# Effects of towed bottom fishing gear on benthic biota: current knowledge and future research priorities

**Michel J. Kaiser**

*Fisheries & Conservation Science Group, School of Ocean Sciences, Bangor University, Menai Bridge, Anglesey, LL59 5AB, UK.*

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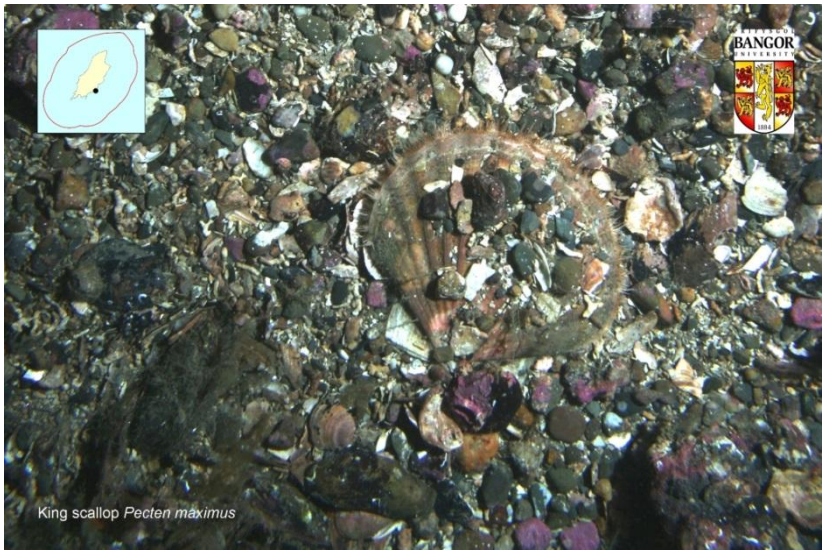
## Talk structure:

- Environmental context
- Limiting factors on benthos
- Acute impacts
- Confirmation with small-scale experiments
- Chronic impact
- Implications for spatial planning/MPAs
- Can we do fish in a better way

## Start at the bottom…..



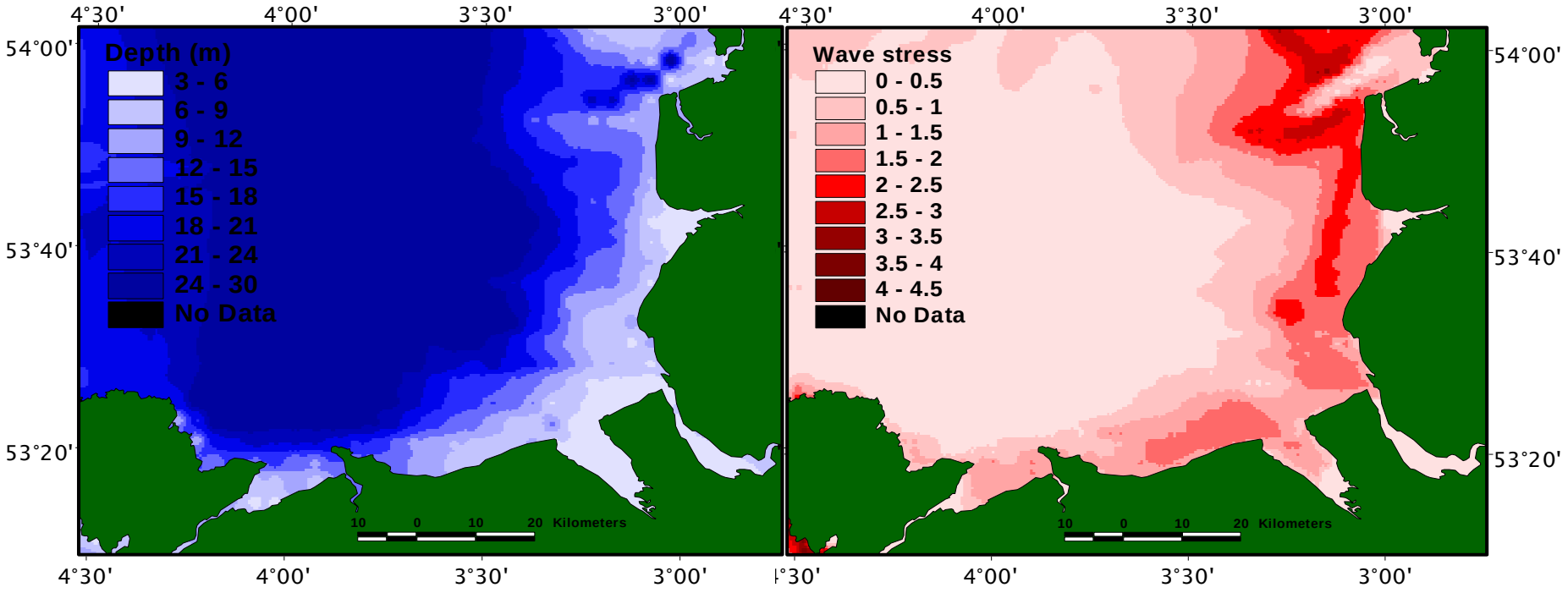




**For each habitat type there will be a range of environmental drivers that dictate upper limits for the inhabitants**

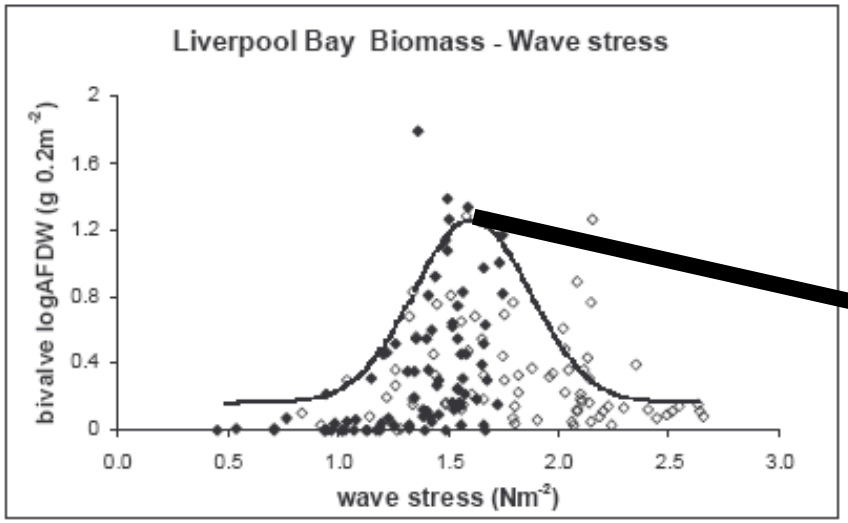
# Physics predicts biology

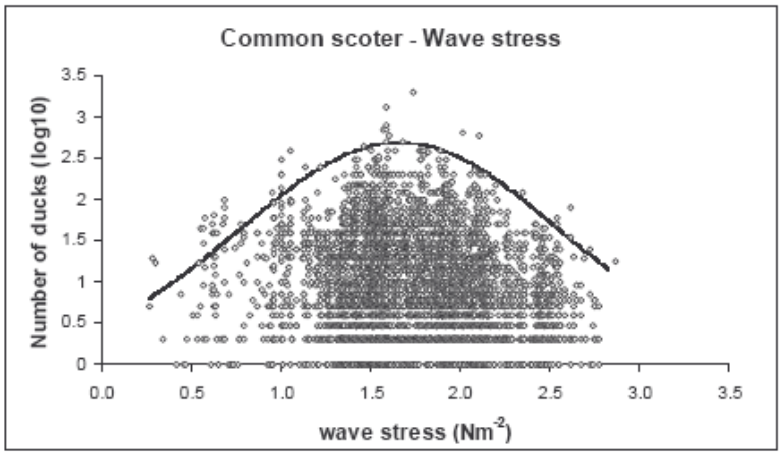
## Depth

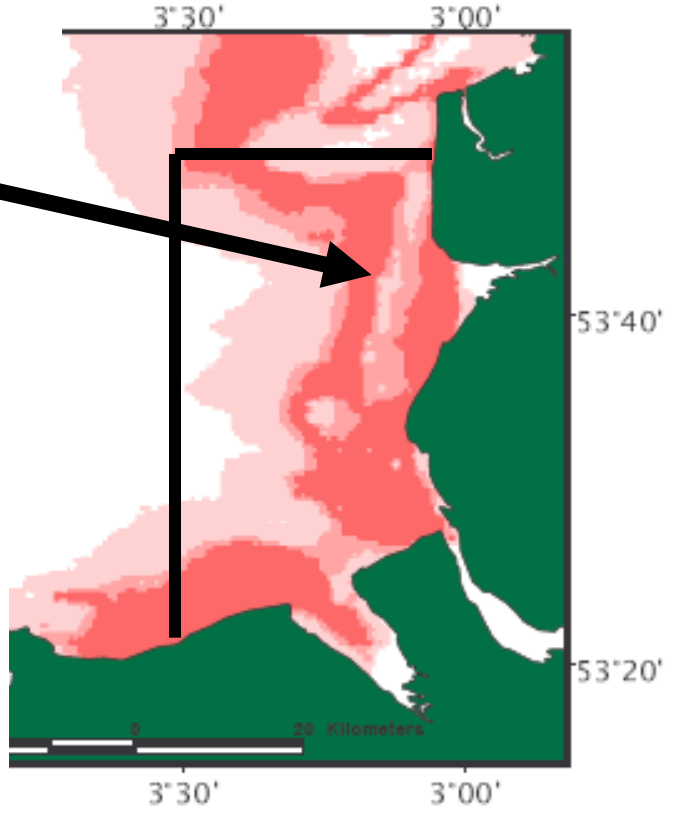
## Wave stress



# Physical parameter (limiting factor) predicts maximum possible carrying capacity




Kaiser et al., 2006 Ibis

# Further evidence that fish co-occur with their prey

Plaice abundance (n •1000 $m^{-2}$)

100
10
1
0.1

1
10
100

Infaunal biomass (g WW •$m^{-2}$)

Hiddink et al. 2011 J. Appl. Ecol.

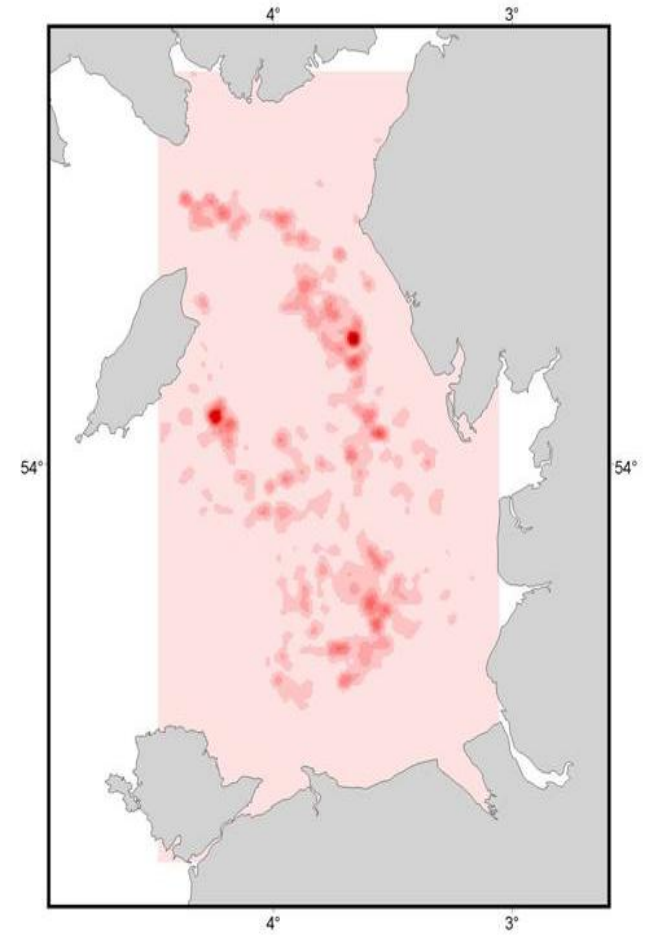
**Fishing is not uniformly distributed**

**Some areas are not fished by gear that impact the seabed**

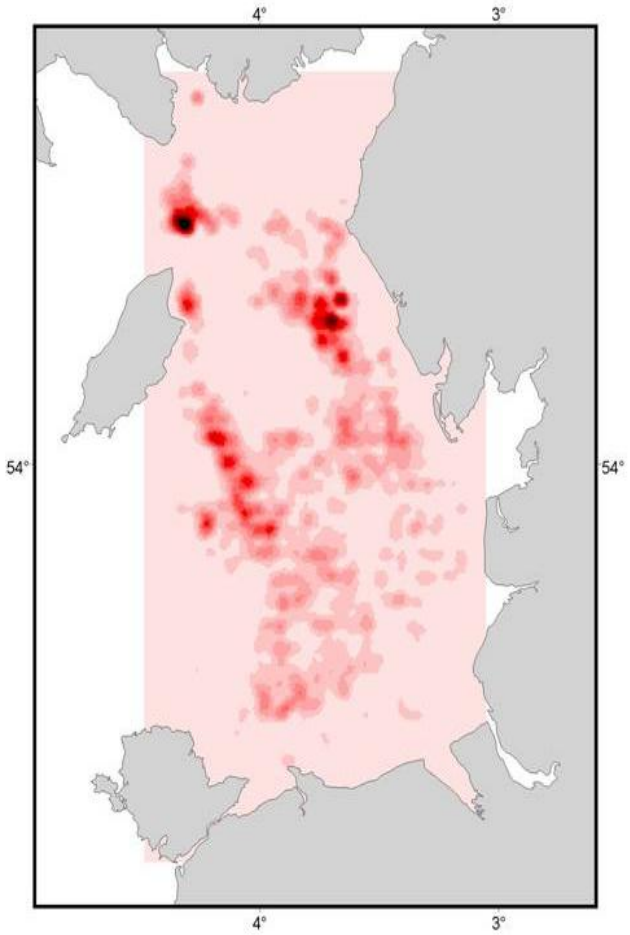
**In the NE Atlantic the footprint is diminishing**

# Expansion and contraction of effort

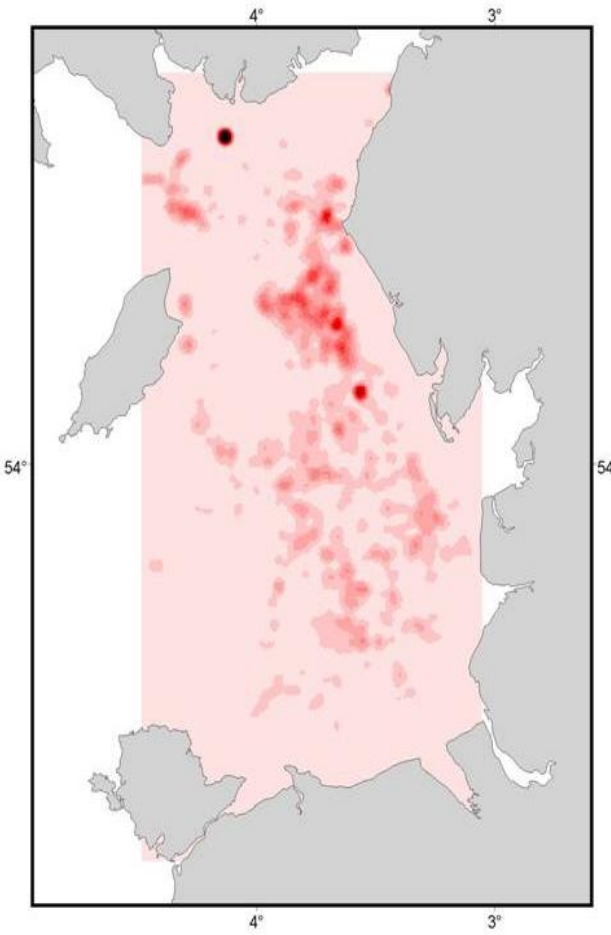
1985 – 1989



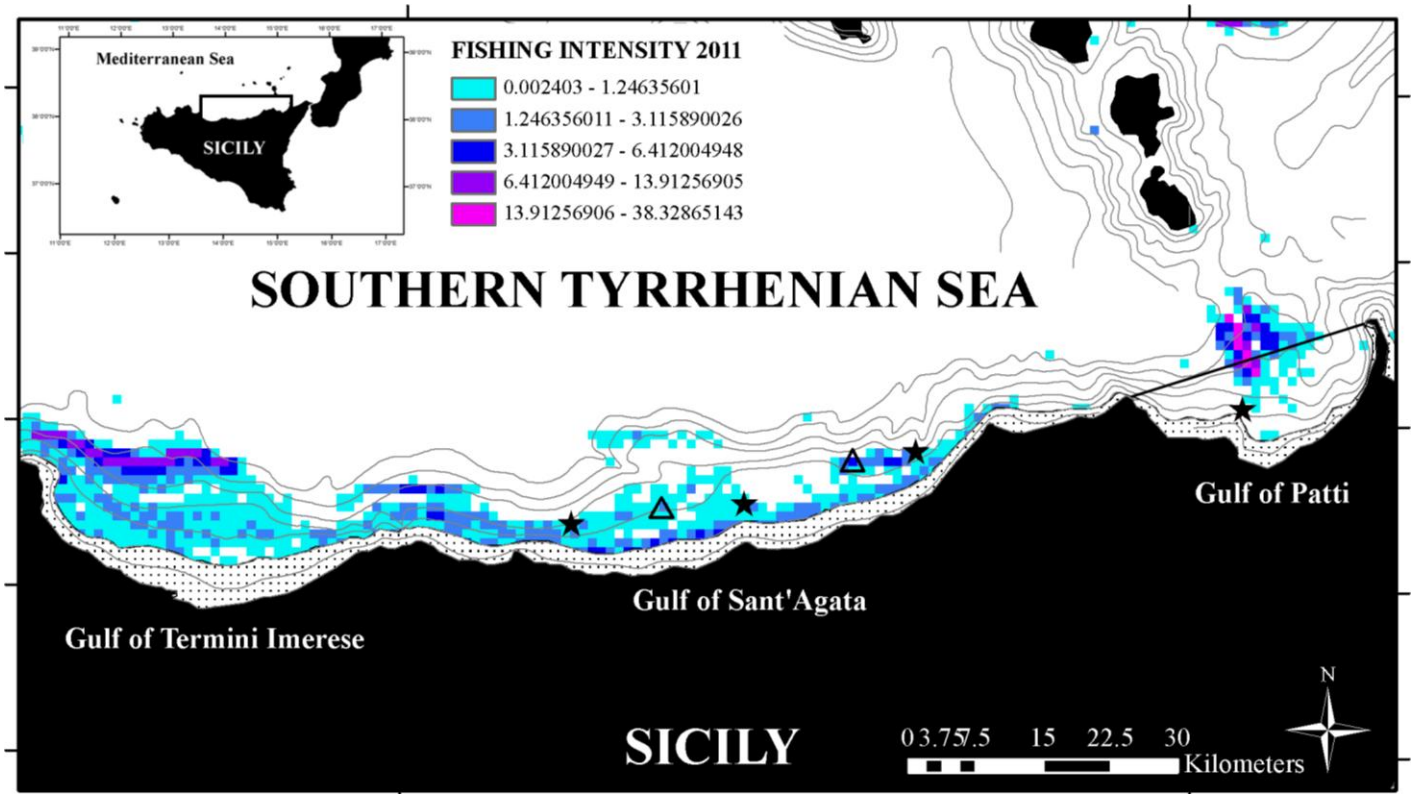

1990 – 1994




1995 – 1999




Landings highest → Landings lowest

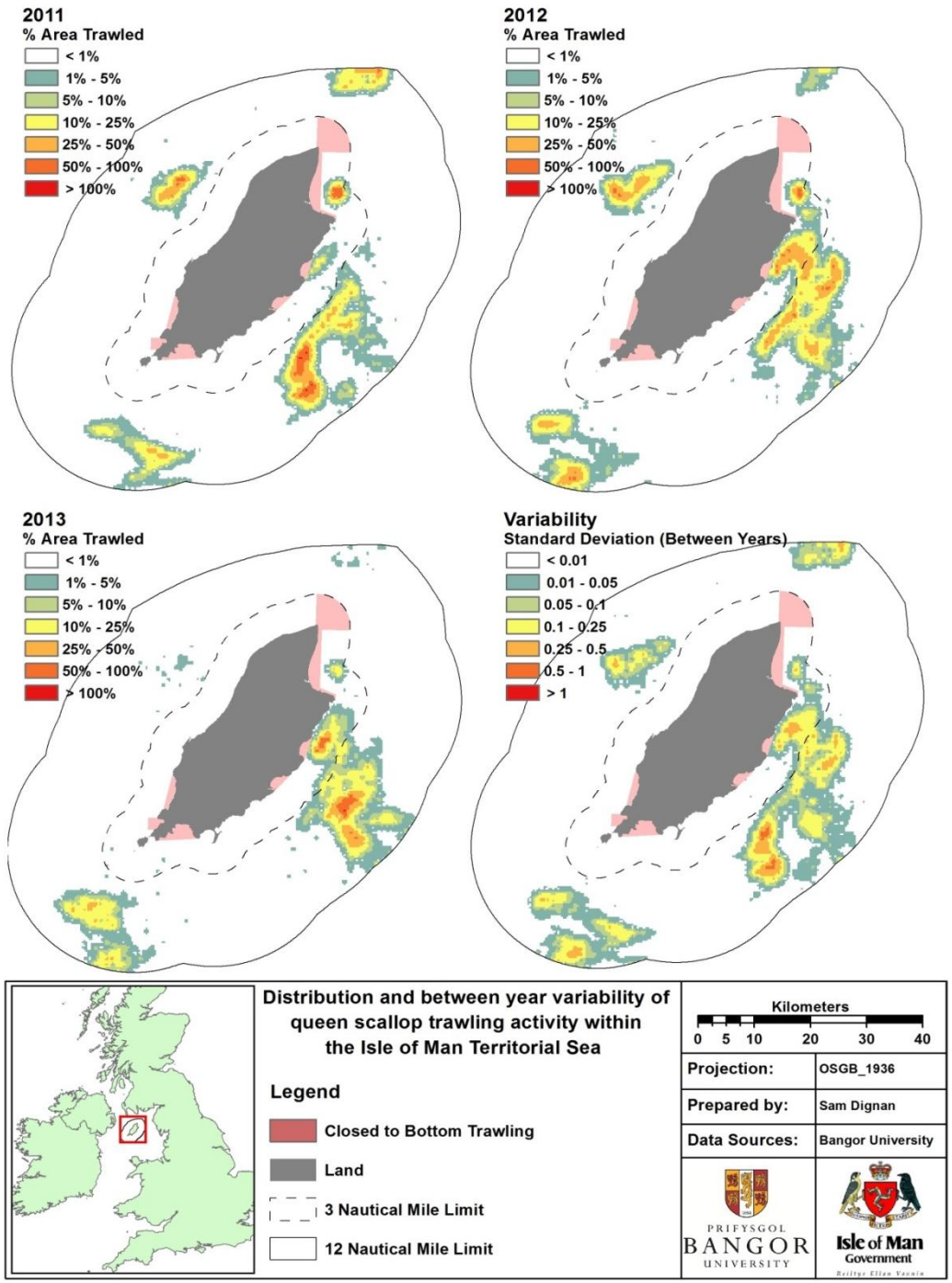



The distribution of fishing activity for >15 m vessels fishing off the coast of Sicily. The fishing activity is highly aggregated and consistent between years. Note that large areas of the sea are not subjected to fishing. The stippled area close to the coast delineates the 50 m depth contour within which no trawling is permitted. Although the Gulf of Patti is an area entirely closed to fishing (within the black line) there is clear evidence that fishers infringe the area to fish down the canyons that occur within this area.

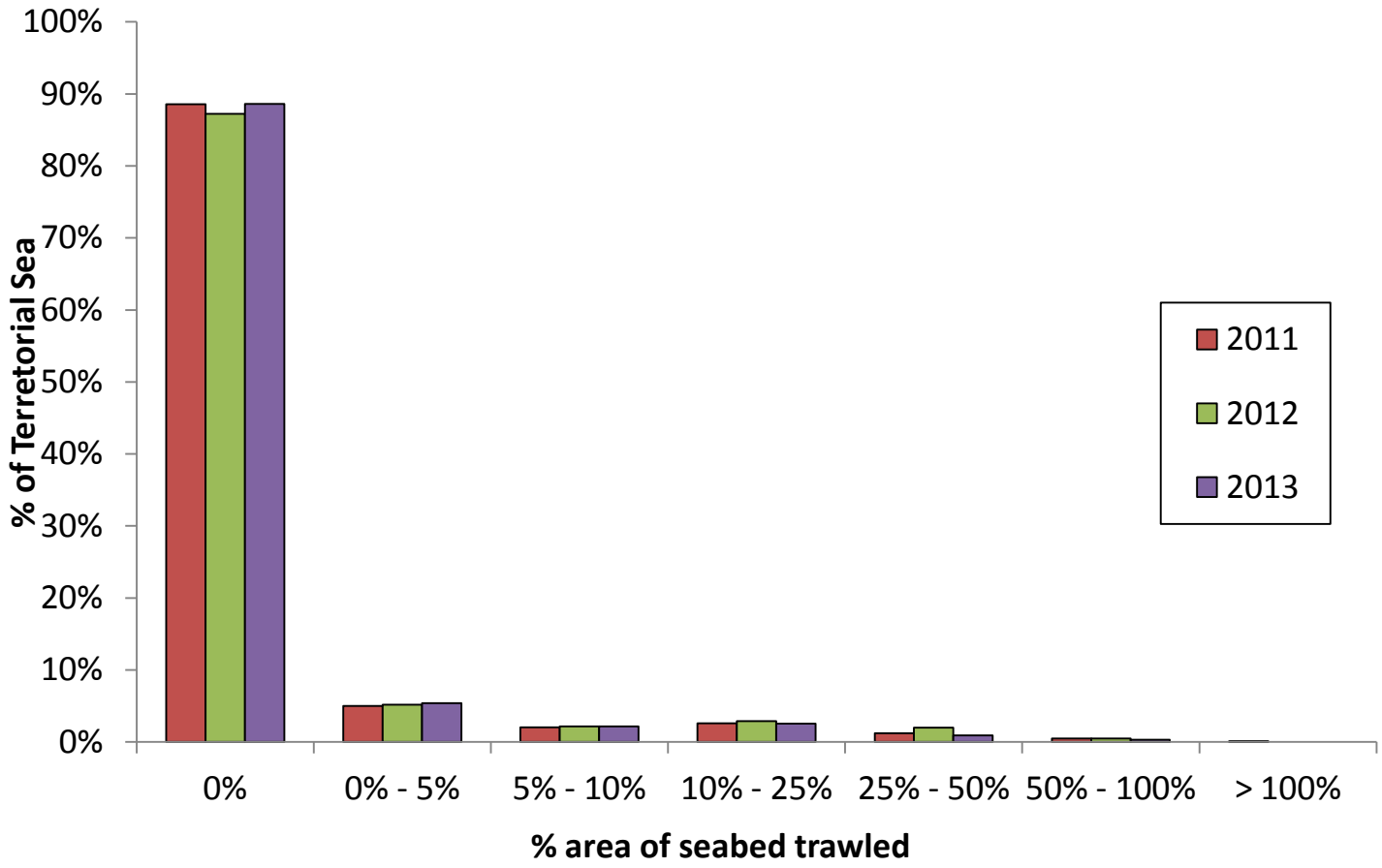
**Source: Mangano *et al.* 2014 Cont. Shelf Res.**

As soon as we add colour to a map we embed an impression that much more of the seabed are fished

100% VMS coverage



# A better way to portray the data



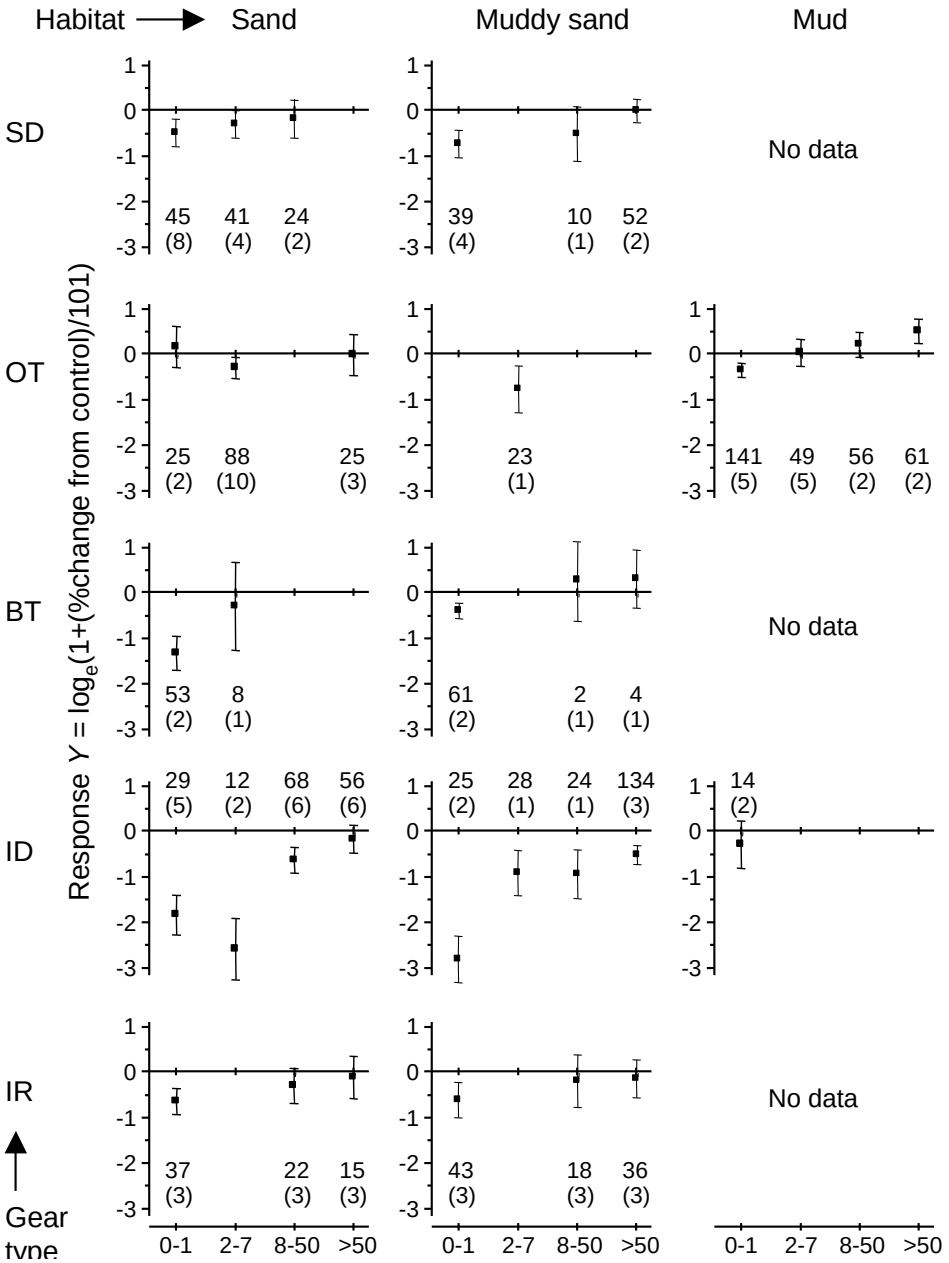
# What we know and what we don’t know from large-scale experiments

# Meta-analysis of response of benthos to different methods of fishing

**Habitat affects the outcome of harvesting.**

**Gaps either because fishing doesn't occur in that habitat or no studies have occurred**

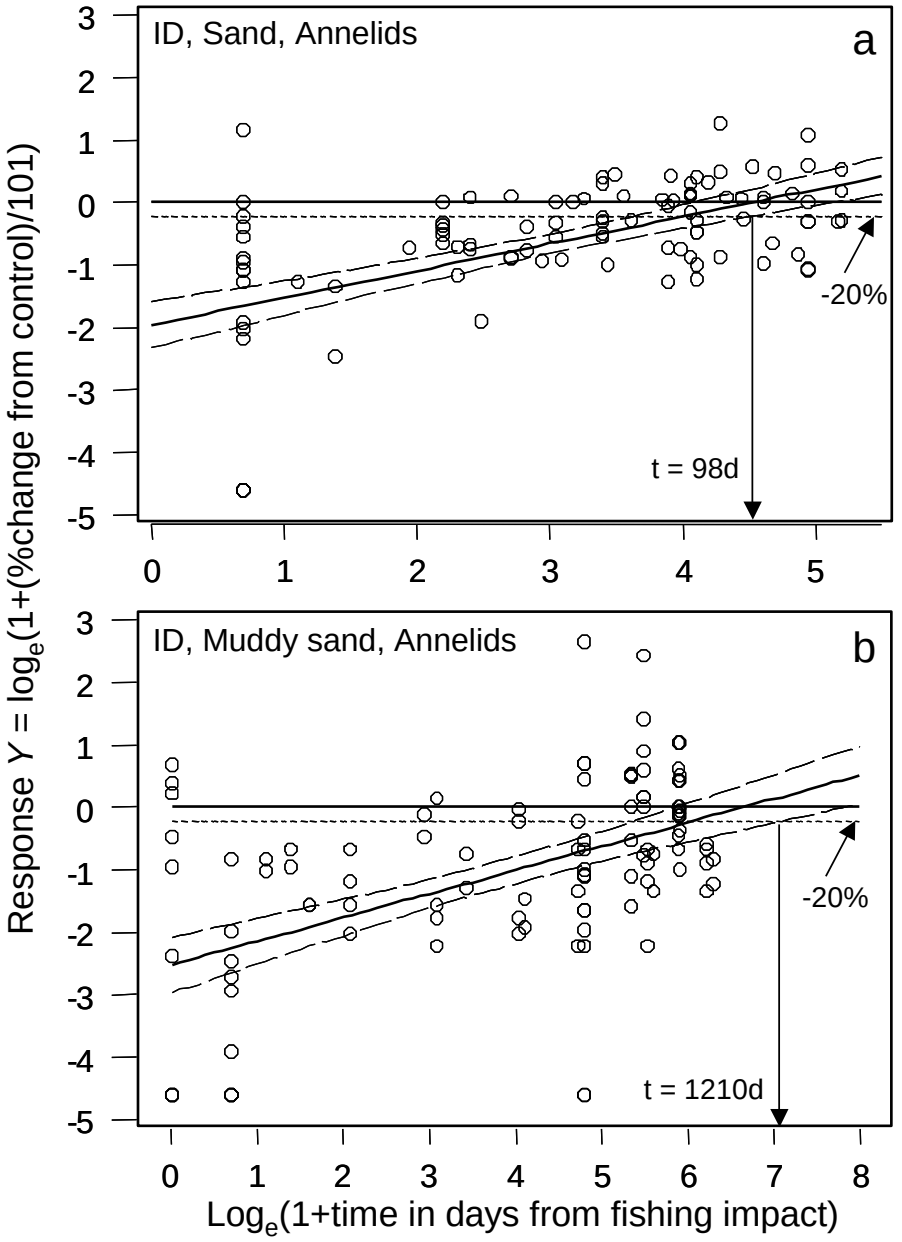
**Kaiser et al. 2006 MEPS**



# How long does recovery take?

Recovery rates is stongly determined by animal life-history and the resilience of its habitat.

See **Kaiser et al. 2006** MEPS for full table of predicted recovery rates of biota in different habitats.

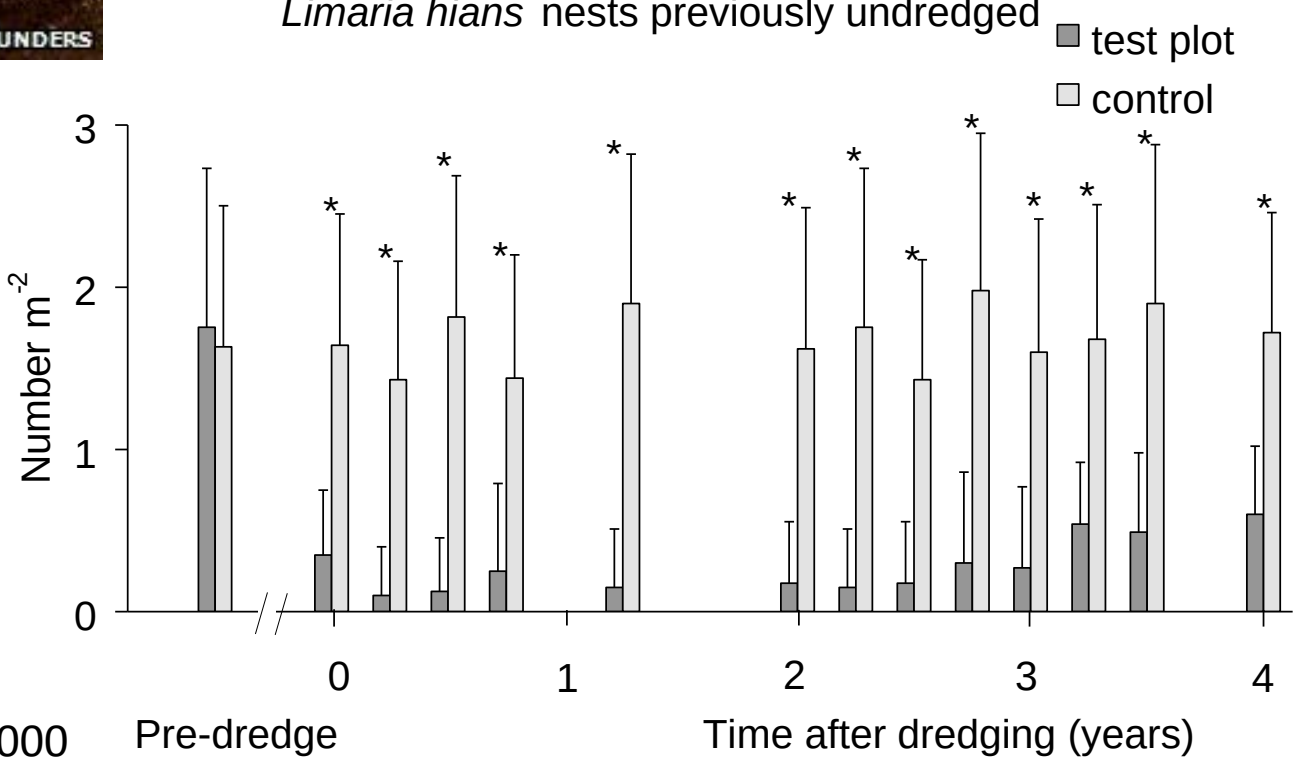



# We are missing studies in biogenic habitats

**However, presently in the UK you would not be permitted to do this experiment**

**Don't tow bottom fishing gear here**

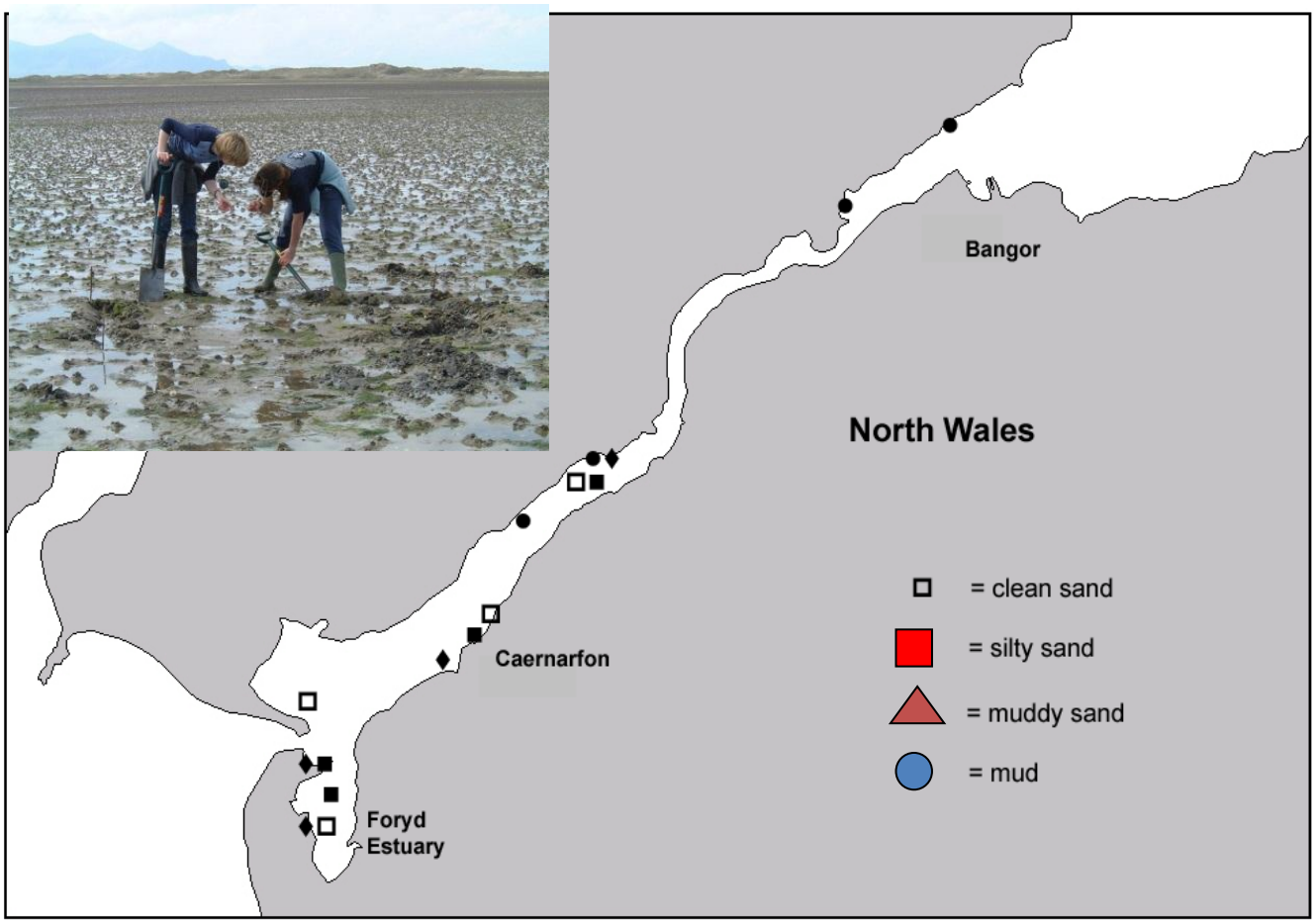
*Limaria hians* nests previously undredged

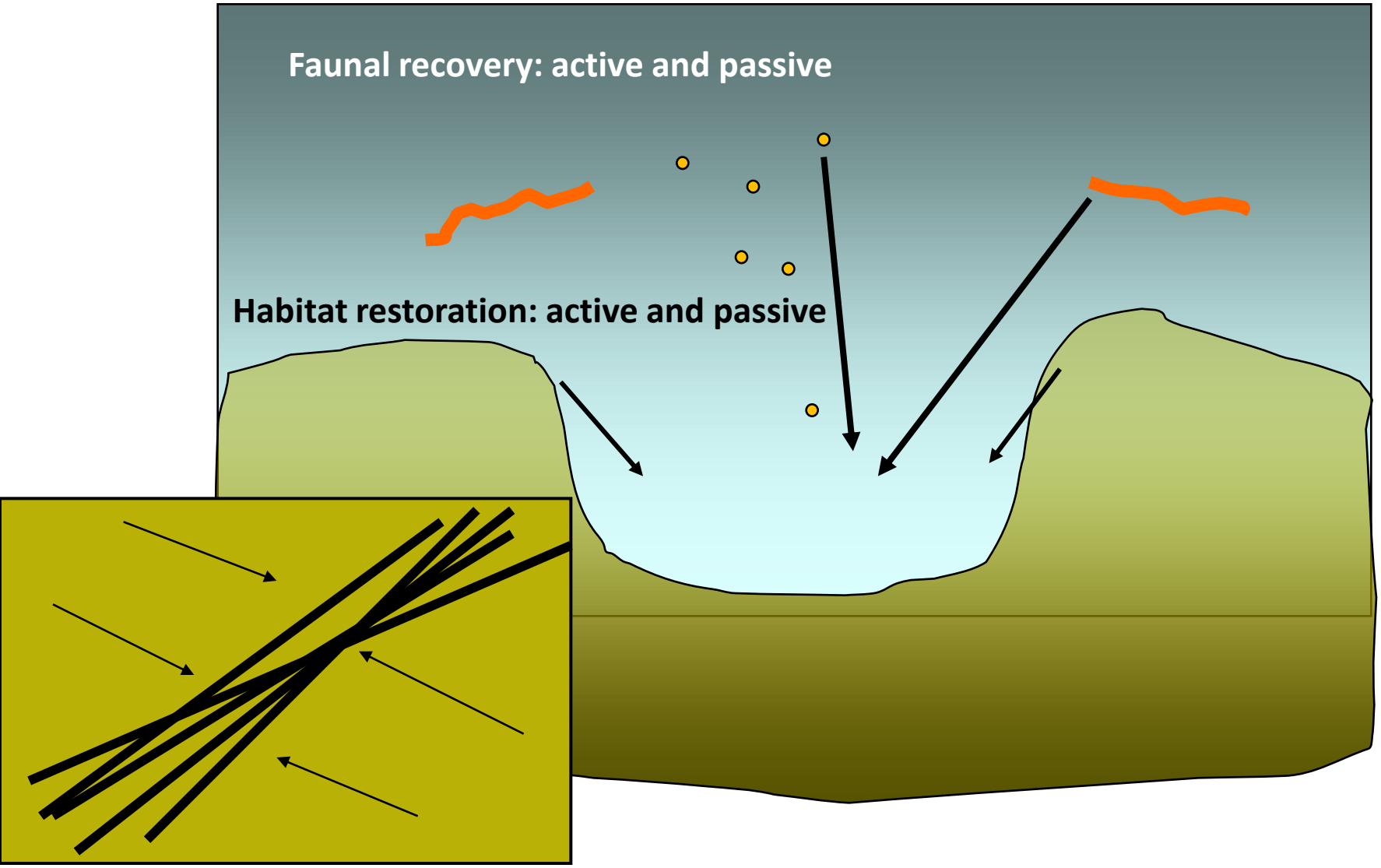


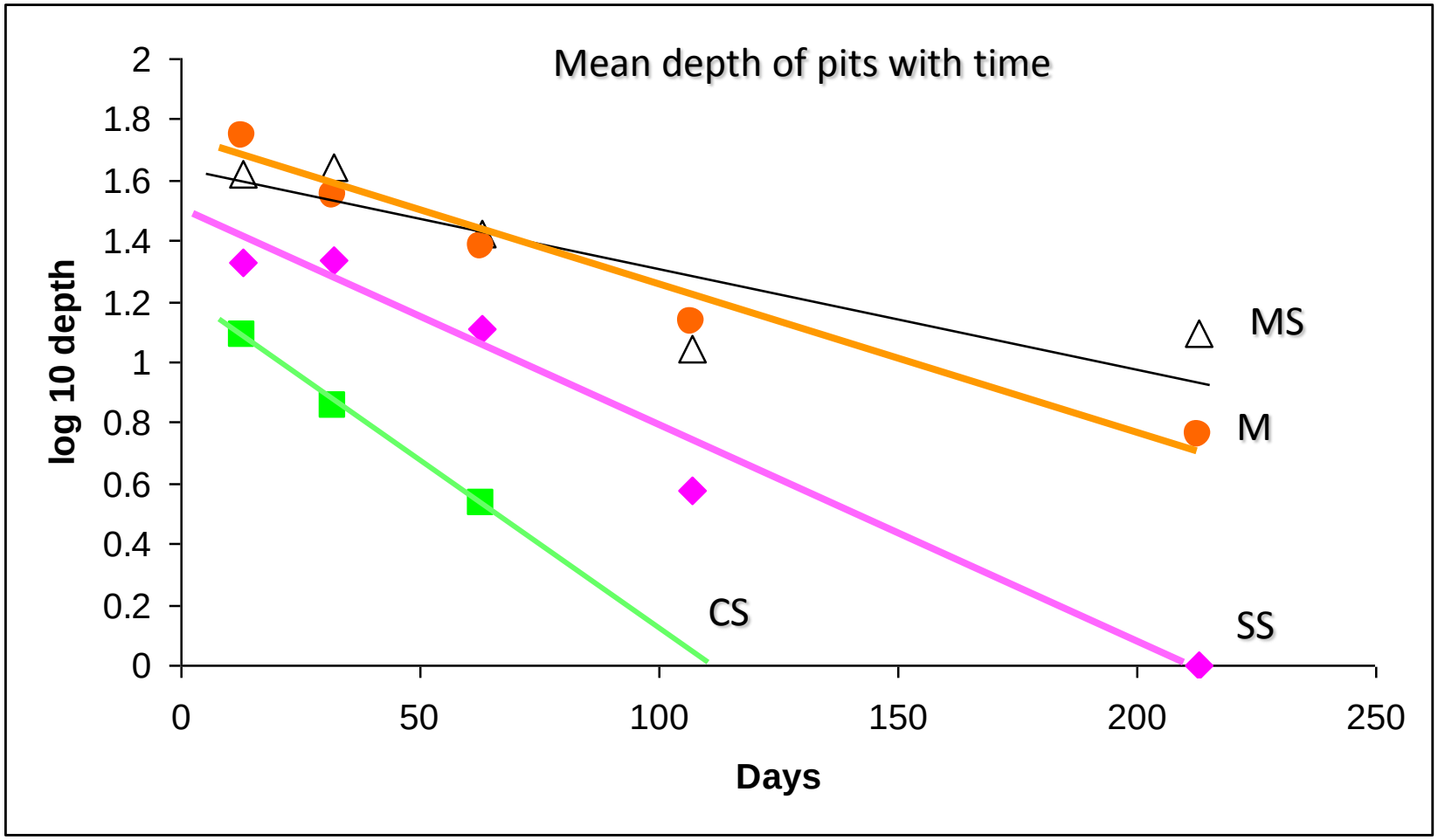

Hall-Spencer & Moore 2000

# From meta-analysis  back to experiments

**Experiments – limited by their specificity**
**Meta-analysis – limited by available studies for some treatments**




Faunal recovery: active and passive
Habitat restoration: active and passive

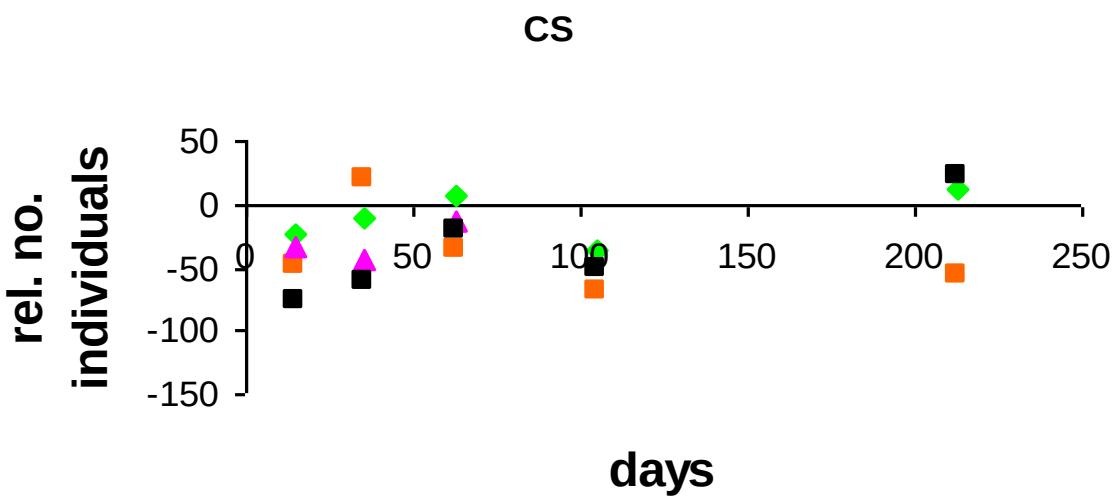


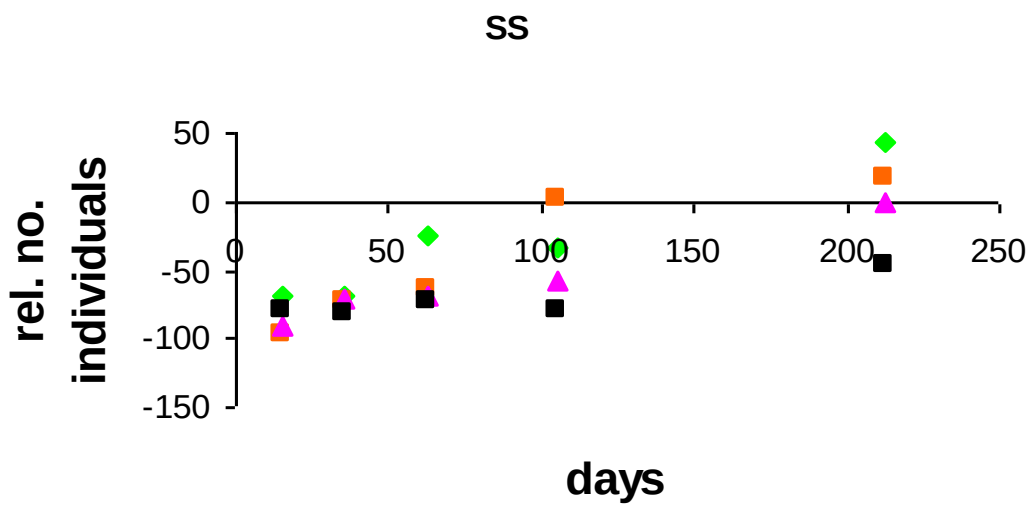

# How long does it take the habitat to recover?

CS – clean sand; SS – silty sand; MS – muddy sand; M - mud

Dernie, Kaiser & Warwick, 2003 J. Anim. Ecol.

# Recovery trajectory by habitat



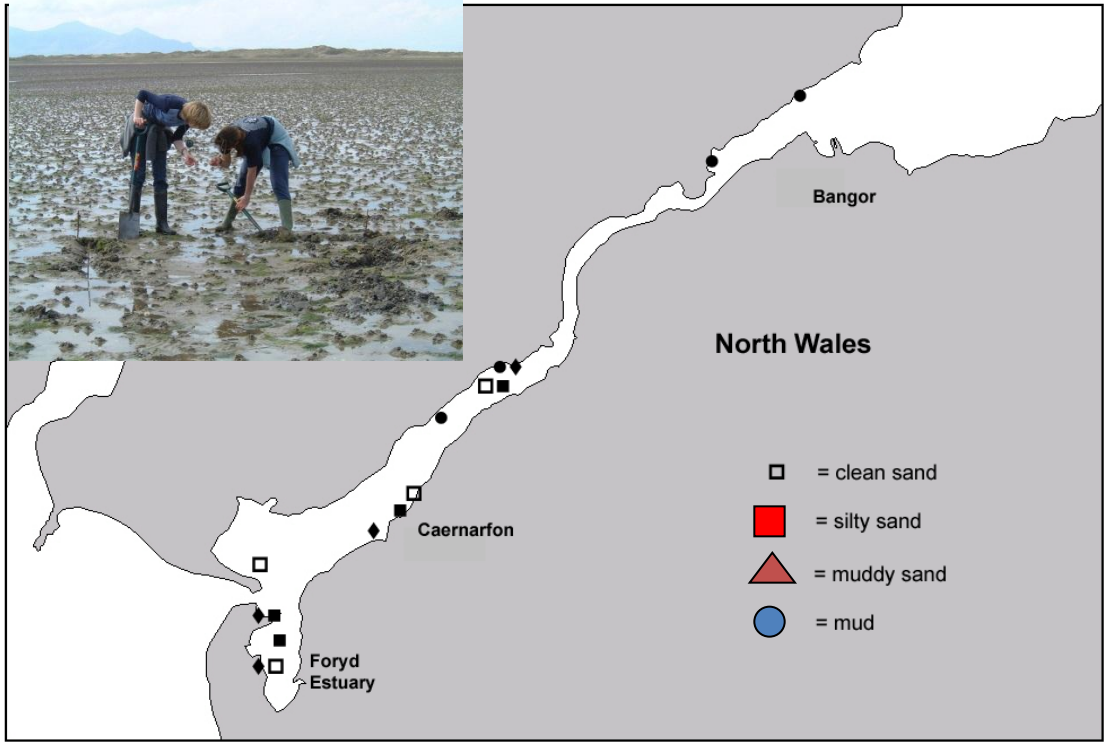

**CS – clean sand; SS – silty sand**

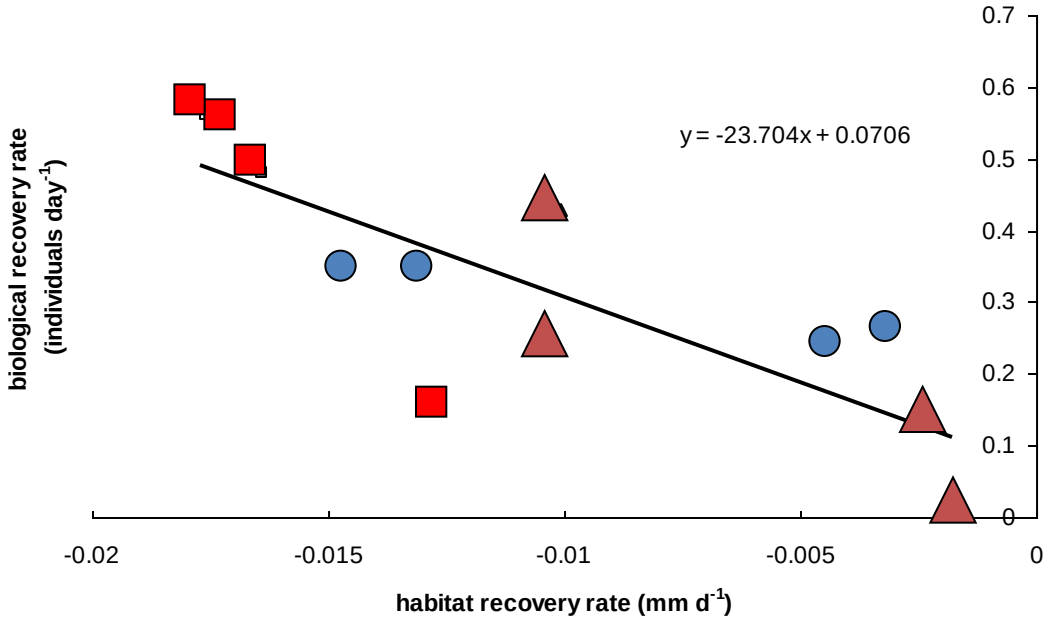
# Can we demonstrate habitat effects in the field?

Note that habitat recovery rate is the rate at which pits infilled.

Biological recovery rate is the rate at which infaunal abundance in treatment plots approached a similar level of abundance in adjacent controls.

Clean sand recovered too quickly to compute a slope




**Dernie, Kaiser & Warwick 2003 J. Anim. Ecol.**

**Large-scale comparative studies demonstrate effects at the scale of the fleet ……..**

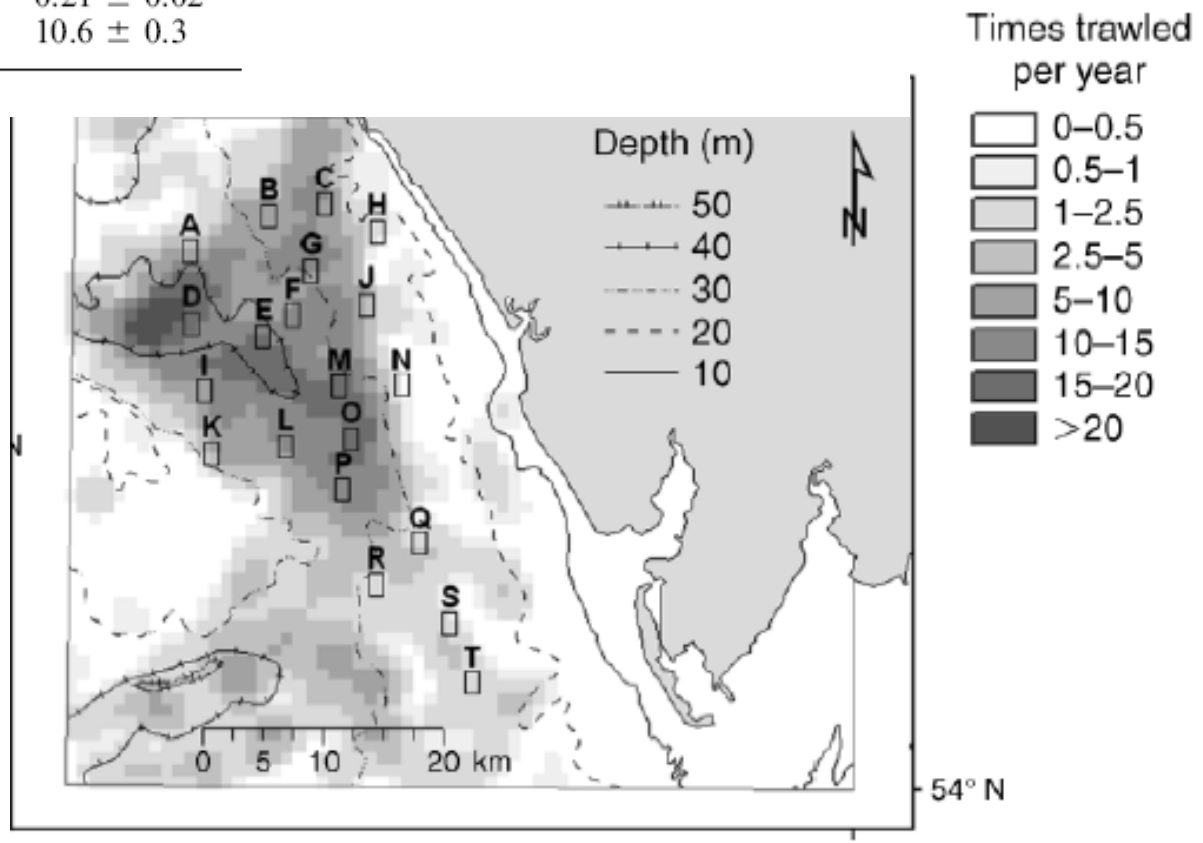
**provided they are designed with considerable care with good reference points**

# Testing model predictions in the field

TABLE 2. Summary of abiotic habitat characteristics (mean ± SD) for station groups, A, b1, and B, identified by the cluster analysis of environmental variables.

| Environmental variables | A |
|---|---|
| Depth (m) | 31 ± 6 |
| Median particle size (mm) | 0.079 ± 0.009 |
| Silt and clay content (%) | 67 ± 14 |
| Organic content (%) | 4.4 ± 2 |
| Sheer stress $N/m^2$ | 0.21 ± 0.02 |
| Near-bottom temperature (°C) | 10.6 ± 0.3 |

Hinz et al. 2008 CJFAS
Hinz et al. 2009 Ecol. Appl.



# Macrofaunal responses

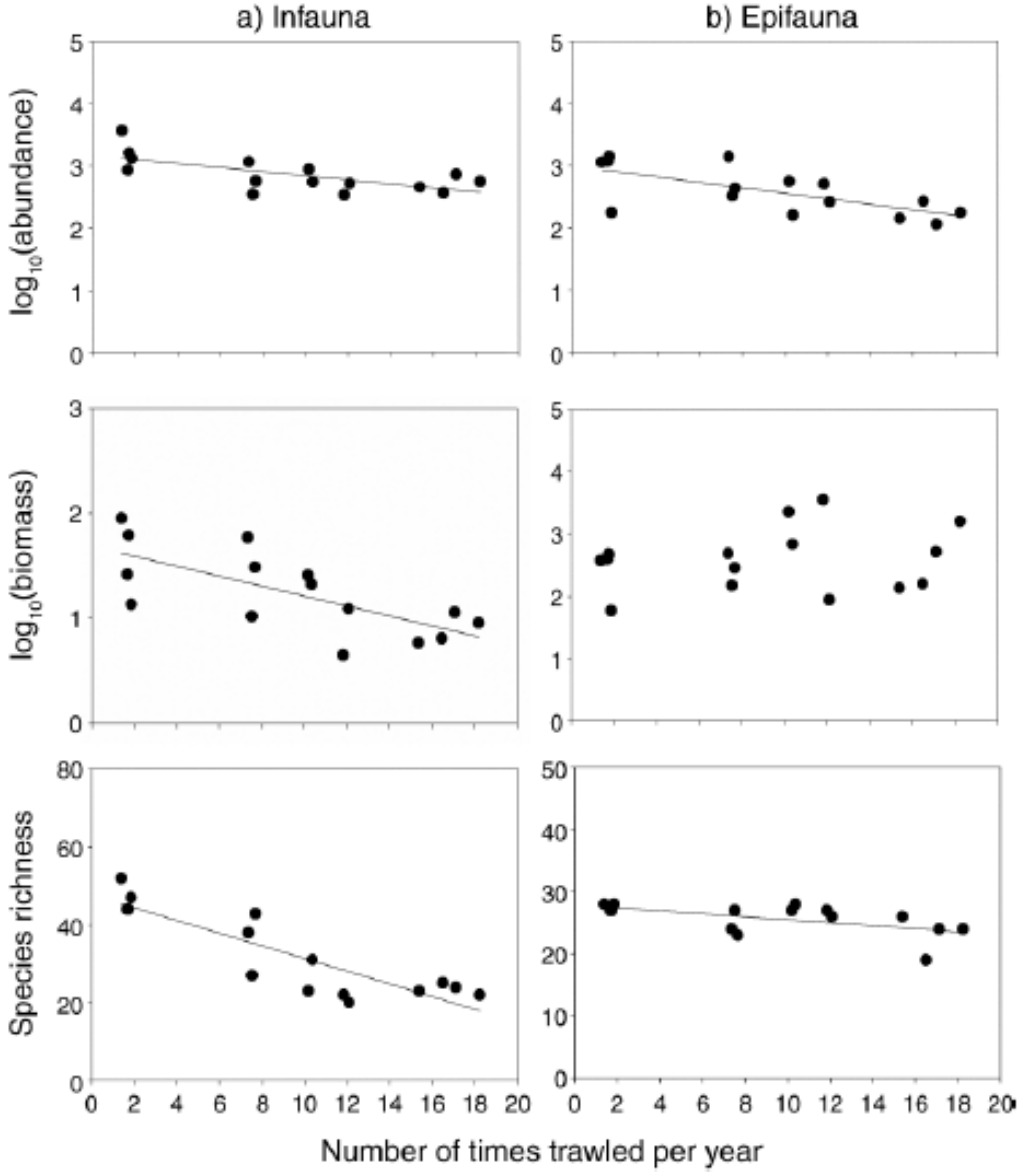



FIG. 3. Relationship of univariate community descriptors, $\log_{10}$-transformed abundance (originally measured as no./$m^2$ for infauna, and no./1000 $m^2$ for epifauna); $\log_{10}$-transformed biomass (wet mass, originally measured as g/$m^2$ for infauna, and g/1000 $m^2$ for epifauna), and species richness with fishing effort (times trawled/year) for (a) infauna and (b) epifauna over stations characterized by muddy sediments.

# Trawling impact on nematodes

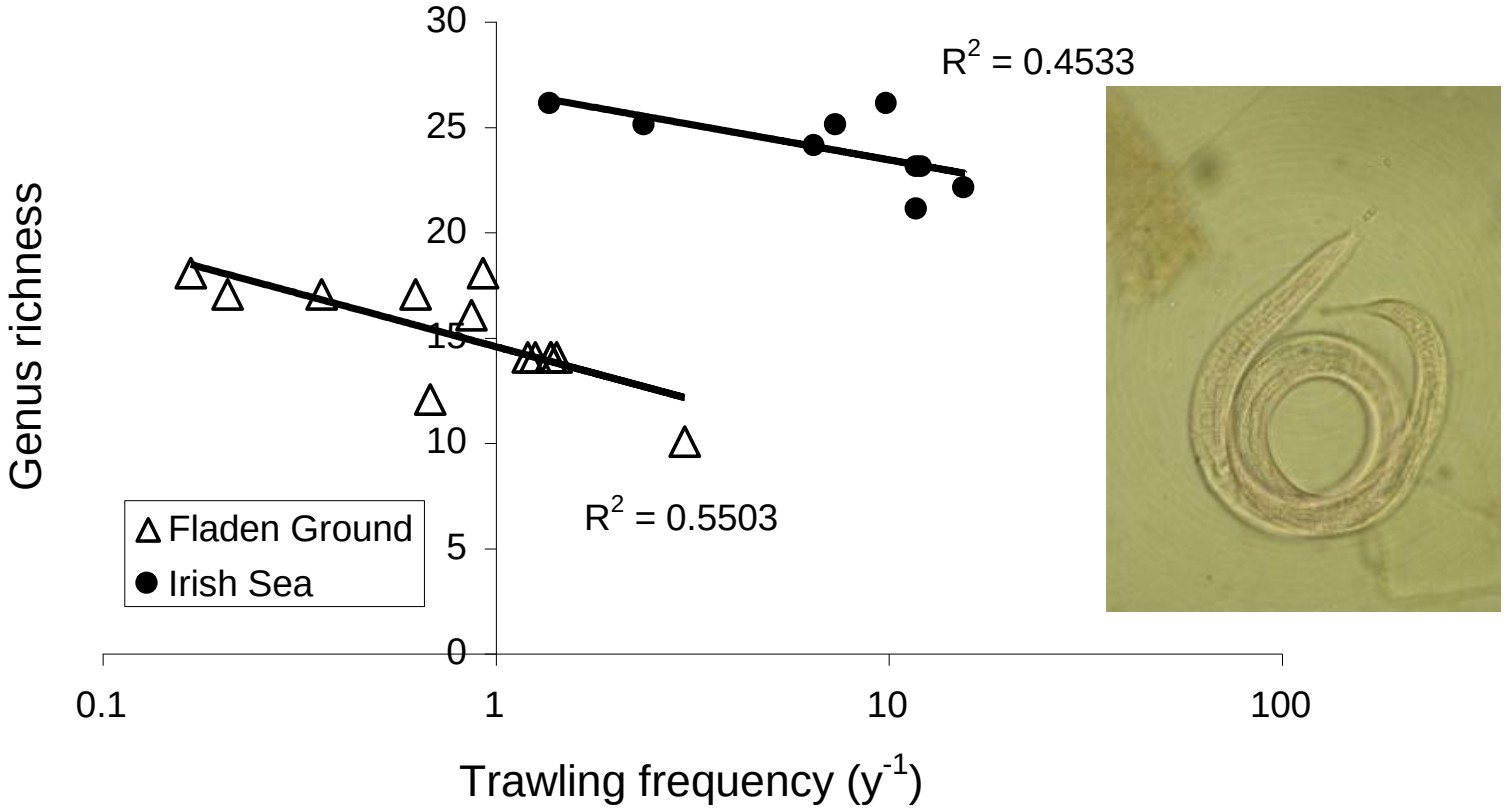



Fig. 10. The response of nematodes (inset image) in the Irish Sea (circles) and the Fladen Ground in the North Sea (triangles) which shows that diversity decreases with increasing fishing intensity.

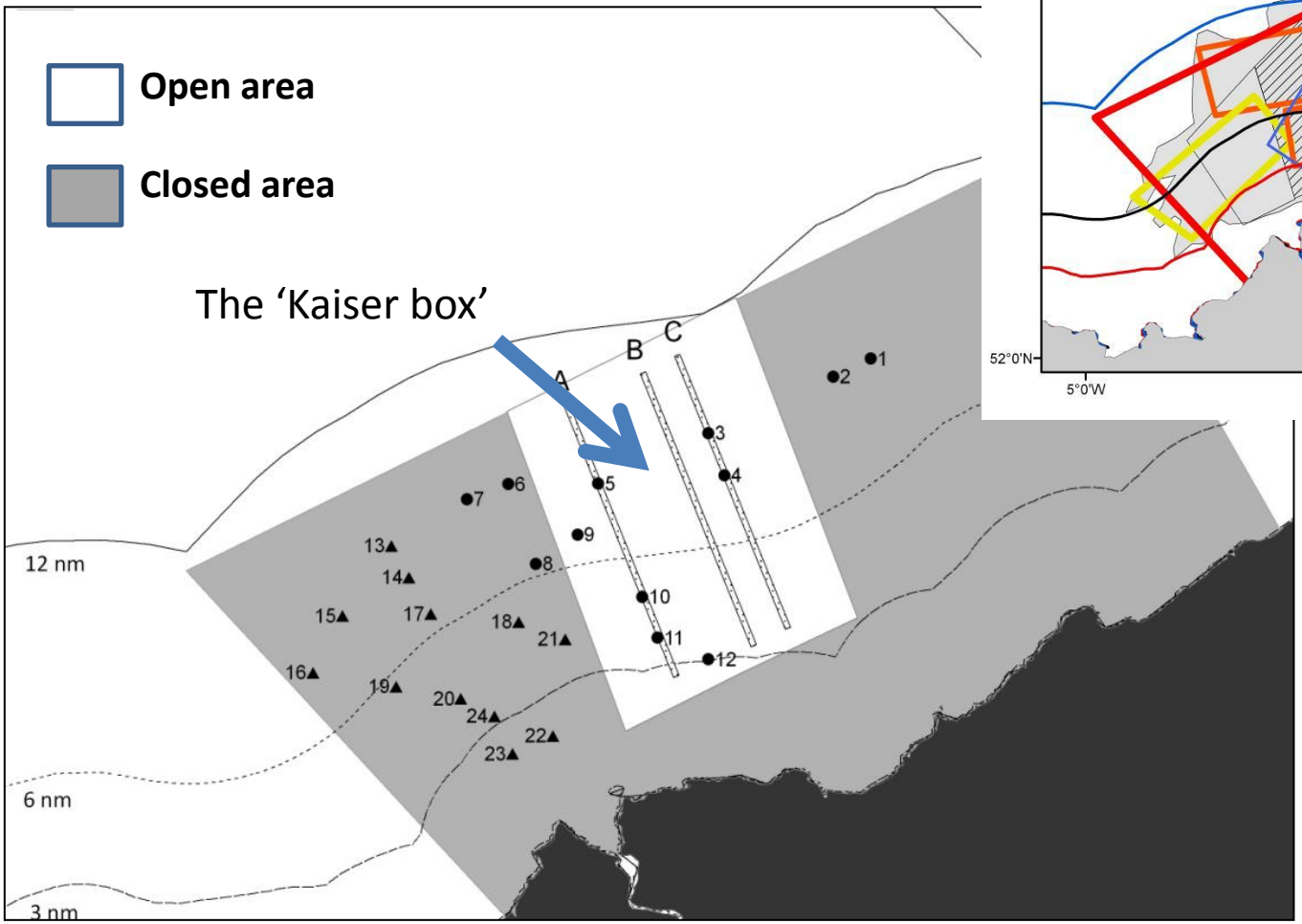
Source: Hinz *et al.* 2008

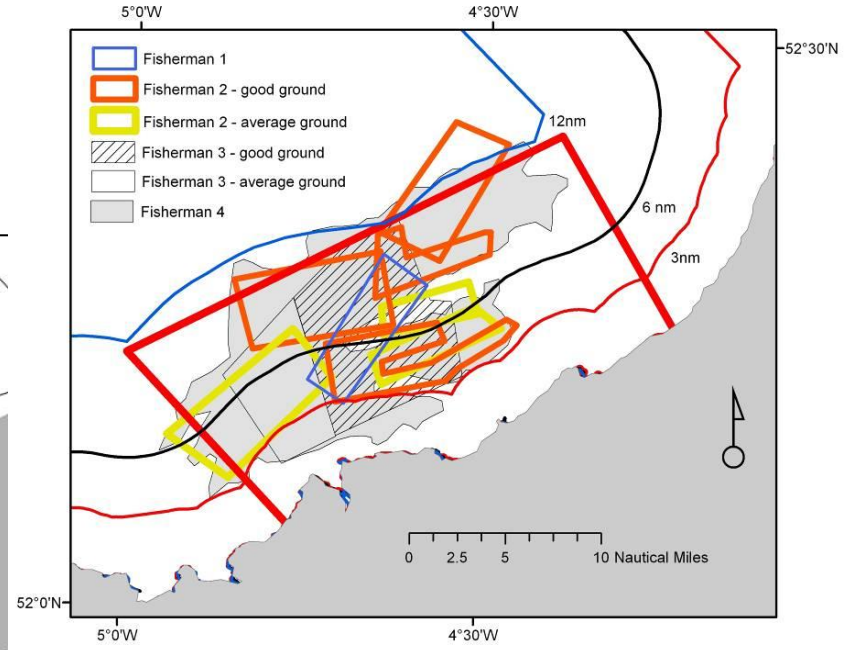
## The Godfather III dilemma

"I've done more fishing impact studies than I care to remember, the last thing we need is another fishing impact study" Michel Kaiser

"Just when I thought I was out…….they suck me back in"
Al Pacino – Godfather III

# Conservation has forced industry to work with science

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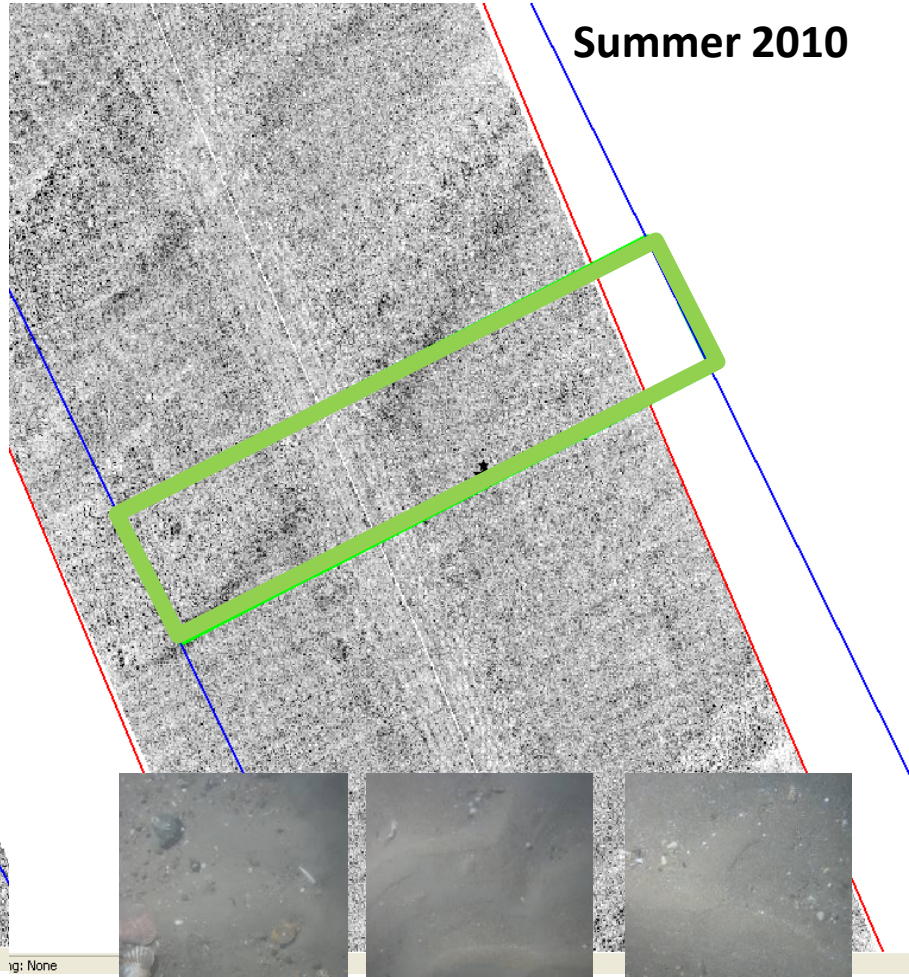




**Repeat acoustic surveys demonstrate that seabed sediments are highly mobile**

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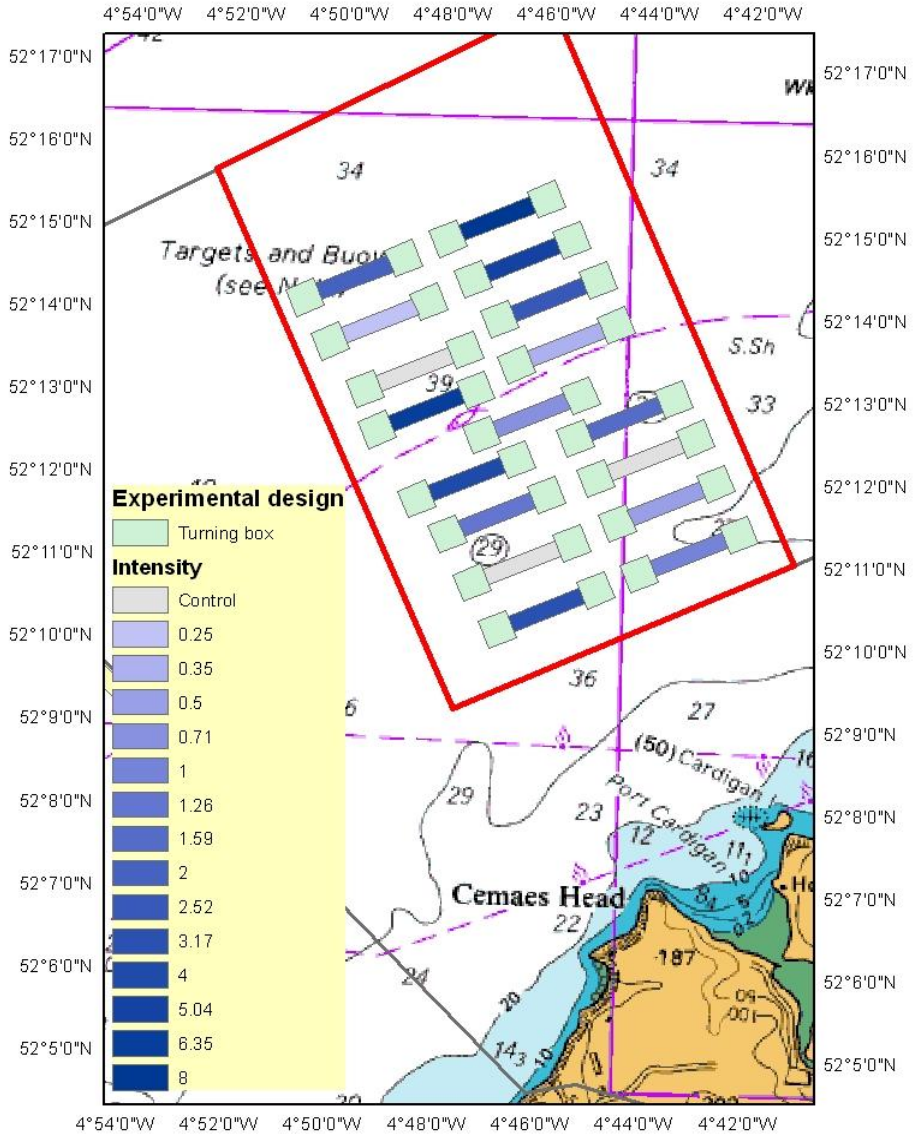
**Aberystwyth, Cardigan Bay, February 2014.**

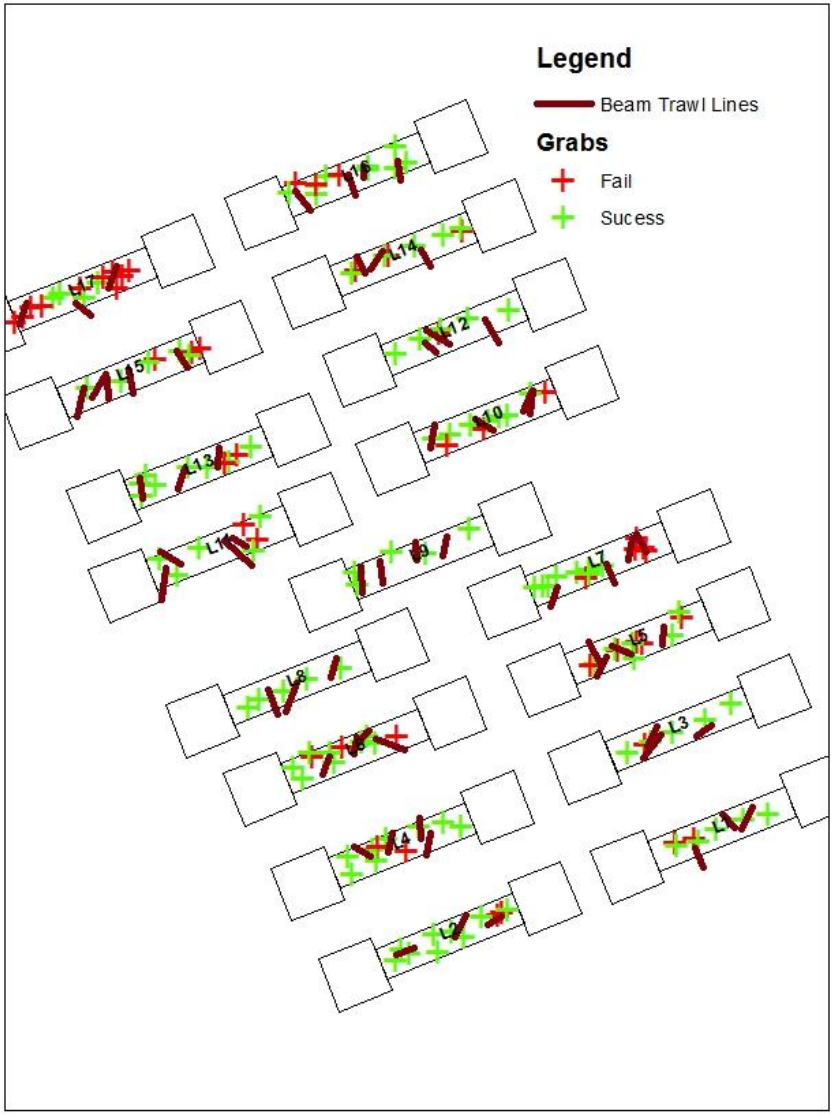
**The seabed comes to the seaside!**

# Experimental area

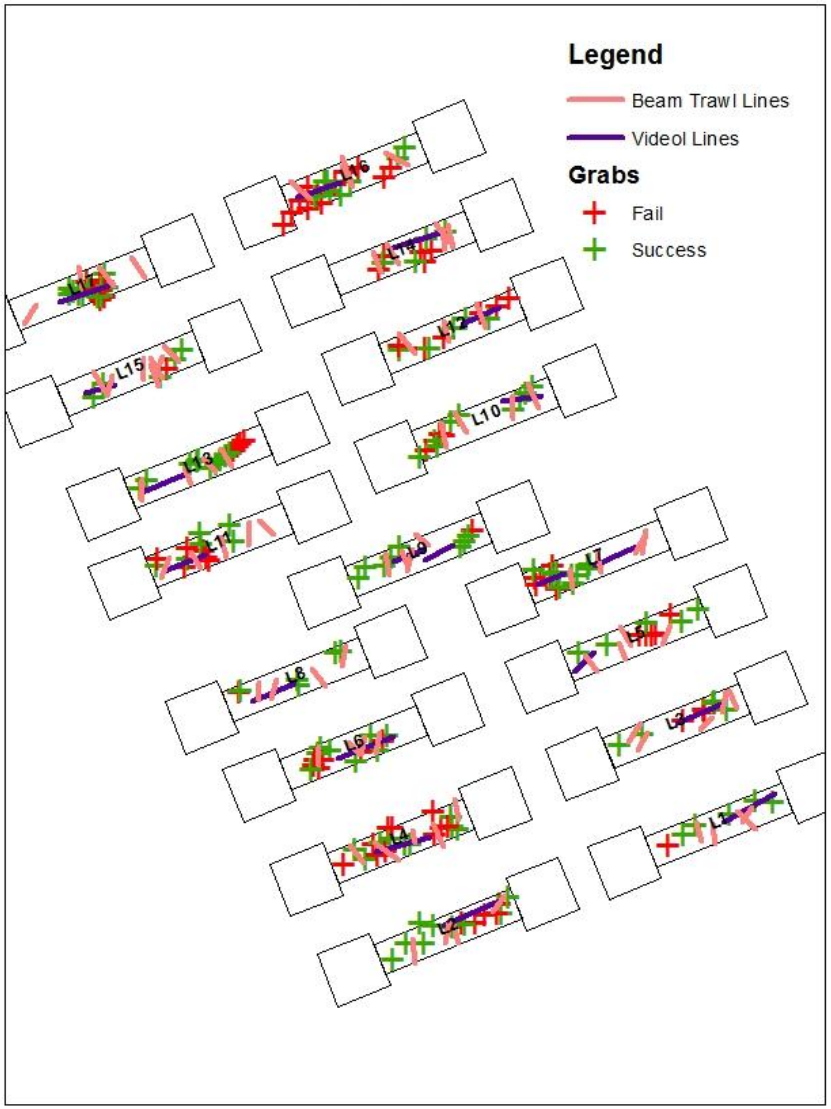


# Research vessel surveys

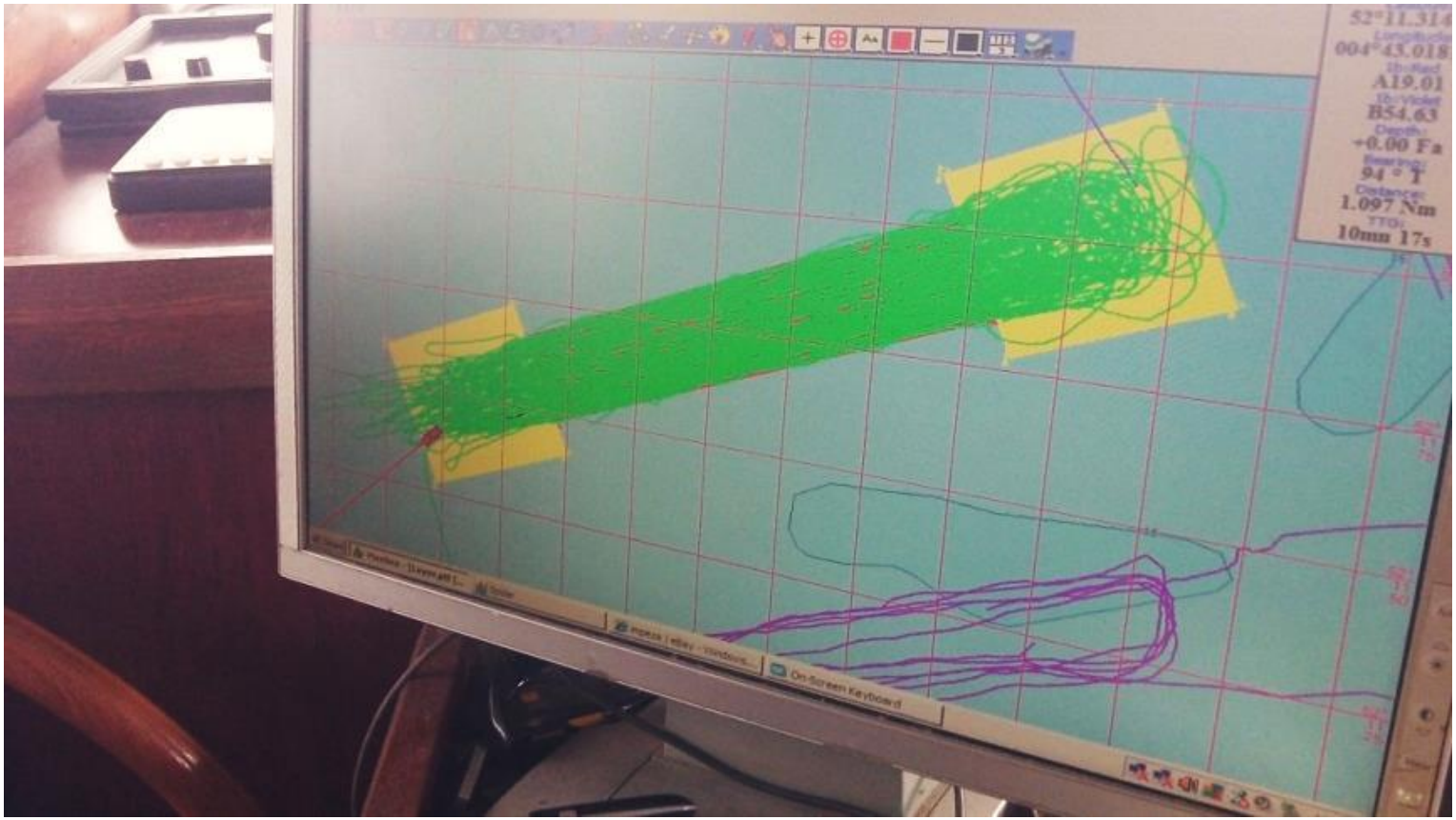
Pre experiment survey
March 2014

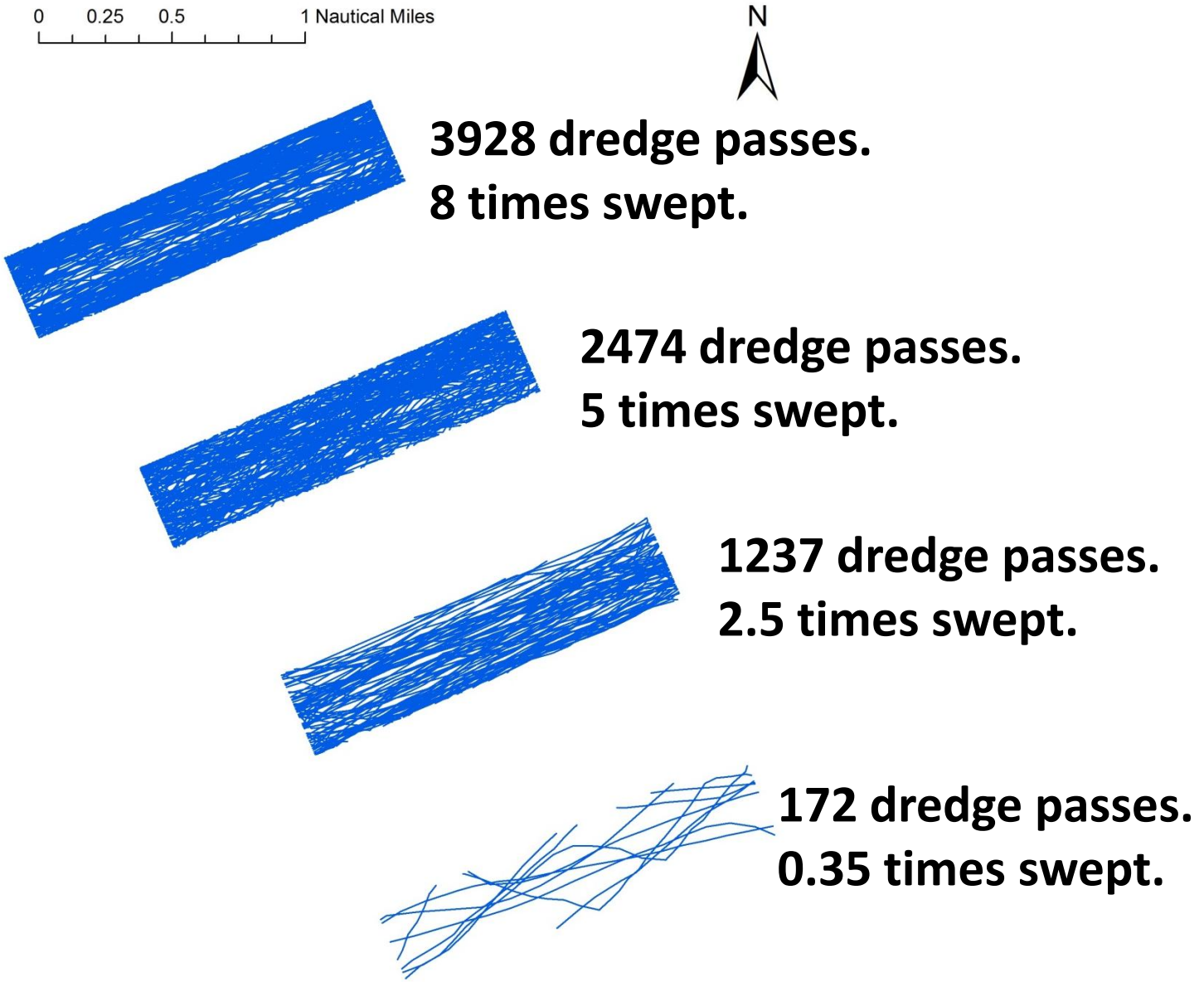



Post experiment survey
May 2014

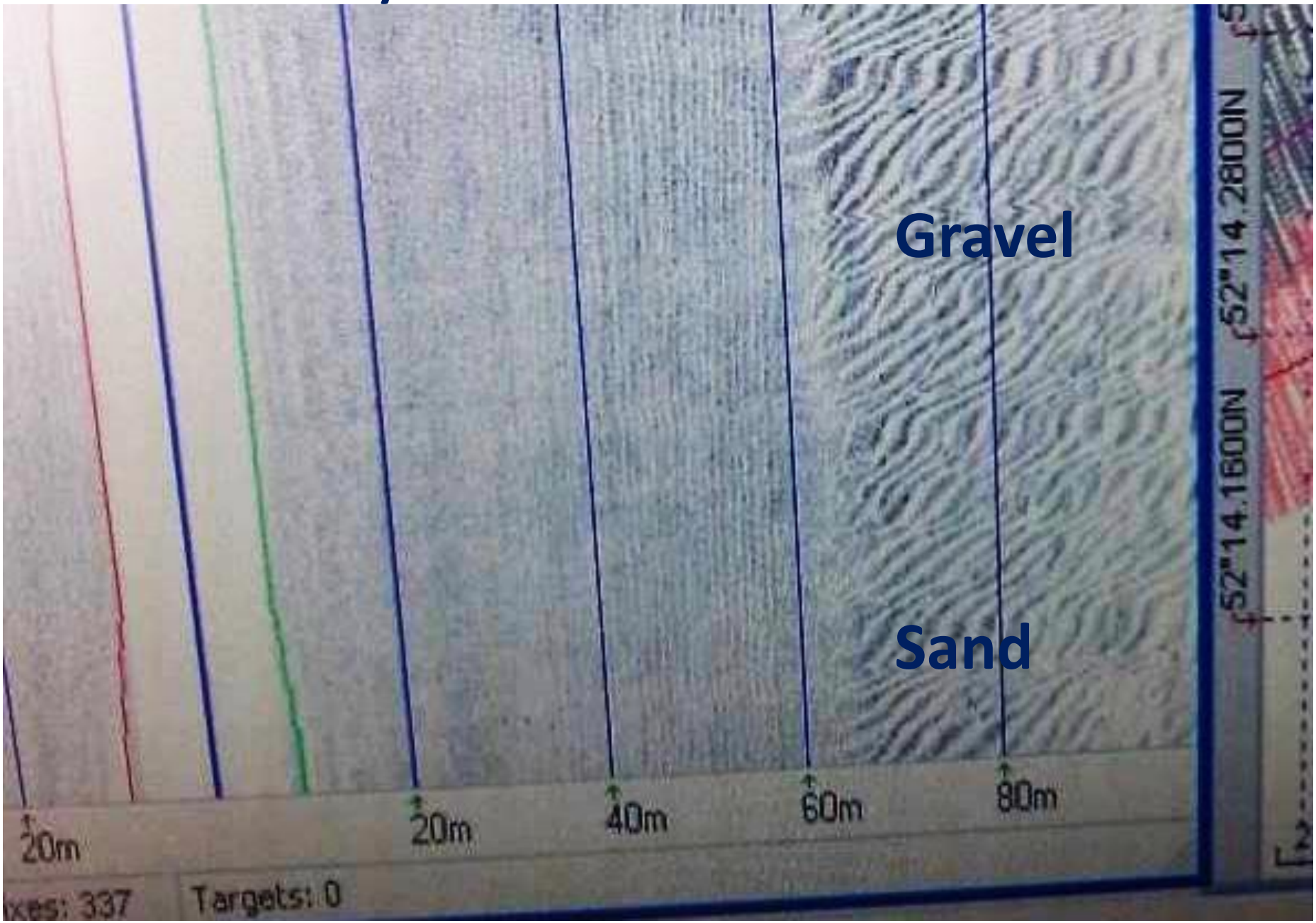


# Vessel tracks




0 0.25 0.5 1 Nautical Miles
N
3928 dredge passes.
8 times swept.
2474 dredge passes.
5 times swept.
1237 dredge passes.
2.5 times swept.
172 dredge passes.
0.35 times swept.

# All lanes surveyed with multibeam and sidescan sonar



# Scallops landed paid for the science

| | |
|---|---|
| Number of vessels participating: | 5 |
| Number of dredges used in total: | 50 |
| Number of hours fished: | 1118 |
| Number of dredge hours fished: | 12030 |
| Number of bags landed: | 7800 |
| Yield of scallop meat: | 29.6 tonnes |
| Revenue generated: | £301,963.92 |
| Fees for fishing: | £246,017.79 |
| Funds generated for science: | £55,946.13 |

# Food production

**29.6 tonnes of scallop meat**
**(fished from 880 Ha….but we could have caught more)**
**=**
**Meat yield from 123 beef cattle**
**=**
**404 Ha farm to provide necessary forage**

**plus all the fertilizers, antibiotics, loss of terrestrial biodiversity etc.**

These are preliminary figures!

# Recommendations

- Minimise footprint
- Survey hotspots for fishing
- Understand wider ecosystem processes – ‘so what’
- Biogeochemistry
- Secondary production
- Primary production