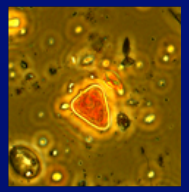
Scientific symposium
"Tools for assessing status of European aquatic ecosystems"
May 6 - 7, 2015, Malmö, Sweden







Assessing uncertainty of indicators: aquatic invasive species and environmental status of waterbodies

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Definitions

- Non-indigenous species (NIS, alien, non-native) introduced outside of natural range and dispersal potential by human activities
  - (natural shifts … do not qualify as a NIS)
- Invasive alien species (IAS) - a subset of established NIS, which have spread, are spreading or have demonstrated their potential to spread elsewhere,
  have an adverse effect on biological diversity, ecosystem functioning, socio-economic values and/or human health in invaded regions.
- IAS cause biological pollution, i.e. disturb environmental quality by effects on: an individual, a population, a community, a habitat or an ecosystem.
- GEnS is the absence or minimal level of biological pollution.

(MSFD TG2 Non-indigenous species report, 2010)

Non-indigenous species in WFD and MSFD

WFD (2000)

- No explicit mentioning of NIS and their potential impact on ecological quality.
- Guidance Document "*Common implementation strategy for WFD*…": the introduction of alien species is considered as an example of biological pressure and impact.
- Debates on the need to consider NIS started in 2008.

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MSFD (2008)

- D2. "*Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems*".
- Annex III, Table 2 (Pressures and impacts / Biological disturbance): introduction of non-indigenous species and translocations.
- TG2 Non-indigenous species report, 2010.
- EC Decision (2010/477/EU) on criteria and methodological standards on GES.

WFD: Ecological Quality Indicators

BIOLOGICAL
- Phytoplankton
- Phytobenthos
- Macrofauna
- Fish

- Species composition, abundance and biomass of natural communities;
- Presence of indicator (sensitive) species and values of relevant indices

PHYSICO-CHEMICAL
- Nutrients
- Salinity
- Transparency
- Oxygen
- Synthetic pollutants
- pH
- Temperature

HYDRO-MORPHOLOGICAL
- Changes in sediment transport
- Water flow
- Channel patterns
- Conditions of the shore zones
- Substrate conditions

- Concentrations of chemicals must meet environmental quality standards;
- Both physico-chemical and hydro-morphological parameters should be in the ranges which ensure proper functioning of the water type specific ecosystem and the achievement of the values specified for the relevant biological quality elements.

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All parameters may be changed by invasive alien species!

WFD: Ecological Quality Indicators

BIOLOGICAL
- Phytoplankton
- Phytobenthos
- Macrofauna
- Fish

- Hybridization with native species,
- Change in species composition
- Change of community structure,
- Elimination of native species (incl. sensitive/indicator species)

PHYSICO-CHEMICAL
- Nutrients
- Salinity
- Transparency
- Oxygen
- Synthetic pollutants
- pH
- Temperature

- Changes in nutrient regime (e.g. due to algal blooms, modification of benthic-pelagic coupling, alteration of food web)
- Bioaccumulation of synthethic pollutants
- Habitat engineering (encrusting of solid objects, changes of bottom sediments)
- Alteration of coastal biotopes

HYDRO-MORPHOLOGICAL
- Changes in sediment transport
- Water flow
- Channel patterns
- Conditions of the shore zones
- Substrate conditions

An example:
IAS can change the ecological quality of a water body

Hydrobiologia **506–509:** 421–426, 2003.

Shift from clear to turbid phase in Lake Chozas (NW Spain) due to the introduction of American red swamp crayfish (*Procambarus clarkii*)

Carlos F. Rodríguez[1], Eloy Bécares[2] & Margarita Fernández-Aláez
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Key words: macrophyte, crayfish, alternative stable states, *Procambarus clarkii*

Spain:

The alien Louisiana red swamp crayfish *Procambarus clarkii*

- destructs 90% of the aquatic vegetation in a lake, which switches to the turbid state.
- Concentration of TP rises by 800%, the water chlorophyll content increases by 100%.
- The trophic status of the lake shifts to hypertrophic.

(Rodrıguez et al., 2005)

Global shifts in freshwater macrofauna

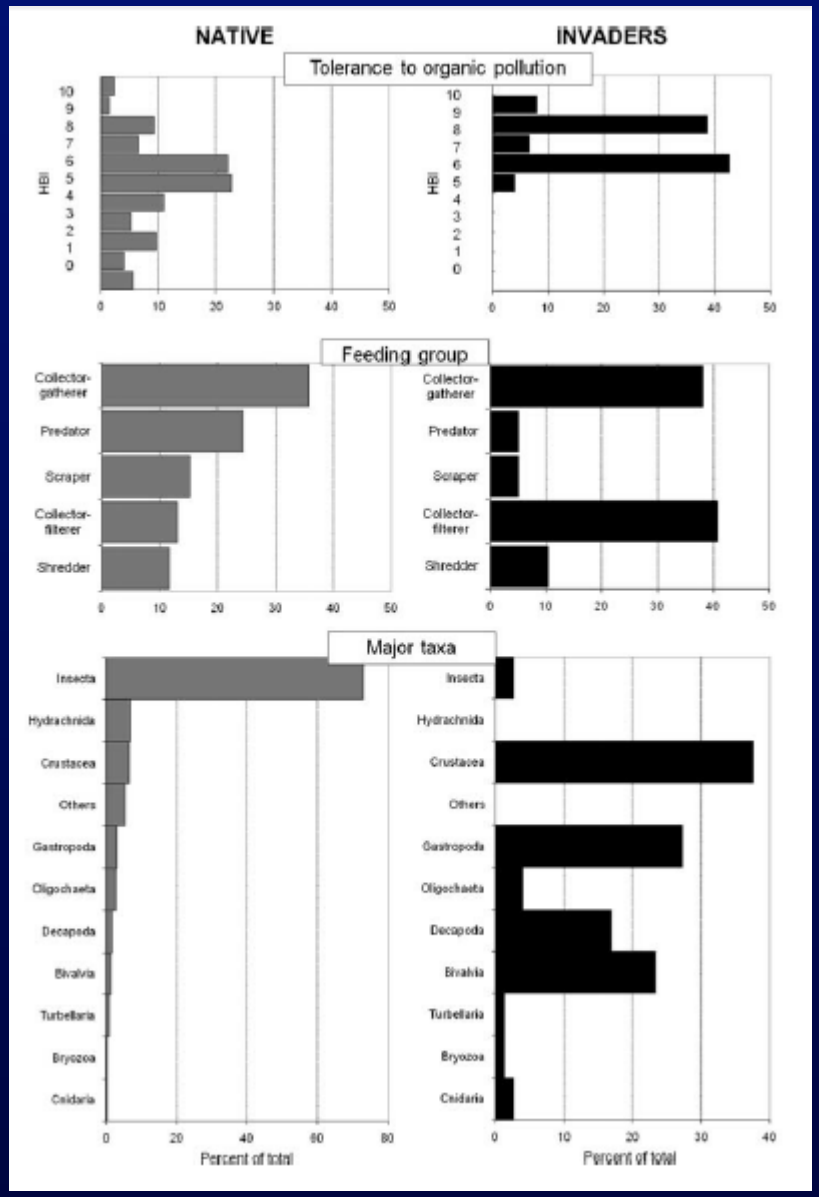
Biol Invasions (2009) 11:2009–2019
DOI 10.1007/s10530-009-9498-0

ORIGINAL PAPER

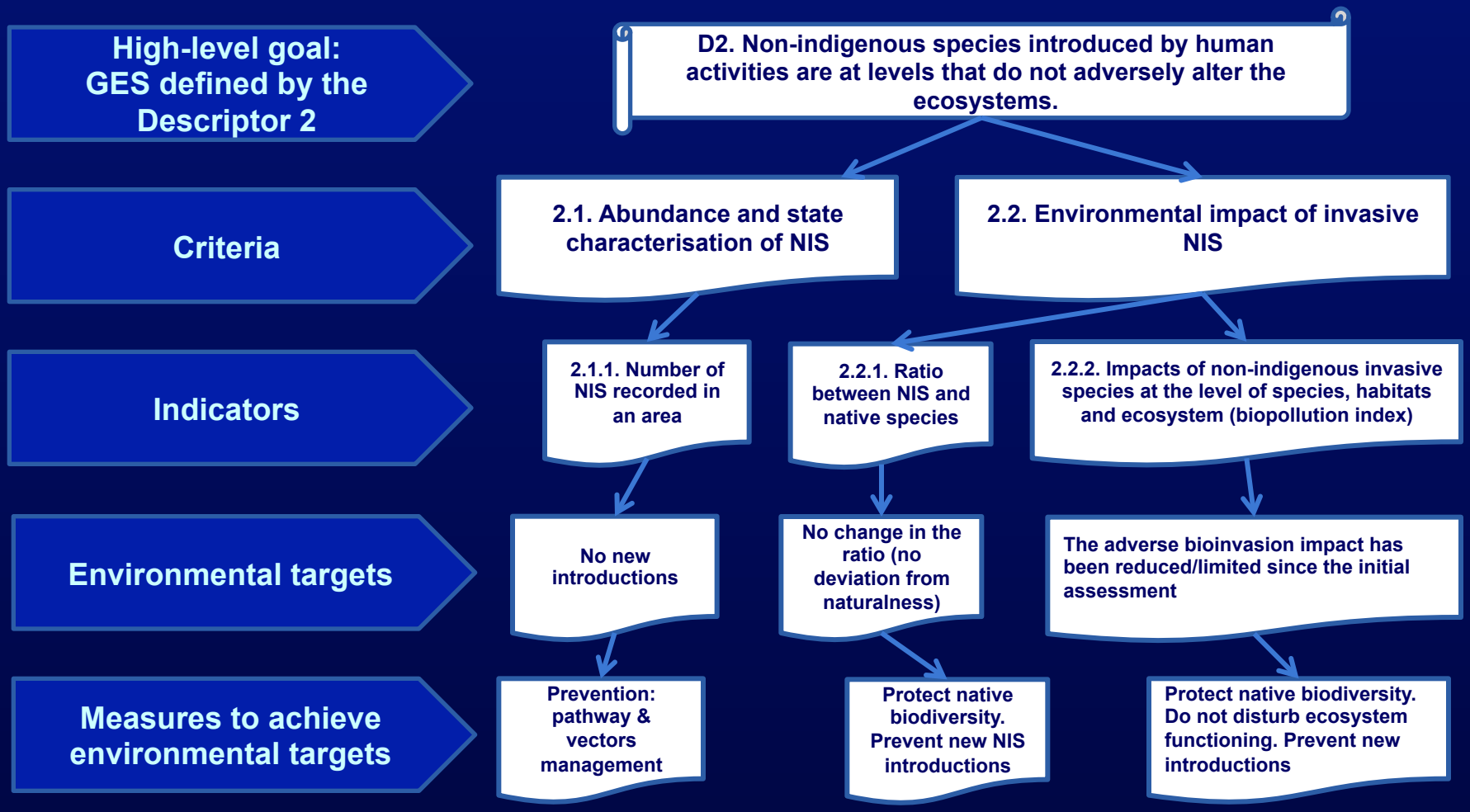
Invaders are not a random selection of species

Alexander Y. Karatayev · Lyubov E. Burlakova · Dianna K. Padilla · Sergey E. Mastitsky · Sergej Olenin

- Compared 119 freshwater macroinvertebrate NIS in North America and Europe to all native freshwater species.
- All invaders are tolerant of at least moderate amounts of organic pollution, while over 35% of native species are only able to live in areas with excellent or very good water quality.
- The ongoing spread of NIS increases the numbers of suspension feeders, thereby enhancing benthic pelagic coupling in waterbodies with high densities of invaders.
- NIS overrepresented by molluscs and crustaceans, while taxa richness of native communities are dominated by insects.



NIS in MSFD:
from high-level goals to indicators and environmental targets



D2 = pressure descriptor

IAS impacts on state descriptors

1. Biological diversity

- Genetic change due to hybridization,
- Decline in populations of native species,
- Shifts in community structure

3. Commercially exploited fish

- Competition with exploited resources,
- Alteration of recruitment and population abundance,
- Reduction in stock due to parasitism

4. Marine food webs

- IAS diseases, parasites, predators, competitors for space, food, light and nutrients, resulting in changes in energy flow

6. Sea floor integrity

- change in physical-chemical structure of bottom sediments by biodeposition, bioturbation, or converting soft sediments into shell deposits or biogenic reefs.

D4. ‘Marine food webs’ and IAS

Criteria
(EC Decision , 2010/477/EU)

4.3. Abundance/distribution of key trophic groups/species

Indicator
(EC Decision , 2010/477/EU)

4.3.1. Abundance trends of functionally important selected groups/species

Parameter
(HELCOM CORESET 2015)

Zooplankton mean size and total stock

HELCOM CORESET (2015): “… *the indicator reacts to the following pressures: fishery-induced mortality, eutrophication leading to dominance of small-sized phytoplankton*.”

IAS impacts

Predation on zooplankton, change in its size structure, reduction in stock, alteration of the food web

Mnemiopsis leidyi

Cercopagis pengoi

IAS causing “noise” in environmental quality assessments: two documented examples

Ecological Indicators 52 (2015) 292–299

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Invasive ecosystem engineers and biotic indices: Giving a wrong impression of water quality improvement?

Anastasija Zaiko[a,*], Darius Daunys[a,b]

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[b] Ecology Department, Faculty of Natural Sciences and Mathematics, Klaipeda University, H. Manto 84, LT 92294 Klaipeda, Lithuania

Hydrobiologia
DOI 10.1007/s10750-010-0391-8

PRIMARY RESEARCH PAPER

Impacts of invasion by *Dreissena polymorpha* (Pallas, 1771) on the performance of macroinvertebrate assessment tools for eutrophication pressure in lakes

Javier Atalah · Mary Kelly-Quinn · Kenneth Irvine · Tasman P. Crowe

Changes in Benthic Quality Index (BQI)
caused by the invasive ecosystem engineer species

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Invasive ecosystem engineers and biotic indices: Giving a wrong impression of water quality improvement?

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[b] Ecology Department, Faculty of Natural Sciences and Mathematics, Klaipeda University, H. Manto 84, LT 92294 Klaipeda, Lithuania

Zaiko, Daunys 2015. Ecol. indicators, 52: 292-299

- **Assessed BQI in a coastal lagoon ecosystem, highly affected by the invasive zebra mussel *Dreissena polymorpha*.**
- ***D. polymorpha* is able of modifying benthic habitats and enhancing local biodiversity = affects benthic species richness, abundance and community structure.**
- **BQI values were significantly higher in the presence of zebra mussel with evident outliers in samples with particularly high zebra mussel abundances.**
- **BQI was artificially elevated providing <u>false signal of the ecological status improvement</u>.**
- **Suggested data correction framework (applicable in other aquatic ecosystems invaded by strong ecosystem engineering species).**

Benthic Quality Index (BQI):

$$BQI_{ES} = \left(\sum_{i=1}^{n} \left(\frac{A_i}{A_{tot}} \cdot ES_{50_{0.05i}} \right) \right) \cdot \log(ES_{50} + 1) \cdot \left(1 - \frac{5}{5 + A_{tot}} \right)$$

<u>Where:</u>

- ***n*** **- observed species number,**
- A_i **- abundance of the species *i*,**
- A_{tot} **- sum of all individuals within a square meter,**
- $ES_{50\,0.05}$ **- sensitivity/tolerance value for species *i*,**
- ES_{50} **- estimated species number for 50 individuals in a square meter.**

(Based on: Rosenberg et al 2004. Mar. Poll. Bull., 49)

Changes in sensitive macroinvertebrate taxa
caused by the invasive ecosystem engineer species

Hydrobiologia
DOI 10.1007/s10750-010-0391-8

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Atalah et al 2010. Hydrobiologia, 654: 37-251

- **Tested three ecological quality assessment tools based on macroinvertebrate assemblages (% Sensitive Taxa to Total Phosphorus (TP), TP Score and Indicator Taxa Metric) in invaded and non-invaded lakes in Ireland.**
- **Noticed significant changes in macroinvertebrate diversity, structure, and composition associated with the invasion by *D. polymorpha.***
- **The three metrics performed consistently well in non-invaded systems, they <u>lost explanatory power</u> for eutrophication pressure in invaded systems.**
- **Metrics may need to be developed separately for invaded and non-invaded systems.**

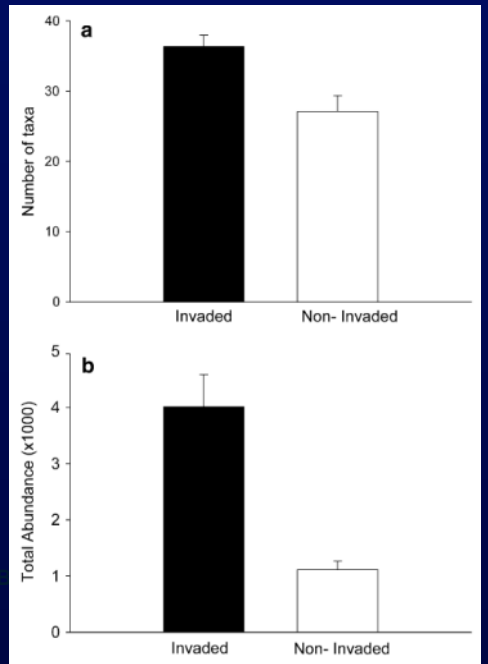


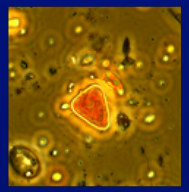
Fig. 4 Mean (+SE) **a** mean number of taxa and **b** total abundance of macroinvertebrates at invaded (*filled bars*, $n = 20$) and non-invaded sites (*empty bars*, $n = 11$)

Conclusions

- The effects caused by invasive alien species may interact with other anthropogenic stressors or even obscure them, producing ‘noise’ in metrics used for environmental quality assessments.
- Such ‘noise’ may indicate a false ‘improvement’ or, *vice versa*, ‘impoverishment’ of environmental conditions.
- IAS effects should be taken into account while assessing the progress towards achieving the goals set by WFD and MSFD.







Thank you for your attention!

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- Mike Elliott and Henn Ojaveer – for valuable comments and discussions