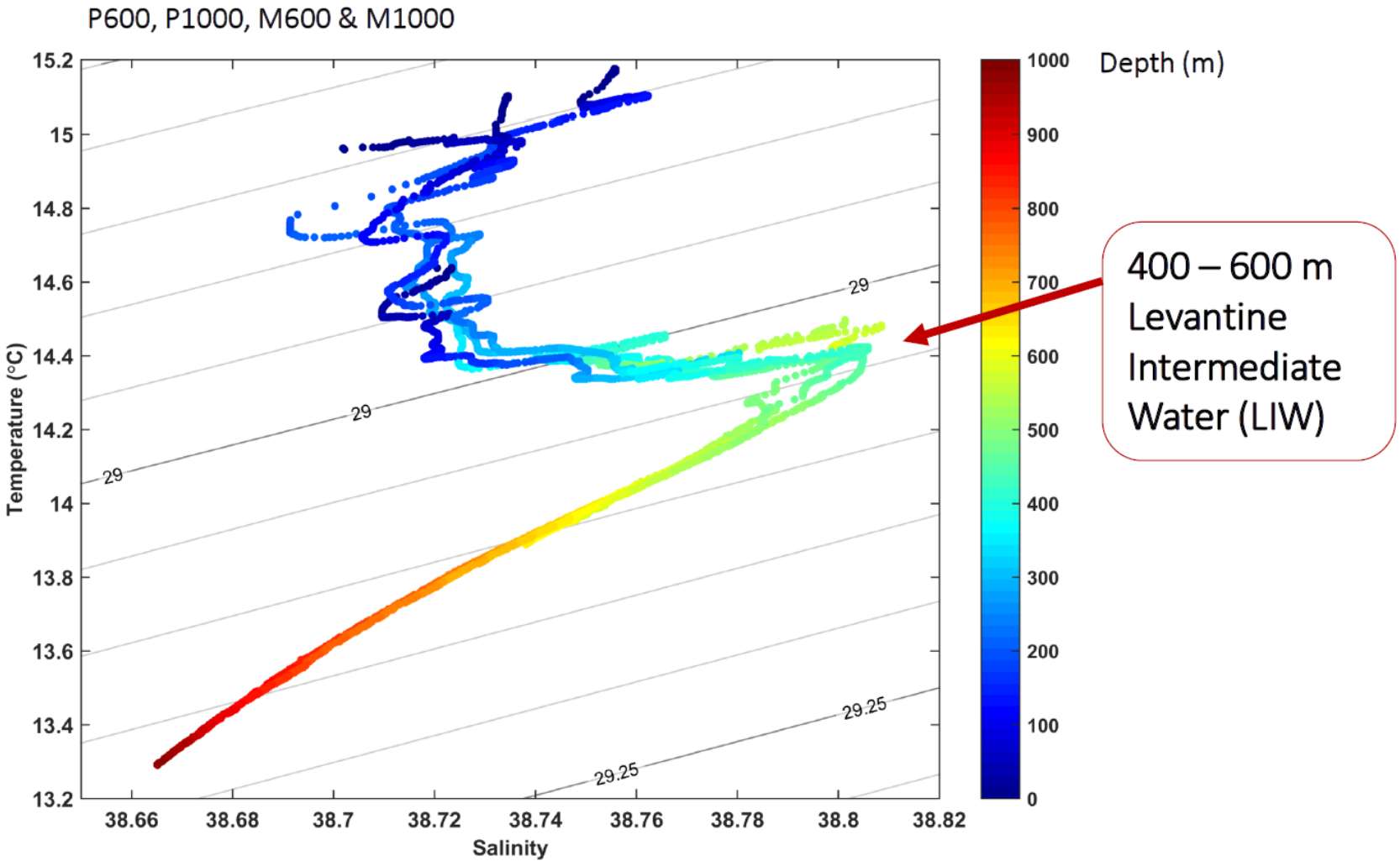
Temperature (°C)
Salinity
Oxygen (mg/L)

P1000

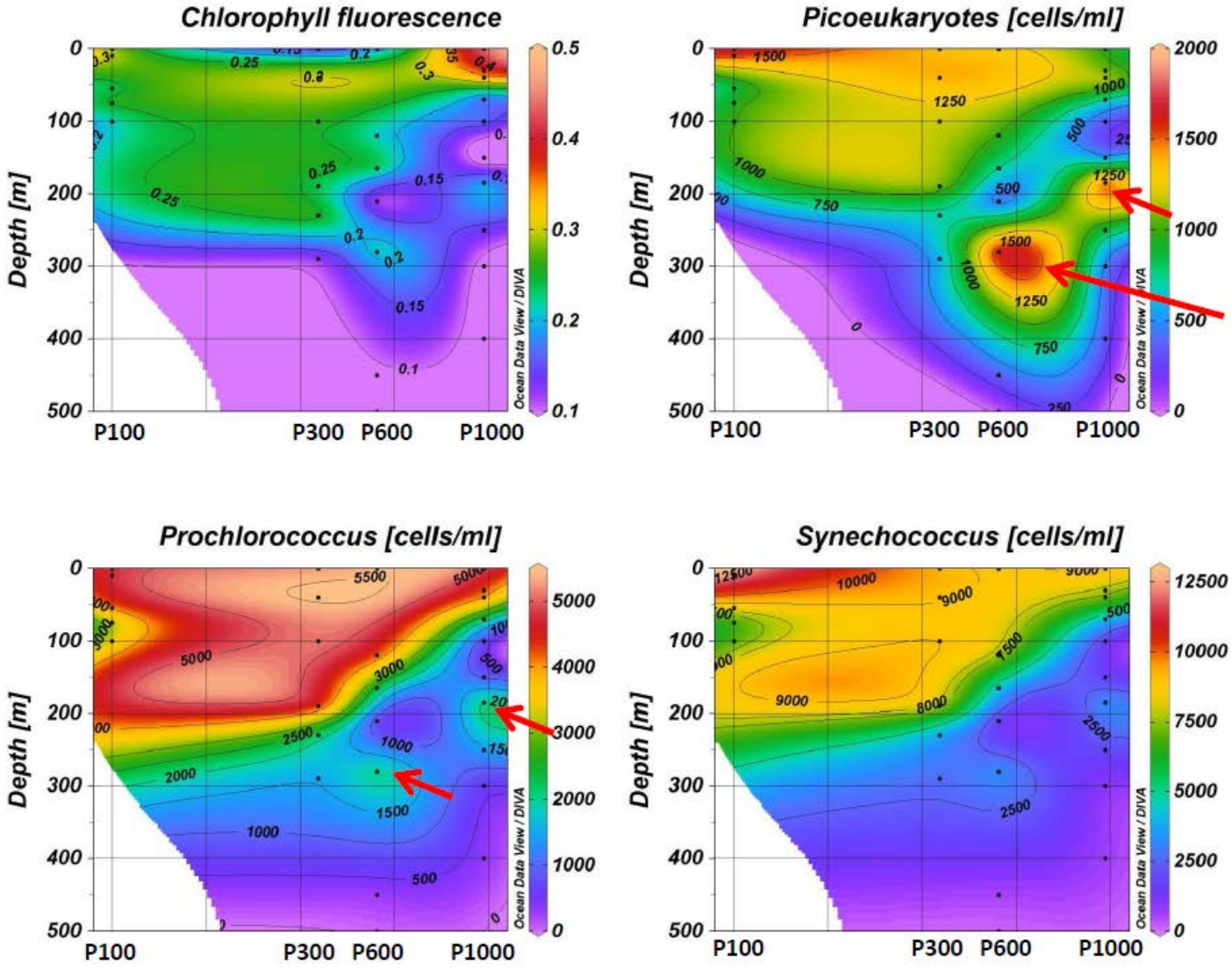


M600

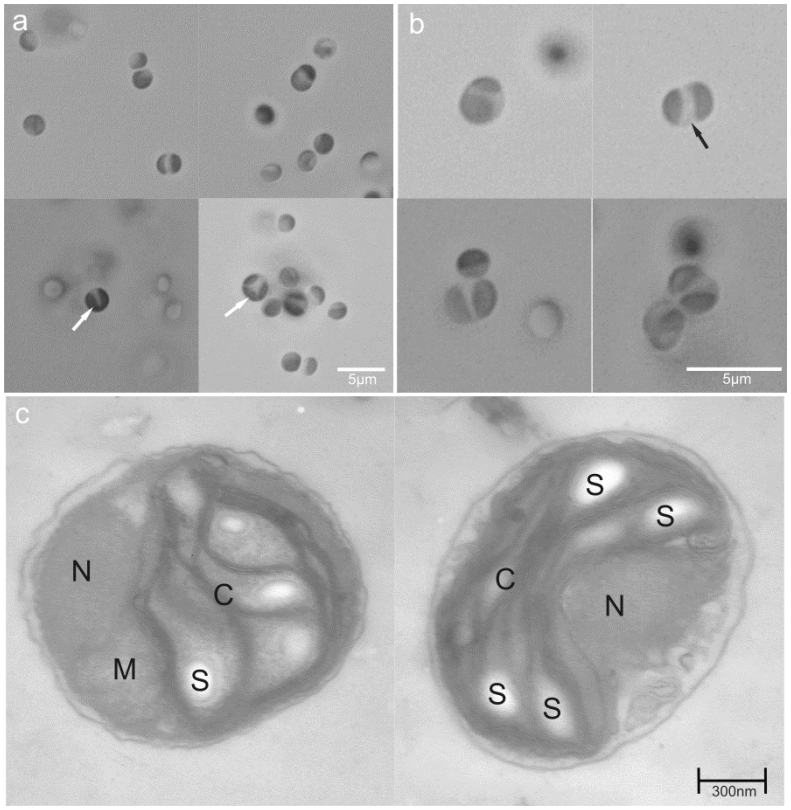


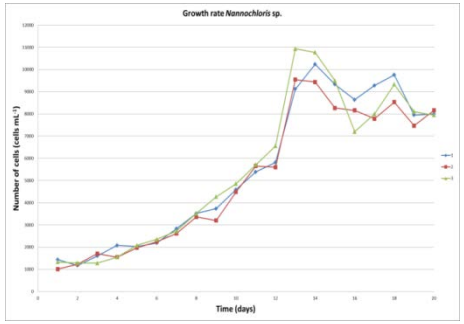

P600, P1000, M600 & M1000
Temperature (°C)
Salinity
Depth (m)
15.2
15
14.8
14.6
14.4
14.2
14
13.8
13.6
13.4
13.2
38.66
38.68
38.7
38.72
38.74
38.76
38.78
38.8
38.82
29
29
29
29.25
29.25
1000
900
800
700
600
500
400
300
200
100
0
400 – 600 m
Levantine
Intermediate
Water (LIW)

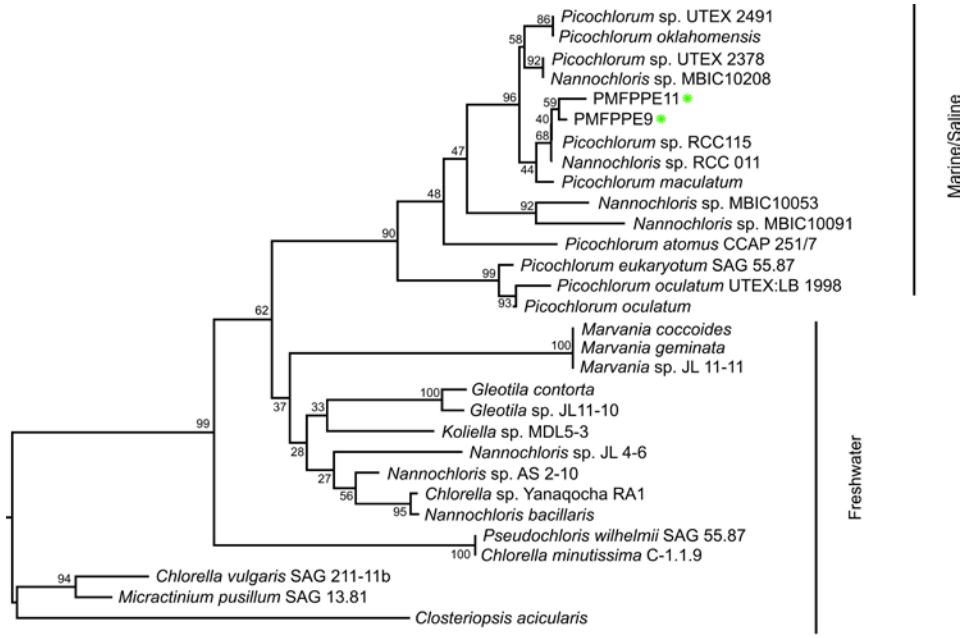
1. Picoeukaryotes

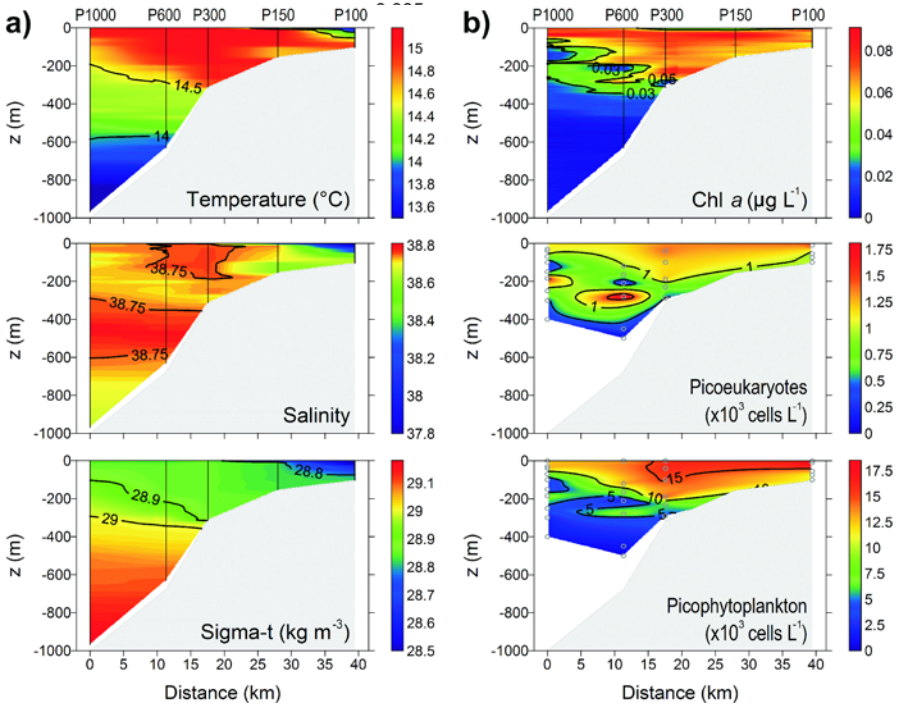


Picochlorum sp



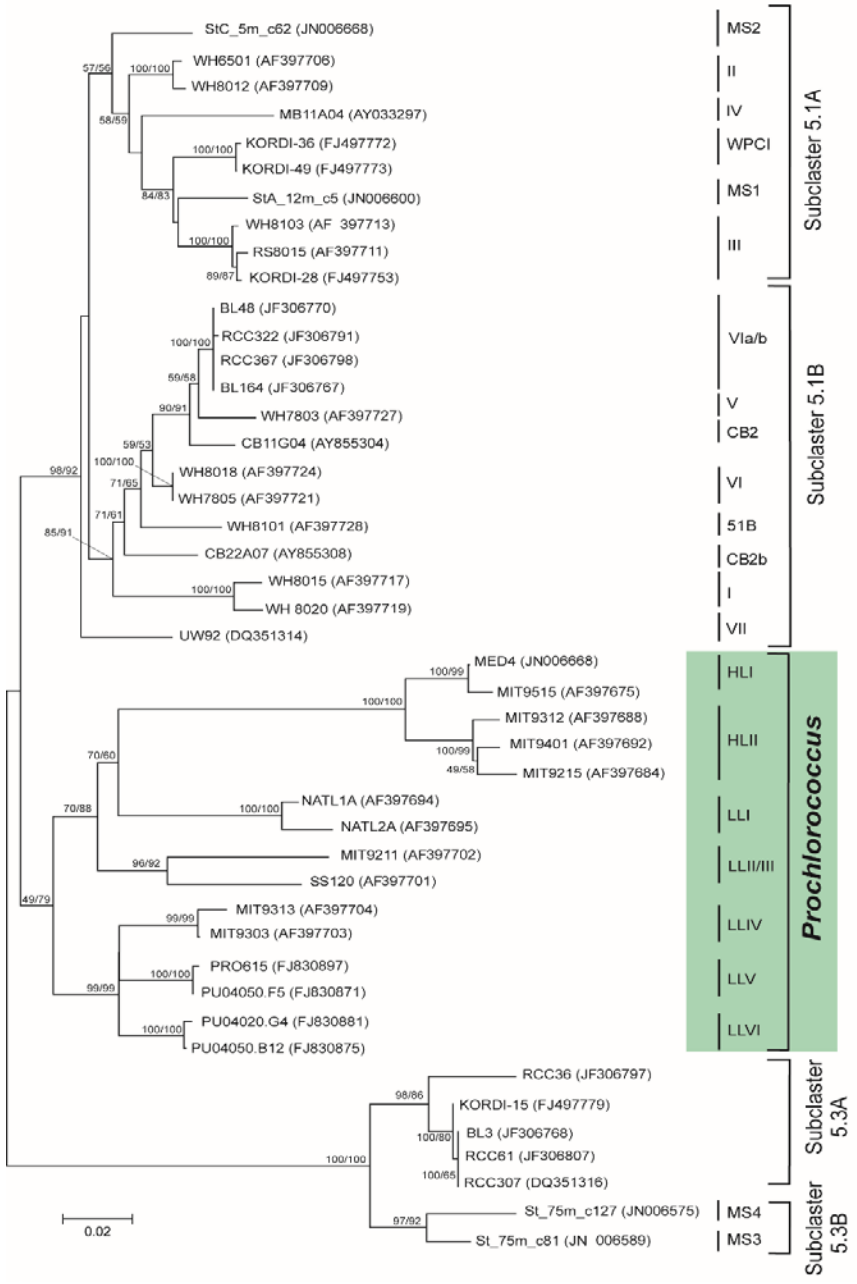






Mejdandžić & Ljubešić, in preparation

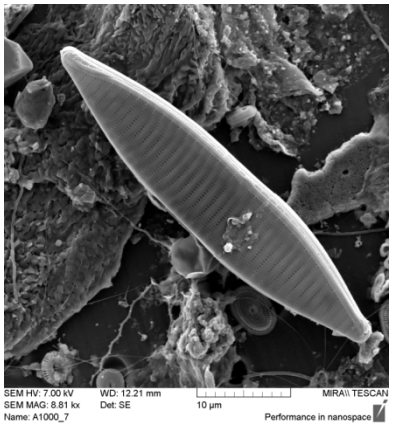
2. cyanobacteria (*Synechoccos*, *Prochloroccous*)



	P150A			P600			M300	
	20m	80m	140m	120m	210m	280m	70m	180m
MS2					2			
II								
IV			1			3		
WPCI					6	2		
MS1				1				
III		1		19	4	17	6	
VIa/b				2	4	1		
V								
CB2								
VI								
51B								
CB2b								
I					3			
VII								
HLI	22	12	12	7	3	8	18	22
HLII								
LLI	0	9	4	1	1	0	5	1
LLII/III								
LLIV								
LLV								
LLVI								
Subclaster 5.3A	3	1	5		5	1	2	3
MS4	1	1						1
MS3	2		4	1	1		2	6
	28	24	26	31	29	32	33	33

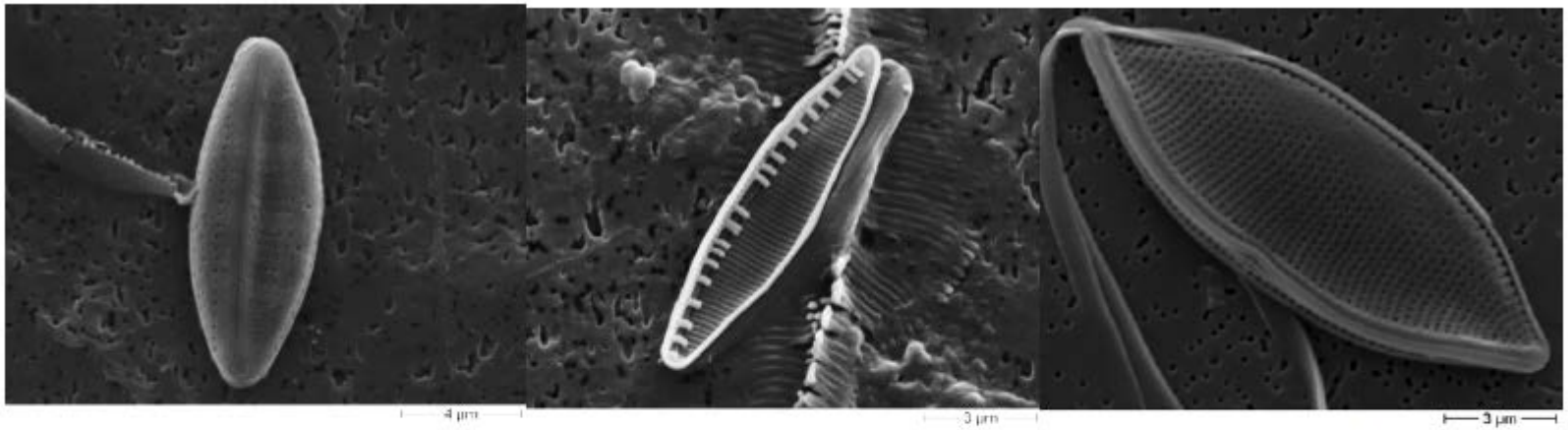
Bošnjak & Petrić

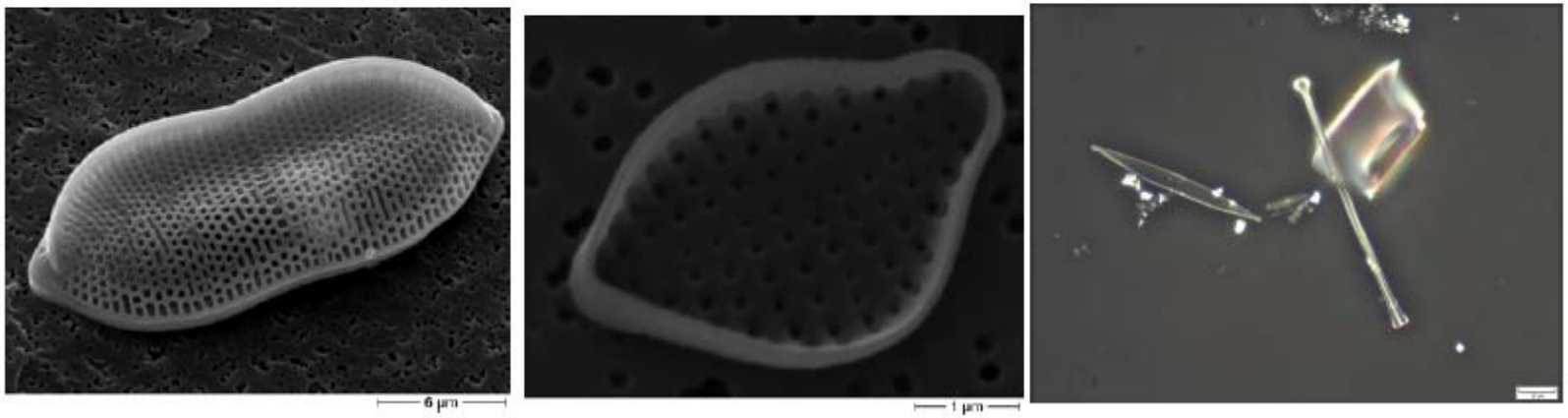
3. Penate diatomes



Nitzschia sicula (Viličić et al. 1994)

Batistić et al 2012





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Article

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Entomoneis tenera sp. nov., a new marine planktonic diatom (Entomoneidaceae, Bacillariophyta) from the Adriatic Sea

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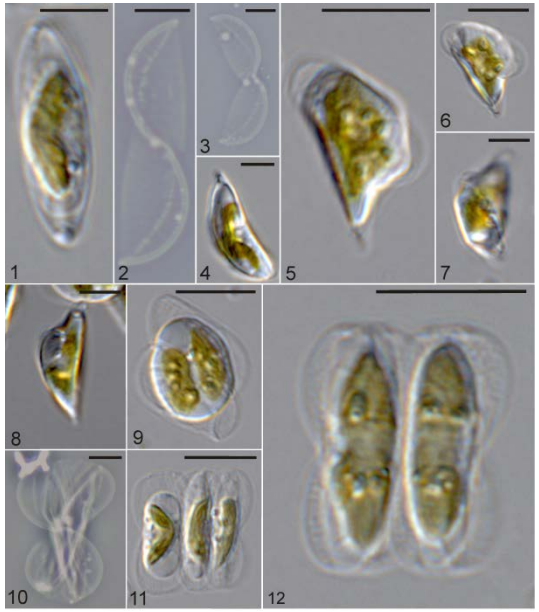
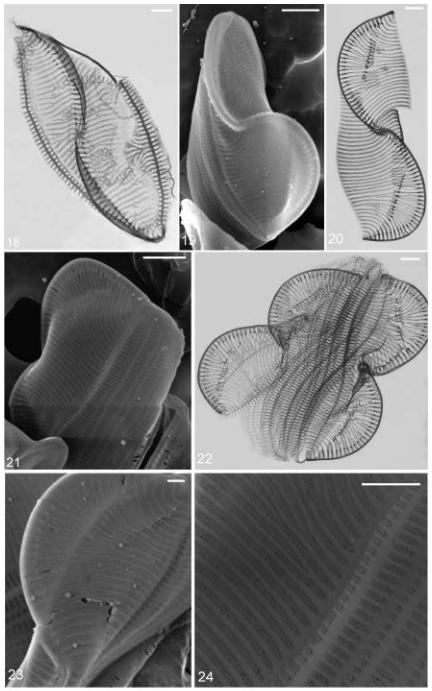
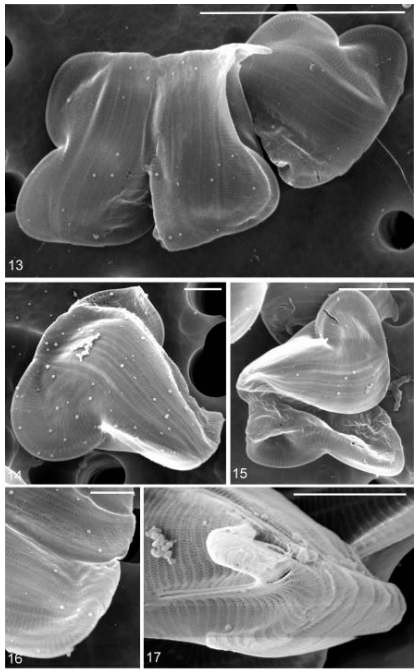
[4]*Forensic Science Center "Ivan Vučetić" Zagreb, Ilica 335, 10000 Zagreb, Croatia*
[5]*Center of Excellence for Science and Technology Integrating Mediterranean Region, Microbial Ecology, Bijenička 54, 10000 Zagreb, Croatia*
**corresponding author suncica.bosak@biol.pmf.hr*



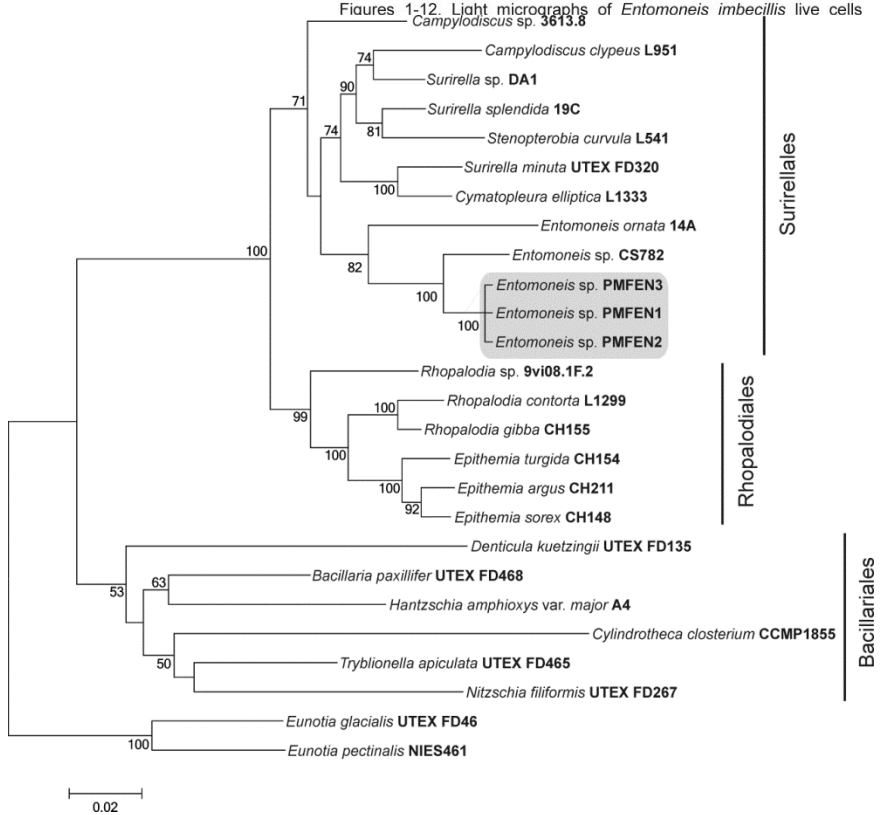
Figures 1-12. Light micrographs of *Entomoneis imbecillis* live cells



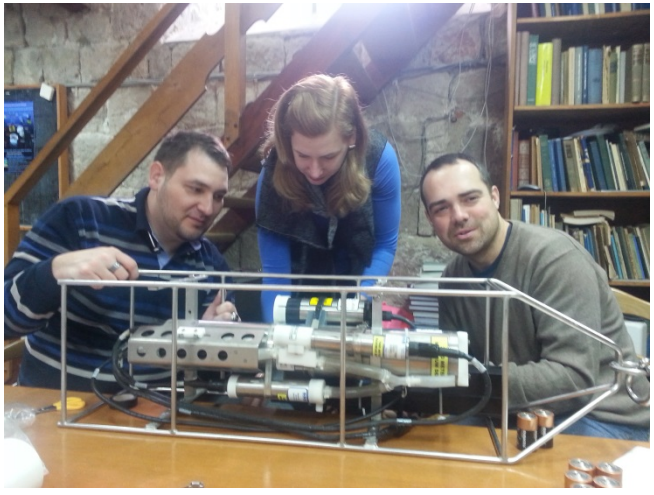
Figures 18-24. SEM and TEM micrographs of *Entomoneis imbecillis*. Scale bars: 5µm - 21; 1µm - 18,20,22,23,24; 2µm - 14,16,17,19



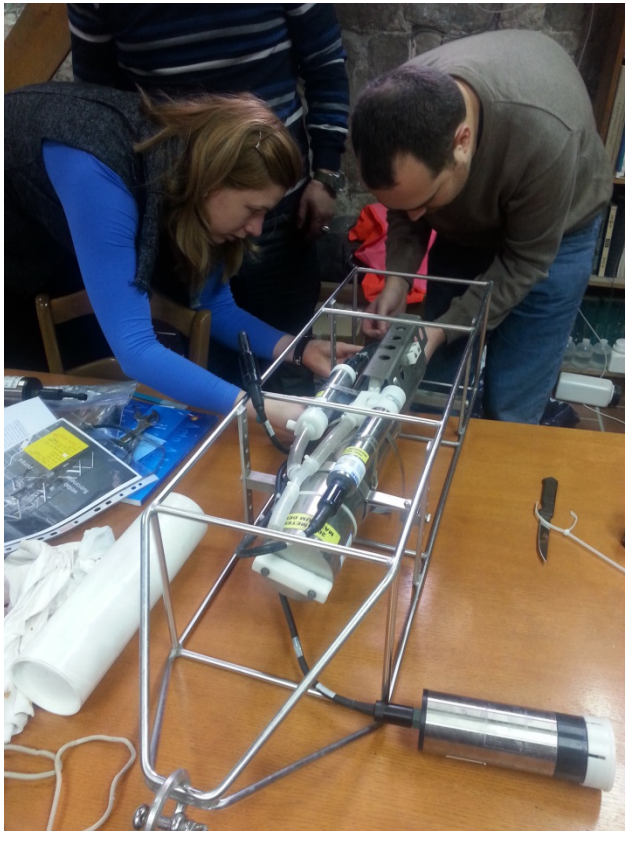
Figures 13-17. SEM micrographs of *Entomoneis imbecillis*. Scale bars: 10µm - 13; 5µm - 15; 2µm - 14,16,17



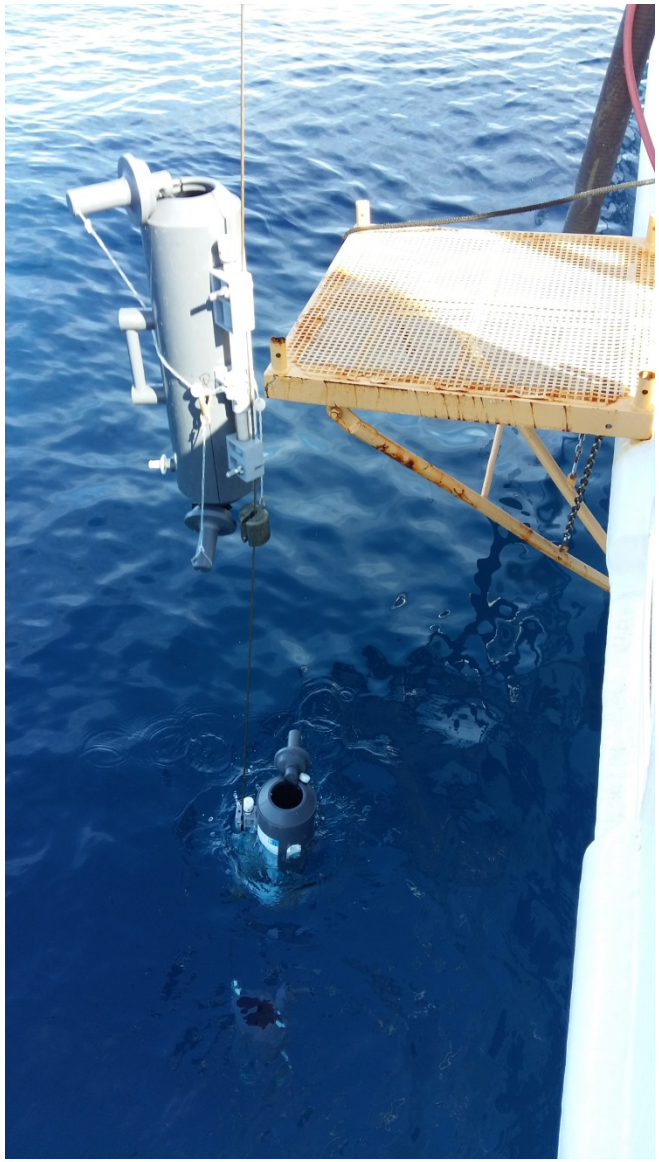
Dubrovnik

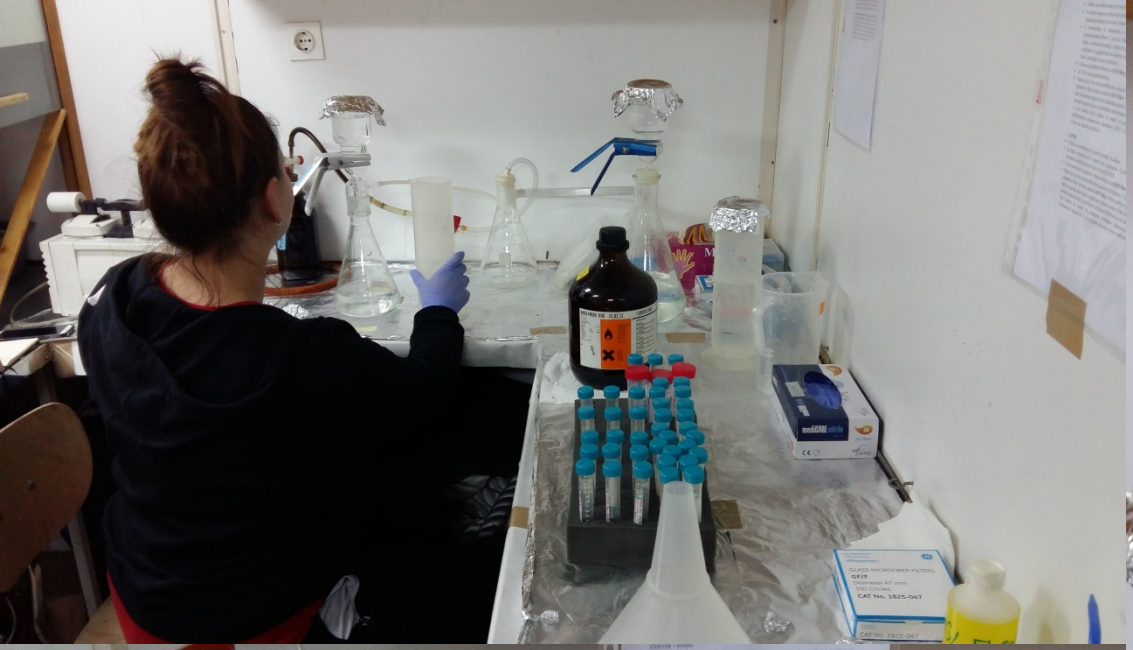



WET Labs




TUBORG
BEER



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