

Seaweed farming in Norway: Blue Carbon and Blue Economy perspectives

By Kasper Hancke¹ and Jorunn Skjermo²

¹Norwegian Institute for Water Research (NIVA)

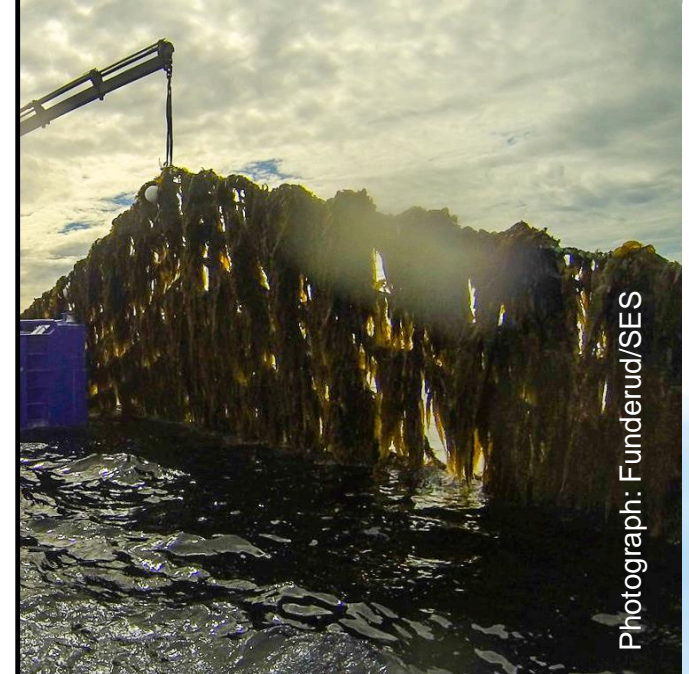
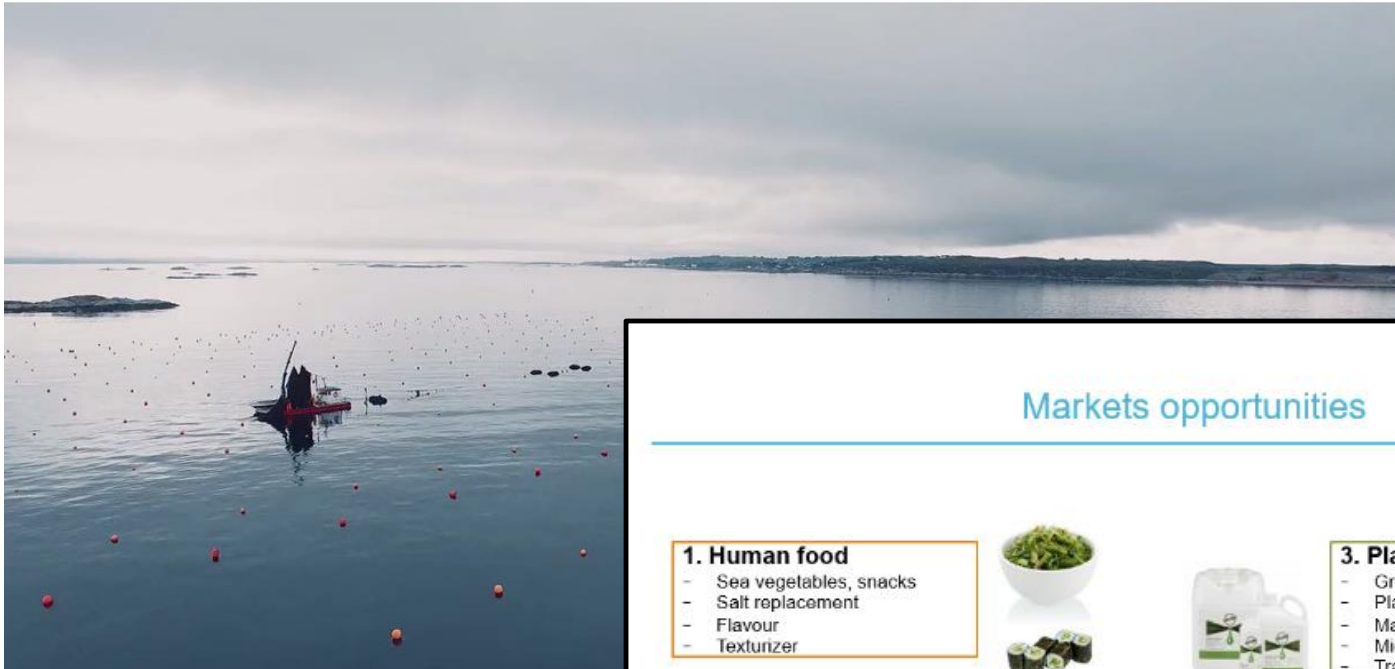
²SINTEF Oceans

BCI workshop, Copenhagen, 11. September 2019

the
**BLUE
CARBON**
initiative

Contact: kasper.hancke@niva.no

Seaweed farming and market opportunities



Photograph: Funderud/SES

Markets opportunities

1. Human food

- Sea vegetables, snacks
- Salt replacement
- Flavour
- Texturizer



2. Health & nutrition (humans and animals)

- Gut health (fibers, prebiotics)
- Immune stimulation
- Anti-oxidants
- Anti-inflammatory
- Anti-biotic
- Protein
- Vitamins
- Minerals
- Fatty acids
- Skin health (cosmetics)
- Animal fur and mucus health
- Pharmaceuticals/bioactives



3. Plant health & nutrition

- Growth promoters
- Plant defense
- Macronutrients (N, P, K)
- Micronutrients (Fe, Ca, Cu)
- Trace elements



4. Specialty chemicals

- Alginate, carrageenan, agar
- Alginate derivatives
- Mannitol and derivatives
- Bioplastics, fiber, textiles
- Minerals



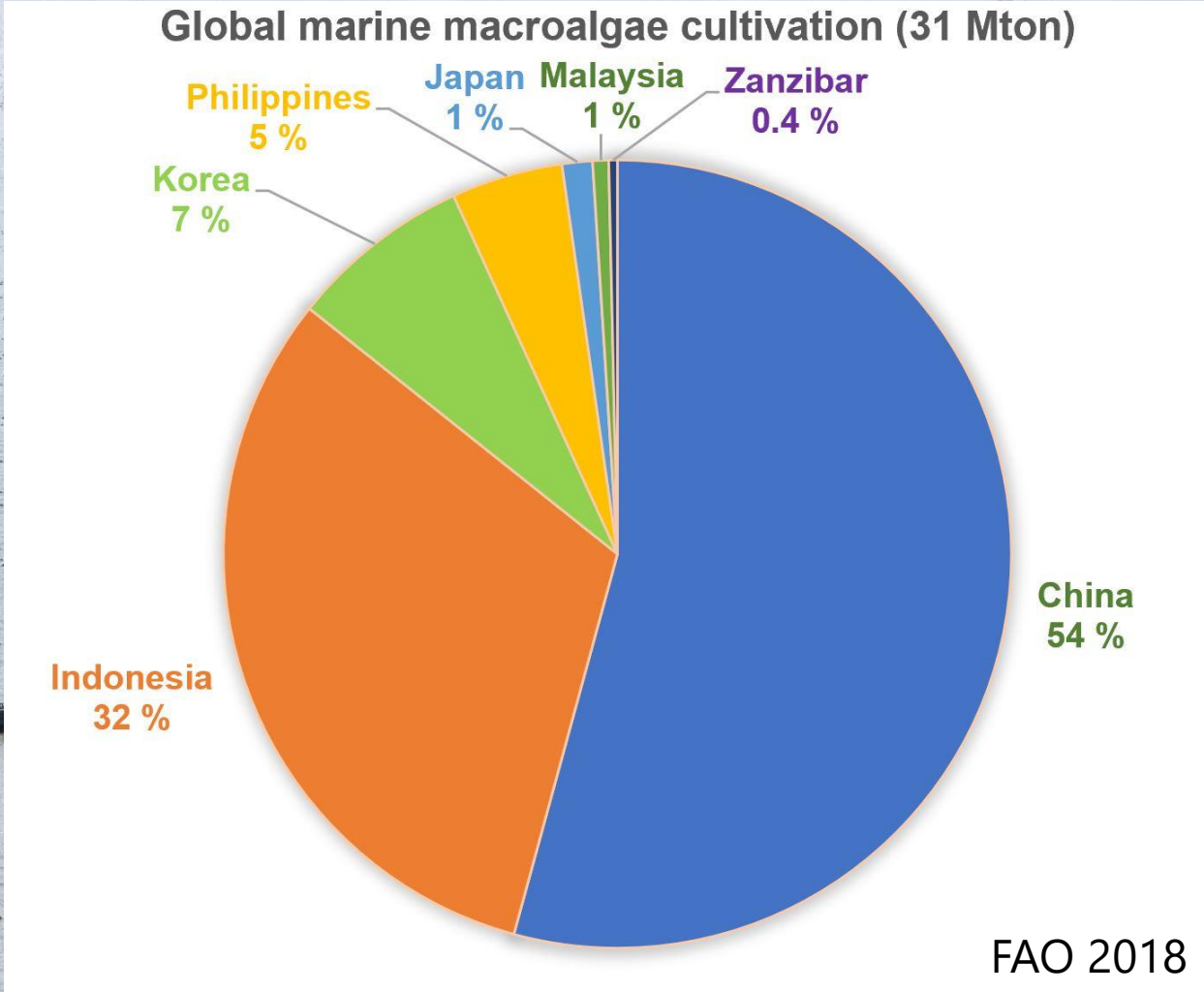
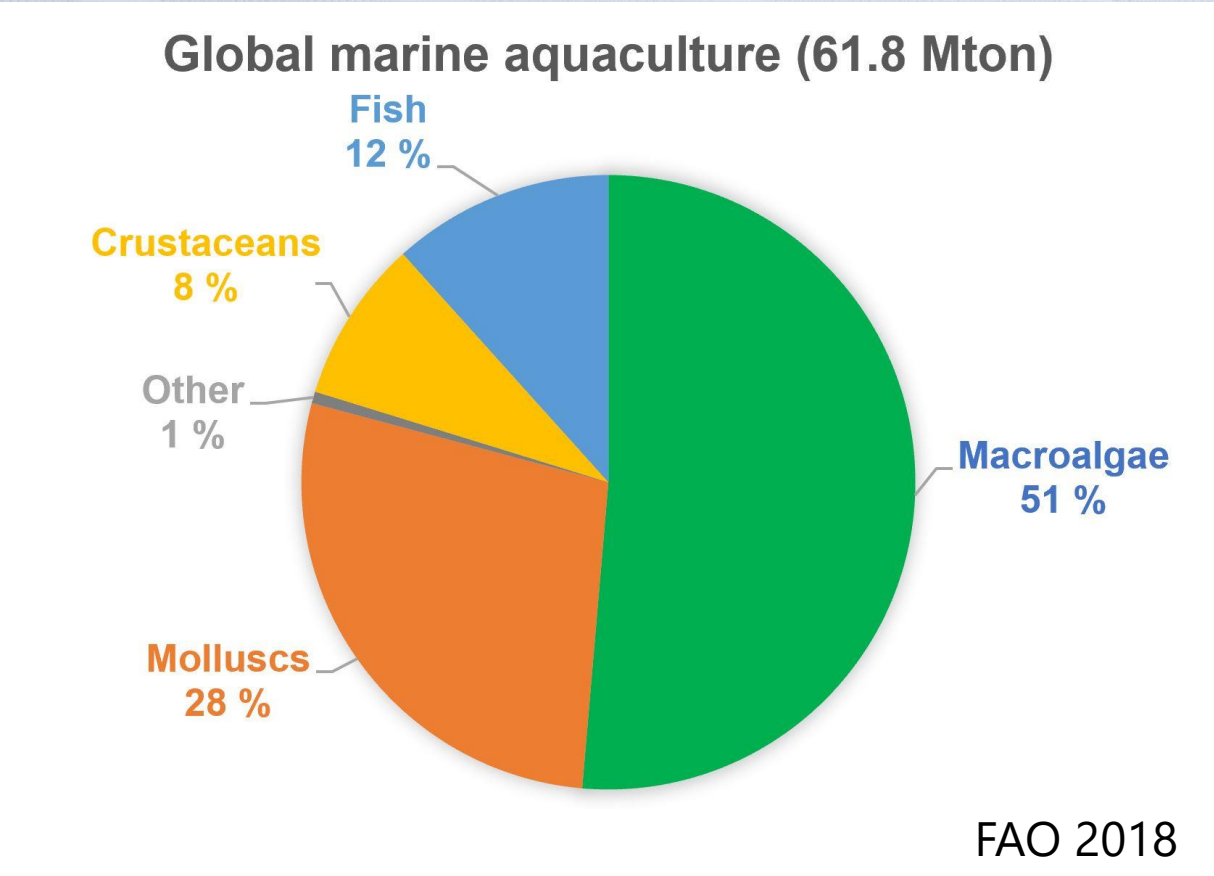
5. Industrial fermentation

- Biofuels
- Biochemicals
- Single cell protein (SCP)

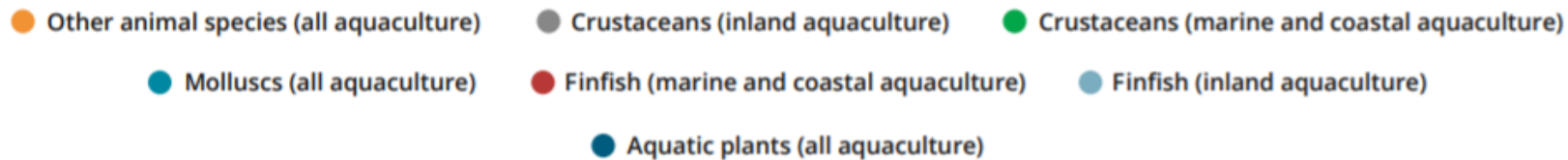
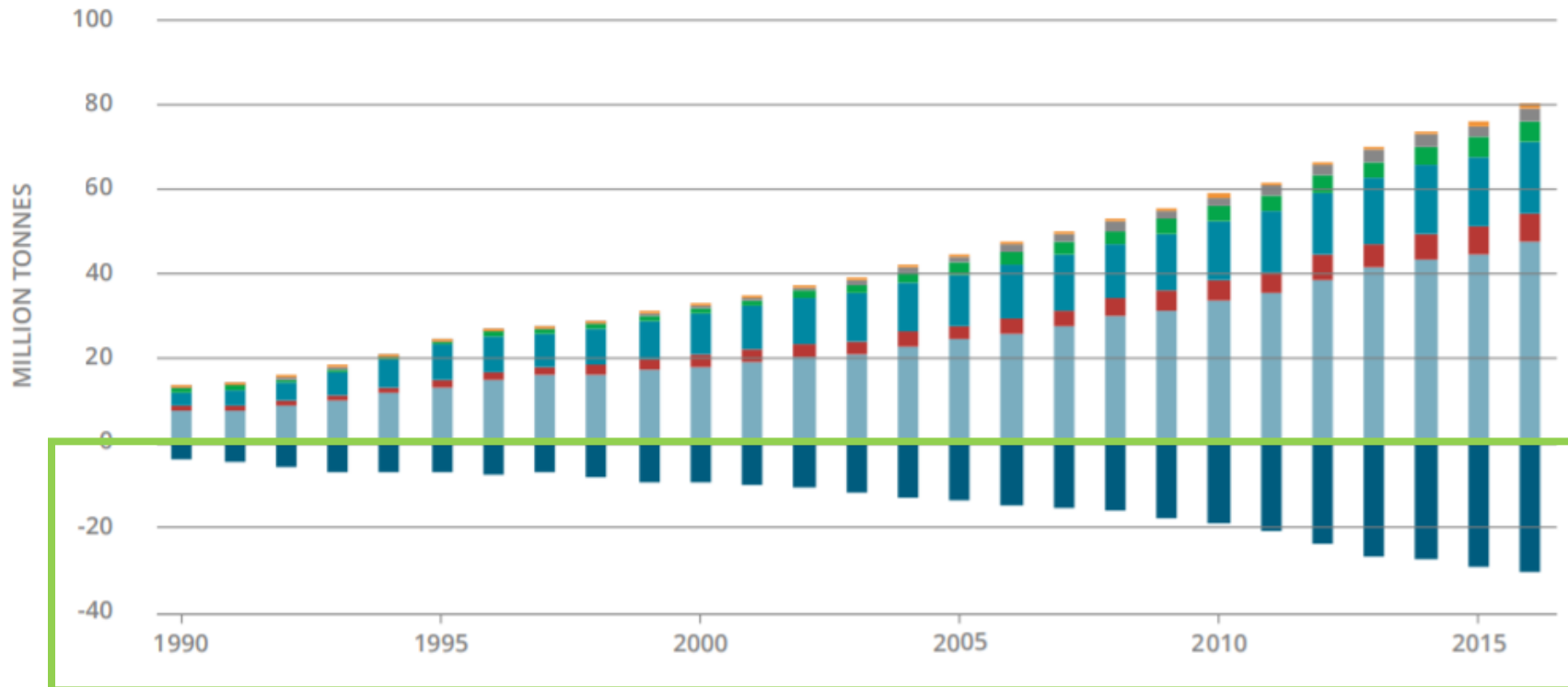


Source: SES presentation 2016

A global perspective on seaweed farming



World aquaculture of food fish and aquatic plants, 1990-2016



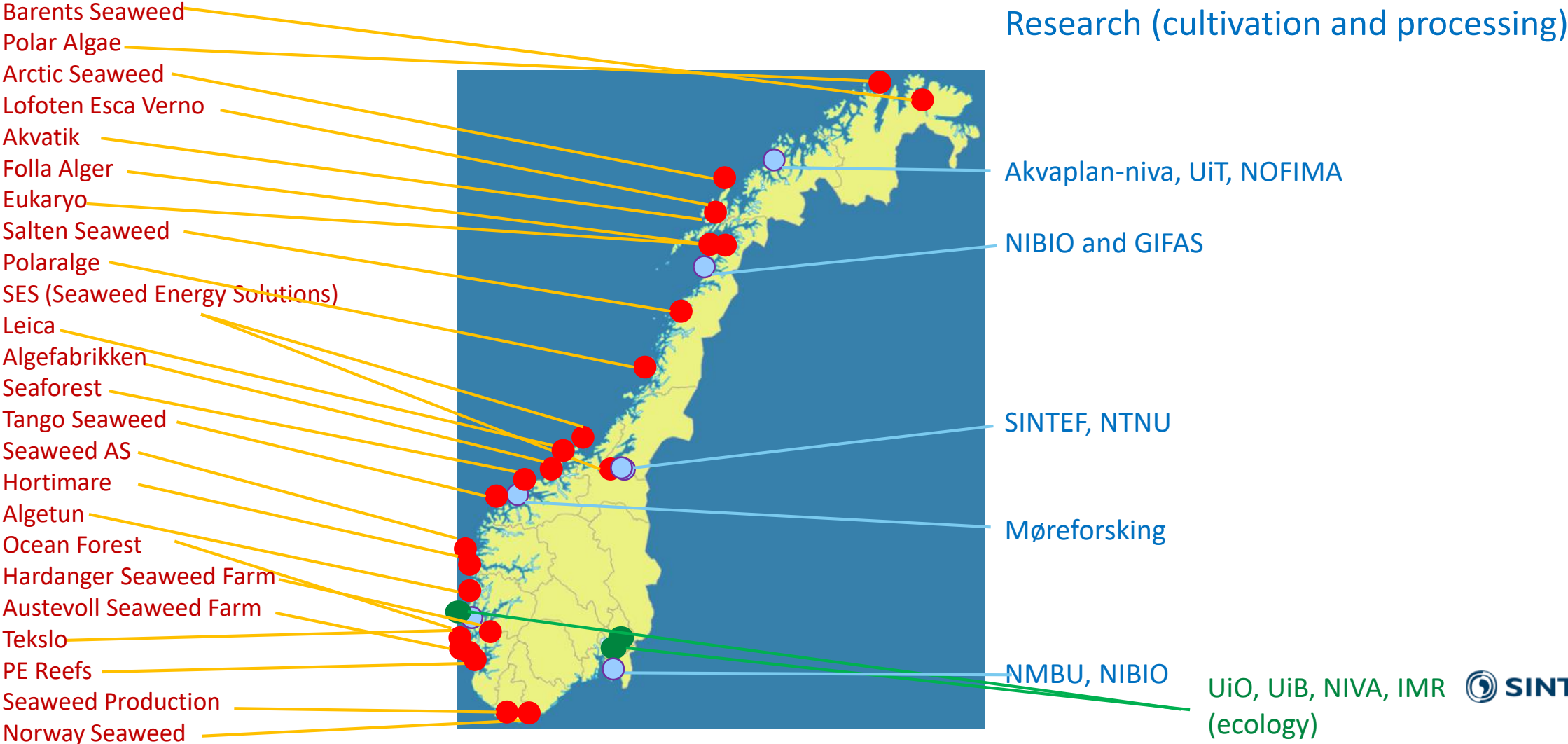
FAO 2017

Globally (2018)

- 32 mill tons
- 14 bill USD
- 7-9% annual increase

Seaweed industry and R&D in Norway

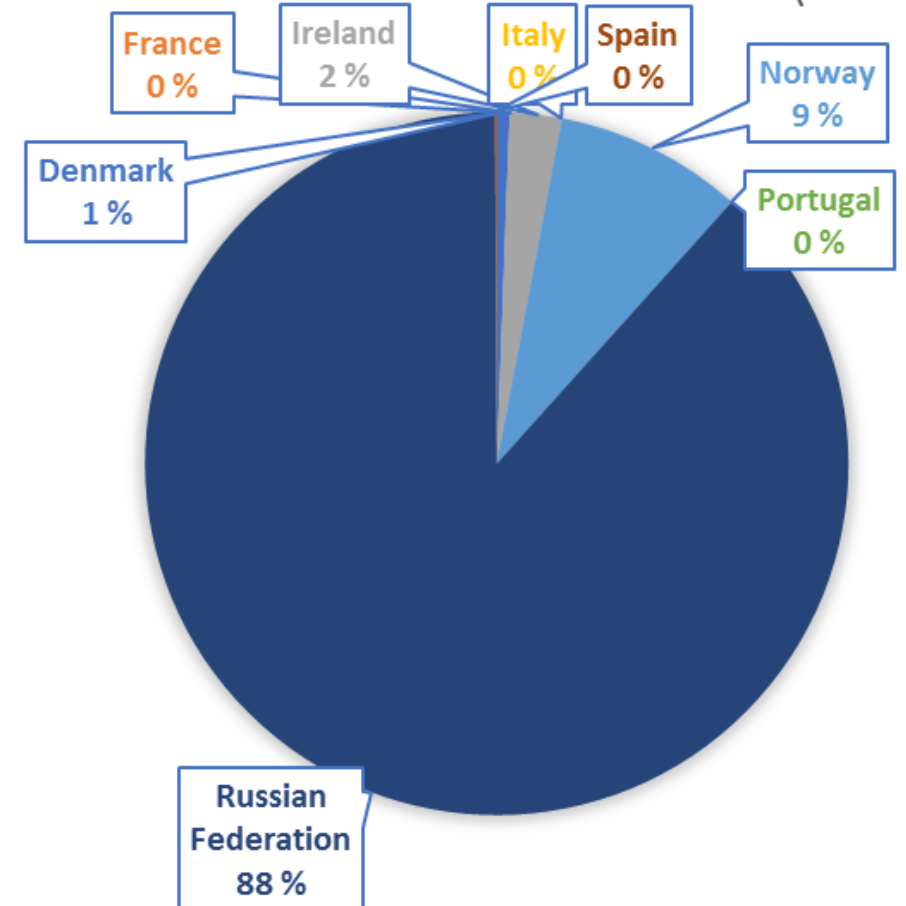
- 29 companies, 264 licenses
- 15 companies with ongoing operations



Norway

- Norway produced 148 tons (2017),
- Cultivation efficiency is 20 to 200 ton/ha

EUROPEAN MACROALGAE CULTIVATION (1500 TON)

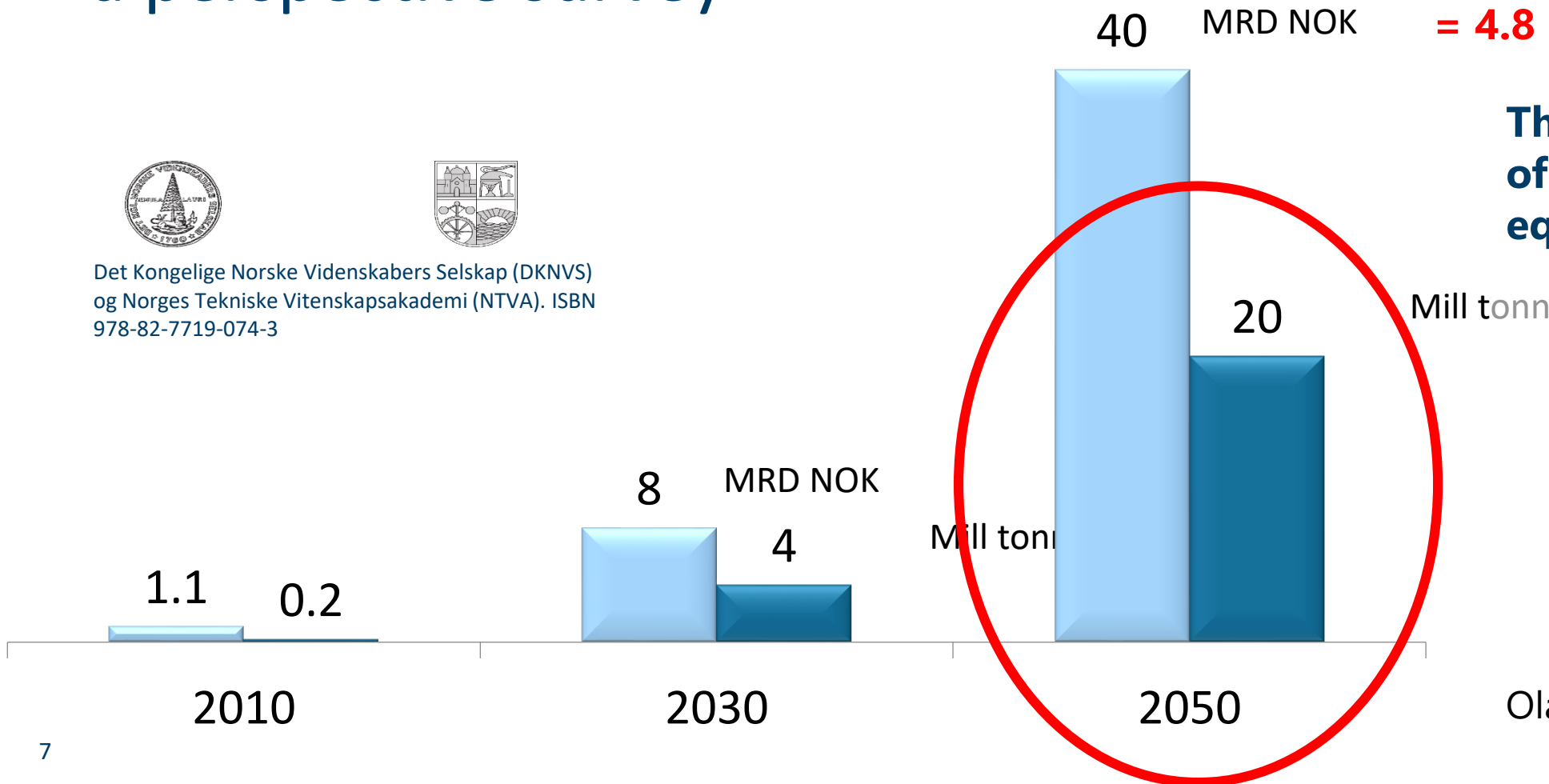


FAO 2018, SINTEF OCEANS

Perceptive of the Norwegian seaweed industry towards 2050 – a perspective survey



Det Kongelige Norske Videnskabers Selskap (DKNVS)
og Norges Tekniske Vitenskapsakademi (NTVA). ISBN
978-82-7719-074-3



= 4.8 bill USD

This requires an area of 2000-3000 km², equivalent almost to

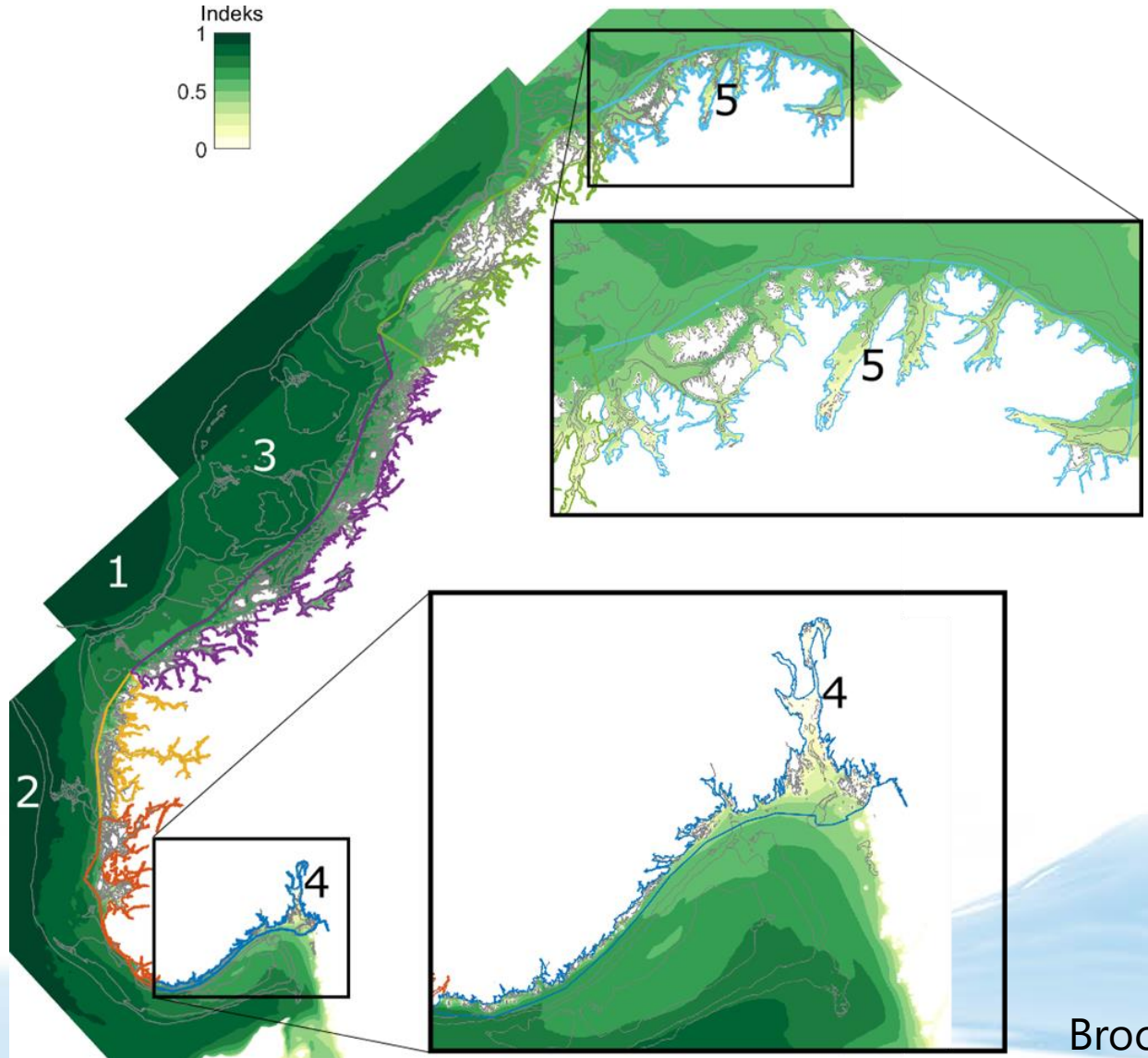
- 22 – 35 cities of Copenhagen, or
- 33 – 50 times the size of Manhattan Island

Olafsen et al. 2012

Cultivation potential in Norway

Cultivation potential is modelled for the Norwegian coast.

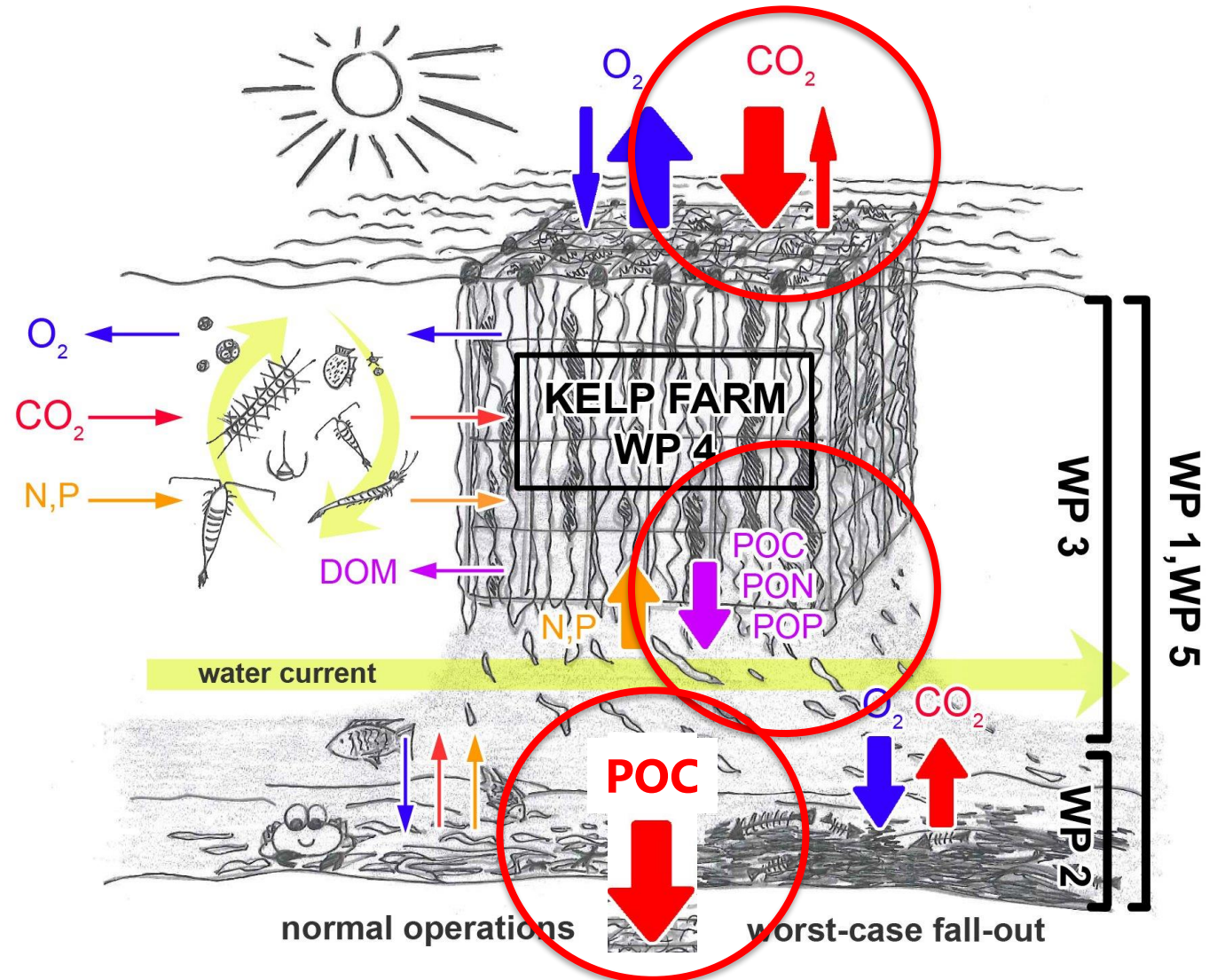
Conc: coastal is good, off-shore better, that is where large biomass can be cultivated (>>mill ton)



Broch et al. 2019

Mechanisms of C sequestration in seaweed cultivation

- CO₂ drawdown by seaweeds, building biomass (photosynthesis)
- Carbon export from cultivation sites by erosion of biomass (30-60% of harvested biomass)
- Exported C/biomass to the coastal region and deep sea



Fieler et al. in prep
Zhang et al 2018

Hancke et al. In prep.

SEAWEED FARMING AND CLIMATE CHANGE

MITIGATION VIA:

Ongoing processes:

C-sequestration

via export of “unseen” production

Food production

with reduced CO₂ foot print

Future potentials:

Bioenergy production

substituting fossil fuels

Reduction of methane emission

via seaweed feed additive to ruminants

Stimulation of land-based production

via seaweed biochar soil amelioration & seaweed prebiotic health benefits to livestock

Climate benefit of circular nutrient management

Via avoidance of CO₂ emissions for synthetic fertiliser production



ADAPTATION TO:

Increased storminess and sea level rise

Shoreline protection via dissipation of wave energy

Ocean Acidification

High daytime pH in seaweed to the benefit of calcifiers

Oxygen inputs to coastal waters

Avoiding ocean deoxygenation with warming

CO₂ sequestration from seaweed farming, perspectives

Assuming cultivation of
20 mill ton seaweed y⁻¹
(Olafsen 2012)

A sequestration potential
of 1500 ton CO₂ km⁻² y⁻¹
(Duarte et al. 2017)

Norwegian C sequestration
potential ~ **4.5 mill. ton**
CO₂ y⁻¹

Norwegian CO₂
emissions
53 mill. ton y⁻¹
(10 ton y⁻¹ pers⁻¹)

- **Equivalent to 8.5 %** of
the Norwegian annual
CO₂ emission

MACROSEA

Industrial cultivation



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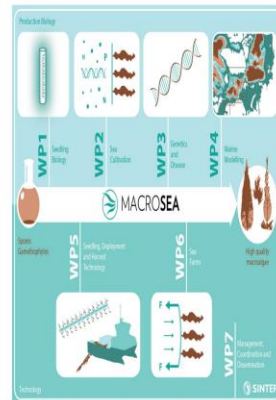
MACROSEA - A KNOWLEDGE PLATFORM FOR INDUSTRIAL MACROALGAE CULTIVATION

The MACROSEA project has a duration of 4 years (2016-2019) and is funded by the Research council of Norway through the Large-scale Programme on Aquaculture Research.

The project targets successful and predictable production of high quality biomass thereby making significant steps towards industrial macroalgae cultivation in Norway.

The project delivers knowledge on seedling quality, sea cultivation, fouling and diseases and functional genetics of selected brown and red macroalgae species.

Growth models for these species will be developed and coupled with 3D hydrodynamics-ecosystem models to estimate site-dependent biomass production, and methods for efficient seeding, deployment and harvest will be proposed. Drag forces and deformation of different farm systems at different sea states will be determined in flume tank experiments, and a numerical model for simulation and visualization of farm designs in dynamic marine systems will be developed.



KELPPRO

Environmental impacts

Welcome to the KELPPRO website
An international research project

KELPPRO

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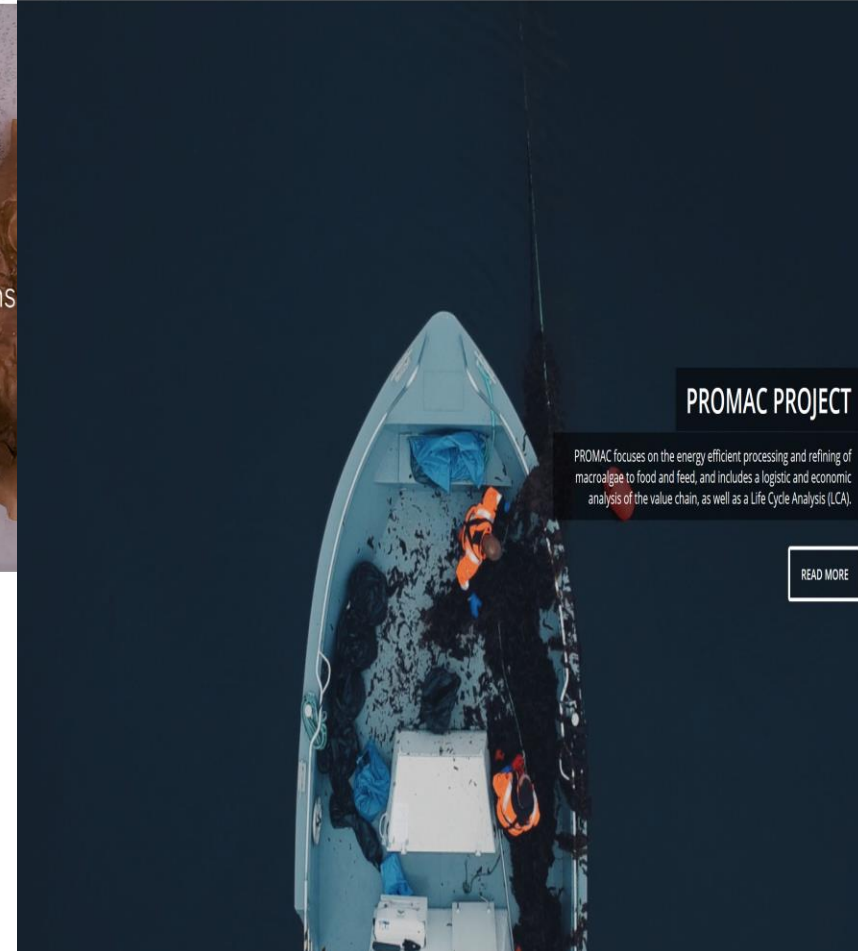


A Research Project funded through RCN (NFR/HAVBRUK2)
Project leader: Dr. Kasper Hancke, NIVA Oslo
Partners: NIVA, SINTEF, NTNU, ApN, IMR, University of Southern Denmark (SDU)
End users: Directorate of Fisheries and Norwegian Environment Agency
Time frame: 2017- 2020 (4 years)

Contact:
 Kasper Hancke (kasperhancke@niva.no)
 PhD, Research Scientist

PROMAC

Product development



Take-home message

- Global seaweed cultivation is 30 mill. ton yr⁻¹ (14 bill USD), increasing 7%
- Norwegian seaweed predicted to cultivate 20 mill. ton in 2050
- C sequestration potential is 8.5% of annual Norwegian CO₂ emission (4.5 mill ton CO₂ yr⁻¹)
- Pathway and fate of the C can be managed and regulated
- Macroalgae cultivation can be managed efficiently, and the produced biomass needs to be if CO₂ mitigation actions are indented

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Thank you for your attention

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