Microalgae strain catalogue

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Microalgae strain catalogue

A strain selection guide for microalgae users: cultivation and chemical characteristics for high added-value products

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3rd Edition

Microalgae strain catalogue - A strain selection guide for microalgae users

3rd edition, University of Manchester, Manchester,UK
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The 3rd edition of this catalogue contains information on the cultivation and composition characteristics of 37 microalgae. Each entry includes relevant links to Atlantic Area stakeholders known to have a relevant connection with each of the species listed, be it in the form of culture collections, research expertise, technology developers, or biomass producers. We invite the readers to visit and/or join the EnhanceMicroAlgae Stakeholder database: an easily accessible, visual and open access database that brings together all the European Atlantic Area players working in the microalgae sector.

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Microalgae production for high added value compounds is identified as a business sector with high growth potential in the coming decades, especially in the Atlantic Area. Barriers to improve an industrial use are dominated by a lack of technology expertise.

*The **EnhanceMicroAlgae** project aims to stimulate research, innovation, industrial development and transnational cooperation within the Atlantic area microalgae sector. The main objective is to contribute to the competitiveness of microalgal-based industries in the Atlantic Area.*

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Introduction

Microalgae are a broad group of diverse microorganisms that are typically single-celled, photosynthetic organisms that derive from marine, brackish, freshwater or terrestrial environments. In this catalogue we include both eukaryotic and prokaryotic (cyanobacteria) species.

There is increasing commercial interest in the usage of microalgae for a wide variety of applications including animal feed, aquaculture, biofertiliser, waste pollutant remediation, sources of nutrients and chemicals for food production, nutraceutical supplements such as omega-3 fatty acids, cosmetics, biofuels and bioenergy, pharmaceutical products, colourings, antioxidants, flavourings, and other uses. These applications all depend on the characteristics and chemical composition of different microalgae species and strains.

It is estimated that there are many thousands of microalgae species with many different properties. In addition, strains of microalgae belonging to the same species or closely related species will have different characteristics and will have differences in their chemical composition due to living in different environments and adapting to the different physical conditions of that environment. Of these many possible strains, only a relatively small number have been collected and are stored within individual labs and in culture collections. Only a small number of strains of different species have been physiologically and biochemically characterised, and an even smaller number of strains are currently commercially used.

While the majority of available microalgae strains remain largely uncharacterised, a substantial amount of research has been performed on a small number of strains with desirable characteristics. However, strain characteristic information can be challenging to identify and is typically found within many different, sometime inaccessible literature sources. Therefore this resource has been developed in order to provide collated information on the cultivation characteristics and chemical composition of selected microalgae species.

Each entry summarises the characteristics of a different species, with details taken from one or more strains of that species, which are present in a publically accessible culture collection. As much details as possible about the cultivation procedures of the strains have been described so that the chemical composition characteristics might be reproducible. However, it must be noted, that strain properties can vary based on different environmental parameters and even between different locations where conditions are considered identical. Moreover, originally identical strains (from the same original source) can adapt their characteristics over time, therefore some caution must be taken when interpreting information assigned to a particular named strain.

We hope that you find this catalogue resource useful and informative. In addition, any feedback to this resource is welcome.

The EnhanceMicroAlgae team

Important notes

- The names of the microalgae species presented within this catalogue are in accordance with their currently accepted taxonomic status at the time of publication. However, names are subject to change as a result of new taxonomic discoveries. The reader is encouraged to refer to AlgaeBase for the most updated names and classification of microalgae.
- Unless otherwise specified, it should be interpreted that cultivation data shown in the following pages was obtained during cultivation in batch operation and in phototrophic growth mode (using either air or artificial supplementation of CO_2).
- A compilation of important algal growth media recipes shown throughout the catalogue is included in Appendix 1.
- Similarly, a (non-exhaustive) list of major Culture Collections is provided in Appendix 2.

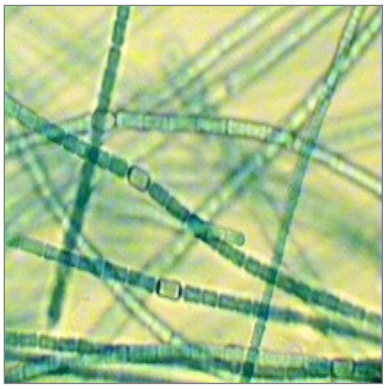
A list of common acronyms used throughout the catalogue is presented below:

Acronym	Description
PBR	Photobioreactor
nd	Non-disclosed
STR	Stirred Tank Reactor
L:D	Light:Dark cycle (photoperiod)
BG11	Blue-Green medium
BBM	Bold's Basal Medium

Definitions:

- Lux (lx): A measure of radiant light from a standard candle that falls on one square meter of surface area one meter from the source.
- Micromol (µmol/m2/s): One micromol per square meter per second. A unit of measure of the amount of light hitting a surface that is in the range of 400-700 nanometers.
- Watts (W): Watts per square meter (W/m 2). A unit of measure of the amount of light energy hitting a surface that is in the range of 400-800 nanometers.

1. *Anabaena cylindrica*



A freshwater filamentous cyanobacteria with robust growth characteristics and a source of pigments. It has nitrogen-fixation characteristics and some strains have been observed to produce hydrogen [1].

Commonly cultivated strains include:
CCAP 1403/2A, IAM M1 (PCC 7122), 10 C (CSMA)

1.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 1403/2A [2]	**System:** PBR **Medium:** BG11 **Temperature:** 22°C **Light:** 70 µmol/m^2/s, 16 h L: 8 h D	0.078	0.171	2.4
IAM M1 (PCC 7122) [3]	**System:** 5 PBR's in series (0.2 dm^3 each) **Medium:** Detmer medium **Carbon source:** CO_2 6% **Temperature:** 298 K (24.85°C) **Light:** 1 klx, L:D cycle N/A	nd	nd	From: 0.667 (1st PBR) to:~2.66 (5th PBR)
10 C [4] (CSMA)	**System:** Fermentor (1 L) **Medium:** BG11 **Carbon source:** CO_2 and acetate **Temperature:** 25°C **Light:** 32 W cool white fluorescent lamp. Continuous illumination	nd	nd	~0.3 (BG11) ~0.6 (BG11+acetate)
PCC 7937 [5]	**System:** PBR (2 L) **Medium:** BG11 **Temperature:** 30°C **Light:** 3000 µmol/m^2/s, 12 h L: 12 h D	0.38 ± 0.14	nd	nd

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

1.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
56% protein [2] 7% lipid 25% carbohydrate --- 38.09±1.18 % protein [5] 16.03±0.90 % lipid 37.07±2.26 % carbohydrate --- 43-56% protein [6] 4-7% lipid 25-30% carbohydrate	nd	nd	nd

1.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *A. cylindrica* AC163
  Location: Université de Caen Normandie, Caen, France

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *A. cylindrica* CCAP 1403/2A, 1403/2B, 1403/30
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Blue Biotechnology and Ecotoxicology Culture Collection (LEGE) at CIIMAR
  CIIMAR is an EnhanceMicroAlgae partner
  Business/organisation type: bio-bank
  Strain(s) available: *Anabena* cf. *cylindrica* LEGE 00235
  Read more about the services offered by the LEGE culture collection in the EnhanceMicroAlgae marketplace.
  Location: Porto, Portugal

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *A. cylindrica* BEA 0794B

Location: Telde Gran Canaria, Spain

- **Name:** IBVF - Instituto de Bioquímica Vegetal y Fotosíntesis, Microalgae Biotechnology Group

Business/organisation type: research & development

Expertise: bioenergy, ecophysiology, molecular biology. Research outputs involving microalgae include (but are not limited to):

- *Anabaena* sp. [5,7], *Porphyridium purpureum* [5], *Scenedesmus vacuolatus* [5], *Nostoc* [5], *Dunaliella salina* [8]

Location: Sevilla, Spain

2. *Ankistrodesmus falcatus*

A fast-growing freshwater microalga. It is considered an important source of lipids and pigments, and it can also accumulate a relatively high protein content [9].

Commonly cultivated strains include:
CCNM-1031, KJ671624, CMSACR1001

2.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
nd [10]	**System:** 500 mL conical flasks **Medium:** BG-11, BBM, Chu-10, Zarrouk **Temperature:** 25 ± 2°C **Light:** 12h L: 12h D, at 30, 60 and 150 µmol/m2/s; 12h L: 12h D, 18h L: 6h D, 6h L: 18h D, 24h L:0h D and 0h L: 24h D at 60 µmol/m2/s	nd	6.14 mg/L/day (*with BG-11 and Chu-10 media*)	210.4 mg/L (*with Zarrouk´s medium*)
nd [9]	**System:** airlift photobioreactor **Medium:** BG-11 **Temperature:** below 30°C in batch and 36°C in continuous cultivation **Carbon source:** CO_2 **Light:** 170 µmol/m^2/s in batch and 185 µmol/m^2/s in continuous cultivation, L:D cycle nd	nd	nd	1.04 (*under batch cultivation*) 1.56 (*under continuous cultivation*)

CMSACR1001 [11]	**System:** 1 L conical flask **Medium:** BG-11 **Temperature:** 25 ± 1 °C **Light:** 60 µmol/m^2/s, 12h L: 12h D	nd	0.035 (*under phytohormones supplementation)*	0.431 (*under phytohormones supplementation)*

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

2.2 Biomass characteristics

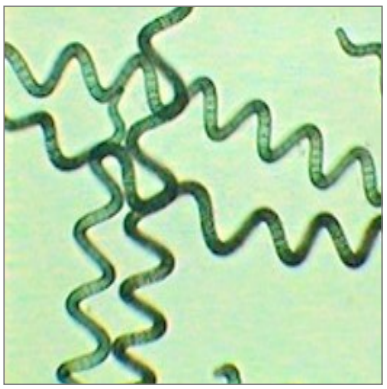
Biomass composition	Element composition	Pigment composition	Fatty acid profile
16.23 – 57.70% lipids [9] --- 35% lipids [11] 43% carbohydrates 17.5% proteins	nd	17.89 µg/mL total chlorophyll [11] 2.65 µg/mL total carotenoids	C12:0 0.15-1.96% [9] C14:0 0.36-0.93% C16:0 28.87-40.66% C16:1 0.25-1.28% C18:0 3.93-6.38% C18:1 20.84-33.48% C18:2 8.01-18.90% C18:3(6) 0.19-0.97% C18:3(3) 3.30-18.70% C18:4 1.14-4.91% C24:0 0.06-3.50%

2.3 Stakeholders in the Atlantic Area

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *A. falcatus* CCAP 202/14A, 202/14B, 202/14C, 202/15C, 202/5C
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *Ankistrodesmus* sp. BEA 0536B, 1117B, 0742B
  Location: Telde Gran Canaria, Spain

3. *Arthrospira platensis*



A filamentous cylindrical cyanobacteria that is commonly known commercially as spirulina. It is widely cultivated as a food source and nutritional supplement particularly because it is rich in protein and contains essential amino acids [12]. It is commonly cultivated in open ponds but can also be grown in photobioreactors. It can grow under a range of temperature conditions but has optimum growth at higher temperatures, ~35°C [13].

Commonly cultivated strains include:
SAG 21.99, SAG 85.79, SAG 257.80, WH879

3.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
SAG 85.79 [2]	**System:** PBR **Medium:** Zarrouk medium **Temperature:** 22°C **Light:** 70 µmol/m^2/s, 16h L: 8h D	0.06	0.21	3.1
SAG 21.99 [14]	**System:** PBR (0.5 L) **Medium:** Zarrouk medium **Temperature:** 30°C **Light:** 120 µmol/m^2/s, Continuous light	nd	0.231	2.274
Mixed culture: *Arthrospira* sp. [15]	**System:** outdoor raceway ponds, surface area 100 m^2, culture depth 30 cm **Medium:** SOT medium **Temperature:** outdoors **Light:** outdoors	nd	34 *(g/m^2/d, accounts for irradiance surface area)*	0.62
WH879 [16]	**System:** Fed-batch PBR (1 L) **Medium:** Zarrouk medium **Temperature:** 28°C **Light:** 300 µmol/m^2/s, Continuous light	nd	0.594 *(feeding only Nitrate)*	6.78 (*feeding fresh medium*)

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

3.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
62% protein [2] 9% lipid 20% carbohydrate	nd	90 mg/g phycocyanin [2] 39.8 mg/g chlorophyll 3.8 mg/g carotene - - - 0.28-1.5% chlorophyll [14] - - - 5-12% phycocyanin [15] - - - 16.1±0.2% phycocyanin [16]	C16:0 40.1% [2] C16:1 9.2% C18:0 1.2% C18:1 5.4% C18:2 17.9% C18:3 18.3% other 7.9%

3.3 Stakeholders in the Atlantic Area

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *A. platensis* CH-9
  Location: Roscoff, France

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *A. platensis* BEA 0007B
  Location: Telde Gran Canaria, Spain

- **Name:** A4F – Algae 4 Future
  EnhanceMicroAlgae partner
  Business/organisation type: bio-bank, producer, research and development, downstream processing
  Expertise: biotechnology, engineering, large-scale development. Their microalgae track-production (large and pilot scale) includes [17]:
  - *Arthrospira platensis*, *Chlamydomonas* sp., *Chlorella vulgaris*, *Dunaliella salina*, *Haematococcus pluvialis*, *Lobosphaera incisa*, *Nannochloropsis oceanica*, *Phaeodactylum tricornutum*, *Prorocentrum cassubicum*, *Raphidonema* sp., *Scenedesmus* sp., *Scotiellopsis* sp., *Synechococcus* sp., *Synechocystis* sp., *Tetraselmis* sp., *Thalassiosira weissflogii*, *Tisochrysis lutea*

Locations: Lisbon, Portugal

- **Name:** Algalimento

EnhanceMicroAlgae Associated partner

Business/organisation type: producer, research and development, downstream processing
Expertise: biotechnology, engineering, large-scale development. Algalimento currently produces all-year round high-quality biomass of [18]:

- *Tetraselmis sp., Spirulina canariensis, Dunaliella salina*

Locations: Lisbon, Portugal

- **Name:** AlgoSource

Business/organisation type: producer, research and development, downstream processing
Expertise: engineering, large-scale development, industrial ecology. Know-how on *Spirulina* and its principal ingredient phycocyanin. The company is also working on extracting molecules of interest from other microalgae [19]:

- *Spirulina, Chlorella, Scenedesmus, Tetraselmis, Isochrysis*

Locations: Saint-Nazaire, France

- **Name:** Aqualgae

Business/organisation type: research and development
Expertise: design and installation of high-productivity photobioreactors, suppliers of culturing media, inoculums, and lyophilised cultures of [20]:

- *Chlorella*, *Haematococcus*, *Arthropsira*, *Tetraselmis*, *Isochrysis*, *Pavlova, Chaetoceros*, *Skeletonema*, *Nitzchia*, *Rhodomonas*, *Nannochloropsis*

Locations: Diana do Castelo, Portugal; and A Coruña, Spain

- **Name:** Bretagne Sipruline

Business/organisation type: producer
Expertise: nutraceuticals. The company sells *Spirulina* in various pack sizes.
Locations: Landévant, France

- **Name:** International Iberian Nanotechnology Laboratory (INL)

EnhanceMicroAlgae partner

Business/organisation type: research and development
Expertise: nanotechnology, nanoscience, encapsulation, food processing and nutrition, nutraceutics, safety assessment, biotechnology, engineering. Researhc outputs include (but not limited to):

- *Arthrospira platensis* [21]

Locations: Braga, Portugal

- **Name:** La Voie Bleue
  Business/organisation type: association
  Expertise: marketing and valorisation, nutraceuticals, sustainable food chains. Promotes Spirulina (and other microalgae) for food by local production, and supports other projects. Read about La Voie Bleue's services in the EnhanceMicroAlgae marketplace
  Locations: Toulouse, France

- **Name:** NeoAlgae
  Business/organisation type: producer, research and development, downstream processing
  Expertise: aquaculture, cosmetics, nutraceuticals, biotechnology. The company produces a wide range of Spirulina-based products for food, cosmetics, and agriculture [22]. Their R&D division specialises on various extracts from *Dunaliella salina*, *Haematococcus pluvialis*, *Chlorella vulgaris*, *Isochrysis galbana*, *Nannochloropsis gaditana* [23]
  Locations: Asturias, Spain

- **Name:** OMA – Olivier MicroAlgues
  Business/organisation type: producer, downstream processing
  Expertise: nutraceuticals. The company sells *Spirulina* in various packs and formats.
  Location: Haute-Goulaine, France

- **Name:** Spanish Society of Microalgae and Subproducts (SEMS)
  Business/organisation type: producer, research and development
  Expertise: biotechnology, chemistry, marketing and valorisation. The company offers various laboratory services and products for agriculture, with various microalgae being produced on a continuous basis [24]:
  - *Arthrospira platensis*, *Nannochloropsis gaditana*, *Scenedesmus* sp., and *Scenedesmus subspicatus*

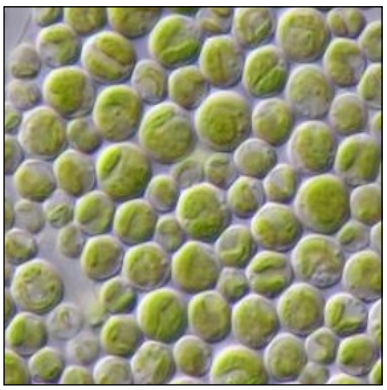
  Locations: Rota, Spain

- **Name:** Scottish Bioenergy Ltd.
  Business/organisation type: producer, technology manufacturer, downstream processing
  Expertise: energy, environment, biotechnology. Company products include a Sprirulina-based colourant (ScotBio Blue) and protein (ScotBio protein), as well as fresh/dry Spirulina.
  Locations: Newhouse, Scotland

- **Name:** Technature
  Business/organisation type: research and development
  Expertise: cosmetics. The company offers a wide line of cosmetic products, some of which are derived from Spirulina extracts (e.g. Toning lotion, Radiance boost marine serum, algae heating body wrap) [25]
  Locations: Dirinon, France

- **Name:** Tinctura
  Business/organisation type: producer, downstram processing
  Expertise: nutraceuticals, large-scale development. Tinctura develops and produces aqueous extracts rich in phycocyanin from French Spirulina.
  Locations: Ploudaniel, France

4. *Auxenochlorella protothecoides*



Formerly known as *Chlorella protothecoides* (Krüger) [26]. A eukaryotic green microalga belonging to Trebouxiophyceae class. It can grow either photoautotrophically, mixotrophically or heterotrophically [27]. *C. protothecoides* shows a high industrial potential for producing lipids and fatty acids at high yield [28].

Commonly cultivated strains include:
UTEX 249, SAG 211-7b

4.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
UTEX 249 [27]	**System:** 250 mL Erlenmeyer flasks **Medium:** BBM **Carbon source:** glucose, glycerol, or acetate **Light:** 16h L: 8h D (autotrophic and mixotrophic) and 24h D (heterotrophic)	nd	1.59±0.50 (*on glucose/acetate; 80:20*)	4.76±1.50 (*on glucose/ acetate; 80:20*)
nd [28]	**System:** 2.8 L glass flasks (PYREX) **Medium:** Modified BBM **Temperature:** 28°C **Carbon source:** CO_2, and glucose **Light:** 60 µmol m^{-2} s^{-1} L:D cycle nd	nd	nd	9.54 ± 0.72 (*mixotrophic cultures)* 10.32 ± 0.83 (*heterotrophic cultures)*
nd [29] *obtained from Culture Collection of Alga at the University of Texas*	**System:** Shaking flasks / 5 L bioreactor **Medium:** BBM **Temperature:** 28°C **Carbon source:** glucose **Light:** 5 µmol/m^2/s L:D cycle nd	nd	nd	51.2 (*in improve fed-batch culture)*

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

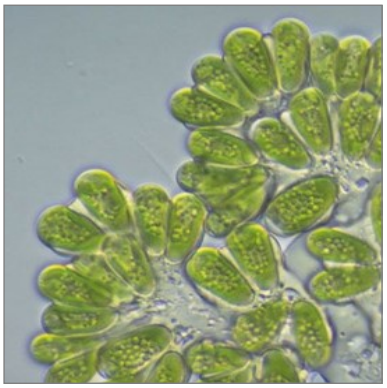
4.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
52% lipids [27]	nd	nd	nd

4.3 Stakeholders in the Atlantic Area

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *A. prototheocoides* CCAP 211/11l, 211/13, 211/17, 211/54, 211/7A, 2117C, 211/7D, 211/8D
  Location: Scottish Marine Institute, United Kingdom

5. *Botryococcus braunii*



A eukaryotic planktonic Trebouxiophyceae strain, naturally found in freshwater and brackish ponds, that is typically a very slow growing microalga due to the high production of triterpene hydrocarbon oils with applications for various classes of biofuel (petroleum, kerosene, diesel) production by hydrocracking. There are a wide variety of *Botryococcus* strains (races) with very diverse oil productivities [30].

Commonly cultivated strains include:
CCAP 807/2, SAG 30.81, CCALA 777, CCALA 778, CCALA 835, UTEX Bb 572, AC755, AC759, AC760, AC761, AC765 [31]

5.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 807/2 [2]	**System:** PBR **Medium:** 3N-BBM **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	0.027	0.098	1.94
AC755 [31]	**System:** Bubble column PBR (0.4 L) **Medium:** Chu 13 medium **Temperature:** 23°C **Light:** 150 µmol/m^2/s, 18h L: 6h D	nd	0.06	~1.75
AC759			0.09	~2.75
AC761			0.15	~3.6
CCALA 777			0.08	~2.2
CCALA 778			0.12	~3.6
CCAP 807/2			0.14	~4.6

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

5.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
40% protein [2] 33% lipid 6% carbohydrate	nd	6% α-carotene [32] 6% β-carotene 22% lutein	C16:0 29.5% [2] C16:1 3.3% C18:0 1.0% C18:1 44.9% C18:2 21.1% other 0.3%

5.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *B. braunii* AC754, AC755 to AC761, AC763, AC767, AC768
  Location: Université de Caen Normandie, Caen, France

- **Name:** Culture Collection of Algae and Protozoa CCAP
  Business/organisation type: bio-bank
  Strain(s) available: *B. braunii* 807/1, 807/2
  Location: Scottish Marine institute, Scotland, UK

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *Botryococcus* sp. A12.415 (not-distributed), A13-394 (not-distributed), CCMP2742
  Location: Roscoff, France

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *B. braunii* BEA 0649B
  Location: Telde Gran Canaria, Spain

- **Name:** Andalusian Center of Science and Marine Technology (CACYTMAR) | Instituto Universitario de Investigacion Marina (INMAR) at University of Cádiz, Spain

  Business/organisation type: Higher education, research & development

  Expertise: biotechnology, ecophysiology, genomics, molecular biology, waste water treatment. Research outputs involving microalgae include (but are not limited to):

  - ***Botryococcus braunii*** [33], *Phaeodactylum tricornutum* [34], [*Chlorella vulgaris*, *Chlorella kessleri*, *Chlorella sorokiniana*, *Scenedesmus obliquus*] [35]

  Location: Cádiz, Spain

6. *Chaetoceros calcitrans*

A marine planktonic diatom. It is a roughly cylindrical alga, elliptical in valve view and rectangular in girdle view. The cells bear long cell wall prolongations (seta) at their poles which join cells together to form chains.
C. calcitrans (Paulsen) Takano is known as a potential species for producing biodiesel[36], with high growth rates even at low light intensities [37].

Commonly cultivated strains include:
CCMP 60/00/00 1315, CCAP 1010/11, CCMP1315; NEPCC 590; PLY537, UPMAAHU10.

6.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCMP 60/00/00 1315 [37]	**System:** 16-29 L bags **Medium:** Conway **Carbon source:** 0.2% CO_2 **Temperature:** 20-23°C **Light:** 750–1000 lx, continuous light	nd	nd	7-13x10^6 cells/mL
UPMAAHU10 [38]	**System:** 1 L flasks (outdoors and lab) **Medium:** Conway **Temperature:** 24-36°C (outdoors); 23°C (lab) **Light:** 140 µmol/m^2/s, 12h L: 12h D (outdoors); 150 µmol/m^2/s, 12h L: 12h D (lab).	nd	nd	2.50±0.20 (outdoors) 2.20±0.10 (lab)

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

6.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
Protein: [38] - 41.60% (outdoors); - 43.10% (lab) Lipid: - 26.80% (outdoors); - 11.71% (lab) Carbohydrate: - 8.70% (outdoors); - 6.62% (lab)	nd	nd	C14:0 18.0% [37] C16:0 13.6% **∑SFA 34.4%** C16:1(n-7) 27.6% C18:1 (n-9) 0.7% **∑MUFA 30.0%** C18:3 (n-3) 0.1% C18:4 (n-3) 2.1% EPA 16.3% DHA 0.4% ∑(n-3) 19.1% 16:3 (n-4) 14.6% 18:2 (n-6) 0.4% **∑PUFA 35.6%**

6.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *C. calcitrans* AC165
  Location: Université de Caen Normandie, Caen, France

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *C. calcitrans* Arg 11, Arg 13, *Chaetoceros* sp.
  Location: Roscoff, France

- **Name:** Culture Collection of Algae and Protozoa CCAP
  Business/organisation type: bio-bank
  Strain(s) available: *C. calcitrans 1085/3*
  Location: Scottish Marine institute, Scotland, UK

- **Name:** ANFACO-CECOPESCA
  EnhanceMicroAlgae project Lead Coordinator

Business/organisation type: Marketing, research & development and innovation support in food and marine technology.
Expertise: biotechnology, ecophysiology, marketing, valorisation and functionality of microalgal compounds. Microalgal expertise includes (not limited to) [39],[40]:

- ***Chaetoceros calcitrans***, *C. salsugineus*, *Conticribra weissflogii* (synonym of *Thalassiosira weissflogii*), *Isochrysis galbana, Nannochloropsis gaditana*, *Pavlova gyrans*, *Phaeodactylum tricornutum*, *Rhodomonas lens*, *Tetraselmis chuii*, *Tisochyrysis lutea*

ANFACO-CECOPESCA offers production of tailor-made microalgal biomass. Read more in the EnhanceMicroAlgae marketplace.
Location: Vigo, Spain

- **Name:** Aqualgae

Business/organisation type: research and development
Expertise: design and installation of high-productivity photobioreactors, suppliers of culturing media, inoculums, and lyophilised cultures of [20]:

- *Chlorella*, *Haematococcus*, *Arthropsira*, *Tetraselmis*, *Isochrysis*, *Pavlova*, ***Chaetoceros***, *Skeletonema*, *Nitzchia*, *Rhodomonas*, *Nannochloropsis*

Locations: Diana do Castelo, Portugal; and A Coruña, Spain

- **Name:** LIENSs - LIttoral, Environment and Societies, at University of La Rochelle

EnhanceMicroAlgae partner
Business/organisation type: research and development
Expertise: Chemistry, environment, medical, nutraceuticals, pharmaceuticals. Research outputs involving microalgae include (but are not limited to):

- *Alexandrium minutum* [41], *Alexandrium tamarense* [41], *Bigelowiella natans* [41], ***Chaetoceros calcitrans*** [41], ***Chaetoceros calcitrans* f. *pumillum*** [41], *Chaetoceros gracilis* [41], *Chaetoceros minus* [41], *Chaetoceros mulleri* [41], *Chaetoceros* sp. *Tenuissimus like* [41], *Chlorella autotrophica* [41], *Chlorella vulgaris* [41], *Chloroarachnion reptans* [41], *Closterium baillyanum* [41], *Cyanophora paradoxa* [41],[42], *Cylindrotheca closterium* [43], *Dunaliella salina* [41],[44], *Dunaliella* sp. [41], *Dunaliella tertiolecta* [41],[45], *Emiliania huxleyi* [41], *Haematococcus pluvialis* [41], ,*Heterocapsa triquetra* [46], *Isochrysis galbana* [41], *Nitzschia* sp. [41], *Odontella aurita* [41], *Ostreococcus tauri* [41], *Phaeodactylum tricornutum* [41], *Porphyridium purpureum* (*Porphyridium cruentum*) [44],[47],[48], *Rhodella violacea* [41], *Rhodomonas salina* [41],[49], *Scenedesmus acutus* [41], *Scenedesmus obliquus* [41], *Skeletonema grethae* [41], *Tetraselmis suecica* [41], *Thalassiosira pseudonana* [41], *Tisochrysis lutea* [50], *Euglena proxima* [41]

The research team at LIENSs works in close collaboration with the Laboratory of phycotoxines (IFREMER) at Nantes, France.
In addition to the microalgae above, the team at LIENSs have experience with the model species Spirulina (*A. platensis*), from which they develop extraction process.
Locations: La Rochelle, France

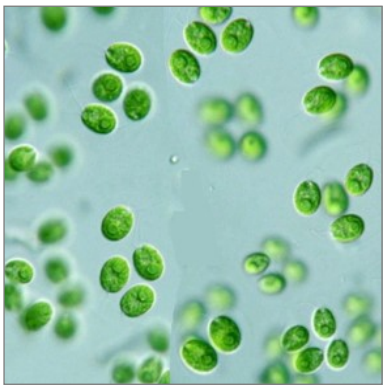
- **Name:** Xanthella Ltd.

Business/organisation type: research and development
Expertise: Design and test bespoke PBRs, consultancy, repair and recycling of old systems, active research and development. The company has worked on [51]:

- ***Chaetoceros muelleri***, *Chlamydomonas acidophila*, *Chlorella sorokiniana*, *Dunaliella primolecta*, *Desmodesmus subspicatus*, *Fragilaria* sp., *Isochrysis galbana*, *Limnoraphis robusta*, *Nannochloropsis* sp., *Phaeodactylum tricornutum*, *Porphyridium cruentum*, *Synechocystis* sp., *T-isochrysis lutea*

Location: European Marine Science Park, Argyl, Scotland

7. *Chlamydomonas reinhardtii*



A photosynthetic biflagellate microalga (Chlorophyta) that has been studied for more than 30 years as a model for basic and applied physiology and biochemistry, partly due to its ease of culturing and the ability to manipulate its genetics [52]. It can be cultivated photoautotrophically and also heterotrophically or mixotrophically [53]. Commercially, it is of interest for producing biopharmaceuticals and biofuel, as well being a valuable research tool in making hydrogen.

Commonly cultivated strains include:
UTEX 90, CC-124, CC-125

7.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
UTEX 90 [54]	**System:** Flat-vertical PBR **Medium:** minimal medium **Carbon source:** glacial acetic acid with supplemental CO_2 **Temperature:** 25-28°C **Light:** outdoor light conditions during May to July 2003 in Dae-jeon, Korea.	nd	nd	1.45 (fresh) 12-18 (concentrated)
CC-124 [55] wild-type mt(-) 137c	**System:** flask on a rotatory shaker **Medium:** TAP medium **Carbon source:** acetic acid **Temperature:** 23 °C **Light:** 150 µmol/m^2/s, continuous light	nd	nd	~1.25x10^7 cells/mL
CC-125 [55] wild-type mt(+) 137c	**System:** flask on a rotatory shaker **Medium:** TAP medium **Carbon source:** acetic acid **Temperature:** 23 °C **Light:** 150 µmol/m^2/s, continuous light	nd	nd	~1.10x10^7 cells/mL

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

7.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
CC-124 [55] 16.8% lipid in Control 39.8% lipid in N-starvation 37.6% lipid in S-starvation CC-125 14.2% lipid in Control 41.4% lipid in N-starvation 39.7% lipid in S-starvation --- *Autotrophic* [56] 26.1% protein 18.9% lipid 50.8% carbohydrate *Mixotrophic* 30.3% protein 27.9% lipid 38.1% carbohydrate *Heterotrophic* 22.2% protein 28.7% lipid 44.8% carbohydrate	Autotrophic [56] 48.1% C 5.8% N 7.3% H 38.8% O Mixotrophic 50.7% C 3.5% N 7.9% H 37.9% O Heterotrophic 50.5% C 10.5% N 7.7% H 31.3% O	Autotrophic [56] 0.9% Chlorophyll-a 1.5% Chlorophyll-b Mixotrophic 0.7% Chlorophyll-a 1.3% Chlorophyll-b Heterotrophic 1.8% Chlorophyll-a 0.8% Chlorophyll-b	C14:0 0.8% [57] C16:0 24% C16:1 1.9% C16:2 1.2% C16:3 0.9% C18:0 5.2% C18:1 23.5% C18:2 15.4% C18:3 21.6% C20:4 0.5% C20:5 4.9% C22:0 0.2% ΣSFA=30.2 ΣMUFA=25.4 ΣPUFA=44.5

7.3 Stakeholders in the Atlantic Area

- **Name:** Culture Collection of Algae and Protozoa CCAP
  Business/organisation type: bio-bank
  Strain(s) available: *C. reinhardtii* 11/32A, 11/32B, 11/32C, 11/32CW15+, 11/45
  Location: Scottish Marine institute, Scotland, UK

- **Name:** **A4F – Algae 4 Future**
  EnhanceMicroAlgae partner
  Business/organisation type: bio-bank, producer, research and development, downstream processing

Expertise: biotechnology, engineering, large-scale development. Their microalgae track-production (large and pilot scale) includes [17]:

- *Arthrospira platensis*, ***Chlamydomonas* sp.**, *Chlorella vulgaris*, *Dunaliella salina*, *Haematococcus pluvialis*, *Lobosphaera incisa*, *Nannochloropsis oceanica*, *Phaeodactylum tricornutum*, *Prorocentrum cassubicum*, *Raphidonema* sp., *Scenedesmus* sp., *Scotiellopsis* sp., *Synechococcus* sp., *Synechocystis* sp., *Tetraselmis* sp., *Thalassiosira weissflogii*, *Tisochrysis lutea*

Locations: Lisbon, Portugal

- **Name:** Department of Chemical and Biological Engineering, The University of Sheffield
  Network: Algal Biotechnology Sheffield Network
  Business/organisation type: Higher education, research & development.
  Expertise: Research outputs with microalgae include (but are not limited to):
  - *Scenedesmus subspicatus* [64], ***Chlamydomonas reinhardtii*** [61],[65], *Dunaliella salina* [65–67], *Micractinum inermum* [65], *Chlorella vulgaris* [68],[69], *Phaeodactylum tricornutum* [70],[71], *Nannochloropsis salina* [66], *Nannochloropsis oceanica* [71]

  Location: Sheffield, UK

- **Name:** Microalgae group at Centro de Investigaciones Científicas Avanzadas (CICA), University of A Coruña
  EnhanceMicroAlgae Partner
  Business/organisation type: Higher education, research & development.
  Expertise: chemistry, ecophysiology, genomics, monitoring. Research outputs involving microalgae at University of A Coruña include (but are not limited to):
  - ***Chlamydomonas reinhardtii*** [72], *Dunaliela salina* [73], *Haematococcus pluvialis* [74]

  Location: A Coruña, Spain

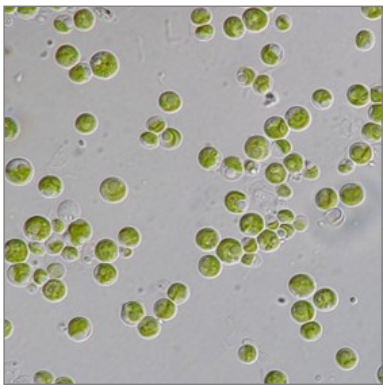
- **Name:** MicroSynbiotiX
  Business/organisation type: research and development
  Expertise: Aquaculture, medical.
  Aiming to reduce antibiotics use in farmed seafood, the company is researching how microalgae can be employed as a delivery transport of recombinant proteins to fish. P-o-C (proof-of-concept) research with *C. reinhardtii* [75].
  Locations: Cork, Ireland and San Diego California, USA

- **Name:** University of Manchester
  EnhanceMicroAlgae Partner
  Business/organization type: Higher education, research & development.
  Expertise: bioenergy, biotechnology, molecular biology, engineering, mathematical models. Research outputs involving microalgae include (but are not limited to):

- ***Chlamydomonas reinhardtii*** [76–79], ***Chlamydomonas acidophila*** [80], *Haematococcus pluvialis* [81], *T-isochrysis lutea* [82], *Pseudanabaena catenata* [83]

Location: Manchester, UK

8. *Chlorella sorokiniana*



A eukaryotic freshwater Trebouxiophyceae strain with fast growth rate with applications for animal feed, nutritional supplement, and biofuel. It can be cultivated autotrophically, mixotrophically or heterotrophically [84],[85]. Some *C. sorokiniana* show a broad temperature range and thermotolerance up to 45°C [86].

Commonly cultivated strains include:
UTEX 1230, UTEX 1602, UTEX 3016, UTEX 2805, IBVF 211-32

8.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
UTEX 1230 [2]	**System:** PBR **Medium:** 3N-BBM **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	0.115	0.185	3.7
IBVF 211-32 [87]	**System:** 2 L stirred tank reactor (STR) **Medium:** Sueoka medium **Carbon source:** CO_2, and acetate **Temperature:** 25°C **Light:** 100 µmol/m^2/s, Continuous light	nd	1.16	1.18 (*on CO_2*) ~3.1 (on acetate)
UTEX 1602 [88]	**System:** 250 mL flasks **Medium:** Kuhl medium **Carbon source:** 1 % CO_2, glucose **Temperature:** 25°C **Light:** 100 µmol/m^2/s, Continuous light	nd	nd	0.68 *(on CO_2)* 5.08 *(on glucose)*
UTEX 2805 [89]	**System:** 250 mL flasks **Medium:** synthetic medium **Temperature:** 27°C **Light:** 60 µmol/m^2/s, L:D cycle nd	nd	nd	2.11±0.26 x 10^6 *(cell/mL)*

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

8.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
56% protein [2] 22% lipid 17% carbohydrate --- 6.65% lipids (*on CO_2*) [88] 31.58% lipids (*on glucose*) --- 40% lipids [87]	46% C [2] 2% N C/N ratio 21	32.4 mg/g total chlorophyll [2] 1.2 mg/g beta-carotene 7.1 mg/g lutein	C16:0 22.0% [2] C16:1 4.3% C16:2 11.5% C16:3 5.1% C18:0 3.5% C18:1 11.3% C18:2 31.1% C18:3 9.1% other 2.1% - - - C16:0 20.99% [88] C16:1 5.56% C16:2 4.82% C18:0 0.33% C18:1 2.95% C18:2 13.79% C18:3 33.31%

Additional biomass considerations:
Supplementation of glucose as a carbon source can increase cell density, biomass production and total lipid yield but decreases protein abundance and chlorophyll biosynthesis [29].

8.3 Stakeholders in the Atlantic Area

- **Name:** Culture Collection of Algae and Protozoa CCAP
  Business/organisation: bio-bank
  Strain(s) available: *C. sorokiniana* 211/8K
  Location: Scottish Marine institute, Scotland, UK

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *C. sorokiniana* BEA 0002 to 0004, BEA 0022, BEA 0302, BEA 0665B, BEA 0061, BEA 0665B
  Location: Telde Gran Canaria, Spain

- **Name:** Andalusian Center of Science and Marine Technology (CACYTMAR) | Instituto Universitario de Investigacion Marina (INMAR) at University of Cádiz, Spain
  Business/organisation: Higher education, research & development
  Expertise: biotechnology, ecophysiology, genomics, molecular biology, waste water treatment. Research outputs involving microalgae include (but are not limited to):

- *Botryococcus braunii* [33], *Phaeodactylum tricornutum* [34], [*Chlorella vulgaris*, *Chlorella kessleri*, ***Chlorella sorokiniana***, *Scenedesmus obliquus*] [35]

Location: Cádiz, Spain

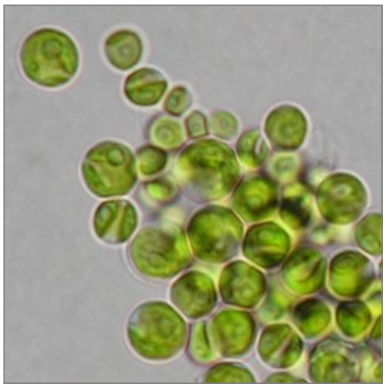
- **Name:** Laboratoire GEnie des Procédés Environnement – Agroalimentaire, GEPEA
  Business/organisation: research and development, higher education
  Expertise: bioenergy, biotechnology, chemistry, engineering. Research outputs involving microalgae include (but are not limited to):
  - *Chlorella vulgaris* [90], ***Chlorella sorokiniana*** [91], *Parachlorella kessleri* [92], *Nannochloropsis oculata* [90]

  Location: Saint-Nazaire, France

- **Name:** Xanthella Ltd.
  Business/organisation: research and development
  Expertise: Design and test bespoke PBRs, consultancy, repair and recycling of old systems, active research and development. The company has worked on [51]:
  - *Chaetoceros muelleri*, *Chlamydomonas acidophila*, ***Chlorella sorokiniana***, *Dunaliella primolecta*, *Desmodesmus subspicatus*, *Fragilaria* sp., *Isochrysis galbana*, *Limnoraphis robusta*, *Nannochloropsis* sp., *Phaeodactylum tricornutum*, *Porphyridium cruentum*, *Synechocystis* sp., *T-isochrysis lutea*

  Location: European Marine Science Park, Argyl, Scotland

9. *Chlorella vulgaris*



A eukaryotic marine Trebouxiophyceae strain that has large- scale commercial cultivation in Asia as a high protein-rich food and feed source, a nutritional supplement, and biofuel source. It can be cultivated autotrophically, mixotrophically or heterotrophically [93–95]. It has quite robust growth for cultivation in open ponds as well as photobioreactors [96].

Commonly cultivated strains include:
CCAP 211/8K, CCAP 211/11B, CCAP 211/21A, CCAP 211/21B, CCAP 211/79, UTEX 2805, UTEX 2714

9.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 211/79 [2]	**System:** PBR **Medium:** Jaworski's medium **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	0.18	0.428	3.0
UTEX 2805 [89]	**System:** 250 mL flasks **Medium:** synthetic medium **Temperature:** 27°C **Light:** 60 µmol/m^2/s, L:D cycle nd	nd	nd	3.2±0.5 x 10^6 *cell/mL*
UTEX 2714 [97]	**System:** 250 mL flasks **Medium:** modified/optimised synthetic medium **Carbon source:** glucose/glycerol **Temperature:** 26°C **Light:** 60 µmol/m^2/s, L:D cycle nd	nd	1.87	5.62
nd [98] *purchased from Connecticut Valley Biological Supply Co. Inc*	**System:** PBR (3.8 gallon, 6 L working volume) **Medium:** BBM **Temperature:** 25°C **Light:** 276 µmol/m^2/s, L:D cycle nd	nd	0.35	~1.6

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

9.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
58% protein [2] 12% lipid 17% carbohydrate --- 51-58% protein [6] 14-22% lipid 12-17% carbohydrate --- 40.10% lipid [97]	52% C [2] 3% N C/N ratio 19	22.6 mg/g total chlorophyll [2] 2.7 mg/g total carotenoid	C14:0 3.1% [2] C16:0 25.1% C16:1 5.3% C16:3 1.3% C18:0 0.6% C18:1 12.6% C18:2 7.2% C18:3 19.1% C20:3 0.8% other 24% --- C14:0 3.01% [99] C16:0 16.99% C16:1 13.61% C16:2 5.47% C16:3 7.93% C18:0 1.51% C18:1 8.55% C18:2 14.44% C18:3 16.63% C20:4 1.24% C20:5 10.17%

9.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *C. vulgaris* AC149, AC150, AC873
  Location: Université de Caen Normandie, Caen, France

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: multiple, including *C. vulgaris* 211/21A, 211/21B, 211/109 to 211/114, 211/79 to 211/82
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *C. vulgaris* BEA 0753B, BEA 0755B
  Location: Telde Gran Canaria, Spain

- **Name:** Algal Research Group, Swansea University

  EnhanceMicroAlgae partner

  Business/organisation type: Higher education, research & development.

  Expertise: Microalgae biotechnology, biomass characterization, upstream and downstream process, chemistry, ecophysiology, engineering, large-scale development, molecular biology. Research expertise with microalgae includes (but is not limited to):

  - *Scenedesmus obliquus and* ***Chlorella vulgaris*** [58], *Arthrospira maxima* [59], *Nannochloropsis spp.* [60], *Micractinum inermum* [61], *Porphyridium purpureum* [62,63], *Nosctoc sp., Isochrysis galbana* and over 25 common microalgae species including green algae, diatoms, cyanobacteria and dinoflagellates.

  Location: Swansea, UK

- **Name:** **A4F – Algae 4 Future**

  EnhanceMicroAlgae Associated partner

  Business/organisation type: bio-bank, producer, research and development, downstream processing

  Expertise: biotechnology, engineering, large-scale development. Their microalgae track-production (large and pilot scale) includes [17]:

  - *Arthrospira platensis*, *Chlamydomonas* sp., ***Chlorella vulgaris***, *Dunaliella salina*, *Haematococcus pluvialis*, *Lobosphaera incisa*, *Nannochloropsis oceanica*, *Phaeodactylum tricornutum*, *Prorocentrum cassubicum*, *Raphidonema* sp., *Scenedesmus* sp., *Scotiellopsis* sp., *Synechococcus* sp., *Synechocystis* sp., *Tetraselmis* sp., *Thalassiosira weissfloii*, *Tisochrysis lutea*

  Locations: Lisbon, Portugal

- **Name:** AlgoSource

  Business/organisation type: producer, research and development, downstream processing

  Expertise: engineering, large-scale development, industrial ecology. Know-how on *Spirulina* and its principal ingredient phycocyanin. The company is also working on extracting molecules of interest from other microalgae [100]:

  - *Spirulina,* ***Chlorella****, Scenedesmus, Tetraselmis, Isochrysis*

  Locations: Saint-Nazaire, France

- **Name:** Andalusian Center of Science and Marine Technology (CACYTMAR) | Instituto Universitario de Investigacion Marina (INMAR) at University of Cádiz, Spain

  Business/organisation type: Higher education, research & development

  Expertise: biotechnology, ecophysiology, genomics, molecular biology, waste water treatment. Research outputs involving microalgae include (but are not limited to):

  - *Botryococcus braunii* [33], *Phaeodactylum tricornutum* [34], [***Chlorella vulgaris***, *Chlorella kessleri*, *Chlorella sorokiniana*, *Scenedesmus obliquus*] [35]

Location: Cádiz, Spain

- **Name:** Aqualgae

  Business/organisation type: research and development
  Expertise: design and installation of high-productivity photobioreactors, suppliers of culturing media, inoculums, and lyophilised cultures of [20]:
  - ***Chlorella***, *Haematococcus*, *Arthropsira*, *Tetraselmis*, *Isochrysis*, *Pavlova, Chaetoceros*, *Skeletonema*, *Nitzchia*, *Rhodomonas*, *Nannochloropsis*

  Locations: Diana do Castelo, Portugal; and A Coruña, Spain

- **Name:** Biorea

  Business/organisation type: producer, research and development, downstream processing
  Expertise: Aquaculture; Cosmetics; Feed; Food; Nutraceuticals; Biotechnology. They specialise in ***Chlorella*** production, but support customers with R&D and production of tailor-made biomass in their patented airlift bioreactors. See their market offer in the EnhanceMicroAlgae marketplace.
  Locations: Lamballe, France

- **Name:** Buggypower

  EnhanceMicroAlgae Associated partner
  Business/organization type: producer, research & development, downstream processing
  Expertise: feed, food, nutraceuticals, biotechnology. The company specialises in [101]:
  - ***Chlorella****, Nannochloropsis, Rhodomonas*

  Location: Lisbon, Portugal (shared services centre & Alguimya store); Funchal, Portugal (Financial office); Porto Santo, Portugal (Buggypower production unit in partnership with Electricity Company of Madeira); San Pedro del Pinatar, Spain (Financial office); Lorqui, Spain (Research and development pilot plant)

- **Name:** Department of Chemical and Biological Engineering, The University of Sheffield

  Network: Algal Biotechnology Sheffield Network
  Business/organisation type: Higher education, research & development.
  Expertise: Research outputs with microalgae include (but are not limited to):
  - *Scenedesmus subspicatus* [64], *Chlamydomonas reinhardtii* [61,65], *Dunaliella salina* [65–67], *Micractinum inermum* [65], ***Chlorella vulgaris*** [68,69], *Phaeodactylum tricornutum* [70,71], *Nannochloropsis salina* [66], *Nannochloropsis oceanica* [71]

  Location: Sheffield, UK

- **Name:** Laboratoire GEnie des Procédés Environnement – Agroalimentaire, GEPEA

  Business/organisation type: research and development, higher education
  Expertise: bioenergy, biotechnology, chemistry, engineering. Research outputs involving microalgae include (but are not limited to):

- ***Chlorella vulgaris*** [90], *Chlorella sorokiniana* [91], *Parachlorella kessleri* [92], *Nannochloropsis oculata* [90]

Location: Saint-Nazaire, France

- **Name:** LIENSs - LIttoral, Environment and Societies, at University of La Rochelle
  EnhanceMicroAlgae partner
  Business/organisation type: research and development
  Expertise: Chemistry, environment, medical, nutraceuticals, pharmaceuticals. Research outputs involving microalgae include (but are not limited to):
  - *Alexandrium minutum* [41], *Alexandrium tamarense* [41], *Bigelowiella natans* [41], *Chaetoceros calcitrans* [41], *Chaetoceros calcitrans* f. *pumillum* [41], *Chaetoceros gracilis* [41], *Chaetoceros minus* [41], *Chaetoceros mulleri* [41], *Chaetoceros* sp. *Tenuissimus like* [41], *Chlorella autotrophica* [41], ***Chlorella vulgaris*** [41], *Chloroarachnion reptans* [41], *Closterium baillyanum* [41], *Cyanophora paradoxa* [41,42], *Cylindrotheca closterium* [43], *Dunaliella salina* [41,44], *Dunaliella* sp. [41], *Dunaliella tertiolecta* [41,45], *Emiliania huxleyi* [41], *Haematococcus pluvialis* [41], ,*Heterocapsa triquetra* [46], *Isochrysis galbana* [41], *Nitzschia* sp. [41], *Odontella aurita* [41], *Ostreococcus tauri* [41], *Phaeodactylum tricornutum* [41], *Porphyridium purpureum* (*Porphyridium cruentum*) [44,47,48], *Rhodella violacea* [41], *Rhodomonas salina* [41,49], *Scenedesmus acutus* [41], *Scenedesmus obliquus* [41], *Skeletonema grethae* [41], *Tetraselmis suecica* [41], *Thalassiosira pseudonana* [41], *Tisochrysis lutea* [50], *Euglena proxima* [41]

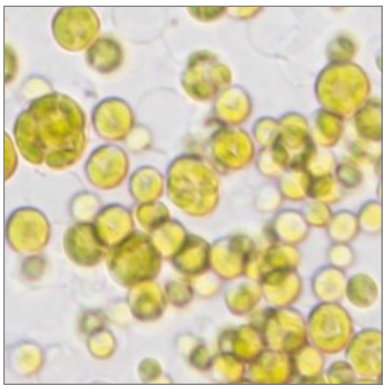
  The research team at LIENSs works in close collaboration with the Laboratory of phycotoxines (IFREMER) at Nantes, France.
  In addition to the microalgae above, the team at LIENSs have experience with the model species Spirulina (*A. platensis*), from which they develop extraction process.
  Locations: La Rochelle, France

- **Name:** NeoAlgae
  Business/organisation type: producer, research and development, downstream processing
  Expertise: aquaculture, cosmetics, nutraceuticals, biotechnology. The company produces a wide range of **Spirulina**-based products for food, cosmetics, and agriculture [102]. Their R&D division specialises on various extracts from [103]:
  - *Dunaliella salina*, *Haematococcus pluvialis*, ***Chlorella vulgaris***, *Isochrysis galbana*, *Nannochloropsis gaditana* [103]

  Locations: Asturias, Spain

- **Name:** Research and training centre of LLDC Algae
  Business/organisation type: producer, research and development, downstream processing
  Expertise: large-scale development. Their range of products include *Chlorella*-based animal feed (Greenfeed [104]) and vitamin B12 for human use (Greenbloom [105]).
  Locations: Bréhan, France

10. Chromochloris zofingiensis



Formerly known as *Chlorella zofingiensis* (Dönz) [26]. A freshwater green microalga. It can grow phototrophically, heterotrophically and mixtrophically, and it is easy to be cultured and scaled up both indoors and outdoors, achieving high cell density. It is considered a potential alternative for astaxanthin production [106].

Commonly cultivated strains include:
UTEX B32

10.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
nd [107]	**System:** 300 mL glass PBRs **Medium:** BG11 **Carbon source:** 5% CO_2 Temperature: 25°C **Light:** 300 µmol/m^2/s, continuous light	nd	nd	2.50
UTEX B32 [108]	**System:** Flat-panel, airlift-loop PBR **Medium:** Modified M8 **Carbon source:** CO_2 Temperature: 25°C **Light:** from 63 to 245 µmol/m^2/s, continuous light	nd	0.75	12

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

10.2 Biomass characteristics

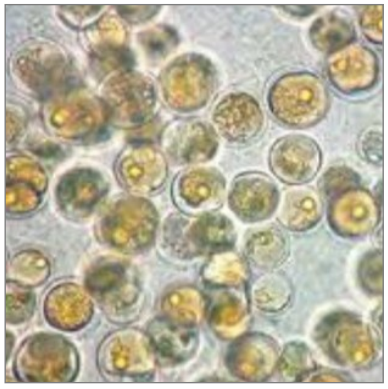
Biomass composition	Element composition	Pigment composition	Fatty acid profile
nd	nd	2.4 mg/g astaxanthin [108] 1.3 mg/g canthaxanthin 0.8 mg/g ketolutein	335 mg/g TAGs [108]

10.3 Stakeholders in the Atlantic Area

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *C. zofingiensis* CCAP 211/14, 211/51, 221/2
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *C. zofingiensis* BEA 0468B, 0496B
  Location: Telde Gran Canaria, Spain

11. Crypthecodinium cohnii



A heterotrophic non-photosynthetic species of dinoflagellate microalgae industrially used in the production of docosahexaenoic acid. DHA fraction can reach 30-50% of the total lipid content [109].

Commonly cultivated strains include:
ATCC 30555, ATCC 30556, ATCC 30772.

11.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
ATCC 30555 [109]	**System:** 1 L fermenters **Medium:** optimized experimental medium **Temperature:** 27°C	nd	nd	25.3
ATCC 30556 [110]	**System:** 250-ml Erlenmeyer flask and 5-L laboratory bioreactors **Medium:** standard medium (9 g/L glucose, 2 g/L yeast extract, 27.8 g/L sea salt) **Temperature:** 25°C **Light:** dark conditions	nd	nd	42 (*under combined stress cultivation of temperature and nitrogen depletion*)
M-1-2 [111] *(a mutant of C. cohnii ATCC 30556)*	**System:** 5-L fermenter **Medium:** basal medium (25 g/L sea salt, 2 g/L yeast extract, 5-45 g/L glucose) **Temperature:** 25°C **Light:** dark conditions	nd	nd	45.17±0.71 (*15-27 g/L glucose*) 45.84±0.52 (*80% medium replacement ratio*)

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

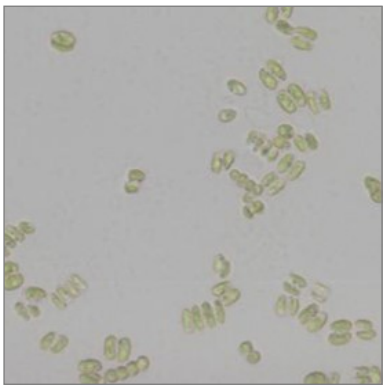
11.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
8-16% protein [109] 22-28% lipid 40-60% starch	nd	nd	22:6(n-3) DHA 36-41% [109] --- 22:6(n-3) DHA 20% [e] --- C12:0 3.08-3.88% [f] C14:0 12.82-14.28% C16:0 18.77-20.25% C18:0 2.19-3.43% C18:1 11.40-12.18% 22:6(n-3) 48.53-49.12%

11.3 Stakeholders in the Atlantic Area

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *C. cohnii* P10-012 (not distributed)
  Location: Roscoff, France

12. Desmodesmus subspicatus



Formerly known as *Scenedesmus subspicatus* (Chodat) [26]. A eukaryotic freshwater Chlorophyceae strain with applications for animal feed, nutritional supplement, and biofuel. It can be cultivated autotrophically, mixotrophically or heterotrophically [112].

Commonly cultivated strains include:
CCAP 276/20

12.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 276/20 [2]	**System:** PBR **Medium:** Jaworski's medium **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	0.09	0.11	2.1
CCAP 276/20 [113]	**System:** 250 mL flasks (200 mL working volume) **Medium:** Jaworski's medium (different P levels) **Temperature:** 25°C **Light:** 144.8 µmol/m^2/s, 16h L: 8h D	nd	nd	$2.4x10^6$ cells mL^{-1} (*in low-P medium*) $5.2x10^6$ cells mL^{-1} (*in intermediate-P medium*) $4.6x10^6$ cells mL^{-1} (*in high-P medium*)
nd [114] *Isolated from the River Nile, Egypt*	**System:** 1 L flasks (700 mL working volume) **Medium:** BBM **Temperature:** 28±2°C **Light:** 2500 lux, L:D cycle nd	nd	~0.9 (*stationary phase*) ~0.65 (*late exponential phase*)	nd

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

12.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
58% protein [2] 16% lipid 29% carbohydrate	nd	19.6 mg/g total chlorophyll [2] 0.3 mg/g total carotenoid --- 0.098±0.061 pg cell^{-1} Chlorophyll-a (*in Low N medium*) [115] 0.617±0.111 pg cell^{-1} Chlorophyll-a (*in High N medium*) [115]	C14:0 1.5% [2] C16:0 21.8% C16:1 6.0% C16:2 4.0% C16:3 0.7% C18:1 17.9% C18:2 21.7% C18:3 3.8% other 22.6%

12.3 Stakeholders in the Atlantic Area

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: Desmodesmus sp. (various), *D. subspicatus* BEA 0750B, 0141B, 0141/1, 0141/2, 0561, 0530B
  Location: Telde Gran Canaria, Spain

- **Name:** Algal Research Group, Swansea University
  EnhanceMicroAlgae partner
  Business/organisation type: Higher education, research & development.
  Expertise: bioenergy, biotechnology, chemistry, ecophysiology, engineering, large-scale development, mathematical models, molecular biology. Research outputs involving microalgae include (but are not limited to):
  - ***Scenedesmus subspicatus*** [64], *Chlamydomonas reinhardtii* [61,65], *Dunaliella salina* [65], *Micractinum inermum* [65], *Porphyridium purpureum* [62,63]

  Location: Swansea, UK

- **Name:** Department of Chemical and Biological Engineering, The University of Sheffield
  Network: Algal Biotechnology Sheffield Network
  Business/organisation type: Higher education, research & development.
  Expertise: Research outputs with microalgae include (but are not limited to):
  - ***Scenedesmus subspicatus*** [64], *Chlamydomonas reinhardtii* [61,65], *Dunaliella salina* [65–67], *Micractinum inermum* [65], *Chlorella vulgaris* [68,69], *Phaeodactylum tricornutum* [70,71], *Nannochloropsis salina* [66], *Nannochloropsis oceanica* [71]

  Location: Sheffield, UK

- **Name:** Spanish Society of Microalgae and Subproducts (SEMS)

  Business/organisation type: producer, research and development

  Expertise: biotechnology, chemistry, marketing and valorisation. The company offers various laboratory services and products for agriculture, with various microalgae being produced on a continuous basis [116]:

  - *Arthrospira platensis*, *Nannochloropsis gaditana*, *Scenedesmus* sp., and ***Scenedesmus subspicatus***

  Locations: Rota, Spain

13. Dunaliella salina

A eukaryotic marine Chlorophyceae strain that is extremely salt - tolerant and is widely cultivated as a source of beta-carotene. It has commercial interest as a source of anti-oxidant, colouring, nutritional supplement and cosmetics [117]–[120]. Large scale cultivation of *D. salina* is typically in open pond or large coastal lagoons [121].

Commonly cultivated strains include:
CCAP 19/18

13.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 19/18 [2]	**System:** PBR **Medium:** F2 (f/2) medium **Temperature:** 22°C **Light:** 70 µmol/m^2/s, 16h L: 8h D	0.135	0.224	1.28
CCAP 19/18 [122]	**System:** PBR **Medium:** sterilised seawater **Temperature:** 21°C **Light:** 300 µmol/m^2/s (blue light, red light) 12h L: 12h D	nd	nd	~1.0 (red light) ~0.7 (blue light)
nd [123] *obtained from NLP corp (Busan, Korea)*	**System:** PBR (5L, 3 L working volume) **Medium:** f/2 medium **Temperature:** 20°C **Light:** 108.9 µmol/m^2/s, 12h L: 12h D	nd	0.0375	0.25
nd [124] *obtained from Guangyu Co. (Shangai, China)*	**System:** Bubble column (350 mL working volume) **Medium:** high-salinity medium **Temperature:** 28°C **Light:** 100, 800 µmol/m^2/s, Continuous	0.66	nd	3.38 (*at 800 µmol/m^2/s*) ~0.5 (*at 100 µmol/m^2/s*)

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

13.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
48% protein [2] 24% lipid 23% carbohydrate --- 57% protein [6] 6% lipid 32% carbohydrate --- ~42% lipids in two-stage system [49]	41% C [2] 2% N C/N ratio 21	27 mg/g beta-carotene [2]	C16:0 28.1% [2] C16:1 2.0% C18:0 2.9% C18:1 17.2% C18:2 9.2% C18:3 15.9% C20:1 4.8% other 19.9%

13.3 Stakeholders in the Atlantic Area

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *D. salina* 19/12, 19/18, 19/20, 19/25, 19/31, *Dunaliella* sp.
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *D. salina* IFDSAL-JY215, IFDSAL-DIOX, DSALGB1, DSALGC3
  Location: Roscoff, France

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *D. salina* BEA 0001, BEA 0162B, 0165B,
  Location: Telde Gran Canaria, Spain

- **Name:** A4F – Algae 4 Future
  EnhanceMicroAlgae Associated partner
  Business/organisation type: bio-bank, producer, research and development, downstream processing
  Expertise: biotechnology, engineering, large-scale development. Their microalgae track-production (large and pilot scale) includes [17]:
  - *Arthrospira platensis*, *Chlamydomonas* sp., *Chlorella vulgaris*, ***Dunaliella salina***, *Haematococcus pluvialis*, *Lobosphaera incisa*, *Nannochloropsis oceanica*, *Phaeodactylum tricornutum*, *Prorocentrum cassubicum*, *Raphidonema* sp.,

Scenedesmus sp., *Scotiellopsis* sp., *Synechococcus* sp., *Synechocystis* sp., *Tetraselmis* sp., *Thalassiosira weissflogii*, *Tisochrysis lutea*

Location: Lisbon, Portugal

- **Name:** Algal Research Group, Swansea University
  EnhanceMicroAlgae partner
  Business/organisation type: Higher education, research & development.
  Expertise: bioenergy, biotechnology, chemistry, ecophysiology, engineering, large-scale development, mathematical models, molecular biology. Research outputs involving microalgae include (but are not limited to):
  - *Scenedesmus subspicatus* [64], *Chlamydomonas reinhardtii* [61,65], ***Dunaliella salina*** [65], *Micractinum inermum* [65], *Porphyridium purpureum* [62,63]

  Location: Swansea, UK

- **Name:** Algalimento
  EnhanceMicroAlgae Associated partner
  Business/organisation type: producer, research and development, downstream processing
  Expertise: biotechnology, engineering, large-scale development. Algalimento currently produces all-year round high-quality biomass of [125]:
  - *Tetraselmis* sp., *Spirulina canariensis,* ***Dunaliella salina***

  Locations: Lisbon, Portugal

- **Name:** Department of Chemical and Biological Engineering, The University of Sheffield
  Network: Algal Biotechnology Sheffield Network
  Business/organisation type: Higher education, research & development.
  Expertise: Environment, biotechnology. Research outputs with microalgae include (but are not limited to):
  - *Scenedesmus subspicatus* [64], *Chlamydomonas reinhardtii* [61,65], ***Dunaliella salina*** [65–67], *Micractinum inermum* [65], *Chlorella vulgaris* [68,69], *Phaeodactylum tricornutum* [70,71], *Nannochloropsis salina* [66], *Nannochloropsis oceanica* [71]

  Location: Sheffield, UK

- **Name:** Group of Biotechnology and Aquaculture, Universidad de Santiago de Compostela
  Business/organization type: research & development, higher education
  Expertise: biotechnology, aquaculture. Research outputs involving microalgae include (but are not limited to):
  - [***Dunaliella salina***, *Dunaliella tertiolecta]* [122], *Haematococcus pluvialis* [126], [*Tetraselmis suecica, Tetraselmis* sp.] [127] *Rhodomonas lens* [128]

  Location: Santiago de Compostela, A Coruña, Spain

- **Name:** IBVF - Instituto de Bioquímica Vegetal y Fotosíntesis, Microalgae Biotechnology Group
  Business/organisation type: research & development
  Expertise: bioenergy, ecophysiology, molecular biology. Research outputs involving microalgae include (but are not limited to):
    - *Anabaena* sp. [5,7], *Porphyridium purpureum* [5], *Scenedesmus vacuolatus* [5], *Nostoc* [5], ***Dunaliella salina*** [8]

  Location: Sevilla, Spain

- **Name:** LIENSs - LIttoral, Environment and Societies, at University of La Rochelle
  EnhanceMicroAlgae partner
  Business/organisation type: research and development
  Expertise: Chemistry, environment, medical, nutraceuticals, pharmaceuticals. Research outputs involving microalgae include (but are not limited to):
    - *Alexandrium minutum* [41], *Alexandrium tamarense* [41], *Bigelowiella natans* [41], *Chaetoceros calcitrans* [41], *Chaetoceros calcitrans* f. *pumillum* [41], *Chaetoceros gracilis* [41], *Chaetoceros minus* [41], *Chaetoceros mulleri* [41], *Chaetoceros* sp. *Tenuissimus like* [41], *Chlorella autotrophica* [41], *Chlorella vulgaris* [41], *Chloroarachnion reptans* [41], *Closterium baillyanum* [41], *Cyanophora paradoxa* [41,42], *Cylindrotheca closterium* [43], ***Dunaliella salina*** [41,44], ***Dunaliella* sp.** [41], *Dunaliella tertiolecta* [41,45], *Emiliania huxleyi* [41], *Haematococcus pluvialis* [41], ,*Heterocapsa triquetra* [46], *Isochrysis galbana* [41], *Nitzschia* sp. [41], *Odontella aurita* [41], *Ostreococcus tauri* [41], *Phaeodactylum tricornutum* [41], *Porphyridium purpureum* (*Porphyridium cruentum*) [44,47,48], *Rhodella violacea* [41], *Rhodomonas salina* [41,49], *Scenedesmus acutus* [41], *Scenedesmus obliquus* [41], *Skeletonema grethae* [41], *Tetraselmis suecica* [41], *Thalassiosira pseudonana* [41], *Tisochrysis lutea* [50], *Euglena proxima* [41]

  The research team at LIENSs works in close collaboration with the Laboratory of phycotoxines (IFREMER) at Nantes, France.
  In addition to the microalgae above, the team at LIENSs have experience with the model species Spirulina (*A. platensis*), from which they develop extraction process.
  Locations: La Rochelle, France

- **Name:** Microalgae group at Centro de Investigaciones Científicas Avanzadas (CICA), University of A Coruña
  EnhanceMicroAlgae Partner
  Business/organisation type: Higher education, research & development.
  Expertise: chemistry, ecophysiology, genomics, monitoring. Research outputs involving microalgae at University of A Coruña include (but are not limited to):
    - *Chlamydomonas reinhardtii* [72], ***Dunaliela salina*** [73], *Haematococcus pluvialis* [74]

  Location: A Coruña, Spain

- **Name:** NeoAlgae
  Business/organisation type: producer, research and development, downstream processing

Expertise: aquaculture, cosmetics, nutraceuticals, biotechnology. The company produces a wide range of **Spirulina**-based products for food, cosmetics, and agriculture [102]. Their R&D division specialises on various extracts from [103]:

- ***Dunaliella salina***, *Haematococcus pluvialis*, *Chlorella vulgaris*, *Isochrysis galbana*, *Nannochloropsis gaditana* [103]

Locations: Asturias, Spain

14. *Dunaliella tertiolecta*

A eukaryotic brackish water Chlorophyceae strain that is less salt tolerant than *D. salina* and has lower productivity of beta-carotene but is of interest for its fatty acid yields with applications for nutritional supplements, and biofuel [129].

Commonly cultivated strains include:
CCAP 19/6B, BE 003

14.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 16/6B [2]	**System:** PBR **Medium:** F2 (f/2) medium **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	0.048	0.128	1.6
CCAP 19/6B [122]	**System:** PBR **Medium:** sterilised seawater **Temperature:** 21°C **Light:** 300 µmol/m^2/s (blue light, red light) 12h L: 12h D	nd	nd	~1.2 (red light) ~0.8 (blue light)
nd [123] *obtained from NLP corp (Busan, Korea)*	**System:** PBR (5L, 3 L working volume) **Medium:** f/2 medium **Temperature:** 20°C **Light:** 108.9 µmol/m^2/s, 12h L: 12h D	nd	0.0442	0.28

BE 003 [130]	**System:** PBR (2.2 L working volume) **Medium:** f/2 medium (modified with various $NaNO_3$ concentrations) **Temperature:** 28°C **Light:** 17.5 klx continuous	nd	nd	0.45±0.02 (*75 mg/L $NaNO_3$*) 1.27±0.07 (*300 mg/L $NaNO_3$*)

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

14.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
58% protein [2] 12% lipid 8% carbohydrate --- ~40% lipids in two-stage system [123]	44% C [2] 2% N C/N ratio 20	3.95±0.06 to 5.1±0.4 mg/g total carotenoids [130]	C16:0 17.7% [2] C16:1 0.9% C16:2 3.0% C16:3 1.2% C16:4 10.6% C18:1 4.9% C18:2 12.4% C18:3 30.2% other 19.1%

14.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *D. tertiolecta* AC148, *Dunaliella* sp. AC769
  Location: Université de Caen Normandie, Caen, France

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *D. tertiolecta* 19/22, 19/23, 19/24, 19/27, 19/42, 19/5, 19/6B, 19/7C
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *D. tertiolecta* IFREMER (PLY83), *Dunaliella* sp.
  Location: Roscoff, France

- **Name:** Spanish Algae Bank

Business/organisation type: bio-bank
Strain(s) available: *D. tertiolecta* BEA 0837B
Location: Telde Gran Canaria, Spain

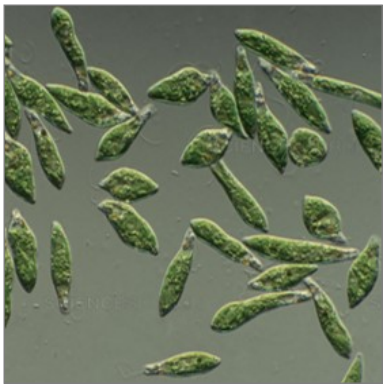
- **Name:** Group of Biotechnology and Aquaculture, Universidad de Santiago de Compostela
  Business/organization type: research & development, higher education
  Expertise: biotechnology, aquaculture. Research outputs involving microalgae include (but are not limited to):
  - [*Dunaliella salina*, ***Dunaliella tertiolecta***] [122], *Haematococcus pluvialis* [126], [*Tetraselmis suecica, Tetraselmis* sp.] [127] *Rhodomonas lens* [131]

  Location: Santiago de Compostela, A Coruña, Spain

- **Name:** LIENSs - LIttoral, Environment and Societies, at University of La Rochelle
  EnhanceMicroAlgae partner
  Business/organisation type: research and development
  Expertise: Chemistry, environment, medical, nutraceuticals, pharmaceuticals. Research outputs involving microalgae include (but are not limited to):
  - *Alexandrium minutum* [41], *Alexandrium tamarense* [41], *Bigelowiella natans* [41], *Chaetoceros calcitrans* [41], *Chaetoceros calcitrans* f. *pumillum* [41], *Chaetoceros gracilis* [41], *Chaetoceros minus* [41], *Chaetoceros mulleri* [41], *Chaetoceros* sp. *Tenuissimus like* [41], *Chlorella autotrophica* [41], *Chlorella vulgaris* [41], *Chloroarachnion reptans* [41], *Closterium baillyanum* [41], *Cyanophora paradoxa* [41,42], *Cylindrotheca closterium* [43], *Dunaliella salina* [41,44], *Dunaliella* sp. [41], ***Dunaliella tertiolecta*** [41,45], *Emiliania huxleyi* [41], *Haematococcus pluvialis* [41], ,*Heterocapsa triquetra* [46], *Isochrysis galbana* [41], *Nitzschia* sp. [41], *Odontella aurita* [41], *Ostreococcus tauri* [41], *Phaeodactylum tricornutum* [41], *Porphyridium purpureum* (*Porphyridium cruentum*) [44,47,48], *Rhodella violacea* [41], *Rhodomonas salina* [41,49], *Scenedesmus acutus* [41], *Scenedesmus obliquus* [41], *Skeletonema grethae* [41], *Tetraselmis suecica* [41], *Thalassiosira pseudonana* [41], *Tisochrysis lutea* [50], *Euglena proxima* [41]

  The research team at LIENSs works in close collaboration with the Laboratory of phycotoxines (IFREMER) at Nantes, France.
  In addition to the microalgae above, the team at LIENSs have experience with the model species Spirulina (*A. platensis*), from which they develop extraction process.
  Locations: La Rochelle, France

15. *Euglena gracilis*



A unicellular phototrophic freshwater microalga. It can grow under phototrophic, heterotrophic and mixotrophic conditions. *E. gracilis* synthetises relevant bioproducts at a commercial level such as protein containing essential amino acids, pro(vitamins), lipids, and the b-1,3-glucan paramylon [132].

Commonly cultivated strains include:
NIES-48

15.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
NIES-48 [133]	**System:** 2.5 L glass vessel bioreactors **Medium:** Chemically defined medium **Carbon source:** 1.8% CO_2 enriched air (for phototrophic growth); glucose (for mixotrophic and heterotrophic growth) **Temperature:** 23, 27, 30°C **Light:** 400 µmol/m^2/s (for phototrophic growth) and dark conditions (for heterotrophic growth)	nd	nd	5 (*in phototrophic cultures with high light and 23*°C) 10.5 (*in mixotrophic cultures at 27*°C)
nd [134] *(obtained from the Culture Collection Centre of the Institute of Applied Microbiology, University of Tokyo, Japan)*	**System:** 500 mL erlenmeyer flasks and airlift photobioreactor **Medium:** BG11 medium and different NPKs **Temperature:** 25°C±1 **Light:** 2570 Lux, L:D cycle: continuous light illumination	nd	nd	26.0 ×10^7 cell/mL (*in flasks*) 228.8 ×10^7 cell/mL (*in airlift PBR*)

NIES-48 [135]	**System:** 15 L polycarbonate culture vessel **Medium:** municipal wastewater **Temperature:** 28±1°C **Light:** 80 µmol/m^2/s, 16 L: 8 D cycle	nd	0.087 (*in a co-culture with bacteria containing 8×10^6 CFU/mL*)	0.7

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

15.2 Biomass characteristics

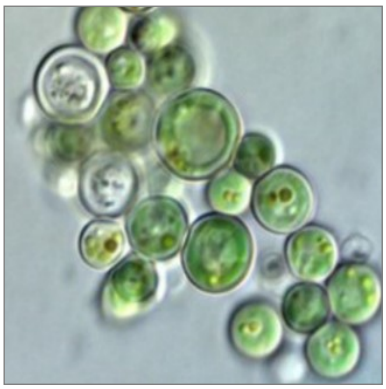
Biomass composition	Element composition	Pigment composition	Fatty acid profile
12-34% protein [133] 22% lipid --- 33.3% protein [134] 16.4% lipid --- 30.9% lipid [135]	nd	6 µg/mL chlorophyll a+b [j] *(in co-culture with bacteria)*	20:5(n-3) EPA 0.48% [133] 22:6(n-3) DHA 0.38%

15.3 Stakeholders in the Atlantic Area

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *E. gracilis* CCAP 1224/38, 1224/5Y, 1224/5Z, *Euglena* sp. CCAP 1224/47
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *Euglena* sp. BEA 0201B, 0799, 0202B
  Location: Telde Gran Canaria, Spain

16. *Galdieria sulphuraria*



A unicellular red microalga which grows efficiently in extreme environments with acidic conditions and high temperatures. *G. sulphuraria* produces a large amount of biomass and many beneficial compounds [136].

Commonly cultivated strains include:
074 W, 064/309

16.1 Cultivation characteristics

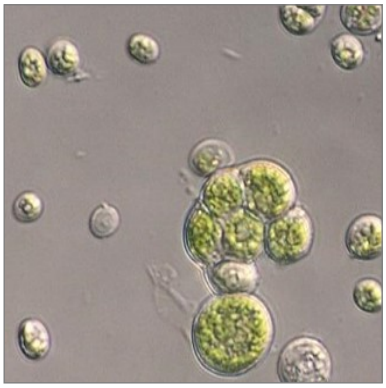
Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
074 W [136]	**System:** 300 mL shaking flasks **Medium:** modified 2 Allen's medium **Carbon source:** glucose (for mixotrophic and heterotrophic growth) **Temperature:** 42°C **Light:** 50 µmol/m^2/s continuous light (for phototrophic and mixotrophic growth), dark (for heterotrophic growth)	nd	nd	3.8 ± 0.2 (*mixotrophic*)
064/309 [137]	**System:** 5 L glass cylindrical bioreactors **Medium:** Allen medium **Carbon source:** glycerol (for heterotrophic growth) **Light:** 150 µmol/m^2/s (for phototrophic growth) L:D cycle nd	nd	nd	5.7 (*autotrophic*) 29 (*heterotrophic*)

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

16.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
26–32% protein [137] 63–69% carbohydrate 11-18% lipid	nd	575 mg/kg astaxanthin [137] 387 mg/kg lutein 12 mg/kg chlorophyll-a 4.5-79 g/kg allophycocyanin 0.2-0.5 g/kg phycocyanin 3.3-6.5 g/kg phycoerytrin	C14:0 0.9-2.7% [137] C16:0 14.7-39.4% C16:1 2.4% C18:0 4.7% C18:1 8.6-57.5% C18:2 19.5-45.2% C18:3 1.1-2.7%

17. Graesiella sp.



A unicellular green microalga with broadly ellipsoidal or globose cells. This microalga presents high capacity of adaptation to a wide range of culture pH [138].

Commonly cultivated strains include:
WBG-1, NC-M1

17.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
WBG-1 [138]	**System:** bubbled column PBR, 10 L circular pond, 30 L tank PBR, 200 m^2 raceway pond **Medium:** modified BG11 medium **Carbon source:** 1% v/v CO_2 **Temperature:** 30°C **Light:** 300 µmol/m^2/s, L:D cycle nd	nd	18.9 g/m^2/d (*in 30L tank*)	161.8 g/m^2 (*in 30L tank*)
NC-M1 [139]	**System:** 1 L Erlenmeyer flasks **Medium:** BG11 medium **Temperature:** 25°C **Light:** 50 µmol/m^2/s, 16h L:8h D cycle	nd	nd	1.2 (*with 45.2 µM Fe*)

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

17.2 Biomass characteristics

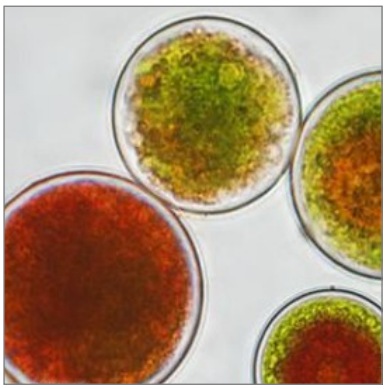
Biomass composition	Element composition	Pigment composition	Fatty acid profile
12-14% protein [138] 32-40% carbohydrate 22-35% lipid (*in 200 m^2 raceway cultivation*) --- 30-65% lipid [139]	nd	nd	C5-C14 5-10% [138] C16-C18 70-75% C19-C24 7-10% --- C14:0 27.4-29.64% [139] C16:0 0.83-5.49% C16:2 1.19-4.99% C18:1 27.43-47.04% C18:2 8.86-22.03% C20:2 6.72-13.52%

17.3 Stakeholders in the Atlantic Area

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *G. emersoni* CCAP 211/1A, 211/1M, 211/1N, 211/15, 211/55, 211/8G, 211/8H, 2118P
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *G. vacuolata* BEA 0618B, 0615B, 0573B, 0616B
  Location: Telde Gran Canaria, Spain

18. Haematococcus pluvialis



A eukaryotic freshwater Chlorophyceae strain with the ability to produce very high concentrations of astaxanthin, with applications for aquaculture, nutritional supplement, and cosmetics, and with antioxidant characteristics. *H. pluvialis* has a green phase then a red phase of growth, which is induced by light, nitrogen or saline stress [140–142].

Commonly cultivated strains include:
CCAP 34/6, SCCAP K-0084, SCCAP K-0084, LUGU, CPCC 93

18.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 34/6 [2]	**System:** PBR **Medium:** Jaworski's medium **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	0.098	0.157	3.14
SCCAP K-0084 [143]	**System:** 250 mL flasks **Medium:** BG11 medium **Carbon source:** ribose, sodium acetate, or gluconate **Temperature:** 25°C **Light:** 45±3 µmol/m^2/s, L:D cycle nd	nd	nd	1.03 (*on ribose*) 0.77 (*on acetate*) 1.12 (*on gluconate*)
SCCAP K-0084 [143]	**System:** 250 mL flasks **Medium:** BG11 medium **Carbon source:** gluconate **Temperature:** 25°C **Light:** 105±3 µmol/m^2/s, L:D cycle nd	nd	nd	2.09
LUGU [144] (*18S GenBankKM115647.1*)	**System:** 1 L flask (650 mL working volume). **Medium:** BG11 medium + fulvic acid	nd	nd	1.57 (with 0 *mg/L fulvic acid*) 1.84

	Carbon source: sodium acetate **Temperature:** 25°C **Light:** 50 µmol/m^2/s L:D cycle nd			(with 5 mg/L fulvic acid)
CPCC 93 [145]	**System:** 2.2 L PBR **Medium:** M1B5 **Temperature:** 23±2°C **Light:** 15-30 klx 12 h L: 12h D	nd	nd	2.028±0.09 (*on air*) 4.37±0.07 (*on 5% CO_2*)

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

18.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
68% protein [2] 26% lipid 9% carbohydrate	36% C [2] 4% N C/N ratio 10 --- 43.57±0.61% C [145] 6.26±0.54% H 1.98±0.16% N 0.47±0.03% S	23.2 mg/g astaxanthin [2] 2.8 mg/g beta-carotene 10.2 mg/g lutein 5.8 mg/g total chlorophyll (in red phase) --- 5.2±1.7 ug/mL chlorophyll [143] (*at 0 µmol/m^2/s*) 41.3±2.9 ug/mL chlorophyll (*at 105 µmol/m^2/s*) --- 5.01 mg/g astaxanthin content [144]	C16:0 22.4% [2] C16:1 0.6% C16:2 2.1% C16:3 3.1% C16:4 5.8% C18:0 0.9% C18:1 19.5% C18:2 28.7% C18:3 12.6% other 4.3%

18.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *H. pluvialis* AC136, 143, 587, 588
  Location: Université de Caen Normandie, Caen, France

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *H. pluvialis* BEA 1360B

Location: Telde Gran Canaria, Spain

- **Name:** A4F – Algae 4 Future

  EnhanceMicroAlgae partner

  Business/organisation type: bio-bank, producer, research and development, downstream processing

  Expertise: biotechnology, engineering, large-scale development. Their microalgae track-production (large and pilot scale) includes [17]:

  - *Arthrospira platensis*, *Chlamydomonas* sp., *Chlorella vulgaris*, *Dunaliella salina*, ***Haematococcus pluvialis***, *Lobosphaera incisa*, *Nannochloropsis oceanica*, *Phaeodactylum tricornutum*, *Prorocentrum cassubicum*, *Raphidonema* sp., *Scenedesmus* sp., *Scotiellopsis* sp., *Synechococcus* sp., *Synechocystis* sp., *Tetraselmis* sp., *Thalassiosira weissflogii*, *Tisochrysis lutea*

  Locations: Lisbon, Portugal

- **Name:** Aqualgae

  Business/organisation: research and development

  Expertise: design and installation of high-productivity photobioreactors, suppliers of culturing media, inoculums, and lyophilised cultures of [20]:

  - *Chlorella*, ***Haematococcus***, *Arthropsira*, *Tetraselmis*, *Isochrysis*, *Pavlova, Chaetoceros*, *Skeletonema*, *Nitzchia*, *Rhodomonas*, *Nannochloropsis*

  Locations: Diana do Castelo, Portugal; and A Coruña, Spain

- **Name:** Group of Biotechnology and Aquaculture, Universidad de Santiago de Compostela

  Business/organization type: research & development, higher education

  Expertise: biotechnology, aquaculture. Research outputs involving microalgae include (but are not limited to):

  - [*Dunaliella salina*, *Dunaliella tertiolecta]* [122], ***Haematococcus pluvialis*** [126], [*Tetraselmis suecica, Tetraselmis* sp.] [127] *Rhodomonas lens* [131]

  Location: Santiago de Compostela, A Coruña, Spain

- **Name:** LIENSs - LIttoral, Environment and Societies, at University of La Rochelle

  EnhanceMicroAlgae partner

  Business/organisation type: research and development

  Expertise: Chemistry, environment, medical, nutraceuticals, pharmaceuticals. Research outputs involving microalgae include (but are not limited to):

  - *Alexandrium minutum* [41], *Alexandrium tamarense* [41], *Bigelowiella natans* [41], *Chaetoceros calcitrans* [41], *Chaetoceros calcitrans* f. *pumillum* [41], *Chaetoceros gracilis* [41], *Chaetoceros minus* [41], *Chaetoceros mulleri* [41], *Chaetoceros* sp. *Tenuissimus like* [41], *Chlorella autotrophica* [41], *Chlorella vulgaris* [41], *Chloroarachnion reptans* [41], *Closterium*

baillyanum [41], *Cyanophora paradoxa* [41,42], *Cylindrotheca closterium* [43], *Dunaliella salina* [41,44], *Dunaliella* sp. [41], *Dunaliella tertiolecta* [41,45], *Emiliania huxleyi* [41], ***Haematococcus pluvialis*** [41], ,*Heterocapsa triquetra* [46], *Isochrysis galbana* [41], *Nitzschia* sp. [41], *Odontella aurita* [41], *Ostreococcus tauri* [41], *Phaeodactylum tricornutum* [41], *Porphyridium purpureum* (*Porphyridium cruentum*) [44,47,48], *Rhodella violacea* [41], *Rhodomonas salina* [41,49], *Scenedesmus acutus* [41], *Scenedesmus obliquus* [41], *Skeletonema grethae* [41], *Tetraselmis suecica* [41], *Thalassiosira pseudonana* [41], *Tisochrysis lutea* [50], *Euglena proxima* [41]

The research team at LIENSs works in close collaboration with the Laboratory of phycotoxines (IFREMER) at Nantes, France.
In addition to the microalgae above, the team at LIENSs have experience with the model species Spirulina (*A. platensis*), from which they develop extraction process.
Locations: La Rochelle, France

- **Name:** Microalgae group at Centro de Investigaciones Científicas Avanzadas (CICA), University of A Coruña

  EnhanceMicroAlgae Partner

  Business/organisation type: Higher education, research & development.
  Expertise: chemistry, ecophysiology, genomics, monitoring. Research outputs involving microalgae at University of A Coruña include (but are not limited to):
  - *Chlamydomonas reinhardtii* [72], *Dunaliela salina* [73], ***Haematococcus pluvialis*** [74]

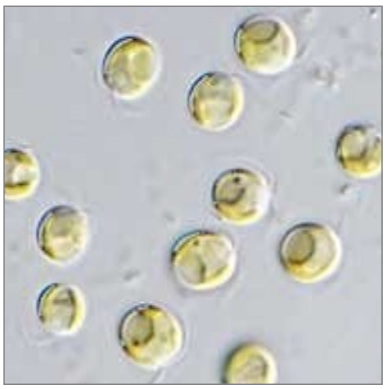
  Location: A Coruña, Spain

- **Name:** NeoAlgae

  Business/organisation type: producer, research and development, downstream processing
  Expertise: aquaculture, cosmetics, nutraceuticals, biotechnology. The company produces a wide range of **Spirulina**-based products for food, cosmetics, and agriculture [102]. Their R&D division specialises on various extracts from [103]:
  - *Dunaliella salina*, ***Haematococcus pluvialis***, *Chlorella vulgaris*, *Isochrysis galbana*, *Nannochloropsis gaditana* [103]

  Locations: Asturias, Spain

19. Isochrysis galbana



A eukaryotic marine microalga which is a species of Haptophyta. For its good nutritive characteristics (especially in relation to polyunsaturated fatty-acid composition), is of substantial interest in aquaculture [146]. It is also investigated for its high amount of fucoxanthin [147].

19.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
nd [148] *from Marine Microalgae Research Center, Ocean University of China*	**System:** Erlenmeyer flasks **Medium:** f/2 **Temperature:** 23°C **Light:** 4.0 mW/cm^2, 16 h L: 8 h D	nd	nd	1.69x10^7 cells/mL *(500 µmol/L phosphorous)*
nd [149] *Aquatic Research Laboratory at Isfahan University of Technology, Isfahan, Iran*	**System:** 10 L carboys **Medium:** Walne's medium **Temperature:** 25°C **Light:** 80 mmol photons/m2/s, 12 h L: 12 h D	nd	nd	1.55x10^7 cells/mL *(144mg/L nitrogen)*

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

19.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
30% protein [148] 33% carbohydrate *(100 µmol/L phosphorous)* --- 36.3% protein [149] *(36 mg/L nitrogen)* 47% carbohydrate *(0 mg/L nitrogen)* 30.6% lipids *(144 mg/L nitrogen)*	nd	3.24% chlorophyll [148] *(100 µmol/L phosphorous)* --- 1.21 mg/L total carotenoid [149] *(72 mg/L nitrogen)*	C14:0 26.34% [149] C16:0 43.46% C16:1 1.4% C18:1n-7 17.25% C18:3n-3 3.52% C20:0 4.42% C20:3n-3 2.03% *(0 mg/L nitrogen)*

19.3 Stakeholders in the Atlantic Area

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *I. galbana* CCAP 927/1, 927/20, 941/3, 949/1
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *I. galbana* AC101 (not distributed), AC34, AC80, PLY240, PLY507, PLY8, GE_FL_IC_SingleCell_103, GE_FL_IC_SingleCell_104, GE_DV_IC_DIL_194
  Location: Roscoff, France

- **Name:** AlgoSource
  Business/organisation type: producer, research and development, downstream processing
  Expertise: engineering, large-scale development, industrial ecology. Know-how on *Spirulina* and its principal ingredient phycocyanin. The company is also working on extracting molecules of interest from other microalgae [100]:
  - *Spirulina, Chlorella, Scenedesmus, Tetraselmis,* ***Isochrysis***

  Locations: Saint-Nazaire, France

- **Name:** ANFACO-CECOPESCA
  EnhanceMicroAlgae project Lead Coordinator

Business/organisation type: Marketing, research & development and innovation support in food and marine technology.
Expertise: biotechnology, ecophysiology, marketing, valorisation and functionality of microalgal compounds. Microalgal expertise includes (not limited to) [39],[40]:

- *Chaetoceros calcitrans*, *C. salsugineus*, *Conticribra weissflogii* (synonym of *Thalassiosira weissflogii*), ***Isochrysis galbana***, *Nannochloropsis gaditana*, *Pavlova gyrans*, *Phaeodactylum tricornutum*, *Rhodomonas lens*, *Tetraselmis chuii*, *Tisochyrysis lutea*

ANFACO-CECOPESCA offers production of tailor-made microalgal biomass. Read more in the EnhanceMicroAlgae marketplace.
Location: Vigo, Spain

- **Name:** Algal Research Group, Swansea University

EnhanceMicroAlgae partner
Business/organisation type: Higher education, research & development.
Expertise: Microalgae biotechnology, biomass characterization, upstream and downstream process, chemistry, ecophysiology, engineering, large-scale development, molecular biology. Research expertise with microalgae includes (but is not limited to):

- *Scenedesmus obliquus and Chlorella vulgaris* [58], *Arthrospira maxima* [59], *Nannochloropsis spp.* [60], *Micractinum inermum* [61], *Porphyridium purpureum* [62],[63], *Nosctoc sp.*, ***Isochrysis galbana*** and over 25 common microalgae species including green algae, diatoms, cyanobacteria and dinoflagellates.

Location: Swansea, UK

- **Name:** Aqualgae

Business/organisation: research and development
Expertise: design and installation of high-productivity photobioreactors, suppliers of culturing media, inoculums, and lyophilised cultures of [20]:

- *Chlorella*, *Haematococcus*, *Arthropsira*, *Tetraselmis*, ***Isochrysis***, *Pavlova, Chaetoceros*, *Skeletonema*, *Nitzchia*, *Rhodomonas*, *Nannochloropsis*

Locations: Diana do Castelo, Portugal; and A Coruña, Spain

- **Name:** LIENSs - LIttoral, Environment and Societies, at University of La Rochelle

EnhanceMicroAlgae partner
Business/organisation type: research and development
Expertise: Chemistry, environment, medical, nutraceuticals, pharmaceuticals. Research outputs involving microalgae include (but are not limited to):

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pluvialis [41], ,*Heterocapsa triquetra* [46], ***Isochrysis galbana*** [41], *Nitzschia* sp. [41], *Odontella aurita* [41], *Ostreococcus tauri* [41], *Phaeodactylum tricornutum* [41], *Porphyridium purpureum* (*Porphyridium cruentum*) [44,47,48], *Rhodella violacea* [41], *Rhodomonas salina* [41,49], *Scenedesmus acutus* [41], *Scenedesmus obliquus* [41], *Skeletonema grethae* [41], *Tetraselmis suecica* [41], *Thalassiosira pseudonana* [41], *Tisochrysis lutea* [50], *Euglena proxima* [41]

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In addition to the microalgae above, the team at LIENSs have experience with the model species Spirulina (*A. platensis*), from which they develop extraction process.
Locations: La Rochelle, France

- **Name:** NeoAlgae

Business/organisation type: producer, research and development, downstream processing
Expertise: aquaculture, cosmetics, nutraceuticals, biotechnology. The company produces a wide range of **Spirulina**-based products for food, cosmetics, and agriculture [102]. Their R&D division specialises on various extracts from [103]:

- *Dunaliella salina*, *Haematococcus pluvialis*, *Chlorella vulgaris*, ***Isochrysis galbana***, *Nannochloropsis gaditana* [103]

Locations: Asturias, Spain

- **Name:** PhytoBloom/Necton

Business/organisation: producer, research and development
Expertise: aquaculture, cosmetics, nutraceuticals, biotechnology. Their line of products include culture media for microalgae, and aquaculture food concentrates from [150]:

- *Nannochloropsis*, *Tetraselmis*, ***Isochrysis***, and *Phaeodactylum*

Location: Olhão and Algarve, Portugal

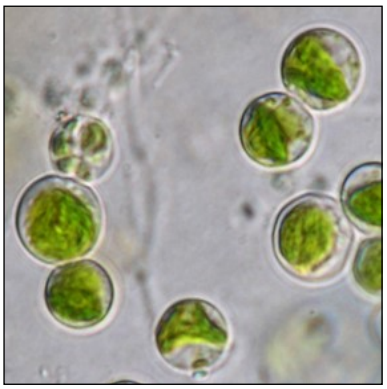
- **Name:** Xanthella Ltd.

Business/organisation: research and development
Expertise: Design and test bespoke PBRs, consultancy, repair and recycling of old systems, active research and development. The company has worked on:

- *Chaetoceros muelleri*, *Chlamydomonas acidophila*, *Chlorella sorokiniana*, *Dunaliella primolecta*, *Desmodesmus subspicatus*, *Fragilaria* sp., ***Isochrysis galbana***, *Limnoraphis robusta*, *Nannochloropsis* sp., *Phaeodactylum tricornutum*, *Porphyridium cruentum*, *Synechocystis* sp., *T-isochrysis lutea*

Location: European Marine Science Park, Argyl, Scotland

20. Jaagichlorella luteoviridis



Formerly known as *Chlorella luteoviridis* (Chodat) [151]. A eukaryotic freshwater Trebouxiophyceae strain (also known as *Heterochlorella luteoviridis* or *Jaagichlorella luteoviridis*) with fast growth rate and along with other *Chlorella* sp. has applications for animal feed, nutritional supplement, and biofuel. It can be cultivated autotrophically, mixotrophically or heterotrophically. [152]

Commonly cultivated strains include:
CCAP 211/3, CCAP 211/4, CCAP 211/5B

20.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 211/3 [2]	**System:** PBR **Medium:** Jaworski's medium **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	0.29	0.36	2.52
Indigenous wastewater *C. luteoviridis* strain [153]	**System:** 250 mL conical flasks (batch; semi-continuous) **Medium:** Raw municipal wastewater secondary treated effluent (RMWSE) + 25 % v/v sludge liquor **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	nd	~0.8 *(batch)* 1.78 *(semi-continuous)*	0.84 *(batch)* 6.01-7.99 *(semi-continuous)*
Indigenous wastewater *C. luteoviridis* strain [153]	**System:** Open pond (150 L, 10 cm depth) **Medium:** RMWSE + 25 % v/v/ sludge liquor **Temperature:** outdoors **Light:** outdoors	nd	~0.31 *(in summer)* ~0.25 *(in spring)*	nd

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

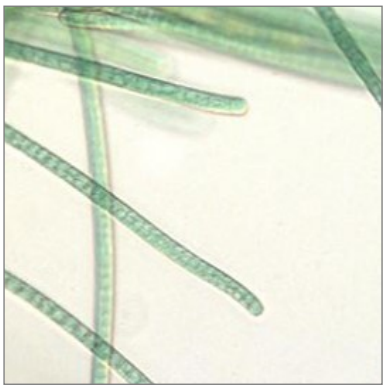
20.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
47% protein [2] 22% lipid 12% carbohydrate	nd	29.8 mg/g total chlorophyll [2] 3.4 mg/g total carotenoid	C14:0 2.4% [2] C16:0 25.0% C16:1 9.3% C18:0 7.2% C18:1 21.3% C18:2 9.7% C18:3 24.9% other 0.2%

20.3 Stakeholders in the Atlantic Area

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *J. luteoviridis* CCAP 211/10A, 211/10C, 211/10E, 211/3, 211/4, 211/5B
  Location: Scottish Marine Institute, United Kingdom

21. *Lyngbya lutea*



Formerly known as *Oscillatoria lutea* (C.Agardh) [26]. A cyanobacteria strain that has interest as a source of chemicals including butylated hydroxytoluene, which has antioxidant characteristics [154].

Commonly cultivated strains include:
CCAP 1459/3

21.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 1459/3 [2]	**System:** PBR **Medium:** BG11 medium **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	0.04	0.05	0.76
nd [155] (*Oscillatoria lutea* var. *contorta*) obtained from the collection of the University of Texas	**System:** 500 mL flasks (250 mL working volume) **Medium:** grown on barley straw extract **Temperature:** 20°C **Light:** 65 µmol/m^2/s, 12h L: 12h D	nd	nd	~600 ug L (*measured as Chlorophyl a*)

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

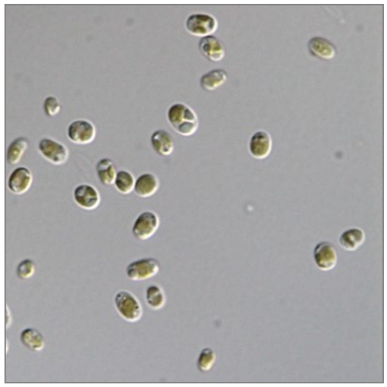
21.2 Biomass characteristics

Biomass composition	Element composition	Pigments	Fatty acids
48% protein [2] 9% lipid 18% carbohydrate	nd	9.8 mg/g chlorophyll [2] 1.7 mg/g carotenoids	nd

21.3 Stakeholders in the Atlantic Area

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *Lyngbya* sp. CCAP 1446/10, 1446/7, 1473/2, 1473/4, *Oscillatoria lutea* var. *contorta* CCAP 1459/3, *Oscillatoria* sp. CCAP 1459/13
  Location: Scottish Marine Institute, United Kingdom

22. *Microchloropsis salina*



Formerly known as *Nannochloropsis salina* [26]. It is a marine microalga widely used in aquaculture as it is rich in PUFA (particularly EPA), antioxidant pigment, and numerous bioactive compounds [156].

Commonly cultivated strains include:
SAG 40.85, CCMP 1776.

22.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
nd [156] *obtained from the culture collection of Cochin University of Science and Technology, India*	**System:** 250 mL conical flasks **Medium:** f/2 medium prepared in artificial seawater **Temperature:** 28±2°C **Light:** 27.02 µmol/m^2/s, L: D cycle nd	nd	nd	9.0x10^6 cells/mL
SAG 40.85 [157]	**System:** 4 m^2 (40 L) open thin-layer cascade reactor **Medium:** ASW medium **Temperature and light:** simulated conditions of Almería	nd	nd	15.4
nd [158] *obtained from the Rajiv Gandhi Centre for Aquaculture, Marine Products Export Development Authority (MPEDA), Sirkali, Tamil Nadu, India*	**System:** Erlenmeyer flasks **Medium:** Walne medium **Carbon source:** glucose and sodium acetate (0.25, 0.5 and 1 g/L) **Temperature:** 27 ºC **Light:** 3000 lux	nd	nd	1.795

22.2 Biomass characteristics

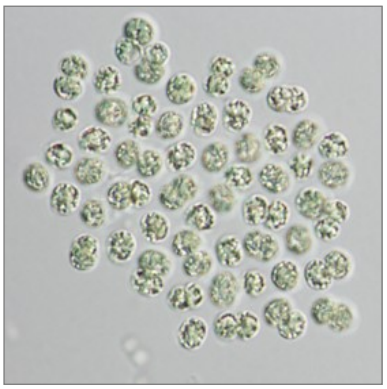
Biomass composition	Element composition	Pigment composition	Fatty acid profile
~20% protein [156] ~15% lipid ~10% carbohydrate --- 48% protein [157] 16% lipid 26% carbohydrate *(in nutrient replete medium)* 12% protein 46% lipid 35% carbohydrate *(in nitrogen-limited medium)* --- 45% lipid [158] *(in heterotrophic conditions)*	nd	~800 µg/L chlorophyll [156] ~850 µg/L total carotenoids	C14:0 6.5% [157] C16:0 22.0% C16:1 31.3% C18:0 0.4% C18:1 4.8% C18:1 0.4% C18:2 1.6% C18:3 0.1% C20:0 0.1% C20:1 0.1% C20:2 0.1% C20:4 4.0% C20:3 0.1% C20:5 28.3% *(in nutrient replete medium)* C14:0 3.4% C16:0 48.6% C16:1 30.1% C18:0 1.2 % C18:1 6.6 % C18:1 0.4 % C18:2 1.3 % C18:3 0.4 % C20:0 0.1 % C20:1 0.1 % C20:2 0.1 % C20:4 2.1 % C20:3 0.1 % C20:5 5.5 % *(in nitrogen-limited medium)*

22.3 Stakeholders in the Atlantic Area

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *M. salina* CCAP 849/2, 849/3, 849/4
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *M. salina* CCMP527
  Location: Roscoff, France

23. *Microcystis aeruginosa*



A cyanobacteria strain known for toxic bloom formation. It can produce neurotoxins and is also a source of butylated hydroxytoluene, which has antioxidant characteristics [159].

Commonly cultivated strains include:
CCAP 1450/1, FACHB-469.

23.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 1450/1 [2]	**System:** PBR **Medium:** BG11 medium **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	0.04	0.06	0.68
FACHB-469 [160]	**System:** 250 mL flasks (150 mL working volume) **Medium:** BG11 medium with dissolved organic carbon, DOM **Temperature:** 25°C **Light:** 50 µmol/m^2/s, 12h L: 12h D	nd	nd	$1.7x10^7$ cells/mL

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

23.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
66% protein [2] 9% lipid 8% carbohydrate --- ~4.5-8 pg cell^{-1} protein [160] ~2-12 pg cell^{-1} polysaccharides *(under various organic sources)*	nd	~0.4-0.55 ug 10^6 cell^{-1} chlorophyll content [161]	nd

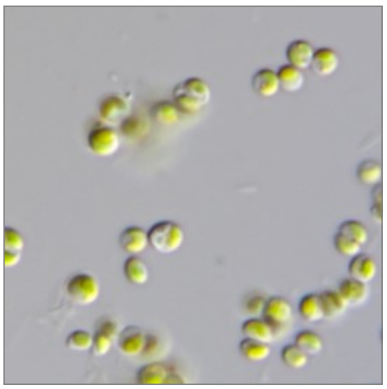
23.3 Stakeholders in the Atlantic Area

- **Name:** Laboratoire Phycotoxines IFREMER

  Business/organisation: research and development, environmental monitoring
  Expertise: chemistry, ecophysiology, molecular biology. Research outputs involving microalgae include (but are not limited to):
  - *Tisochhrysis lutea* [162], ***Microcystis aeuriginosa*** [163]

  The research team at IFREMER works in close collaboration with the EnhanceMicroAlgae team at LIENSs, University of La Rochelle, France.
  Location: Nantes, France

24. Nannochloropsis oculata



A eukaryotic marine strain of the Eustigmatophyceae class with applications for nutritional supplement, and biofuel, particularly due to its fatty acid characteristics. It can be cultivated autotrophically in photobioreactor or open pond conditions, with a stress induction such as nitrogen starvation, typically used to induce higher fatty acid yields [164,165].

Commonly cultivated strains include:
CCAP 849/1

24.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 849/1 [2]	**System:** PBR **Medium:** F2 (f/2) medium **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	0.09	0.32	2.5
nd [123] *obtained from NLP corp (Busan, Korea)*	**System:** PBR (5L, 3 L working volume) **Medium:** f/2 medium **Temperature:** 20°C **Light:** 108.9 µmol/m^2/s, 12h L: 12h D	nd	0.0475	0.51
nd [166] *obtained from the Fisheries Research Institute (Pingtung, Taiwan)*	**System:** 3 L PBR Two stages: 1st N replete, 2nd N deplete **Medium:** Basal medium with 35 g/L salinity **Temperature:** 25°C **Light:** 300, 500 µmol/m^2/s, Continuous	nd	nd	3.36 (at *300 µmol/m^2/s*) 3.44 (at *500 µmol/m^2/s*)

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

24.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
40% protein [2] 33% lipid 10% carbohydrate --- ~30% lipids in two-stage system [123] --- 43.2% lipid [166] (at 300 *µmol/m²/s)* 44.5% lipid (at 500 *µmol/m²/s)*	55% C [2] 3% N C/N ratio 21	nd	C14:0 7.2% [2] C16:0 23.4% C16:1 26.9% C16:3 0.5% C18:1 13.2% C18:2 1.2% C20:4 2.7% C20:5 14.3% other 10.1% --- C14:0 4.13% [99] C16:0 20.70% C16:1 17.12% C16:2 3.88% C16:3 5.35% C18:0 0.98% C18:1 7.46% C18:2 8.75% C18:3 10.08% C20:4 2.88% C20:5 18.67% ΣSFA=25.8 ΣMUFA=24.58 ΣPUFA=49.62 --- ΣSFA=34.15-40.15% [166] ΣPUFA=29.96-44.54%

24.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *N. oculata* AC225, ACAC227
  Location: Université de Caen Normandie, Caen, France

- **Name:** Culture Collection of Algae and Protozoa CCAP
  Business/organisation type: bio-bank
  Strain(s) available: *N. oculata* CCAP 849/1, CCAP 849/7
  Location: Scottish Marine institute, Scotland, UK

- **Name:** Algal Research Group, Swansea University

  EnhanceMicroAlgae partner

  Business/organisation type: Higher education, research & development.

  Expertise: Microalgae biotechnology, biomass characterization, upstream and downstream process, chemistry, ecophysiology, engineering, large-scale development, molecular biology. Research expertise with microalgae includes (but is not limited to):

  - *Scenedesmus obliquus and Chlorella vulgaris* [58], *Arthrospira maxima* [59], ***Nannochloropsis*** *spp.* [60], *Micractinum inermum* [61], *Porphyridium purpureum* [62,63], *Nosctoc sp., Isochrysis galbana* and over 25 common microalgae species including green algae, diatoms, cyanobacteria and dinoflagellates.

  Location: Swansea, UK

- **Name:** Aqualgae

  Business/organisation: research and development

  Expertise: design and installation of high-productivity photobioreactors, suppliers of culturing media, inoculums, and lyophilised cultures of [20]:

  - *Chlorella*, *Haematococcus*, *Arthropsira*, *Tetraselmis*, *Isochrysis*, *Pavlova, Chaetoceros*, *Skeletonema*, *Nitzchia*, *Rhodomonas*, ***Nannochloropsis***

  Locations: Diana do Castelo, Portugal; and A Coruña, Spain

- **Name:** Buggypower

  EnhanceMicroAlgae Associated partner

  Business/organization type: producer, research & development, downstream processing

  Expertise: feed, food, nutraceuticals, biotechnology. The company specialises in [101]:

  - *Chlorella, **Nannochloropsis**, Rhodomonas*

  Location: Lisbon, Portugal (shared services centre & Alguimya store); Funchal, Portugal (Financial office); Porto Santo, Portugal (Buggypower production unit in partnership with Electricity Company of Madeira); San Pedro del Pinatar, Spain (Financial office); Lorqui, Spain (Research and development pilot plant)

- **Name:** Laboratoire GEnie des Procédés Environnement – Agroalimentaire, GEPEA

  Business/organisation: research and development, higher education

  Expertise: bioenergy, biotechnology, chemistry, engineering. Research outputs involving microalgae include (but are not limited to):

  - *Chlorella vulgaris* [90], *Chlorella sorokiniana* [91], *Parachlorella kessleri* [92], ***Nannochloropsis oculata*** [90]

  Location: Saint-Nazaire, France

- **Name:** PhytoBloom/Necton

  Business/organisation: producer, research and development

Expertise: aquaculture, cosmetics, nutraceuticals, biotechnology. Their line of products include culture media for microalgae, and aquaculture food concentrates from [167]:

- ***Nannochloropsis***, *Tetraselmis*, *Isochrysis*, and *Phaeodactylum*

Location: Olhão and Algarve, Portugal

25. Nostoc sp.

A cyanobacteria strain that is grown as a food and feed source, and a nutritional supplement in Asia due to its protein and vitamin constituents [168].

Commonly cultivated strains include:
CCAP 1403/17, TISTR 8872, TISTR 8873

25.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 1403/17 [2]	**System:** PBR **Medium:** BG11 medium **Temperature:** 22°C **Light:** 70 µmol/m^2/s, 16h L: 8h D	0.122	0.197	1.38
TISTR 8872 [169]	**System:** Conical flasks (300 mL working volume) **Medium:** BG11 medium **Temperature:** 28±1°C **Light:** 60 µmol/m^2/s, 12h L: 12h D	nd	nd	0.3±0.0
TISTR 8873 [169]	**System:** Conical flasks (300 mL working volume) **Medium:** BG11 medium **Temperature:** 28±1°C **Light:** 60 µmol/m^2/s, 12h L: 12h D	nd	nd	0.2±0.04

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

25.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
42% protein [2] 8% lipid 33% carbohydrate --- From 30.66±0.58 to 32.85±1.52% starch [169]	nd	0.6 mg/g chlorophyll [2] 1.7 mg/g carotenoids	nd

25.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *Nostoc commune* AC661
  Location: Université de Caen Normandie, Caen, France

- **Name:** Blue Biotechnology and Ecotoxicology Culture Collection (LEGE) at CIIMAR
  CIIMAR is an EnhanceMicroAlgae partner
  Business/organisation type: bio-bank
  Strain(s) available: *Nostoc* sp. LEGE 06158, 06077, 07365, 13413, 12447, 12448, 12449, 12450, 12451, 12453, 12454, 12456,
  Read more about the services offered by the LEGE culture collection in the EnhanceMicroAlgae marketplace.
  Location: Porto, Portugal

- **Name:** Culture Collection of Algae and Protozoa CCAP
  Business/organisation type: bio-bank
  Strain(s) available: *Nostoc* sp. CCAP 1403/17, 1453/25, 1453/27, 1453/28, 1453/31, 1453/4
  Location: Scottish Marine institute, Scotland, UK

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *Nostoc* sp. A12.448
  Location: Roscoff, France

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *Nostoc* sp. BEA 1063B, 1249B, 1559B, 0874B, 1279B, 1605B , 0886B, 1557B, 0877B, 1039B, 1454B
  Location: Telde Gran Canaria, Spain

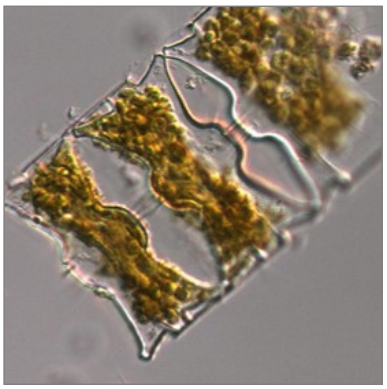
- **Name:** Algal Research Group, Swansea University
  EnhanceMicroAlgae partner
  Business/organisation type: Higher education, research & development.
  Expertise: Microalgae biotechnology, biomass characterization, upstream and downstream process, chemistry, ecophysiology, engineering, large-scale development, molecular biology. Research expertise with microalgae includes (but is not limited to):
  - *Scenedesmus obliquus and Chlorella vulgaris* [58]*, Arthrospira maxima* [59]*, Nannochloropsis spp.* [60]*, Micractinum inermum* [61]*, Porphyridium purpureum* [62,63]*,* ***Nosctoc sp.****, Isochrysis galbana* and over 25 common microalgae species including green algae, diatoms, cyanobacteria and dinoflagellates.

  Location: Swansea, UK

- **Name:** IBVF - Instituto de Bioquímica Vegetal y Fotosíntesis, Microalgae Biotechnology Group
  Business/organisation: research & development
  Expertise: bioenergy, ecophysiology, molecular biology. Research outputs involving microalgae include (but are not limited to):
  - *Anabaena* sp. [5,7]*, Porphyridium purpureum* [5]*, Scenedesmus vacuolatus* [5]*,* ***Nostoc*** [5]*, Dunaliella salina* [8]

  Location: Sevilla, Spain

26. Odontella aurita



A marine diatom with interest as a nutritional supplement, and pharmaceutical applications due to its fatty acid characteristics, in particular the accumulation of polyunsaturated fatty acids [170].

Commonly cultivated strains include:
CCAP 1054/1, SCCAP K 1251

26.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 1054/1 [2]	**System:** PBR **Medium:** f/2 + Si medium **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	0.001	0.011	0.2
SCCAP K1251 [171]	**System:** PBR (1.2 L working volume) **Medium:** Modified L1 medium **Temperature:** 25±1°C **Light:** 150 µmol/m^2/s for 1st two days, then 300 µmol/m^2/s continuous	nd	nd	3.95 (*low nitrogen*) 5.84 (*high nitrogen*)
SCCAP K1251 [172]	**System:** Glass column (300 mL working volume) **Medium:** Artificial seawater enriched with L1 medium **Temperature:** 25±1°C **Light:** 150 µmol/m^2/s Continuous	nd	nd	6.34 (*high nitrogen*) 6.58 (*high phosphorous*)

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

26.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
48% protein [2] 5% lipid 20% carbohydrate --- ~25% protein [171] ~10% lipids 60.33% Chrysolaminarin (carbohydrate) --- 15.3% protein [172] 15.9% lipid 50.4% carbohydrate 47.2 % β-1,3-glucan	30% C [2] 5% N C/N ratio 6.5	2.33% fucoxanthin [171] (carotenoid) 60.33% Chrysolaminarin	C14:0 27.2% [2] C16:0 7.7% C16:1 18.7% C16:2 3.1% C16:3 5.7% C16:4 3.1% C18:1 1.9% C18:2 1.2% C18:4 0.8% C20:5 22.8% other 7.8%

26.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *O. aurita* AC815, AC816
  Location: Université de Caen Normandie, Caen, France

- **Name:** Culture Collection of Algae and Protozoa CCAP
  Business/organisation type: bio-bank
  Strain(s) available: *O. aurita* CCAP 1007/3, 1054/1
  Location: Scottish Marine institute, Scotland, UK

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *O. aurita* Santec 04, NCC87 D-Od.au. IA1
  Location: Roscoff, France

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *Odontella* cf. *aurita* BEA 0932B
  Location: Telde Gran Canaria, Spain

- **Name:** LIENSs - LIttoral, Environment and Societies, at University of La Rochelle

  EnhanceMicroAlgae partner

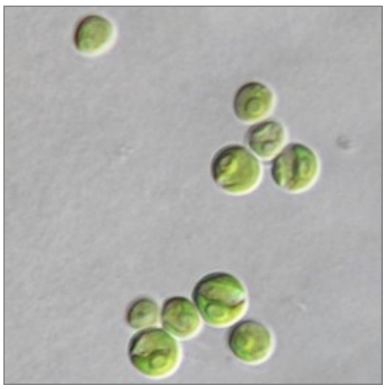
  Business/organisation type: research and development

  Expertise: Chemistry, environment, medical, nutraceuticals, pharmaceuticals. Research outputs involving microalgae include (but are not limited to):

  - *Alexandrium minutum* [41], *Alexandrium tamarense* [41], *Bigelowiella natans* [41], *Chaetoceros calcitrans* [41], *Chaetoceros calcitrans* f. *pumillum* [41], *Chaetoceros gracilis* [41], *Chaetoceros minus* [41], *Chaetoceros mulleri* [41], *Chaetoceros* sp. *Tenuissimus like* [41], *Chlorella autotrophica* [41], *Chlorella vulgaris* [41], *Chloroarachnion reptans* [41], *Closterium baillyanum* [41], *Cyanophora paradoxa* [41,42], *Cylindrotheca closterium* [43], *Dunaliella salina* [41,44], *Dunaliella* sp. [41], *Dunaliella tertiolecta* [41,45], *Emiliania huxleyi* [41], *Haematococcus pluvialis* [41], ,*Heterocapsa triquetra* [46], *Isochrysis galbana* [41], *Nitzschia* sp. [41], ***Odontella aurita*** [41], *Ostreococcus tauri* [41], *Phaeodactylum tricornutum* [41], *Porphyridium purpureum* (*Porphyridium cruentum*) [44,47,48], *Rhodella violacea* [41], *Rhodomonas salina* [41,49], *Scenedesmus acutus* [41], *Scenedesmus obliquus* [41], *Skeletonema grethae* [41], *Tetraselmis suecica* [41], *Thalassiosira pseudonana* [41], *Tisochrysis lutea* [50], *Euglena proxima* [41]

  The research team at LIENSs works in close collaboration with the Laboratory of phycotoxines (IFREMER) at Nantes, France.
  In addition to the microalgae above, the team at LIENSs have experience with the model species Spirulina (*A. platensis*), from which they develop extraction process.
  Locations: La Rochelle, France

27. *Parachlorella kessleri*



A eukaryotic freshwater Trebouxiophyceae strain with potential applications for animal feed, nutritional supplement, and biofuel. It can be cultivated autotrophically, mixotrophically or heterotrophically [173]. *Chlorella kessleri* (Fott & Nováková) is considered to be a synonym of *Parachlorella kessleri* [26].

Commonly cultivated strains include:
CCAP 211/11G, QWY28, GB1

27.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 211/11G [2]	**System:** PBR **Medium:** Jaworki's medium **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	0.36	0.413	2.74
QWY28 [174] *collected from rivers in the district of Harbin city, China*	**System:** Conical flasks **Medium:** Artificial seawater **Temperature:** 30°C **Light:** 200 µmol/m^2/s, L:D cycle nd	nd	0.633±0.027	3.8
QWY28 [174] *collected from rivers in the district of Harbin city, China*	**System:** 500 mL glass vessels, 2.5 % CO_2 **Medium:** Raw swine wastewater **Temperature:** 27-30°C **Light:** 200 µmol/m^2/s, L:D cycle nd	nd	0.775±0.026	6.2
QWY28 [174] *collected from rivers in the district of Harbin city, China*	**System:** 500 mL glass vessels, 2.5 % CO_2 **Medium:** Raw swine wastewater **Temperature:** 27-30°C **Light:** 600 µmol/m^2/s, L:D cycle nd	nd	1.150±0.056	9.2

GB1 [175] *GenBank KX151669.1*	**System:** 500 mL flasks (200 mL working volume) **Medium:** BG11 **Carbon source:** glucose **Temperature:** 25±2°C **Light:** 28 µmol/m^2/s, Continuous	nd	0.176±0.00 (*phototrophic*) 1.362±0.01 (*mixotrophic*) 1.311±0.01 (*heterotrophic*)	1.043±0.02 (*phototrophic*) 8.176±0.06 (*mixotrophic*) 7.871±0.09 (*heterotrophic*)

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

27.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
51% protein [2] 25% lipid 16% carbohydrate --- 54% carbohydrate [174] (*of which ~35% is glucose*) --- 41.29±0.90% protein [175] 20.14±0.58% lipid 34.15±0.42% carbohydrate	nd	23.6 mg/g total chlorophyll [2] 4.1 mg/g total carotenoid --- 9.17±0.11 mg/g Chlorophyll a [175] 3.98±0.02 mg/g Chlorophyll b 2.60±0.02 mg/g carotenoids	C14:0 1.1% [2] C16:0 12.1% C16:1 7.2% C18:0 4.2% C18:1 24.2% C18:2 23.5% C18:3 26.8% C20:0 0.5% other 2.1%

27.3 Stakeholders in the Atlantic Area

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *Parachlorella* sp. BEA 0045, 0046, 0047B, 0060,
  Location: Telde Gran Canaria, Spain

- **Name:** Andalusian Center of Science and Marine Technology (CACYTMAR) | Instituto Universitario de Investigacion Marina (INMAR) at University of Cádiz, Spain
  Business/organisation: Higher education, research & development
  Expertise: biotechnology, ecophysiology, genomics, molecular biology, waste water treatment. Research outputs involving microalgae include (but are not limited to):
  - *Botryococcus braunii* [33], *Phaeodactylum tricornutum* [34], [*Chlorella vulgaris*, ***Chlorella kessleri***, *Chlorella sorokiniana*, *Scenedesmus obliquus*] [35]

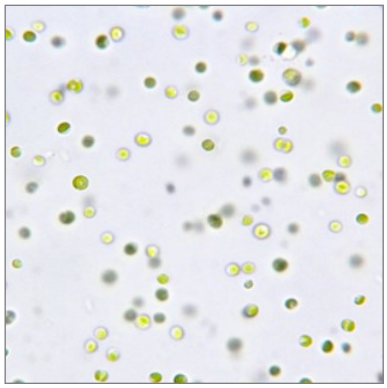
  Location: Cádiz, Spain

- **Name:** Laboratoire GEnie des Procédés Environnement – Agroalimentaire, GEPEA

  Business/organisation: research and development, higher education
  Expertise: bioenergy, biotechnology, chemistry, engineering. Research outputs involving microalgae include (but are not limited to):
  - *Chlorella vulgaris* [90], *Chlorella sorokiniana* [91], ***Parachlorella kessleri*** [92], *Nannochloropsis oculata* [90]

  Location: Saint-Nazaire, France

28. Picochlorum sp.



Green microalgae which is able to cope with environmental perturbations, thriving in freshwater as well as in 3-fold the salinity of seawater, and in a wide range of light intensities (80-2000 µE/m^2/s), and temperatures (16-33°C). *Picochlorum* species present huge biotechnological interest since they are characterised by high biomass production, high protein and carotenoid content, and lipid accumulation [176].

Commonly cultivated strains include:
SENEW3, QUCCCM 127.

28.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
nd [177]	**System:** 400 mL square Pyrex bottles **Medium:** filter sterilized seawater, enriched with trace nutrients **Carbon source:** 0.75–1% CO_2 **Temperature:** 29–33 °C **Light:** 900-2000 µmol/m^2/s, L: D cycle nd	nd	~100 g/m^2/d	nd
QUCCCM 127 [178]	**System:** DASGIP parallel bioreactor system **Medium:** supplemented sea water **Temperature:** 30-45°C **Light:** 60 µmol/m^2/s, 12h L: 12h D cycle	nd	98.3 (*35 °C*) 250 (*20% CO2*)	nd

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

28.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
55-58% protein [178] 24-28% lipid 9-14% carbohydrate	51% C [t] 12% N	~9% total chlorophyll [177] content	C14:0 0.40-0.59% [178] C16:0 17.6-22% C16:1 0.19-0.26% C18:0 1.39-1.68% C18:1 1-2.22% C18:2 17.45-24% C20:1 48.55-59.94% C20:5 0.58-1.14% C22:1 0.86-1.11%

28.3 Stakeholders in the Atlantic Area

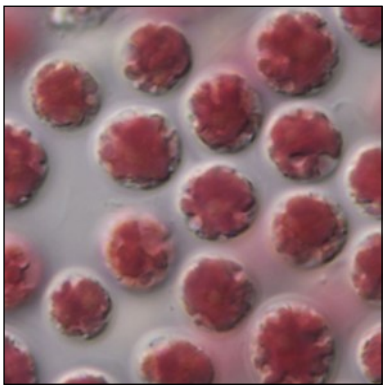
- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *P. oculatum* AC142, *P. maculatum* AC627
  Location: Université de Caen Normandie, Caen, France

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *Picochlorum* sp. CCAP 6079/1
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *P. atomus* CCMP508, *P. costavermella* BCC143000, *Picochlorum* sp. (various)
  Location: Roscoff, France

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *P. eukaryotum* BEA 0756B, *P. maculatum* BEA 0741B, *P. oklahemense* BEA BEA 0398, 0399, 0400, 0401, 0402, 0421, 0422, 0654B, 0153B, 0154B, 0155B
  Location: Telde Gran Canaria, Spain

29. *Porphyridium purpureum*



SCS-02, CCAP 1380/3, CoE1

A species of marine red algae belonging to the Porphyridiophyceae family. It presents high potential to produce B-phycoerythrin (B-PE), long chain polyunsaturated fatty acids (LC-PUFAs) and exopolysaccharides (EPS) which are excellent feedstock for food, nutraceuticals and pharmaceuticals [179]. *Porphyridium cruentum* (S.F.Gray) is considered to be a synonym of *Porphyridium purpureum* (Bory) [26].

Commonly cultivated strains include:

29.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
SCS-02 [180]	**System:** Glass column PBR **Medium:** ASW medium **Temperature:** 25±1°C **Light:** 350 µmol/m^2/s, continuous light	nd	nd	5.54 *(high nitrogen)*
CCAP 1380/3 [63]	**System:** two 600 L PBRs *(one for Batch Culture and another for semi-continuous culture)* **Medium:** f/2 commercial medium *(Cell-hi F2P, Varicon)* **Temperature:** those registered in Summer season in Wales (11-22°C) **Light:** those registered in Summer season in Wales (average of 376.4 µmol/m^2/s)	26.60 *(Batch)* 47.04 *(Semi-continuous)*	72.5 *(Batch)* 145 *(Semi-continuous)*	0.97 *(Batch)* 1.04 *(Semi-continuous)*
CoE1 [181]	**System:** 1 L flasks **Medium:** ASW, KOCK, Pringsheim II and f/2 medium. **Temperature:** 25°C	nd	nd	9.95 *(ASW medium)* 9.25 *(*Pringsheim II *medium)*

	Light: from 110 to 220 µmol/m^2/s, continuous light			8.34 *(KOCK medium)* 2.58 *(f/2 medium)*

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

29.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
47.1% protein [180] *(high nitrogen)* 12% lipid *(high nitrogen)* 52.1% carbohydrate *(low nitrogen)* --- ~ 15-22% protein [63] ~ 17-20% lipid ~ 15-25% carbohydrate	nd	nd	C16:0 ~32% [180] C16:1 ~2% C18:0 ~1% C18:1 ~2% C18:2 ~11% C20:4 ~27% C20:5 ~15% --- C16:0 13.32% [181] C18:0 2.32% C18:2 8.38% C20:3 1.26% C20:4 9.03% C20:5 2.60% Others 2.90% *(220 µmol/m^2/s, 3 L/min of aeration)*

29.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *P. purpureum* AC120, AC121, AC122
  Location: Université de Caen Normandie, Caen, France

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *P. purpureum* CCAP 1380/11, 1380/1A, 1380/3, 1380/5, 1380/9
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Algal BioSciences – National University of Ireland
  Business/organisation type: research & development
  Expertise: biotechnology, ecophysiology. Research outputs involving microalgae include (but are not limited to):
    - ***Porphyridium purpureum*** [182], *Pavlova lutheri* [183]

  Location: Galway, Ireland

- **Name:** Algal Research Group, Swansea University
  EnhanceMicroAlgae partner
  Business/organisation type: Higher education, research & development.
  Expertise: Microalgae biotechnology, biomass characterization, upstream and downstream process, chemistry, ecophysiology, engineering, large-scale development, molecular biology. Research expertise with microalgae includes (but is not limited to):
    - *Scenedesmus obliquus and Chlorella vulgaris* [58], *Arthrospira maxima* [59], *Nannochloropsis spp.* [60], *Micractinum inermum* [61], ***Porphyridium purpureum*** [62],[63], *Nosctoc sp., Isochrysis galbana* and over 25 common microalgae species including green algae, diatoms, cyanobacteria and dinoflagellates.

  Location: Swansea, UK

- **Name:** IBVF - Instituto de Bioquímica Vegetal y Fotosíntesis, Microalgae Biotechnology Group
  Business/organisation type: research & development
  Expertise: bioenergy, ecophysiology, molecular biology. Research outputs involving microalgae include (but are not limited to):
    - *Anabaena* sp. [5],[7], ***Porphyridium purpureum*** [5], *Scendesmus vacuolatus* [5], *Nostoc* [5], *Dunaliella salina* [8]

  Location: Sevilla, Spain

- **Name:** LIENSs - LIttoral, Environment and Societies, at University of La Rochelle
  EnhanceMicroAlgae partner
  Business/organisation type: research and development
  Expertise: Chemistry, environment, medical, nutraceuticals, pharmaceuticals. Research outputs involving microalgae include (but are not limited to):
    - *Alexandrium minutum* [41], *Alexandrium tamarense* [41], *Bigelowiella natans* [41], *Chaetoceros calcitrans* [41], *Chaetoceros calcitrans* f. *pumillum* [41], *Chaetoceros gracilis* [41], *Chaetoceros minus* [41], *Chaetoceros mulleri* [41], *Chaetoceros* sp. *Tenuissimus like* [41], *Chlorella autotrophica* [41], *Chlorella vulgaris* [41], *Chloroarachnion reptans* [41], *Closterium baillyanum* [41], *Cyanophora paradoxa* [41],[42], *Cylindrotheca closterium* [43], *Dunaliella salina* [41],[44], *Dunaliella* sp. [41], *Dunaliella tertiolecta* [41],[45], *Emiliania huxleyi* [41], *Haematococcus pluvialis* [41], ,*Heterocapsa triquetra* [46], *Isochrysis galbana* [41], *Nitzschia* sp. [41], *Odontella aurita* [41], *Ostreococcus tauri* [41], *Phaeodactylum tricornutum* [41], ***Porphyridium purpureum*** (*Porphyridium cruentum*) [44],[47],[48], *Rhodella violacea* [41], *Rhodomonas salina* [41],[49], *Scenedesmus acutus* [41], *Scenedesmus obliquus* [41], *Skeletonema grethae* [41],

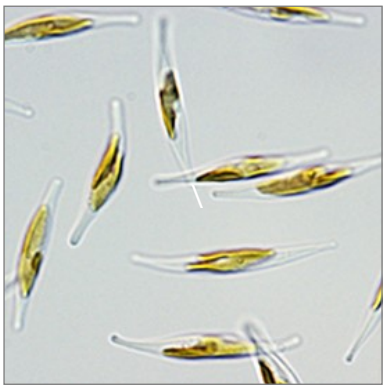
Tetraselmis suecica [41], *Thalassiosira pseudonana* [41], *Tisochrysis lutea* [50], *Euglena proxima* [41]

The research team at LIENSs works in close collaboration with the Laboratory of phycotoxines (IFREMER) at Nantes, France.
In addition to the microalgae above, the team at LIENSs have experience with the model species Spirulina (*A. platensis*), from which they develop extraction process.
Locations: La Rochelle, France

- **Name:** Xanthella Ltd.
  Business/organisation type: research and development
  Expertise: Design and test bespoke PBRs, consultancy, repair and recycling of old systems, active research and development. The company has worked on [51]:
  - *Chaetoceros muelleri*, *Chlamydomonas acidophila*, *Chlorella sorokiniana*, *Dunaliella primolecta*, *Desmodesmus subspicatus*, *Fragilaria* sp., *Isochrysis galbana*, *Limnoraphis robusta*, *Nannochloropsis* sp., *Phaeodactylum tricornutum*, ***Porphyridium cruentum***, *Synechocystis* sp., *T-isochrysis lutea*

  Location: European Marine Science Park, Argyl, Scotland

30. *Phaeodactylum tricornutum*



A marine diatom strain with ability to produce high yields of fatty acids including polyunsaturated fatty acids, therefore leading to applications for animal feed, nutritional supplement, and biofuel [184,185].

Commonly cultivated strains include:
CCAP 1055/1, CCMP 632, PTN0301, CCMP 632.

30.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCAP 1055/1G [2]	**System:** PBR **Medium:** f/2 + Si medium **Temperature:** 22°C **Light:** 150 µmol/m^2/s, 16h L: 8h D	0.084	0.16	3.2
PTN0301 [186] *Isolated from water samples collected in the North Sea*	**System:** 1 L bottles **Medium:** modified f/2 medium, with air or CO_2 supply **Temperature:** 20±1°C **Light:** 90-110 µmol/m^2/s, 16h L: 8h D	nd	nd	1.6 (*with CO_2*) 1.0 (*with air*)
PTN0301 [186] *Isolated from water samples collected in the North Sea*	**System:** open ponds (1000 L) **Medium:** digestate from anaerobic digestion **Temperature:** outdoors **Light:** outdoors	0.041	nd	Between 0.3 and 0.8

CCMP 632 [187]	**System:** 1 L flasks (800 mL working volume) **Medium:** mixture of municipal wastewater (MW) and seawater (SW) **Temperature:** 20±1°C **Light:** 120 µmol/m^2/s, 12h L: 12h D	nd	0.289±0.0001 (*in MW:SW=2:1*) 0.238±0.002 (*in MW:SW=1:1*)	1.04±0.01 (*in MW:SW=2:1*) 0.97±0.02 (*in MW:SW=1:1*)

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

30.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
42% protein [2] 12% lipid 39% carbohydrate --- *Growth on air* [186] 41.5±0.4% protein 26.7±0.0% lipid 9.5±2.3% polysaccharides *Growth on CO_2* [186] 33.5±1.0% protein 33.8±3.7% lipid 24.0±0.1% polysaccharides	nd	nd	C14:0 7.5% [2] C16:0 12.6% C16:1 23.8% C16:2 4.1% C16:3 8.4% C16:4 2.9% C18:1 1.4% C18:2 2.1% C20:4 0.7% C20:5 30.2% other 6.3% --- C14:0, 6.55±0.32% [186] C16:0, 19.24±0.19% C16:3+C16:1, 49.41±2.68% C18:0, 0.74±0.10 % C86:2+C18:1, 3.63±0.25% C20:4, 1.15±0.12% C20:5, 17.77±2.23%

30.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *P. tricornutum* AC171, AC590, AC591
  Location: Université de Caen Normandie, Caen, France

- **Name:** Culture Collection of Algae and Protozoa CCAP
  Business/organisation type: bio-bank
  Strain(s) available: *P. tricornutum* CCAP 1052/1A, 1052/1B, 1052/6, 1055/1 to 1055/9

Location: Scottish Marine institute, Scotland, UK

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *P. tricornutum* IFREMER, Klaus 11b, Pt1_8.6, *Phaeodactylum* sp.
  Location: Roscoff, France

- **Name:** ANFACO-CECOPESCA
  EnhanceMicroAlgae project Lead Coordinator
  Business/organisation type: Marketing, research & development and innovation support in food and marine technology.
  Expertise: biotechnology, ecophysiology, marketing, valorisation and functionality of microalgal compounds. Microalgal expertise includes (not limited to) [39],[40]:
  - *Chaetoceros calcitrans*, *C. salsugineus*, *Conticribra weissflogii* (synonym of *Thalassiosira weissflogii*), *Isochrysis galbana, Nannochloropsis gaditana*, *Pavlova gyrans*, ***Phaeodactylum tricornutum***, *Rhodomonas lens*, *Tetraselmis chuii*, *Tisochyrysis lutea*

  ANFACO-CECOPESCA offers production of tailor-made microalgal biomass. Read more in the EnhanceMicroAlgae marketplace.
  Location: Vigo, Spain

- **Name:** **A4F – Algae 4 Future**
  EnhanceMicroAlgae partner
  Business/organisation type: bio-bank, producer, research and development, downstream processing
  Expertise: biotechnology, engineering, large-scale development. Their microalgae track-production (large and pilot scale) includes [17]:
  - *Arthrospira platensis*, *Chlamydomonas* sp., *Chlorella vulgaris*, *Dunaliella salina*, *Haematococcus pluvialis*, *Lobosphaera incisa*, *Nannochloropsis oceanica*, ***Phaeodactylum tricornutum***, *Prorocentrum cassubicum*, *Raphidonema* sp., *Scenedesmus* sp., *Scotiellopsis* sp., *Synechococcus* sp., *Synechocystis* sp., *Tetraselmis* sp., *Thalassiosira weissflogii*, *Tisochrysis lutea*

  Locations: Lisbon, Portugal

- **Name:** Andalusian Center of Science and Marine Technology (CACYTMAR) | Instituto Universitario de Investigacion Marina (INMAR) at University of Cádiz, Spain
  Business/organisation: Higher education, research & development
  Expertise: biotechnology, ecophysiology, genomics, molecular biology, waste water treatment. Research outputs involving microalgae include (but are not limited to):
  - *Botryococcus braunii* [33], ***Phaeodactylum tricornutum*** [34], [*Chlorella vulgaris*, *Chlorella kessleri*, *Chlorella sorokiniana*, *Scenedesmus obliquus*] [35]

  Location: Cádiz, Spain

- **Name:** ABIMS – Analysis and Bioinformatics for Marine Science

  Business/organisation: platform, informatics
  Expertise: bioinformatics, database, metagenomics, molecular biology, software development, transcriptomics. Research outputs associated to the company, as listed in their publications page, include (but are not limited to):
  - ***Phaeodactylum tricornutum*** [188], *Synechococcus* sp.[189]

  Location: Roscoff, France

- **Name:** Bantry Marine Research Station

  Business/organisation: producer, research and development
  Expertise: aquaculture, environment, nutraceutics, ecophysiology. Research outputs involving microalgae include (but are not limited to):
  - ***Phaeodactylum tricornutum*** [190]

  Location: Cork, Ireland

- **Name:** Department of Chemical and Biological Engineering, The University of Sheffield
  Network: Algal Biotechnology Sheffield Network
  Business/organisation type: Higher education, research & development.
  Expertise: Research outputs with microalgae include (but are not limited to):
  - *Scenedesmus subspicatus* [64], *Chlamydomonas reinhardtii* [61,65], *Dunaliella salina* [65–67], *Micractinum inermum* [65], *Chlorella vulgaris* [68,69], ***Phaeodactylum tricornutum*** [70,71], *Nannochloropsis salina* [66], *Nannochloropsis oceanica* [71]

  Location: Sheffield, UK

- **Name:** LIENSs - LIttoral, Environment and Societies, at University of La Rochelle
  EnhanceMicroAlgae partner
  Business/organisation type: research and development
  Expertise: Chemistry, environment, medical, nutraceuticals, pharmaceuticals. Research outputs involving microalgae include (but are not limited to):
  - *Alexandrium minutum* [41], *Alexandrium tamarense* [41], *Bigelowiella natans* [41], *Chaetoceros calcitrans* [41], *Chaetoceros calcitrans* f. *pumillum* [41], *Chaetoceros gracilis* [41], *Chaetoceros minus* [41], *Chaetoceros mulleri* [41], *Chaetoceros* sp. *Tenuissimus like* [41], *Chlorella autotrophica* [41], *Chlorella vulgaris* [41], *Chloroarachnion reptans* [41], *Closterium baillyanum* [41], *Cyanophora paradoxa* [41,42], *Cylindrotheca closterium* [43], *Dunaliella salina* [41,44], *Dunaliella* sp. [41], *Dunaliella tertiolecta* [41,45], *Emiliania huxleyi* [41], *Haematococcus pluvialis* [41], ,*Heterocapsa triquetra* [46], *Isochrysis galbana* [41], *Nitzschia* sp. [41], *Odontella aurita* [41], *Ostreococcus tauri* [41], ***Phaeodactylum tricornutum*** [41], *Porphyridium purpureum* (*Porphyridium cruentum*) [44,47,48], *Rhodella violacea* [41], *Rhodomonas salina* [41,49], *Scenedesmus acutus* [41], *Scenedesmus obliquus* [41], *Skeletonema grethae* [41],

Tetraselmis suecica [41], *Thalassiosira pseudonana* [41], *Tisochrysis lutea* [50], *Euglena proxima* [41]

The research team at LIENSs works in close collaboration with the Laboratory of phycotoxines (IFREMER) at Nantes, France.
In addition to the microalgae above, the team at LIENSs have experience with the model species Spirulina (*A. platensis*), from which they develop extraction process.
Locations: La Rochelle, France

- **Name:** PhytoBloom/Necton
  Business/organisation: producer, research and development
  Expertise: aquaculture, cosmetics, nutraceuticals, biotechnology. Their line of products include culture media for microalgae, and aquaculture food concentrates from [167]:
  - *Nannochloropsis*, *Tetraselmis*, *Isochrysis*, and ***Phaeodactylum***

  Location: Olhão and Algarve, Portugal

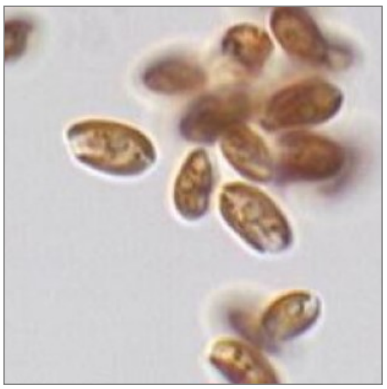
- **Name:** Sparos
  Business/organisation: producer, research and development
  Expertise: aquaculture, ecophysiology, genomics. Research outputs associated to the company include (but are not limited to):
  - ***Phaeodactylum tricornutum*** [191], *Tetraselmis* sp. [192], *Nannochloropsis oceanica* [193]

  Location: Olhão, Portugal

- **Name:** Xanthella Ltd.
  Business/organisation type: research and development
  Expertise: Design and test bespoke PBRs, consultancy, repair and recycling of old systems, active research and development. The company has worked on [51]:
  - *Chaetoceros muelleri*, *Chlamydomonas acidophila*, *Chlorella sorokiniana*, *Dunaliella primolecta*, *Desmodesmus subspicatus*, *Fragilaria* sp., *Isochrysis galbana*, *Limnoraphis robusta*, *Nannochloropsis* sp., ***Phaeodactylum tricornutum***, *Porphyridium cruentum*, *Synechocystis* sp., *T-isochrysis lutea*

  Location: European Marine Science Park, Argyl, Scotland

31. Rhodomonas sp.



A flagellate unicellular red alga belonging to the class Cryptophyceae with cell size between 9.2 and 9.9 µm. This marine microalga plays a significant role as live food in aquaculture due to its protein, EPA and DHA content [194]. Also a source of phycoerythrin.

Commonly cultivated species and strains include:
Rhodomonas sp. (strain Hf-1)
R. salina (strains CCAP 978/27, CCMP 1319, CS-174, CS-24)
R. lens (strain CMP 739)

31.1 Cultivation characteristics of *Rhodomonas* sp.

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
Hf-1 [194]	**System:** 200 mL Erlenmeyer flasks **Medium:** f/2 medium, salinity of 28 psu. **Temperature:** 20°C **Light:** 35 µmol/m^2/s, continuous light.	nd	nd	4.36±0.20 x 10^6 *cell/mL (temperature, 24°C)* 3.74±0.28 x 10^6 *cell/mL (salinity, 21 psu)* 3.60±0.49 x 10^6 *cell/mL (light intensity 80* µmol/m^2/s*)* 4.57±0.22 x 10^6 *cell/mL (light colour, White)*
nd [195] *from the Dutch aquaculture industry*	**System:** Flat-panel PBR **Medium:** ASW medium **Temperature:** (15–20–25–30°C) **Light:** 60–195–330–495–600 µmol/m^2/s, continuous light.	nd	1.4 *(25°C, 600 µmol/m^2/s)*	11.25 x 10^6 *cell/mL (25°C, 600 µmol/m^2/s)*

nd [196] *isolated from coastal waters in north-eastern Brazil (state of Paraíba).*	**System:** 500 mL Erlenmeyer flasks **Medium:** f/2 medium, salinity of 34 psu. **Temperature:** 21± 2°C **Light:** 50 µmol/m^2/s, 12h L: 12h D.	nd	nd	11.3 x 10^5 *cell/mL (N-sufficient medium)* 5.0 x 10^5 *cell/mL (N-starved medium)*

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

31.2 Biomass characteristics of *Rhodomonas* sp.

Biomass composition	Element composition	Pigment composition	Fatty acid profile
Protein: [196] ~ 30 µg/10^6cell *(N-sufficient medium)* ~ 25 µg/10^6cell *(N-starved medium)* Carbohydrates: ~ 25 µg/10^6cell *(N-sufficient medium)* ~ 150 µg/10^6cell *(N-starved medium)*	nd	Chlorophyll a: [196] ~ 1.3µg/10^6cell *(N-sufficient medium)* Chlorophyll c: ~ 1.1 µg/10^6cell *(N-sufficient medium)* Phycoerythrin: ~ 5.5 µg/10^6cell *(N-sufficient medium)*	Σ SFA 13-16% [195] Σ MUFA 3-7% Σ PUFA *(excl. EPA + DHA)* 47-56% Σ EPA + DHA 11-22%

31.3 Cultivation characteristics of *R. salina*

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
nd [197]	**System:** 200 mL Erlenmeyer flasks. Continuous culture (unknown dilution rate), seawater **Medium:** Conway medium **Temperature:** 20°C **Light:** cool white fluorescents, 1,500 lux, continuous light **Aeration:** mixture air: CO_2=98.5:1.5%	nd	nd	nd

CS-24 and CS-174 [198]	**System:** 1-L Erlenmeyer flasks. Batch mode **Medium:** Modified f/2 medium: 0.441 or 3.529 mM N, 0.018 or 0.144 mM P; salinity 33 psu **Temperature**: 19±1 °C and 29±1 °C **Light:** 100 or 200 µmol/m^2/s, continuous irradiance	nd	CS-24: 0.07 g dry weight/L *(3.529 mM N, 0.144 mM P; 200 µmol/m^2/s, 19 or 29 °C)* CS-174: 0.105 g dry weight/L *(3.529 mM N, 0.144 mM P; 200 µmol/m^2/s, 19 °C)*	CS-24: 3.2 x 10^6 cell/mL and 0.7 g dry weight/L *(3.529 mM N, 0.144 mM P; 200 µmol/m^2/s, 19 or 29 °C)* CS-174: 4.7 x 10^6 cell/mL and 1.05 g dry weight/L *(3.529 mM N, 0.144 mM P; 200 µmol/m^2/s, 19 °C)*

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

31.4 Biomass characteristics of *R. salina*

Biomass composition	Element composition	Pigment composition	Fatty acid profile
Total sterol content [197] 55.68 fg/cell Cholesterol 9.71% Brassicasterol 90.29% --- Protein [199]: CS-24 and CS-174 Max. ~ 55% d.w. *(3.529 mM N, 0.144 mM P)* Min. ~ 35% d.w. *(0.441 mM N, 0.018 mM P)* Lipids [199]: Max. CS-24 ~ 18% d.w. Max. CS-174 ~ 25% d.w. *(0.441 mM N, 0.144 mM P, 200 µmol/m^2/s, 19 °C)* Min. CS-24 ~ 5% d.w. Min. CS-174 ~ 6% d.w. *(0.441 mM N, 0.018 mM P, 200 µmol/m^2/s, 29 °C)*	nd	*nd*	Total fatty acids [197]: 11.34 pg/cell Σ SFA 37.11% Σ MUFA 15.61% Σ PUFA 46.77% EPA 4.78% DHA 3.58% --- **CS-24** [199]**:** Max. Σ SFA ~ 42% *(0.441 mM N & 0.144 mM P, 3.529 mM N & 0.144 mM P, 29 °C)* Max. Σ MUFA ~ 27% *(0.441 mM N & 0.144 mM P, 3.529 mM N & 0.018 mM P, 3.529 mM N & 0.144 mM P, 19 °C)* Max. Σ PUFA 55% *(0.441 mM N & 0.144 mM P, 200 µmol/m^2/s, 19 °C)* Max. EPA 10% *(0.441 mM N & 0.144 mM P, 200 µmol/m^2/s, 19 °C)* Max. DHA 6.4%

			(3.529 mM N & 0.018 mM P, 200 µmol/m²/s, 19 °C) **CS-174** [199]**:** Max. Σ SFA ~ 47% *(0.441 mM N & 0.144 mM P, 3.529 mM N & 0.144 mM P, 200 µmol/m²/s, 29 °C)* Max. Σ MUFA ~ 26% *(3.529 mM N & 0.144 mM P, 100 µmol/m²/s, 19 °C)* Max. Σ PUFA 55% *(0.441 mM N & 0.144 mM P, 200 µmol/m²/s, 19 °C)* Max. EPA 13.2% *(0.441 mM N & 0.144 mM P, 200 µmol/m²/s, 19 °C)* Max. DHA 6.5% *(0.441 mM N & 0.144 mM P, 200 µmol/m²/s, 19 °C)*

31.5 Cultivation characteristics of *R. lens*

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCMP 739 [131]	**System:** 80-mL, 30-mm diameter glass tubes. Semi-continuous culture (10%-20%-30%-40%-50% daily dilution rate) **Medium:** Algal-1 [200], salinity 35 psu **Temperature:** 21±1.5°C **Light:** cool white fluorescents, 242 µmol/m²/s, light:dark cycle of 12 h:12 h **Aeration:** mixture air:CO_2	nd	0.38 g d.w./L/d *(40 % dilution rate)*	Max: 22.16 × 106 cells/mL, *(10% dilution rate)* Min. 7.17 × 106 cells/mL *(50% dilution rate)*

CCMP 739 [201]	**System:** 4-L Erlenmeyer flasks or 10-L polycarbonate carboys. **Medium:** f/2 medium; salinity 34-35 psu **Temperature**: room temperature, 22-29 °C **Light:** natural sunlight	nd	nd	nd

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

31.6 Biomass characteristics of *R. lens*

Biomass composition	Element composition	Pigment composition	Fatty acid profile
Protein [131]: Max. 64 pg/cell, 45% of organic fraction *(40% dilution rate)* Min. 36 pg/cell, 64% of organic fraction *(10% dilution rate)* Lipids [131]: Max. ~ 42% of organic fraction *(10% dilution rate)* Min. ~ 20% of organic fraction *(30%-40% dilution rate)*	nd	Total chlorophylls [131]: 1.4-2.0 pg/cell *(50% and 40% dilution rate, respectively)* Phycoerythrin [131]: 3.4-8.5 pg/cell *(10% and 50% dilution rate, respectively)*	Σ SFA max. 54% [131] *(10% dilution rate)* Σ MUFA max. 8% *(10% dilution rate)* Σ PUFA max. 65% *(20%-40% dilution rate)* EPA max. 9% *(20% dilution rate)* DHA max. 4% *(20% dilution rate)* --- Σ SFA ~ 22.2% [202] Σ MUFA ~ 12.3% Σ PUFA ~ 65.5% EPA 11.9% DHA 7.4%

31.5 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *Rhodomonas* sp. AC162
  Location: Université de Caen Normandie, Caen, France

- **Name:** Culture Collection of Algae and Protozoa CCAP
  Business/organisation type: bio-bank
  Strain(s) available: *R. salina* CCAP 978/27, *R. maculata* CCAP 979/14, *R. atrorosea* CCAP 978/6A, 978/6B, *R. baltica* CCAP 979/9, *R. chrysoidea* CCAP 978/6
  Location: Scottish Marine institute, Scotland, UK

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *Rhodomonas* sp. (various), *R. salina* CCMP322, AC721, AC160
  Location: Roscoff, France

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *Rhodomonas* sp. BEA 0081B, 0223B, 0113, 0113B, 0116B, 0117B, 0121B, 0124, 0689B, 0125B,
  Location: Telde Gran Canaria, Spain

- **Name:** ANFACO-CECOPESCA
  EnhanceMicroAlgae project Lead Coordinator
  Business/organisation type: Marketing, research & development and innovation support in food and marine technology.
  Expertise: biotechnology, ecophysiology, marketing, valorisation and functionality of microalgal compounds. Microalgal expertise includes (not limited to) [39],[40]:
    - *Chaetoceros calcitrans*, *C. salsugineus*, *Conticribra weissflogii* (synonym of *Thalassiosira weissflogii*), *Isochrysis galbana, Nannochloropsis gaditana*, *Pavlova gyrans*, *Phaeodactylum tricornutum*, ***Rhodomonas lens***, *Tetraselmis chuii*, *Tisochyrysis lutea*

  ANFACO-CECOPESCA offers production of tailor-made microalgal biomass. Read more in the EnhanceMicroAlgae marketplace.
  Location: Vigo, Spain

- **Name:** Aqualgae
  Business/organisation: research and development
  Expertise: design and installation of high-productivity photobioreactors, suppliers of culturing media, inoculums, and lyophilised cultures of [20]:
    - *Chlorella*, *Haematococcus*, *Arthropsira*, *Tetraselmis*, *Isochrysis*, *Pavlova, Chaetoceros*, *Skeletonema*, *Nitzchia*, ***Rhodomonas***, *Nannochloropsis*

  Locations: Diana do Castelo, Portugal; and A Coruña, Spain

- **Name:** Buggypower

EnhanceMicroAlgae Associated partner

Business/organization type: producer, research & development, downstream processing

Expertise: feed, food, nutraceuticals, biotechnology. The company specialises in [101]:

- *Chlorella, Nannochloropsis,* ***Rhodomonas***

Location: Lisbon, Portugal (shared services centre & Alguimya store); Funchal, Portugal (Financial office); Porto Santo, Portugal (Buggypower production unit in partnership with Electricity Company of Madeira); San Pedro del Pinatar, Spain (Financial office); Lorqui, Spain (Research and development pilot plant)

- **Name:** Group of Biotechnology and Aquaculture, Universidad de Santiago de Compostela

Business/organization type: research & development, higher education

Expertise: biotechnology, aquaculture. Research outputs involving microalgae include (but are not limited to):

- [*Dunaliella salina*, *Dunaliella tertiolecta]* [122], *Haematococcus pluvialis* [126], [*Tetraselmis suecica, Tetraselmis* sp.] [127], ***Rhodomonas lens*** [131]

Location: Santiago de Compostela, A Coruña, Spain

- **Name:** LIENSs - LIttoral, Environment and Societies, at University of La Rochelle

EnhanceMicroAlgae partner

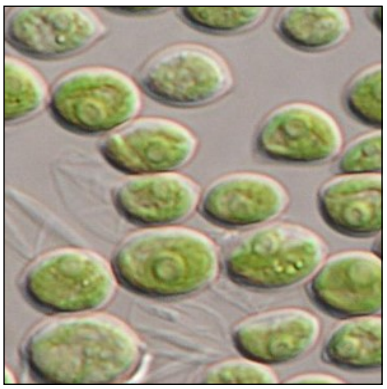
Business/organisation type: research and development

Expertise: Chemistry, environment, medical, nutraceuticals, pharmaceuticals. Research outputs involving microalgae include (but are not limited to):

- *Alexandrium minutum* [41], *Alexandrium tamarense* [41], *Bigelowiella natans* [41], *Chaetoceros calcitrans* [41], *Chaetoceros calcitrans* f. *pumillum* [41], *Chaetoceros gracilis* [41], *Chaetoceros minus* [41], *Chaetoceros mulleri* [41], *Chaetoceros* sp. *Tenuissimus like* [41], *Chlorella autotrophica* [41], *Chlorella vulgaris* [41], *Chloroarachnion reptans* [41], *Closterium baillyanum* [41], *Cyanophora paradoxa* [41,42], *Cylindrotheca closterium* [43], *Dunaliella salina* [41,44], *Dunaliella* sp. [41], *Dunaliella tertiolecta* [41,45], *Emiliania huxleyi* [41], *Haematococcus pluvialis* [41], ,*Heterocapsa triquetra* [46], *Isochrysis galbana* [41], *Nitzschia* sp. [41], *Odontella aurita* [41], *Ostreococcus tauri* [41], *Phaeodactylum tricornutum* [41], *Porphyridium purpureum* (*Porphyridium cruentum*) [44,47,48], *Rhodella violacea* [41], ***Rhodomonas salina*** [41,49], *Scenedesmus acutus* [41], *Scenedesmus obliquus* [41], *Skeletonema grethae* [41], *Tetraselmis suecica* [41], *Thalassiosira pseudonana* [41], *Tisochrysis lutea* [50], *Euglena proxima* [41]

The research team at LIENSs works in close collaboration with the Laboratory of phycotoxines (IFREMER) at Nantes, France.
In addition to the microalgae above, the team at LIENSs have experience with the model species Spirulina (*A. platensis*), from which they develop extraction process.
Locations: La Rochelle, France

32. Scenedesmus obliquus



A freshwater green unicellular microalga belonging to the class Chlorophyceae. Its cells can be grouped to form colonies and they are non-motile. It is one of the most widely used lipid-producing microalgae [203].

Commonly cultivated strains include:
FACHB 416, SJTU-3

32.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
nd [204] *from laboratory of live food culture, Institute of Tropical Aquaculture, University Malaysia Terengganu, Malaysia.*	**System:** 1 L Erlenmeyer flasks in outdoor natural conditions **Medium:** BBM **Temperature:** 17-34°C **Light:** nd Environmental light/dark cycle	nd	nd	1.50×10^7 *(cell/mL)*
nd [204] *from laboratory of live food culture, Institute of Tropical Aquaculture, University Malaysia Terengganu, Malaysia.*	**System:** 1 L Erlenmeyer flasks, laboratory control conditions **Medium:** BBM **Temperature:** 25°C **Light:** 2000 µmol/m^2/s, Continuous light	nd	nd	2.80×10^7 *(cell/mL)*
FACHB 416 [205]	**System:** 250 mL conical flasks. **Medium:** BG-11 medium + *0, 25, 50, 100, 200, 500 mg/L*	nd	nd	1.60×10^7 *(cell/mL) (at LAS concentrations <100 mg/L)*

	linear alkylbenzene sulfonate (LAS) **Temperature:** 25°C **Light:** 50 µmol/m^2/s, 12h L: 12h D			

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

32.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
Outdoor natural conditions [204] 30.7±0.01% protein ~20±0.0% lipid ~20±0.0% carbohydrates *Control conditions* [204] 37.7±0.02% protein ~37±0.0% lipid 38.2±0.02% carbohydrates --- 26.9 ± 3.8% protein [206] 12.7 ± 1.3% lipid 11.9 ± 1.1% carbohydrate --- *25 mg/L LAS treatment* [205] 24.0% lipid	nd	nd	C15:0 3.3% [205] C16:0 22.6% C18:0 1.8% C18:1 8.6% C18:2 3.5% C18:3 47.7% C20:5 10.4% C22:0 2.1%

32.3 Stakeholders in the Atlantic Area

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *Scenedesmus* sp. BEA 0146/1, 0146/2, 0579B, 0380, 0146B, 0580B, 0381, 0838B, 0333, 0562, 0334, 0354, 0565
  Location: Telde Gran Canaria, Spain

- **Name:** Algal Research Group, Swansea University
  EnhanceMicroAlgae partner
  Business/organisation type: Higher education, research & development.
  Expertise: Microalgae biotechnology, biomass characterization, upstream and downstream process, chemistry, ecophysiology, engineering, large-scale development, molecular biology. Research expertise with microalgae includes (but is not limited to):

- ***Scenedesmus obliquus*** *and Chlorella vulgaris* [58]*, Arthrospira maxima* [59]*, Nannochloropsis spp.* [60]*, Micractinum inermum* [61]*, Porphyridium purpureum* [62,63]*, Nosctoc sp., Isochrysis galbana* and over 25 common microalgae species including green algae, diatoms, cyanobacteria and dinoflagellates.

Location: Swansea, UK

- **Name:** AlgoSource

Business/organisation type: producer, research and development, downstream processing
Expertise: engineering, large-scale development, industrial ecology. Know-how on *Spirulina* and its principal ingredient phycocyanin. The company is also working on extracting molecules of interest from other microalgae [100]:

- *Spirulina, Chlorella,* ***Scenedesmus****, Tetraselmis, Isochrysis*

Locations: Saint-Nazaire, France

- **Name:** Andalusian Center of Science and Marine Technology (CACYTMAR) | Instituto Universitario de Investigacion Marina (INMAR) at University of Cádiz, Spain

Business/organisation: Higher education, research & development
Expertise: biotechnology, ecophysiology, genomics, molecular biology, waste water treatment. Research outputs involving microalgae include (but are not limited to):

- *Botryococcus braunii* [33]*, Phaeodactylum tricornutum* [34]*,* [*Chlorella vulgaris*, *Chlorella kessleri*, *Chlorella sorokiniana*, ***Scenedesmus obliquus***] [35]

Location: Cádiz, Spain

- **Name:** LIENSs - LIttoral, Environment and Societies, at University of La Rochelle

EnhanceMicroAlgae partner

Business/organisation type: research and development
Expertise: Chemistry, environment, medical, nutraceuticals, pharmaceuticals. Research outputs involving microalgae include (but are not limited to):

- *Alexandrium minutum* [41]*, Alexandrium tamarense* [41]*, Bigelowiella natans* [41]*, Chaetoceros calcitrans* [41]*, Chaetoceros calcitrans* f. *pumillum* [41]*, Chaetoceros gracilis* [41]*, Chaetoceros minus* [41]*, Chaetoceros mulleri* [41]*, Chaetoceros* sp. *Tenuissimus like* [41]*, Chlorella autotrophica* [41]*, Chlorella vulgaris* [41]*, Chloroarachnion reptans* [41]*, Closterium baillyanum* [41]*, Cyanophora paradoxa* [41,42]*, Cylindrotheca closterium* [43]*, Dunaliella salina* [41,44]*, Dunaliella* sp. [41]*, Dunaliella tertiolecta* [41,45]*, Emiliania huxleyi* [41]*, Haematococcus pluvialis* [41]*, ,Heterocapsa triquetra* [46]*, Isochrysis galbana* [41]*, Nitzschia* sp. [41]*, Odontella aurita* [41]*, Ostreococcus tauri* [41]*, Phaeodactylum tricornutum* [41]*, Porphyridium purpureum* (*Porphyridium cruentum*) [44,47,48]*, Rhodella violacea* [41]*, Rhodomonas salina* [41,49]*, Scenedesmus acutus* [41]*,* ***Scenedesmus obliquus*** [41]*, Skeletonema grethae* [41]*, Tetraselmis suecica* [41]*, Thalassiosira pseudonana* [41]*, Tisochrysis lutea* [50]*, Euglena proxima* [41]

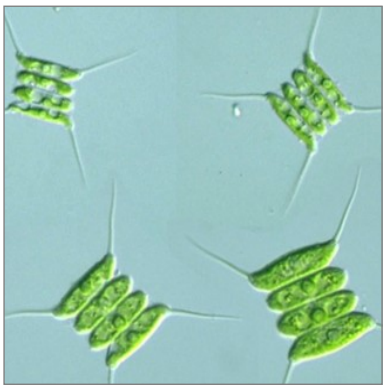
The research team at LIENSs works in close collaboration with the Laboratory of phycotoxines (IFREMER) at Nantes, France.

In addition to the microalgae above, the team at LIENSs have experience with the model species Spirulina (*A. platensis*), from which they develop extraction process.
Locations: La Rochelle, France

- **Name:** uFraction8

  Business/organisation type: start-up, research and development, downstream processing
  Expertise: technology, harvesting. The start-up company is developing technologies suitable for biomass filtration, separation, and de-watering. The start-up has tested their innovative solution with ***Scenedesmus***, although their innovative solution can be used for a wide range of microorganisms.
  Locations: Falkirk, Scotland

33. Scenedesmus quadricauda



A freshwater green unicellular microalga belonging to the class Chlorophyceae. It can grow in wide range of industrial waste waters with reasonably good adaptation ability [207] and it is considered a versatile biofuel feedstock [208].

Commonly cultivated strains include:
ABU12

33.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
ABU12 [209]	**System:** 200 mL Erlenmeyer flasks **Medium:** BBM **Temperature:** 23±2°C **Light:** 150 µmol/m^2/s, continuous light	nd	nd	~0.75
nd [207]	**System:** 7 L tank. **Medium:** Wastewater *(from Shek Wu Hui Sewage Treatment Works)* **Temperature:** 28°C **Light:** 7000 lux, 12h L: 12h D	nd	nd	0.995 *(acclimated culture)* 0.940 *(non-acclimated culture)*
nd [210] *from reservoirs in the region of Fez (northern Morocco)*	**System:** Erlenmeyer flasks **Medium:** synthetic medium **Temperature:** 20-25°C **Light:** 300 µmol/m^2/s, 16h L: 8h D	nd	~0.99	nd

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

33.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
Acclimated culture [207] ~20.0% lipid *Non-acclimated cultures* ~18.0% lipid --- 4.38 – 9.55% protein [210] 6.91 – 10.60% lipid 3.67 – 24.76% carbohydrates	nd	*Acclimated culture* [207] ~5.5mg/L chloropyll-a *Non-acclimated culture* ~5.3mg/L chloropyll-a	*Acclimated culture* [207] C14:0 0.7% C16:0 50.4% C16:1 1.6% C18:0 3.1% C18:1n9 3.0% C18:2n6 24.3% C18:3n3 14.6% C18:3n6 2.3% *Non-acclimated culture* C14:0 0.9% C16:0 55.6% C16:1 2.4% C18:0 1.5% C18:1n9 3.3% C18:2n6 19.9% C18:3n3 14.4% C18:3n6 2.1%

33.3 Stakeholders in the Atlantic Area

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *S. quadricauda* CCAP 276/16, 276/21
  Location: Scottish Marine Institute, United Kingdom

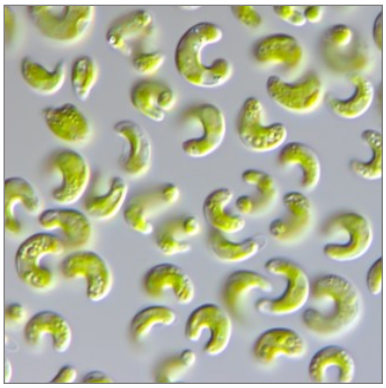
- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *Scenedesmus* sp. BEA 0146/1, 0146/2, 0579B, 0380, 0146B, 0580B, 0381, 0838B, 0333, 0562, 0334, 0354, 0565
  Location: Telde Gran Canaria, Spain

- **Name:** AlgoSource
  Business/organisation type: producer, research and development, downstream processing
  Expertise: engineering, large-scale development, industrial ecology. Know-how on *Spirulina* and its principal ingredient phycocyanin. The company is also working on extracting molecules of interest from other microalgae [100]:

- *Spirulina, Chlorella, **Scenedesmus**, Tetraselmis, Isochrysis*

Locations: Saint-Nazaire, France

34. *Selenastrum capricornutum*



A unicellular freshwater green microalga belonging to the class of Chlorophyceae. It presents fast growth and a moderate sensitivity to toxic compounds. *S. capricornutum* has been described as a new promising microalga for biodiesel production due to its fatty acid composition [211].

Commonly cultivated strains include:
UTEX 1648.

34.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
nd [u] *from the laboratory of the Regional Environmental Protection Agency, Perugia Italy (ARPA)*	**System:** 12 L cylindrical photobioreactor **Medium:** four nutrient solutions and deionized water **Temperature:** 22 ± 1ºC **Light:** 140 µmol/m^2/s, continuous light	nd	nd	2.4
UTEX 1648 [212]	**System:** 75 L, 40 cm high plastic round containers **Medium:** f/2 medium **Temperature:** 23-40°C **Light:** nd	nd	37.6 g/m^2/d	nd

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

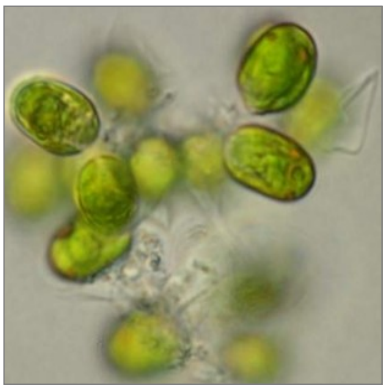
34.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
17.5% lipids [211] --- 32.3-38.4% protein [212] 11.8 ± 34.6% lipid 33-49.8% carbohydrate	nd	nd	C14:0 0.17% [211] C16:0 19.57% C16:1 0.32% C18:0 1.26% C18:1 54.82% C18:2 4.30% C18:3 6.10% C20:1 0.55% C20:3 1.19%

34.3 Stakeholders in the Atlantic Area

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *S. capricornutum* CCAP 278/5
  Location: Scottish Marine Institute, United Kingdom

35. *Tetraselmis subcordiformis*



A marine unicellular green microalga with a cell size of 10–20 µm that is a widely used feed in aquaculture for its high nutrient levels. It has been proven to accumulate starch autotrophically or mixotrophically [213,214].

Commonly cultivated strains include:
FACHB-1751

35.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
FACHB-1751 [215]	**System:** 600 mL glass air bubble column PBR *(500 mL working volume)* **Medium:** ASW *(P deprivation and P repletion)* **Temperature:** 25°C **Light:** 200 µmol/m^2/s, continuous light	nd	0.68±0.13 *(P-deprivation recultivated in P-replete medium)*	5.3±0.4 *(P-deprivation recultivated in P-replete medium)*
nd [216] *from the Culture Collection of Microalgae at Shanghai Ocean University in China*	**System:** 60 L PBR **Medium:** f/2 medium **Temperature:** 15, 20, 25, 30 °C **Light:** 100 µmol/m^2/s, continuous light	nd	nd	~0.10 d^{-1} *(at 20°C)*

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

35.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
46.9±1.9% starch [215] *(P-deprivation recultivated in P-replete medium)* --- 22.25% lipid [216] *(at 20°C)* --- 18.0 ± 0.3% protein [206] 10.7 ± 0.8% lipid 47.4 ± 1.4% carbohydrate	nd	nd	C16:0 14.93–18.49% [216] C16:3n3 6.77–12.30% C18:3n3 15.99–23.65% C20:0 9.04– 10.09%

35.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *Tetraselmis* sp. AC255, AC260, AC264, AC802
  Location: Université de Caen Normandie, Caen, France

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *T. subcordiformis* CCAP 161/1A, 161/1B, 161/3
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available:, *Tetraselmis* sp. (various)
  Location: Roscoff, France

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *Tetraselmis* sp. BEA 0647B, 0076B, 0648B, 0098/1, 1321B, 0098/2, 1323B, 0098B, 0754B, 0758B, 0646B
  Location: Telde Gran Canaria, Spain

- **Name:** A4F – Algae 4 Future

  EnhanceMicroAlgae partner

  Business/organisation type: bio-bank, producer, research and development, downstream processing

  Expertise: biotechnology, engineering, large-scale development. Their microalgae track-production (large and pilot scale) includes [17]:

  - *Arthrospira platensis*, *Chlamydomonas* sp., *Chlorella vulgaris*, *Dunaliella salina*, *Haematococcus pluvialis*, *Lobosphaera incisa*, *Nannochloropsis oceanica*, *Phaeodactylum tricornutum*, *Prorocentrum cassubicum*, *Raphidonema* sp., *Scenedesmus* sp., *Scotiellopsis* sp., *Synechococcus* sp., *Synechocystis* sp., ***Tetraselmis* sp.**, *Thalassiosira weissflogii*, *Tisochrysis lutea*

  Locations: Lisbon, Portugal

- **Name:** Algalimento

  EnhanceMicroAlgae Associated partner

  Business/organisation type: producer, research and development, downstream processing

  Expertise: biotechnology, engineering, large-scale development. Algalimento currently produces all-year round high-quality biomass of [125]:

  - ***Tetraselmis sp.***, *Spirulina canariensis, Dunaliella salina*

  Locations: Lisbon, Portugal

- **Name:** AlgoSource

  Business/organisation type: producer, research and development, downstream processing

  Expertise: engineering, large-scale development, industrial ecology. Know-how on *Spirulina* and its principal ingredient phycocyanin. The company is also working on extracting molecules of interest from other microalgae [100]:

  - *Spirulina, Chlorella, Scenedesmus,* ***Tetraselmis****, Isochrysis*

  Locations: Saint-Nazaire, France

- **Name:** Aqualgae

  Business/organisation: research and development

  Expertise: design and installation of high-productivity photobioreactors, suppliers of culturing media, inoculums, and lyophilised cultures of [20]:

  - *Chlorella*, *Haematococcus*, *Arthropsira*, ***Tetraselmis***, *Isochrysis*, *Pavlova, Chaetoceros*, *Skeletonema*, *Nitzchia*, *Rhodomonas*, *Nannochloropsis*

  Locations: Diana do Castelo, Portugal; and A Coruña, Spain

- **Name:** Group of Biotechnology and Aquaculture, Universidad de Santiago de Compostela

  Business/organization type: research & development, higher education

Expertise: biotechnology, aquaculture. Research outputs involving microalgae include (but are not limited to):

- [*Dunaliella salina*, *Dunaliella tertiolecta*] [122], *Haematococcus pluvialis* [126], [***Tetraselmis suecica, Tetraselmis* sp.**] [127] *Rhodomonas lens* [131]

Location: Santiago de Compostela, A Coruña, Spain

- **Name:** PhytoBloom/Necton

Business/organisation: producer, research and development
Expertise: aquaculture, cosmetics, nutraceuticals, biotechnology. Their line of products include culture media for microalgae, and aquaculture food concentrates from [167]:

- *Nannochloropsis*, ***Tetraselmis***, *Isochrysis*, and *Phaeodactylum*

Location: Olhão and Algarve, Portugal

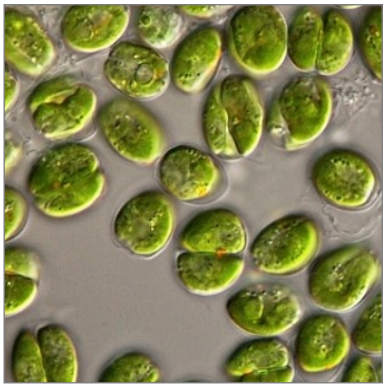
- **Name:** Sparos

Business/organisation: producer, research and development
Expertise: aquaculture, ecophysiology, genomics. Reseaarch outputs associated to the company include (but are not limited to):

- *Phaeodactylum tricornutum* [191], ***Tetraselmis* sp.** [192], *Nannochloropsis oceanica* [193]

Location: Olhão, Portugal

36. *Tetraselmis suecica*



A marine unicellular green microalga. It is a motile chlorophyte that can be used as a feedstock in aquaculture due to its high lipid content. *T. suecica* can be also used to treat wastewater [217].

Commonly cultivated strains include:
CS187

36.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CS187 [217]	**System:** 2 L Erlenmeyer flasks **Medium:** seawater and anaerobically-digested piggery effluent (ADPE) **Temperature:** 25 ± 1ºC **Light:** 175 µmol/m^2/s, 12h L: 12h D cycle	nd	59.8 mg/L/d	nd
nd [218] *from NLP Corp. (Busan, Korea)*	**System:** 20-L circular cylindrical tank **Medium:** f/2 medium **Temperature:** 20 ± 1ºC **Light:** 36.3, 60.5, 84.7, 108.9, 133.1 µmol/m^2/s, continuous light	nd	nd	0.89 *(at 108.9 µmol/m2/s)* *1.1* *(at 18.5 mg/L Nitrogen)*

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

36.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
~30mg/L/d lipid [217] ~7mg/L/d carbohydrate --- 17.28% protein [218]	nd	1.5% chlorophyll [217] content	C16:0 ~55.0% [218] C18:0 ~1.0% C18:1 ~20.0% C18:2(6) ~2.0% C18:3 ~0.8%

36.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *T. suecica* AC254, *Tetraselmis* sp. AC255, AC260, AC264, AC802
  Location: Université de Caen Normandie, Caen, France

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *T. suecica* CCAP 66/22A, 66/22B, 66/22C, 66/22D, 66/38, 66/4
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *T. suecica* TS-Droze, *Tetraselmis* sp. (various)
  Location: Roscoff, France

- **Name:** Spanish Algae Bank
  Business/organisation type: bio-bank
  Strain(s) available: *Tetraselmis* sp. BEA 0647B, 0076B, 0648B, 0098/1, 1321B, 0098/2, 1323B, 0098B, 0754B, 0758B, 0646B
  Location: Telde Gran Canaria, Spain

- **Name:** Algalimento
  EnhanceMicroAlgae Associated partner
  Business/organisation type: producer, research and development, downstream processing
  Expertise: biotechnology, engineering, large-scale development. Algalimento currently produces all-year round high-quality biomass of [125]:

- ***Tetraselmis sp.***, *Spirulina canariensis, Dunaliella salina*

Locations: Lisbon, Portugal

- **Name:** AlgoSource

Business/organisation type: producer, research and development, downstream processing
Expertise: engineering, large-scale development, industrial ecology. Know-how on *Spirulina* and its principal ingredient phycocyanin. The company is also working on extracting molecules of interest from other microalgae [100]:

- *Spirulina, Chlorella, Scenedesmus,* ***Tetraselmis****, Isochrysis*

Locations: Saint-Nazaire, France

- **Name:** Group of Biotechnology and Aquaculture, Universidad de Santiago de Compostela

Business/organization type: research & development, higher education
Expertise: biotechnology, aquaculture. Research outputs involving microalgae include (but are not limited to):

- [*Dunaliella salina*, *Dunaliella tertiolecta]* [122], *Haematococcus pluvialis* [126], [***Tetraselmis suecica****, Tetraselmis* sp.] [127] *Rhodomonas lens* [131]

Location: Santiago de Compostela, A Coruña, Spain

- **Name:** LIENSs - LIttoral, Environment and Societies, at University of La Rochelle

EnhanceMicroAlgae partner
Business/organisation type: research and development
Expertise: Chemistry, environment, medical, nutraceuticals, pharmaceuticals. Research outputs involving microalgae include (but are not limited to):

- *Alexandrium minutum* [41], *Alexandrium tamarense* [41], *Bigelowiella natans* [41], *Chaetoceros calcitrans* [41], *Chaetoceros calcitrans* f. *pumillum* [41], *Chaetoceros gracilis* [41], *Chaetoceros minus* [41], *Chaetoceros mulleri* [41], *Chaetoceros* sp. *Tenuissimus like* [41], *Chlorella autotrophica* [41], *Chlorella vulgaris* [41], *Chloroarachnion reptans* [41], *Closterium baillyanum* [41], *Cyanophora paradoxa* [41,42], *Cylindrotheca closterium* [43], *Dunaliella salina* [41,44], *Dunaliella* sp. [41], *Dunaliella tertiolecta* [41,45], *Emiliania huxleyi* [41], *Haematococcus pluvialis* [41], ,*Heterocapsa triquetra* [46], *Isochrysis galbana* [41], *Nitzschia* sp. [41], *Odontella aurita* [41], *Ostreococcus tauri* [41], *Phaeodactylum tricornutum* [41], *Porphyridium purpureum* (*Porphyridium cruentum*) [44,47,48], *Rhodella violacea* [41], *Rhodomonas salina* [41,49], *Scenedesmus acutus* [41], *Scenedesmus obliquus* [41], *Skeletonema grethae* [41], ***Tetraselmis suecica*** [41], *Thalassiosira pseudonana* [41], *Tisochrysis lutea* [50], *Euglena proxima* [41]

The research team at LIENSs works in close collaboration with the Laboratory of phycotoxines (IFREMER) at Nantes, France.
In addition to the microalgae above, the team at LIENSs have experience with the model species Spirulina (*A. platensis*), from which they develop extraction process.
Locations: La Rochelle, France

- **Name:** PhytoBloom/Necton

  Business/organisation: producer, research and development

  Expertise: aquaculture, cosmetics, nutraceuticals, biotechnology. Their line of products include culture media for microalgae, and aquaculture food concentrates from [167]:

  - *Nannochloropsis*, ***Tetraselmis***, *Isochrysis*, and *Phaeodactylum*

  Location: Olhão and Algarve, Portugal

37. Tisochrysis lutea

A marine flagellate microalga extensively used as a feed stock in aquaculture and commonly known as T-iso. It is genetically distinct from *Isochrysis galbana*, despite seemingly being morphologically identical [219]. *T. lutea* has been recognized as one of the most suitable species for DHA production due to its fast growth and high DHA content (12–14%) [220]. It is also obtaining increased interest for fucoxanthin production [220].

Commonly cultivated strains include:
CCMP1324.

37.1 Cultivation characteristics

Strain	Cultivation Conditions	Mean biomass productivity [a]	Maximum productivity [a]	Maximum production [a]
CCMP1324 [220]	**System:** 500-mL Erlenmeyer fask *(in experimental setup 1);* 1-L bioreactor *(in experimental setup 2)* **Medium:** f/2-Si medium **Carbon source:** glucose, glycerol, and sodium acetate (*in experimental setup 1*) **Temperature:** 23°C **Light:** 3000 lux, 14h L: 10h D cycle	nd	0.02 *(growing mixotrophically with glycerol as source of carbon)*	1.4 *(growing mixotrophically)*
nd [221] *obtained from NECTON, S.A. (Olhão, Portugal)*	**System:** flat panel photobioreactors **Medium:** commercial culture medium stock NutriBloom Plus **Temperature:** 16.5, 20, 25, and 30 °C. **Light:** 50, 150, 300, and 500 µmol/m^2/s, 18h L: 6h D cycle	nd	0.35 *(at 300 µmol/m^2/s)* 0.42 *(at 30 °C)*	1.91 *(at 300 µmol/m^2/s)* 1.81 *(at 30 °C)*

[a] Unless otherwise specified, productivity is given in g/L/d and production in g/L

37.2 Biomass characteristics

Biomass composition	Element composition	Pigment composition	Fatty acid profile
36.7% protein [222] 22.0% lipid 9.4% carbohydrate *(phototrophy)* 41.7% protein 19.3% lipid 7.5% carbohydrate *(mixotrophy)*	C/N ratio 92.5 [220]	16.39 mg/g [221] fucoxanthin *(50 µmol/m²/s, dilution rate 0.47 d⁻¹,30 °C)* --- 7.8 mg/g chlorophyll-a [222] 4.8 mg/g carotenoids *(phototrophy)* 18.9 mg/g chlorophyll-a [222] 4.8 mg/g carotenoids *(mixotrophy)*	C13:0 0.64–0.80% [220] C14:0 14.13–17.75% C15:0 0.22–0.39% C16:0 10.17–13.44% C16:1 4.78–11.24% C17:0 0.80–0.92% C18:0 0.30–0.97% C18:1 12.54–13.36% C18:2 9.10–12.28% C18:3 4.86–10.39% C18:4 12.88–14.5% C20:0 0.24–3.07% C22:6 9.37– 13.77%

37.3 Stakeholders in the Atlantic Area

- **Name:** Algobank-Caen
  Business/organisation type: bio-bank
  Strain(s) available: *T. lutea* AC102, AC620
  Location: Université de Caen Normandie, Caen, France

- **Name:** CCAP Culture Collection of Algae and Protozoa
  Business/organisation type: bio-bank
  Strain(s) available: *T. lutea* CCAP 927/14, 927/19,
  Location: Scottish Marine Institute, United Kingdom

- **Name:** Roscoff Culture Collection
  Business/organisation type: bio-bank
  Strain(s) available: *T. lutea* Poulet, Caen, T-iso, AC620, AC102, CCMP463, PLY506A, PLY506B, PLY506C, PLY562
  Location: Roscoff, France

- **Name:** Laboratoire Phycotoxines IFREMER
  Business/organisation: research and development, environmental monitoring

Expertise: chemistry, ecophysiology, molecular biology. Research outputs involving microalgae include (but are not limited to):

- ***Tisochhrysis lutea*** [162], *Microcystis aeuriginosa* [163]

The research team at IFREMER works in close collaboration with the EnhanceMicroAlgae team at LIENSs, University of La Rochelle, France.
Location: Nantes, France

- **Name:** LIENSs - LIttoral, Environment and Societies, at University of La Rochelle
  EnhanceMicroAlgae partner
  Business/organisation type: research and development
  Expertise: Chemistry, environment, medical, nutraceuticals, pharmaceuticals. Research outputs involving microalgae include (but are not limited to):
  - *Alexandrium minutum* [41], *Alexandrium tamarense* [41], *Bigelowiella natans* [41], *Chaetoceros calcitrans* [41], *Chaetoceros calcitrans* f. *pumillum* [41], *Chaetoceros gracilis* [41], *Chaetoceros minus* [41], *Chaetoceros mulleri* [41], *Chaetoceros* sp. *Tenuissimus like* [41], *Chlorella autotrophica* [41], *Chlorella vulgaris* [41], *Chloroarachnion reptans* [41], *Closterium baillyanum* [41], *Cyanophora paradoxa* [41,42], *Cylindrotheca closterium* [43], *Dunaliella salina* [41,44], *Dunaliella* sp. [41], *Dunaliella tertiolecta* [41,45], *Emiliania huxleyi* [41], *Haematococcus pluvialis* [41], ,*Heterocapsa triquetra* [46], *Isochrysis galbana* [41], *Nitzschia* sp. [41], *Odontella aurita* [41], *Ostreococcus tauri* [41], *Phaeodactylum tricornutum* [41], *Porphyridium purpureum* (*Porphyridium cruentum*) [44,47,48], *Rhodella violacea* [41], *Rhodomonas salina* [41,49], *Scenedesmus acutus* [41], *Scenedesmus obliquus* [41], *Skeletonema grethae* [41], *Tetraselmis suecica* [41], *Thalassiosira pseudonana* [41], ***Tisochrysis lutea*** [50], *Euglena proxima* [41]

  The research team at LIENSs works in close collaboration with the Laboratory of phycotoxines (IFREMER) at Nantes, France.
  In addition to the microalgae above, the team at LIENSs have experience with the model species Spirulina (*A. platensis*), from which they develop extraction process.
  Locations: La Rochelle, France

- **Name:** Xanthella Ltd.
  Business/organisation type: research and development
  Expertise: Design and test bespoke PBRs, consultancy, repair and recycling of old systems, active research and development. The company has worked on [51]:
  - *Chaetoceros muelleri*, *Chlamydomonas acidophila*, *Chlorella sorokiniana*, *Dunaliella primolecta*, *Desmodesmus subspicatus*, *Fragilaria* sp., *Isochrysis galbana*, *Limnoraphis robusta*, *Nannochloropsis* sp., *Phaeodactylum tricornutum*, *Porphyridium cruentum*, *Synechocystis* sp., ***T-isochrysis lutea***

  Location: European Marine Science Park, Argyl, Scotland

Appendix 1. Media recipes

A compilation of the microalgae media recipes shown in this strain catalogue is presented in this appendix. The reader should be aware that recipes shown here follow the standard protocol where culturing medium is prepared by mixing specific quantities of stock solutions so as to reach the desired components' medium concentrations.

Unless otherwise specified, all media is prepared by carrying out the following protocol:

1. Prepare all necessary *stock solutions** by dissolving each component in 1 L of distilled H_2O (dH2O);
2. Add/mix the corresponding quantity of stock solutions into dH2O;
3. Bring final volume to 1 L;
4. Adjust pH if required; and
5. Autoclave (sterilize at 15 psi for 15 min).

* Preparation of *stock solutions* is very useful during media preparation as it reduces weighing errors, particularly for those components that are necessary in very small quantities (micronutrients). Whilst we have aimed to provide preparation instructions for stock solutions within all the media recipes presented here, the reader should be aware that stock solution's recipes can be modified accordingly so long as the final medium concentration of each component is met.

It is also important to note that microalgae media recipes have been subject to modifications (e.g. replacing one component for another, increasing or decreasing component concentrations, etc.) to fit the desired cultivation needs, such as optimisation of biomass or metabolite concentration, maximise nutrient uptake, etc. We would therefore encourage the reader to browse the open literature, where different variations of the recipes shown here, as well as many others, have been widely explored.

Useful sources for algal media recipes

- CCAP media recipes [223]
- Algal Culturing Techniques, by Rober A. Andersen, Elsevier Academic Press (2005) [224]

A.1. Artificial Seawater (ASW) medium

ASW components and concentrations[223]

Component	Stock solution *g per 1000 mL H_2O*	Quantity for 1L medium
Extra salts		3.75 mL
$NaNO_3$	30	
Na_2HPO_4	1.2	
K_2HPO_4	1	
Vitamin solution		2.5 mL
Biotin	0.0002	
Calcium pantothenate	0.02	
Cyanocabalamin	0.004	
Folic acid	0.0004	
Inositol	1.0	
Nicotinic acid	0.02	
Thiamine HCl	0.1	
Thymine	0.6	
Soil extract (SE1)	See below	25 mL
Tricine		0.5 g

Soil extract (SE1)
Soil should be air-dried. Dried soil is autoclaved together with a volume of distilled water equivalent to double the volume of soil. Once autoclaved, the supernatant is decanted, filtered (Whatman No 1 paper), and placed in appropriate vessels until used for media preparation. Soil selection is an important consideration for ASW media. Readers are referred to the recipe provided by CCAP [223].

A.2. Blue-Green medium (BG11)

Mix stock solutions and bring to 1 L; adjust pH to 7.1 (with NaOH or HCl).

BG11 medium components and concentrations[223]

Component	Stock solution *g per 500 mL dH_2O*	Quantity for 1L medium
$NaNO_3$	75	10 mL
K_2HPO_4	2	10 mL
$MgSO_4 \cdot 7H_2O$	3.75	10 mL
$CaCl_2 \cdot 2\ H_2O$	1.80	10 mL
Citric acid	0.3	10 mL
Ammonium ferric citrate green	0.3	10 mL
$EDTA \cdot Na_2$	0.05	10 mL
Na_2CO_3	1	10 mL
Trace metals solution	*See recipe below*	1 mL

Trace metals solution (also known as A5 + Co Trace metals solution) [223]

Component	Quantity per 1L dH_2O
H_3BO_3	2.860 g
$MnCl_2 \cdot 4H_2O$	1.810 g
$ZnSO_4 \cdot 7H_2O$	0.220 g
$CuSO_2 \cdot 5H_2O$	0.08 g
$Na_2MoO_2 \cdot 2H_2O$	0.39 g
$Co(NO_3)_2 \cdot 6H_2O$	0.05 g

A.3. Bold's Basal Medium (BBM) and 3N-BBM

The recipe for BBM is presented below. 3N-BBM is identical to BBM medium but requiring 3 times the nitrogen (i.e. 3N) used in BBM.

BBM medium components and concentration[223]

Component	**Stock solution** ***g per 400 mL dH_2O***	**Quantity for 1L medium**
Macronutrients		
$NaNO_3$	10	10 mL
$MgSO_4 \cdot 7H_2O$	3	10 mL
NaCl	1	10 mL
K_2HPO_4	3	10 mL
KH_2PO_4	7	10 mL
$CaCl_2 \cdot 2H_2O$	1	10 mL
BBM trace elements solution	See recipe below	1 mL
Boric acid solution	See recipe below	1 mL
Alkaline EDTA solution	See recipe below	1 mL
Acidified Iron solution	See recipe below	1 mL

BBM trace elements solution[223]

Component	**Quantity per 1L dH_2O**
$ZnSO_4 \cdot 7H_2O$	8.82 g
$MnCl_2 \cdot 4H_2O$	1.44 g
MoO_3	0.71 g
$CuSO_4 \cdot 5H_2O$	1.57 g
$Co(NO_3)_2 \cdot 6H_2O$	0.49 g

BBM additional solutions[223]

Component	Quantity per 1L dH_2O
Boric acid solution	
H_3BO_3	11.42 g
Alkaline EDTA solution	
EDTA	50 g
KOH	31 g
Acidified Iron solution	
$FeSO_4 \cdot 7H_2O$	4.98 g
H_2SO_4	1 mL

A.4. Chu 13 medium (Modified)

Chu 13 medium components and concentrations [225]

Component	Quantity for 1L medium
KNO_3	400 mg
K_2HPO_4	80 mg
$MgSO_4 \cdot 7H_2O$	200 mg
$CaCl_2 \cdot 2H_2O$	107 mg
Fe citrate	20 mg
Citric acid	100 mg
Micronutrients	
$CoCl_2$	0.02 mg
H_3BO_3	5.72 mg
$MnCl_2 \cdot 4H_2O$	3.62 mg
$ZnSO_4 \cdot 7H_2O$	0.44 mg
$CuSO_4 \cdot 5H_2O$	0.16 mg
Na_2MoO_4	0.084 mg
H_2SO_4 0.072 N	1 drop

A.5. Conway medium

Conway medium components and concentrations [226]

Component	Quantity for 1L medium
KNO_3	100 mg
Na_3HPO_4	20 mg
Trace metals	
$Na_2H_2EDTA{\cdot}2H_2O$	45 mg
$FeCl_3{\cdot}6H_2O$	1.3 mg
$ZnCl_2$	4.2 mg
$MnCl_2{\cdot}4H_2O$	0.36 mg
$CoCl_2{\cdot}6H_2O$	4 mg
$CuSO_4{\cdot}5H_2O$	4 mg
$(NH_4)_6Mo_7O_{24}{\cdot}4H_2O$	1.8 mg
H_3BO_3	33.4 mg
Vitamins	
Thiamin HCl	0.2 mg
Cyanocobalamin	0.01 mg

A.6. Detmer medium (DM) modified

Detmer medium components and concentrations [227]

Component	Quantity for 1 L medium
$Ca(NO_3)_2 \cdot 4H_2O$	1 g
KH_2PO_4	0.26 g
$MgSO_4 \cdot 7H_2O$	0.55 g
KCl	0.25 g
$FeSO_4 \cdot 7H_2O$	0.02 g
EDTA·2Na	0.2 g
Trace elements	
H_3BO_3	0.0029 g
$ZnCl_2$	0.00011 g
$MnCl_2 \cdot 4H_2O$	0.00181 g
$(NH_4)_6MoO_{24} \cdot 4H_2O$	0.000018 g
$CuSO_4 \cdot 5H_2O$	0.00008 g

A.7. f/2 medium

This is a seawater medium, prepared by bringing up the final volume to 1 L with filtered natural seawater. Adjust pH to 8 with 1 M NaOH or HCl.

f/2 medium components and concentrations [223]

Component	Stock solution *qty per 1 L dH_2O*	Quantity for 1L medium
$NaNO_3$	75 g	1 mL
$NaH_2PO_4 \cdot H_2O$	5.65 g	1 mL
Trace metals solution	*See recipe below*	1 mL
Vitamins solution	*See recipe below*	1 mL

f/2 trace metals solution [223]

Component	Quantity per 1L *dH_2O*
Na_2EDTA	4.16 g
$FeCl_3 \cdot 6H_2O$	3.15 g
$CuSO_4 \cdot 5H_2O$	0.01 g
$ZnSO_4 \cdot 7H_2O$	0.022 g
$CoCl_2 \cdot 6H_2O$	0.01 g
$MnCl_2 \cdot 4H_2O$	0.18 g
$Na_2MoO_4 \cdot 2H_2O$	0.006 g

Vitamins solution [103] (filter-sterilise and store frozen).

Component	Quantity per 1L dH_2O
Cyanocobalamin (Vitamin B_{12})	0.0005 g
Thiamine HCl (Vitamin B_1)	0.1 g
Biotin	0.0005 g

A.8. f/2+Si (Guillard's medium for diatoms)

This is a seawater medium, prepared by bringing up the final volume to 1 L with filtered natural seawater. Adjust pH to 8 with 1 M NaOH or HCl.

f/2 + Si medium components and concentrations [223]

Component	Stock solution g per 1 L dH_2O	Quantity for 1L medium
$NaNO_3$	75	1 mL
$NaH_2PO_4 \cdot H_2O$	5.65	1 mL
Trace metals solution	*See recipe below*	1 mL
Vitamins solution	*See recipe below*	1 mL
Sodium metasilicate solution		1 mL
$Na_2SiO_3 \cdot 9H_2O$	30 g	

F/2 + Si trace metals solution [223]

Component	Quantity per 1L dH_2O
Na_2EDTA	4.16 g
$FeCl_3 \cdot 6H_2O$	3.15 g
$CuSO_4 \cdot 5H_2O$	0.01 g
$ZnSO_4 \cdot 7H_2O$	0.022 g
$CoCl_2 \cdot 6H_2O$	0.01 g
$MnCl_2 \cdot 4H_2O$	0.18 g
$Na_2MoO_4 \cdot 2H_2O$	0.006 g

Vitamins solution [223] (filter-sterilise and store frozen).

Component	Quantity per 1L dH_2O
Cyanocobalamin (Vitamin B_{12})	0.0005 g
Thiamine HCl (Vitamin B_1)	0.1 g
Biotin	0.0005 g

A.9. Jaworski's Medium (JM)

JM medium components and concentrations [223]

Component	**Stock solution** ***g per 200 mL dH₂O***	**Quantity for 1L medium**
$Ca(NO_3)_2 \cdot 4H_2O$	4 g	1 mL
KH_2PO_4	2.48 g	1 mL
$MgSO_4 \cdot 7H2O$	10 g	1 mL
$NaHCO_3$	3.18 g	1 mL
EDTA solution		1 mL
EDTA·Fe·Na	0.45 g	
EDTA· Na2	0.45 g	
Trace elements solution		1 mL
H_3BO_3	0.496 g	
$MnCl_2 \cdot 4H_2O$	0.278 g	
$(NH_4)_6Mo_7O_{24} \cdot 4H_2O$	0.2 g	
Vitamins solution	*See recipe below*	1 mL
NaNO3	16 g	1 mL
$Na_2HPO_4 \cdot 12H_2O$	7.2 g	1 mL

Vitamins solution [223] (filter-sterilise and store frozen).

Component	**Quantity per 200 mL dH_2O**
Cyanocobalamin (Vitamin B_{12})	0.0008 g
Thiamine HCl (Vitamin B_1)	0.0008 g
Biotin	0.0008 g

A.10. Kuhl medium

Kuhl medium components and concentrations [88]

Component	Quantity for 1 L medium
KNO_3	1 g
$NaH_2PO_4 \cdot H_2O$	0.621 g
$Na_2HPO_4 \cdot 2H_2O$	89 mg
$MgSO_4 \cdot 7H_2O$	246.5 mg
EDTA	9.3 mg
H_3BO_3	0.061 mg
$CaCl_2 \cdot 2H_2O$	14.7 mg
$FeSO_4 \cdot 7H_2O$	6.95 mg
$ZnSO_4 \cdot 7H_2O$	0.287 mg
$(NH_4)_6Mo_7O_{24} \cdot 4H_2O$	0.01235 mg
$MnSO_4 \cdot H_2O$	0.169 mg
$CuSO_4 \cdot 5H_2O$	0.00249 mg

A.11. SOT medium

Bring final volume to 1 L and adjust pH to 9.

SOT medium components and concentrations [228]

Component	Stock solution *g per 1L dH_2O*	Quantity for 1L medium
$NaHCO_3$		16.8 g
K_2HPO_4		0.5 g
$NaNO_3$		2.5 g
K_2SO_4		1 g
NaCl		1 g
$MgSO_4 \cdot 7H_2O$		0.2 g
$CaCl_2 \cdot 2H_2O$		0.04 g
$FeSO_4 \cdot 7H_2O$		0.01 g
EDTA		0.08 g
Trace metal Mix A5		1 mL
H_3BO_3	2.86	
$MnCl_2 \cdot 4H_2O$	1.81	
$ZnSO_4 \cdot 7H_2O$	0.222	
$NaMoO_4 \cdot 2H_2O$	0.39	
$CuSO_4 \cdot 5H_2O$	0.079	
$Co(NO_3)_2 \cdot 6H_2O$	49.4 mg	
Trace metal Mix B6 (modified)		1 mL
NH_4NO_3	0.23	
$K_2Cr(SO_4)_4 \cdot 24H_2O$	96 mg	
$NiSO_4 \cdot 7H_2O$	47.8 mg	
$Na_2WO_4 \cdot 2H_2O$	17.9 mg	
$Ti_2(SO_4)_3$	40 mg	

A.12. Sueoka medium

Sueoka medium components and concentrations [87]

Component	Stock solution *g per 1L dH_2O*	Quantity for 1L medium
KH_2PO_4		0.72 g
K_2HPO_4		1.44
$MgSO_4 \cdot 7H_2O$		0.02
$CaCl_2 \cdot 2H_2O$		0.01
NH_4Cl		0.5
Trace elements		1 mL
EDTA	10	
H_3BO_3	2.28	
$ZnSO_4 \cdot 7H_2O$	4.4	
$MnCl_2 \cdot 4H_2O$	1.02	
$FeSO_4 \cdot 7H_2O$	1	
$CoCl_2 \cdot 6H_2O$	0.32	
$CuSO_4 \cdot 5H_2O$	0.32	
$Mo_7O_{24}(NH_4)_6 \cdot 4H_2O$	0.22	

A.13. Walne's medium

Walne's medium components and concentrations [149]

Component	**Stock solution** ***g per 1 L dH₂O***	**Quantity used for 1 L medium**
$NaNO_3$	100	1 mL
EDTA (Disodium salt)	45	
H_3BO_3	33.6	
$NaH_2PO_4 \cdot 4H_2O$	20	
$FeCl_3 \cdot 6H_2O$	1.3	
$MnCl_2 \cdot 4H_2O$	0.36	
Trace metals solution	*g per 100 mL*	1 mL
$ZnCl_2$	2.1	
$CoCl_3 \cdot 6H_2O$	2	
$(NH4)_26MO_7O_{24} \cdot 4H_2O$	0.9	
$CuSO_4 \cdot 5H_2O$	2	
Vitamin solution		1 mL
Thiamine	10	
Cyanocobalamin	10	
Biotin	0.2	

A.14. Zarrouk medium

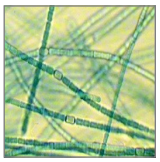
Zarrouk medium components and concentrations [16,229]

Component	Stock solution g per 1L dH_2O	Quantity used for medium
$NaNO_3$		2.5 g
K_2HPO_4		0.5 g
K_2SO_4		1 g
NaCl		1 g
$MgSO_4 \cdot 7H_2O$		0.2 g
$CaCl_2 \cdot 2H_2O$		0.04 g
$FeSO_4 \cdot 7H_2O$		0.01 g
EDTA		0.08 g
$NaHCO_3$		16.8 g
Micronutrient solution		1 mL
H_3BO_3	2.86	
$MnCl_2 \cdot 4H_2O$	1.81	
$ZnSO_4 \cdot 4H_2O$	0.222	
Na_2MoO_4	0.0177	
$CuSO_4 \cdot 5H_2O$	0.079	

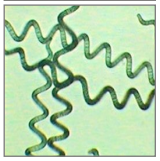
Appendix 2. Culture collections

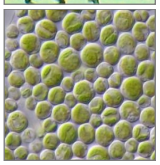
Acronym	Name	Link
AC	**Algobank-Caen** Université de Caen Normandie *France*	Click here
BEA	**Spaniard Algae Bank (Banco Español de Algas)** *Spain*	Click here
CCAP	**Culture Collection of Algae and Protozoa** at Scottish Association for Marine Science *UK*	Click here
CPCC	**Canadian Phycological Culture Centre** Canada *Formerly known as the University of Toronto Culture Collection (UTCC) of Algae and Cyanobacteria*	Click here
CSMA	**Culture Collection of the Centro di Studio dei Microrganismi Autotrofi** *Italy*	n/a
IBVF	**Biological Culture Service of the Institute of Plant Biochemistry and Photosynthesis** *Spain*	Click here
LEGE-CC	**Blue Biotechnology and Ecotoxicology Culture Collection** at CIIMAR *Portugal*	Click here
NCMA *Formerly CCMP*	**National Center for Marine Algae and Microbiota** at Bigelow Laboratory *USA* *Formerly known as the Culture Collection of Marine Phytoplankton (CCMP)*	Click here
NIES	**National Institute for Environmental Studies** *Japan*	Click here
PCC	**Pasteur Culture Collection of Cyanobacteria** *France*	Click here
RCC	**Roscoff Culture Collection** *France*	Click here
SAG	**Sammlung von Algenkulturen der Universität Göttingen /** Culture Collection of Algae at Göttingen University *Germany*	Click here
SCCAP	**Scandinavian Culture Collection of Algae & Protozoa** at The University of Copenhagen *Denmark*	Click here
UTEX	**Culture Collection of Algae at The University of Texas at Austin** *USA*	Click here

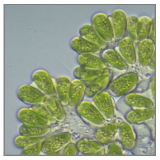
Appendix 3. List of images


1. Anabaena cylindrica [230]


2. Ankistrodesmus falcatus [232]

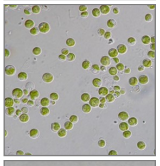

3. Arhtrospira platensis [234]

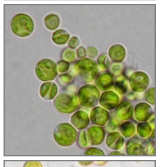

4. Auxenochlorella protothecoides [236]

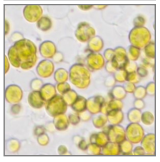

5. Botryococcus braunii [154]

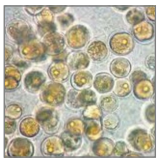

6. Chaetoceros calcitrans [239]

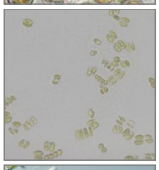

7. Chlamydomonas reinhardtii [241]


8. Chlorella sorokiniana [243]


9. Chlorella vulgaris [245]

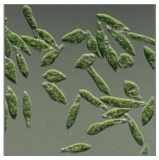

10. Chlorella zofingiensis [247]

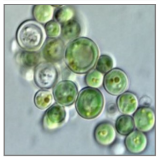

11. Crypthhecodinium cohnii [231]

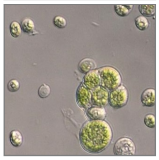

12. Desmodesmus subspicatus [233]

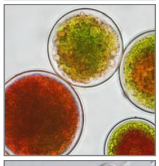

13. Dunaliella salina [235]

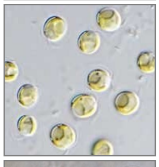

14. Dunaliella tertiolecta [237]

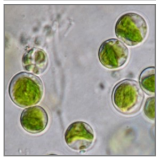

15. Euglena gracilis [238]

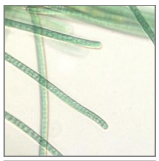

16. Galdieria sulphuraria [240]


17. Graesiella sp. [242]

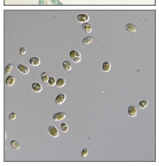

18. Haematococcus pluvialis [244]


19. Isochrysis galbana [246]

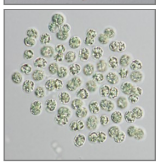

20. Jaagichlorella luteoviridis [248]



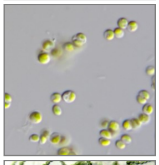
21. Lyngbya lutea [249]



22. Microchloropsis salina [251]

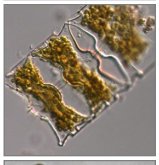


23. Microcystis aeruginosa [253]

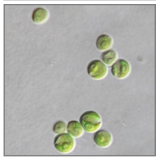


24. Nannochloropsis oculata [255]

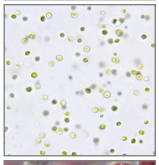
25. Nostoc sp. [257]



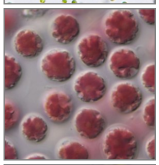
26. Odontella aurita [259]



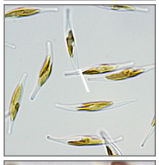
27. Parachlorella kessleri [261]



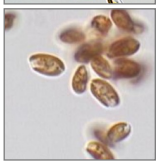
28. Picochlorum sp.



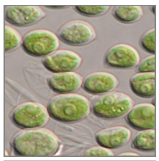
29. Porphyridium purpureum [262]



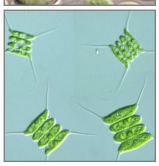
30. Phaeodactylum tricornutum [263]



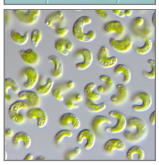
31. Rhodomonas sp. [264]



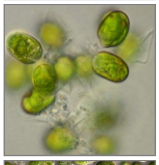
32. Scenedesmus obliquus [250]



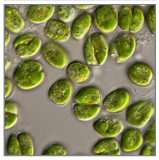
33. Scenedesmus quadricauda [252]



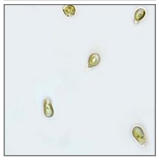
34. Selenastrum capricornutum [254]



35. Tetraselmis subcordiformis [256]



36. Tetraselmis suecica [258]



37. Tisochrysis lutea [260]

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[1] J.C. Weissman, J.R. Benemann, Hydrogen production by nitrogen-starved cultures of Anabaena cylindrica, Appl. Environ. Microbiol. 33 (1977) 123–131. https://www.ncbi.nlm.nih.gov/pubmed/402109.

[2] Unpublished data, (n.d.).

[3] A. Wijanarko, K. Ohtaguchi, Carbon Dioxide Removal and Biomass Production by Anabaena cylindrica IAM Ml using Reactor in Series, Stud. Surf. Sci. Catal. 153 (2004) 461–468. doi:10.1016/S0167-2991(04)80296-9.

[4] L. Lama, B. Nicolaus, V. Calandrelli, M.C. Manca, I. Romano, A. Gambacorta, Effect of growth conditions on endo- and exopolymer biosynthesis in Anabaena cylindrica 10 C, Phytochemistry. 42 (1996) 655–659. doi:10.1016/0031-9422(95)00985-X.

[5] R. García-Cubero, J. Moreno-Fernández, M. García-González, Modelling growth and CO2 fixation by Scenedesmus vacuolatus in continuous culture, Algal Res. 24 (2017) 333–339. doi:10.1016/j.algal.2017.04.018.

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