ECOLOGICAL MODELLING OF COASTAL ECOSYSTEMS USING FLEXSEM

https://marweb.dmu.dk/Flexsem

AARHUS UNIVERSITY
DEPARTMENT OF BIOSCIENCE

BOOS
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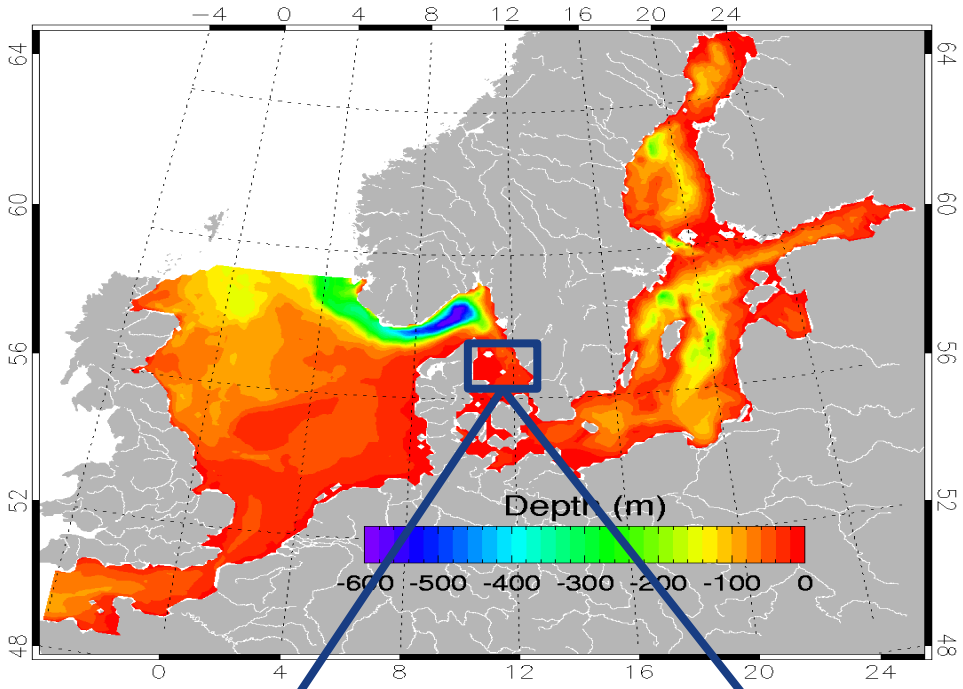
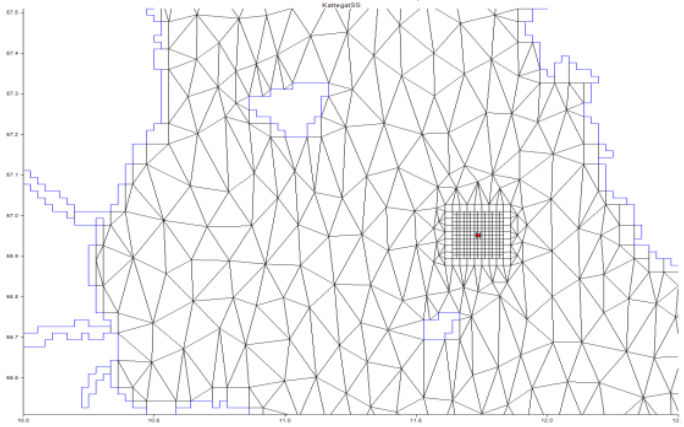
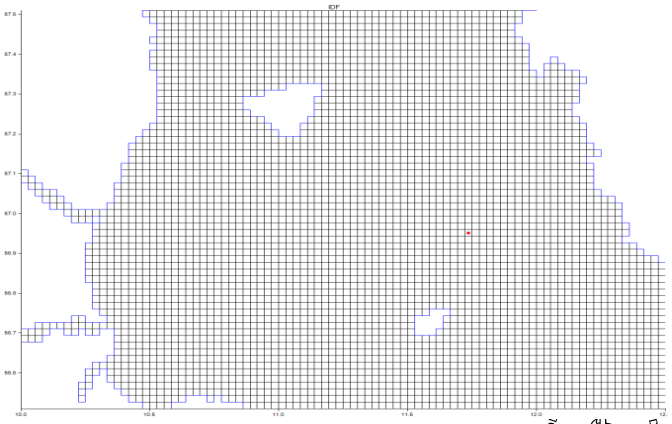
FLEXSEM

- Crop out local area
- Change grid
- Off-line or full hydrodynamics
- Forcing data from regional models
- Fast (runs on normal pc)
- Flexible e.g. new modules
- Tracers, NPZD models
- Easy to add variables ec.
- C++ and txt files as input
- Open source



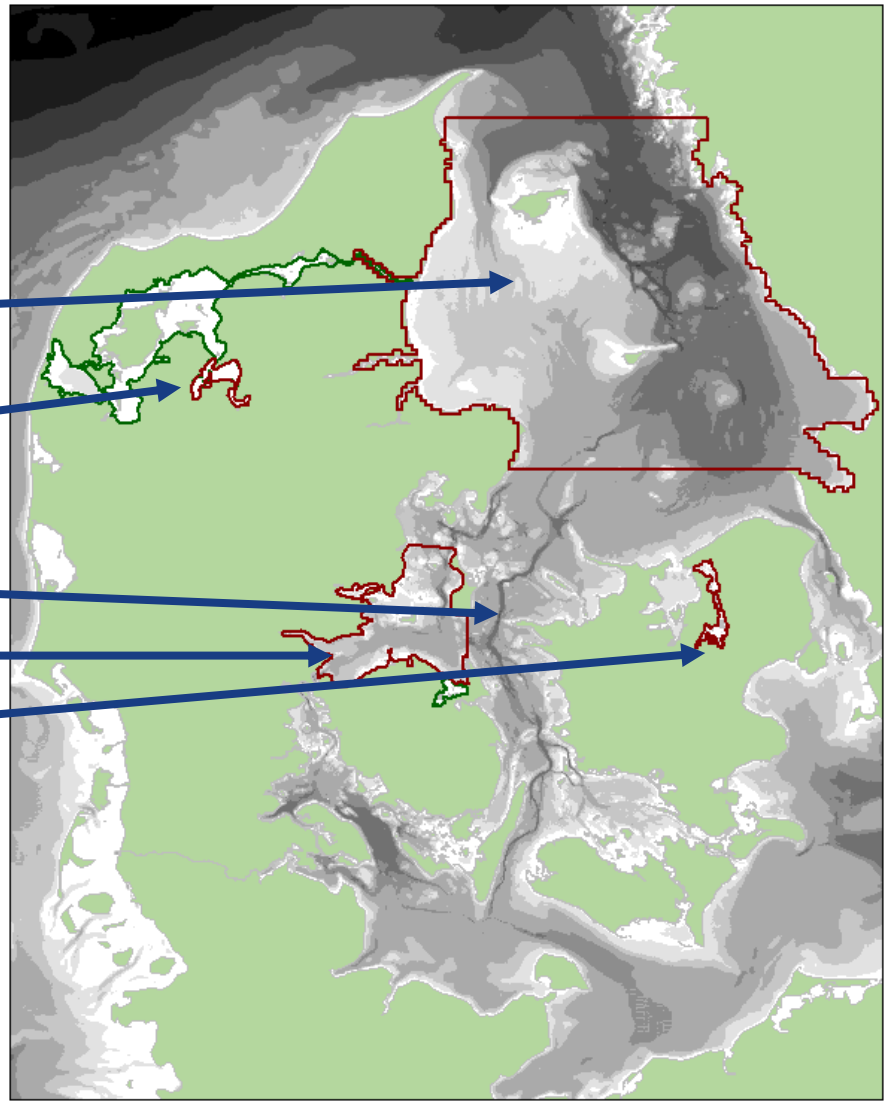
Crop out the Kattegat on different mesh types





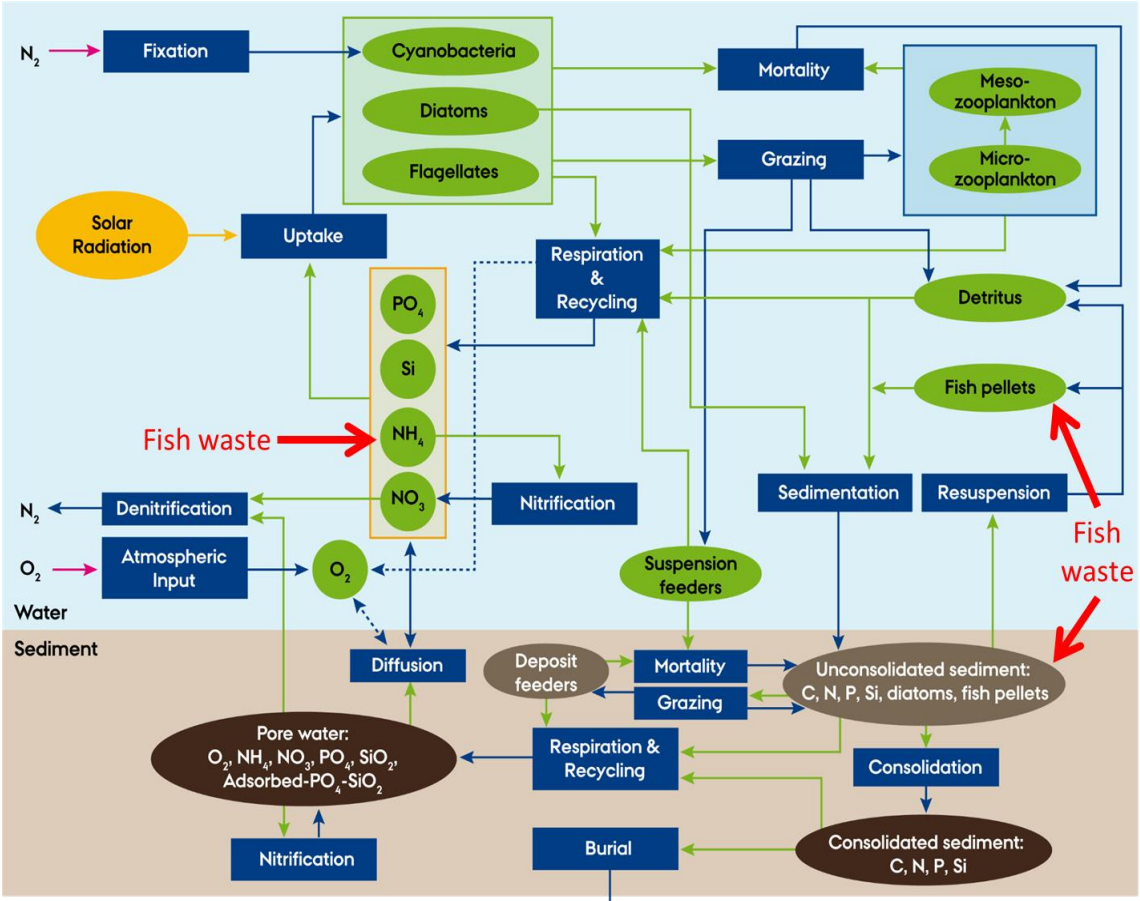
ECOLOGICAL MODELS

- Kattegat
- Limfjorden (Skive-Lovns)
- Samsø Belt
- Horsens Fjord
- Roskilde Fjord
- Disko Bay, Greenland
- ...



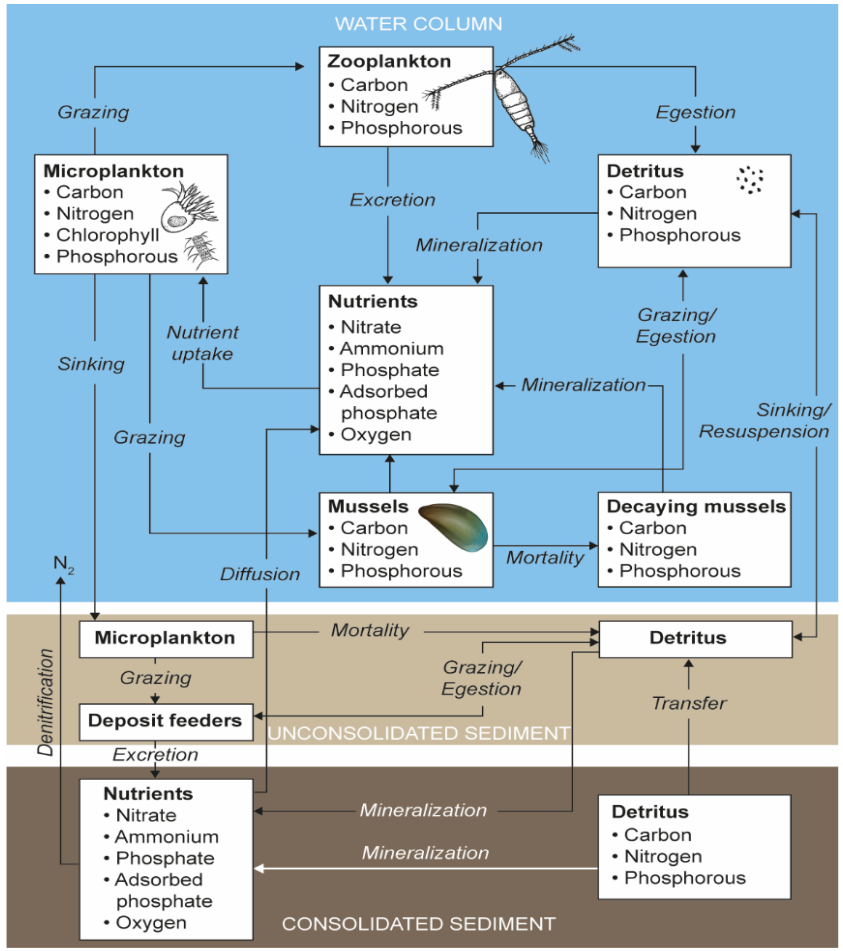
FLEXSEM-ECOLOGICAL MODELS

ERGOM



Neumann 2000, Maar et al. 2011, 2018

DANECO



Timmermann 2019, Maar et al. 2009

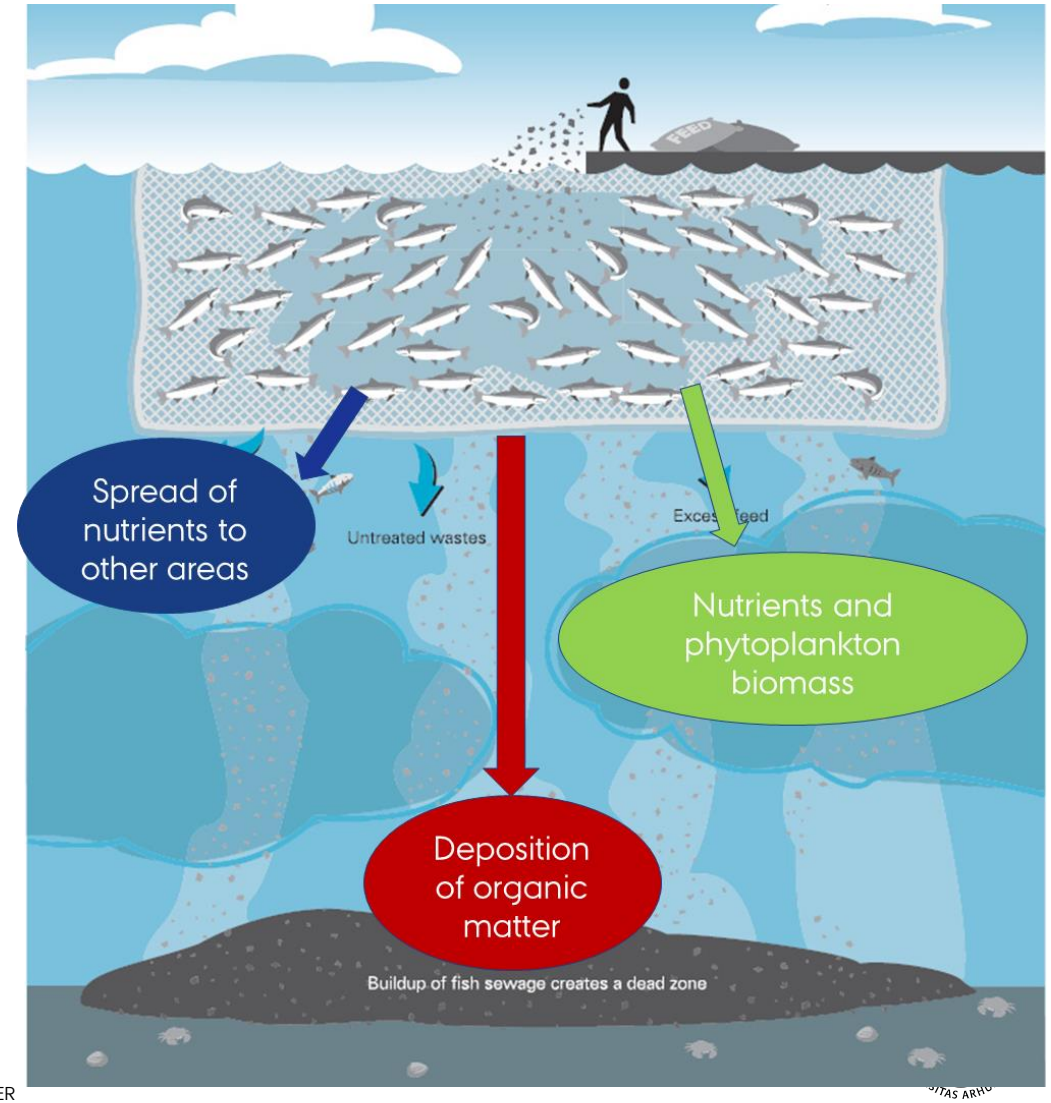
DIFFERENT APPLICATIONS

1. Nutrient retention in fjords
2. Trophic cascades in the Kattegat
3. Mussel dredging and sediment plumes
4. Mussel transplantation to mitigate hypoxia in the Limfjorden
5. Mussel mitigation farming
6. **Ecological impacts of fish farms in the Samsø Belt**

MODELLING THE ENVIRONMENTAL IMPACTS OF FUTURE OFFSHORE FISH FARMS IN THE INNER DANISH WATERS

Marie Maar, Janus Larsen, Karsten Dahl, Bo Riemann

2018. Aquaculture Environment Interactions 10:115



DANISH FISH FARMS

RAINBOW TROUT

- Existing farms
- Recirculation farms on land
- Proposed new farms
- Pilot projects
- Closed farms

Political wish for new farms, first in the Kattegat and later potentially in other areas

Offshore farms less impact?

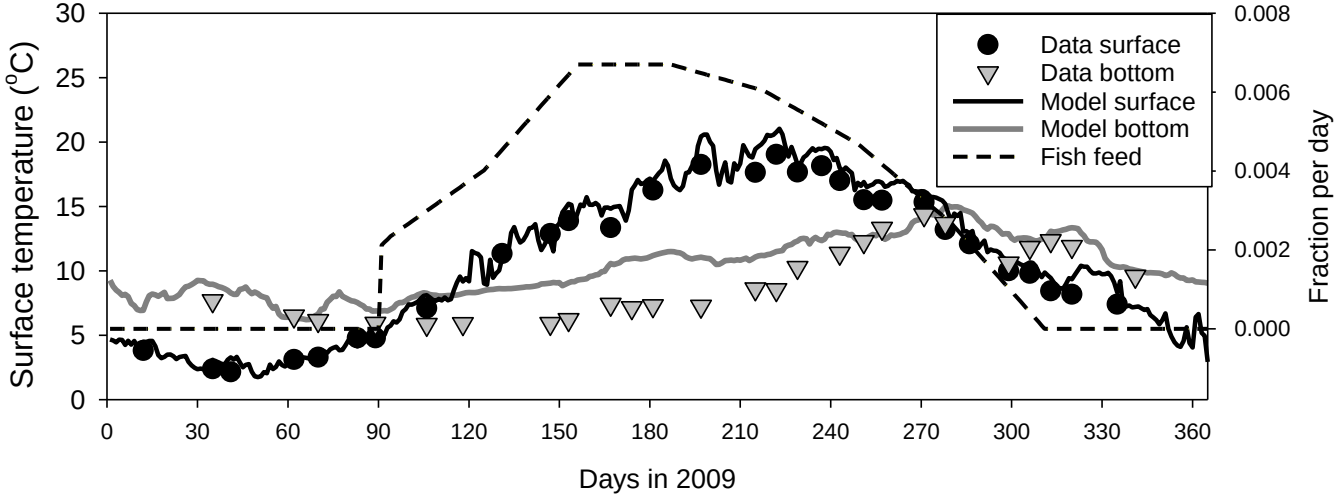
Modificeret fra:
Sportsfiskeren, 1, 2015

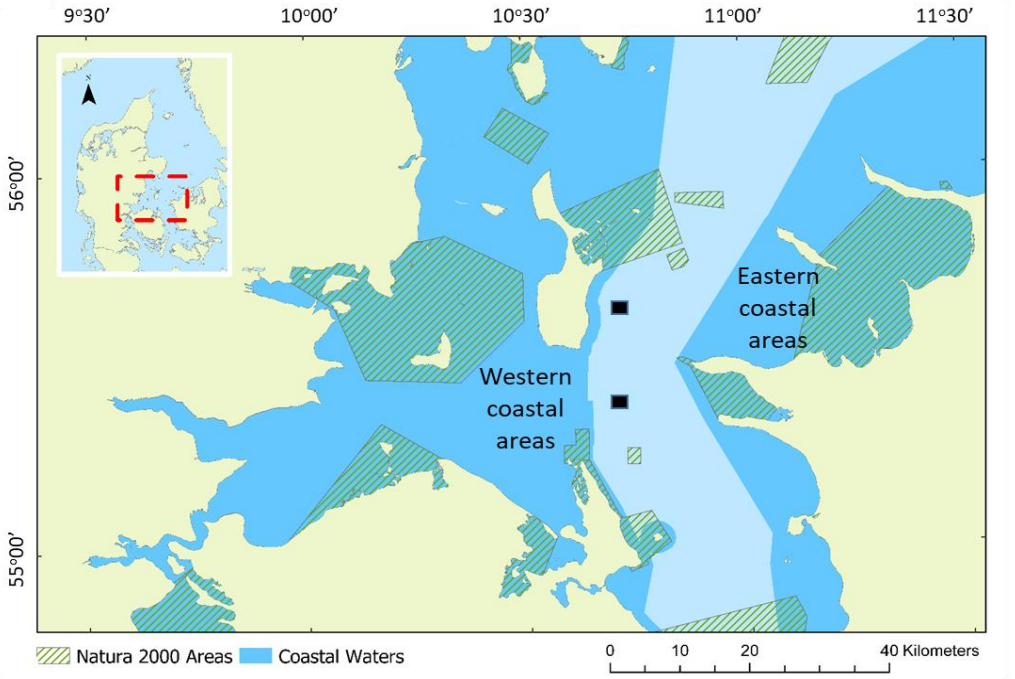
EJERE AF HAVBRUG I DANMARK

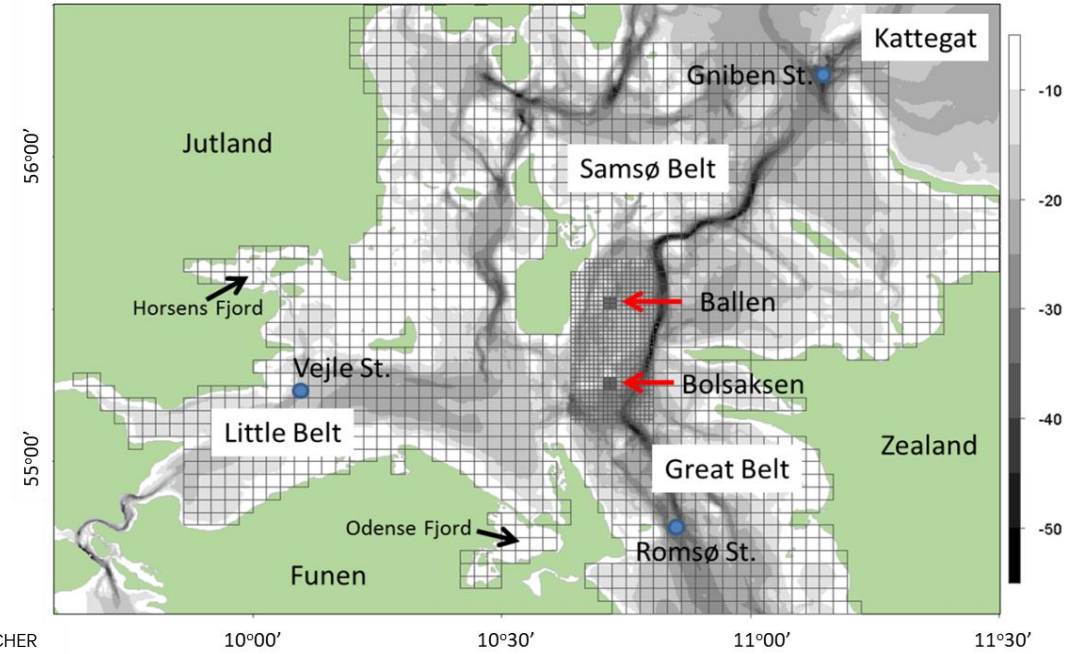
1. Snaptun Fish Export A/S
2. Aquapri Denmark A/S
3. Musholm A/S
4. Hjarnø Havbrug A/S
5. Aft Aps (økologiske ørreder)

2 POTENTIAL FISH FARMS

- HBM-Flexsem-ERGOM
- Rainbow trout (2250 t)
- 100 t-N and 12.8 t-P release per farm annually (www.aquawaste.dk)
- Production from April to November



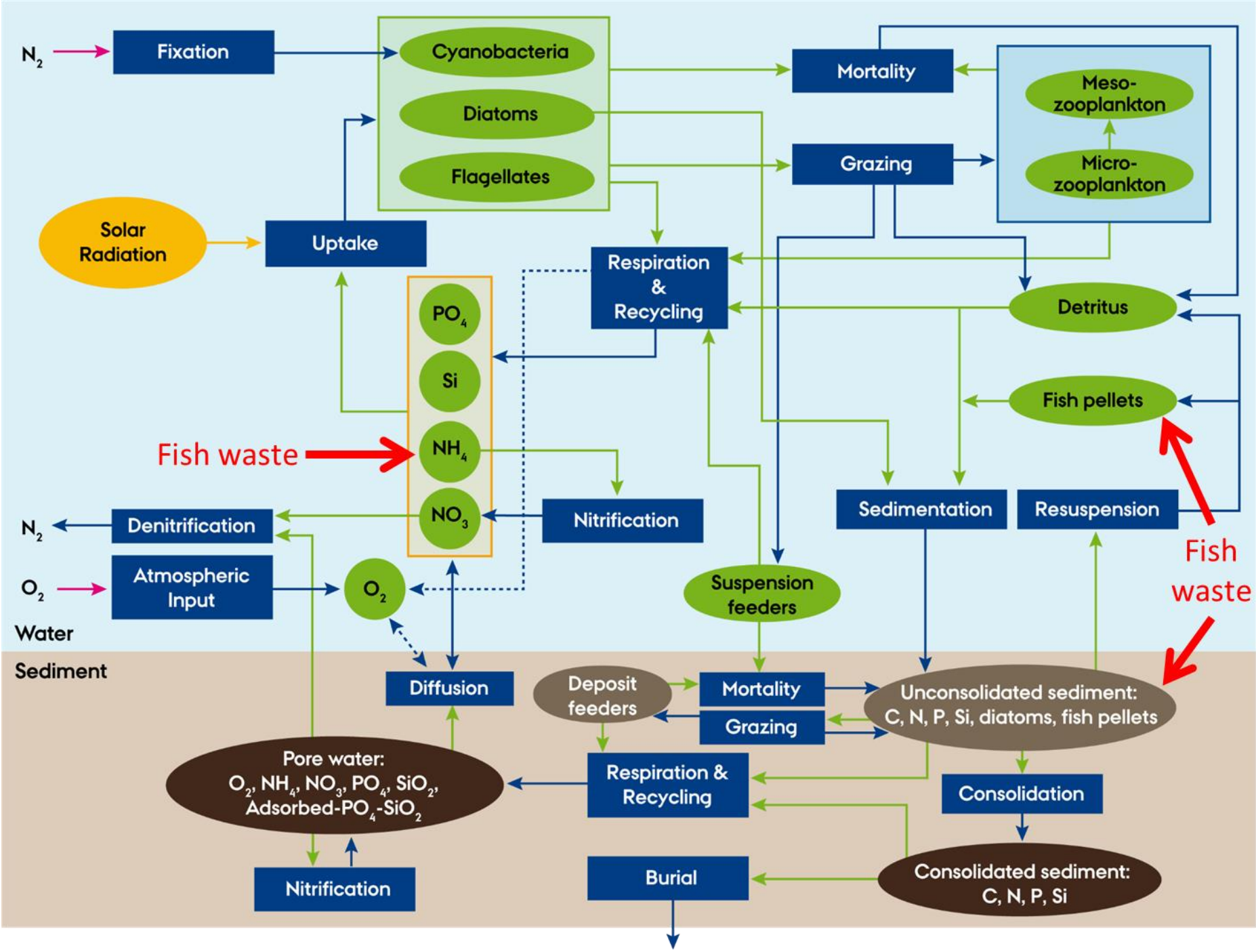




Flexsem-ERGOM

Offshore farm size:
Scenario 100-t N

Coastal farm size:
Scenario 25-t N



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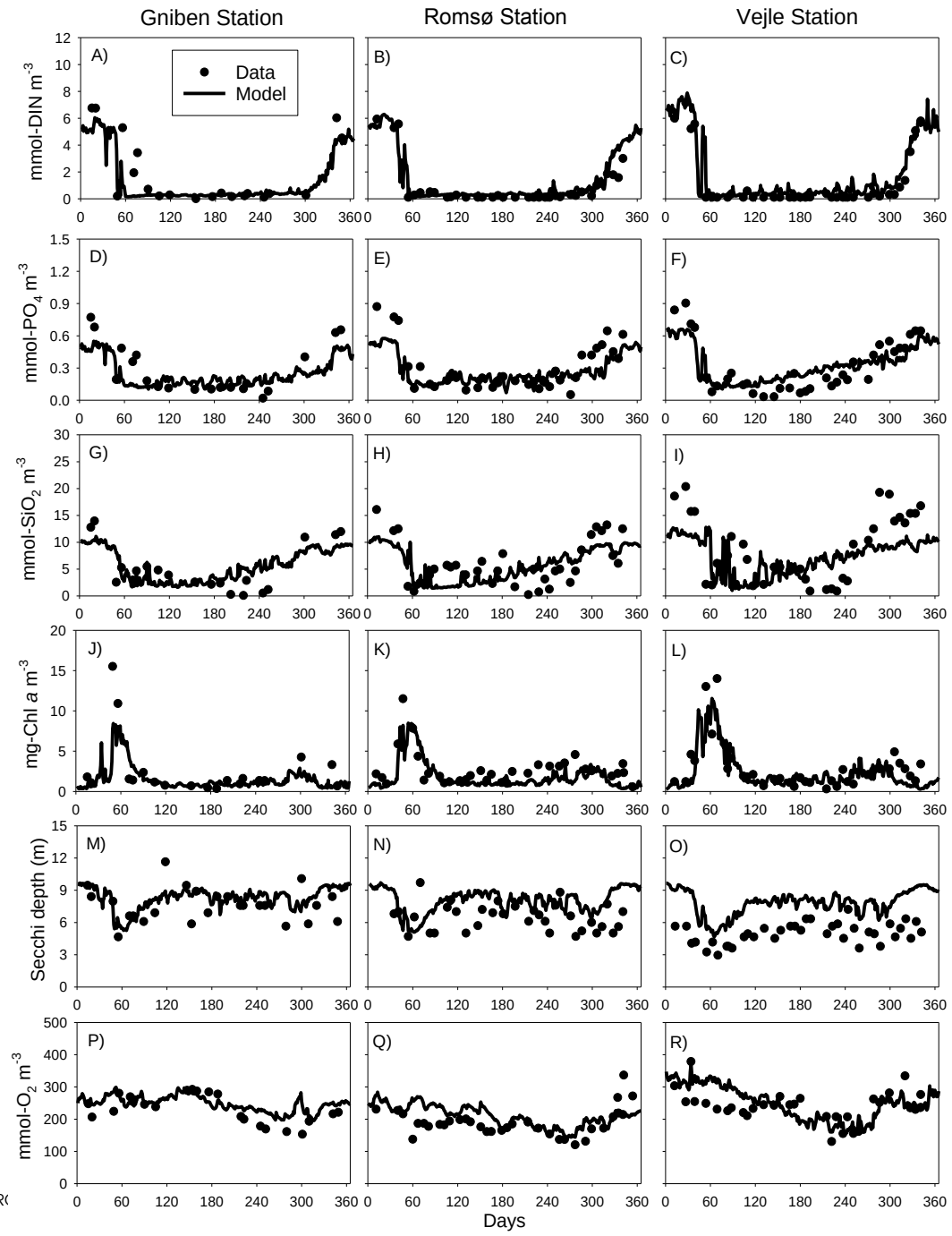
VALIDATION

	R^2			PMB (%)		
	Gniben	Romsø	Vejle	Gniben	Romsø	Vejle
Surface						
Temperature	0.99	0.99	0.96	8	9	6
Salinity	0.80	0.90	0.77	-18	-13	-15
DIN	0.81	0.96	0.92	-23	-20	-15
PO_4	0.80	0.87	0.90	-14	12	1
SiO_2	0.71	0.69	0.55	3	-5	-18
Chl a	0.66	0.82	0.83	-35	-28	-19
Primary production	-	0.85	0.88	-	25	26
Secchi depth	0.49	Ns	0.81	10	20	38
Bottom						
Temperature	0.86	0.88	0.91	28	23	16
Salinity	0.78	0.62	0.65	-10	-16	-25
DIN	Ns	Ns	Ns	-1	-3	32
PO_4	Ns	Ns	Ns	-25	-8	-10
SiO_2	Ns	Ns	Ns	-31	-16	-1
O_2	0.73	0.33	0.61	8	11	5

R^2 and percentage model bias

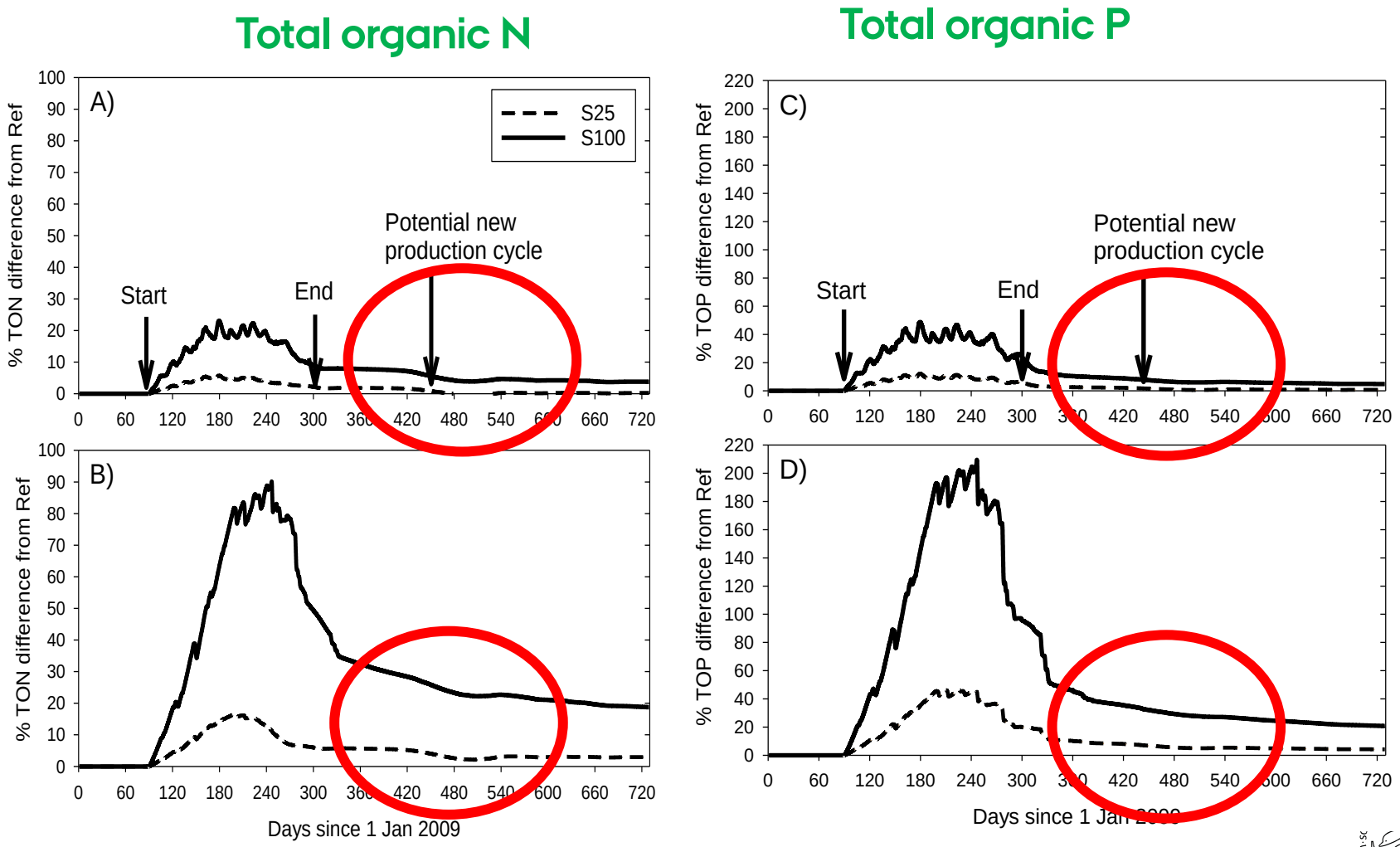


BENTHIC IMPACTS

Accumulation of organic matter

Ballen
High resuspension

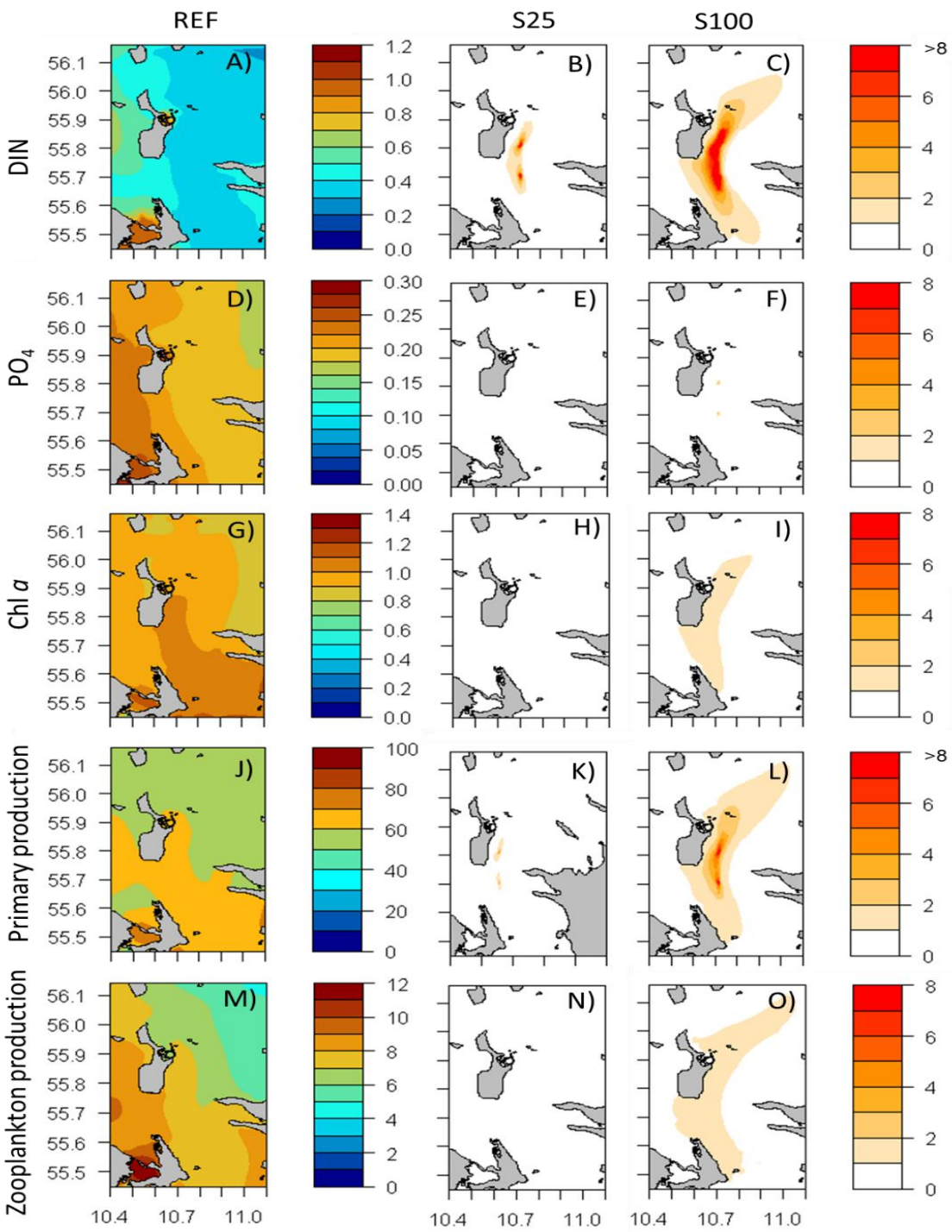
Bolsaksen
Low resuspension



SPATIAL CHANGE

- S100, July, 5 m depth
- Highest increases for DIN (<30 km)
- Small changes for PO4 and Chl a
- No changes for oxygen and Secchi depths
- Increase in primary and secondary production offshore
- Minor changes in coastal areas
- Natura 2000 areas impacted

- Size of farm important

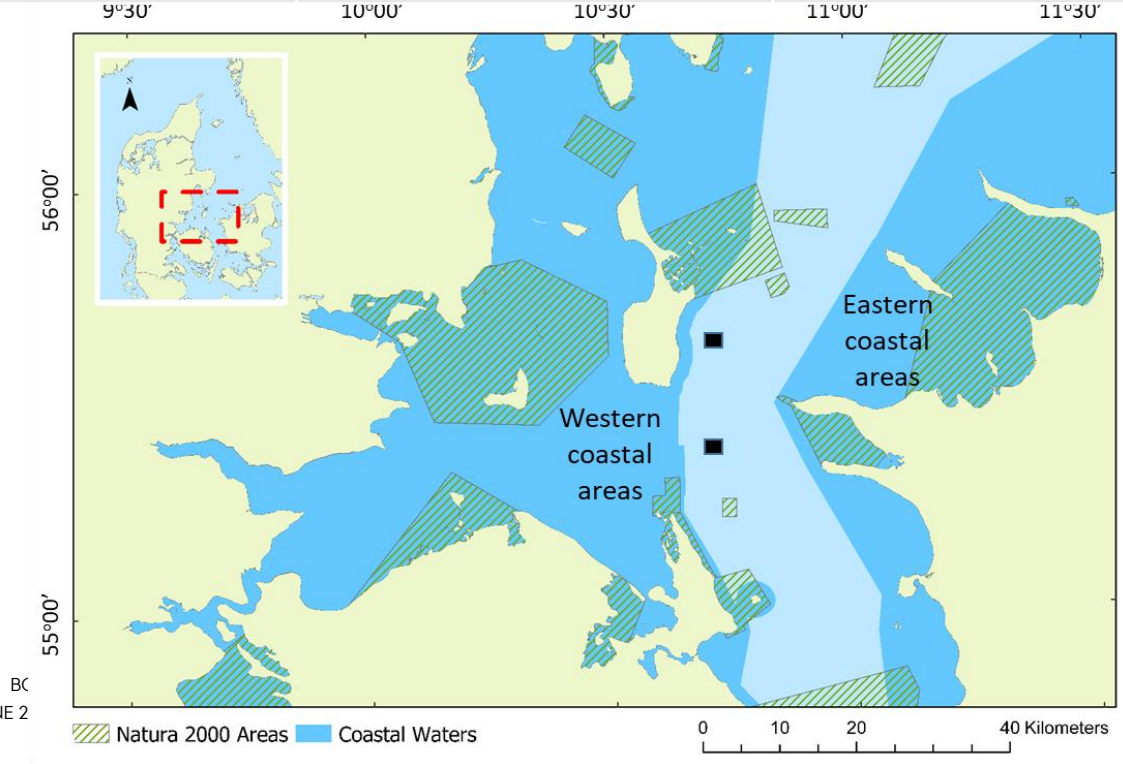


NUTRIENT TRANSPORTS (GROSS)

Scenarios	W. Coastal Water Areas		E. Coastal Water Areas	
	Total-N (t)	Total-P (t)	Total-N (t)	Total-P (t)
S100	30.4	3.0	11.7	1.0

Transport into coastal areas

21% of total-N input
16% of total-P input



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SUMMARY

- Accumulation of organic matter below the farms
- DIN and primary production increased in open waters
- No or minor change in PO4, Chl a, oxygen, Secchi depths
- Minor change in coastal waters
- Natura 2000 areas impacted
- Nutrient transport into coastal areas
- Farm size and design, fallow period, resuspension sites, cumulative effects
- Nutrient compensation by eg mussel farming