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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• 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
4. Ecological sensitive areas
5. Benthic-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

coast

‘open’ sea

zone (number of observations)
Average number of Harpacticoidea species per zone
Average number of macrobenthos species per zone

'West coast'
Coastal gradient: eastern coast less diverse than western
Average hyperbenthos density per zone

Onshore – offshore gradient: decreasing density
Holohyperbenthos (permanent)

Merohyperbenthos (temporary)
2. Spatial patterns on sandbanks ecosystem

**Meiobenthos**: Flemish Banks, Hinder Banks, Zeeland Banks, February and October
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 and the transitional species associations

The diagram illustrates the distribution of macrobenthic communities across different depths and mud content with median grain size. The communities are grouped into categories labeled I to IV, each represented by different symbols and colors to indicate their characteristics.
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

winter

N/km²
b) spring

[Map with legend: 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
Melanitta nigra

Sterna hirundo/paradisaea
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

- **Flemish Sandbanks:** West coast, East coast

- **Echiichthys vipera** PO
- **Syngnathinae spp.** PO
- **Clupeidae spp.** PO
- **Hippoglossoides platessoides** PO
- **Merlangius merlangus** PO
- **Trisopterus minutus** PO
- **Cottidae spp.** PO
- **Pholis gunnellus** PO
- **Pleuronectes platessa** PO
- **Pleuronectes flesus** PO
- **Bothidae spp.** PO
- **Trisopterus luscus** PO
- **Agonus cataphractus** PO
- **Pomatoschistus spp.** PO
- **Ammodytidae spp.** PO
- **Callionymus spp.** PO
- **Limanda limanda** PO
- **Solea solea PO**
- **Gadus morhua PO**
- **Trachurus trachurus PO**
- **Buglossidium luteum** PO
- **Pomatoschistus spp. PO**

- September
- October
- February
- March
- April
- May
- June
- July

- Ind. 100 m$^3$
Belgian sandbanks:
impact of sand and gravel extraction on benthos biodiversity

95% of sand extraction on BCS on the Kwintebank

1.5 million m³ sand per year
Belgian sandbanks: impact of sand and gravel extraction on benthos biodiversity

Harpacticoid communities 1978

Sand extraction

Erosion

Geomorphology

Sediment characteristics

Harpacticoid communities 1997

Sand extraction intensity

- Very high
- High
- Low
- Very low

Strong erosion
Weak erosion
No change
Strong accumulation
(Anonymous, 1993)

Depth (below MLLWS)
- 0 - 5 m
- 5 - 10 m
- 10 - 15 m
- 15 - 20 m
- 20 - 25 m
- 25 - 30 m
- 30 - 35 m
- 35 - 40 m

(1)
Altered species composition

Big endobenthic and epibenthic species → Small interstitial 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 view.

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**

![Map showing oil vulnerability value in winter](image)
4. Ecological sensitive areas

Disturbance sensitive areas for seabirds

a) winter

Disturbance vulnerability value
5. Benthic-Pelagic coupling

Phytoplankton → Zooplankton → Phaeocystis → Organic matter

Winter: 330
Spring: 115
Summer: ?

Benthos
Total organic matter

- Station 115
- Station 330

Data points:
- Mar 3
- April 21
- April 28
- April 30
- May 3
- May 11
- May 20
- June 28
- July 14
- October 25
Nematode densities

**Station 115**

![Bar chart showing nematode densities at Station 115 from March to July.](chart)

**Station 330**

![Bar chart showing nematode densities at Station 330 from March to July.](chart)
Abundance patterns of dominant nematodes at station 330

Ind/10 cm²

BEFORE

D cucculata
N angelica
P ditlevseni
T denticulatus
N munita

D schulzi
S celtica
I sordidum
R quemer

D celtica

March
April
May
June
July

DURING

AFTER

Chromadorita n sp2
Epsilonema sp2
E pustulatum
M marinus
O perfectus
R inaequalis
Tricoma sp1
A celtica
Diversity index ($N_0$) of nematodes

Station 115

Station 330

Diversity index ($N_0$) of nematodes.
Macrobenthic response:

Station 115

Density of juvenile polychaetes at station 115
Macrobenthic response:

Density of juvenile polychaetes at station 330

- **Nephtys juv**
- **Scoloplos armiger juv**
- **Ophelia limacina juv**
- **Lanice conchilega juv**

Station 330 data:
- 18 ma
- 27 apr
- 30 apr
- 12 mei
- 20 mei
- 29 juni
- 12 jul
- 26 okt
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

- Pminutus
- Plozanoi
- Pnorvegicus
- Gflavescens
- Pmicrops
- Pmarmoratus
- Ppictus
- Gaculeatus
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 on 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 subtle.
Subtle differences between populations of sand gobies is due to variation at some DNA microsatellite loci.

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

- zone
- spring
- summer
- autumn
- winter
The northern tip + especially the centre of the Kwinte Bank

strongly impacted areas
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*