Susceptibility and resilience to invasions: macrozoobenthic communities in the Dutch delta waters.

Sander Wijnhoven, Pim van Avesaath & Herman Hummel

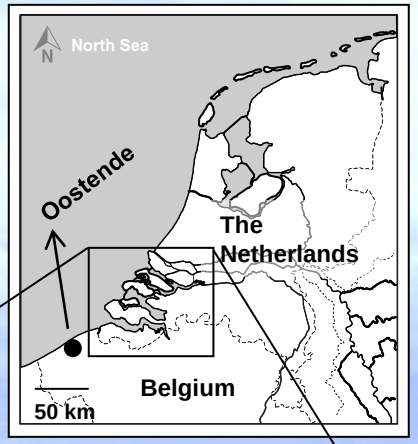
Monitor Taskforce,
Royal Netherlands Institute for Sea Research
(NIOZ - Yerseke)

NIS conference 2013

November 20th-22nd

Oostende - Belgium

The Dutch delta



- Present day Dutch delta largely result of drastic safety precautions and measures to accelerate economic activities in a changing political and policy environment
- Therefore there is now a series of highly modified water bodies heavily used amongst others for/by
  - shipping
  - aquaculture / fisheries
  - recreation

  but also with important nature functions
- The waterbodies however differ in
  - intensity and nature of activities
  - abiotic conditions
  - intensity and nature of pressures

System characteristics	Grevelingen	Oosterschelde	Veerse Meer	Westerschelde
Total surface area (km^2)	108	351	20	300
Average depth (m)	5	9	5	10
Maximum depth (m)	48	55	25	67
Volume (10^6 m^3)	575	2750	89	2689
Tidal range (m)	0.05	2.5-3.4	0.1	4.4-5.5
Salinity (PSU)	27-33 → 29-31	31-33	14-21 → 23-29	10-32
Water exchange (x volume)	3 → 7	234	5 → 14	1020

System characteristics

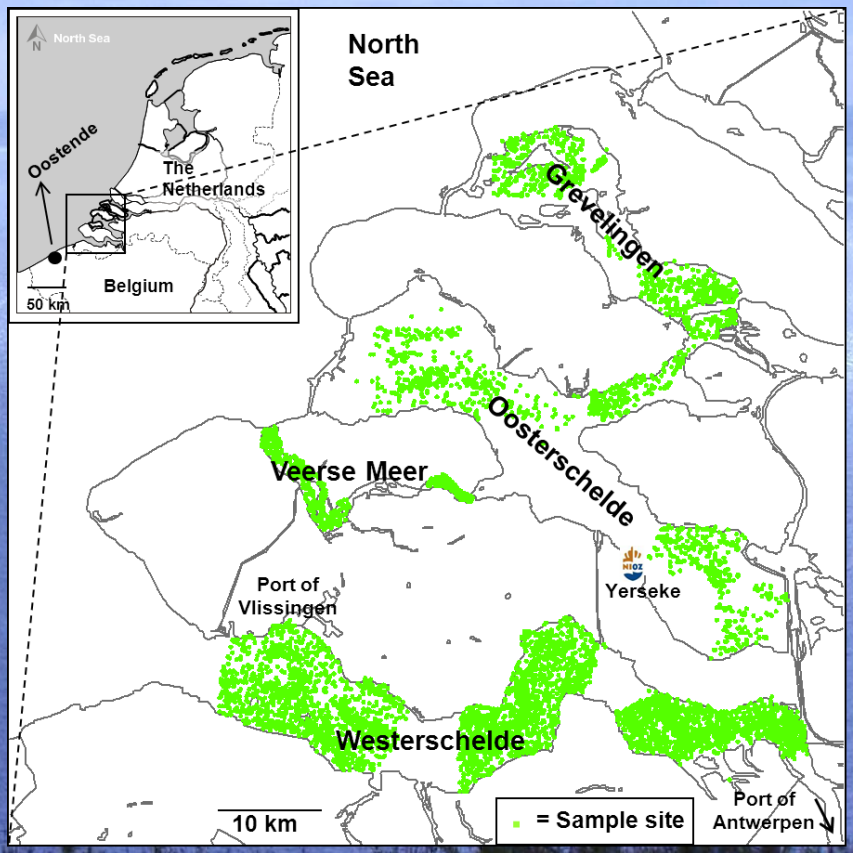
- Grevelingen; closed saltwater lake (ongoing deterioration since the 70s, water exchange doubled in 1999)
- Oosterschelde; semi-enclosed tidal bay (relative nutrient poor, intensively used for aquaculture)
- Veerse Meer; closed deteriorated brackish lake (increased water exchange and salinity since 2004)
- Westerschelde; open estuary (with, although improving, high pollutant and nutrient levels)

Exotic species introductions on a daily basis

- What makes that exotic species
  - successfully settle?
  - expand and start to dominate locally or regionally?
- Are there ways to prevent exotic species becoming dominant or to counter invaders?

Investigated on basis of a large data-set (BIOMON programme commissioned by the former Dutch Ministry of I&E);

- 15457 samples
- macrozoobenthic communities
- of soft sediment environments
- taken biannually
- between 1990 and 2008
- in a standardized way



De Bruyne, Van Leeuwen, Gmelig Meyling & Daan (red.), 2013.

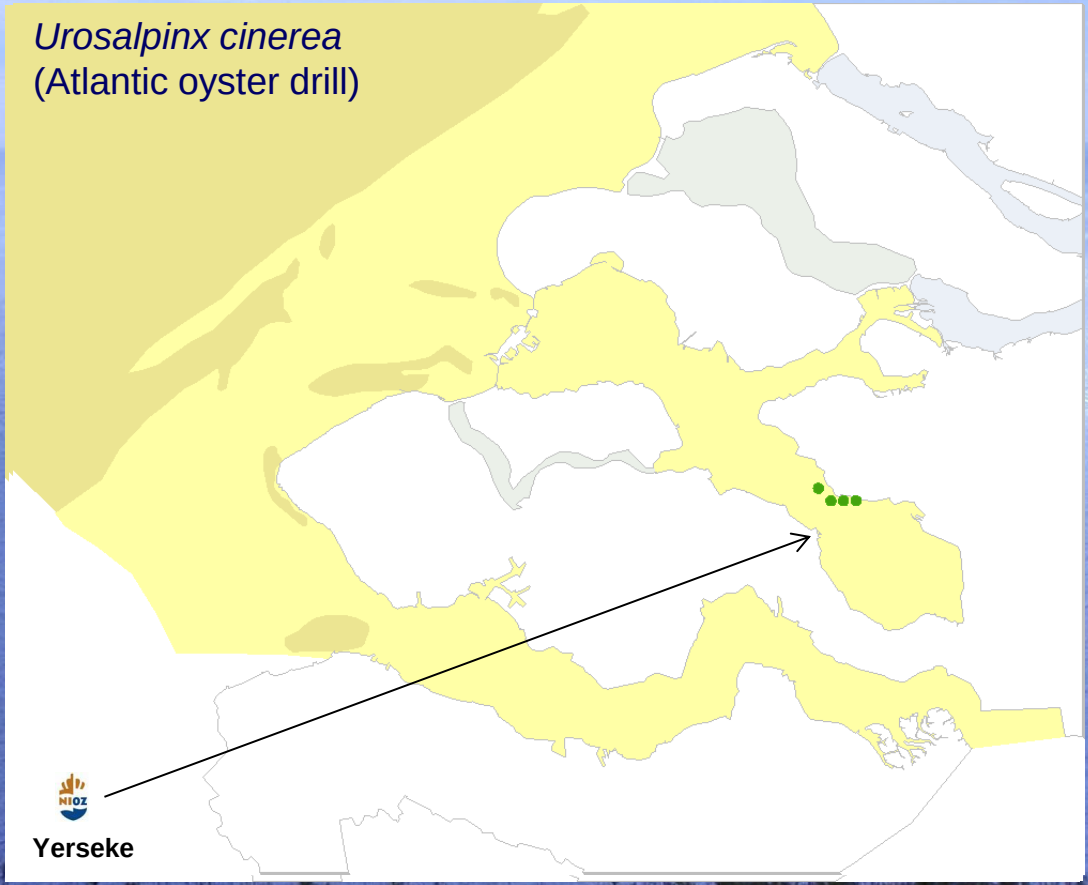
Exotic species occurrence

- **Observations from the 'Dutch marine Molluscs atlas project'**

There are definitely hotspots for exotic species occurrence

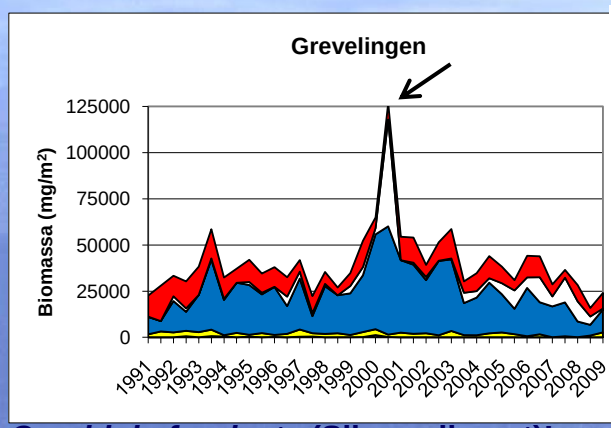
- **Those are areas with high rates of species introductions**
- **with plenty opportunities for settlement**
- **and environmental conditions suitable for a range of species**

But those appear not to be the locations completely dominated by exotic species!



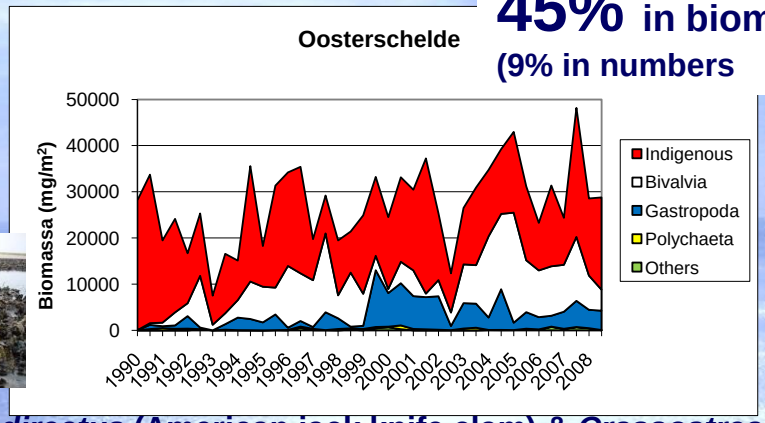
The role of exotic species in the Dutch delta

Developments in total biomass of non-indigenous (bivalves, gastropods, polychaetes, others) compared to indigenous species



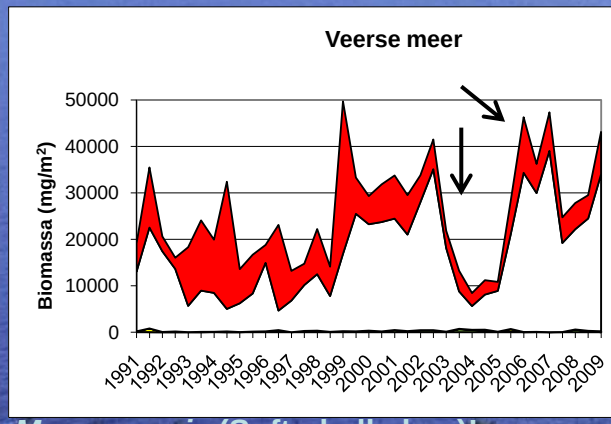
74% in biomass (14% in numbers)

Crepidula fornicata (Slipper limpet)!



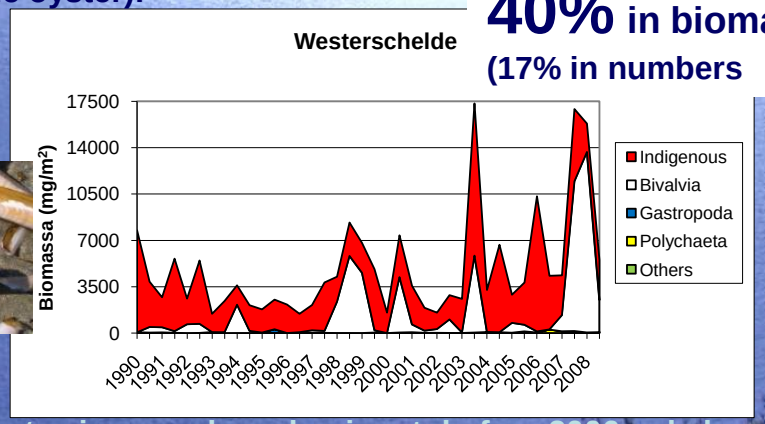
45% in biomass (9% in numbers

Ensis directus (American jack knife clam) & *Crassostrea gigas* (Pacific oyster)!



81% in biomass (23% in numbers)

Mya arenaria (Soft-shell clam)!



40% in biomass (17% in numbers

E. directus is nowadays dominant; before 2006 only locally present in low numbers!

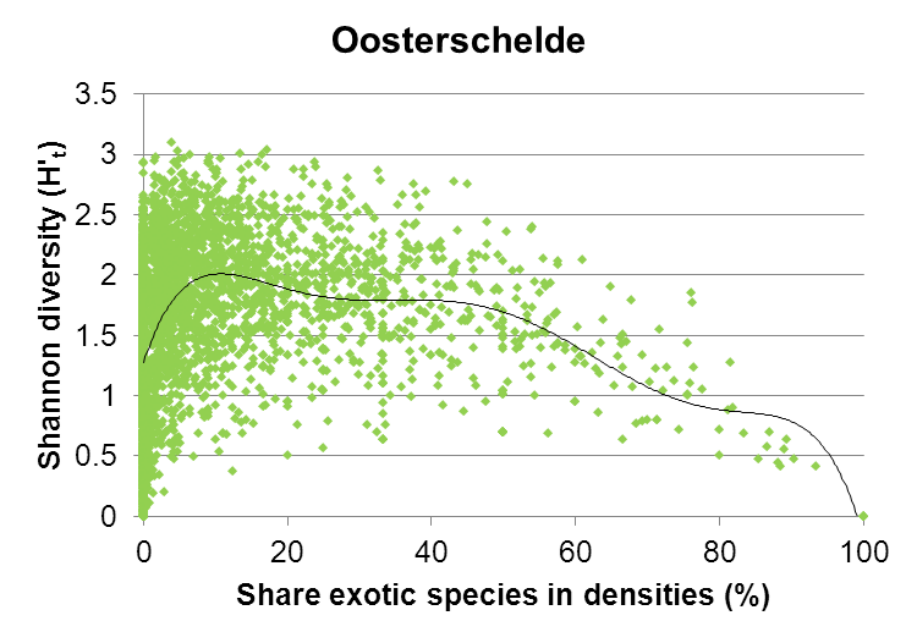
The role of exotic species in the delta

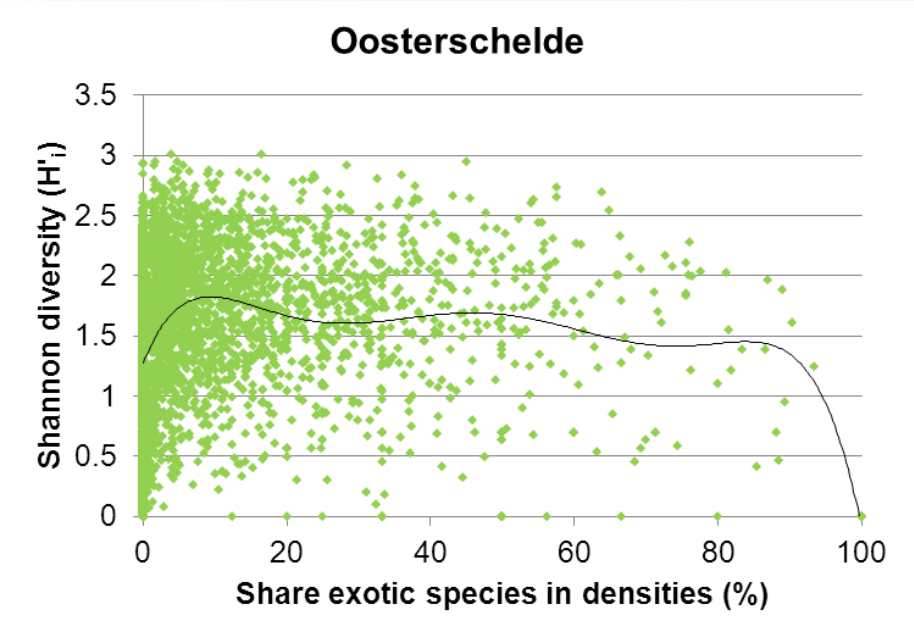
- Share of exotic species in biomass is largely dependent of the exotic bivalves
  - Exotic bivalves are particularly successful in systems in change, and profit from improving environmental conditions
- Share of exotic species in densities is largely dependent of the exotic polychaete worm species
  - Exotic polychaetes are especially successful in poor quality systems (well-known phenomenon of dominance by worms over bivalves), but appear to decrease at improving conditions

- *Crepidula* has a position in between;
  - can profit from improving water quality
  - but is also relative resistant to 'disturbed' conditions when not too harsh (e.g. anoxia)
  - is however a typical species of low dynamic environments

Exotic species and community diversity

- What is the impact of exotic species on the local diversity?



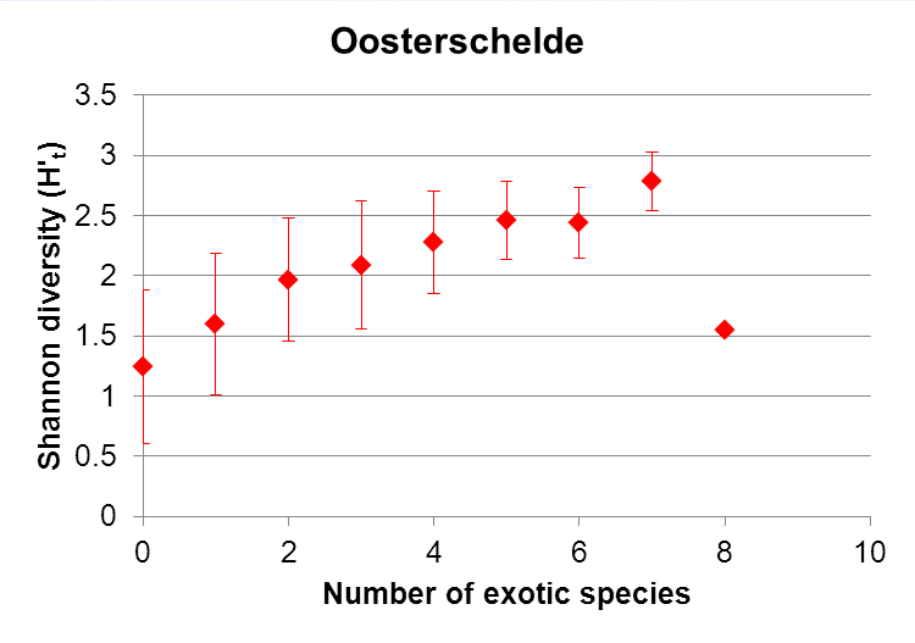


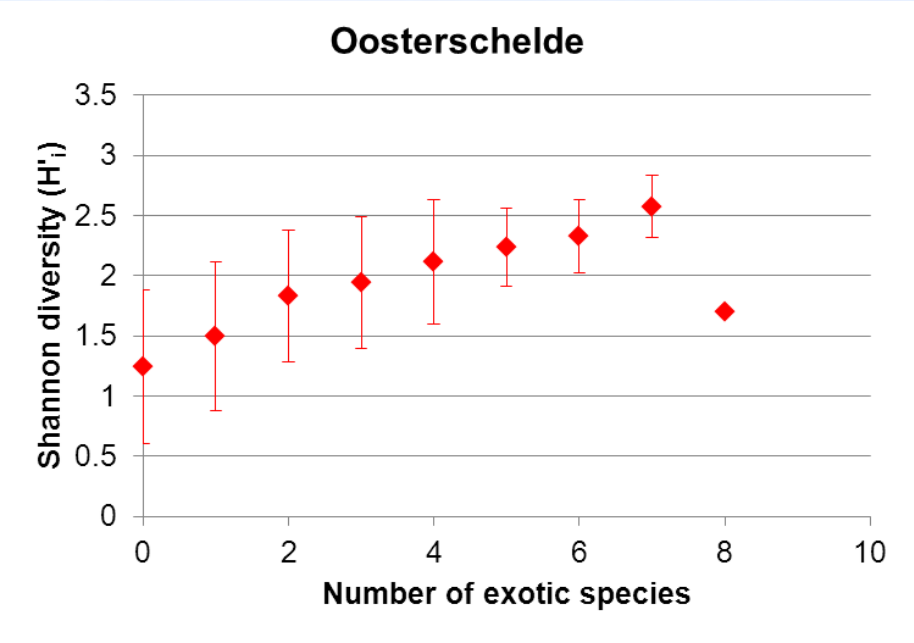
- Higher local diversity with exotic species than without exotic species, unless exotic species really start to dominate
- When only indigenous fauna is taken into account; diversity is only lower at complete dominance by exotic species

(Similar patterns in other waterbodies)

Exotic species and community diversity

- Are low diversity communities more susceptible towards exotic species settlement?

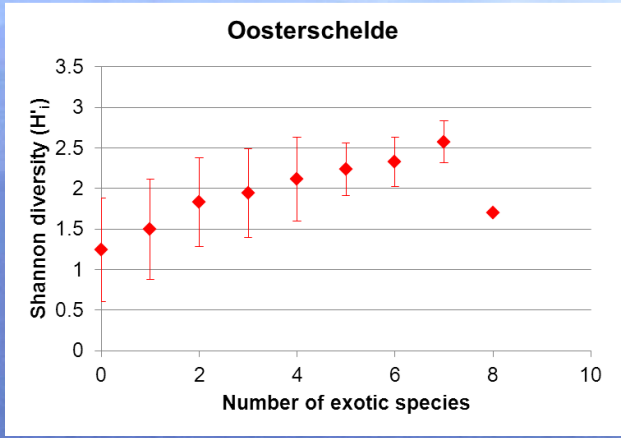


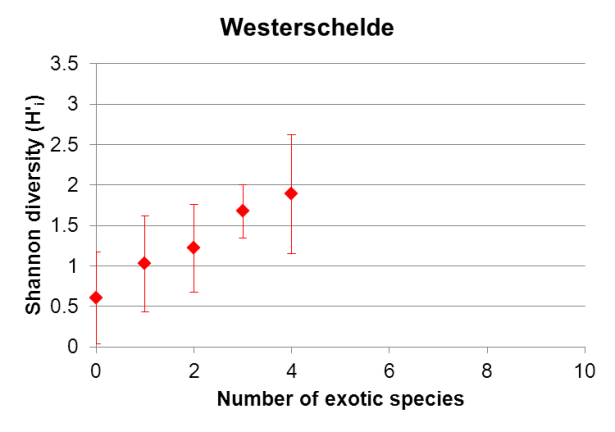


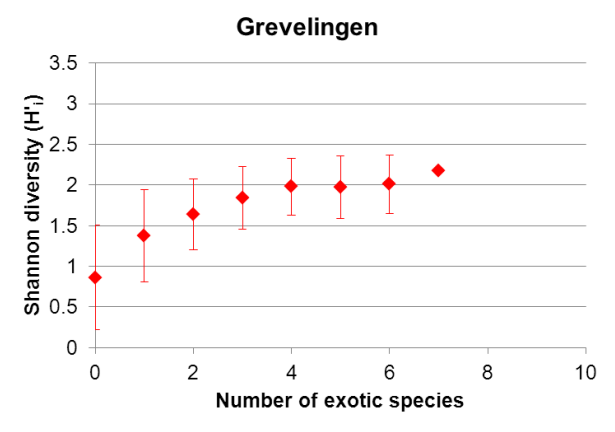
- No; exotic species seem to profit from the same environmental conditions as indigenous species,
- Exotic species seem to contribute to the diversity in a similar way as indigenous species

Exotic species and community diversity

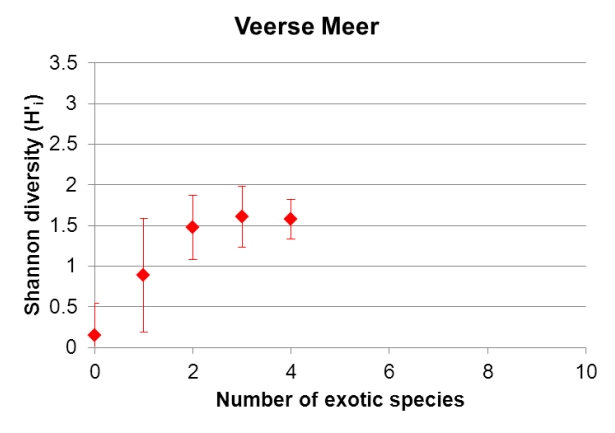
- However, in lower diversity systems the number of exotic species in the communities is also lower





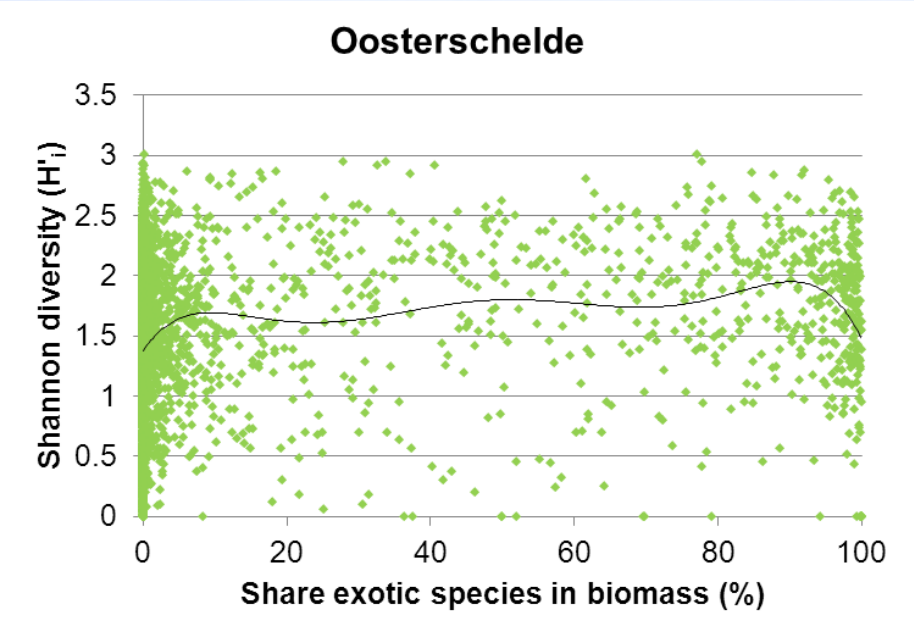


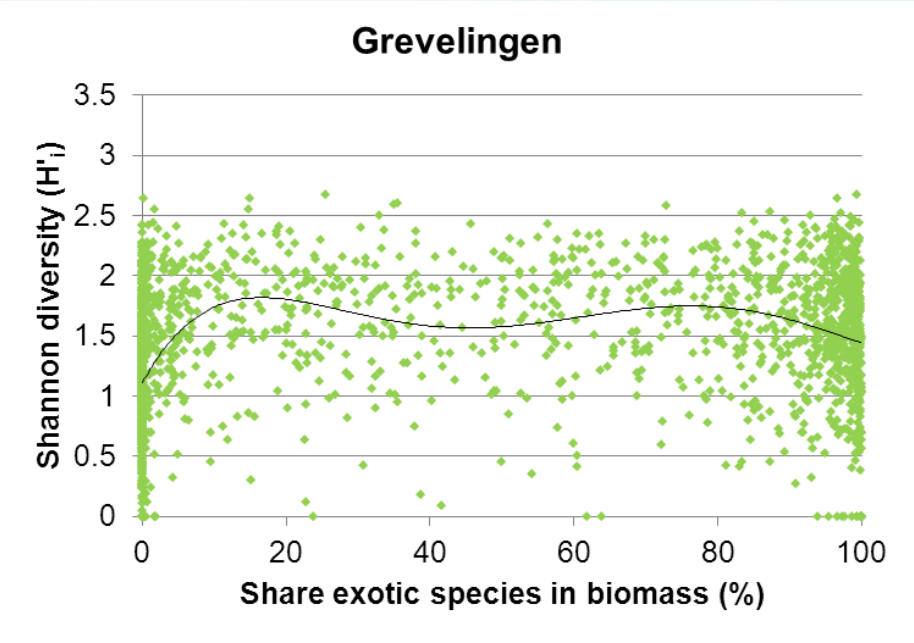
- But interestingly, in the closed systems the indigenous diversity does not further increase with the settlement of additional exotic species



Exotic species and community diversity

- This might be the result of complete dominance of those communities by exotic species as observed in biomass

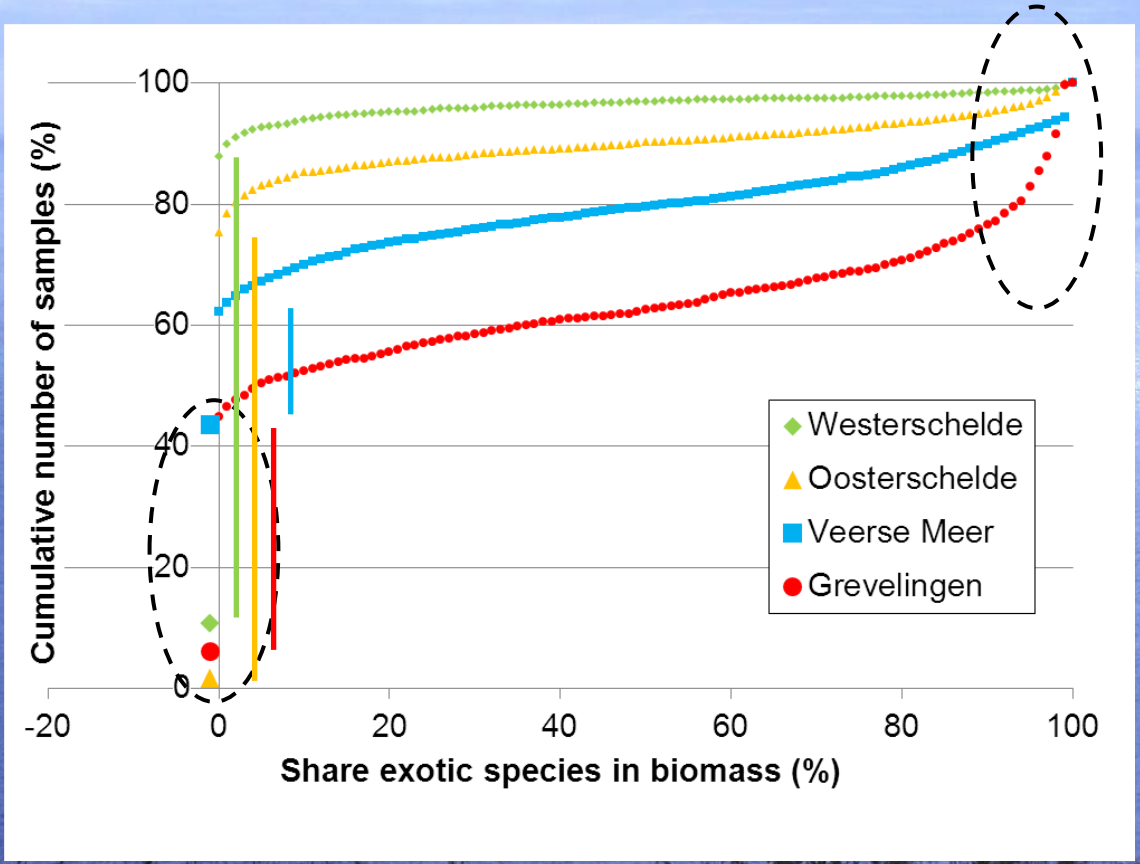




- In Oosterschelde high percentage of samples with small share of exotic biomass; in Grevelingen high percentage of samples with high share of exotic biomass and low percentage of samples with small share of exotic biomass

What determines the dominance by exotic species?

- When the environmental conditions are poor; a substantial part of the system can be unsuitable or of poor quality for macrobenthos (including exotic species)
- In open systems; a relative small part of the system is 'invaded' by exotic species
  This is independent of the introduction rate that can (locally) be very high
- Closed systems appear to be more susceptible to exotic species dominance
  Once exotic species settle, they generally start to dominate the (local) communities



Susceptibility to invasions

- The number of exotic species in a system is dependent of the introduction rate and the settlement opportunities
- Local disturbances can lead to opportunities for exotic species to expand,
  where communities of closed systems are more susceptible to 'unnatural' disturbances
- Local disturbance will more likely lead to (local) exotic species dominance in closed systems,
  where whole system disturbance can lead to dominance of the entire system by exotic species

Management implications

- Communities of open systems with large natural dynamics are most resistant (and possibly resilient) towards exotic species invasions
- As restoration measures often involve disturbance of the prevailing conditions, the presence of exotic species already in the system should be taken into account, as it can be particularly the exotic species that profit
- To restore waterbodies successfully, besides water quality improvement measures, active management of the exotic species populations might be essential (e.g. removing exotic species and/or supporting indigenous species/communities)

Thank you for your attention!

-Thanks to the research assistants of the Monitor Taskforce who did the sampling, sorting and taxonomic identification.
-Thanks to the Directorate General 'Rijkswaterstaat (RWS)' of the former Dutch Ministry of Infrastructure and Environment who funded the sampling program used for this study.
-Thanks to Team Invasive Species of the former Dutch Ministry of Economics, Agriculture and Innovation who made possible a historic analyses of the exotic macrofaunal data.
-Part of the work is done within the frame the EC FP7 project VECTORS.