BOOK OF ABSTRACTS

Non-indigenous species in the North-East Atlantic

20-22 November 2013

Ostend, Belgium

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PREFACE

The threat presented by non-indigenous species (NIS) in the Ocean is well-documented and is of great concern to scientists and policymakers. Scientists are alarmed by the introduction, spread and impact of these NIS. These species are often identified as a threat for ecology, economy or human health. Policymakers share this concern. They have the difficult task of designing appropriate measures to reduce the threat and impact of non-indigenous species while balancing the interests of various stakeholders.

Management of NIS is most effective when scientists and policymakers work together. Therefore the Institute for Agricultural and Fisheries Research (ILVO), the Flanders Marine Institute (VLIZ), the Royal Belgian Institute of Natural Sciences (RBINS) and the Marine Biology Section of Ghent University joined forces to organise this conference, "Non-indigenous species in the North-East Atlantic", held on 20-22 November, 2013. The conference is open to policymakers, managers, scientists, educational institutions, industry, non-governmental institutions and anyone with an interest in the marine environment.

This conference highlights the problem of NIS from various perspectives, unifies science and policy, and expands each participants' network further than the usual boundaries. One central topic of the conference is the European Marine Strategy Framework Directive (MSFD). The MSFD emanated from a wide variety of marine legislations and regulations. The goal of this Directive is to provide a legislative framework for a sustainable management of human activities at all levels, from local to regional to national to international seas. We hope that by joining the perspectives of scientists, policymakers, the industry and other stakeholders during this conference, implementation of the MFSD may become easier and more effective.

This Book of Abstracts presents the current research and policy measures related to non-indigenous species. These pages cover subjects from science to policy and from threats to opportunities. I thank all of the authors and participants for their past and current contributions to this work and look forward to future meetings, collaborations and networking. By joining our knowledge, our resources and our forces, we can more effectively manage the presence of non-indigenous species in our waters.

Ostend, 20 November 2013

Dr. Johan Robbens
For the organising and scientific committee

PROGRAMME

Wednesday 20 November 2013

12h00 Registration

Welcome and introduction

12h30 Opening speech
Johan Vande Lanotte, Vice Prime Minister and Minister of Economy, Consumers and North Sea, Belgium

13h00 **Non-indigenous species from a scientific point of view**
Arjan Gittenberger, Naturalis Biodiversity Center, The Netherlands

13h30 **Non-indigenous species and policy**
Myriam Dumortier, European Commission Environment Directorate-General, Belgium

14h00 Coffee break

Session 1: "What is the reason of their success and what are their vectors"

14h30 Introduction on session 1:
The ongoing hardening of the coasts, an ecosystem altering mechanism favouring non-indigenous species. The example of the Southern North Sea
Francis Kerckhof, Royal Belgian Institute of Natural Sciences, Belgium

15h00 Presentations selected from the submitted abstracts

- **Susceptibility and resilience to invasions: macrozoobenthic communities in the Dutch delta waters**
  Sander Wijnhoven, Royal Netherlands Institute for Sea Research (NIOZ), The Netherlands
- **Benthic macrofauna on the coast line rocky substrates of the southern Caspian Sea**
  Amir Faraz Ghasemi, Department of Marine Biology, Faculty of Marine Science and Oceanography, Khorramshahr University of Marine Science and Technology, Iran
- **Does latitude matter? A comparison of three non-indigenous species between the North and Mediterranean Seas**
  Floriane Delpy, Aix-Marseille University, Mediterranean Institute of Oceanography (MIO), France

16h00 Closure

Thursday 21 November 2013

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Filip Volckaert, Catholic University of Leuven, Belgium

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- **Current distribution and population dynamics of *Mnemiopsis leidyi* populations in the Belgian part of the North Sea and the Westerschelde estuary**
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  Pieter Boets, Laboratory of Environmental Toxicology and Aquatic Ecology, Ghent University, Belgium
- **Marine non-native species in the north of Scotland and implications for the marine renewable industry**
  Chris Nall, Environmental Research Institute, University of Highlands and Islands, Scotland
- **Alien fauna and flora in the Scheldt Estuary (Zeeschelde, Flanders, Belgium)**
  Jeroen Speybroeck, Research Institute for Nature and Forest, Belgium

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Patrick ten Brink, Institute for European Environmental Policy (IEEP), Belgium

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  Björn Fagerholm, Institute of Coastal Research, Department of Aquatic Resources, Swedish University of Agricultural Sciences, Sweden
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  Sofie Vandendriessche, Institute for Agricultural and Fisheries Research (ILVO), Animal Science Unit, Aquatic Environment and Quality, Bio-environmental Research Group, Belgium
- **NE Atlantic islands susceptibility to MNIS**
  Joana Micael, CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Pólo dos Açores, Universidade dos Açores, Portugal

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Marleen De Troch, Marine Biology section Ghent University, Belgium

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Jeroen Wijsman, Institute for Marine Resources & Ecosystem Studies Wageningen IMARES, The Netherlands

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- **Risk screening tools for non-native marine species**
  Phil Davison, Salmon & Freshwater Fisheries Team, Centre for Environment, Fisheries & Aquaculture Science, UK
- **Using generic environmental indicators as part of the alien species assessment tool box under the different EU Directives**
  Gert Van Hoey, Institute for Agricultural and Fisheries Research (ILVO), Animal Science Unit, Aquatic Environment and Quality, Bio-environmental Research Group, Belgium
- **Modelling the risk of *Mnemiopis leidyi* blooms in the North Sea**
  Kate Collingridge, Centre for Environment, Fisheries and Aquaculture Science, UK

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Sonia Vanderhoeven, Belgian Biodiversity Platform, Belgium

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- **Pacific oyster *Crassostrea gigas* control within the intertidal zone of the North East Kent European Marine Sites, UK**
  Willie McKnight, Contractor, Eastern Channel Team, Natural England, UK

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Svein Ruud, NorwayKingCrab, Norway

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- **Invasive American razor clam *Ensis directus* in Belgian waters: a true opportunity for shell-fisheries?**
  Kris Hostens, Institute for Agricultural and Fisheries Research (ILVO), Animal Science Unit, Aquatic Environment and Quality, Bio-environmental Research Group, Belgium.

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Bart Naeyaert, Deputy Province of West Flanders responsible for agriculture and fisheries; integrated water management; infrastructure and legal matters, Belgium

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  Floriane Delpy, Aix-Marseille University, Mediterranean Institute of Oceanography (MIO), France

16h00 Closure

Opening speech

Johan Vande Lanotte

Vice Prime Minister of Economy, Consumers and North Sea
Belgium

Non-indigenous species from a scientific point of view

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Among scientists semantic misunderstandings are not uncommon when discussing non-indigenous species. Taxonomists, ecologists, molecular biologists and geologists can have different views on how the species concept should be defined. The NE Atlantic mussel *Mytilus edulis* is an example where scientists tend to use different species definitions. As a result mussels that are considered indigenous according to some, are considered to be non-indigenous by others under the same circumstances. Taking semantics into account, it remains important that scientists of multiple disciplines join forces while studying the dynamics of species'distributions. Population genetics may prove valuable for identifying distribution pathways, but it is still necessary to study additionally the taxonomy, physiology, ecology and/or the geological history of non-indigenous species. As the environment is always changing, regions that used to be unsuitable for the settlement of species may become suitable or vice versa. In recent years several molluscs and cnidarians have expanded their ranges into the North Sea, most probably by their natural distribution capacities. Although such natural range expansions usually take place gradually, volcanic eruptions, extreme storms, sea water level changes, continental shifts and fluctuating temperatures (ice ages), have also caused more abrupt range expansions of species, over relatively large distances. At present, the number of introductions has mainly raised because of human activities. In the marine environment one should hereby acknowledge that most marine species have a pelagic stage during which they can disperse over relatively large distances, along with the sea currents. Therefore, both the main oceanic and tidal currents and the pelagic larval stages of non-indigenous species should be studied to understand their potential future impacts. Such studies have been conducted in western Europe mostly for only a small number of species, like the Japanese oyster *Crassostrea gigas*, the American razor shell *Ensis directus*, and *Sargassum muticum*, i.e. species that have been wide-spread and present in western Europe for decades. From a scientific point of view relatively little is known, however, about species that have expanded their populations in more recent years like the invasive Dripping sea squirt *Didemnum vexillum* and the Oriental shrimp *Palaemon macrodactylus*. Another lack in scientific knowledge concerns the distribution patterns of non-indigenous species as recent rapid species assessments in the Wadden Sea have shown. Furthermore the transport vectors and stepping-stones for non-indigenous species within the NE Atlantic are understudied. Much is hypothesized about the role of pleasure crafts and shellfish transports, but little is known on a western European scale. The value of stepping stones like shipwrecks also appears underestimated. A recent series of expeditions to the central North Sea illustrate their importance for at least some invasive species. In conclusion, from a scientific point of view, much has been hypothesized but much remains to be studied about non-indigenous species in the NE Atlantic.

Non-indigenous species and policy

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Invasive alien species (IAS) are one of the most important causes of biodiversity loss and can also have serious consequences for the economy and human health. It has been estimated that IAS are costing at least €12billion per year in Europe. IAS respect no borders. Action in one Member State is often undermined by lack of action in another Member State. Therefore it is important to act jointly at the EU level.

Following its announcement in the EU Biodiversity Strategy, the European Commission has recently proposed a dedicated legislative instrument on IAS. Key elements in this proposal are the need to prioritise, to coordinate and build upon existing systems and to shift attention from reaction to prevention. Prioritisation would be pursued through a list of IAS of Union concern, based on risk assessment and developed in cooperation with the Member States. IAS of Union concern would be banned from the EU, there would be an early warning rapid response system pursuing the swift eradication of any newly establishing population, while established populations would have to be eradicated, contained or controlled. There would be specific attention for priority pathways of unintentional introduction, i.a. ships ballast water and sediments and ships biofouling.

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http://ec.europa.eu/environment/nature/invasivealien/index_en.htm

The ongoing hardening of the coasts, an ecosystem altering mechanism favouring non-indigenous species. The example of the Southern North Sea

Kerckhof Francis, Ilse De Mesel, Bob Rumes and Steven Degraer

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Coastal communities all over the world have witnessed major changes in the past decades, largely as a result of the rapid and ongoing hardening of the shore. This phenomenon is particularly well noticeable along the coast of the shallow Southern North Sea.

The number, diversity and size of various anthropogenic hard structures in marine environments, either moving (e.g. ships and rigs, floating buoys including aquaculture devices) or fixed (e.g. coastal defence and harbour works, windmill farms) is rapidly increasing. All of them are directly associated with different types of human activities such as maritime transport, coastal defence, aquaculture and energy production/transfer.

The increased availability of man-made hard substrata, together with the increased activities of vectors such as shipping, allows not only a much faster and more intense transport of certain species all over the globe but the migrants now find more suitable habitat to settle and to prosper in regions beyond their original distribution.

While some of the activities (like shipping, harbours and coastal defence) extend back in time for centuries and are already recognised as important vectors for species movement, offshore renewable energy production is a more recent activity with clear intensification during recent decades. Wind farms extend also further off shore and will in the future occupy large areas of the shallow waters of the North Sea. Some of the hard substrates such as wind farms create completely new habitats in the marine ecosystem. For instance, wind turbine foundations create three different zones for epifouling organisms in the intertidal zone, each with a specific fauna part of it being non-indigenous. The number of non-indigenous species proved to be particularly high in the intertidal zone. This is important for the obligate intertidal hard substrata species, for which offshore habitat did not exist in the Southern North Sea until recently. Importantly, wind turbines are often found in sandy environments and these artificial hard structures may act as a stepping stones for non-indigenous biota.

The increased availability of man-made structures in the marine environment poses a current concern, but the decommissioning of many of these structures when becoming obsolete will pose future problems.

It has been argued that the newcomers may augment local biodiversity. However, it becomes more and more evident that these non-native species pose a burden to the native biodiversity: they alter local communities and there are many unwanted economic effects on activities such as shipping and aquaculture (clogging nets).

The issue of artificial substrates is not only relevant to introduced species, but also contributes to the overall change of marine biodiversity. The presence of a large number of non-native organisms – both spreading and introduced species – has already resulted in major changes in coastal habitats. Increased availability of artificial hard substrate hence promotes: 1) establishing of introduced species, 2) spreading of southern species, 3) strengthening of the strategic position of the populations and stepping stone effect.

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

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An increasing number of exotic macrozoobenthic species is recorded in the Dutch delta waters. With respect to the ecological integrity of these systems, it is important to know what determines the successful settlement and expansion of these populations. Based on a long-term monitoring data set for the Dutch delta waters it was investigated whether the susceptibility and resilience of benthic communities to invasion differs with the biotic and abiotic conditions prevailing in these systems. Large differences in the level of invasion were found between the water bodies. The share of exotic species varied between 9 and 23% of the total density and 40 to 81% of the total biomass. These striking differences in dominance patterns of the exotic species between water bodies were related to the prevailing community structure resulting from the level of environmental degradation, the water exchange rate with the open sea, and/or the size of the water body. It is hypothesized here that successful settlement is determined by local physical-chemical characteristics fitting species tolerances and necessities to fulfil their life-cycle. Relative high exotic species concentrations can therefore be found in areas with a high rate of species introductions on a daily basis (hot spots of introduction). Local dominance of exotic species is however related to disturbances decreasing competitive abilities of (native) species already present. When potentially competitive (native) populations are weakened in entire regions, exotic species can become successful in larger regions taking over a particular niche, as was observed for the shore crab communities of the Dutch delta waters (Van den Brink *et al.*, 2012). Generally the success of newly introduced species is only temporary; after the introduction, a lag-phase and an exponential increase of the populations, those populations start to decline and balanced co-existence with native species is reached. The total sequence from introduction to decline typically takes about 15 years in the Dutch delta waters (Hummel & Wijnhoven, 2013). Whether exotic species become invasive seems to be related to the environmental quality state of systems in which they have settled successfully. The environmental quality state determines the resistance of communities already present. Most successful exotic species appear to be those changing their environment; i.e. ecosystem engineers. Moreover these exotic engineering species facilitate associated communities and thereby suppress settlement and expansion of other (native) species. The consequences and potentials for policy and water management will be discussed.

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Benthic macrofauna on the coast line rocky substrates of the southern Caspian Sea

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Rocky substrates support a variety of habitats and heterogeneity which provide a wide range of resources underpinning rich diversity of biota. Within the Caspian Sea, rocky substrates and their biocenose as a patch structures were rarely investigated. In our study, in order to determine the community structure of the benthic macrofauna in the rocky substrates of the southern Caspian, two time samplings (with scraping a surface of 400cm^2 in five replicates) were conducted in summer (August) and winter (March) of 2012. In total, 4,473 specimens of the six species were identified. Total abundances were recorded 1,910 and 20,455ind.m^{-2} in summer and winter respectively. Among the species, *Balanus improvises* and *Mytilaster lineatus* were the dominant, with relative abundance of 98.69 and 94.45% in summer and winter respectively. Another stable species*, Palaemon elegans* was observed in summer and winter with relative abundance of 1.3 and 0.17 % respectively. *Alitta succinea* (4.2%), *Rhithropanopeus harrisii* (0.81%) and *Gmelina pusilla* (0.36%) were observed only in winter. Except *G. pusilla*, the others are NIS. Origins of *P. elegans* and *M. lineatus* are Atlantic-Mediterranean, while others are from American coasts of Atlantic (Grigorovich *et al*, 2002). *A. succinea* have been intentionally introduced as a food reserve for commercially exploited fish (Ghasemi *et al*, 2013). *P. elegans* and *M. lineatus* have been released accidentally. *R. harrisii* and *B. improvises* unintentionally introduced by shipping activity via ballast water or hull fouling of ships (Grigorovich *et al*, 2002).

It seems that wave hydrodynamic force is one important in determining the abundances and dynamics of communities. As during the field samplings we observed the empty samples in stormy days. In this case species severely attached on the bottom such as *B. improvises* and *M. lineatus* could establish in area with strong currents on all rigid substrates very well (Karpinsky *et al*, 2005). Beside demersal predators are not able to separate them from the substrate actively. The mobile species such as *P. elegans*, *R. harrisii* and *A. succinea*, due to high ability to swimming, could rapidly colonize the rocky beds after storm events and their restoration lasted shorter than *G. pusilla*. Moreover, the environmental variables related to seasonal changes such as temperature, salinity and day length, due to their effects on the reproduction activity of macrofauna and their predators, affected directly on the abundances and dynamics of communities (Taheri and Foshtomi, 2010).

Many invasions appear to have relatively negligible ecological consequences, whereas others cause dramatic disruptions to biodiversity and food webs. The NIS collected in the present study may co-exist with native species and even force out them. For instance two endemic Caspian bivalves, *Dreissena elata* and *D. caspica* having been replaced completely by *Mytilaster* (Karpinsky *et al*, 2005). In other hand, some others may inhabit on the vacant ecological niches and play a key role as a significant food resource (Zenkevitch, 1963). So, further studies are required to monitor their impacts and interactions on the native fauna of the Caspian Sea.

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Does latitude matter? A comparison of three non-indigenous species between the North and Mediterranean Seas

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Non-indigenous planktonic species may appear in ecosystems either naturally (i.e. migration) or through anthropogenic activities (i.e. ballast waters, etc.). Some of these species can manage to settle, survive and reproduce in contrasted environments from the place they originate from but also between the places they have colonised. We compared the life strategies of three common non-indigenous species of both North and Mediterranean Seas: the cladoceran *Penilia avirostris*, the copepod *Pseudodiaptomus marinus* and the ctenophore *Mnemiopsis leidyi*. Our objectives are to understand how these species manage to survive in contrasted environments, to explain their success in areas where they do not originate from and to discuss on what their impact can be on those ecosystems. For the North Western Mediterranean Sea, we used the data of a two-years monitoring survey (2010-11): GELAMED project which aimed at studying the zooplankton variability in three French Mediterranean lagoons (Bages-Sigean, Thau and Berre) and their adjacent coastal areas. North Eastern Atlantic Ocean data were taken from recent published scientific literature, scientific presentations or public long term series database (i.e. L4: http://www.westernchannelobservatory.org.uk/). *Penilia avirostris* is a tropical/subtropical species naturally present in warm temperate waters. This species has been observed in the Western Mediterranean coasts since 1920s (Lochhead, 1954). Its expansion into the North Sea started in 1999, correlated with the increase of sea surface temperature (SST) (Johns *et al.*, 2005). *P. avirostris* has established an autumnal population both in the Mediterranean and North Seas (1,232ind.m^{-3} in September 2010 and over 1,000ind.m^{-3} in October 1999 respectively). The appearance of the two other targeted species *Pseudodiaptomus marinus* and *Mnemiopsis leidyi* seemed to be linked with human activities, mainly ship ballast waters. The Asian copepod *P. marinus* was reported for the first time in 2008 in the Berre Lagoon (Delpy, 2013) and in 2010 in the North Sea (Brylinski *et al.*, 2012), reaching abundances up to 206 and 120ind.m^{-3} respectively. The ctenophore *M. leidyi* was observed conspicuously in 2005 in the Berre and Bages-Sigean Lagoons (D. Thibault-Botha and D. Bonnet, pers. com.) and in 2006 in the North Sea (Boersma *et al.*, 2007; Antajan, unpublished data). Aside from ballast waters, a passive dispersion by coastal currents between the different sites is also a possibility. *M. leidyi* has established sustainable populations in the French coastal areas of the North and Mediterranean Seas, with maximum abundances of 61ind.m^{-3} near Gravelines (Antajan, unpublished data), 122ind.m^{-3} in the Bages-Sigean Lagoon and 26ind.m^{-3} in the Berre Lagoon. The overwintering population of *M. leidyi* observed in the North Sea contrasts with the summer and autumnal proliferations described in the French Mediterranean Lagoons. In 2010-11, temperature influences its life cycle with a succession of cyddipid larvae in winter, transitional stages in winter/spring and adults from spring to autumn (Delpy, 2013). However, severe winter of 2011-12 has led to a drastic fall in its abundance, until its disappearance for several months. The invasive and

dispersion success of this species seems to be strongly influenced by intensity and duration of the winter period.

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Thursday 21 November 2013

8h30 Registration

Session 2: "Structural biodiversity"

9h00 Introduction on session 2:

Dispersal of and connectivity between marine populations – thoughts on (non-)indigenous species

Filip Volckaert, Catholic University of Leuven, Belgium

9h30 Presentations selected from the submitted abstracts

- **Current distribution and population dynamics of *Mnemiopsis leidyi* populations in the Belgian part of the North Sea and the Westerschelde estuary**
  Lies Vansteenbrugge, Institute for Agricultural and Fisheries Research (ILVO), Animal Science Unit, Aquatic Environment and Quality, Bio-environmental Research Group, Belgium
- **Assessment of biopollution in Belgian coastal harbours**
  Pieter Boets, Laboratory of Environmental Toxicology and Aquatic Ecology, Ghent University, Belgium
- **Marine non-native species in the north of Scotland and implications for the marine renewable industry**
  Chris Nall, Environmental Research Institute, University of Highlands and Islands, Scotland
- **Alien fauna and flora in the Scheldt Estuary (Zeeschelde, Flanders, Belgium)**
  Jeroen Speybroeck, Research Institute for Nature and Forest, Belgium

10h50 Coffee break

Session 3: "What are the threats for environment, economy and security?"

11h20 Introduction on session 3:

The multiple costs of invasive alien species

Patrick ten Brink, Institute for European Environmental Policy (IEEP), Belgium

11h50 Presentations selected from the submitted abstracts

- **Monitoring of alien species at nuclear power plants in Sweden**
  Björn Fagerholm, Institute of Coastal Research, Department of Aquatic Resources, Swedish University of Agricultural Sciences, Sweden
- **Jellypress & jellyperception**
  Sofie Vandendriessche, Institute for Agricultural and Fisheries Research (ILVO), Animal Science Unit, Aquatic Environment and Quality, Bio-environmental Research Group, Belgium
- **NE Atlantic islands susceptibility to MNIS**
  Joana Micael, CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Pólo dos Açores, Universidade dos Açores, Portugal

12h50 Lunch

Session 4: "Functional biodiversity"

13h50 Introduction on session 4:

Invasive species in marine food webs: their key to success?

Marleen De Troch, Marine Biology section Ghent University, Belgium

14h20 Presentations selected from the submitted abstracts

- **Competition and niche segregation following the arrival of *Hemigrapsus takanoi* in the formerly *Carcinus maenas* dominated Dutch delta**
  Anneke van den Brink, IMARES Wageningen UR, Wageningen Institute for Marine Resources and Ecosystem Studies, The Netherlands
- **Ecological insights into one of the most successful marine invaders: the brown seaweed *Sargassum muticum***
  Aschwin Engelen, Center for Marine Sciences (CCMAR), Portugal
- **Is the *Carcinus maenas* population endangered due to competition with the invasive crabs, *Hemigrapsus* spp.?**
  Moâna Gothland, Laboratoire d'Océanologie et de Géoscience – LOG UMR CNRS 8187, France

15h20 Coffee break

Session 5: "Assessing the risks of non-indigenous species"

15h50 Introduction on session 5:
Risks of introducing non-indigenous species by shellfish transfer
Jeroen Wijsman, Institute for Marine Resources & Ecosystem Studies Wageningen IMARES, The Netherlands

16h20 Presentations selected from the submitted abstracts

- **Risk screening tools for non-native marine species**
  Phil Davison, Salmon & Freshwater Fisheries Team, Centre for Environment, Fisheries & Aquaculture Science, UK
- **Using generic environmental indicators as part of the alien species assessment tool box under the different EU Directives**
  Gert Van Hoey, Institute for Agricultural and Fisheries Research (ILVO), Animal Science Unit, Aquatic Environment and Quality, Bio-environmental Research Group, Belgium
- **Modelling the risk of *Mnemiopis leidyi* blooms in the North Sea**
  Kate Collingridge, Centre for Environment, Fisheries and Aquaculture Science, UK

17h20 Closure

Dispersal of and connectivity between marine populations – thoughts on (non-)indigenous species

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The high potential for dispersal of marine organisms is constrained by behaviour. However, the degree to which passive hydrodynamic forces (advection and diffusion) and active biological forces (life history traits and behaviour) play a role is not well understood. Also the importance of connectivity between habitats used during a life time is poorly known. That is unfortunate because they are essential features for the long term survival of native organisms and hence the communities they live in. But the same features influence the dispersal of non-indigenous species. Tools such as microchemical analyses of otoliths, genomic markers and modelling have sufficient resolution to clarify dispersal patterns in the present and the past. In one case, the dispersal patterns of sole *Solea solea* are increasingly understood. The insights are extrapolated to other organisms, including non-indigenous species.

Current distribution and population dynamics of *Mnemiopsis leidyi* populations in the Belgian part of the North Sea and the Westerschelde estuary

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One of the most notorious marine invasive species is the ctenophore *Mnemiopsis leidyi*. The success of this species is attributed to its efficiency in occupying niches in an ecosystem. The combination of high feeding, growth and reproduction rates enable *M. leidyi* populations to rapidly increase in favourable conditions and facilitate range expansion. This caused economic and ecological problems in the Black Sea after the accidental introduction in the early 1980s. The ctenophore was recently observed in Belgian waters and thus poses a potential threat for the ecosystem of the southern North Sea.
This study presents detailed spatial and temporal distribution patterns of *M. leidyi* in the Belgian Part of the North Sea (BPNS), the Westerschelde estuary and three Belgian ports (Nieuwpoort, Oostende and Zeebrugge). In addition, the population dynamics of this non-indigenous species were elucidated for this area and its distribution was linked to prevalent environmental conditions.
Ctenophores were sampled using a WP3 plankton net or hand net at each station in the study area during monthly sampling campaigns in 2011 and 2012.
Results show the seasonal occurrence of *M. leidyi* from August until December. The ctenophore was present in the port of Oostende and Zeebrugge, the Westerschelde and a nearshore station, whereas it was never observed off shore (> 50km from the coast). Densities were generally quite low ($\leq$0.5ind.m^{-3}) compared to other invaded areas (average density in the Black Sea: 12.4ind.m^{-3}). Nevertheless, densities up to 18.37ind.m^{-3} were observed at the port of Oostende in September 2012 and up to 1.85ind.m^{-3} in the Westerschelde estuary (October 2012). These areas form semi-enclosed basins with mild hydrodynamics, which allow larger populations. The same trend was observed in the estuaries of The Netherlands (Lake Grevelingen and Oosterschelde) and in bays along the east coast of the United States (*M. leidyi*'s native habitat). Furthermore, the Westerschelde and ports clearly function as breeding grounds for this species. Larvae were present in September 2012 in the ports and in October and December 2012 in the Westerschelde.
Although *M. leidyi* populations in Belgium are generally rather small, they can increase at a local and seasonal scale, causing a considerable impact on the ecosystem.

Assessment of biopollution in Belgian coastal harbours

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Harbours, which are often characterised by anthropogenic stress in combination with intensive international ship traffic tend to be very susceptible to aquatic invasions. Since alien macrocrustaceans are known to be very successful invaders across many European waters, a study was made on their occurrence in the four Belgian coastal harbours (Nieuwpoort, Ostend, Blankenberge and Zeebrugge). Biological and physical-chemical data were gathered at 43 sampling sites distributed along a salinity gradient in the four harbours. One fourth of all crustacean species recorded were alien and represented on average 30% of the total macrocrustacean abundance and 65% of the total macrocrustacean biomass. The large share of alien crustaceans relatively to the total macrocrustacean biomass was mainly due to several large alien crab species found in the samples. Most alien species were found in the oligohaline zone, whereas the number of indigenous species was highest at the euhaline zone. The low number of indigenous species present at low salinities was probably not only caused by salinity, but also by the lower water quality in this salinity range. Based on the site-specific biocontamination index (SBCI, Arbačiauskas *et al.*, 2008), the harbour of Nieuwpoort and Ostend scored low with regard to biopollution, indicating the limited abundance and the low number of alien macrocrustaceans. Sampling locations situated more inland (brackish water) generally had a higher SBCI. Zeebrugge and Blankenberge were characterised by a severe biopollution. For Zeebrugge this is probably related to the intensive transcontinental commercial ship traffic, whereas for Blankenberge this could be due to introduction of alien species via recreational crafts or due to its geographic location in the proximity of Zeebrugge. Consistent monitoring of estuarine regions and harbours, which are seen as hotspots for introductions, could help to detect alien species in an early stage in order to avoid or limit their further distribution.

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Marine non-native species in the north of Scotland and implications for the marine renewable industry

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The world's largest commercial wave and tidal energy production site is planned for the Pentland Firth and Orkney waters, north Scotland (The Crown Estate, 2011). Despite the positive impacts of the wave and tidal industry, the creation of sustainable energy, there is potential for a number of environmental impacts (Boehlert & Gill, 2010). One such impact is the spread and establishment of marine non-native species as a result of increased vector activity with respect to vessel traffic and the wet movement of devices (Gollasch, 2002) and the addition of large amounts of artificial habitat (Mineur *et al.*, 2012). To monitor and potentially mitigate against this impact, it is important to determine the presence and distribution of marine non-native species prior to the development. In this study published and unpublished records of fouling marine non-native species in Scotland were centralised into a single inventory. These species were then targeted in rapid assessment surveys (Arenas *et al.*, 2006) of twenty eight harbours in the north Scottish mainland and Orkney Isles, during August and September 2012.

Collation of previous records found that twenty three fouling marine non-native species were known to be present in Scotland. Distribution of these records was uneven and largely underrepresented in the north and east of mainland Scotland, likely as result of low survey effort. In the north Scotland rapid assessment surveys, nine targeted species were found: *Austrominius modestus*, *Botrylloides violaceus*†, *Caprella mutica*, *Codium fragile ssp. fragile*, *Corella eumyota*, *Heterosiphonia japonica*, *Neosiphonia harveyi*, *Schizoporella japonica* and *Tricellaria inopinata*. The non-native bryozoan *Bugula simplex* which was not targeted was also found and this constituted the first confirmed Scottish record. The surveys provided sixty five new locality records and extended the northern UK range of the majority non-native species found. The number of non-native species was greater in busier and larger harbours and a positive association was also found between the number of non-native species and the presence of floating harbour structures. This study represents the first comprehensive survey of marine non-native species in the north of Scotland and provides a baseline dataset which can be used to help monitor the facilitation of non-native species by the wave and tidal energy industry. The findings also highlight the non-native species which could initially colonise and be spread by wave and tidal energy devices or maintenance vessels in the north of Scotland.

† = identification confirmation required

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Alien fauna and flora in the Scheldt Estuary (Zeeschelde, Flanders, Belgium)

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Over the last 150 years, the number of non-native species occurring in areas far from their original range has increased significantly, also in the North Sea and adjacent estuaries. The Scheldt Estuary is no exception. Persistent ecosystem monitoring as well as less structured additional sampling in the Zeeschelde (the Flemish brackish and freshwater part of the Scheldt Estuary) allows documentation of presence, abundance and spatial distribution of vascular plants, macroinvertebrates and fish. Among all three groups of biota, non-indigenous species are found. Thirty-eight non-native plant species have been found, of which four are considered invasive, thus a threat to natural tidal marsh vegetation. Forty-six or forty-seven non-indigenous invertebrate species, discovered from as early as 1835 until as recently as 2012, include annelids (10 or 11 species), crustaceans (17 species) and molluscs (9 species). Among the fish fauna, six species are considered of alien origin and one additional species is treated as naturalised, while more species may be expected in the near future. Continued monitoring allows tracing the evolution of these species within the estuary through time and space, and can provide information on how to deal with invasive species.

The multiple costs of invasive alien species

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Invasive alien species (IAS) are recognised as one of the key pressures directly driving biodiversity loss globally. Similar to climate change, the effects of IAS on ecosystems are very difficult to reverse, underlining the importance of early action to avoid long term impacts. IAS in Europe cause a series of often devastating ecological impacts – they affect ecosystem composition and function, and are a major driver of species extinction. Some of Europe's most threatened species are affected by IAS.

The over 12,000 alien species present in Europe can also negatively affect the flow of ecosystem services that benefit society and the economy, causing economic damage and impacts on public health and wellbeing. IAS have been seen to negatively affect water quality and retention, destabilisation of soil and erosion, changed nutrient cycles leading to changed food chains and/or disruption of plant-pollinator interactions. These impacts on ecosystem services have further led to negative impacts on the economy and local livelihoods include, for example, lost yield, reduced water availability and land degradation. Public health and wellbeing impacts are also common including allergies, skin problems, transmission of human diseases and the introduction of potentially dangerous animals.

IAS impacts can have direct economic implications, e.g. loss of agricultural or forestry output or costs of clean-up. Other wellbeing impacts, such as negative effects on public health, can also be presented in economic terms. Building on the estimated costs associated with 131 documented cases of IAS impacts in Europe, related to in total of 64 IAS, Kettunen and coauthors developed an EU-wide cost of IAS estimate in 2009 (Kettunen *et al.*, 2009). They estimated that IAS damage have already cost EU stakeholders at least 12 billion EUR per year over the past 20 years. With increasing trade and travel, key pathways for the spread of IAS, the risks of impacts can only be expected to increase unless additional measures are taken to address the risk and mitigate impacts.

In 2013 the European Commission, taking into account the biodiversity impacts of IAS as well as the economic value of the impacts, published a proposed Regulation (COM(2013) 620) on the prevention and management of the introduction and spread of IAS. This also responds to the EU 2020 Biodiversity Strategy action to develop a dedicated legislative instrument on IAS.

The EU legislative proposal focuses on three types of interventions; prevention, early warning and rapid response and management of established species. If adopted, the Regulation would also entail costs to EU Member States and stakeholders, e.g. through trade bans of IAS of Union concern, surveillance systems, analysis of pathways and costs of control measures. However, the costs of these measures under the proposed Regulation were estimated at significantly lower than the potential avoided costs of addressed IAS.

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Monitoring of alien species at nuclear power plants in Sweden

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Using huge quantities of seawater for cooling, coastal nuclear power plants may present suitable habitats for growing and a core for dispersal of non-indigenous species. Cooling water installations have proven to constitute favourable environments for sessile filter feeding organisms providing, substrate, constant food supply and elevated temperatures increasing growth (c.f. Rajagopal *et al.*, 2012). In addition, the outlet area of the cooling water will be artificially heated providing suitable habitat for non-indigenous warm water species that would otherwise not survive in the region. Despite this, monitoring at Swedish nuclear power plants so far have primarily focussed on effects of the heated cooling water on native fish and benthic macro fauna with no attention towards invasive species. Sessile organisms within the different paths for cooling water inside the power plants have also long been overseen. After a government initiative a program specifically focusing on alien and invasive species started in 2011 at the Ringhals power plant on the Swedish west coast. This program, still considered to be in a pilot phase, focus on scuba diving inventories in a gradient for area affected by cooling water. Monitoring waterways inside the power plant started in 2013. So far three species not indigenous for Sweden were observed taking advantage of the habitat affected by the heated cooling water: the brown algae *Sargassum muticum*, the red algae *Bonnemaisonia hamifera* and the Japanese oyster *Crassostrea gigas*. These were all found in the coastal areas close to the point where cooling water is emitted. Data from inside the power plant is still waiting for analyses. Development of monitoring of alien species at coastal nuclear power plants could constitute an effective early-warning system for aquatic invasive species

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Jellypress & jellyperception

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One of the objectives of the MEMO-project (INTERREG Iva 2 Seas) is the evaluation of the socio-economic effects of the introduction and presence of the non-indigenous ctenophore *Mnemiopsis leidyi*. Among the most immediate and obvious effects are the potential harm to the fisheries industry and the deterioration of recreational quality. For these stakeholders, MEMO partners elucidated how they are affected by jellyfish in general, how they perceive the problem, and how they manage to avoid negative impacts.

In this study, we focused on the perception of jellyfish (including ctenophores) in general and of *M. leidyi* in particular by the tourist sector and by fishermen in Belgium. We gathered data using questionnaires that were distributed physically (field survey) and digitally (e-mail survey). Additionally, we did a media search concerning jellyfish articles in newspapers to check whether media impressions correspond with the survey results.

The results of a survey among beach tourists show that tourists are not much bothered with jellyfish unless they already got stung. Most people are very cautious, since they do not know whether the species in question is capable of stinging. When children are involved, tourists do not take risks and avoid contact with jellyfish at all cost. People would like to be informed by experts about the risks of the jellyfish they could encounter. Another issue is the sight and smell of larger jellyfish washed ashore, which is considered to be unpleasant. In the case of *M. leidyi*, there is no risk of stings and the individuals are small and inconspicuous when washed ashore. Hence, beach tourists are largely unaware of its presence. This is not the case for divers who know the different jellyfish species and their distribution well. In short, the response to jellyfish differs substantially between tourist sectors. Fishermen do not perceive jellyfish as a problem, unless they are large (e.g. *Rhizostoma* sp.) or unless they sting (e.g. *Chrysaora* sp.).

The media search showed that jellyfish get more and more attention, with an emphasis on blooms and threats worldwide. For *M. leidyi*, the amount of press attention does not correspond with the public perception.

These insights into the perception of jellyfish presence and impacts by different stakeholders can contribute to the incorporation of jellyfish as a factor in the process of integrated coastal zone management.

NE Atlantic islands susceptibility to MNIS

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It is largely known that introduced species not only are a cause by itself of biodiversity loss but also they interact with biodiversity as modifying factors for habitat destruction, pollution and climate change, compromising the integrity of marine ecosystems (Rilov & Crooks, 2009). However, our understanding of the current status of marine introductions is still very limited in most regions of the world (Campbell *et al.*, 2007). The problem of jeopardize natural marine biodiversity is especially serious on islands, as millions of years of physical isolation has favored the evolution of unique species and ecosystems. Moreover, the evolutionary processes associated with isolation have also resulted in island species being especially vulnerable to competitors, predators, pathogens and parasites from other areas (Vitousek, 1990).

Exhaustive reviews on macroalgae introductions have been published especially for the Mediterranean Sea but also for the Atlantic (e.g. Wallentinus, 2002; Minchin, 2007) and other seas. Nevertheless, to the authors' knowledge, there are no studies focused on non-indigenous macroalgae in Atlantic oceanic islands. The emphasis of the present work is in the Azores islands, since this archipelago represents an important geographical link between the NE Atlantic and NW Atlantic coasts.

Although the Azores archipelago, comprising nine islands, is strongly-isolated from other lands (about 800 km from Madeira archipelago, 1,500 km from western coast of Europe and 1,900 km from eastern coast of America) over 7% of its macroalgae are considered non-indigenous species in contrast to the 2.8% introduced macroalgae at a global scale (following Williams & Smith, 2007 and Guiry, 2012). As it is reported for mainland coastal regions, maritime transport encompassing ballast water and vessel fouling seems to be the most likely vector of macroalgae introduction in the Azores archipelago. At least 80% of the non-indigenous macroalgae seems to have found suitable condition to establish in Azores as they have spread to at least another island, and from these, 28% have a potential invasive status in at least one location in the world.

While eradication of macroalgae has proven to be feasible in some small islands (McNeely, 2004), evidence from *Caulerpa webbiana* in Faial Island in the Azores suggests that non-indigenous macroalgae can have negative economic impacts and be incredibly difficult and costly to eradicate or even to control.

Considering the number of algae species currently recorded as non-indigenous, the vulnerability of the biodiversity of the islands in face of newcomers and the difficulties to control and eradicate them, efforts to prevent new introductions must be urgently addressed in the Azores Islands.

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Invasive species in marine food webs: their key to success?

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The Convention on Biological Diversity (CBD) identified "Invasive Alien Species" as a major factor in the loss of biodiversity based on their capacity to out-compete or prey on native species and subsequently cause a degradation of the biodiversity in the area of their introduction (CBD, 2002). Next to their impact, the success of introducing native species largely depends on their interaction with the new environment and its native species. Invasive species will consequently interfere with existing trophic interactions. Although invasive species often resemble closely to their native counterparts, differences in their foraging and antipredator strategies may disrupt native food webs (e.g. Kimbro *et al.*, 2009). It is therefore essential to document the feeding ecology of invasive species in every detail i.e. from food uptake to assimilation efficiency and in terms of food selectivity and feeding flexibility.

The use of biochemical markers (e.g. stable isotopes and fatty acids) can contribute to quantify more precisely the energy flow and the strength of species interactions in marine food webs. Especially at the lower trophic levels of food webs, the information is scarce. Often invasive species are very fast consumers/grazers but to what extent they also use the energy from their food source can for example be estimated by means of prelabelled food sources in controlled lab experiments. Food selectivity experiments can document the level of variability of their diet as one of the reasons for the success of their invasion. Furthermore, the effect of removal or reduction of the invasive species on the native species in a particular area needs to be studied. The impact of the invasive species may remain even after its removal because of indirect effects (e.g. Hansen *et al.*, 2013).

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Competition and niche segregation following the arrival of *Hemigrapsus takanoi* in the formerly *Carcinus maenas* dominated Dutch delta

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In a combined study including a 20 year monitoring programme of the benthic communities of four Dutch delta waters and a snapshot survey conducted in the Oosterschelde tidal bay in 2011, the populations of the native portunid European shore crab *Carcinus maenas* and the introduced varunid crabs *Hemigrapsus takanoi* and *Hemigrapsus sanguineus* were investigated. Whereas *C. maenas* was the most common shore crab in these waters, its numbers have declined on the soft sediment substrates during the last 20 years. As the two exotic crab species were first recorded in the Dutch delta in 1999, they could not have initiated the decline of the native *C. maenas*. However, within a few years *H. takanoi* completely dominated the intertidal hard substrate environments; the same environments on which juvenile *C. maenas* depend. On soft sediment substrate the native and exotic shore crab species are presently more or less equally abundant. *H. takanoi* might initially have taken advantage of the fact that *C. maenas* numbers were declining. Additionally *H. takanoi* are thriving in expanding oyster reefs of *Crassostrea gigas* (Pacific oyster) in the Dutch delta waters, which provide new habitat. Nowadays *H. takanoi* appears to be a fierce interference competitor or predator for small *C. maenas* specimens by expelling them from their shelters. These interactions have led to increased mortality of juvenile *C. maenas*. At present the *C. maenas* populations seem to be maintained by crabs that survive and reproduce on available soft sediment habitats where *H. takanoi* densities are low.

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Ecological insights into one of the most successful marine invaders: the brown seaweed *Sargassum muticum*

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The processes behind local colonization and establishment of the brown seaweed *Sargassum muticum* were investigated. Results from a wide variety of field and laboratory studies, show that colonisation is benefiting from the semi-lunar periodicity of gamete release (Engelen *et al.*, 2008), but microrecruit survival is not clearly affected by lunar phase and microrecruit survival did not differ from the native brown seaweed *Cystoseira humilis*. Population growth rates increased and became more stable as the species became established and dominant. In this respect especially the persistence of non reproductive adults is of importance, both during the colonization and the establishment phase (Engelen & Santos, 2009). Fauna associated to *S. muticum* differed in the native and introduced range from competing seaweeds at both ranges (Engelen *et al.*, 2013). Multiple food choice experiments showed that meso-herbivores in Portugal prefer native seaweeds as food source rather than the invader (Monteiro *et al*, 2009; Engelen *et al.*; 2011), this is however not due to chemical defense. On the contrary, waterborn cues released upon the grazing of *S. muticum* induces chemical defense in closely related brown seaweeds (Yun *et al.*; 2012). *S. muticum* benefits from high growth rates and the relative low grazing pressure on the species to increased the competetiveness of the invader. This invader could probably best be typified as a space grabber that relies on a combination of r- and (mainly) K-traits and may benefit from the need of perennial competitors to allocate energy to defense against grazing.

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Is the *Carcinus maenas* population endangered due to competition with the invasive crabs, *Hemigrapsus* spp.?

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Being the consequence of the rise of maritime trade, the introduction of invasive species is one of the most important human perturbations disrupting coastal ecosystems, together with fishing, pollution, destruction of habitats and climate change (Jackson *et al.*, 2001). Invasive species can change the structure and the functioning of marine ecosystems (Grosholz, 2002) at all biological levels (genome, individual, population, species, communities and ecosystem) via predation, parasitism, pathogenic transfers, physical and chemical modifications of habitats (Beisel and Lévêque, 2010). Among the alien species identified in France, *Hemigrapsus takanoi* (Asakura and Watanabe, 2005) and *Hemigrapsus sanguineus* (De Haan, 1835), native from the north-western Pacific, have been reported on the intertidal zone of the French coast. Nowadays, they are observed from Mount-Saint-Michel Bay to the Belgium border (Dauvin and Dufossé, 2011; Gothland *et al.*, in revision). Locally, the endemic species *Carcinus maenas*, seems to regress in favour to *Hemigrapsus* species (e.g. Opal coast) but this is not a generality and the success of invasion does not appear uniform along the coast (e.g. *C. maenas* remains largely dominant in south of Boulogne-sur-Mer, to the Normandy and along the western coast of Cotentin). In this context, several reasons for this heterogeneity of the success of the invasion were identified by (i) studying the dynamics and biological traits of each species but also (ii) evaluating their food preferences. Thus, crab populations from five study sites were surveyed during 13 months. Thus, the densities, the ecological characteristics of their habitat (sediment nature), the breeding season and the period of recruitment, the sexual maturity and the longevity were evaluated. The fatty acids (FA) and stable carbon and nitrogen isotopic ($\delta^{13}C$, $\delta^{15}N$) compositions of crabs and of several sources (11 including algae, gastropods, bivalves and polychaetes) were seasonally investigated to evaluate the food preferences of *C. maenas* and *Hemigrapsus*. We showed that *H. sanguineus* and *H. takanoi*, through their demographic behaviours corresponded to population with a "r-selected strategy" either more competitive for the conquest of the space than population with a "k-selected strategy" as *C. maenas*. We also underlined the presence of an interspecific competition for resource and the importance of the combination of density-dependent cannibalism and space competition in the nursery area of *C. maenas*, which contribute to the success of the *Hemigrapsus*.

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Risks of introducing non-indigenous species by shellfish transfer

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The Oosterschelde (South-West part of The Netherlands) is for more than a century an important area for shellfish aquaculture (*Mytilus edulis* and *Crassostrea gigas*). For aquaculture purposes, shellfish have been imported for a long time from various countries like France, Germany, UK, Ireland and North America. Besides an aquaculture area, the Oosterschelde is also an important marine protected area and inhibits a large diversity, not only of indigenous species, but also non-indigenous species (NIS), which makes the Oosterschelde the hotspot for marine NIS in The Netherlands. Many of those NIS were related to aquaculture as primary vector for introduction (Wolff, 2005). The most famous introduction is that of the Pacific oyster (*Crassostrea gigas*), that has been introduced in 1963 for aquaculture purposes and has expanded in the wild. At present the species covers large areas in the intertidal mudflats and competes with aquaculture species for food. Legislation is directed to prevent new introductions and further spreading of NIS into new areas with shellfish transfer.

Mussels are imported into The Netherlands to complement the local production and to provide mussel seed for the bottom culture. With the import of mussels, there is a risk of introducing new NIS into the Oosterschelde. Legislation requires intensive monitoring and shellfish associated species inventories (SASI) with the shellfish import. Risk analysis helps to quantify the risks associated with the different species. In this paper risks of introducing NIS associated to shellfish transfers will be discussed. Risk assessment has been applied to assess the risk of introducing NIS with the shellfish imports. The risk assessment is subdivided into a quantification of the chance of a successful introduction and the quantification of the effect. The assessments are made based on literature review and expert judgement.

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Risk screening tools for non-native marine species

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There have been numerous adaptations of the Pheloung *et al.* "Weed Risk Assessment (WRA)", including five screening tools for marine and freshwater fishes and invertebrates. These tools are comprised of 49 questions within two subject themes (Biogeography/History and Biology/Ecology) and eight sections (Domestication/Cultivation; Climate and Distribution; Invasive elsewhere; Undesirable traits; Feeding guild; Reproduction; Dispersal mechanisms; Persistence attributes). Assessments result in an outcome score, ranging from −11 to 54, with which to categorise the potential risk of a species being invasive as low, medium, or high. Of these tools, the freshwater Fish Invasiveness Screening Kit (FISK) has been applied in at least 15 countries on five continents and was the highest scoring assessment tool in a recent evaluation study by the Canadian Science Advisory Secretariat (Research Document 2012/097), which recommended that the 'sister' screening tools for non-native marine fishes (MFISK) and marine invertebrates (MI-ISK) should be applied and evaluated. Also available is a taxonomically generic version (GISK) of the WRA, developed for the EU Regulation on the use of alien species in aquaculture, which consists of 45 questions within four sections (Domestication/Introduction History, Risks of Establishment/Persistence, Risks of Dispersal, Risks of Impacts/Undesirable traits). All three of these screening tools for marine non-native species benefit from the same attributes that made FISK popular (self-explanatory, easy to use). In this communication, the potential application and further development of MFISK, MI-ISK and GISK will be examined within a North-East Atlantic context.

Using generic environmental indicators as part of the alien species assessment tool box under the different EU Directives

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In Europe, nature directives, such as the Water Framework Directive [WFD], the Marine Strategy Framework Directive [MSFD], and the Habitat Directive [HD] were designed to improve the health of the marine ecosystem. Currently, this health is seriously threatened by an increasing amount of human pressures, including the introduction of non-native or alien species. These species negatively affect biological diversity and as a consequence, also affect human and animal health and production in agriculture and fisheries. To counteract the effects of alien species introductions, several EU Member States have formalized their policy in an invasive species strategy. A key component of these strategies is often the establishment and maintenance of a national alien species database. Ideally, those are linked to regional (e.g. NOBANIS, DAISIE) or even global (e.g. GISD) databases. Additionally, the aforementioned EU nature directives include the assessment of alien species in one or another way. Within the MSFD, a descriptor is dedicated to this aspect. For Belgium, this indicator says that the introduction of new alien species of macrofauna or flora should be avoided and the present invasive alien species abundance should not increase significantly. The assessment of these criteria can be supported by the application of generic indicators from other descriptors (e.g. sea floor integrity, biodiversity, commercial fish, food web). For this aspect, some research is already done in the framework of the WFD, whereas alien species are not explicitly accounted for in the directive. The argument for the latter is that no explicit assessment of alien species is required, assuming that significant invasive alien species pressures will affect the environmental status and can hence be detected by the generic status assessments (Vandekerkhove *et al.*, 2013). But is this indeed the case? In this study, we show evidence that generic benthic indicators (BEQI, BPc, m-AMBI, IQI, …) can indeed be effective in detecting changes in the presence of invasive alien species (e.g. *Ensis directus*, *Crassostrea gigas*) and in the status of the ecosystem. The analyses, however, also indicated that it is difficult to pick up signals on newly arrived alien species, but that patterns in invasive species can be closely followed. As a conclusion, we can state that the monitoring and indicator assessment running for all the generic indicators really helps to assess alien species, as required in descriptor 2 of the MSFD.

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Modelling the risk of *Mnemiopis leidyi* blooms in the North Sea

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Recent records of the invasive ctenophore *Mnemiopis leidyi* in the North Sea are a cause for concern due to the detrimental effects this invader has had on marine ecosystems in the Black and Caspian Seas. Fish stocks in the North Sea may be affected by competition and predation from *Mnemiopsis leidyi*, so it is important to determine whether the species, having been introduced, is likely to become established and bloom in the North Sea.
This study applies temperature, salinity and food constraints to data from the GETM-ERSEM model to evaluate the suitability of the North Sea for survival and reproduction of this invasive species. Large parts of the North Sea were found to be suitable for *Mnemiopsis leidyi* reproduction in summer months, although in most areas the suitable time window would not allow completion of more than two life cycles. The highest risk areas were in southern coastal and estuarine regions and in the Skagerrak and Kattegat, due to a combination of high temperature and food concentrations. Importantly, food was found to limit winter survival and so may restrict the overwintering population. Continued monitoring of this species, especially in areas predicted to be at a high risk, will be essential to determine whether it is likely to become a problem in the North Sea.

Friday 22 November 2013

8h30 Registration

Session 6: "Control and early warning systems"

9h00 Introduction on session 6:
Building knowledge for invasive species policy and management: the need for collaborative learning between actors
Sonia Vanderhoeven, Belgian Biodiversity Platform, Belgium

9h30 Presentations selected from the submitted abstracts

- **Eliminating Hull-borne aquatic invasive species - an alternative, Non-toxic, practical approach**
  Simon Bray, Hydrex NV, België
- **Ballast water management risk assessment for exemptions**
  Stephan Gollasch, GoConsult, Germany
- **A metabarcoding approach to analyse the composition and growth of species on wood panels coated with eight anti-fouling paints in the harbour of 't Horentje, The Netherlands**
  Hilde van Pelt-Heerschap, IMARES-WUR, The Netherlands
- **Pacific oyster *Crassostrea gigas* control within the intertidal zone of the North East Kent European Marine Sites, UK**
  Willie McKnight, Contractor, Eastern Channel Team, Natural England, UK

10h50 Coffee break

Session 7: "Non-indigenous species, are there opportunities?"

11h20 Introduction on session 7:
Live king crab export from Norway - and optimal market utilization based on international trend and tradition
Svein Ruud, NorwayKingCrab, Norway

11h50 Presentations selected from the submitted abstracts

- **Invasive American razor clam *Ensis directus* in Belgian waters: a true opportunity for shell-fisheries?**
  Kris Hostens, Institute for Agricultural and Fisheries Research (ILVO), Animal Science Unit, Aquatic Environment and Quality, Bio-environmental Research Group, Belgium.

12h10 Closing speech
Bart Naeyaert, Deputy Province of West Flanders responsible for agriculture and fisheries; integrated water management; infrastructure and legal matters, Belgium

12h40 Closure

Building knowledge for invasive species policy and management: the need for collaborative learning between actors

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Like many disciplines related to biodiversity conservation, invasion biology is expected to produce knowledge that gives answers to environmental questions raised by decision makers and nature managers. However, for the time being, the potential of research is not effectively enough realized through policy or practice (Matzek *et al.*, 2013). This is due to a mixture of factors, from social foundation to enabling processes or information base issues that impede the effectiveness of knowledge to be concretely implemented in actions.

Filling this knowing-doing gap does not only require to increase the amount of information produced by the scientific community, but to reshape the way the knowledge is created, exchanged, experienced and used in practice. This is a great challenge that should engage end-users in the knowledge creation process.

Communities of practice involve a variety of actors concerned by the issue: scientists from natural to social sciences, policy makers, practitioners, NGO's, the private sector, etc. They are interdisciplinary and may be used to facilitate interfacing between science, policy and management.

Complementarily to such networking processes, the development of information systems is crucial for ensuring accessibility to scientifically reliable information (Katsanevakis *et al.*, 2013) (such as occurrence data, reports, scientific articles, etc.), expert registries, but also some kind of knowledge resulting from the digestion of scientific information. The latter is indeed not always understandable or ready to use for policy makers and practitioners and must be translated, simplified or set in another perspective through risk analysis report, black-watch-alert lists, etc.

Working in this way should help to increase scientific credibility and build strong and effective partnership between the different actors willing to act concretely against invasive alien species

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Eliminating Hull-borne aquatic invasive species – an alternative, Non-toxic, practical approach

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Ship, boat and barge hull fouling has increasingly come to the fore as a vector for aquatic invasive species (AIS/NIS). In 2011 the IMO issued guidelines for mitigating this threat, the introduction of exotic species being regarded as one of the greatest threats to global biodiversity. These guidelines are very much under review. Australia and New Zealand are revising the ANZECC Code with a view to protecting their waters from bioinvasion. California is revising state regulations for the same reasons. Conventional wisdom on the subject recommends the use of biocidal antifouling paint to prevent attachment of nuisance species. However, it is acknowledged that copper and other biocides are not effective in keeping the hull entirely free of macrofouling, especially the protected, niche areas, and that copper and biocide tolerant invasive species pose a worse threat of invasion than those which have not become tolerant to antifouling paint biocides. It is acknowledged that in-water cleaning is needed to prevent the spread of hull-borne NIS, yet current biocidal paints are not suitable for in-water cleaning: the abrasive tools used damage and deplete the coatings and cause a pulse discharge of biocides hazardous to the local environment and non-target organisms and further afield when disposed of in dredge spoil. For these reasons in-water cleaning of biocidal antifouling coatings is prohibited in many areas. Foul-release coatings are also not suitable for in-water removal of macrofouling. Current stress is on preventing ships from arriving at their destination with excessive fouling, whereas global elimination of bioinvasion would require that ships leave port with a clean hull. Fuel savings attributed to sailing with a clean hull more than cover the costs involved. An alternative approach to eliminating the hull-borne NIS threat, is the use of a non-toxic surface treated coating system which can be cleaned in the water with no threat to coating or to the environment. This approach can eliminate the hull-borne AIS threat in an economical and environmentally benign way. This presentation will explain this alternative approach and its benefits.

Ballast water management risk assessment for exemptions

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Requirements to address the transfer of harmful aquatic organisms and pathogens with ballast water were set by the 2004 International Convention for the Control and Management of Ship´s Ballast Water and Sediments (BWM Convention). The BWM Convention includes provisions that vessels on certain routes may be exempted from BWM requirements provided this is based on solid risk assessment (RA). RA has to be conducted according to the International Maritime Organisation Guidelines for Risk Assessment under Regulation A-4 of the BWM Convention (G7 Guidelines). As the BWM Convention is nearing its entry into force, vessels have to comply with requirements thereby triggering an interest to conduct RA for exemptions. This contribution presents an exemptions RA model for intra-Baltic shipping based on BWM Convention, G7 Guidelines as an elementary framework and further noting the regionally agreed Helsinki Commission RA guidance for exemptions. We present the RA methods and elements that were selected for the application of ballast water management exemptions in intra-Baltic shipping. This is worldwide the first RA model for ballast water management exemptions according to the BWM Convention. The current lack of reliable biological information (including human pathogens) present the ballast water donor and recipient areas were identified as the most limiting factor to conduct RA. However, this study may be of particular interest for regional seas with similar RA relevant features as in the Baltic Sea, such as an intensive shipping pattern and different salinities throughout the sea.

A metabarcoding approach to analyse the composition and growth of species on wood panels coated with eight anti-fouling paints in the harbour of 't Horentje, The Netherlands

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Identification of pathways for the introduction of harmful marine species point to shipping and aquaculture as the most critical pathways for marine invasions globally. Biofouling on ships is a significant transport mechanism for the introduction of invasive species in many waters. The use of effective safe anti-fouling systems is important to minimize biofouling and transfer of non-indigenous species. Anti-fouling paints have been developed for preservation of ships and boat hulls. However, many paints showed to be harmful to benthic organisms and persistent in the environment. As a consequence, industries are busy developing new generation anti-fouling paints. The aim of this study was to evaluate the composition and growth of species on wood panels coated with eight anti-fouling paints in marine waters. Experiments were carried out on panels immersed for two months in the harbour of 't Horentje in The Netherlands. Every two weeks, the composition and growth of species on the panels were analysed by photographs, DNA concentration measurements and metabarcoding analysis by pyrosequencing. Results will be presented.

Pacific oyster *Crassostrea gigas* control within the inter-tidal zone of the North East Kent European Marine Sites, UK

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In 1964 Pacific oysters were imported to the United Kingdom from British Columbia by the Ministry of Agriculture, Food and Fisheries. The aim was to assist the shellfish industry by identifying an alternative species following the decline of the native oyster *Ostrea edulis*. Field trials conducted around the UK confirmed that the Pacific oyster was commercially viable (Spencer, 1990). Pacific oysters were not considered capable of proliferation in northern European waters due to low sea temperatures. However in the 1990's wild populations were recorded in Devon (Couzens, 2006). Since then further settlement has been recorded in Essex and Kent. Similar settlement was seen in other European nations such as France, Ireland and The Netherlands (Fey *et al.*,2010).
In 2007 Kent Wildlife Trust recorded Pacific oysters at levels not previously seen within the North East Kent European Marine Sites (NEKEMS). In response, Natural England commissioned a research project to establish a baseline record of inter-tidal distribution and density. This led to a monitoring programme and the identification of Western Undercliff, Ramsgate as a recruitment hotspot suitable for testing control work. The purpose of this work was to assess the effectiveness of control measures undertaken by volunteer labour to impede the spread of wild Pacific oysters and limit the damage to designated features within the inter-tidal zone of the NEKEMS. This was achieved by conducting a one-year field trial from July 2012 until July 2013 at a selected location during which a small group of volunteers physically reduced the number of oysters towards a pre-determined target. A similar trial had taken place in Strangford Lough, Northern Ireland (Guy, 2010). Control of non-native species within a protected area was seen as a specialist activity and was supervised directly by Natural England complying with the Department for Environment, Food and Rural Affairs three-stage hierarchical approach to non-native species policy (DEFRA, 2008). The effectiveness of the project was determined by data collected prior to and during the period of the trial. The location had been selected from the management scheme's monitoring programme because of the large number of oysters present, high levels of annual recruitment and the threat to native species and biotopes. It was considered that these factors would present a credible challenge to the volunteer workforce. Trial data indicated that oyster numbers were considerably reduced within the trial zone but had increased at each of three control sites in adjacent zones. The method used had minimal impact on native species and habitats but was labour intensive warranting the use of volunteers. No health and safety incidents were recorded. Natural England is currently assessing the trial in terms of effectiveness, sustainability and as a management option for controlling selected Pacific oyster populations.

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Live king crab export from Norway – and optimal market utilization based on international trend and tradition

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Norway King Crab as was established in 2008 based on a combination of Russian and Norwegian aquaculture knowledge, merged with outstanding market knowledge and Norwegian financial and human capital. Live seafood is a long tradition in many parts of the world, like China, Asia and Middle East. Live seafood is also a merging trend all over the world, growing like the spread out of sushi the last 20 years. Live seafood secures the optimal quality, regularity and also economy. If a seafood item can be distributed and sold live – it will be!

Mr. Svein Ruud will outline the story behind, the brand strategy and the further perspective for live king crab and live seafood from Norway.

Invasive American razor clam *Ensis directus* in Belgian waters: a true opportunity for shell-fisheries?

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The invasive American razor clam *Ensis directus*, has established permanent populations in the North Sea since it reached the German Bight in the late 1970s and is widely spread at the Belgian coast since late 1980s. Periodically, huge numbers of dying specimens and shells are washed ashore. Several questions arose with respect to the population structure and the environmental impact of this invasive species in the Belgian part of the North Sea (BPNS). It is shown that *E. directus* has become a prominent component of the benthic community in the southern bight of the North Sea (more or less limited to the 12nM zone) in terms of distribution, abundance and biomass. The most common length class of the Belgian *E. directus* population was around 11-12cm length with a maximum observed length of 16cm over the last years. Stable adult populations were found around Nieuwpoort Bank, Oostende Bank and the northern slope of the Vlakte van de Raan. It is suggested that *E. directus* can provide a valuable food source for seabirds (common scoter) and flatfish (dab, plaice, sole), especially when high recruitment takes place.

The abundance of *E. directus* also triggered the shellfisheries sector's interest in its commercial exploitation. Scientific findings from the BPNS as well as experience gained by the *Ensis* fishery in Dutch waters suggest that at the observed recruitment rates, this species could be well-suited for a targeted fishery within Belgian waters. The impact of such a fishery on the ecosystem is expected to be limited if it is carried out on a small-scale, as done in the Dutch *Ensis* fishery. However, before such exploitation can take place in the BPNS, we advise for more detailed investigations on the balance between the expected benefits for the local fishery sector and the potential impacts on the ecosystem.

Closing speech

Bart Naeyaert

Deputy Province of West Flanders responsible for agriculture and fisheries; integrated water management; infrastructure and legal matters
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POSTER PRESENTATIONS

Crab invasions in the Barents Sea: consequences and opportunities

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Two invasive crab species currently play a significant role in the Barents Sea ecosystem: red king crab (*Paralithodes camtschaticus*) and snow crab opilio (*Chionoecetes opilio*). The first crab species was introduced deliberately from the Pacific Region in the second half of the XX century. The reasons for the second crab species invasion are still unclear and may be associated either with an incidental transport of larvae in the ballast water or with the migration of adult species under the influence of natural environmental factors.

Despite the fact that crabs have formed self-reproducing populations in the Barents Sea, occupying huge aquatic areas, the process of acclimatization of these species has not been completed yet. Furthermore, ecological features of the species don't cause competitive interactions between them and the geographical distribution of the populations differs significantly. The population of red king crab occupies the southern part of the Barents Sea and it is distributed southwestward and southeastward. Snow crab opilio occupies the central part of the Barents Sea and migrates actively northeastward and northwestward.

The results of studies on the impact of red king crab showed that consumption of benthos by red king crab represents a small part of the total estimated benthos production and this doesn't provide any basis to assert that there is a significant impact and that undermining of food supply for bottom fish species takes place. Analysis of the impact of red king crab on the state of the benthic communities in some areas of the Barents Sea showed structural changes. However, these changes didn't affect the total benthic biomass and benthic biodiversity. Ecological consequences of later invasion of snow crab opilio are studied to a far lesser extent but similar to red king crab food spectrum and similar estimates of abundance suggest a similar adaptation in the ecosystem.

Moreover, by this time red king crab and snow crab opilio have become commercial species in the Barents Sea and the predictions for their fisheries remain quite optimistic. Exploitation of red king crab has been carried out by Russia and Norway since 1994 with the total catch about 8 – 10 thousand tons in some years. According to the predictions annual catch of red king crab in the coming years may be around 6-8 thousand tons. In 2013 experimental fishery of snow crab opilio was carried out in the international waters of the Barents Sea for the first time. The total catch didn't exceed 500 tons but according to the forecasts for abundance dynamics of snow crab opilio its annual catch in the coming years may be about 20-50 thousand tons.

Thus, despite the risk of negative effects on the Barents Sea ecosystem there are quite obvious positive aspects in introduction of alien species for the economic prosperity of the region.

Risk assessment of non-indigenous marine invaders: A combined approach of morphological and molecular analysis allowed unambiguous identification of the comb jelly *Mnemiopsis leidyi* in the Belgian Part of the North Sea (BPNS)

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Every year, several reports are published on non-indigenous aquatic species that enter marine environments worldwide using different pathways and vectors. Some of these species, can interfere with commercial or recreational use of these environments upon introduction and can cause economic damage. Risk assessment involves the estimation of potential harm with regard to the native marine environment. Within this process, managers and researchers are forced to work together and the first step, before any action can be undertaken, is an early and unambiguous identification of the non-indigenous species. The comb jelly, *Mnemiopsis leidyi,* is an invasive species originating from western Atlantic coastal waters that is present in European waters for more than two decades. This species was responsible for the collapse of commercial fish stocks in the Black Sea. The structural fragility of jellyfish and the existence of native species that are morphologically very similar to *M. leidyi,* cause problems in making a correct identification and this has led to some erroneous observations in the past. Risk assessment of non-indigenous marine invaders can only be successful if identification is unambiguous and therefore difficult morphological analysis' should be combined with a molecular biological analysis method. In the study of the distribution of *M. leidyi* in the Belgian part of the North Sea [1], molecular identification with primers for the nuclear internally transcribed spacer (ITS) region and the mitochondrial cytochrome b (CYTB) and cytochrome oxidase I (COI) region completed morphological identification of caught *M. leidyi* specimens. Since genetic analyses happen in a laboratory environment, preservation of the samples is required. To overcome the problems of poor DNA extract quality that are associated with classical formaline preservation, different fixative methods were tested and scored on their ability to preserve morphological features and allow extraction of DNA with sufficient concentration and good purity. The sequence results of the molecular analysis will be used to prepare species specific DNA probes and to develop primers for short species specific barcodes to allow identification of *M. leidyi* in fish stomachs and water samples.

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AquaNIS: a new generation information system on aquatic non-indigenous and cryptogenic species

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Scientific and managerial attention to the problem of biological invasions results in growing number of electronic resources on non-indigenous species (NIS). Currently there are more than 250 websites on NIS worldwide. The databases have been used increasingly for various analyses, though key information needs for bioinvasion management and research are only partially met. An advanced information system dealing with aquatic NIS and crypogenic species (CS) introduced to marine, brackish and coastal freshwater environments of Europe and adjacent regions has been developed recently: AquaNIS, available at www.corpi.ku.lt/databases/aquanis. AquaNIS inherited and incorporated multiple NIS data collections from earlier projects and initiatives to which the co-authors contributed, such as: Baltic Sea Alien Species Database, FP6 and FP7 projects DAISIE, IMPASSE, MEECE and VECTORS. AquaNIS differs substantially from existing NIS information sources in its organizational principles, structure, functionality, and output potential for end-users. The system is designed to assemble, store and disseminate comprehensive data on NIS, and assist the evaluation of the progress made towards achieving management goals, e.g.: the EU Marine Strategy Framework Directive, IMO Ballast Water Management Convention and similar legislation addressing the problem of biological invasions, where the availability of advanced, scientifically validated and up-to-date information support on NIS is essential.

Geographical information in AquaNIS is arranged in a hierarchical order ranging from oceans, ocean sub-regions, Large Marine Ecosystems (LMEs), sub-regions of LMEs to smaller entities, from which a user can make a selection. For example, to ballast water management related risk assessment, the occurrence of NIS can be documented to the level of ports and port vicinities. Presently AquaNIS comprises data on 1197 NIS & CS introduction events into the six LMEs of the Atlantic margin of Europe (from Norwegian Sea to Iberian Coast) as well as, Mediterranean, Black and Baltic Sea. The latter component is freely available online, while the rest will be gradually opened in 2014-2015 after validation of data. AquaNIS invites regional NE Atlantic experts and taxonomy specialists to cooperate developing this information system as a common tool, practical for management and useful for research.

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under Grant Agreement No. 266445 for the project Vectors of Change in Oceans and Seas Marine Life, Impact on Economic Sectors (VECTORS).

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Non-indigenous species of the Belgian part of the North Sea and adjacent estuaries

VLIZ Alien Species consortium*

Flanders Marine Institute (VLIZ) and its consortium of experts on non-indigenous species conduct an ongoing effort to collect and maintain a list of alien species with documented established poplations in the Belgian part of the North Sea (BNS) and its adjacent estuaries.
The list strives to include all currently known alien and cryptogenic species registered in salt and brackish environments in the Belgian part of the North Sea, the Belgian coastal zone and adjacent estuaries (Yser, Scheldt, Ostend Sluicedock). This effort scrutinizes both the intentional and accidental introductions by man or by other vectors. Alien species for which no evidence is available of established populations, are not included in the list, nor are species whose distribution is limited to the freshwater environment. Newly registered species as a consequence of (expected) natural migrations, are also excluded.
The initiative provides an online source of information on alien species for the BNS, as well as on the network of experts for this study area (since 2008). This includes definitions, information sheets, pictures and a fully documented reference list, by species. Each information sheet describes the life cycle and ecology of the species, the introduction pathways and distribution, the potential effects of the species on its environment and possible mitigation measures. To date (July 2013), 72 alien species with established populations have been identified in the study area. The taxa Arthropods (28) and Algae (11), count the highest number of alien species.

***VLIZ Alien Species Consortium (network of experts):**
http://www.vliz.be/imis/imis.php?module=project&proid=2170

and the fully documented list of alien species is available from :
http://www.vliz.be/wiki/Lijst_niet-inheemse_soorten_Belgisch_deel_Noordzee_en_aanpalende_estuaria