

# How do seaweed cultivation affect marine ecosystems - experiences from a Norwegian project

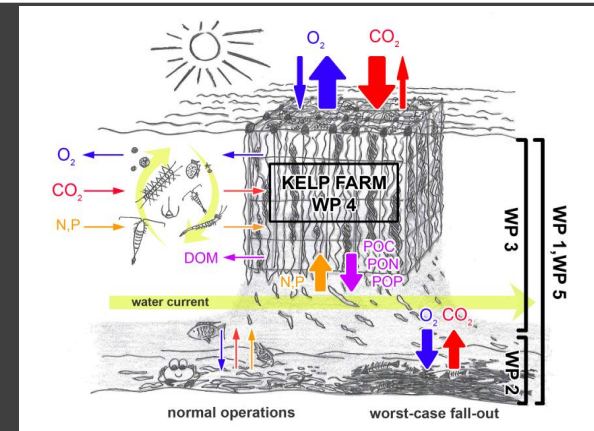
## Hvordan kan tangdyrking påvirke havmiljøet - erfaringer fra et norsk prosjekt

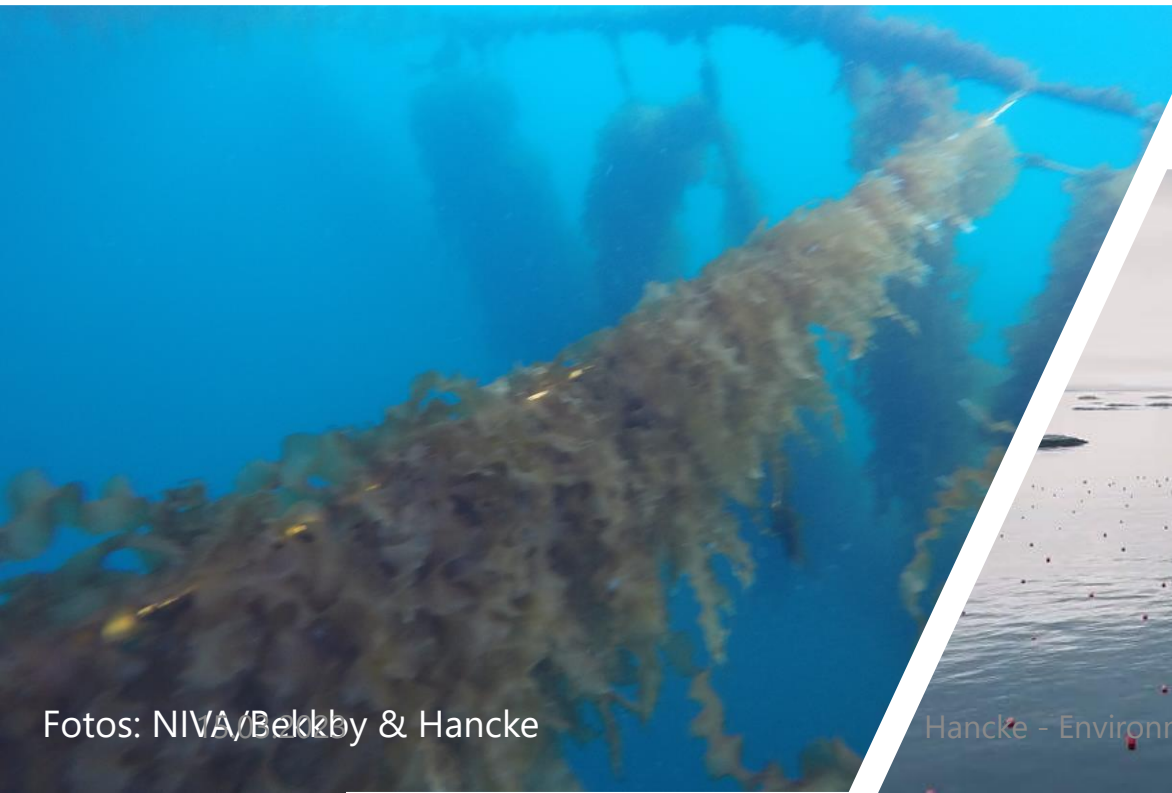
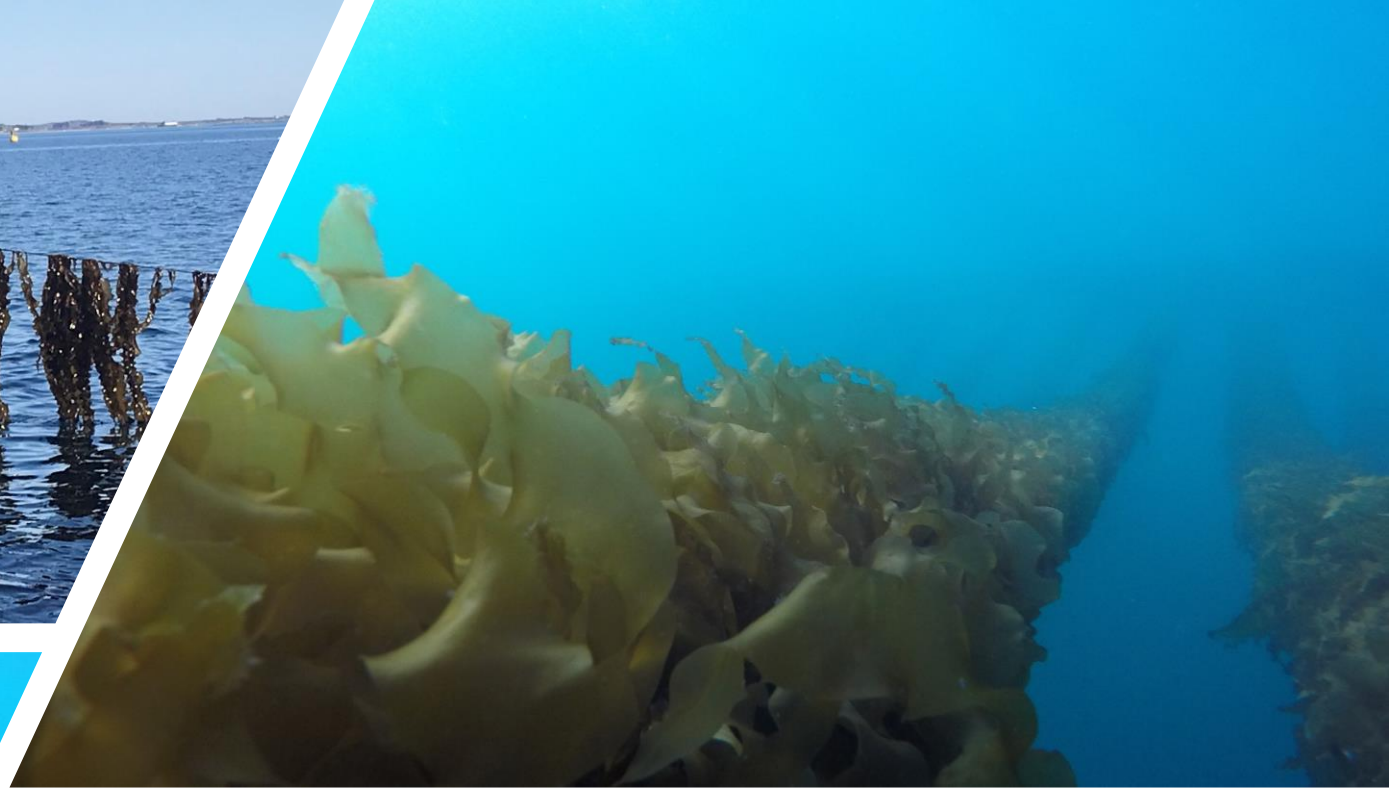
KELPPRO

Kelp industrial production: Potential impacts on coastal ecosystems  
2017-2020

Kasper Hancke, PhD – Senior Research Scientist at the Norwegian Institute for Water Research (NIVA), [Kasper.Hancke@niva.no](mailto:Kasper.Hancke@niva.no)

ASuReMacro – Seaweed workshop, 15 March 2023, Sudurøy, The Faroes Islands





Fotos: NIVA/Bekky & Hancke

Hancke - Environmental impacts of kelp cultivation

Foto: SES/Funderud

# Seaweed cultivation today, globally & in Europe



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9bn

DOLLARS

Current seaweed food production is valued at 9 billion dollars annually.



Our leading initiative is

0m

HIDDEN CHAMPION OF THE OCEAN

Seaweed as a growth engine for a sustainable European future



Funded by SUN Institute

A Coalition to advance sustainable and seaweed industry

Summary for Decision-makers

The Ocean as a Solution to Climate Change

Five Opportunities for Action



451 x 585  
15.03.2023



# Seaweed cultivation today, Norway

**forskning.no** Kultur Helse Miljø Samfunn Teknologi Naturvitenskap

DENNE ARTIKKELEN ER PRODUSERT OG FINANSIERT AV NORSK INSTITUTT LES MER.

## Tror norsk tareoppdrett kommer på størrelse med Hardangervidda

I 2017 ble det produsert 145 tonn i norske tareanlegg. I 20 millioner tonn, ifølge studie.

**Åltespeilen**  
Tirsdag 24. november 2020

Saken er produsert og finansiert av Norsk institutt for vannforskning (NIVA) - Les mer

Tang og tare vil trolig bli en mye større kilde til både menneskers og dyrs kosthold samt som råstoff i andre industrier.  
Foto: Seaweed Solutions AS

22 | Viten

## Tare dyrking er i ferd med å bli stor industri. Er vi forberedt?

**Viten**  
**Hartvig Christie**, seniorforsker, Norsk institutt for vannforskning (Niva)

**Kasper Hancke**, seniorforsker, Norsk institutt for vannforskning (Niva)

En oppskalering av tareindustrien står sannsynligvis på trappene langs norskekysten. Da er det viktig å forstå økosystemets spilleregler.

turlige tare skogen og samtidig øke ressurshøsting av tarebiomasse til industrielle formål.  
ren, vil også CO<sub>2</sub>-opptaket redusere risikoen for forurengning av havet. I tillegg vil tare dyrking ta opp næringsstoffer fra

## KAN BÆREKRAFTIG TARE... En kraftig oppskalering av tare dyrkingsindustrien bærekraftig måte for økosystemene i havet?

**NIVA** Norwegian Institute for Water Research (NIVA)

## KELPPRO

Kelp industrial production: Potential impacts on coastal ecosystems

Kasper Hancke, Ole Jacob Broch, Trine Bekkby, Yngvar Olsen, Reinhold Fieler, Hege Gundersen, Morten O Alver, and Hartvig Christie

AQUA2018  
27 August 2018, Montpellier

normal operations water case fall-out

Images by SES, NIVA and Tango Seaweed

**NIVA** Norwegian Institute for Water Research (NIVA)



Is it possible to create a sustainable seaweed aquaculture?

**YES!**



**Keywords for success:**

- 1) Play on team with nature!
- 2) Secure efficient and knowledge-based management, scaled to the growing industry

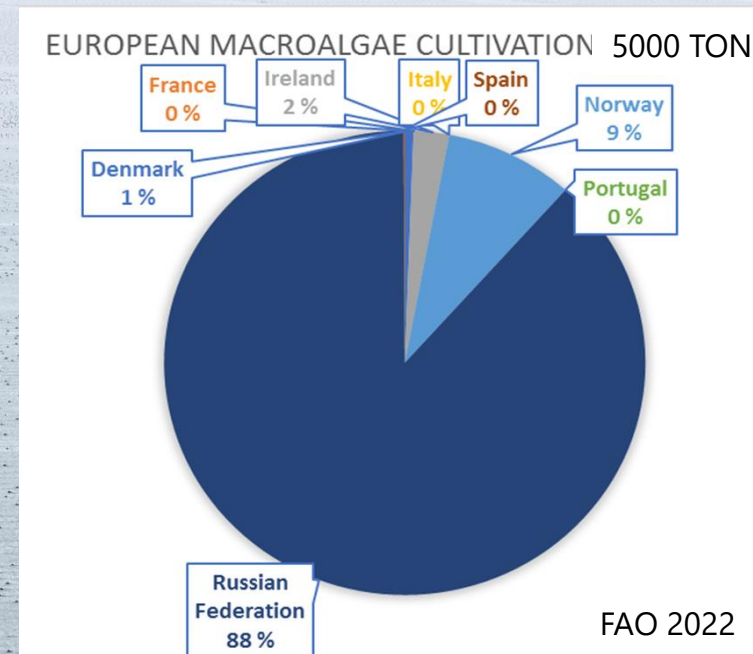
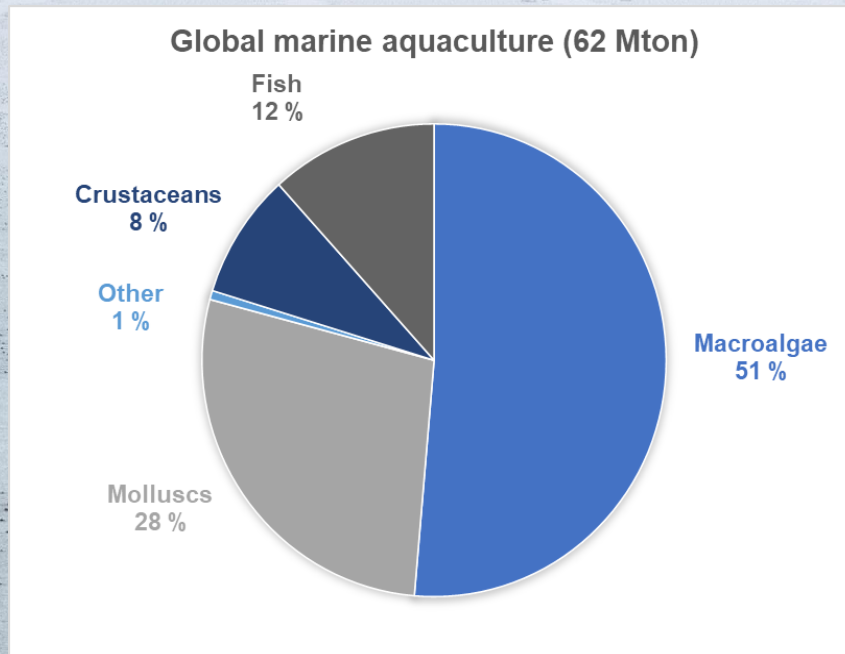
# Why spend time on environmental impacts?



*Sangou Bay, Kina*  
15.03.2023

Hancke - Environmental impacts of kelp cultivation

# Why spend time on environmental impacts?



- Global seaweed production > **32 mill. tonnes** (FAO 2022)
- Norway produce ~350 tonnes (2020)
- Faroe Islands 185 tonnes (2021)
- Future prospect in **Norway** is **20 mill. tonnes** by 2050 (Olafsen 2012)
- This requires an area of 2000-3000 km<sup>2</sup>, equivalent to an area of ~2 times the area of the Faroe Islands (1396 km<sup>2</sup>)

# Why spend time on environmental impacts?

**Because of this!**



[www.visitnorway.com](http://www.visitnorway.com)

*Sangou Bay, Kina*  
15.03.2023

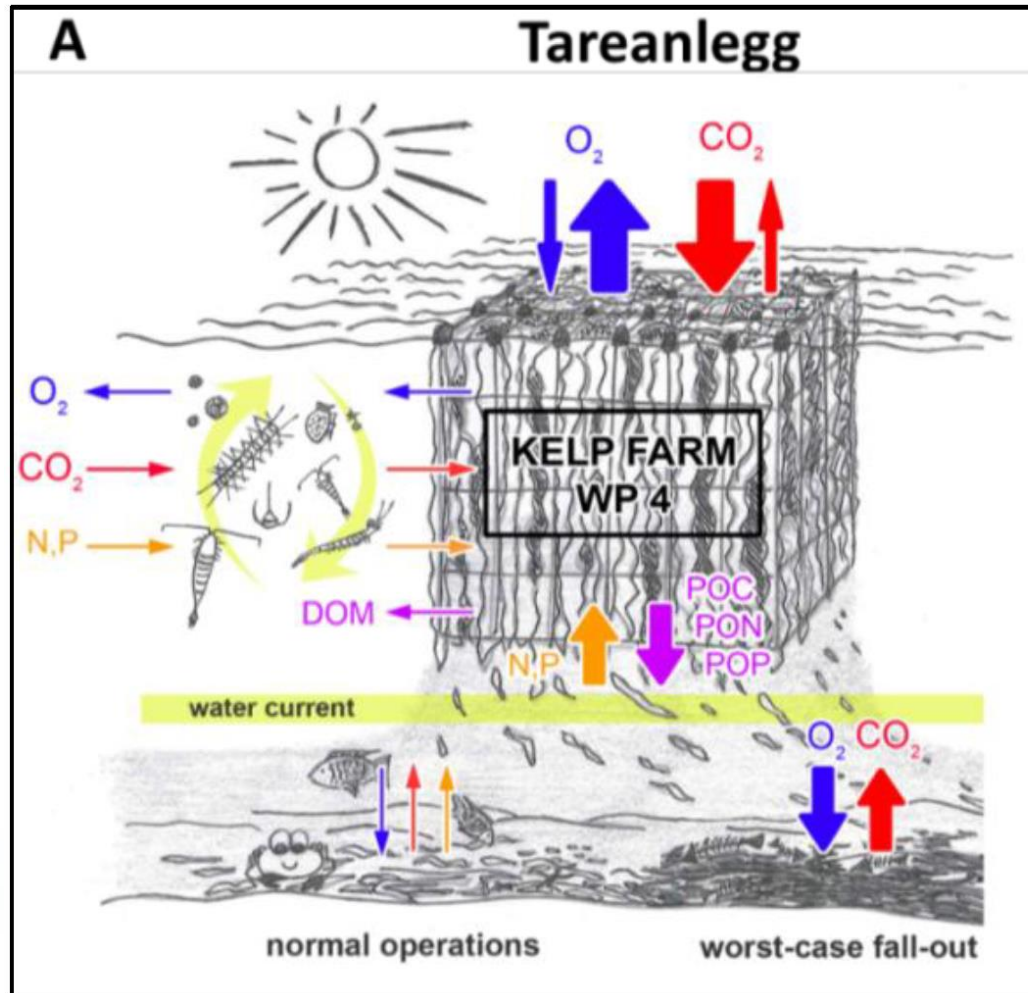


Why spend time on environmental impacts?

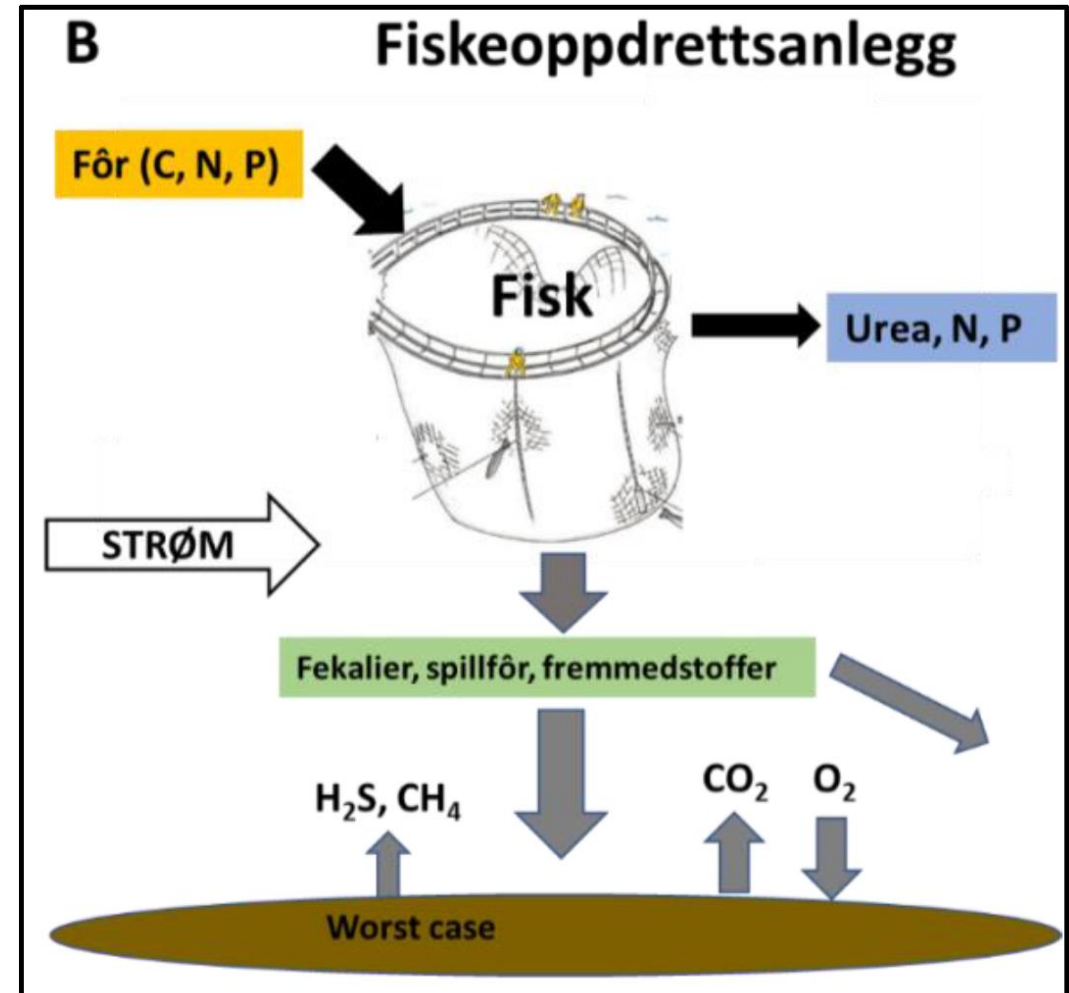
.. and because of this 😊



# Seaweed cultivation *versus* fish aquaculture



Negative net release of nutrients



Positive net release of nutrients

Hancke et al. 2021

# KELPPRO - Kelp industrial production: Potential impacts on coastal ecosystems

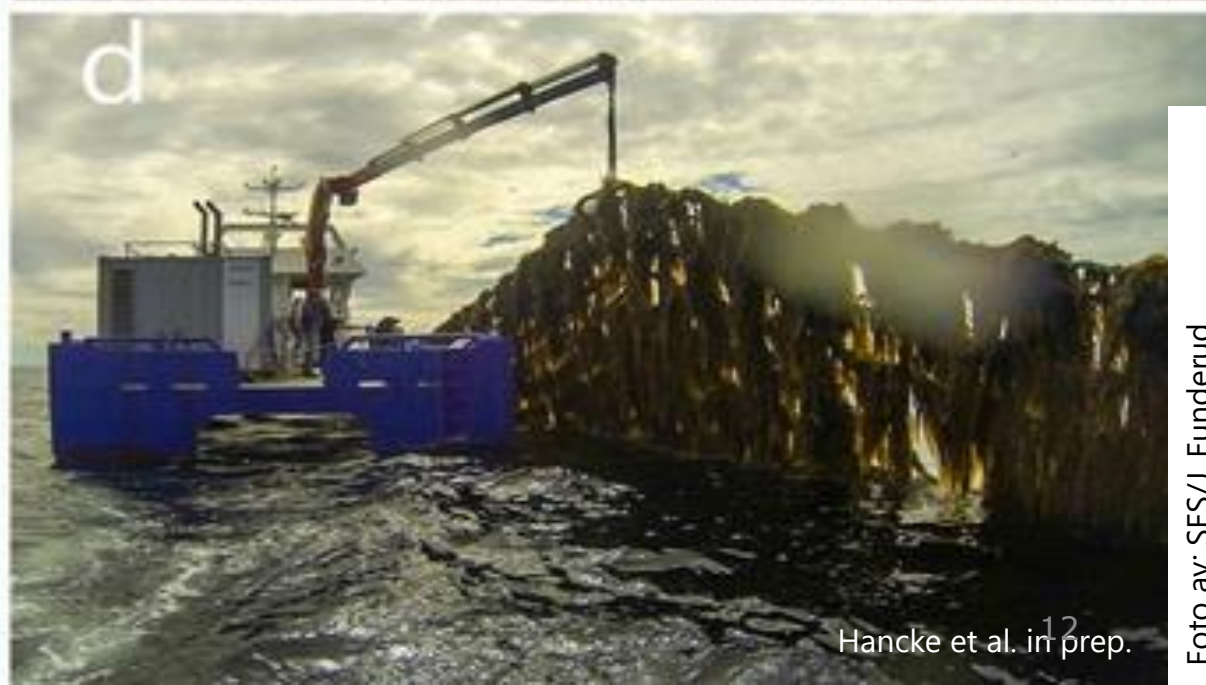
## Aim:

Provide an **integrated assessment of positive and negative impacts** of industrial-scaled kelp farming on the marine ecosystem

## Three main questions:

- 1) Will large scale kelp farming **impact the coastal ecosystems** – open water and sea floor habitats and functioning?
- 2) Will farmed kelp detritus provide **valuable bio-resources or pose a threat** to natural coastal ecosystems?
- 3) Will kelp farming facilities provide ecosystem functioning as **'artificial' forest habitats**?





# Potential environmental impacts of extensive seaweed cultivation

Open water

Nutrients

CO<sub>2</sub>

Oxygen

Biomass

Foto: Hancke/NIVA

Foto: e-Dexter/NIVA

Seafloor

Deposition

Bad conditions

Oxygen deficiency

Positive impacts are

- Nutrient uptake, reducing eutrophication
- CO<sub>2</sub> uptake, reducing ocean acidification and climate mitigation potential
- Oxygen production
- Increased primary production
- Stimulate biodiversity

Negative impacts are

- Reduced light availability
- Depletion of limited nutrients
- Depositing of organic matter on the seafloor, leading to
- poor environmental conditions,
- oxygen deficiency,
- change in natural biodiversity
- Spreading of unwanted species, genetic material and diseases

**KELPPRO**

**Seaweed farming – good or bad news to the coast and society?**

KELPPRO, an NFR funded research project (2017–2020) investigates if novel large-scale kelp farming can be accompanied by a sustainable marine management, and asking the following key questions:

- 1) Will future large-scale seaweed farming impact our coastal environment, the water masses or life at the sea floor?
- 2) Will kelp farming provide valuable bio-resources or pose a threat to natural coastal ecosystems?
- 3) Will seaweed farms work as artificial kelp forests and work against climate change?

KELPPRO applies both field investigations, laboratory experiments and numerical modelling to provide a holistic and comprehensive assessment. Involved are both research institutes, universities, seaweed farmers and industry.

**2017**

normal operations      worst-case fall-out

**2018**

**2019**

**2020**

**2021**

**Examples of erosion**

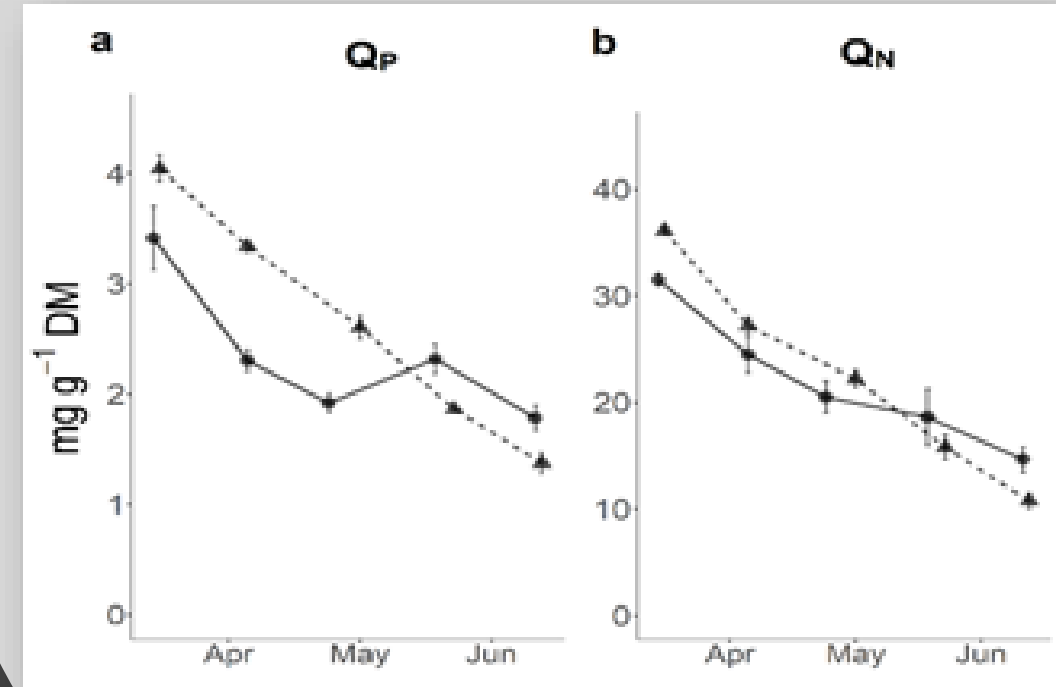
Indices  
1  
0.5

Kelppro 17055.T24  
Control site  
sediment  
21/8-19

# Effects on life in the water column

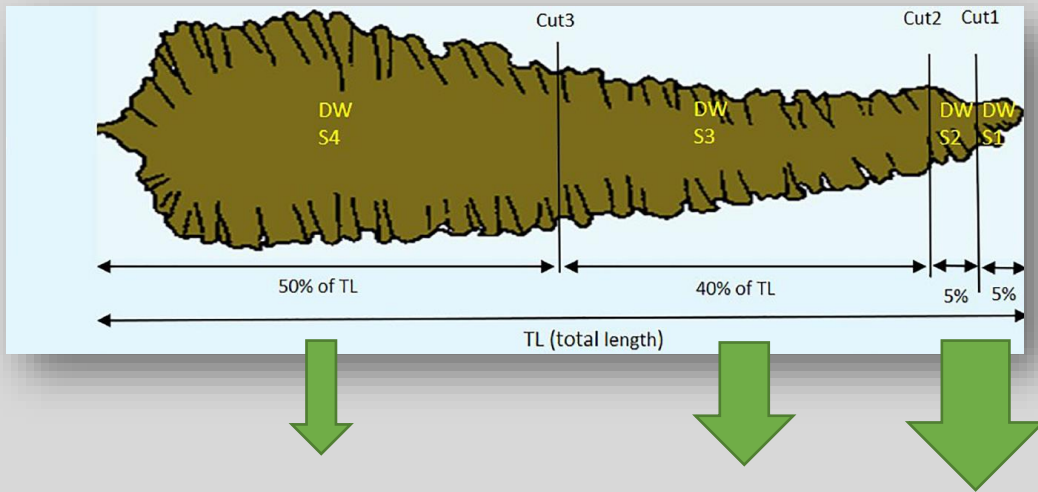
## Competition on nutrients between microalgae and kelp?

- Kelp take up nutrients in early spring and growth largely on that throughout the season
- Phytoplankton has a much faster and more efficient nutrient uptake and kelp (>10 times)
- **No significant negative influence found of kelp cultivation on natural phytoplankton and the pelagic foodweb**



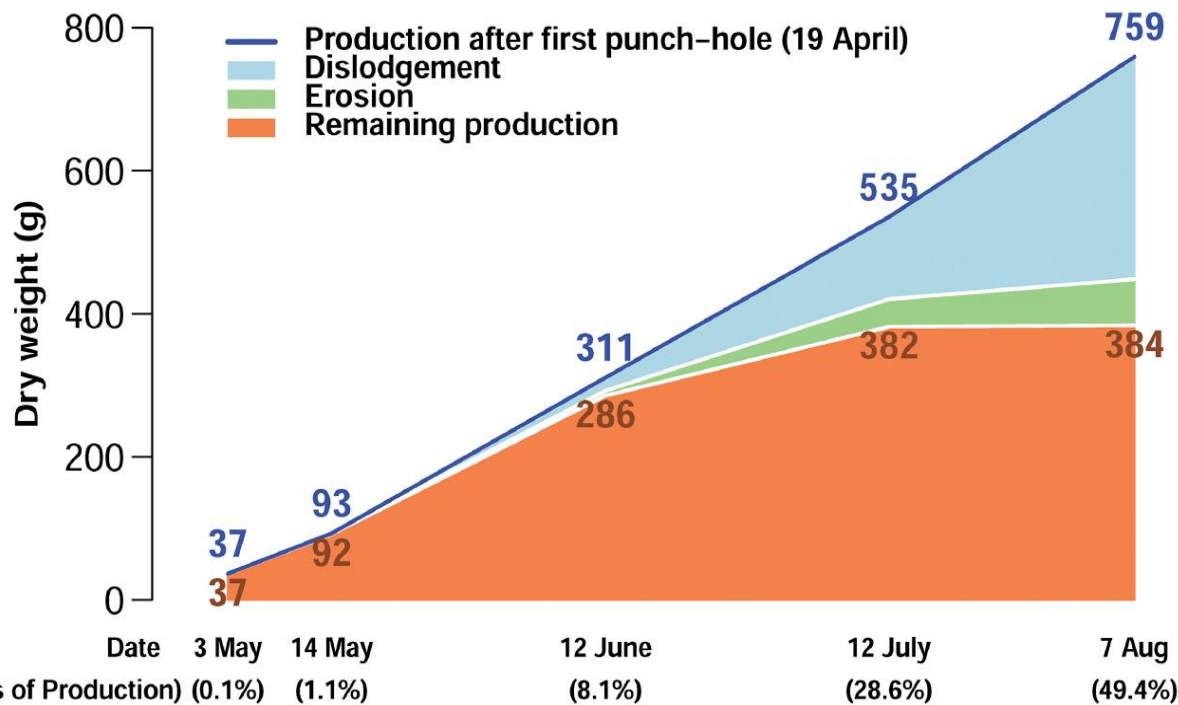
**Content of phosphorus (a) and nitrogen (b) in cultivated kelp (*Saccharina latissima*), through season 2018.**

Njåstad, Olsen et al. in prep.



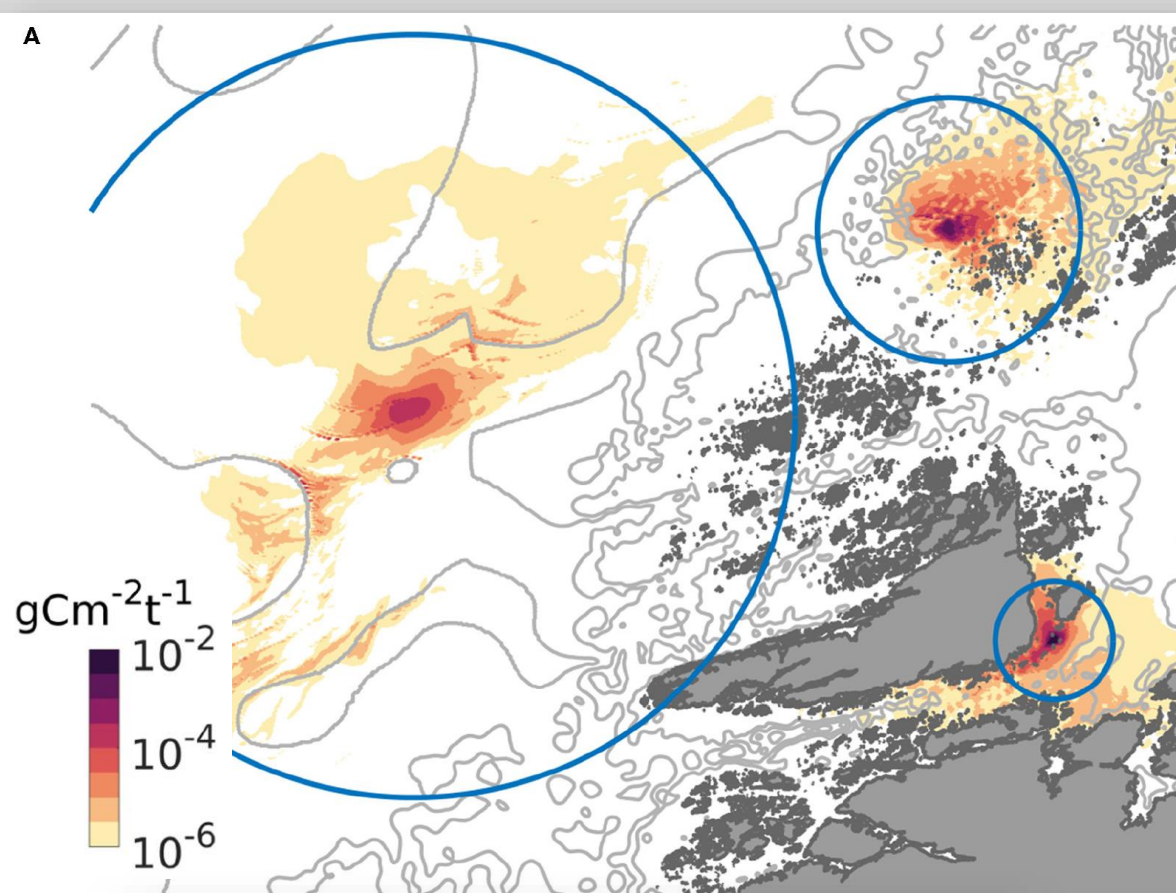
# Export of organic matter from farmed kelp (Sugar kelp) *Saccharina latissima*

- Kelp farming may export significant of organic matter to the environment
- Farm export 8-15% of harvested biomass under normal production scenarios (Norway)
- >50% after the summer (Fieler et al., 2021)
- In *China*, studies have documented >60% loss of biomass during production (Zhang et al., 2012)



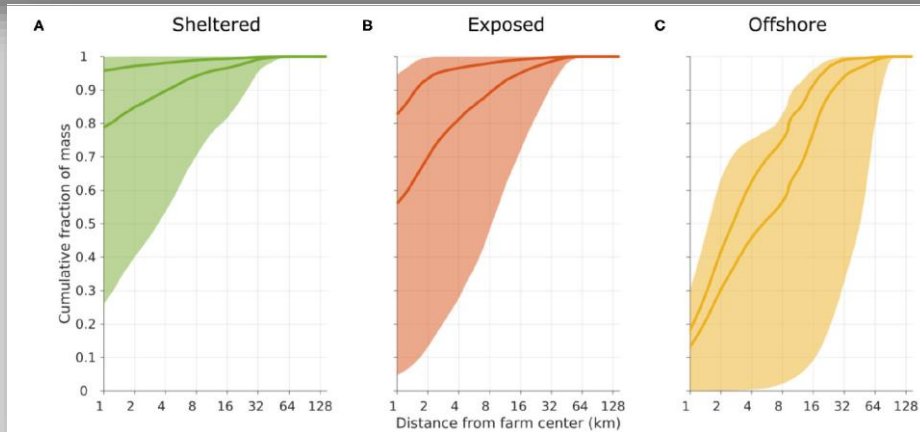


A



## Sedimentation of farmed kelp on the seafloor – modelling results

- Kelp farms spread and deposit kelp organic matter **from 1 to 100's of kilometers**
- Kelp typically speed over large areas in thin layers depending on physical surroundings and geography of the region
- Carbon addition to the seafloor range from micrograms to gram per square meter per tonnes cultivated



# Seafloor biodiversity

Kelp can provide a food source to seafloor fauna or pose a threat to life at the seafloor

- At normal farming conditions effects on seafloor fauna is minimal
- By 'massive' accumulations of kelp on the seafloor ( $>8 \text{ kg m}^{-2}$ ) biodiversity decreased and a few species increased in numbers
- **The documented effect was short:  $>90 \%$  was gone in three months and conditions normalized**



Borgersen et al. in prep.

Hancke et al. in 2022





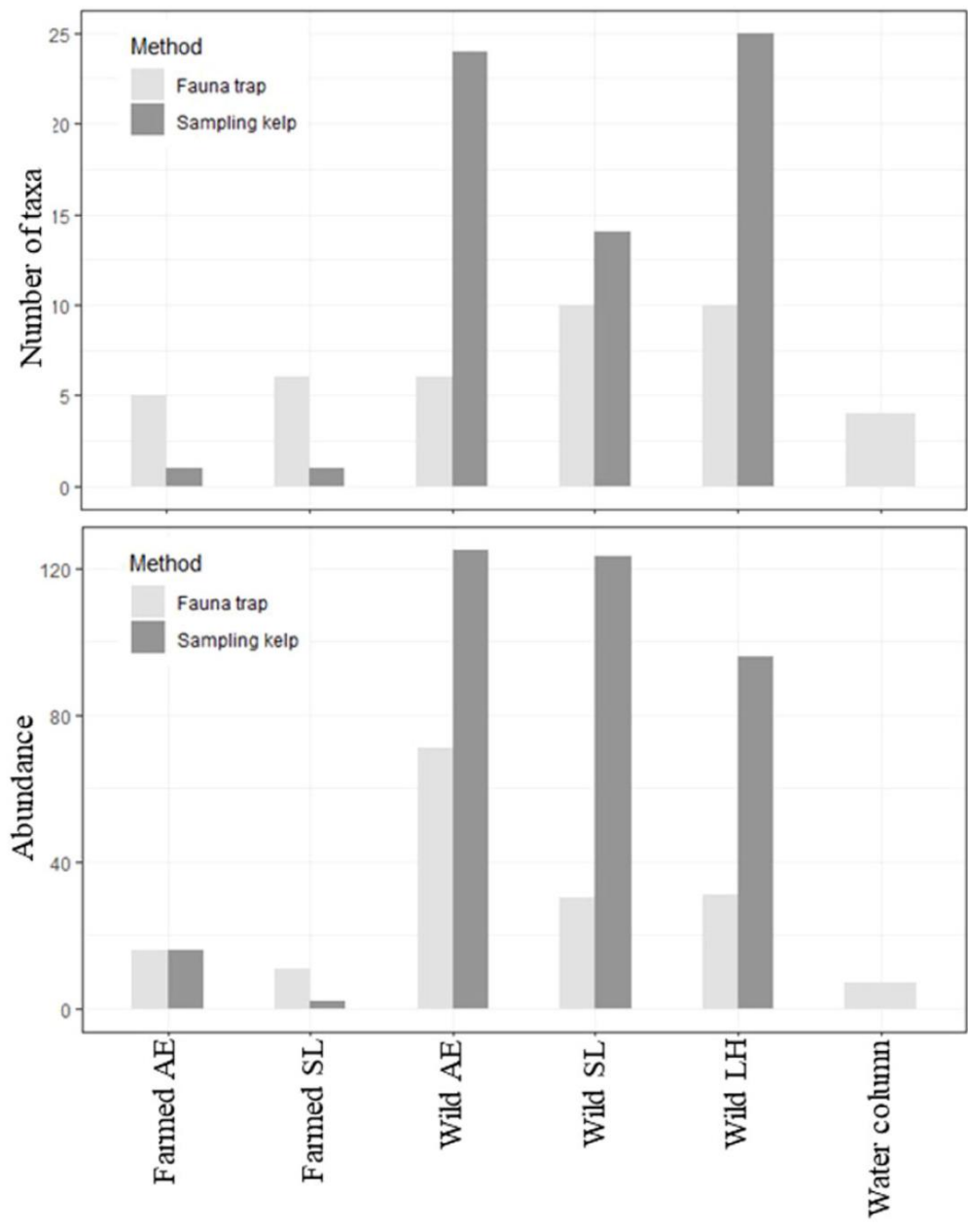
Foto: Hartvig Christie (NIVA) og SES



«Large quantities of *Caprella mutica* was found late in the fall

# Kelp farms as artificial reef

- Kelp farms provide an 'artificial' ecosystem
- Length of the grow season impact the fauna community
- **Kelp farms can be a vector for alien species and spreading of genetic material**

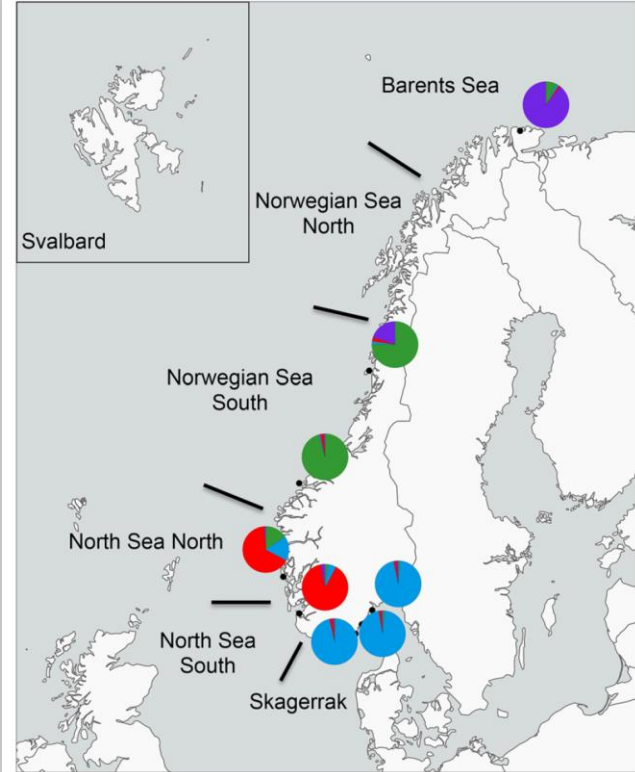


# Kelp farms as artificial reef

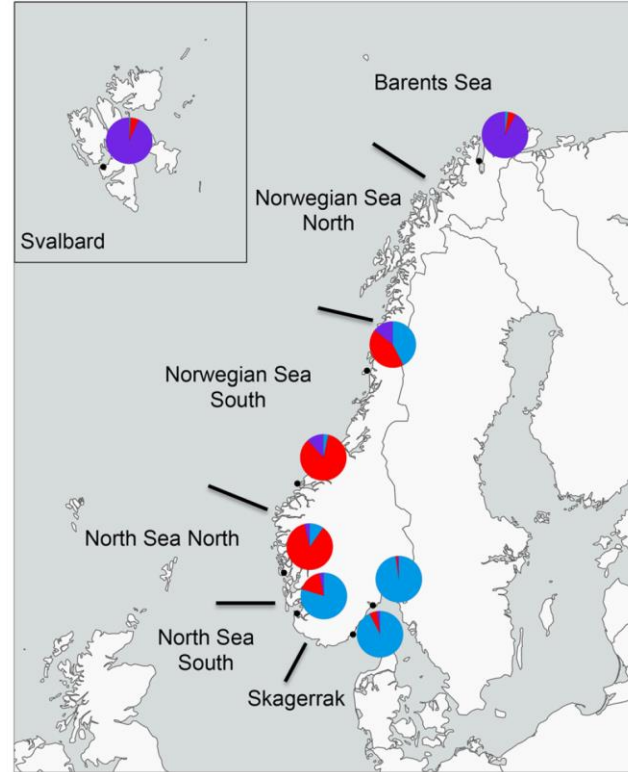
- Kelp farms had a **lower number of taxa** than wild kelp forests
- Kelp farms had a **lower abundance of fauna** than natural kelp forests
- **SeaBee farms are known to host diseases in Asia**
- Still, scientific documentation is **still sparse on fauna and seaweed diseases**



*Laminaria hyperborea*



*Saccharina latissima*



## Genetic variability in kelp (wild)

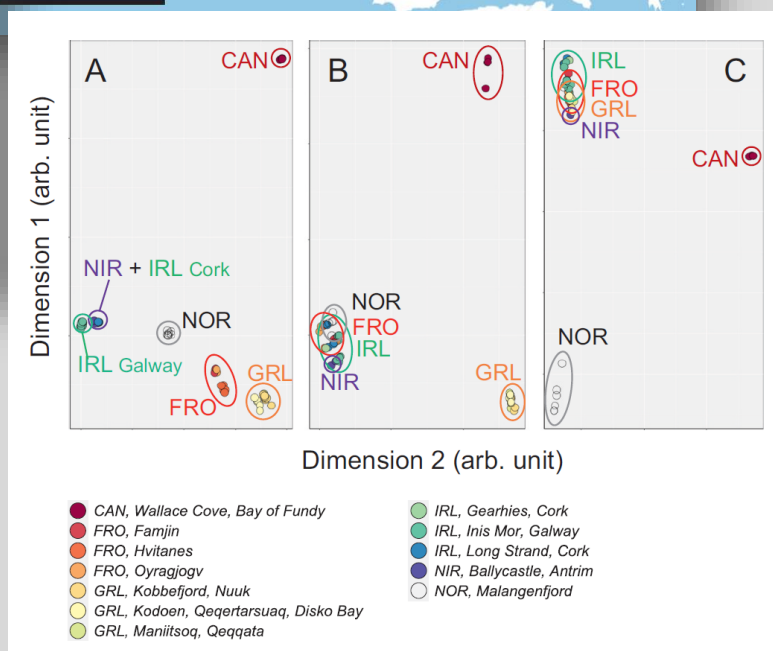
- Genetic variability in wild kelp forests along the Norwegian coast (*L. hyperborea* and *S. latissima*)
- Little knowledge on the local variability

Inaba et al 2022

Evenkow et al. 2019

# Genetic variability in kelp (wild)

- Genetic variability in wild kelp forests along the Norwegian coast (*L. hyperborea* and *S. latissima*)
- Little knowledge on the local variability
- Genetic variability between fjords in the Faroese Islands and across the North Atlantic (*Palmaria* & *Alaria*)
- Ask Agnes for details



# «Size matters», av tareanlegget

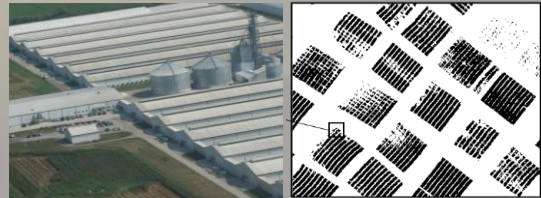
Today's farms:  
30-300 tonn



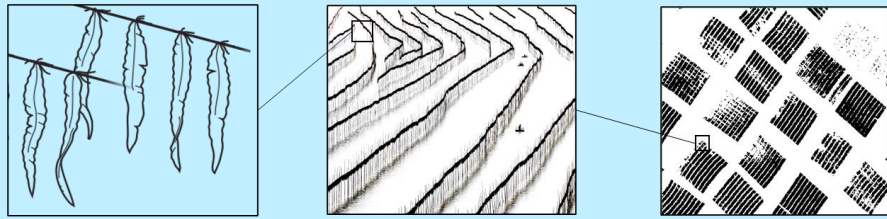
Moderate farms:  
1.000-3.000 tonn



Industrial-scaled farms:  
10.000-30.000 tonn

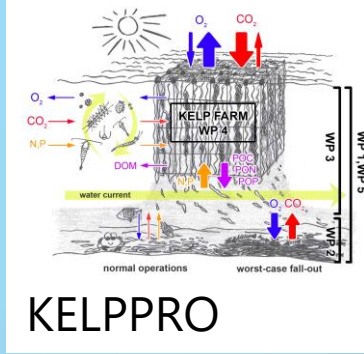
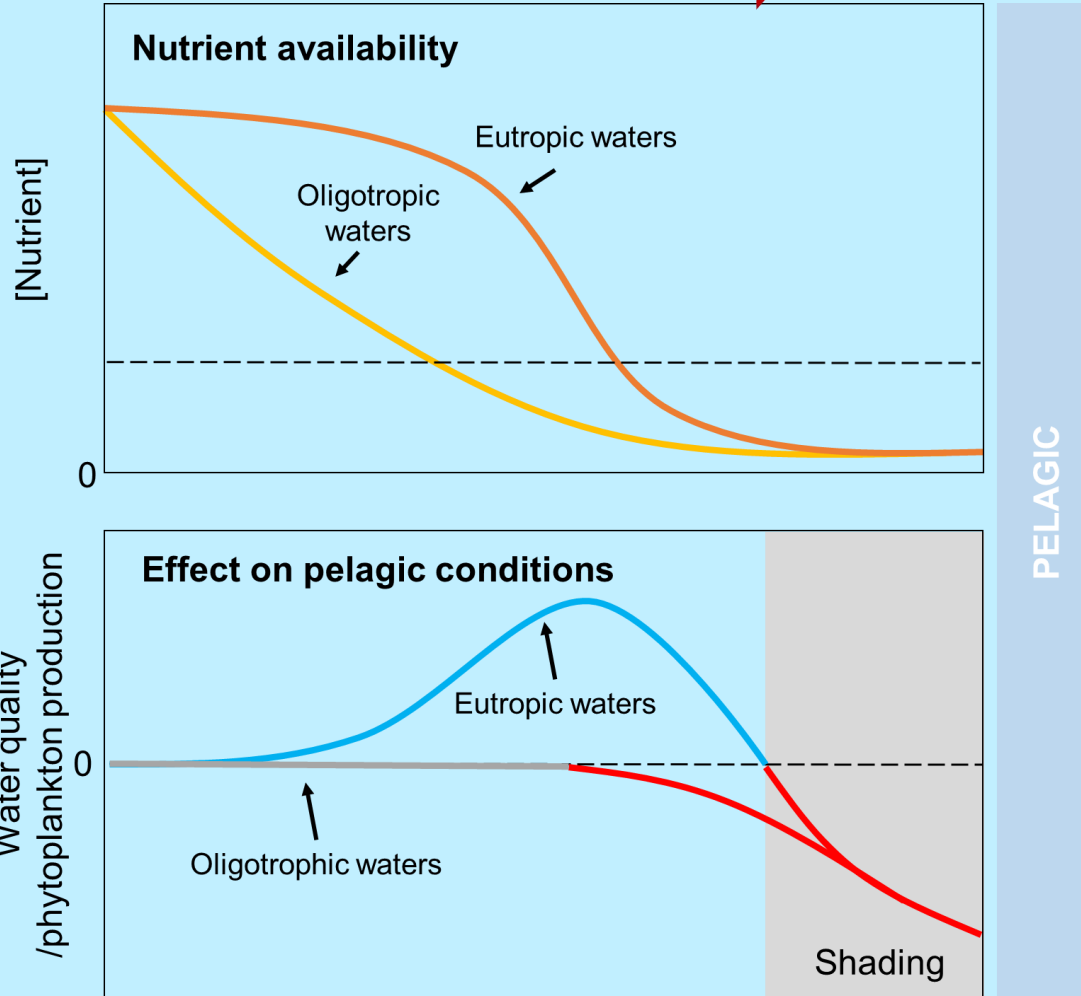


## Kelp farm size (area/density)



Small farm

Industrial farm





# «Size matters», av tareanlegget

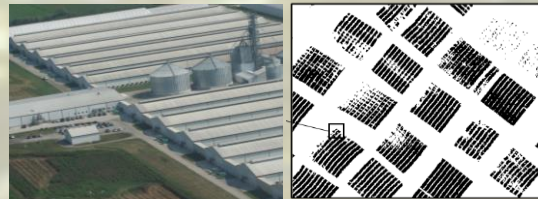
Today's farms:  
30-300 tonn



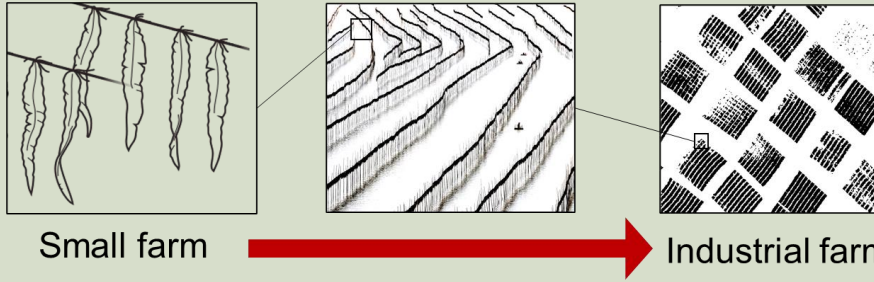
Moderate farms:  
1.000-3.000 tonn



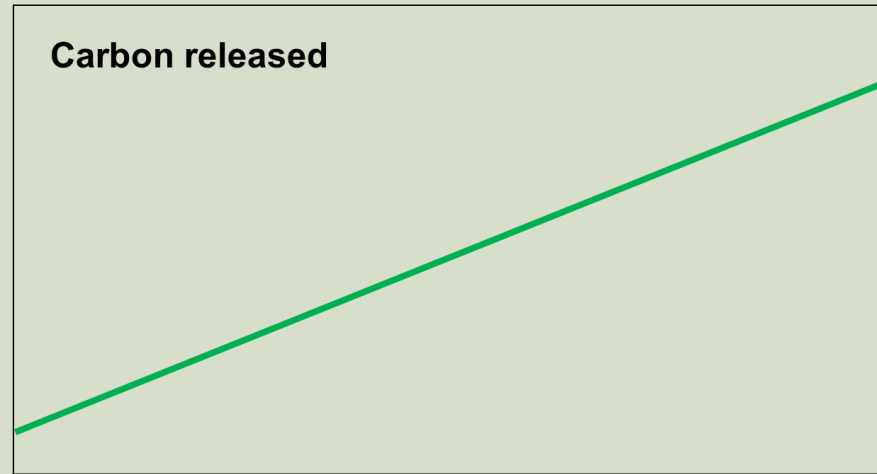
Industrial-scaled farms:  
10.000-30.000 tonn



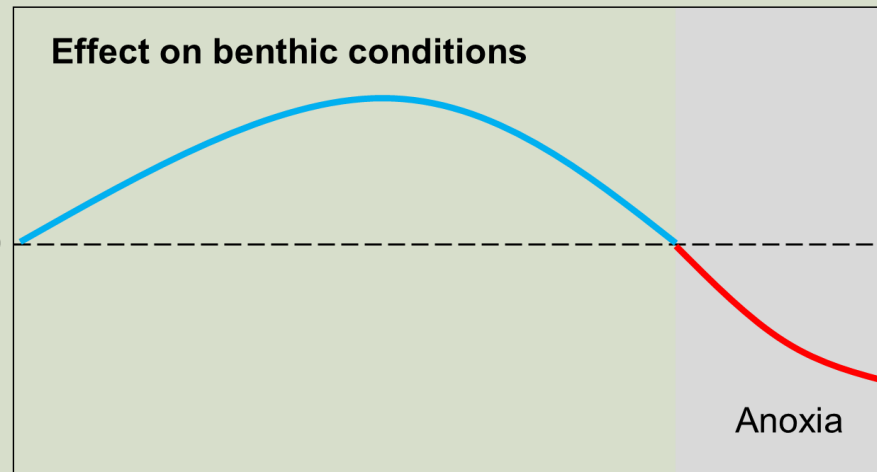
## Kelp farm size (area/density)



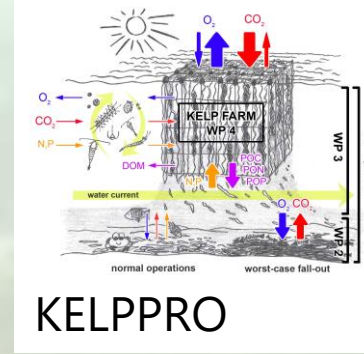
Detritus exported to seafloor



Benthic diversity/productivity



BENTHIC



KELPPRO

## Short summery

- **Substantial positive effects of seaweed cultivation** (elevated production, nutrient reduction, climate mitigation)
- **No larger negative impact of kelp cultivation** on phytoplankton or functioning on life in the open water column
- **No significant impacts** of present-day kelp cultivation were documented **on seafloor fauna** (business as usual)
- **Large scale cultivation** and deposition of kelp on the seafloor **might negatively impact seafloor biodiversity**
- Kelp farms **may act as a vector for alien species and genetic dispersal**

KELPPRO WORK PACKAGES PUBLICATIONS NEWS CONTACT

# KELPPRO

Kelp industrial production: Potential impacts on coastal ecosystems

The research project **KELPPRO** aims to provide an integrated assessment of positive and negative impacts of industrial-scaled kelp farming on coastal environments, and is funded by The Research Council of Norway (HAVBRUK2).

normal operations worst-case fall-out

# Anbefalinger til forvaltningen og forslag til utvikling av overvåkingsprogram



01.05.2023

Dagens anlegg:  
30-300 tonn



Moderate anlegg:  
1.000-3.000 tonn



Industri skala:  
10.000-30.000 tonn

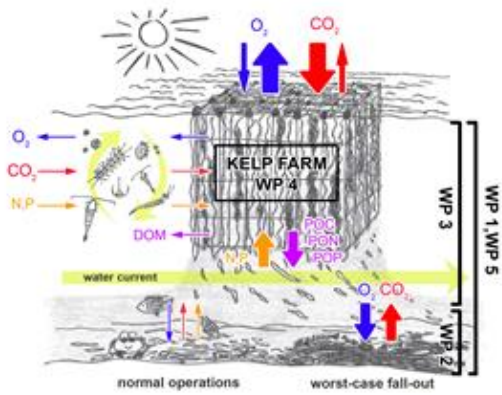


Tabell 3. Oversikt over mulige overveielser og anbefalinger knyttet til overvåkingsstrategi. Se Tabell 1 for mer informasjon vedrørende anleggstørrelsene.

Små anlegg 30 – 300 tonn per år	Mellomstore anlegg 1 000 – 3 000 tonn per år	Store anlegg 10 000 – 30 000 tonn per år
<p><b>Forundersøkelse:</b> Strøm, eventuell kartlegging av naturlige tareforekomster i området.</p>	<p><b>Forundersøkelse:</b> Strøm, registrering av naturlige tareforekomster og andre habitater/bunntyper i området, registrering av fremmede arter i omliggende tareforekomster.</p>	<p><b>Forundersøkelse:</b> Strøm, registrering av naturlige tareforekomster og andre habitater/bunntyper i området, registrering av fremmede arter i omliggende tareforekomster.</p>
<p><b>Overvåkingsprogram:</b> Enkel registrering av fremmede arter i toreanlegget. Ved stor tetthet av små anlegg kan det være aktuelt å anvende strategien til mellomstore anlegg.</p>	<p><b>Overvåkingsprogram:</b> Overvåking av fremmede arter i toreanlegget, både under drift og etter høsting av tare, og i omliggende tareforekomster. Ved stor tetthet av mellomstore anlegg kan det være aktuelt å anvende strategien til store anlegg.</p>	<p><b>Overvåkingsprogram:</b> Overvåking av fremmede arter i toreanlegget, både under drift og etter høsting av tare, og i omliggende tareforekomster. Eventuell overvåking av bunnforhold og av vannmassene.</p>
<p><b>Spesialovervåking:</b> Ved tap av større mengder tare kan overvåking av bunnpåvirkning settes inn der taren akkumulerer.</p>	<p><b>Spesialovervåking:</b> Ved tap av større mengder tare kan overvåking av organisk bunnpåvirkning settes inn der taren akkumulerer.</p>	<p><b>Spesialovervåking:</b> Ved tap av større mengder tare kan overvåking av organisk bunnpåvirkning settes inn der taren akkumulerer.</p>

# Publications from KELPPRO – [www.kelppro.net](http://www.kelppro.net)

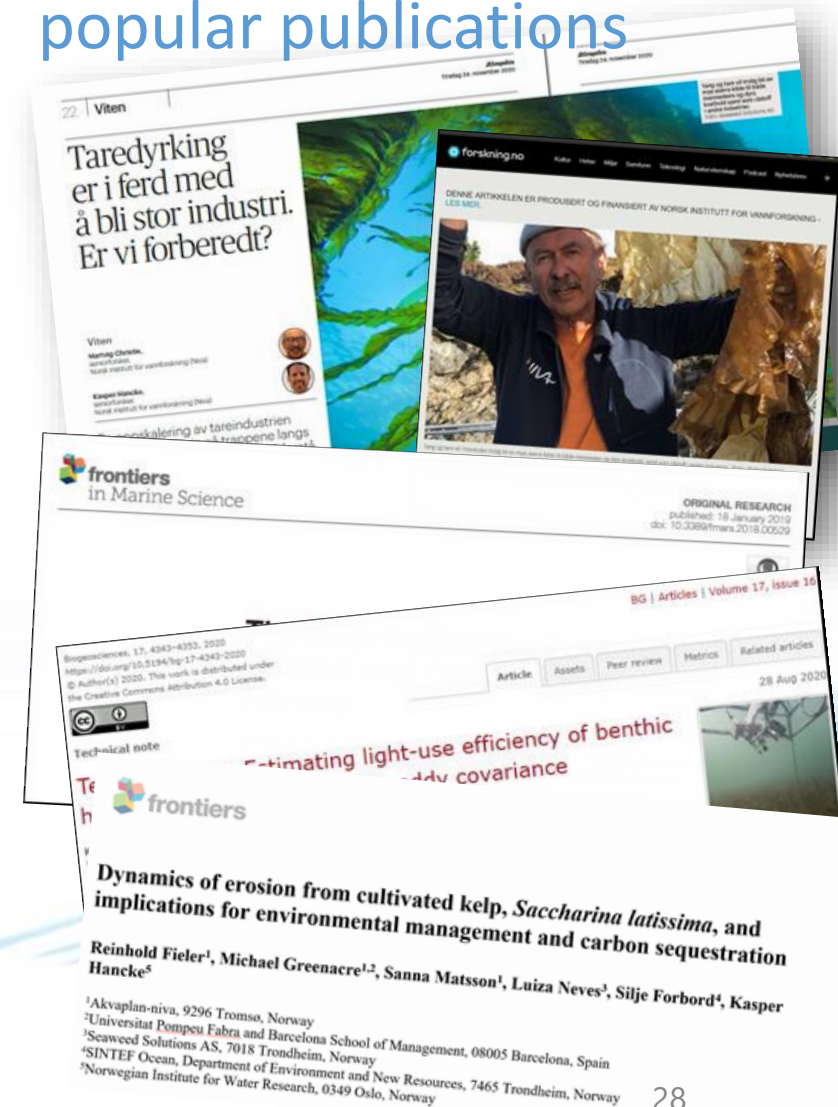
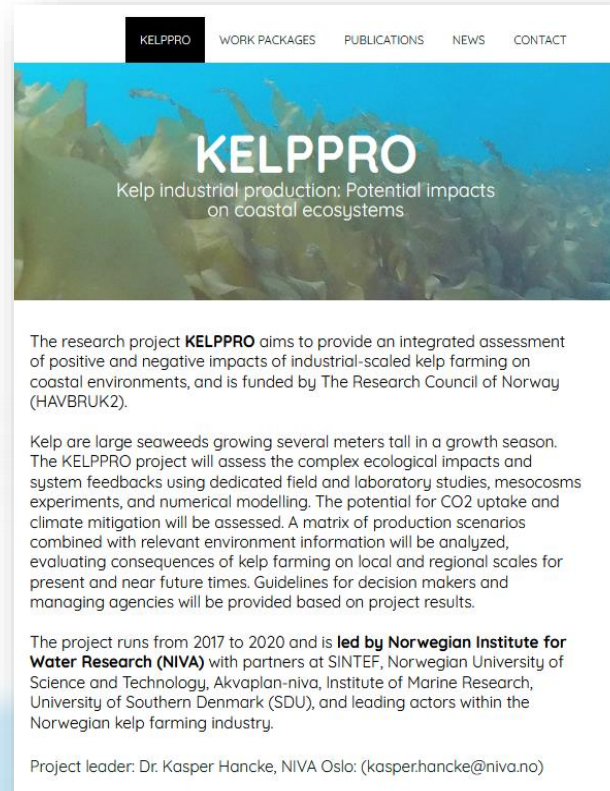
Scientific and popular publications



## Summarizing report



## Website



# Thank you for your attention!

Please find more information on  
[www.kelppro.net](http://www.kelppro.net)

Acknowledgments to the:

- Researchers
- Technicians
- Students
- Industry members
- Advisory board
- Stakeholders
- The Research Council of Norway for funding!

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