Algae Biomass – Novel Foods Workshop, 28-29. October 2014

The use of algae in feed products - AQUACULTURE

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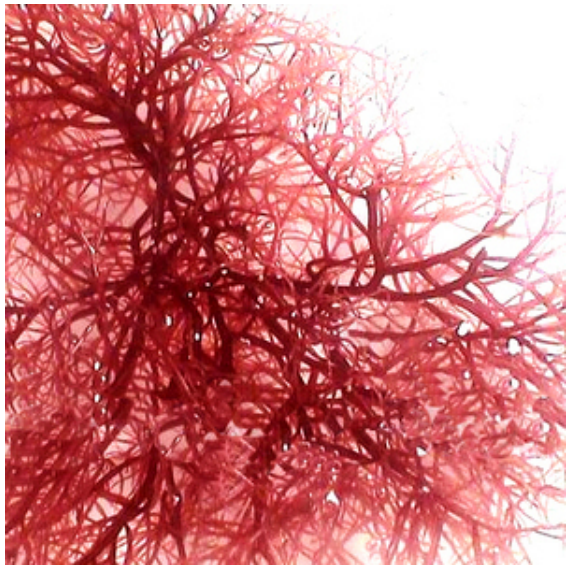
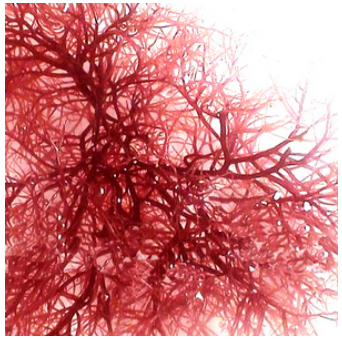
Seaweed in aquaculture feed

- Whole, fresh biomass:
  - Gracilaria, Laminaria, Sargassum for abalone, sea cucumber, sea urchin (e.g. Qi et al. 2010)



Seaweed in aquaculture feed



- Whole, as seaweed meal:
  - Porphyra, 10% replacement of protein and lipid in diet for rainbow trout (Soler-vila et al. 2009)
  - Ulva, 5% replacement of lipids with Ulva meal in diet for Nile tilapia (Ergün et al. 2008)
  - Gracilaria, Porphyra, Ascophyllum and Ulva, 5-10% of protein in sea bream and sea bass (Mustafa et al. 1995; Valente et al. 2005)
  - Sargassum, Macrocystis et al. in shrimps diet, 10%
- Commercial seaweed meal:
  - OceanFeed™, mixture of several species, 15% inclusion in salmon diet improves colour and lice resistance (Ocean Harvest Technology)

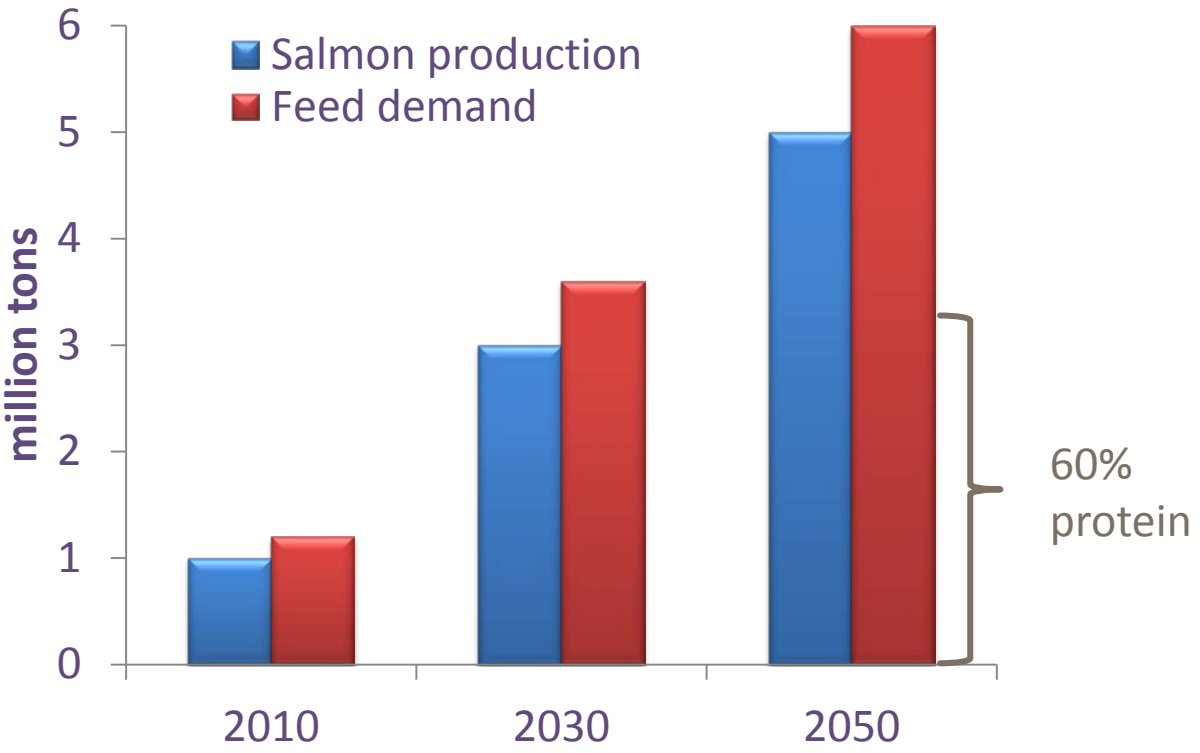
What is the potential?

- 5-15% inclusion of seaweed meal gives beneficial effects (or neutral)

- Higher inclusions of whole seaweed causes problem due to anti-nutrient effects:
  - Polyphenols (lower protein digestion)
  - Heavy metals (arsenic, cadmium, mercury, lead)
  - Kainic acid (neurotoxin)
  - Too high mineral levels

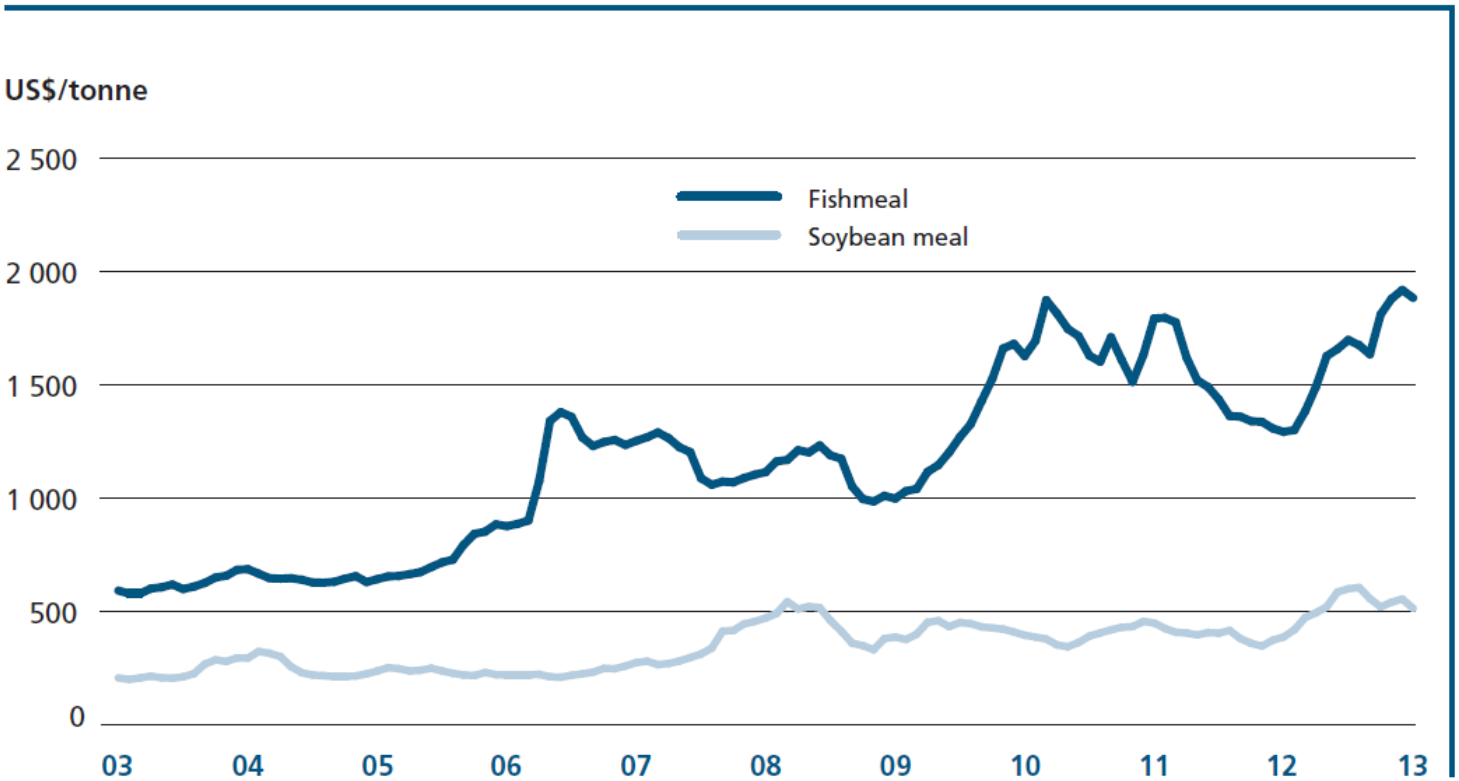
- Bigger replacement possible by using pure components
  - Increased costs – still attractive?

Expected growth in Norwegian salmon production – and in feed demand



DKNVS/NTVA (Olafsen et al., 2012)

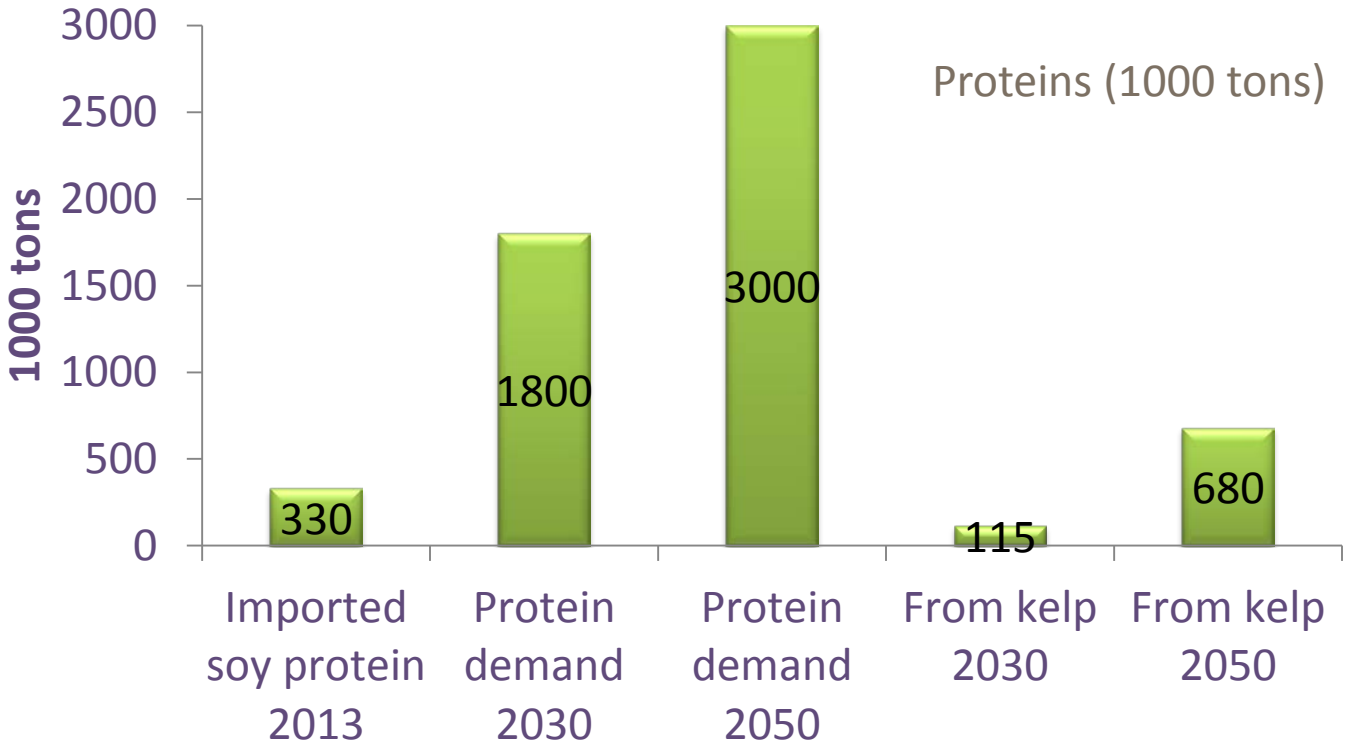
Trends in the price of fishmeal and soybean meal



Source: FAO. 2013. FAO Fisheries and Aquaculture Information and Statistics Branch. Rome.

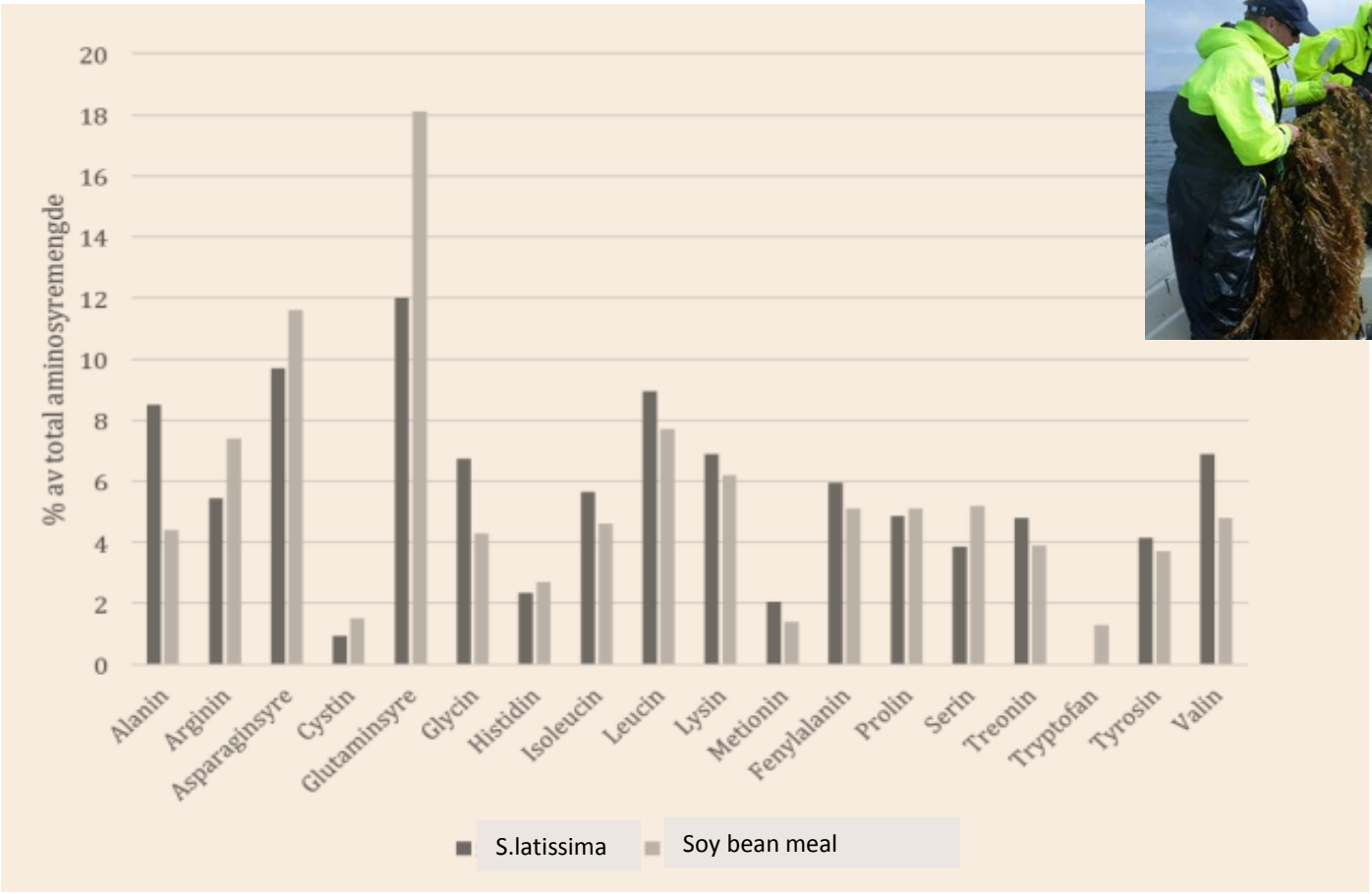
Feed production potential from seaweeds

- 680.000 tons protein from **20 million tons** of seaweed
- Sustainable production
- Increase the degree of self-sufficiency



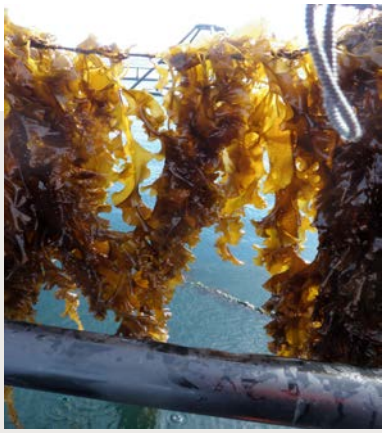
PS: Kelps cultivated in IMTA grow faster, have a higher N content and more protein

Amino acid profiles in seaweed and soy bean meal



Source: Holdt&Kraan, 2011; Experts in Team, NTNU, 2014

Sugar kelp as protein source for salmon feed



Why cultivated biomass?

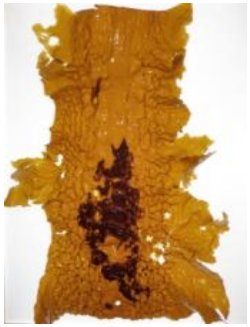
- Large volumes possible (170 tons ha^{-1})
- Environmental friendly, sustainable production of biomass, no (known)negative effect on the benthic ecosystem
- Attractive biomass (composition affected by season and age)
- Effective harvesting and freshness of biomass
- Possibilities for nutrients recycling (IMTA)
- Wide range of species (480 in Norway)
- No use of arable land, fresh water, pesticides or fertilizers

Saccharina latissima:
170 tons biomass ha^{-1} year^{-1}

(Broch et al., 2013)

Area needed for cultivation of 20 million tons:

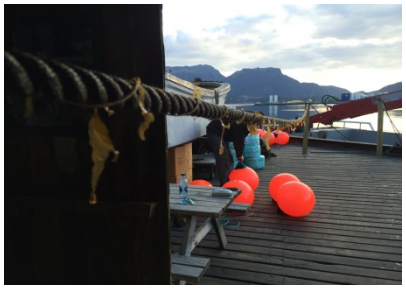
1 200 km^2



From spores to biomass

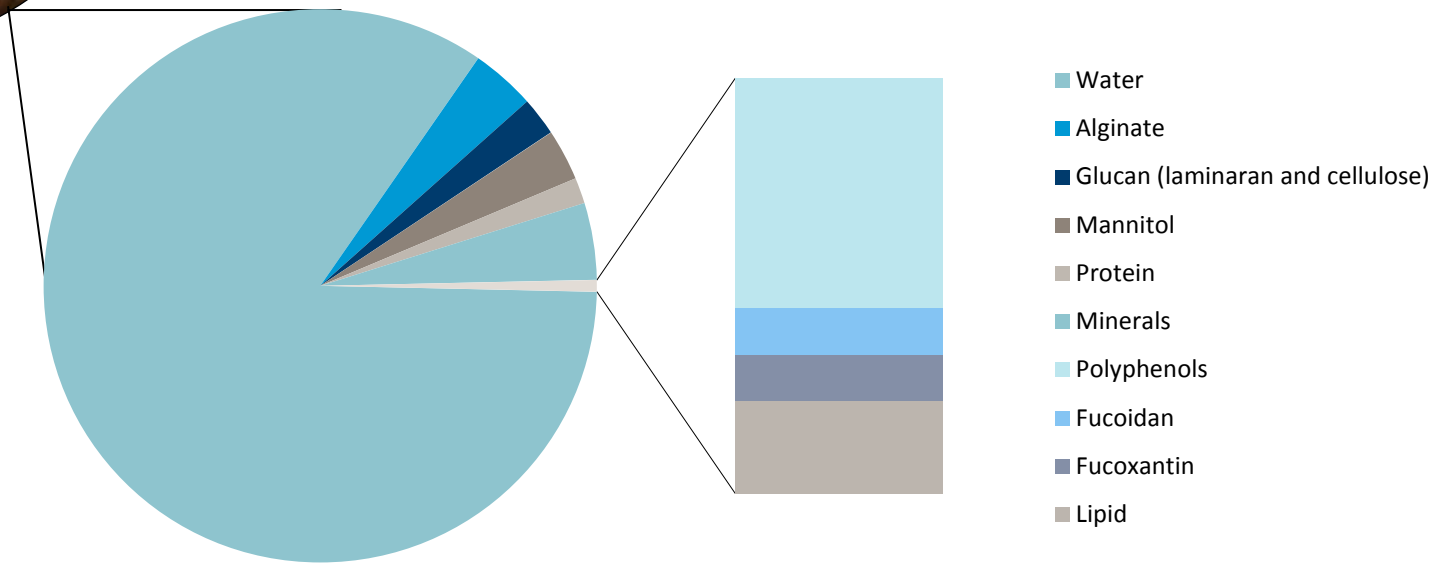





Low-tech

Cultivated macroalgae as feedstock (example: *Saccharina latissima*)



"Biorefinery is a sustainable processing of biomass into several products and energy"

Cultivation

Extraction

Food end feed

- Carbohydrates
- Proteins
- Minerals
- Bioactives

Thermochemical conversion

Hydrothermal conditions

- Biofuels
- Chemicals

Chemical conversion

Water based chemistry

DHMF – (Bis(hydroxmethyl)furan)

Polyuretan and polyesters

Biochemical/-technological conversion

High viscosity

- Biofuels
- Chemicals
- Food and feed

Value chain biorefinery: ~300 Billion $ in 2020

(The World Economic Forum)

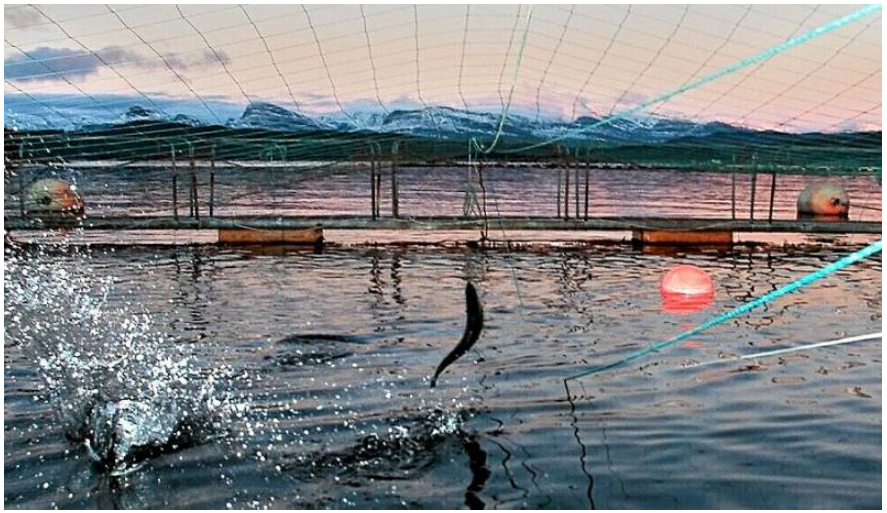
Bio-active compounds in aquaculture feed

Laminaran (β-1,3 glucan) and high-M-alginate

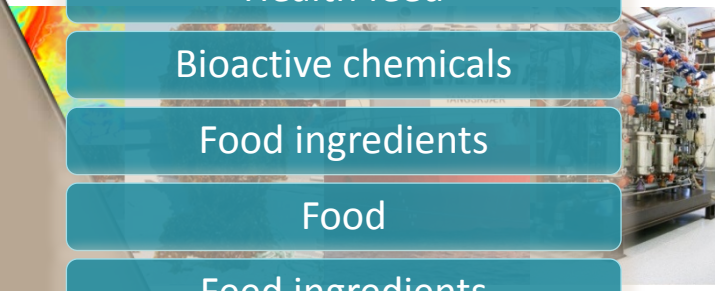
- Immunomodulatory

Pigments: Fucoxanthin, Astaxanthin and Tocopherol

- Antioxidant activity, colour



Seedlings production → Sea cultivation → Harvesting → Pre-treatment, storage → Processing → Distribution → Market



Value

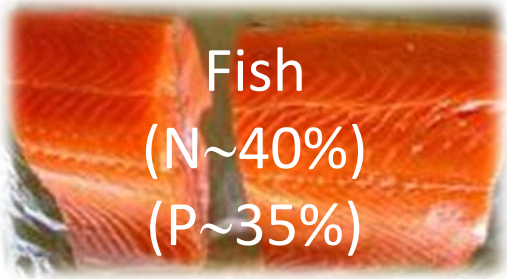
Volume

- Pharmaceuticals
- Health feed
- Bioactive chemicals
- Food ingredients
- Food
- Feed ingredients
- Fertilizers
- Bioenergy
- Platform chemicals

Cycling of nutrients in salmon aquaculture

Integrated multi-trophic aquaculture (IMTA)

Particulate nutrients
(~15% N)
(~44% P)



Dissolved nutrients
(~45% N)
(~18% P)

Wang et al., 2012. Aquaculture and Environment Interactions, *2:267-283*

Challenges

Industry:

- Marked pull
- Immature technology

Research:

- Large variations in productivity (volumes)
- Large variations in chemical composition
- Footprints

Potential

1 ha (0.01 km^2) cultivation area:

- 170 tons biomass sugar kelp (wet)
- 26 tons dry matter
- 15 tons carbohydrates
- 3.8 tons protein

Thanks to SINTEF for the priority project 'Biobased products from sustainable resources (seaweed)'

Thank you ☺