Structural and functional biodiversity of North Sea ecosystems:

species and their habitats as indicators for a sustainable development of the Belgian continental shelf

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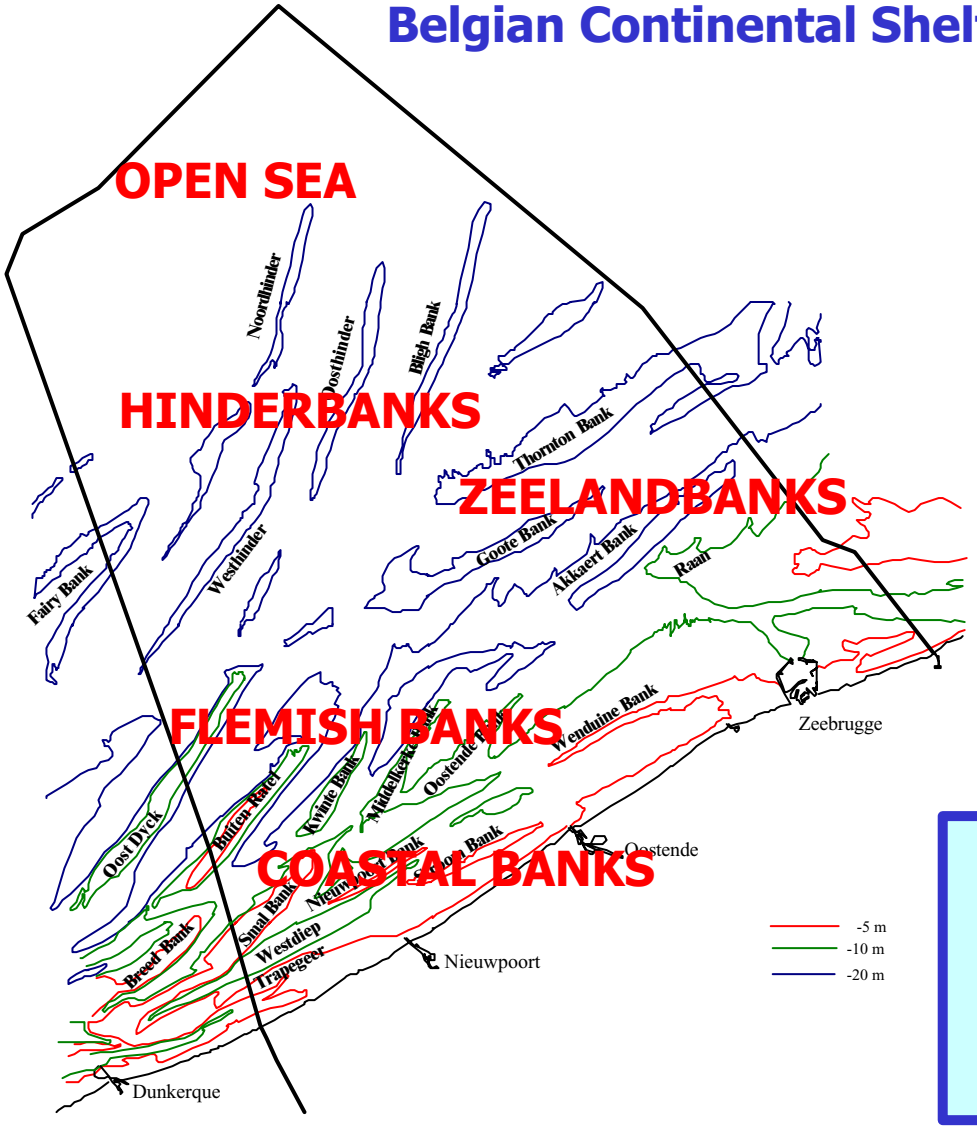
Belgian Continental Shelf



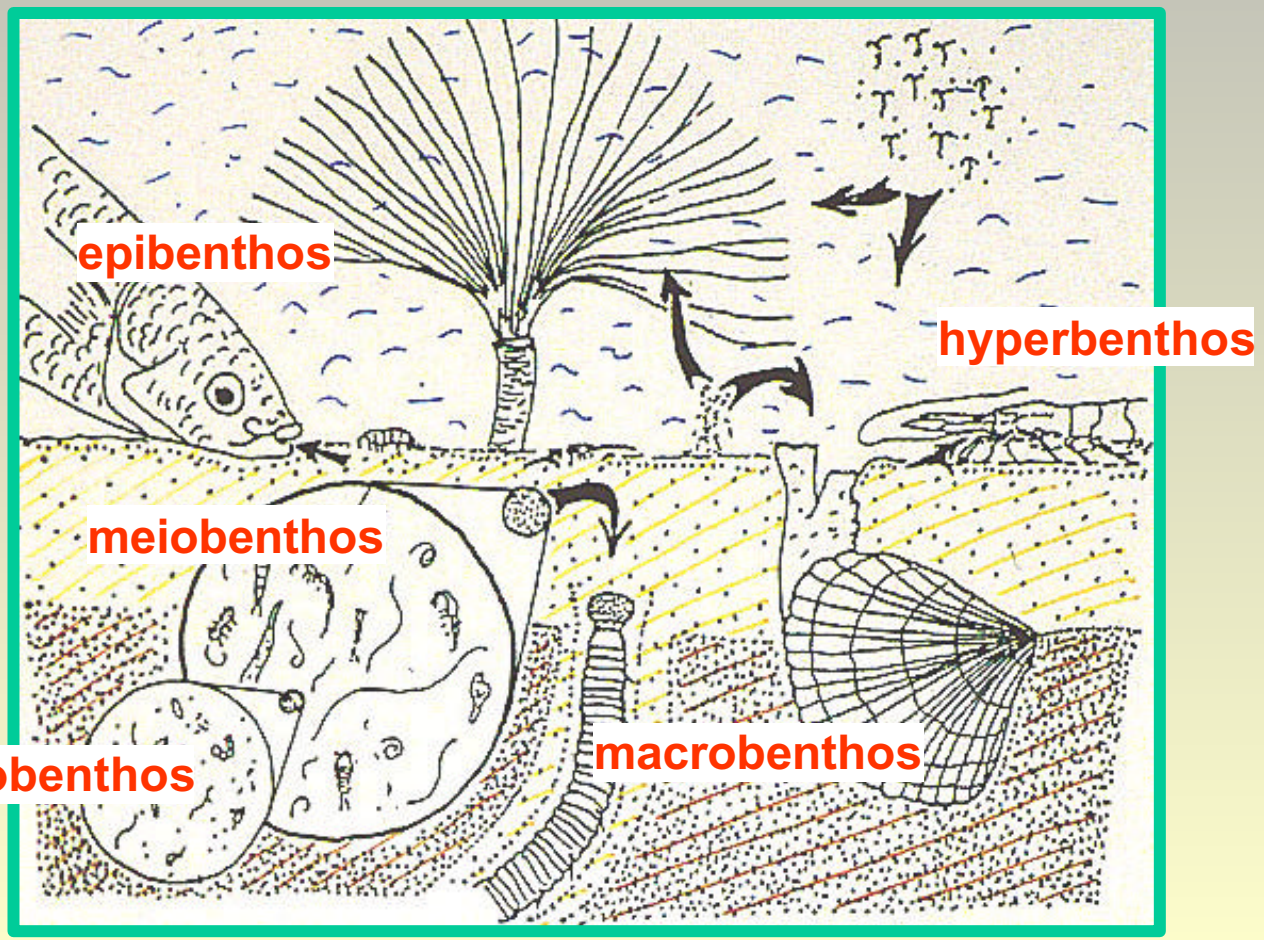
- Shallow subtidal sandbanks close to the coast

- Resting and foraging area for seabirds

- **project aims to assess the factors that determine and influence the marine biodiversity**

Marine Biodiversity with focus upon :

All **benthic compartments** and **parasites** of demersal fish



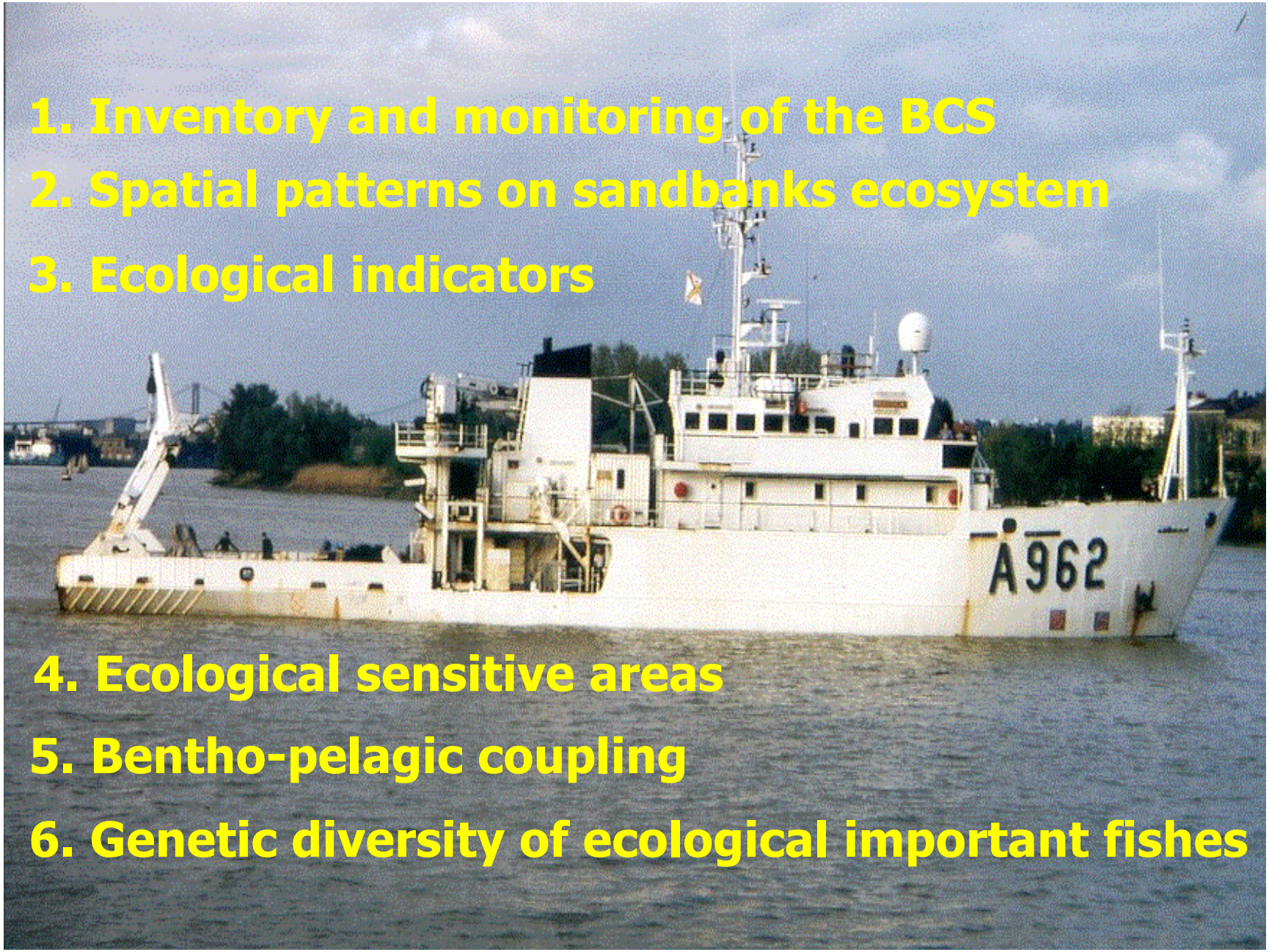
Marine Biodiversity with focus upon :

Seabirds

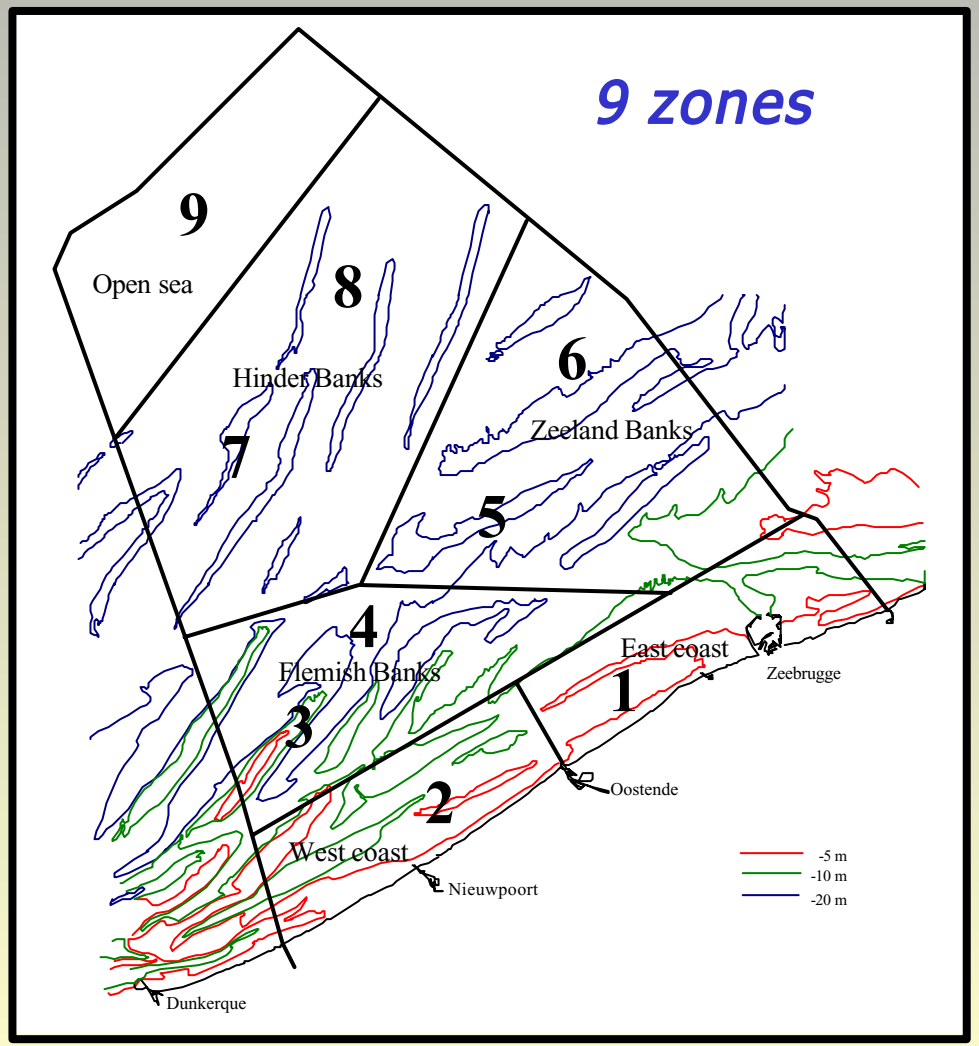
Marine Biodiversity Structure at the

- community level (species diversity)
- genetic level (intraspecific diversity)

With focus on the use of the diversity of the benthos
and the seabirds as
bio-indicators for sustainable development


1. Inventory and monitoring of the BCS
2. Spatial patterns on sandbanks ecosystem
3. Ecological indicators
A962
4. Ecological sensitive areas
5. Bentho-pelagic coupling
6. Genetic diversity of ecological important fishes

1. INVENTORY



Mammals : 5

Birds : 121

Fish : 65

Echinoderms : 12

Crustacea : 220

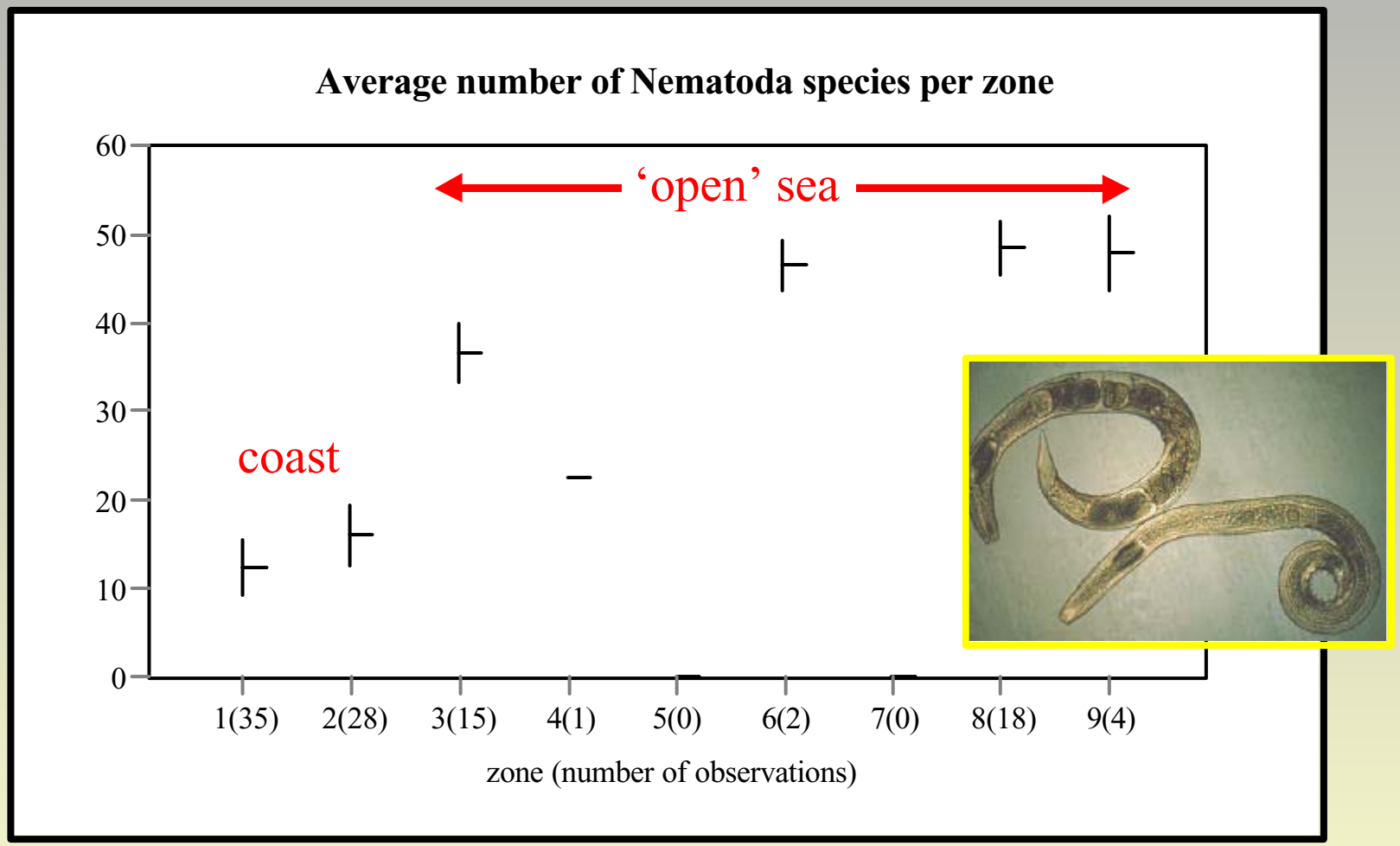
Mollusca : 40

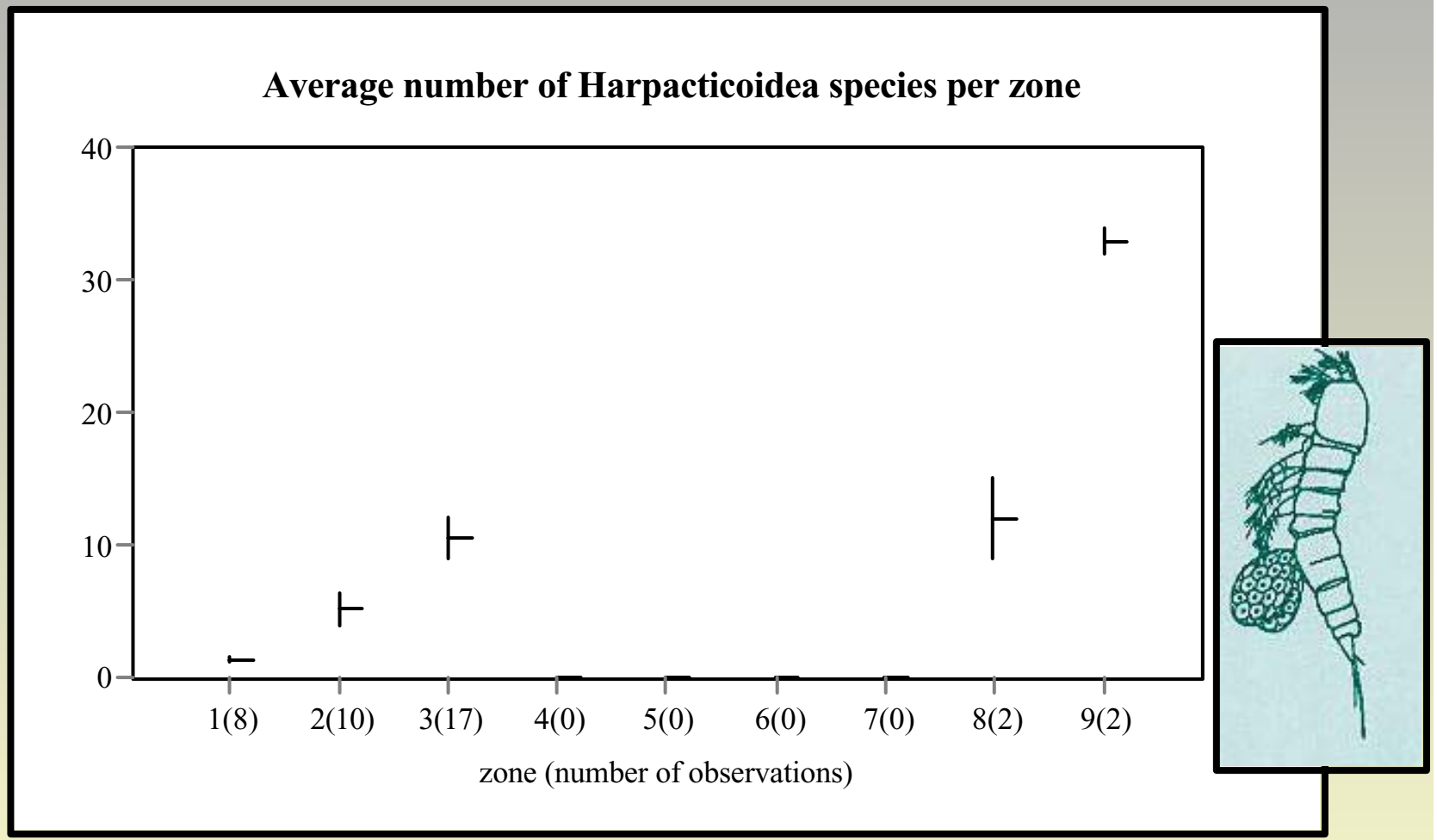
Annelida : 108

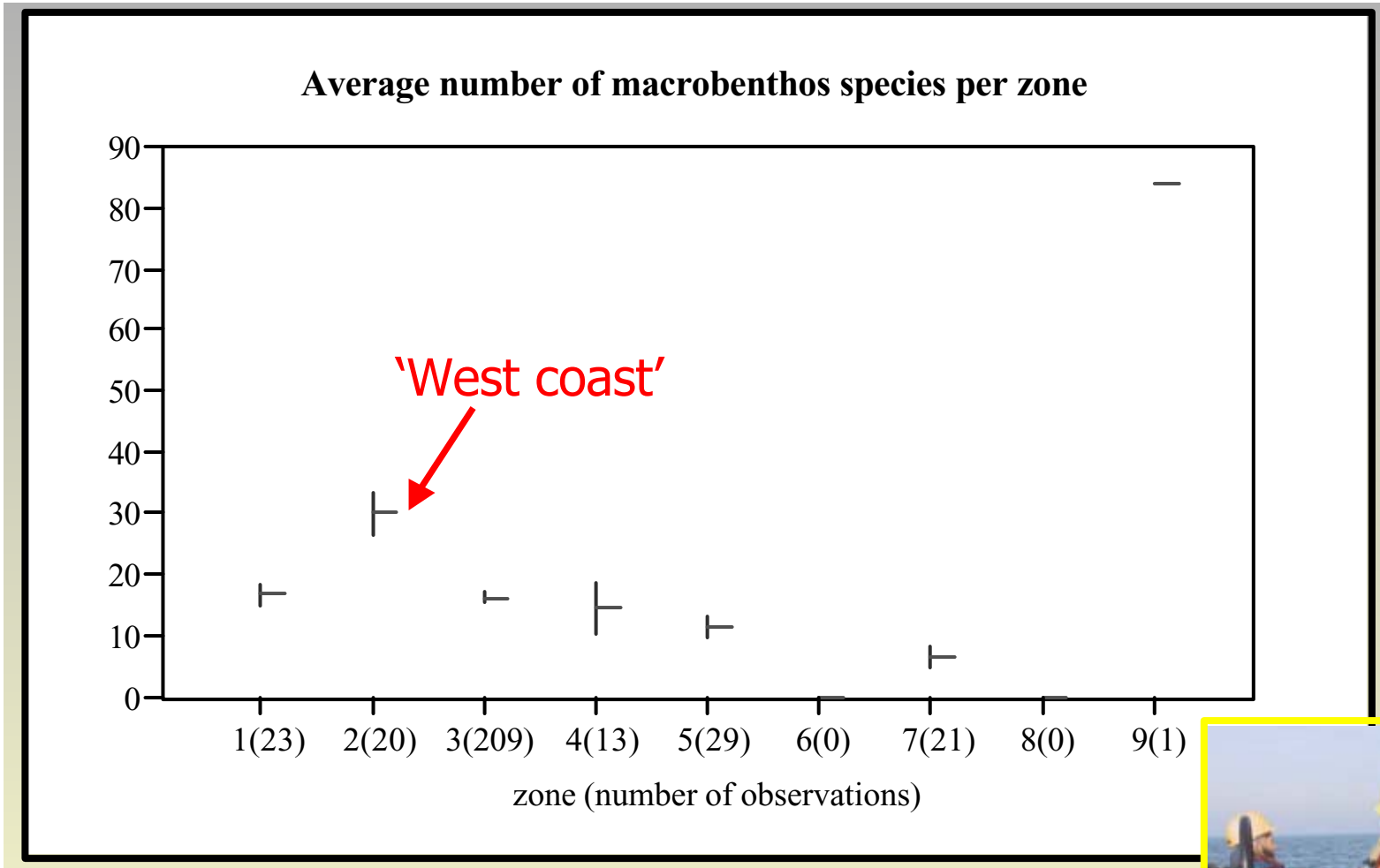
Nematoda : 460

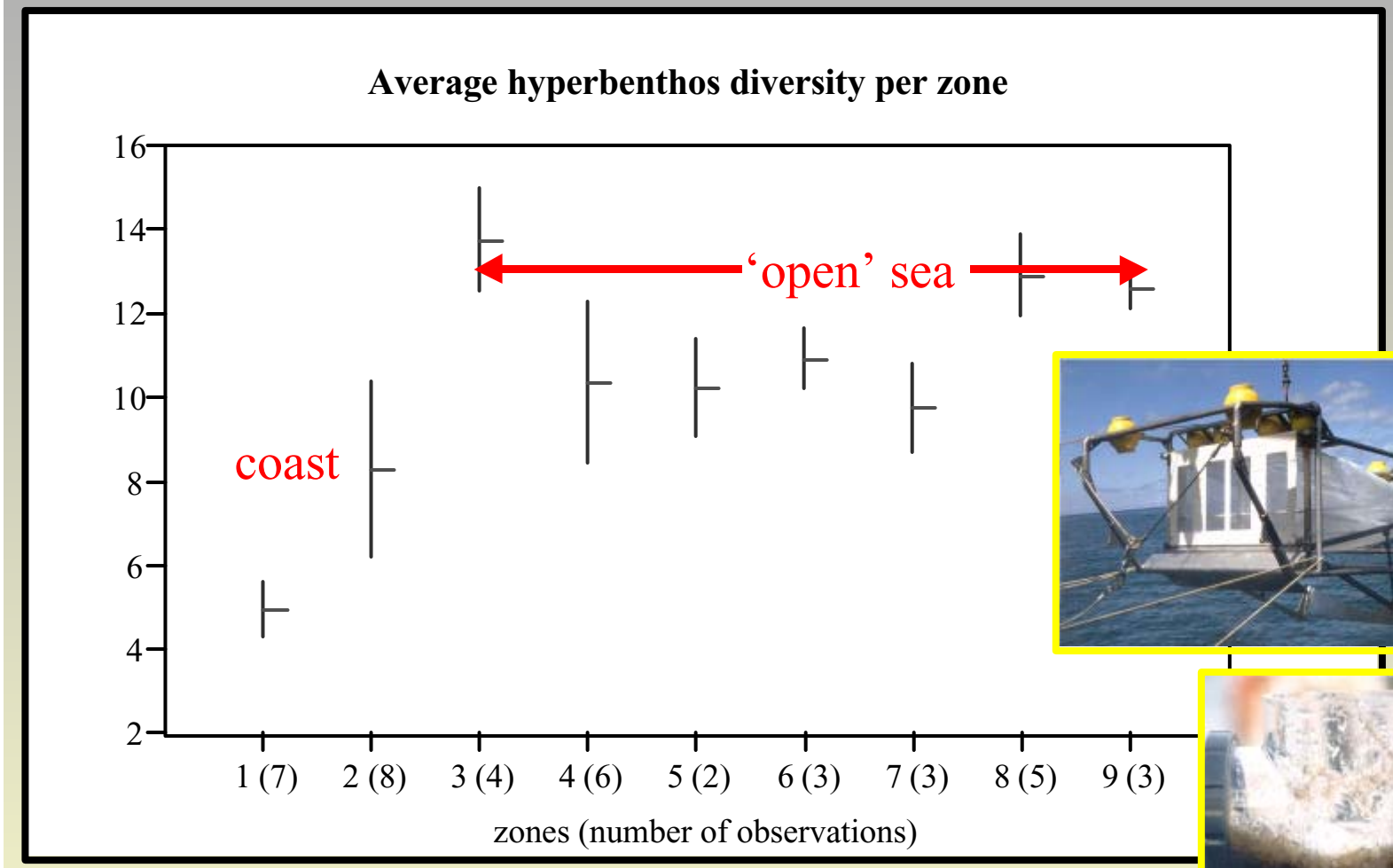
Others : 15

TOTAL :
1056 metazoan species

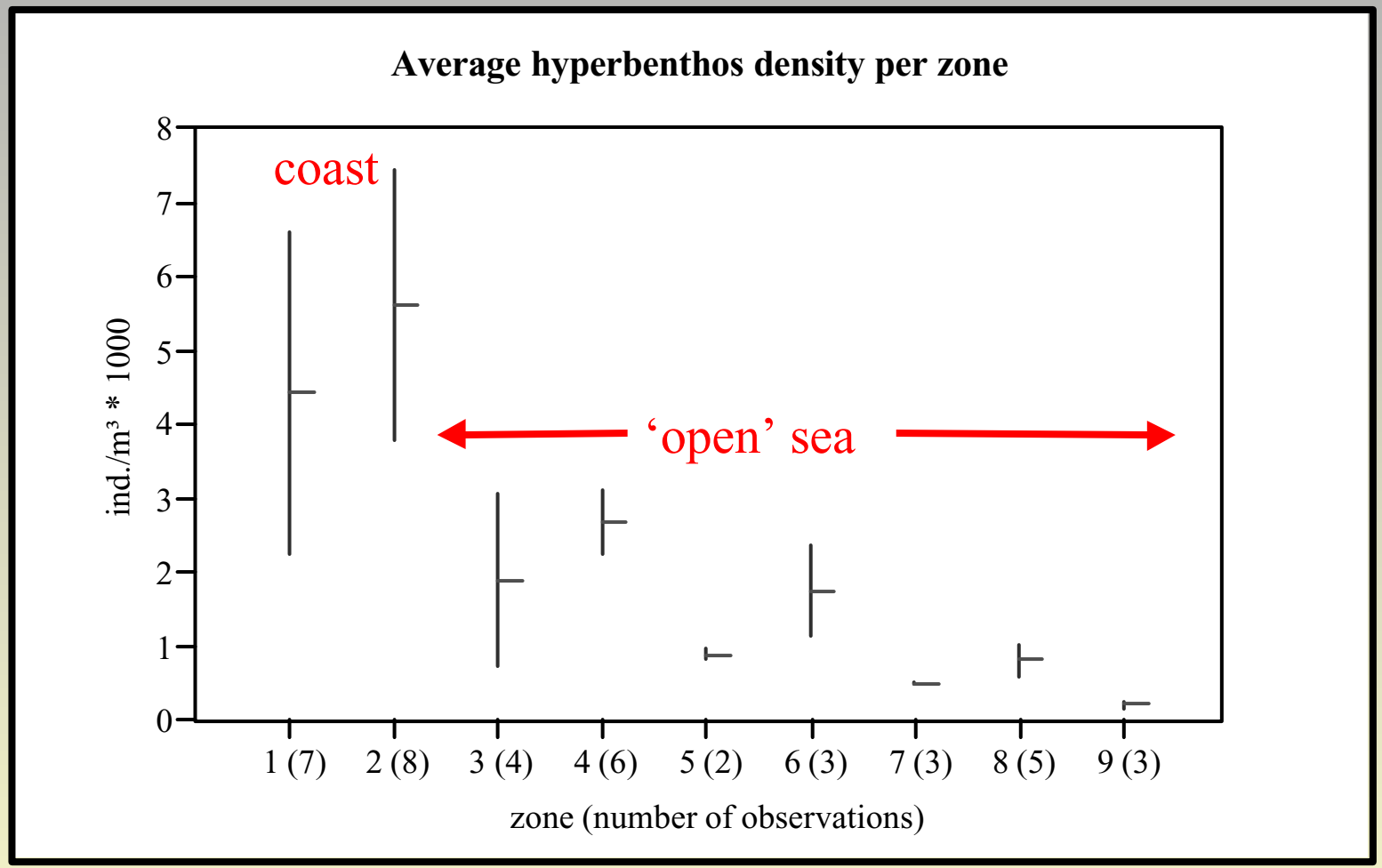

Average number of Nematoda species per zone
60
50
40
30
20
10
0
‘open’ sea
coast
1(35)
2(28)
3(15)
4(1)
5(0)
6(2)
7(0)
8(18)
9(4)
zone (number of observations)


Average number of Harpacticoidea species per zone
40
30
20
10
0
1(8)
2(10)
3(17)
4(0)
5(0)
6(0)
7(0)
8(2)
9(2)
zone (number of observations)

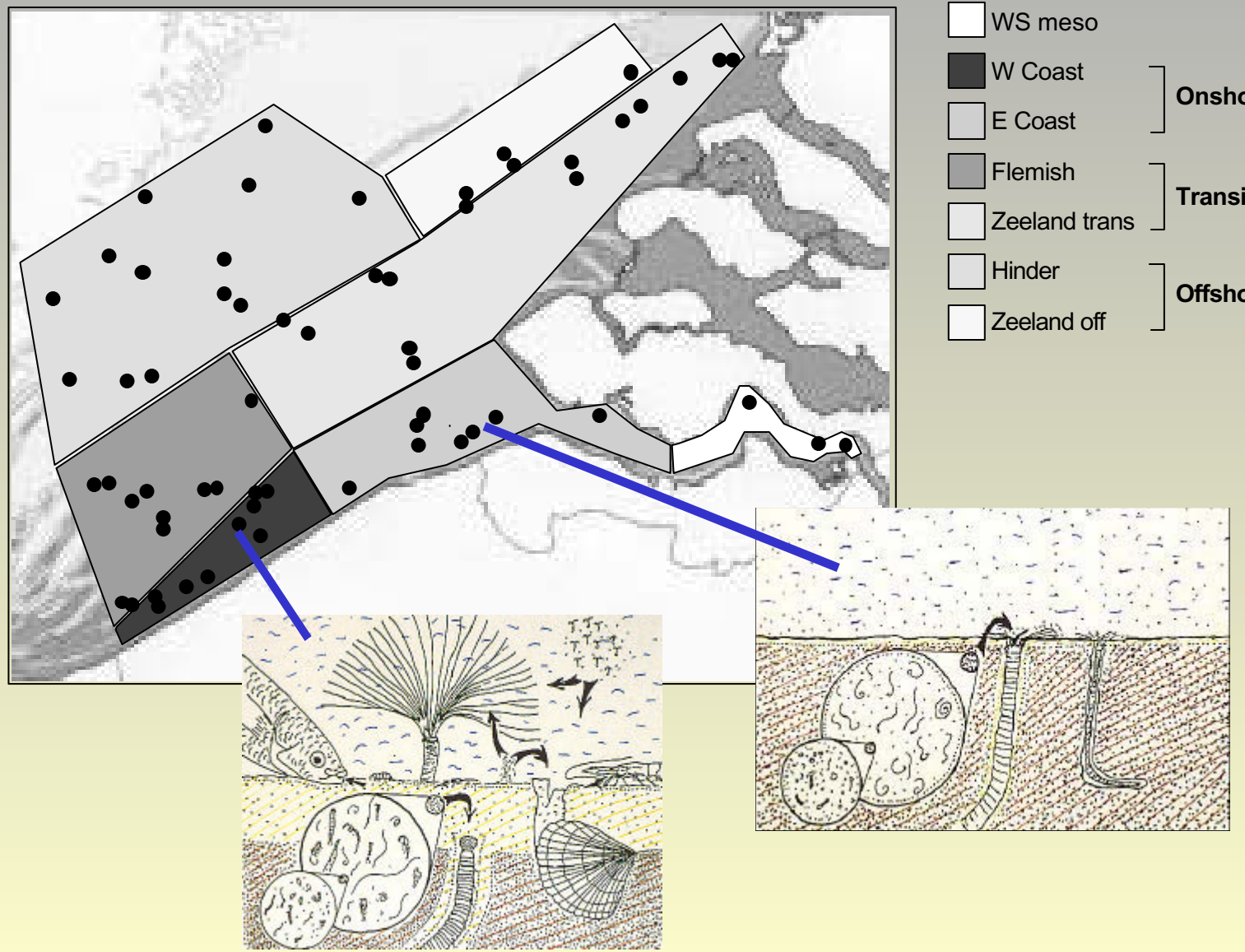

Average number of macrobenthos species per zone
90
80
70
60
50
40
30
20
10
0
'West coast'
1(23)
2(20)
3(209)
4(13)
5(29)
6(0)
7(21)
8(0)
9(1)
zone (number of observations)



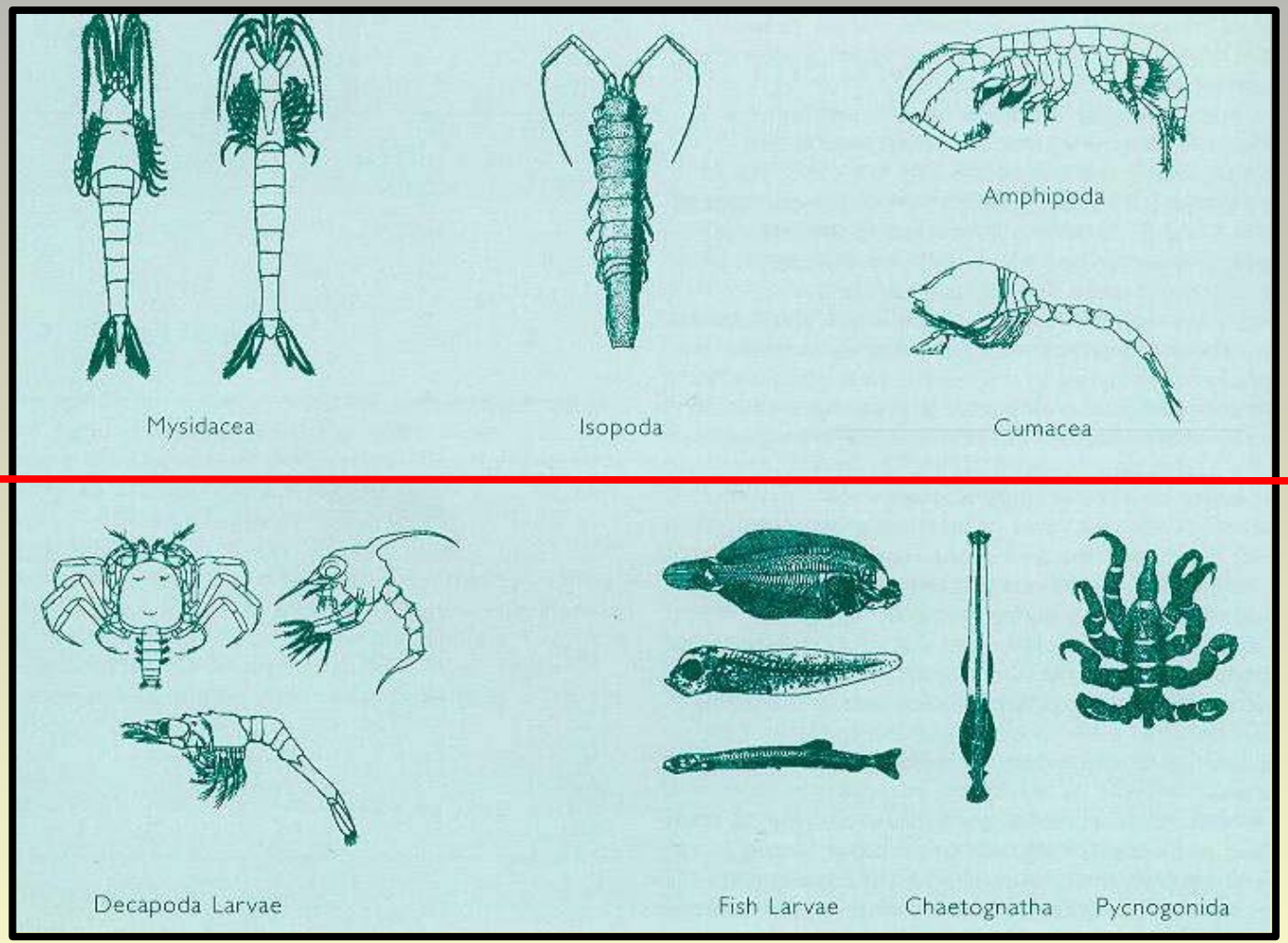
Coastal gradient : eastern coast less diverse than western



Onshore – offshore gradient : decreasing density


WS meso
W Coast
E Coast
Onshore
Flemish
Zeeland trans
Transitional
Hinder
Zeeland off
Offshore

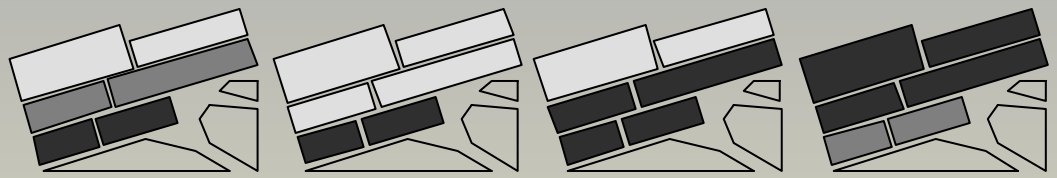
Holohyperbenthos (permanent)



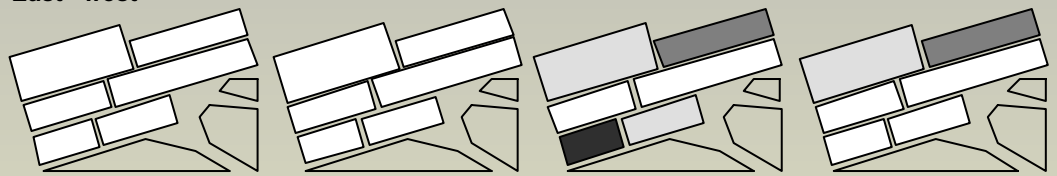
Merohyperbenthos (temporary)

Holohyperbenthos

Onshore - offshore



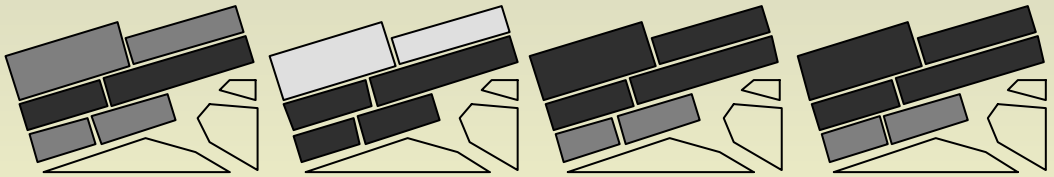
East - west



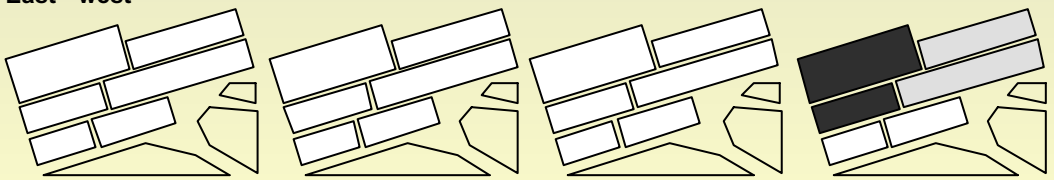
Density Biomass Species richness Species diversity

Merohyperbenthos

Onshore - offshore



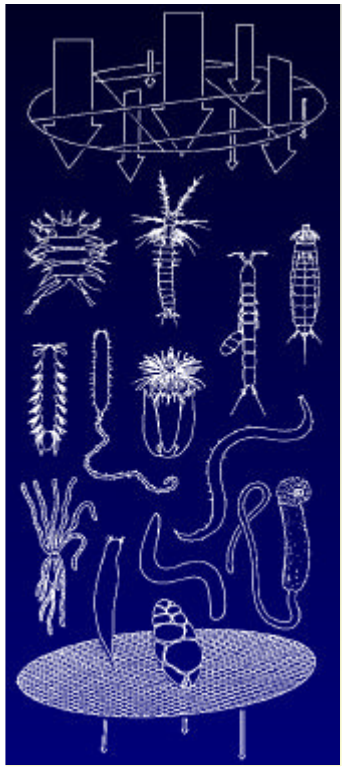
East - west



Density Biomass Species richness Species diversity

2. Spatial patterns on sandbanks ecosystem

Meiobenthos : Flemish Banks, Hinder Banks, Zeeland Banks, February and October

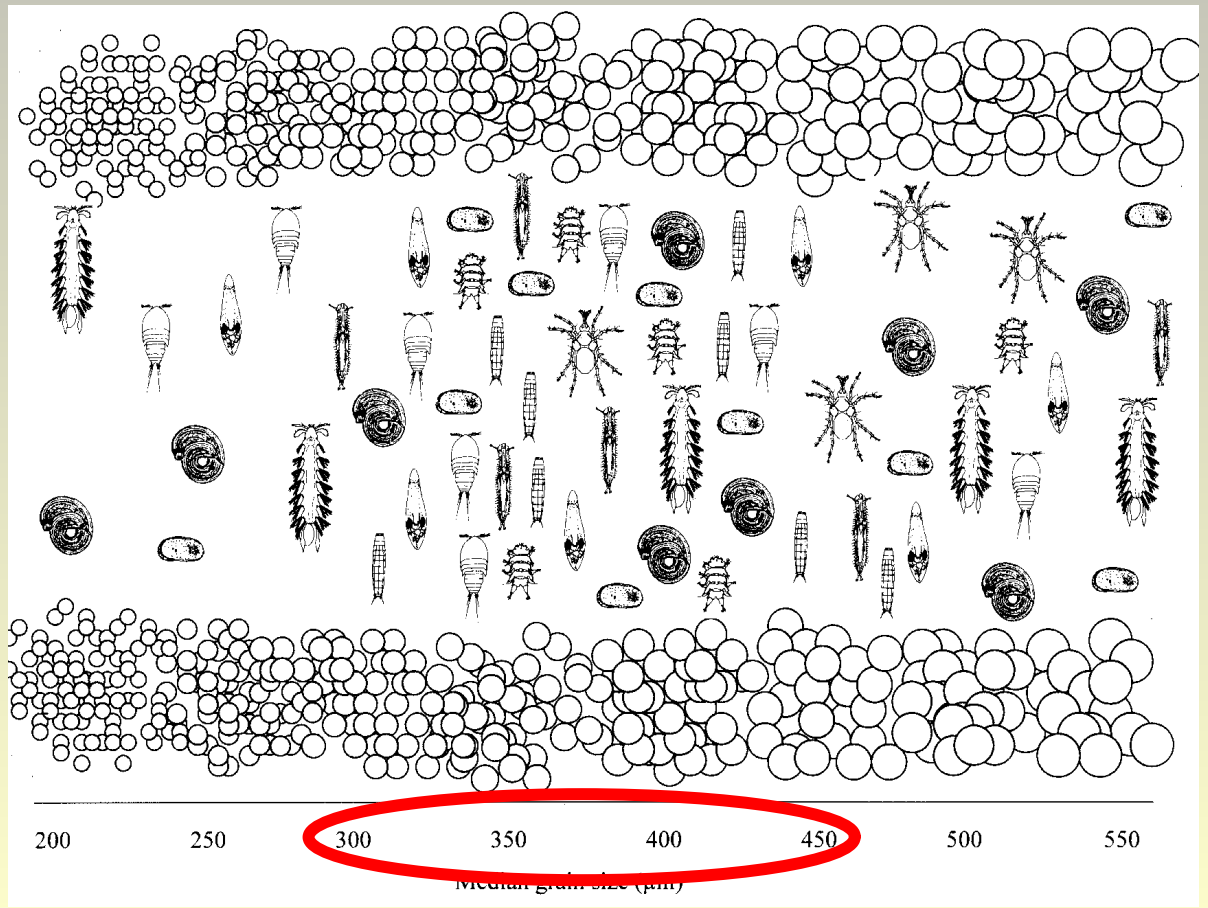


1 mm

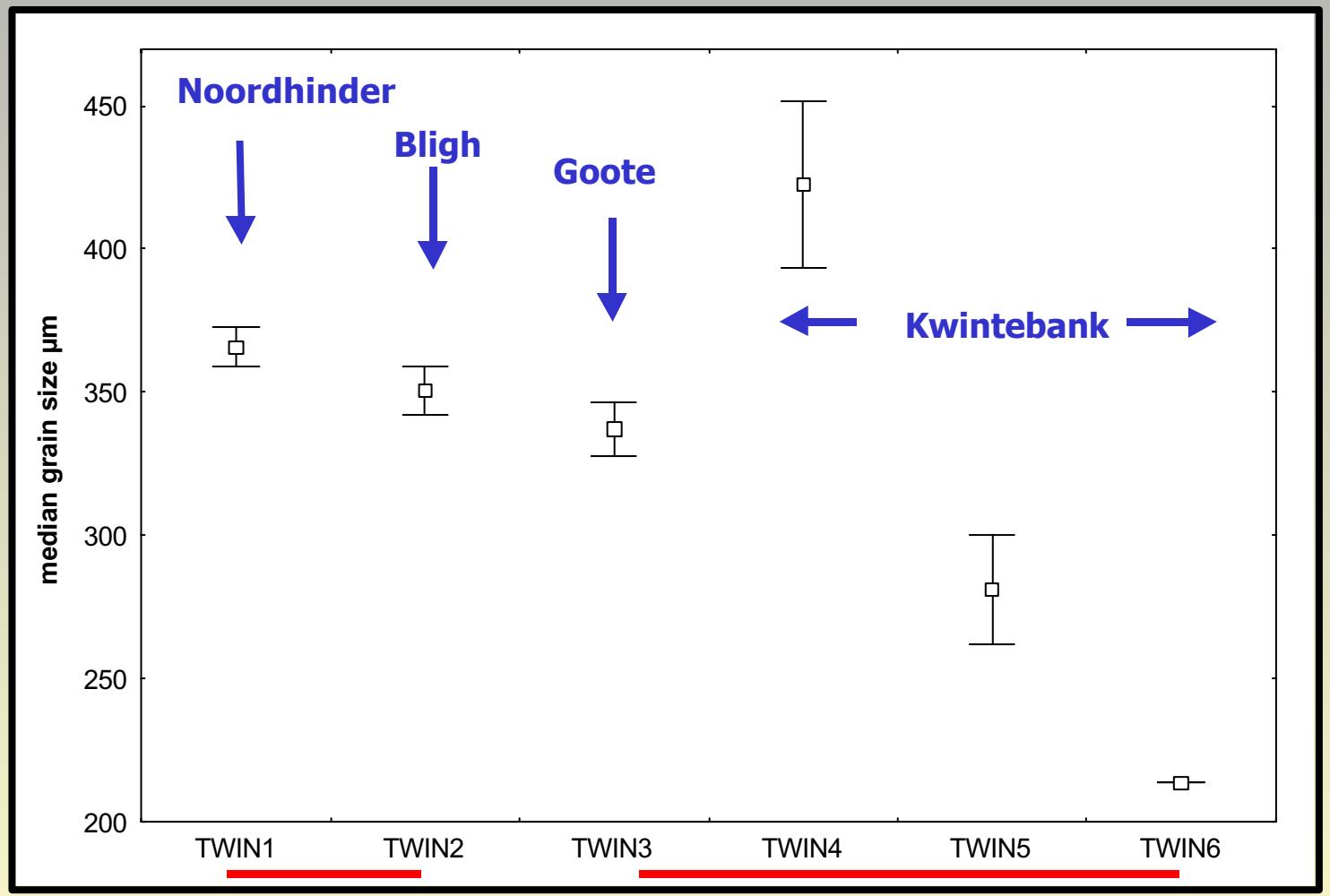
38 µm

2. Spatial patterns on sandbanks ecosystem

4 meiobenthic communities related with sediment grain size :
No differences between sandbank systems



6 nematode species associations related to different sandbanks



Each sandbank corresponds with a different nematode association :
'biological islands' ??

Macrobenthos-species associations

I. ***Abra alba – Mysella bidentata*** **community**

gullies of the western coastal sandbanks,
southern Flemish banks; fine sand with high mud content

II. ***Nephtys cirrosa*** **community**

medium sand, very low mud content,

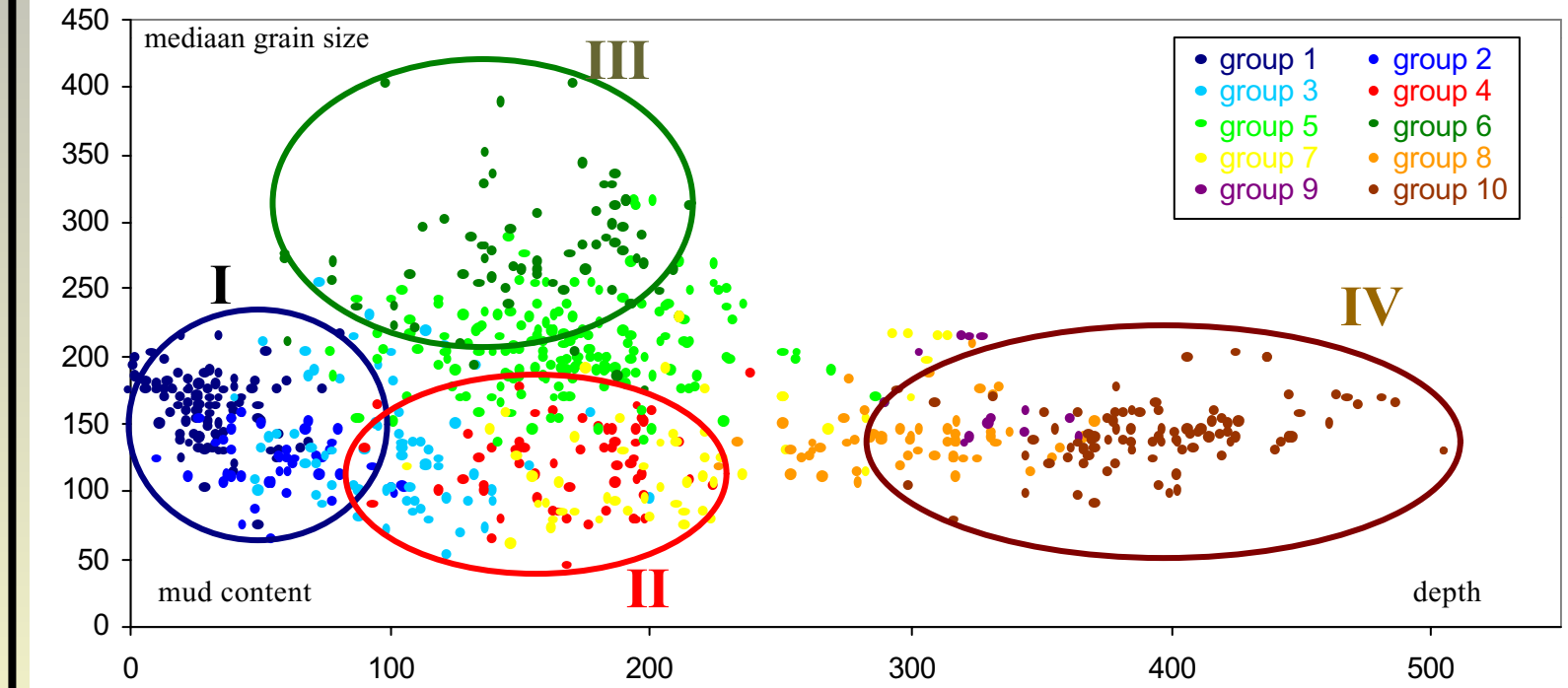
III. ***Ophelia limacina – Glycera lapidum*** **community**

Coarse sands; offshore sandbanks
(Flemish Banks, Hinder Banks, Zeeland Banks)

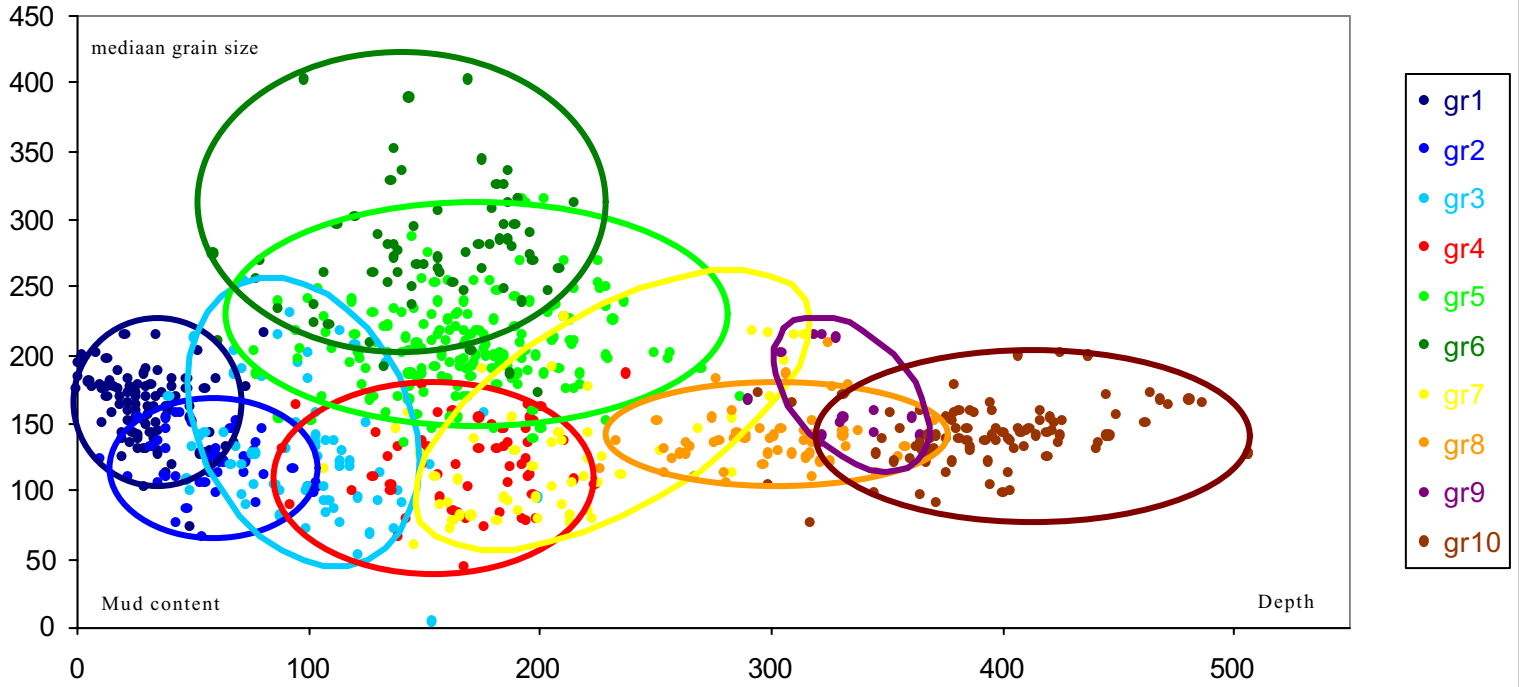
IV. ***Eurydice pulchra – Scolelepis squamata*** **community**

Intertidal sandy beaches

Macrobenthic communities



Macrobenthic communities and transitional species associations



Seabirds : 121 species from which 23 true marine species

6 focal seabird species and

Red-throated Diver
Common Scoter
Little Gull
Sandwich Tern
Common Tern
Little tern

5 'locally important' species

Great-crested Grebe

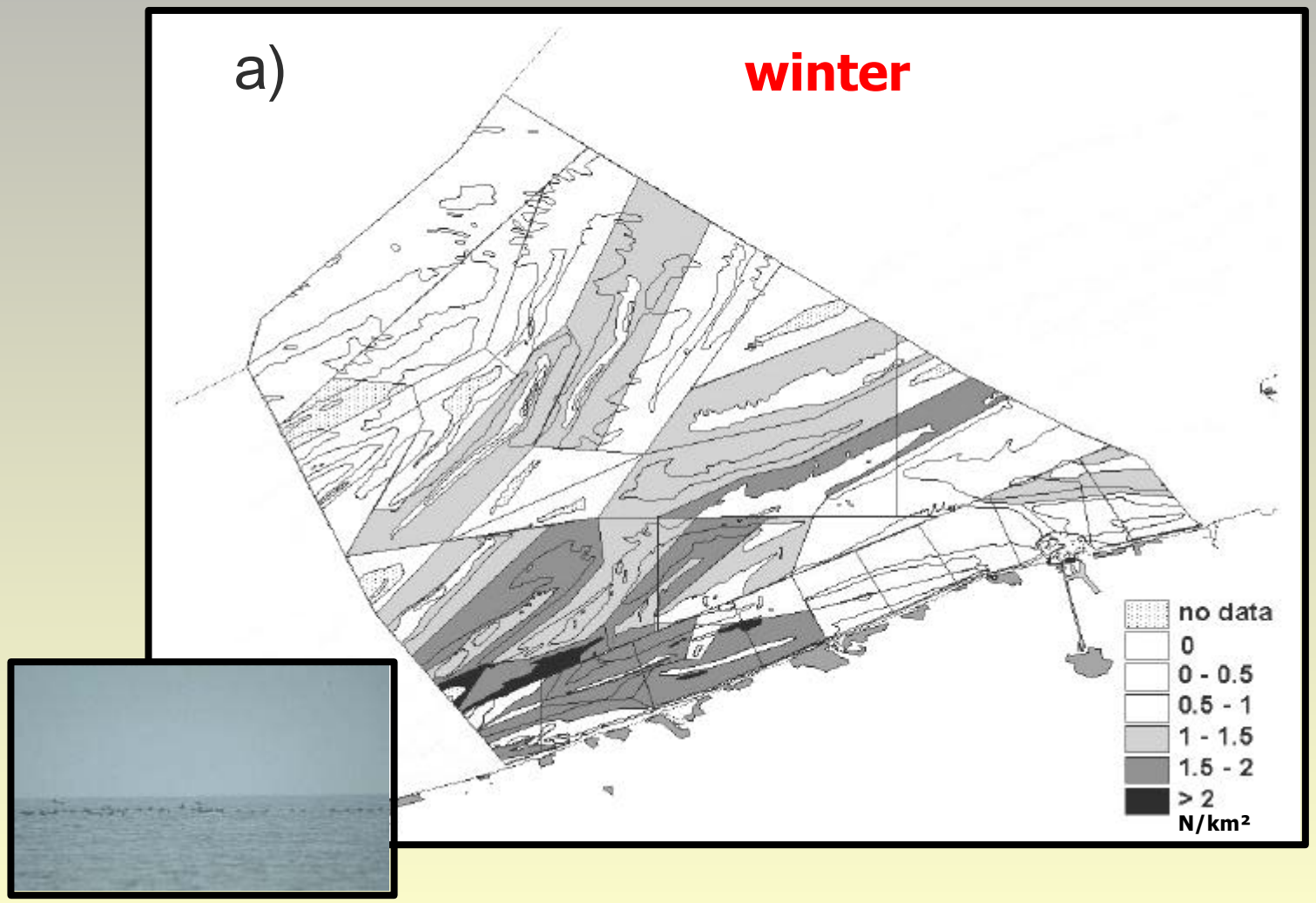
Great Skua

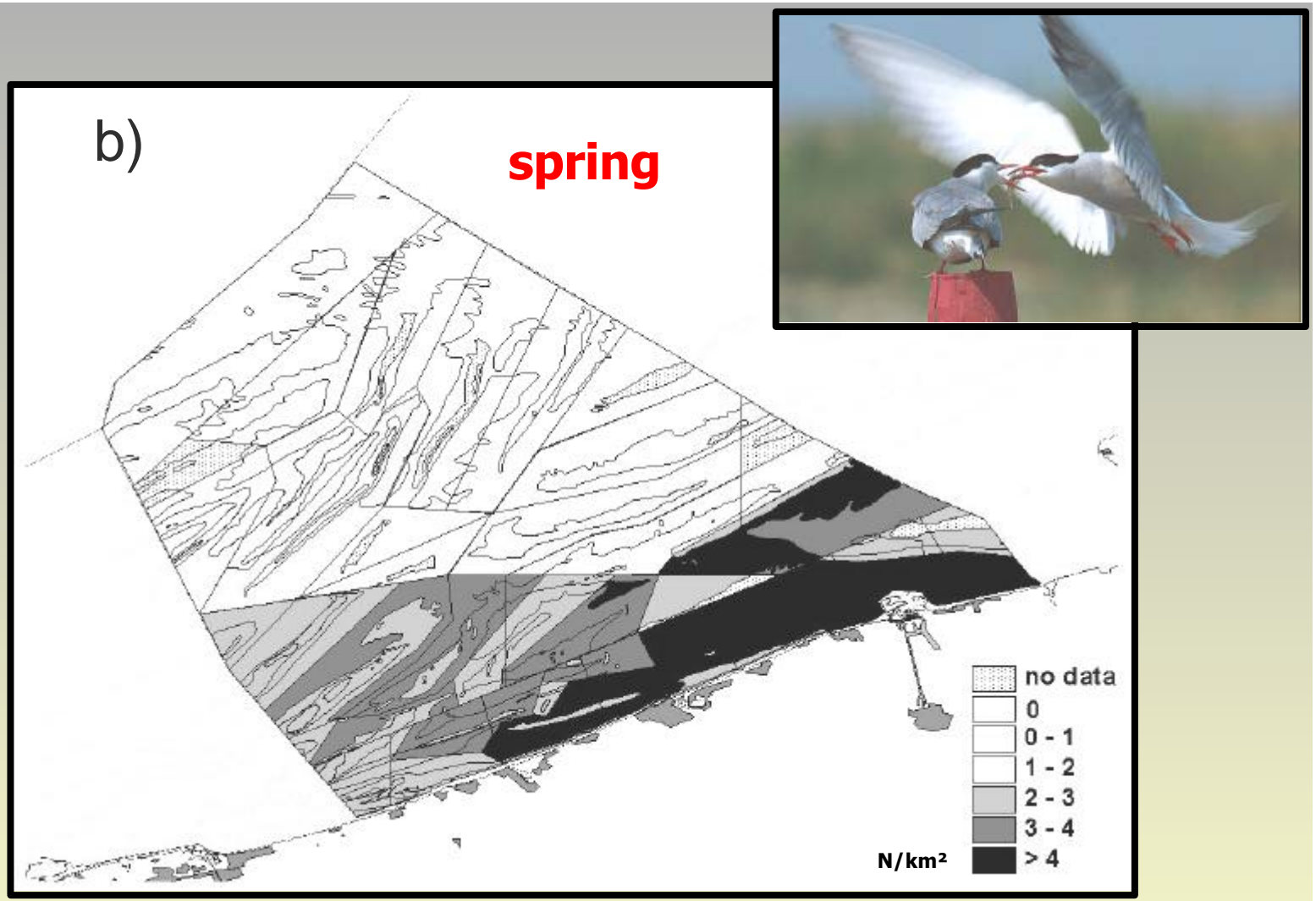
Lesser Black-backed Gull

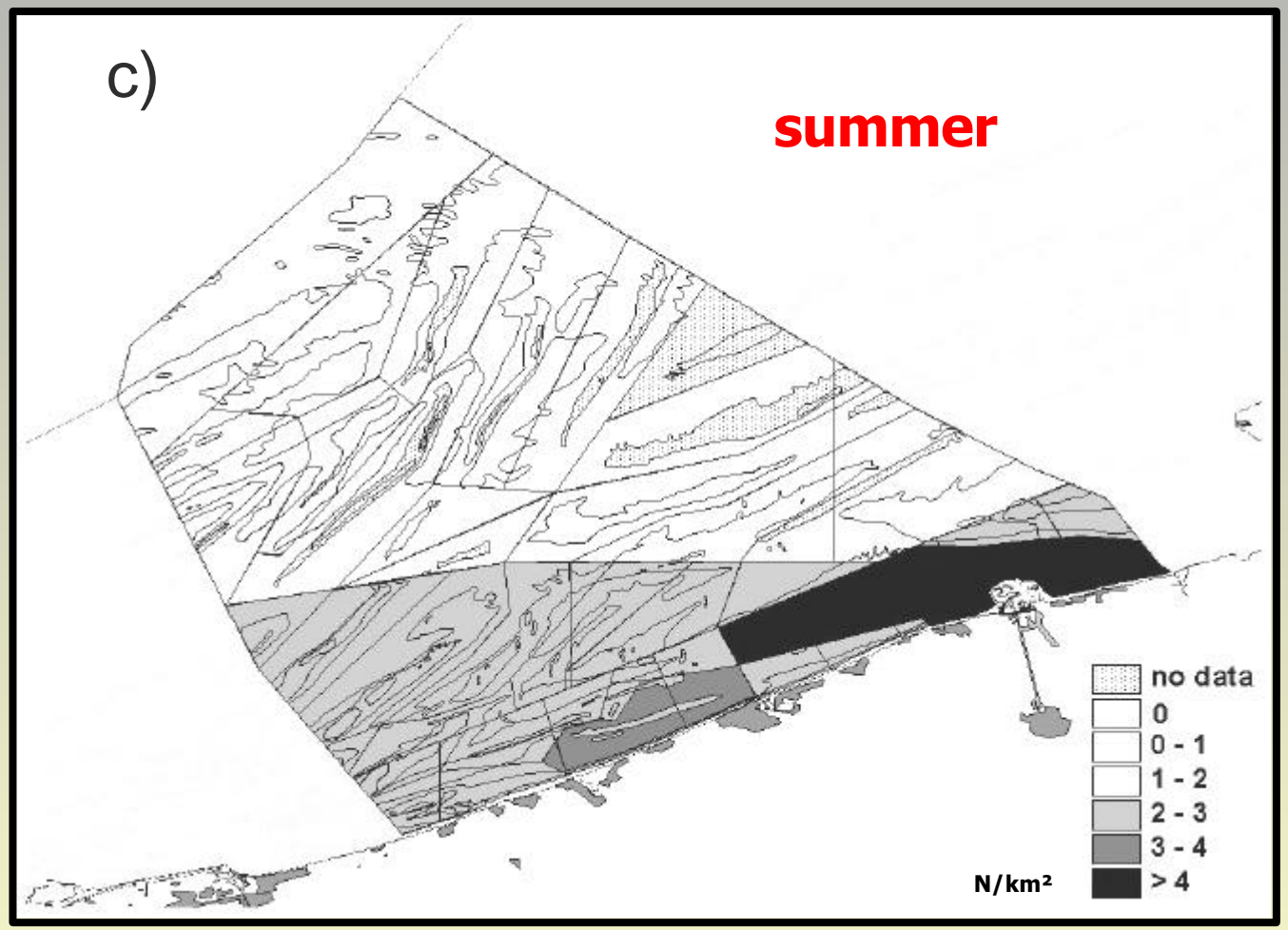
Herring Gull

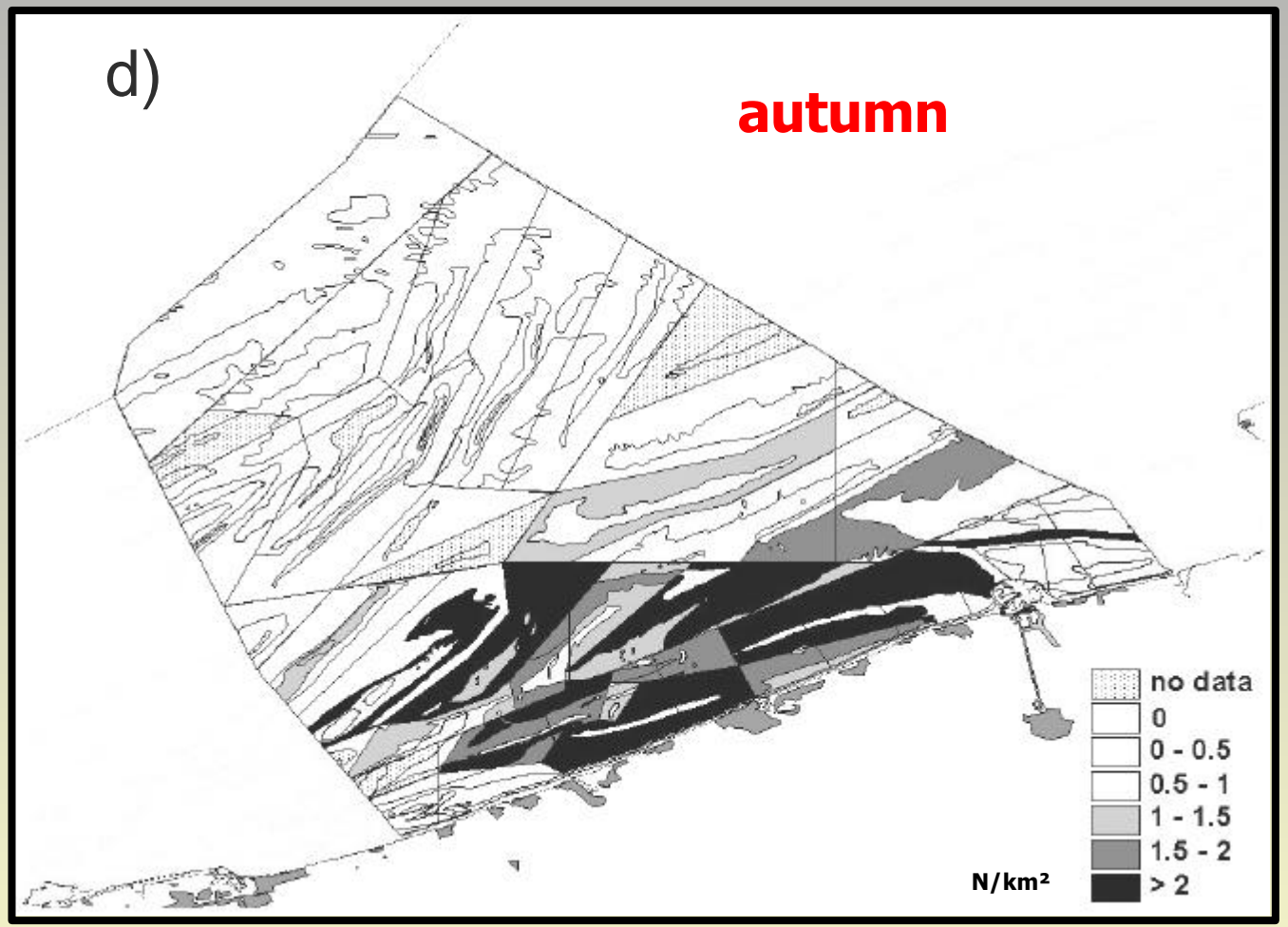
Great Black-backed Gull

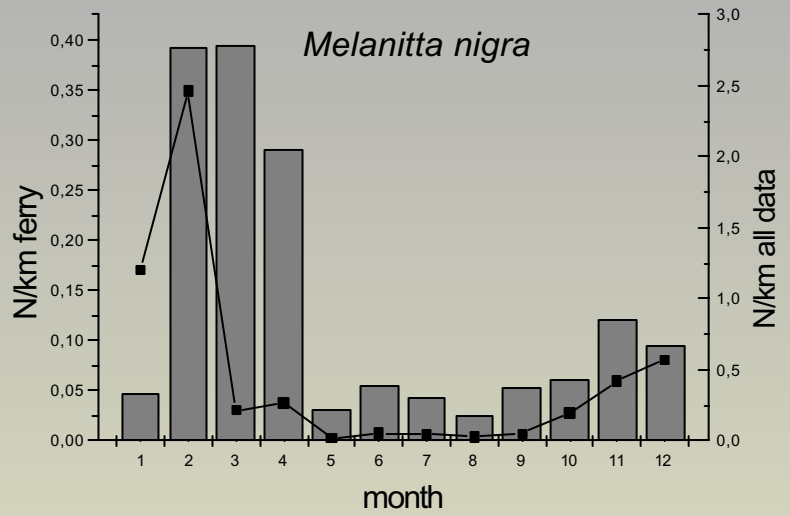
Hotspots for focal seabird species

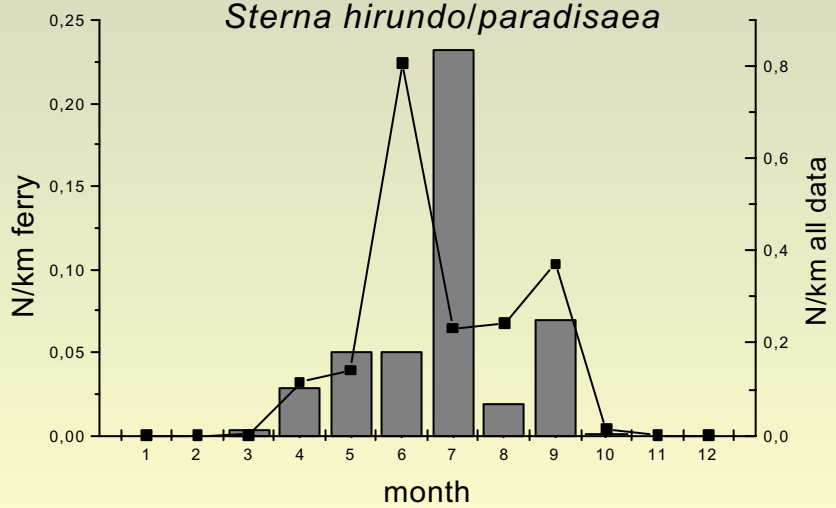



b)
spring
no data
0
0 - 1
1 - 2
2 - 3
3 - 4
> 4
N/km²


c)
summer
no data
0
0 - 1
1 - 2
2 - 3
3 - 4
> 4
N/km²


d)
autumn
no data
0
0 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
> 2
N/km²


Melanitta nigra
N/km ferry
N/km all data
month
0,00
0,05
0,10
0,15
0,20
0,25
0,30
0,35
0,40
0,0
0,5
1,0
1,5
2,0
2,5
3,0
1
2
3
4
5
6
7
8
9
10
11
12

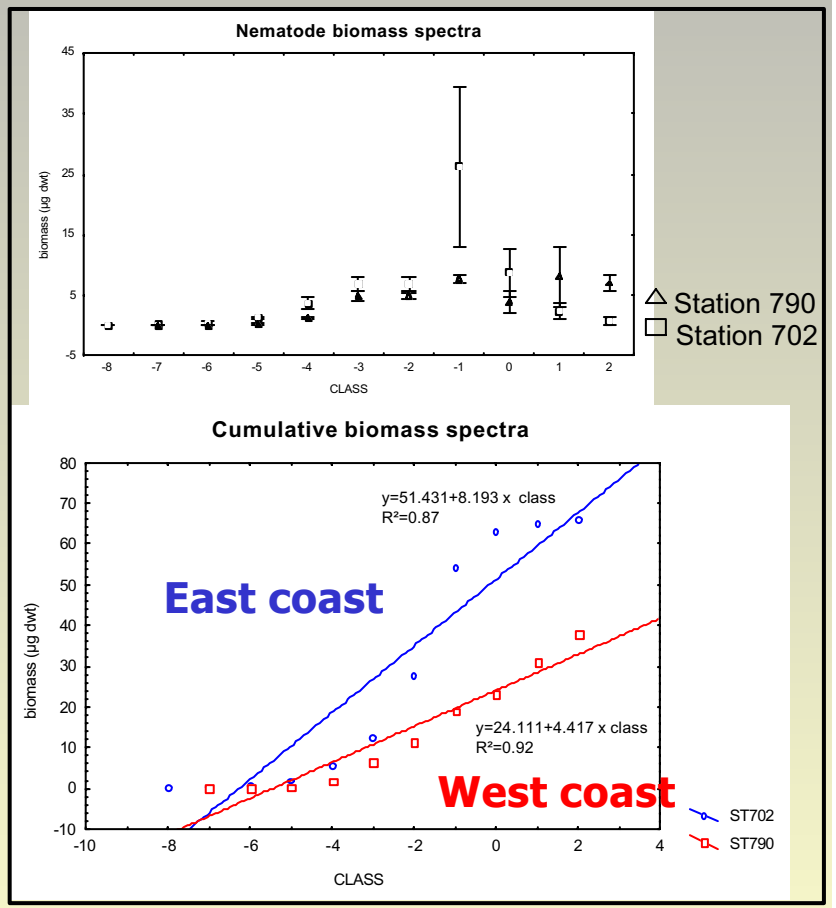

Sterna hirundo/paradisaea
N/km ferry
N/km all data
month
0,00
0,05
0,10
0,15
0,20
0,25
0,0
0,2
0,4
0,6
0,8
1
2
3
4
5
6
7
8
9
10
11
12

3. Ecological indicators

an easy measure for community change due to general disturbances

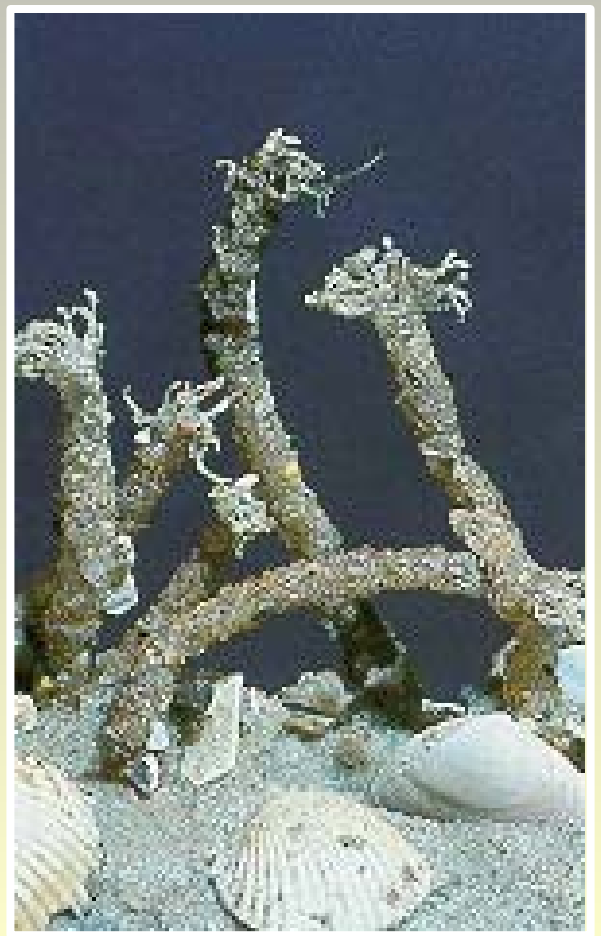
Nematode Biomass Spectra

- **Distinction between disturbance on sandbanks due to sand extraction**
- **Eutrophication along the coast**
- **Effect of Spring phytoplankton bloom**



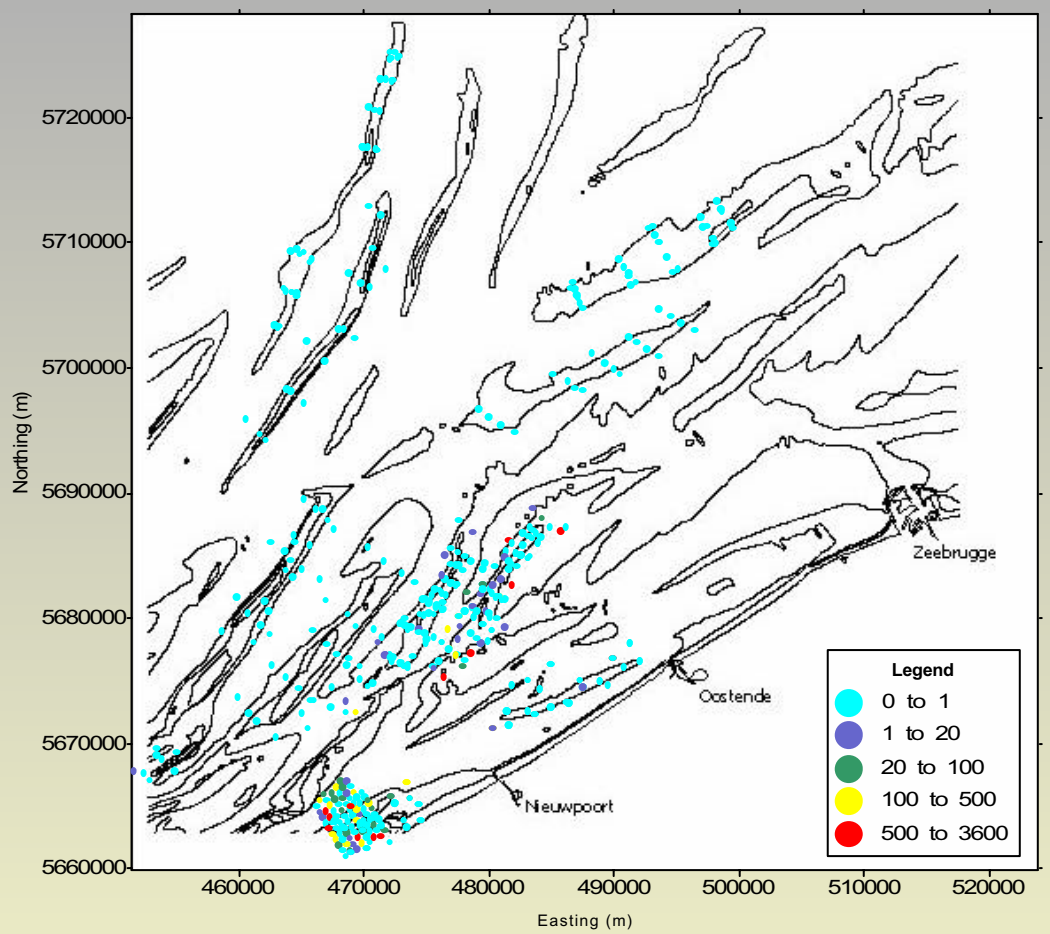
3. Ecological indicators

Distribution of *Lanice conchilega*
and the *Abra alba – Mysella bidentata* community



'tube' building polychaete, 30-40 cm in sediment

forming 'reef'-like structures



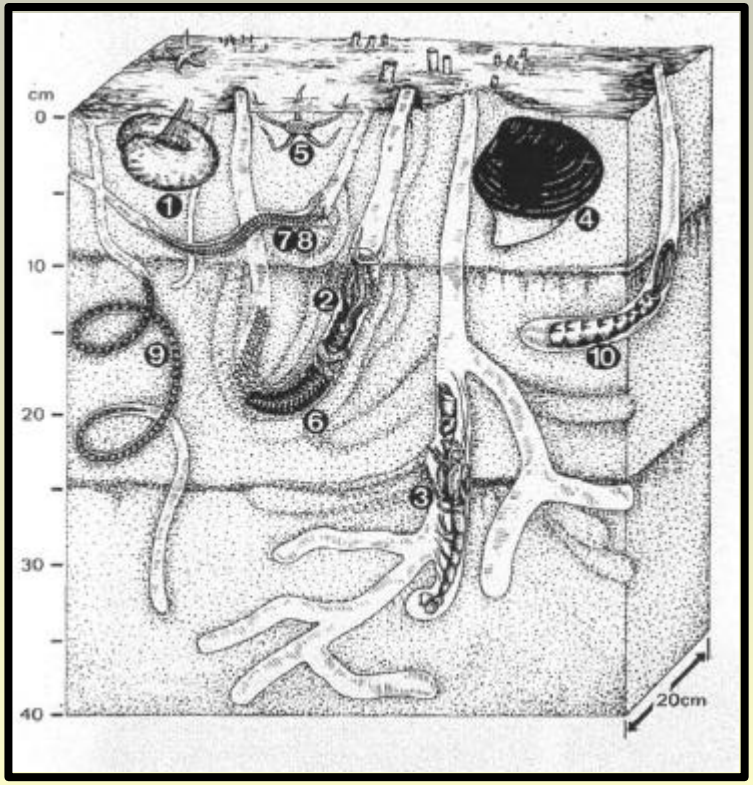
Lanice conchilega :

gullies nearby the Flemish Banks, Middelkerke and Kwintebank
gullies and flanks of the Coastal Banks
(Abra alba- Mysella bidentata .. Community)

benthic indicator – communities

rather than

benthic indicator species



Temporal dynamics;
very complex biological interactions;

Successful recruitment of 1 species may trigger a chain reaction of changing biological interactions (competition, predation, ..) causing major shifts in species composition and density of the community

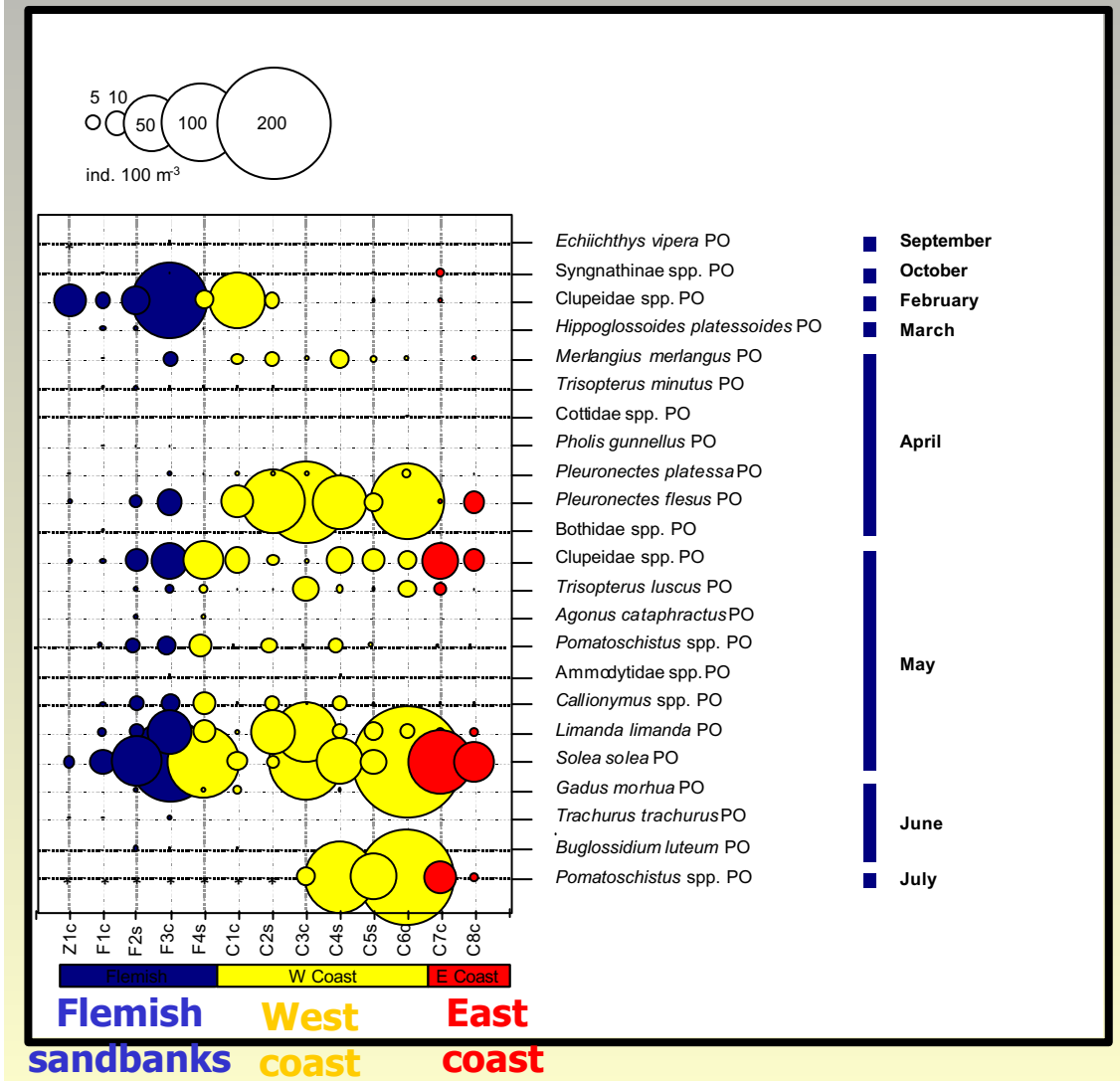
3. Ecological indicators

6 focal seabird species

- numbers and distribution

- international importance and local densities
- feeding strategy (fish and macrobenthos)
- behavioural ecology
- contaminants in (tern) eggs and feathers

4. Ecological sensitive areas



Belgian Sandbanks :

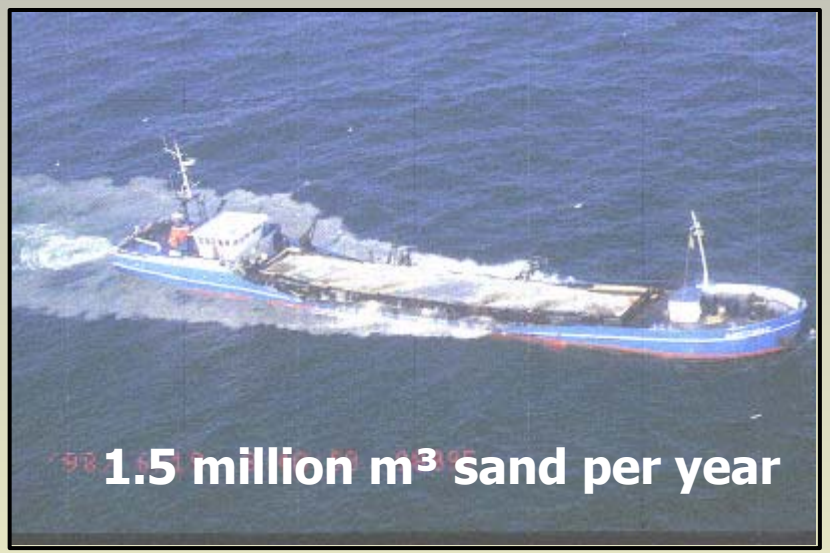
nursery potential and transit area for fish and macrocrustaceans

Belgian sandbanks :

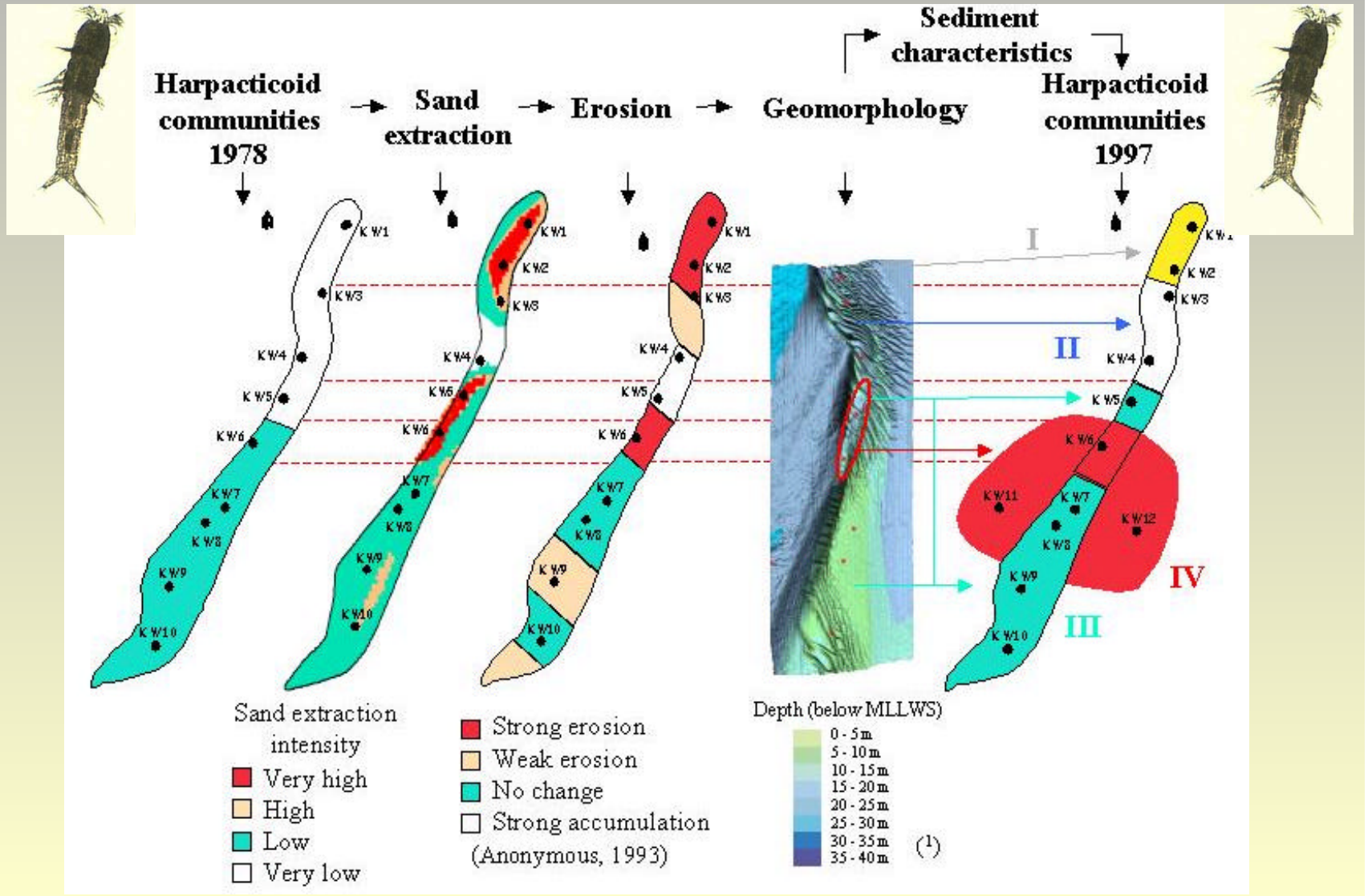
impact of sand and gravel extraction on

benthos biodiversity

95 % of sand extraction
on BCS
on the Kwintebank

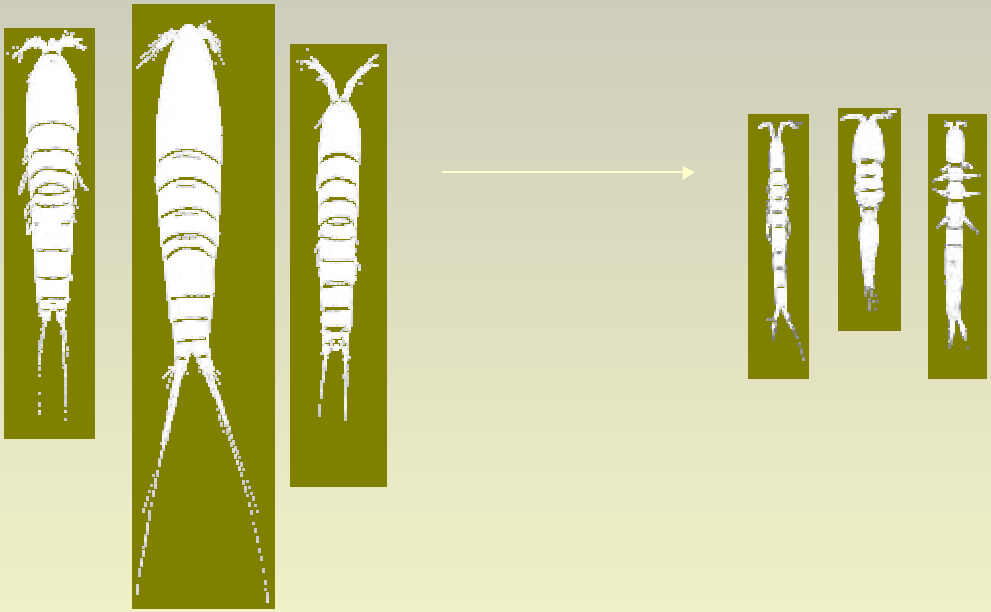


Belgian sandbanks : impact of sand and gravel extraction on benthos biodiversity



Altered species omposition

Big endobenthic and epibenthic species → Small intertsitial species



Importance of copepods as food for fish decreases

Kwintebank is a *case study* but is not considered as the most important sandbank from a biological point of vue

Thanks to historical data BOTH

from sedimentology and biology

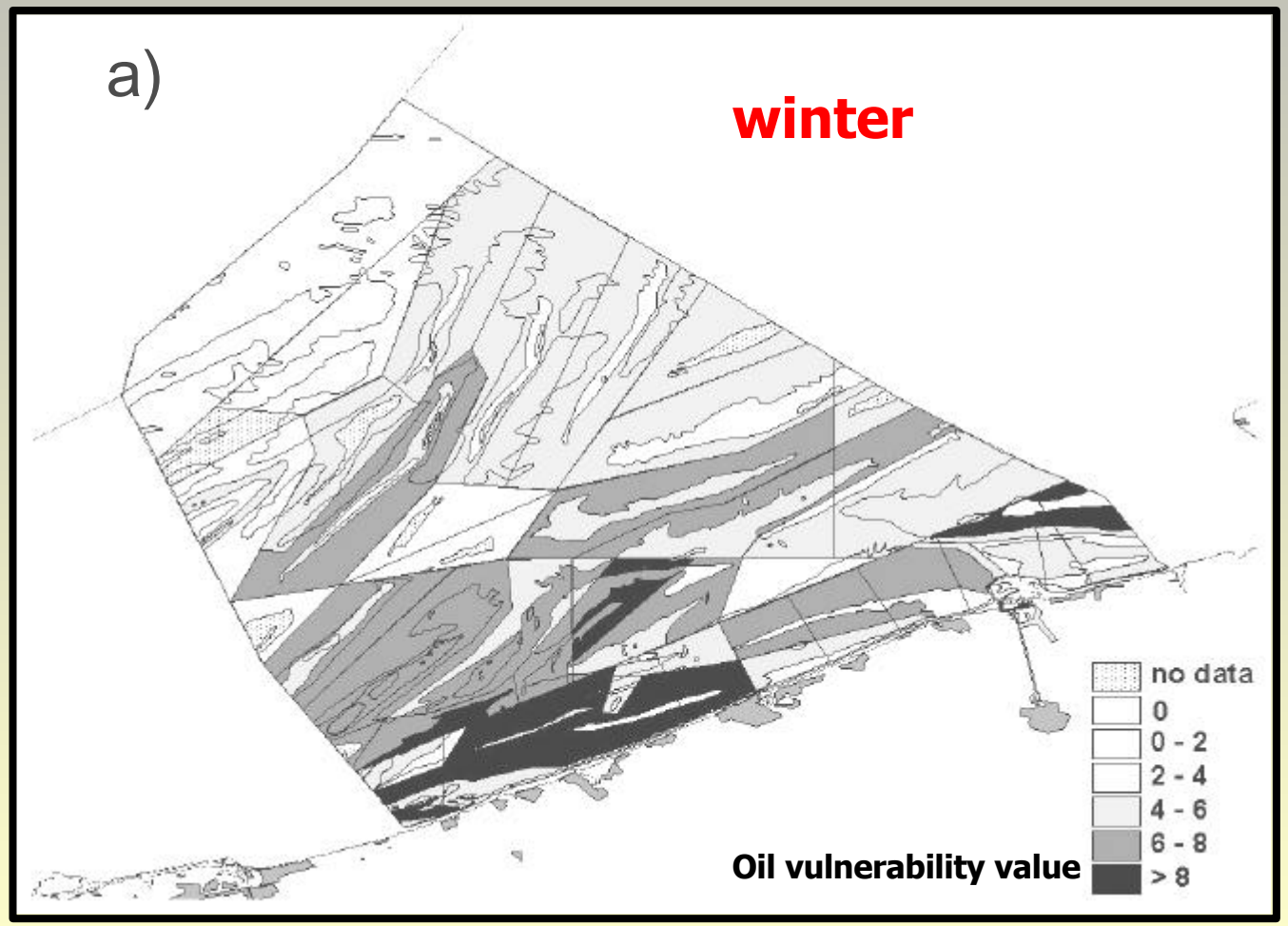
it is indicated that sand extraction

INDEED has an impact on biodiversity !

IMPORTANCE of LONG TERM MONITORING !

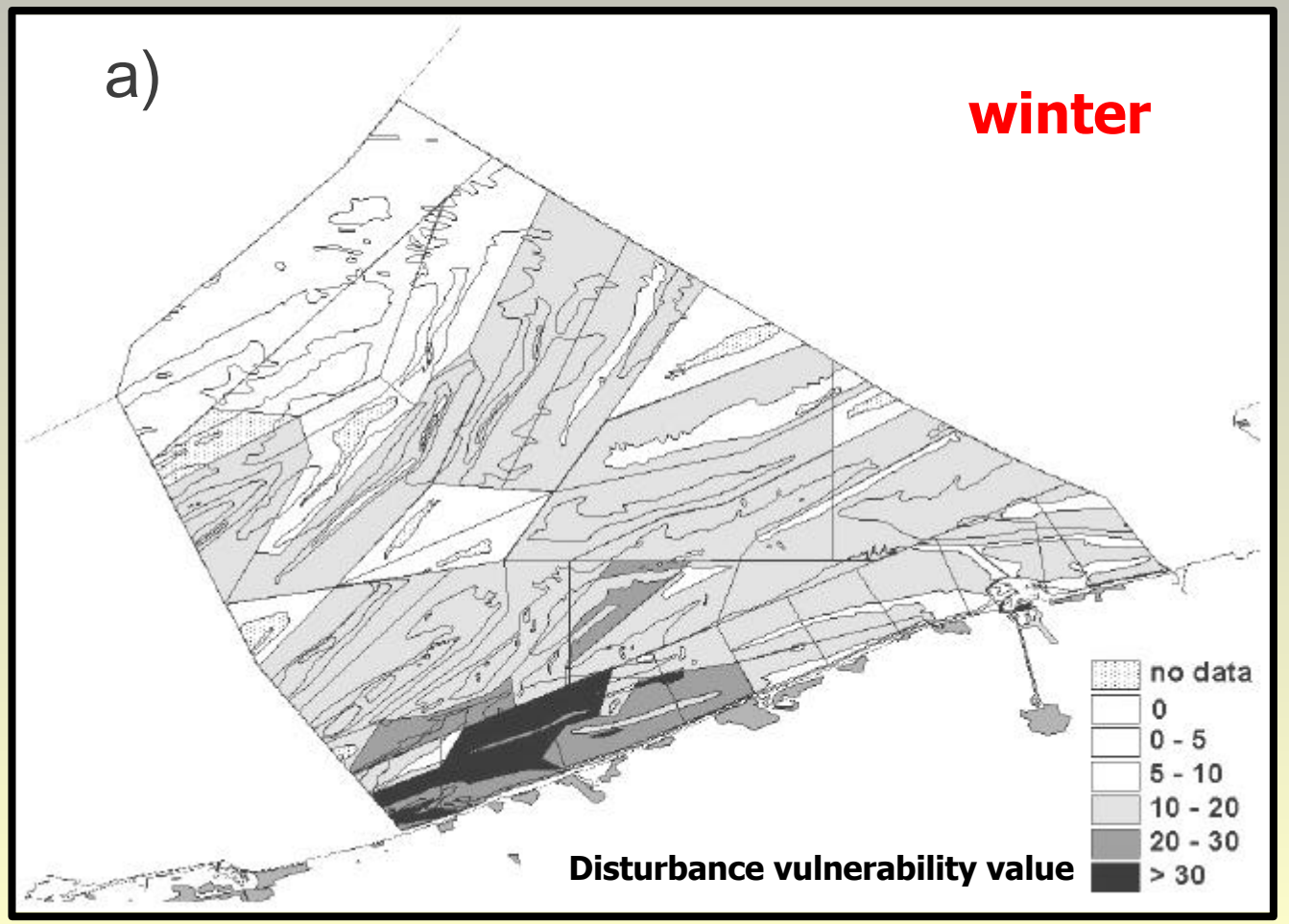
4. Ecological sensitive areas

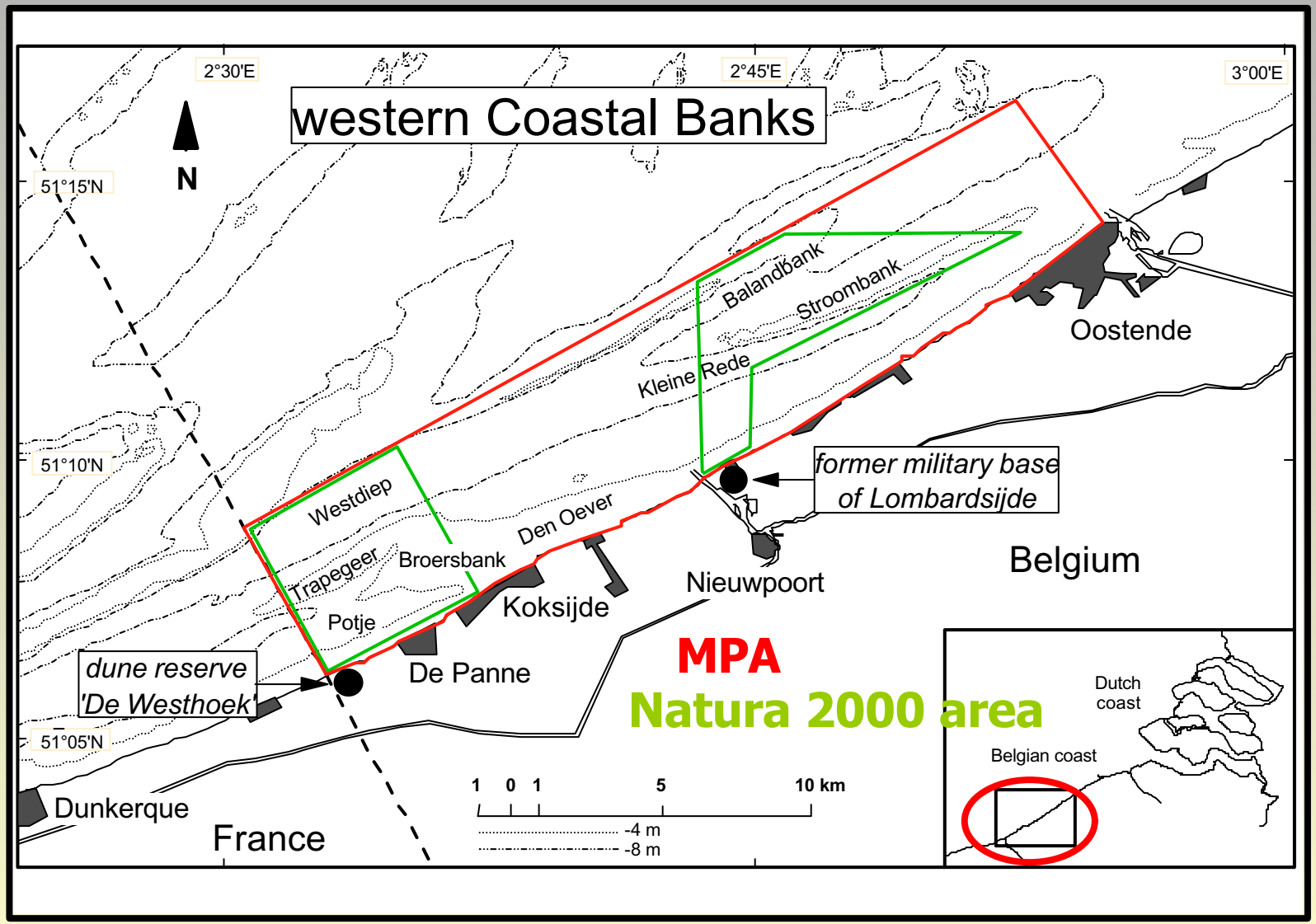
Oil sensitive areas for seabirds



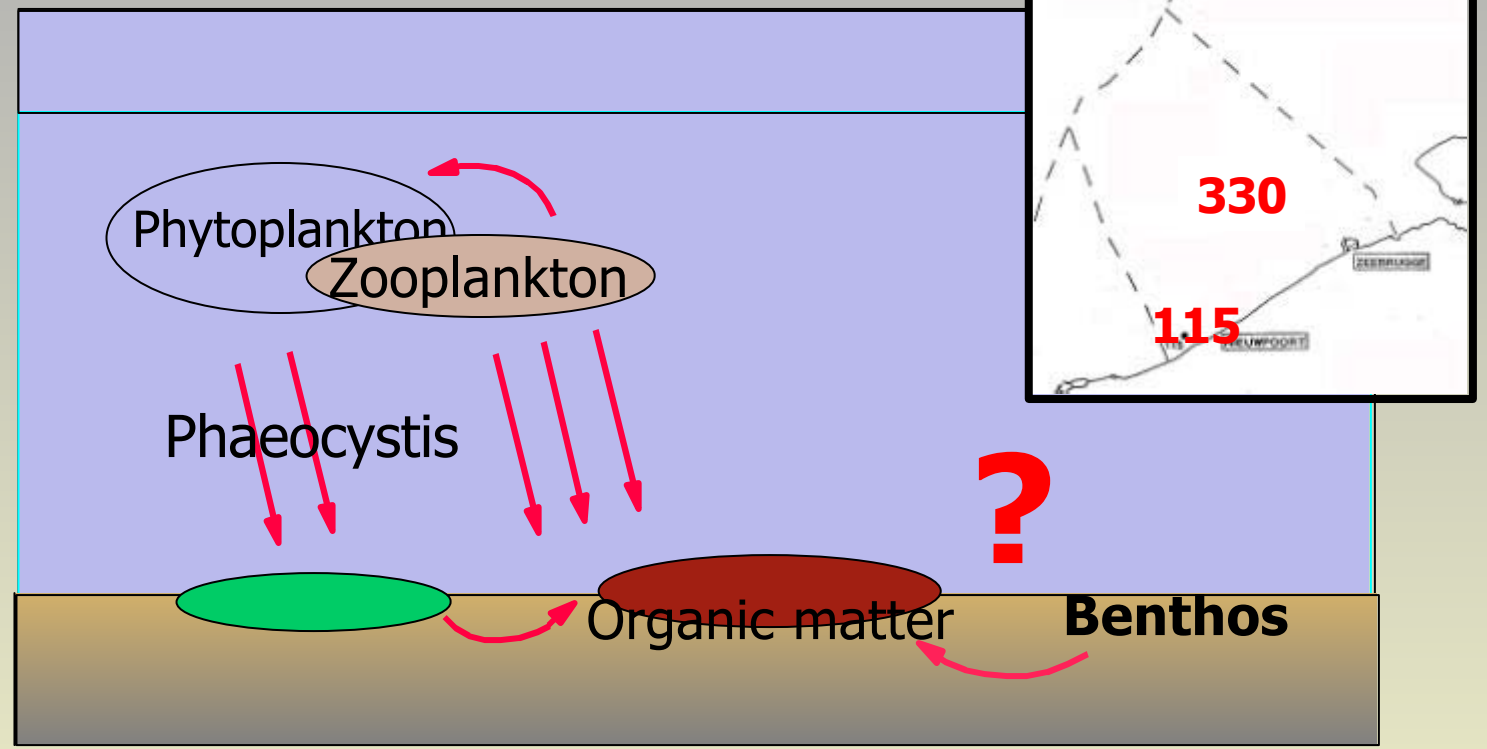
4. Ecological sensitive areas

Disturbance sensitive areas for seabirds



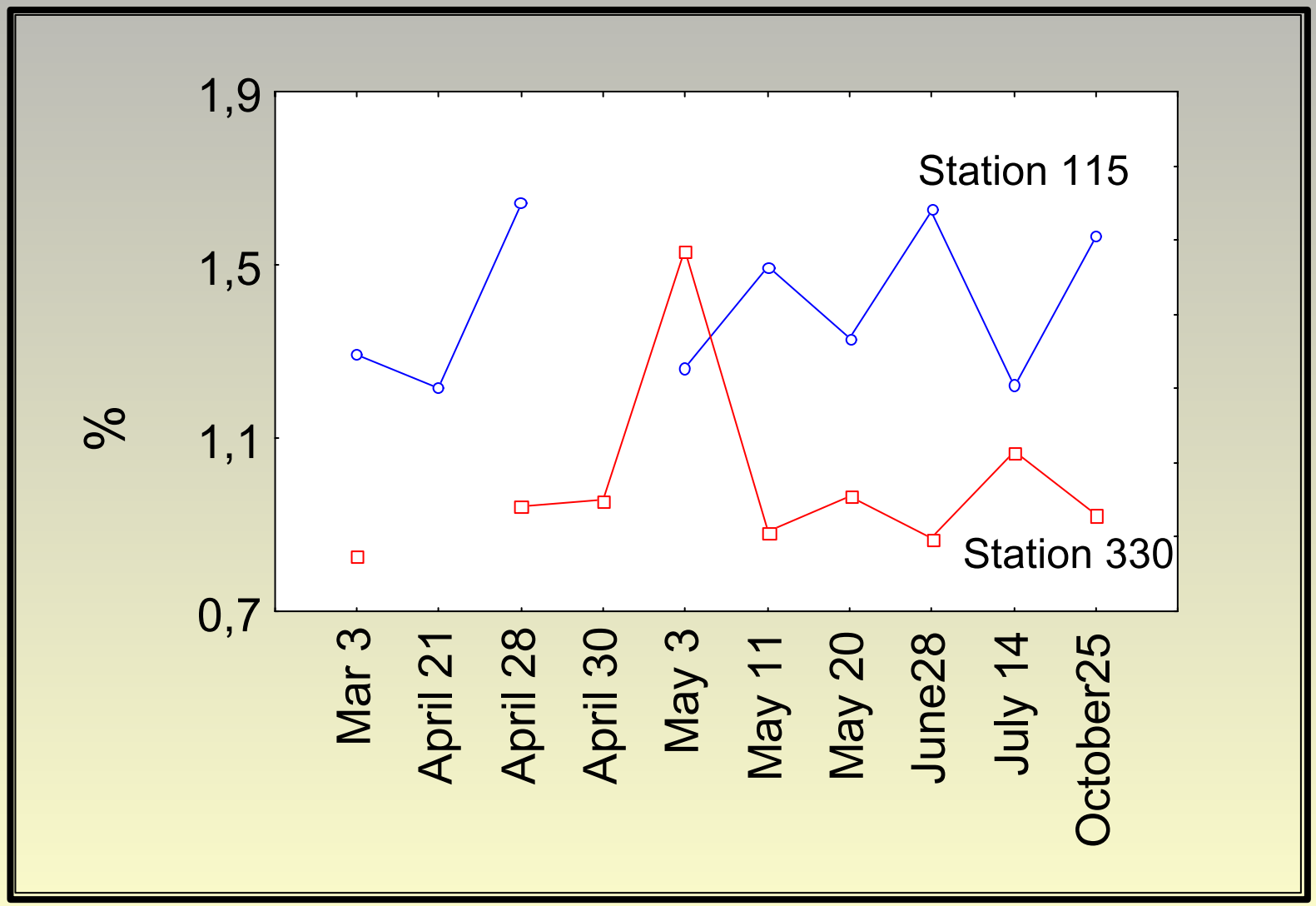

western Coastal Banks
2°30'E
2°45'E
3°00'E
N
51°15'N
51°10'N
51°05'N
Balandbank
Stroombank
Kleine Rede
Oostende
Westdiep
Trapegeer
Broersbank
Den Oever
Potje
Koksijde
De Panne
Nieuwpoort
former military base
of Lombardsijde
Belgium
dune reserve
'De Westhoek'
MPA
Natura 2000 area
Dutch
coast
Belgian coast
1 0 1 5 10 km
-4 m
-8 m
Dunkerque
France

5. Bentho-Pelagic coupling

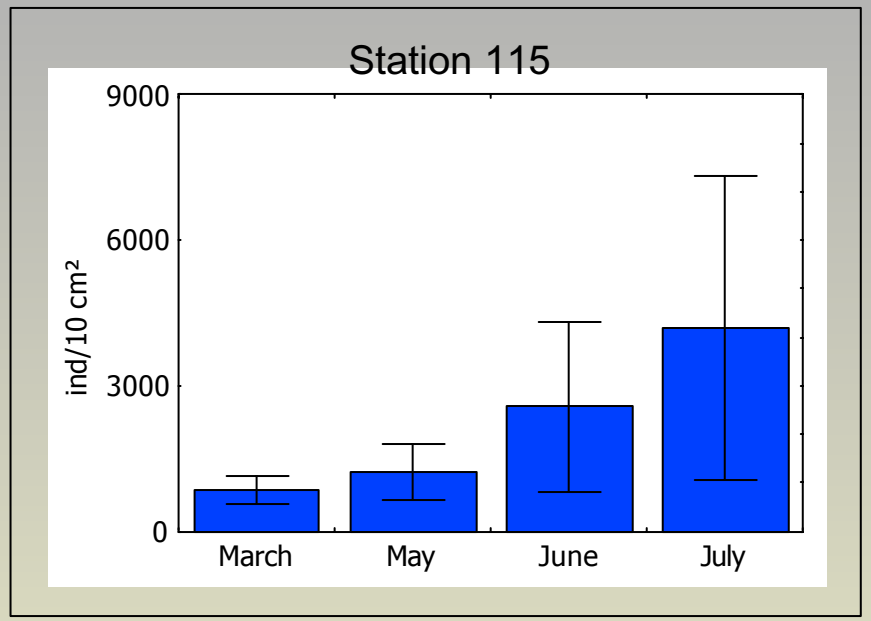


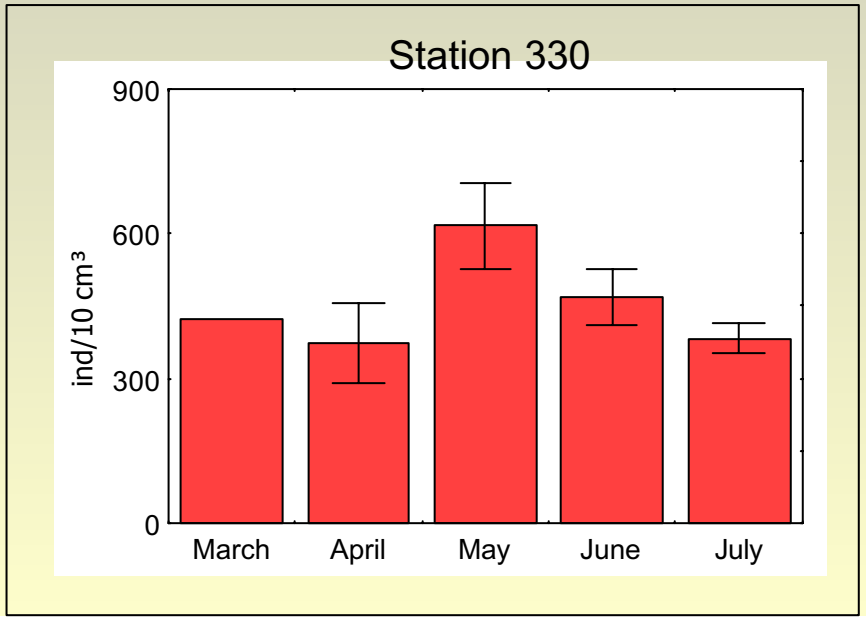
Winter **Spring** **Summer**

Total organic matter

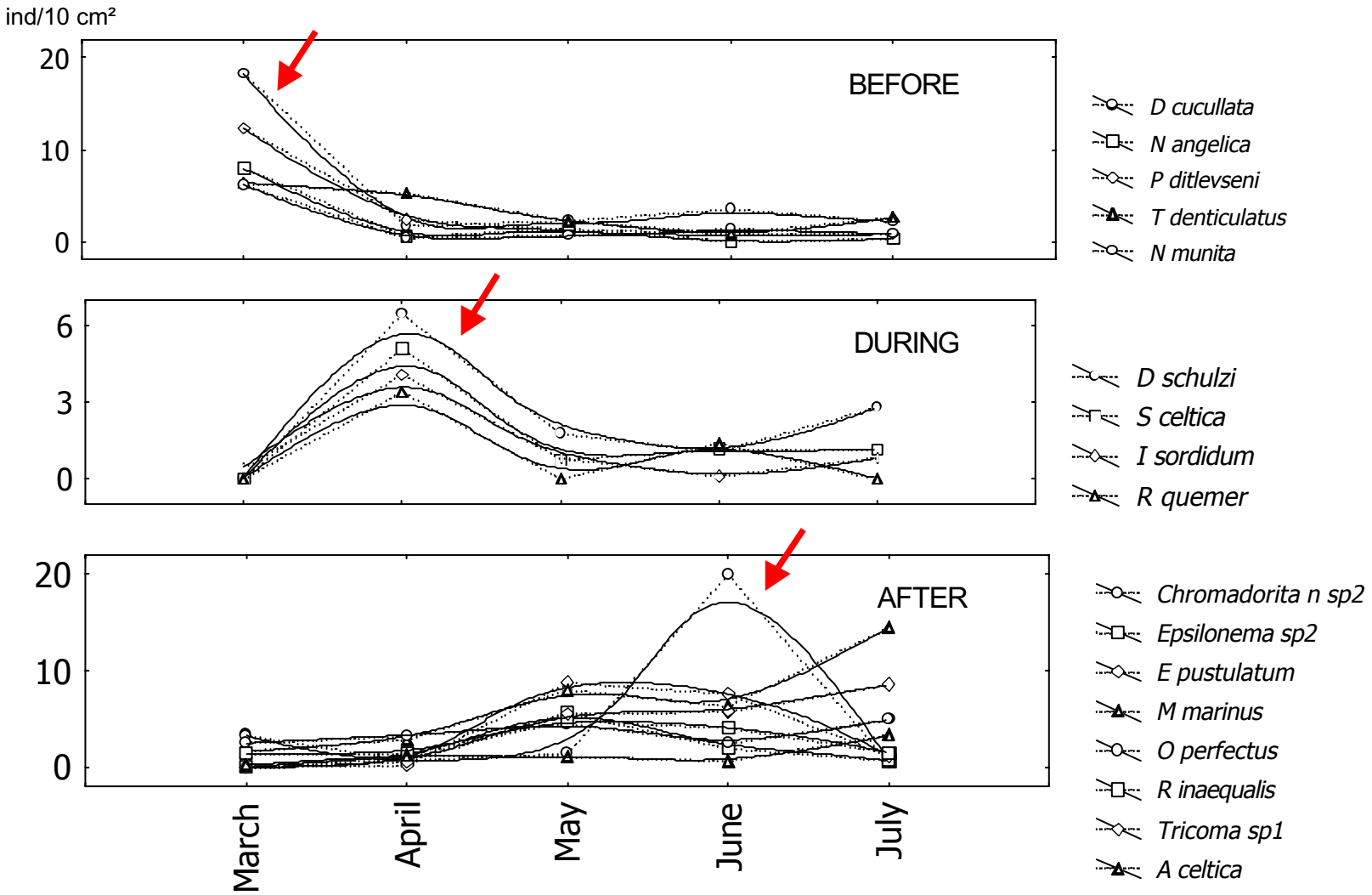


Nematode densities





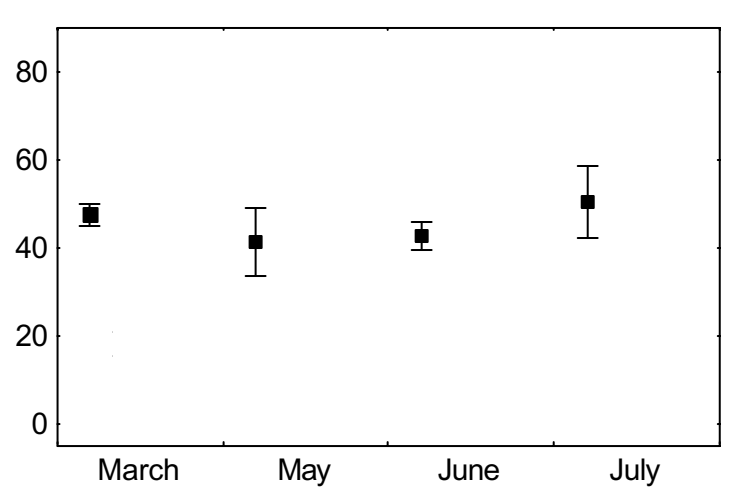
Abundance patterns of dominant nematodes at station 330



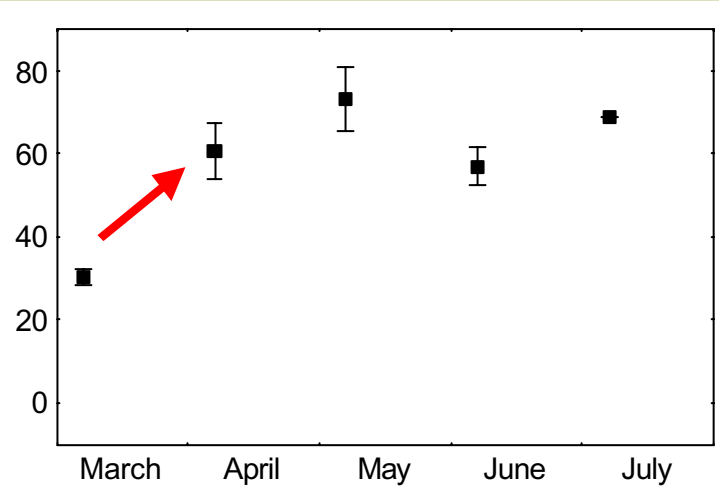
Diversity index (N_0) of nematodes

Station115

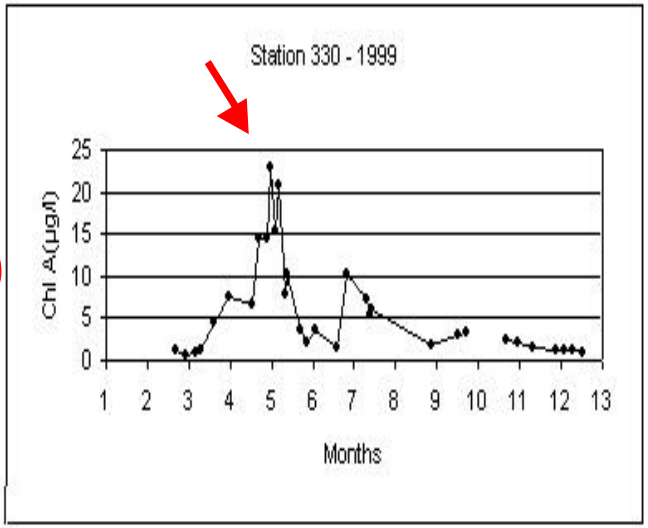
115



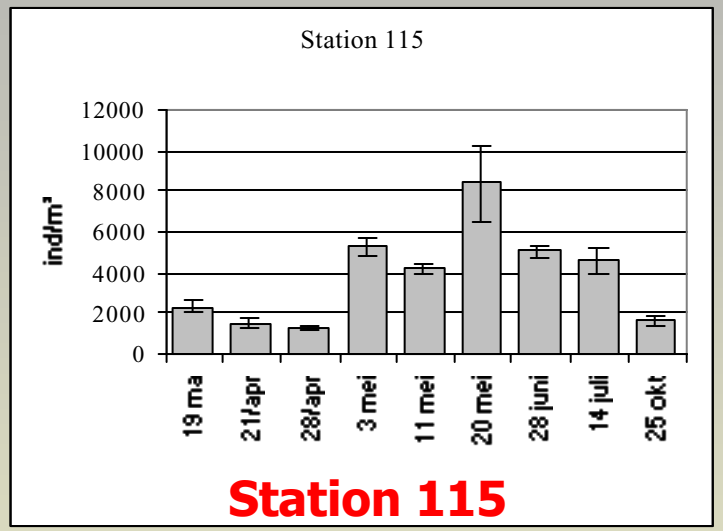
Station 330

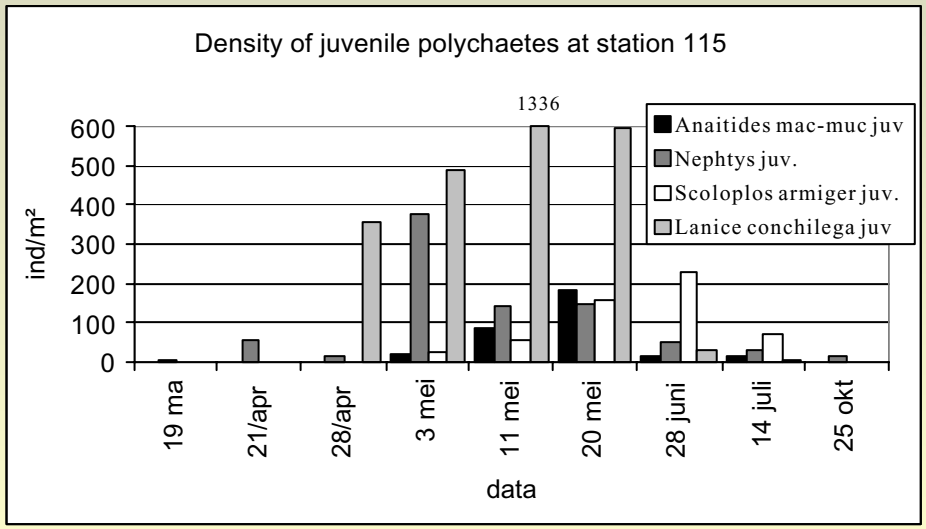


330

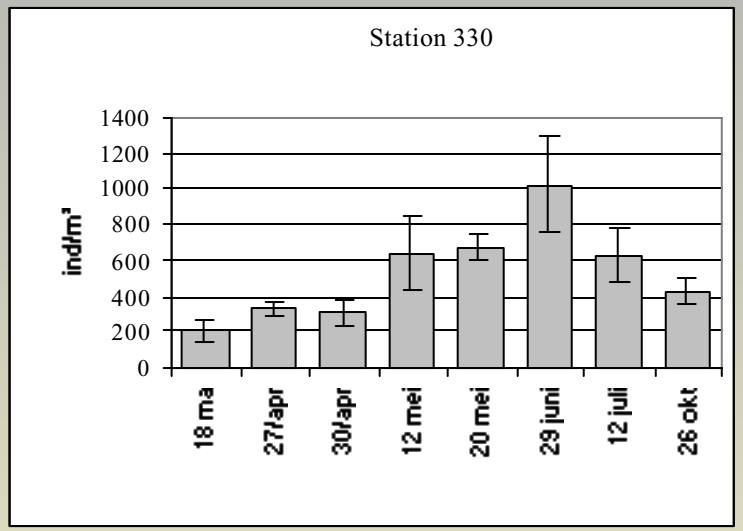


Macrobenthic response :

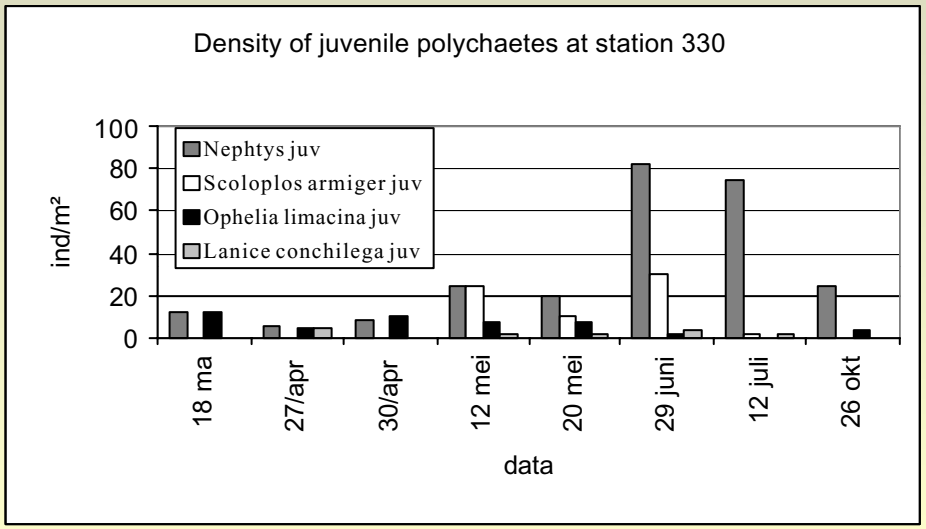




Macrobenthic response :



Station 330



Station 115 (coastal station)

Rather continuous and sufficient supply of organic matter :

Species poor but abundant nematode community

Species rich macrobenthos community

Station 330 (offshore station)

More episodic nutrient supply :

Species rich and abundant nematode community,

in favour of opportunistic nematode species

Species poor macrobenthos community

6. Genetic diversity of ecological important fishes

- Biological diversity includes the genetic structure of their populations.

- The patterns of genetic diversity and structure incorporate dynamic processes such as currents, climate, food web structure and energy flow.

- Marine organisms show a high level of relatedness due to the connectivity of the ocean, their large number of progeny and mobility.

- Nevertheless, they do show some level of discreteness which is analysed with ecological and genetic methods in marine gobies and their parasites.

6.1. SPECIES DESIGNATION

Gobies of the genus *Pomatoschistus* occur in the NE Atlantic and Mediterranean Sea.

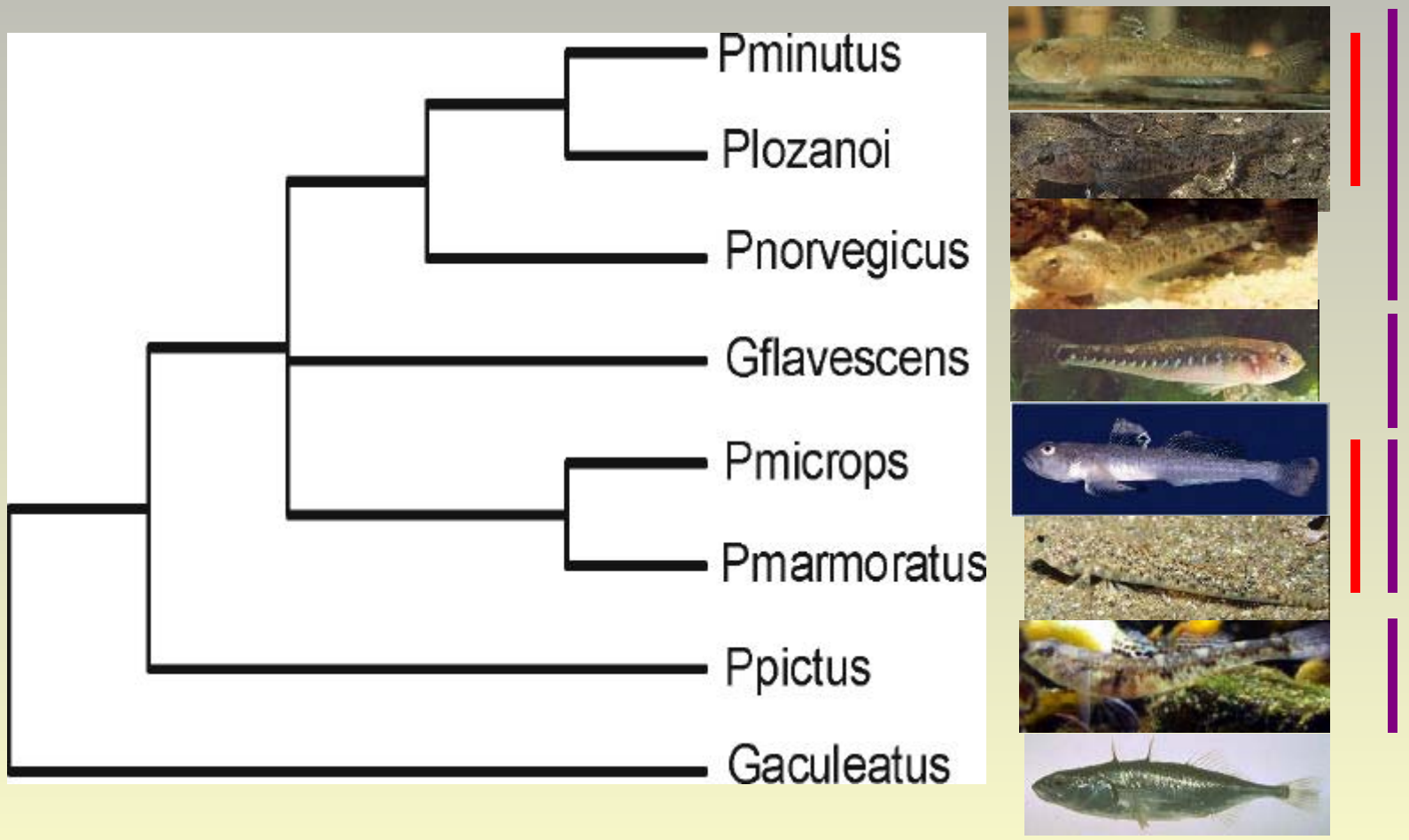
They are very abundant and small.

They feed on small benthic organisms and are food for other fish.

Evolutionary relationships among species show that an ancestor must have invaded the Atlantic, and radiated into various habitats, including fresh water.

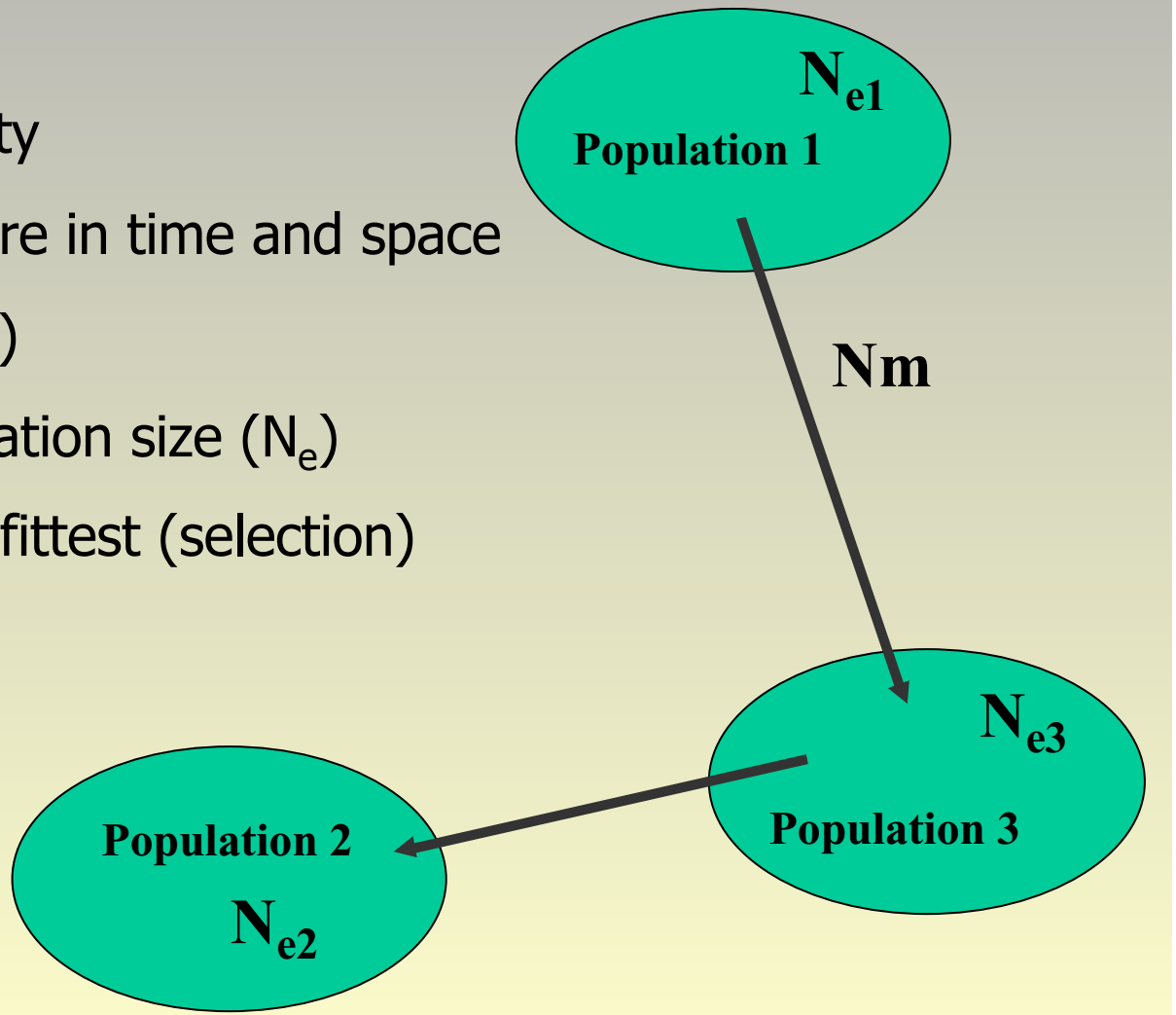
Closely related gobies are: lozano's and sand goby, the common and marbled goby.

Species diversity of POMATOSCHISTUS gobies



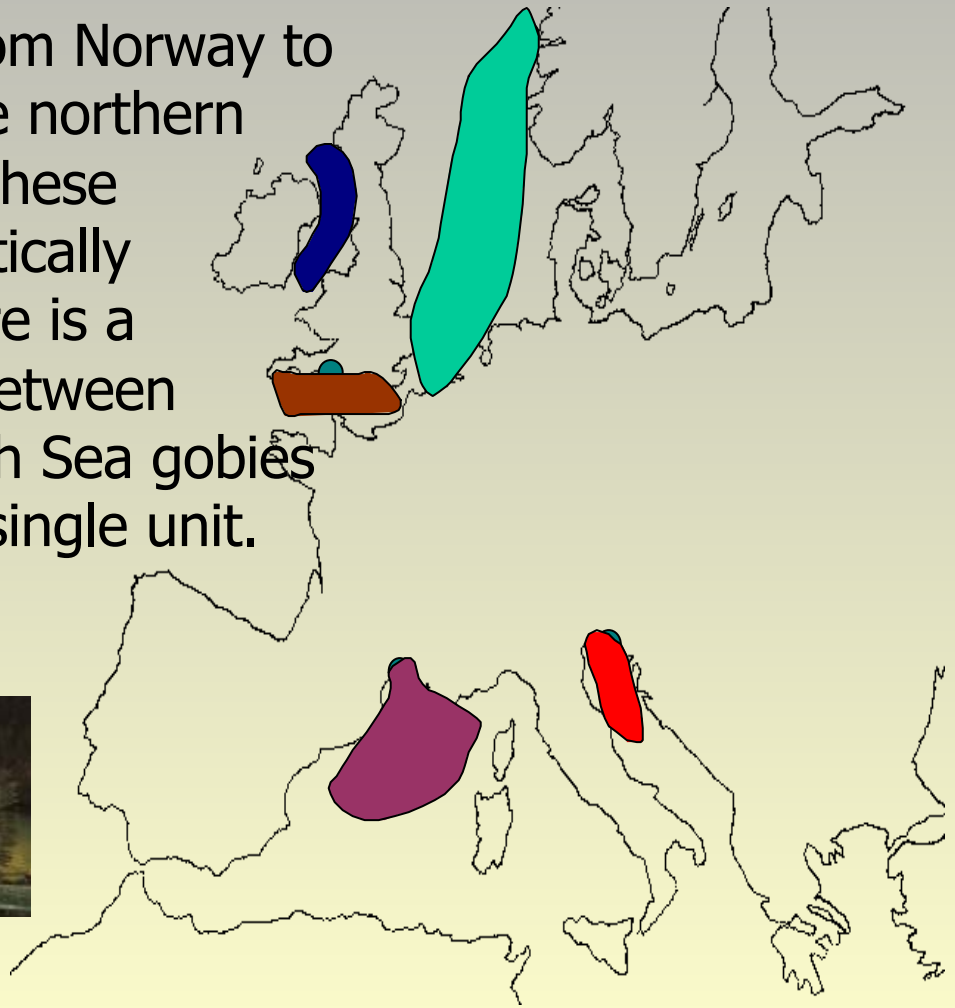
POPULATION GENETICS addresses

- Genetic diversity
- Genetic structure in time and space
- Gene flow (Nm)
- Effective population size (N_e)
- Survival of the fittest (selection)



6.2. GENETIC DIVERSITY & STRUCTURE ON A CONTINENTAL SCALE

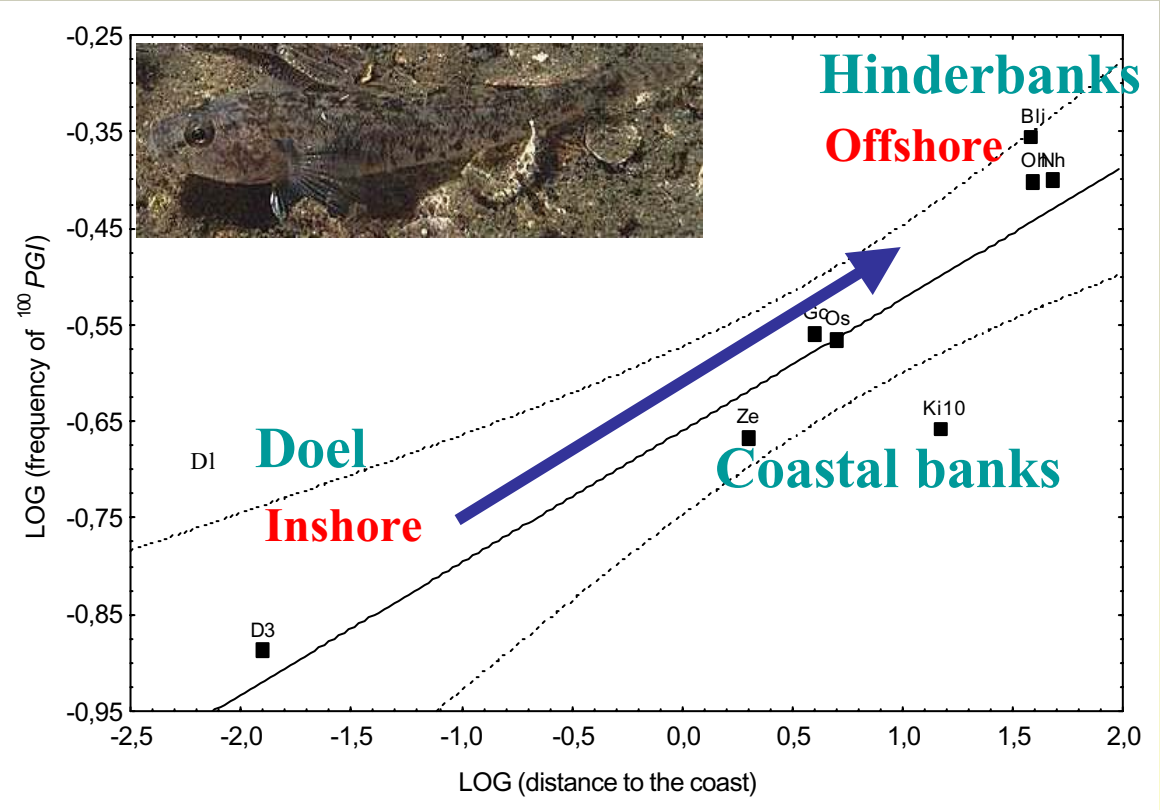
Sand gobies occur from Norway to Morocco, and into the northern Mediterranean Sea. These populations are genetically different. Hence there is a limited connectivity between the populations. North Sea gobies seem to belong to a single unit.

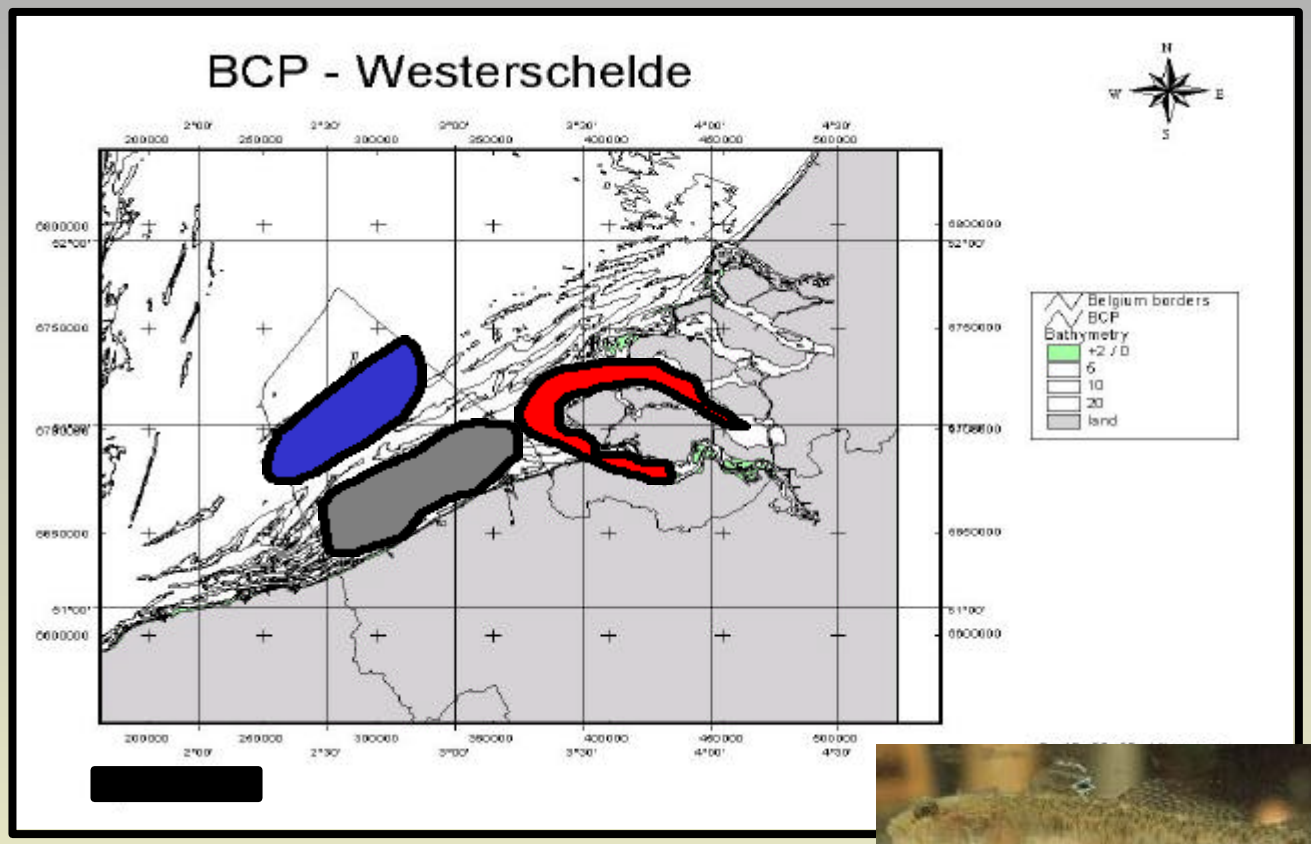


6.3. GENETIC STRUCTURE ON THE BELGIAN CONTINENTAL SHELF

Investigation a much smaller scale (10 km).

Allozyme markers reveal an inshore – offshore gradient in lozano's goby

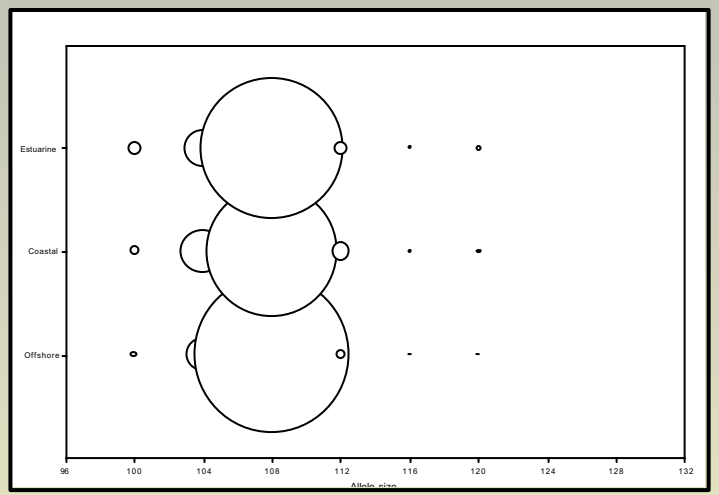


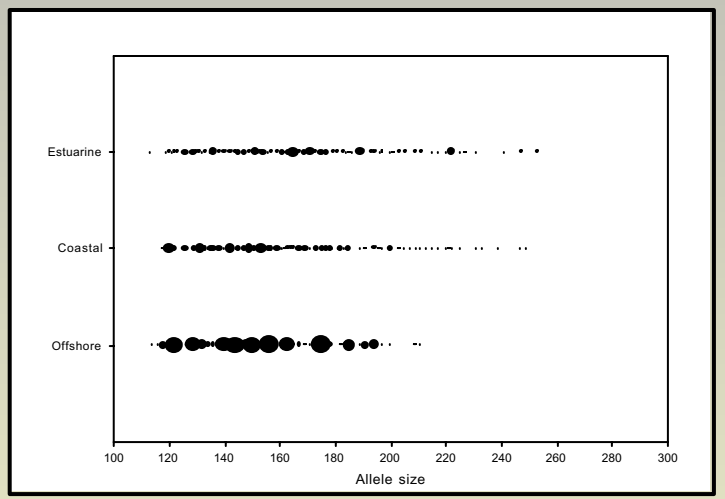


The sand goby differentiates between inshore and offshore with DNA fingerprints.
Conclusion: patterns are present, but they are <u>subtle</u>.

Subtle differences between populations of sand gobies is due to variation at some DNA microsatellite loci.

LocsA

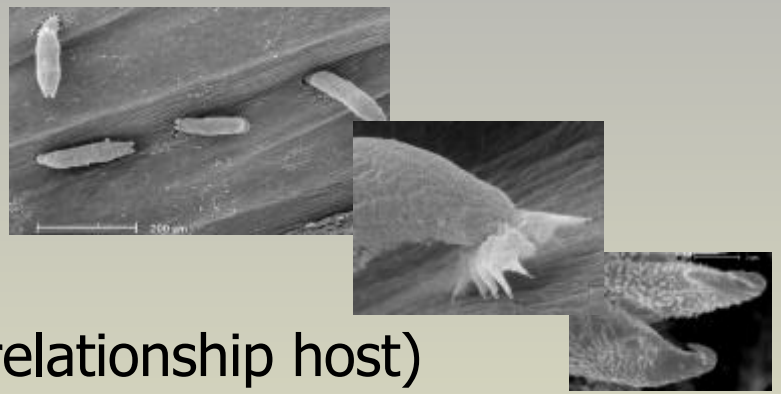




Allele frequencies at locus A show limited variation

Allele frequencies at locus B show much variation

6.4. RELATIONSHIP BETWEEN HOST AND PARASITE



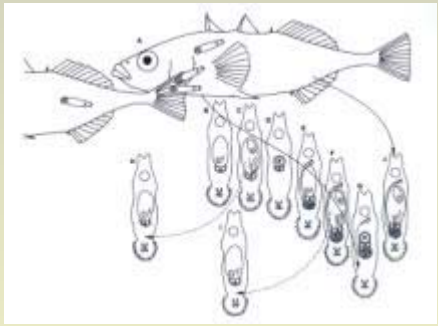
Gyrodactylus:

- ectoparasite, mostly on fish
- monogenean:
  - direct life cycle (close relationship host)
  - highly host-specific

    ≡ **coevolution**
- viviparous:
  - auto-infection

    ≡ **sympatric speciation**

    ≡ **speciation by host-switching**



Parasites are linked to their host, but have the opportunity to switch among individuals, populations and **species**.

Gyrodactylus

Pomatoschistus

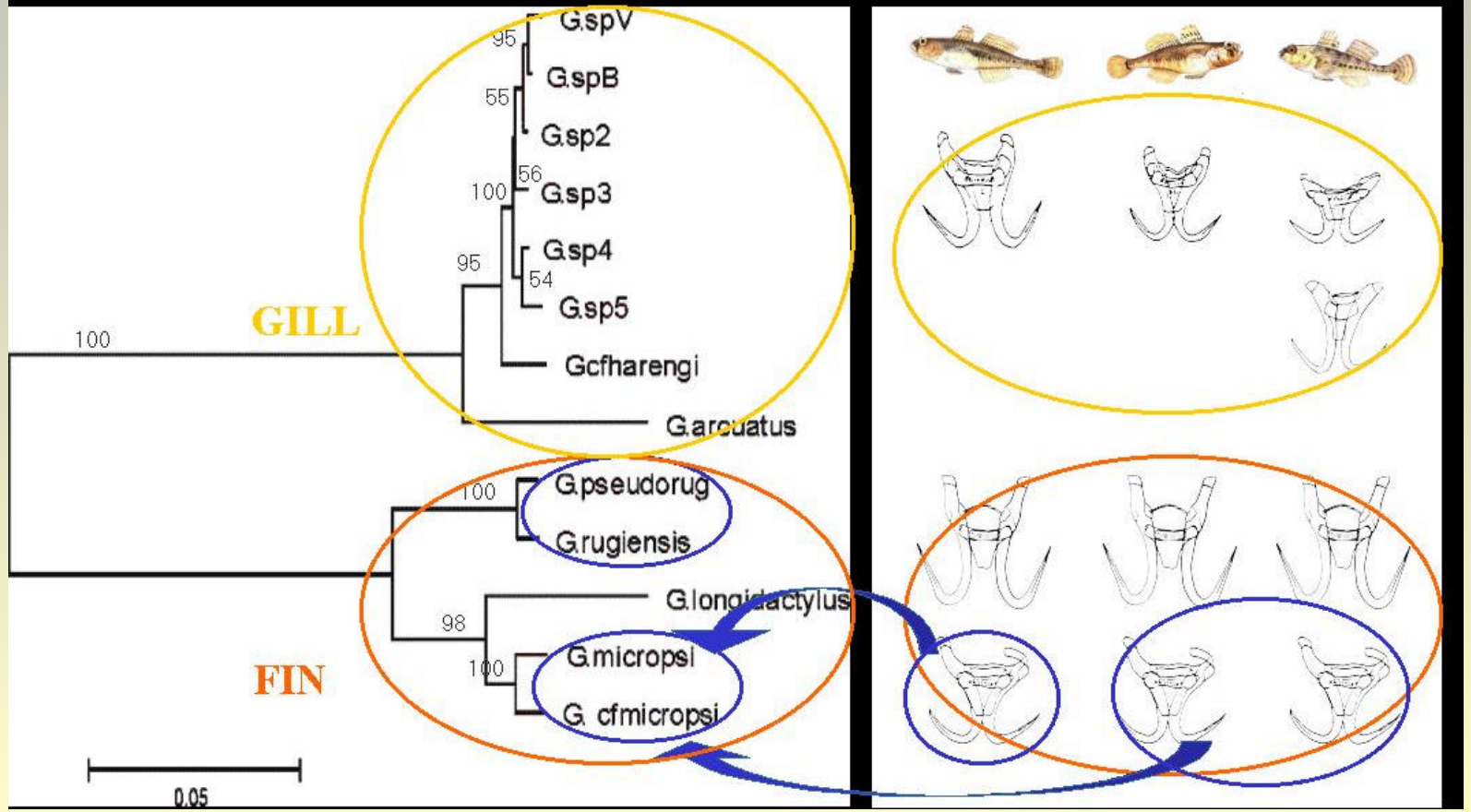
1. Parasitological survey

2. Molecular phylogeny host and parasite

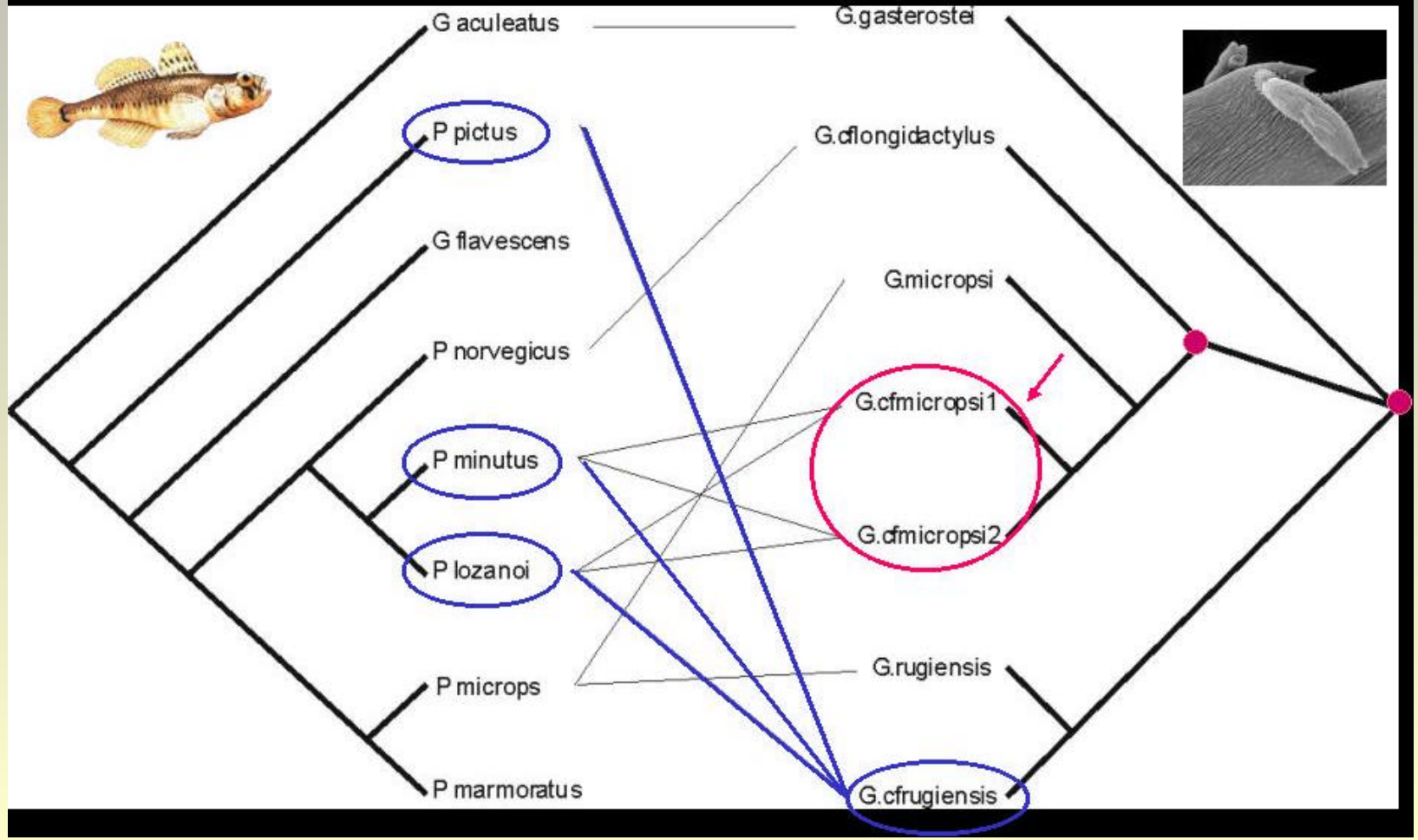
3. Comparison between phylogenies

- co-speciation
- host-switching

Parasite fauna of gill group is genetically and morphologically less differentiated



Host-parasite evolution: host switching & microspeciation in fin group



CONCLUSION

✓ **Structural patterns of marine biodiversity of benthos and birds of the BCS and its relationship with the environment are well known !**

✓ **Some functional responses are understood !**

✓ **Ecological important areas are indicated !**

✓ **Bio-indicators for sustainable management are presented !**

✓ **Speciation patterns are beginning to be understood**

FUTURE RESEARCH ??

- **Food web interactions** that shape benthic and bird communities ?
- **Dispersal** mechanisms on the BCS ?
- Total benthic community **metabolism ?**
- **Monitoring** : long term series of benthos and birds ?

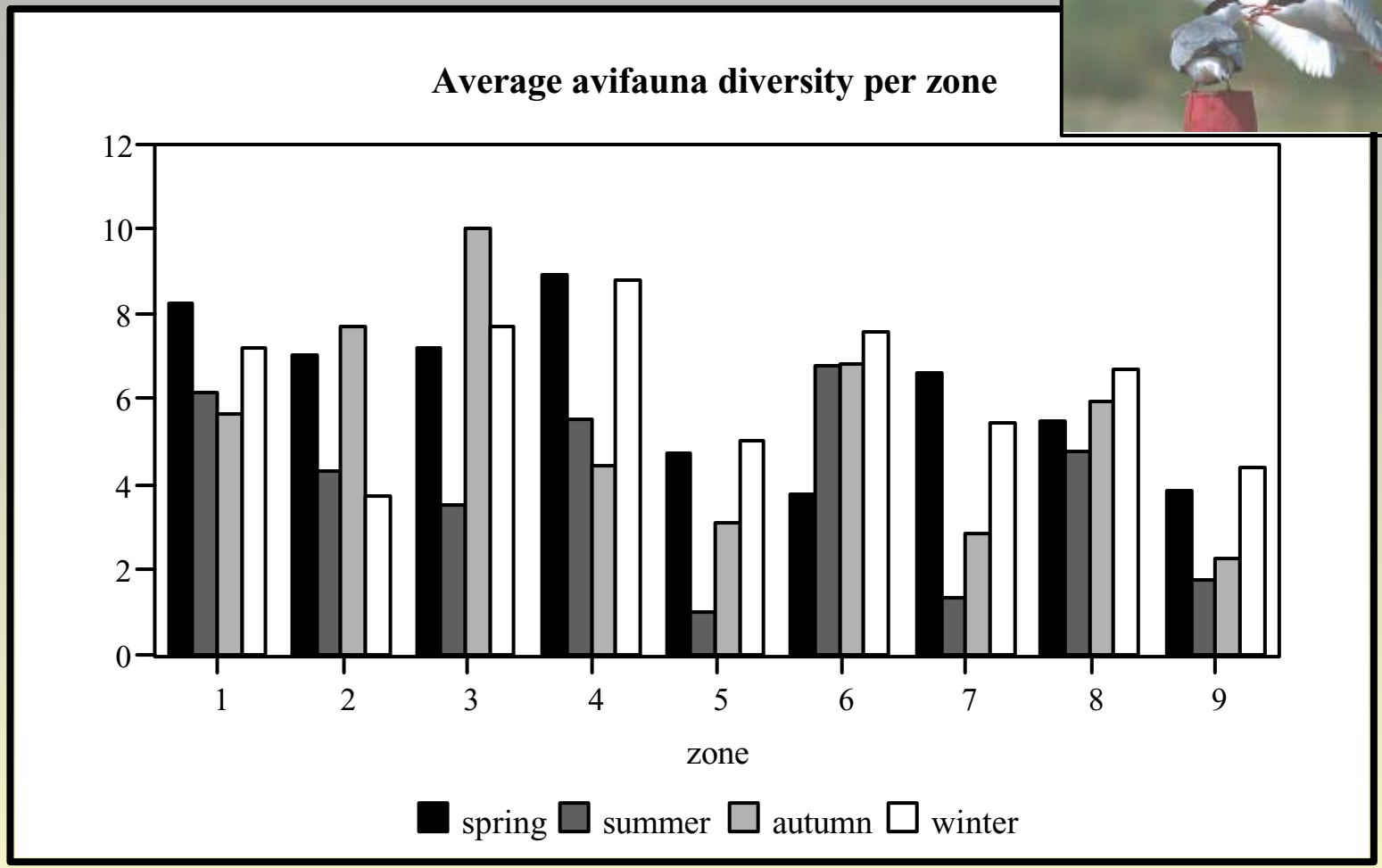
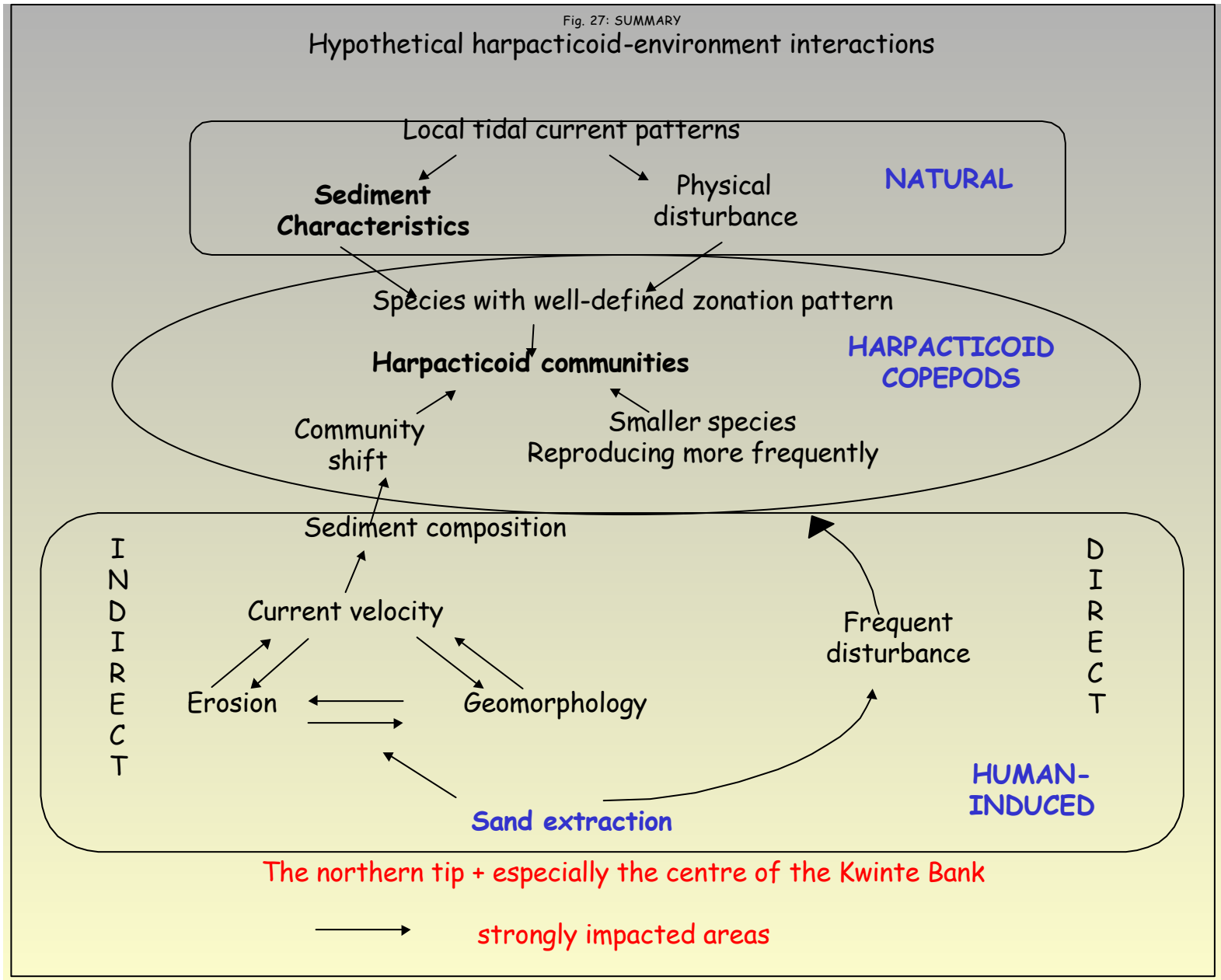

Average avifauna diversity per zone
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
zone
spring
summer
autumn
winter

Fig. 27: SUMMARY

Hypothetical harpacticoid-environment interactions



6.5. MANAGEMENT RELEVANCE OF MARINE GENETIC RESEARCH

- assessment of biodiversity

- determination of evolutionary significant management units for coastal zone management

- stock management of fisheries

- impact of global change

- identification & source of exotics