Trawling impact on megabenthos and sediment in the Barents Sea: use of satellite vessel monitoring and video

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There is very little quantitative information on the recovery dynamics of species after trawling.

Benthic infauna communities might take at least 18 month to recover (Tuck et al. 1998).

Macrobenthic invertebrates (molluscs, crustaceans, annelids and echinoderms) may take 1-3 years to recover (Sarda et al. 2000, Desprez, 2000).

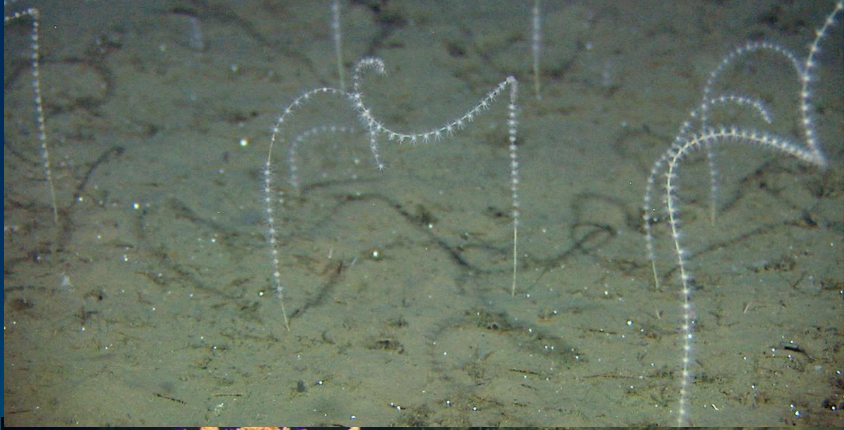
Large sessile fauna will take years to decades to recover. Indirect evidence (Pitcher 2000, and Sainsbury et al. 1997) suggests that large sponges probably take more than 15 years to recover.

Trawl experiment shows that the removal rate for epibenthic species varies between 5% and 20% of the biomass.

Removal rate for sea-whipes (gorgonians), sea fans (gorgonians) and large sponges (porifera) are 5%, 10% and 20% respectively.

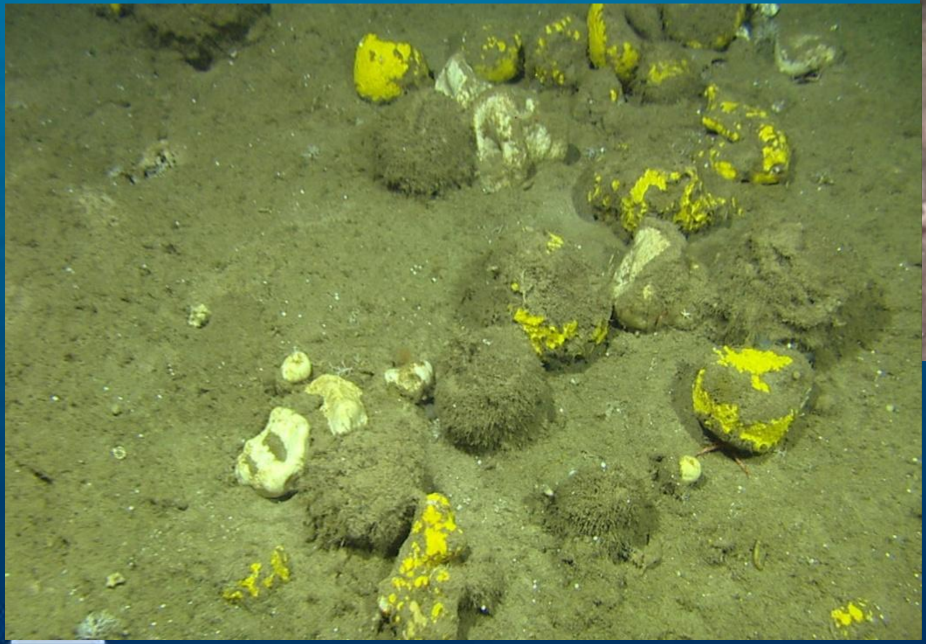
An experiment with repeated trawling showed that each trawl removed roughly 5-20 % of the biomass of sessile epifauna and 13 trawls removed 70-90 % of the estimated initial biomass.

(Pitcher et al 2000)



Sponges often line up in the trawl tracks and are covered with sediment.

They have been moved around by the trawl, can they survive this?



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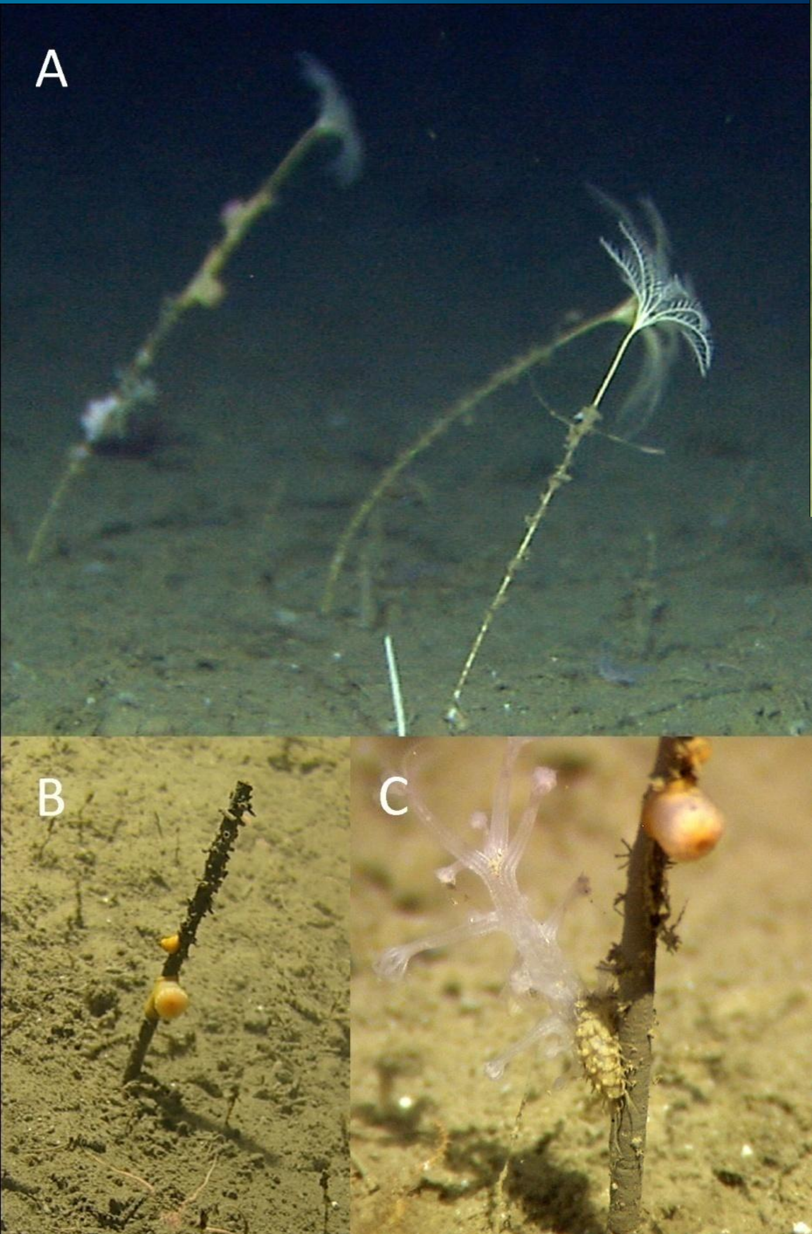

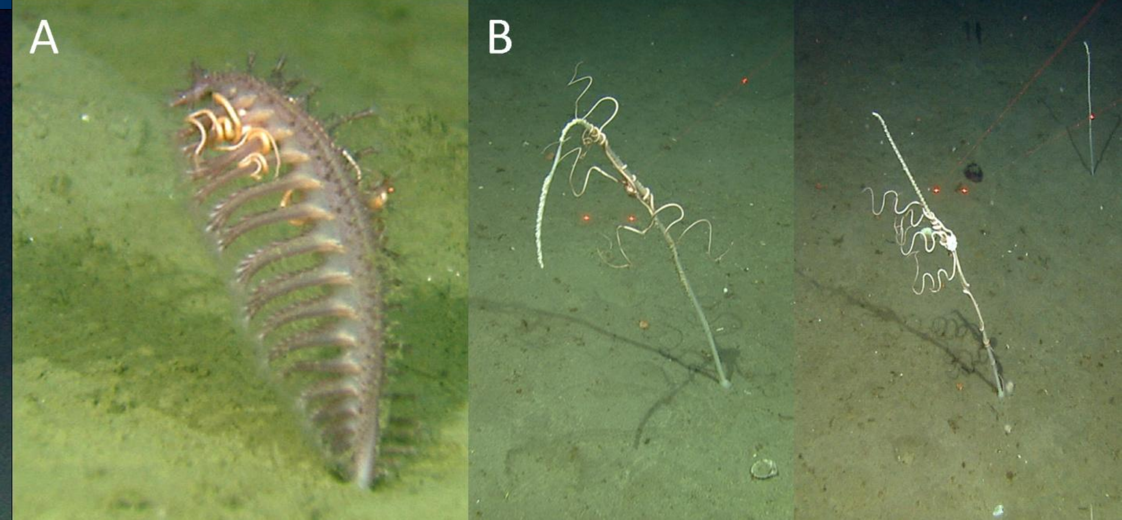

Organisms reaching into faster-moving water above the bottom in the benthic boundary layer provide substrates for many organisms


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SPECIAL TOPIC

Biological structures as a source of habitat heterogeneity and biodiversity on the deep ocean margins

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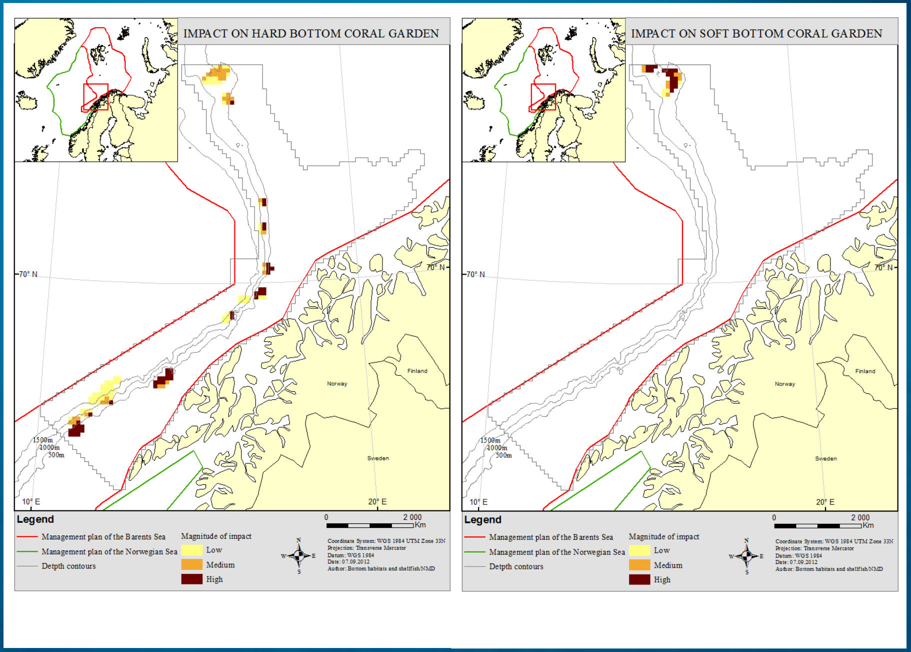
Impact from human activities on vulnerable marine ecosystems



POSTER 5. Mapping pressures and impacts on the ecosystem of the Barents Sea

G. Gonzalez-Mirelis, P. Buhl-Mortensen, L. Buhl-Mortensen
Institute of Marine Research, Bergen, Norway

POSTER 11. Impact on coral reefs from bottom fisheries in the Southern Barents Sea and evidence of recovery

P. Buhl-Mortensen
Institute of Marine Research, Bergen, Norway

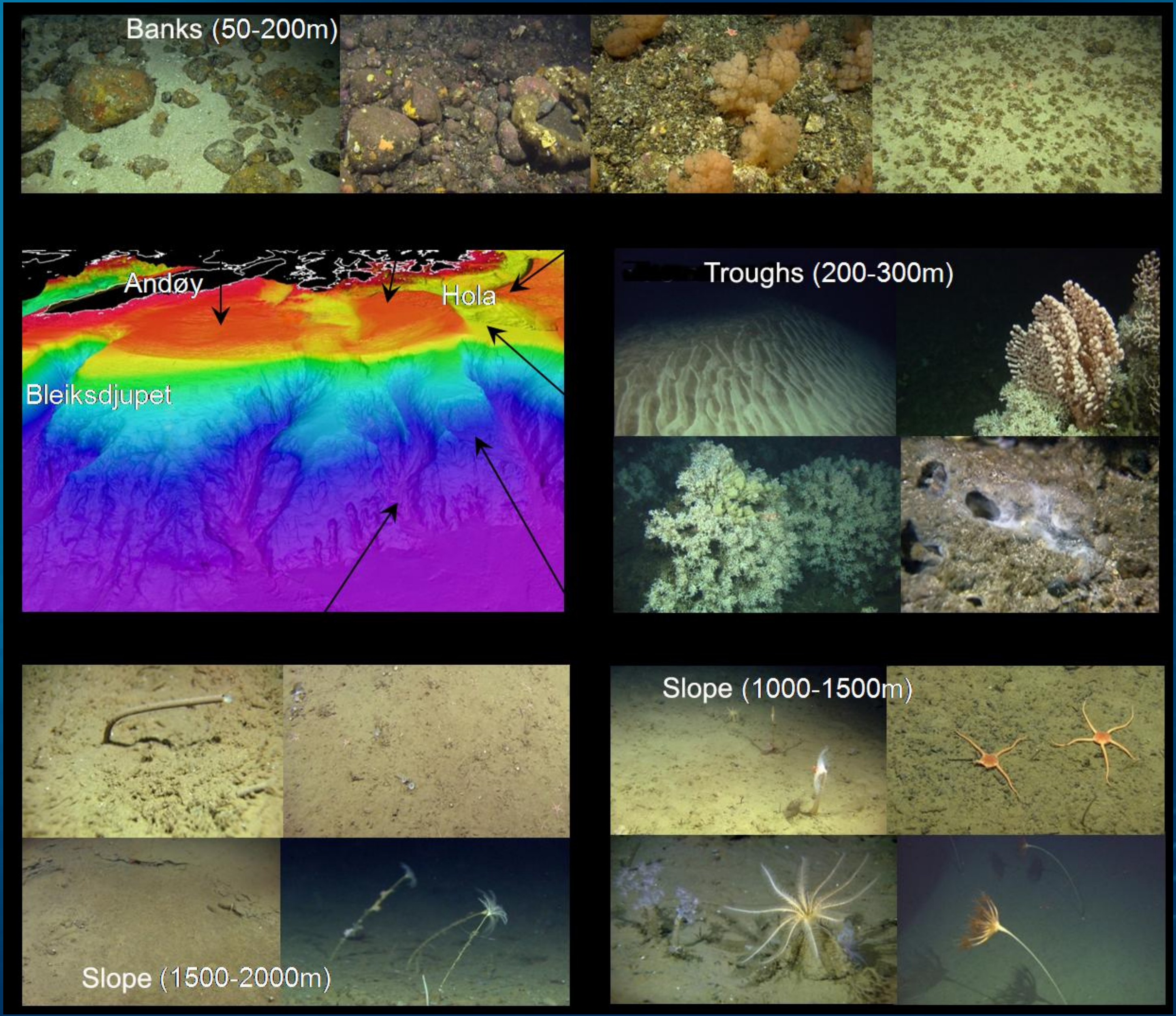
The main objectives of the study

Study the relation between observed trawl marks and trawling intensity indicated by VMS-data

Megabenthos density and diversity in areas of different trawling history

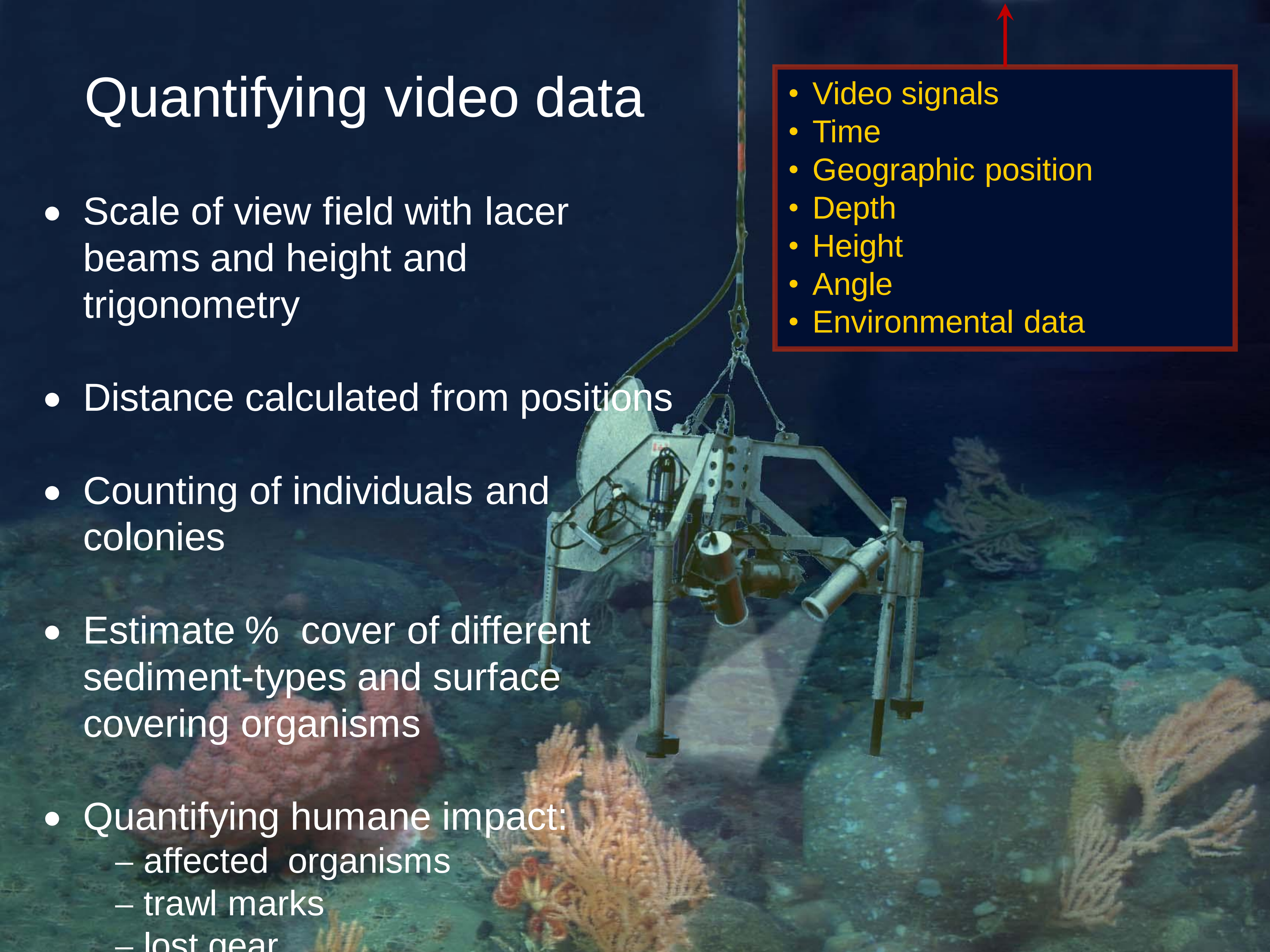
Find indicators relevant for a sustainable and ecosystem-based management of fisheries

Challenging landscapes and habitats on shelf and slope



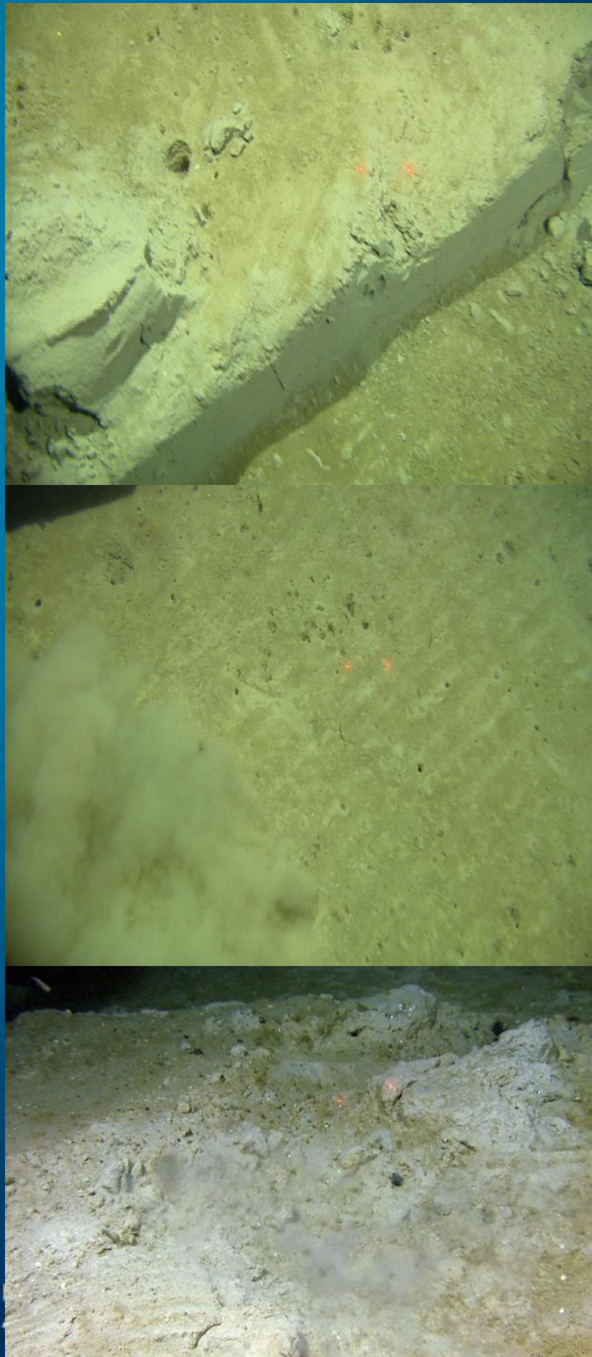
Quantifying video data

- Scale of view field with lacer beams and height and trigonometry
- Distance calculated from positions
- Counting of individuals and colonies
- Estimate % cover of different sediment-types and surface covering organisms
- Quantifying humane impact:
  - affected organisms
  - trawl marks
  - lost gear



- Video signals
- Time
- Geographic position
- Depth
- Height
- Angle
- Environmental data

Physical impact on the substratum from otter trawl observed by video



A

B

C

A. Cut in sediment from trawl door.

B. Marks after chain in trawl opening.

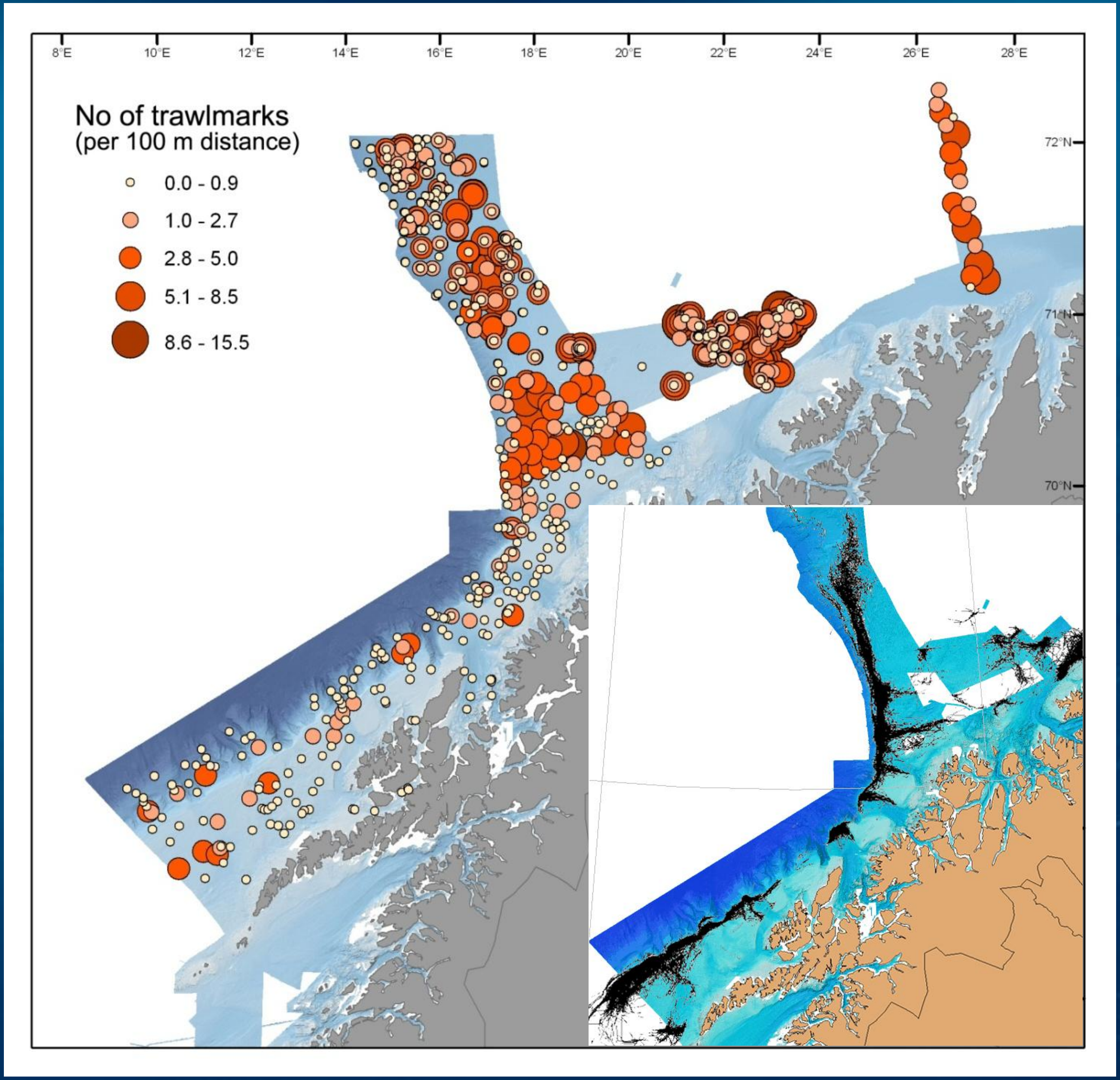
C. Sediment turned over by a trawl.

Red dots are from laser beams 10 cm apart.

Density of trawl marks per 100 m of video observation

It is not uncommon with tracks every 25 meter

In some areas they occur with 10 meters distance



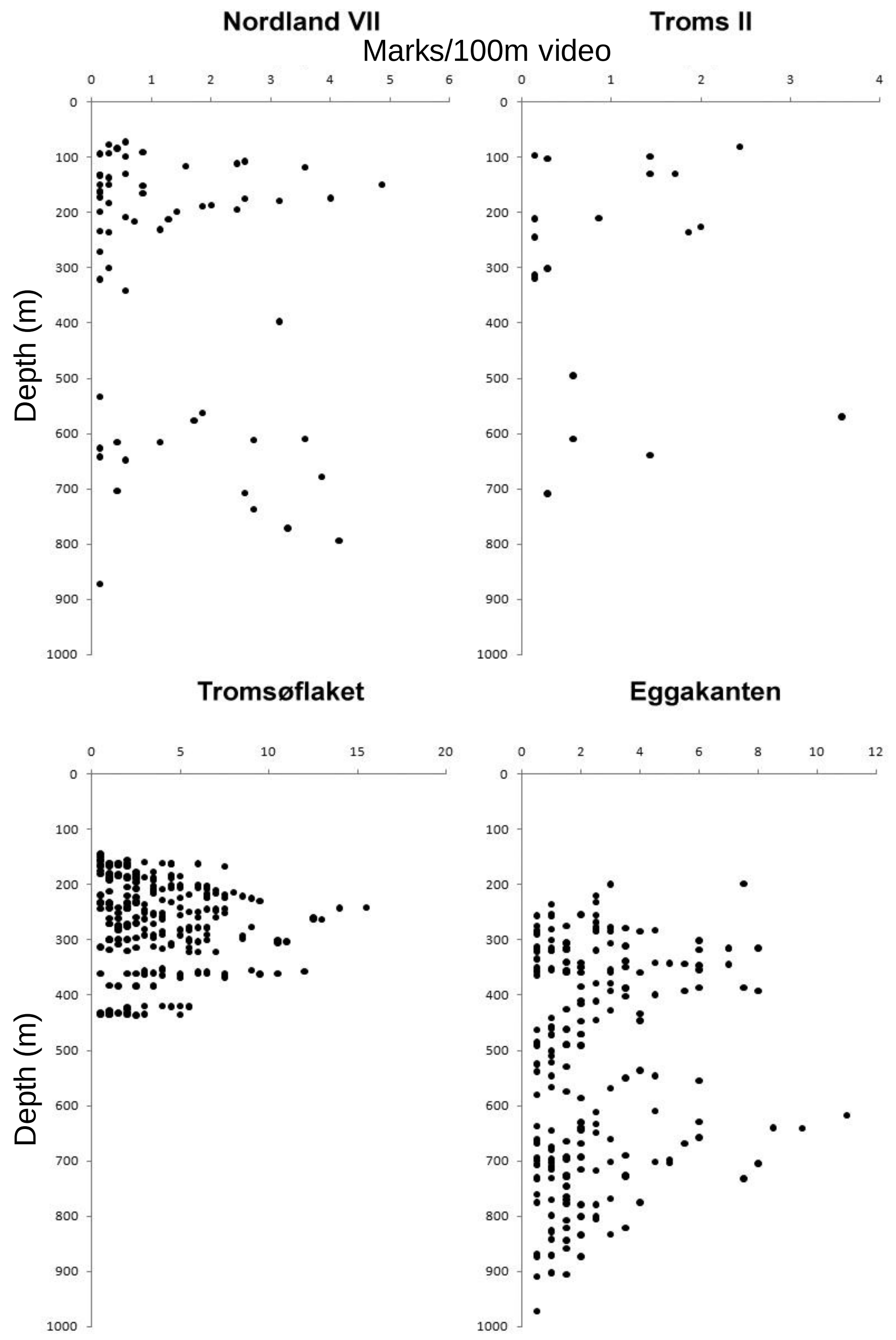
Depth distribution of trawl marks

Distribution indicates different fisheries

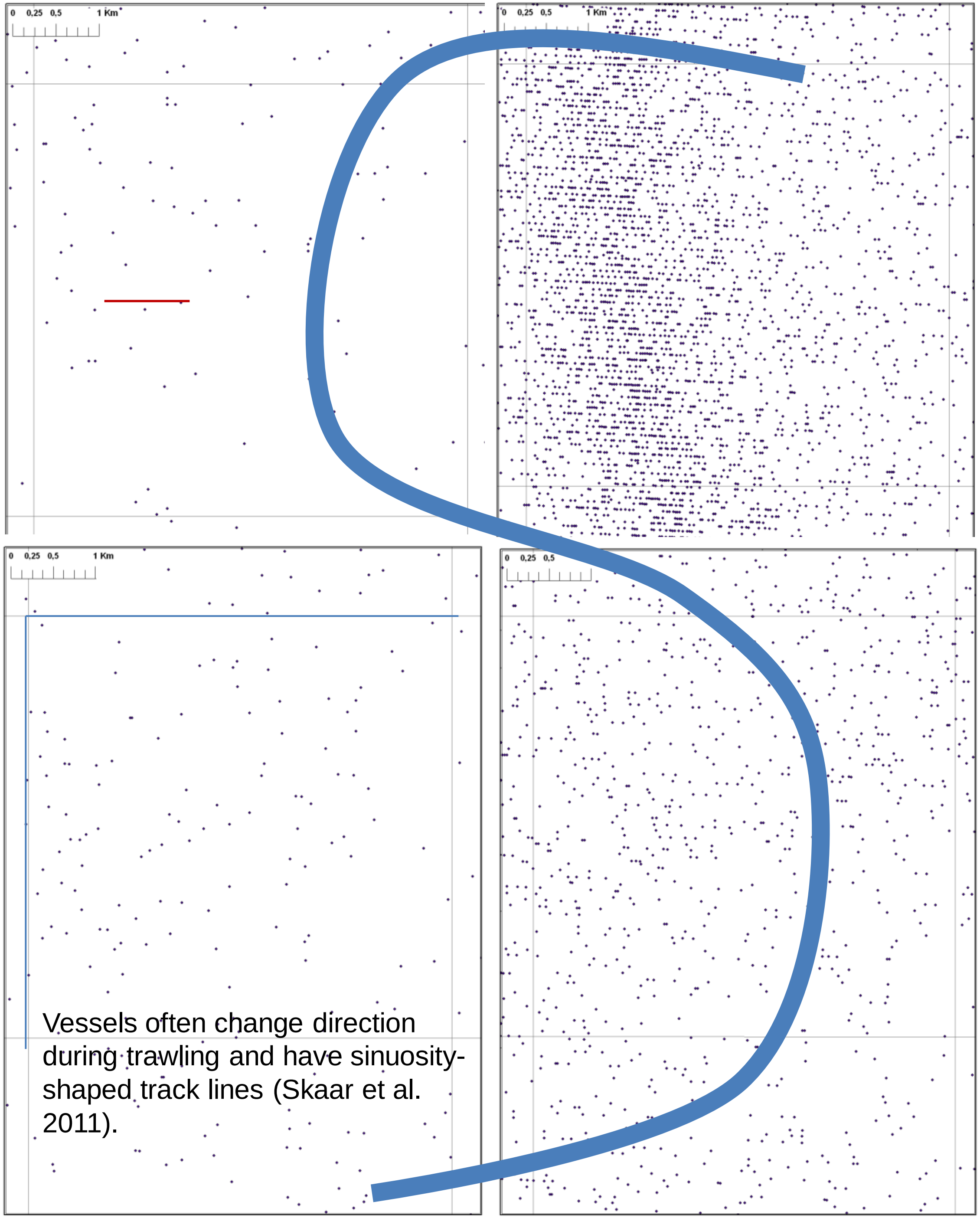
Maximum at 100 - 400 m is related to whitefish fisheries

The maximum at 600 - 700 m is related to fisheries of Greenland Halibut

Trawl marks were found down to 900 m



Relation between VMS records and impact at fauna sampling site



One otter trawl haul covers in average 5,9 km^2 (trawling time 4 hours speed 7.41 km/h and width of trawl of 200 m)

This is 24% of the area of a grid cell.

With one VMS registration per hour three registrations will corresponds to one trawl haul

Length of the video transects is 700m and width 2,5m, area covered is 1750 m^2

What is the relevant VMS-data for a megafauna impact analysis?

What area size should be used to relate fauna observations from 700 meters video transects to trawling history using VMS?

Is a 5x5 km grid where position of fauna observation in a cell dictates what VMS data is relevant the correct approach?

How long history of VMS data is relevant for a megafauna impact study?

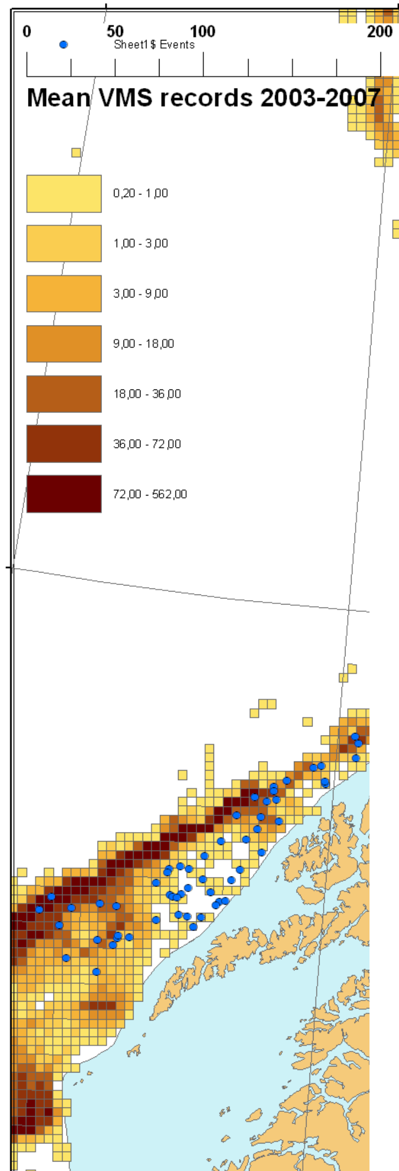
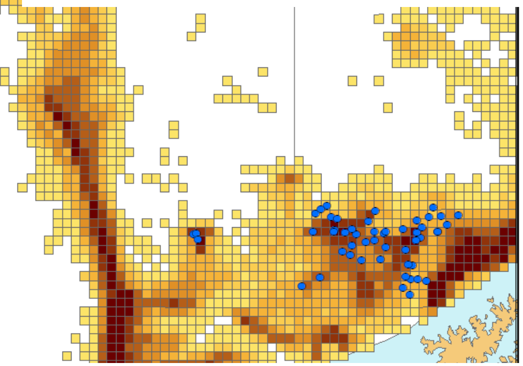
We use 3 years data to calculate yearly mean number of VMS registrations

Two approaches were used to relate fauna observations to history of fishery in an area: VMS records in 5 x 5 km grids and fauna sample centered with a 2 km radius of VMS registrations

Two approaches were used for the analysis of megafauna response to fisheries intensity : direct use of VMS registrations and defined pressure groups

Fishery intensity for otter trawl

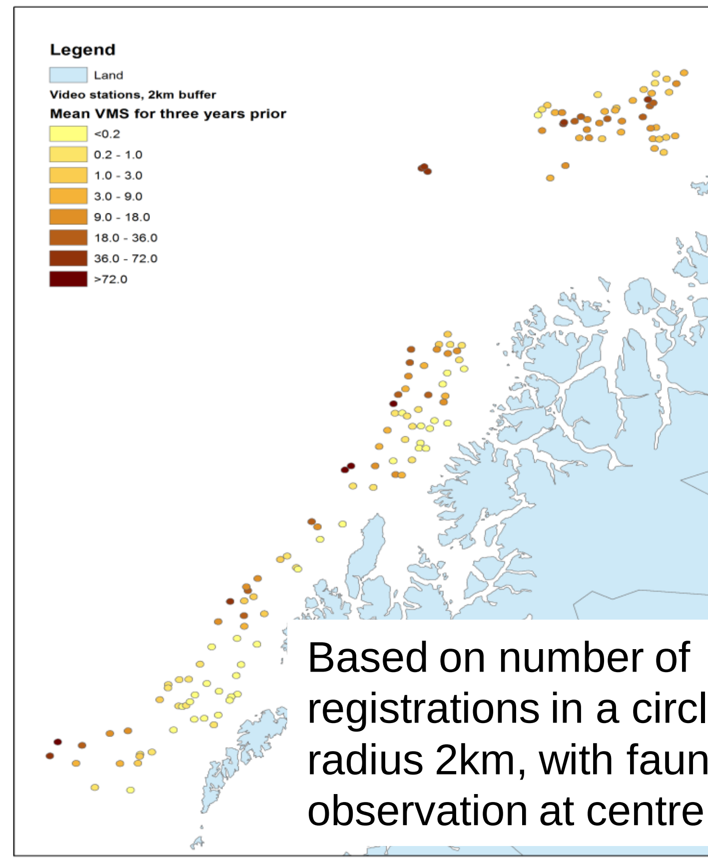
VMS records
1/hour for period 2003-2007
boats > 15 m
speed < 4,5 knot

Based on number of registrations in 5x5 km grid.

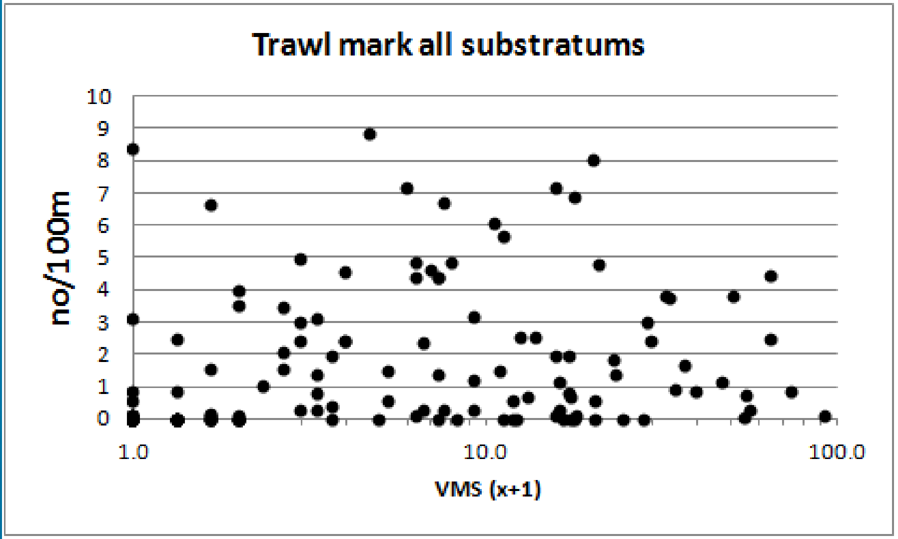
No. of video in the different fishery intensity groups in 3 depth zones. Dataset used is in red.

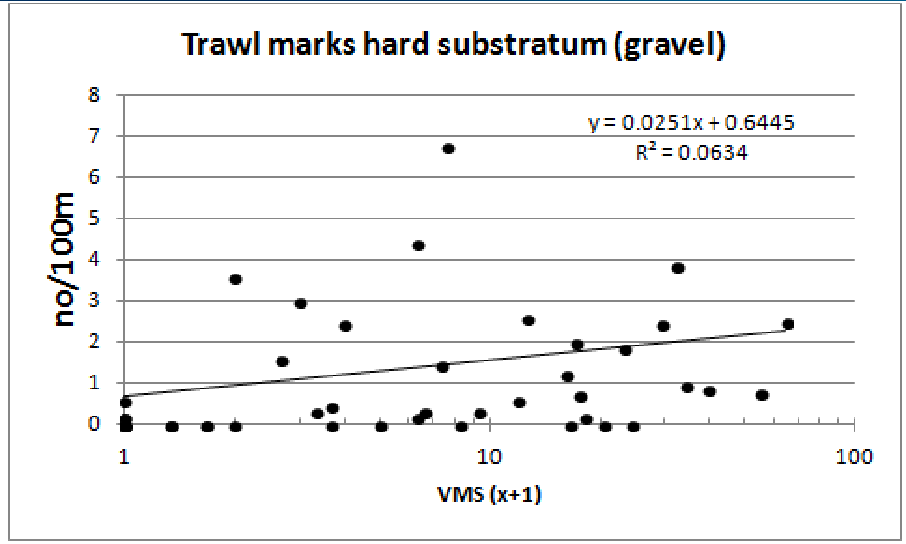
FI	VMS/y	Trawls/ y	50-400	400-1000	>1000
1	0	0	18	5	33
2	0.2-0.9	0.01-0.3	26	2	10
3	1-3	0.3-1	23	7	
4	3.1-9	1-3	18	6	
5	9.1-18	3-6	18	5	
6	18.1-36	6-12	22	2	
7	36.1-72	12-24	19		
8	>72	>24	10	3	
SUM			**154**	**30**	**43**

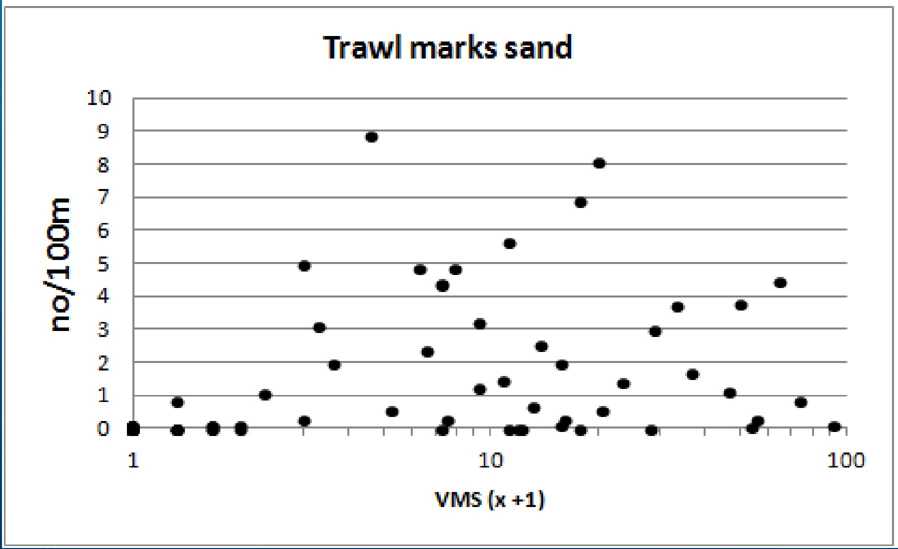


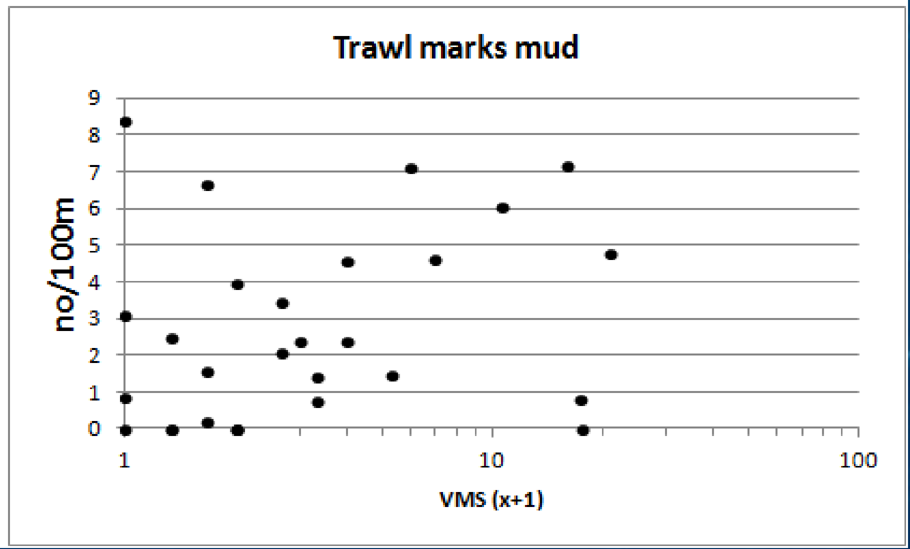
Based on number of registrations in a circle, radius 2km, with fauna observation at centre.

Relation between density of trawl marks and fisheries intensity









Pearson correlation (r) for the relation between trawling intensity and depth, observed trawl marks (no/100 m), mega fauna abundance (no/100m^2) and number of taxa (no/transect).

Pearson's correlation coefficients are in red for $p < 0.05$.

Density of trawl marks is not significantly correlated with fisheries intensity with exception for hard substratum (gravel and sandy gravel sediments).
However the observed density of trawl mark is highest on soft bottoms.

Diversity and density og megafauna shows a significant and negative correlation with trawling intensity.

	Trawling intensity	Depth	Trawl marks	Mega fauna density
All substratum , df 149 -2 for r > 0,19 p < 0,05				
Depth (m)	-0.02			
Trawl marks	0.10	**0.39**		
Density	**-0.26**	0.00	0.10	
Diversity	**-0.28**	-0.09	-0.06	**0.51**
Hard substrate, df 50 -2 for r > 0,24 p <0,05				
Depth	**0.25**			
Trawl mark	**0.25**	**0.53**		
Density	**-0.29**	0.04	-0.10	
Diversity	**-0.36**	0.10	0.07	**0.66**
Sand substrate, df 70 -2 for r > 0,20 p < 0,05				
Depth	-0.02			
Trawl marks	0.14	**0.21**		
Density	**-0.29**	0.01	0.07	
Diversity	**-0.30**	0.11	0.01	**0.57**
Mud substrate, df 29 -2 for r > 0,31 p < 0,05				
Depth	-0.20			
Trawl marks	0.22	0.27		
Density	0.12	**-0.38**	0.24	
Diversity	-0.22	**-0.61**	-0.27	0.19

Results from linear regression analysis of the relation between fisheries intensity and megafauna abundance and diversity based on VMS registrations

For quantification of fisheries intensity a circle defined by a radius of 2 km with the midpoint of video transect at its centre.

Results are significant for abundance and taxa, when all bottom types are pooled.
On hard bottom the relation is significant for taxa, on sand for both taxa and abundance and for mud the relation is no significant.

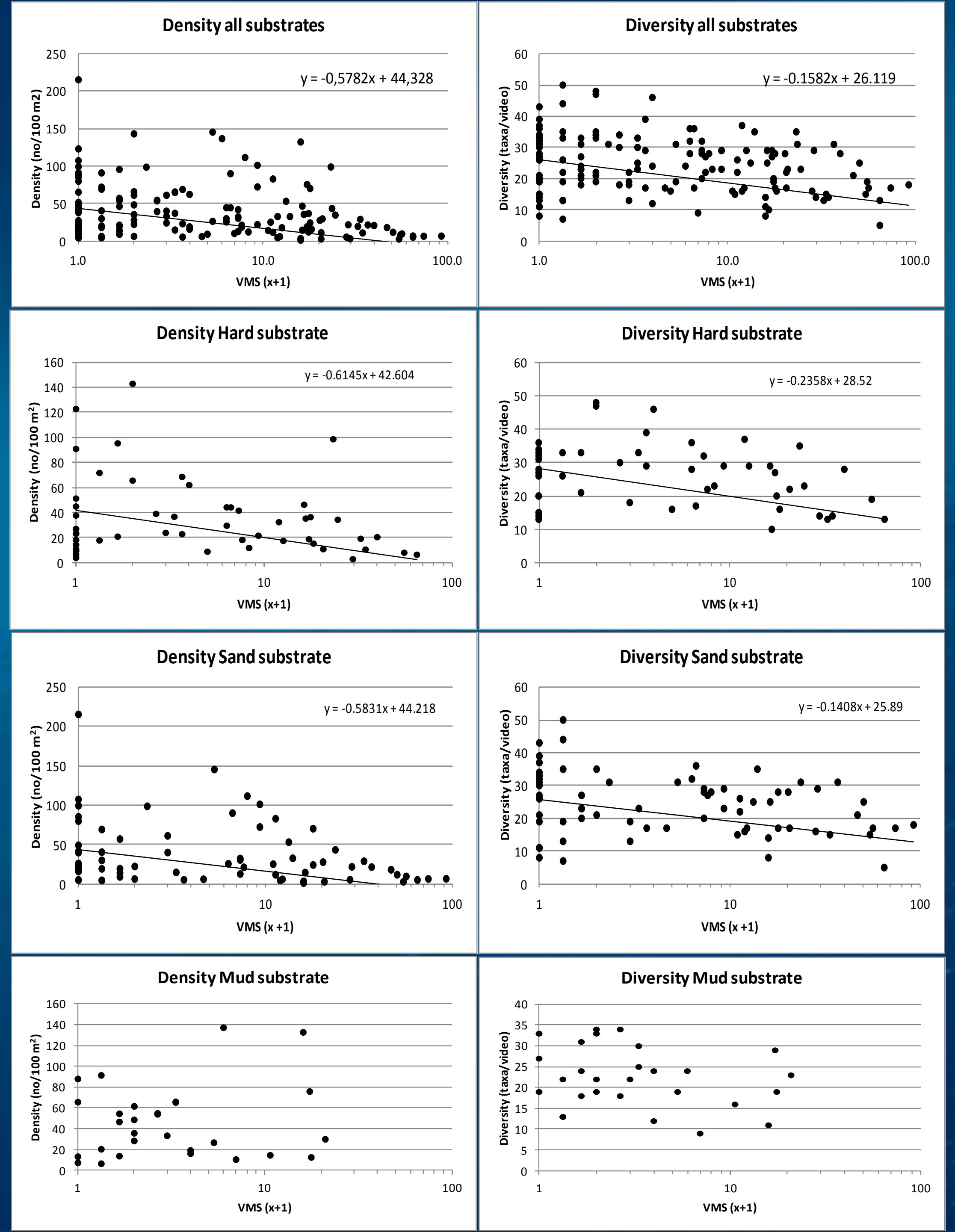
N = number of video transekts 700 meters each, r = correlation coeffisient,
p = significanse level and NS = not significant

		Density		Diversity	
Substratum	N	R	p	R	p
All	149	0.26	0.0014	0.28	0.0005
Hard	50	0.29	0.044	0.36	0.01
Sand	70	0.29	0.02	0.3	0.013
Mud	29	0.12	NS	0.22	NS

Linear regression analysis of the relation between fisheries intensity based on VMS registrations and megafauna abundance and diversity and

Mega fauna density (left) and diversity (right) on different substrates plotted against trawling intensity (mean VMS/year).

Linear equation is provided where the correlation is significant ($p < 0.05$).



All substratum df = 149 - 2, r = 0.15 for p <0.05			
Fauna groups	*r*	*Taxa*	*r*
Porifera large	**-0.23**	**Axinellidae**	**-0.21**
Porifera total	**-0.22**	**Porifera small**	**-0.17**
Porifera encrusting	**-0.20**	**Porifera encrusting**	**-0.17**
Crustacea	-0.12	***Craniella zetlandica***	**-0.16**
Ophiuroidea	-0.11	**Porifera yellow**	**-0.15**
Holothuroidea	-0.11	**Porifera white**	**-0.14**
Crinoidea	-0.11	**Polychaeta tube**	**-0.14**
Polychaeta	-0.10	*Hymedesmia spp*	-0.13
Echinoidea	-0.10	Paguridae	-0.13
		Antho dicotoma	-0.13
		Aplysilla sulfurea	-0.12
		Bivalvia	-0.12
		Tethya cranium	-0.11
		Ophiuroidea	-0.11
		Parastichopus tremulus	-0.11
		Serpulidae	-0.11
		Antedonacea	-0.11
		Cerianthidae	-0.11
		Porifera orange	-0.11
		Ditrupa arietina	-0.10
		Echinoidea	-0.10
		Pennatulacea	-0.10
		Porifera round	-0.10
		Bryozoa	-0.10
		Hydrozoa	-0.10
		Porifera bat	-0.10
		Filograna implexa	0.10
		Gastropoda	0.11
		Tubularia sp.	0.13
		Poranidae	**0.20**
		Asteroidea White	**0.24**

Of the 97 most common taxa there was 19 with positive and 78 with negative correlation

Two Asteroidea showed a significantly positive

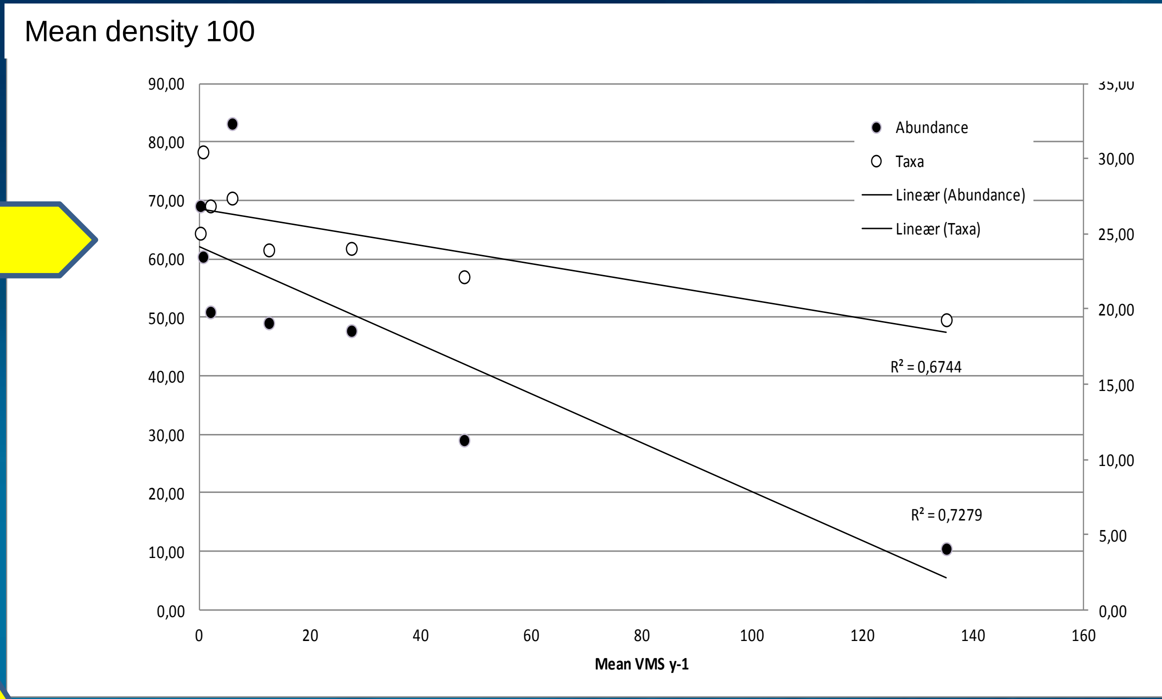
Seven spong taxa showed a significant and negative correltion

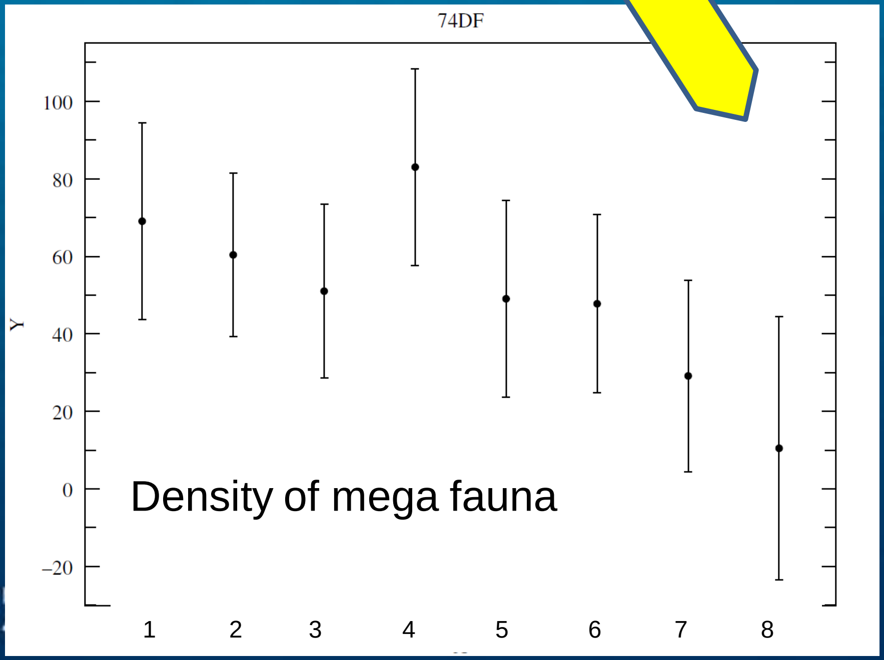
Linear correlation

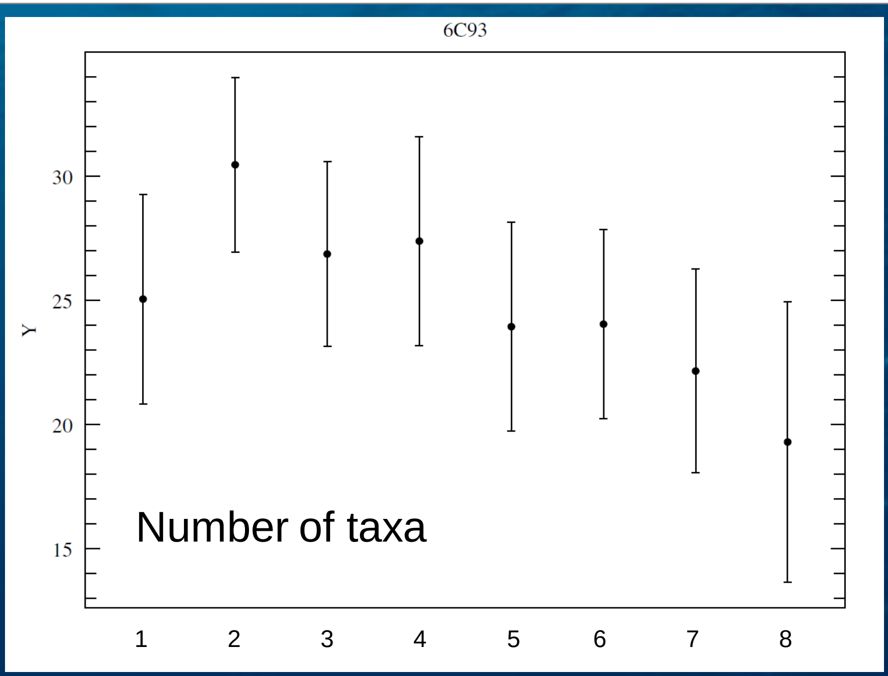
between fishery intensity (5x5 km) and mega fauna density and number of taxa

R2= 0,73 and = 0,67

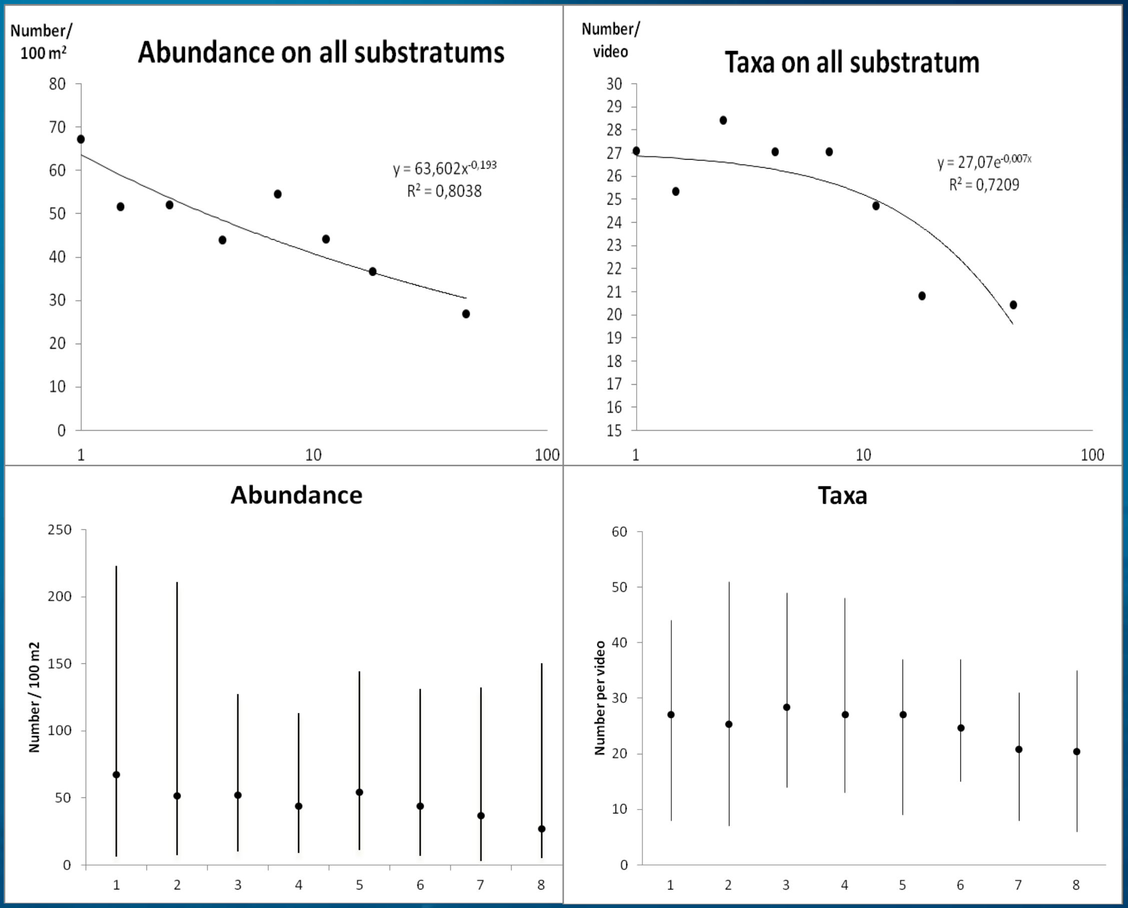
Results from ANOVA - test of variation in density and number of taxa within eight fishery intensity groups. p < 0.05 og F= 2.51. Figures shows mean and 95% confidence interval







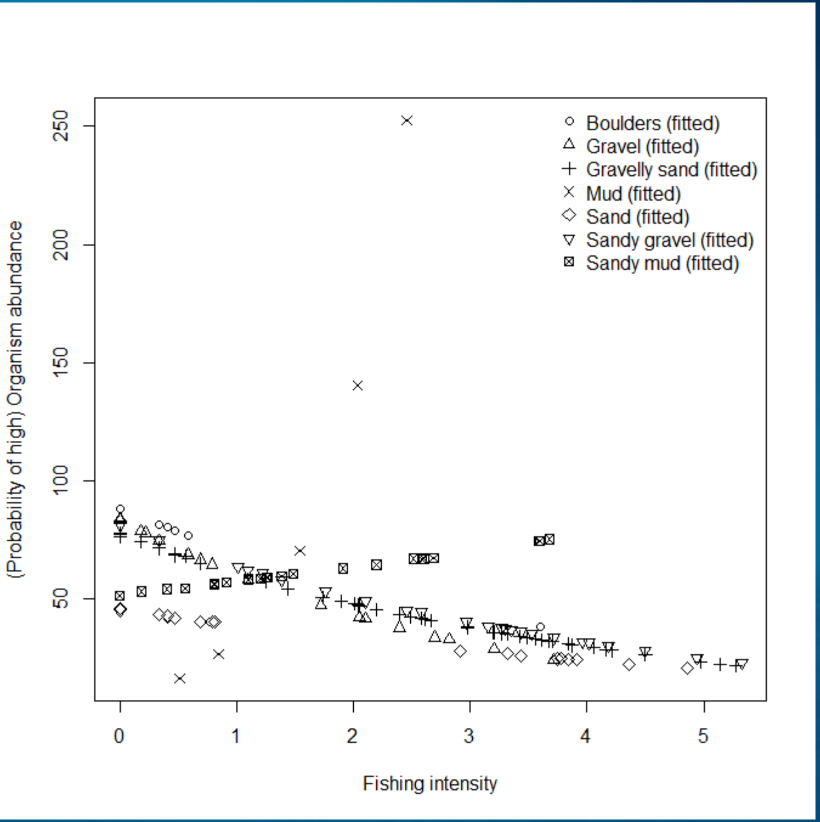
Mean abundance and number of taxa of megafauna for eight FI groups (VMS 2 km radius)

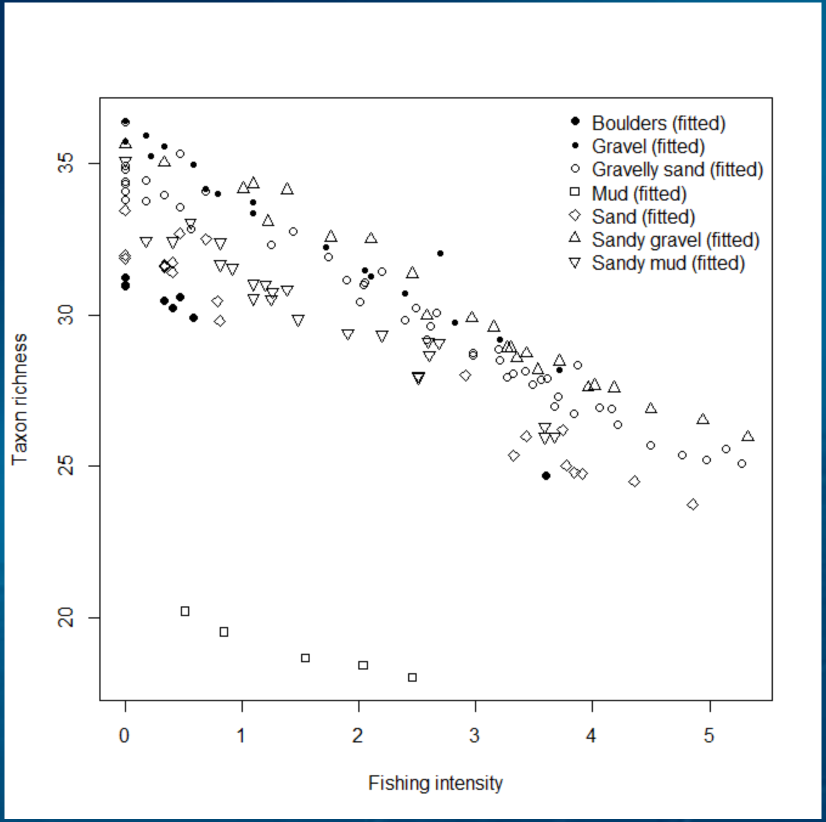


Upper figure presents log (mean+1)

Lower figure untransformed mean with maximum and minimum values within group

Preliminary results



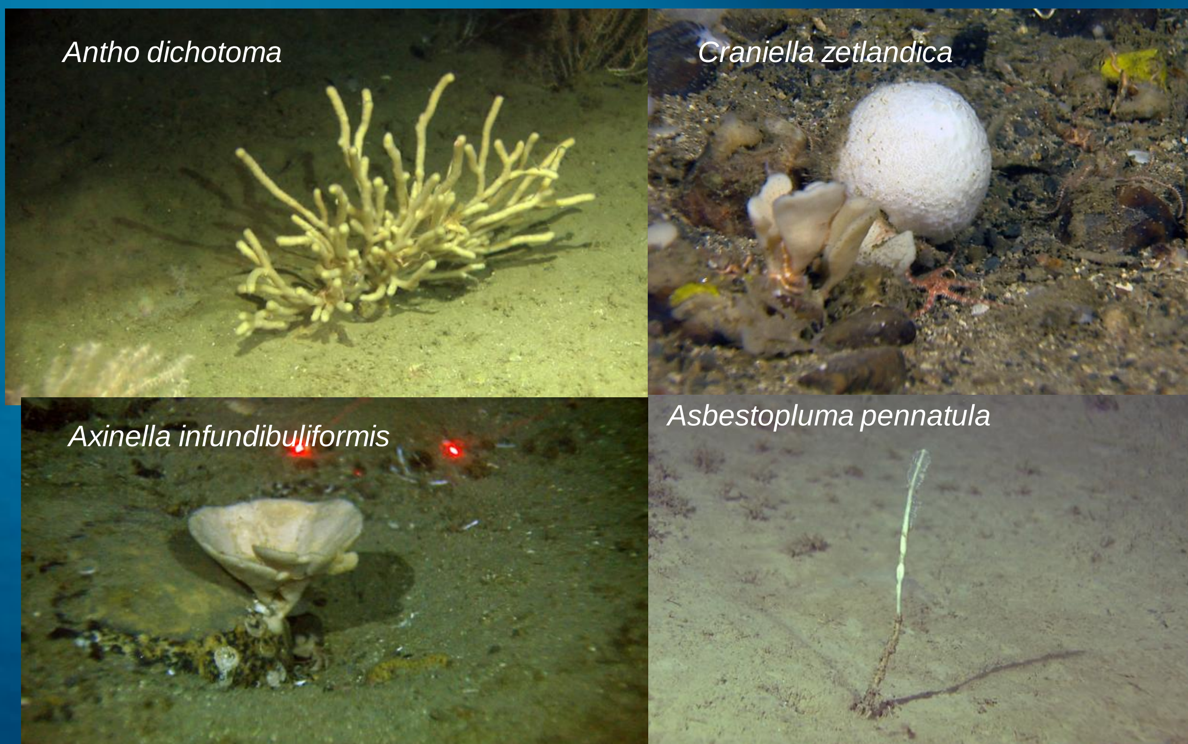


Relationship between total abundance of megafaunaa and fishing intensity GLM.

Relationship between taxon richness and fishing intensity GLM

Fishery sensitive taxa

Of 134 common taxa 100 shoed a negative correlation with FI for nine of these this is significant ($p < 0.05$) and 5 are sponges

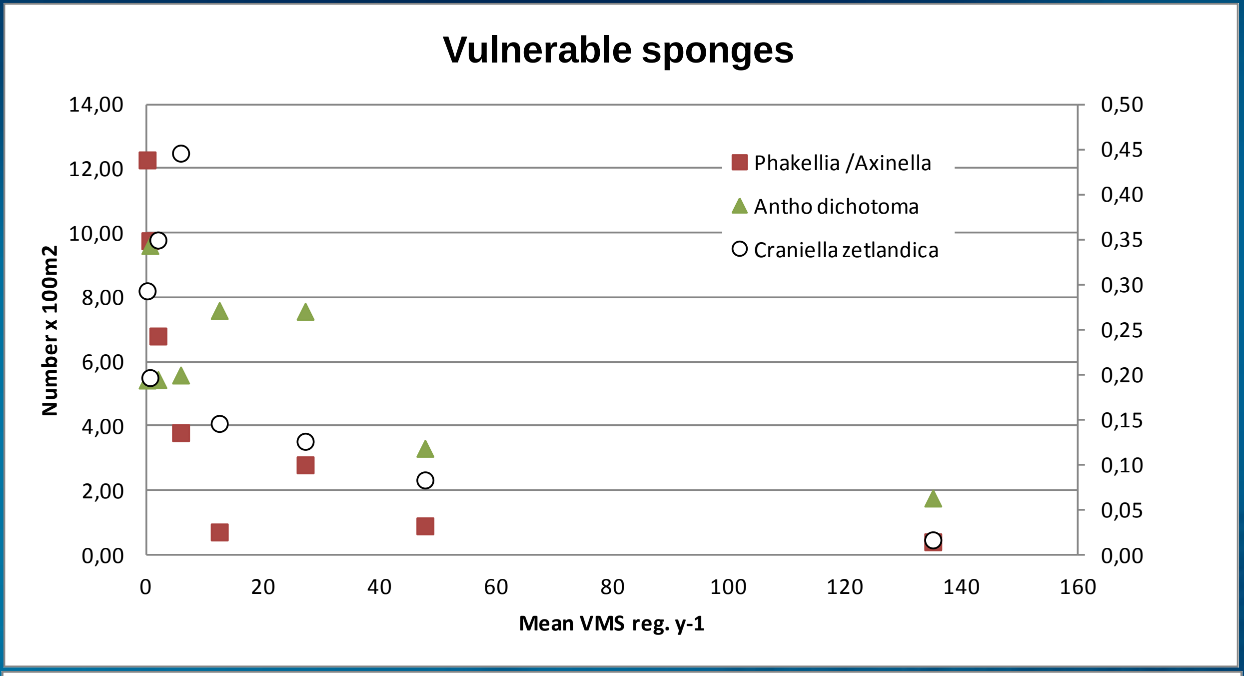


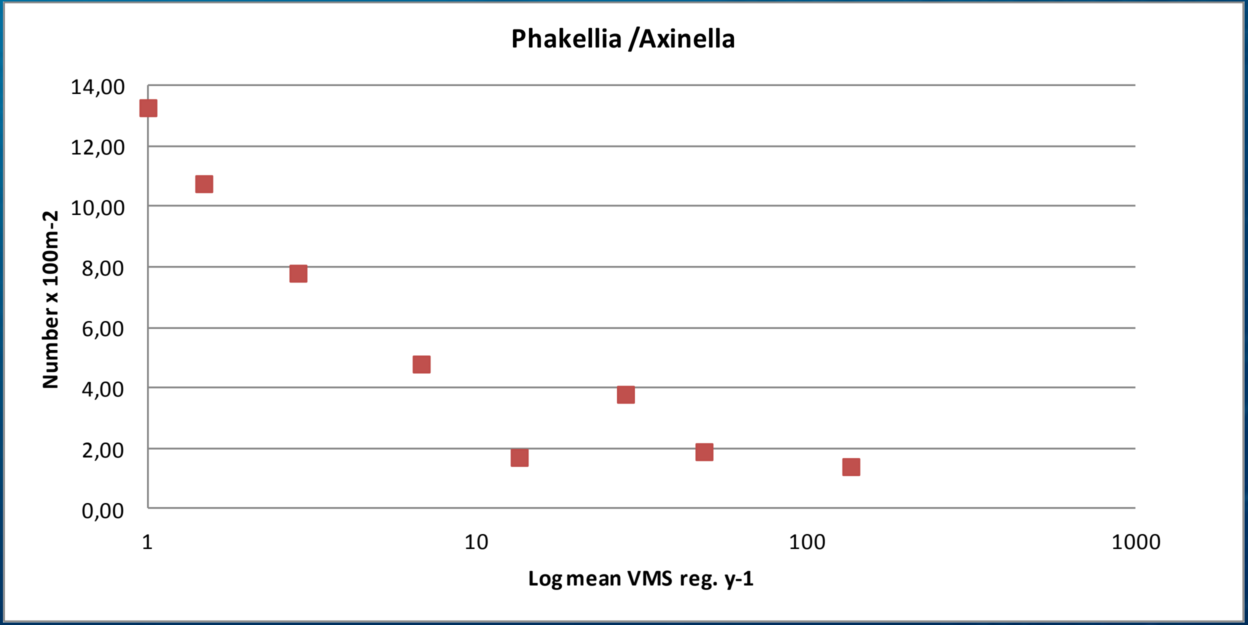
Correlation between VMS reg./år and density of mega fauna taxa

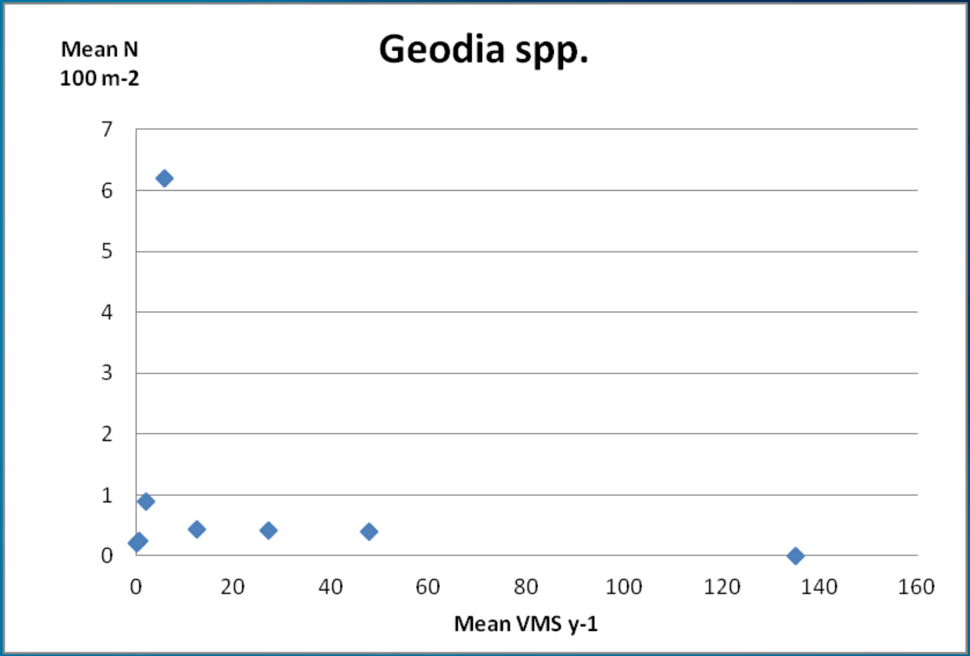
Pearson's r **$p < 0.05$ * $p < 0.1$ (df 7)

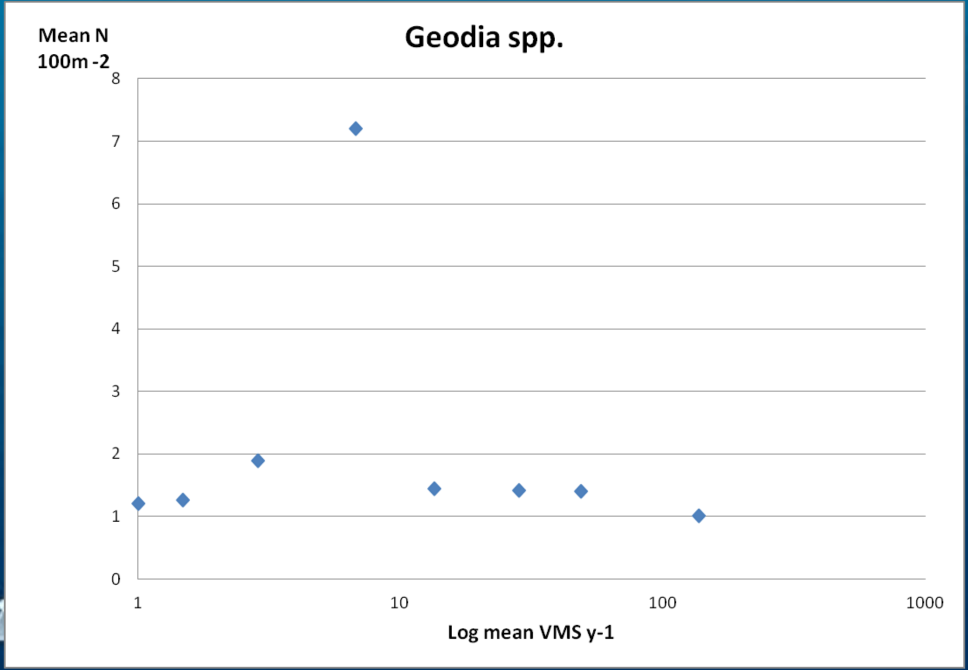
	Snitt VMS	
Antho dichotoma	-0,74	**
Craniella zetlandica	-0,71	**
Porifera small	-0,65	**
Hyas coactatus	-0,64	**
Bivalvia	-0,63	**
Phakellia /Axinella	-0,59	**
Porifera encrusting	-0,59	**
Ascidia	-0,59	**
Ophiuroidea	-0,58	**
Asbestopluma	-0,56	*
Bryozoa	-0,56	*
Crinoidae	-0,54	*
Porifera round	-0,54	*
Holothuroidea	-0,54	*
Galatheidae	-0,53	*
Porifera	-0,51	*
Porifera bat	-0,51	*
Hydrozoa	-0,50	*
Paguridae	-0,50	*
Serpulidae	-0,49	*
Parastichopus tremulus	-0,49	*
Porifera orange	-0,48	*
Solaster endeca	-0,47	*
Gastropoda	0,72	**
Asteroidea White	0,76	**
Poranidae	0,79	**

The response appears to be logarithmic.
Density for some species is clearly lower already at 0,5 to 2 VMS registrations per year corresponding to trawling ca 0,2 – 1 times per year









Unexpected results?

Pearson correlation between abundance of mega fauna and fishing intensity. ** p 0.05 = 0.150 *p 0.1 =0.117, df 153

	VMS mean
Geodia	-0,07
Steletta	-0,05
Stylocordyla	0,03

Main conclusion

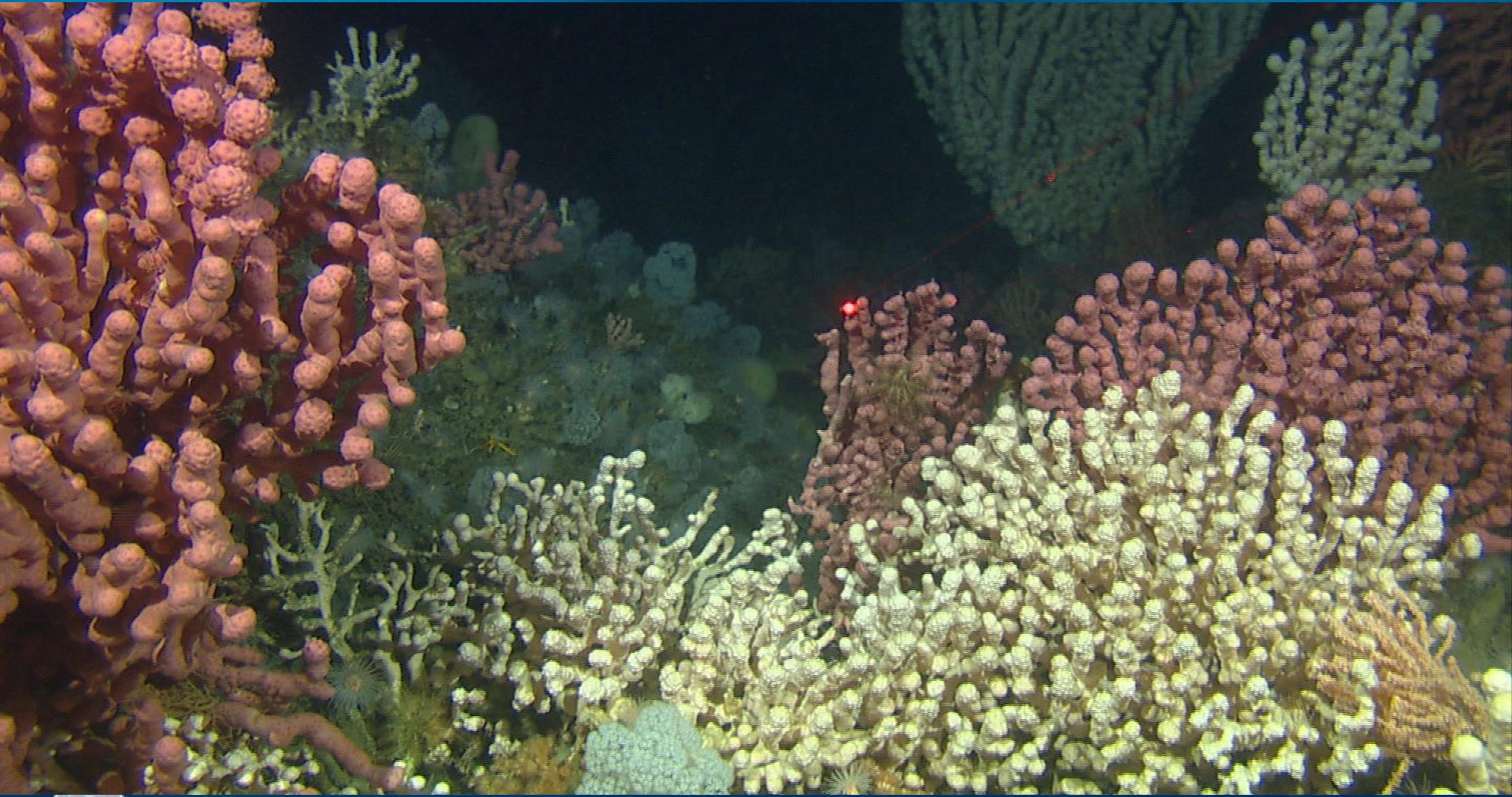
A clear and negative relation between fisheries-intensity and density of mega benthos. The response appears logarithmic and a negative effect is found even at very low intensities

In the study area the sponges is a vulnerable group and of these *Antho dichotoma, Craniella zetlandica* og *Phakellia /Axinella* appears to be particularly sensitive

Other groups that expresses a clear and negative response are:
Sea pens, ophiuroids, sessile polychaets.

Positive response are shown by large gastropods and some asteroids e.g. Poranidae.

The end!



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