Commercial culture of 3 marine diatoms in raceways

or

A 37 years story (1976-2013, still going..)

J.P. BRAUD - Innovalg

Brief history of tank culture

- 1976-1982: Preliminary studies (22 Pleubian)
- 1982-1992: Developement of raceways (50 Blainville)
  - 1982: 200 m²
  - 1984: 500 m²
  - 1987: 1000 m²
- 1992: Building of the Algoculture center (85 Bouin - SBI)
  - 1994: starting micro-algae culture
- 1997: Sanofi Bio-Industries ceased its culture activity
- 1998: Rising Innovalg and buying the SBI facilities

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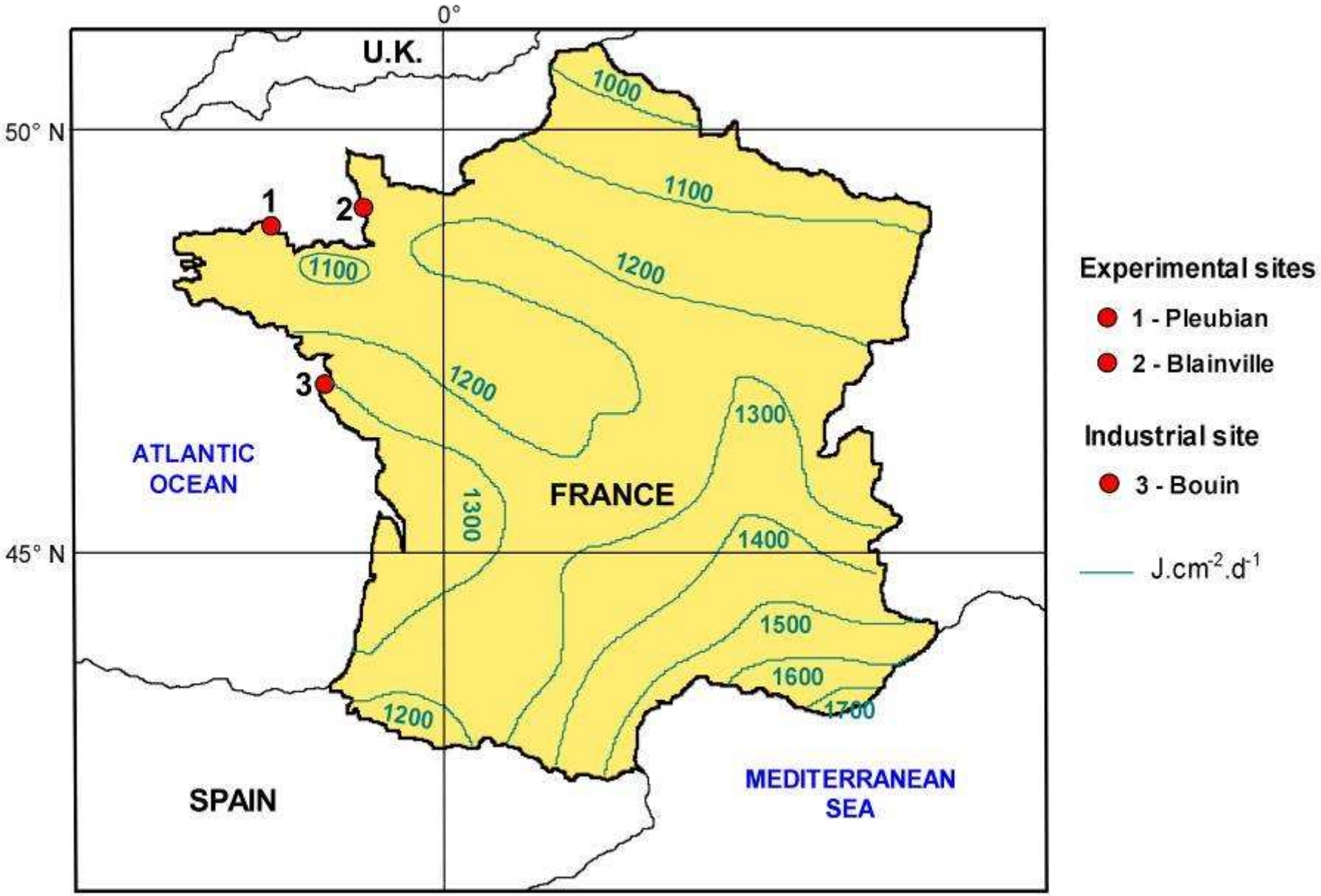

Fig. 1: Location of the cultivation sites and annual average daily global solar radiation on land (from Perrin de Brichambaut *et al.*, 1968)

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Pleubian 1976-1982
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Blainville 1982 - 1991
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Blainville

The 1st 1000 m² tank (1987)

Bouin 1992 - ….
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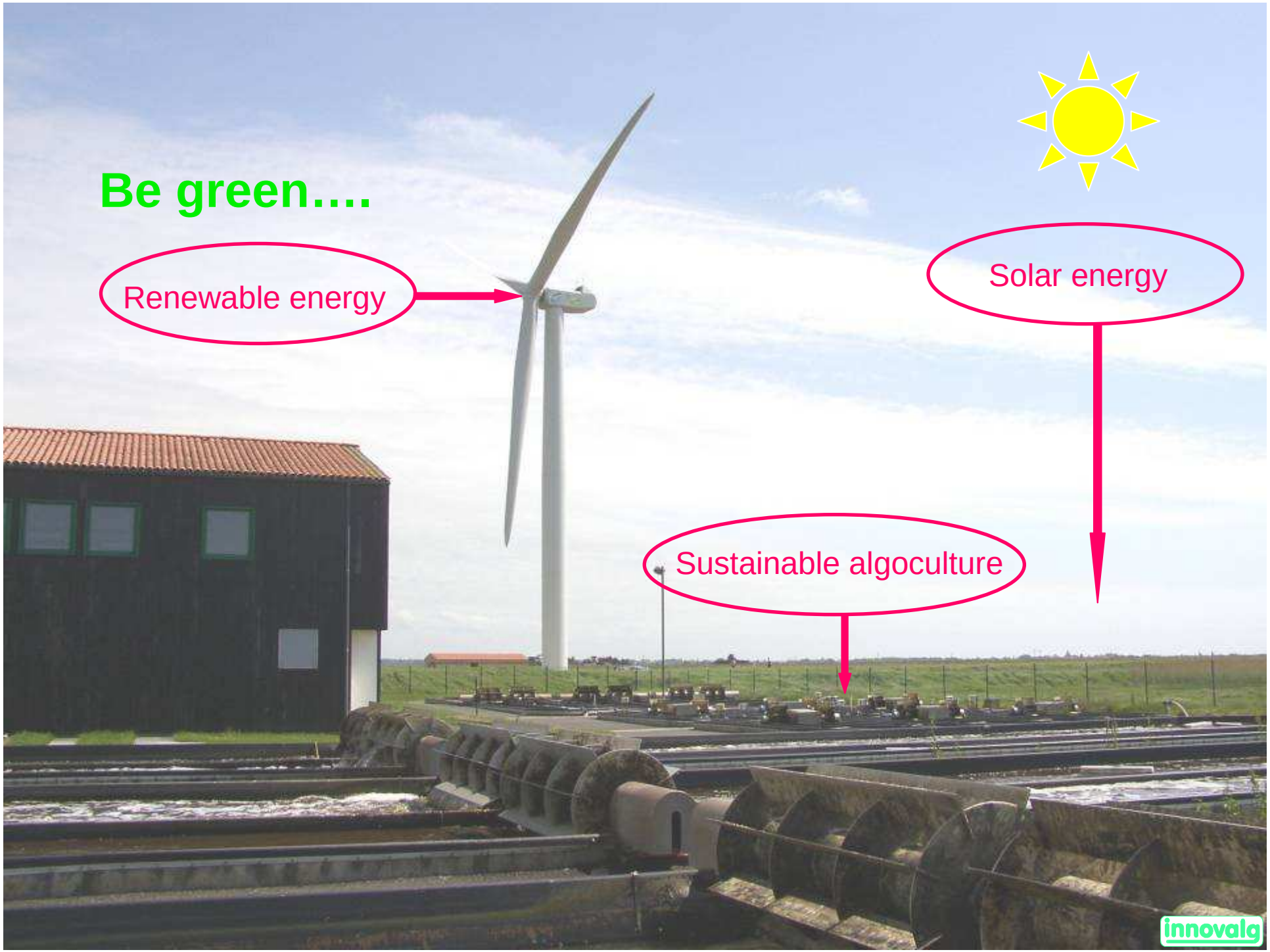
Be green….
Renewable energy
Solar energy
Sustainable algoculture
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Bouin (Control room)
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Bouin (a part of my lab
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Phaeodactylum -1000 m²
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The cultivated (or studied) algae

Macro-algae

- *Chondrus crispus & Mastocarpus stellatus*
- *Cystoclonium purpureum*
- *Calliblepharis ciliata*
- *Ceramium botryocarpum*
- *Palmaria palmata*
- *Enteromorpha spp*
- *Monostroma obscurum*

Micro-algae

- *Odontella aurita*
- *Phaeodactylum tricornutum*
- *Skeletonema costatum*

All strains, even micro-algae, isolated from the wild

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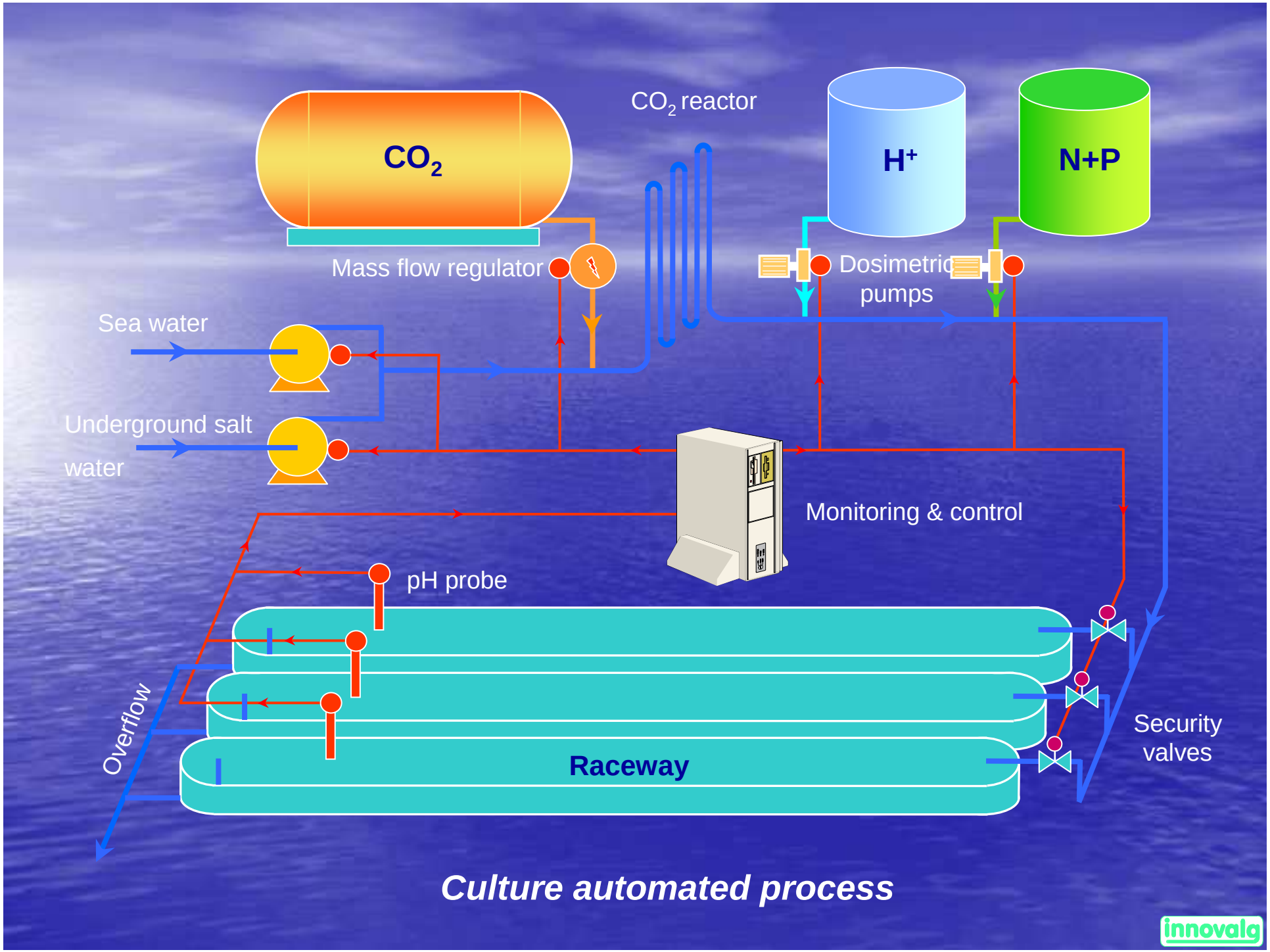
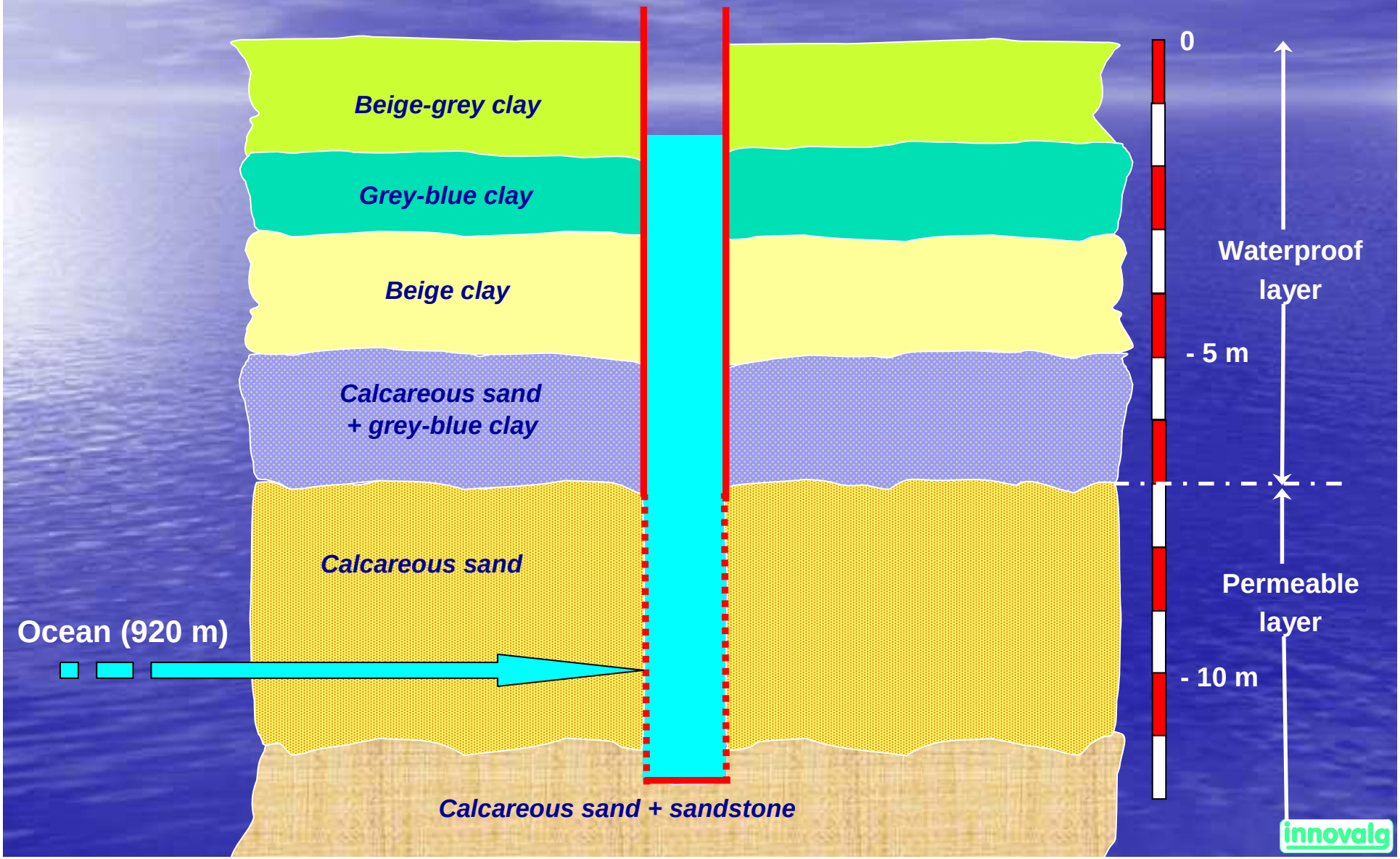


Culture automated process

Underground salt water well 534 – 2 – 82 (Innovalg) (geological scheme)



Average composition of the underground salt water (Innovalg)

Temperature	13.7 ± 0.3 ℃	
Salinity	30.5 ± 0.3 g/l	
pH	7.09 ± 0.12	
D.I.C	10.47 ± 0.63 mmole/l	→ Sea water x 5
Ammonium	332 ± 0.74 µmole N-NH_4/l	→ Sea water x 7
Nitrates	3.9 ± 9.6 µmole N-NO_3/l	
Phosphates	30.3 ± µmole P-PO_4)/l	
Silicium	417 ± 113 µmole Si/l	→ Sea water x 15
Calcium	436 ± 100 mg Ca/l	
Sodium	7640 mg Na/l	
Magnesium	1234 ± 206 mg Mg/l	
Potassium	387 ± 79 mg K/l	
Sulphates	2566 ± 600 mg SO_4/l	
Iron	4.8 ± 0.8 mg Fe/l	→ Sea water x 500
Copper	5.4 µg Cu/l	
Manganese	0.9 mg Mn/l	
Zinc	3.5 µg Zn/l	

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Continuous culture

(the « Wall Street » method)

- Input of a circulating capital (inoculation)
- Waiting a while for increase of capital (biomass adjusted to incident energy)
- Taking the interest without cuting into the capital (each day for micro, each week for macro-algae).
- Changing investment with the conditions (moving from one specy to another accordingly to season).

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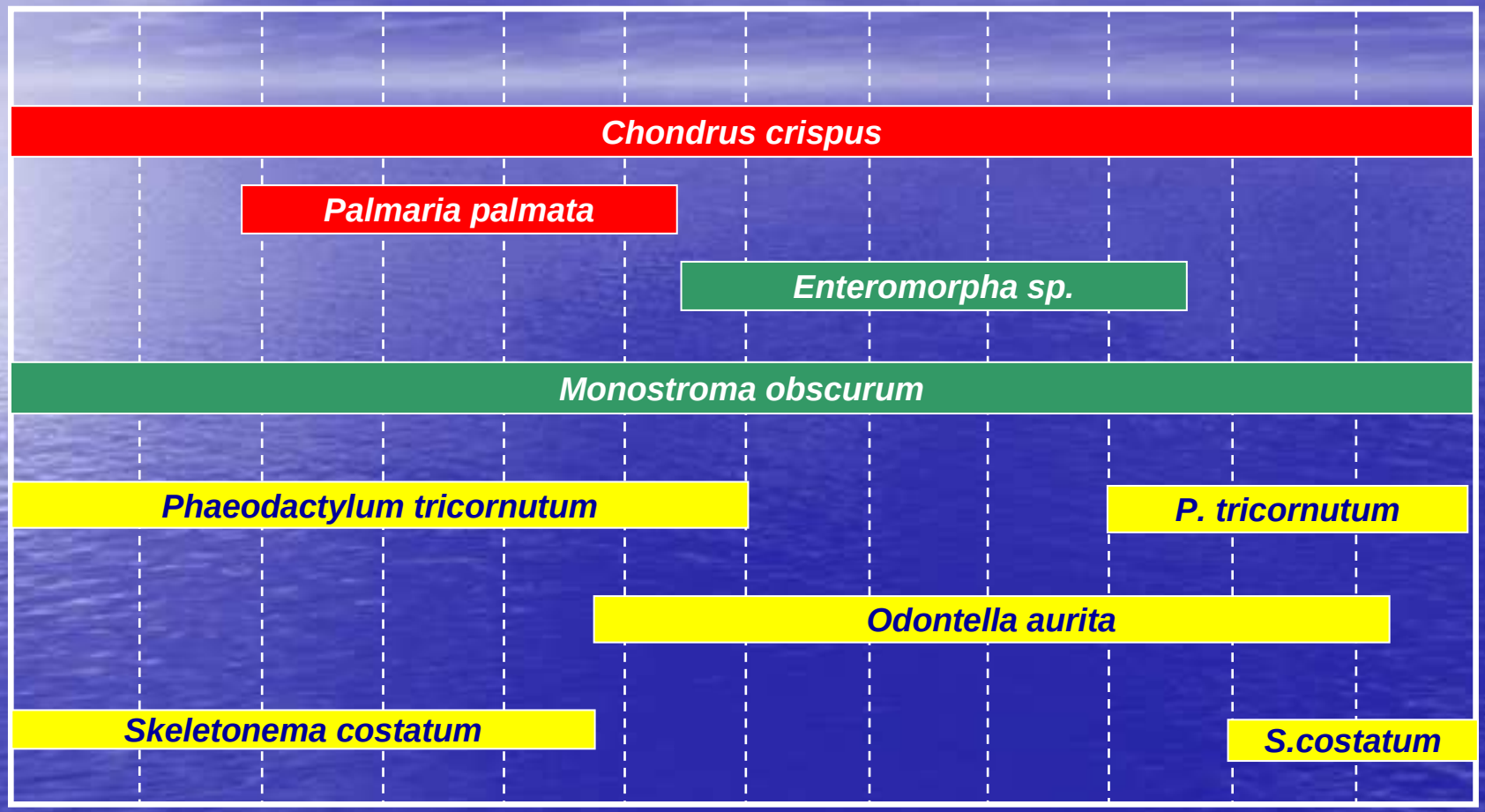
Algal seasonality



Jan Fev Mar Avr Mai Jun Jul Aou Sep Oct Nov Dec

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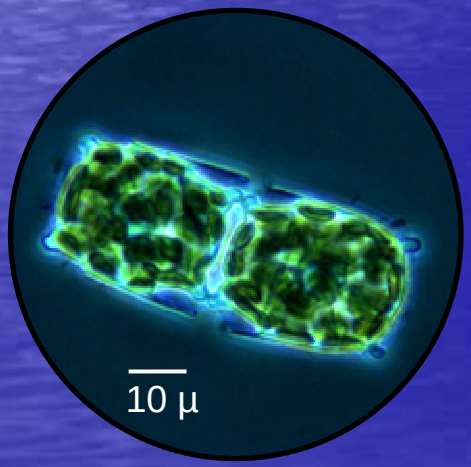
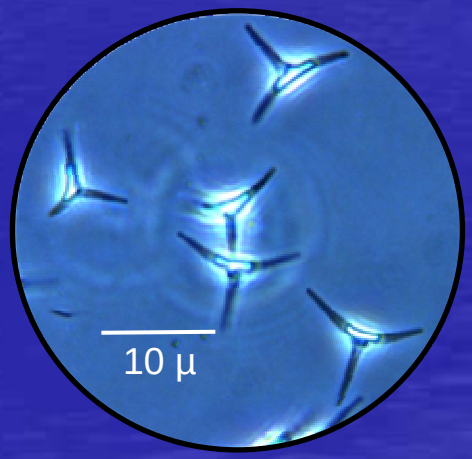
Harvesting methods

Macro-algae: vortex pump on self draining trailer.

Micro-algae: function of the cell size.





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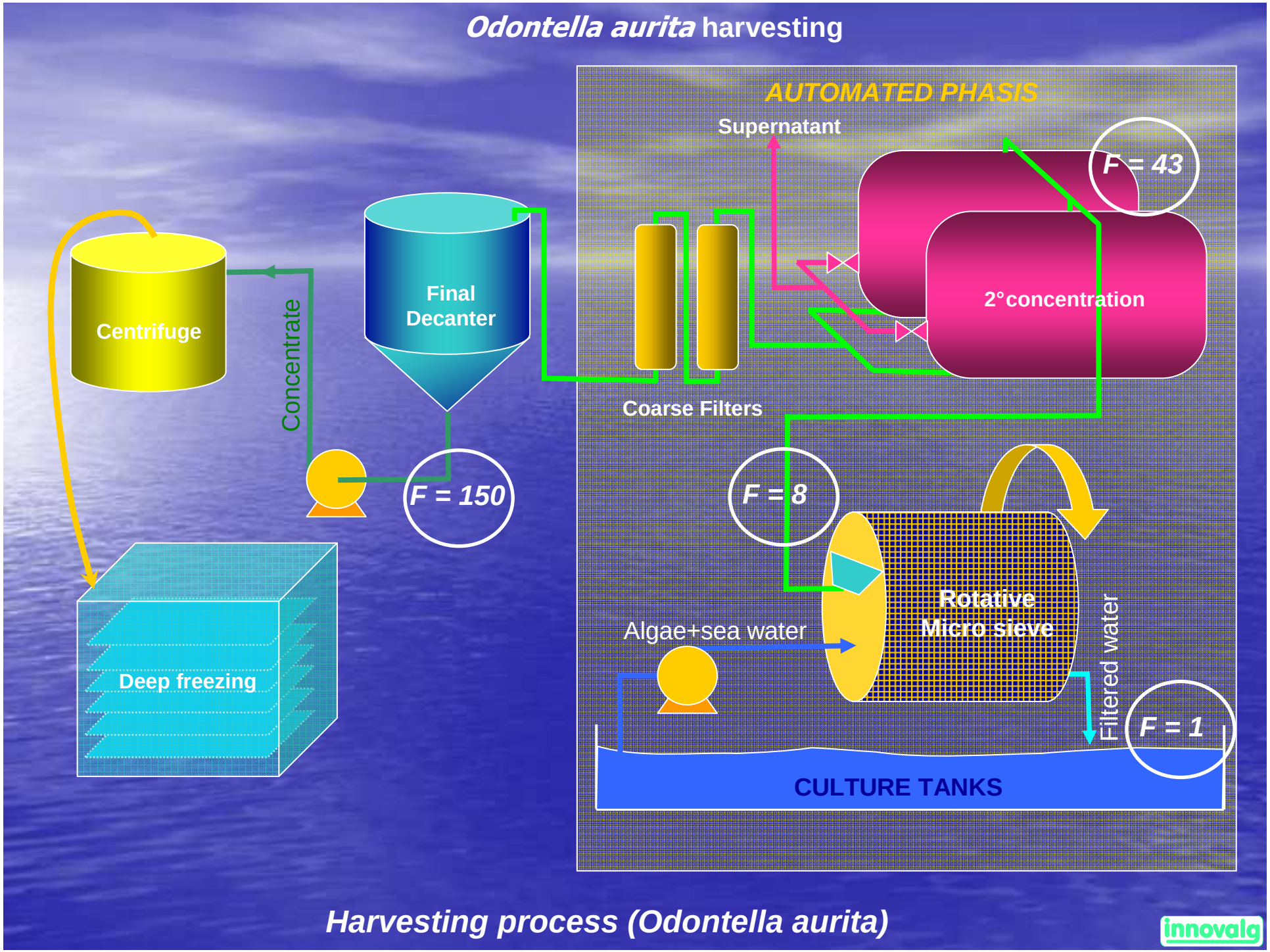
Odontella aurita harvesting



Harvesting process (Odontella aurita)

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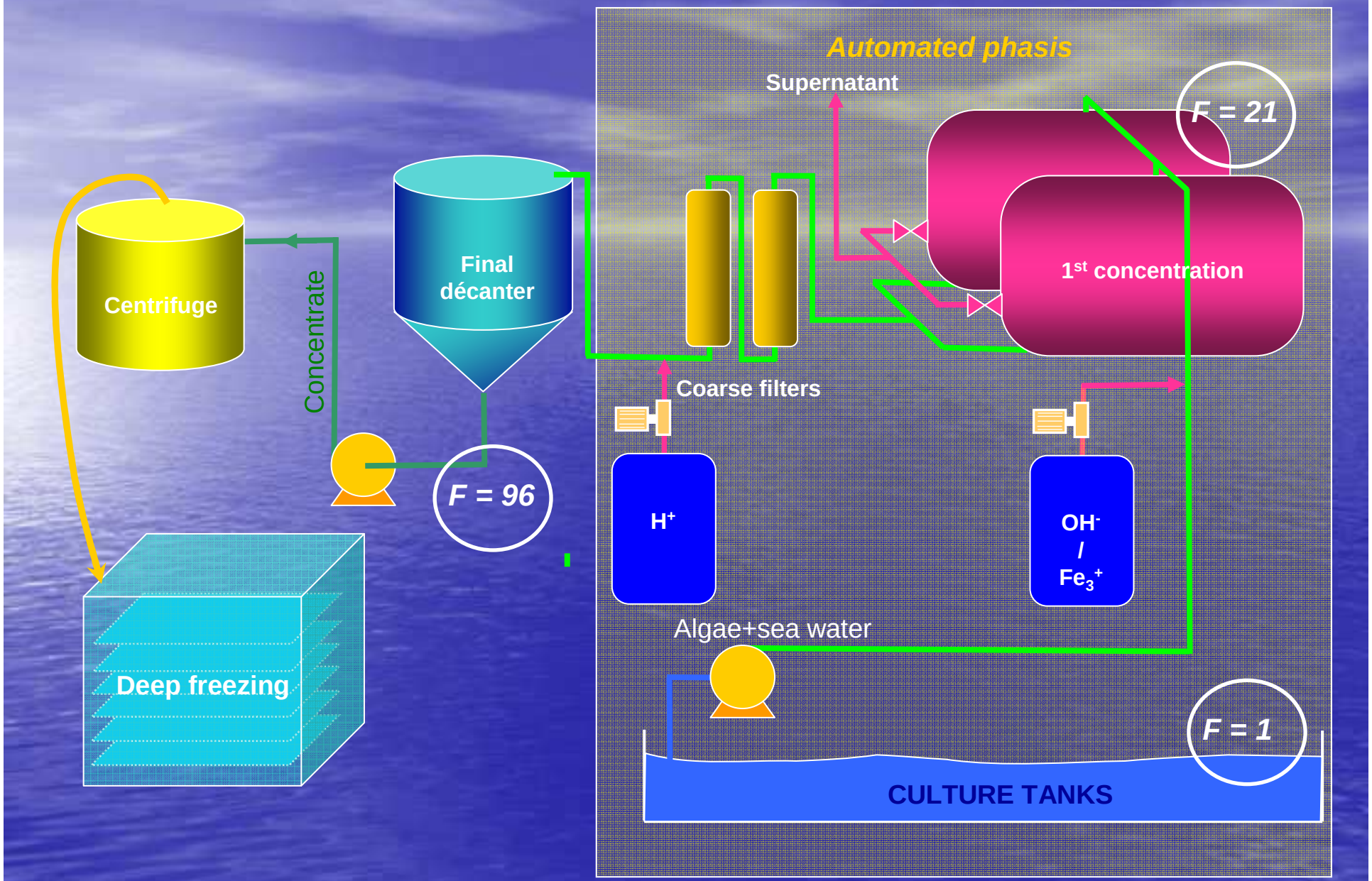
P. Tricornutum and S. costatum harvesting



Harvesting process (P.tricornutum, S. costatum)

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Composition of Odontella aurita

Mineral salts 28-37%	
Cl	8.7%
Si	3.8 % (*)
SO_4	3.1%
P	0.35%
I	287 ppm
Na	4.7%
K	2.9%
Fe	0.8%
Mg	0.8%
Ca	0.6%
Mn	338 ppm
Zn	23 ppm
Cu	8 ppm
Se	0.8 ppm

Total pigments	9.1 mg/g
Chlorophyll a	30.0%
Fucoxanthin	20.4%
Phaeophytin a	13.4%
Chlorophyll c	11.3%
Phaeophorbid a	10.9%
Diatoxanthin	2.9%
β carotene	2.1%
Chlorophyllid a	1.6%
Diadinoxanthin	0.4%
Chlorophyll b	0.2%
Lutein	0.1%
Zeaxanthin	0.1%

(*) of which 10% bound in organic compounds

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Composition of Odontella aurita

Vitamins	
Rétinol	< 100 UI
E	25 ppm
C	200 ppm
B2	26 ppm
B6	2 ppm
PP	108 ppm

Total sterols	0.6%
[27:2] 22-déhydrocholesterol	22.1%
[27:1] cholesterol	11.3 %
[28:2] brassicasterol	33.8 %
[28:2] 24-méthylènecholesterol	9.9 %
[28:1] campesterol	3.3 %
[29:2] clerosterol	9.0 %
[29:2] stigmasterol	5.3 %
[29:1] β sitosterol	3.7 %
[30:2] 24-isopropénylcholesterol	0.7%

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Composition of Odontella aurita

Total lipids : 8.7±1.2 %.gMS^{-1} (N=142)

Neutral lipids	Glycolipids	Phospholipids
46.0 %	51.5 %	2.5%

MGDG	DGDG	SQDG
43.9%	48.2%	7.9 %

Fatty acids profile (% of total FA)

C14:0	14.2	C18:0	1.4
C14:1 (ω7)	0.6	C18:1 (ω9)	2.0
C15:0	1.1	C18:2 (ω6)	1.3
C16:0	20.9	C18:3 (ω6)	0.6
C16:1 (ω7)	21.0	C18:4 (ω3)	0.7
C16:2 (ω4)	0.8	C20:3 (ω3)	1.7
C16:3 (ω4)	2.2	C20:5 (ω3)	23.7
C16:4 (all isom)	3.6	C22:6 (ω6)	2.5

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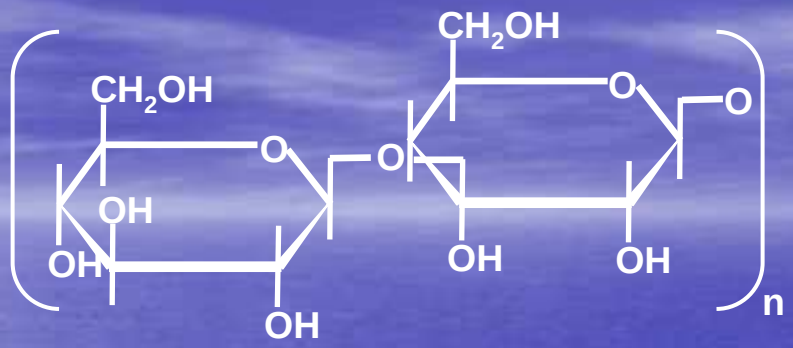
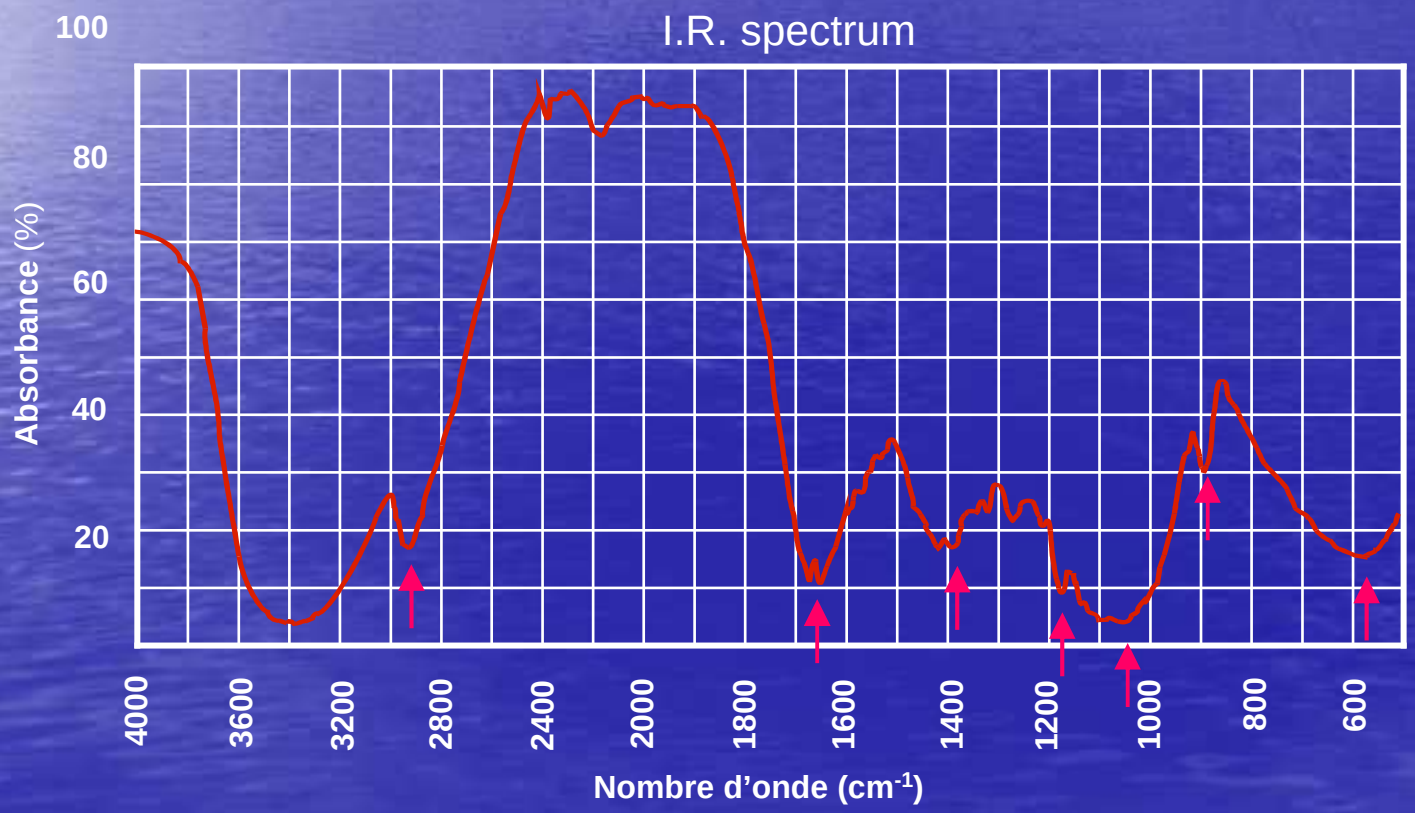
Storage polysaccharide (chrysolaminarine) of Odontella aurita



Yield: 7 – 10%/DM



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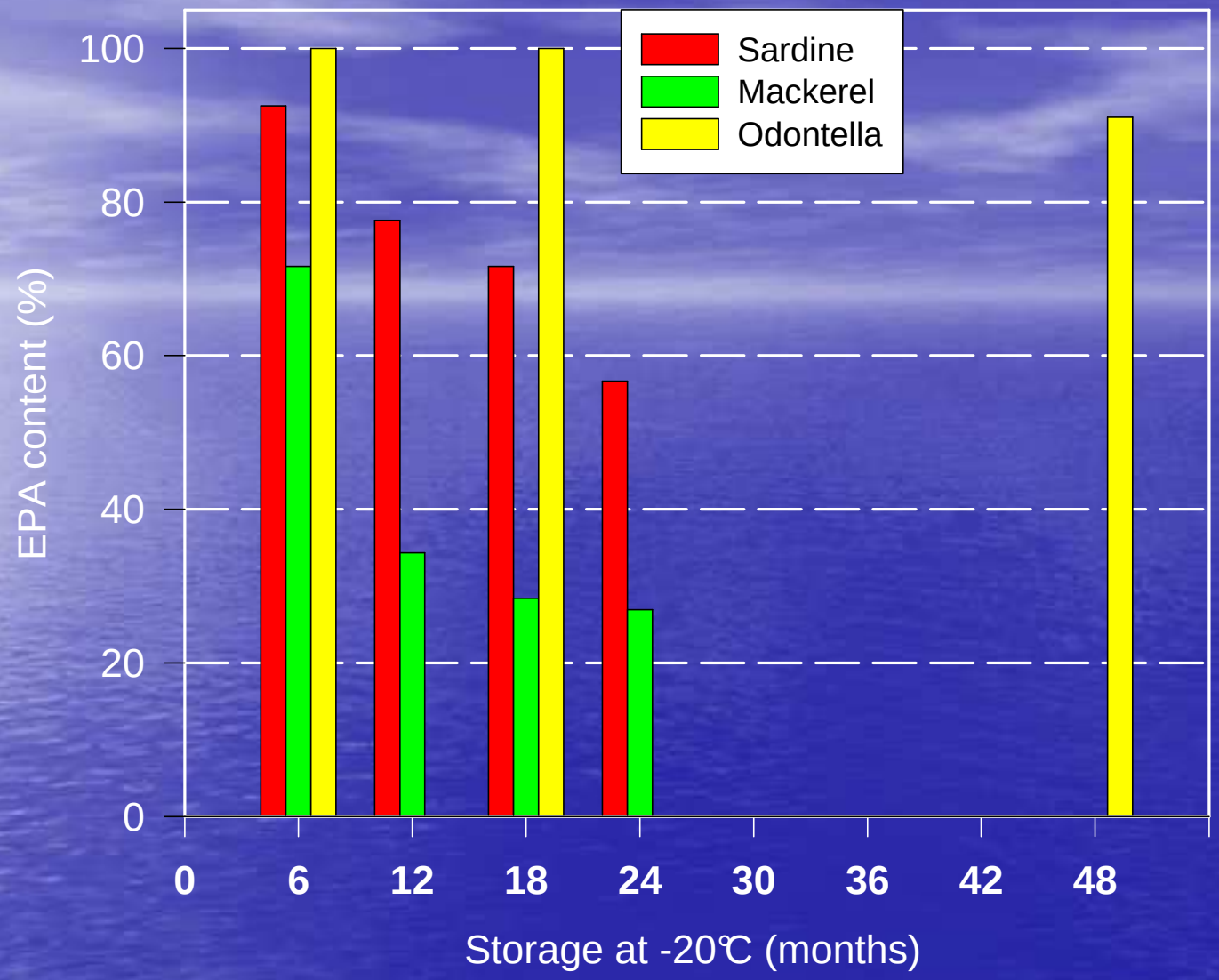

Evolution of EPA content, compared to the initial, for fatty fishes and *O. aurita* during deep freeze storage.

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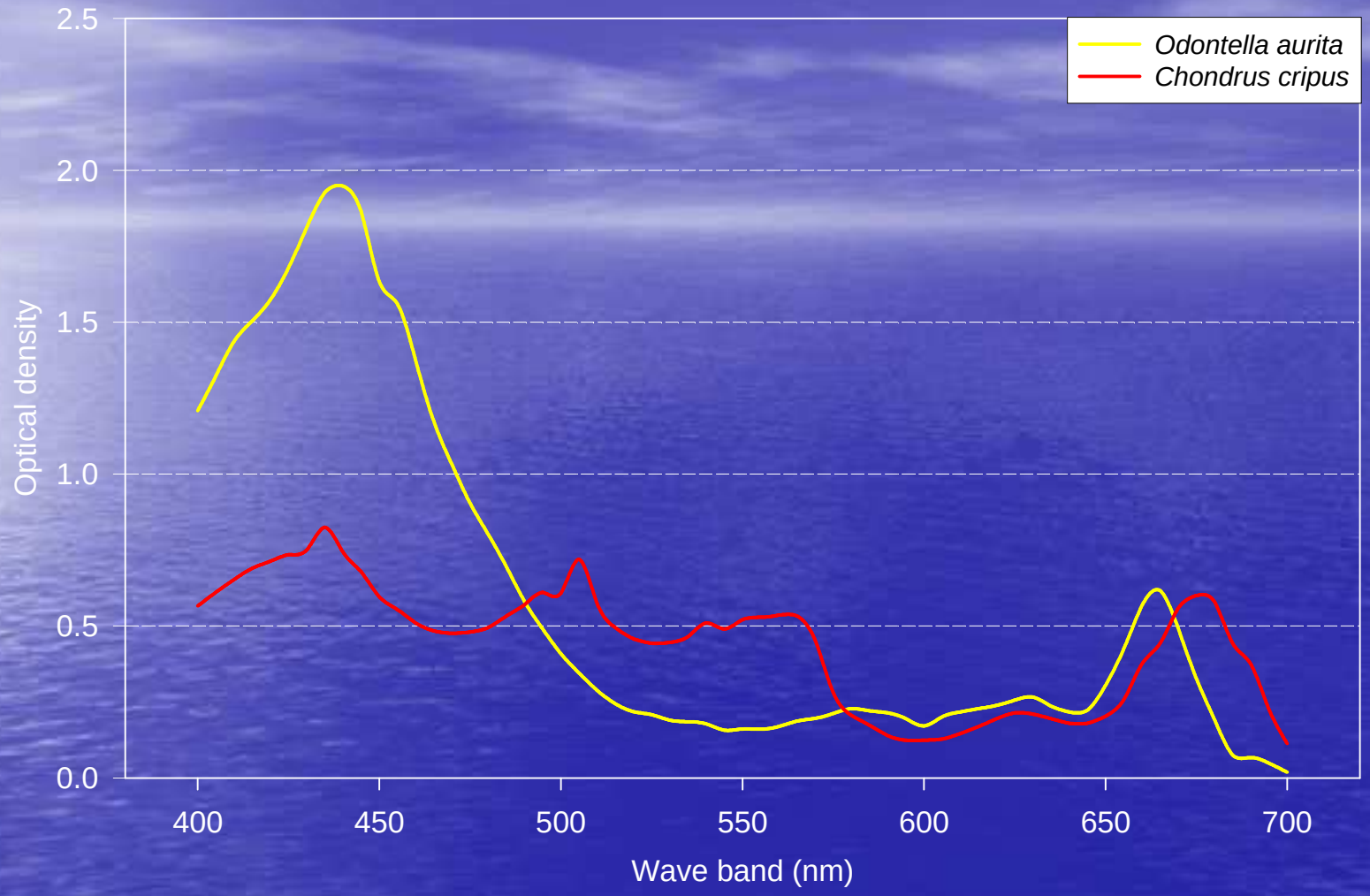
Co-culture



Absorption spectra comparison for *Chondrus crispus* and *Odontella aurita*.

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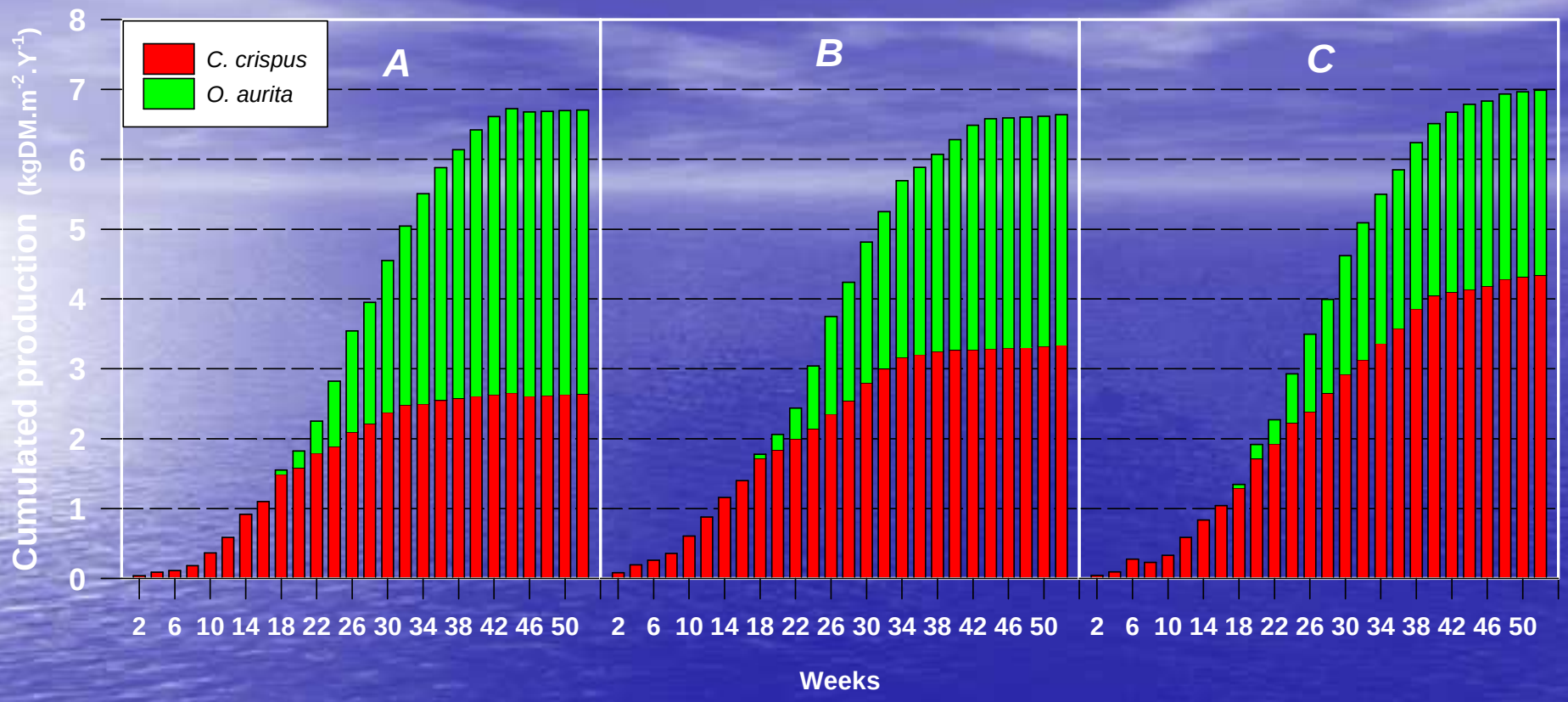
Co-culture



Total dry biomass obtained, on a yearly cycle, by management of the mean circulating concentration of *O. aurita* (A = 140, B = 124, C = 98 mgDW.L^{-1})

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Commercial uses of the diatoms

Cosmetics
(*O. aurita, P. tricornutum, S. costatum*)

O. Aurita has been approved as human food in Dec 2002 (EC regulation « Novel foods » 258/97)

Dietary suplements
(*O. aurita*)

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For the completion of the story, see you in

…. 37 years.

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