Eutrophication modelling to assess environmental impact on marine habitats from aquaculture

Mads J. Birkeland, Ian Sehested Hansen, Mai-Britt Kronborg, Sophia Elisabeth Bardram Nielsen, Florence Cuttat

DHI Agern Allé 5 2970 Hørsholm, Denmark, mbi@dhigroup.com

Background

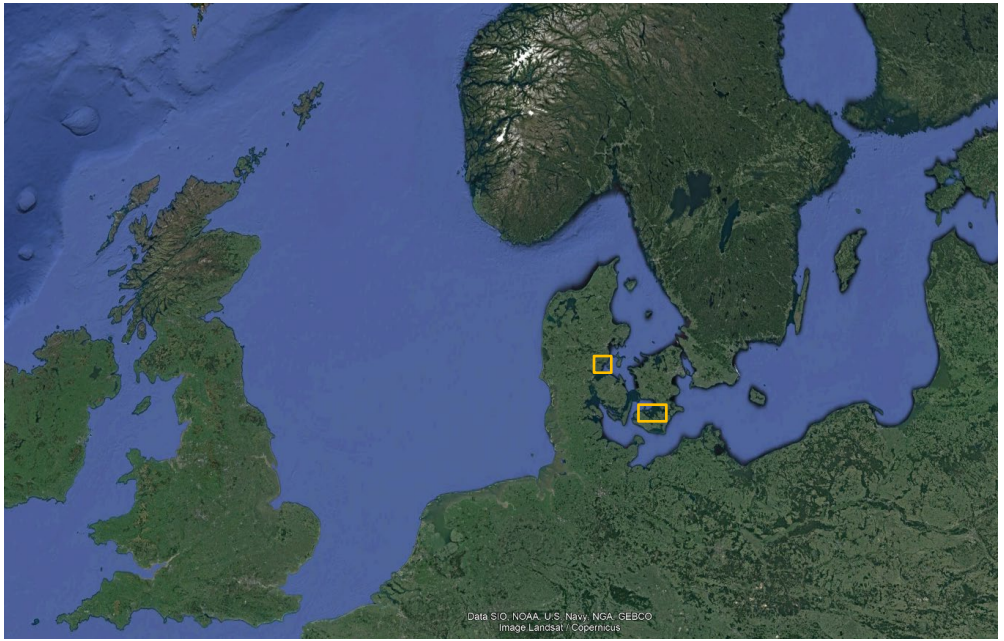
1. Public pressure and concern about environmental impact
2. Pressure from green NGOs
3. Political pressure
4. New legislative framework
5. Pressure on Danish EPA

➢ Habitat assessment of 12 ***existing*** marine fish farms

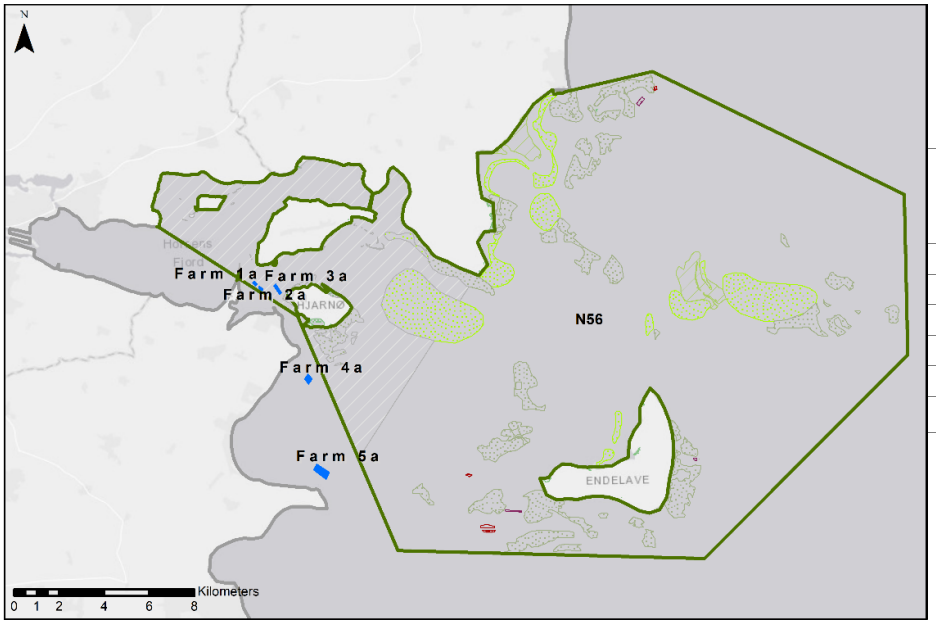
A comparative study on assessment of impact from marine aquaculture on marine habitats in two water bodies

- Generic methods for the assessment of marine aquaculture in relation to Natura 2000 areas

- In accordance with the latest methodological guidance on the provisions of Article 6(3) and (4) of the Habitat Directive (The 1992 European Union Directive on the conservation of natural habitats and of wild fauna and flora)

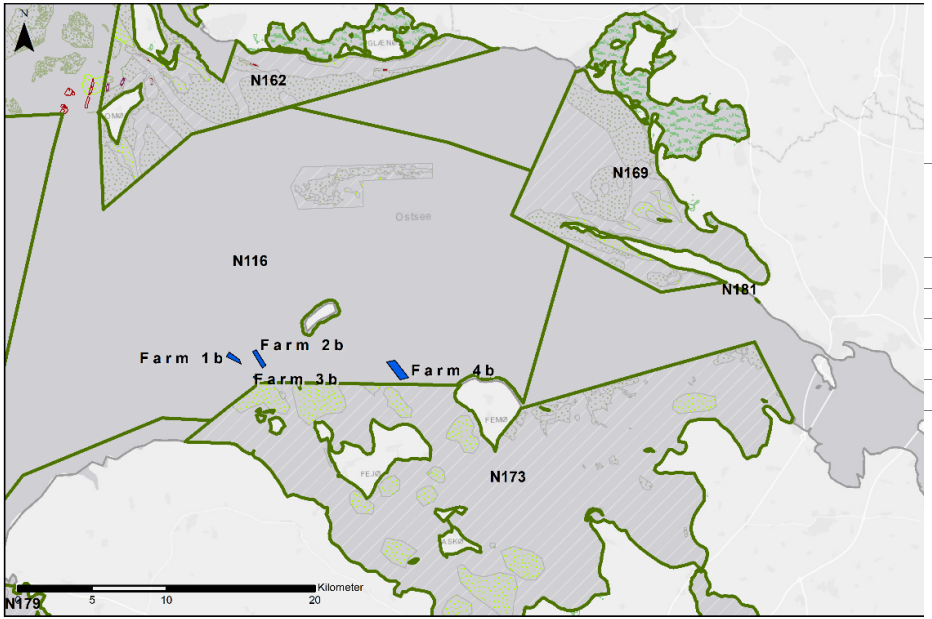


Area a: Marine fish farms in and around Natura 2000 area no. 56



Farm	Long/Lat.	Distance to N56 (km)	Net production (ton y^{-1})	Nitrogen (ton y^{-1})	Phosphorus (ton y^{-1})	Particulate organic carbon (ton y^{-1})
Farm 1a	10° 2.930'E/55° 50.110'N	Inside N56	170	6.9	0.8	10.0
Farm 2a	10° 2.207'E/55° 50.076'N	Inside N56	170	6.9	0.8	10.0
Farm 3a	10° 2.002'E/55° 50.199'N	Inside N56	266	10.4	1.2	15.0
Farm 4a	10° 4.241'E/55° 47.947'N	0.5	230	9.0	1.0	13.0
Farm 5a	10° 4.554'E/55° 45.786'N	1.4	190	6.5	0.7	9.4
Total (1a-5a)			**1026**	**39.7**	**4.5**	**57.5**

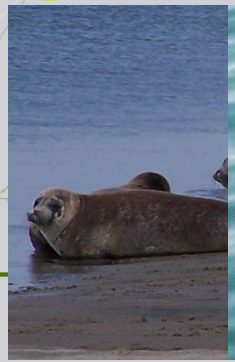
Area b: Marine fish farms around Natura 2000 area no. 173



Farm	Long/Lat.	Distance to N173 (km)	Net production (ton y^{-1})	Nitrogen (ton y^{-1})	Phosphorus (ton y^{-1})	Particulate organic carbon (ton y^{-1})
Farm 1b	11° 15.750'E/55° 0.746'N	1.8	400	16.5	1.8	25.9
Farm 2b	11° 17.22'E/55° 00.73'N	1.0	266	11.0	1.2	17.2
Farm 3b	11° 17.192'E/54° 9.813'N	0.2	465	19.2	2.1	30.2
Farm 4b	11° 25.650'E/55° 0.200'N	0.3	720	22.0	2.4	34.5
Total (1b-4b)			**1851**	**68.7**	**7.5**	**107.8**

Marine fish farming of Rainbow trout in Inner Danish Waters

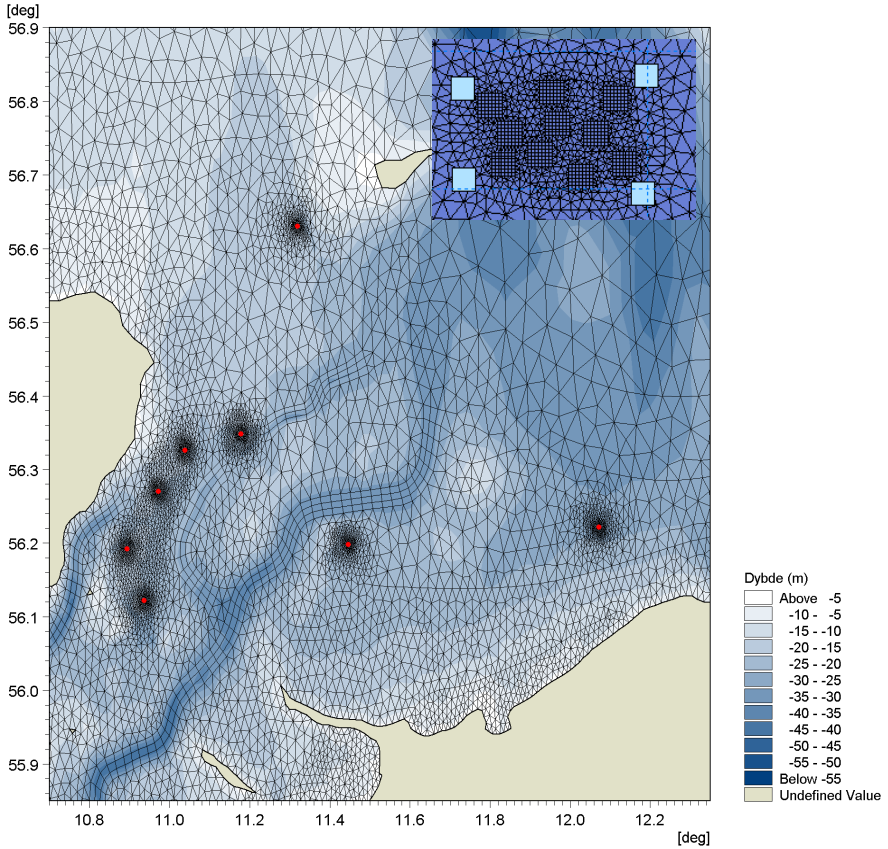
Natura 2000 site and habitat types

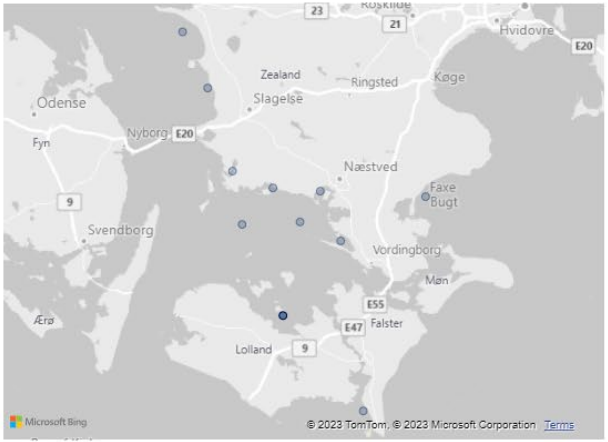


Method and model optimization

Hydrodynamic modelling

Eutrophication and deposition modelling



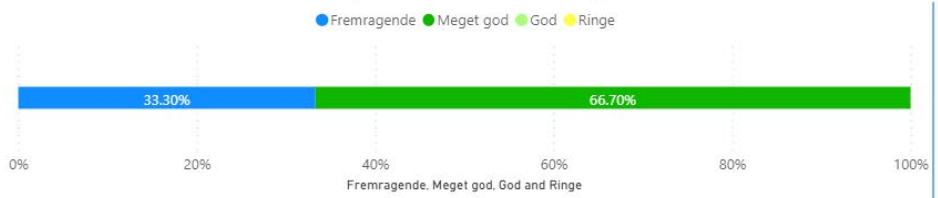


SMF ECO Lab model kalibrering (2014-2016)

100.00

Over "God"

Model performance (PBias, SRC og CF)



STO0201061

First Station

Dato

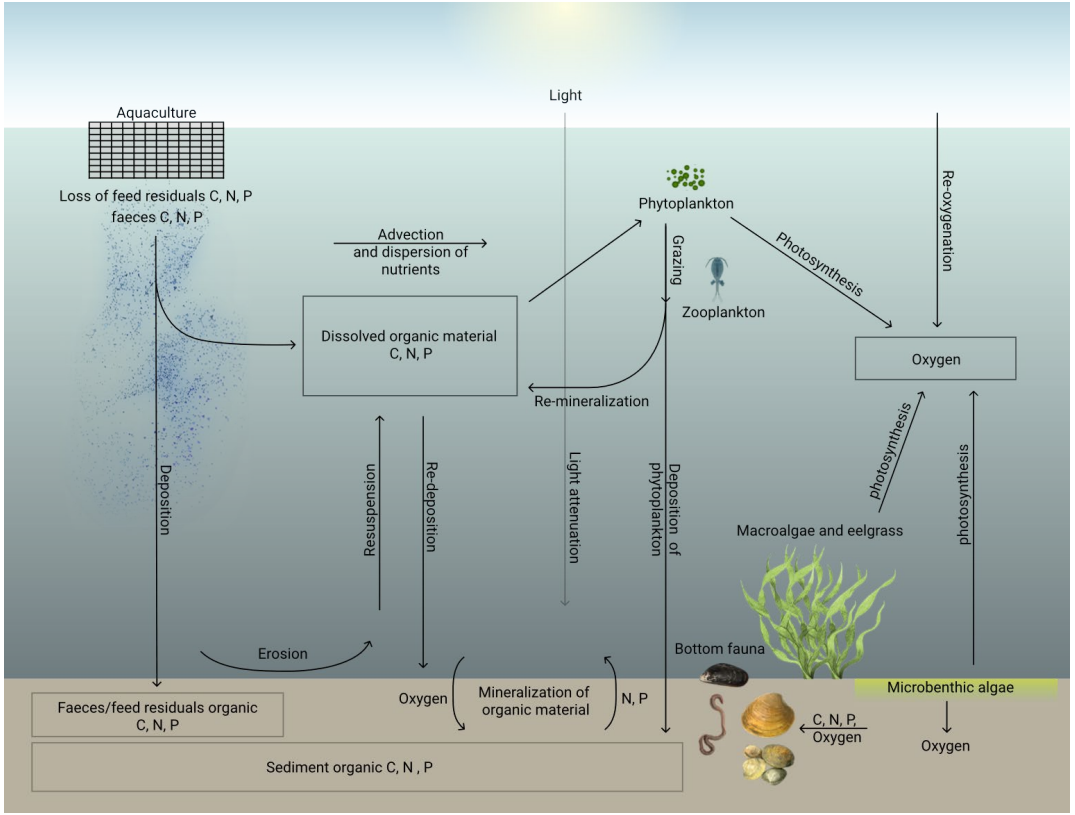
1/1/2014 12/31/2016

Parameter

- DIN [mg/l]
- DIP [mg/l]
- Klorofyl-a [mg/l]
- Lyshenfald [m-1]
- Opløst ilt [mg/l]
- Total Fosfat [mg/l]
- Total Nitrogen [mg/l]

Opløst ilt [mg/l]

ECO Lab - Eutrophication and deposition modelling



Environmental impact from marine aquaculture: Biological quality elements, key indicators, and impact criteria

Quality elements

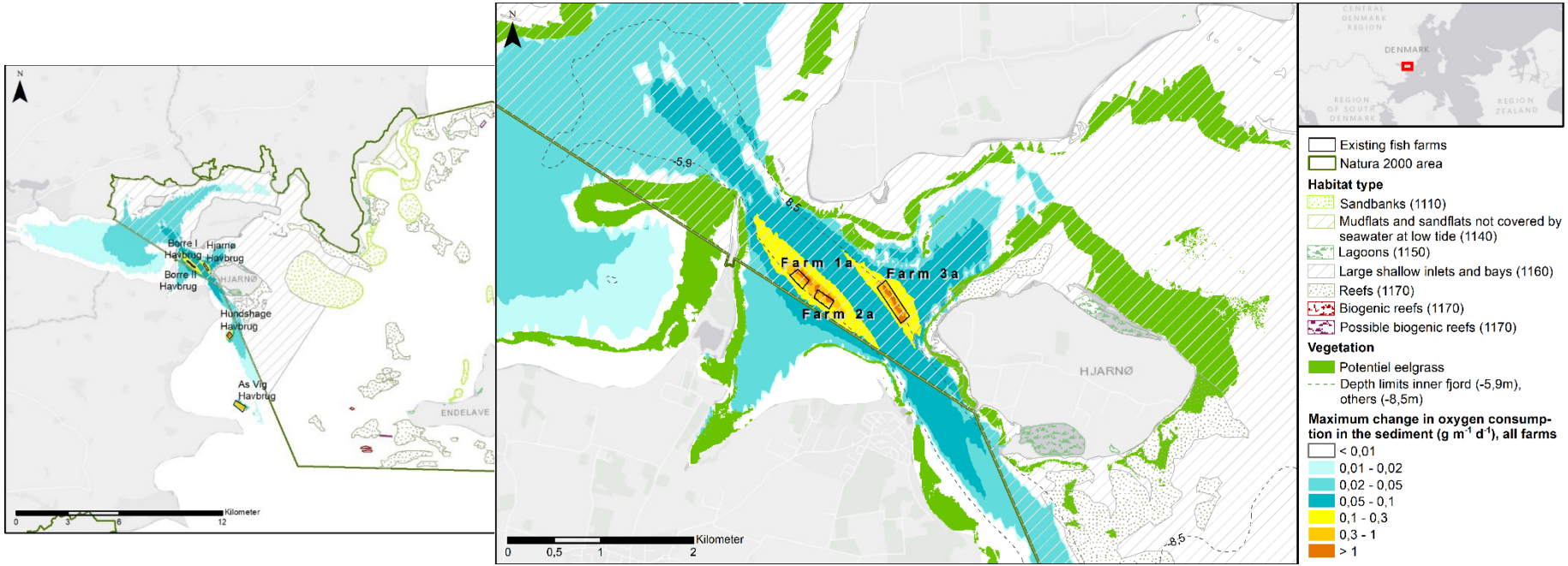
- Eelgrass
- Macroalgae
- Benthic fauna
- Benthic microalgae

Key indicators

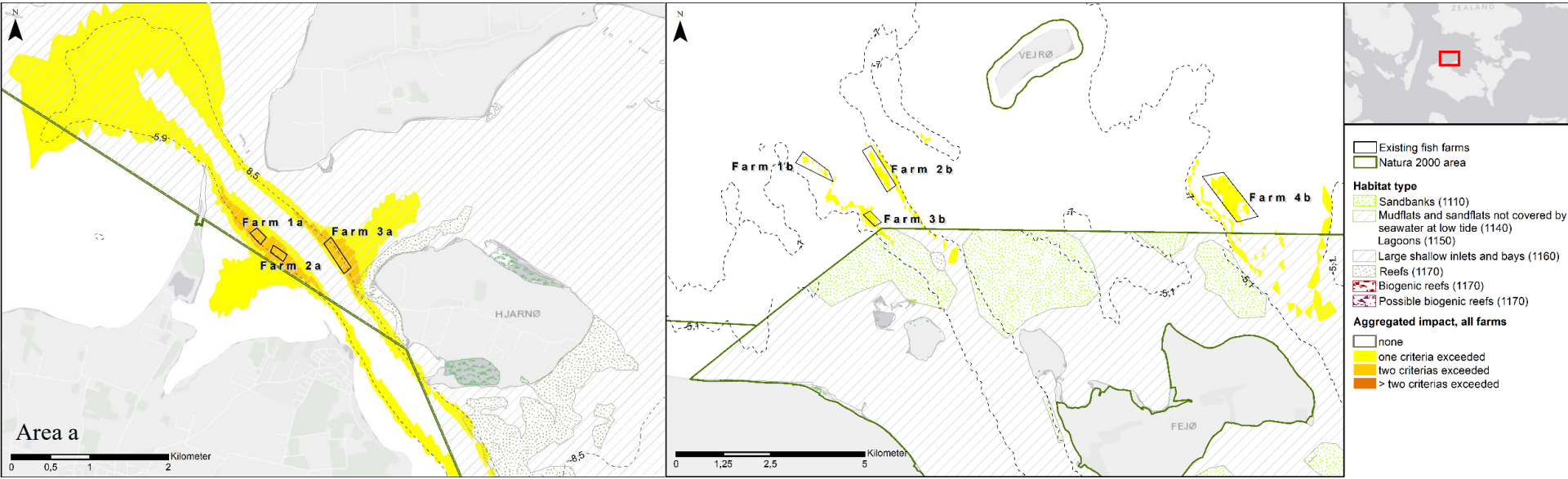
- Light at seabed
- Oxygen in bottom water
- Organic enrichment of sediment
- Mechanical burrial

in accordance with the biological quality elements used in the EU Water Framework Directive

Organic enrichment of sediment



Agregated impact



Agregated impact

Area a:

Element and habitat type	Impact (ha (%))	"High" Impact (ha (%))
Large shallow inlets and bays	**420 (6.7%)**	**10.7 (0.2%)**
Eelgrass	4.2 (0.4%)	4.2 (0.4%)
Macroalgae	40 (7.4%)	0.5 (0.1%)
Benthic fauna	65 (1.0%)	3.7 (0.06%)
Benthic microalgae	403 (7.4%)	5.5 (0.1%)
Reef	**4.6 (0.2%)**	**0.9 (0.03%)**
Eelgrass	0.9 (0.1%)	0.9 (0.1%)
Macroalgae	4.6 (0.2%)	0 (0%)
Benthic fauna	0.4 (0.02%)	0 (0%)
Benthic microalgae	4.6 (0.2%)	0 (0%)

Area b:

Element and habitat type	Impact (ha (%))	"High" Impact (ha (%))
Large shallow inlets and bays	**59 (0.10%)**	**0 (0%)**
Eelgrass	0 (0%)	0 (0%)
Macroalgae	5.9 (0.11%)	0 (0%)
Benthic fauna	0 (0%)	0 (0%)
Benthic microalgae	59 (0.11%)	0 (0%)
Sandbanks	**2.8 (0.06%)**	**0.5 (0.01%)**
Eelgrass	0 (0%)	0 (0%)
Macroalgae	0.3 (0.06%)	0.1 (0.01%)
Benthic fauna	0.3 (0.01%)	0 (0%)
Benthic microalgae	2.8 (0.06%)	0.5 (0.01%)

Discussion and conclusion

Area a: The potential impact and high impact, can:

- Hamper the re-establishment of eelgrass, and reduces the density and number of perennial macroalgae, and the growth of benthic microalgae.
- Reduce ecosystem carbon, nitrogen, and phosphorus fixation,
- Reduce the area of growth- and spawning grounds in eelgrass beds and other bottom vegetation
- Increase the flux of nutrients from the sediment due to reduced oxygen buffer in the surface sediment. The potential impact is not irreparable but will persist if aquaculture operations continue.

Area b:The potential impact will:

- Not affect eelgrass or the re-establishment of eelgrass, nor have any significant effect on the density and number of perennial macroalgae, the growth of benthic microalgae, or bottom fauna.

Perspetives

- The present study is based on a comparative assessment of environmental impact from marine aquaculture inside and nearby two different Danish N2000 areas.
- Production practices are the same in the two areas, and production volume and discharge of C, N and P, is 1.6-1.7 times higher in area b compared to area a, the potential impact on marine habitats is significantly lower in area b.
- This is a consequence of location (no farms inside N2000 area) and the physical and hydrodynamic conditions with higher wind exposure and water exchange and lower retention time in area a compared to area b.

The physical and hydrodynamic conditions in area b, mitigates potential impacts on sediment chemistry and bottom flora and fauna, by frequent resuspension events caused by high current and wave induced shear stress on the seabed. At the same time high water exchange and low retention time of water mitigates potential impacts on water quality and growth conditions for benthic flora communities.

For mere information:

visit www.dhigroup.com

contact info@dhigroup.com