INTERREG IVA 2 Mers Seas Zeeën Programme

SEFINS – Safeguarding the Environment From Invasive Non-native Species

Work Package 1 Report

Towards a register of introduced species in estuaries from the 2 Seas Area




Front cover photo credits : Arjan Gittenberger (top left; boat hull fouled with macroalgae), Jo Packet (top right; *Dreissena polymorpha*), Tim Adriaens (bottom left; *Cotula coronopifolia*), INBO (bottom right; the Scheldt and Antwerp harbour)

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SEFINS builds on the previous INTERREG projects RINSE and MEMO, which focused on invasive non-native species in the terrestrial and marine environment, respectively.

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Contents

Introduction

In comparison to terrestrial or marine environments, estuarine areas are much less studied when it comes to introduced species. Nonetheless, estuaries in Western Europe are considered to be hubs of industrial, recreational and/or residential activities, while at the same time being of high ecological value. Combined, these elements are likely to facilitate the introduction of non-native species, with all of the above fields being potentially susceptible to their impacts.

Understanding ongoing species invasions requires knowledge of what, where, when, and how species become introduced, and how their populations develop, spread and may exert negative impacts, either economically or ecologically. These data would provide the necessary basis for the cost-effective policy and management measures needed to avert such invasions. Yet, we are still some distance from having even the most basic of these data at our disposal.

In this report, we showcase three estuaries from the four countries within the Two Seas Area (The Netherlands, Belgium, France and England). As these estuaries differ considerably in scale, shape, ecological status and land use, together they outline our current understanding of estuarine species introductions across Western Europe. We will briefly review what local information sources exist for these estuaries, and see how these cases compare. We will subsequently frame these cases in international efforts on data gathering and handling.

Estuaries from the 2 Seas Area

Estuaries form an integral part of the natural landscape of the Two Seas Area. The coastlines of northern France and England, for instance, have many rivers which naturally empty into the sea, with the river mouths harboring small, medium or large estuaries of different sizes and shapes (Davidson & Buck 1997).

In Belgium and the Netherlands, smaller estuaries are found only on the rivers Yser and Eems, respectively. In contrast, the confluence of the rivers Rhine, Meuse and Scheldt forms one of the largest delta areas of Europe. Though coastal defense measures (among other interventions) have drastically altered the tidal and brackish habitats in this region, the accompanying urban and industrial developments have further opened the window of opportunity for aquatic invasions.

Invasive Non-native Species

When human activities lead a given species to overcome the geographical barriers of its native range and get a foothold elsewhere, it is considered 'introduced'. The species itself is then termed 'alien' or 'non-native'. If this species is perceived as causing harm, it is moreover referred to as 'invasive' (D'hondt *et al.* 2015). For many marine species, however, the native range often cannot be easily defined, in which case the species is called 'cryptogenic' (Kerckhof *et al.* 2007).

Due to the high intensity of industrial, recreational, commercial and residential activities, coastal waters are heavily exposed to introductions of alien species (López-Legentil *et al.* 2015). Well-known examples of such introduction pathways include ballast water (the arrival of species within water pumped into vessels), hull fouling (the attachment of species onto boats),

aquaculture (escapes or contaminants from cultivated shellfish, crayfish or fish) and horticulture (escapes or stowaways from garden ornamentals).

Not all species introductions lead to species invasions. In fact, only a minority of species become invasive, but current data are insufficient to put these dynamics into numbers. Notwithstanding, some invasions have already exerted pronounced impacts in coastal and estuarine environments, such as the Pacific oyster *Crassostrea gigas* which forms extensive reefs that compete with native communities of commercial interest like mussel beds (Nehls *et al*. 2006). Other examples are discussed below.

Figure 1. Pacific oyster *Crassostrea gigas* reef at Nieuwpoort, Belgium (© Francis Kerckhof, MUMM).

In order to prevent the consequences of (further) biological invasions, several legislative measures are being put in place. Two particularly relevant instruments in this respect are the European regulation on invasive alien species (EC 2014) and the convention on ballast water management of the International Maritime Organization (IMO 2015). Both are dedicated to biological invasions at the international level and are currently installed or awaiting ratification.

Policy and management measures heavily depend on the availability of accurate data, the most basic of which would refer to what species are present where. Such species checklists, or registers, may prove to be very simple yet useful tools to inform invasive species management.

Registers

When compiling information to feed into a species register for a specific area, no two sources will have the exact same scope. They are likely to differ with respect to several criteria, such as the geographical and biological constraints of the source at hand, as illustrated in Figure 2.

This report is interested mainly in sources that fall into class 6, however the biological and geographical scopes of most sources vary either slightly or strongly from those. This does not necessarily render them irrelevant, but their interpretation is bound by some conditions. By definition, sources from class 9 have the most scientific detail, but they show only a piece of the puzzle. At the other extent, those from class 3 tend to be the most complete (cf. databases, checklists and registers). However, their level of detail is comparatively lower as primary data is condensed.

Other criteria to evaluate information sources in light of alien species registers are listed below. Note that there is often a trade-off between some of these criteria.

1 – At least part of the source deals with species that are considered introduced for the area, and explicitly labels those species as such (using the identifier 'introduced', or an associated term like 'non-native', 'alien'...).

2 – The source is taxonomically as exhaustive as possible. In this regard, aggregative sources such as databases, checklists, or registers qualify as better sources than primary literature.

3a – The spatial resolution of the source is as high as possible. Ideally, it refers to spatially referenced species occurrences beneath the estuary level.

3b – The spatial extent of the source is as wide as possible. Ideally, it spans the estuary entirely.

4a – The temporal resolution of the source is as high as possible. Ideally, all species occurrences are dated by year.

4b – The temporal extent of the source is as wide as possible. Ideally, it goes back over a century.

5 – The source provides as much additional detail as possible. For the purpose of this exercise, impacts and pathways of spread are considered variables of interest.

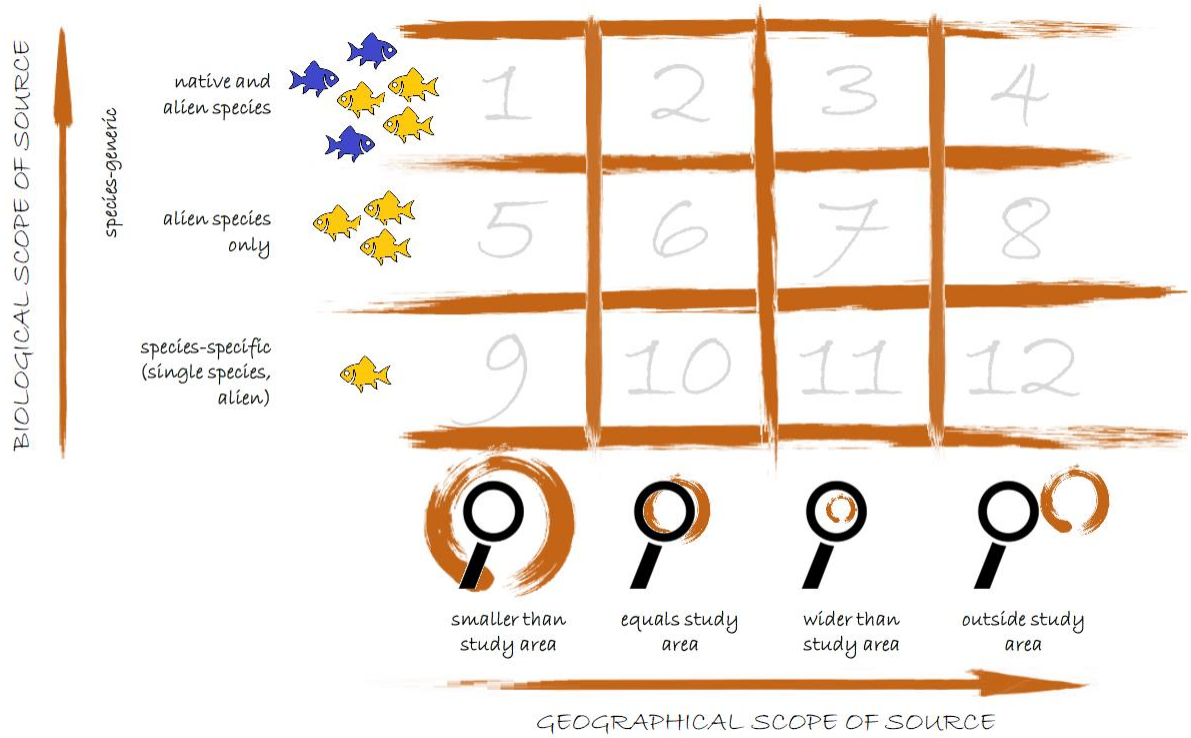

Figure 2. A schematic classification of information sources on alien species present in an area of interest according to two main variables

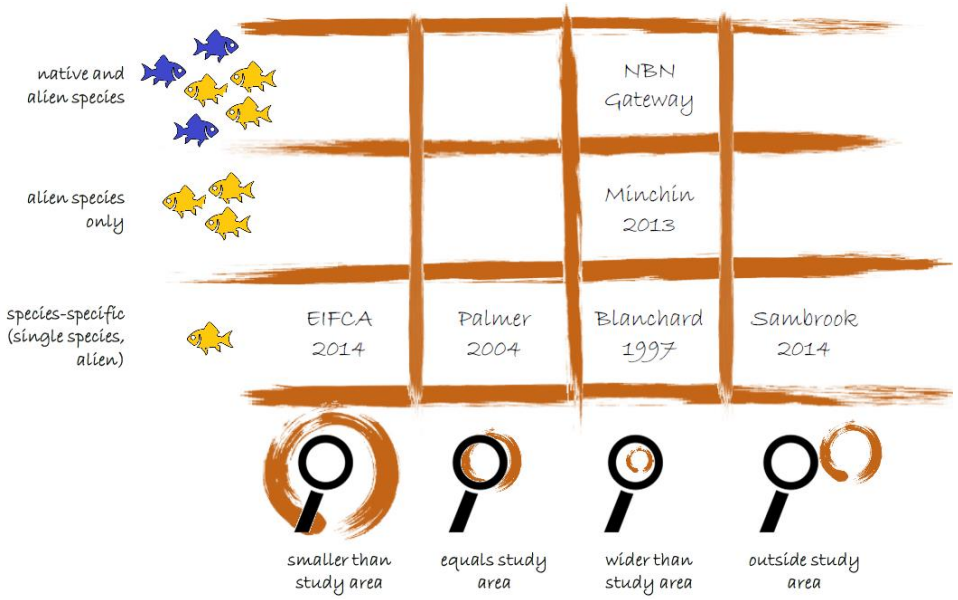

Figure 3. Demonstration of how useful information sources on alien species in the Wash estuary fit into the scheme of the previous figure. The NBN gateway is a nation-wide observation portal for all species inhabiting the UK (3). Minchin *et al.* (2013) provide a checklist of all alien species recorded in British brackish and marine waters so far (7). EIFCA (2014) reports of the distribution of *Crassostrea gigas* and *Crepidula fornicata* in the Gat Sand mussel beds, which make part of the Wash estuary (9). Palmer (2004) reports on the occurrence of *Ensis directus* in the Wash (10). Blanchard (1997) reports on the occurrence of *Crepidula fornicata* along the British coast (11). Sambrook *et al.* (2014) reports on the presence of *Didemnum vexillum* in marinas in Wales, the conditions of which differ little from those in the Wash (12).

Case-studies

Case 1: The Wash (UK)

A BRIEF INTRODUCTION

The Wash is the largest embayment in the United Kingdom (Appendix 1A, Figure 4). It is located on the east coast of England, where the counties of Norfolk and Lincolnshire meet. The bay is fed by the rivers Great Ouse, Witham, Welland and Nene. It spans an area of approximately 660 km^2.

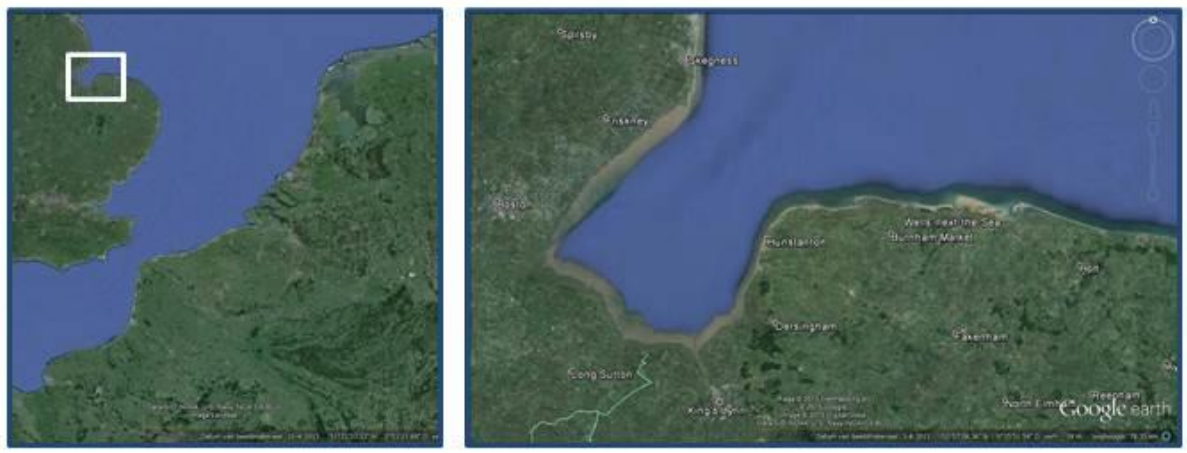

Figure 4. Location and overview of the Wash (figure: Google).

Around half of the Wash is permanently covered in water. The remaining regions are composed of a mixture of mudflat, sand flats and salt marsh. Much of the Wash is very shallow, with several large sand banks exposed at low tide. It harbors habitats unique in the UK, such as *Sabellaria spinulosa* reefs. It also supports important wading, breeding and migratory bird populations, a seal colony and multiple bivalve and crustacean fisheries, as well as supplying a nursery ground for juvenile fish species. As a consequence, the Wash contains multiple national designations and is an internationally recognized European Marine Site (EMS), forming part of the Natura 2000 series.

The Wash is used as an anchorage for commercial shipping access to ports at King's Lynn and Boston, handling cargo in the region of £2 million each year. A large wind farm is located just offshore of the entrance to the Wash. The area also hosts commercial fisheries of shrimp, cockles and mussels. The land surrounding the Wash is used for sea defences, stock grazing, arable farming and military weapons training. The largest urban areas are spread around the coastline at Skegness, Boston, King's Lynn and Hunstanton. Land based recreation in the Wash includes wildfowling, bird watching and walking whilst popular water sports conducted in the area include sailing, windsurfing and power boating.

SOURCES AND REGISTERS OF INTRODUCED SPECIES

Note that an overview of information sources on alien species in the Wash is graphically presented in Figure 3.

There are no information sources dedicated solely to introduced species within the Wash. There are also no monitoring projects currently listed in the database of non-native species projects in Great Britain around the Wash area (NNSS 2015).

A few informative reports and studies exist that focus on one or a few species in particular. Some of these pertain specifically to the Wash (e.g. Palmer 2004, ESFJC 2009, EIFCA 2014), while others have a broader geographic scope (e.g. Blanchard 1997; *Ensis directus*, *Crepidula fornicata* and *Crassostrea gigas*). The most taxonomically generic register of introduced species for British marine and brackish waters is provided by Minchin *et al.* (2013), who listed 90 such species.

Data on macrofauna and macro-algae could also be extracted from The Archive for Marine Species and Habitats Data (DASSH 2015). This includes 532 entries from between 1986 and 2009, none of which are non-native.

Species occurrence data from all over the UK is gathered in the National Biodiversity Network's Gateway, which provides extensive dated and spatially referenced observations at a resolution below the estuary level (NBN 2015). Essentially, this provides an opportunity to extract registers of alien species present within the estuary, though this feature is currently not enabled in the system.

Case 2: The Scheldt (NL, BE)

A BRIEF INTRODUCTION

The river Scheldt (NL: de Schelde, FR: l'Escaut) originates in Northern France, has most of its course in Belgium, and flows out into sea in The Netherlands (Appendices 1C-D, Figure 5). Because the river mouth is funnel-shaped, the tide extends far inland, up to the city of Ghent (160 km upstream), where it becomes impaired by sluices. Its tributaries (Durme, Rupel, Nete, Dijle and Zenne) are also under tidal influence. The part of the Schelde which flows from Ghent downstream to the Dutch-Belgian border is referred to as the Zeeschelde. Downstream from the border to the North Sea, it is referred to as the Westerschelde. The Zeeschelde is 105 km long and 44 km^2 in surface area, while the Westerschelde is 58 km long with a surface area of 310 km^2 (Meire *et al.* 2005).

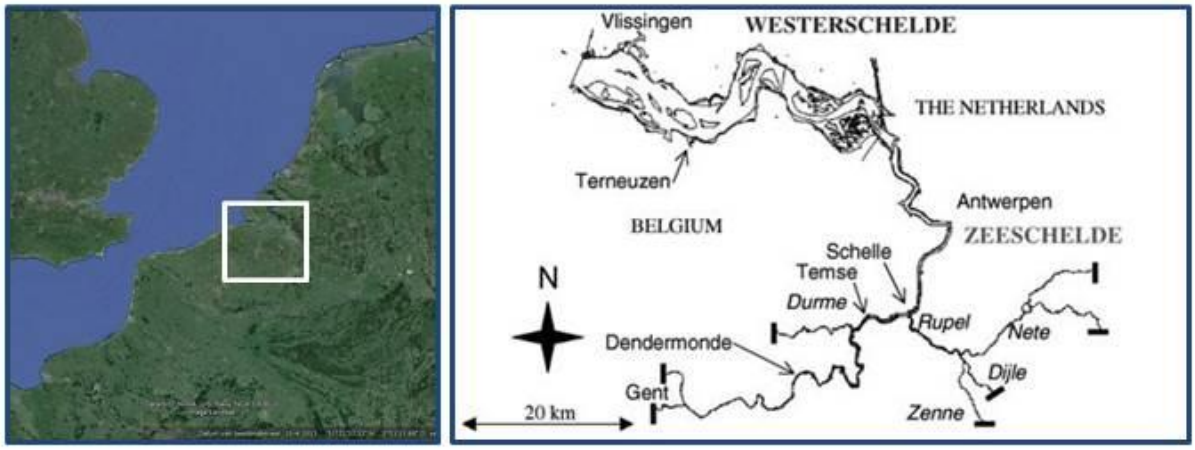

Figure 5. Location and overview of the Scheldt, downstream from Ghent. (figure: Google, left; Meire *et al.* 2005, right).

The estuarine environment of the Westerschelde is composed of intertidal sand flats, mudflats and marshes. The Zeeschelde spans a salinity gradient from brackish to fresh water, with mudflats and marshes occurring throughout. The river becomes more channelized as it moves upstream. The Scheldt estuary is a designated Natura 2000 site on both sides of the border, containing Special Areas of Conservation (SAC) and SPA's. It is an important wintering and stop-over site for waders and waterfowl using the North-East Atlantic flyway; a spawning, nursing and foraging area for many fish species; and a resting and feeding area for seal and harbor porpoise.

The Scheldt is a major shipping route. Industrial, residential and recreational activities are most intense near the city of Antwerp, which accommodates about 500,000 inhabitants and holds the second largest European port (by tonnage). The Dutch harbors of Vlissingen and Terneuzen are also located within the Westerschelde.

SOURCES AND REGISTERS OF INTRODUCED SPECIES

The marine and coastal areas of Belgium and The Netherlands are relatively well-studied with regard to biological communities. The primary literature on introduced species therefore encompasses many detailed species-specific accounts (e.g. van Haaren & Soors 2009, Soors *et al.* 2013, Faasse 2014) and exhaustive reviews (e.g. Wolff 2005, Kerckhof *et al.* 2007). Below, we briefly present two dynamic lines of information on introduced species in the Scheldt, into which many of these studies have become incorporated.

Integrated monitoring

Given its pivotal importance for the Flanders region and the southern Netherlands, a Long Term Vision has been formulated for the whole of the Scheldt estuary, implemented and managed by a cross-border commission (Vlaams-Nederlandse Scheldecommissie, VNSC). As part of this, a permanent working group coordinates a long-term monitoring and research program (MONEOS), in support of policy and management measures within the estuary's limits (Meire & Maris 2008).

The natural quality (or 'naturalness') of the Scheldt forms one of three main pillars of the Long Term Vision (along with safety and accessibility). The identification of alien species therefore forms an integral part of the MONEOS monitoring scheme and their numbers are treated as indicative for assessing the health of the ecosystem.

The first register was compiled in 2009 and listed 83 species mostly from the marine and brackish zones (Anon. 2010). This list indicated that most recorded species were crustaceans or molluscs, and that the number of introduced species had steadily increased over time (Figure 6).

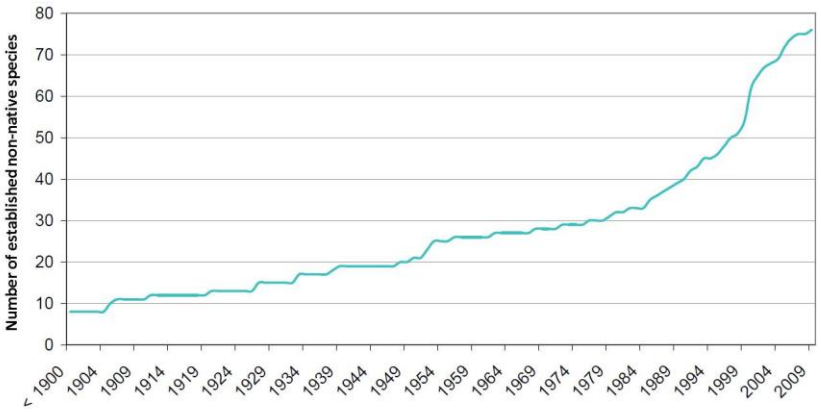

Figure 6. The cumulative number of established, non-native species in the Scheldt estuary (figure adapted from Anon. 2010).

Maris *et al.* (2013) presented an updated list, taking a slightly wider ecological scope as well as historical perspective. This list contains 126 species, shown in Table 1. Trends are discussed by taxonomic group in order to evaluate the ecosystem's state in 2009 by Depreiter *et al.* (2013). It is planned to re-evaluate these trends on a six-yearly basis.

All data and reports concerning the Scheldt are available through a dedicated online repository (ScheldeMonitor 2015).

Table 1. Introduced species recorded in the Scheldt, after Maris *et al.* (2013).

	birds	43	*Potamothrix vejdovskyi*	85	*Stephanopyxis palmeriana*
1	*Aix galericulata*	44	*Branchiura sowerbyi*	86	*Alexandrium tamarense*
2	*Aix sponsa*	45	*Bratislavia dadayi*	87	*Chaetoceros muelleri*
3	*Alopochen aegyptiacus*	46	*Ficopomatus enigmaticus*	88	*Chattonella* sp.
4	*Anas americana*	47	*Brachiodrilus hortensis*	89	*Corethron criophilum*
5	*Anas platyrhynchos domesticus*	48	*Alitta virens*	90	*Coscinodiscus wailesii*
6	*Anser anser domesticus*	49	*Aphelochaeta marioni*	91	*Cyclotella scaldensis*
7	*Anser indicus*	50	*Boccardiella ligerica*	92	*Fibrocapsa japonica*
8	*Anser sygnoides*	51	*Microphthalmus similis*	93	*Gymnodinium mikimotoi*
9	*Branta canadensis*	52	*Proceraea cornuta*	94	*Odontella sinensis*
10	*Branta hutchinsii*	53	*Sabellaria spinulosa*	95	*Pleurosigma planctonicum*
11	*Cairina moschata*	54	*Syllidia armata*	96	*Prorocentrum triestinum*
12	*Chen canagica*	55	*Syllis gracilis*	97	*Thalassiosira angstii*
13	*Chenonetta jubata*		**arthropods**	98	*Thalassiosira hendeyi*
14	*Chloephaga picta*	56	*Callinectes sapidus*		**zooplankton**
15	*Cygnus atratus*	57	*Rhithropanopeus harrisii*	99	*Acartia tonsa*
16	*Marmaronetta angustirostris*	58	*Synidotea laticauda*	100	*Pseudodiaptomus marinus*
17	*Oxyura jamaicensis*	59	*Eriocheir sinensis*		**macrophytes**
18	*Phoenicopterus chilensis*	60	*Melita nitida*	101	*Acorus calamus*
19	*Plegadis falcinellus*	61	*Chelicorophium curvispinum*	102	*Angelica archangelica*
20	*Tadorna cana*	62	*Elminius modestus*	103	*Azolla filiculoides*
21	*Tadorna tadornoides*	63	*Hemigrapsus* spp.	104	*Bidens frondosa*
	fish	64	*Dikerogammarus villosus*	105	*Coronopus didymus*
22	*Atherina boyeri*	65	*Mytilicola intestinalis*	106	*Echinochloa crus-galli*
23	*Carassius auratus*	66	*Palaemon macrodactylus*	107	*Elodea nuttallii*
24	*Carassius gibelio*	67	*Monocorophium sextonae*	108	*Epilobium ciliatum*
25	*Cyprinus carpio*	68	*Gammarus tigrinus*	109	*Erigeron canadensis*
26	*Ictalurus punctatus*	69	*Synidotea laevidorsalis*	110	*Fallopia japonica*
27	*Lepomis gibbosus*		**molluscs**	111	*Festuca rubra* var. *litoralis*
28	*Micropogonias undulatus*	70	*Petricola pholadiformis*	112	*Hydrocotyle ranunculoides*
29	*Pimephales promelas*	71	*Mercenaria mercenaria*	113	*Impatiens glandulifera*
30	*Pseudorasbora parva*	72	*Ensis directus*	114	*Lolium multiflorum*
31	*Salvelinus fontinalis*	73	*Rangia cuneata*	115	*Populus canescens*
32	*Sander lucioperca*	74	*Mytilopsis leucophaeata*	116	*Populus nigra* cv. *italica*
33	*Umbra pygmaea*	75	*Dreissena polymorpha*	117	*Populus* x *canadensis*
34	*Vimba vimba*	76	*Venerupis philippinarum*	118	*Pyrus communis*
	annelids	77	*Crassostrea gigas*	119	*Quercus rubra*
35	*Quistadrilus multisetosus*	78	*Potamopyrgus antipodarum*	120	*Salix dasyclados*
36	*Limnodrilus cervix*	79	*Corbicula* spp.	121	*Salix eriocephala*
37	*Potamothrix hammoniensis*	80	*Crepidula fornicata*	122	*Senecio inaequidens*
38	*Marenzelleria viridis*	81	*Teredo navalis*	123	*Symphoricarpos albus*
39	*Potamothrix moldaviensis*	82	*Mya arenaria*	124	*Trifolium hybridum*
40	*Tubificoides heterochaetus*		**phytoplankton**	125	*Veronica persica*
41	*Psammoryctides moravicus*	83	*Heterosigma akashiwo*	126	*Xanthium strumarium*
42	*Marenzelleria neglecta*	84	*Rhizosolenia indica*		

VLIZ Alien Species Consortium

The VLIZ Alien Species Consortium represents a network of scientists with taxonomical and/or invasion biological expertise in marine and coastal areas. Led by Flanders Marine Institute (VLIZ), it provides the facilities to allow the exchange and publication of information. As of 2012, it encompassed about 50 scientists from 22 different institutes.

The Consortium published an exhaustive list of non-native species of the marine and brackish zones from the Belgian North Sea and adjacent estuaries (Vandepitte *et al.* 2012). The list is maintained online and updated regularly with new data (VLIZ 2015). As the study area includes the Westerschelde and the Zeeschelde downstream from Antwerp, the Consortium has also substantially contributed to the work presented above.

Waarnemingen.be

Similar to the National Biodiversity Network's Gateway in the UK, a popular online recording platform for species observations, referred to as '*waarnemingen.be*', provides the opportunity of extracting species registers below the estuary level. It includes a module that is dedicated to early warning (including species identification sheets for observers, and the possibility for managers to activate area-specific alerts), and is linked with the RINSE app for on-field recordings (Adriaens *et al.* 2015).

Case 3: The Canche (FR)

A BRIEF INTRODUCTION

The estuary of the river Canche (FR: la Canche, NL: de Kwinte) is located between the villages of Étaples and Le-Touquet-Paris-Plage in the region of Pas-de-Calais in Northern France (Appendix 1B, Figure 7). The river itself is only 88 km long, but has a high flow due to its many tributaries. The surface area of the estuary covers approximately 15 km^2.

Figure 7 – location and overview of the Canche estuary (figure: Google)

Though partly transformed through urban development, the Canche estuary has a bay shape characteristic of the Picardy region. The system encompasses coastal dunes, sand flats, mudflats and salt marshes, home to many plant, amphibian and bird species (both sedentary and migratory), amongst other organisms. This species richness has led the area to be classified as a ZNIEFF (Natural Zone of Ecological, Faunistic, and Floristic Interest) and Natura 2000 area. Both the Canche estuary and bay form part of a new Marine Natural Park.

The village of Étaples has a small leisure port (with pontoons for about 240 boats), and a very small fishing port (for about 6 boats). Around 18.500 people inhabit the area, though this number doubles or triples during summer holiday season.

SOURCES AND REGISTERS OF INTRODUCED SPECIES

There are no information sources dedicated to introduced species, as a group, within the Canche. Some informative reports and studies exist that focus on broader geographic scopes (e.g. Dewarumez *et al.* 2011, Grulois 2006; on the Opal Coast), or focus more on inland systems (Toussaint & Hendoux 2005, Godin 2005; on freshwater and humid habitats of Nord-Pas-de-Calais).

Since 2005, a national reference bank for biodiversity data has been operated by the Natural History Museum, which includes geographical data down to a regional level and discriminates between native and introduced species (MNHN 2015). The system identifies species according to their status, and can therefore be used to compile registers. Table 2 provides some statistics on the registers for the areas encompassing the Canche.

Table 2. Statistics on species communities for geographic entities enclosing the Canche estuary, after MNHN (2015)

	Department	Maritime zone	Municipality	Municipality
	Pas-de-Calais	**Pas-de-Calais territorial sea**	**Étaples**	**Touquet-Paris-Plage**
Native	2570	402	288	354
Introduced	257	8	26	27
Introduced invasive	50	3	5	5
Cryptogenic	15	1	3	4

The majority of the terrestrial areas comprise of plants. The eight introduced species listed for the maritime zone of Pas-de-Calais are: razor clam *Ensis directus*, softshell crab *Callinectes sapidus*, Chinese mitten crab *Eriocheir sinensis*, oriental shrimp *Palaemon macrodactylus*, bristleworm *Polydora ciliata*, slipper shell *Crepidula fornicata*, Japanese shore crab *Hemigrapsus sanguineus* and brush-clawed shore crab *Hemigrapsus takanoi*; mollusc *Cornu aspersum* is listed as cryptogenic.

Discussion

Estuarine species in the Two Seas Area

In the following paragraphs, we briefly review the knowledge available on introduced species within the Two Seas Region, with a particular focus on our study areas (Wash, Scheldt and Canche).

SPECIES

It is evident that estuaries of the Wash (EN), the Scheldt (NL, BE) and the Canche (FR) differ greatly in many respects (morphology, size, land use, population density). The same is also true for the sources supplying information on the introduced species present within each area.

For the Wash and the Canche, data on introduced species are collected mostly on an *ad hoc*, incidental or species-specific basis. These primary data may support dedicated registers at broader geographic scales (e.g. Minchin *et al.* 2013 for British waters), or may be incorporated into biodiversity portals (NBN 2015, MNHN 2015). However, the resulting species lists are inevitably incomplete and biased (with regards to taxa, areas or observers) as they are based on anecdotal information instead of rigid sampling schemes. Monitoring schemes that include introduced species exist only in the Scheldt, and count 126 species from various taxonomic groups (Anon. 2010, Maris *et al.* 2013; Table 1).

Yet, even the monitoring scheme conducted in the Scheldt is not exhaustive with regards to introduced species, as benthic organisms are sampled only on soft substrate. The many man-made substrates such as dykes, buoys and cobbles are not considered, despite their potential attractiveness as new niches for alien species settlement. Current monitoring schemes should therefore also focus on hard substrates, an approach currently being piloted under this same project (Gittenberger & Rensing 2015, Wijnhoven *et al*. 2015). In addition, campaigns which aim to exhaustively register the entire resident community of introduced species are rarely performed (see Gittenberger *et al.* 2014 for a notable exception in the port of Rotterdam).

Given the size of the Wash estuary and the wide range of activities occurring within it, the lack of information on alien species is striking. This clearly identifies this area as a priority for further research and a key location for implementation of tailored sampling and/or monitoring schemes.

PATHWAYS

The main pathways of species introductions are well-known (including ballast water, hull fouling, aquaculture and horticulture), and considerable work is being performed on marine introduction routes (e.g. Gollasch 2002, Mineur *et al.* 2007, McCollin & Brown 2014; WGITMO and WGBOSV working groups of the International Council for the Exploration of the Sea (ICES)). Yet, it is often difficult to establish a firm link between an already established introduced species and the vector by which it arrived (Hewitt *et al.* 2009). Linkages between species emergence and vectors can be made by reasoned argument, however, and many of the species accounts referenced throughout this report provide such argumentation. As legislative measures put focus on preventative measures for reasons of cost-efficiency, a good understanding of the (relative) importance of introduction vectors (and subsequent vectors of spread) remains

crucial, and may inform monitoring schemes that focus on specific pathways rather than specific species (Essl *et al.* in press).

A special case with regard to the Two Seas Area is represented by the man-made canal network that now links the North Sea with the Donau basin, and has allowed species from the Ponto-Caspian region to become introduced into Western Europe (and *vice versa*). As highlighted by Gallardo & Aldridge (2015), Great Britain might be on the brink of an invasion meltdown led by assemblages of Ponto-Caspian freshwater species. As many of these species are increasingly shared amongst the countries of the Two Seas Area, the authors call for a preventative strategy that focuses on pathways and on the lower reaches of certain rivers, including tributaries of The Wash. Likewise, monitoring efforts in Belgium and The Netherlands might put particular focus on the main entrance routes for these species in order to allow for a rapid response.

IMPACTS

The local impacts of introduced species are discussed in some the sources referenced above. Some illustrative example species in this regard are:

- **Pacific oyster *Crassostrea gigas*** – Following its deliberate introduction into The Netherlands in 1964, Pacific oysters have colonized almost the entire coastline of the Two Seas Region, and now represent a dominant part of nearshore communities (Kerckhof *et al.* 2007, Troost 2010). Reported impacts include competition with commercial shellfish species, cascading effects within the ecosystem and injuries to recreational divers or swimmers. Local concerns on the species' emergence have therefore been raised at several occasions (e.g. ESFJC 2009, VLIZ 2014).
- **Comb jelly *Mnemiopsis leidyi*** – Since 2005, there have been many observations of this ctenophore species within the Two Seas Region, an overview of which is provided by Antajan *et al.* (2014). Estuarine populations are considered a year-round source of the species for the wider North Sea and Channel (Derveaux *et al.* 2014). Although currently though to be absent from the Canche (Antajan *et al.* 2014) and Wash (Sweet 2011), the species is known to be present in the Scheldt estuary (Vansteenbrugge *et al.* 2015). This comb jelly is considered a major contributing factor to the collapse of commercial anchovy fiseries in the Black and Caspian Seas at the end of the 20th century. It is currently unknown whether fishing grounds in the Two Seas Region are equally at risk (Van Ginderdeuren *et al.* 2012, Vansteenbrugge in prep.).
- **Asian shore crab *Hemigrapsus sanguineus*** – The Asian shore crab has also shown a rapid spread throughout the Two Seas Region since its discovery in 1999. It has been shown to displace resident native crab species and to be a voracious predator of native shellfish species (Epifanio 2013).
- **Tree Groundsel *Baccharis halimifolia*** (Figure 9) – Tree groundsel is a shrub species native to eastern North America. It has been recorded within the Two Seas Region for all four countries, though its main stronghold lies to the south of Brittany (Caño *et al.* 2013). This species can completely overgrow salt marshes in this area with many direct consequences on native vegetation and indirect effects, for instance, on migratory birds (Arizaga *et al.* 2013). It is currently unclear whether a similar effect could develop in the region, if left uncontrolled.

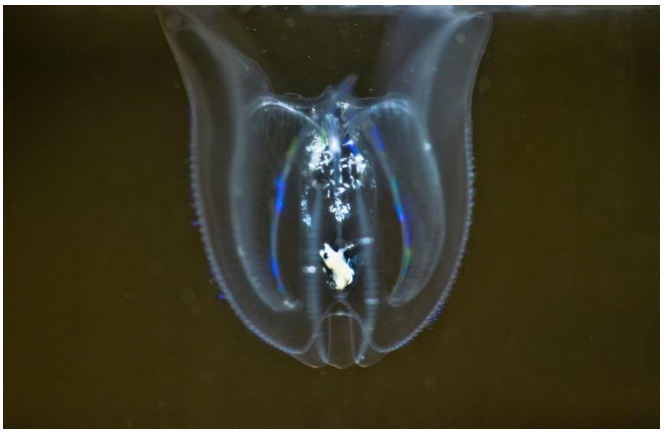

Figure 8. Comb jelly *Mnemiopsis leidyi* (© Lies Vansteenbrugge, ILVO).

Figure 9. Tree Groundsel *Baccharis halimifolia* (© Edu Boer, NVWA).

Overall, there are very few studies on the impacts of alien species. We still lack essential baseline knowledge on local situations and on entire species. It is still unclear whether *Mnemiopsis* is present on the UK coast, and despite the huge numbers of Chinese mitten crab *Eriocheir sinensis* (cf. Van Ryckegem *et al.* 2014), surprisingly little is known about their interactions with native species (Dittel & Epifanio 2009). The latter is also true for other crustacean species (Soors *et al.* 2010), the polychaete *Marenzelleria* spp. (Soors *et al.* 2013, Kauppi *et al.* 2015), the rapidly spreading plant species *Cotula coronopifolia* (van Valkenburg pers. comm.) as well as many other invasive species.

Introduced species registers

The data used to compile local registers (such as those discussed above) may feed into registers at larger scales. Several existing registers are dedicated to introduced species. In fact, Groom *et al.* (2015) warn that many initiatives for the collation of alien species data are currently emerging in parallel, which is troubling given the aim of combating invasions in a strategic and cost efficient manner.

REGIONAL SCALE: THE TWO SEAS AREA

As part of the preceding RINSE project, Zieritz *et al.* (2014) compiled all records of non-native species in the four Two Seas Region countries from 55 different sources into a single registry. The list presents records for each of the countries separately, and includes an indication of the environments inhabited by the species (terrestrial, freshwater and/or marine). Their list included no less than 6661 taxa (species, subspecies and hybrids), 817 of which are aquatic. The register does not include information on pathways of spread or impacts.

This register may serve as a basis for an estuarine register of introduced species. Some (dynamic) sources should be re-visited to look for status updates and new species since January 2013. Additional, targeted sources may also be consulted. It should be taken into account that Zieritz *et al.* (2014) list species at country level. As a country can border multiple seas at once, some complexity arises in terms of interpretation. This may be the reason why many species native to the Two Seas Area are listed (e.g. sea sparkle *Noctiluca scintillans*, common oyster *Ostrea edulis*). Data cleaning therefore seems appropriate if the register is taken forward for specific purposes.

EUROPEAN AND GLOBAL SCALE

The World Register of Marine Species (WoRMS) is the world's most authoritative and comprehensive list of names of marine organisms (valid names, synonyms and vernacular names, amongst other information; WoRMS Editorial Board 2015). Within this framework, the World Register of Introduced Marine Species (WRIMS) was launched in March 2015 (Appendix 1E, Anonymous 2015, Pagad *et al.* 2015). It essentially provides further detail on those species from within WoRMS that have been spread by humans beyond their historic ranges. The database came about through a collaboration led by Flanders Marine Institute and the Invasive Species Specialist Group of the International Union for Conservation of Nature. Databases were compiled over 2 years and refer to nearly 2500 scientific papers. As of 2015, it includes information on 1619 species. WRIMS includes information on pathways of spread and impacts.

Though WRIMS is dedicated to marine species, species that are only partly or marginally linked to the sea can be included, such as anadrome and catadrome organisms (e.g. Chinese mitten crab *Eriocheir sinensis*, Canada goose *Branta canadensis*). The majority of estuarine introduced species are thus eligible for inclusion into WRIMS, though this is not the case for purely terrestrial and freshwater species unless tailored provisions are made (e.g. inclusion as a thematic subset). Given its broad geographic and taxonomic coverage, scientific rigidity, and sustainability, WRIMS nonetheless proves very relevant with respect to the aims of this report.

Other databases dedicated to introduced species are the DAISIE and EASIN registers at European level (DAISIE 2015, EASIN 2015), and the GISD, GRIIS and CABI registers at global level (GISD 2015, CABI 2015, GRIIS in prep.). Many of these databases are inter-linked with one another, but differ slightly in their scopes and objectives (e.g. species listing vs. detailed accounts, taxonomic coverage).

Marine species datasets from all of the world's oceans are being centralized in the Ocean Biogeographic Information System, of which EurOBIS represents the European node (EurOBIS 2015, Appendix 1E). It is also linked to the Global Biodiversity Information Facility (GBIF 2015, Appendix 1F), which probably is the most integrative database with regard to species

distributions worldwide. As of 2015, GBIF compiles data from no less than 15,817 datasets, among which are the previously mentioned databases (already integrative by themselves). Information on species origin, alien range, pathways, impacts etc. can be extracted from OBIS and GBIF, if the primary datasets allow.

DATA CONDITIONS

As any database is likely to be confronted with a rapidly growing body of information, it is essential for any data portal to set transparent standards with regards to the data included (e.g., see the French Natural History Museum, British National Biodiversity Network and GBIF; GBIF 2010, SINP 2013, French 2014, Appendix 1F).

Species observation portals that are dynamic, i.e. that continuously allow for species and status updates, are extremely valuable tools with respect to the early warning and rapid response measures deemed key to tackle the problems of invasive species (see EC 2014). This can be efficiently realized only when data are available and useable by all, irrespective of country or purpose; i.e. if the data are 'open' (Groom *et al.* 2015). This is currently not the case for several databases, and this should be a focus for further work. Another issue that sometimes is underestimated is the importance of verification of reported sightings.

Conclusions

Many species are transported around the globe and introduced outside of their native range. If perceived as causing harm, these species are referred to as 'invasive'. When compared to purely terrestrial or marine environments, estuarine environments are under-studied with regard to invasive species.

Cross-country sharing and updating of information on the status of introduced species is fundamental, so that the presence of species is detected early, and the risks they pose are rapidly tackled. This is ever so relevant in light of the stipulated requirements on monitoring and early detection in the European Regulation 1143/2014 (EC 2014).

Taking the Wash (EN), Scheldt (BE, NL) and Canche (FR) estuaries as examples, it is clear that the ways in which data is currently collected (monitored) and used (reposited), differ greatly across countries.

Regarding data collection, a broad monitoring scheme that takes alien species into account is in place only for the Scheldt. Monitoring schemes that are tailored for alien species detection might be put in place on strategic locations or under-sampled niches across the Two Seas' countries. Hard substrates are examples of such under-sampled niches. A pilot study using a hard-substrate transect methodology did reveal significant range extensions of some alien species (Wijnhoven *et al.* , 2015).

Regarding data use, there are no dynamic repositories that are purely devoted to introduced species at the regional level, though these do exist at European and global scales. It would be advisable for newly collected data to feed, without delay, into pre-existing databases that have broad geographic and taxonomic coverage, are dynamic yet long-lasting, and apply data openness.

The availability of accompanying information like on pathways of spread and impacts is limited. Whereas some species are relatively well-known in these regards, further research is needed for others.

Acknowledgements

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Appendices

The following appendices refer to oral presentations given on the SEFINS Work Package 1 workshop held on 15 April 2015 in Ostend (Belgium).

Appendix 1A – The Wash: European Marine Site (Sharron Bosley, 18 slides)

Appendix 1B – The Canche estuary (Céline Fontaine, 12 slides)

Appendix 1C – 'De Schelde', a brief introduction (Johan van Valkenburg, 13 slides)

Appendix 1D – A brief presentation of the Belgian Scheldt (Bram D'hondt, 14 slides)

Appendix 1E – WRIMS: World Register of Introduced Species (Leen Vandepitte, 31 slides)

Appendix 1F – Data interoperability and standards for species checklists (Peter Desmet, 37 slides)

The Wash

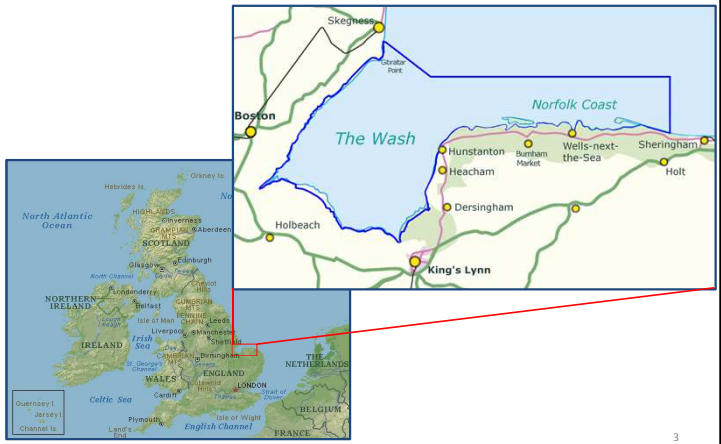
European Marine Site

Sharron J. Bosley
Project Manager

Overview

- The Wash and North Norfolk Coast EMS
- Conservation Features
- Current Knowledge on Non-native Species
- Impact of Current Non-native Species
- Vectors for Non-native Species in The Wash
- Non-native Knowledge Gaps

The Wash & North Norfolk Coast EMS



The Wash and North Norfolk Coast

- Largest embayment in UK = 2nd largest expanse of mud and sand flats
- North Norfolk Coast = best British example of barrier beach system
- Habitats unique in the UK and EU e.g. Ross worm *(Sabellaria spinulosa)* reef
- Internationally important breeding bird species & migratory assemblages
- Common seals

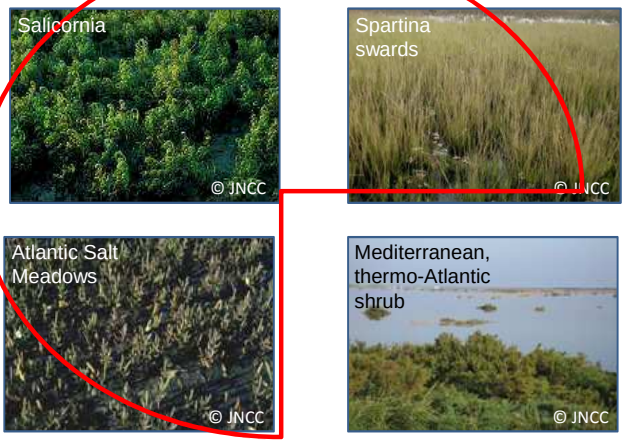
The Wash & North Norfolk Coast EMS

- National and international conservation designations:-
  - ✓ National Nature Reserves
  - ✓ Site of Special Scientific Interest
  - ✓ Area of Outstanding Natural Beauty (1968)
  - ✓ Heritage Coast
  - ✓ Biosphere Reserve
  - ✓ Ramsar site (1976 & 1988)
- 3 Special Protection Areas (SPA)
- 2 Special Areas of Conservation (SAC)
- Elite Natura 2000 series → **the most important areas for wildlife in Europe**

SAC Annex I Habitat Features:

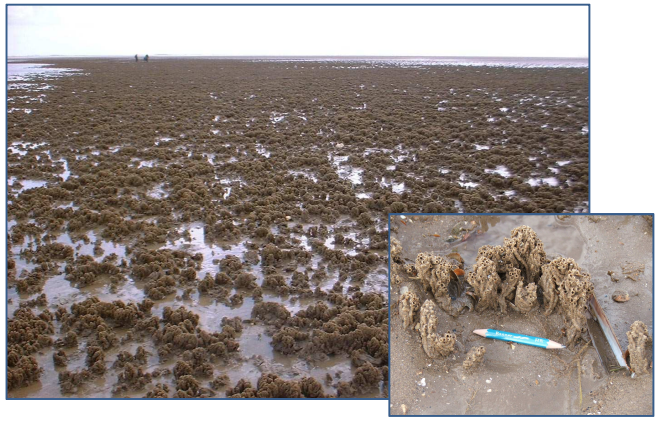
6

SAC Annex I Habitat Features:



7

SAC Annex I Habitat Feature



8

SAC Annex II Species:

9

SPA Annex I Bird Species

10

Unique Geomorphological Landscape

11

Vulnerability of Conservation Features

- Changes in the physical environment
- Coastal squeeze
- Sea level rise, storm surges
- Changes in erosion patterns
- Abstraction of freshwater for irrigation
- Changes in sediment budget
- Disturbance and disruption
- Visitor pressure

12

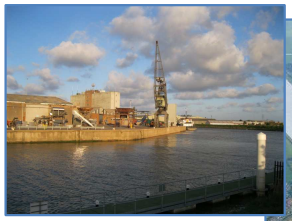
Current Knowledge on Non-native Species

- NBN Gateway and GB Non-native Species Secretariat
- Scientific literature
- Anecdotal evidence
- Eastern Inshore Fisheries & Conservation Authority
  - Pacific oyster (*Crassostrea gigas*)
  - Slipper limpet (*Crepidula fornicata*)
  - American jackknife clam (*Ensis directus*)

Impact of Current Non-native Species

- Changes in the physical environment i.e. littoral and sublittoral
- Changes in food availability to birds
- Impact to commercial shipping e.g. fouling
- Impact on commercial fisheries
- Impact on tourism

Vectors for Non-native Species in The Wash



Vectors for Non-native Species in The Wash

	Vector
Marina	Yachts, tenders, inflatables, outboards
Harbours	Recreational and commercial vessels, cargoes
Boatyard	Recreational and commercial vessels
Slipways	Recreational and commercial vessels
Shellfish lays	Harvesting vessels, imported stock
Construction / development	Slow-moving vessels, barges, service vessels, equipment
Marine Event	Yachts and other recreational vessels, recreational equipment

Non-native Knowledge Gaps

Lot's of Knowledge Gaps!

- No formal monitoring
- Very little information on NNIS
- Site low risk
- Promotion of recreational boating
- Spread of NNIS from North and South

Validates necessity for SEFINS project

17

18

The Canche Estuary

RINSE

SEFINS Meeting – Oostend – 15th April 2015

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www.rinse-europe.eu

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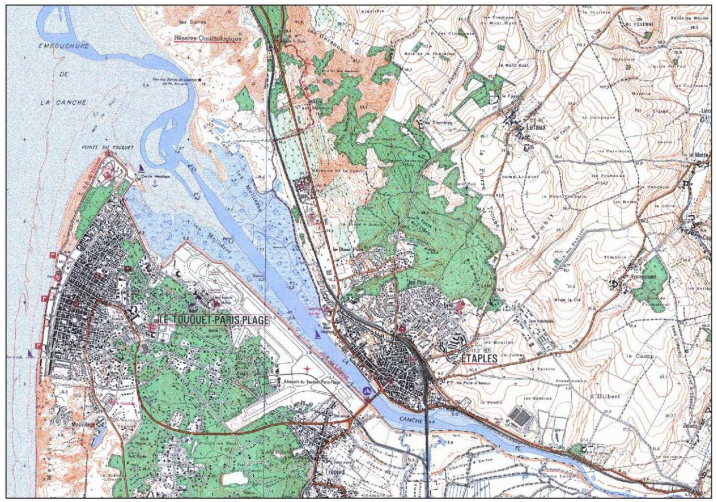
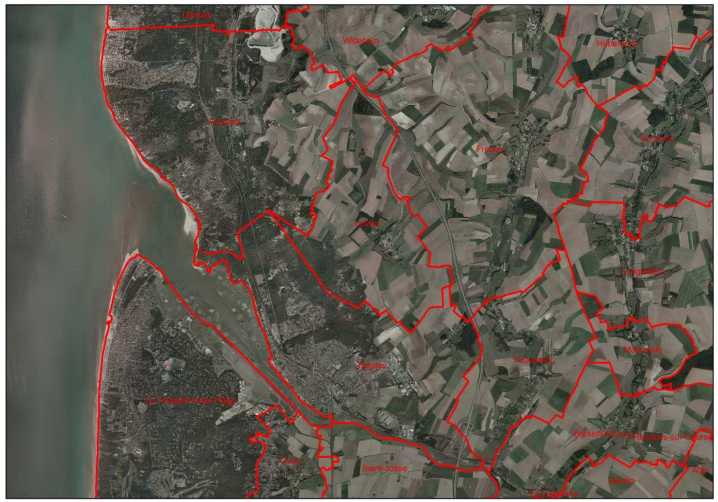
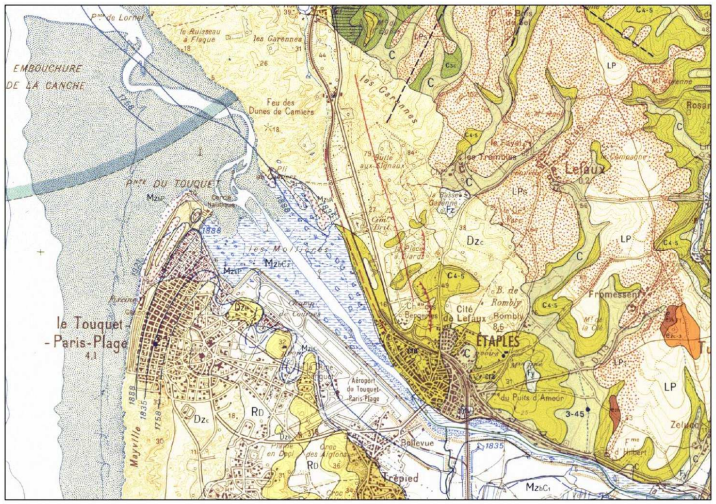
Crossborder cooperation programme 2007-2013 Part-financed by the European Union (European Regional Development Fund)



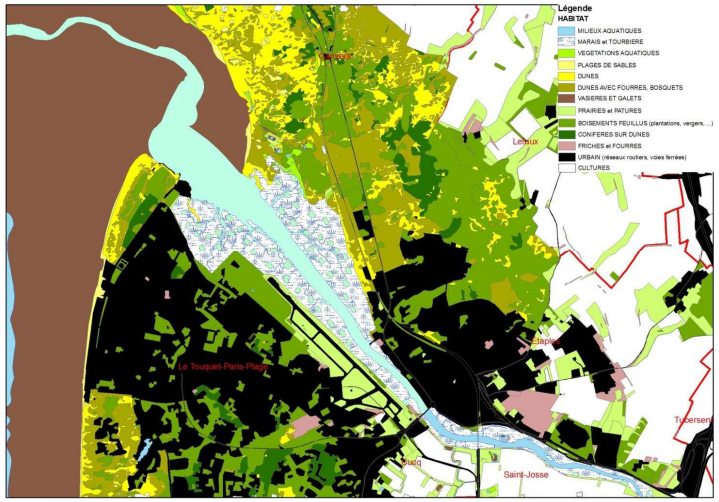
Crossborder cooperation programme 2007-2013 Part-financed by the European Union (European Regional Development Fund)



Crossborder cooperation programme 2007-2013 Part-financed by the European Union (European Regional Development Fund)



Crossborder cooperation programme 2007-2013 Part-financed by the European Union (European Regional Development Fund)



The Canche Estuary

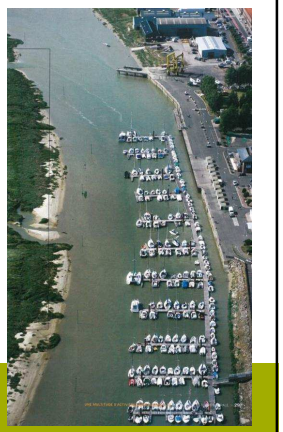
- Canche river = 88 km
- Canche catchment ≈ 1 300 km²
- Estuary area ≈ 1 500 Ha (15 km²)
- Average annual flow : 12 m^3/s

The Canche Estuary

- Around 18 500 inhabitants in the area
- Population density between 170 to 860 inh/km²
- Double or triple during the summer

The Canche Estuary

- Etaples harbour : pontoons with 240 rings (20 for visitors)
- Etaples fishing port : 6 fishing boats
- 3 other areas without pontoons : 300 rings



The Canche Estuary

RINSE

- Wildlife ≈ 485 species
- ≈ 75 birds
- amphibians (frog, toad, …)
- mammals (common seal, …)
- fishes (eel, trout, salmon,…)
- plants (saltwort, common sea-lavander, …)

The Canche Estuary

RINSE

- Non native species
  - Source INPN (MNHN)

SELT protocol

RINSE

Thank you

RINSE

Nederlandse Voedsel- en Warenautoriteit
Ministerie van Economische Zaken

'De Schelde'

A brief introduction

Johan van Valkenburg

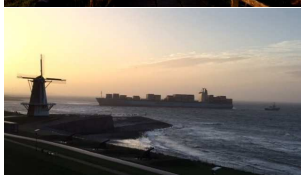
2 Mers Seas Zeeën
INTERREG IV A
FRANCE - ENGLAND - VLAANDEREN - NEDERLAND

"Investing in your future"
Crossborder cooperation programme
2007-2013 Part-financed by the European Union
(European Regional Development Fund)

Scheldt estuary

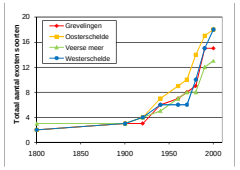
Economic activities

- Major shipping route
- Harbours & marinas
- Industry & aquaculture
- Tourism/recreation

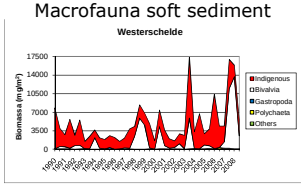


Alien species knowledge state-of-the-art

- Code of conduct invasive aquatic plants annex 1 of 7 species listed 6 are present in NL, all 6 are present in Zeeland Zuid-Holland delta.
- Increase alien species since 1950's [numbers and biomass]



Macrofauna soft sediment



40% in biomass
(17% in numbers)

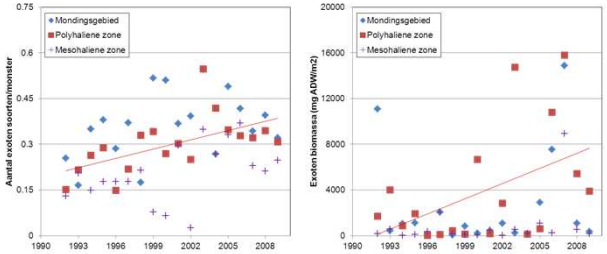
NDFF info for major taxonomic groups

- Birds Western Scheldt [no data on breeding]
- Moluscs 13 species

- Decapoda 4 species (*Balanus improvisus* & *Elminius modestus* missing)
- Macrophytes [distinction at species level only]

Macrobenthos of the Western Scheldt:

Average number of exotic species and average exotic biomass (significant trends for the polyhaline zone)



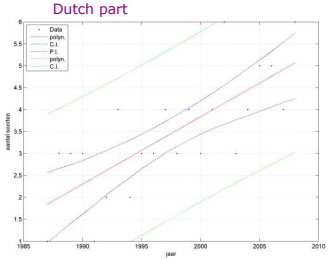
Based on the MWTL/BIOMON soft sediment macrofauna monitoring program
Graphs extracted from the T2009 evaluation of the Scheldt estuary

 Ysebaert, T., de Mesel, I., Wijnhoven, S., Kromkamp, J. (2013). Flora en fauna. Hoofdstuk 9 in: Depreiter, D., Cleveringa, J., van der Laan, T., Maris, T., Ysebaert, T., Wijnhoven, S. (eds). T2009 rapportage Schelde estuarium. IMDC, ARCADIS, Universiteit van Antwerpen, IMARES, NIOZ, p. 386-457 +Bijlagen.

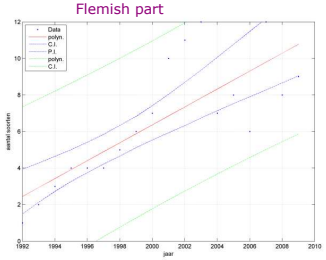
Waterbird trends for the Scheldt estuary:

Average number of exotic species observed during monitoring is increasing in the Dutch as well as the Flemish part

Dutch part



Flemish part



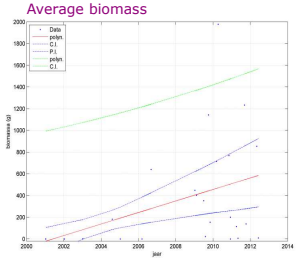
Based on the SOVON (NL) and INBO (B) monitoring data
Graphs extracted from the T2009 evaluation of the Scheldt estuary

 Ysebaert, T., de Mesel, I., Wijnhoven, S., Kromkamp, J. (2013). Flora en fauna. Hoofdstuk 9 in: Depreiter, D., Cleveringa, J., van der Laan, T., Maris, T., Ysebaert, T., Wijnhoven, S. (eds). T2009 rapportage Schelde estuarium. IMDC, ARCADIS, Universiteit van Antwerpen, IMARES, NIOZ, p. 386-457 +Bijlagen.

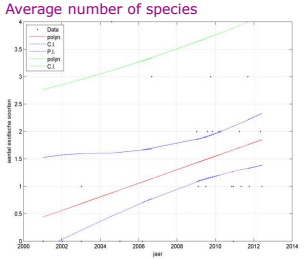
Fish trends for the Scheldt estuary:

Average exotic biomass and number of exotic species (per catch-day) as observed during fyke catches in the Oligohaline zone (B)

Average biomass



Average number of species



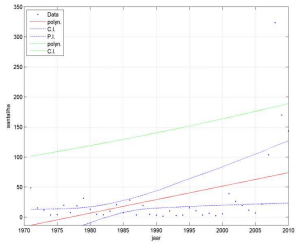
Based on the INBO (B) monitoring data
Graphs extracted from the T2009 evaluation of the Scheldt estuary

 Ysebaert, T., de Mesel, I., Wijnhoven, S., Kromkamp, J. (2013). Flora en fauna. Hoofdstuk 9 in: Depreiter, D., Cleveringa, J., van der Laan, T., Maris, T., Ysebaert, T., Wijnhoven, S. (eds). T2009 rapportage Schelde estuarium. IMDC, ARCADIS, Universiteit van Antwerpen, IMARES, NIOZ, p. 386-457 +Bijlagen.

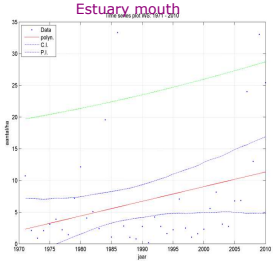
Fish trends for the Scheldt estuary:

Average number of exotic specimens per hectare as observed during trawl catches in the Western Scheldt (NL)

Mesohaline zone



Estuary mouth



Based on the IMARES (NL) monitoring data
Graphs extracted from the T2009 evaluation of the Scheldt estuary

Ysebaert, T., de Mesel, I., Wijnhoven, S., Kromkamp, J. (2013). Flora en fauna. Hoofdstuk 9 in: Depreiter, D., Cleveringa, J., van der Laan, T., Maris, T., Ysebaert, T., Wijnhoven, S. (eds). T2009 rapportage Schelde estuarium. IMDC, ARCADIS, Universiteit van Antwerpen, IMARES, NIOZ, p. 386-457 +Bijlagen.

Pathways

- Ballast water
- Ship hull fouling
- Accidental and non-accidental introduction
- Interconnected waterways fresh water
- Regions with similar conditions globally connected

Impact Crassula helmsii

Information sources available

- Nederlandse databank Flora & Fauna(NDFF)
- Database GIMARES
- Database NIOZ

‘Knowledge gaps’

- NDFF access only for subscribers
- NDFF verification issues depending on organism group
- GIMARES & NIOZ private databases

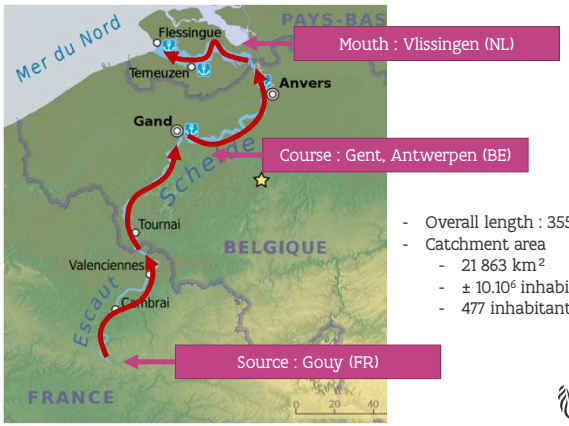
- No targeted monitoring for alien species

Contents

www.inbo.be

Flanders State of the Art

Geography



Mouth : Vlissingen (NL)

Course : Gent, Antwerpen (BE)

Source : Gouy (FR)

- Overall length : 355 km
- Catchment area
  - 21 863 km²
  - ± 10.10^6 inhabitants
  - 477 inhabitants / km²

www.inbo.be

Flanders State of the Art

Geography

Westerschelde

- ~ 'Western Scheldt'
- 58 km – 310 km²
- See presentation by Johan

Zeeschelde

- ~ 'Sea Scheldt'
- From Ghent to Dutch border
- Defined by the tide, with sluices impairing the tide at Ghent
- 105 km – 44 km²
- Only 39% of the upstream discharge (remainder is diverted by canals)

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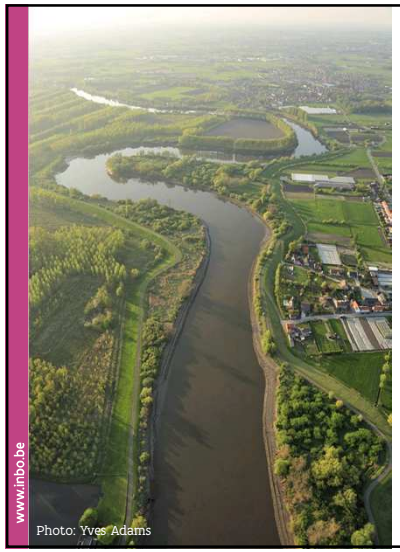
Flanders State of the Art

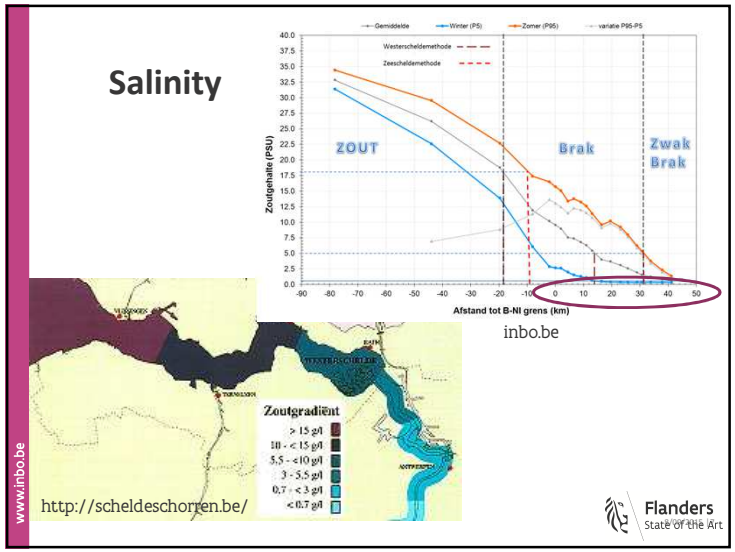


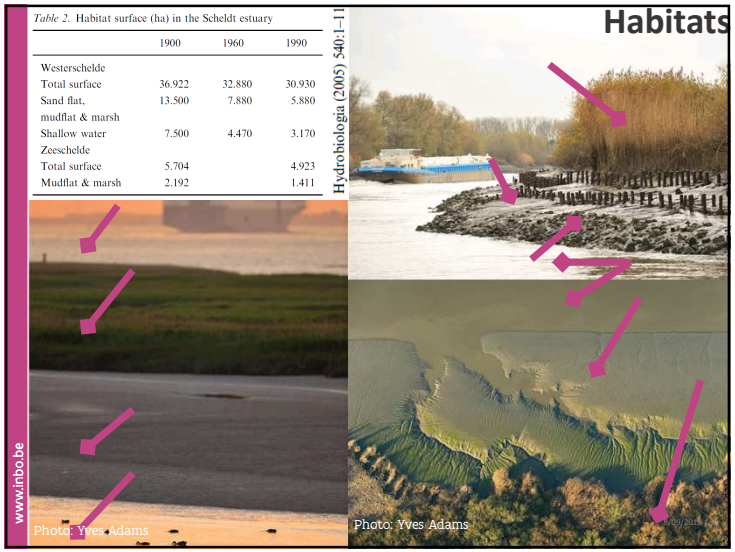
Hydrology

- Typical rain-fed lowland river
- Funnel-shaped
- > Tidal range of ±5 m at ±100 km from the mouth
- Tides 'n tributaries

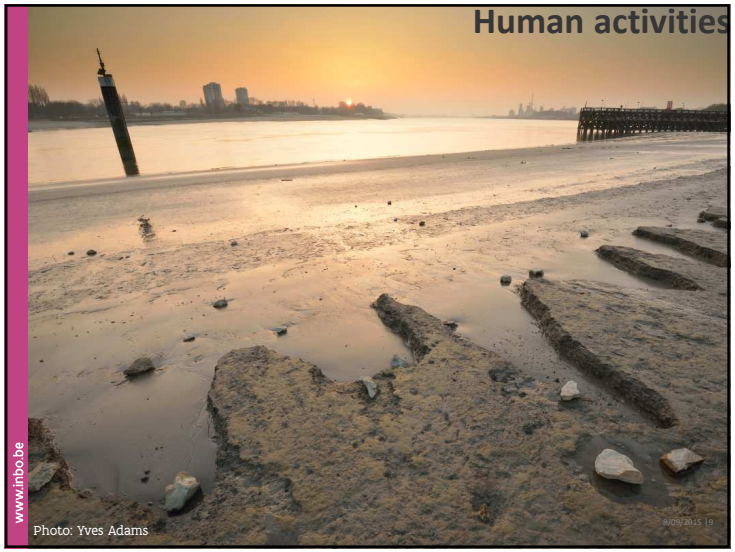
- *Under construction*: 4000 ha floodplain (re)creation for flood defence

Flanders
State of the Art





Human activities



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Human activities

- numerous industrial, residential and recreational facilities along its course
- main *hub* : Antwerp
  - → 502 604 inhabitants
  - → the second largest port of Europe by tonnage
  - → several (small) recreational harbours

Flanders
State of the Art

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Alien species

- Monitoring programmes
  - → MONEOS / Scheldemonitor
  - → Situation as of 2009
    - × **83 alien species** (Scheldemonitor)
    - × **127 alien species** (data T2009 report)
  - → Under revision (2015)
- Primary data

***Bratislavia dadayi* (Michaelsen, 1905) (Annelida: Clitellata: Naididae): a new non-indigenous species for Europe, and other non-native annelids in the Schelde estuary**
Jan Soors[1]*, Ton van Haaren[2], Tarmo Timm[3] and Jeroen Speybroeck[1]

Alien species in the marine and brackish ecosystem: the situation in Belgian waters
Francis Kerckhof [1], Jan Haelters[1] and Stephan Gollasch[2]

New crustacean invaders in the Schelde estuary (Belgium)
Jan Soors[1], Marco Faasse[2,3], Maarten Stevens[1], Ingrid Verbessem[1], Nico De Regge[1] & Ericia Van den Bergh[1]

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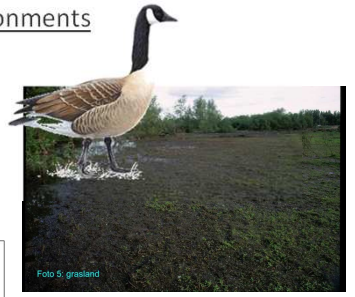
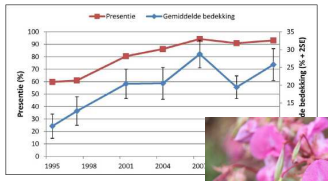
- Impacts : terrestrial environments
- Situation relatively well-known



Branta canadensis (Cf. **RINSE project**)



Impatiens glandulifera

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- Impacts : aquatic environments
- Impacts ill-known

Marenzelleria neglecta

Neomysis americana

Eriocheir sinensis

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- Knowledge gaps
- Impacts of aquatic alien species
- Alien species of hard-substrate environments
- Introduction vectors
- Introduction routes (cf. tributaries)

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Flanders
State of the Art

WRIMS:
World Register of Introduced Species

History, current status
& links with other initiatives

Leen Vandepitte – Stefanie Dekeyzer

Vlaams Instituut voor de Zee vzw
Flanders Marine Institute

2 Mers Seas Zeeën
INTERREG IV A
"Investing in your future"
Crossborder cooperation programme
2007-2013 Part-financed by the European Union
(European Regional Development Fund)

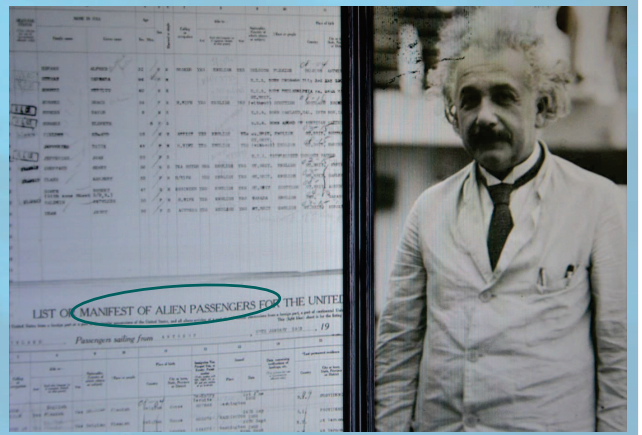
- Alien species
- Belgian list of marine alien species
- World List of Introduced Marine Species
- European marine alien species @ VLIZ
  - EMODNet Biology
  - EurOBIS
  - LifeWatch

Alien species

What's in a name?

"Alien" in the VLIZ-context…:

An alien or non-indigenous species is a species which has arrived in an area different from its original area and which is thriving there (= has established populations).



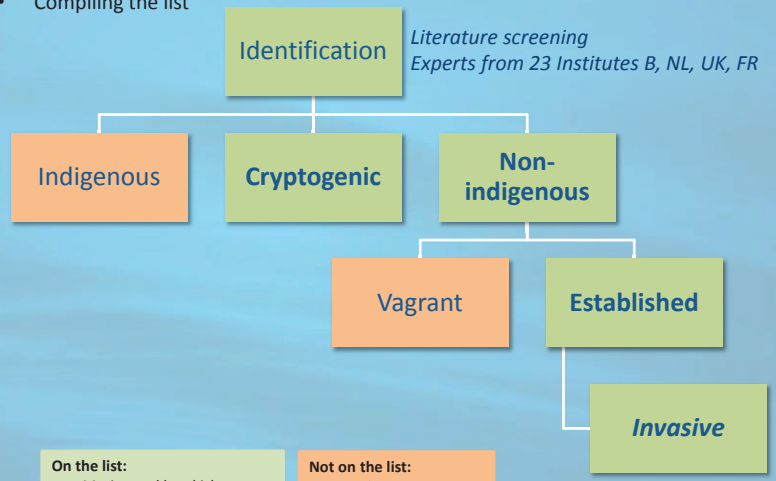
Alien species in the Belgian part of the North Sea and adjacent estuaries

- VLIZ initiative, in response to:
  - repeated questions from public
  - information needs of European & international marine policy
- Start: June 2006
- Literature-based, validated by network of experts:

  VLIZ Alien Species Consortium: > 50 experts from 23 institutes
- Names checked against World Register of Marine Species (WoRMS)
  - Taxonomic standard, internationally recognized
  - Avoids confusion

Study area:
- ✓ Belgian part of the North Sea
- ✓ Estuaries
- ✓ Ports
- ✓ Sluice dock

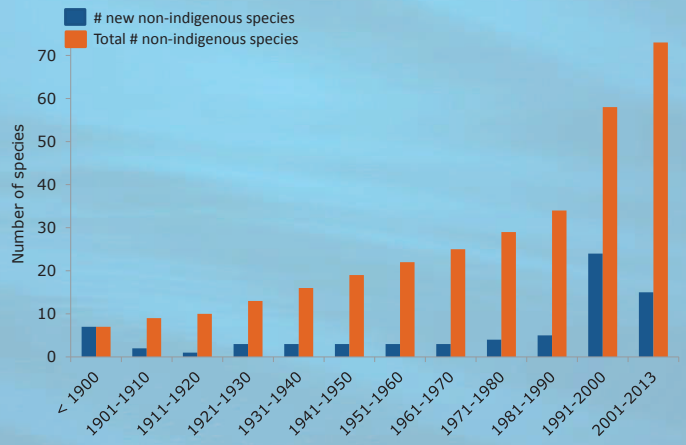
- Compiling the list



On the list:
- Marine and brackish water
- Established populations
- Introduced by man
- Cryptogenic species

Not on the list:
- Fresh water species
- Vagrant species
- Natural dispersion

- History of aliens in Belgian marine waters
  - Strong increase since the 1970s
  - Since 1980: doubling of # aliens in study area
  - 73 alien species on the list, of which 14 documented as invasive
  - Probably still some aliens undocumented…: no experts, insufficient literature, …



www.vliz.be/wiki

*** …only available in Dutch… ***

- Non-indigenous species?
- Definitions
- Study area
- List of non-indigenous species
- Belgian policy context
  - Belgian law related to the protection of the marine environment
  - European Marine Strategy Framework Directive (MSFD)
  - Internation Convention for the Control and Management of Ships' Ballast Water and Sediments
  - Un-invited guests
- VLIZ Alien Species Consortium

All information available online, but not in structured (database) format!

- Scientific name (link to WoRMS)
- Native distribution
- First occurrence in Belgium
- Distribution in Belgium
- Distribution in neighbouring countries
- Introduction pathway(s)
- Reasons for success in our region
- Factors affecting distribution
- (Potential) effects and measures
- Species characteristics
- Did you know…?
- References

Going global…
What about marine alien species on world scale?

WRIMS:
World Register of Introduced Marine Species

part of World Register of Marine Species (WoRMS)

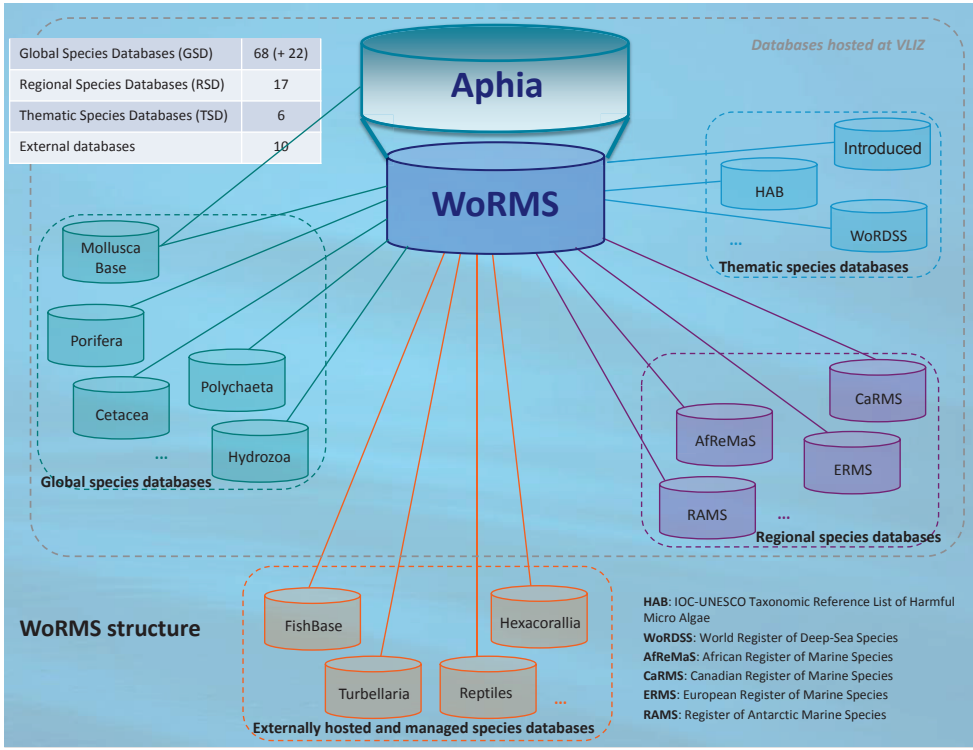
World Register of Marine Species – WoRMS

WoRMS aims to provide the most authoritative list of names of all marine species globally, ever published

- Not just a name-index, but expert-based taxonomic database
  - >200 taxonomic editors
  - Elected Steering Committee (SC) (12+1 members)
  - Data management team
- Permanent host institute: VLIZ
- Web-based system, including web-services
- International standards

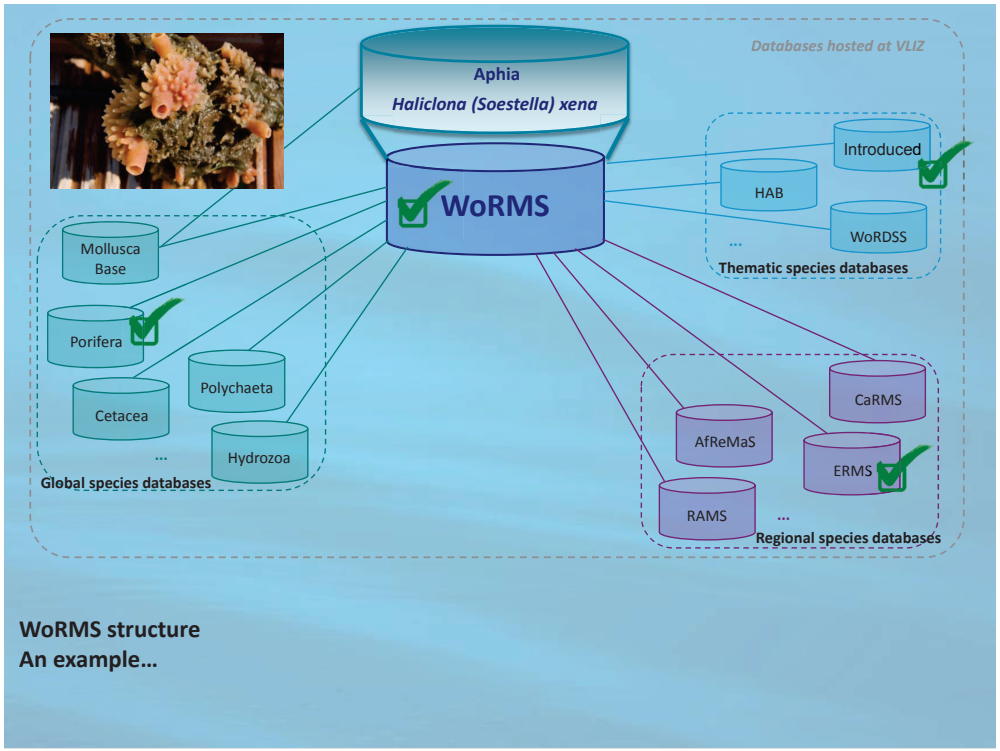
- Background
  - 2004: MarBEF EU FP6 => creation of online ERMS
  - 2007: further development to World Register

Global Species Databases (GSD)	68 (+ 22)
Regional Species Databases (RSD)	17
Thematic Species Databases (TSD)	6
External databases	10



WoRMS structure

HAB: IOC-UNESCO Taxonomic Reference List of Harmful Micro Algae
WoRDSS: World Register of Deep-Sea Species
AfReMaS: African Register of Marine Species
CaRMS: Canadian Register of Marine Species
ERMS: European Register of Marine Species
RAMS: Register of Antarctic Marine Species



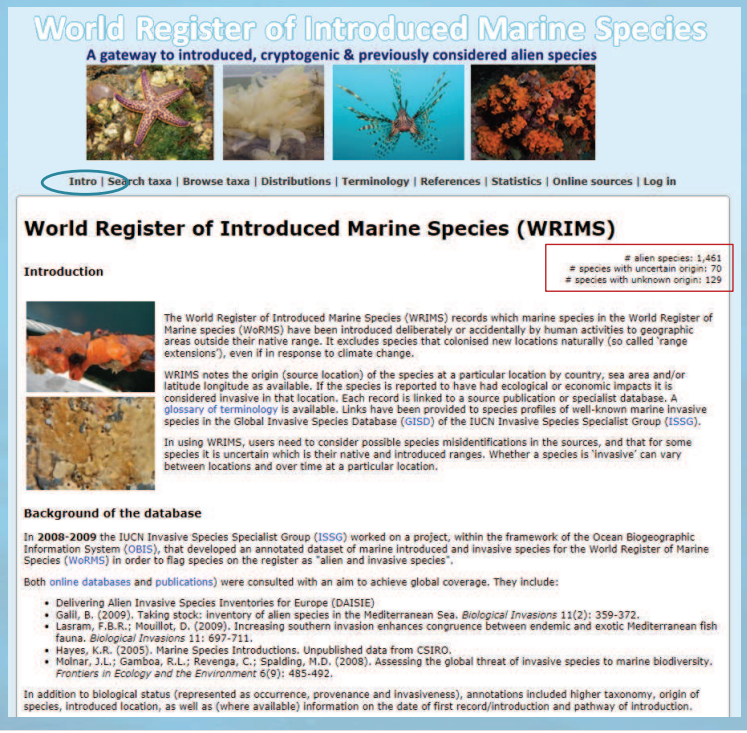
WoRMS structure
An example…

WRIMS – history:

- 2008-2009:
  - Collaboration IUCN Invasive Species Specialist Group (ISSG) and OBIS
  - Annotated dataset of marine introduced and invasive species
  - Species flagged in WoRMS as “alien species”
  - 2,165 species *(based on published literature & unpublished info)*
- 2013-…:
  - Collaboration ISSG with VLIZ, in framework of EMODnet Biology project
  - Document information related to “invasiveness” of alien species
  - Update species list of 2008-2009
  - Create/fine-tune terminology on alien species
  - +/- 1,660 species *(=based on published literature)*
- Launched March 2015

- Documentation of **traits** related to alien species
  - Distribution, in combination with:
    - Occurrence
      - *absent, present, established, reported …*
    - Origin
      - *native, alien, uncertain/unknown…*
    - Invasiveness
      - *not invasive, of concern, invasive …*
    - Date of arrival or first record
    - Abundance and population trends
    - Mangement information
    - Impacts
    - Pathways / Vectors

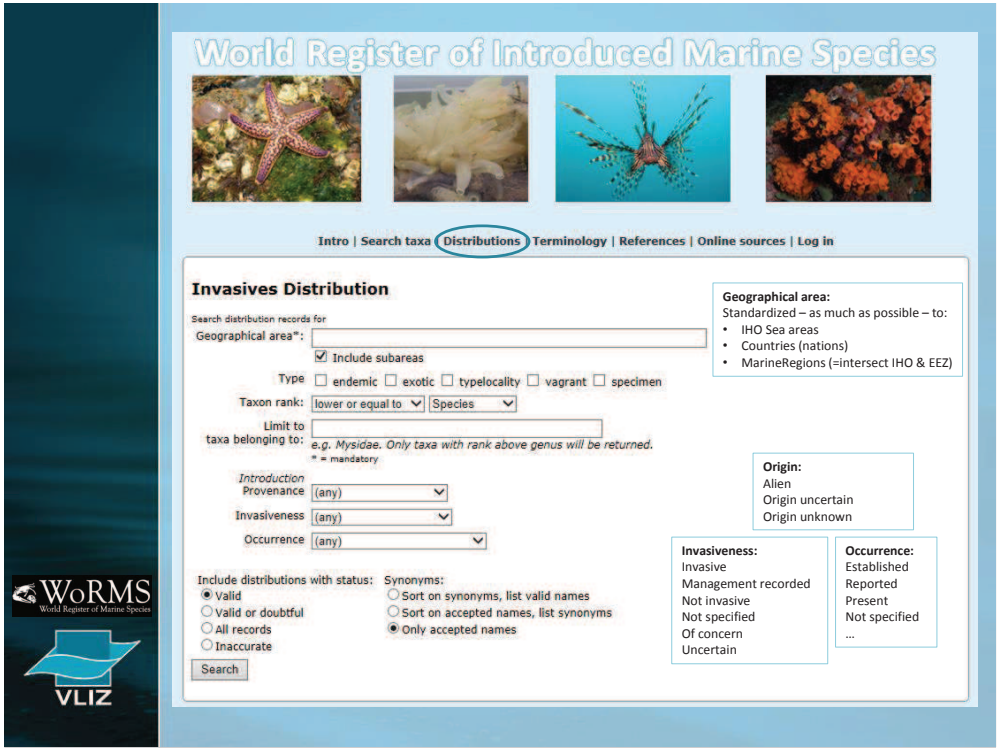
  Information extracted from published literature
- Documentation of all this trait information possible through financial support of EMODnet Biology Project
- Other traits in WoRMS: IUCN Red List status, fossil range, environment, body size …

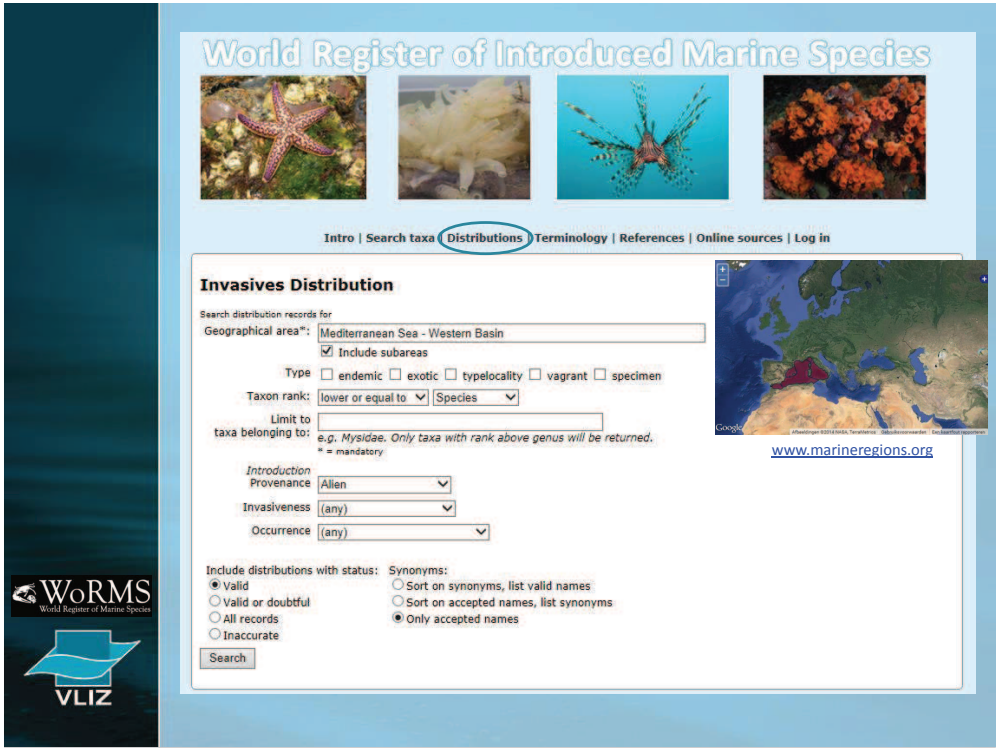


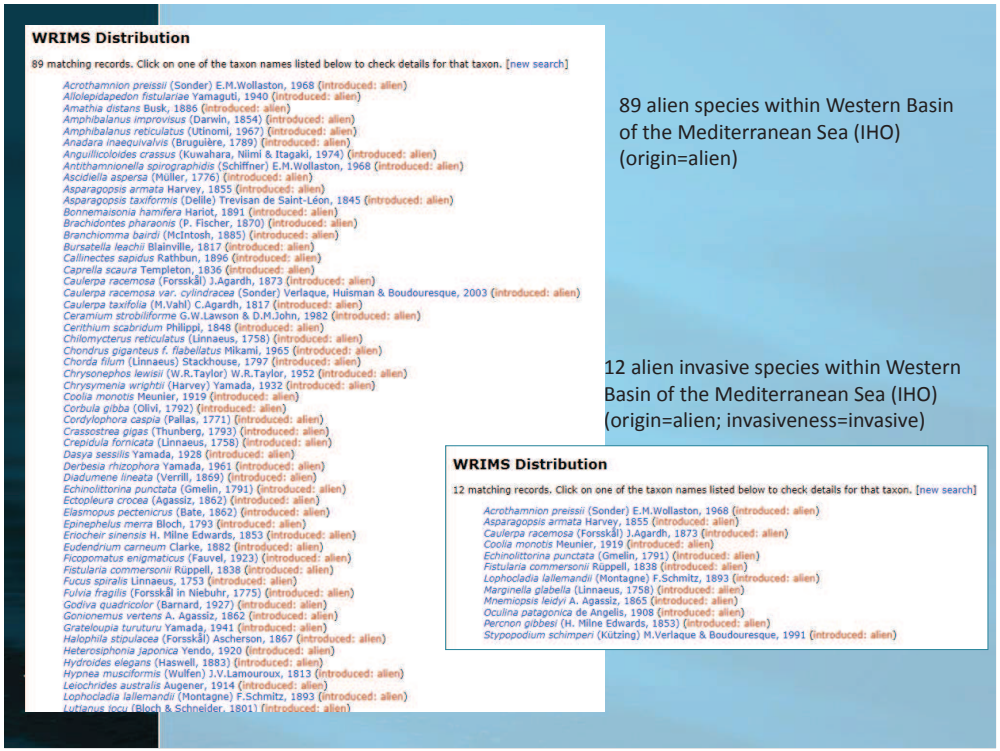
- **Partners**

- **Sources**

Online databases	Journals
Molnar et al. (2008)	Aquatic Invasions
Hayes et al. (2005)	BioInvasions Records
DAISIE	Marine Biodiversity Records
GISD	Mediterranean Marine Science Journal
EASIN	New Mediterranean Biodiversity Records
AquaNIS	Biological Invasions
NEMESIS	

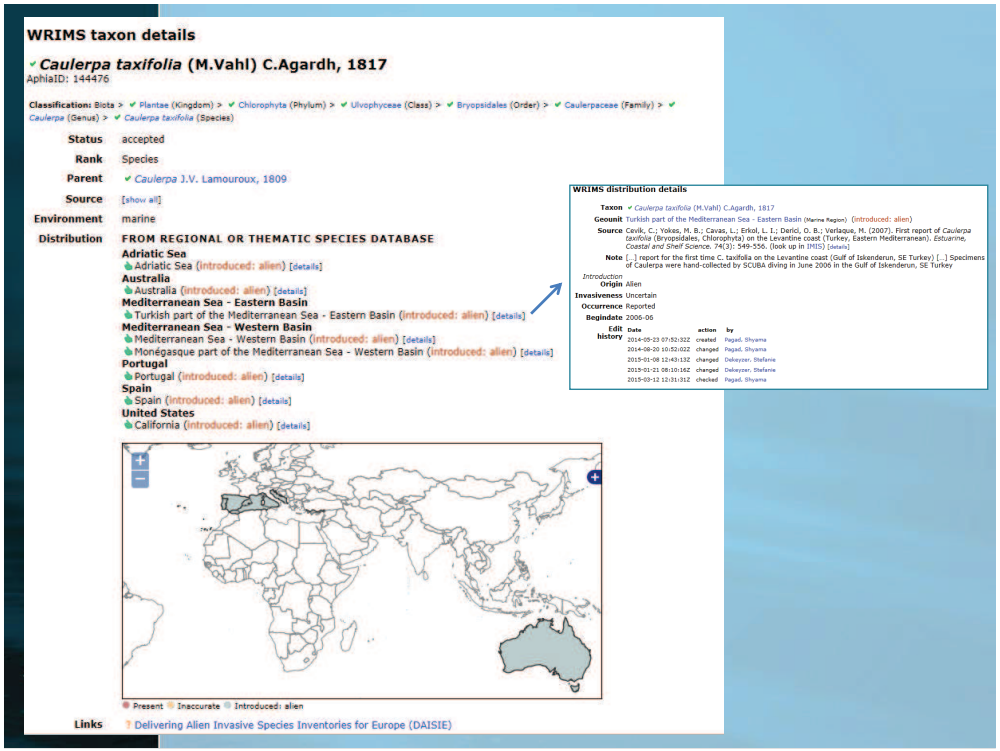


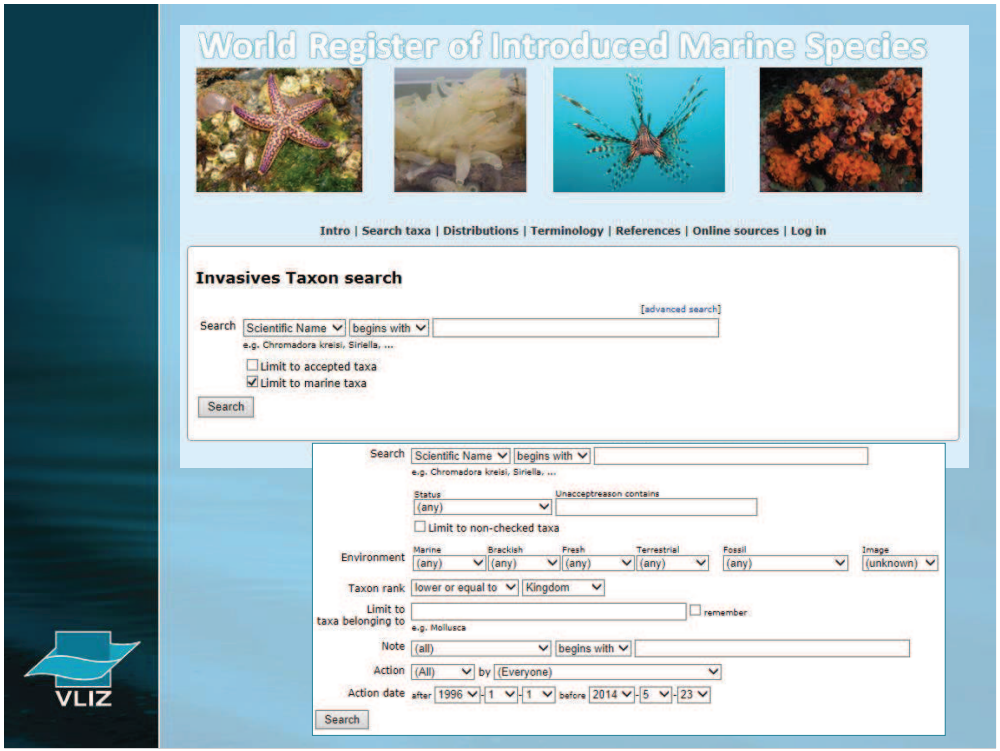


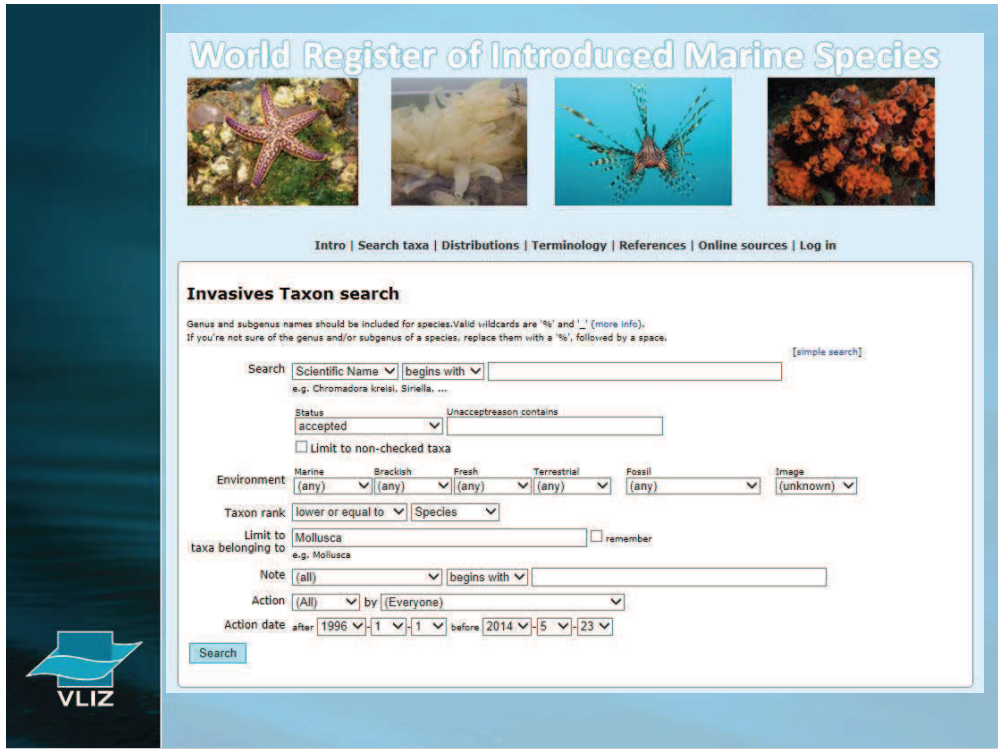


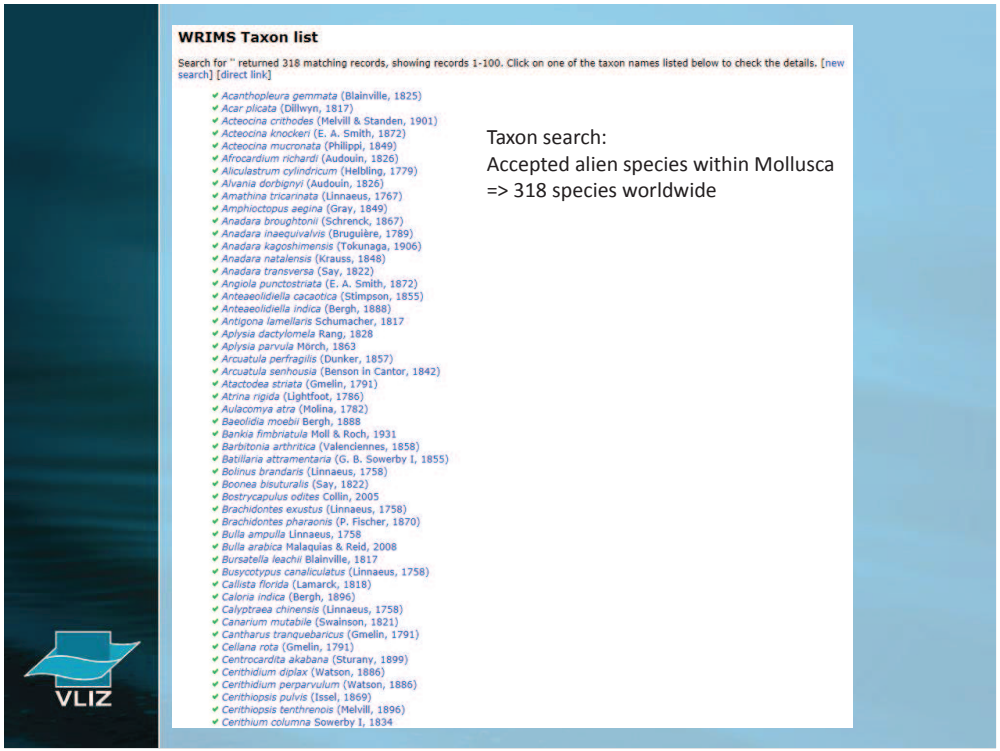
89 alien species within Western Basin of the Mediterranean Sea (IHO) (origin=alien)

12 alien invasive species within Western Basin of the Mediterranean Sea (IHO) (origin=alien; invasiveness=invasive)









Taxon search:
Accepted alien species within Mollusca
=> 318 species worldwide

The in-between: Europe

European marine alien species @ VLIZ

& linking with other data systems

EMODNet Biology

Basic design principles of EMODNet:

Assemble fragmented and inaccessible **marine data into interoperable, contiguous and publicly available data** streams for complete **maritime basins**.

Setting up EMODNet based on 8 principles:

1. Collect data once and use it many times
2. Freedom of use for publicly funded data
3. Clarify ownership, accuracy and precision
4. Requires sustainable funding at EU level
5. Focus on sea-basins
6. User driven
7. Develop interoperable standards
8. Build on existing structures

European Ocean Biogeographic Information System EurOBIS

- EMODnet principle: "build on existing systems"
- EurOBIS = data system behind EMODnet Biology
- What – where – when: publication of distribution data of marine species
  - collected within European marine waters
  - collected by European researchers outside European marine waters
- Data from:
  - Research
  - ***Monitoring***
  - Museum collections
  - Literature-based data (including latitude-longitude and coordinate precision)
- No specific focus on alien species, but present in many datasets…
- Combining taxonomy – distribution – traits => multitude of possibilities

Under development!

EMODNet Biology – data products

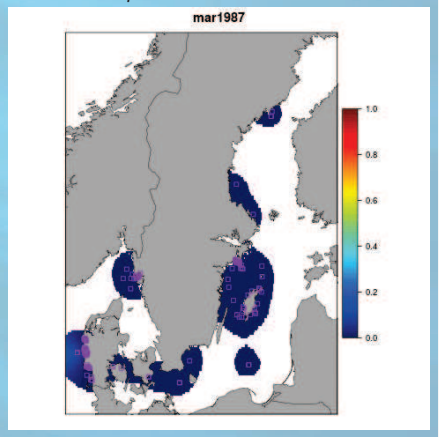
Calculate spatially distributed ***data products*** specifically relevant for ***Marine Strategy Framework Directive Descriptor 2 (non-indigenous species)*** based on guidance provided by the MSFD Common Implementation Strategy.

Data product example: gridded map of *Marenzelleria sp*.

- Monitoring data from
  - Sweden
  - Denmark
  - Finland (*to come*)
- Evolution of invasion of this species in the Baltic, with its probability of occurrence

Long-term plans:

- Create more data products, based on taxonomy, distribution and traits
- Modelling the distribution of alien seaweeds in Europe



Gridded map of the probability of occurrence of *Marenzelleria* sp. In the Baltic, based on presence-absence data

LifeWatch = distributed virtual laboratory

- Part of European Strategy Forum on Research Infrastructures (ESFRI)
- Will be used for:
  - Biodiversity research
  - Climatological & environmental impact studies
  - Support development of ecosystem services
  - Provide information for policy makers
- Will consist of:
  - Biodiversity observatories, databases, web services and modeling tools
  - Integration of existing systems, upgrades, new systems

LifeWatch Taxonomic Backbone

Marine & non-marine

Aims at containing the following taxonomic and species related data:

Goal of the taxonomic backbone = establishing workflows

- Web-services allowing to query several data systems in one click
- Example questions to be answered by the taxonomic backbone:
  - Which invasive planktonic species are known to occur in the Black Sea?
  - Where does species 'X' appear?
  - Which species from the Habitat/Bird Directive are on the IUCN Red List?
- Long-standing ecological questions:
  - To what extent is biotic invasion and native species loss creating ecosystems with altered properties?
  - What determines the rate at which species distributions respond to climate change?

(From: Sutherland et al. (2013). Identification of 100 fundamental ecological questions. Journal of Ecology)

Thank you!

Questions?

www.marinespecies.org/introduced
www.eurobis.org
www.emodnet-biology.eu
www.vliz.be/en/non-indigenous-species
www.vliz.be/wiki

Data interoperability and standards for

Species checklists

RESEARCH INSTITUTE
NATURE AND FOREST

Peter Desmet

SEFINS meeting – 2015-04-15 – ILVO, Ostend, Belgium

Your data

is formatted to your needs

My data

is formatted to my needs

Your data ≠ my data

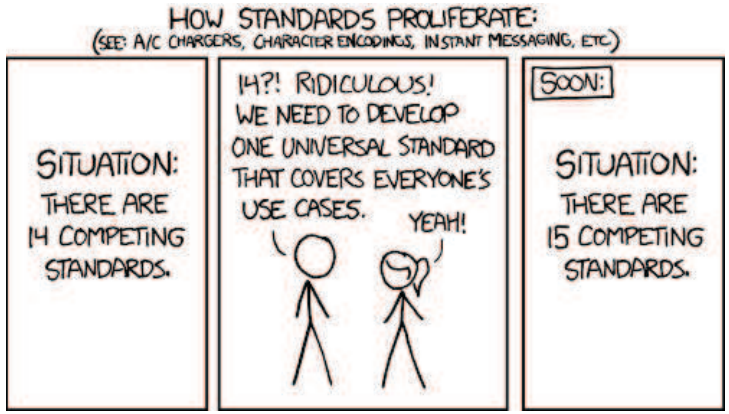
Likely to have different structure, field names, value lists, etc.

This is fine in isolation, but terrible for

collaboration

Need for standards

for understanding, using & combining biodiversity data



xkcd.com/927

TDWG

Biodiversity Information Standards

tdwg.org

Biodiversity
Information
Standards
TDWG

Darwin Core

A community-developed standard
for publishing biodiversity data

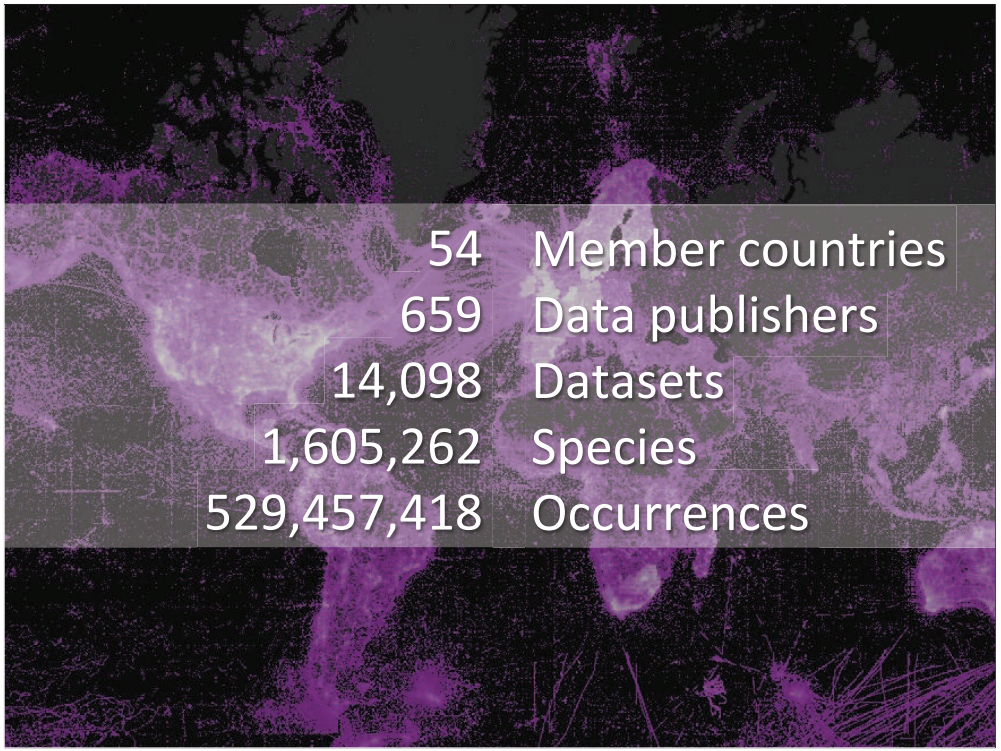
rs.tdwg.org/dwc

GBIF

Global Biodiversity Information Facility

gbif.org

GBIF



So how does it work?

Darwin Core Archive

Exchange format for biodiversity data

Supports

Checklist datasets

Occurrence datasets

Sampling datasets

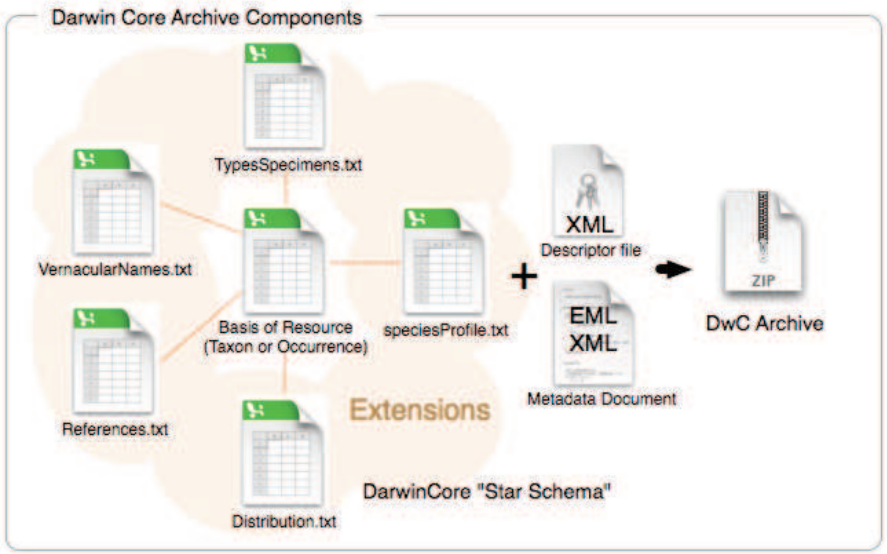
Defines

Structure

Field names

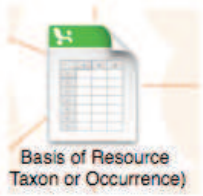
Value lists

Metadata



Taxon core

The central record is a taxon/species



rs.gbif.org/core/dwc_taxon.xml

Taxon core

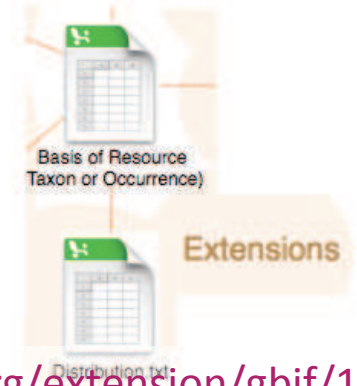
taxonID	1
scientificName	Aeshna affinis Vander Linden, 1820
kingdom	Animalia
phylum	Arthropoda
class	Insecta
order	Odonata
family	Aesnidae
genus	Aeshna
specificEpithet	affinis
taxonRank	species
scientificNameAuthorship	Vander Linden, 1820

Taxon core

datasetName	Red list of dragonflies in Flanders, Belgium
datasetID	http://dataset.inbo.be/rl-libellen-checklist
language	en
license	http://creativecommons.org/publicdomain/zero/1.0/
rightsHolder	INBO

Distribution extension

A taxon has zero or more distribution records



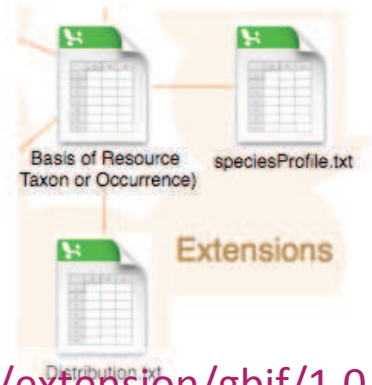
rs.gbif.org/extension/gbif/1.0/distribution.xml

Distribution extension

taxonID	1
locationID	*See rs.gbif.org/areas*
locality	Flanders
countryCode	BE
lifeStage	Adult
occurrenceStatus	present
threatStatus	LC
establishmentMeans	invasive
eventDate	2006/now
source	…
occurrenceRemarks	…

Species profile extension

A taxon has zero or more species profile records



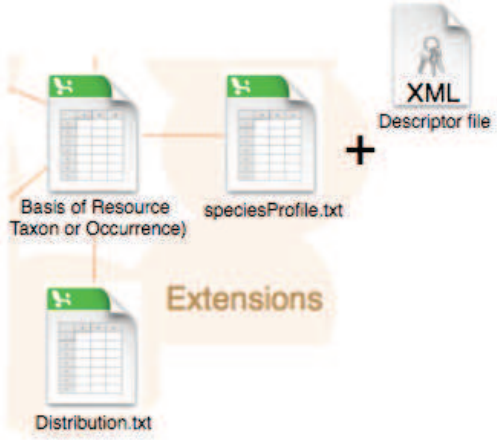
rs.gbif.org/extension/gbif/1.0/speciesprofile.xml

Species profile extension

taxonID	1
isMarine	TRUE
isFreshwater	TRUE
isTerrestrial	FALSE
isInvasive	TRUE
ageInDays	*maximum*
sizeInMillimeters	*maximum*
massInGrams	*maximum*
habitat	9.10 *(from IUCN habitat vocabulary)*
sex	male, female

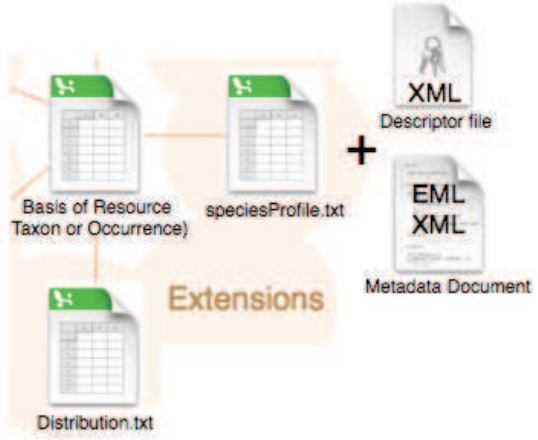
meta.xml

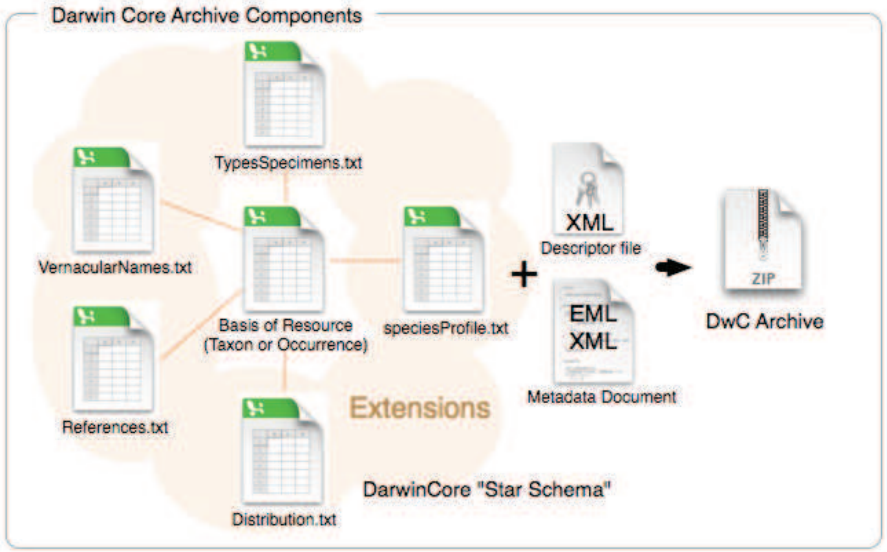
A file describing the relations



eml.xml

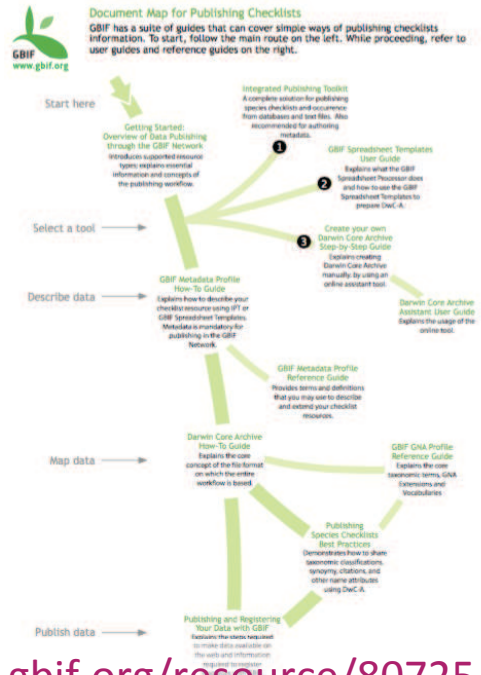
A file describing the dataset metadata





Checklist publication

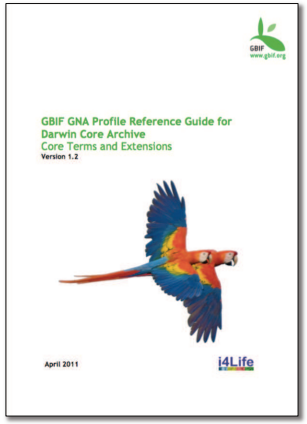
is supported by GBIF



gbif.org/resource/80725

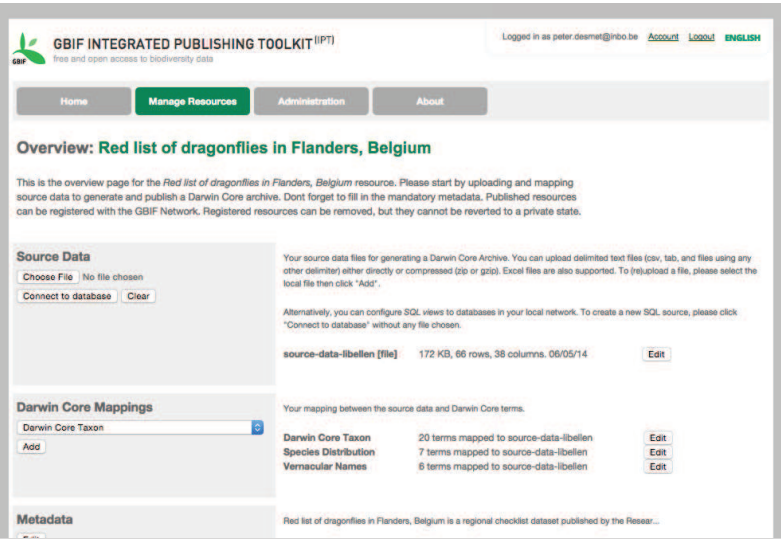
Documentation

www.gbif.org/resources



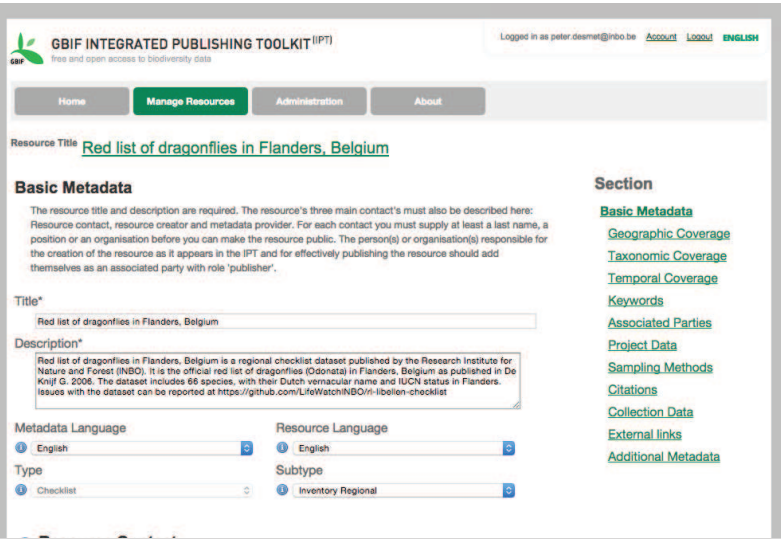
Tools

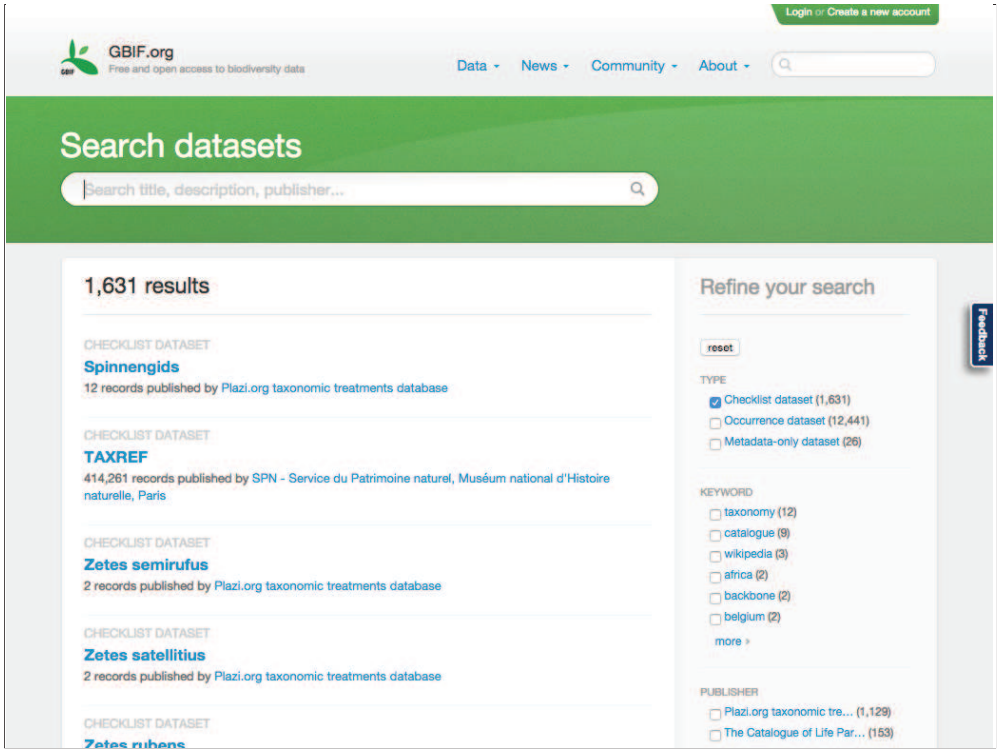
GBIF Integrated Publishing Toolkit (IPT)

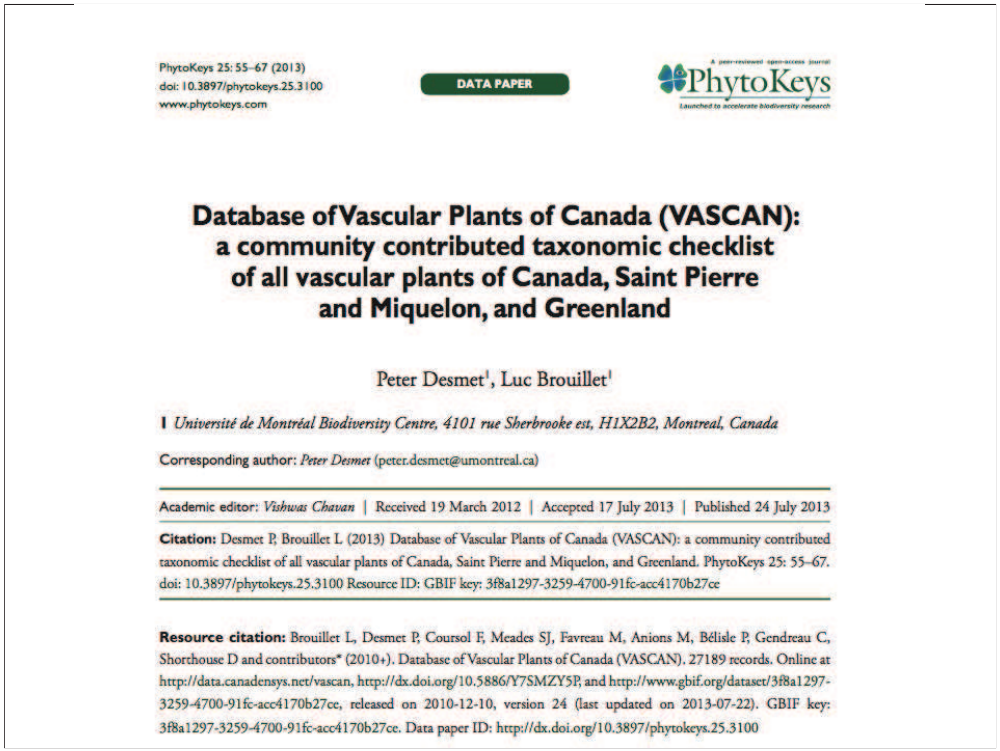


Tools

ipt.gbif.org







PhytoKeys 25: 55–67 (2013)
doi: 10.3897/phytokeys.25.3100
www.phytokeys.com

DATA PAPER

PhytoKeys

Database of Vascular Plants of Canada (VASCAN): a community contributed taxonomic checklist of all vascular plants of Canada, Saint Pierre and Miquelon, and Greenland

Peter Desmet[1], Luc Brouillet[1]

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Corresponding author: *Peter Desmet* (peter.desmet@umontreal.ca)

Academic editor: *Vishwas Chavan* | Received 19 March 2012 | Accepted 17 July 2013 | Published 24 July 2013

Citation: Desmet P, Brouillet L (2013) Database of Vascular Plants of Canada (VASCAN): a community contributed taxonomic checklist of all vascular plants of Canada, Saint Pierre and Miquelon, and Greenland. PhytoKeys 25: 55–67. doi: 10.3897/phytokeys.25.3100 Resource ID: GBIF key: 3f8a1297-3259-4700-91fc-acc4170b27ce

Resource citation: Brouillet L, Desmet P, Coursol F, Meades SJ, Favreau M, Anions M, Bélisle P, Gendreau C, Shorthouse D and contributors* (2010+). Database of Vascular Plants of Canada (VASCAN). 27189 records. Online at http://data.canadensys.net/vascan, http://dx.doi.org/10.5886/Y7SMZY5P, and http://www.gbif.org/dataset/3f8a1297-3259-4700-91fc-acc4170b27ce, released on 2010-12-10, version 24 (last updated on 2013-07-22). GBIF key: 3f8a1297-3259-4700-91fc-acc4170b27ce. Data paper ID: http://dx.doi.org/10.3897/phytokeys.25.3100

Upload	source data
Standardize	to Darwin Core
Document	with metadata
Publish	your dataset
Register	with GBIF
Submit	a scholarly data paper


Thanks!
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