# The Bay of Seine: a resilient socio-eco-system under cumulative pressures. A methodological approach.

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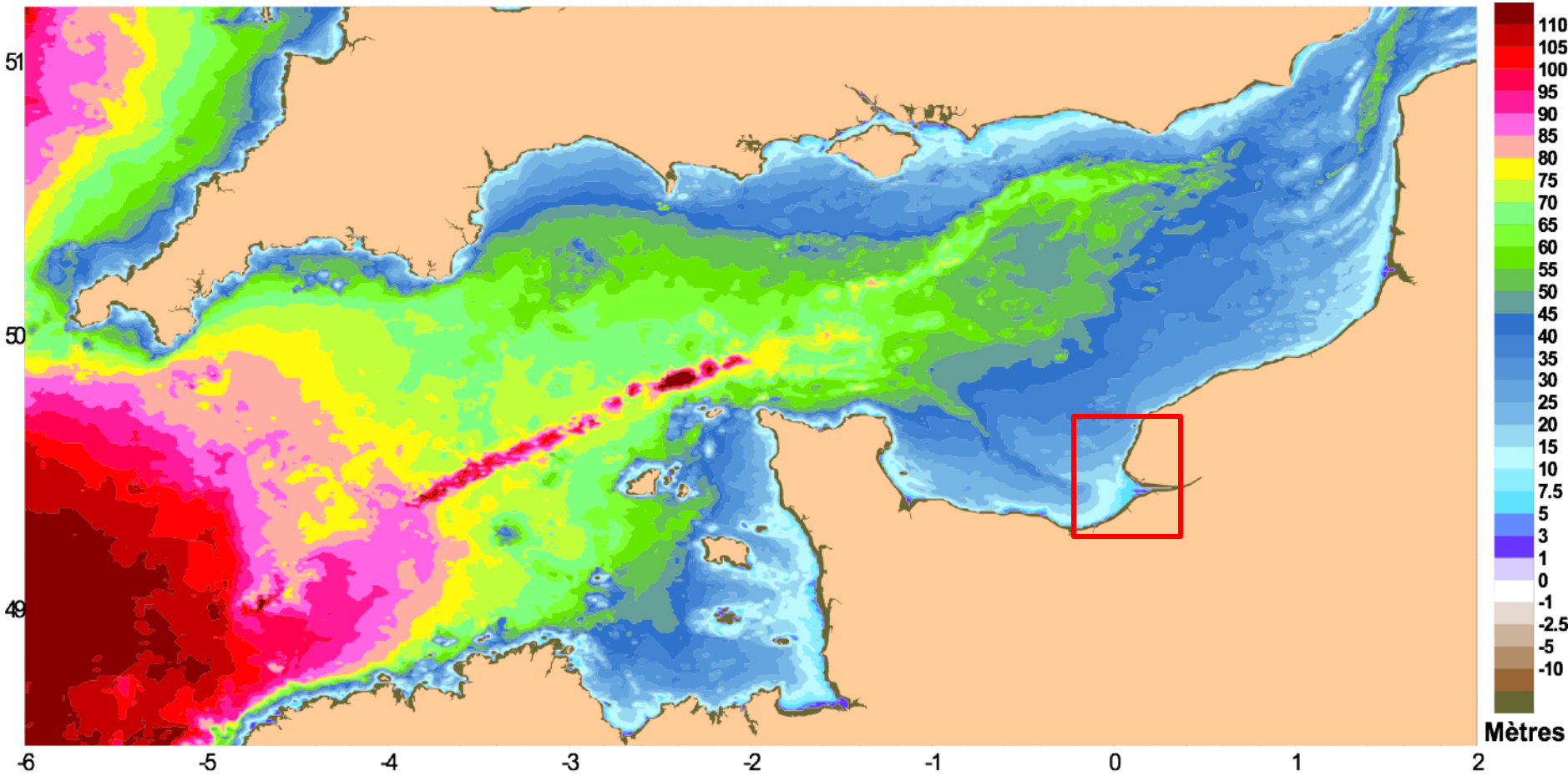
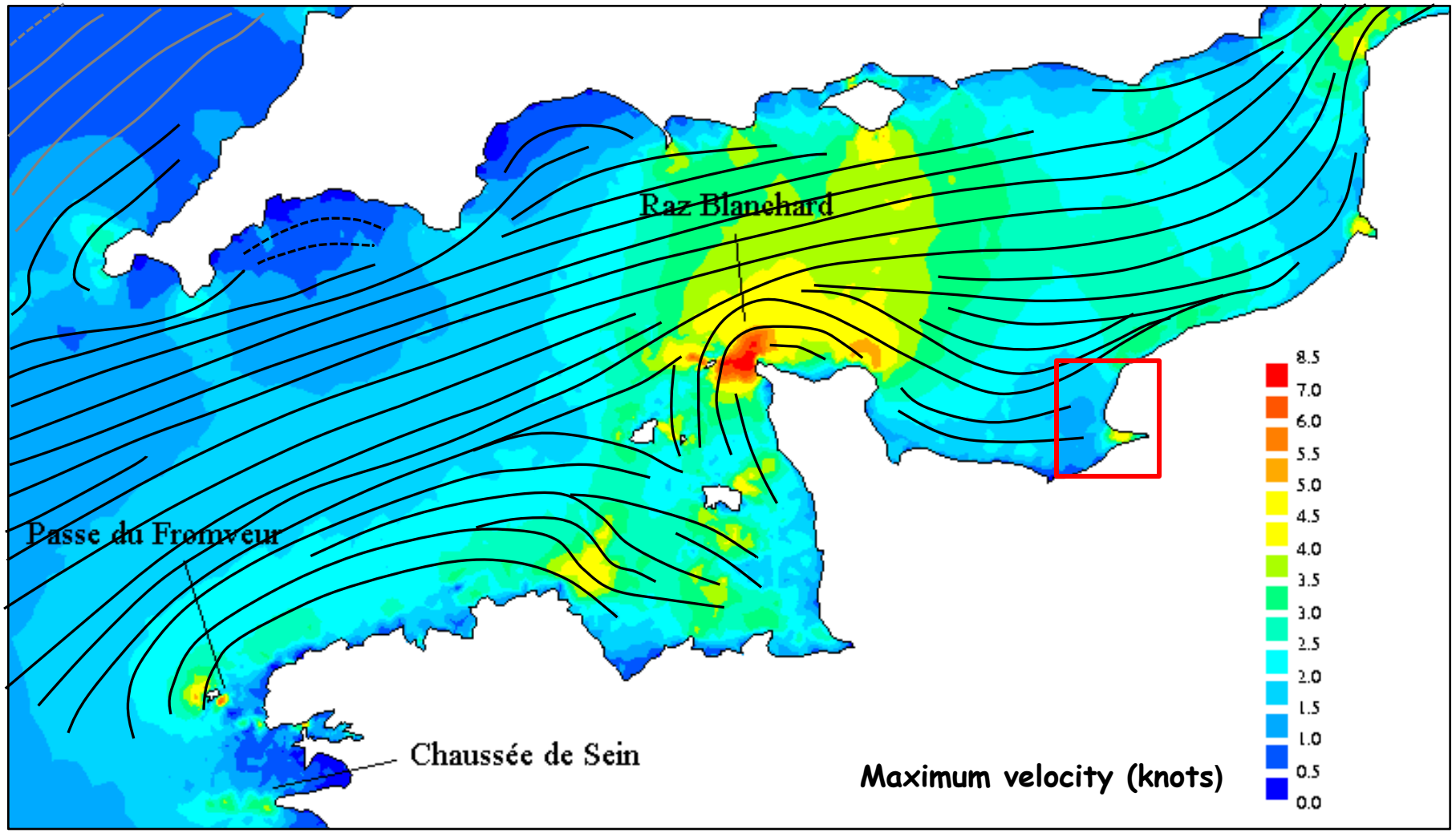
# The eastern Bay of Seine: a high impacted ecosystem concerned by a lot of human activities and stakeholder interventions

# A shallow area

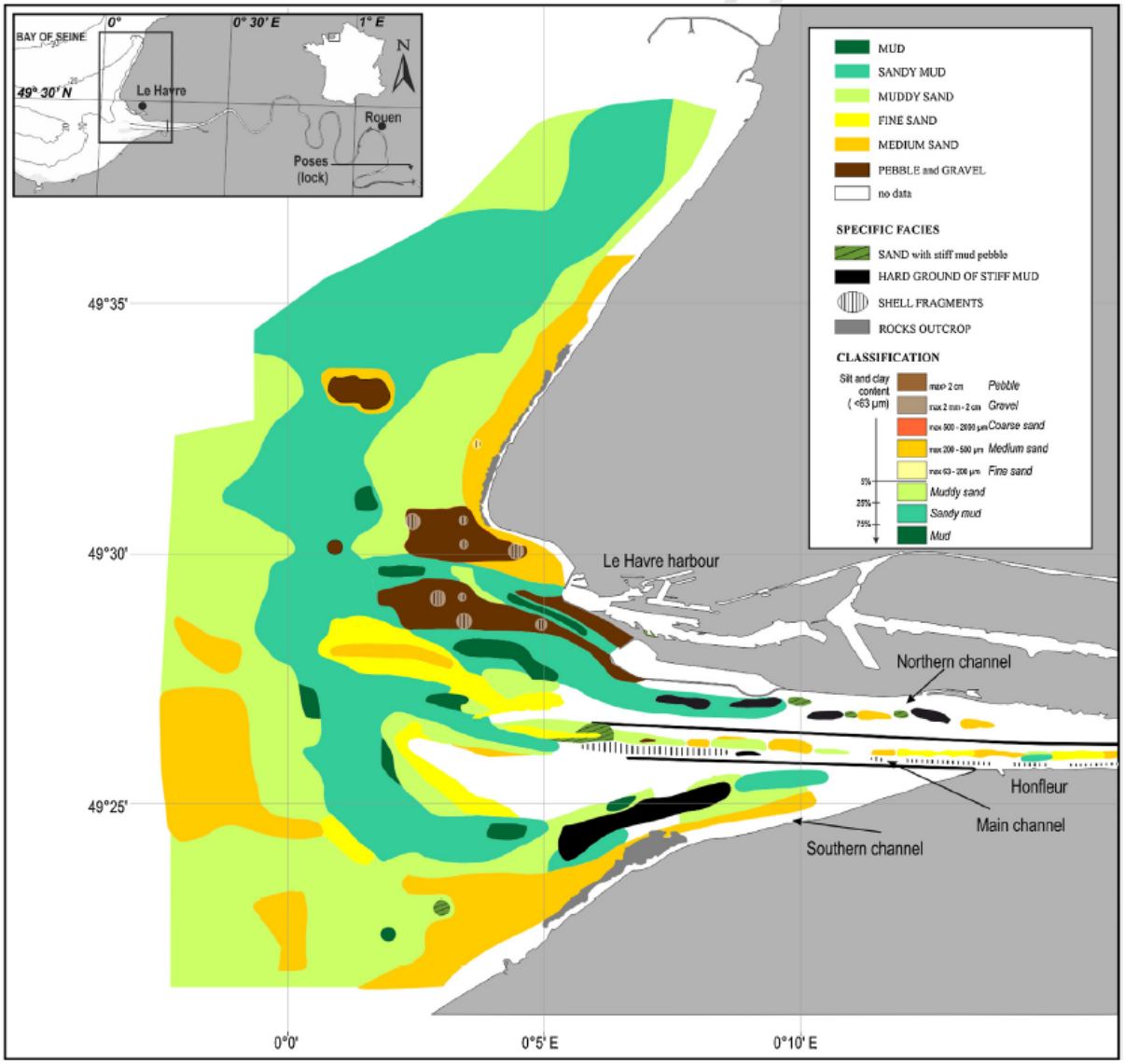



Data from IFREMER, with the authorisation of P. Bailly du Bois, IRSN, Octeville, F

# With low tidal currents



# In a zone dominated by sandy and muddy habitats






D'après Lesourd et al., 2016. Comptes Rendus Geoscience

## Covered by rich macrobenthic communities:Thiébaut et al., 1997.

P. pellucidus

*A. brachiata*

*S. martinensis*

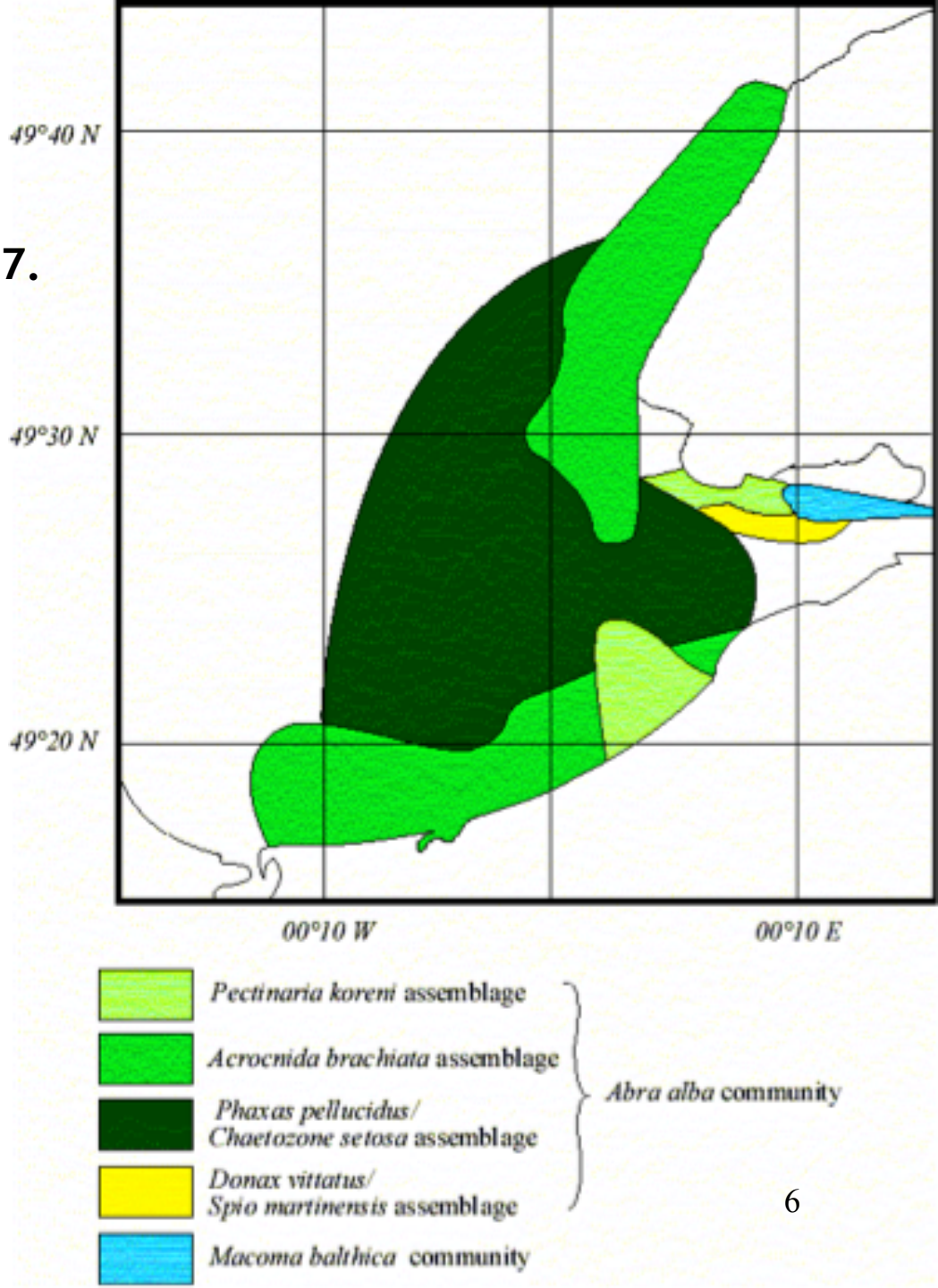
M. baltica

A.alba

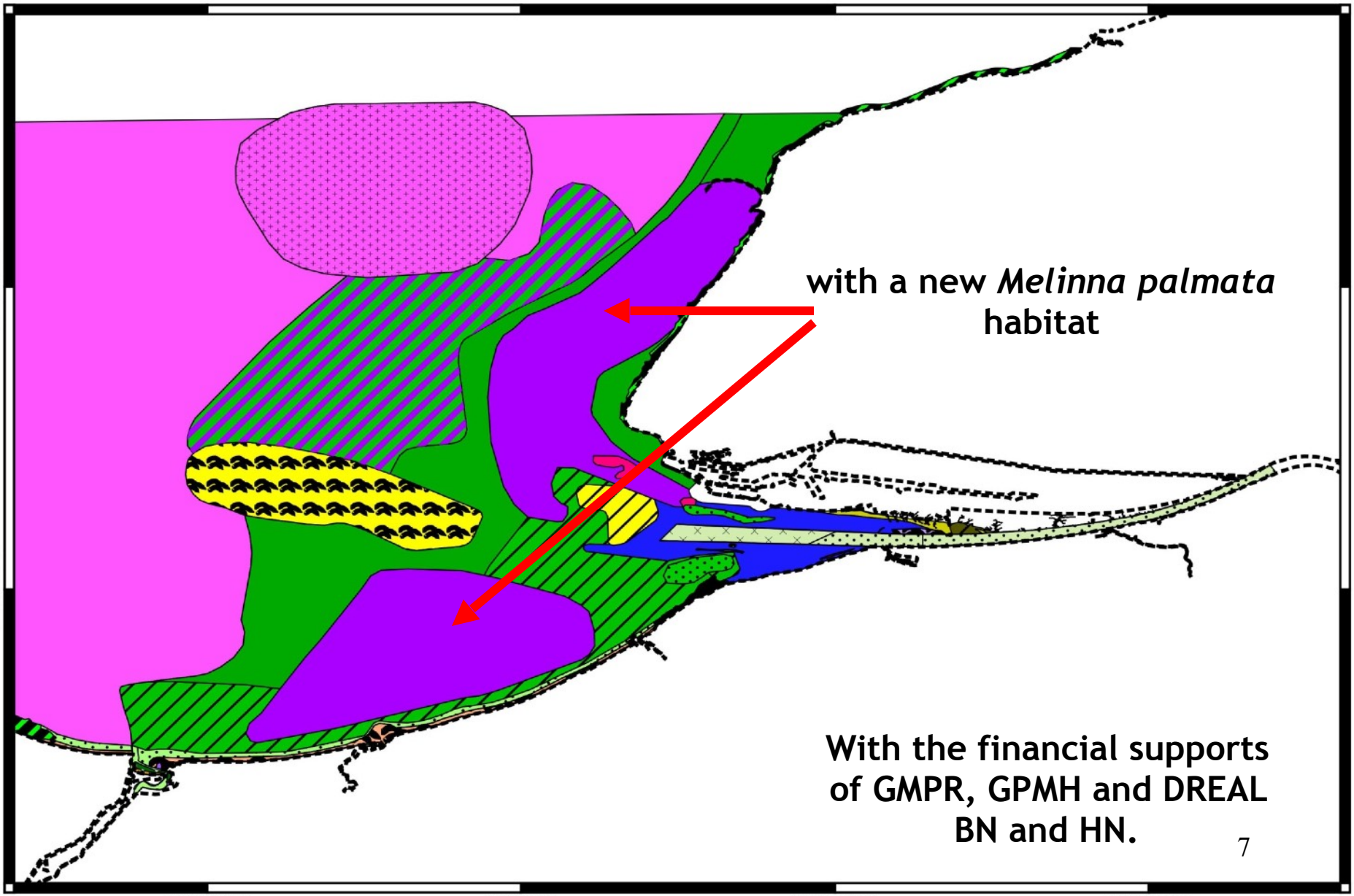
O. fusiformis

P. koreni

D. vittatus



# Under silty augmentation and installation of new benthic habitats: Baffreau et al., 2015

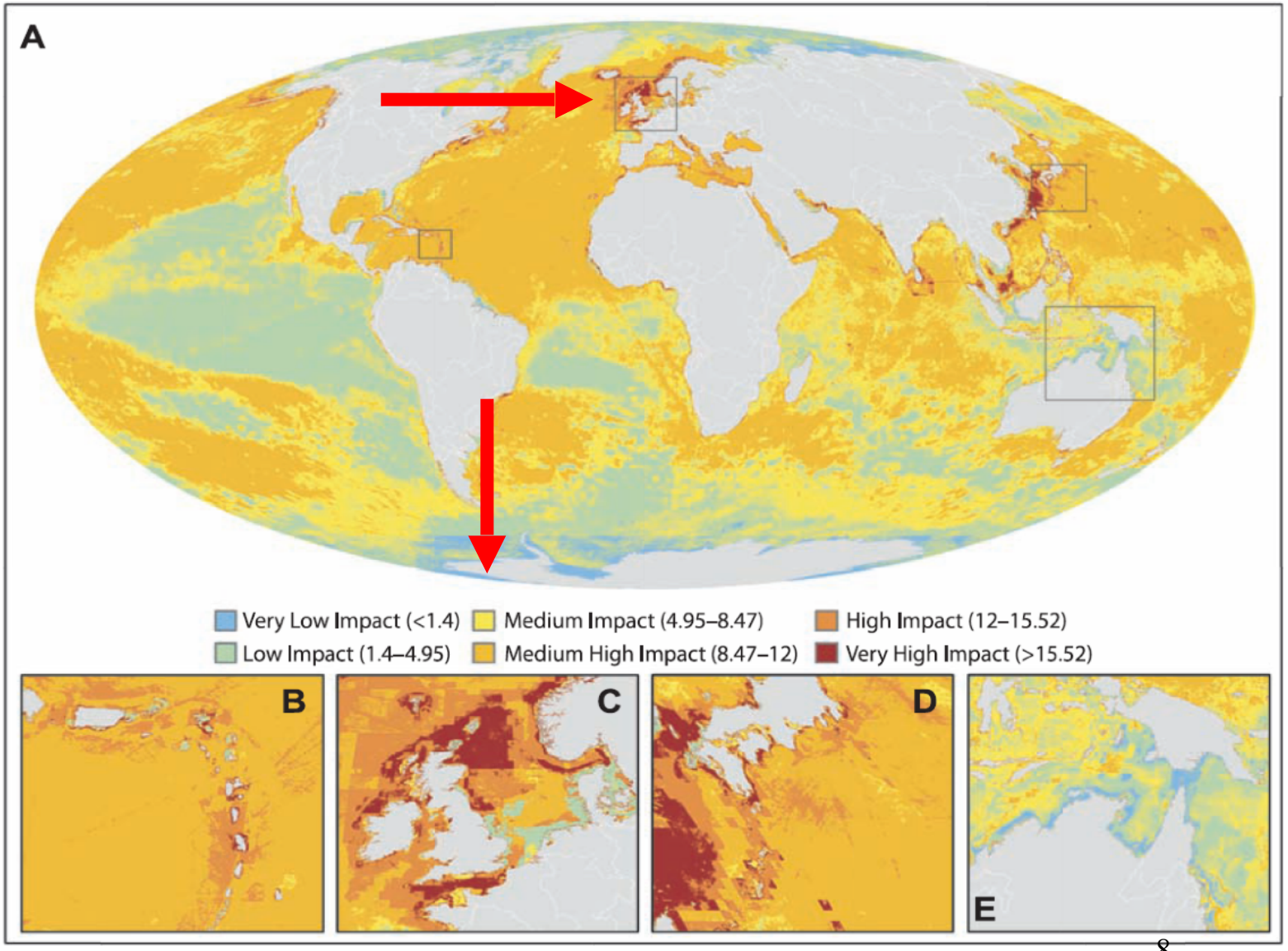



with a new *Melinna palmata* habitat

With the financial supports of GMPR, GPMH and DREAL BN and HN.

# One of the worldwide Ocean area with very high human impact

**Fig. 1.** Global map (**A**) of cumulative human impact across 20 ocean ecosystem types. (Insets) Highly impacted regions in the Eastern Caribbean (**B**), the North Sea (**C**), and the Japanese waters (**D**) and one of the least impacted regions, in northern Australia and the Torres Strait (**E**).






From Halpern et al., 2008. Science 319, 948-952

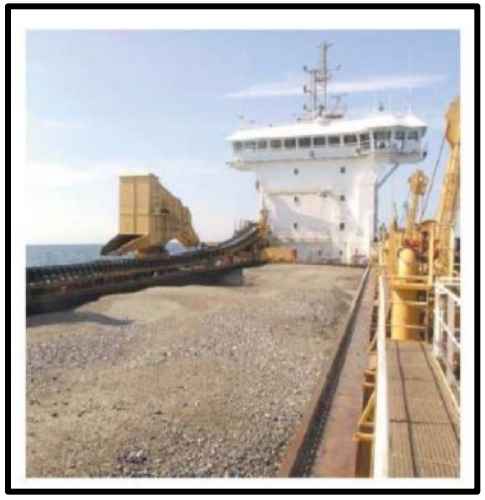
**With a lot of activities in the eastern part of the Bay of Seine**

## Wind farms

## Sediment dredging and deposit

## Artificial reefs

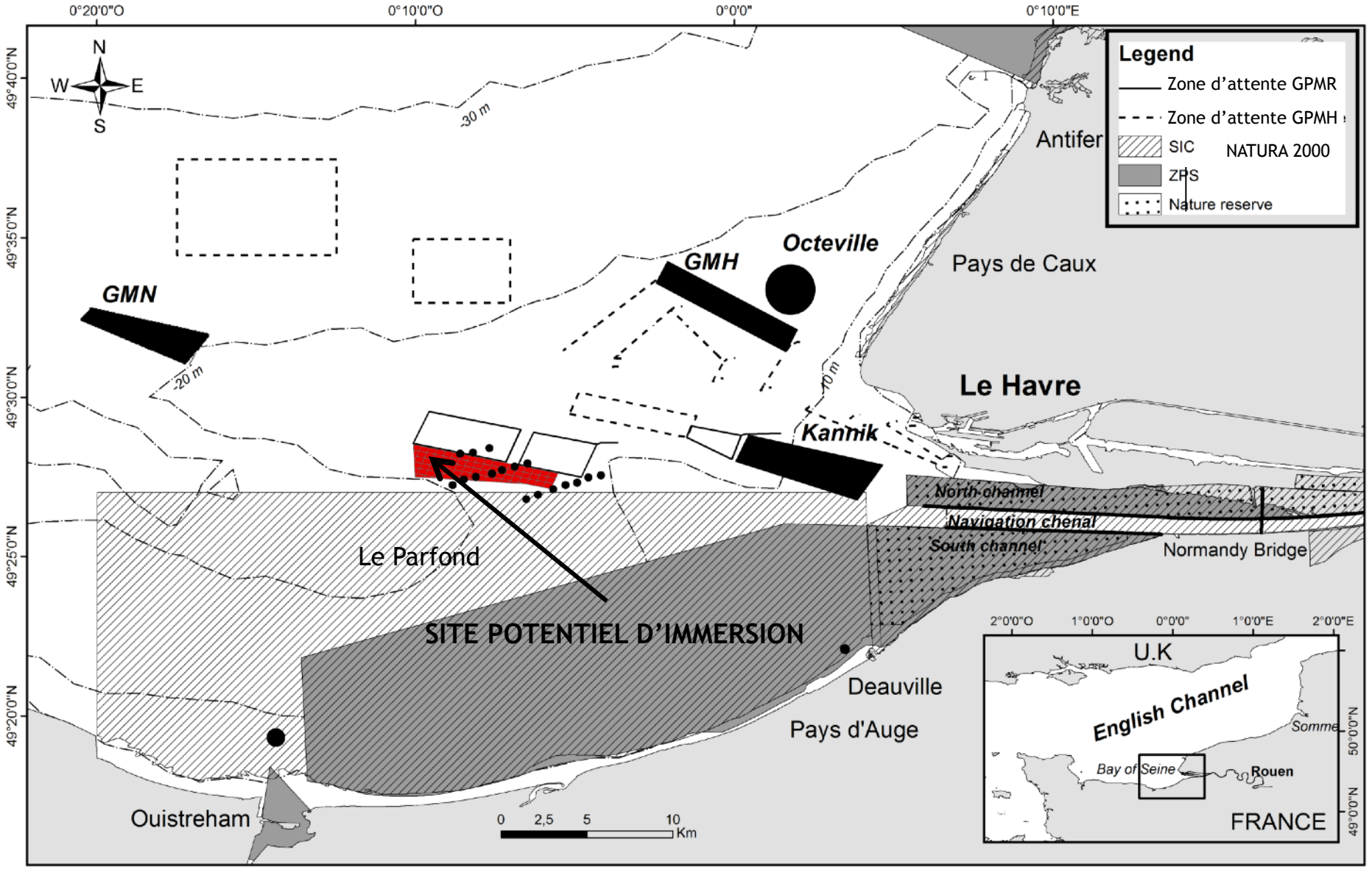
## Granulate extraction



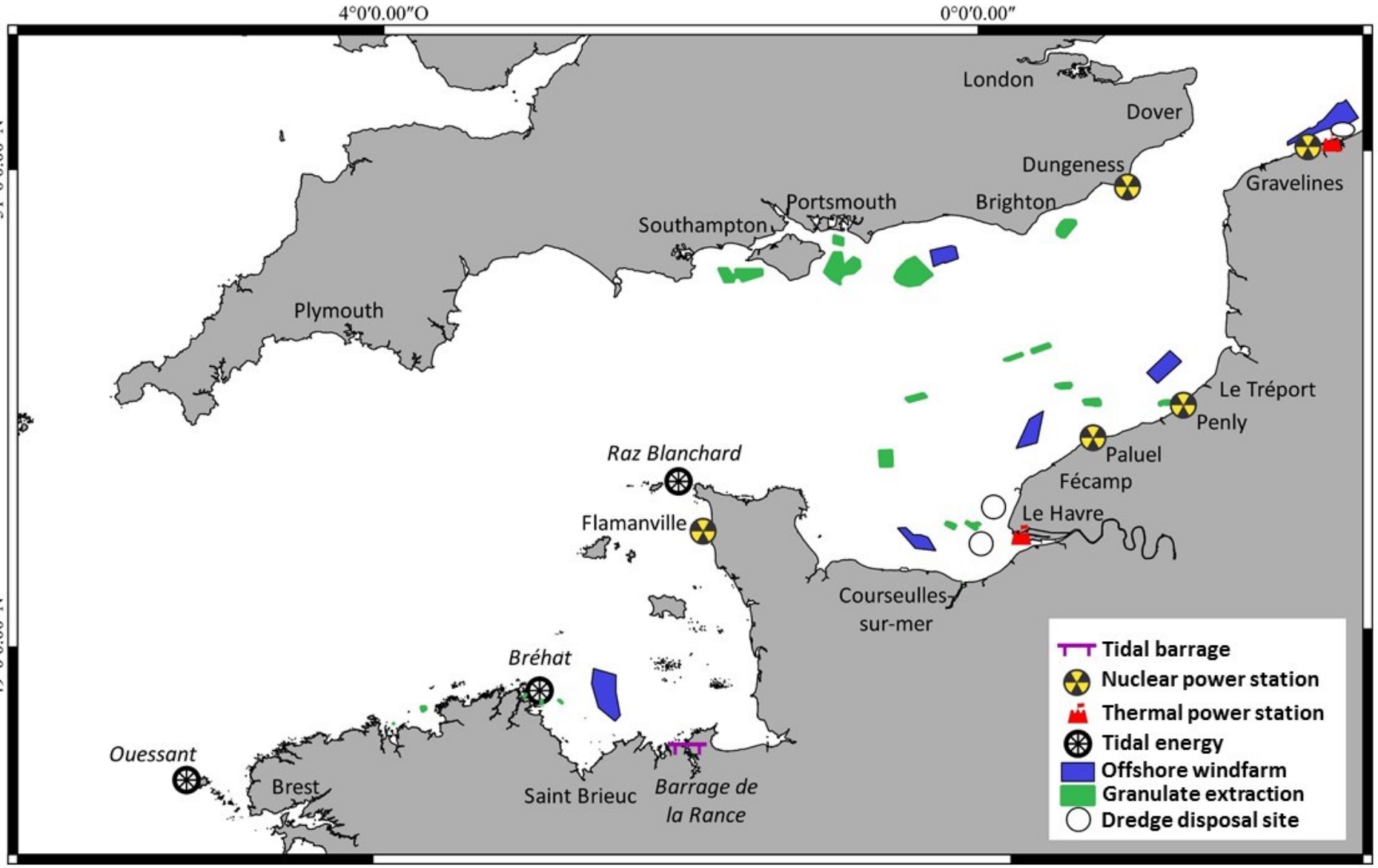
## Fishing

## Port 2000 Le Havre

# A mosaic of habitats with human pressures and protections (Marmin, 2013)



# Human activities in the English Channel



# The need to develop a global ecosystem approach to apprehend the functioning of this socio-eco-system under cumulative pressures: Ecological Network Analysis via Ecopath model and qualitative models

# Ecopath trophic model

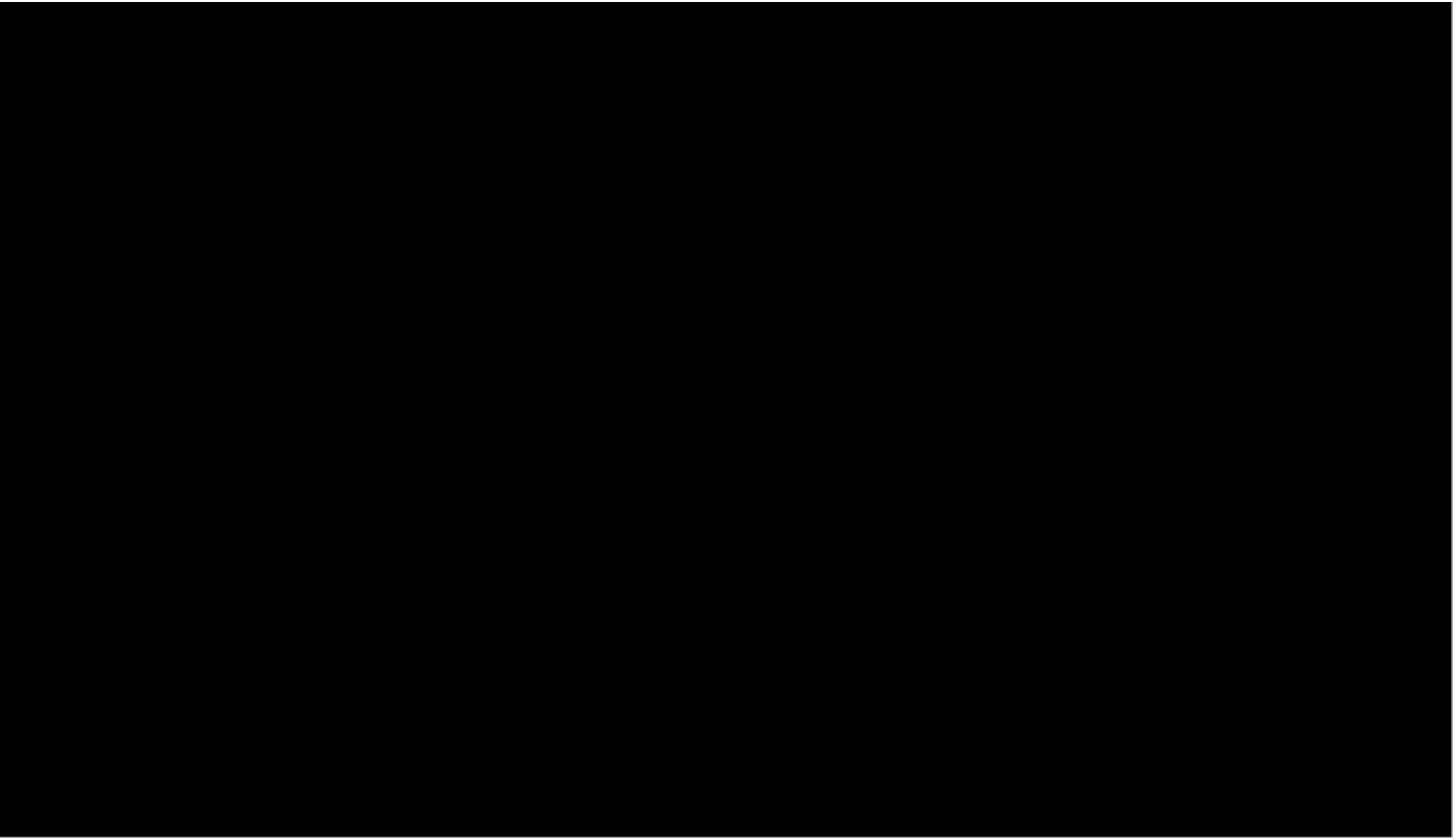
Ecopath is used to estimate the **structure** and **functioning** of a **whole ecosystem**.

**Biomasses** are distributed between different **trophic compartments** (one or several species that share a common diet).

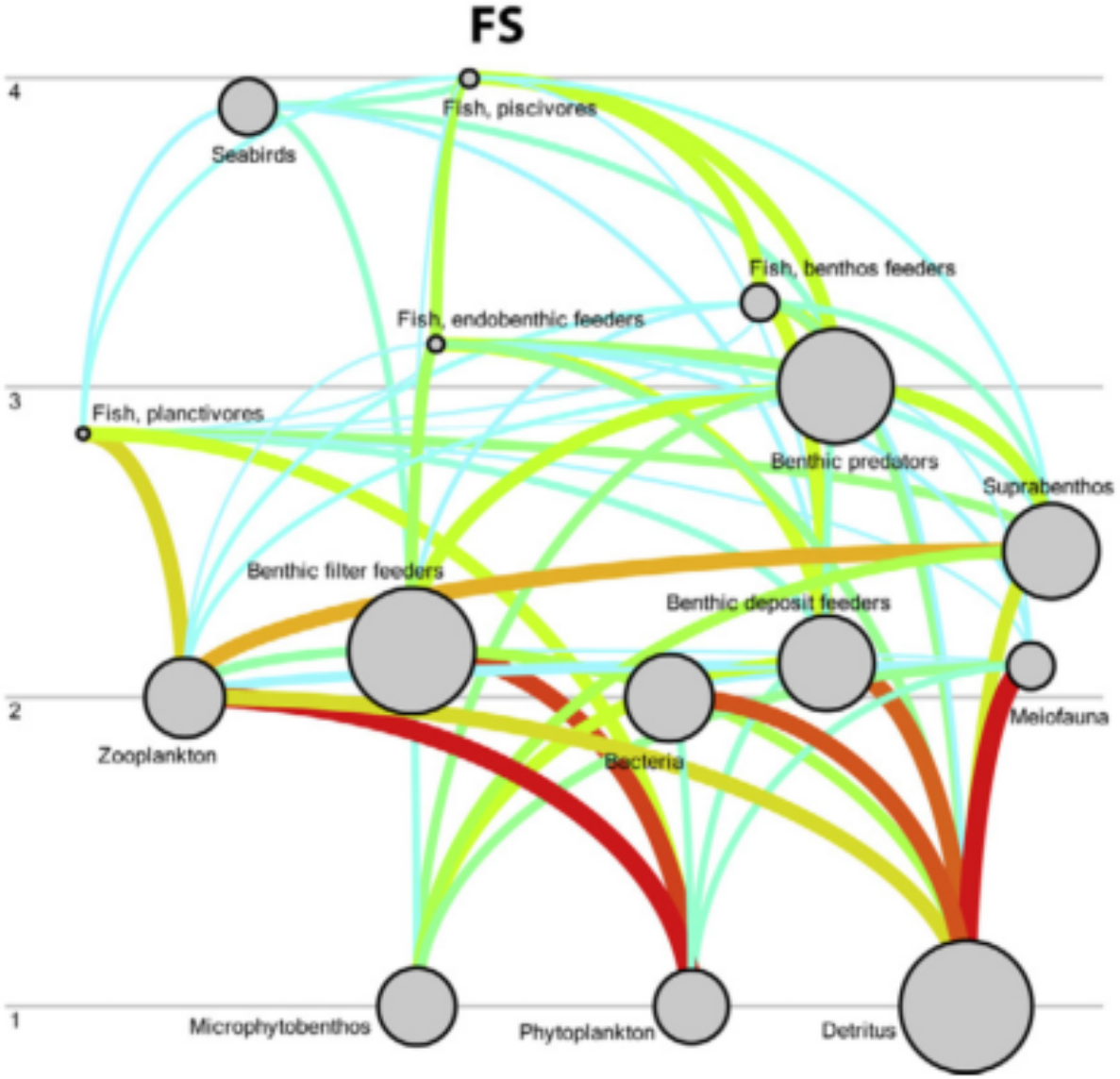
**This approach allows to:**

- ➢ Quantify the **flows** of biomasses in an ecosystem,
- ➢ Assess the **role of the different compartments** in the system,
- ➢ Evaluate the response of the food web to **change,**
- ➢ Calculate the **Ecological Network Analysis** (ENA) such as Finn's Cycling Index (**FCI**).
- ➢ Evaluate ecosystem maturity (through ratio).

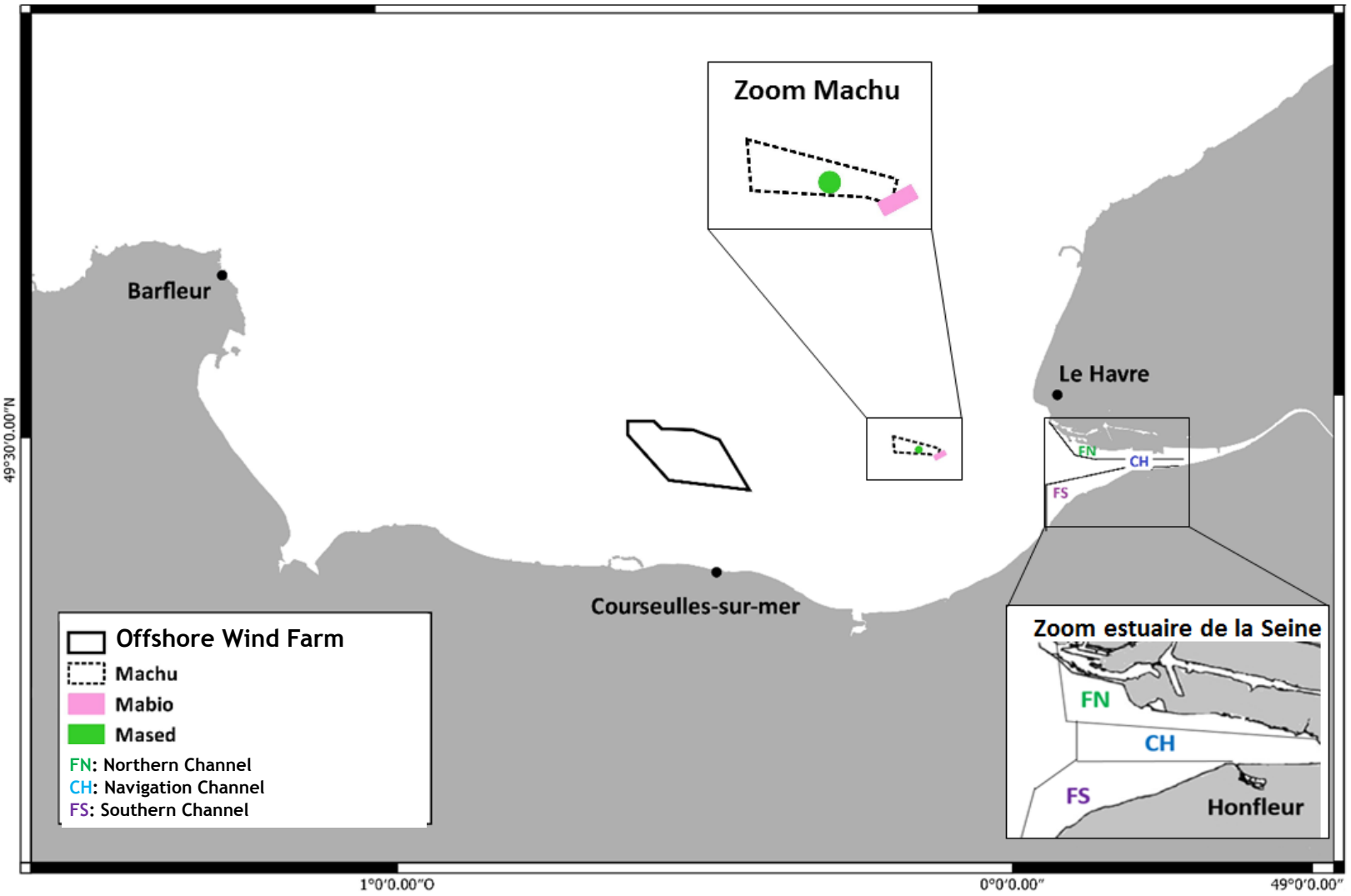
# Trophic levels as y-axis and benthic/ pelagic partitioning on x-axis



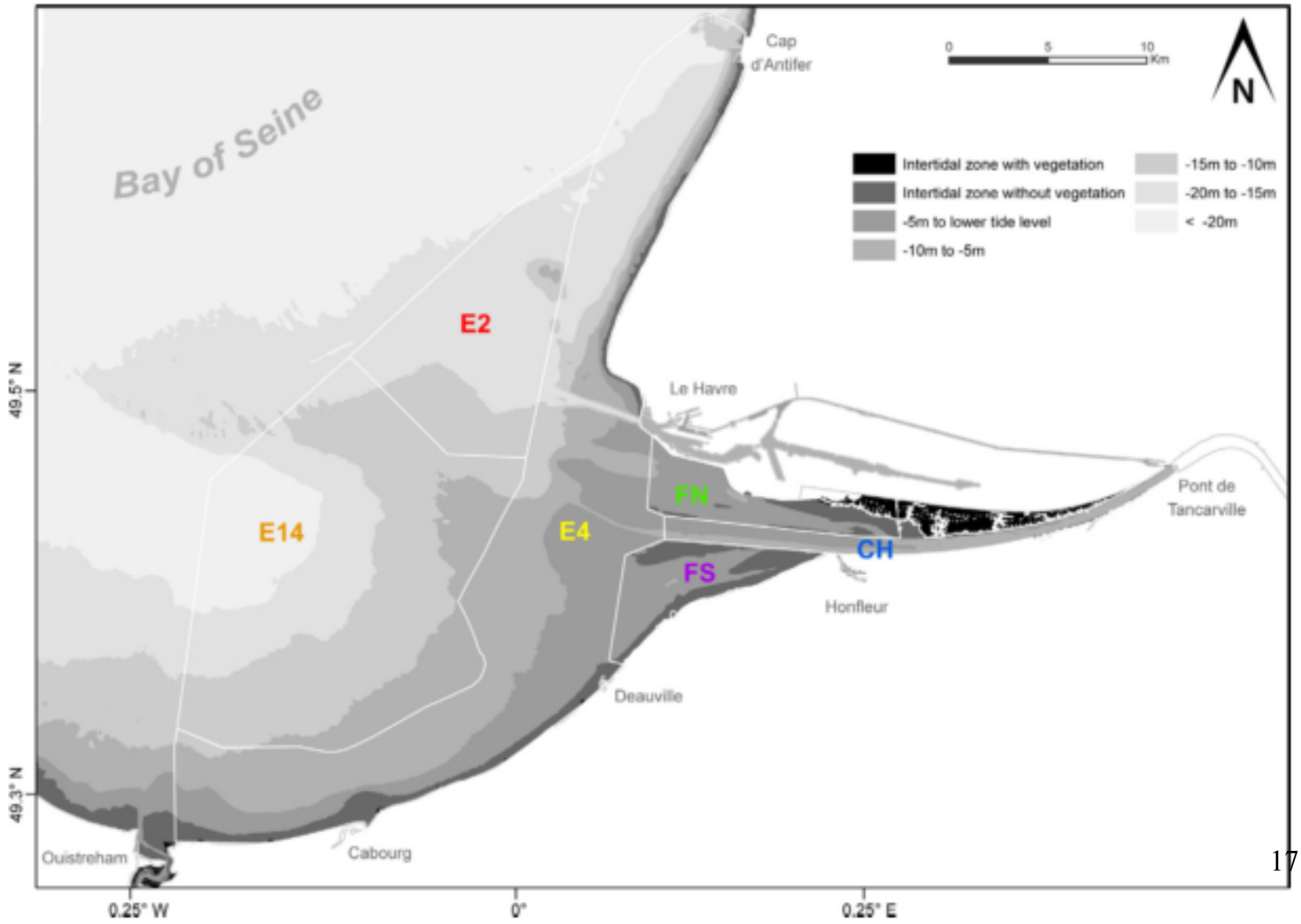
# Example of the flow values for the South Channel of the Seine estuary



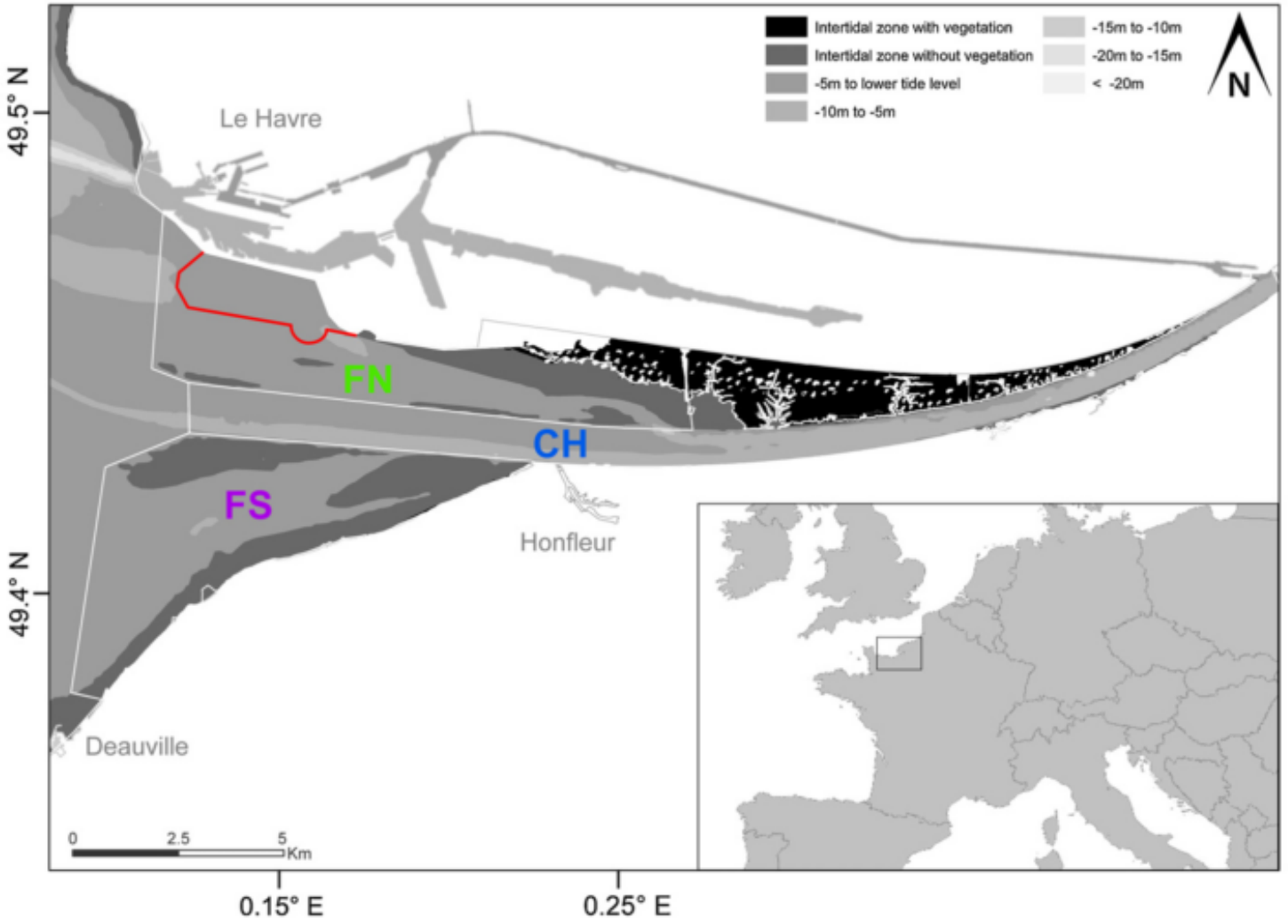
# Several models are made for different zones and periods



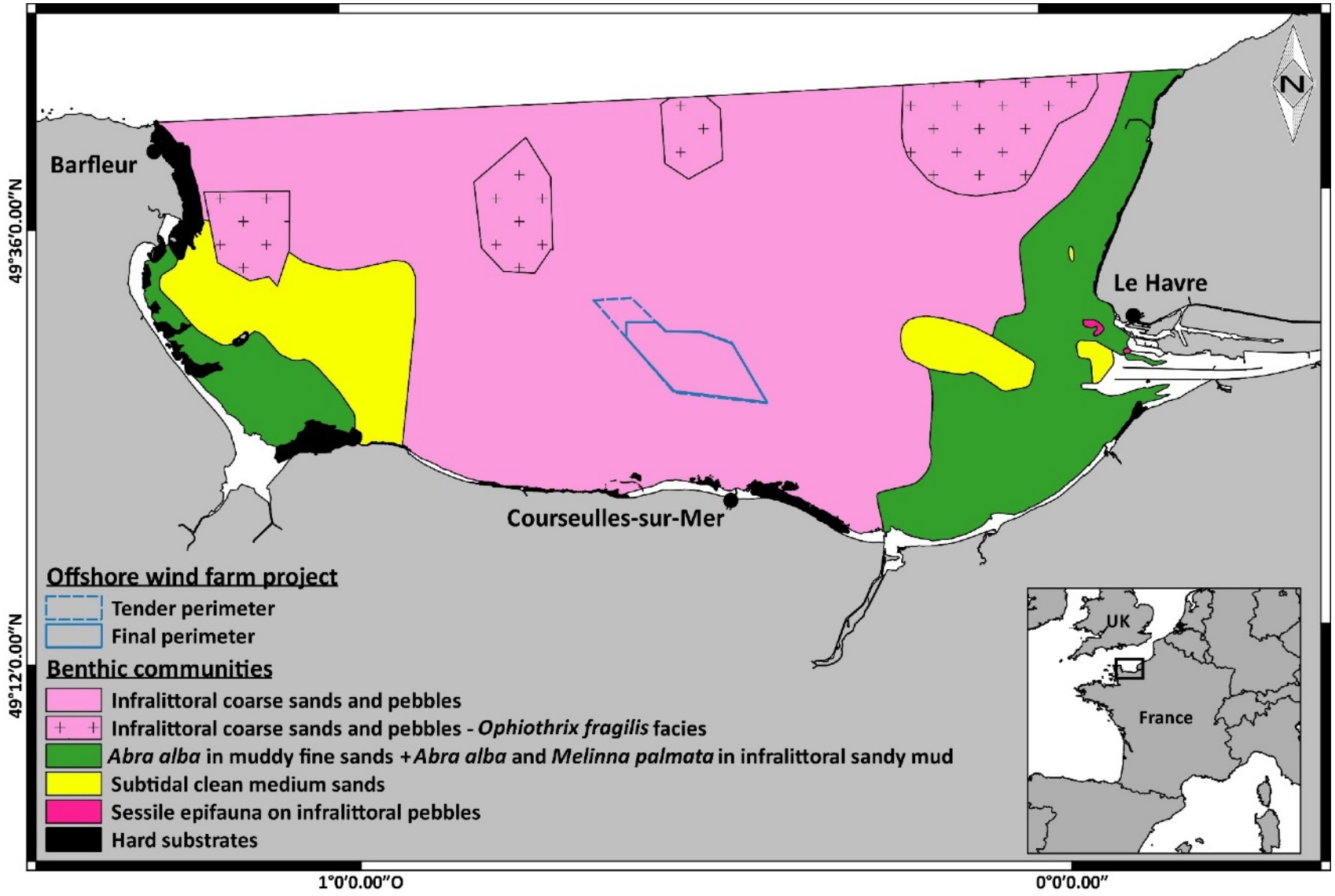
# Mosaic of habitats with six estuarine zones in 1996-2002, before Port 2000 construction:Tecchio et al., 2015. Ecological Modelling



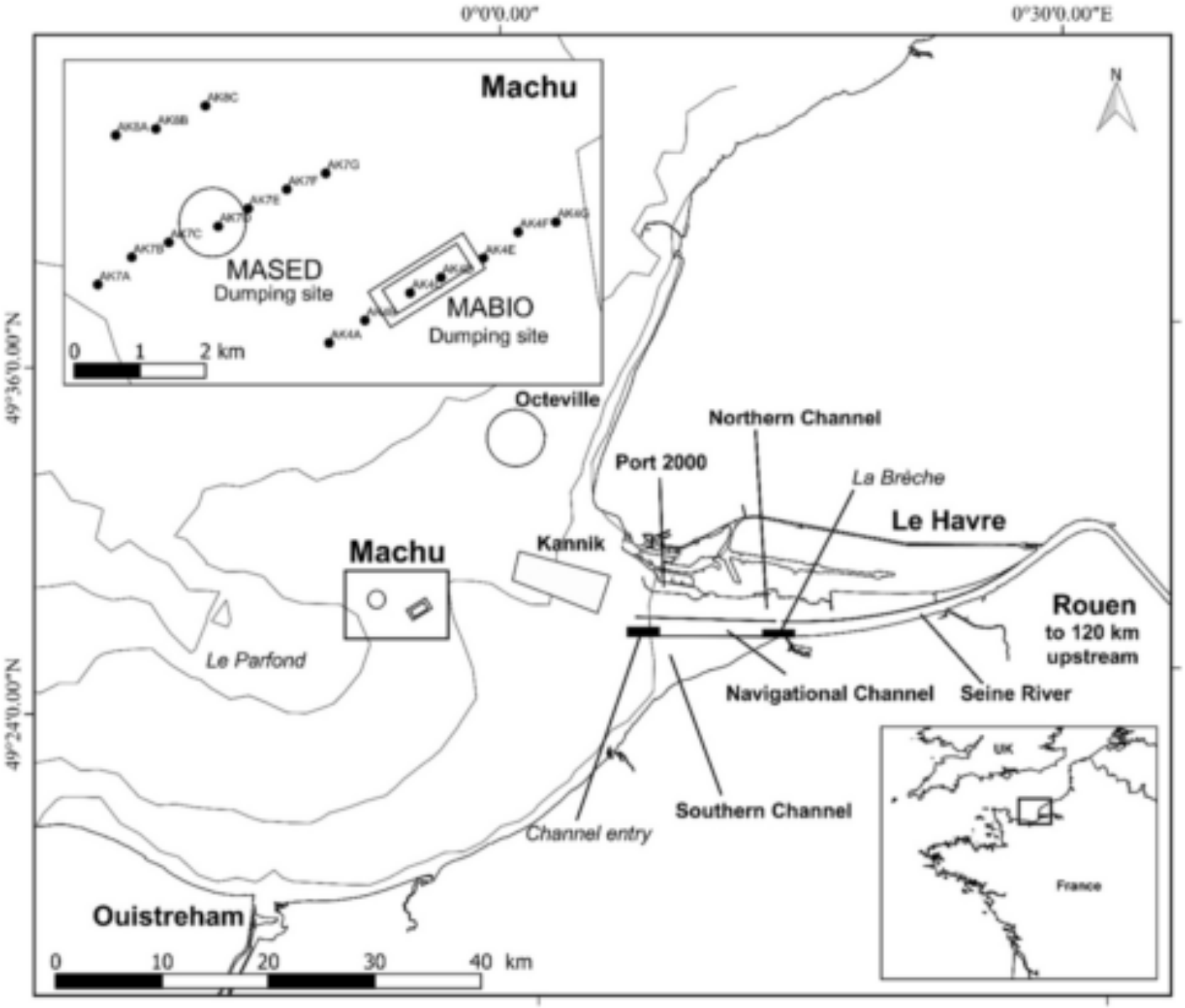
**Comparison of three estuarine habitats in two periods: 1996-2002 and 2005-2002 before and after Port 2000 construction: Tecchio et al. 2016. Ecological Indicators.**



# Sensitivity analysis of the food web of the Courseulles-sur-Mer offshore Wind Farm Project to evaluate the impact of the reef effect: Raoux et al., 2017. Ecological Indicators.



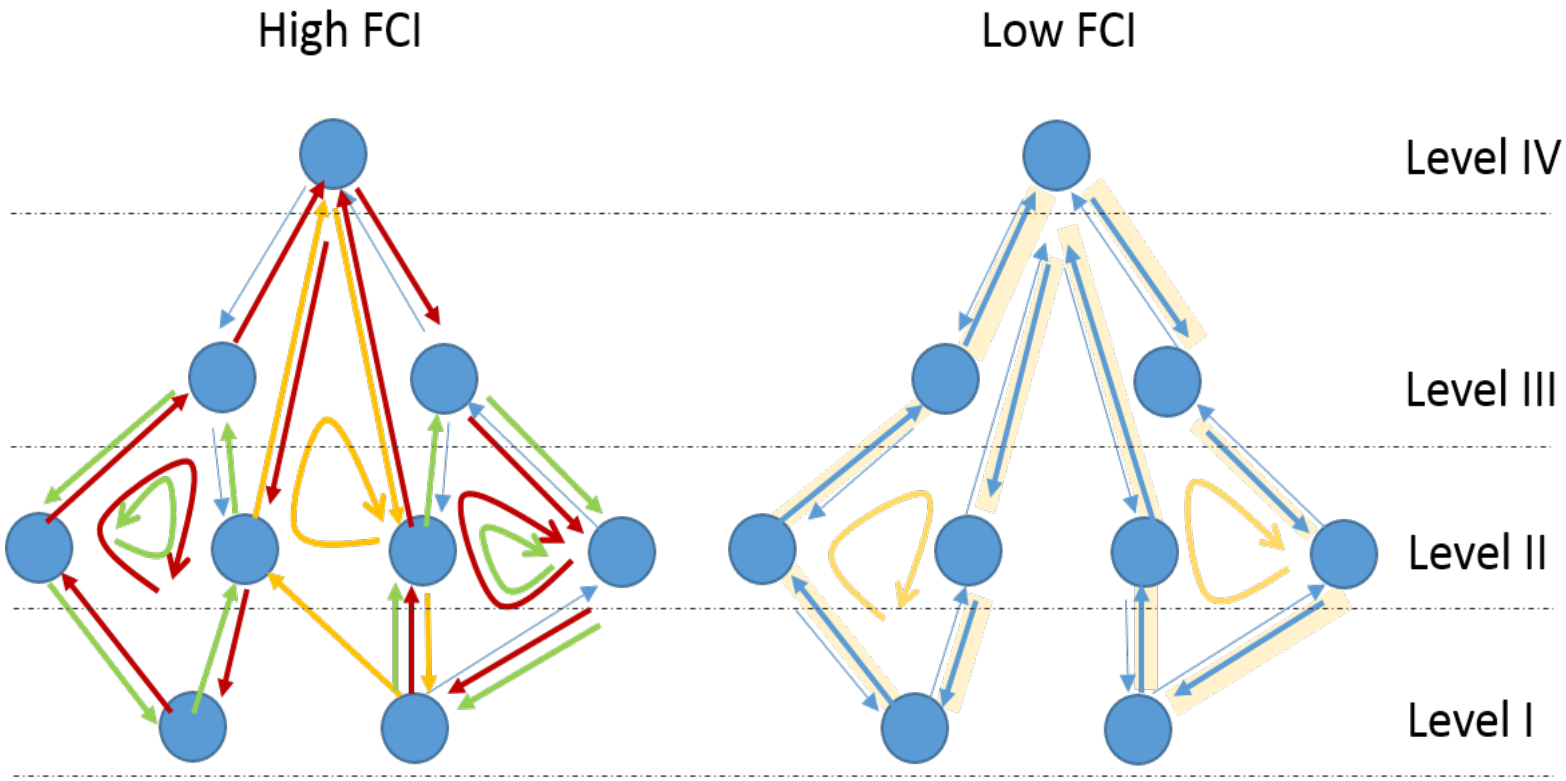
# Effect of experimental sediment deposit on the Machu site: a Before/After approach on MABIO zone: Pezy et al. 2017. Marine Pollution Bulletin and submitted Ecological Indicators.



# Finn’s Cycling Index

FCI gives the percentage of all flows generated by cyclin

FCI is relevant as **indicator of stress**: an **increase** in carbon recycling can be interpreted as a response to stress



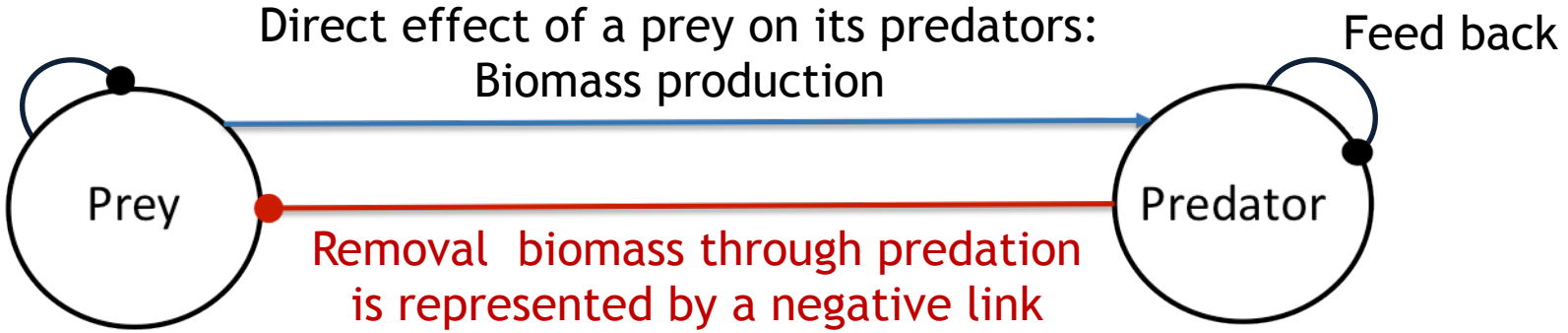

**Schematic representation of the FCI concept**

| Ecosystems | | FCI | Stress Gradient | References |
|---|---|---|---|---|
| Seine Estuary | South Channel | 4% |  | Tecchio et al., 2015 |
| | Navigation Channel | 9% | | |
| | **North Channel** | **19%** | | |
| Mabio | Control area | 9% |  | Pezy et al., 2017 |
| | Impacted area | 9% | | |
| | **Influenced area** | **13%** | | |
| Bay of Seine | Before Construction | 9% |  | Raoux et al., 2017 |
| | **Reef effect** | **13%** | | |

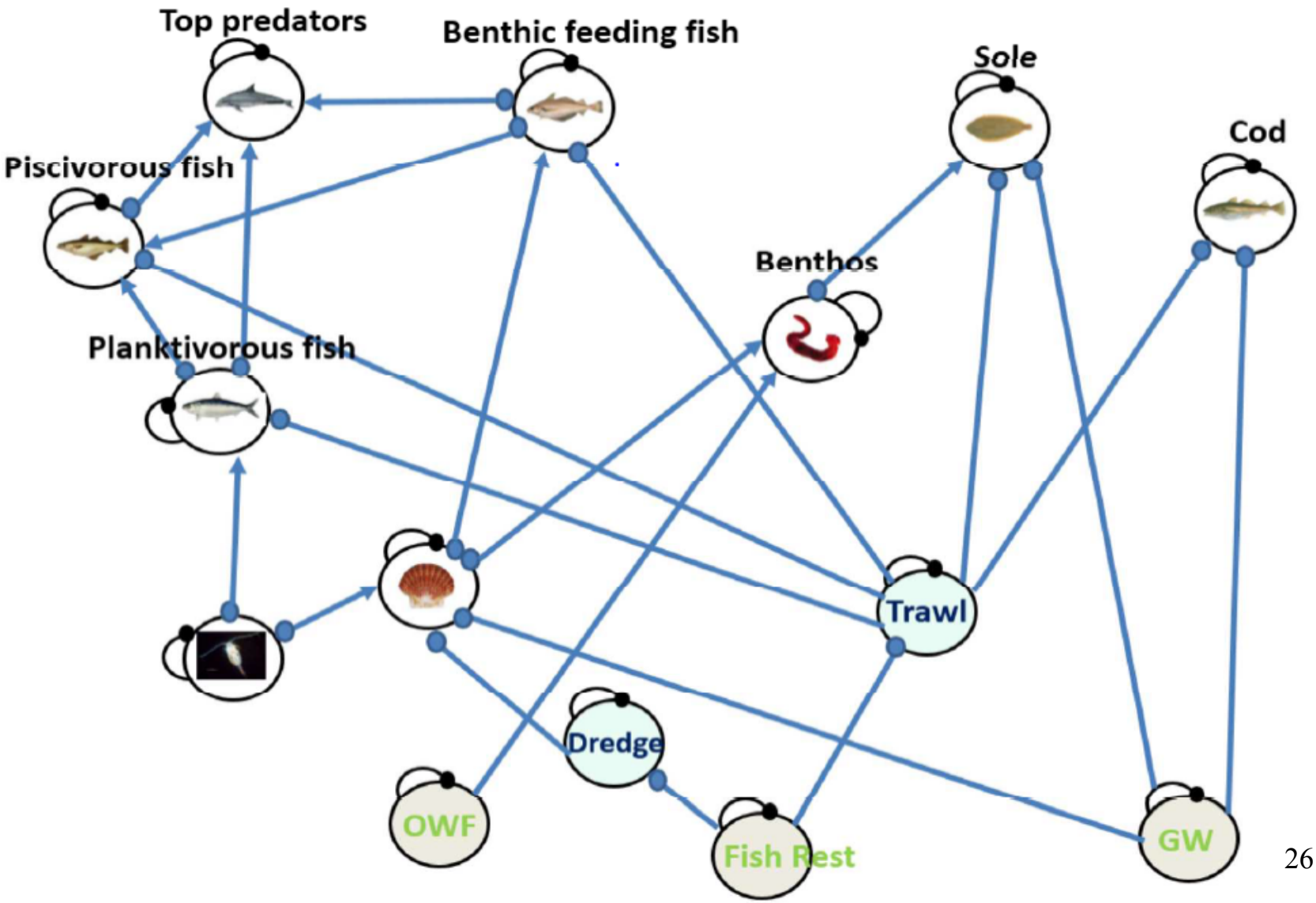
# Qualitative approach

## Development of qualitative and probabilistic models

- Interactions coded in positive or negative effects → signed graph (use to describe the main interactions within the system),
- Human interactions will be a part of the ecosystem,
- Approach used to understand how exposure to multiple stressor (human or natural) **cumulatively** impact on the ecosystem.



**Study case: offshore wind farm project of the Bay of Seine toward socio-ecological modelling**

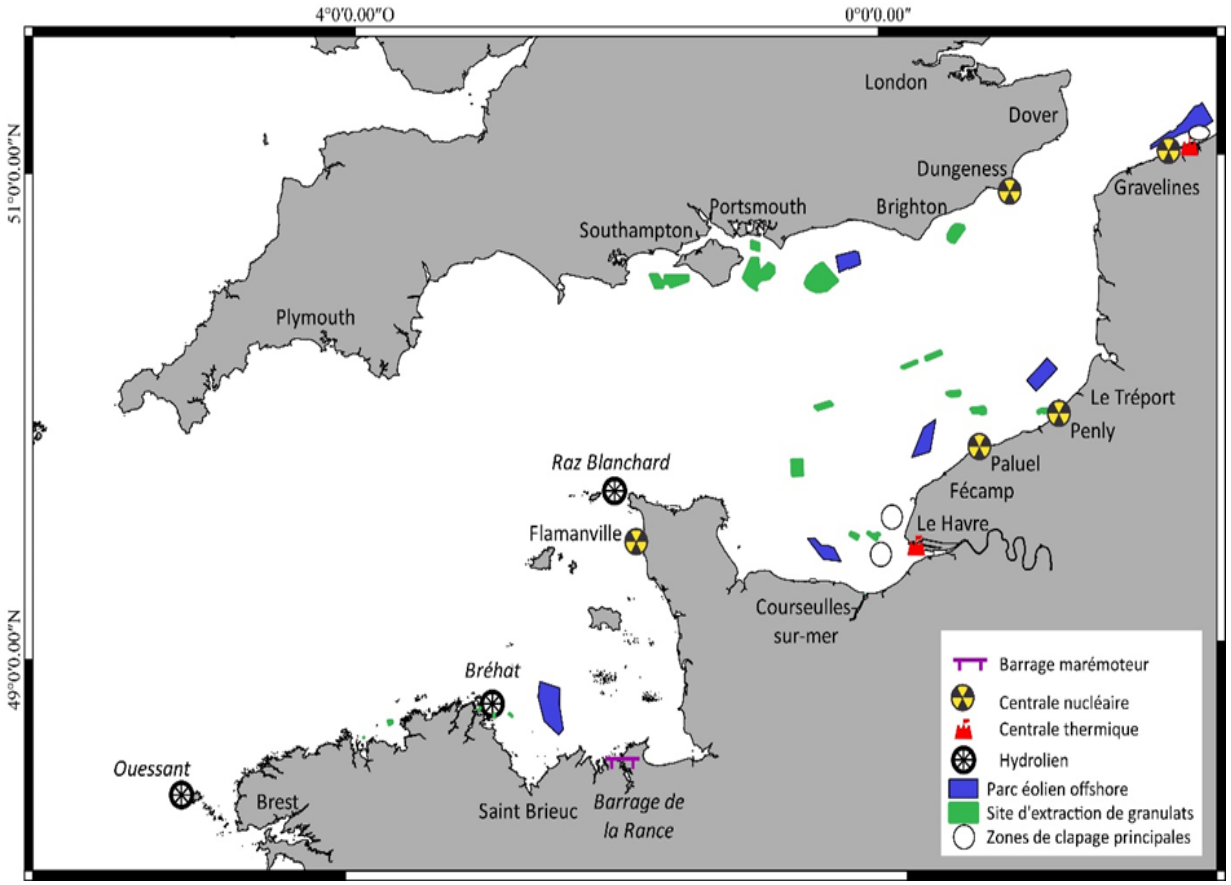


## First results: Raoux et al. in revision in Marine Policy

To analyze **response predictions** →probabilistic models BBN.

**Sensitivity analysis** were performed using the software netica to assess **cumulative impacts at the scale of the Courseulles-sur-mer offshore wind farm area.**

# The future: study of cumulative impacts in the eastern part of the English Channel




- Study the **cumulative effects** of the climate change and other human activities with the installation of the EMR infrastructure on the trophic web structure and functioning (ANR TROPHIK project).
- **Long-term survey of human activities**: a potential observatory of climate change

# Thanks for your attention

Description of index

Omnivory is understood as the act of feeding on more than one food source. Libralato (2008) presented the system omnivory index (SOI) as a mean index that quantifies the distribution of feeding interactions among trophic levels of the food web through the weighted average of omnivory of the consumers.

Going from higher to lower SOI mean values could be represented (Figure 7) as a transitional shift from a food web with a web-like structure (i.e. with several pathways and omnivory relationships between compartments/species) to a chain-like structure (i.e. with less pathways and a structure formed of several simplified food chains).

Formula

SOI is the average omnivory index of all consumers weighted by the logarithm of each consumer's food intake. The logarithms are used as weighting factors because it can be expected that intake rates are approximately log normally distributed (Christensen and Walters 2004).

What implications to food web/ecosystem status?

Omnivory increases the complexity of ecological food webs and thus, SOI represents an overall measure of the complexity of a given ecological network, allowing for the intercomparison among ecosystems and for assessing their development stage and maturity. The SOI is largely applied as a quantification of the web-like structure of weighted and directed food webs (Libralato 2008).The SOI index has also been described as a relevant indicator of stress (Lobry et al. 2008, Selleslagh et al. 2012). As omnivory gives flexibility to the system, more omnivorous systems are able to absorb perturbations and to recover quicker after them (Fagan, 1997; Libralato, 2008). In addition, according to Fagan (1997), an increase in the degree of omnivory has a stabilizing role on the system.