Bottom trawling impacts on the deep-sea benthic communities from the SW Portuguese continental slope (NE Atlantic)

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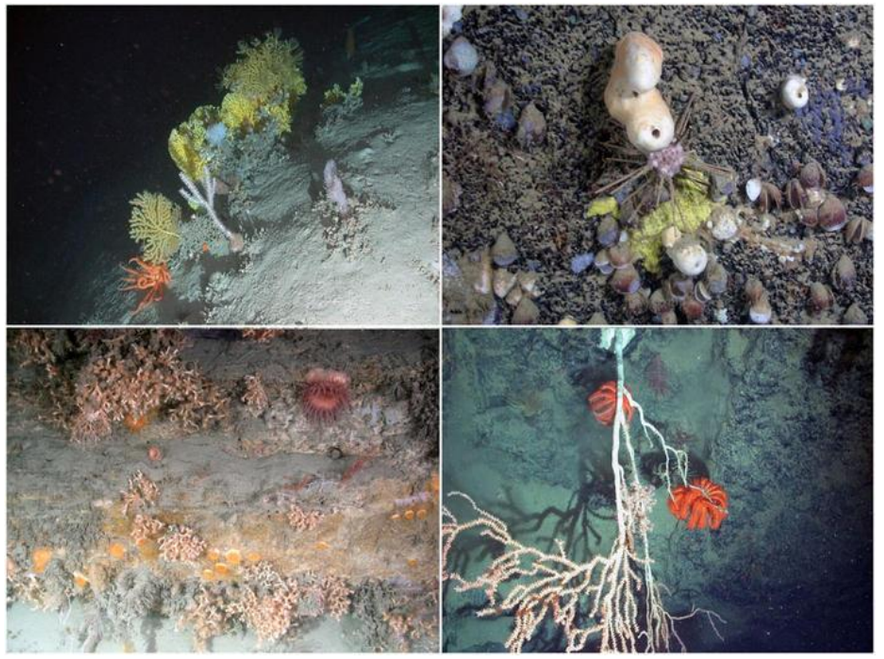
Deep-sea and human activities

- Largest single ecosystem on earth
- Supports one high levels of biodiversity (Approx. 5% explored)
- Provide essential goods and services (CO_2 sink, mineral and biological resources)



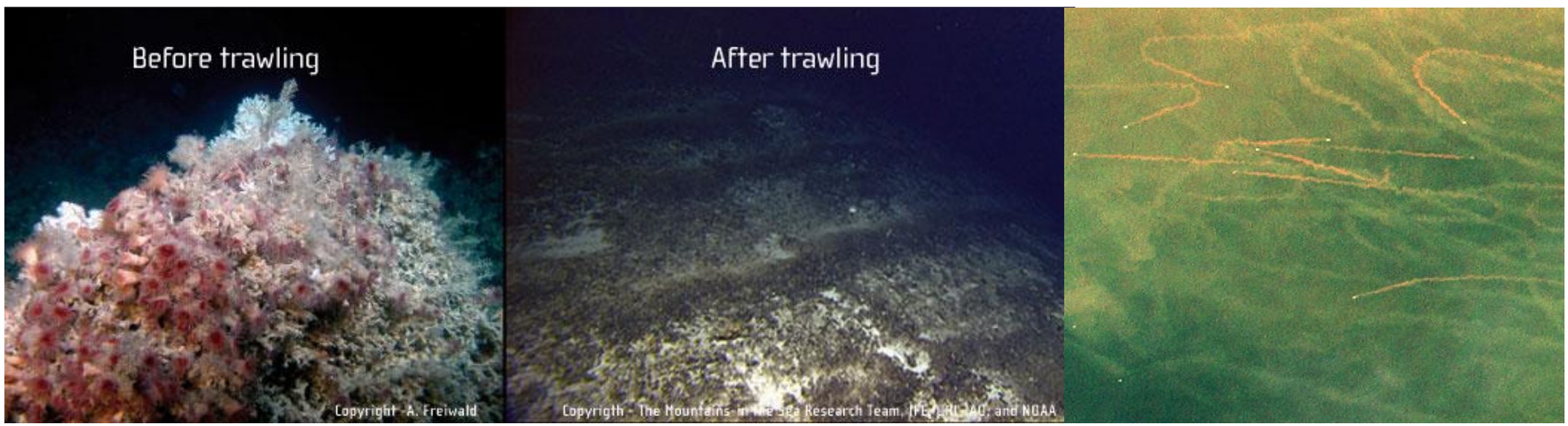
- Trawling is considered to **exploit biological resources beyond safe limits**, with nearly no global regulations (OSPAR zones), and with **major consequences to benthic communities**
- Mostly concentrated on the **upper continental slope and seamounts**

Impact assessment problems (methodologies, remoteness, variety of habitats and large spectrum of functions and services provided)

Ramirez-Llodra et al., 2011

Effects in deep-sea benthic communities

- Most knowledge arises from shallow-waters and common approaches of difficult application → Habitats with **low resilience** (K-selected life history traits)
- Few deep–sea studies showed (seamounts and cold-water corals):
  - losses in faunal **standing stocks and diversity**
  - damage/**removal of sessile habitat-forming organisms**
  - **sediment resuspension** (changes in biogeochemistry)
  - alteration of sea floor topography (e.g. submarine canyons)



e.g. Koslow et al., 2001; Fosså et al., 2002; Althaus al., 2009; Clark and Rowden, 2009; Puig et al., 2012

Effects in deep-sea benthic communities

- Mostly based on independent **results from a faunal group or subsystem** (e.g. epibenthic megafauna)
- **Larger fauna seem to be easily removed** leading to communities dominated by small-size fauna (reduction of competition and predation interactions)

Benthic fauna classification in size groups (adapted from Tyler 2003)

Group	Lower Size limit	Sampler	Representative taxa
Micro-	<63 µm	corer	Bacteria
Meio-	32 - 63 µm	corer	Nematodes, copepods
Macro-	250-500 µm	corer	Polychaetes, crustaceans
Mega-	cm	Trawls, Photographs	Fishes, echinoderms

Can we expected size dependent responses to physical disturbance?

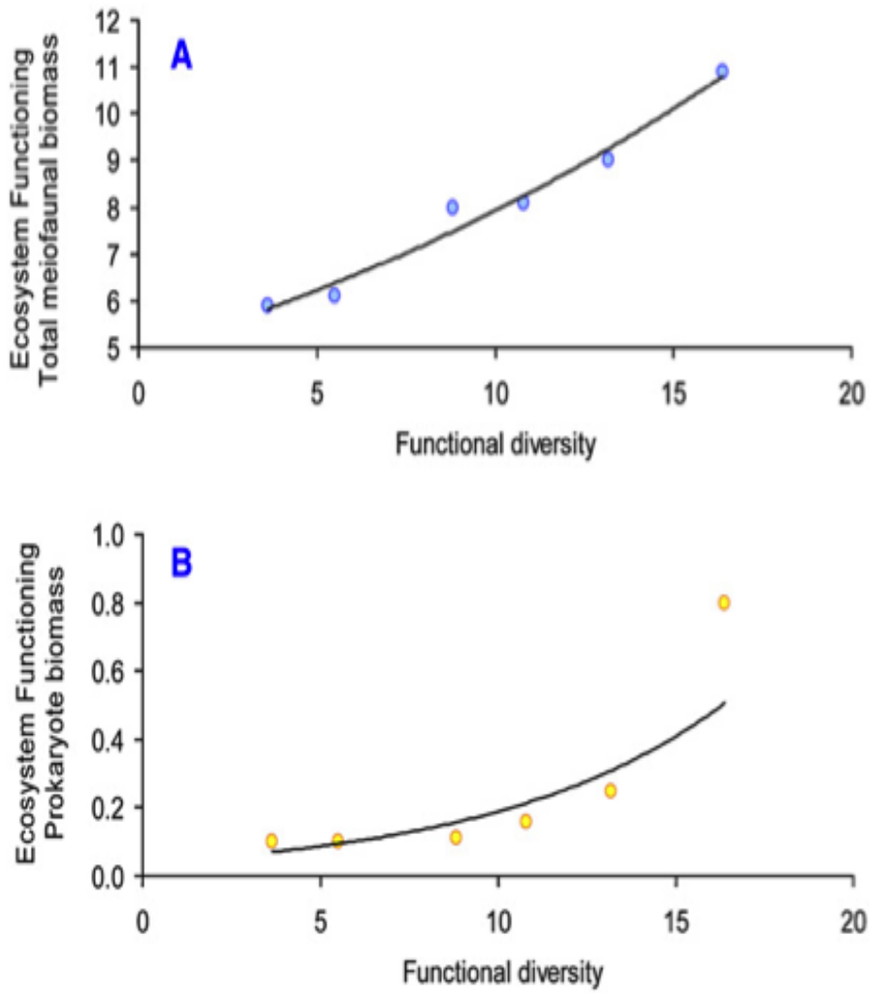
Jennings et al., 2001

Effects in the ecosystem functioning

Significance of biodiversity loss?

- **Positive biodiversity-functioning** relationship, where **loss of biodiversity** seems to **affect energy and matter fluxes** (e.g. oxygen production, nutrient cycling, burial of organic matter) and consequently the ecosystem's **efficiency and stability** (resistance and resilience)

- Macrofaunal key role in the sediment biogeochemistry
  - Promoting bioturbation and bio-irrigation to the anoxic layers

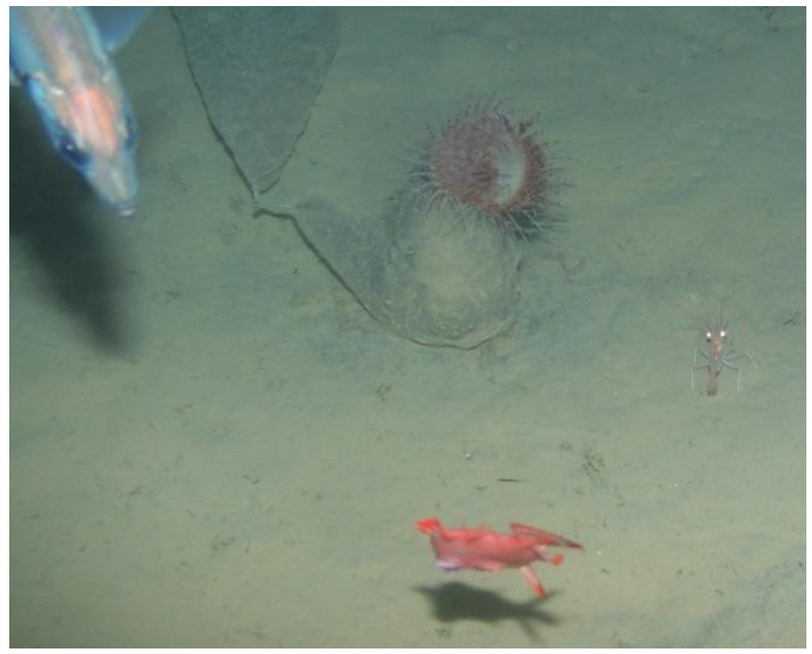


Danovaro et al., 2008; Loreau, 2008

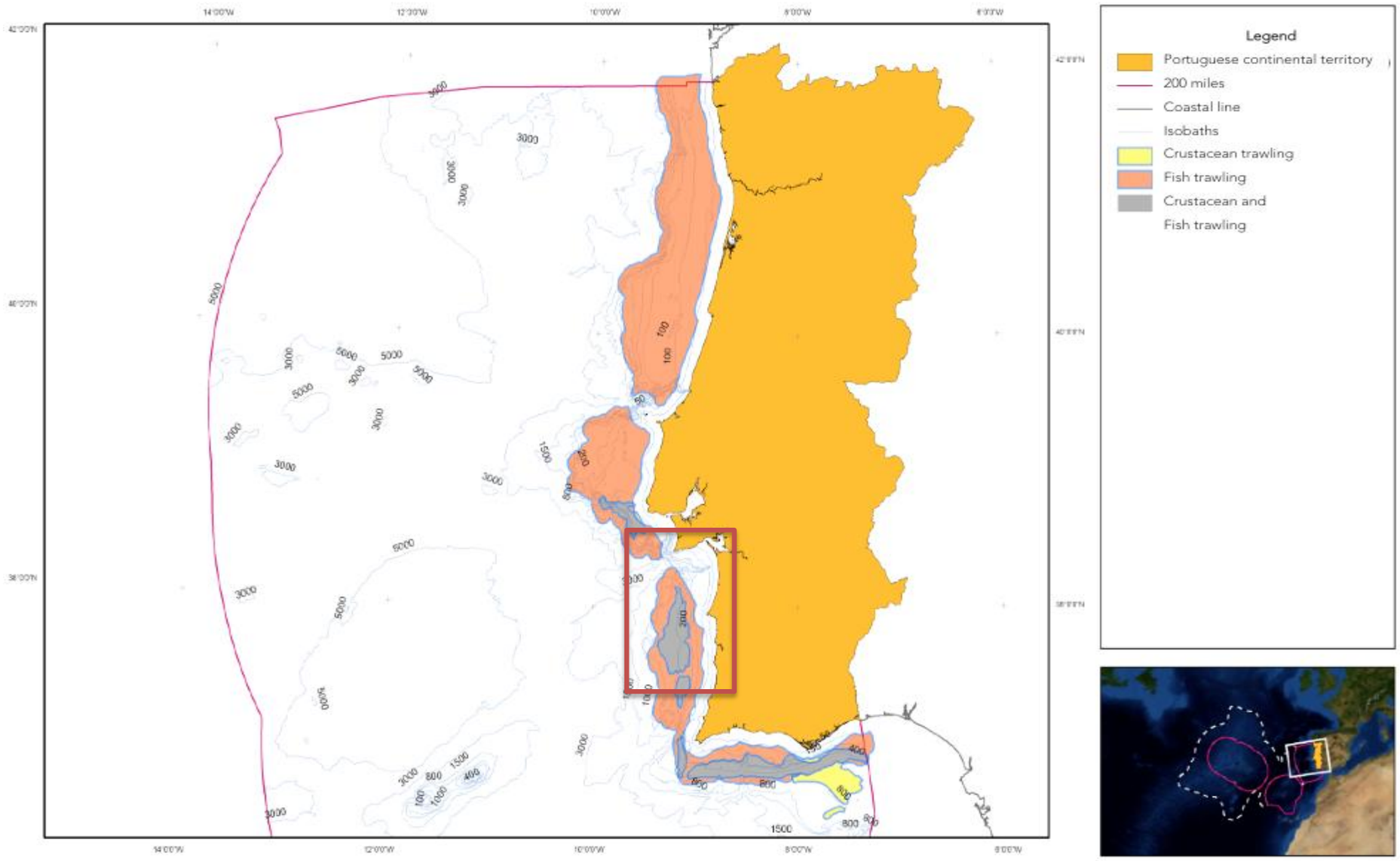
Aim

Investigate **trawling disturbance effects on the different size groups** of the deep-sea benthos **composition and diversity** in relation with **ecosystem functioning** (stock and flux of energy and material) on the continental slope





Fisheries Portuguese margin (NE Atlantic)



DGRM, 2013

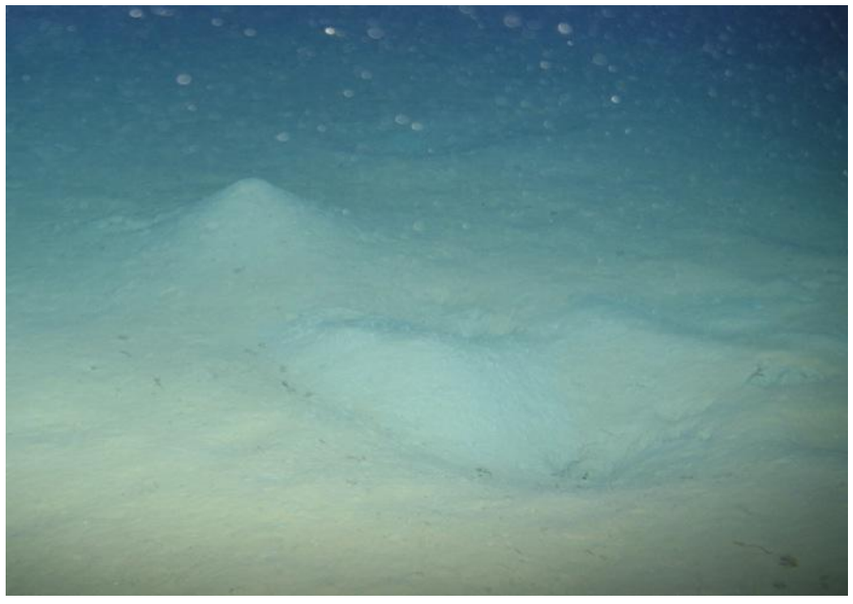
- Portaria n.o 769/2006 de 7 de Agosto, Artigo 8º:

  “Fishing with trawl gear may not be exercised within six miles of the coastline…”

Fisheries in the SW Portuguese margin (NE Atlantic)

- Bottom trawling in the SW Portugal target mostly **deep-water crustaceans** of high commercial value at 200 to 800m water depth

- High levels of by-catch and discarding (50-90%)



Norway lobster

(*Nephrops norvegicus*)

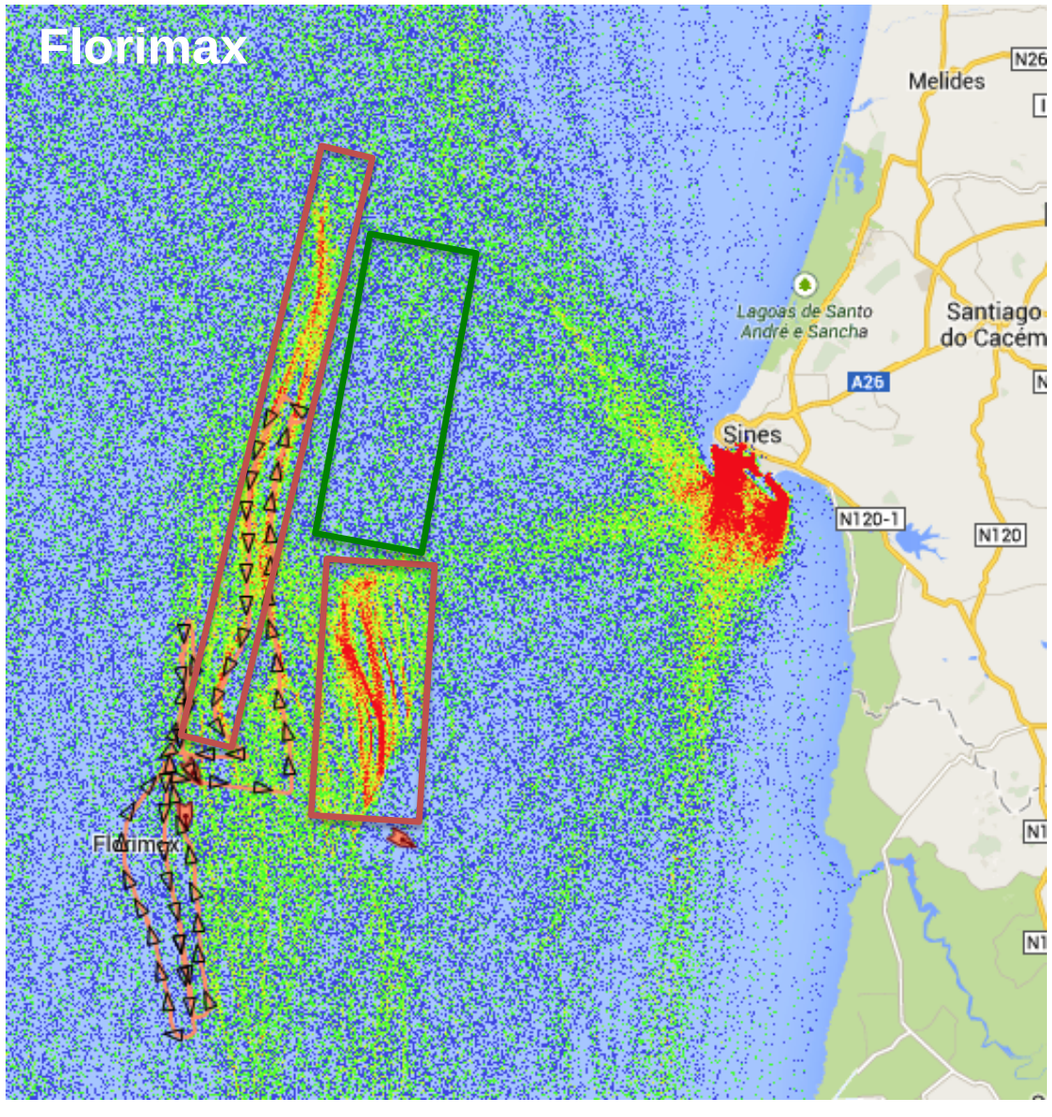
Distribution limited to muddy sediments in order to excavate burrows

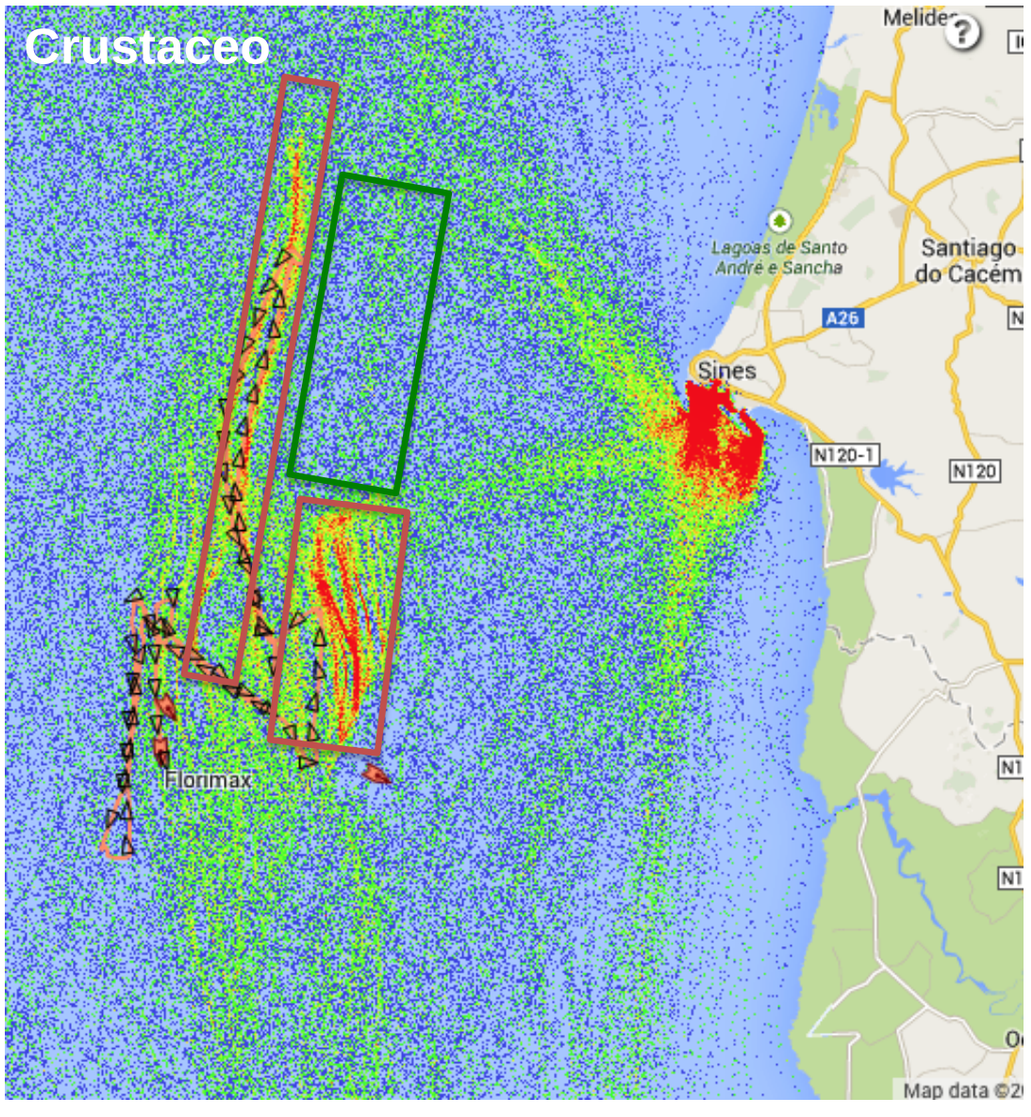
↓

Restriction of trawling areas

Erzini et al., 2003 and Leocádio et al., 2012

Fisheries in the SW Portuguese margin (NE Atlantic)

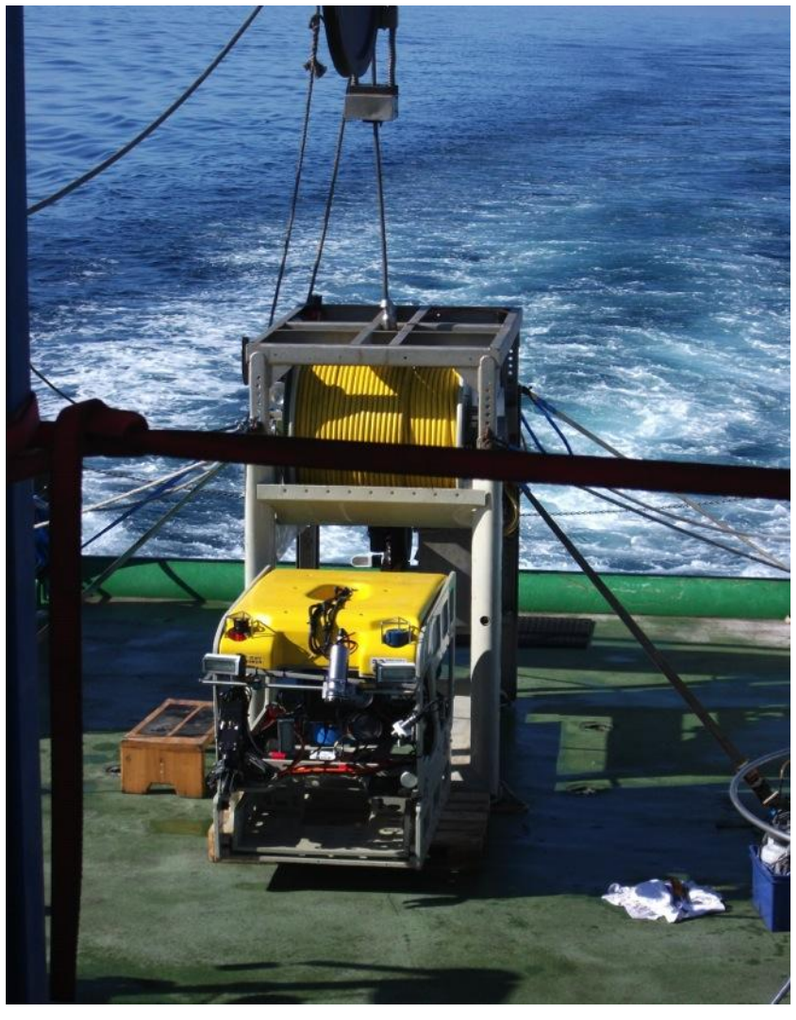


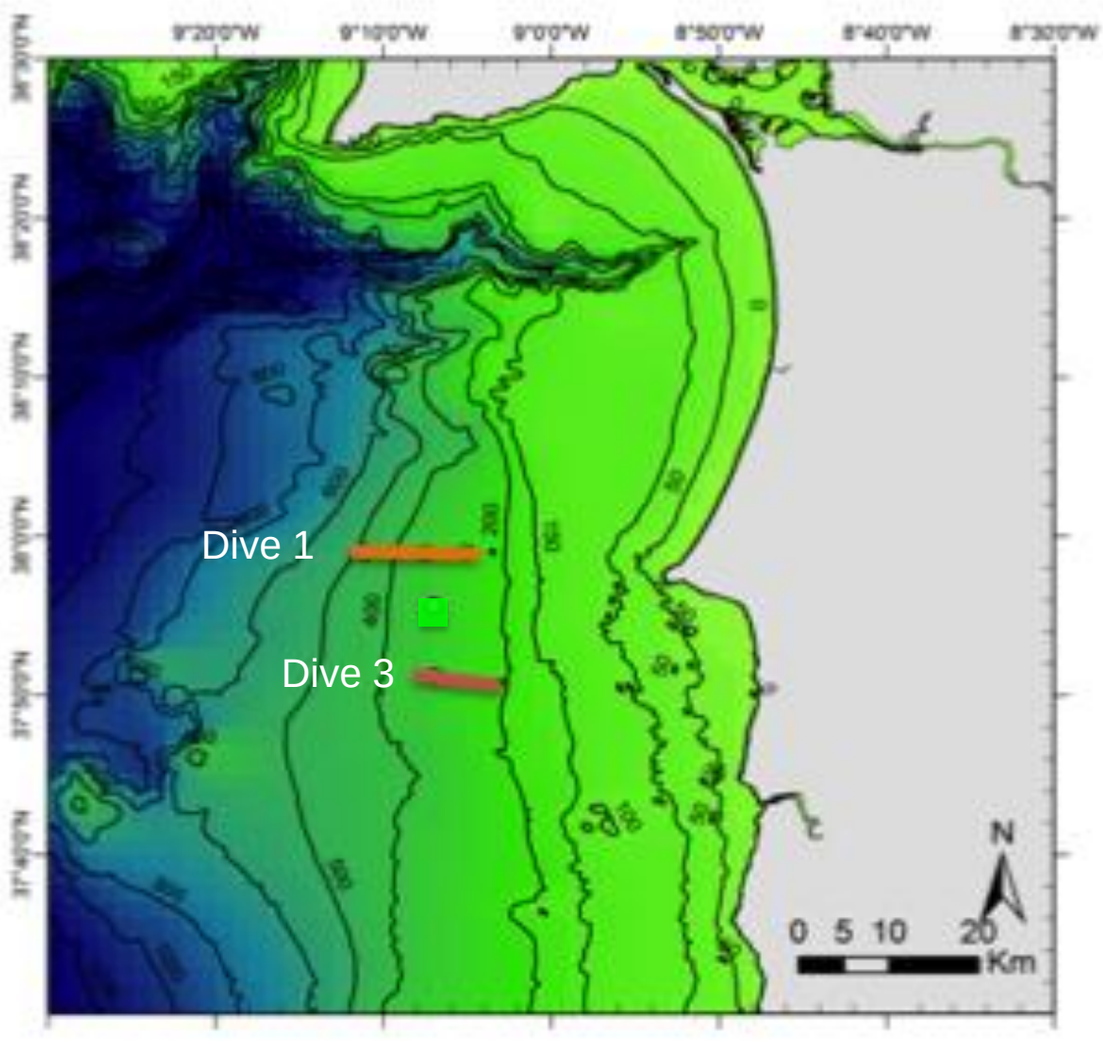


Source: https://www.marinetraffic.com

Study area and sampling design

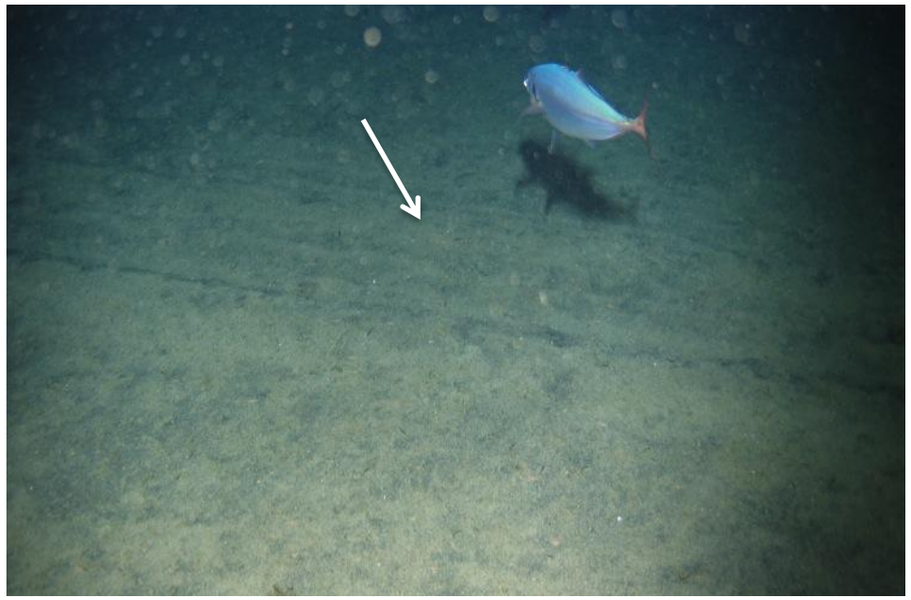
- **June 2013** - ROV survey (2 transects)
  - 500m-200m (“trawled” – “not-trawled”)
  - Video recording for megafauna analysis

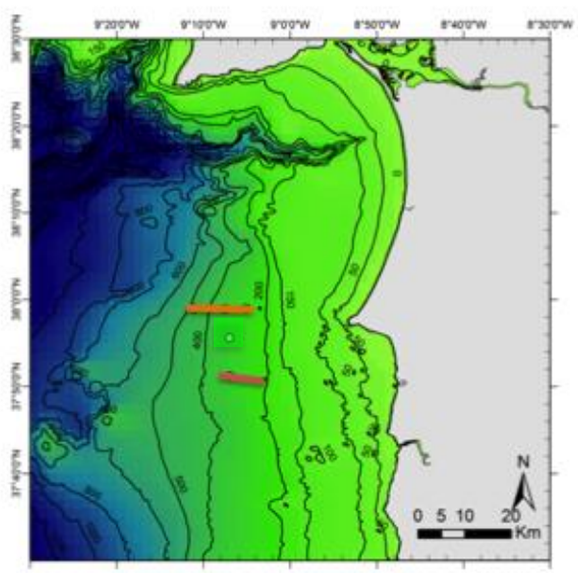


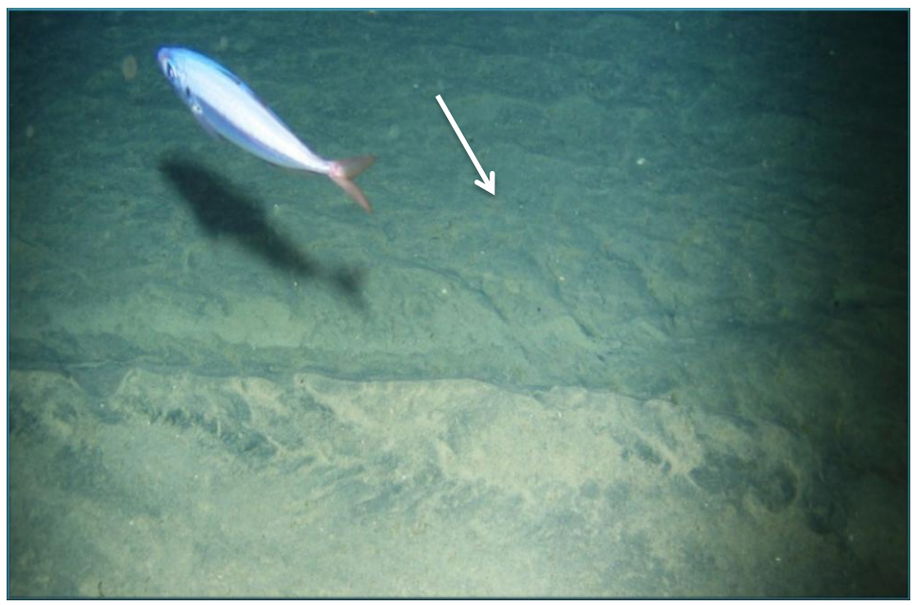


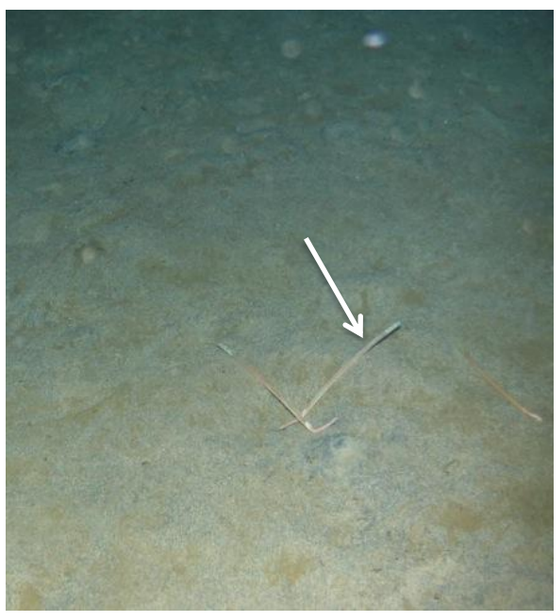
Study area and sampling design

Sampling site selection based on ROV observations





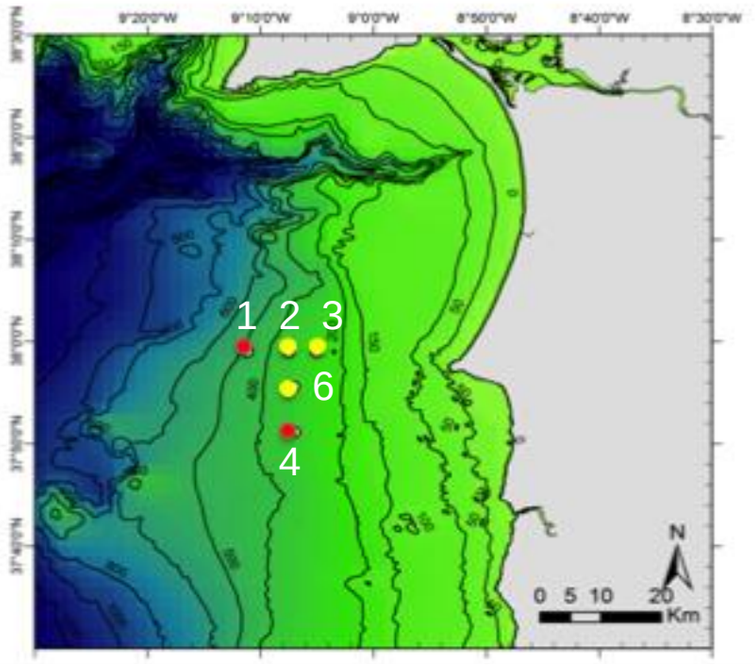




Study area and sampling design

Faunal diversity:

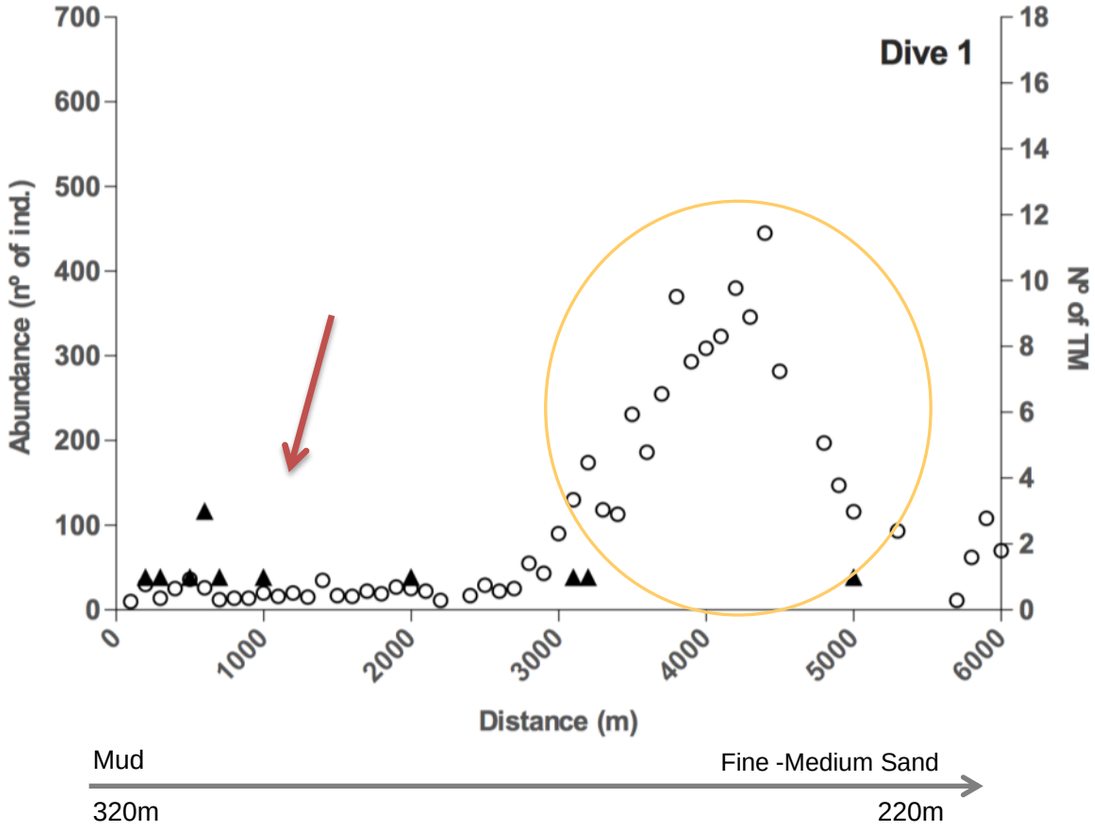
- 5 stations (2 trawled, 3 not-trawled; n=3) :
  - Environmental parameters (MUC)
  - Microfauna (MUC)
  - Meiofauna (MUC)
  - Macrofauna (Box-corer and MUC)

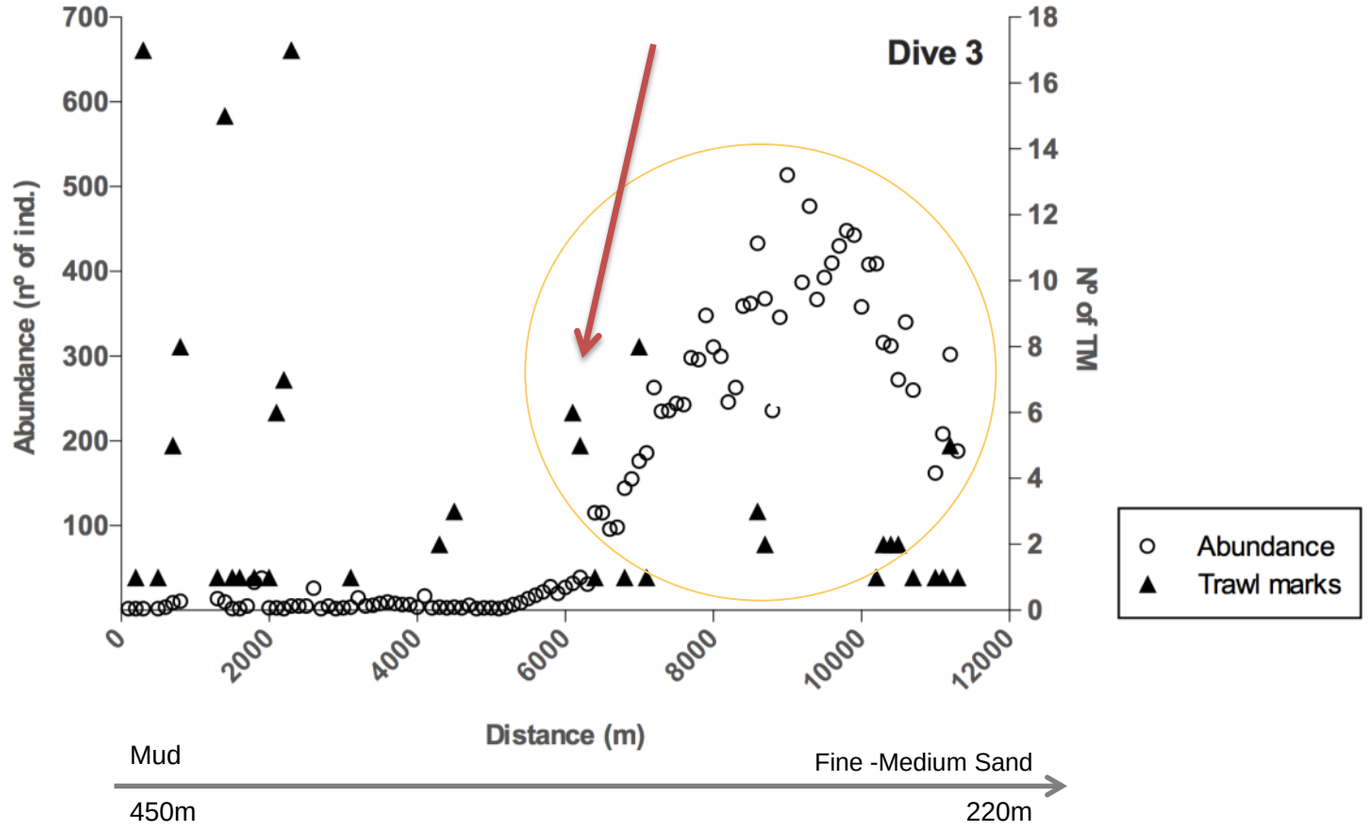


Pulse-chase experiment:

- Sediment cores (st 4 (T) and st 2 (NT))
- 24h acclimation + ^{13}C labelled algae (ca. 2.8 mg C)
- T0 (control), T3, T8 cores were processed for:
  - Bacterial biomass/production (PLFAs),
  - Bioturbation (^{13}C TOC)
  - Pore-water irrigation (Ammonia)

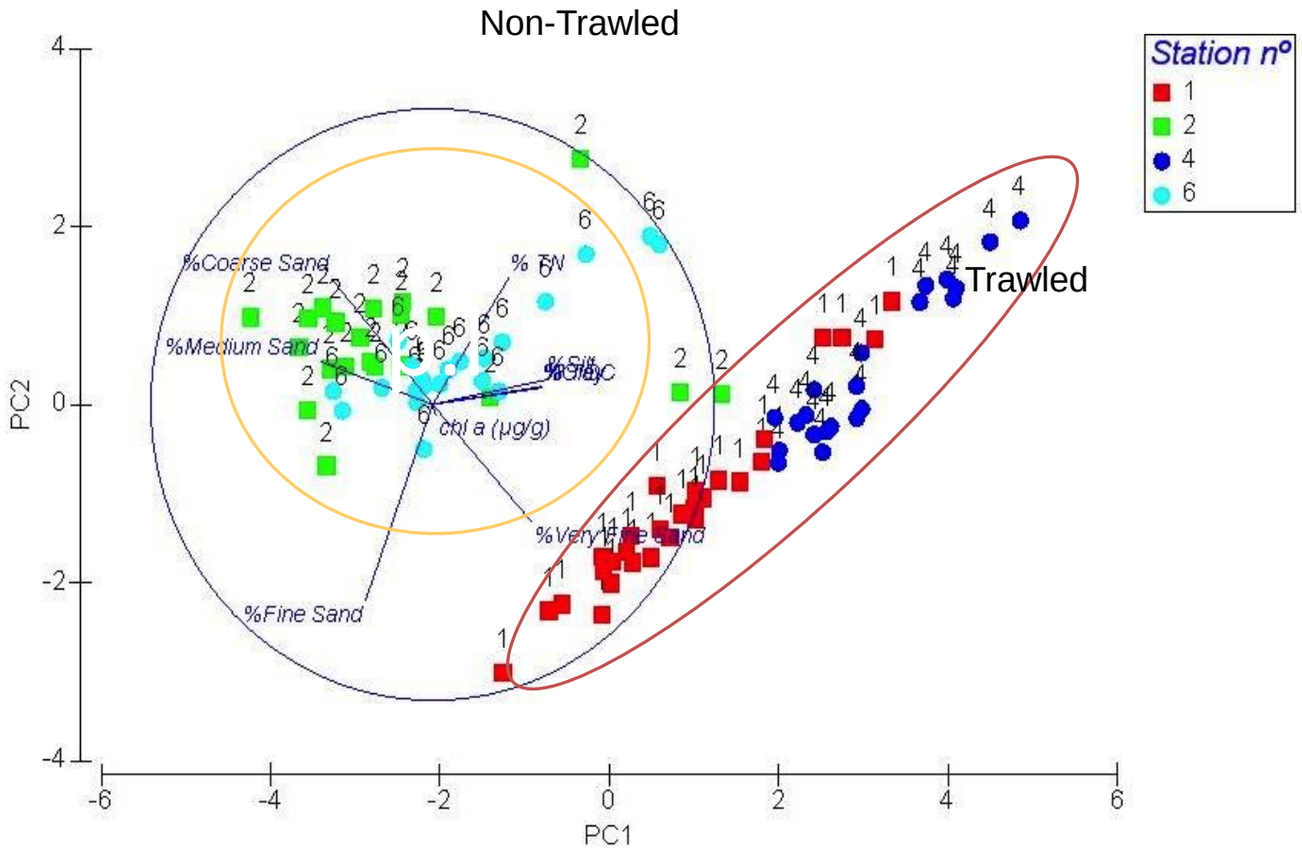
Results - Megafauna

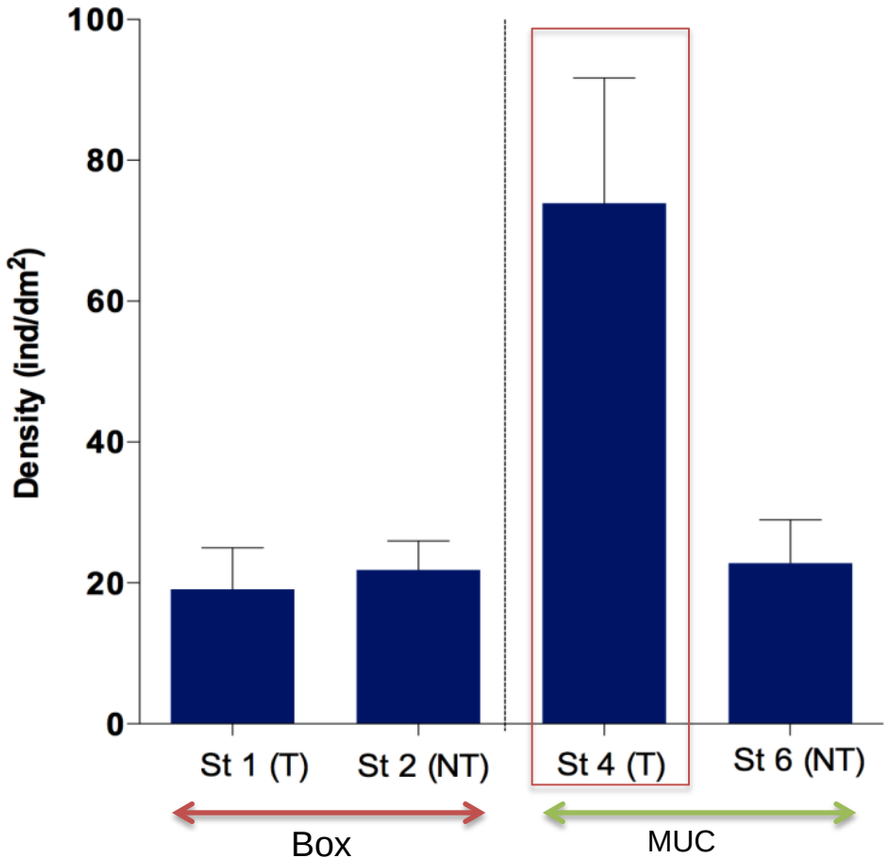




- Significant differences in composition ($p<0.001$) between high intensity trawled and low trawling intensity areas
- Onuphidae polychaetes were the main responsible

Results - Environmental and Macrofauna

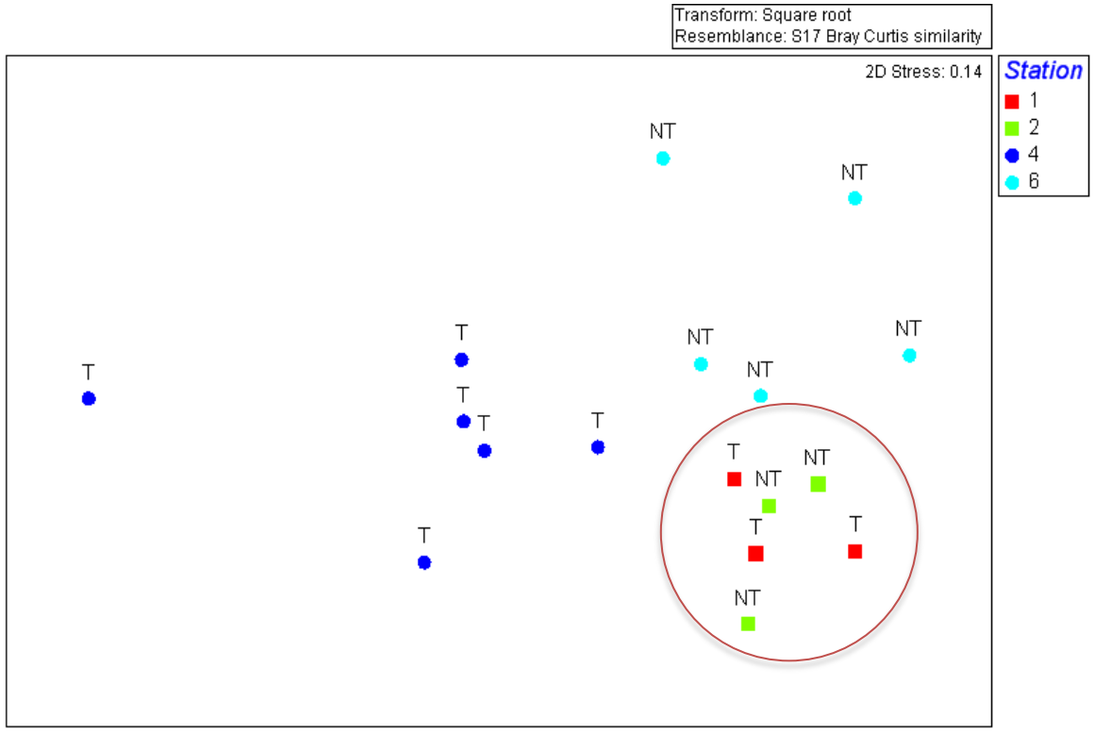


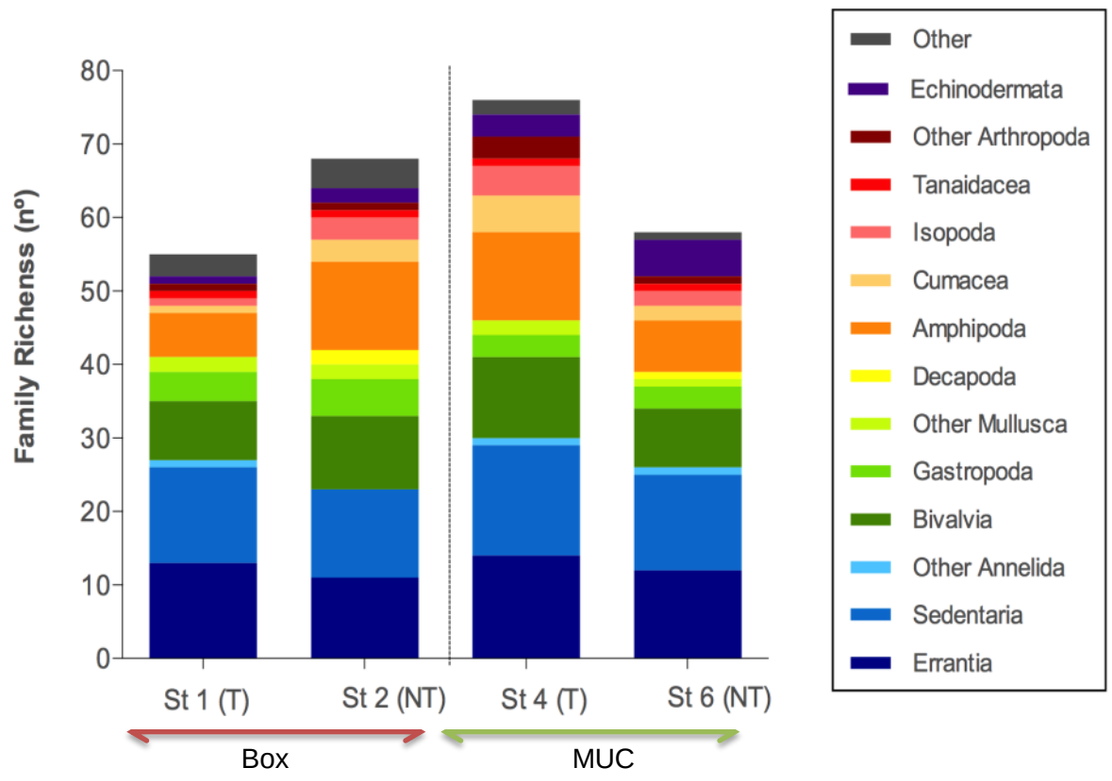


- Grain size main driver for the impact separation:
  - T - mainly muddy sediments
  - NT - Fine-coarse sand

- Inverse pattern between T and NT stations considering the sampling method
- St4 (T) - natural high densities?

Results – Macrofauna

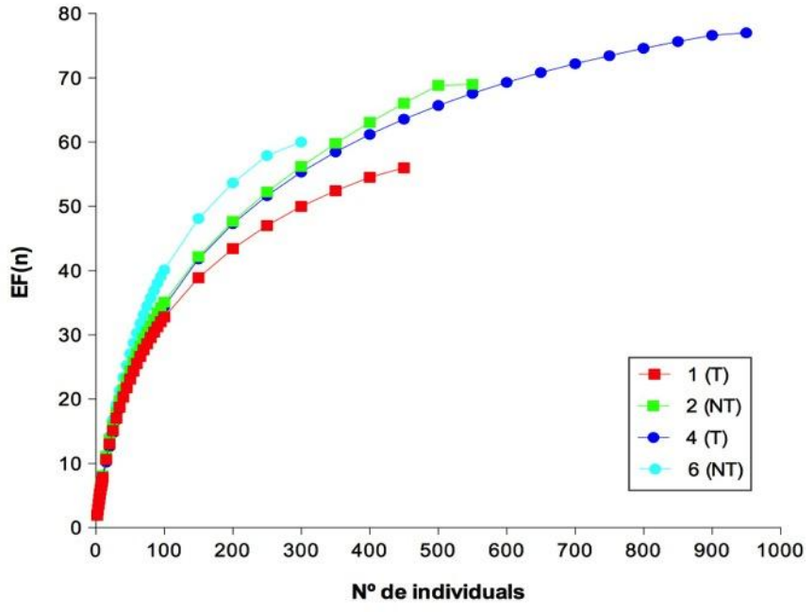




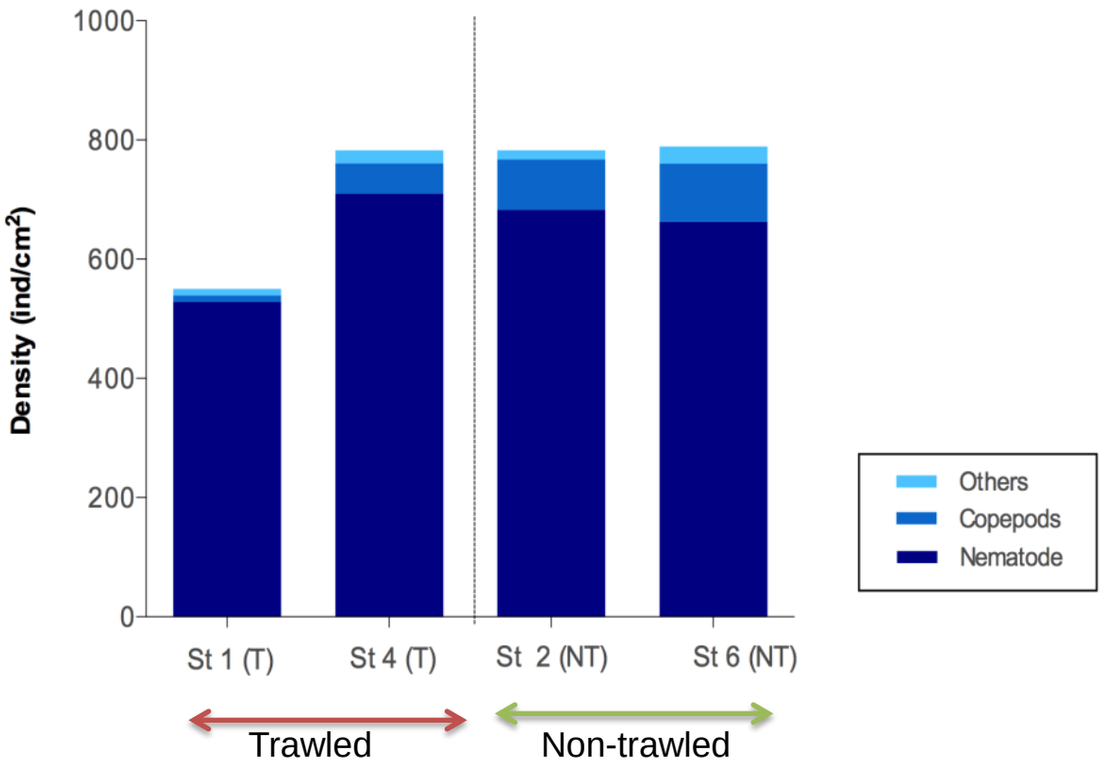
- ANOSIM showed significant differences between trawled and not-trawled stations (Global R: 0.26; p= 0.011) at the family level

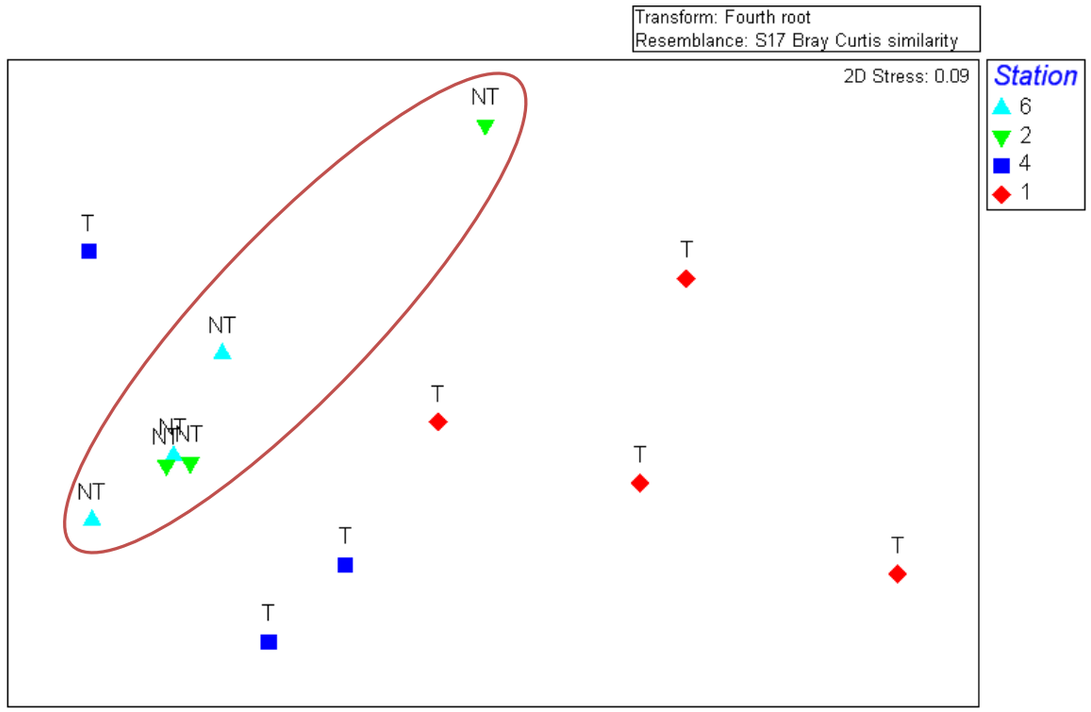
Do we have a sampler effect (Box or MUC)?

Do we have lack of taxonomic resolution?



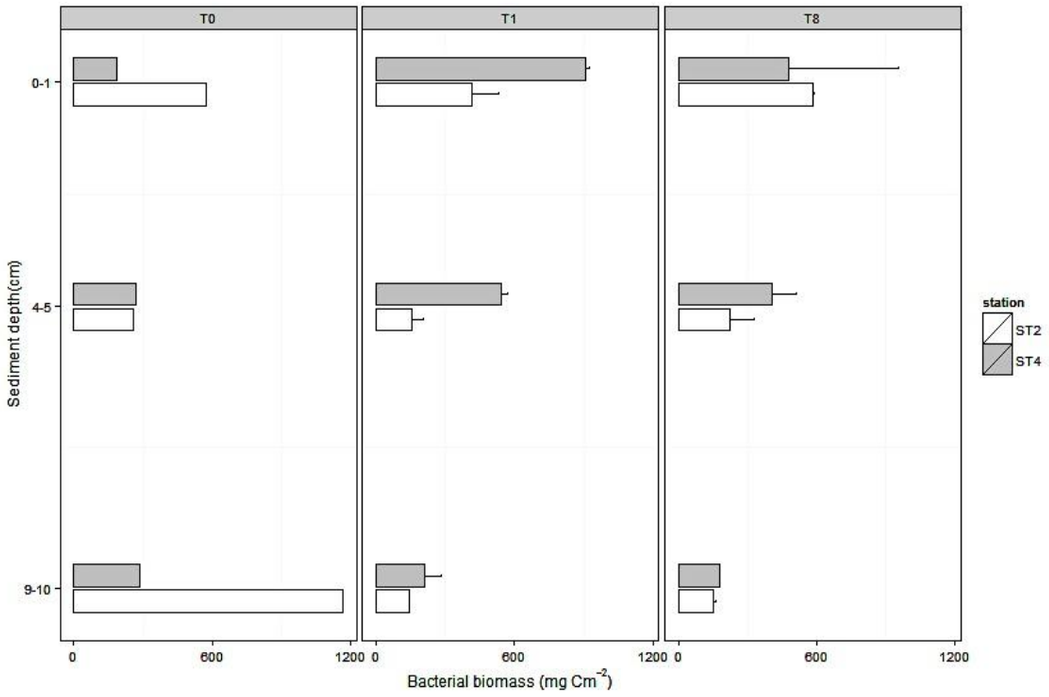
Results - Meiofauna

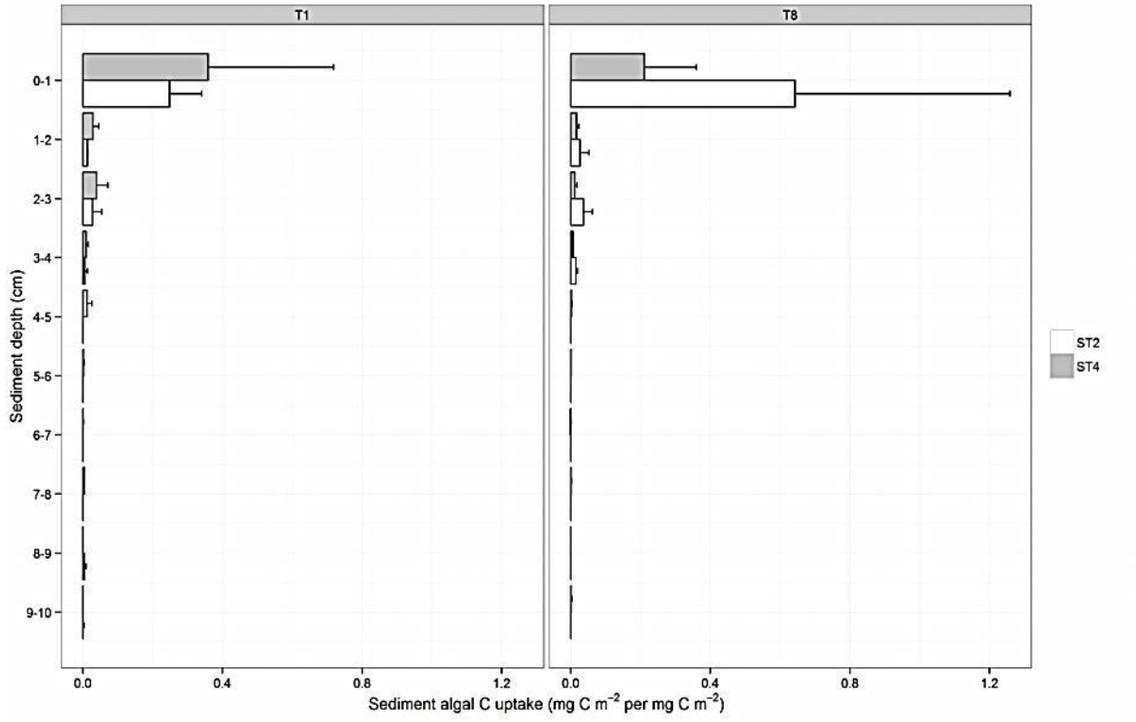




There were **no significant differences in the abundances** between impacted and non impacted stations, however **community composition showed significant differences** (Global R: 0.168; p=0.043)

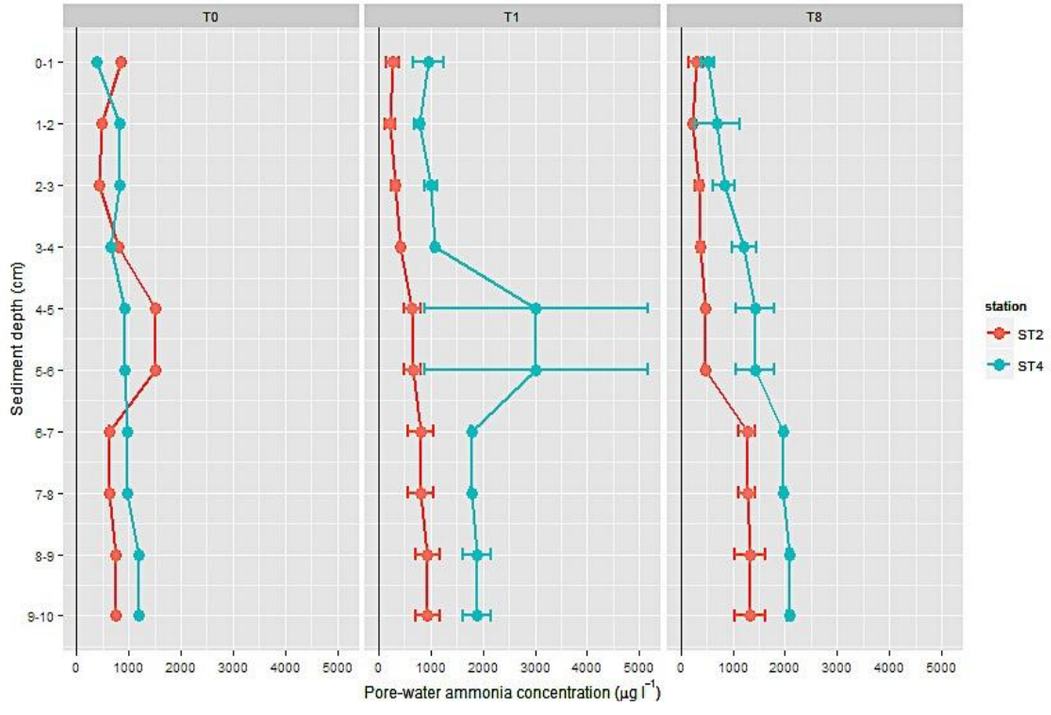
Results - Pulse-chase experiment





- Absence of a negative effect on bacterial biomass/production → TOC ca. 1.5x at St 4 (T)
- St 2 showed higher bioturbation (8 days)
- Pore-water irrigation seemed to **differ significantly**, with highest irrigation in St2 (NT).

Highly variable results due to the reduced number of replicates



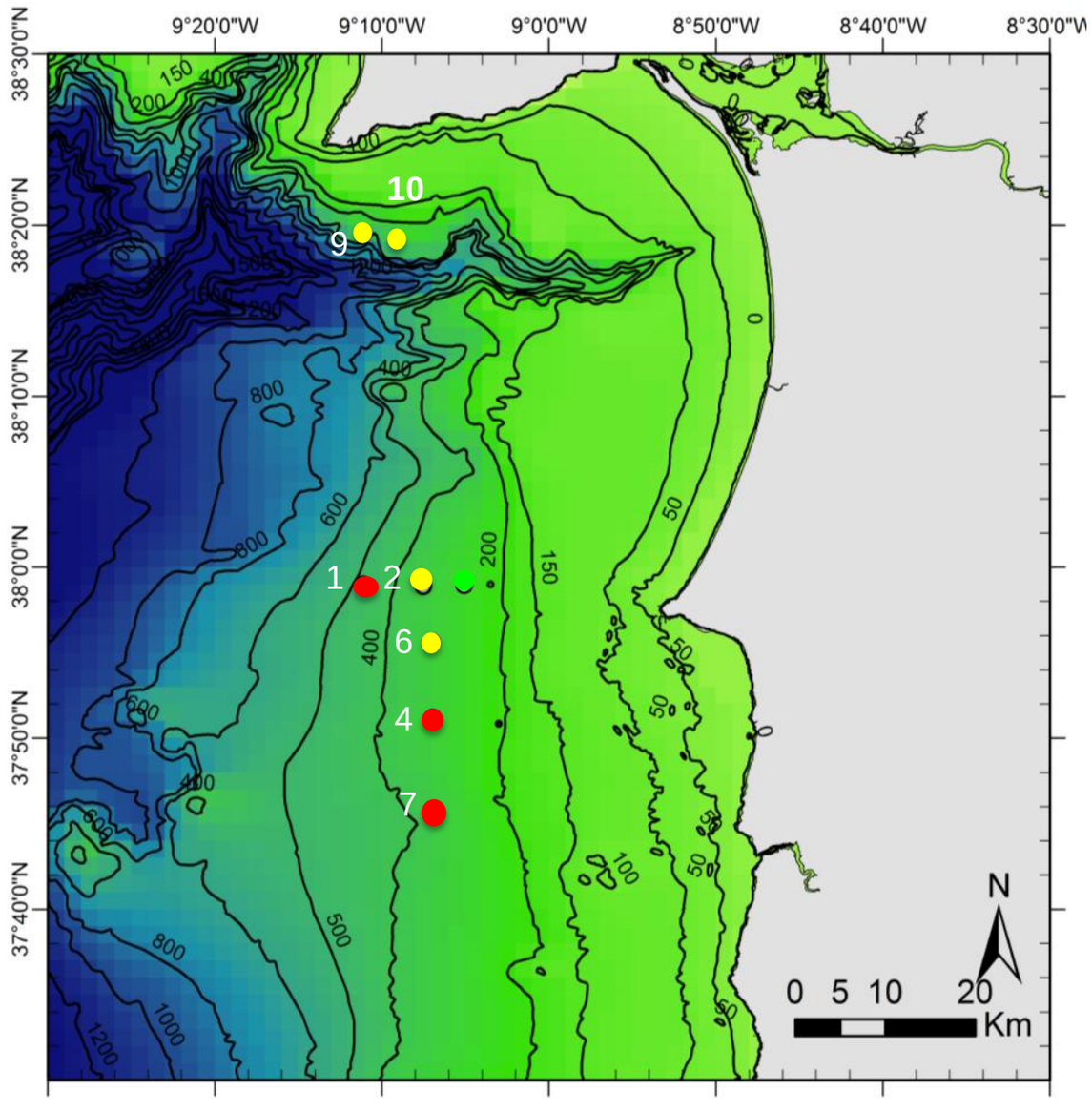
Summary

- Sediment grain size was the main factor responsible for differences between T and NT areas, related to *Nephrops norvegicus* habitats (muddy sediments)
- In general, **faunal analysis showed inconclusive results between impact levels**. Several factors may be responsible:
  - Lack of good reference stations (similar sediment type)
  - Sampler effect - (MUC - exclude larger fauna, overestimate abundances)
  - Lack of taxonomic resolution
  - Necessary to include faunal functional traits (biomass, feeding type, mobility, etc.)
- Functioning experiment, showed that both bioturbation and bioirrigation were higher in NT stations, although the high variability within the low number of replicates.

More sampling, different results?

- **RV Pelagia - May 2014**
  - 4 new ROV surveys (confirmation of trawled and reference areas)
- **RV Belgica – June 2014**
  - Additional stations (including NT areas with similar grain size)
  - Consistent sampling methods (Macrofauna)
  - Repetition of the experiment more replicates

At each station 3 replicate within a 1nm (N/S) were collected in order to study spatial variability within different trawling intensity area



Acknowledgments

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