POTENTIAL CULTIVATION AREAS AND ENVIRONMENTAL INTERACTIONS

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SINTEF Ocean

Plan

- Suitable areas for cultivation of macroalgae (and a bit about production potential)
  - Project financed by Møre and Romsdal county
  - Similar ongoing assignment for Trøndelag county

- Environmental interactions: KELPRO
  - Project financed by the Research Council of Norway, 2017-2020, 8,5 MNOK
  - Lead by NIVA
  - Partners: NTNU, AkvaPlanNIVA, IMR, SINTEF, Univeristy of South Denmark, SES, Hortimare
  - Project just started -> will just say a few words about the project

Candidate species

- Species ready for industrial cultivation today
  - Sugar kelp (*Saccharina latissima*)
  - Dabberlocks(*Alaria esculenta*)
  - Oarweed (*Laminaria digitata*)
  - Dulse (*Palmaria palmata*)

- Other species that may be relevant
  - Ulva spp (*Ulva lactuca*)
  - Porphyra spp (*Porphyra umbilicalis*) (large scale cultivation in Asia)

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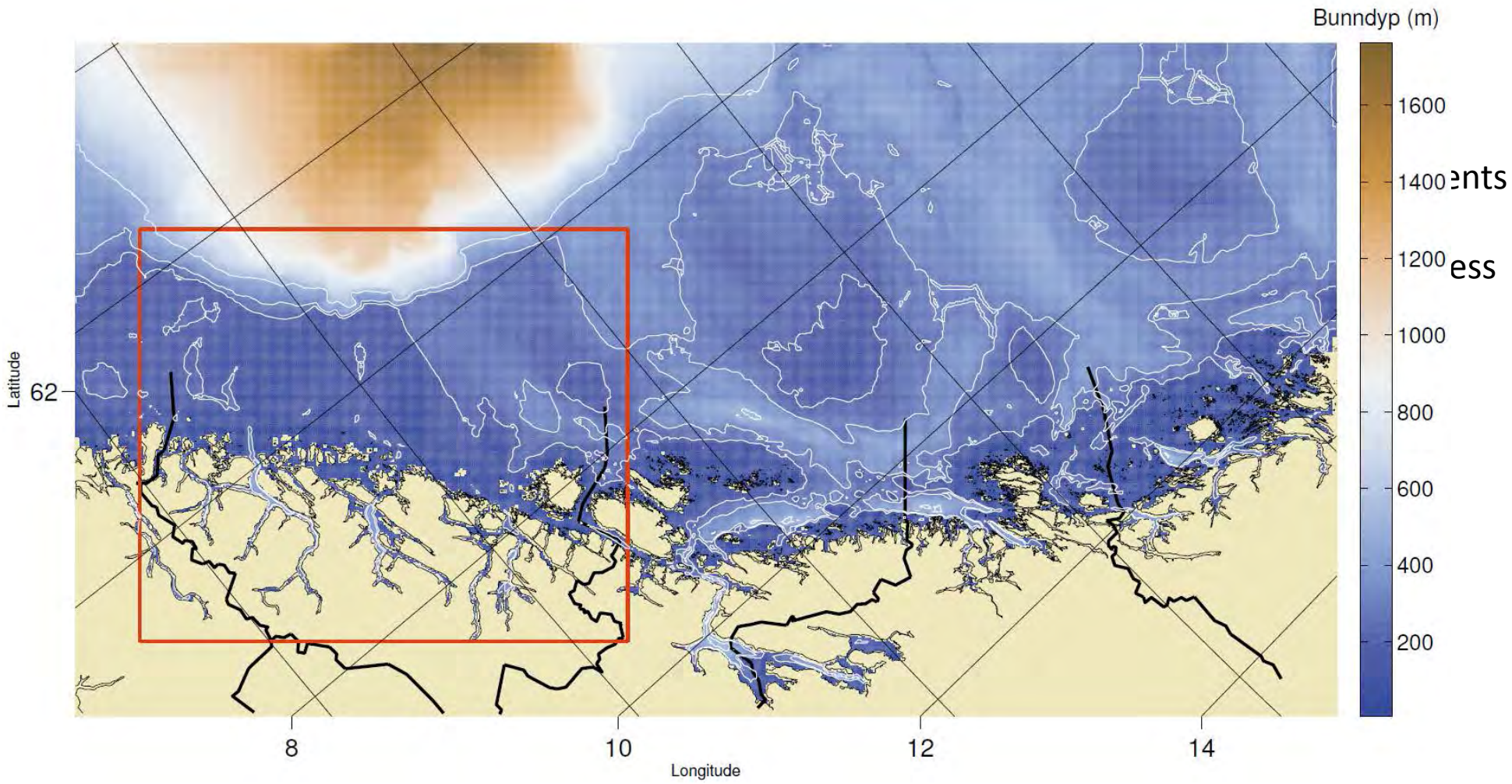
Suitable areas for cultivation – how?



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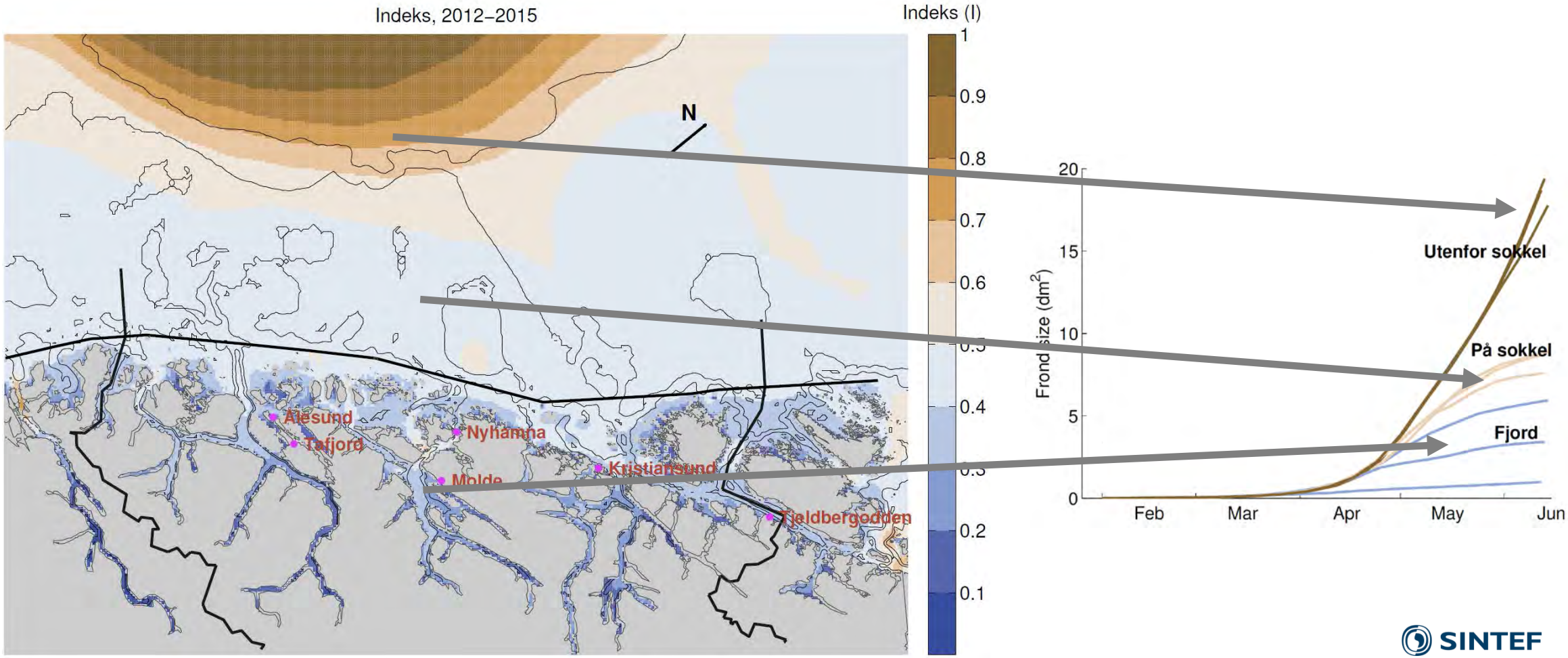
Suitable areas for cultivation



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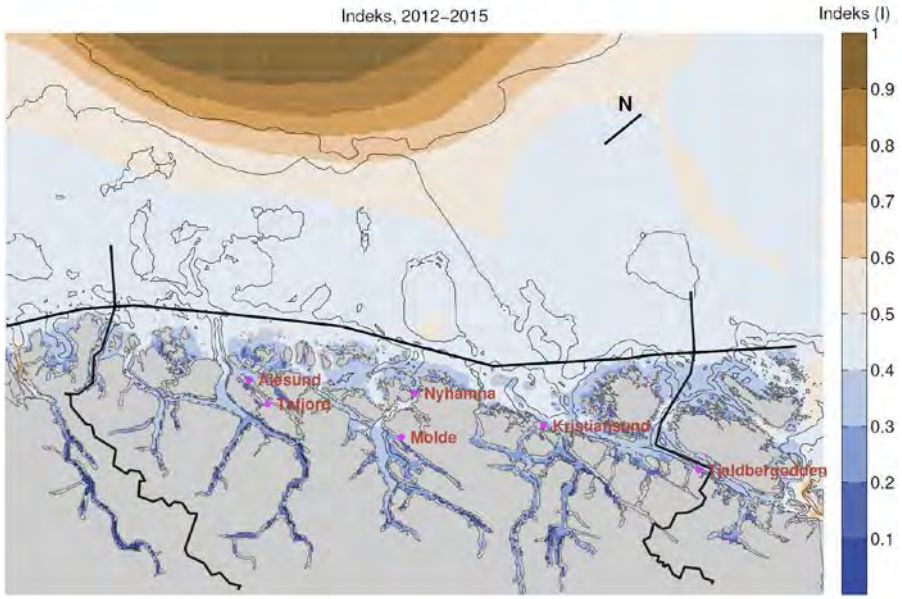
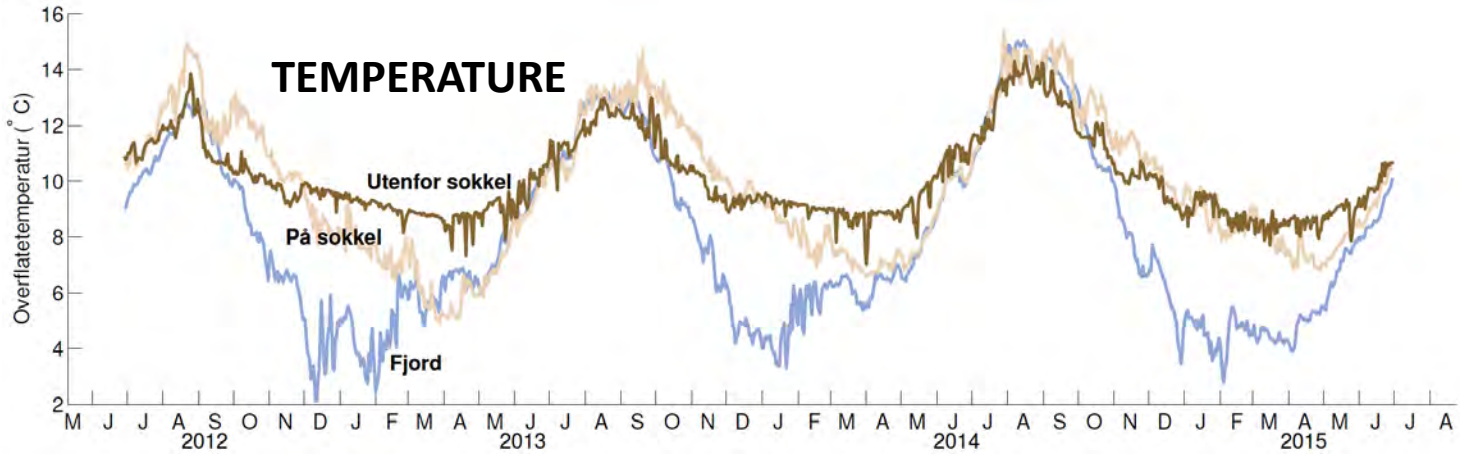
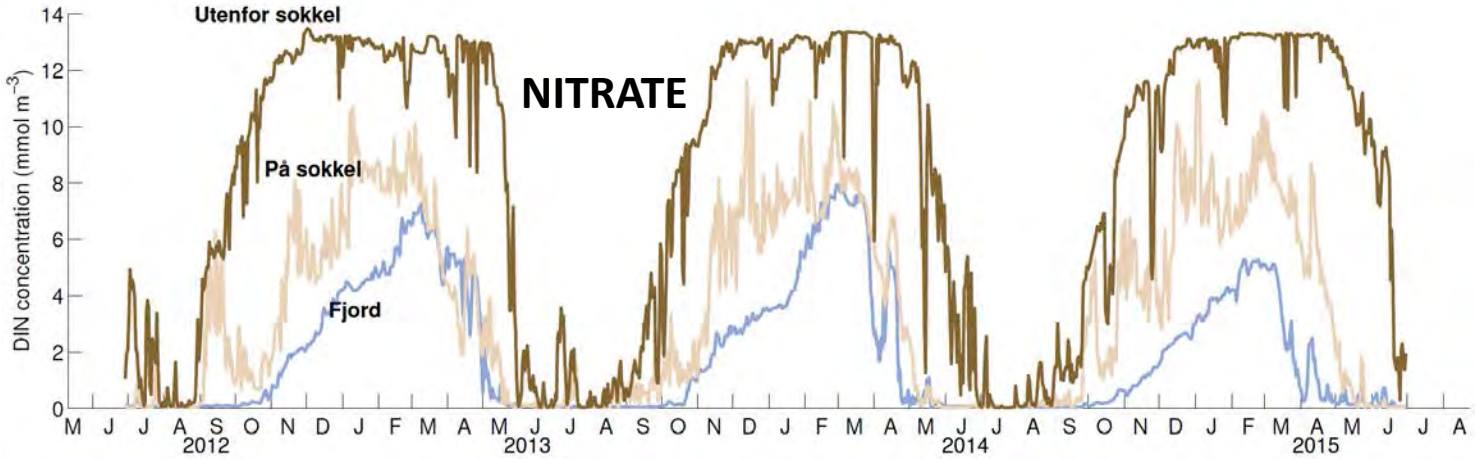
Suitable areas for cultivation



- The model simulations generally indicate higher and more stable concentrations of nutrients outside the shelf than along the coast and in the fjords
- This **general picture** is in line with field surveys
- Challenge: currents and waves?





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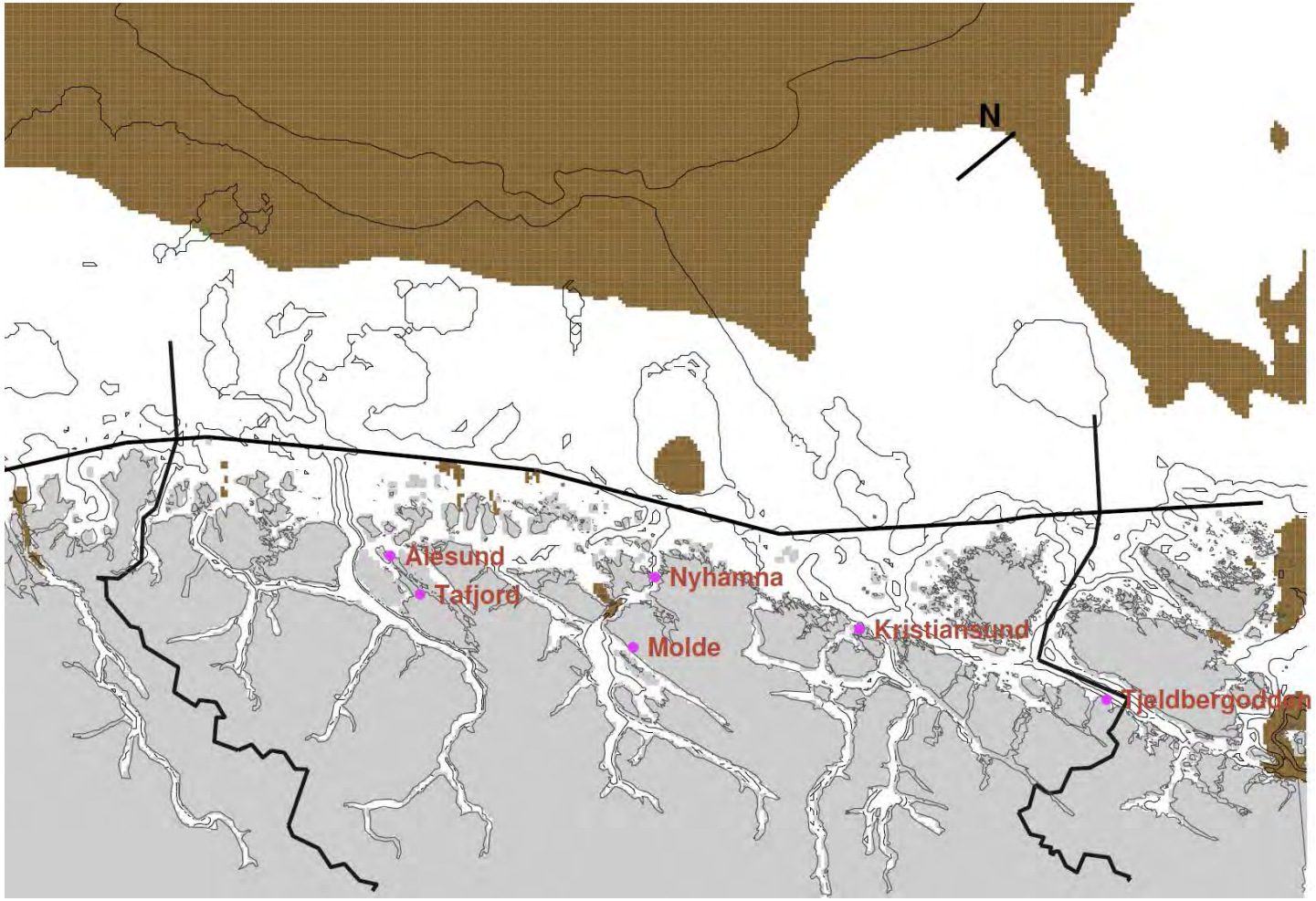
The "75 percentile" region



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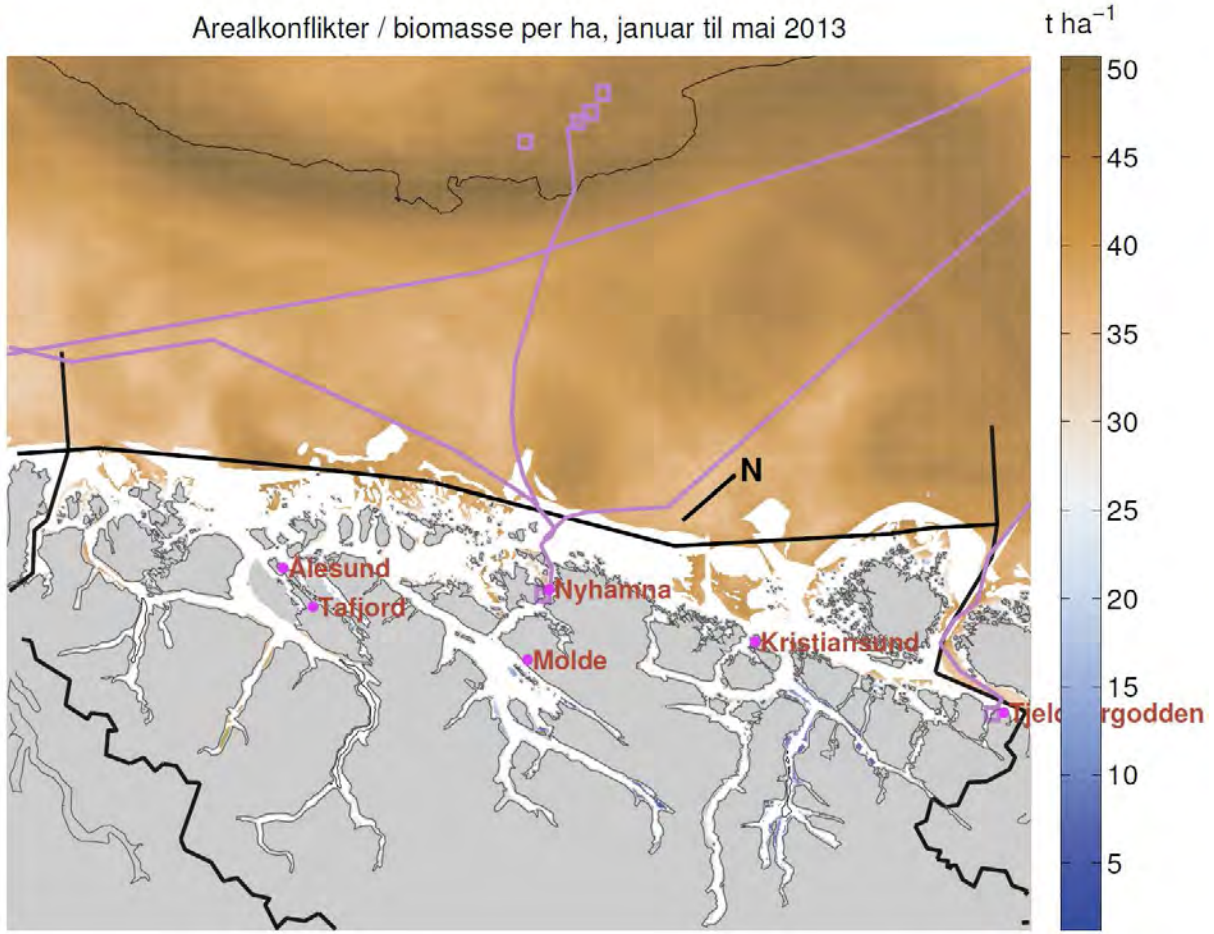
Potential areal conflicts

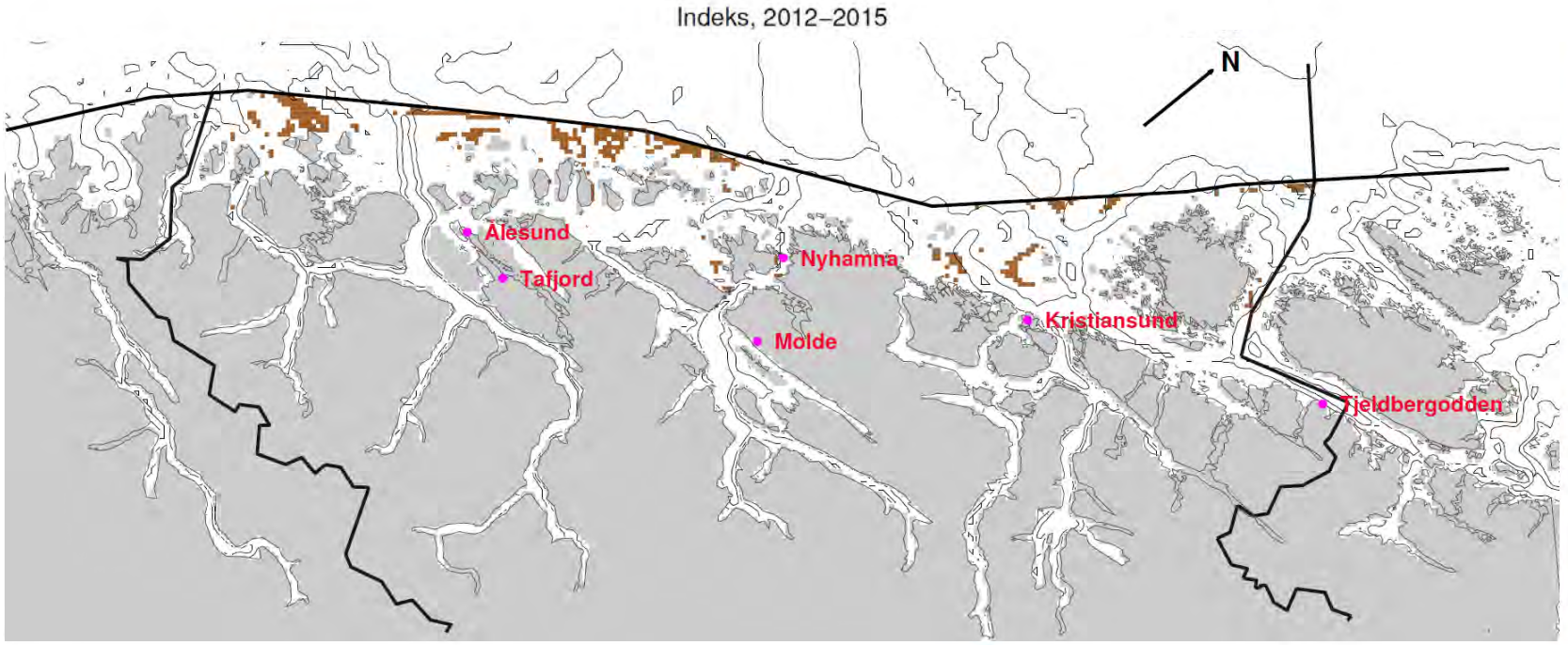
- Natural kelp harvesting zones
- Fareway
- Fisheries
- Oil and gas

- Potential conflicts mainly inside sea line
- In general large areas with good potential available → conclicts should **not** be a hindrance to industrial cultivation



Data on "conflicts" from the Norwegian Directorate of Fisheries (www.fiskeridir.no)

Inside the territorial zone: index and 75 precentile regions without conflicts



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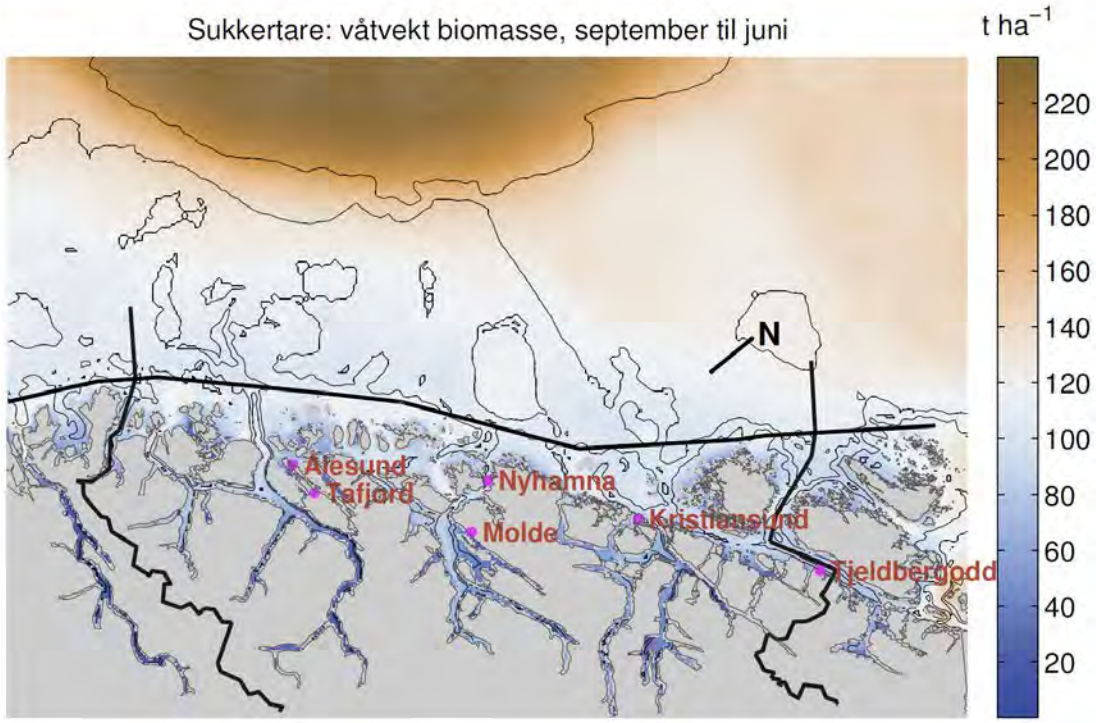
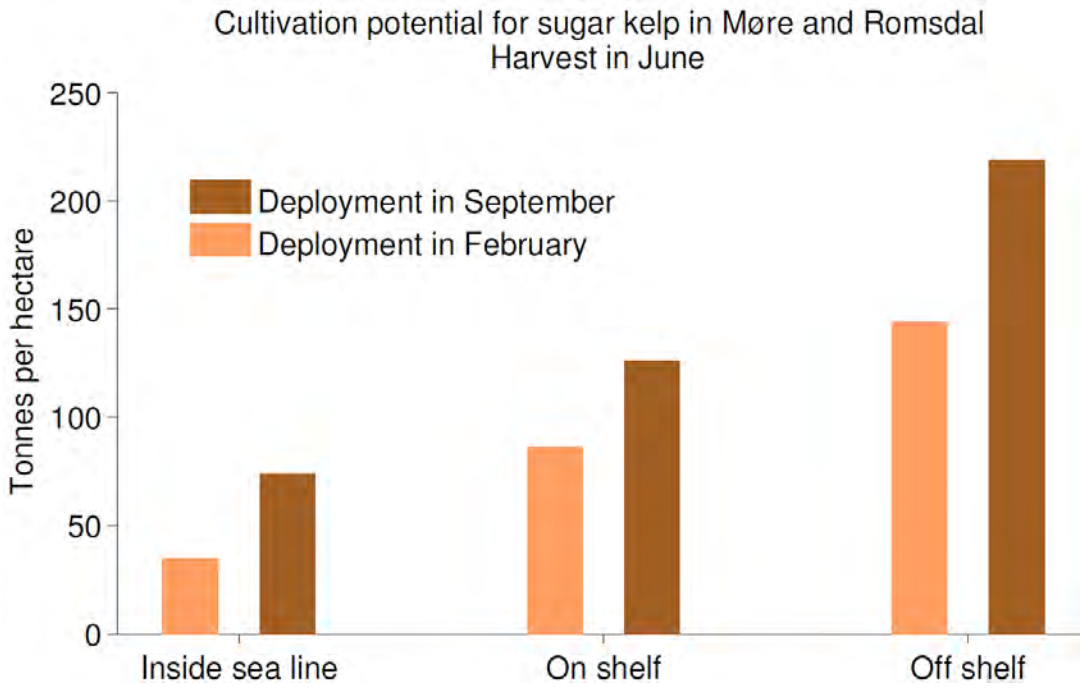
The potential for biomass production





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Potential for biomass production

Sea area in the county of Møre og Romsdal	Estimated available area(km^2)	Potential for kelp cultivation ($t\,ha^{-1}$)	CO_2-uptake ($t\,ha^{-1}$)
Inside the territorial zone	6271	35–74	7–15
Inside the territorial zone without conflict areas	ca. 990	38–73	7–15
Continental shelf outside TZ	ca. 17 600	86–126	14–23
Continental shelf outside TZ without conflict areas	ca. 17 150	87–127	14–23
Outside the continental shelf	> 20 000	144–219	20–34

- For sugar kelp
- Average over regions and three years
- Still mainly a comparison of different regions under *otherwise similar conditions* – other literature values vary from 22 til 270 t FW ha^{-1}

Total: 3.5 to 7 million t annually (if everything could be realized simultaneously!)

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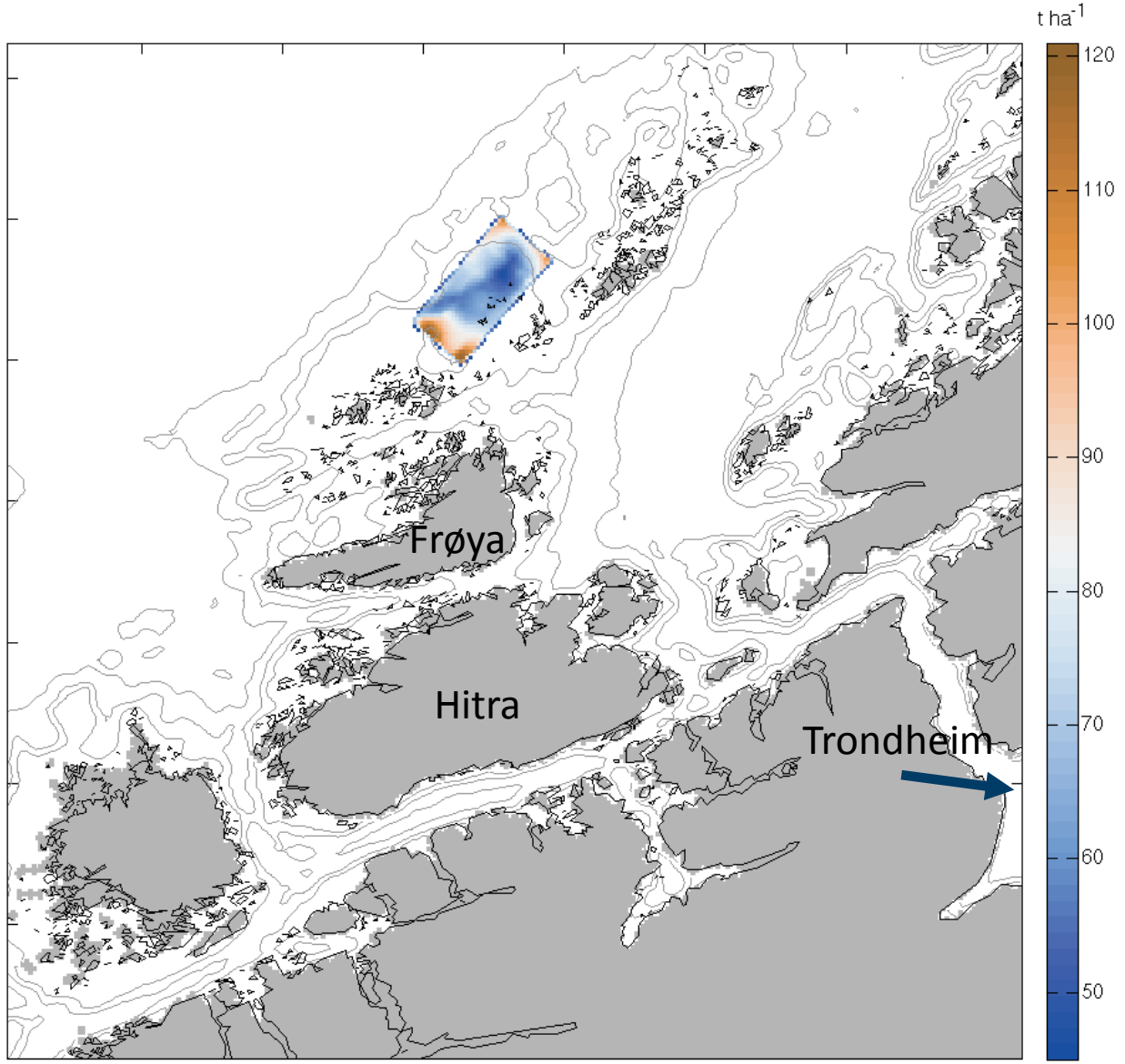
Is it possible to realise the full potential in a large region?

Simulation exercise

- Cultivation January - June
- ~ 130 km^2 cultivation region
- Total production ~ 960,000 t
- Average production 75 t ha^{-1}
- Trondheimsfjorden: 1420 km^2
- Results from China
  - 979,006 t DW in 40,201 ha (Zhang et al. 2015)
  - 24 t DW ha^{-1}



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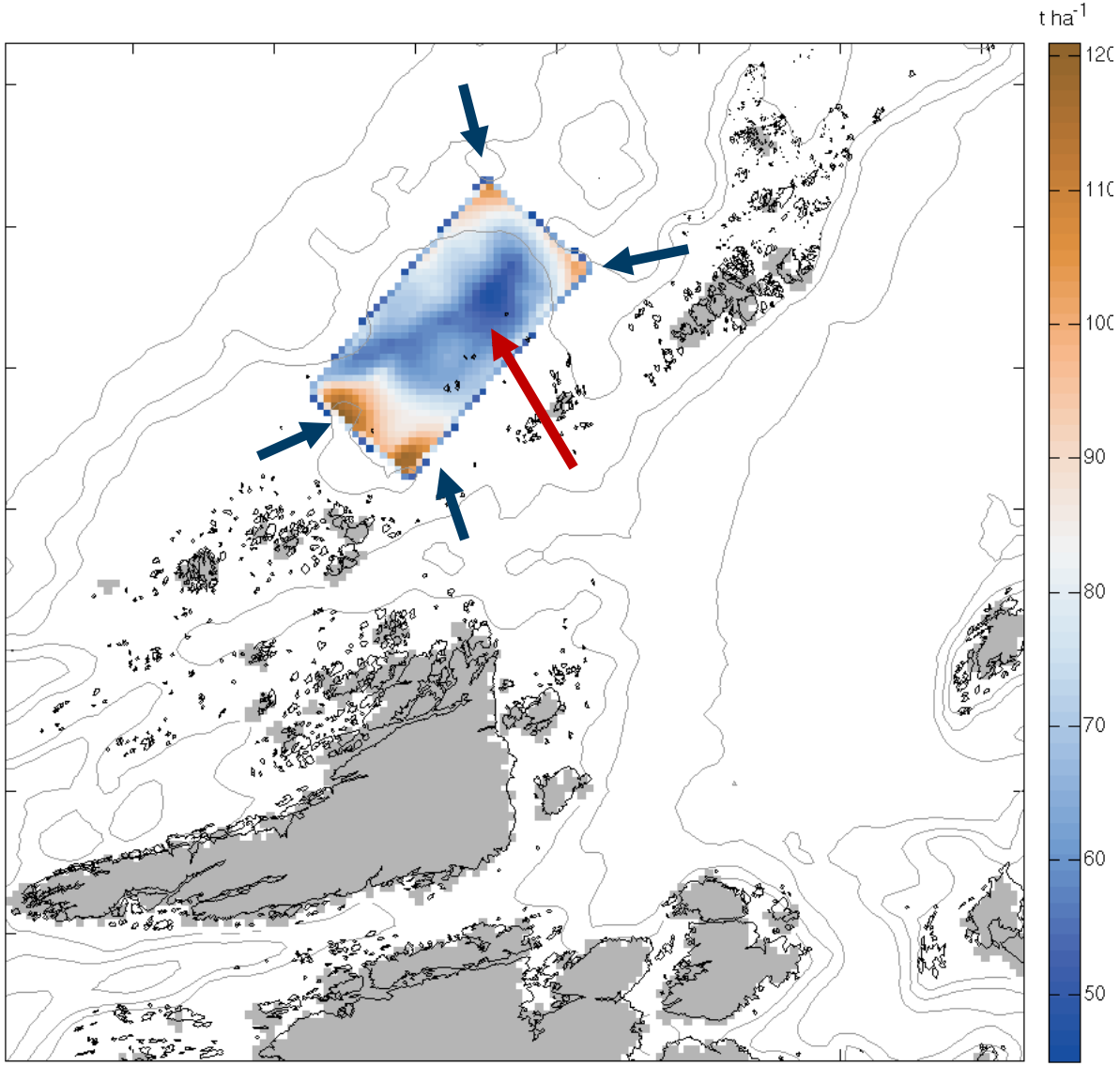
Nutrient depletion?

- Model run with feedback between kelp nutrient uptake and the environment
- Signs of reduced availability of nutrients deep inside region
- Uptake on boundaries lead to less nutrients transported inside
- Calls for investigation into
  - Carrying capacity
  - Environmental effects – e.g. significance of nutrient uptake



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Kelp industrial production: Potential impacts on coastal ecosystems (KELPPRO)

- a research proposal funded by the RCN HAVBRUK2 program in Dec 2016

- **Project lead**: Kasper Hancke, NIVA
- **Scientific partners**: SINTEF, NTNU, ApN, IMR, University of Southern Denmark (SDU)
- **Industrial partners**: Seaweed Energy Solutions (SES), Hortimare

- Duration: 2017-2020 (4 years)
- Budget: 8.5 MNOK in total

KELPPRO - Kelp industrial production: Potential impacts on coastal ecosystems

Aim:

to provide an integrated assessment of positive and negative impacts of industrial-scaled kelp farming on the marine ecosystem of coastal Norway

Credit: Image courtesy of Bio Architecture Lab

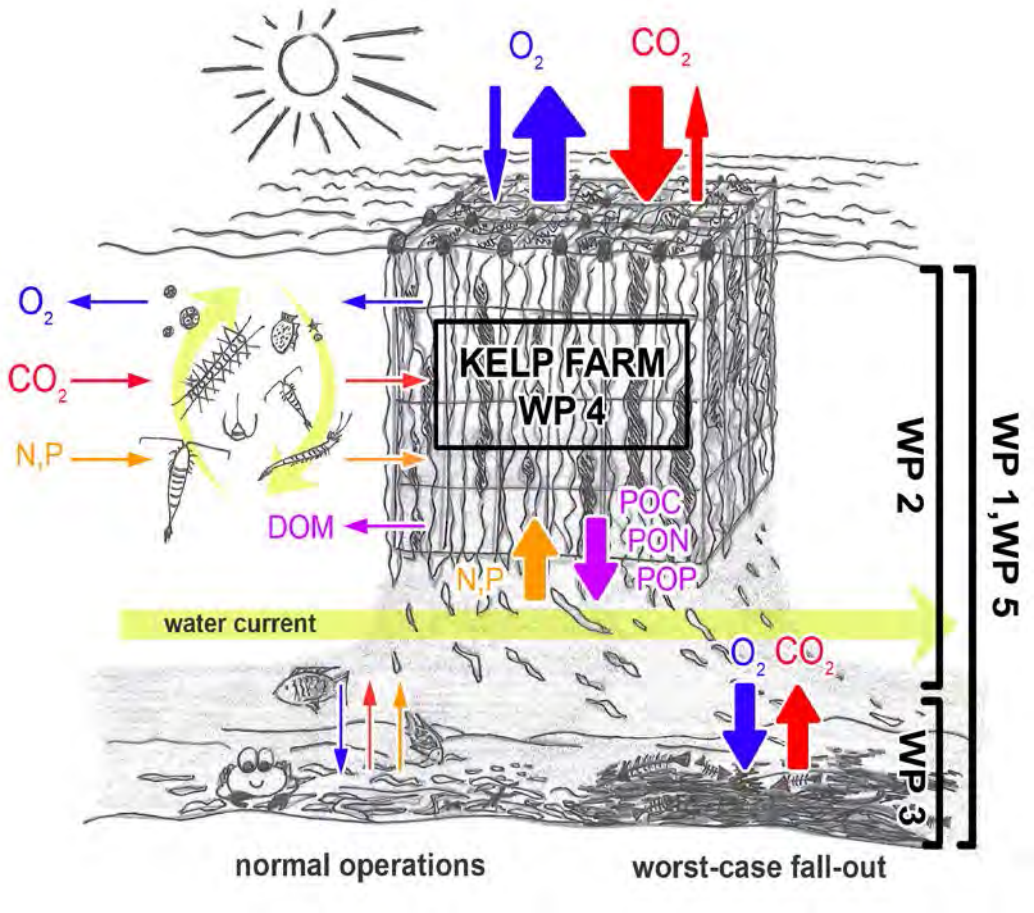
Main Q:

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

Credit: SINTEF (www.sintef.no)

Research focus:

- WP#1: Industrial kelp cultivation scenarios
- WP#2: Effects of industrial kelp farming on sea floor ecosystems
- WP#3: Effects on open water ecosystems
- WP#4: Industrial kelp facilities as 'artificial kelp forests'
- WP#5: Integration and dissemination



*Integrated **fieldwork**, **mesocosms experiments** and **numerical modelling** is planned*

Source: SES

Conclusions

- The results indicate a great potential for biomass production on and outside "continental shelf"
- Also good potential within fjords and in coastal areas, though higher interannual variability (?)
- The outlook for an industry based on cultivated macroalgae in Møre and Romsdal (and probably the rest of the country) is bright

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