

# Production of high value microalgae for aquaculture



Provide chemical solutions for tomorrow's problems

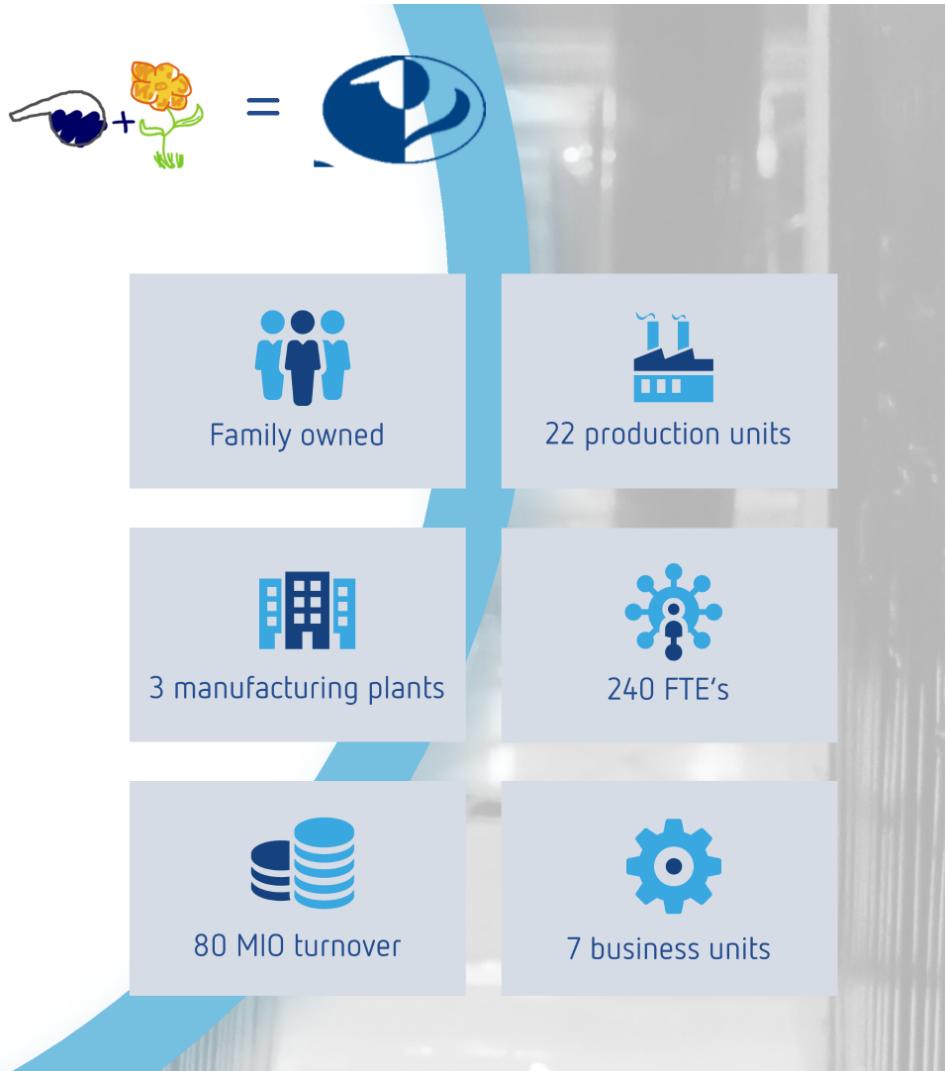


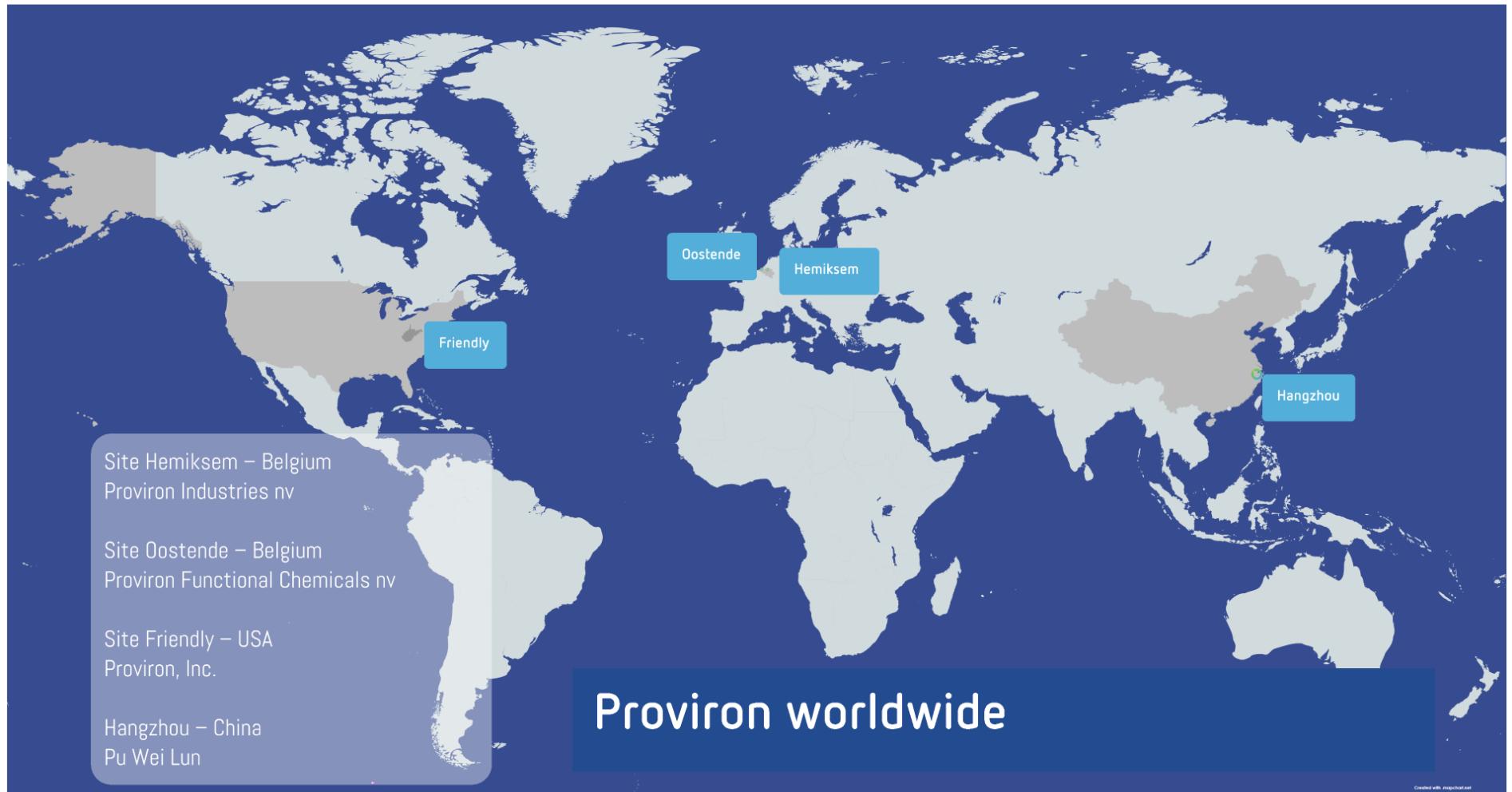
What's in a name?

Proviron  
worldwide

History of  
Proviron

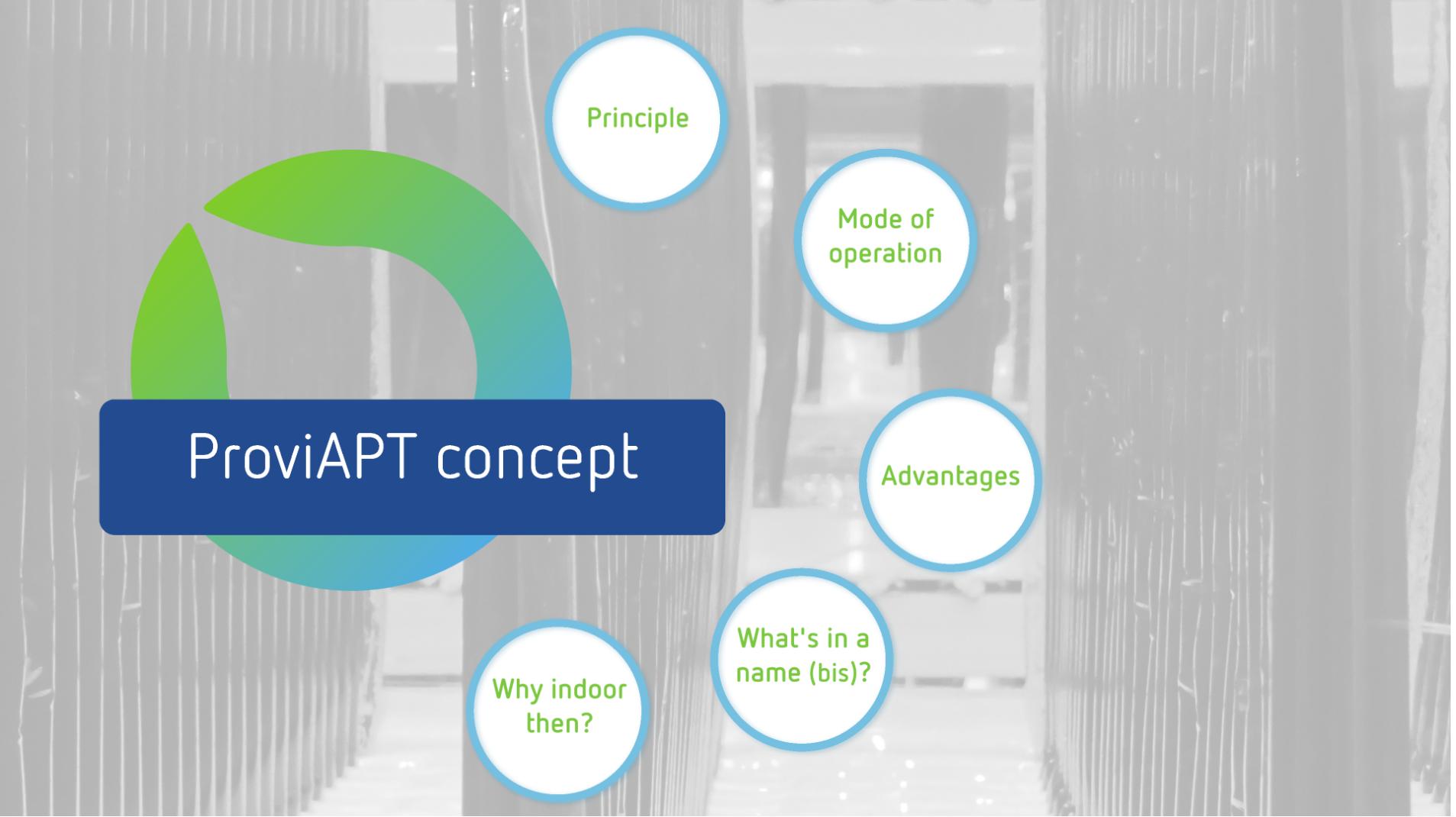
# Process and Environment





# From a traditional chemical producer to a developer of renewables based solutions

- 1977  
Proviron Engineering (Hemiksem)
- 1983  
Proviron Industries (Hemiksem)
- 1996  
Proviron Fine Chemicals (Oostende)  
Proviron Inc. (Friendly, WV, USA)
- 2000  
Sulphur Silane derivatives (Oostende)
- 2006  
Biodiesel unit (Oostende)
- 2009  
Innovations – Microalgae (Hemiksem)
- 2011  
Pu Wei Lun (Hangzhou, China)
- 2014  
ADF in Provifrost portfolio (Oostende)  
Animal Health (H)
- 2016  
70 M €, 230 employees  
Divestment Proviron Basic Chemicals (Oostende)



## ProViAPT concept

Principle

Mode of  
operation

Advantages

Why indoor  
then?

What's in a  
name (bis)?

# Principle

Originally conceived as an outdoor **closed photobioreactor system** consisting of

- **Self-supporting** water filled 'bag'
- (Active) **temperature control**
- Multiple flat panels **integrated**
- **Thin plates, reduced height**
- 100% (**recyclable**) **feed grade** plastic film material
- **Fully automated** reactor production



# Mode of operation

## Closed photobioreactor system

- Filtered air + reduced air intake by recirculation
- Filtered nutrients
- No pathogen reservoirs in vicinity of production plant
- Computer steered - minimal hands-on work



## GMP certified (Feed Chain Alliance (FCA))

- Feed/food grade nutrients
- Traceability
- No antibiotics, no pesticides, no heavy metals
- FCA certificate BE01/1522.GF



## Real time monitoring

- Flows, CO<sub>2</sub> usage
- Productivity
- Photosynthetic efficiency
- Follow up culture health



# What's in a name?

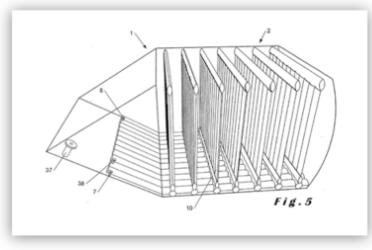
ProviAPT - Proviron Advanced Photobioreactor Technology

Merriam-Webster

**apt** *adjective*

🔊 /æpt/

1 · unusually fitted or qualified



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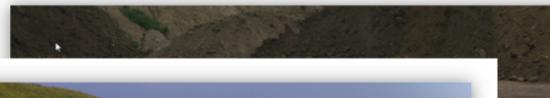
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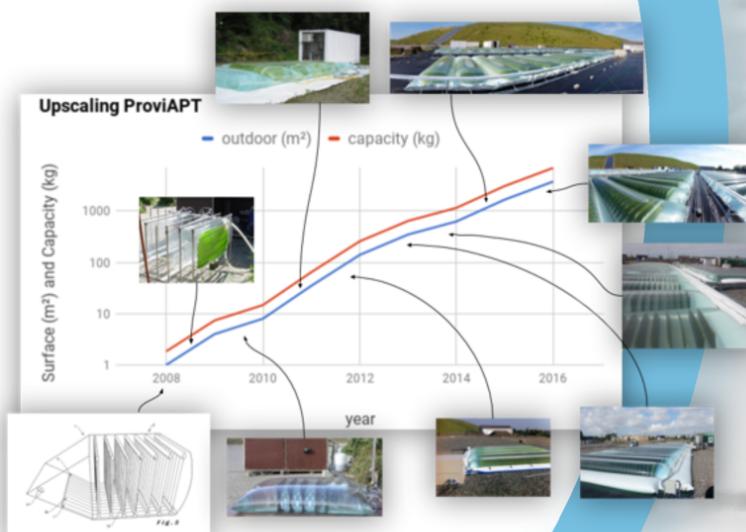
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ProviAPT *synonym*

1 · Proviron Algae Party Tent



# Why indoor?

- Reliable **year round supply** of microalgae with **high and invariable quality**
- **Species specific parametrisation** of growth conditions (nutrients, light quality/quantity/regimes, temperature, ...) in function of increased biomass yield, enhanced compound content, ...
- **Even better control** of contamination
- Vertical farming: **high areal productivities**





Research

MAgICAL

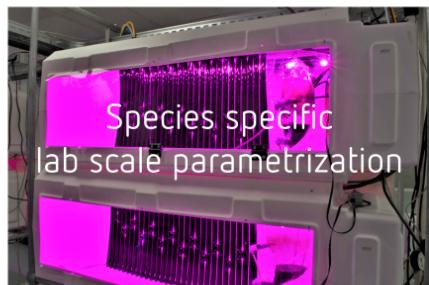
DigitAlgaesation

BlueMarine<sub>3</sub>.com

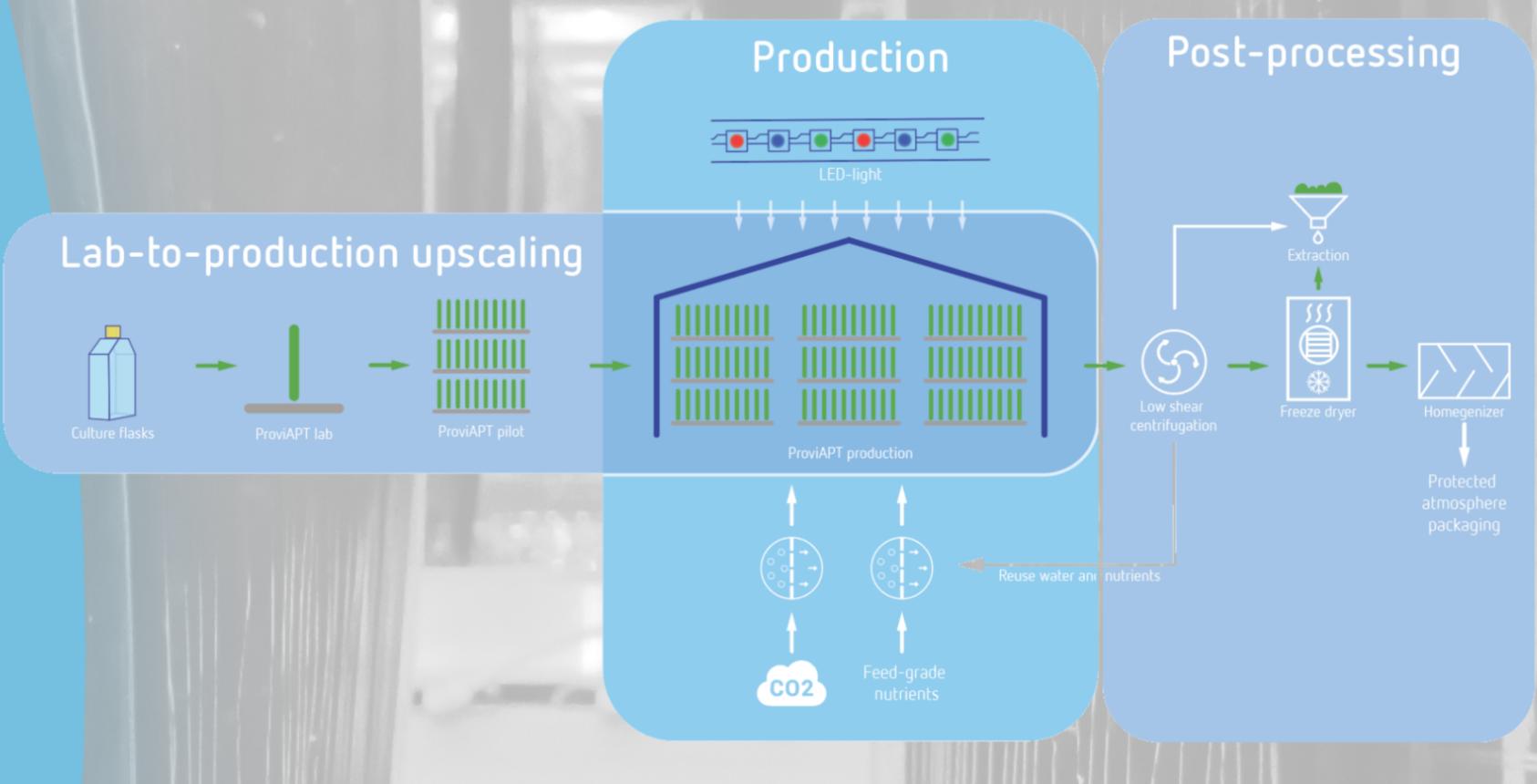
# MAgICAL

Microalgae with high value in Aquaculture cultivation using a highly efficient Indoor photobioreactor Cultivation process Assisted by LED

Development of indoor algae cultivation system and workflow for:



# ProviAPT workflow



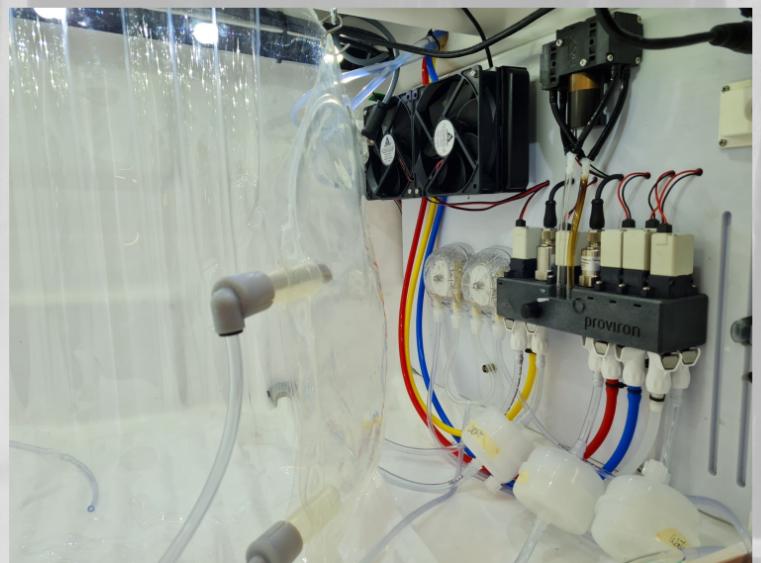
# ProviAPT Lab

- Volume: 6.4 Liters (1 panel)
- Batch or semi-continuous operation
- Sterile operation (0.2 µm air/media filtration)
- Automated operation and nutrient addition
- Recipe building from up to 20 components
- White, red, blue and far red LED lights up to 1000 µmol/m<sup>2</sup>/s
- Real time control and monitoring of CO<sub>2</sub> levels, temperature, light conditions, air pressure, flows, growth, light efficiency, RGB culture color, ...



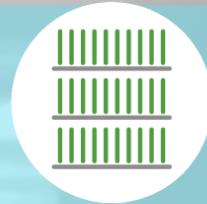
Algae species screening  
Optimization of light conditions (growth, composition, periodicity)  
Nutrient screening

High predictive value!



## ProviAPT Pilot

- Volume: 210 Liters (35 panels)
- Batch or semi-continuous operation
- Sterile operation (0.2 µm air/media filtration)
- Automated operation and nutrient addition
- Recipe building from up to 20 components
- Real time control and monitoring of CO<sub>2</sub> levels, temperature, light conditions, air pressure, flows, growth, yield on light, ...



Proof of concept  
Operational parameters



## ProviAPT Production

- 1 battery of 6 units or 3360 m<sup>2</sup> reactor surface
- Batch or semi-continuous operation
- Sterile operation (0.2 µm air/media filtration)
- Automated operation and nutrient addition
- Recipe building from up to 20 components
- Real time control and monitoring of CO<sub>2</sub> levels, temperature, light conditions, air pressure, flows, growth yield on light, ...

Highly productive: up to 1.5 g/L/day

Typical cell densities: 2 - 3 g/L



# Post-processing

- Low shear centrifugation
- Desludging centrifugation
- Freeze drying
- Packaging (protected atmosphere)



## Implementation of AI approaches to microalgae production

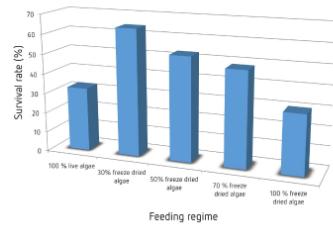
- historical data real time measurements available
- data mining from lab setups completed
- data mining tools for pilot and indoor underway
- new sensors being installed (improved turbidity measurements, spectral data, microscopic analysis(?) ...)
- develop predictive algorithms to steer production process



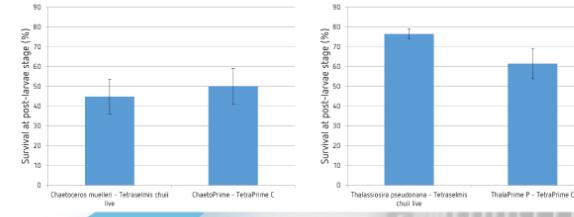
## Development of a multispecies hatchery for shrimp and bivalve larvae, and seaweeds

- Automatisation of hatchery processes (eg. development of automated dosing unit for liquid feed)
- Optimization of algae growth conditions for optimal nutritional content and functionality
- Optimization of post-processing of microalgae (centrifugation versus filtration, drying, ...)
- Development of microalgae diets under different presentation forms (live versus paste versus freeze dried)

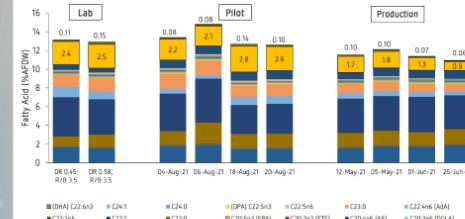
Pacific oyster - Survival at setting



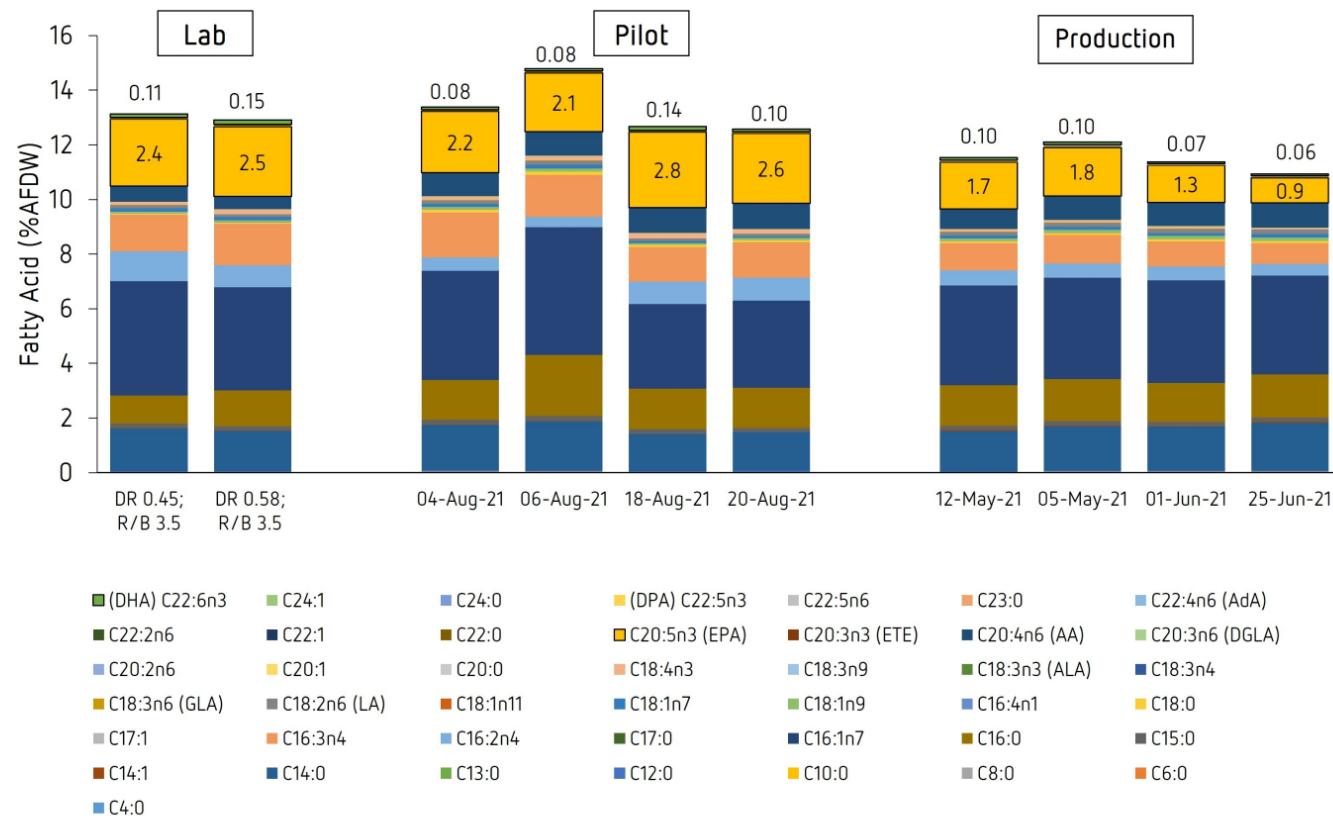
Shrimp larval growth – live versus FD algae

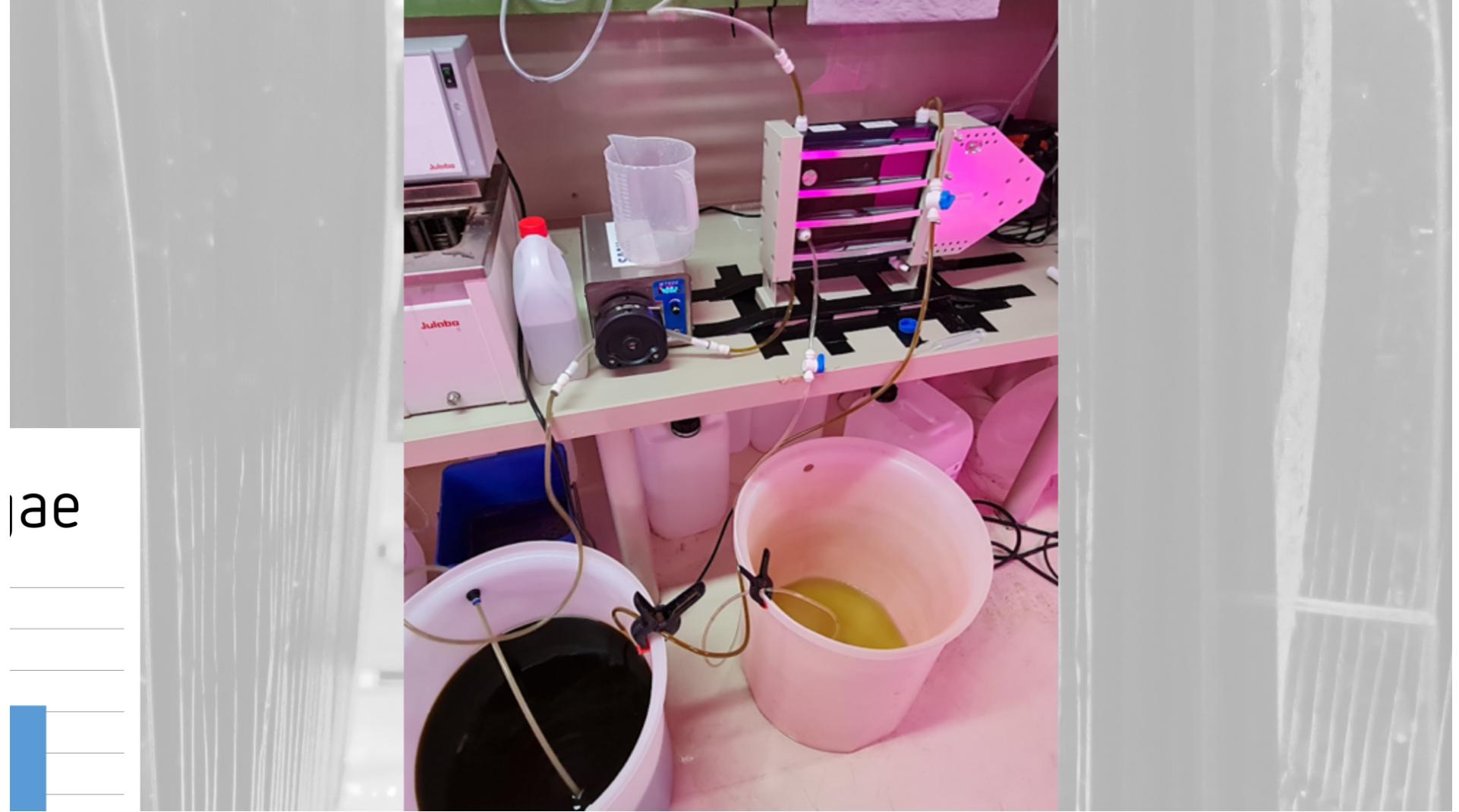


*Chaetoceros muelleri*: FA content lab vs pilot vs production



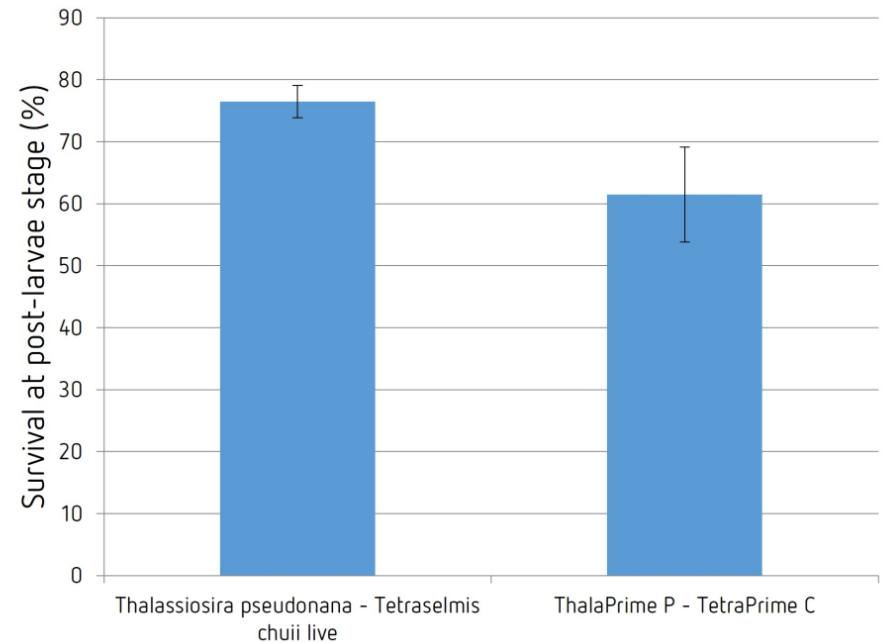
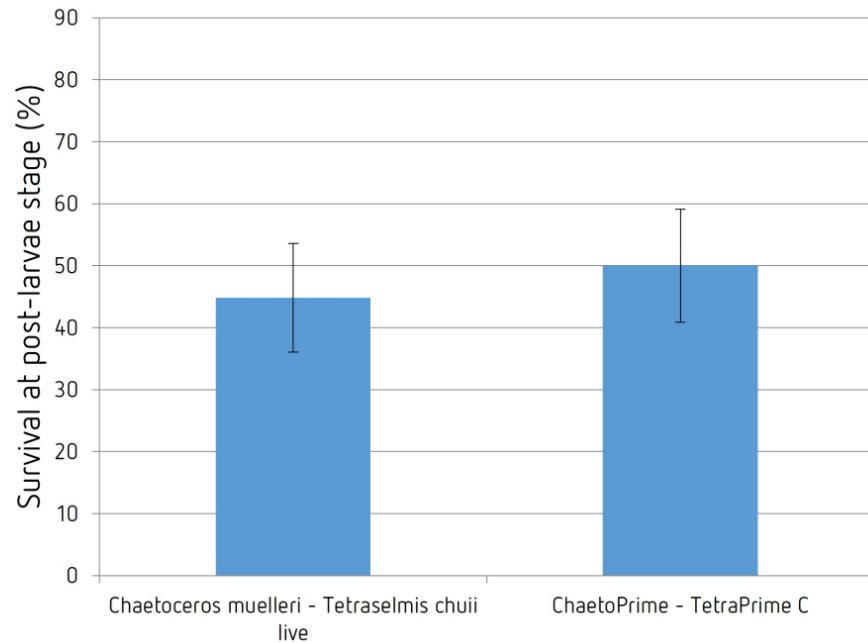
## *Chaetoceros muelleri*: FA content lab vs pilot vs production



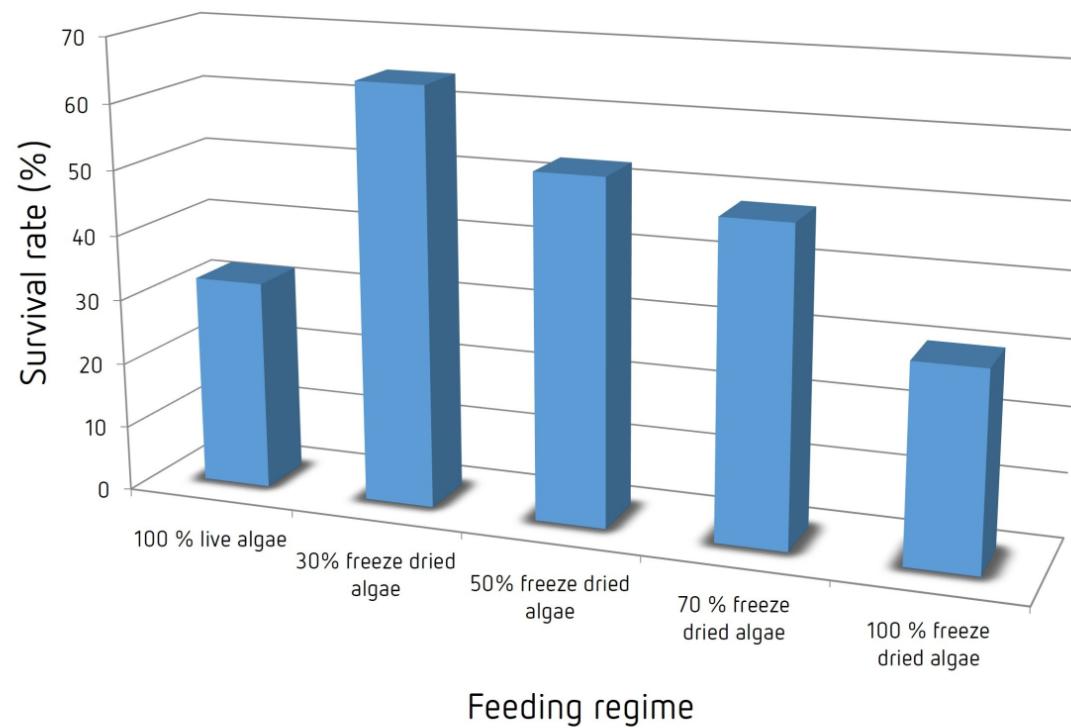


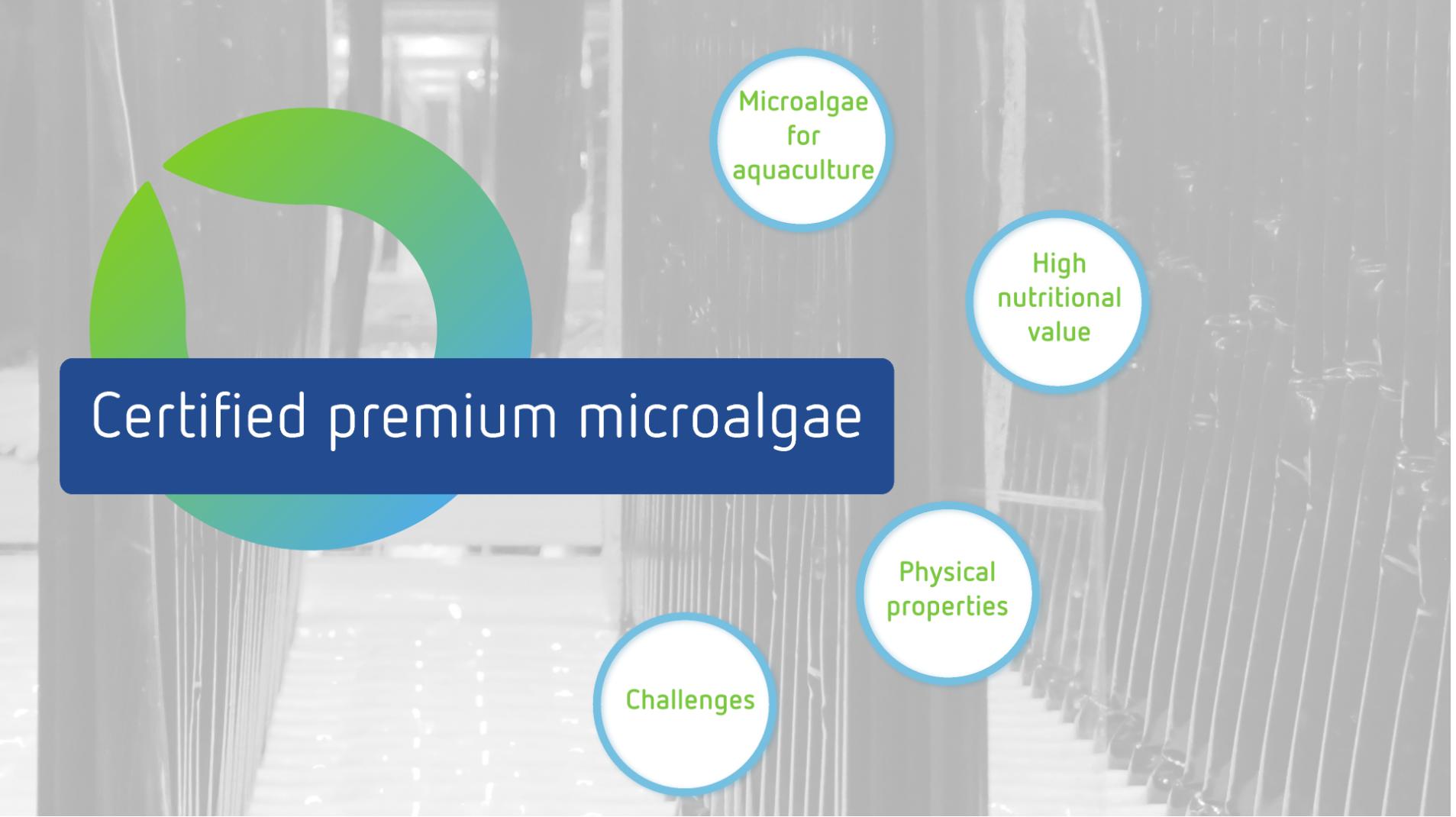
|ae

# Shrimp larval growth – live versus FD algae



# Pacific oyster - Survival at setting





## Certified premium microalgae

Microalgae  
for  
aquaculture

High  
nutritional  
value

Physical  
properties

Challenges

# Freeze dried microalgae for aquaculture

Guaranteed pathogen-free algae products as an **off-the-shelf solution** for larviculture



fin fish



crustaceans



bivalves



echinoderms



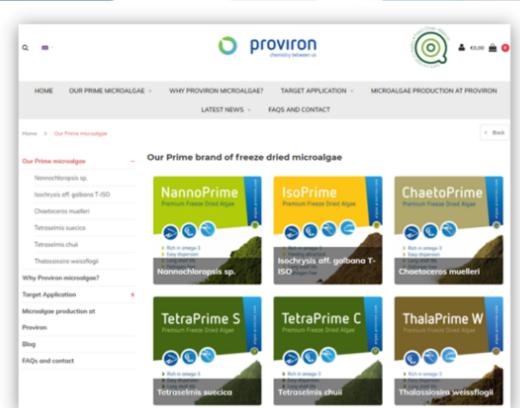
live feeds



corals

**Hard to cultivate** high value species:

- *Tisochrysis lutea* (aka *Isochrysis aff. galbana* (T-ISO))
- *Chaetoceros muelleri*
- *Thalassiosira pseudonana*
- *Conticriba weissflogii* (aka *Thalassiosira weissflogii*)
- *Rhodomonas salina*
- *Diacronema lutheri* (aka *Pavlova lutheri*)



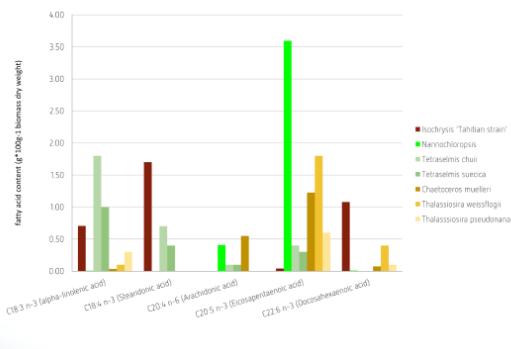
The screenshot shows the Proviron website's product catalog for freeze-dried microalgae. It features a grid of six products under the heading "Our Prime brand of freeze dried microalgae":

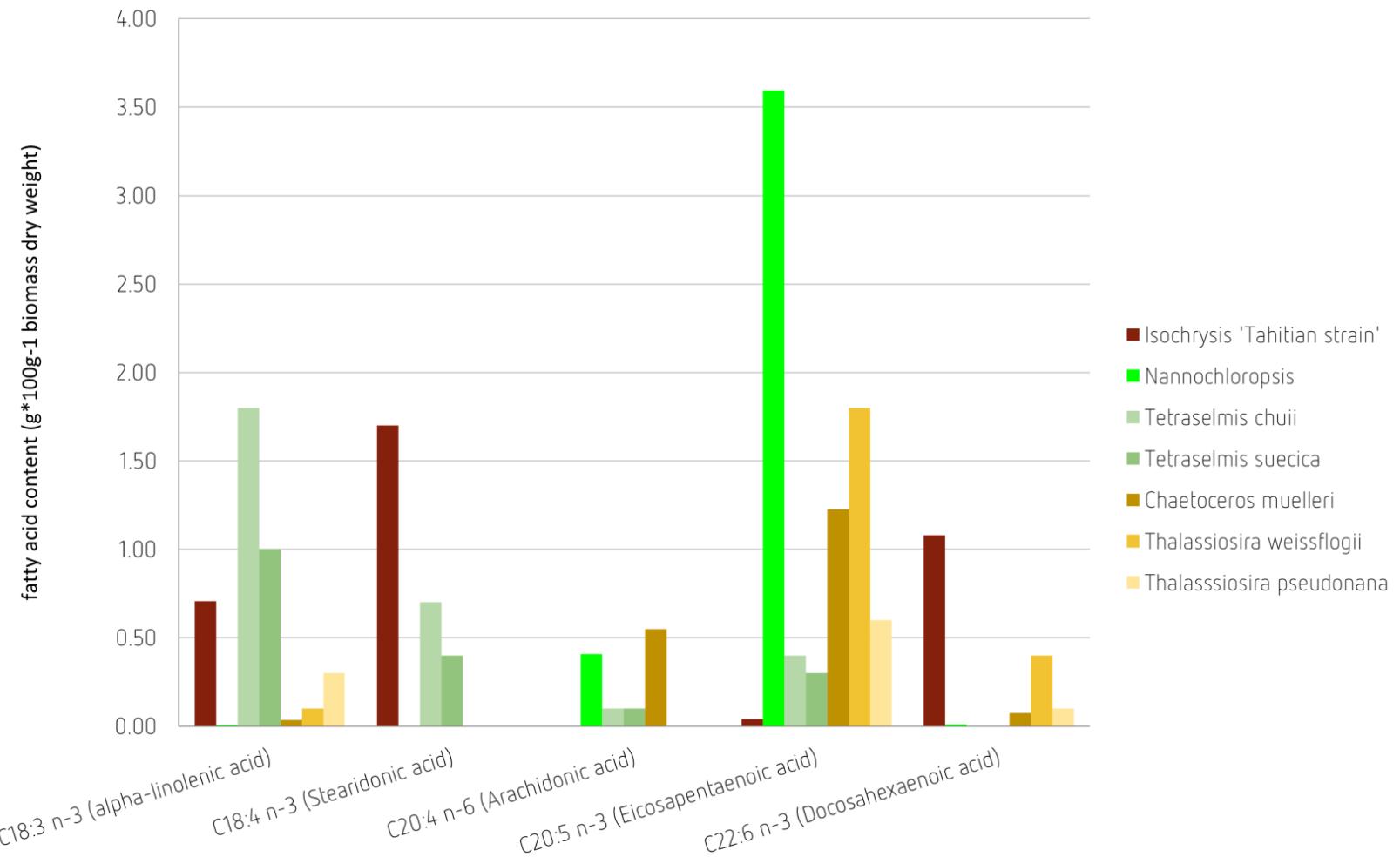
- NannoPrime** (Nannochloropsis sp.)
- IsoPrime** (Isochrysis aff. galbana T-ISO)
- ChaeoPrime** (Chaetoceros muelleri)
- TetraPrime S** (Tetraselmis suecica)
- TetraPrime C** (Tetraselmis chui)
- ThalaPrime W** (Thalassiosira weissflogii)

Each product card includes a small image of the alga, its scientific name, and a brief description.

# High nutritional value

- Rich in lipids
- High in omega-3 fatty acids  
essential for (larval) development
- Arachidonic acid  
prostaglandin precursor  
reproduction & immune response
- High in pigments, carotenoids & antioxidants  
stress competence, immune responses
- Interesting phytosterol content  
moultting and reproduction





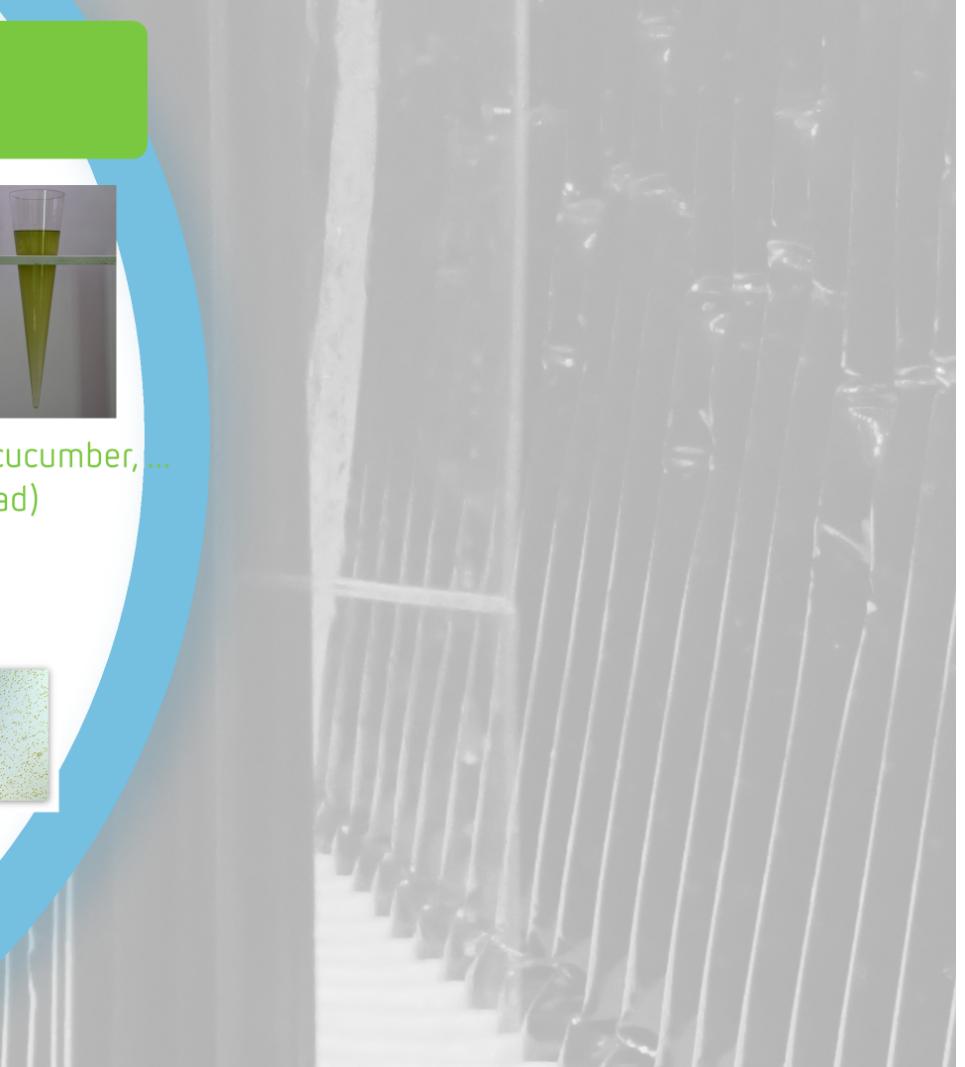
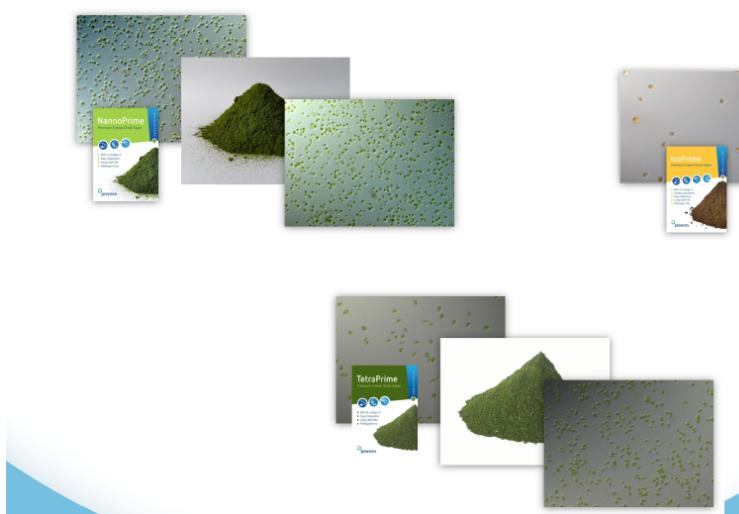
	NannoPrime <i>Nannochloropsis</i> sp.	IsoPrime <i>Isochrysis</i> sp. Tahitian strain	TetraPrime S <i>Tetraselmis suecica</i>	TetraPrime C <i>Tetraselmis chuii</i>	ChaetoPrime <i>Chaetoceros muelleri</i>	ThalaPrime W <i>Thalassiosira weissflogii</i>	ThalaPrime P <i>Thalassiosira pseudonana</i>
<b>Sterol content (mg/kg)</b>							
Cholesterol	3900 - 4807	23 - 70	18	39	1500	< 10	< 10
Brassicasterol	0	1400 - 1887	< 10	< 10	< 10	< 10	< 10
Fucosterol	1574	0	nd	nd	nd	nd	nd
Ergosterol	5 - 20	nd	nd	nd	nd	nd	nd
Campesterol	< 10	< 10	2000	2000	600	690	390
Stigmasterol	21	< 10	< 10	< 10	12	< 10	< 10
Beta sitosterol	570	< 10	< 10	13	1100	340	87
Cholestanol	< 10	< 10	< 10	< 10	< 10	< 10	< 10

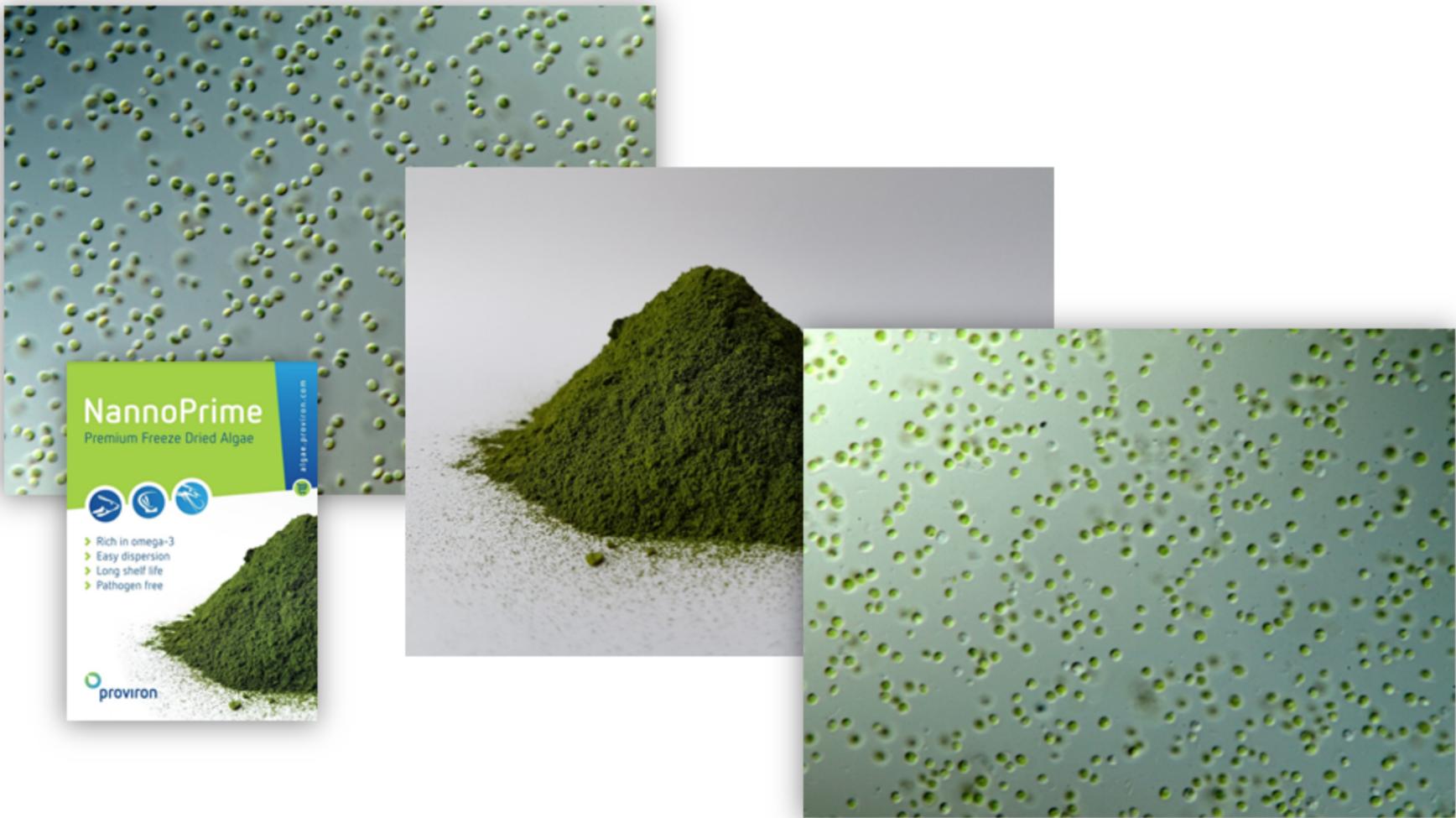
# Single cell dispersion

Increased buoyancy - prolonged residence in water column  
'Green water technique'



Very important for earliest larval stages of shrimp, oyster, sea cucumber, ...  
IF (algae particle size > larval mouth gape) THEN (larva = dead)





# Challenges!

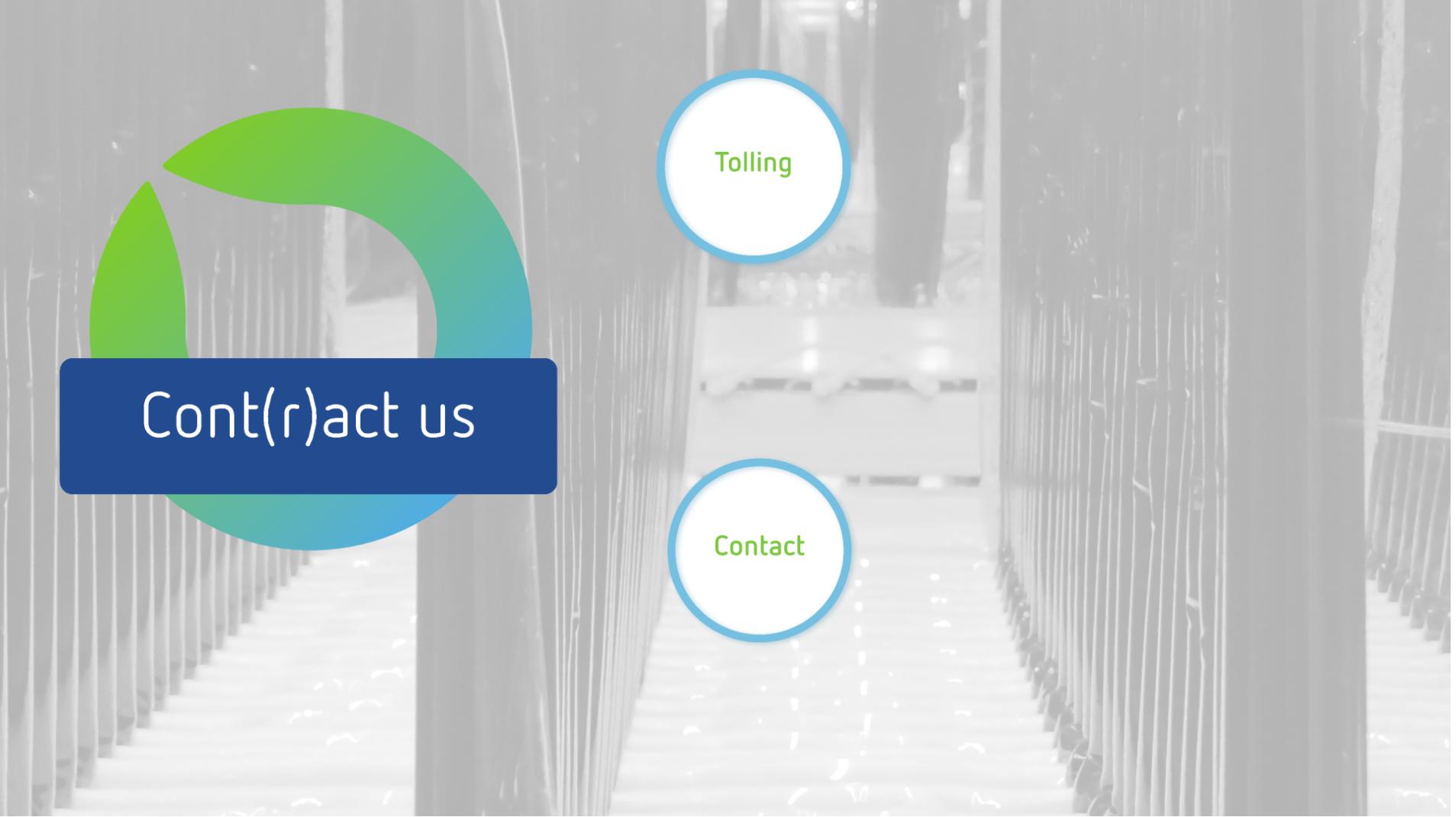
## Ease of use



## One fits all solution?

- loss of certain functions during processing?
- other (complementary) presentation forms?
- ...

## Logistics

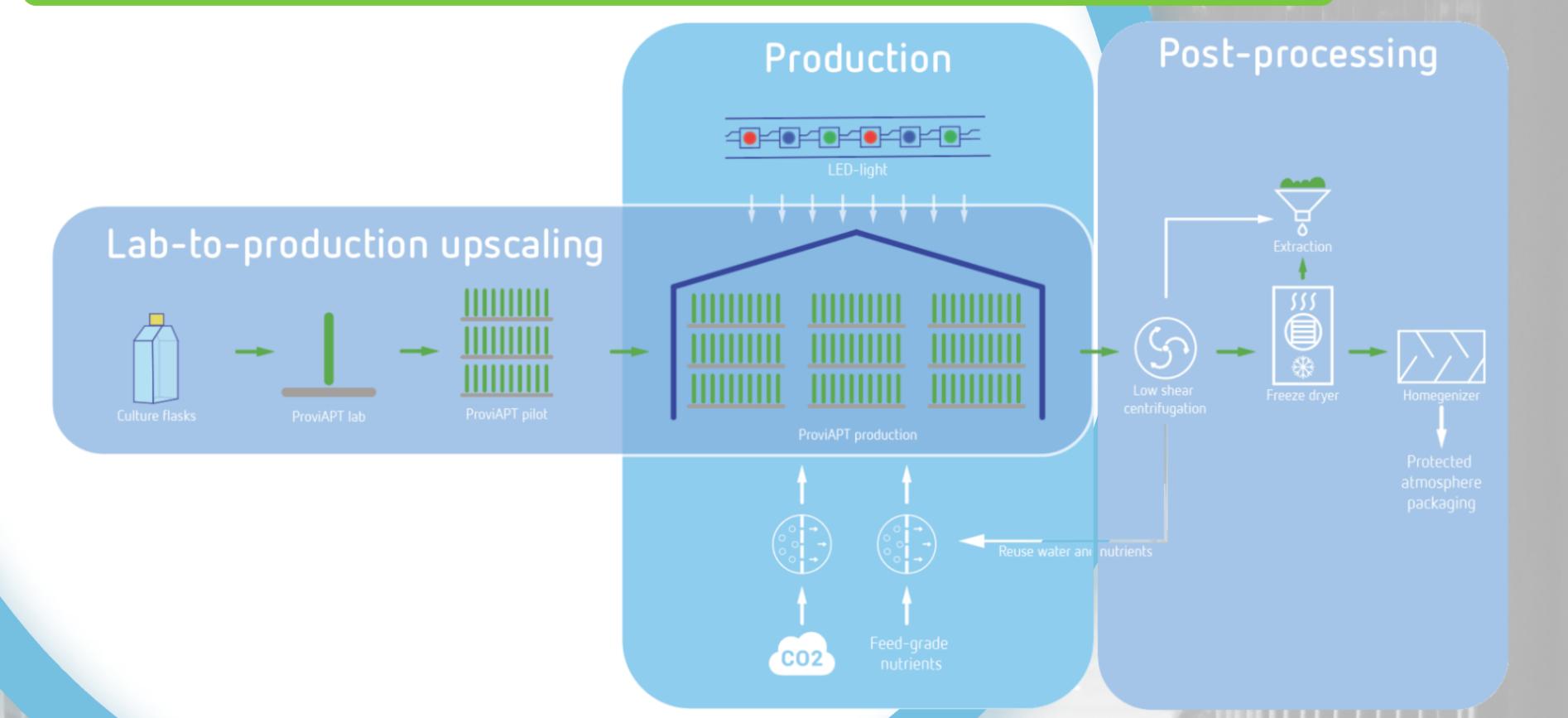


Cont(r)act us

Tolling

Contact

# Contract manufacturing





# Thanks for having us!

[www.proviron.com](http://www.proviron.com)  
[algae.proviron.com](http://algae.proviron.com)

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