Microalgae as a bioresource for high-value components, focusing on aquafeeds – Forskning ved Nord universitet

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Why microalgae?

SCIENTIFIC REPORTS

OPEN

Marine microalgae commercial production improves sustainability of global fisheries and aquaculture

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Microalgae important for Norwegian aquaculture

- PwC Seafood Barometer 2017
- Sustainable growth towards 2050
- 5 million tons marine products in 2050, 5x more than today
- Algae -important ingredient in future salmon feed

55.6% of leaders in the industry **believe algae will be the most important ingredient** in salmon feed in the future.

PwC's Point of View:
After solving the short term issues regarding lice and lice treatment, the next big challenge to overcome is where and how to find sustainable feed ingredients with the right nutritional content for salmon.

We believe that the salmon feed in 2050 will still have a high share of plant based ingredients, but with a significant share of algae and a small share of by-products. The share of traditional fish oil and meal will continue to fall.

The government has a vision of Norway becoming the world's leading seafood nation

Verdiskapning basert på produktive hav i 2050
In 2012, notable scientists, researchers and opinion leaders published a report called "value creation based on productive oceans in 2050". They have estimated that it is possible to have a six-fold increase in sales value of Norwegian marine production, by 2050. This requires, among other things, **a production of salmon and trout of 5 million tonnes – almost a five-fold from today's level.**[1]

Verdens fremste sjømatnasjon
In 2013, the Norwegian Ministry of Fisheries and Coastal Affairs released parliament report no. 22 (Meld. St. 22),where the government's vision for Norway, as a seafood nation, is detailed. **The government wants Norway to be the world's leading seafood nation**, and adopts the view and vision that seafood production can be increased six-fold by 2050.[2]

Havbruksmeldingen
In 2014, the Norwegian Ministry of Fisheries and Coastal Affairs published parliament report no. 16 (Meld. St. 16), presenting their view on how vision 2050 can be reached. Global demand for salmon increases, but production growth has stagnated due to sustainability challenges. Historically, regulations and policies for growth, and changing governments, have shown nothing but predictability. The allocation of new licenses has been termed a "beauty contest" by the press. **The government, therefore, suggested a predictable system for sustainable growth based on environmental indicators.** This framework has been named «The Traffic Light System», where Norway is divided into 13 production areas and gives each area a green, yellow or red light. The new system came into effect in October 2017.[3]

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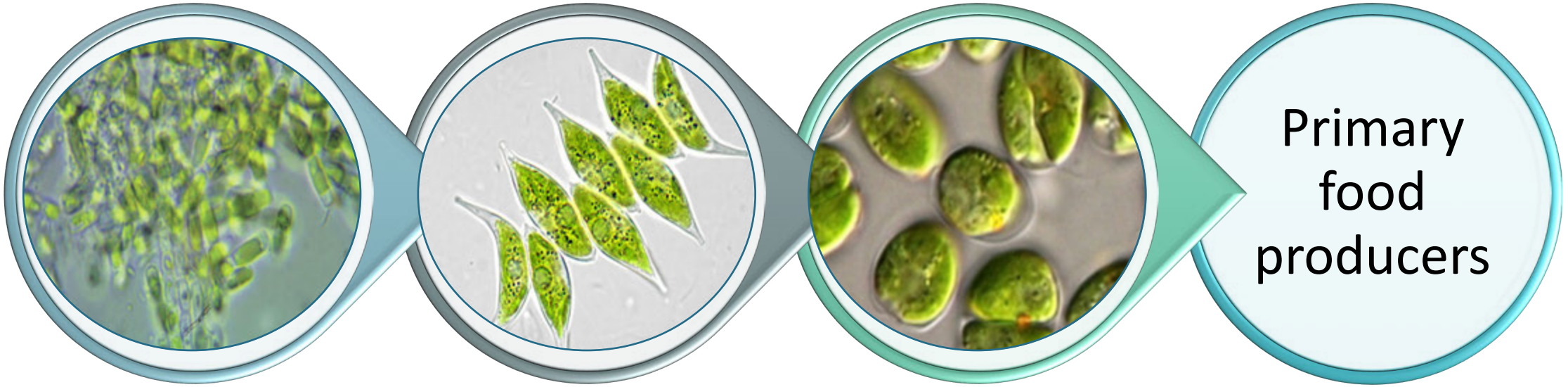
Microalgae as a bioresource

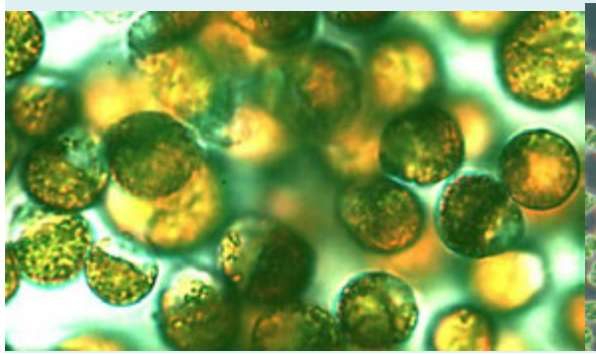


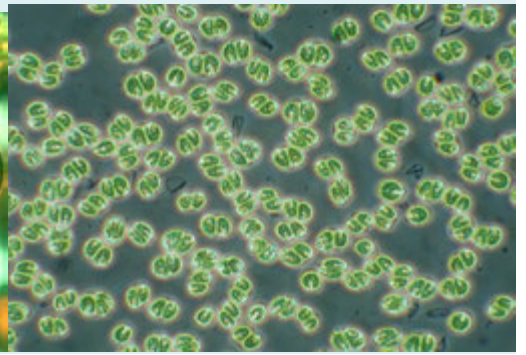
Part of the aquatic food web. Organisms at lower trophic levels as food and feed sources.

Algae: photosynthetic organisms

- Macroalgae
  - Multicellular
  - Composition
    - 10-25% protein
    - 30-50% carbohydrates
    - 0.5-5% lipids

- Microalgae
  - Unicellular
  - Composition
    - 30-70% protein
    - 10-30% carbohydrates
    - 10-50% lipids
    - Rich in ω-3 fatty acids

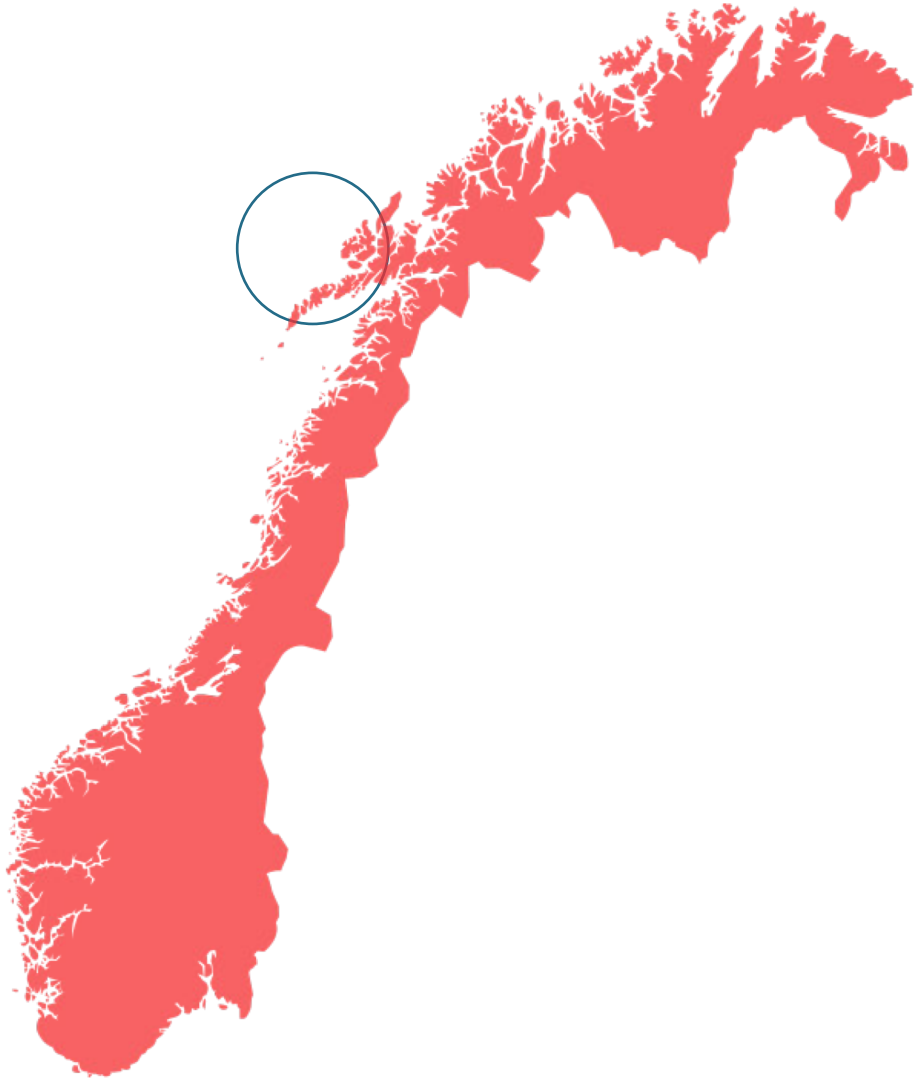




Mikroalger som för ingredienser for laks

- 1.24 million tonn laks
- 1.42 million tonn med fôr
  - 12 % fiskemel: 170,000 tons
  - 9% fiske olje: 130,000 tons

- **Erstattet med mikroalger**
  - Til å erstatte fiskemel: 170,000 tons of algae
  - Til å erstatte fiske olje: 430,000 tons of algae
- Totalt behov for mikroalger: 600,000 tons
- Produksjon: 500 tonn mikroalger/daa/år
- Overflatebehov: 120 000 daa: 10% av Lofoten



Microalgae for the global the aquafeed industry

600 000 tons

roalgae

IntraFish

Omega-3 algae factory on track for mid-2019 delivery

Atlanti

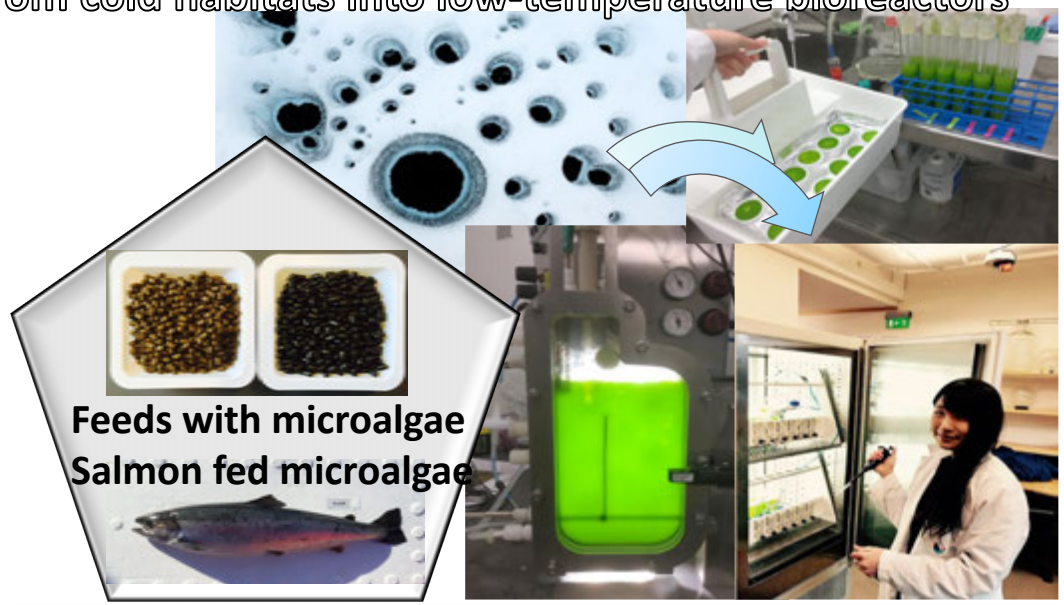
The Nebraska factory has capacity to supply 15 percent of the global farmed salmon industry with EPA and DHA.

The construction of a $200 million facility in Nebraska to make omega-3 oil from marine algae is

Fishmeal Fish oil Plant ingredients Others Fishmeal Fish oil Plant ingredients Others

Microalgae research at Nord

From cold habitats into low-temperature bioreactors



Wageningen University, The Netherlands
Cornell University; Duke University US
Colorado School of Mines, US
Thai Union Feed Mills, Thailand
CIIMAR, University of Porto, Portugal
Sparos Lda, Portugal
Tokyo Univ. of Marine Science & Technology, Japan
Norwegian Institute for Bioeconomy Research, Norway
GIFAS, NORCE, NOFIMA, Norway

2009-2011: Defatted microalgae from biorefinery as aquafeeds

2012-2015: Large-Scale Production of Fuels & Feed from Marine Microalgae - CORNELL UNIVERSITY, US
2017-2020: Marine Algae Industrialisation Consortium - DUKE UNIVERSITY, US

2014-2018: Biotechnology for the future marine industry

2016-2020: Marinalga4 aqua

CIIMAR, Portugal

2017-2021: Algae to Future -NIBIO

2017-2020: Metabolism of novel strains of Arctic algae (Dr Chris Hulatt)

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Microalgae in aquafeeds – Laboratory scale and farm trials – Nord University and collaborators

Pacific white shrimp

Atlantic salmon

Common carp

Wolffish

European seabass

Red sea bream

Microalgae species employed in aquafeeds

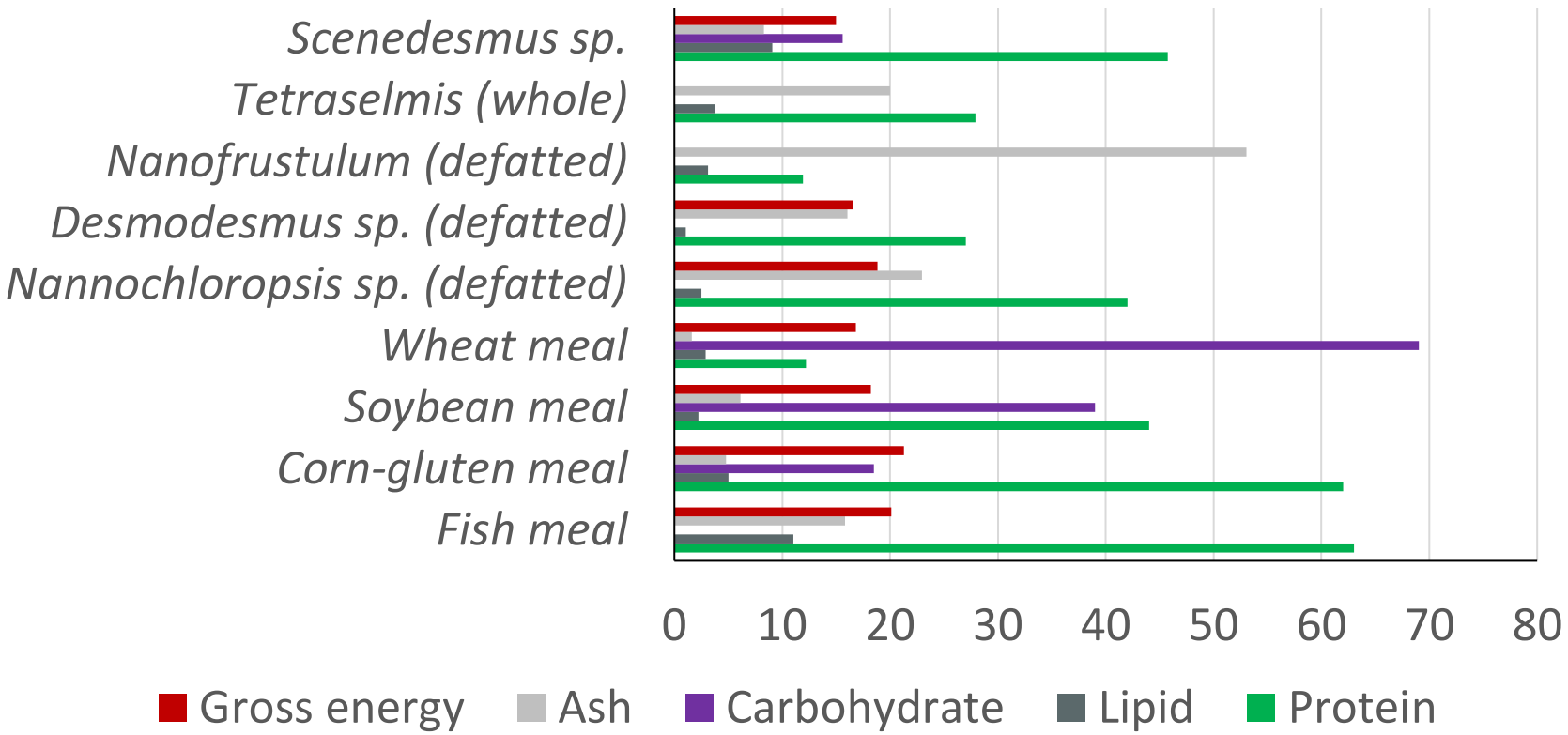
Full fat - No prior processing

- *Nannochloropsis oceanica*
- *Phaeodactylum tricornutum*
- *Scenedesmus* sp.

Defatted – Protein-rich fraction

- *Nannochloropsis* sp.
- *Nanofrustulum* sp.
- *Desmodesmus* sp.
- *Tetraselmis* sp.

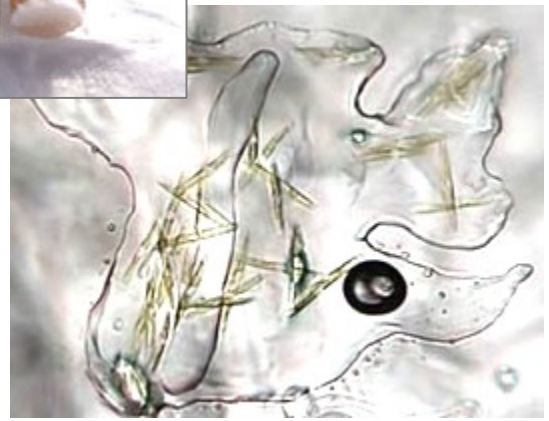
Nutrients in microalgae and other aquafeed ingredients



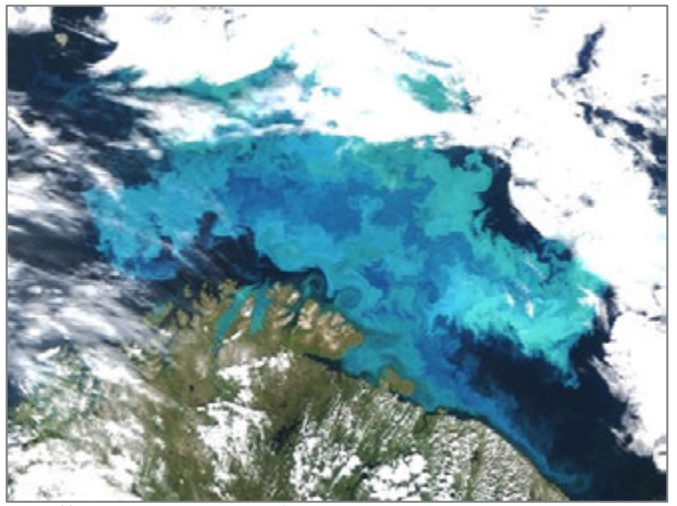
Ideal microalgae: high protein content, EPA, DHA, carotenoids and functional polysaccharides - all with good bioaccessibility and bioactivity

Cold adapted microalgae – Growth, product synthesis at low temperatures?

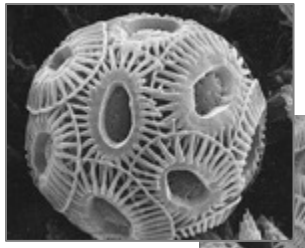
Inside sea ice

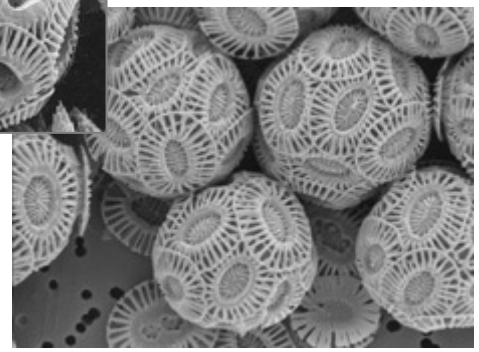


Polar seas

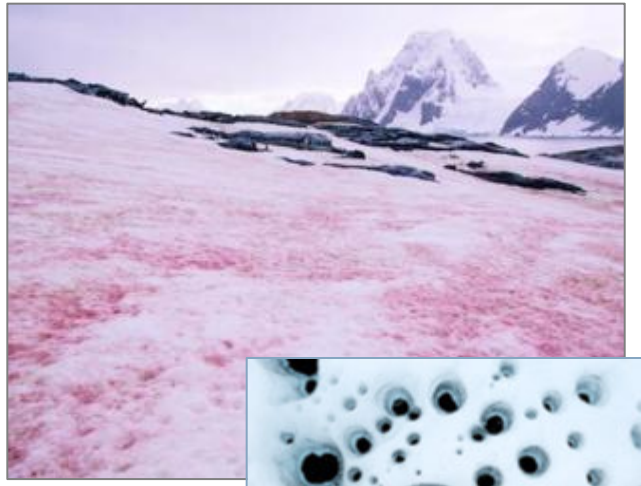


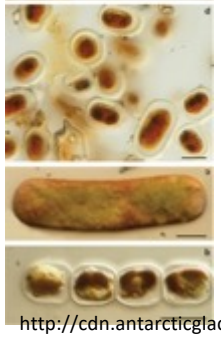
https://eoimages.gsfc.nasa.gov/



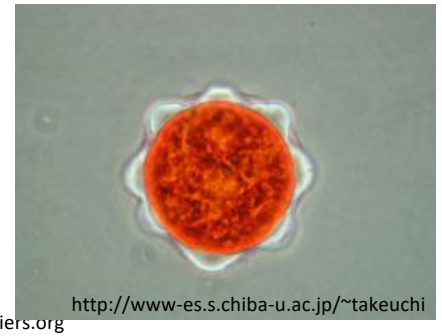


Snow and bare ice (glaciers)





http://cdn.antarcticglaciers.org



http://www-es.s.chiba-u.ac.jp/~takeuchi

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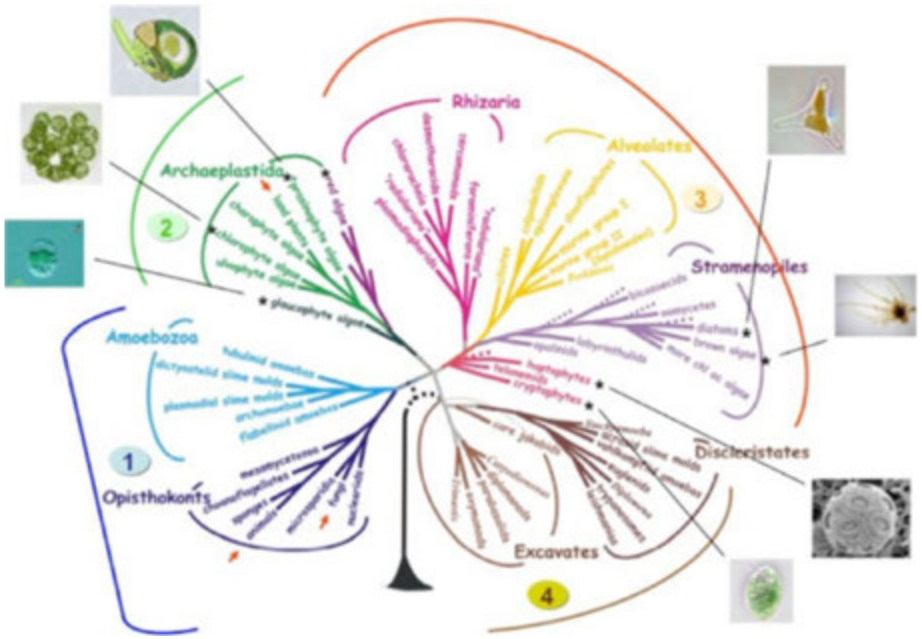
Microalgae metabolism through genomics



Credit: Decoding algal genomes: tracing back the history of photosynthetic life on Earth. Tirichine & Bowler, 2011. The Plant Journal, 66.

- Protist diversity – many varieties and flavors!
- Explore coldwater and nutrition-related strains
- A few strains in detail
- Develop as molecular factories for novel products and/or cold-climate cultivation
- Can we develop novel bioprocesses for colder climates or better products?

Forskningsrådet

COLORADOSCHOOLOFMINES
EARTH • ENERGY • ENVIRONMENT

European Commission

MARIE CURIE ACTIONS

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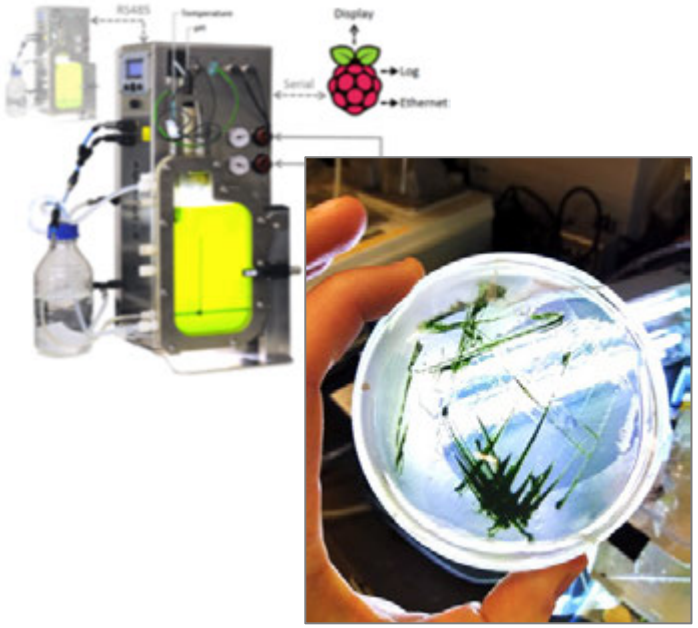
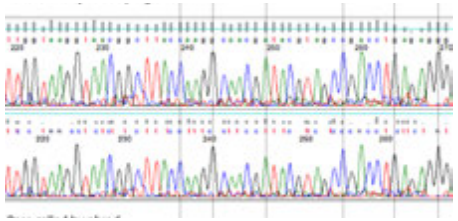
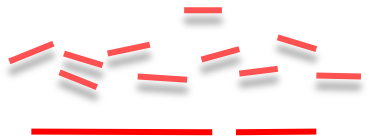
Cultivation → Genome sequencing → Metabolic modeling

Coldwater microalgae



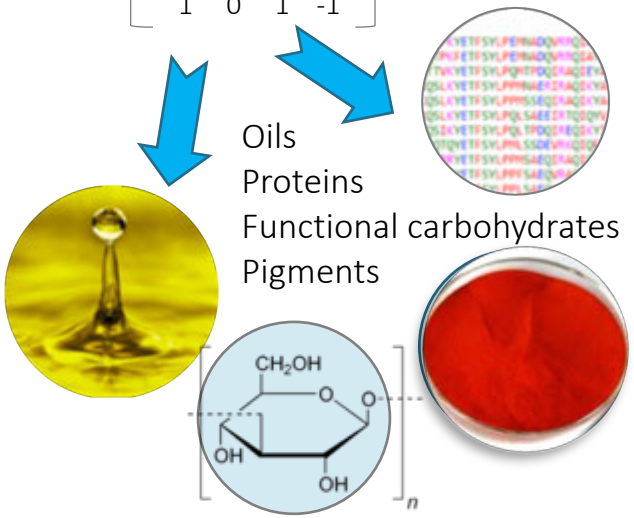
RNA-seq proteomics





Cell factories
Computational modelling
Product optimization

$$\begin{bmatrix} 1 & 2 & -1 & 0 \\ 0 & 0 & -1 & 2 \\ -1 & -1 & 0 & 0 \\ 1 & 0 & 1 & -1 \end{bmatrix}$$



Mission AlgaeNORD

- Microalgae for fish feeds
- Bioprocess bioengineering
- Arctic microalgae
- Recirculation systems
- Valorization of agro-food waste

cellana

the kona demonstration facility

ANNONSE — Denne temaavisen er en annonse fra Mediaplanet — ANNONSE

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PÅ NETT! Tang er fremtidens mat. Få tips til gode matretter.

MATAVFALL blir til biogjødsel, biogass og mat. s.8

NY INNOVASJON bidrar til økt mattrygghet og kan redusere matsvinn s.10

Fremtidens matproduksjon

Mikroalger – den nye biobaserte næringen i Norge?

Mikroalger er viktig for alt liv på jorden. Trolig finnes det mer enn 50 000 arter, fordelt på økosystemer i vann og på land.

Algedyrking i ulike foto-bioreaktorer fra AlgaePARC, Wageningen Universitet, Nederland.

Økende kunnskap om helsefordeler med å spise mikroalger har ført til større interesse for å utvikle matvarer med mikroalger.

Fremtidens får ressurs

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Rene Wijffels
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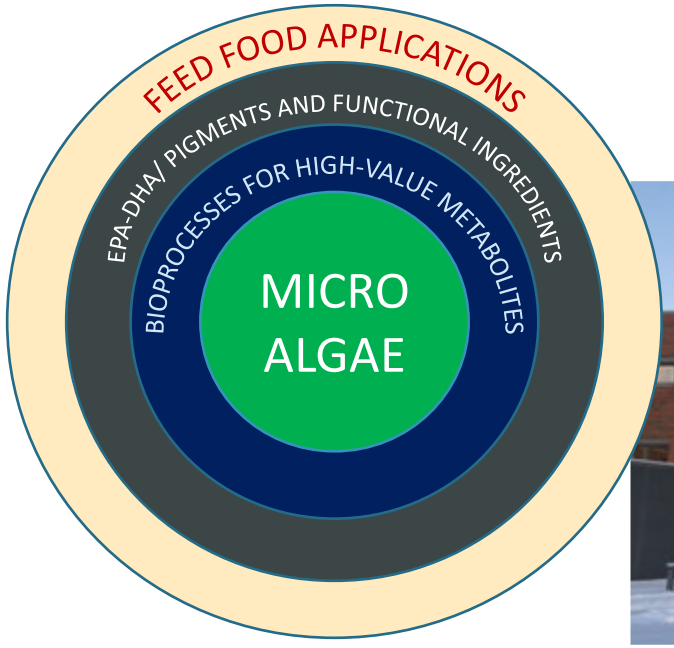

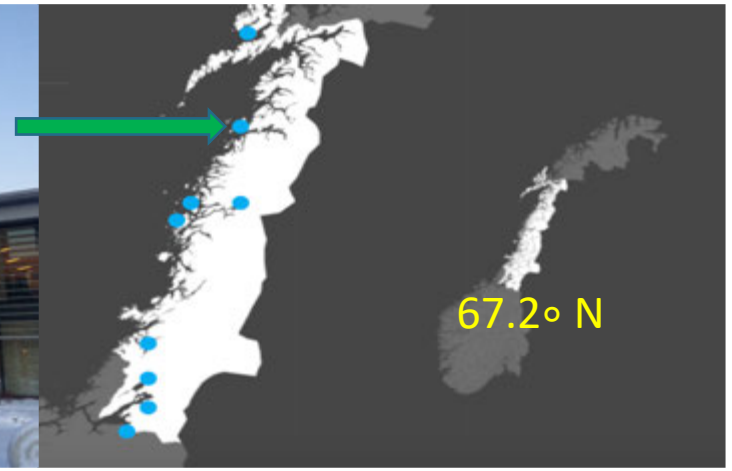

Takk for oppmerksomheten

www.algaeconsortium.com

ALGAE BIOMASS ORGANIZATION

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www.eaba-association.org

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