UPSCALING IMPLEMENTATION OF BIOREFINERY AND IDENTIFICATION OF MARKET BARRIERS

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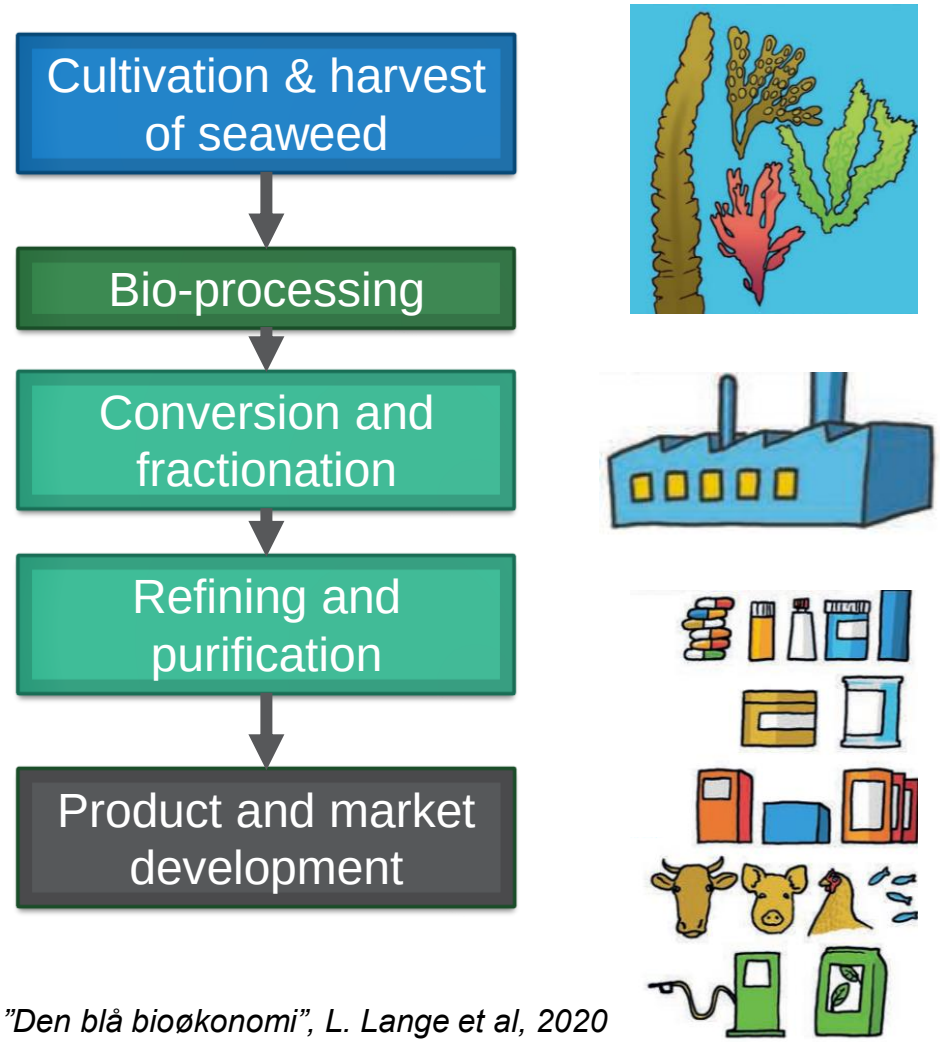
MacroCascade Final Conference

The critical path

- Sustainable biomass providing reliable supply in sufficient volume
- Cost effective processes
- Competitive products

….and focus on “Scaling up the low hanging fruits”!



Source: Illustrations from ”Den blå bioøkonomi”, L. Lange et al, 2020

Feasbility of replication of MACR

Three environmental conditions:

- Water depth → 30-150m
- Sea temperature → maximum 15 C
- Nutrient availability → minimum 3 µM

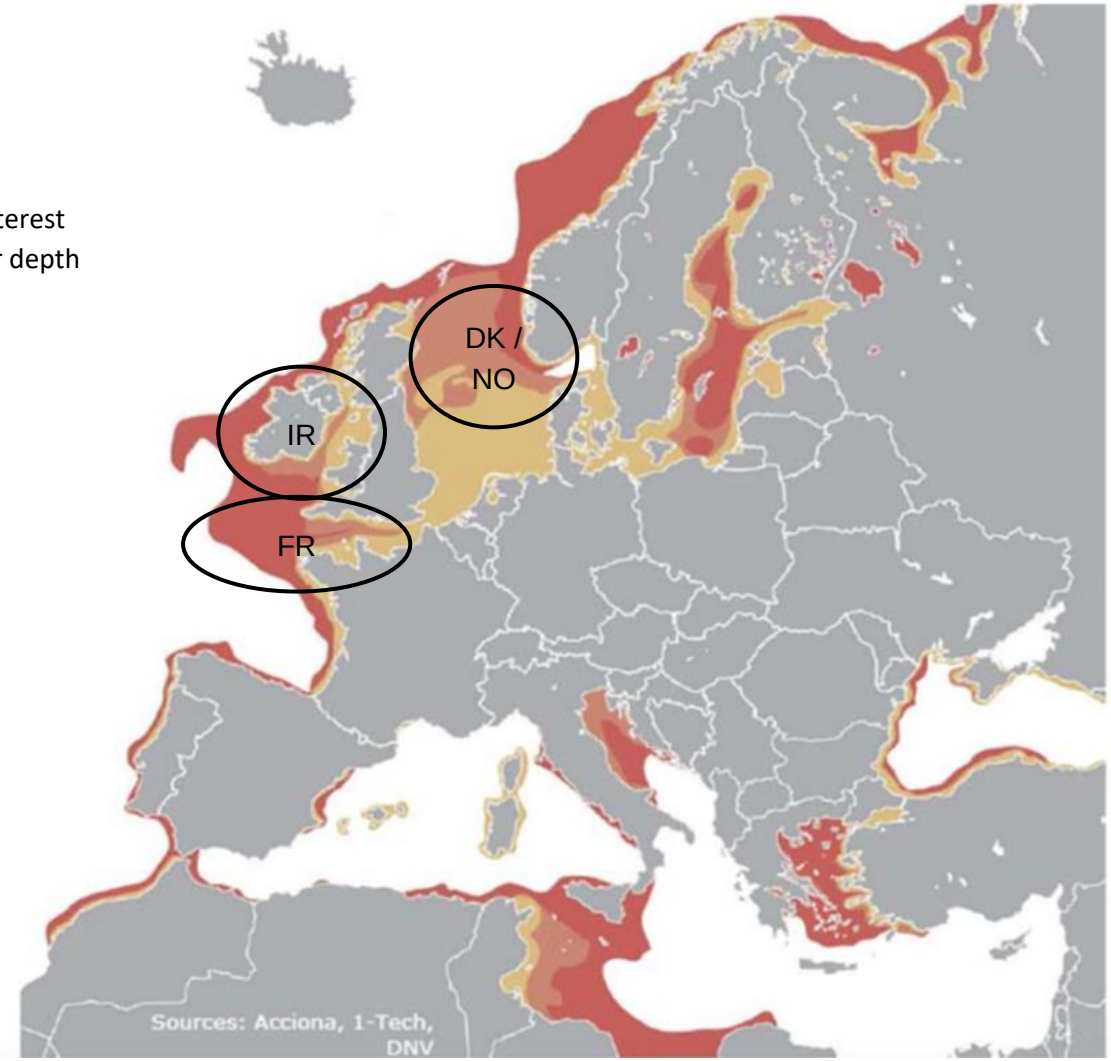
Sea depth around Europe.

= areas of interest due to water depth

DK = Denmark

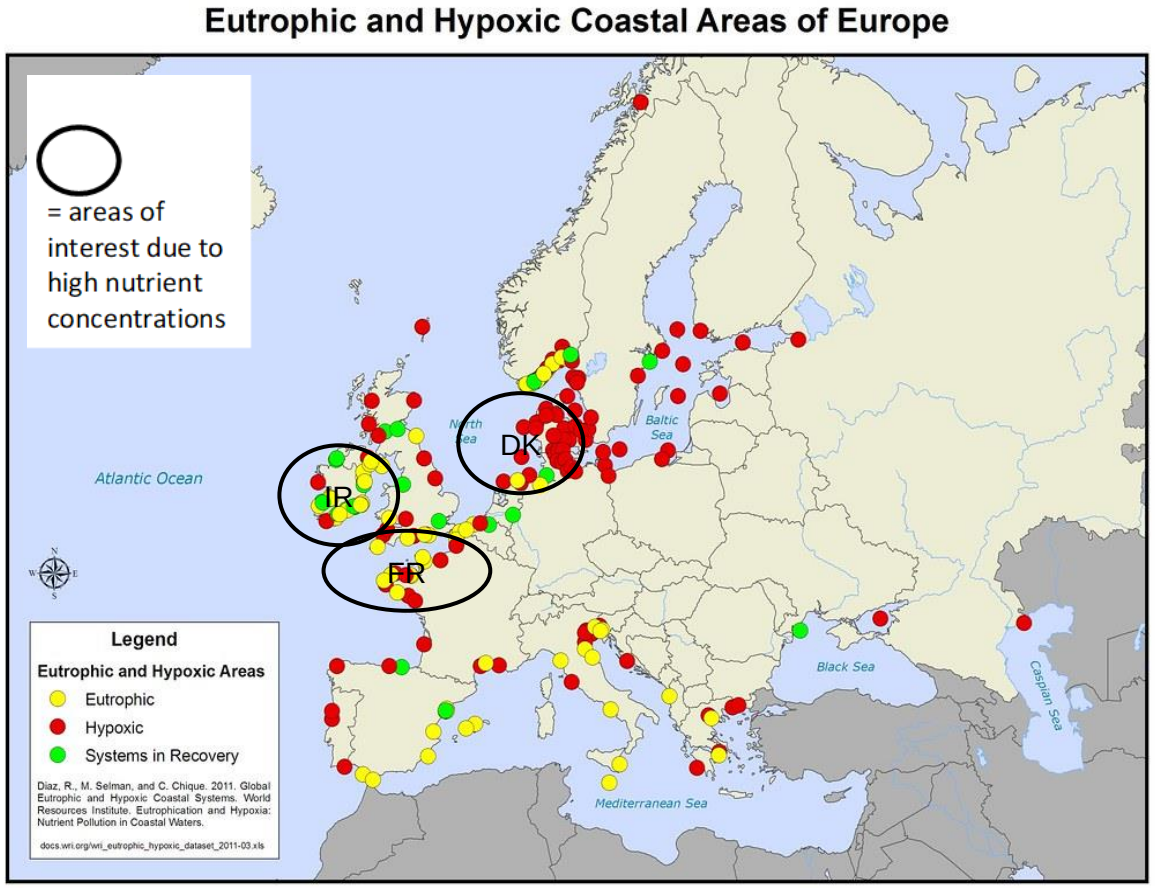
IR = Ireland

FR = France



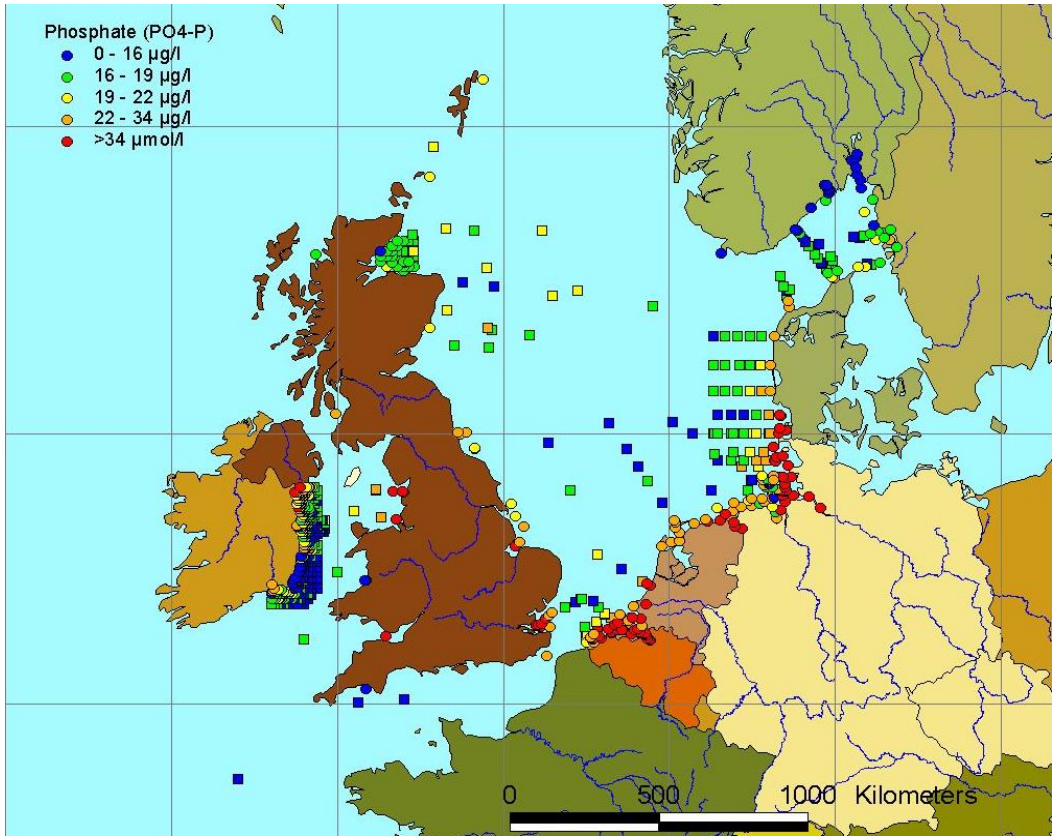
Source DNV-GL, 2014 via Carbon Trust, Floating Offshore Wind:Market and Technology Review 2015.

Nutrient supply in Europe



Eutrophic and hypoxic coastal areas of Europe.

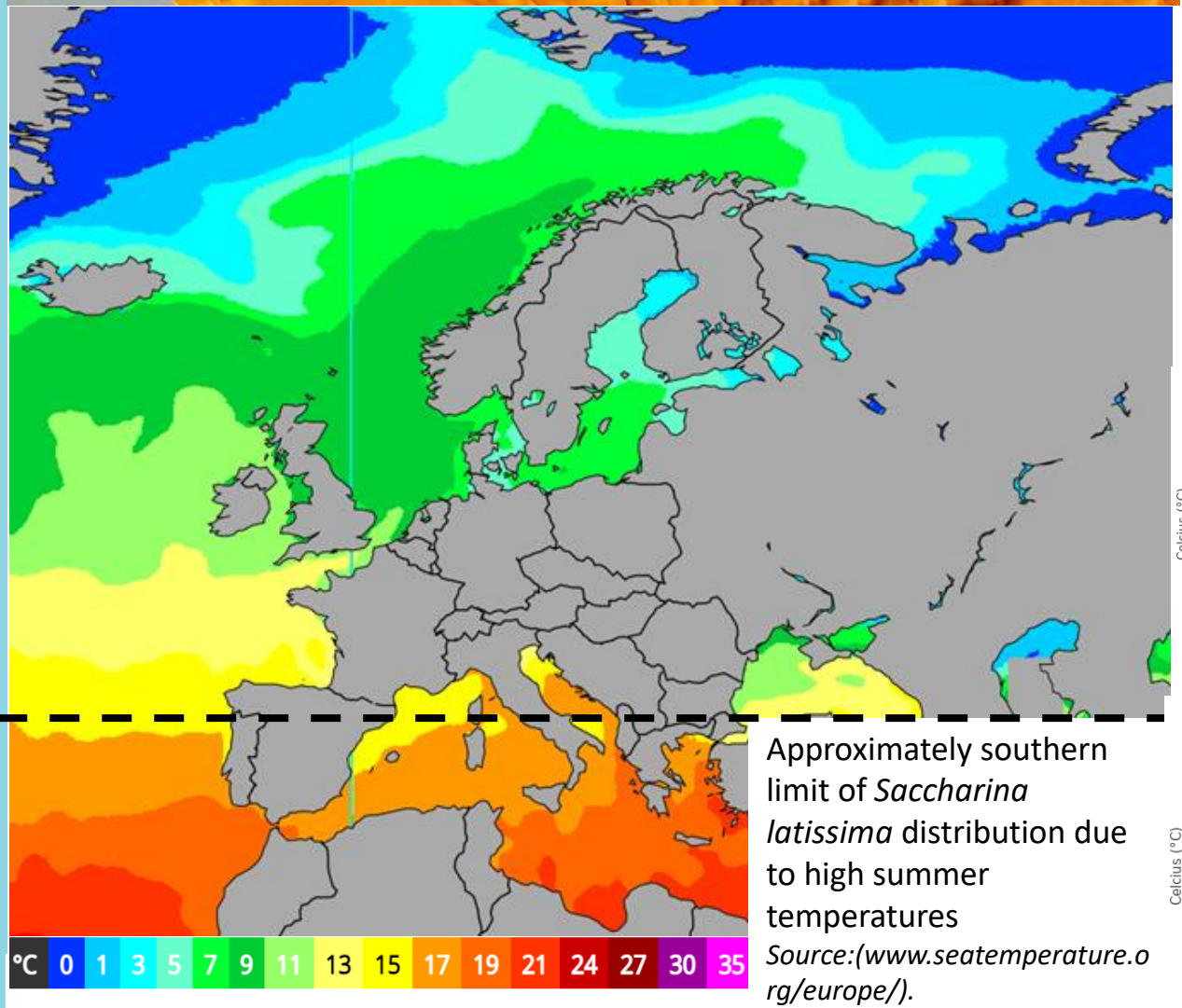
Source: https://www.eea.europa.eu/



Phosphate in the sea around Denmark, Ireland (and France)

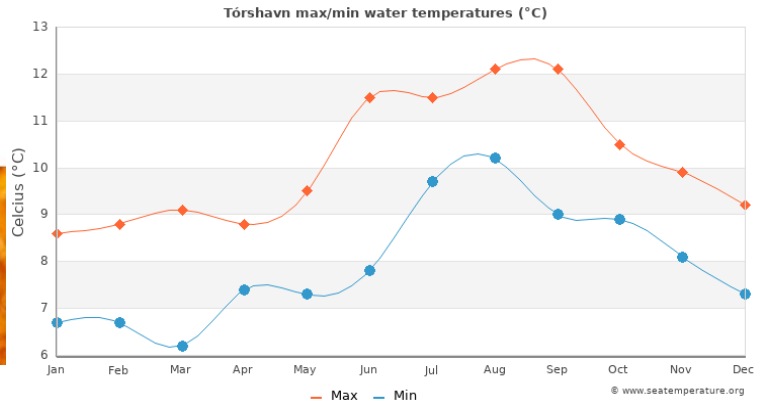
Source: . https://www.eea.europa.eu/

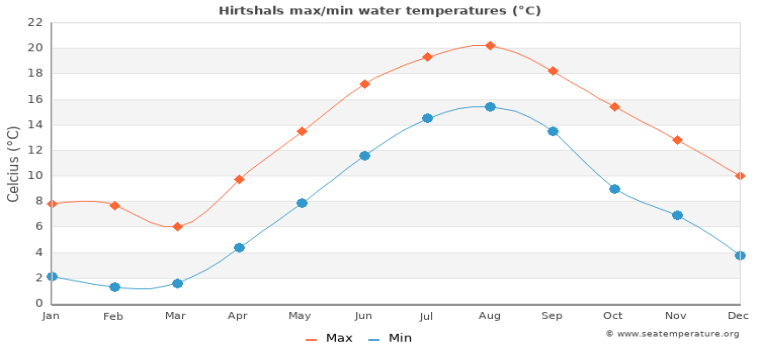
European Ocean temperature

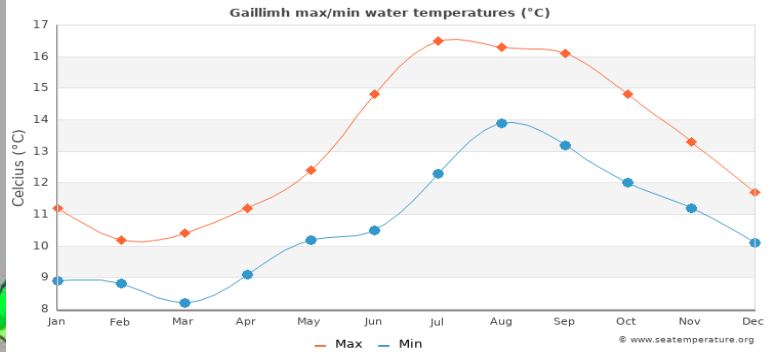


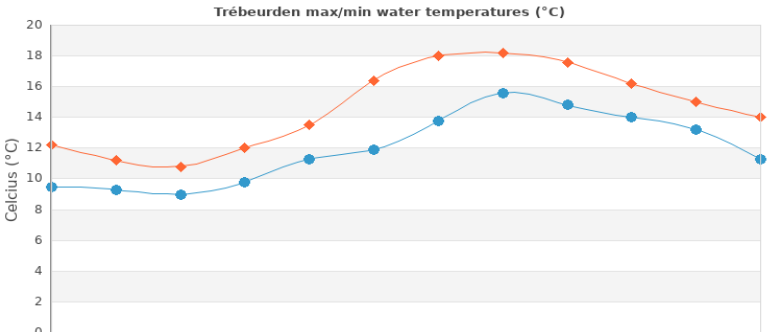
Approximately southern limit of *Saccharina latissima* distribution due to high summer temperatures

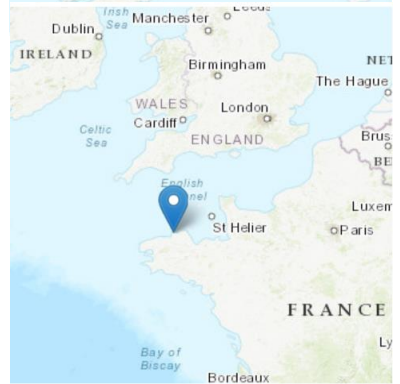
Source:(www.seatemperature.org/europe/).







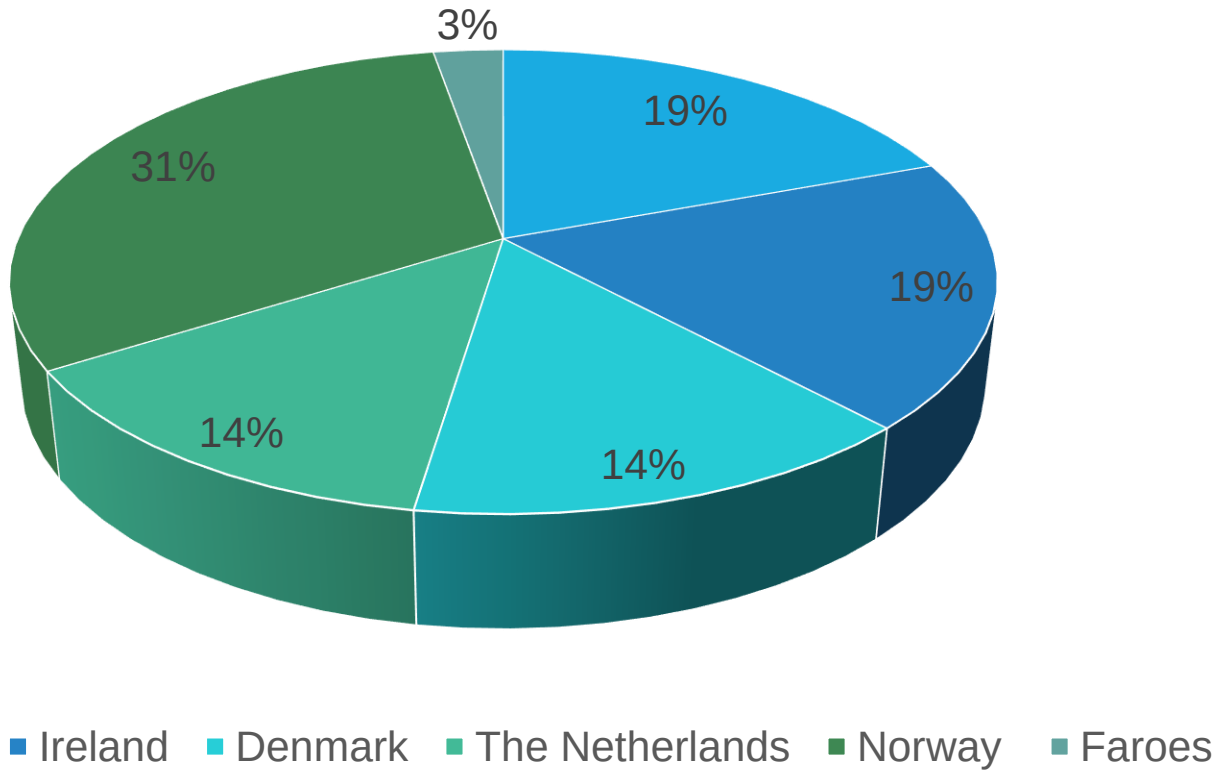




Biomass potential

- Based on the species *S. lattissma*,
  - Area: 30-150m dept
  - Cultivated on a ”standard” MACR rig
  - Yield: 4kg/m/year (wet weight)
  - or 30 tons ww/year/ha
- Potential total area: 28 Mio. ha
- Potential has to be reduced due to:
  - Fishing
  - Offshore energy
  - Shipping routes
  - Protected areas
  - Sites with other activities (military, sailing routes, tourism etc.)
  - Sites near cities etc.

1% utilisation of potential area for seaweed cultivation = 8,4 Mio. tons/year



Harvest & process strategy

Proven harvest periods											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Sep	Oct	Nov	Dec
France											
Ireland											
Denmark											
The Netherlands											
Norway, south											
Norway, west											
Norway, north											
Faroe Island											
Potential processing strategy											
Conversion & fractionation into storage stable intermediates											
Refining & purification into final products											

Other issues on implementation:

Conversion/fractionation unit:

- Fixed on one location?
- Land-based & mobile between farms?
- Floating producing vessel?

Collaboration between farms:

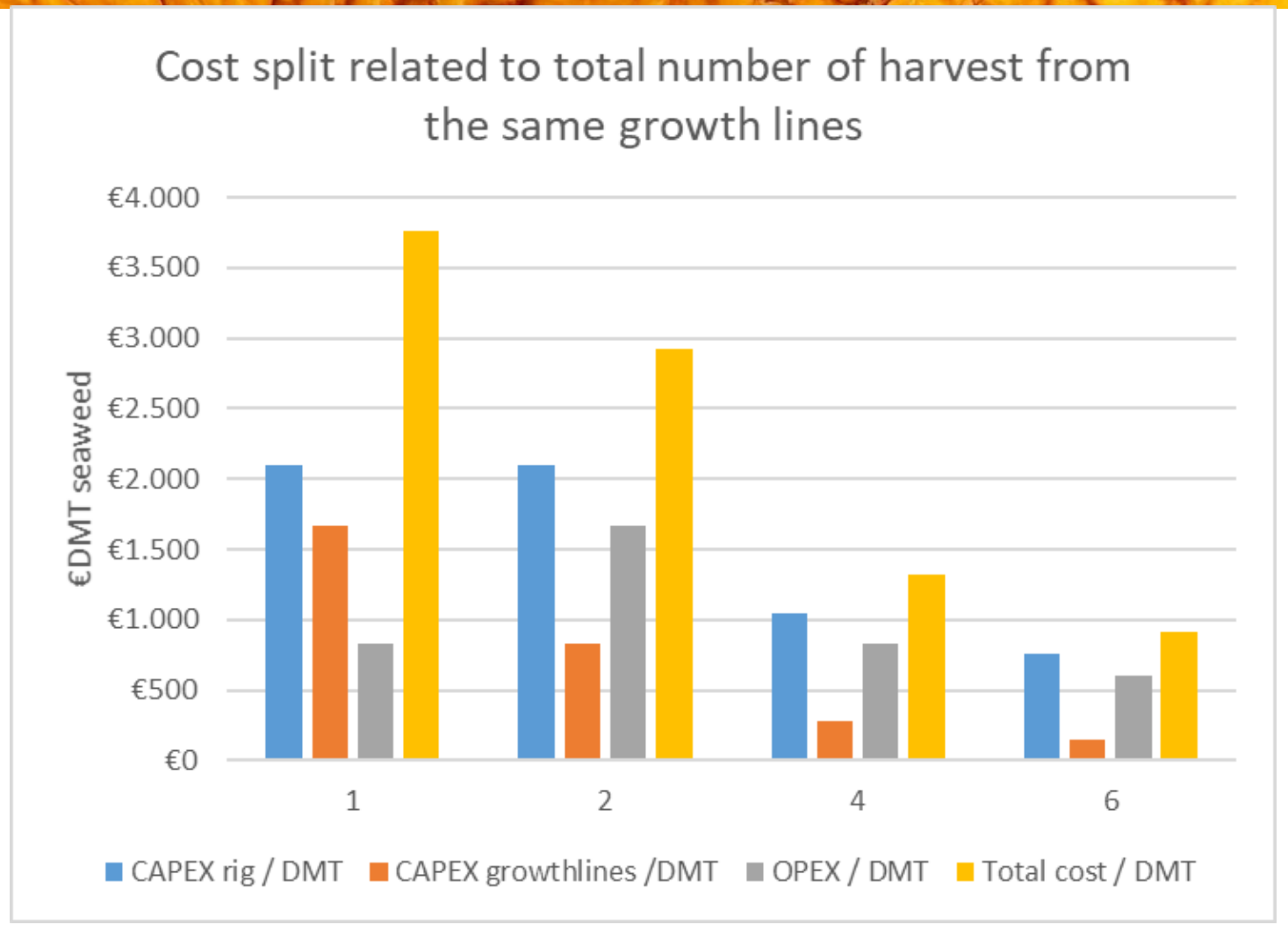
- Cooperate on supplies to the same processing unit?

Logistics etc.:

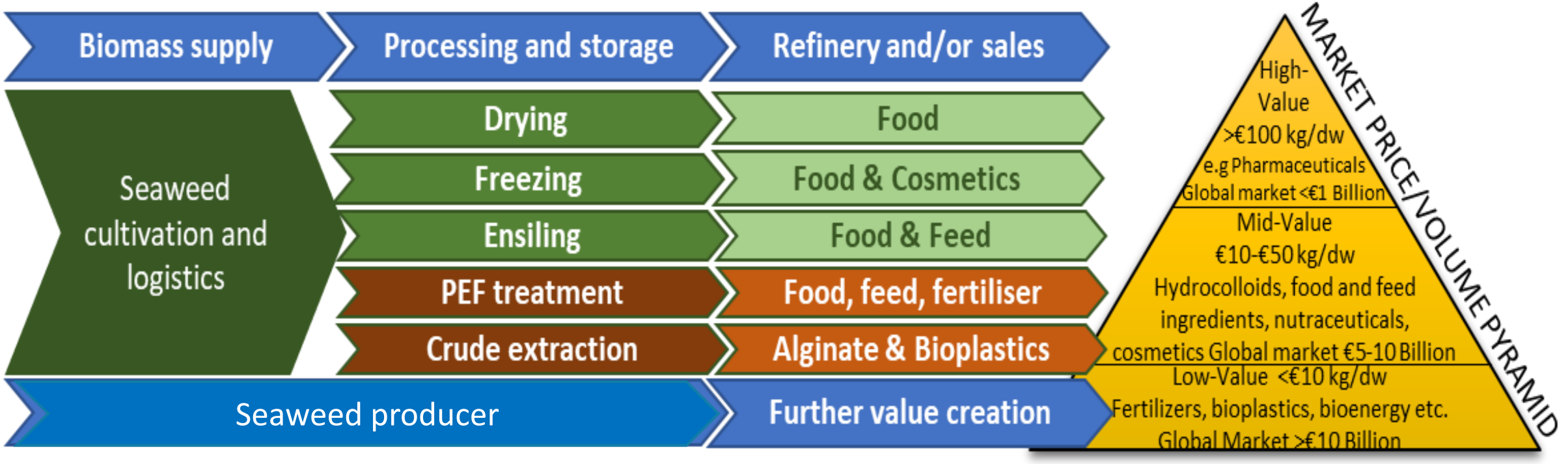
- Transportation time
- Cost of energy
- Human resources with skills & competences

Illustration of cultivation cost

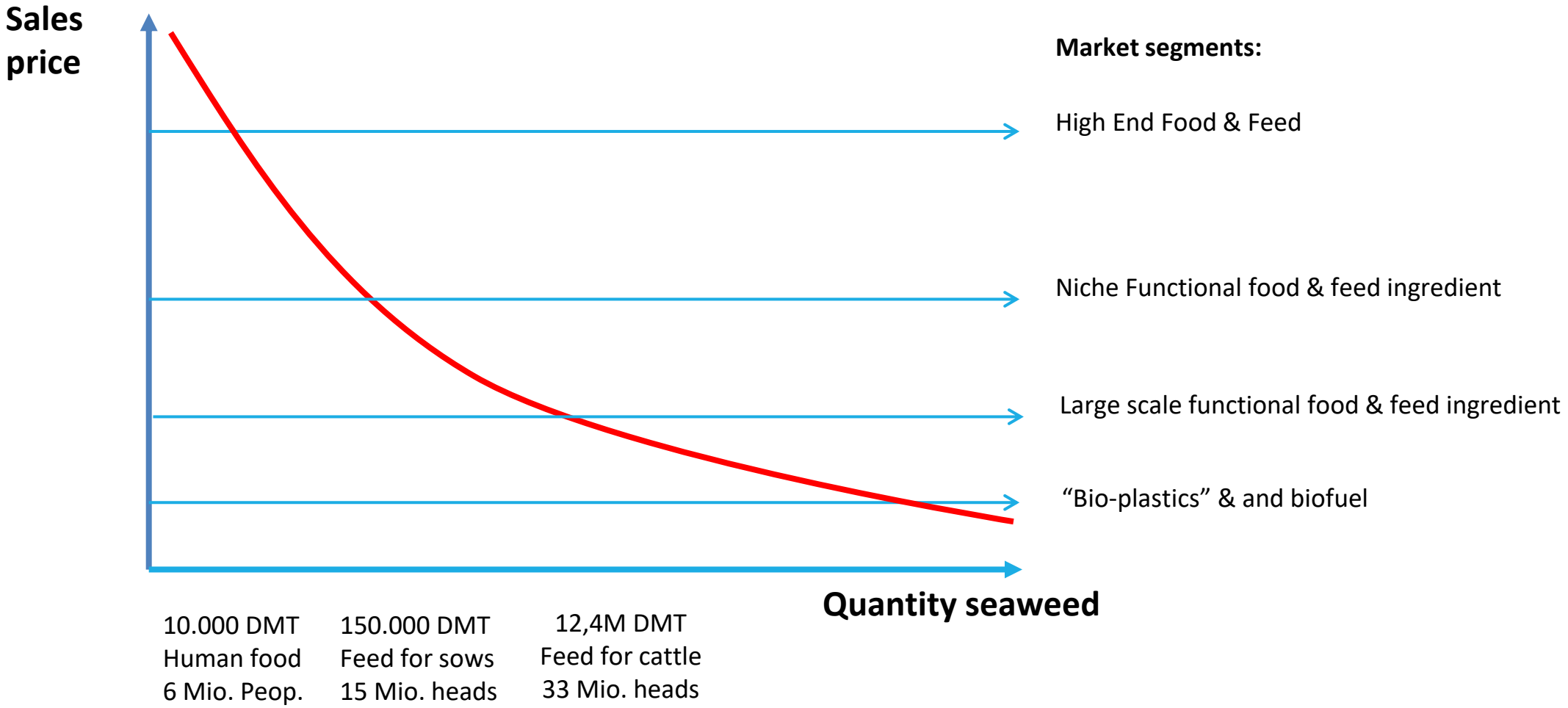
Based on numbers from Ocean Rainforest 2017



Seaweed value chain



The challenge of upscaling vs. market segments



Microbioal refinery: Fermentation

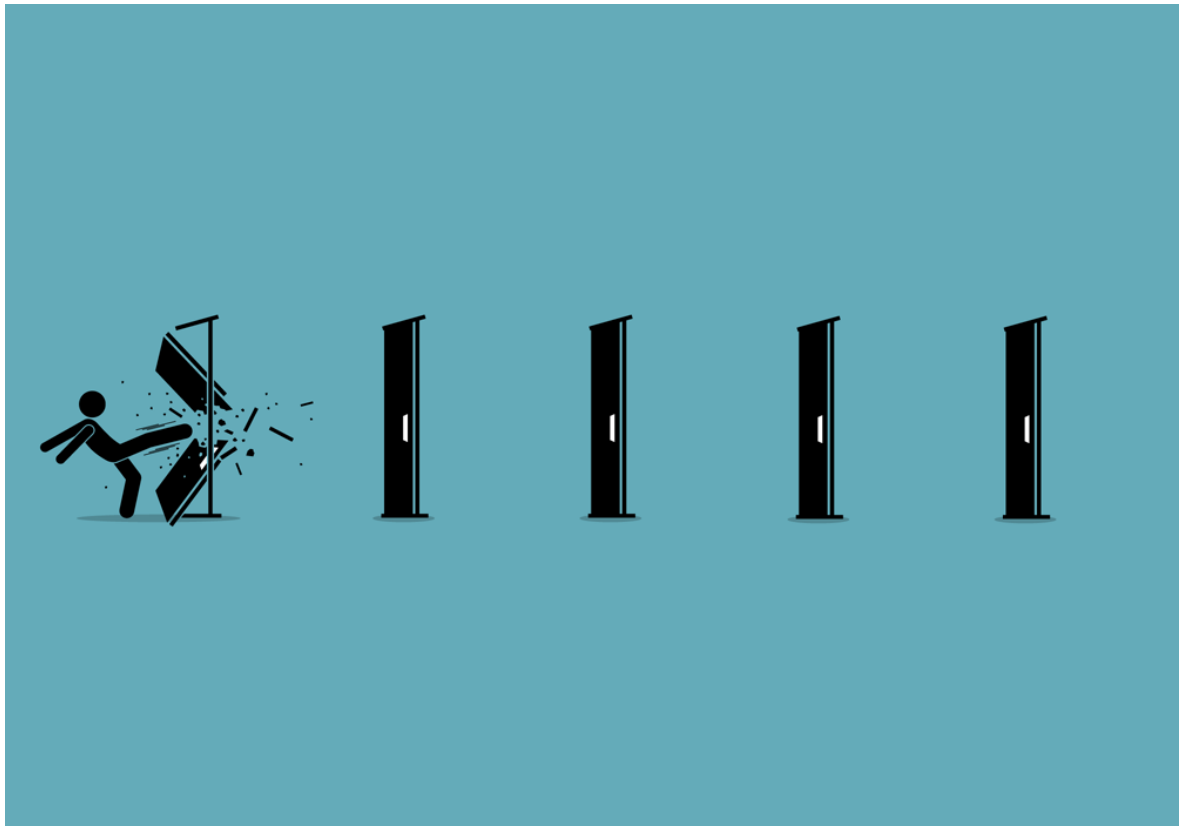
Strengths	Weaknesses
• Cost-efficient production • Can contain 80-90% water. • Proven pre- and pro-biotic	• The functional fermented product is new in the market • Need to conduct market development • Need to document product claims. • Still unknowns concerning optimized functionalities of the ensiling/fermentation process.
Opportunities	**Threats**
• Enormous market opportunities within feed additives. • Market segments: Pigs, Broilers, Salmon, Cattle • Value proposition: increased health and productivity + reduction of methane emissions. • Similar healthy functionality to existing stable food products for humans.	• Slow market uptake • Lack of valorisation of the methane reduction. • The fermented seaweed must be mixed with canola or similar vegetable product to achieve the desired functionality. • The final product must be dried in most cases and therefore requires access to large-scale drying equipment.

Cascading biorefinery

Strengths	Weaknesses
• A successful cascading biorefinery can produce high, medium, and low-value products for different market segments • Obtain full utilisation of the biomass. • Use enzymatic extraction methods to target specific functionalities in product applications	• No seaweed biorefinery has been demonstrated with a production of >5 tons wet weight per day. • A commercial plant will require 50-200 tones (ww)/day, operating 24/7, with a minimum operation of 200 days/year.
Opportunities	**Threats**
• Process large quantities of seaweed • Sustainable production process (based on a low temperature and enzymatic processes) • Can use fresh seaweed biomass • In parallel ensilage for post-harvest processing.	• Complexity of the biorefinery processes • CAPEX to establish the production setup • Risk for the commercial success of the operation. • A potential lack of reliable fresh biomass represents an OPEX risk.

Main market barriers

- Iodine content (especially food market)
- Lack of differentiation between in-organic and organic arsenic
- Premature requests on certification programs
  - Costly for start-ups
- Lack of valuation of Ecosystem Services
- License framework and marine spatial planning
  - Delays commercial up-scaling for reliable supply



Conclusion

- Sufficient ocean area to supply large scale seaweed processing in Europe
- Several harvests from the same seeded line improves cost-efficiency significantly – along with mechanization of harvest systems
- Important to identify product and market segments and suitable pathways into the market
- Scale up low hanging fruits with microbial refinery (fermentation)
- Pilot scale biorefinery to prove commercial methods & products
- Address market barriers to prevent hinderance of industry development

Acknowledgement

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https://www.macrocascade.eu/