

# Macro- and Microalgae

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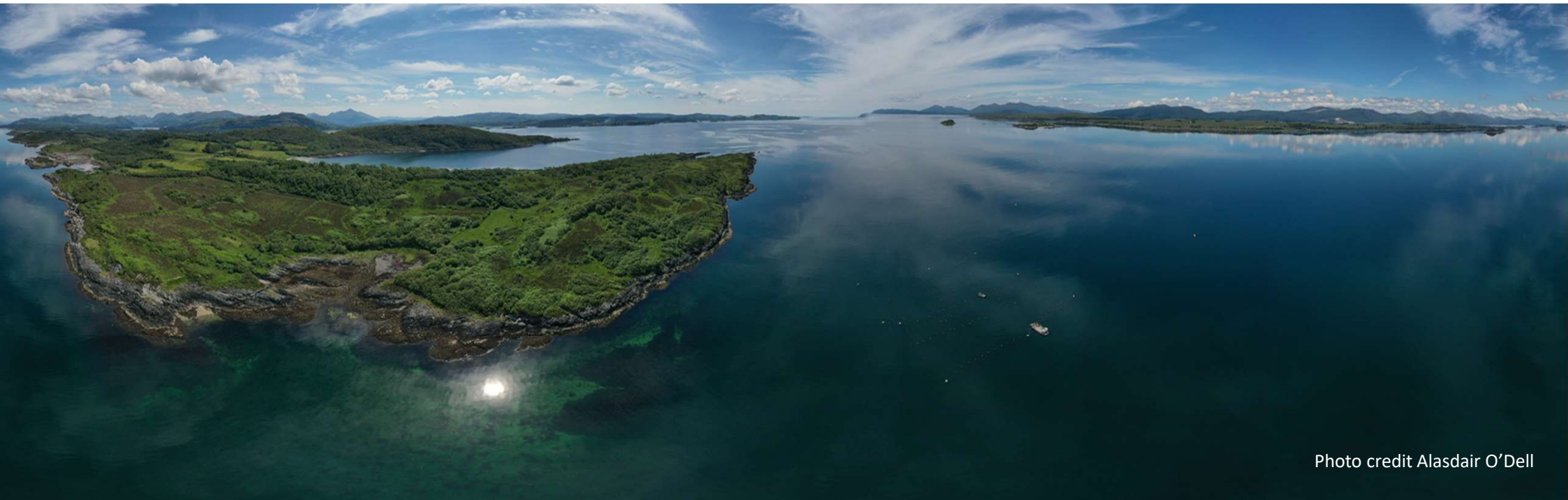
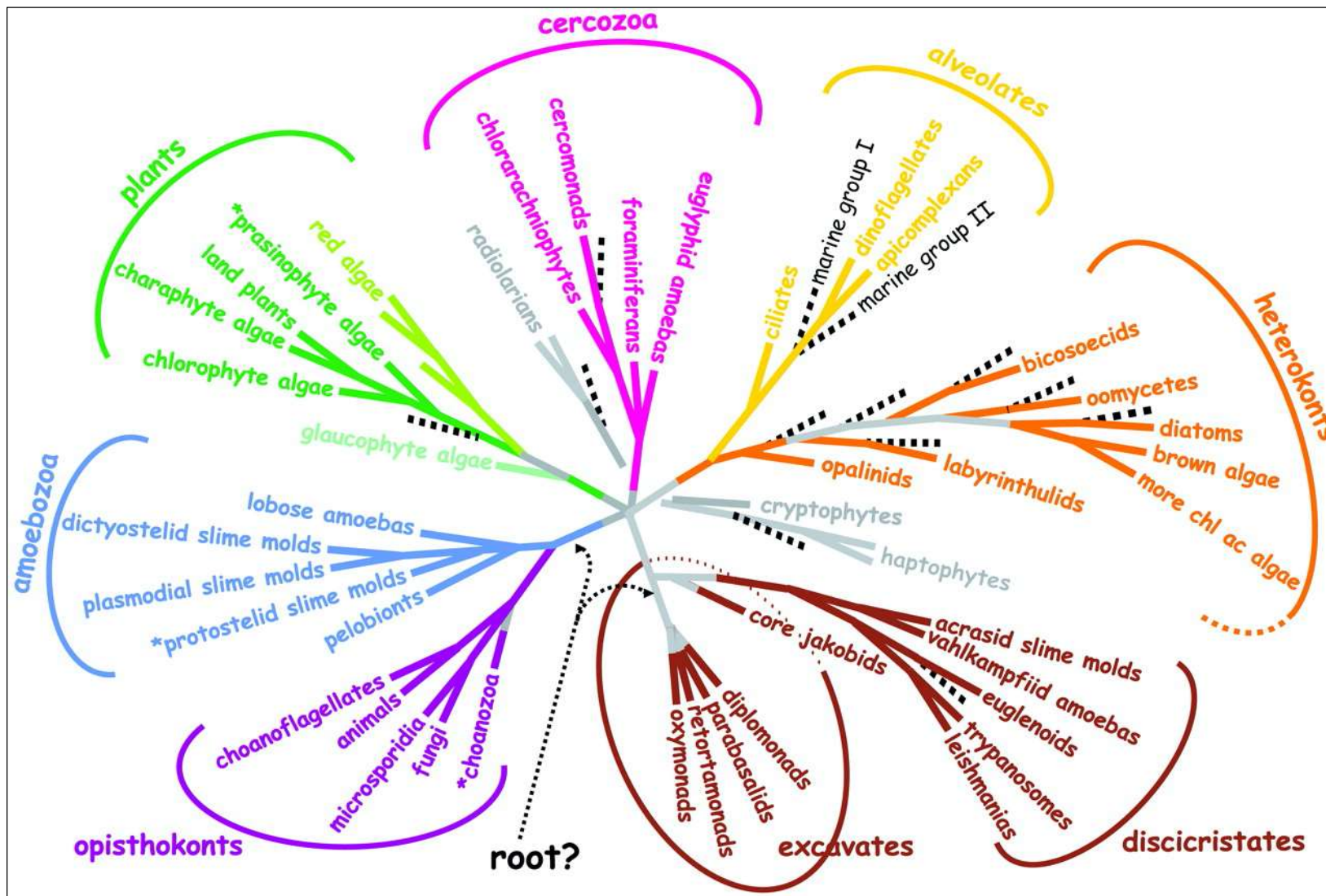


Photo credit Alasdair O'Dell



# Current Algal Uses

- Food and animal feed
- Phycocolloids
- Biofuels
- Wastewater treatment
- High-value products (pigments, carotenoids, and terpenes):
  - *Functional Foods*
  - *Cosmetics*
  - *Pharmaceuticals*
  - *Nutraceuticals*



**A**  
*Haematococcus pluvialis*, Israel  
Astaxanthin Production  
<https://www.algatech.com/>

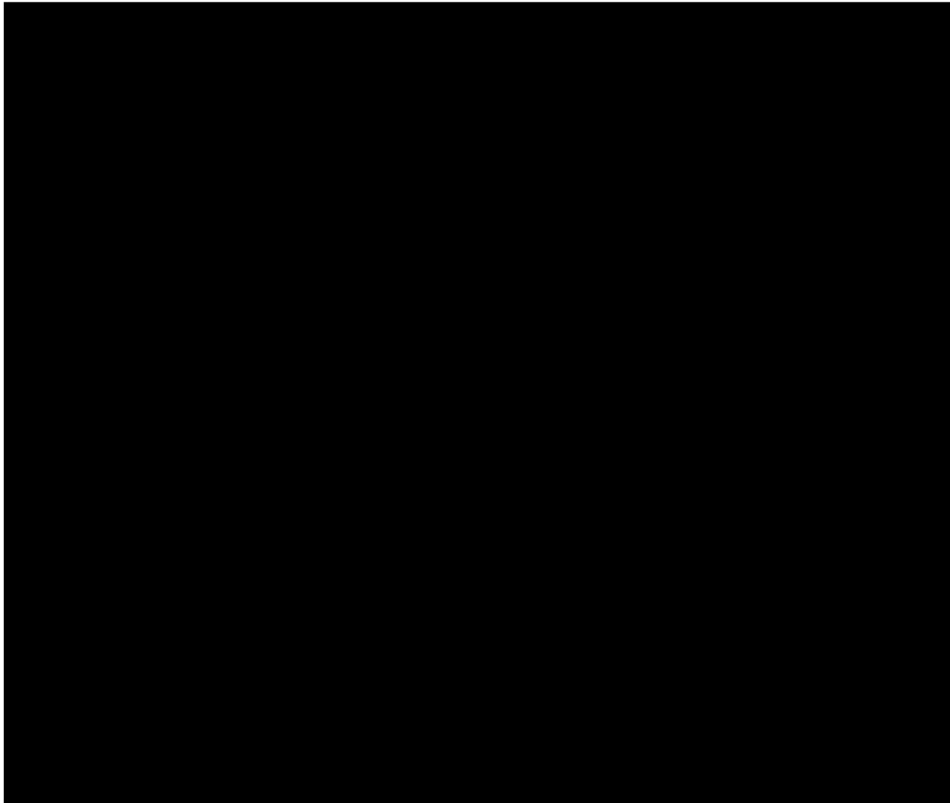


**B**  
*Dunaliella salina*, Australia  
 $\beta$ -carotene Production  
Milledge, 2011



**C**  
*Spirulina platensis*, USA  
Health food  
<http://www.bsb.murdoch.edu.au/groups/beam/BEA-M-Appl4a.html>

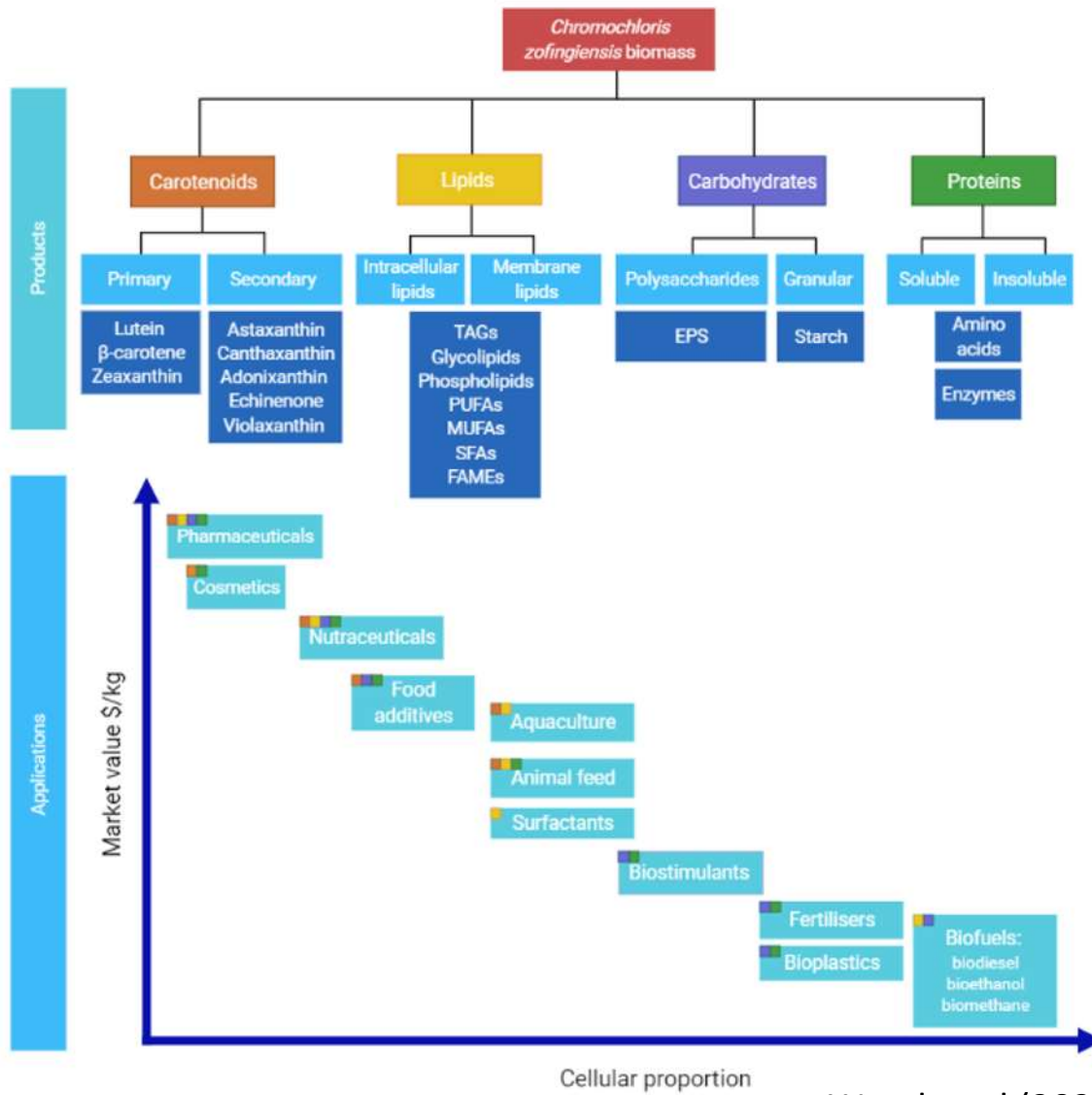
# Culture Collection of Algae and Protozoa



## Overview

- CCAP is one of the most diverse service collection for living strains of microalgae, macroalgae, cyanobacteria, protozoa, and algal pathogens
- CCAP holds nearly 3,000 strains, with more than 1,100 species (including 345 type strains)
- Strains collected from every continent, representing an immense environmental and genetic biodiversity
- CCAP's catalogue includes extremophiles and an algal pathogen collection





Wood et al (2022) Biomass Conversion and Biorefinery



<https://www.algenuity.com>



-Autotrophic microalgae production is approx. 12.000 ton/year:

- Arthrospira, (10 – 30 €/kg dw)
- Chlorella, (20 – 40 €/kg dw)
- Haematococcus, (100 – 250 €/kg dw)
- Dunaliella (200 – 2000 €/kg dw)

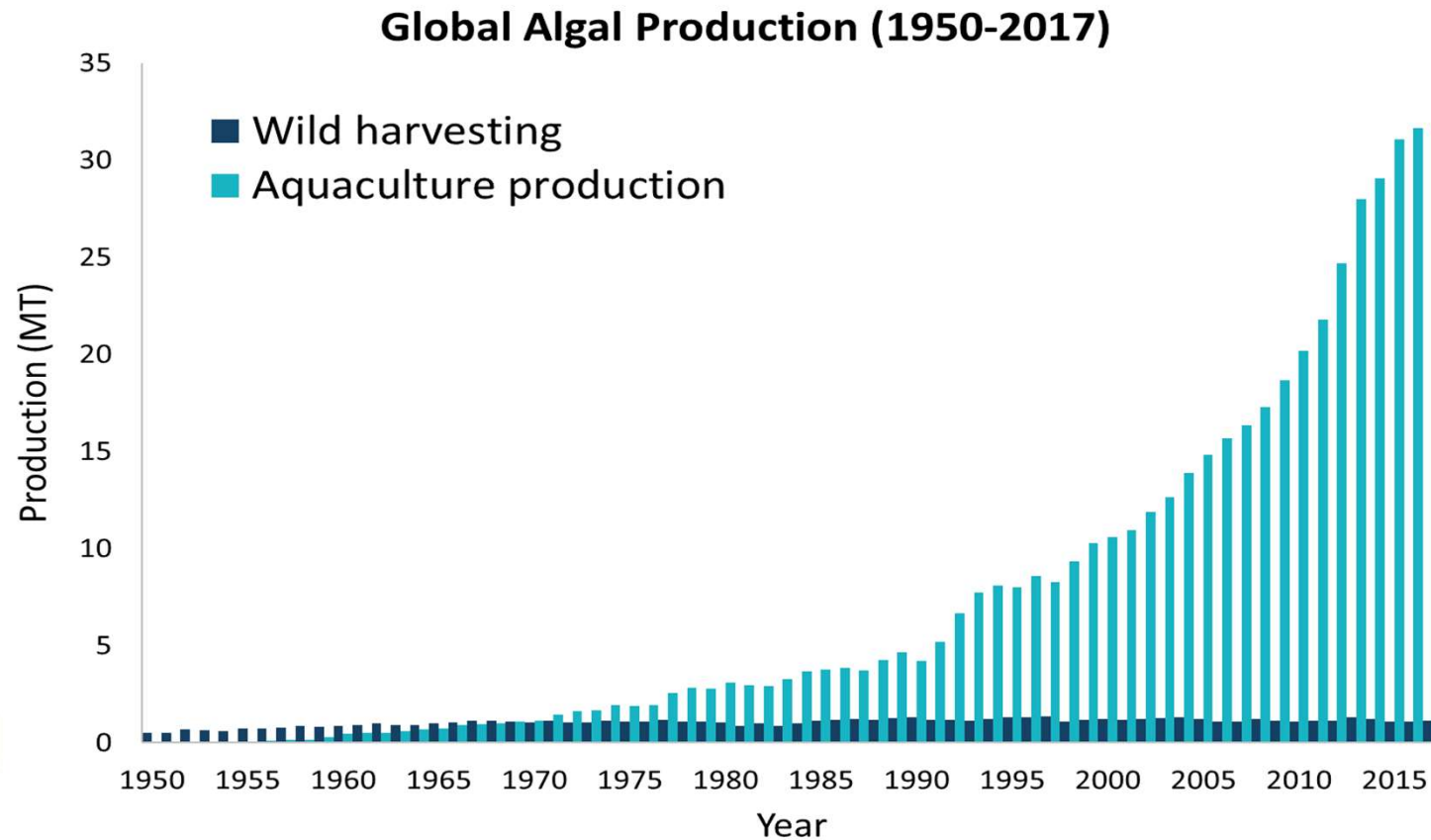
Heterotrophic microalgae production is approx. 6.000 ton/year:

- Schizochytrium, Crypthecodinium and Ulkenia
- Algenuity- Chlorella colours

Top 10 production companies: Cyanotech, Cognis Betatene, Earthrise (DIC), Taiwan Chlorella, Parry Agro, Algatechnologies, and Roquette (autotrophic), and Martek, now DSM (heterotrophic)

Production in aquaculture hatcheries is approx. 2.000 ton/year

# Global Seaweed Production



Global production of cultivated and wild harvested algae between 1950 and 2017 (from FAO 2018)



# Seaweed Products

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- Rich in:
  - Minerals
  - Trace elements
  - Fibre
- Viable protein source
- Sea vegetables
- Processed ingredients

Food Markets



- Plant bio-stimulants
- Agricultural fertilisers
- Nutritional and active compounds for animal feed
- Aquatic feed

Plant Health and Animal Feed



- Skin and hair care
- Make up
- Beauty and spa treatments
- Dietary supplements
- Pharmaceutical products
- Anti-inflammatory properties

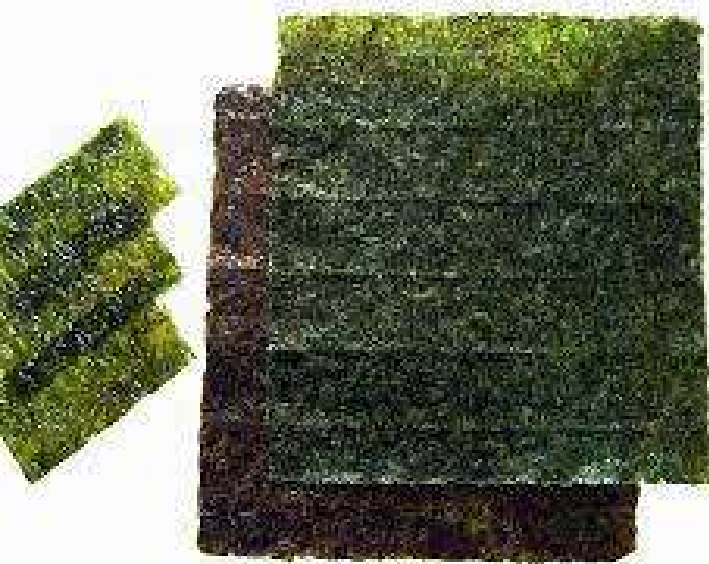
Health and Wellbeing



- Third generation biofuel feedstock
- Renewable fuel source
- Bioplastics

Biofuels and Novel Materials



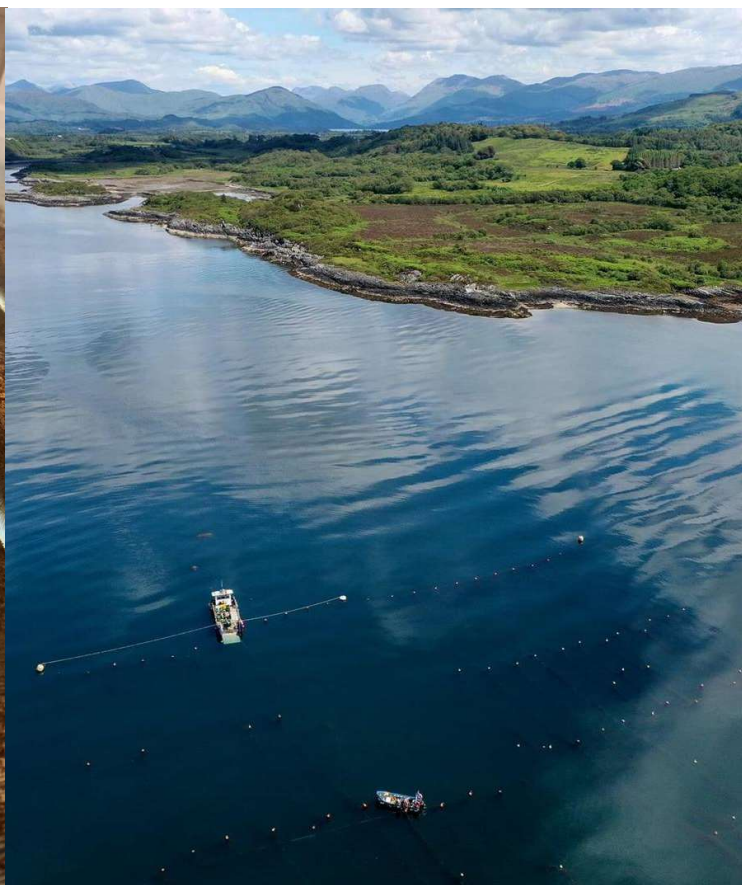


Seaweed  
**NURSERY**



Seeding Technologies  
Deployment Strategies

Seaweed  
**FARM**



Grow-out Systems  
Biomass ~ Environment  
Co-Cultivation

Seaweed  
**ACADEMY**



Knowledge Transfer  
Training

# Seaweed Species

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*Saccharina latissima*

Sugar kelp, sweet kelp / kombu,



*Alaria esculenta*

Winged seaweed, dabberlocks, wakame, tang



*Laminaria digitata*

Oarweed, kombu, kelp

# Seaweed Species

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*Chondrus  
crispus*



*Gracilaria sp.*



*Palmaria  
palmata*



*Porphyra spp.*



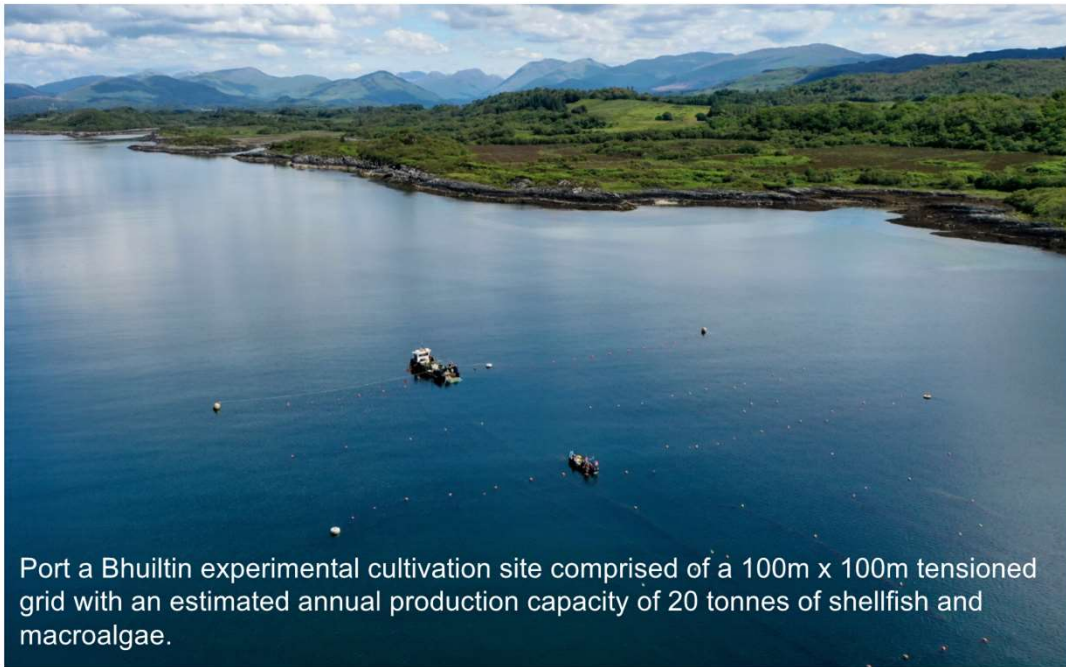
*Ulva spp.*



*Undaria  
pinnatifida*

# Our cultivation site

SAMS operates an integrated cultivation site and our work focuses on optimising techniques for the co-cultivation of low-trophic species to achieve efficiencies that generate improvements in growth performance, quality, and efficiency needed to drive profitable business models.

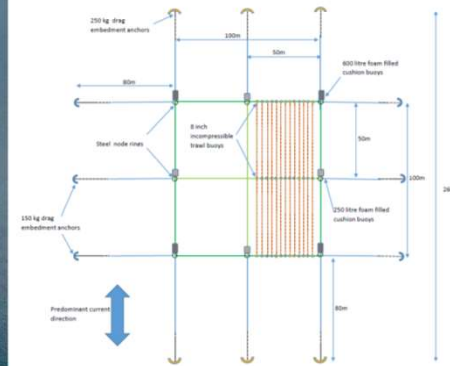


## Shellfish

*Ostrea edulis* – European flat oyster    *Alaria esculenta* - Dabberlocks



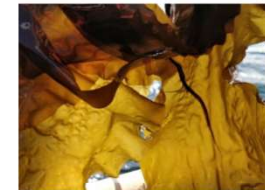
*Pecten maximus*



## Seaweeds



*Saccharina latissima* – Sugar kelp



*Laminaria digitata* - Oarweed



+ *Ulva* spp.  
*Palmaria palmata*

# Intended Application

~ 180 days of cultivation

Deployment late Oct – Harvest late April

## LOW Yield

- Low fouling cover
- Low heavy metal & iodine content
- High lipid & N content

Food & Feed Products  
Speciality Products

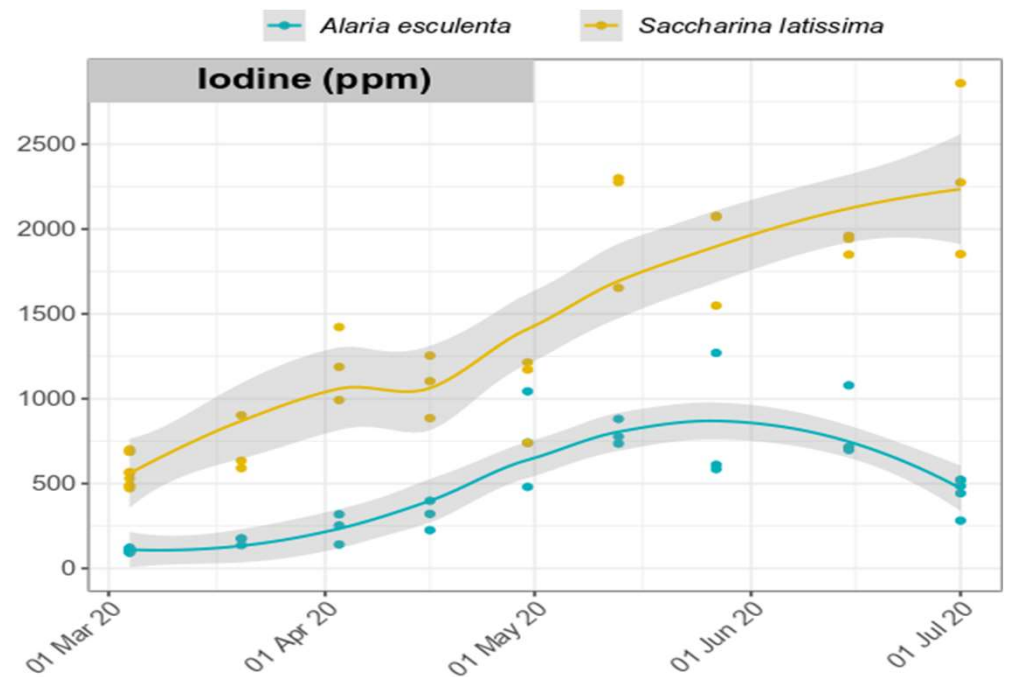
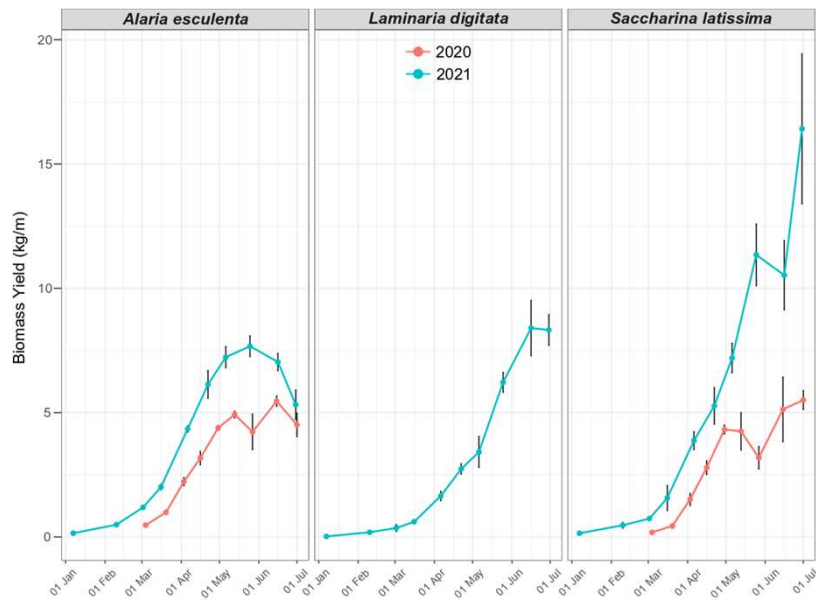
## HIGH Yield

- high fouling cover & frond damage
- high heavy metal & iodine
- High carbohydrate & C content

Bioenergy  
Bio-Packaging

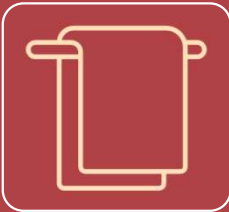
# Optimum Seaweed Harvest

- Kelp yield, morphology and composition vary throughout the cultivation cycle as well as between years
- Best time for harvest determined by downstream application
  - Late harvest → higher biomass and carbohydrate content (e.g. biofuel/biogas, alginates)
  - Early harvest → low fouling pressure and heavy metal content (food/feed applications)



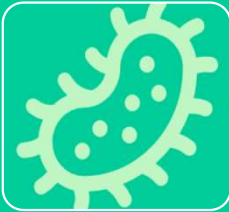


# Primary processing techniques



## Drying

- Reduces water activity of biomaterials
- Increases shelf-life of products
- Deters microbial growth and other degradation



## Ensiling

- Anaerobic digestion
- Alternative to drying seaweed biomass
- Fermented so more readily digestible



## Freezing

- Most widely used for long-term storage
- Prevents microbial growth
- Rate of biochemical reactions reduced

# SAMS Algae Past and Present- Especially

- Dr Adrian MacLeod
- Dr Mikey Ross
- Dr Kati Michalek
- Dr Arlene Ditchfield
- CCAP
- Cecilia Rad Menéndez
- Dr David Green
- Dr Adam Hughes
- Alison Mair
- Richard Abell
- Dr Alex Thomson
- Rob Grisenthwaite
- Dr Marie-Mathilde Perrineau
- Dr Francisca Vermeulen
- Rhianna Rees
- Sam Reeves
- Dr Cecilia Biancacci
- Callum O'Connell
- Iain Gatward
- Alasdair O'Dell
- Ryan Marchington
- Jenny Black
- Gail Twigg
- Lars Brunner
- Hayley Swanlund
- George Hurst