



Karbonlagring i tareskog / Carbon sequestration in macroalgae beds and kelp forests

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Norwegian kelp forest, Frøya, Trøndelag, April 2019

VIDEO OF KELP FOREST

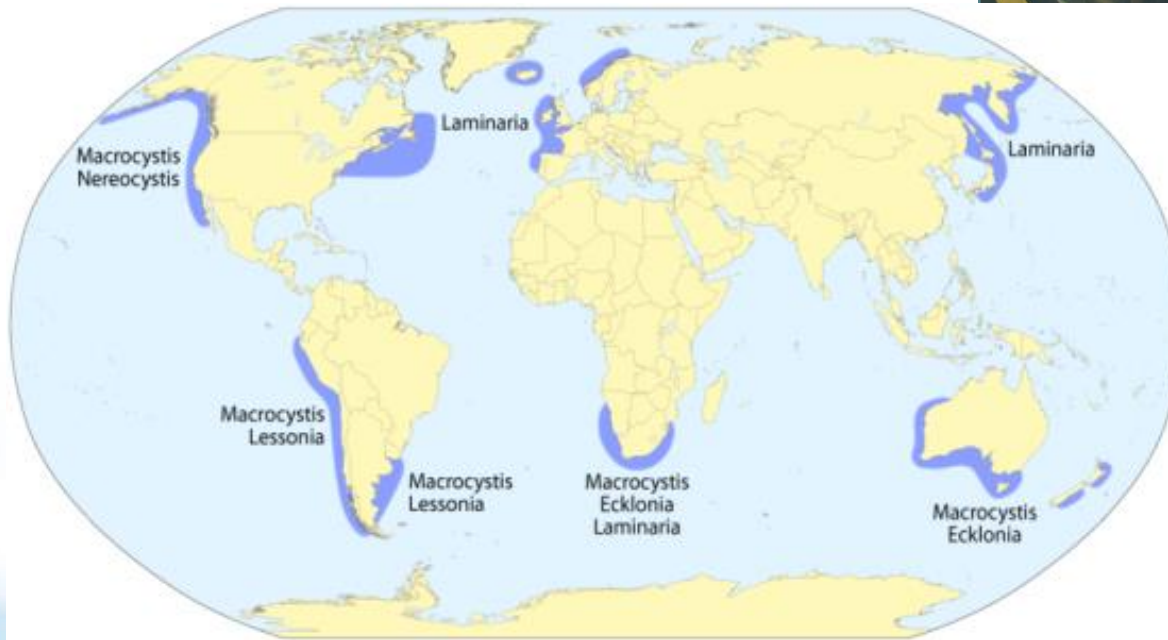


By KELPPRO/Kasper Hancke

Macroalgae/Kelp forests

- Macroalgae, small and large seaweeds
- Live in temperate waters globally
- Mostly at high salinities (>35 PSU)
- On hard bottom substrate/rocky seafloor

*Kelp forests
are marine
'rain forests'*



*Norway holds the
largest
macroalgae forest
in Europe, and
holds the longest
coast line in the
world*

Foto: Janne K. Gittmark

Maximilian Dörrbecker

KELP FOREST

Stortare

(*Laminaria hyperborea*)



Sukkertare

(*Saccharina latissima*)



Butare

(*Alaria esculenta*)



Fingertare

(*L. digitata*)



Draughtare

(*Saccorhiza polyschides*)



The ecological relevance of kelp forest ecosystems

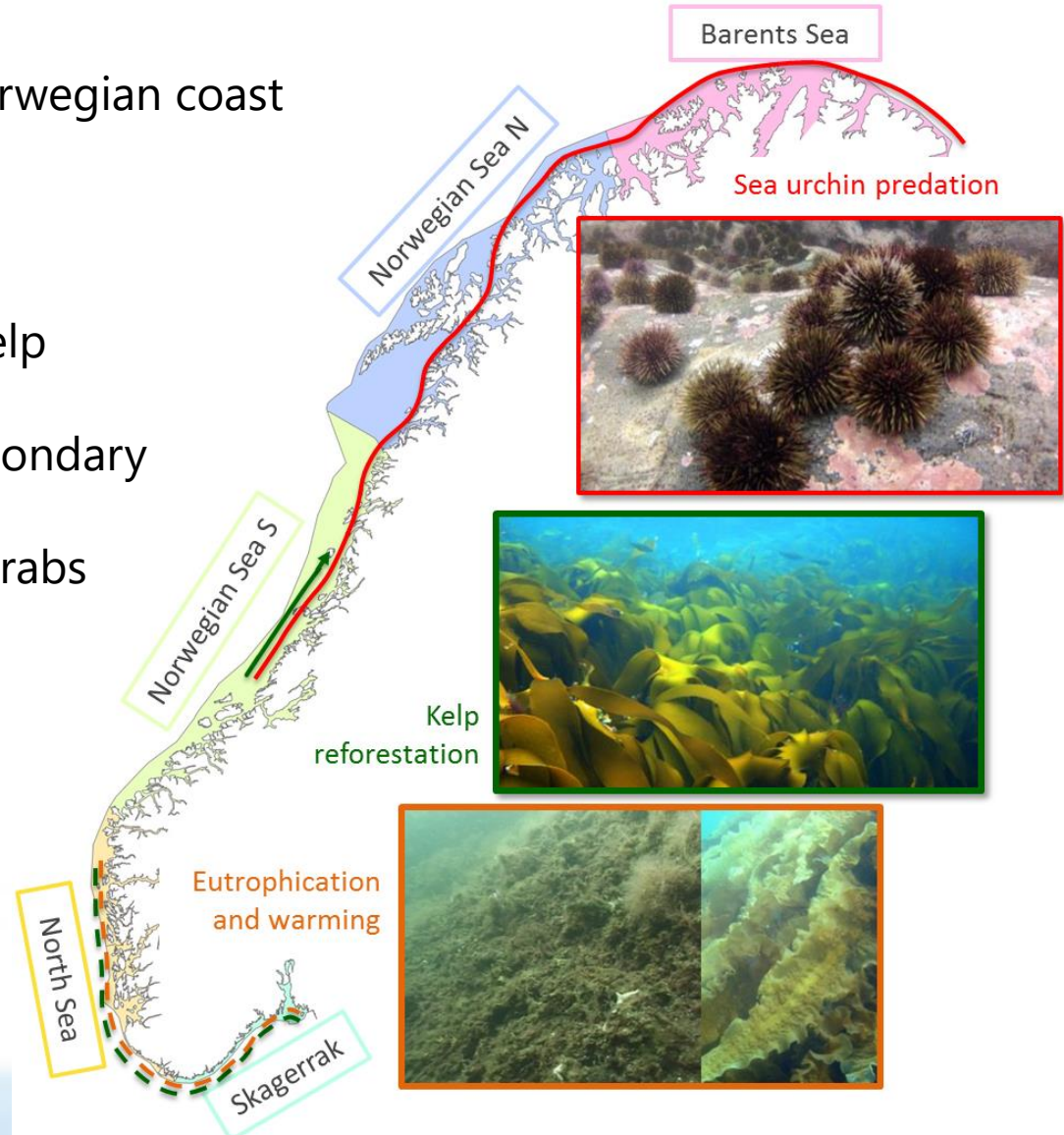
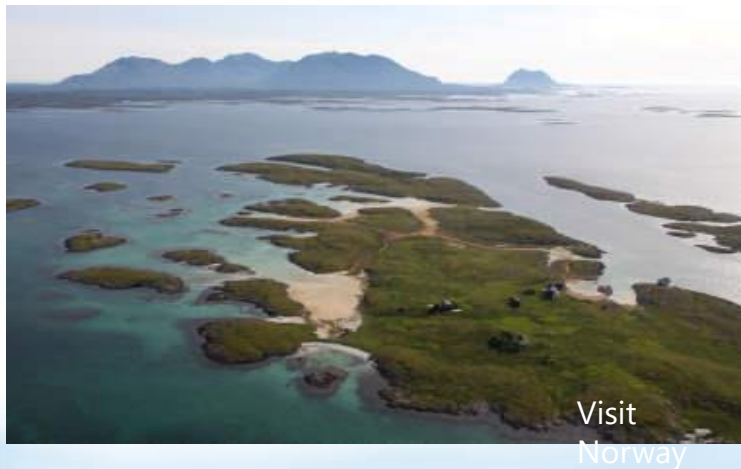
~8000 km² of kelp forest on Norwegian coast

~80 mill. ton of kelp biomass

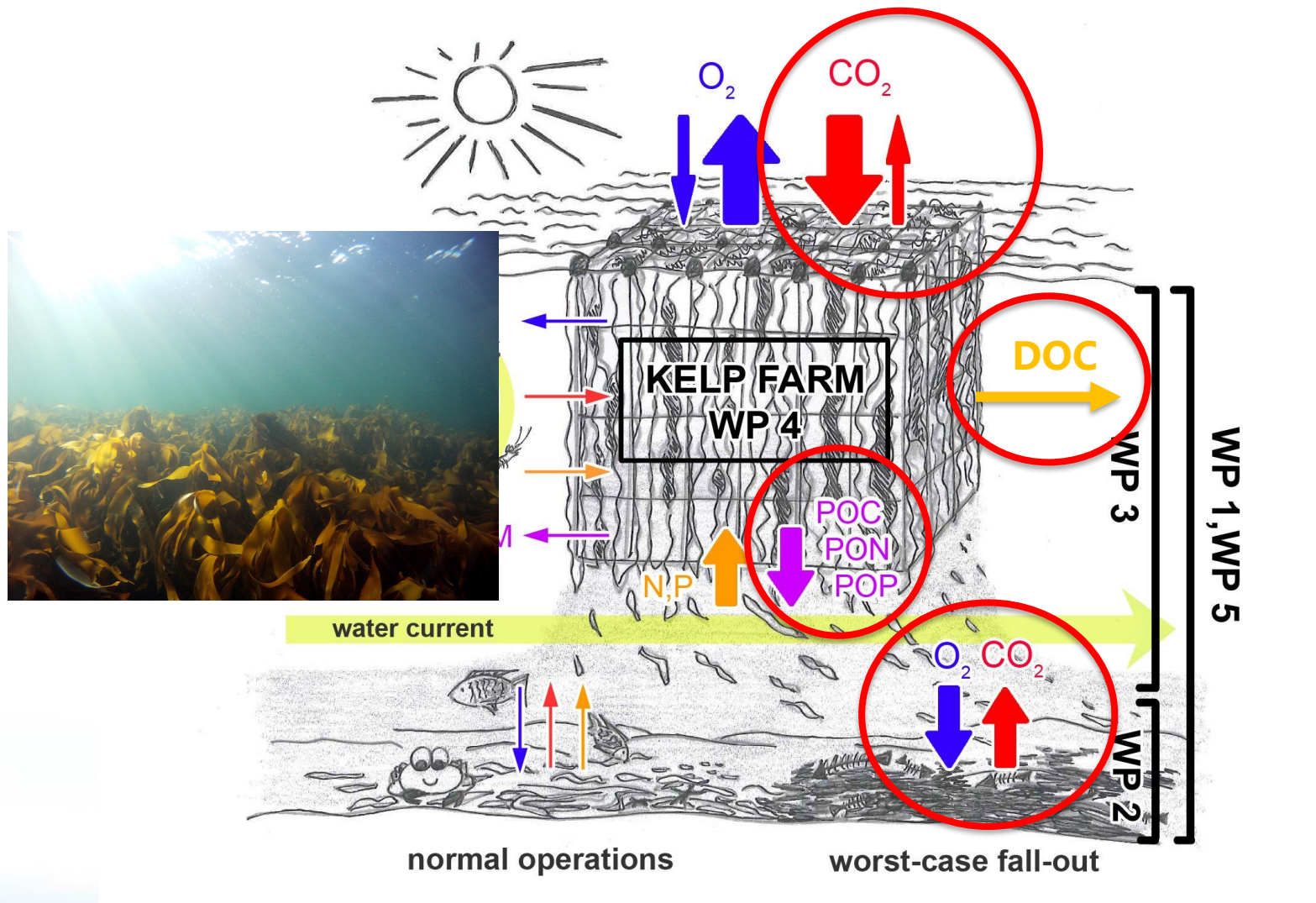
~8.7 mill ton kelp Carbon

Kelp forest ensure

- Coastal primary production (kelp biomass)
- Increasing biodiversity and secondary production
- Increase harvestable fish and crabs



Conceptual figure; including kelp CO₂ uptake and export





“.. terrestrial forests can help mitigate climate impacts by taking up CO2...”

NRK
Nyheter

#nrkdebatt



Blue Carbon

*"Out of all the biological carbon (or **green carbon**) captured in the world, over half (**55%**) is captured by marine organisms and is hence called **blue carbon**"*

BLUE CARBON

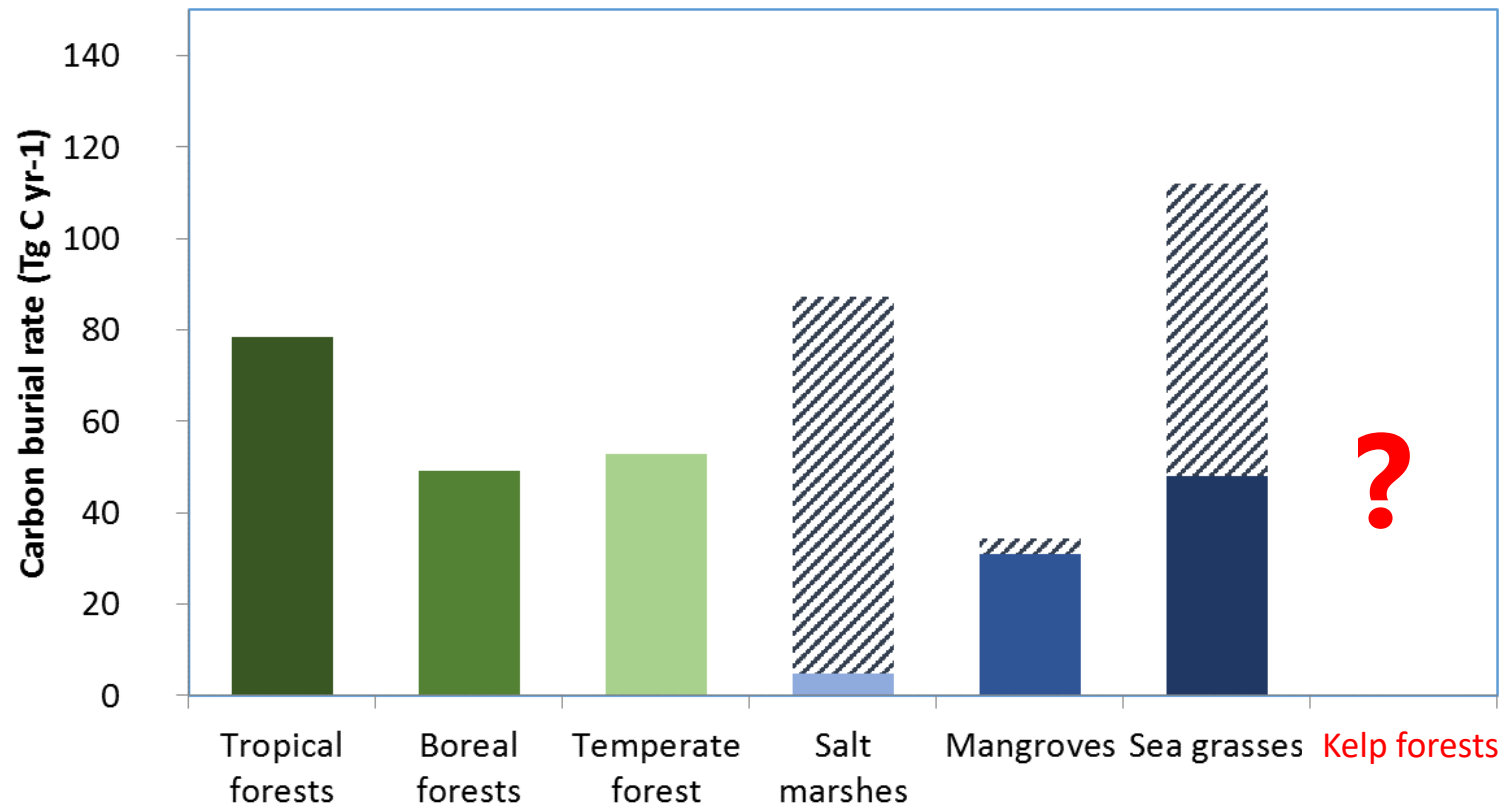
THE ROLE OF HEALTHY OCEANS IN BINDING CARBON



Blue carbon sinks are built by plants and trees (otherwise known as angiosperms such as mangroves, salt-marsh plants and seagrasses) but the coastal ocean also contains vast areas covered by algal beds. **Most macroalgal beds (including kelp forests) do not bury carbon, as they grow on rocky substrates where burial is impossible.**

Marine *versus* terrestrial carbon storage

Globally, the marine carbon sequestration is on the same scale as the terrestrial sequestration

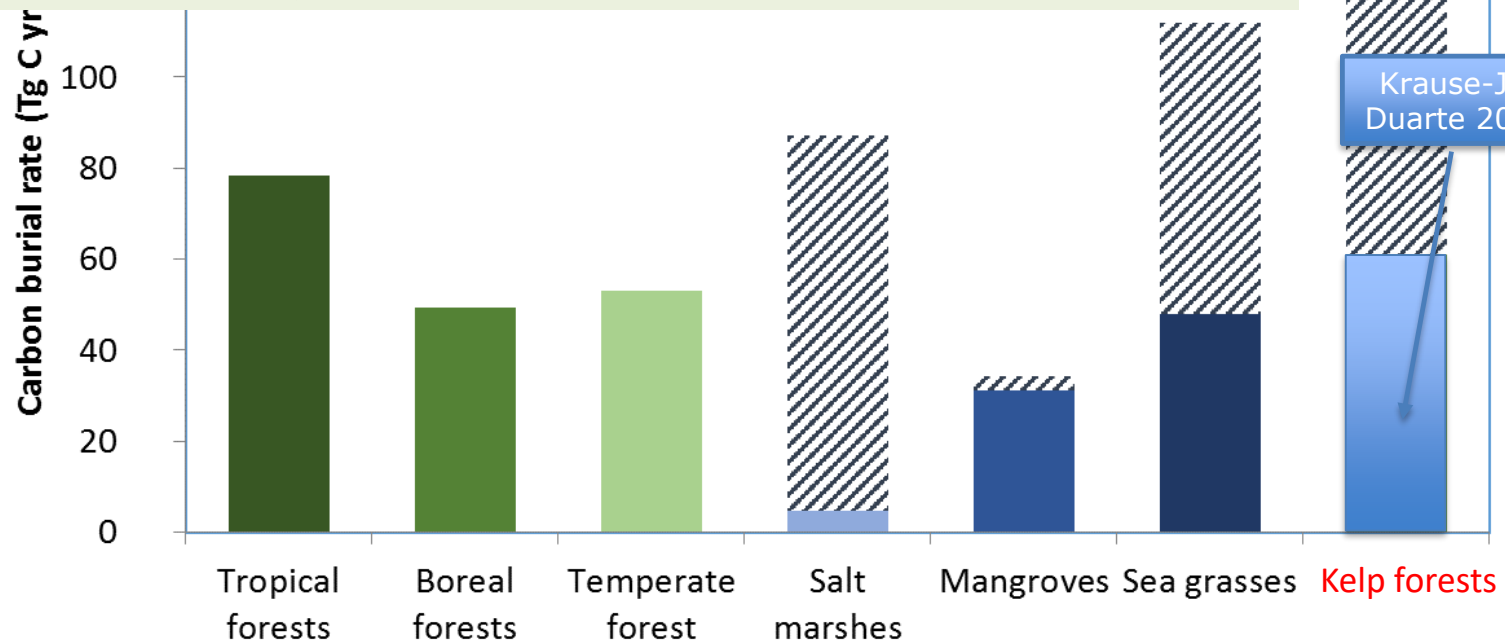


Data from McLeod m.fl. 2011

Marine *versus* terrestrial carbon storage

Putting marine kelp forests on the global carbon map!

"The importance of KELP forest communities as carbon sinks have been largely overlooked.... "



Data from McLeod m.fl. 2011 and
Krause-Jensen and Duarte 2016

Substantial role of macroalgae in marine carbon sequestration

Dorte Krause-Jensen^{1,2*} and Carlos M. Duarte³

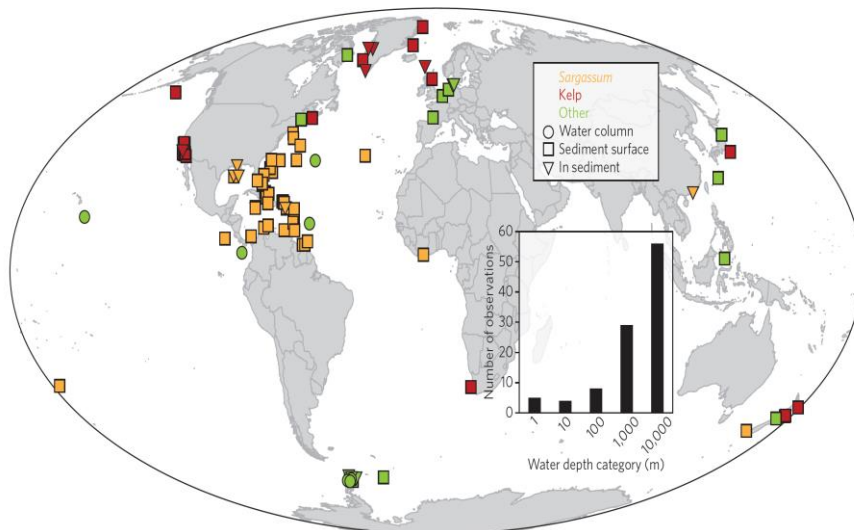
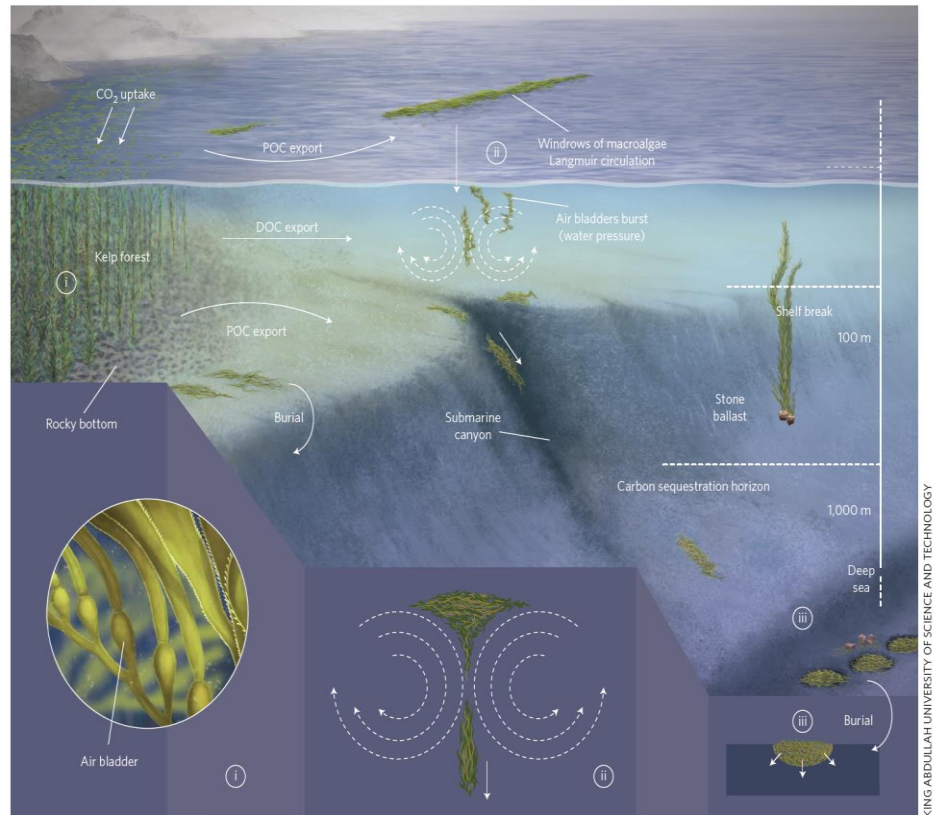
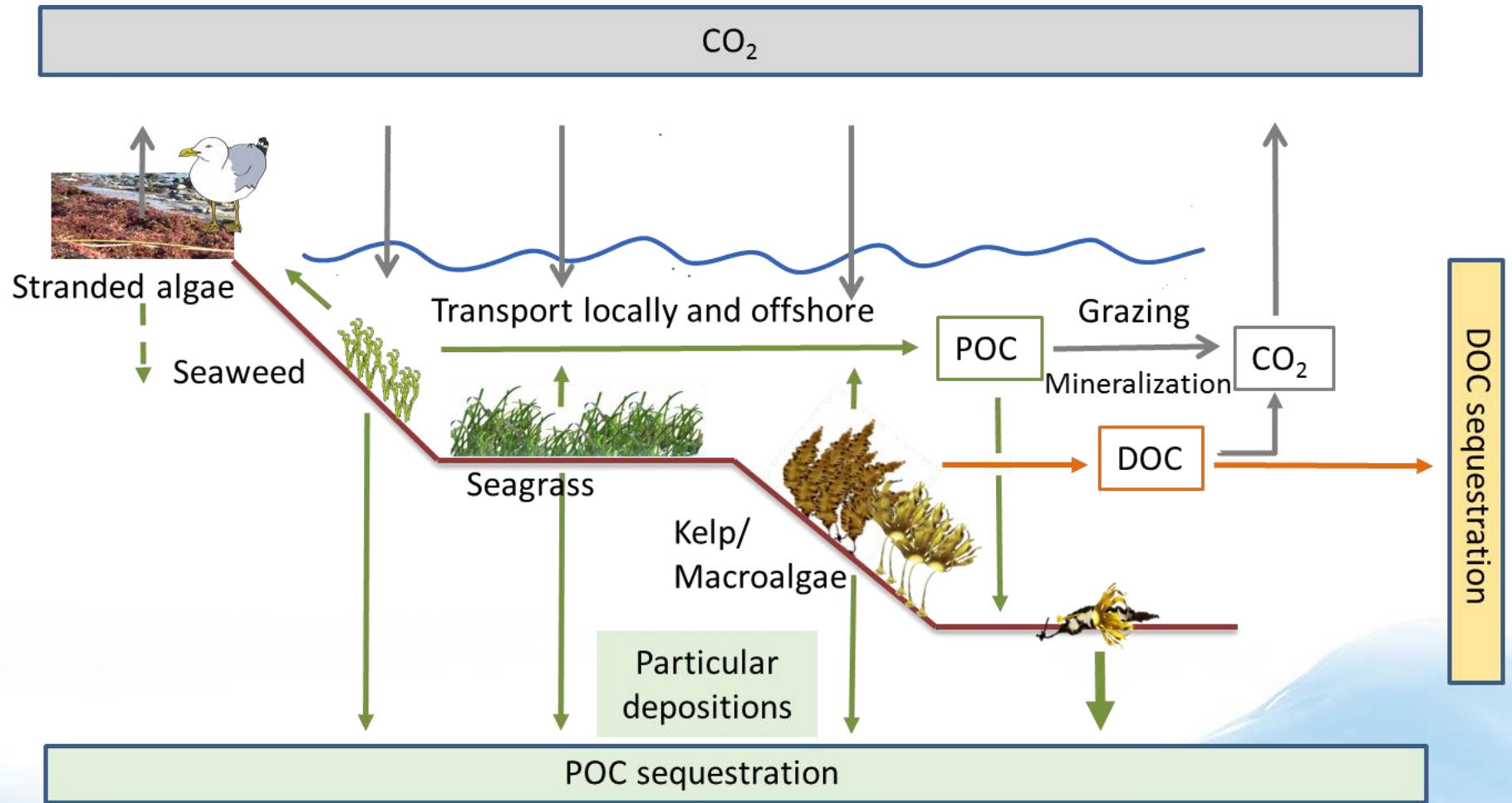


Figure 1 | Map of the locations where macroalgal carbon storage has been reported. The types of macroalgae are indicated for observations



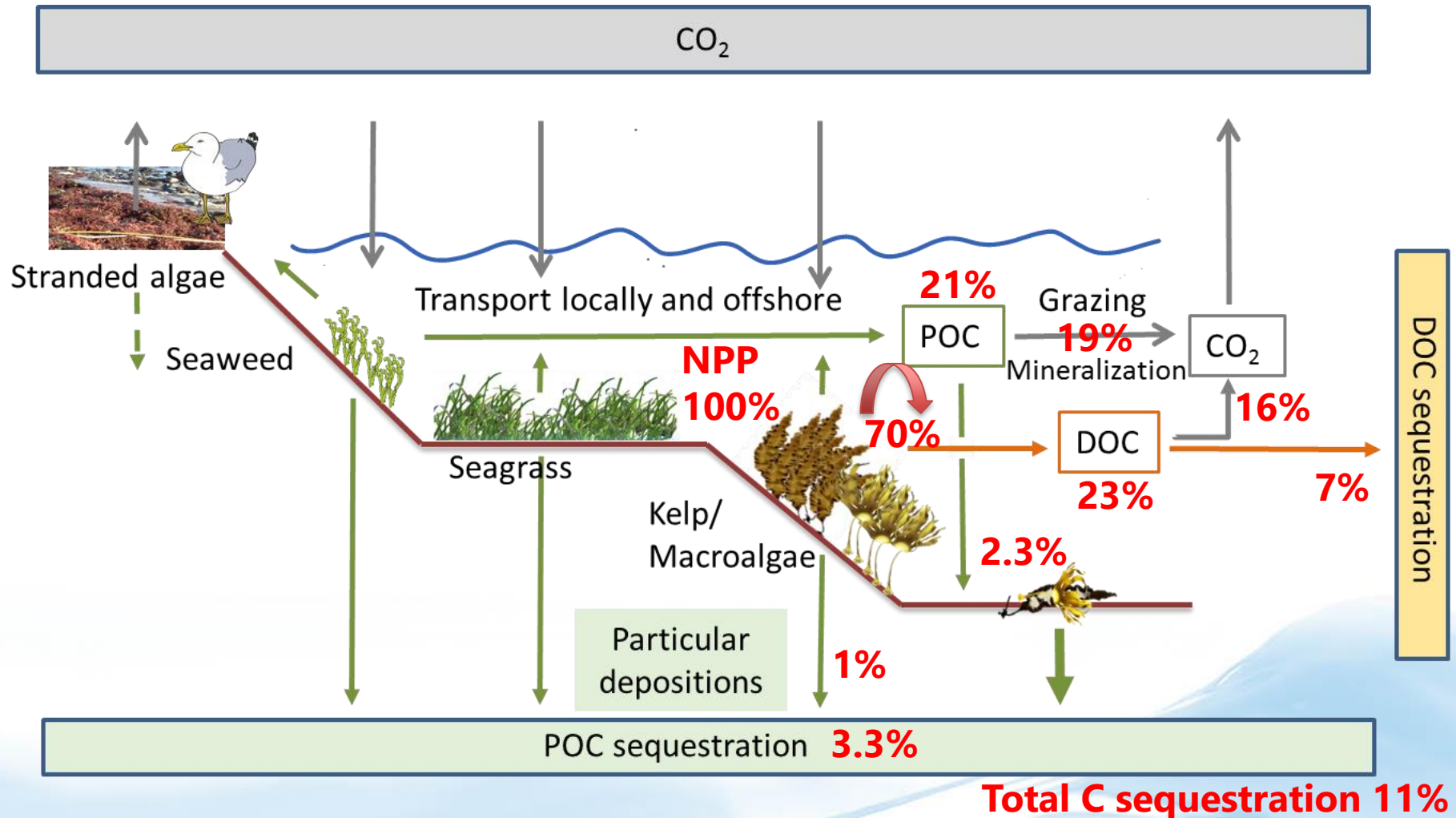
So here we are!

The major Blue Forest Carbon pathways of Nordic waters



Does the global budget apply to the Nordic?

% according to Krause-Jensen & Duarte 2016



The carbon budget

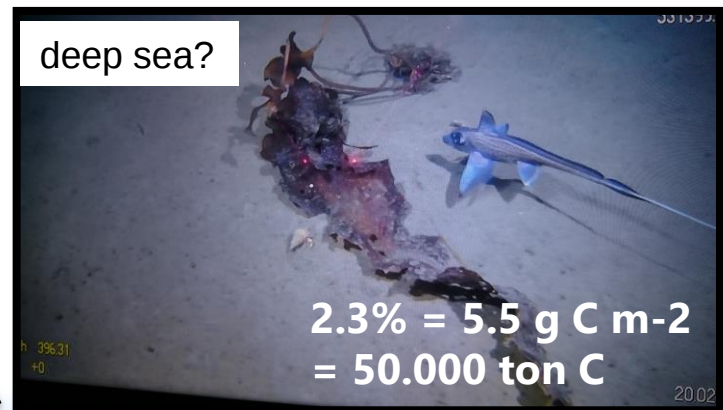
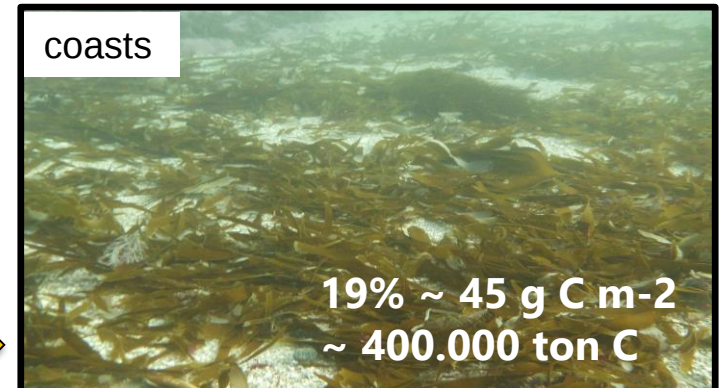
Production: $100 - 500 \text{ g C m}^{-2}$

(Krumhansl & Scheibling 2011, and others)



DOC export
equivalent
to the
particular

Particular Carbon
exported



Photographs: K. Filbee-Dexter and T Bakken

Numbers refer to C export per year to Norwegian waters, assuming 9000 km^2 of kelp forest (calculations according to Krause-Jensen & Duarte 2016, global assessment budget).

The carbon budget

Production: 100 – 500 g C m⁻²

(Krumhansl & Scheibling 2011, and others)



Photographs: K. Filbee-Dexter and T Bakken

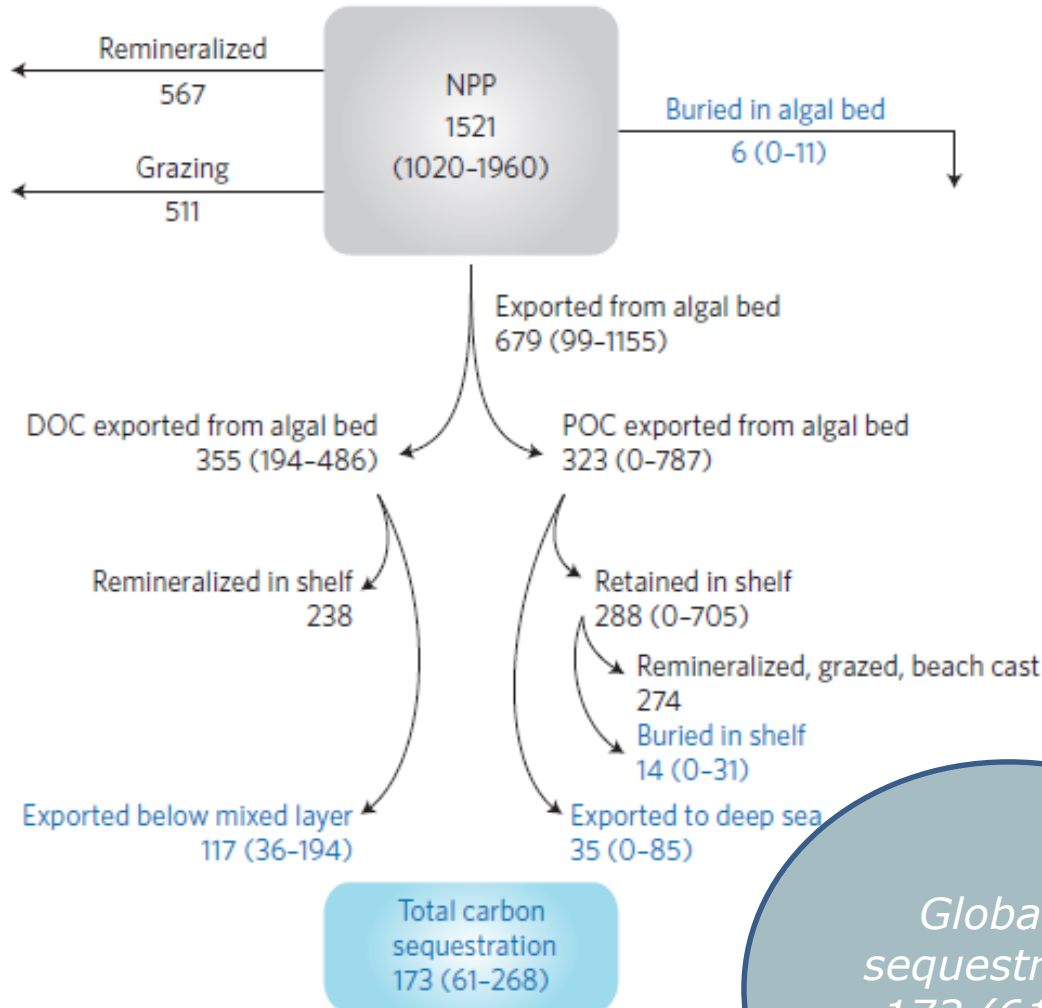
Total Norwegian
production
~ 2.9 mill ton C y⁻¹

Total export ~ 40%
(POC + DOC)
~ 1.2 mill ton y⁻¹

Total carbon
sequestration (11%)
~ 370.000 ton C

- **Equivalent to ~1 %** of
the total Norwegian CO₂
emission per year
(~50 mill. ton y⁻¹)

The carbon budget on the global scale



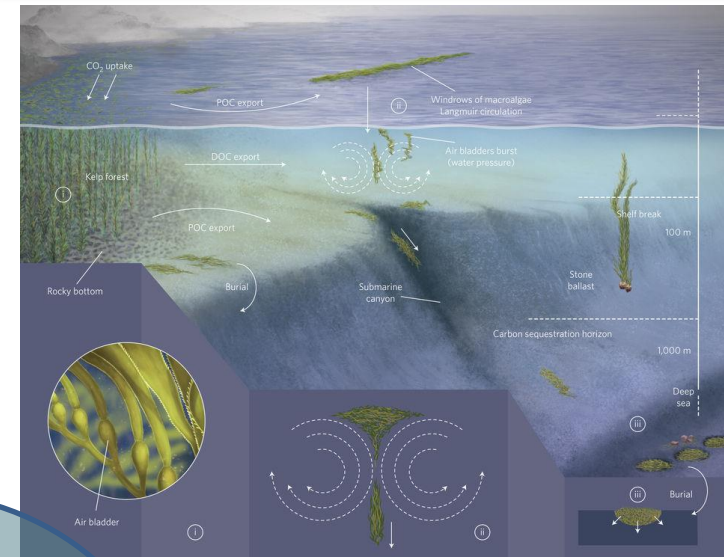
nature
geoscience

PROGRESS ARTICLE

PUBLISHED ONLINE: 12 SEPTEMBER 2016 | DOI: 10.1038/NGE02790

Substantial role of macroalgae in marine carbon sequestration

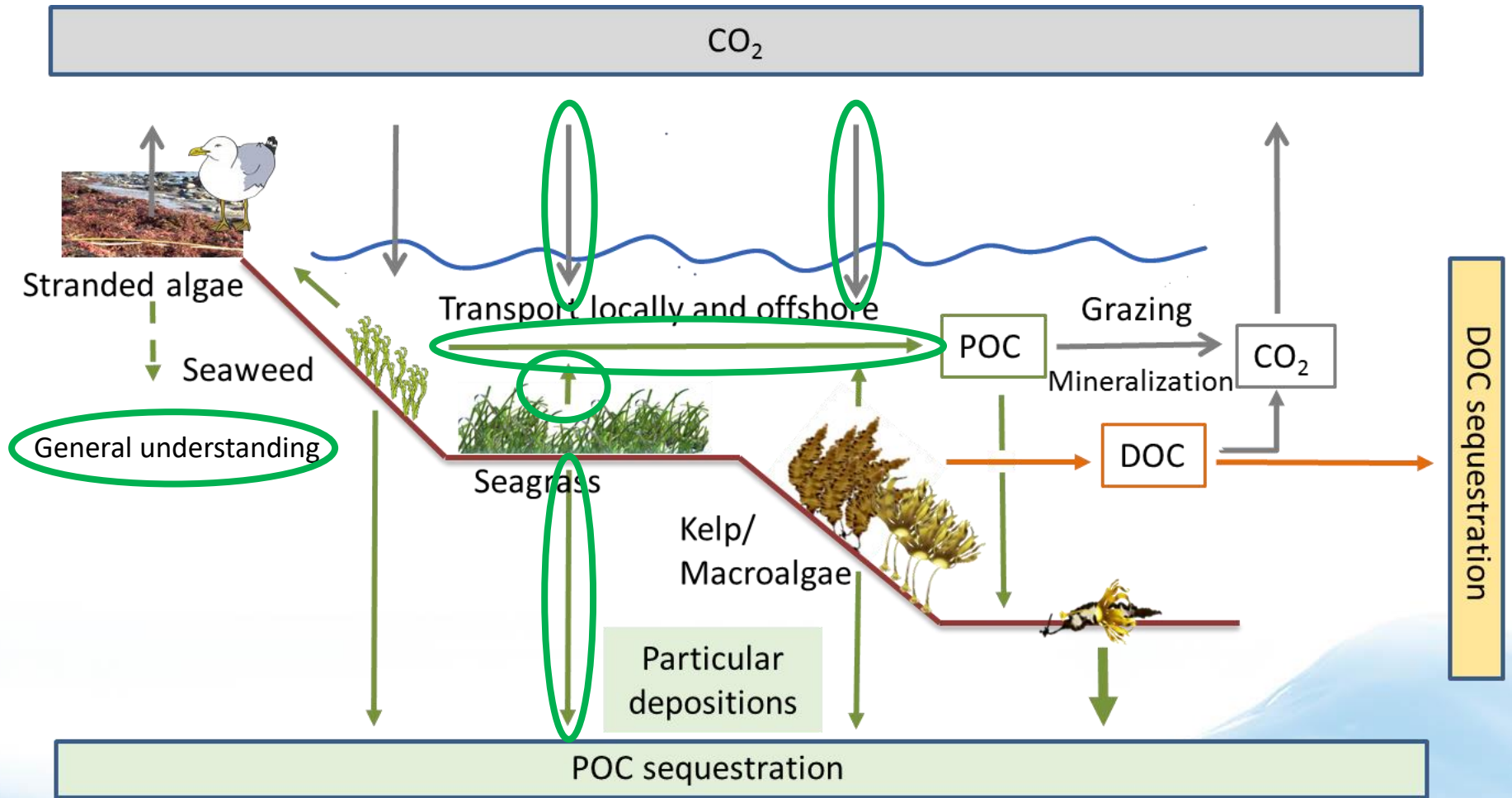
Dorte Krause-Jensen^{1,2*} and Carlos M. Duarte³



*Global C
sequestration
~173 (61-268)
Tg C y⁻¹*

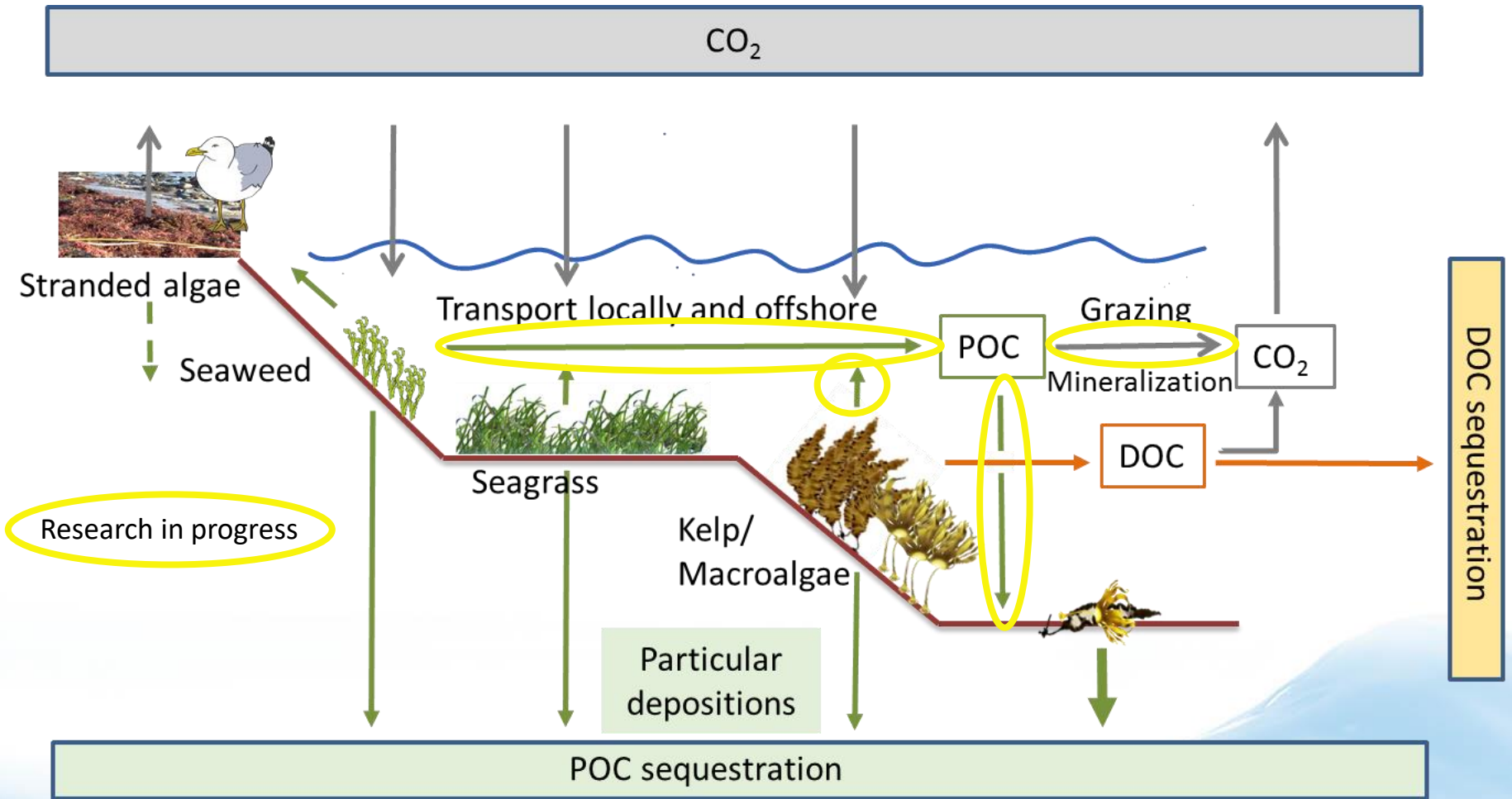
Here we do have a good grip on...

The major Blue Forest Carbon pathways of Nordic waters



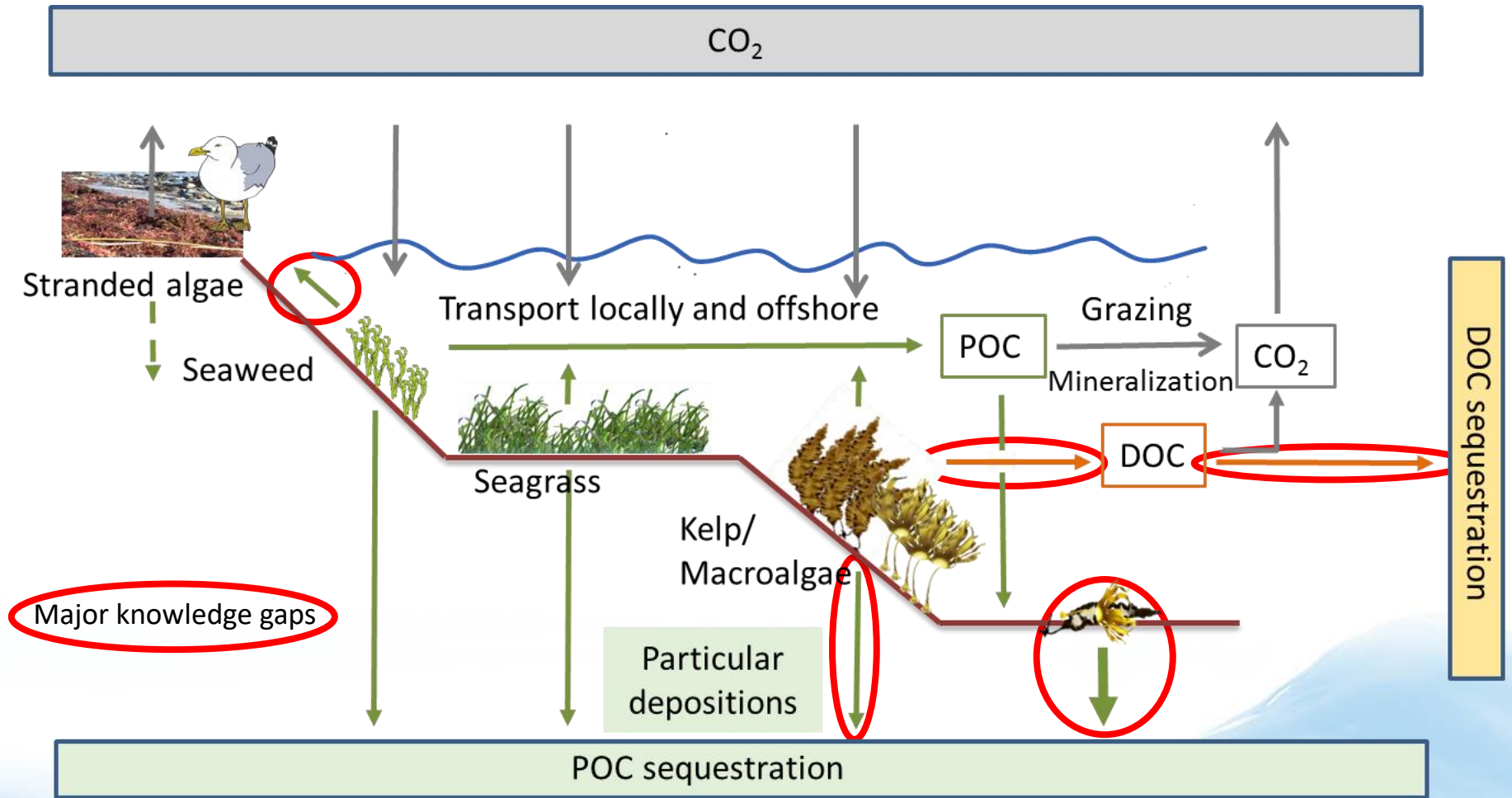
So here we are!

The major Blue Forest Carbon pathways of Nordic waters



Major knowledge gaps.. Summering up.

The major Blue Forest Carbon pathways of Nordic waters



NORDIC BLUE CARBON

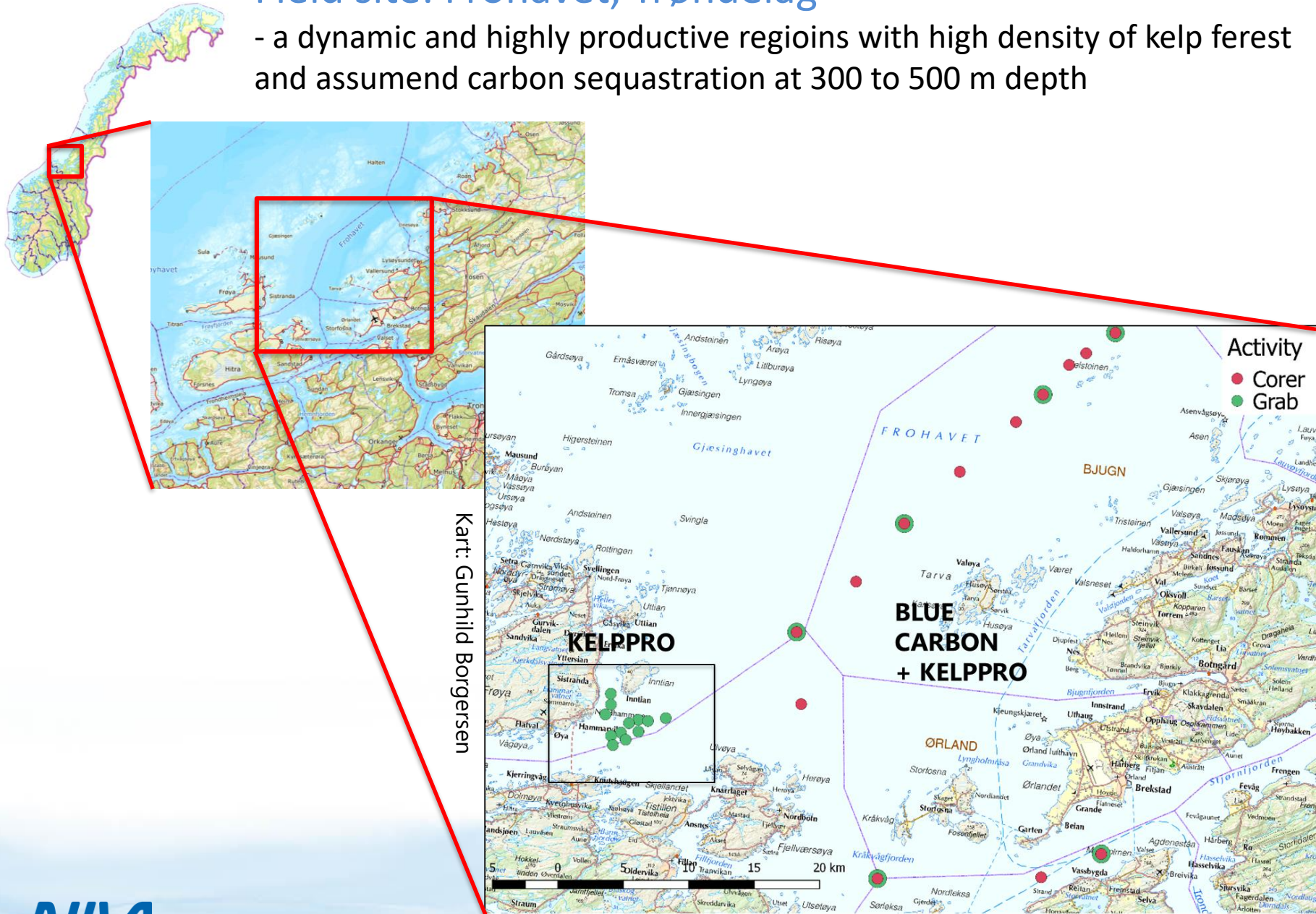
A RESEARCH PROJECT FUNDED BY THE NORWEGIAN ENVIRONMENT
AGENCY (2017-2020) ON CLIMATE ADAPTATION, CARBON CAPTURE
AND LONG-TERM STORAGE IN BLUE FORESTS IN THE NORDIC REGION

FIND OUT MORE

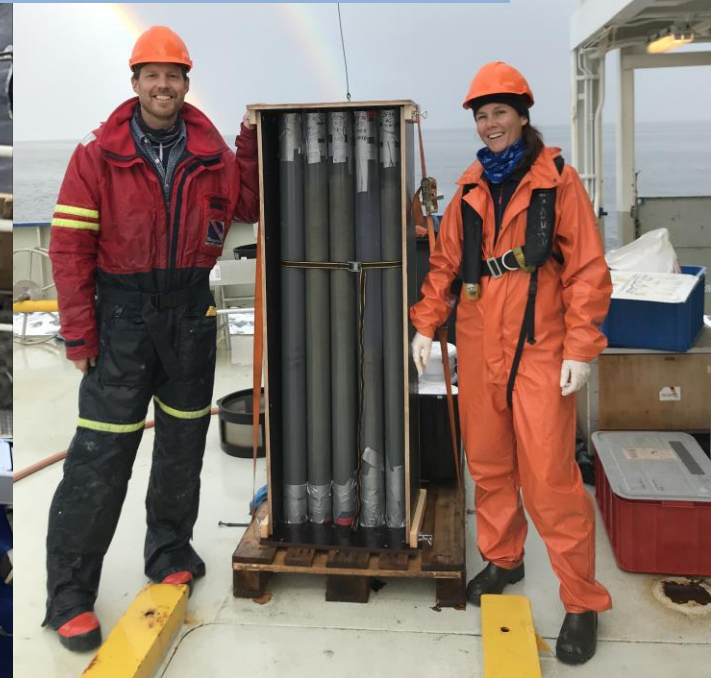
<http://nordicbluecarbon.no/>

Field site: Frohavet, Trøndelag

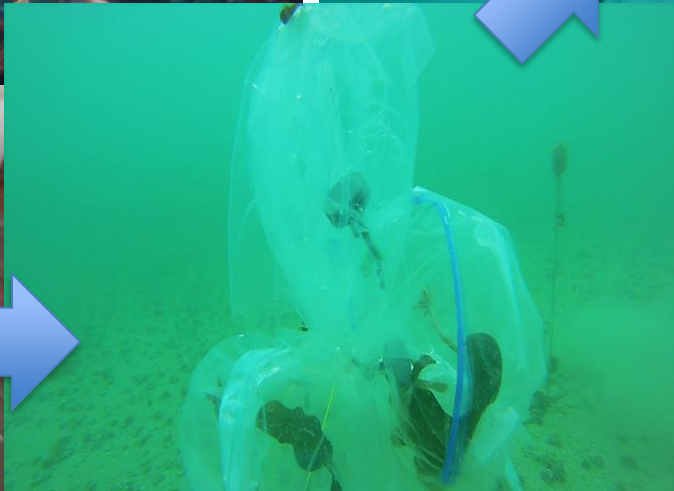
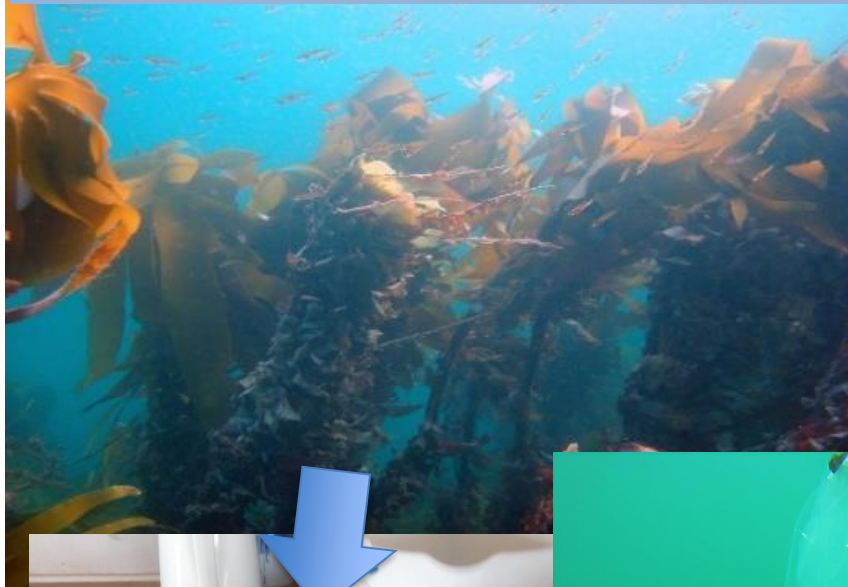
- a dynamic and highly productive regions with high density of kelp forest and assumend carbon sequestration at 300 to 500 m depth



Carbon sequestration measurements, Frohavet, Norway, Oct 2018



Measurements of Dissolved Organic Carbon export from kelp, Malangen, Norway, May 2018



DET NORSKE BLÅ SKOG NETTVERKET (NBFN)

- Øke bevisstheten
- Få ny kunnskap
- Påvirke gjennom politiske agendaer



Norwegian Blue Forests Network (NBFN)

Mobilizing Norwegian expertise for sustainable management of the blue forests in Norway and abroad



Conclusion & perspectives

- Macroalgal forests are key coastal habitats and essential for marine primary productivity
- They support seafloor and open water foodwebs and contribute expressively to marine C-sequestration
- Sustainable management of macroalgal habitats support ecosystem health and offer opportunities to mitigate and adapt to climate change
- Macroalgae farming provide options to elevate local and global CO₂ uptake and C sequestration

Questions?

Thanks to all contributing authors on related research projects:

- Nordic Blue Carbon (NIVA, AU, GU, IMR, NBFN)
- EuroMarine- Role of Macroalgae Carbon in the global Carbon budget
- KELPEX (NIVA, IMR, WAU, RUC)
- KELPFate (NIVA, NBFN, IMR)
- KELPFloat (NBFN, NIVA, IMR)
- KELPPRO (NIVA, SINTEF, NTNU, ApN, IMR)
- BURSE (NBFN, NIVA, IMR)
- SEAME (NBFN, IMR, NIVA)