Native and non-native species of the Dutch Wadden Sea in 2014

Issued by the Office for Risk Assessment and Research, The Netherlands Food and Customer Product Safety Authority of the Ministry of Economical Affairs

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1 Summary

In the summer of 2014 a rapid assessment was done of the marine algae and macrofauna of both the hard substrata and soft substrata in the Dutch Wadden Sea. Between August and October the diversity of native and non-native species was assessed 242 times at different times and locations in either samples or during visual inspections of specific Wadden Sea habitats. A large variety of sampling methods was used ranging from snorkeling, turning over rocks at low tide, and dredging shellfish beds to taking bottom samples with a hand corer, a petit ponar and a van Veen-grab from littoral and sublittoral zones. In total 254 species were found of which 48 are probably non-native to the Netherlands. For 8 of these it remains uncertain whether they are non-native as their native range is unknown in literature, i.e.they are considered cryptogenic. Five species are here recorded for the first time: the algal species *Dasysiphonia japonica,* the ascidian *Diplosoma listerianum,* the bryozoan *Tricellaria inopinata* and the crustaceans *Leptomysis lingvura* and *Melita nitida*. In addition to the fieldwork, a literature study of published and unpublished non-native species records in The Wadden Sea was done. On the basis of these records and the 2014 inventory, in total ten species were added to the list of non-native species in the Dutch Wadden Sea as presented after the last non-native species inventory in 2011 by Gittenberger *et al.* (2012): the algal species *D. japonica,* the annelid *Streblospio benedicti,* the ascidian *D. listerianum,* the bryozoans *Smittoidea prolifica* and *T. inopinata,* the cnidarian *Mitrocomella polydiademata*, the crustaceans *L. lingvura* and *M. nitida*, the molluk *Rangia cuneata* and the oyster herpes virus Ostreid herpesvirus-1 µvar. This raised the total number of species on this list to 82 in 2014. Although some of the "new" non-natives may have been missed in prior monitoring efforts, others may concern recent introductions.

In comparison to the previous non-native species inventories in 2009 and 2011, a number of non-native species has substantially expanded their range within The Wadden Sea. The colonial sea-squirt *Didemnum vexillum* for example, was mainly found in the marina of Terschelling in 2009. In 2011 it was also recorded to be abundant just south of Terschelling on a sublittoral oyster reef, and it was spotted on the hull of a boat in the marina of Oudeschild, Texel. In 2014 it was abundant in the marinas of both Vlieland and Terschelling, and it was found to cover large proportions of the subtidal oyster reefs off both Texel and Terschelling. It is unclear to what degree the range expansions of non-native species that were recorded in 2014, are an effect of increased survival in the year 2014. As the winter of 2013 to 2014 was relatively warm, i.e. the second warmest winter since 1706, some non-native species may have been able to settle and grow at locations in The Wadden Sea where they would not have survived had the winter been colder.

2 Introduction

The Wadden Sea area is composed mostly of salt marshes, mudflats and islands, where sea water mixes with fresh water in an area stretching over the Netherlands, Germany and Denmark (Gittenberger *et al.*, 2010). It is known for its habitat variation and unique biodiversity. Because of these unique characters UNESCO has placed the Dutch and German parts of The Wadden Sea, an area of about 10,000 km^2, on the World Heritage List in June 2009. To make an assessment of the risk of introducing non-native species into this area by importing mussel seed from the Oosterschelde in the south of the Netherlands, species inventories focusing on non-native species were conducted in 2009 and 2011 (Gittenberger *et al.*, 2010, 2012). Based on these inventories that resulted in the discovery of close to twenty

non-native species previously unknown for The Wadden Sea, it was concluded that little knowledge existed until 2009 about the diversity of non-native species present in The Wadden Sea.

Because mussel seed is imported into The Wadden Sea from the province of Zeeland, and trilateral discussions between the Netherlands, Germany and Denmark about the management of non-native species in The Wadden Sea are ongoing, the Office for Risk Assessment and Research of the Netherlands Food and Consumer Product Safety Authority of the Ministry of Economical Affairs, issued an additional inventory of non-native species in The Wadden Sea in 2014. The focus of the 2009 and 2011 inventories was on the species that live in association with hard substrates as most non-native species in the marine environment concern fouling species and relatively little was known about the species diversity on hard substrates in The Wadden Sea. The 2014 inventory focused additionally on species that live in and on the sandy bottoms of The Wadden Sea.

The main goals of this species inventory were:

[1] To get a reliable inventory of macrofauna and macroflora that is related to both hard substrata and soft substrata in the Dutch Wadden Sea;

[2] To focus on non-native species in general, and especially on those species that are not known for the Dutch Wadden Sea yet;

[3] To produce a close to complete list of the non-native species present in the Dutch Wadden Sea.

[4] To make a comparison with the inventories of 2009 and 2011.

3 Materials and methods

3.1. Locations

To make comparisons between the inventory in 2014 and the inventories in 2009 and 2011 (Gittenberger *et al.*, 2010, 2012) the same locations or locations close by were searched for hard substratum associated species. This was done with a focus on harbours, where most non-native species were found during previous inventories. Although sublittoral mussel beds and oyster reefs in the Dutch Wadden Sea were not specifically found to be hot spots of non-natives during the previous inventories, they were sampled more intensively during the 2014 inventory. This was done because shellfish aquacultural activities more in general are often linked to non-native species distribution in literature. For assessing the hard substrate related species, 183 samples were taken and/or local species assessments were done at different times and from different habitats (Fig. 1; Appendix I). In the analyses of the data eleven regions within The Wadden Sea were distinguished, as was also done by Gittenberger *et al.* (2010, 2012), i.e. [A] Texel; [B] Vlieland; [C] Terschelling; [D] Ameland; [E] Schiermonnikoog; [F] Den Helder; [G] Afsluitdijk; [H] Harlingen; [I] Holwerd-Lauwersoog; [J] Eems; [K] Wadden Sea (open water) (Fig. 1B).

Before selecting the locations for assessing the soft substrate related species, a quick review was done of the SIBES (Synoptic Intertidal Benthic Survey) data of previous years for the littoral zones and the MWTL monitoring data available for the sublittoral zones, to check for any obvious hotspots of non-native species within The Wadden Sea. No such hotspots could be identified on the basis of that data. Therefore the locations for the soft substrate sampling were chosen more or less randomly spread over the entire Wadden Sea. It was made certain however that harbour areas and areas with mussel beds and oyster reefs were included, as these are in theory known as potential places where non-native species may be imported by shipping and aquaculture activities (Fig. 2). In total 241 bottom samples were taken to assess the diversity in the soft substrates of The Wadden Sea (Fig. 2; Appendix I).

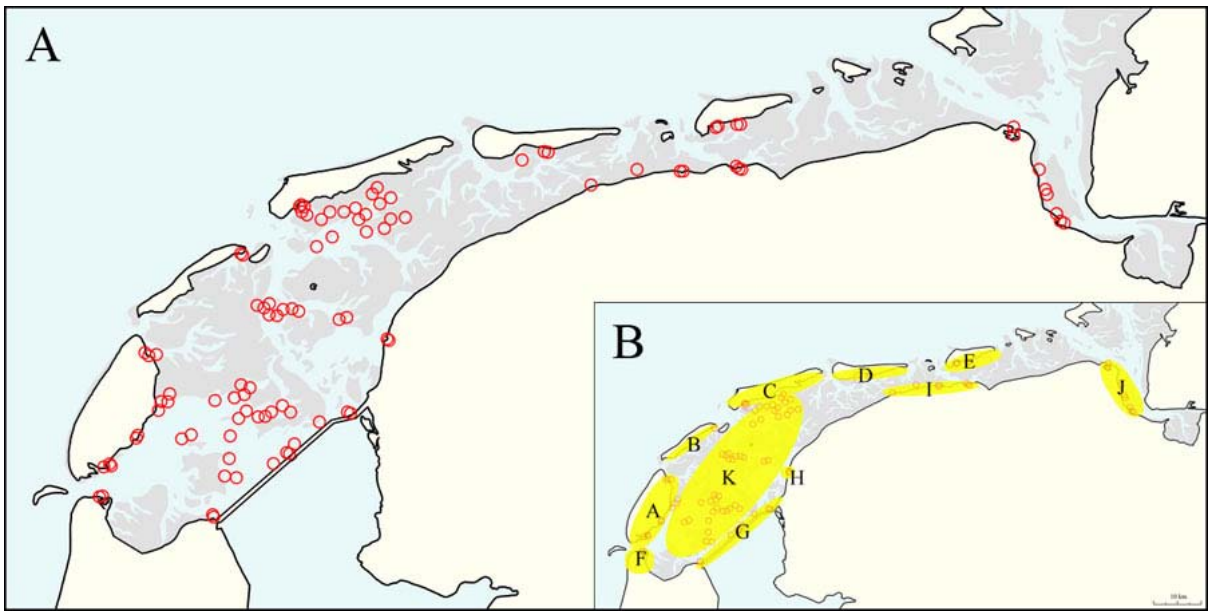

Fig. 1. A, Locations with hard substratum that were searched during the Dutch Wadden Sea inventory 2014; B, Regions [A] Texel; [B] Vlieland; [C] Terschelling; [D] Ameland; [E] Schiermonnikoog; [F] Den Helder; [G] Afsluitdijk; [H] Harlingen; [I] Holwerd-Lauwersoog; [J] Eems; [K] Wadden Sea (open water).

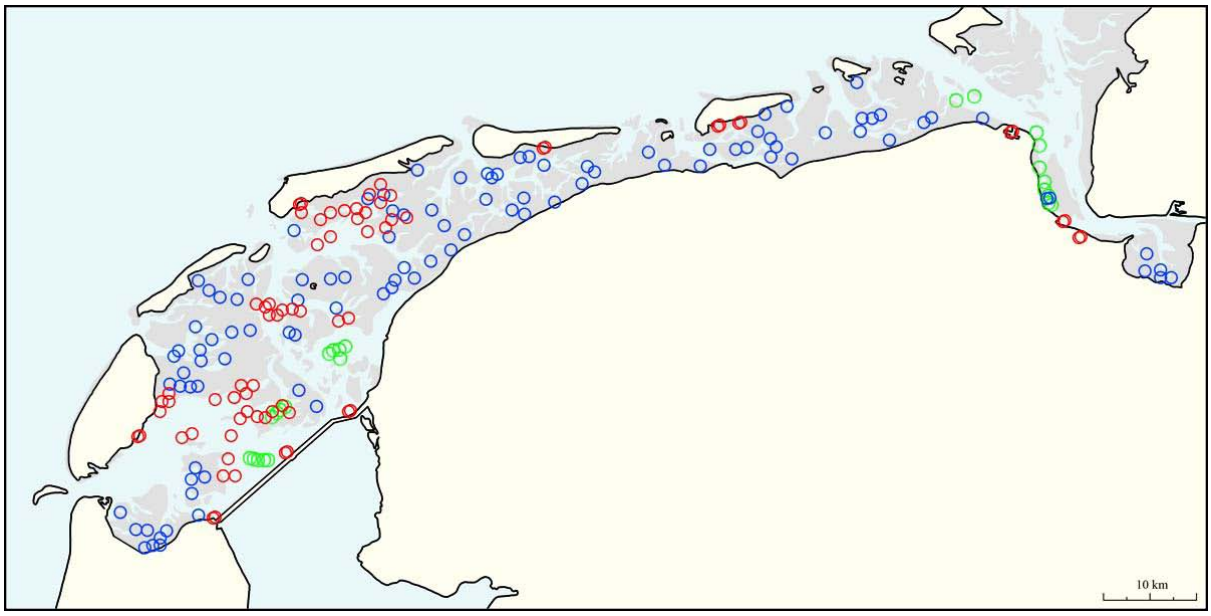

Fig. 2. Locations with soft substratum that were sampled during the Dutch Wadden Sea inventory 2014; Littoral bottom samples taken with a Hand corer (Blue circles) and sublittoral bottom samples taken with a Petit ponar (Red circles) or a Van Veen grab (Green circles).

3.2 Sampling methods

In order to find as many species as possible, a wide range of methods was used. For the hard substrate associated species these were based on the previous non-native species focused inventories in The Wadden Sea (Gittenberger *et al.*, 2010, 2012), which are similar to those used by the Netherlands Centre for Biodiversity (NCB) Naturalis, and during rapid assessments of harbours along the American east coast as described by McIntyre *et al.* (2013), and Wells *et al.* (2014). For each locality the methods were selected on the basis of [1] the goal of recording as many non-native species as possible, [2] the characteristics of the localities, e.g. littoral, sublittoral, its micro-habitats, etc., and [3] the local restrictions for safety purposes or enforced by law. If feasible, every locality was searched for at least half an hour per person, after which the search was continued until less than one extra species was expected to be found within double the time searched. Whenever a species was recorded, the rest of the time was spent focusing on finding other species at that location. At most locations, virtually all species present were found within the first few minutes.

The following methods were used:

Hard substrate sampling:

• Visual inspection of the inside, base and outside of floating objects and of non-floating objects at low tide. This was usually done while snorkelling, but also from shore by looking over the edge of a floating dock.

• Usage of a net and grabbing devices to collect material from under the low tide water line.

• Turning over rocks, oysters and other hard substrata during low tide, for access to the underside and the bottom underneath.

• Surfacing submerged objects, which hung (on a rope) in the water along the sides of piers and floating docks. Species that prefer deep water were found with this method.

• Searching off-shore locations in the central Wadden Sea with a mussel dredge lowered into the water from the vessels ‘De Stormvogel’ and “De Harder” of the Waddenunit of the Ministry of Economical affairs. These localities included subtidal mussel beds and oyster reefs. The boat was also used to check some off-shore floats from which ropes were hanging for catching mussel spat.

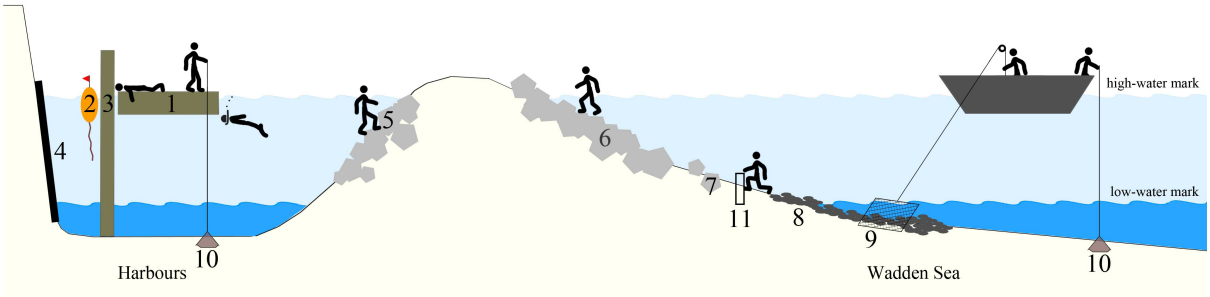

Fig. 3. Sampling methods used during the Wadden Sea inventory 2014; Hard substrate habitats were searched with visual inspections from the water surface, while snorkeling, or in the littoral zone during low tide. Hard substrate samples in the sublittoral zone were taken with a mussel dredge from a boat. Habitat that were searched include [1] floating docks, [2] floating and submerged objects like buoys and ropes, [3] objects like poles and jetties, [4] harbour walls, [5] the sheltered sides and the [6] exposed sides of dikes, [7] rocks, [8] shellfish reefs in the littoral zone and [9] shellfish reefs in the sublittoral zone. Soft substrate habitats in [10] the sublittoral zone were sampled from a floating dock or from a boat with a bottom grab, i.e. a Petit ponar or a Van Veen grab. In [11] the littoral zone these samples were taken with a hand corer.

Soft substrate sampling:

• For assessing species that live in the soft substrata of The Wadden Sea hand corer samples (bottom surface 0.017 m^2; about 25 cm deep) were taken in the littoral zones within the Synoptic Intertidal Benthic Survey (SIBES). For the sublittoral zones Petit ponar samples (bottom surface 0.023 m^2) were taken in combination with van Veen-grab samples (bottom surface of 0.18 m^2) from a ship. The bottom samples were sieved with a mesh size of 1 mm.

Details about each of the samples that were taken and the local species assessments that were done, can be found in Appendix I.

Species accumulation curves were calculated for the assessment of species associated with hard substrata, and separately for the samples that focused on the diversity of species that live in or on the soft substrata. This was done to get a rough indication of the number of species that was recorded, in comparison to the number of species that could have been found with the methods used in 2014 if an indefinite number of samples would have been taken. The calculations were conducted with the program Primer 6.1.10.

3.3 Fieldwork schedule

The fieldwork was conducted between 19 August and 30 October 2014 in various teams. In August to September, two researchers visited most of the marinas of The Wadden Sea and locations with hard substrates in between the harbours, as was also done during the inventories in 2009 and 2011 (Gittenberger *et al.*, 2010, 2012). There they conducted a search of the habitats present, with a focus on floating docks as previous inventories have shown them to concern hotspots of non-native species (Gittenberger *et al.*, 2010, 2012). This team also took bottom samples with a petit ponar at most of these sites. In addition in this period two days were spend on the western Wadden Sea with the ship "Stormvogel" of the Waddenunit, focusing on taking samples with a mussel dredge of sublittoral shellfish beds, including mussel beds, oyster reefs and various mixed shellfish beds. To also assess the infauna in the soft substrate at these sites, petit ponar bottom samples were taken in addition to the samples taken with the dredge. Finally the boat was used to visit and search floating mussel spat collectors in the central Wadden Sea.

The SIBES bottom samples in the littoral and the van Veen-grab samples in the sublittoral were also all taken before the end of September.

At the start of October five researchers and 24 biology students of Leiden University, conducted an inventory of the habitats in 12 harbours, in separate research teams (one harbour per day per team). In each harbour the habitats were searched by the students and independently by the supervising researcher. All identifications done by the students were checked on the basis of the species lists of the supervisors and on the basis of the reference material (preserved specimens or photos) that were collected. After

Table 1. Wadden Sea inventory 2014 totals. * Seven of these species were recorded during the 2014 inventory. Records of the other three species were done separately from this inventory. Abbrev. MM = Michaelis Menten.

Dutch Wadden Sea inventory 2014	
# Locations	424
# Species found during 2014 inventory	254
# Non-native species recorded during 2014 inventory	48
# New non-natives since Gittenberger *et al.* (2012)	10*
# Non-native or crytogenic species recorded in the Dutch Wadden Sea (Table 5)	82
Hard substratum samples / local species assessments	
# Locations	183
# Species found during 2014 inventory	201
Maximum # species expected based on MM (S_{max})	211.2
# Non-native species recorded during 2014 inventory	44
Soft substratum samples	
# Locations	241
# Species found during 2014 inventory	128
Maximum # species expected based on MM (S_{max})	136.7
# Non-native species recorded during 2014 inventory	20

Table 2. Different localities in The Wadden Sea that were sampled during the inventory in 2014. For each locality the location numbers (Appendix I) in that locality and the region (Fig. 1) in which it lies, is given. If measured, the turbidity, salinity and pH is provided.

Region	Location	Locality	Turbidity (NTU)	Salinity (ppt)	pH
A	1-7	Texel, 't Horntje	5.25	18.08	8.01
A	8-10	Texel, arrival ferry	30.7	17.95	7.98
A	11-26	Texel, Oudeschild, marina	3.88	17.91	7.96
A	27-29	Texel, Cocksdorp	-	-	-
B	30-40	Vlieland, marina	1.52	25.97	7.97
C	41	Terschelling	-	-	-
C	42-58	Terschelling, marina	2.47	20.56	7.97
D	59-75	Ameland, marina	7.36	21.38	7.94
D	76	Ameland, KNRM dike	386	19.59	7.55
E	77-80	Schiermonnikoog, arrival ferry	35.00	22.13	7.97
E	81-93	Schiermonnikoog, marina	22.90	21.53	7.89
F	94-99	Den Helder, marine marina	0.84	19.82	7.76
G	100-119	Den Oever, marina	7.57	8.90	7.24
G	120-123	Den Oever, fishing harbour	19.9	5.53	8.19
G	124-127	Breezanddijk	16.1	11.32	8.19
G	128-134	Kornwerderzand	15.2	8.73	7.55
H	135-140	Harlingen, Nieuwe Willemshaven	17.58	12.79	7.97
I	141-142	Holwerd	73.90	13.68	8.31
I	143	Wierum	57.90	17.47	7.60
I	144	Moddergat	-	-	-
I	145-157	Lauwersoog, fishing harbour	7.36	20.9	7.97
J	158-172	Eemshaven	2.26	18.42	7.95
J	173	Nieuwstad, Oyster reef	-	-	-
J	174	Delfzijl, Oyster reef	-	-	-
J	175-190	Delfzijl, marina	3.97	14.93	8.01
K	191-305	Wadden Sea, sublittoral	Min: 4,15 Max: 30,7	Min: 8,34 Max: 22,73	Min: 7,96 Max:8,29
L	321-424	Wadden Sea, littoral	-	-	-

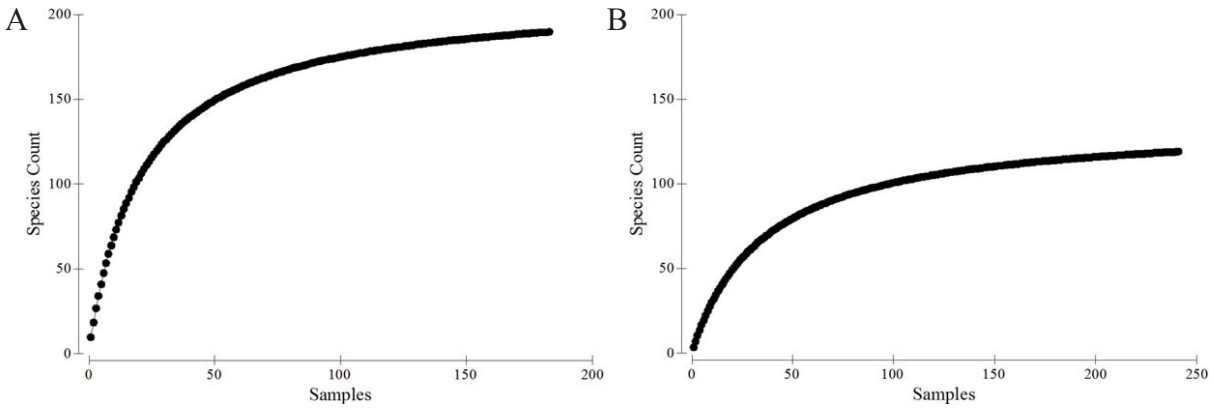

Fig. 4. Michaelis Menten species accumulation curves concerning the monitoring focused on [A] hard substratum and [B] soft substratum related species and the average number of additional species found for each extra location searched.

the student excursion, one day was spend on the ship "De Harder" of the Waddenunit to take sublittoral samples of shellfish beds with a dredge and soft substrate samples with a van Veen-grab in the eastern part of the Dutch Wadden Sea, off Eemshaven.

3.4 Reference material

For reference purposes, whenever possible, each species was photographed in detail with a camera with at least 12.8 megapixels, and/or collected and preserved on ethanol 70%, ethanol 96%, and/or formalin 4% according to the preservation standards that are commonly used by taxonomists in natural history museums (Templado *et al.*, 2010) to ensure that the diagnostic characters of organisms remain preserved. For example, the algae were preserved in formalin 4%, and sea-squirts were first sedated in a mixture of menthol/seawater before they were preserved in ethanol. As a standard for the scientific names, the World Register of Marine Species (www.marinespecies.org) was used. Whenever possible, the species were also photographed and filmed in situ, i.e. underwater, and the microhabitat of each species was described. All files/images were stored on at least two separate hard disks in two separate buildings.

4. Results

In table 1 a summary is given of the species inventory 2014 results. The inventory was conducted while water temperatures were still above 10°C. The 424 locations that were sampled and/or searched for species (Appendix I), varied in their salinities between 5.53 and 25.97 ppt as was measured at a selection of the locations with a Hanna instruments multimeter HI 9829 during the fieldwork (Table 2). A total of 254 native and non-native species (Tables 3-4) were recorded of which respectively 201 and 128 species were found during the monitoring efforts that focused respectively on hard substrates and soft substrates in The Wadden Sea. Still respectively about 10 and 9 more species are expected to be found according to the Michaelis Menten (MM) method if an indefinite number of samples would have been taken. The MM species accumulation curve equations (Fig. 4) indicated however that respectively 199.9 and 127.2 were expected to be found with double the research effort. These estimates should be considered rough indications, especially because of the variety of sampling methods that was used. They do illustrate however that even if the number of samples would have been doubled, this would not have resulted in many additional species records.

As was also the case during the non-native species inventory in 2009 (Gittenberger *et al.*, 2010) the highest diversity of non-native, hard substrate associated species in 2014 was found off Texel, i.e. 26 species (Fig. 5). In total 201 species were recorded during the monitoring that focused on hard substrate related species, of which 44 species are of non-native or unknown origin (Fig. 5). In the soft substratum 128 species were found of which 20 are of non-native or unknown origin (Fig. 6). All of these non-native species were recorded in the sublittoral, while only 7 out of the 20 were recorded in the littoral zone of The Wadden Sea (Fig. 6).

Of all species that were found during The Wadden Sea inventory in 2014, 48 had a non-native origin or were cryptogenic, i.e. their native range is unknown in literature (Table 3). Four non-native species were only recorded while monitoring the soft substrates of The Wadden Sea and not during the hard substratum focussed monitoring. Twenty-five non-native species were only recorded during the monitoring of hard substrates.

Five species are here recorded for the first time for the Dutch Wadden Sea: the algal species *Dasysiphonia japonica*, the ascidian *Diplosoma listerianum*, the bryozoan *Tricellaria inopinata* and the crustaceans *Leptomysis lingvura* and *Melita nitida*.

In addition to the fieldwork, a literature study of published and unpublished non-native species records in The Wadden Sea was done. On the basis of these records another five additional species could be added to the list of non-native species in the Dutch Wadden Sea as presented after the last non-native species inventory in 2011 by Gittenberger et al. (2012): the annelid *Streblospio benedicti*, the bryozoan *Smittoidea prolifica*, the cnidarian *Mitrocomella polydiademata*, the molluk *Rangia cuneata* and the oyster herpes virus Ostreid herpesvirus-1 µvar. *S. benedicti*, may have been present since the early 20th century (Redeke, 1933). It was by mistake

Table 3. Species of non-native origin and species of unknown origin, i.e. cryptogenic species (*) that were found during the Dutch Wadden Sea inventory in 2014.

	Species	**Group**
1	*Antithamnionella spirographidis*	Algae
2	*Ceramium botryocarpum*	Algae
3	*Ceramium tenuicorne*	Algae
4a	*Codium fragile atlanticum*	Algae
4b	*Codium fragile fragile*	Algae
5	*Colpomenia peregrina*	Algae
6	*Dasysiphonia japonica*	Algae
7	*Gracilaria vermiculophylla*	Algae
8	*Neosiphonia harveyi*	Algae
9	*Sargassum muticum*	Algae
10	*Ulva pertusa*	Algae
11	*Undaria pinnatifida*	Algae
12	*Alitta virens*	Annelida
13	*Aphelochaeta marioni* *	Annelida
14	*Ficopomatus enigmaticus*	Annelida
15	*Marenzelleria viridis*	Annelida
16	*Neodexiospira brasiliensis*	Annelida
17	*Streblospio benedicti*	Annelida
18	*Aplidium glabrum* *	Ascidiacea
19	*Botrylloides violaceus*	Ascidiacea
20	*Didemnum vexillum*	Ascidiacea
21	*Diplosoma listerianum* *	Ascidiacea
22	*Molgula manhattensis*	Ascidiacea
23	*Molgula socialis*	Ascidiacea
24	*Styela clava*	Ascidiacea
25	*Bugula stolonifera*	Bryozoa
26	*Smittoidea prolifica*	Bryozoa
27	*Tricellaria inopinata* *	Bryozoa
28	*Cordylophora caspia*	Cnidaria
29	*Diadumene cincta* *	Cnidaria
30	*Diadumene lineata*	Cnidaria
31	*Amphibalanus improvisus* *	Crustacea
32	*Austrominius modestus*	Crustacea
33	*Caprella mutica*	Crustacea
34	*Eriocheir sinensis*	Crustacea
35	*Hemigrapsus sanguineus*	Crustacea
36	*Hemigrapsus takanoi*	Crustacea
37	*Jassa marmorata*	Crustacea
38	*Leptomysis lingvura*	Crustacea
39	*Melita nitida*	Crustacea
40	*Palaemon macrodactylus*	Crustacea
41	*Mnemiopsis leidyi*	Ctenophora
42	*Crassostrea gigas*	Mollusca
43	*Crepidula fornicata*	Mollusca
44	*Ensis directus*	Mollusca
45	*Mya arenaria*	Mollusca
46	*Haliclona* cf *xena* *	Porifera
47	*Hymeniacidon perlevis*	Porifera
48	*Leucosolenia somersi* *	Porifera

not included in the list of species of non-native in Gittenberger et al. (2012). *S. prolifica* was first sighted in The Wadden Sea in 2008, east off Texel on a mussel cuture plot on the inside of a dead Mya shell. It was first recorded in literature by Dekker & Drent (2013). The other three species concern non-natives that were recorded after 2011 in habitats that were not specifically searched during the 2014 inventory: In March 2014 the medusae of the North Atlantic hydroid *Mitrocomella polydiademata*, a new species for the Netherlands, were caught off Balgzand (Van Walraven, *in prep.*). The North American wedge clam *Rangia cuneata* was recorded from Termunterzijl, Groningen by Luijten (2014). This bivalve species, which occurs in brackish waters varying between oligo- and mesohaline, appears to be quickly spreading in the Netherlands in recent years as is also illustrated by its recent discovery in 2014 in the port of Rotterdam (Gittenberger *et al.*, *in press*.). It can be expected to be found in all brackish water harbours along the mainland of The Wadden Sea in the near future. In the summer of 2012 young Pacific oysters at various locations in the Dutch Wadden Sea were screened for the presence of the Oyster herpes virus OsHV-1 µvar. This virus, which finds its origin in the NW Pacific (Mineur *et al*., in press), was detected at various locations in the eastern part of the Dutch Wadden Sea (Gittenberger & Engelsma, 2013; Gittenberger *et al., in press*.).

Starting with a list of only 50 species of non-native or unknown origin that were known for the Dutch Wadden Sea prior to 2009 (Wijsman & De Mesel, 2009), the present list includes 82 species (Table 5). Although some of the added species include recent introductions, most of these species probably concern species that were missed prior to 2009 because the monitoring programs in The Wadden Sea do not specifically focus on recording non-native species diversity like the 2009, 2011 and 2014 inventories did (Gittenberger *et al.*, 2010, 2012). Of the 82 species (Table 5), 5 have not been recorded in the Dutch Delta area yet. These species concern the algal species Ceramiaceae sp. (Gittenberger et al., 2012), the bivalve *Corambe obscura*, the fish *Trinectes maculatus*, the crustacean *Platorchestia platensis* and the jellyfish *Mitrocomella polydiamata*. The risk that they will be imported in the Delta from the Dutch Wadden Sea is limited as most of these species are probably not settled in the Dutch Wadden Sea. They are either assumed to be extinct in the Dutch Wadden Sea or were only recorded once or twice and not repeatedly over the years (Gittenberger *et al*., 2012; Walraven, *in prep*.; Wolff, 2005).

In comparison to the previous non-native species inventories in 2009 and 2011, a number of non-native species have substantially expanded their range within The Wadden Sea in 2014. This includes for example the algae *Antithamnionella spirographidis* and *Ceramium tenuicorne*, the ascidians *Aplidium glabrum, Didemnum vexillum* and *Botrylloides violaceus*, the bryozoan *Bugula stolonifera* and the prawn *Palaemon macrodactylus*. The colonial sea-squirt *Didemnum vexillum* was for example found concentrated in the marina of Terschelling in 2009, while in 2011 it was also abundant on the oyster reef south of Terschelling, and present on the hull of a boat in the harbour of Oudeschild, Texel. In 2014 it was abundant in the marinas of both Vlieland and Terschelling, and it was found to cover large proportions of the oyster reefs off both Texel and Terschelling. It is unclear to what degree the range expansions of the non-native species that were recorded in 2014, are an effect of increased survival in the year 2014. In the winter of 2013-2014 on average the temperature in “De Bilt” (standard point of temperature measurements in the Netherlands) was 6.0°C instead of the “normal” 3.4°C, making it the second warmest winter since temperature measurements started in 1706 (www.knmi.nl). Only 10 days of frost were recorded, the lowest number since 1901. Temperatures below 0°C are usually recorded 38 days per year (www.knmi.nl). As the winter of 2013 to 2014 was relatively warm, some non-native species may have been able to settle, grow and survive in relatively

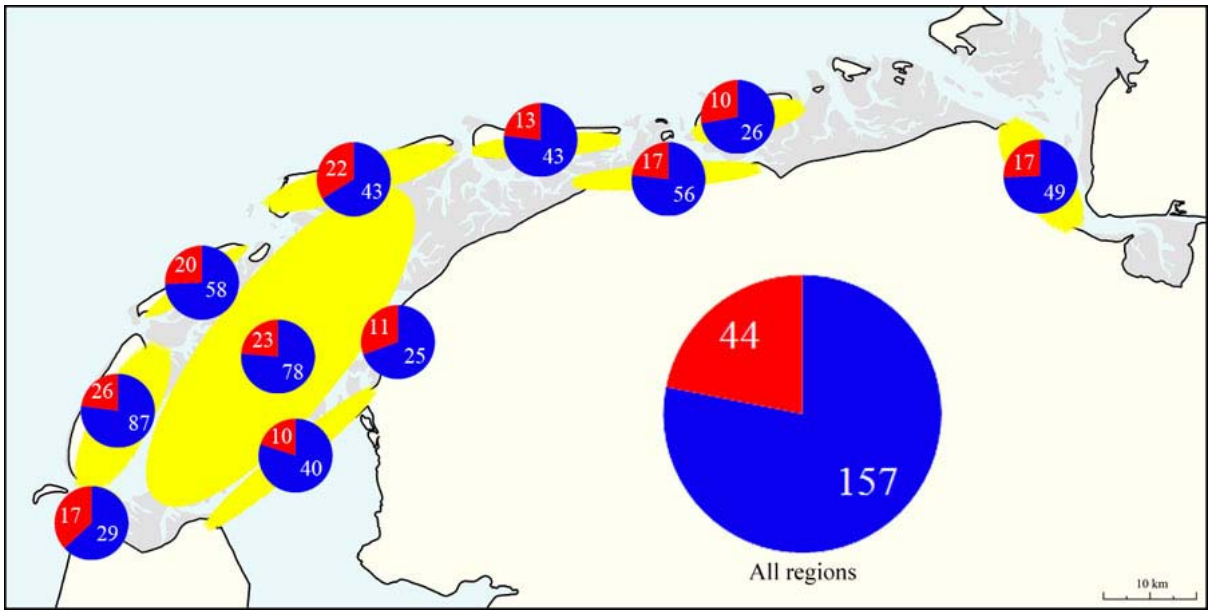

Fig. 5. Species diversity recorded during the monitoring focusing on hard substratum related species, per region (Fig. 1). [Red] number of species of non-native or unknown origin; [Blue] number of native species for the Dutch Wadden Sea.

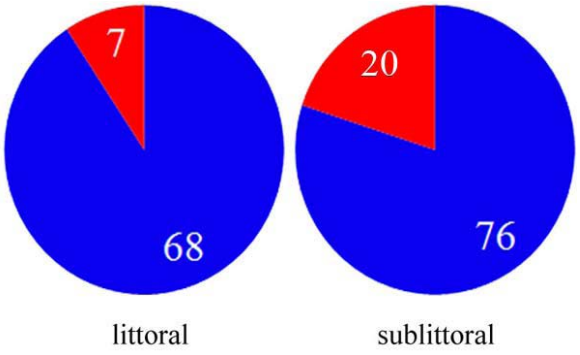

Fig. 6. Species diversity recorded during the monitoring focusing on soft substratum related species throughout the entire Dutch Wadden Sea, separately for the sublittoral and littoral zones (Fig. 2) respectively. [Red] number of species of non-native or unknown origin; [Blue] number of native species for the Dutch Wadden Sea.

large numbers at locations in The Wadden Sea where they would not have survived had the winter been colder. Species like the prawn *Palaemon macrodactylus* were for example already known in literature from a wide range of locations within The Wadden Sea. In 2009 and 2011 this prawn species was not found during the non-native species inventories however, while it was found to be common and widespread during the 2014 inventory. In the following paragraphs the cryptogenic and non-native species recorded during the 2014 inventory are described in more detail.

Table 4. All species that were found during the Dutch Wadden Sea inventory in 2014. Cryptogenic species and species of non-native origin are highlighted.

Species	Author	Group	Origin
Acinetospora crinita	(Carmichael) Sauvageau	Algae	Native
Acrochaetium secundatum	(Lyngbye) Nägeli	Algae	Native
Aglaothamnion hookeri	(Dillwyn) Maggs & Hommersand	Algae	Native
Aglaothamnion pseudobyssoides	(Crouan & Crouan) Halos	Algae	Native
Aglaothamnion roseum	(Roth) Maggs & L'Hardy Halos	Algae	Native
Aglaothamnion tenuissimum	(Bonnemaison) Feldmann-Mazoyer	Algae	Native
Antithamnionella spirographidis	(Schiffner) E.M.Wollaston	Algae	Non-native
Ascophyllum nodosum	(Linnaeus) Le Jolis	Algae	Native
Blidingia marginata	(J.Agardh) P.J.L.Dangeard	Algae	Native
Blidingia minima	(Nägeli ex Kützing) Kylin	Algae	Native
Bryopsis hypnoides	J.V.Lamouroux	Algae	Native
Bryopsis plumosa	(Hudson) C.Agardh	Algae	Native
Callithamnion corymbosum	(Smith) Lyngbye	Algae	Native
Ceramium botryocarpum	A.W.Griffiths ex Harvey	Algae	Non-native
Ceramium cimbricum	H.E.Petersen	Algae	Native
Ceramium deslongchampsii	Chauvin ex Duby	Algae	Native
Ceramium tenuicorne	(Kützing) Waern	Algae	Non-native
Ceramium virgatum	Roth	Algae	Native
Chaetomorpha ligustica	(Kützing) Kützing	Algae	Native
Chaetomorpha linum	(O.F. Müller) Kützing	Algae	Native
Chondrus crispus	Stackhouse	Algae	Native
Cladophora cf *dalmatica*	Kützing	Algae	Native
Cladophora hutchinsiae	(Dillwyn) Kützing	Algae	Native
Cladophora laetevirens	(Dillwyn) Kützing	Algae	Native
Cladophora sericea	(Hudson) Kützing	Algae	Native
Cladophora vagabunda	(Linnaeus) Hoek	Algae	Native
Codium fragile subsp. *atlanticum*	(A.D.Cotton) P.C.Silva	Algae	Non-native
Codium fragile subsp. *fragile*	(Suringar) Hariot	Algae	Non-native
Colpomenia peregrina	Sauvageau	Algae	Non-native
Dasysiphonia japonica	(Yendo) H.-S. Kim	Algae	Non-native
Ectocarpus siliculosus	(Dillwyn) Lyngbye	Algae	Native
Elachista fucicola	(Velley) J.E.Areschoug	Algae	Native
Erythrotrichia bertholdii	Batters	Algae	Native
Erythrotrichia carnea	(Dillwyn) J.Agardh	Algae	Native
Fucus spiralis	Linnaeus	Algae	Native
Fucus vesiculosus	Linnaeus	Algae	Native
Gracilaria gracilis	(Stackhouse) Steentoft, Irvine & Farnham	Algae	Native
Gracilaria vermiculophylla	(Ohmi) Papenfuss	Algae	Non-native
Gracilariopsis longissima	Steentoft, Irvine & Farnham	Algae	Native
Hincksia granulosa	(Smith) P.C.Silva	Algae	Native
Hincksia sandriana	(Zanardini) Silva	Algae	Native
Hypoglossum hypoglossoides	(Stackhouse) F.S.Collins & Hervey	Algae	Native
Mastocarpus stellatus	(Stackhouse) Guiry	Algae	Native
Neosiphonia harveyi	J.W.Bailey	Algae	Non-native
Polysiphonia fucoides	(Hudson) Greville	Algae	Native
Polysiphonia nigra	(Hudson) Batters	Algae	Native
Polysiphonia stricta	(Dillwyn) Greville	Algae	Native

Species	Author	Group	Origin
Porphyra purpurea	(Roth) C.Agardh	Algae	Native
Porphyra umbilicalis	Kützing	Algae	Native
Pterothamnion plumula	(J.Ellis) Nägeli	Algae	Native
Pylaiella littoralis	(Linnaeus) Kjellman	Algae	Native
Rhizoclonium riparium	(Roth) Harvey	Algae	Native
Sargassum muticum	(Yendo) Fensholt	Algae	Non-native
Spongonema tomentosum	(Hudson) Kützing	Algae	Native
Stylonema alsidii	(Zanardini) K.M.Drew	Algae	Native
Ulothrix flacca	(Dillwyn) Thuret	Algae	Native
Ulva cf lactuca	Linnaeus	Algae	Native
Ulva clathrata	(Roth) C. Agardh	Algae	Native
Ulva compressa	Linnaeus	Algae	Native
Ulva curvata	(Kützing) De Toni	Algae	Native
Ulva flexuosa	Wulfen	Algae	Native
Ulva intestinalis	Linnaeus	Algae	Native
Ulva linza	Linnaeus	Algae	Native
Ulva pertusa	Kjellman	Algae	Non-native
Ulva prolifera	Müller	Algae	Native
Ulva pseudocurvata	Koeman & Hoek	Algae	Native
Ulva ralfsii	(Harvey) Le Jolis	Algae	Native
Ulva rigida	C.Agardh	Algae	Native
Ulva torta	(Mertens) Trevisan	Algae	Native
Undaria pinnatifida	(Harvey) Suringar	Algae	Non-native
Urospora neglecta	(Kornmann) Lokhorst & Trask	Algae	Native
Vertebrata lanosa	(Linnaeus) Christensen	Algae	Native
Alitta succinea	(Leuckart, 1847)	Annelida	Native
Alitta virens	(M. Sars, 1835)	Annelida	Non-native
Amphitrite figulus	(Dalyell)	Annelida	Native
Aphelochaeta marioni	(Saint-Joseph, 1894)	Annelida	Cryptogenic
Arenicola marina	(Linnaeus, 1758)	Annelida	Native
Aricidea minuta	Southward, 1956	Annelida	Native
Bylgides sarsi	(Kinberg, 1866)	Annelida	Native
Capitella capitata	(Fabricius, 1780)	Annelida	Native
Eteone longa	(Fabricius, 1780)	Annelida	Native
Eulalia viridis	(Linnaeus, 1767)	Annelida	Native
Eumida sanguinea	(Örsted, 1843)	Annelida	Native
Eunereis longissima	Johnston, 1840	Annelida	Native
Ficopomatus enigmaticus	(Fauvel, 1923)	Annelida	Non-native
Harmothoe extenuata	(Grube, 1840)	Annelida	Native
Harmothoe imbricata	(Linnaeus, 1767)	Annelida	Native
Harmothoe impar	(Johnston, 1839)	Annelida	Native
Hediste diversicolor	(Müller, 1776)	Annelida	Native
Heteromastus filiformis	(Claparède, 1864)	Annelida	Native
Lagis koreni	Malmgren, 1866	Annelida	Native
Lanice conchilega	(Pallas, 1766)	Annelida	Native
Lepidonotus squamatus	(Linnaeus, 1758)	Annelida	Native
Magelona johnstoni	Fiege, Licher & Mackie, 2000	Annelida	Native
Magelona mirabilis	(Johnston, 1865)	Annelida	Native
Malacoceros fuliginosus	(Claparède, 1870)	Annelida	Native
Malmgreniella lunulata	(Delle Chiaje, 1830)	Annelida	Native
Marenzelleria viridis	(Verrill, 1873)	Annelida	Non-native

Species	Author	Group	Origin
Myrianida prolifer	(O.F. Müller, 1788)	Annelida	Native
Mysta picta	(Quatrefages, 1866)	Annelida	Native
Neoamphitrite figulus	(Dalyell, 1853)	Annelida	Native
Neodexiospira brasiliensis	(Grube, 1872)	Annelida	Non-native
Nephtys caeca	(Fabricius, 1780)	Annelida	Native
Nephtys cirrosa	(Ehlers, 1868)	Annelida	Native
Nephtys hombergii	Savigny in Lamarck, 1818	Annelida	Native
Nephtys longosetosa	Örsted, 1842	Annelida	Native
Nereis pelagica	Linnaeus, 1758	Annelida	Native
Phyllodoce mucosa	Örsted, 1843	Annelida	Native
Polydora ciliata	(Johnston, 1838)	Annelida	Native
Polydora cornuta	Bosc, 1802	Annelida	Native
Pygospio elegans	Claparède, 1863	Annelida	Native
Scolelepis bonnieri	(Mesnil, 1896)	Annelida	Native
Scolelepis foliosa	(Audouin & Milne Edwards, 1833)	Annelida	Native
Scolelepis squamata	(O.F. Muller, 1806)	Annelida	Native
Scoloplos armiger	(Müller, 1776)	Annelida	Native
Spio martinensis	Mesnil, 1896	Annelida	Native
Spiophanes bombyx	(Claparède, 1870)	Annelida	Native
Streblospio benedicti	Webster, 1879	Annelida	Non-native
Streblospio shrubsolii	(Buchanan, 1890)	Annelida	Native
Aplidium glabrum	(Verrill, 1871)	Ascidiacea	Cryptogenic
Botrylloides violaceus	Oka, 1927	Ascidiacea	Non-native
Botryllus schlosseri	(Pallas, 1766)	Ascidiacea	Native
Ciona intestinalis	(Linnaeus, 1767)	Ascidiacea	Native
Didemnum vexillum	Kott, 2002	Ascidiacea	Non-native
Diplosoma listerianum	(Milne-Edwards, 1841)	Ascidiacea	Cryptogenic
Molgula manhattensis/ socialis	(De Kay, 1843)/ Alder, 1863	Ascidiacea	Non-native
Styela clava	Herdman, 1881	Ascidiacea	Non-native
Alcyonidioides mytili	(Dalyell, 1848)	Bryozoa	Native
Alcyonidium gelatinosum	(Linnaeus, 1761)	Bryozoa	Native
Bugula stolonifera	Ryland, 1960	Bryozoa	Non-native
Conopeum reticulum	(Linnaeus, 1767)	Bryozoa	Native
Cryptosula pallasiana	(Moll, 1803)	Bryozoa	Native
Electra pilosa	(Linnaeus, 1767)	Bryozoa	Native
Farrella repens	(Farre, 1837)	Bryozoa	Native
Smittoidea prolifica	Osburn, 1952	Bryozoa	Non-native
Tricellaria inopinata	d'Hondt & Occhipinti Ambrogi, 1985	Bryozoa	Cryptogenic
Aurelia aurita	(Linnaeus, 1758)	Cnidaria	Native
Chrysaora hysoscella	(Linnaeus, 1767)	Cnidaria	Native
Clytia cf gracilis	(Sars, 1850)	cnidaria	Native
Clytia hemisphaerica	(Linnaeus, 1767)	Cnidaria	Native
Cordylophora caspia	(Pallas, 1771)	Cnidaria	Non-native
Diadumene cincta	Stephenson, 1925	Cnidaria	Non-native
Diadumene lineata	(Verrill, 1869)	Cnidaria	Non-native
Dynamena pumila	(Linnaeus, 1758)	Cnidaria	Native
Ectopleura larynx	(Ellis & Solander, 1786)	Cnidaria	Native
Hartlaubella gelatinosa	(Pallas, 1766)	Cnidaria	Native
Hydractinia echinata	(Fleming, 1828)	Cnidaria	Native
Metridium senile	(Linnaeus, 1761)	Cnidaria	Native
Obelia bidentata	Clark, 1875	Cnidaria	Native
Obelia dichotoma	(Linnaeus, 1758)	Cnidaria	Native

Species	Author	Group	Origin
Obelia geniculata	(Linnaeus, 1758)	Cnidaria	Native
Obelia longissima	(Pallas, 1766)	Cnidaria	Native
Rhizostoma pulmo	(Macri, 1778)	Cnidaria	Native
Sagartia elegans	(Dalyell, 1848)	Cnidaria	Native
Sagartia troglodytes	(Price in Johnston, 1847)	Cnidaria	Native
Sagartiogeton undatus	(Müller, 1778)	Cnidaria	Native
Sertularia cupressina	Linnaeus, 1758	Cnidaria	Native
Tubularia indivisa	Linnaeus, 1758	Cnidaria	Native
Urticina felina	(Linnaeus, 1761)	Cnidaria	Native
Amphibalanus improvisus	(Darwin, 1854)	Crustacea	Cryptogenic
Apohyale prevostii	(Milne-Edwards, 1830)	Crustacea	Native
Austrominius modestus	(Darwin, 1854)	Crustacea	Non-native
Balanus crenatus	Bruguiére, 1789	Crustacea	Native
Bathyporeia pilosa	Lindström, 1855	Crustacea	Native
Bathyporeia sarsi	Watkin, 1938	Crustacea	Native
Bodotria scorpioides	(Montagu, 1804)	Crustacea	Native
Cancer pagurus	Linnaeus, 1758	Crustacea	Native
Caprella linearis	(Linnaeus, 1767)	Crustacea	Native
Caprella mutica	Schurin, 1935	Crustacea	Non-native
Carcinus maenas	(Linnaeus, 1758)	Crustacea	Native
Corophium arenarium	Crawford, 1937	crustacea	Native
Corophium volutator	(Pallas, 1766)	Crustacea	Native
Crangon crangon	(Linnaeus, 1758)	Crustacea	Native
Cumopsis goodsir	(Van Beneden, 1861)	Crustacea	Native
Echinogammarus obtusatus	(Dahl, 1938)	Crustacea	Native
Eriocheir sinensis	H. Milne Edwards, 1853	Crustacea	Non-native
Gammarus locusta	(Linnaeus, 1758)	Crustacea	Native
Hemigrapsus sanguineus	(De Haan, 1835)	Crustacea	Non-native
Hemigrapsus takanoi	Asakura & Watanabe, 2005	Crustacea	Non-native
Idotea balthica	(Pallas, 1772)	Crustacea	Native
Jaera cf. albifrons	Leach, 1814	Crustacea	Native
Jassa marmorata	Holmes, 1905	Crustacea	Non-native
Lekanesphaera hookeri	(Leach, 1814)	Crustacea	Native
Lekanesphaera rugicauda	(Leach, 1814)	Crustacea	Native
Leptomysis lingvura	(Sars G.O., 1866)	Crustacea	Non-native
Macropodia rostrata	(Linnaeus, 1761)	Crustacea	Native
Melita nitida	Smith, 1873	Crustacea	Non-native
Melita palmata	(Montagu, 1804)	Crustacea	Native
Mesopodopsis slabberi	(Van Beneden, 1861)	Crustacea	Native
Monocorophium acherusicum	(Costa, 1853)	Crustacea	Native
Monocorophium insidiosum	(Crawford, 1937)	Crustacea	Native
Neomysis integer	(Leach, 1814)	Crustacea	Native
Pagurus bernhardus	(Linnaeus, 1758)	Crustacea	Native
Palaemon adspersus	Rathke, 1837	Crustacea	Native
Palaemon elegans	Rathke, 1837	Crustacea	Native
Palaemon macrodactylus	Rathbun, 1902b	Crustacea	Non-native
Palaemon serratus	(Pennant, 1777)	Crustacea	Native
Palaemon varians	Leach, 1813	Crustacea	Native
Palaemon varians	Leach, 1813	Crustacea	Native
Pilumnus hirtellus	(Linnaeus, 1761)	Crustacea	Native
Porcellana platycheles	(Pennant, 1777)	Crustacea	Native
Praunus flexuosus	(Müller, 1776)	Crustacea	Native

Species	Author	Group	Origin
Sacculina carcini	Thompson, 1836	Crustacea	Native
Semibalanus balanoides	(Linnaeus, 1758)	Crustacea	Native
Urothoe poseidonis	Reibish, 1905	Crustacea	Native
Beroe cucumis	Fabricius, 1780	Ctenophora	Native
Mnemiopsis leidyi	A. Agassiz, 1865	Ctenophora	Non-native
Pleurobrachia pileus	(O. F. Müller, 1776)	Ctenophora	Native
Asterias rubens	Linnaeus, 1758	Echinodermata	Native
Ophiothrix fragilis	(Abildgaard, in Müller, 1789)	Echinodermata	Native
Ophiura ophiura	(Linnaeus, 1758)	Echinodermata	Native
Psammechinus miliaris	(P.L.S. Müller, 1771)	Echinodermata	Native
Anurida maritima	(Guérin-Méneville, 1836)	Instecta	Native
Abra alba	(W. Wood, 1802)	Mollusca	Native
Abra tenuis	(Montagu, 1803)	Mollusca	Native
Aeolidia papillosa	(Linnaeus, 1761)	Mollusca	Native
Barnea candida	(Linnaeus, 1758)	Mollusca	Native
Cerastoderma edule	(Linnaeus, 1758)	Mollusca	Native
Crassostrea gigas	(Thunberg, 1793)	Mollusca	Non-native
Crepidula fornicata	(Linnaeus, 1758)	Mollusca	Non-native
Ecrobia ventrosa	(Montagu, 1803)	Mollusca	Native
Ensis directus	(Conrad, 1843)	Mollusca	Non-native
Kurtiella bidentata	(Montagu, 1803)	Mollusca	Native
Lepidochitona cinerea	(Linnaeus, 1767)	Mollusca	Native
Littorina littorea	(Linnaeus, 1758)	Mollusca	Native
Littorina saxatilis	(Olivi, 1792)	Mollusca	Native
Macoma balthica	(Linnaeus, 1758)	Mollusca	Native
Mya arenaria	Linnaeus, 1758	Mollusca	Non-native
Mytilus edulis	Linnaeus, 1758	Mollusca	Native
Peringia ulvae	(Pennant, 1777)	Mollusca	Native
Retusa obtusa	(Montagu, 1803)	Mollusca	Native
Scrobicularia plana	(da Costa, 1778)	Mollusca	Native
Tellina fabula	Gmelin, 1791	Mollusca	Native
Tellina tenuis	da Costa, 1778	Mollusca	Native
Tergipes tergipes	(Forskål, 1775)	Mollusca	Native
Emplectonema neessi	(Örsted, 1843)	Nemertea	Native
Tetrastemma melanocephalum	(Johnston, 1837)	Nemertea	Native
Agonus cataphractus	(Linnaeus, 1758)	Pisces	Native
Atherina presbyter	Cuvier, 1829	Pisces	Native
Liparis liparis	(Linnaeus, 1766)	Pisces	Native
Pholis gunnellus	(Linnaeus, 1758)	Pisces	Native
Pleuronectes platessa	Linnaeus, 1758	Pisces	Native
Pomatoschistus microps	(Krøyer, 1838)	Pisces	Native
Pomatoschistus minutus	(Pallas, 1770)	Pisces	Native
Solea solea	(Linnaeus, 1758)	Pisces	Native
Syngnathus acus	Linnaeus, 1758	Pisces	Native
Salicornia europaea	Linnaeus	Plantae	Native
Halichondria bowerbanki	Burton, 1930	Porifera	Native
Halichondria panicea	(Pallas, 1766)	Porifera	Native
Haliclona cf xena	De Weerdt, 1986	Porifera	Cryptogenic
Hymeniacidon perlevis	(Montagu, 1814)	Porifera	Non-native
Leucosolenia somersi	(Bowerbank, 1874)	porifera	Cryptogenic
Leucosolenia variabilis	(Haeckel, 1870)	Porifera	Native
Sycon ciliatum	(Fabricius, 1780)	Porifera	Native

Table 5. Review of all 82 species of non-native or unknown origin that have been recorded for the Dutch Wadden Sea. Species for the Dutch Wadden Sea that were added to the list presented by Gittenberger *et al.,* 2012, are highlighted. * These species are not included in the present list as non-native or cryptogenic even though they are considered as such in literature.

	Species	**Source of occurrence in the Dutch Wadden Sea**	**Origin and remarks**
	ALGAE		
1	*Alexandrium tamarense* (Lebour) Balech	Wijsman & Mesel, 2009	Cryptogenic (Wolff, 2005)
*	*Alaria esculenta* (Linnaeus) Greville	Wijsman & Mesel, 2009	* The record referred to in Wijsman & De Mesel (2009) probably concerns a specimen that washed ashore in The Wadden Sea. In our non-native species list we only include algae that were found attached to the substrate, i.e. settled.
2	*Acrochaetium densum* (K.M.Drew) Papenfus	Stegenga, 2002;	Pacific (Stegenga & Vroman, 1976)
3	*Antithamnionella spirographidis* (Schiffner) Wollaston	This species inventory; Gittenberger *et al.*, 2010, 2012	N Pacific (Maggs & Stegenga, 1999)
4	*Botrytella* sp.	Stegenga & Mol, 1996	Crytogenic (Wolff, 2005)
5	*Ceramium cimbricum* H.E. Petersen	Gittenberger *et al.*, 2010, 2012	Crytogenic; probable non-native for NW Europe
6	*Ceramium botryocarpum* A.W.Griffiths ex Harvey	This species inventory; Gittenberger *et al.*, 2012	NE Atlantic (Maggs & Hommersand, 1993)
7	*Ceramium tenuicorne* (Kützing) Waern	This species inventory; Gittenberger *et al.*, 2012	NE Atlantic (Maggs & Hommersand, 1993)
8	Ceramiaceae sp.	Gittenberger *et al.*, 2010	Crytogenic; The specimen missed the reproductive organs that are needed for an identification to the species level. Based on the morphological characters that were present, it was concluded that it probably concerns a non-native species for NW Europe.
9	*Chattonella marina* Hara & Chihara	Vrieling *et al.*, 1995	Crytogenic (Wolff, 2005)
10	*Chattonella antiqua* (Hada) Ono in Ono & Takano	Vrieling *et al.*, 1995	Crytogenic (Wolff, 2005)
11a	*Codium fragile* ssp. *atlanticum* (A.D.Cotton) P.C. Silva	This species inventory; Gittenberger *et al.*, 2010, 2012	NW Pacific (Silva, 1955)
11b	*Codium fragile* ssp. *tomentosoides* synoniem of *Codium fragile sp. fragile*	This species inventory; Stegenga & Prud'homme and Reine, 1998	NW Pacific (Chapman, 1999)
*	*Colpomenia peregrina* Sauvageau	This species inventory; Wolff, 2005	* NW Atlantic (Wolff, 2005); Assuming that Colpomenia sinuosa is a synonym of *Colpomenia peregrina*, Wolff (2005) refers to Van Goor (1923) as the source of The Wadden Sea sighting. See remarks of *Colpomenia sinuosa*.
12	*Colpomenia sinuosa* (Mertens ex Roth) Derbès & Solier	Van Goor, 1923	Pacific (South & Tittley 1986); Wolff (2005) considers this species to be a synonym of *Colpomenia peregrina* without further argumentation. We consider *C. peregrina* and *C. sinuosa* to be two valid species.
13	*Coscinodiscus wailesii* Gran & Angst	Edwards *et al.*, 2001	N Pacific (Edwards *et al.*, 2001)
14	*Dasysiphonia japonica* (Yendo) H.-S. Kim	This species inventory	NW pacific (Sjøtun *et al.*, 2008)

	Species	Source of occurrence in the Dutch Wadden Sea	Origin and remarks
15	*Fibrocapsa japonica* Toriumi & Takano	Vrieling *et al.*, 1995	Crytogenic (Wolff, 2005)
16	*Gracilaria vermiculophylla*, (Ohmi) Papenfuss	This species inventory; Gittenberger *et al.*, 2010, 2012	Pacific (Gollasch & Nehring, 2006)
17	*Heterosigma akashiwo* (Y. Hada)	Wijsman & Mesel, 2009	Pacific? (Minchin, 2007)
18	*Odontella sinensis* (Greville) Grunow	Leewis, 1985	Indian Ocean (Eno *et al.*, 1997)
19	*Pleurosigma simonsenii* G.R. Hasle	Kat, 1982	Indian Ocean (Eno *et al.*, 1997)
*	*Mastocarpus stellatus* (Stackhouse) Guiry	Gittenberger *et al.*, 2010, 2012; Wijsman & Mesel, 2009	* Cryptogenic; This species has been recorded in The Wadden Sea since the early 19th century and there are no indications that it may have been introduced by humans. We therefore consider that it is unlikely that M. stellatus is an exotic species as is indicated by Wijsman & De Mesel (2009).
20	*Neosiphonia harveyi* (Bailey) Kim, Choi, Guiry & Saunders	This species inventory; Gittenberger *et al.*, 2010, 2012; Maggs & Stegenga, 1999; Wijsman & Mesel, 2009	N Pacific (Maggs & Stegenga, 1999)
21	*Prorocentrum triestinum* Schiller	Wijsman & Mesel, 2009	Crytogenic (Wolff, 2005)
22	*Sargassum muticum* (Yendo) Fensholt	This species inventory; Gittenberger *et al.*, 2010, 2012; Prud'homme van Reine & Nienhuis, 1982;	NW Pacific (Wallentinus, 1999)
23	*Ulva pertusa,* Kjellman	This species inventory; Gittenberger *et al.*, 2010, 2012; Stegenga & Mol, 2002	N Pacific (Stegenga & Mol, 2002)
24	*Undaria pinnatifida* (Harvey) Suringar	This species inventory; Gittenberger *et al.*, 2010, 2012 Ruijter, 2008	NW Pacific (Stegenga, 1999)
	ANNELIDA		
25	*Alitta virens* (M. Sars, 1835)	This species inventory; Horst, 1920	N Atlantic or N Pacific (Nehring & Leuchs, 1999)
26	*Aphelochaeta marioni* (de Saint Joseph, 1894)	This species inventory; Wijsman & Mesel, 2009	Crytogenic, probably native (Wolff, 2005)
27	*Ficopomatus enigmaticus* (Fauvel, 1923)	This species inventory; Gittenberger *et al.*, 2010	SW Pacific (Grosholz & Ruiz, 1996)
28	*Neodexiospira brasiliensis* (Grube, 1872)	This species inventory; Gittenberger *et al.*, 2010	Tropics, including Brasil (Eno *et al.* 1997)
29	*Marenzelleria viridis* (Verrill, 1873)	This species inventory; Dekker, 1991	W Atlantic (Bick & Zettler, 1997)
30	*Streblospio benedicti* Webster, 1879	This species inventory; Sebesvari *et al.*, 2006	North America (Carlton, 1979; Wolff, 2005). * This species was mistakenly not included in the non-native species list in Gittenberger *et al.*, 2012
	ASCIDIACEA		
31	*Aplidium glabrum* (Verrill, 1871)	This species inventory; Gittenberger *et al.*, 2010, 2012	Cryptogenic, possibly native to NE Atlantic (Wolff, 2005)
32	*Botrylloides violaceus* Oka, 1927	This species inventory; Gittenberger *et al.*, 2010, 2012	NW Pacific (Minchin, 2007)

	Species	Source of occurrence in the Dutch Wadden Sea	Origin and remarks
33	*Didemnum vexillum* Kott 2002	This species inventory; Gittenberger *et al.*, 2010, 2012	NW Pacific (Stefaniak *et al.*, 2009)
34	*Diplosoma listerianum* (Milne-Edwards, 1841)	This species inventory	The origin of this cosmopolitan species, which was described in 1871 from the Mediterranean, is unknown.
35	*Molgula manhattensis* (De Kay, 1843)	This species inventory; Gittenberger *et al.*, 2012	NW Atlantic (Haydar *et al.*, 2011)
36	*Molgula socialis* Alder, 1863	This species inventory; Gittenberger *et al.*, 2010, 2012	NE Atlantic (Monniot, 1969)
37	*Styela clava* (Herdman, 1881)	This species inventory; Gittenberger *et al.*, 2010, 2012; Huwae, 1974	NW Pacific (Lützen, 1999)
	BRYOZOA		
38	*Bowerbankia gracilis* Leidy, 1855	Wijsman & Mesel, 2009	Crytogenic (Wolff, 1999)
39	*Bowerbankia imbricata* (Adams, 1798)	Wijsman & Mesel, 2009	Crytogenic (Wolff, 2005)
40	*Bugula stolonifera* Ryland 1960	This species inventory; Gittenberger *et al.*, 2010, 2012; D'Hondt & Cadée, 1994	NW Atlantic (Cohen & Carlton, 1995)
41	*Smittoidea prolifica* Osburn, 1952	This species inventory (Dekker & Drent 2013)	Pacific coast of north America (Faasse *et al.*, 2013)
42	*Tricellaria inopinata* d'Hondt & Occhipinti Ambrogi, 1985	This species inventory	Probably NE Pacific (Cook *et al.*, 2013)
	CNIDARIA		
43	*Cordylophora caspia* (Pallas, 1771)	This species inventory; Gittenberger *et al.*, 2010, 2012	Ponto-Caspian (Nehring & Leuchs, 1999)
44	*Diadumene cincta* Stephenson, 1925	This species inventory; Gittenberger *et al.*, 2010, 2012; Pax, 1936	Crytogenic (Den Hartog & Ates, 2011) or Pacific (Gollasch & Nehring, 2006).
45	*Diadumene lineata* Verrill, 1870	This species inventory; Gittenberger *et al.*, 2012; Van Urk, 1956	NW Pacific (Gollasch &Riemann-Zürneck, 1996)
46	*Gonionemus vertens* A. Agassiz, 1862	Gittenberger *et al.*, 2012	NW Atlantic (Werner, 1950) or N Pacific (Edwards, 1976).
47	*Nemopsis bachei* L. Agassiz, 1849	Wijsman & Mesel, 2009	NW Atlantic (Faasse & Ates, 1998)
48	*Mitrocomella polydiademata* (Romanes, 1876)	Van Walraven, *in prep*	Atlantic
	CRUSTACEA		
49	*Amphibalanus improvisus* (Darwin, 1854)	This species inventory; Gittenberger *et al.*, 2010, 2012; Huwae, 1985;	Crytogenic, probably native for NE Atlantic (Gollasch, 2002)
50	*Astrominius modestus* (Darwin, 1854)	This species inventory; Gittenberger *et al.*, 2010, 2012; Huwae, 1985	SW Pacific (Harms, 1999)

	Species	Source of occurrence in the Dutch Wadden Sea	Origin and remarks
51	*Callinectes sapidus* Rathbun, 1896	Wijsman & Mesel, 2009; Wolff, 2005	NW Atlantic (Christiansen, 1969)
52	*Caprella mutica* Schurin, 1935	This species inventory; Gittenberger *et al.*, 2010, 2012	Pacific (Schrey & Buschbaum, 2006)
53	*Eriocheir sinensis* H. Milne-Edwards, 1853	This species inventory; Gittenberger *et al.*, 2010; Adema, 1991	NW Pacific (Adema, 1991)
54	*Hemigrapsus sanguineus* (De Haan, 1853)	This species inventory; Gittenberger *et al.*, 2010, 2012; Wijsman & Mesel, 2009	NW Pacific (Breton *et al.*, 2002)
55	*Hemigrapsus takanoi* Asakura & Watanabe, 2005	This species inventory; Gittenberger *et al.*, 2010, 2012; Wijsman & Mesel, 2009	NW Pacific (Asakura & Watanabe, 2005)
56	*Jassa marmorata* Holmes, 1905	This species inventory; Gittenberger *et al.*, 2010, 2012; Dankers & van Moorsel 2001	NW Atlantic (Conlan, *pers comm*; Conlan, 1990)
57	*Leptomysis lingvura* (Sars G.O., 1866)	This species inventory	NE Atlantic (Tattersall & Tattersall, 1951)
58	*Limnoria lignorum* (Rathke, 1799)	Hubrecht *et al.*, 1893; Wijsman & Mesel, 2009	Crytogenic, probably native for NE Atlantic (Wolff, 2005)
59	*Melita nitida* Smith, 1873	This species inventory	N America (Faasse & van Moorsel, 2003).
60	*Mytilicola intestinalis* Steuer, 1902	Korringa, 1952; Wijsman & Mesel, 2009	Mediterranean (Steuer 1902); In 2009 a high percentage of especially relatively old mussels was found to be infested by this mussel parasite (*pers comm* Nico Laros). Even though *M. intestinalis* has caused a lot of ecological and economical damage in the mussel industry in the past, its effect on the mussel population dynamics in recent year is unstudied and therefore unknown.
61	*Palaemon macrodactylus* Rathbun, 1902	This species inventory; Faasse, 2005; Ruijter, 2007; Schrieken, 2008; Tulp, 2006	NW Pacific (d'Udekem d'Acoz et all., 2005)
62	*Platorchestia platensis* Krøyer, 1845	Den Hartog, 1961; Wijsman & Mesel, 2009	Crytogenic (Wolff, 2005)
63	*Rhithropanopeus harrisii* (Gould, 1841)	Gittenberger *et al.*, 2012; Tesch, 1922;	W Atlantic (Eno *et al.*, 1997)
64	*Sinelobus stanfordi* (Richardson, 1901)	Gittenberger *et al.*, 2010	Cryptogenic (Haaren & Soors, 2009)
	CTENOPHORA		
65	*Mnemiopsis leidyi* A. Agassiz, 1865	This species inventory; Gittenberger *et al.*, 2010, 2012; Gittenberger, 2008; Tulp, 2006	W Atlantic (Gittenberger, 2008)
	INSECTA		
66	*Telmatogeton japonicus* Tokunaga, 1933	Gittenberger *et al.*, 2012	Pacific (Raunio *et al.*, 2009)

	Species	Source of occurrence in the Dutch Wadden Sea	Origin and remarks
	MOLLUSCA		
67	*Corambe obscura* (Verrill, 1870)	Butot, 1984; Wijsman & Mesel, 2009	W Atlantic (Swennen & Dekker, 1987); This species probably went extinct in The Wadden Sea after the Zuiderzee was closed (Butot, 1984).
68	*Crassostrea gigas* (Thunberg, 1793)	This species inventory; Gittenberger *et al.*, 2010, 2012; Drinkwaard, 1999	NW Pacific (Eno *et al.*, 1997)
69	*Crepidula fornicata* (Linnaeus, 1758)	This species inventory; Gittenberger *et al.*, 2010, 2012; Korringa, 1942	NW Atlantic (Nehring & Leuchs, 1999)
70	*Ensis directus* (Conrad, 1843)	This species inventory; Essink & Tydeman, 1985	NW Atlantic (De Bruyne & De Boer, 1984)
71	*Mytilopsis leucophaeata* (Conrad, 1831)	Van Benthem Jutting,1943; Wijsman & Mesel, 2009	NW Atlantic (Gittenberger & Janssen, 1998)
72	*Mya arenaria* Linnaeus, 1758	This species inventory; Wijsman & Mesel, 2009	NW Atlantic& N Pacific (Cohen & Carlton, 1995)
73	*Petricola pholadiformis* Lamarck, 1818	Van Benthem Jutting, 1943; Wijsman & Mesel, 2009	NW Atlantic (Eno *et al.*, 1997)
74	*Rangia cuneata* (Soweby, 1832)	Luijten, 2014	Gulf of Mexico and maybe the NW Atlantic (Gittenberger et al, 2015 *in press*)
75	*Teredo navalis* Linnaeus, 1758	Van Benthem Jutting,1943; Wijsman & Mesel, 2009	Crytogenic (Wolff, 2005)
	NEMATODA		
76	*Anguillicola crassus* Kuwahara, Niimi & Itagaki, 1974	Wijsman & Mesel, 2009; Wolff, 2005	NW Pacific (Minchin, 2007)
	PISCES		
77	*Atherina boyeri* Risso, 1810	Kloosterman & Schrieken, 2003; Wijsman & Mesel, 2009	NE Atlantic (Wolff, 2005)
78	*Trinectes maculatus* (Bloch & Schneider, 1801)	Wijsman & Mesel, 2009; Wolff, 2005	NW Atlantic (Wolff, 2005); Only one specimen was recorded. This species has probably not established itself in The Wadden Sea.
	PORIFERA		
79	*Haliclona xena* De Weerdt, 1986	This species inventory; Gittenberger *et al.*, 2012; Soest *et al.*, 2007	Crytogenic (Van Soest *et al.*, 2007)
80	*Hymeniacidon perlevis* (Montagu, 1818)	This species inventory; Gittenberger *et al.*, 2012	NE Atlantic (Van Soest *et al.*, 2007)
81	*Leucosolenia* aff. *somesi* (Bowerbank, 1874)	This species inventory; Gittenberger *et al.*, 2012	Crytogenic (Van Soest *et al.*, 2007)
	VIRALES		
82	Ostreid herpesvirus-1 µvar (OsHV-1 µvar)	Gittenberger & Engelsma, 2013; Gittenberger *et al, in press*	NW Pacific (Mineur *et al., in press*)

4.1 Species of non-native or unknown origin

4.1.1 Algae

4.1.1.1 *Antithamnionella spirographidis* (Schiffner) E.M.Wollaston (Figs 7-8)

Origin:
North Pacific (Maggs & Stegenga 1999).

Distribution:
In the Netherlands *Antithamnionella spirographidis* was first found in 1974 in the Dutch Delta area (Stegenga & Prud'homme van Reine 1998). During a non-native species inventory in 2009 it was recorded for the first time in the Dutch Wadden Sea (Gittenberger *et al.*, 2010), i.e. off The Wadden Sea Islands Texel and Terschelling. In 2011 it was also found more to the east, off Schiermonnikoog and Eemshaven (Fig. 7; Gittenberger *et al.*, 2010, 2012). In 2014 *A. spirographidis* was additionally recorded in the harbours of Lauwersoog and Den Helder (Fig. 7). Most individuals were found on floating docks, but they were also recorded in littoral and sublittoral zones on dikes and mussel beds. The salinities at the locations where the species was found in 2014, varied from 17.91 to 22.13 ppt (Fig. 7; Table 2; Appendix II).

Impact:
Antithamnionella spirographidis (Fig. 8) is a relatively small red alga, which only occurred on hard substrata. It is not expected to have a large impact on The Wadden Sea ecosystem (Gittenberger *et al.*, 2010)

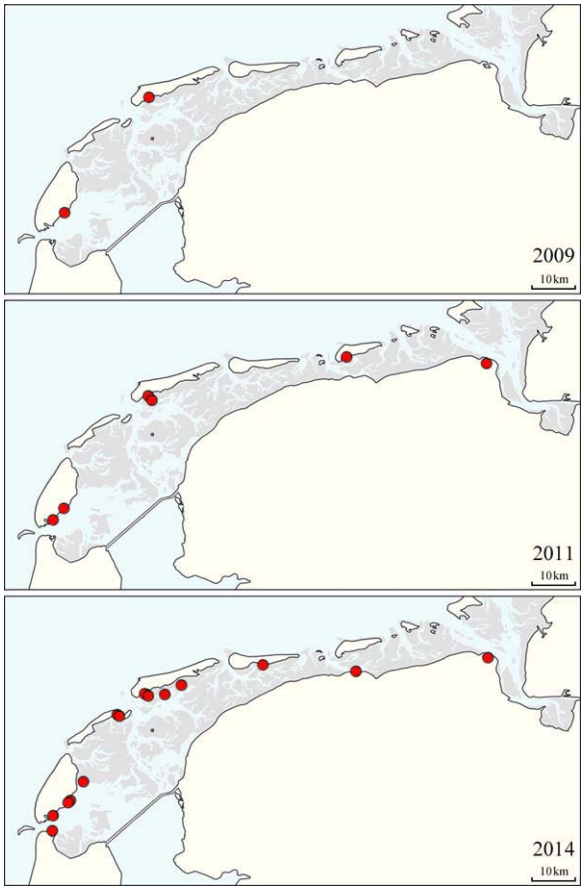

Fig. 7. Locations where *Antithamnionella spirographidis* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

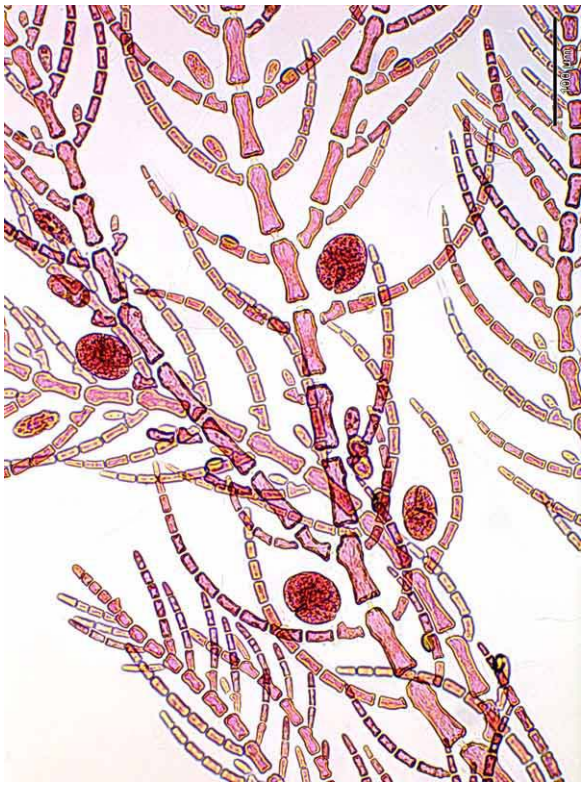

Fig. 8. *Antithamnionella spirographidis in vitro* detail with tetrasporangia.

4.1.1.2 *Ceramium botryocarpum*
A.W.Griffiths ex Harvey (Figs 9-10)

Origin:
NE Atlantic: *Ceramium botryocarpum* is a non-native species for the Netherland, but it is native for North West Europe, with a natural range from Portugal to the British Iles (Araujo *et al.*, 2009, Maggs & Hommersand, 1993).

Distribution:
During the species inventory in 2011 the alga *Ceramium botryocarpum* was recorded for the first time in the Dutch Wadden Sea. It was found only once, on a littoral oyster reef off Texel (Fig. 9; Gittenberger *et al.*, 2012). In 2014 it was also found east of Texel, on sublittoral mussel beds (Fig. 9). The salinities at the locations where the species was found in 2014, varied from 17.91 to 20.07 ppt (Table 2; Appendix II). The species was first found settled in the Netherlands, in Zeeland in 2006 (Gittenberger *et al.*, 2012).

Impact:
Ceramium botryocarpum (Fig. 10) specimens remain relatively small and rare in their distribution and are therefore not expected to have a large impact on The Wadden Sea ecosystem (Gittenberger *et al.*, 2012).

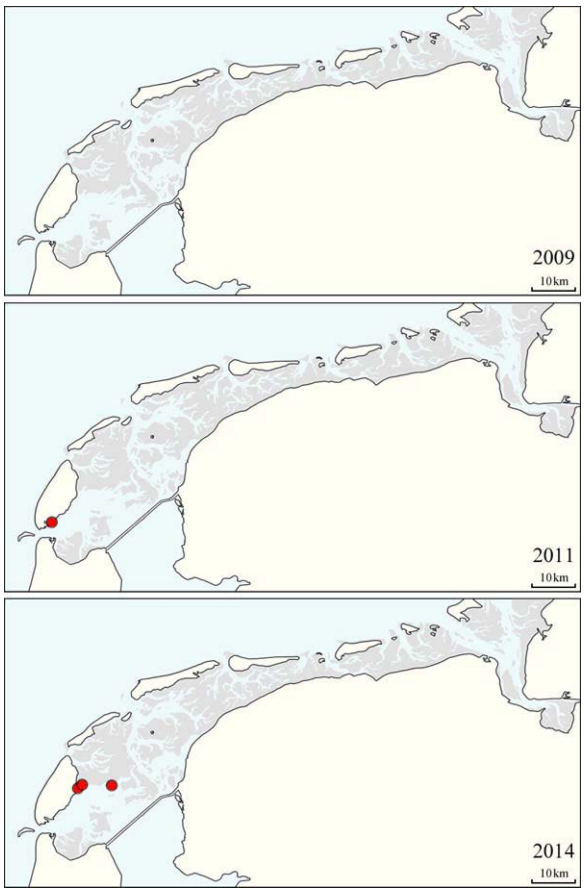

Fig. 9. Locations where *Ceramium botryocarpum* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

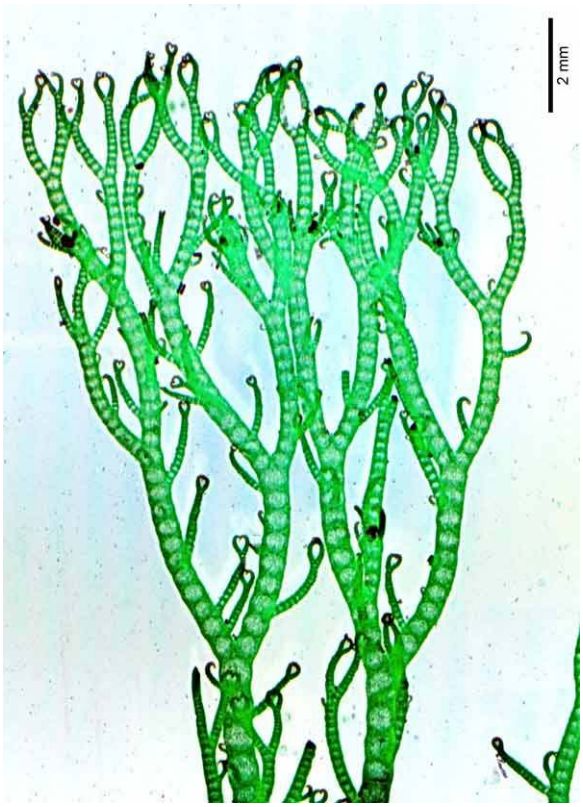

Fig. 10. *Ceramium botryocarpum in vitro*

4.1.1.3 *Ceramium tenuicorne*
(Kützing) Waern (Fig. 11)

Origin:
NE Atlantic: *Ceramium tenuicorne* is a non-native species for the Netherland, but it is native for North West Europe, with a natural range from France and around the British Iles to Norway (Maggs & Hommersand, 1993 as *C. strictum*).

Distribution:
During the species inventory in 2011 the alga *Ceramium tenuicorne* was recorded settled for the first time in the Netherlands on a floating dock in the Eemshaven (Fig. 11; Gittenberger *et al.*, 2012). In 2014 it was found in many more harbours throughout The Wadden Sea, where it again was found solely on floating docks (Fig. 11). It was therefore probably transported through the Dutch Wadden Sea with recreational vessels. The salinities at the locations where the species was found in 2014, varied from 17.91 to 25.97 ppt (Table 2; Appendix II).

Impact:
Ceramium tenuicorne is a relatively small red alga, which has only been found on floating docks. It is therefore not expected to have a large impact on The Wadden Sea ecosystem.

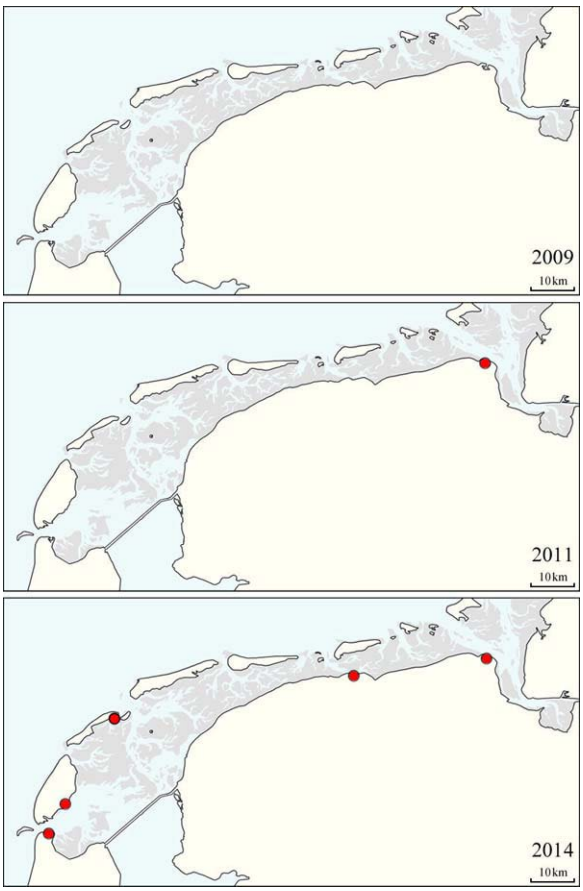

Fig. 11. Locations where *Ceramium tenuicorne* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

4.1.1.4 *Codium fragile fragile*
(Suringar) Hariot (Figs 12-13)

Origin:
Altough Silva (1955) indicates that *Codium fragile* originates from the NW Pacific, Brodie *et al.* (2007) indicate that *Codium fragile* subsp. *atlanticum* is a native species for NW Europe, while *Codium fragile* subsp. *fragile* is a non-native (sub)species. The "non-native" subspecies *Codium fragile fragile* was first recorded in the Dutch Wadden Sea more than a century ago, while the "native" subspecies *Codium fragile atlanticum* was first recorded during The Wadden Sea inventory in 2009 (Gittenberger *et al.*, 2010).

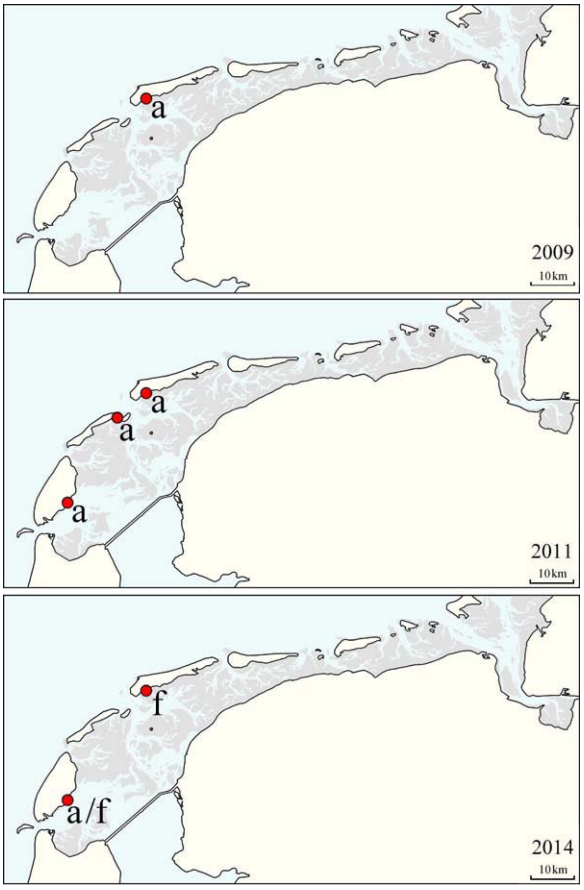

Fig. 12. Locations where *Codium fragile* was found during The Wadden Sea inventories in 2009, 2011 and 2014. Subspecies: a = C. f. atlanticum, f = C. f. fragile.

Distribution:
During the species inventory in 2009 *Codium fragile atlanticum* was found on a floating dock on Terschelling. In 2011 the species was also found on Vlieland and Texel (Fig. 12; Gittenberger *et al.*, 2010, 2012). In 2014 both subspecies were found in the harbour of Oudeschild, Texel. *Codium fragile fragile* was also found on a floating dock in the harbour of Terschelling (Fig. 12). The salinities at the locations where the species was found in 2014, varied from 17.91 to 20.65 ppt (Table 2; Appendix II).

Impact:
Codium fragile fragile (Fig. 13), was described from Den Helder by Van Goor (1923) as *C. mucronatum* var. *tomentosoides*. It was present in 1900, and is still found in the Dutch Wadden Sea (Stegenga & Prud'homme van Reine, 1998). This taxon has not had any recorded impact on the ecosystem. It is therefore unlikely that *Codium fragile* subsp. *fragile* or *Codium fragile* subsp. *atlanticum*, which has similar habitat preferences, will have an impact on The Wadden Sea ecosystem.

Fig. 13. *Codium fragile* subsp. *fragile in situ* on a floating dock in the harbour of Terschelling.

4.1.1.5 *Colpomenia peregrina*
(Sauvageau) Hamel (Figs 14-15)

Origin:
NW Atlantic Ocean (Wolff, 2005)

Distribution:
Colpomenia peregrina was not found during the species inventories in 2009 and 2011. In 2014 it was only found in the harbour of Oudeschild, Texel (Fig. 14). The salinity at this location was 17.91 ppt. (Table 2; Appendix II). Van Goor (1923) first recorded the species as the synonym *C. sinuosa* in the Dutch Wadden Sea in May 1921 (Wolff, 2005).

Impact:
Although *Colpomenia peregrina* is found in the Dutch Wadden Sea for almost a century (Van Goor, 1923), it does not seem to have a wide distribution range. In 2014 it was found at only one locality in The Wadden Sea, i.e. the harbour of Oudeschild. It is therefore unlikely that the species will have a large impact on The Wadden Sea ecosystem.

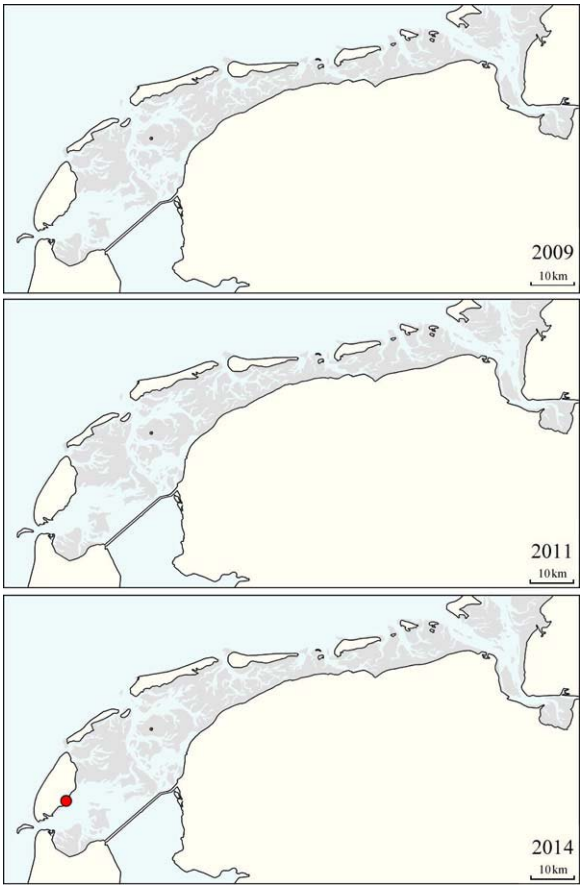

Fig. 14. Locations where *Colpomenia peregrina* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 15. *Colpomenia peregrina*

4.1.1.6 *Dasysiphonia japonica*
(Yendo) H.-S. Kim (Figs 16-17)

Origin:
NW pacific (Sjøtun *et al.*, 2008)

Distribution:
This concerns the first record of *Dasysiphonia japonica* for The Wadden Sea. *D. japonica* was not found during the non-native species inventories in the region in 2009 and 2011 (Gittenberger *et al.*, 2010, 2012). In 2014 it was only found in The Wadden Sea on a floating dock in the harbour of Den Helder (Fig. 16). The salinity at this location was 19.82 ppt (Table 2; Appendix II). *D. japonica* was first recorded in the Netherlands in 1994 in the province of Zeeland (Maggs & Stegenga, 1999 as *Heterosiphonia japonica*).

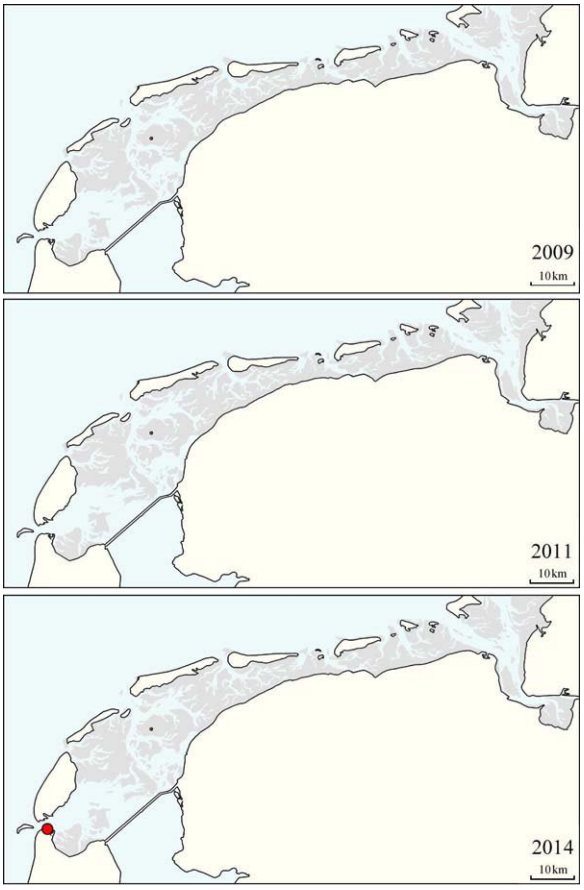

Fig. 16. Locations where *Dasysiphonia japonica* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Nowadays *Dasysiphonia japonica* is distributed along the entire European coastline from Spain to Norway (Sjotun *et al.*, 2008; Gittenberger *et al.*, 2012).

Impact:
Dasysiphonia japonica (Fig. 17) has a preference for calm waters and does not grow well at salinities lower than 15 ppt (Bjærke & Rueness, 2004). This may explain why the species was not found previously in The Wadden Sea, regardless of the fact that *D. japonica* is known to occur both to the south and the north. The open water of The Wadden Sea is known for its rough waters, especially in storms during the winter. The sheltered habitat in which *D. japonica* was found in het harbour of Den Helder probably enabled its settlement there. Although it may spread to other similar harbours, it is unlikely that this algal species will have a distinct impact on The Wadden Sea ecosystem.

Fig. 17. *Dasysiphonia japonica in vitro* detail with tetrasporangia

4.1.1.7 *Gracilaria vermiculophylla*
(Ohmi) Papenfuss (Figs 18-19)

Origin:
W Pacific (Gollasch & Nehring 2006, Thomsen *et al.* 2007).

Distribution:
During the species inventories in 2009, 2011 and 2014 the algal species *Gracilaria vermiculophylla* was found widespread throughout The Wadden Sea, usually in the littoral zone on sand, on oyster reefs and on mussel beds (Fig. 18; Gittenberger *et al.*, 2010. 2012). In 2014, the locations where the species was found, varied in salinity from 8,90 to 20,72 ppt (Table 2; Appendix II). In the Netherlands this species was first recorded in the Dutch Delta area, close to Yerseke in 1994 (Stegenga *et al.,* 2007).

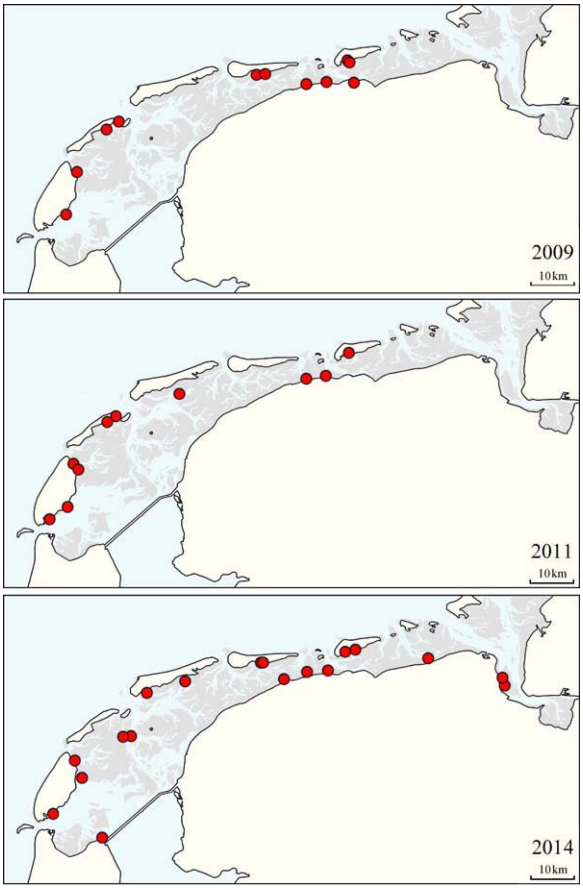

Fig. 18. Locations where *Gracilaria vermiculophylla* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Impact:
In the German and Danish parts of The Wadden Sea *Gracilaria vermiculophylla* is known as an invasive species that can have a substantial impact on the local ecosystem by becoming one of the most dominant marcoalgae present covering large surface areas (Thomsen *et al.* 2007). As is illustrated in figure 19, some individuals in the Dutch Wadden Sea are also relatively large. During the present species inventory these algae were found widespread from Texel to Delfzijl, at least locally dominating the bottom. *Gracilaria vermiculophylla* therefore probably does have a distinct impact on the Dutch Wadden Sea ecosystem.

Fig. 19. *Gracilaria vermiculophylla in situ* on a littoral oyster reef off Ameland.

4.1.1.8 *Neosiphonia harveyi*

(Bailey) Kim, Choi, Guiry & Saunders (Figs 20-21)

Origin:

N Pacific (Maggs & Stegenga 1999).

Distribution:

During the species inventories in 2009, 2011 and 2014 the algal species *Neosiphonia harveyi* was found widespread throughout the entire Wadden Sea (Fig. 20; Gittenberger *et al.*, 2010, 2012). In 2014 most specimens were found settled on floating docks although the species was also recorded more offshore in the central Wadden Sea (Fig. 20). In 2014 it was found at salinities between 18.42 and 25.97 (Table 2; Appendix II). *N. harveyi* was first recorded in the Netherlands in 1960, from the Kanaal door Zuid-Beveland in the Dutch Delta area (Maggs & Stegenga 1999 as *Polysiphonia harveyi*), where it is at present a widespread and common species.

Impact:

It is unclear whether this small alga (Fig. 21) may have an impact on the ecosystem of The Wadden Sea (Gittenberger *et al.*, 2010). If most specimens remain to be found on floating docks, the impact on The Wadden Sea ecosystem will remain limited.

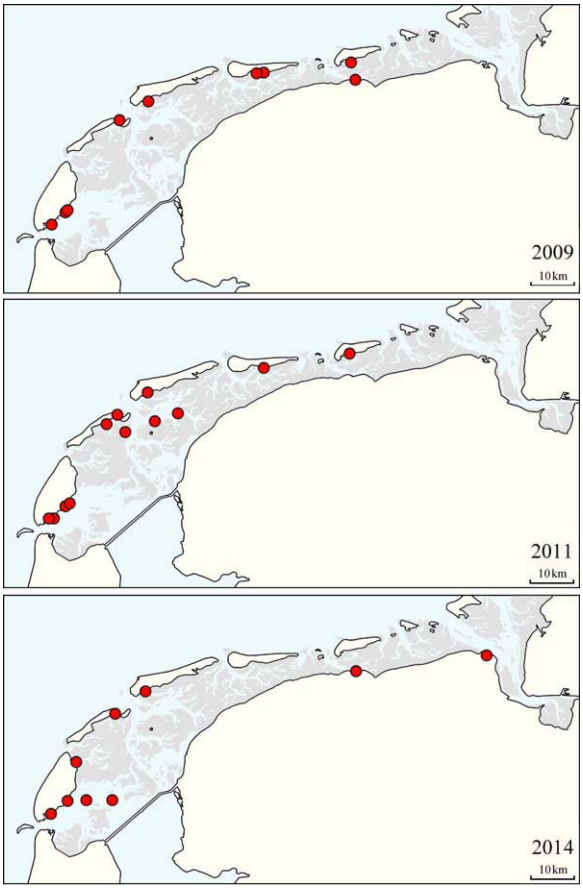

Fig. 20. Locations where *Neosiphonia harveyi* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

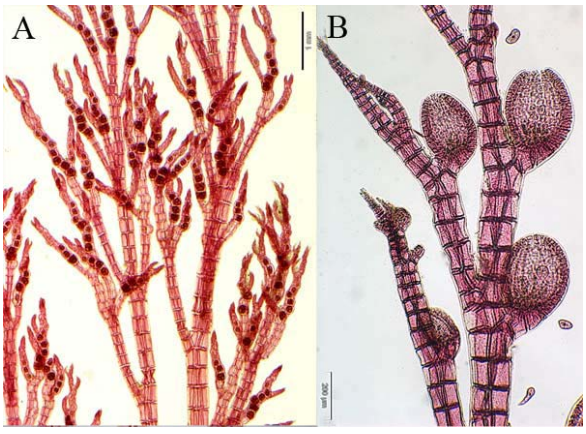

Fig. 21. *Neosiphonia harveyi in vitro.* A: with tetrasporangia, B: with cystocarpen.

4.1.1.9 *Sargassum muticum*
(Yendo) Fensholt (Figs 22-23)

Origin:
NW Pacific (Silva 1955).

Distribution:
During the species inventories in 2009, 2011 and 2014 the algal species *Sargassum muticum* was found widespread throughout the western Dutch Wadden Sea (Fig. 22; Gittenberger *et al.*, 2010, 2012). In 2014 it was mainly found in the lower littoral and sublittoral zones in harbours and on dikes, at salinities between 17.91 and 25.97 ppt (Table 2; Appendix II). Attached thalli of the Japanese Sargasso weed *S. muticum* were first recorded in the Netherlands in 1980 in The Wadden Sea off Texel. A few months later it was also found in the Dutch Delta (Prud'homme van Reine 1980, 1982).

Impact:
At none of the localities *Sargassum muticum* (Fig. 23) was found as a dominant species during the species inventories in 2009, 2011 and 2014. Instead, it was usually rare (Gittenberger *et al.*, 2010, 2012). Therefore, at the time of these surveys, *S. muticum* did not seem to have a large impact. In other regions in especially southern Europe the specimens of this species tend to grow much larger and cover large areas having a distinct impact on their surroundings (Ribera & Boudouresque, 1995).

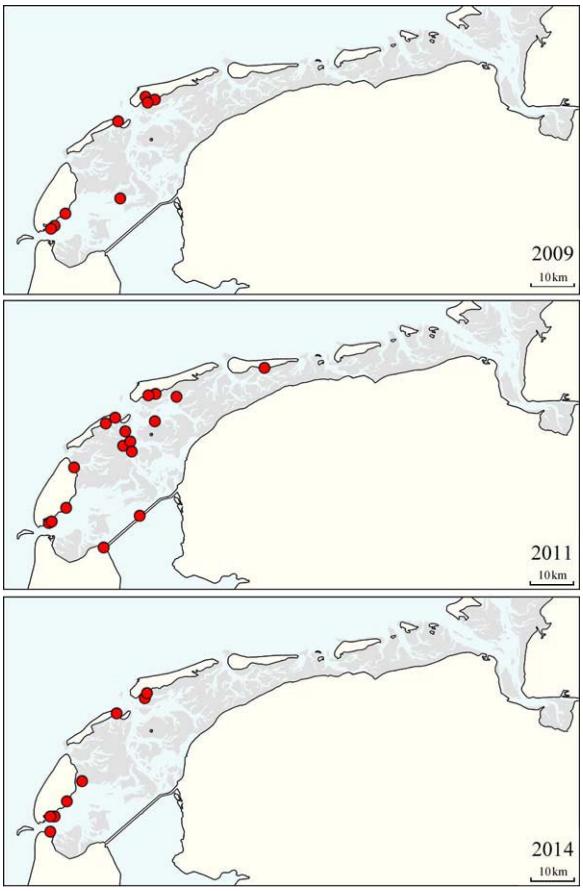

Fig. 22. Locations where *Sargassum muticum* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 23. *Sargassum muticum in situ* in a tidal pool in an oyster reef off Terschellling.

4.1.1.10 *Ulva pertusa*
Kjellman (Figs 24-25)

Origin:
NW Pacific (Silva 1955).

Distribution:
During the species inventories in 2009, 2011 and 2014 the algal species *Ulva pertusa* was found widespread throughout the Dutch Wadden Sea (Fig. 24; Gittenberger *et al.*, 2010, 2012). In 2014 it did appear to occur more widespread, especially in the central Wadden Sea and along the mainland, than in 2009 and 2011 (Fig. 24). In 2014 it was found at salinities between 8.9 and 25.97 ppt (Table 2; Appendix II). The first record of this species in the Netherlands was done in the Dutch Delta region in 1993 (Stegenga & Mol, 2002). Since then, the species has quickly spread throughout the Netherlands.

Impact:
This sea lettuce species is locally very abundant, having a distinct impact. Because it is hard to distinguish *Ulva pertusa* in the field (Fig. 25) from native *Ulva* species (Koeman & Van den Hoek 1981), its overall impact on The Wadden Sea ecosystem remains uncertain however.

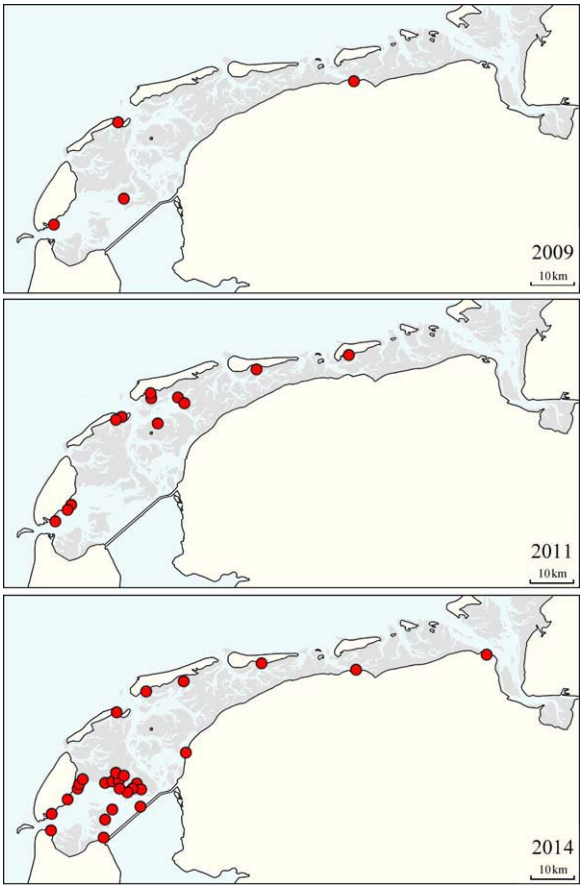

Fig. 24. Locations where *Ulva pertusa* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

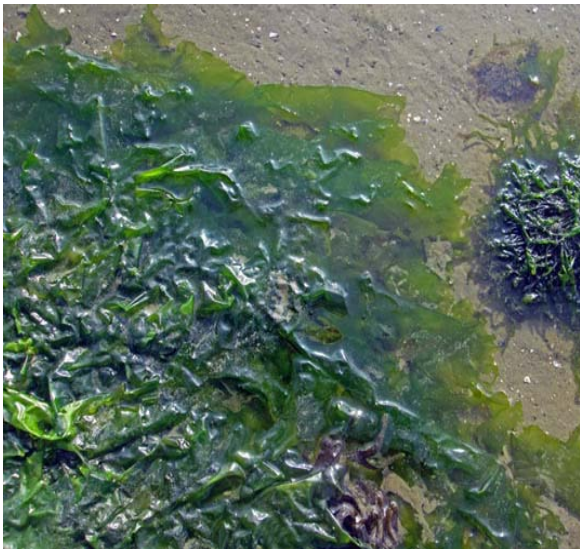

Fig. 25. *Ulva pertusa* on a littoral oyster reef off Terschelling.

4.1.1.11 *Undaria pinnatifida*
(Harvey) Suringar (Figs 26-27)

Origin:
NW Pacific (Silva 1955).

Distribution:
During the species inventories in 2009, 2011 and 2014 Wakame, i.e. *Undaria pinnatifida*, was found to be common on the floating docks in the marina of Terschelling (Fig. 26; Gittenberger *et al.*, 2010, 2012). Additionally one specimen was recorded in The Wadden Sea in 2014, just south off Terschelling, on a sublittoral oyster reef (Table 2; Appendix II).

Impact:
It is questionable whether the relatively murky water and sandy bottoms of The Wadden Sea form a suitable habitat for this large brown kelp species of which the individuals can become up to two meters long. This is confirmed by the fact that although the species has the ability to rapidly expand its populations when habitats are suitable, it has only remained abundant in The Wadden Sea in the marina of Terschelling since its first sighting there in 2008 (De Ruijter, 2008). The small oyster reef south of Terschelling probably lies relatively sheltered, which has enabled the local settlement of the specimen recorded there in 2014 (Figs 26-27).

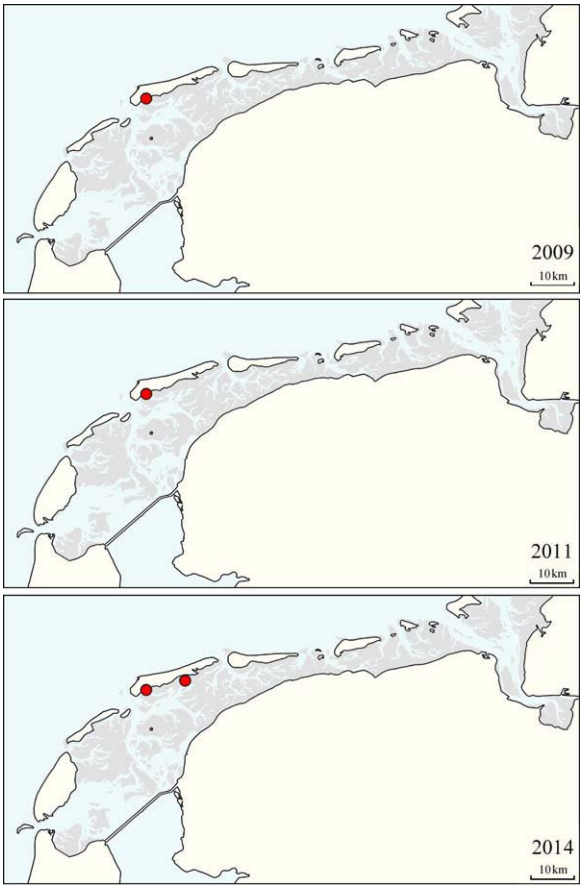

Fig. 26. Locations where *Undaria pinnatifida* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 27. *Undaria pinnatifida* on a floating dock in the harbour of Terschelling.

4.1.2 Annelida

4.1.2.1 *Alitta virens*
(M. Sars, 1835) (Fig. 28)

Origin:
North Atlantic or North Pacific (Nehring & Leuchs, 1999)

Distribution:
Horst (1920) first recorded this species for the Netherlands in The Wadden Sea off Den Helder. Nowadays it is a common species in the Netherlands (Korringa, 1951; Wolff, 2005). This is also confirmed by the non-native species inventory in 2014 during which *Alitta virens* was found widespread in The Wadden Sea (Fig. 28).

Impact:
Alitta virens has become a common species in the Netherlands and therefore probably has a distinct impact on the ecosystem.

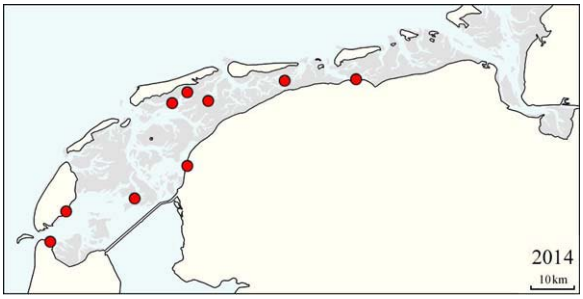

Fig. 28. Locations where *Alitta virens* was found during The Wadden Sea inventory in 2014.

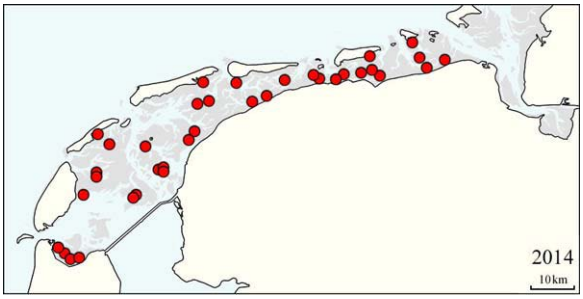

Fig. 29. Locations where *Aphelochaeta marioni* was found during The Wadden Sea inventory in 2014.

4.1.2.2 *Aphelochaeta marioni*
(Saint-Joseph, 1894) (Figs 29-30)

Origin:
French side of the Channel. It is doubtful whether this is a native species in the Netherlands (Wolff, 2005)

Distribution:
Aphelochaeta marioni may be a native species in the Netherlands. Wolff (2005) however mentions that if it is native, 'it is remarkable that Horst, a well-known Dutch specialist on polychaete taxonomy in the early 20th century, did not record this common species'. During the inventory in 2014 *A. marioni* was commonly found, widespread in the soft-sediment samples throughout The Wadden Sea (Fig. 29) where it has been commonly found over the last decades (Dekker & Drent, 2013). As the non-native species inventories in 2009 and 2011 focused on the hard substrates present, it was not recorded during those inventories (Gittenberger *et al.*, 2010, 2012).

Impact:
Aphelochaeta marioni is a common, widespread species in the Netherlands and therefore probably has a distinct impact on the ecosystem competing for food and space with other small polychaetes.

Fig. 30. *Aphelochaeta marioni.*

4.1.2.3 *Ficopomatus enigmaticus*
(Fauvel, 1923) (Figs 31-32)

Origin:
SW Pacific (Grosholz & Ruiz, 1996)

Distribution:
Ficopomatus enigmaticus is widespread in the Netherlands in brackish waters, like the harbour of Harlingen where it was first recorded for The Wadden Sea in 2009 (Fig. 31). During the non-native species inventory in 2014 it was only found at one location with a relatively low salinity (14.93 ppt), i.e. on a buoy in the marina of Delfzijl (Table 2; Appendix II; Fig. 31).

Impact:
With its tubes this worm (Fig. 32) can build relatively large and strong calcareous reefs (Schwindt *et al.* 2001), which can hinder or even completely obstruct the water flow in pipelines and cooling systems. Because of its preference for brackish waters, it will probably not cause any significant problems in The Wadden Sea, but it may do so in neighbouring waters with relatively low salinities (Gittenberger *et al.*, 2010).

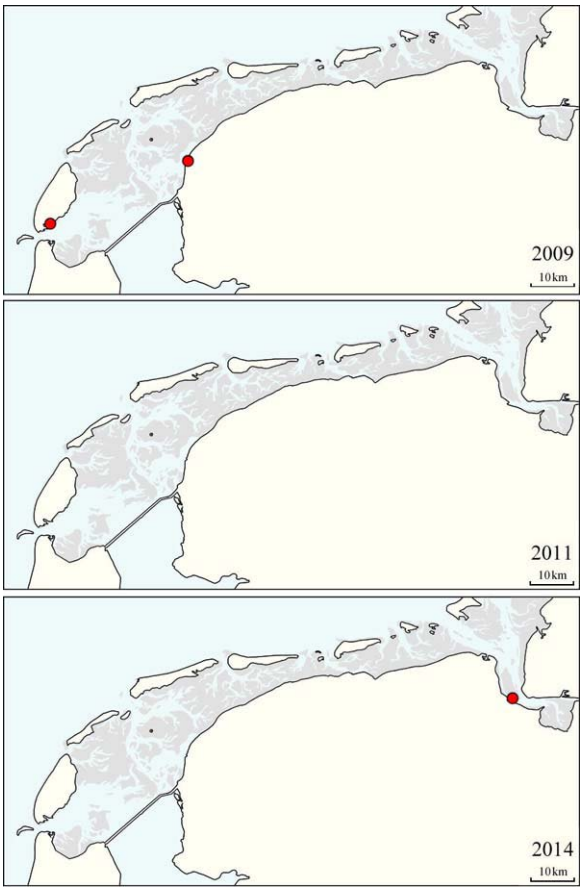

Fig. 31. Locations where *Ficopomatus enigmaticus* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

4.1.2.4 *Marenzelleria viridis*
(Verrill, 1873) (Fig. 33)

Origin:
NW Atlantic (Barnes, 1994).

Distribution:
Marenzelleria viridis was first recorded in the Netherlands in the Ems estuary in 1983 (Essink & Kleef, 1988). Since then the species has rapidly expanded its population and during the non-native species inventory in 2014 it was found widespread in bottom samples throughout the entire Wadden Sea (Fig. 33).

Impact:
As *Marenzellaria viridis* is a common, widespread species in the more brackish parts of the Wadden Sea (Dekker & Drent, 2013), it probably has a distinct impact on the local ecosystem (Essink & Dekker, 2002).

Fig. 32. *Ficopomatus enigmaticus* on a buoy in the marina of Delfszijl.

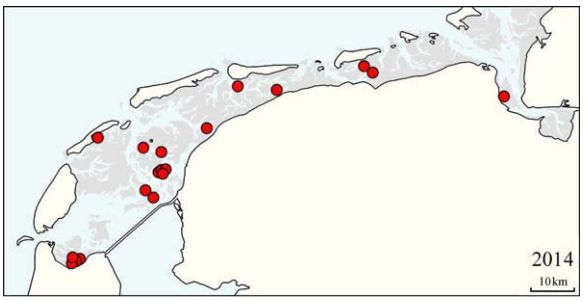

Fig. 33. Locations where *Marenzelleria viridis* was found during The Wadden Sea inventory in 2014.

4.1.2.5 *Neodexiospira brasiliensis*
(Grube, 1872) (Figs 34-35)

Origin:
Tropics, including Brasil (Eno *et al.* 1997).

Distribution:
Neodexiospira brasiliensis was first recorded from The Wadden Sea in 2009 in the NIOZ harbour, Texel (Fig. 34), where the minute spiral calcareous tubes were found on the alga *Mastocarpus stellatus* in the littoral zone on the dike in the NIOZ harbour, Texel (Gittenberger *et al.*, 2010). In 2014 the species was again recorded in The Wadden Sea from the same location (Fig. 34). In the Netherlands it was first recorded in the Dutch Delta by Critchley & Thorp (1985).

Impact:
The small calcareous tubes of *Neodexiospira brasiliensis* are several millimetres in diameter (Fig. 35). They were only found at one locality during the surveys in 2009 and 2014. This species is therefore not expected to have any impact on the ecosystem.

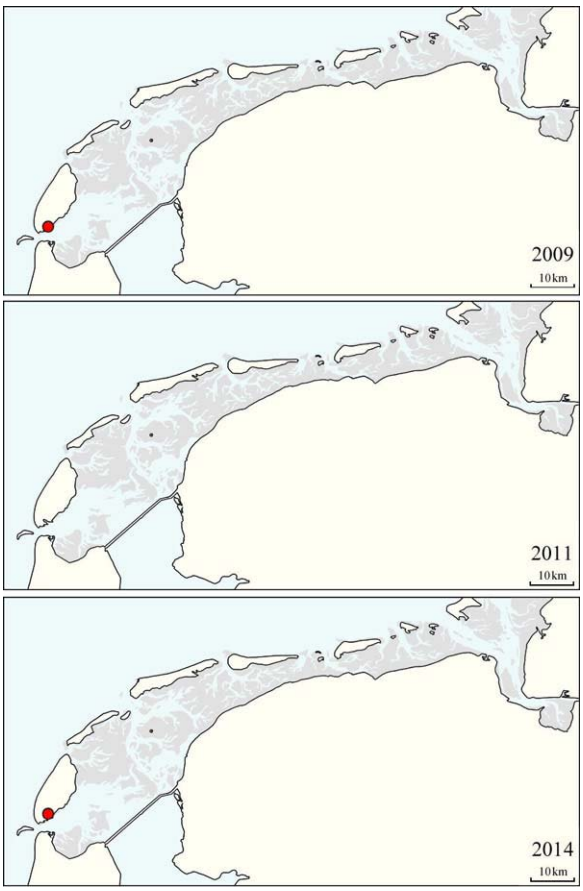

Fig. 34. Locations where *Neodexiospira brasiliensis* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 35. *Neodexiospira brasiliensis*

4.1.2.6 *Streblospio benedicti*
Webster, 1879 (Figs 36-37)

Origin:
North America (Carlton, 1979; Wolff, 2005).

Distribution:
As there may be two *Streblospio* species present in European waters that closely resemble each other morphologically it is unclear for how long *Streblospio benedicti* occurs in the Netherlands. Wolff (2005) describes that Horst (1910) already recorded *Streblospio* from the brackish Zuiderzee and Redeke (1933) found it to be common in Dutch brackish inland waters. Korringa (1951) recorded the species in the Oosterschelde estuary. During the non-native species inventory in The Wadden Sea in 2014 *S. benedicti* was found in bottom samples taken at several locations close to the mainland next to the Afsluitdijk and off Harlingen (Fig. 36).

Impact:
The tube-building infaunal spionid polychaete *Streblospio benedicti* (Fig. 37) is widely abundant in the muddy sands of tidal flats in The Wadden Sea (Sebesvari *et al.*, 2006), with a preference for the brackish parts of the estuaria. There it feeds on surface deposits and suspended organic matter, probably having a distinct impact on the ecosystem.

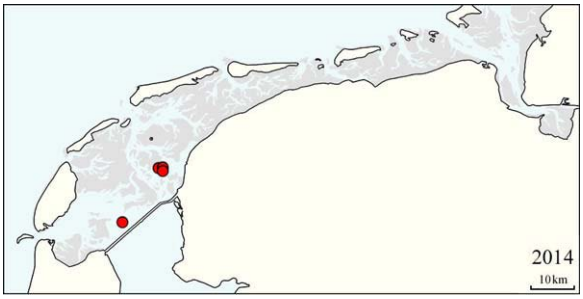

Fig. 36. Locations where *Streblospio benedicti* was found during The Wadden Sea inventory in 2014.

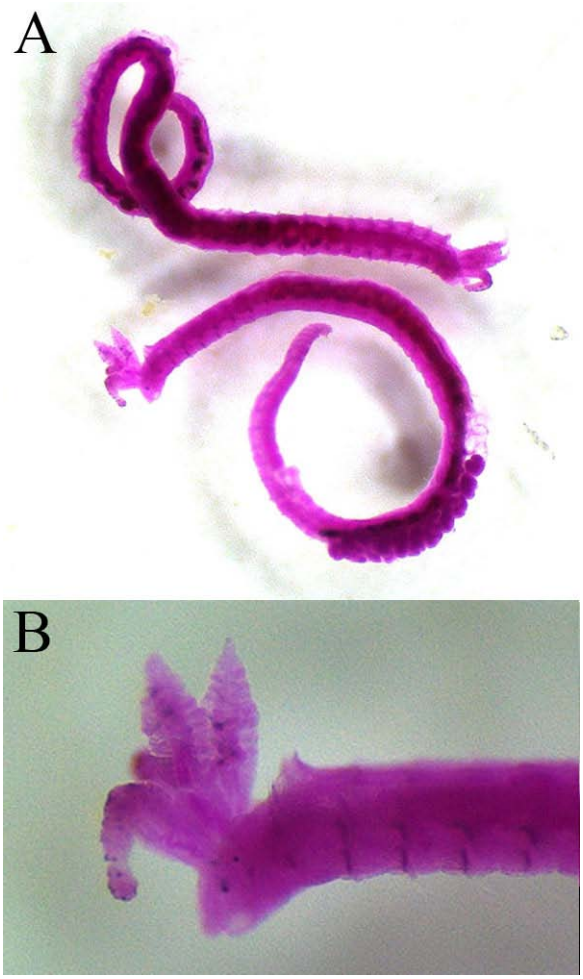

Fig. 37. *Streblospio benedicti*

4.1.3 Ascidiacea

4.1.3.1 *Aplidium glabrum*
(Verrill, 1871) (Figs 38-39)

Origin:
Cryptogenic, possibly native to the NE Atlantic NE Atlantic (Wolff, 2005).

Distribution:
During the non-native species focused inventory in 2009 *Aplidium glabrum* was first recorded for The Wadden Sea in the marina of Terschelling. There it was also found during a similar inventory in 2011 (Fig. 38; Gittenberger *et al.*, 2010, 2012). In 2014 it was again found in the harbour of Terschelling, but also in the harbours of Vlieland and Schiermonnikoog (Fig. 38). There it was solely found on floating docks at salinities between 17.91 and 25.97 ppt (Table 2; Appendix II). In the Netherlands it was first recorded in the Dutch Delta region in 1977 (Buizer, 1983).

Impact:
The colonies of this species can cover mussel ropes (Gittenberger 2007, 2009) and areas of a rocky bottom, as may be observed in the seawater lake the Grevelingen, Zeeland (Gittenberger *et al.*, 2010). In the literature *A. glabrum* is not known to cause extensive ecological damage in areas where it is introduced, however. In The Wadden Sea it was only found on floating docks. The chance that this species will have a significant impact on The Wadden Sea ecosystem is therefore assumed to be small.

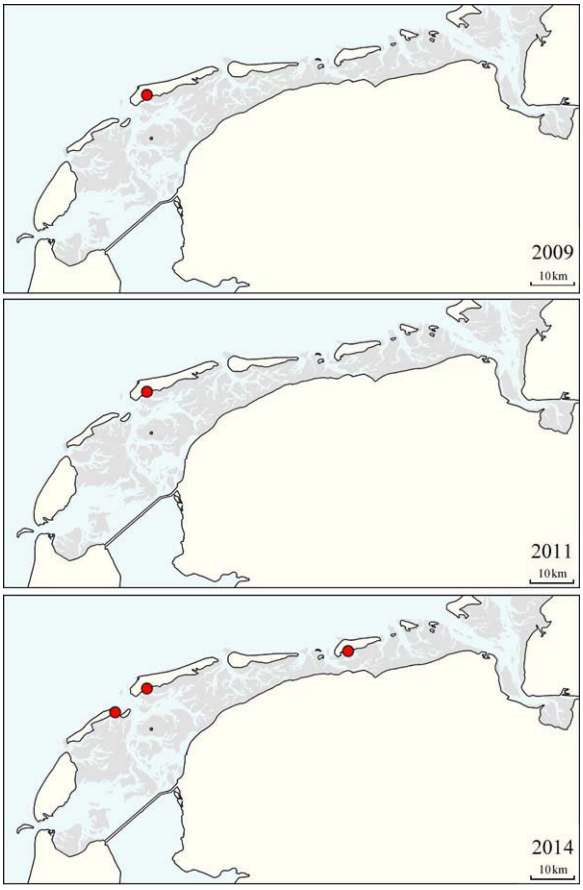

Fig. 38. Locations where *Aplidium glabrum* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 39. *Aplidium glabrum in situ* on a floating dock in the harbour of Vlieland.

4.1.3.2 *Botrylloides violaceus*
Oka, 1927 (Figs 40-41)

Origin:
NW Pacific (Minchin 2007).

Distribution:
During the non-native species focused inventory in 2009 *Botrylloides violaceus* was first recorded for The Wadden Sea (Gittenberger *et al.*, 2010). In 2007 *Botrylloides violaceus* like colonies were already sighted in the NIOZ harbour (Dekker, *pers. obs.*). It occurred abundantly on the floating docks in virtually all the harbours of The Wadden Sea islands (Fig. 40). In those same harbours it was also found during the inventory in 2011 and 2014. Additionally in 2014 it was found for the first time in two mainland harbours, i.e. the harbours of Den Helder and Eemshaven (Fig. 40). Although it was also found on walls and jetties, virtually all records are from floating docks. In 2014 it was found at salinities between 17.91 and 25.97 ppt (Table 2; Appendix II).

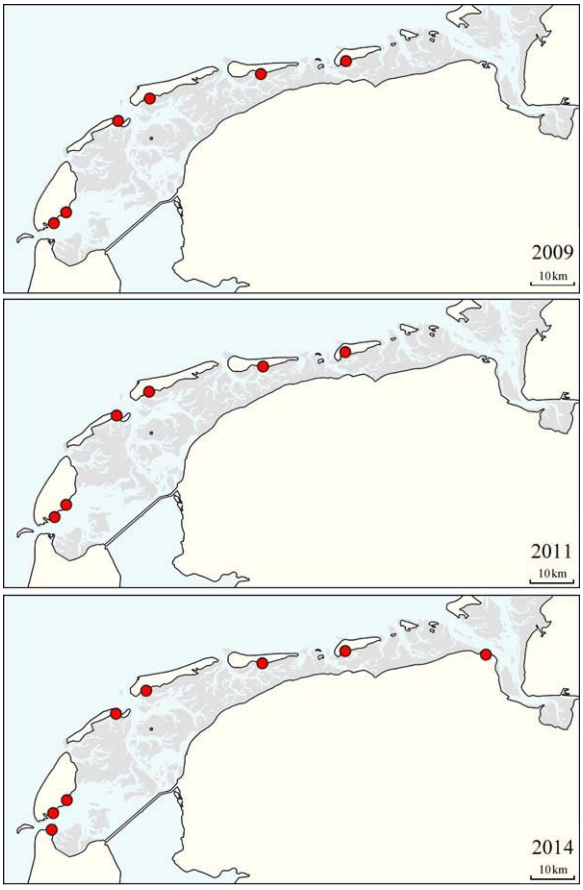

Fig. 40. Locations where *Botrylloides violaceus* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Impact:
This abundant and very distinctly coloured species (Fig. 41) can overgrow large surface areas and outcompete native species like the ascidian *Botryllus schlosseri* for space (Gittenberger & Moons, 2011). It was predicted by Gittenberger *et al.* (2010) that *Botrylloides violaceus* may have a distinct impact on The Wadden Sea. This prediction was based on its spread in 2009 and the fact that it became and still is a dominant species in the Dutch sea inlet the Oosterschelde, Zeeland, within a few years after its first sighting in 1999 (Gittenberger, 2007). Over the years *B. violaceus* has remained restricted in The Wadden Sea to sheltered hard substratum habitats in marinas where it is mainly found on the floating docks. The chance that this species will have a significant impact on The Wadden Sea ecosystem as a whole is therefore assumed to be small.

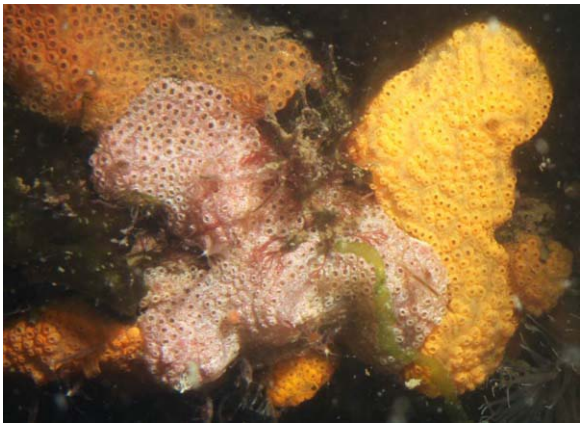

Fig. 41. *Botrylloides violaceus in situ* on a floating dock in the harbour of Oudeschild, Texel.

4.1.3.3 *Didemnum vexillum*
Kott, 2002 (Figs 42-43)

Origin:
NW Pacific (Stefaniak *et al.* 2009).

Distribution:
Since it was first recorded in The Wadden Sea in 2008 and 2009 in the vicinity of the marina of Terschelling (Gittenberger *et al.*, 2010; Dekker & Drent, 2013) *Didemnum vexillum* was additionally found on the hull of a sailing boat in the marina of Oudeschild, Texel, in 2011 (Gittenberger *et al.*, 2012). In 2014 it had expanded its distribution even further into the more saline areas of The Wadden Sea (Fig. 42). It was found abundantly in the marinas of Texel, Vlieland and Terschelling (Fig. 43A). Additionally it covered most of the oysters on various sublittoral oyster reefs off Terschelling and Texel (Fig. 43B). In 2014 it was recorded at salinities between 17.91 and 25.97 ppt (Table 2; Appendix II).

Impact:
In the Netherlands *Didemnum vexillum* was first recorded in 1991 in the Dutch Delta, where it remained inconspicuous in its so-called lag time until 2006, after which it rapidly expanded its population and became one of the most dominant species in the ecosystem (Gittenberger 2007). In most areas where it was introduced, it had a severe impact on the native ecosystem by overgrowing large areas of the bottom and suffocating virtually every organism. *D. vexillum* is mainly found on hard substrata, but has also shown the ability to overgrow sandy bottoms (Gittenberger, 2007). Gittenberger (2010) describes a risk analysis of this species for The

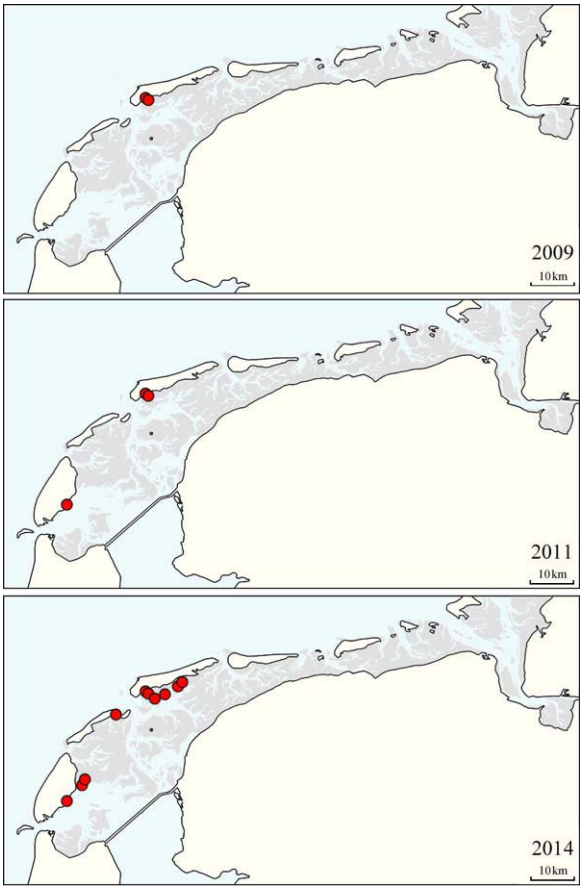

Fig. 42. Locations where *Didemnum vexillum* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 43. *Didemnum vexillum* A: *in situ* on a floating dock in the harbour of Teschelling and B: on oysters in the sublittoral oyster reef in front of Terschelling.

Wadden Sea. As was predicted by Gittenberger (2010) *Didemnum vexillum* is expanding its population within The Wadden Sea to the more saline areas. There it is especially dominant on the sublittoral Pacific oyster reefs. Although *D. vexillum* does not seem to kill the oysters, the colonies probably do inhibit the settlement of mussels and other sessile organisms on the oysters concerned. By doing so this species may have a distinct impact on the populations of these species in The Wadden Sea.

4.1.3.4 *Diplosoma listerianum*
(Milne-Edwards, 1841) (Figs 44-45)

Origin:
The origin of this cosmopolitan species, which was described in 1841 from the Mediterranean, is unknown.

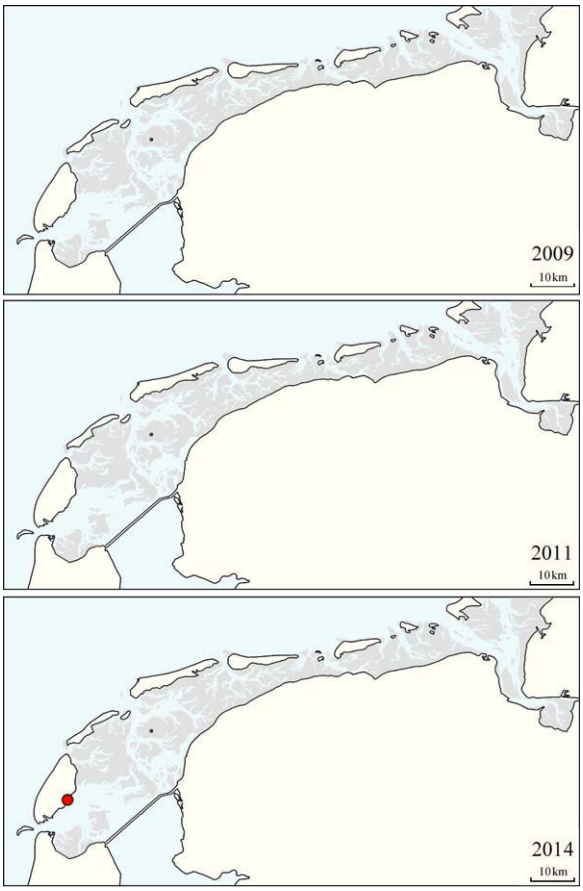

Fig. 44. Locations where *Diplosoma listerianum* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Distribution:
This is the first record of this colonial ascidian species for The Wadden Sea (44). One colony was found settled on the underside of a floating dock in the marina of Oudeschild, Texel (Fig. 45). The salinity in this harbour when the specimen was collected was 17.91 ppt (Table 2; Appendix II). In the Netherlands, according to Buizer (1983), the species was first recorded in 1977. Huus (1933) already records *Diplosoma listerianum* however from the coast of Norway, Denmark down to the Netherlands and Belgium, the United Kingdom, and the Mediterranean.

Impact:
Diplosoma listerianum occurs wide-spread throughout Europe and is known from the Delta region to the south, and offshore to the west and north of The Wadden Sea. Regardless the present record is the first for The Wadden Sea. The species probably was not recorded before from the region because its colonies prefer more sheltered habitats with relatively clear waters (Gittenberger & Stegenga, 2012). The chance that this species will have a significant impact on The Wadden Sea ecosystem is therefore assumed to be small.

Fig. 45. *Diplosoma listerianum in situ* on a floating dock in the harbour of Oudeschild, Texel.

4.1.3.5 ***Molgula manhattensis*** (De Kay, 1843)
Molgula socialis Alder, 1863
(Figs 46-47)

Origin:
Although molecular studies indicate that the native area of *Molgula manhattensis* lies in the NW Atlantic, it remains uncertain whether this species may also be native to the NE Atlantic where it also occurs widespread (Haydar *et al.*, 2011). *Molgula socialis* concerns a species that is native to the NE Atlantic, probably also including the Dutch waters (Gittenberger *et al.* 2010; Monniot, 1969)

Distribution:
In the past virtually all *Mogula* records in the Netherlands in literature were assumed to concern *Molgula manhattensis*. Recent morphological and molecular studies have shown that these *Molgula* specimens concern two species however, which can only be identified by molecular analyses and/or the time consuming anatomical dissection of adult specimens. This was not done for all *Molgula* specimens that were encountered during the inventory. Based on the anatomical analysis of a selection of specimens it could be concluded that both species in 2014 occur widespread in the Dutch Wadden Sea (Fig. 46), as was also concluded in a similar manner during the inventories in 2009 (Gittenberger *et al.*, 2010) and 2011 (Gittenberger *et al.*, 2012). The Molgula spp. in 2014 were found at salinities between 12.79 and 25.97 ppt, mainly on floating docks and on mixed mussel/oyster beds (Table 2; Appendix II).

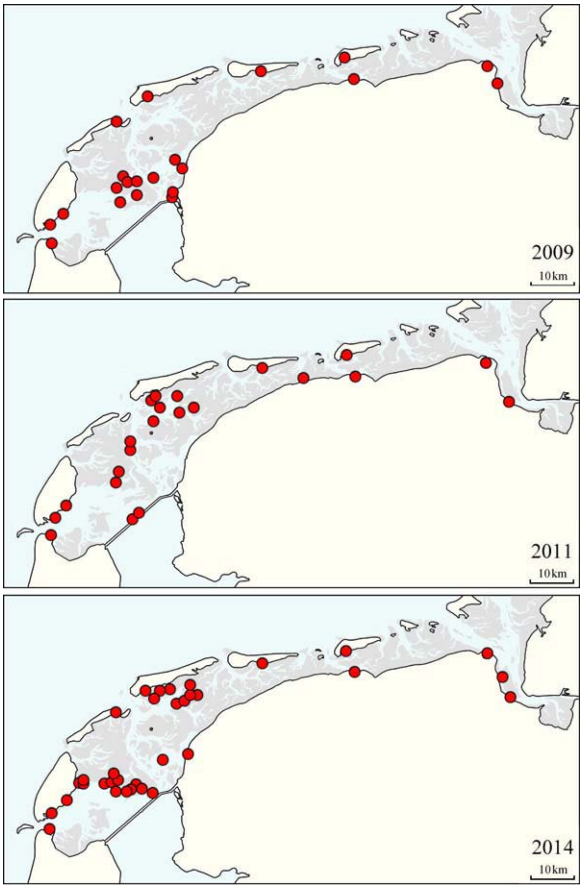

Fig. 46. Locations where *Molgula manhattensis/ socialis* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Impact:
Molgula socialis is most likely native to The Wadden Sea (Gittenberger *et al.*, 2010) and *M. manhattensis* may be native. Both species occur widespread in The Wadden Sea. Their impact on the ecosystem remains unknown (Gittenberger *et al.*, 2012).

Fig. 47. *Molgula manhattensis/ socialis in situ* on a floating dock in the NIOZ harbour ‘t Horntje, Texel.

4.1.3.6 *Styela clava*
Herdman, 1881 (Figs 48-49)

Origin:
NW Pacific (Lützen 1999).

Distribution:
During the inventory in 2014 *Styela clava* showed a similar distribution pattern as was found in 2009 and 2011 during those non-native species inventories in The Wadden Sea (Fig. 48; Gittenberger *et al.*, 2010; 2012). It was found at salinities between 17.91 and 25.97 ppt, widespread, occurring mostly on floating docks and mixed oyster/mussel beds (Table 2; Appendix II). In the Netherlands the club tunicate *S. clava* was first found in 1974, in the Dutch Wadden Sea in the harbour of Den Helder (Huwae & Lavaleye, 1975) where the species was also recorded in 2014.

Impact:
Over the years *Styela clava* has become part of the Dutch Wadden Sea ecosystem. Although it is also found in the central Wadden Sea, *S. clava* becomes particularly abundant in harbours, having a distinct impact on its surroundings there.

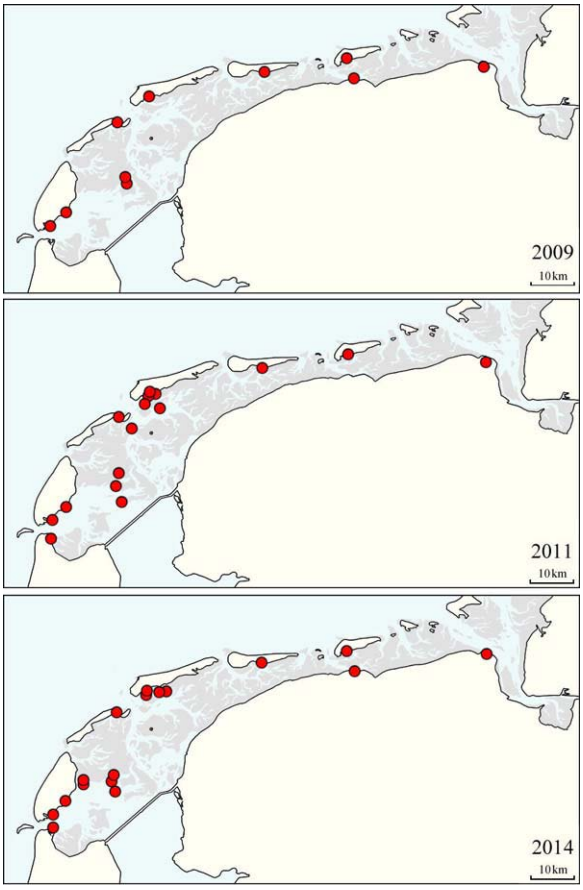

Fig. 48. Locations where *Styela clava* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 49. *Styela clava in situ* on a floating dock in the harbour of Oudeschild, Texel.

4.1.4 Bryozoa

4.1.4.1 *Bugula stolonifera* Ryland, 1960 (Figs 50-51)

Origin:
NW Atlantic (Cohen & Carlton 1995).

Distribution:
During the species inventories in 2009 and 2011 the bryozoan *Bugula stolonifera* was only found off The Wadden Sea islands, but not in the mainland harbours (Fig. 50; Gittenberger *et al.*, 2010, 2012). In 2014 it was also found in a harbour on the mainland, i.e. the marine pleasure craft harbour of Den Helder (Fig. 50). The salinities at the locations where the species was found in 2014, varied from 17.91 to 25.97 (Table 2; Appendix II). In the Netherlands it was first found in 1993 in the NIOZ harbour, Texel (D'Hondt & Cadée 1994), where it was also found during the present species inventory (Fig. 50).

Impact:
Bugula stolonifera was only found in marinas and there it was mainly found on floating docks. Although the species can be very abundant locally (Fig. 51), it does not seem the have expanded its distribution range much within The Wadden Sea. It is therefore unlikely that the species will have a large impact on The Wadden Sea ecosystem in the future.

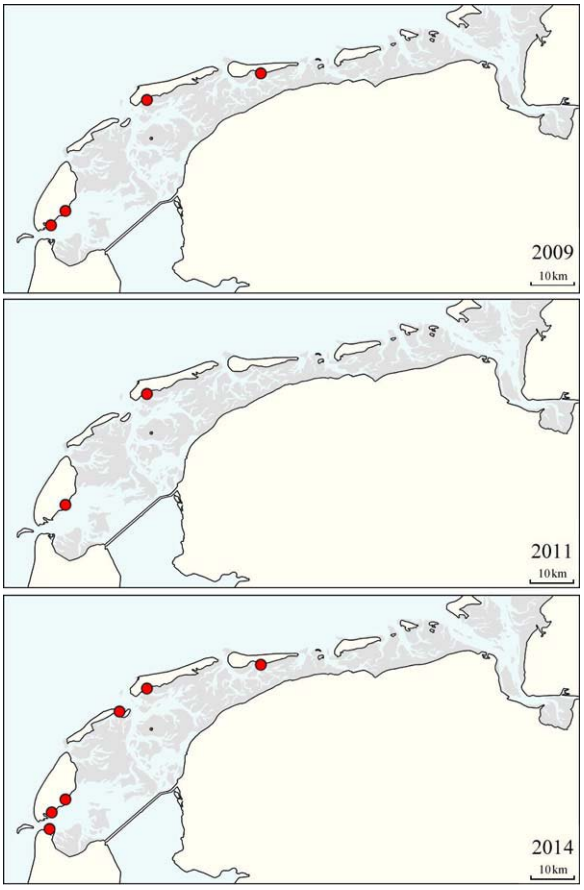

Fig. 50. Locations where *Bugula stolonifera* was found during The Wadden Sea inventories in 2009 and 2011 (Gittenberger et al, 2010, 2012) and in 2014.

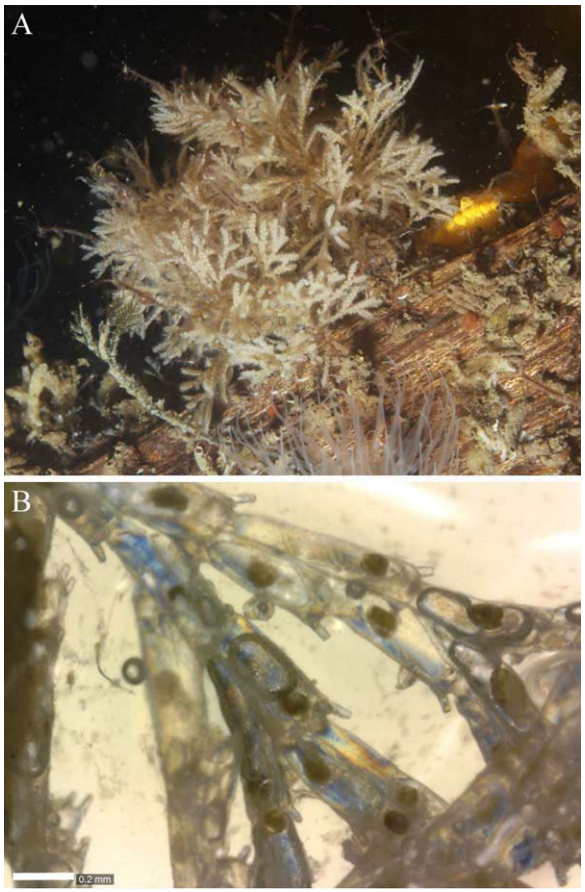

Fig. 51. *Bugula stolonifera.* A: *in situ* on a floating dock in Oudeschild, Texel; B: preserved specimen, scale bar is 0.2 mm.

4.1.4.2 *Smittoidea prolifica*
Osburn, 1952 (Figs 52-53)

Origin:
Pacific coast of North America (Faasse *et al.*, 2013)

Distribution:
Smittoidea prolifica was first sighted in The Wadden Sea in 2008, east off Texel on a mussel cuture plot on the inside of a dead *Mya* shell (Dekker & Drent 2013). Since 2008 the species was not found anymore in the Dutch Wadden Sea until 2014. During the inventory it was widespread in the western Wadden Sea off Terschelling and Texel on mostly sublittoral mussel and oyster banks (Fig. 52). There it had settled at salinities between 20.07 and 22.63 ppt forming small reddish crusts on the inside of empty oyster, mussel and razor shells (Table 2; Appendix II). In the Netherlands *Smittoidea prolifica* was first recorded in 1995 in the Dutch Delta (Faasse *et al*., 2013; Van Moorsel, 1996). It has furthermore been found in the port of Rotterdam and in the Prinses Amalia windpark off IJmuiden (Faasse et al., 2013; Vanagt et al., 2013).

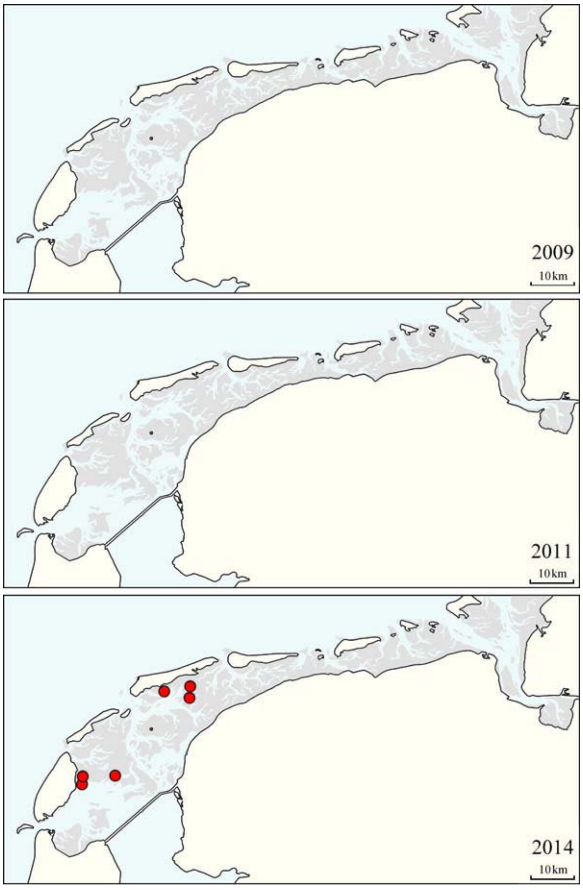

Fig. 52. Locations where *Smittoidea prolifica* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Impact:
In 2014 *Smittoidea prolifica* (Fig. 53) was found widespread at various localities in the western Wadden Sea, while the species with its brightly coloured reddish colonies was not found during the non-native species inventories in 2009 and 2011 (Gittenberger *et al.*, 2010; 2012). This illustrates its potential to relatively quickly expand its populations in regions like The Wadden Sea. The small encrusting calcareous patches formed by the colonies of *S. prolifica* on the inside of empty oyster, mussel and razor shells probably will not have a large impact on the surrounding ecosystem however.

Fig. 53. *Smittoidea prolifica in vivo,* on an oyster that was collected from a sublittoral oyster reef in front of Breezanddijk. Scale bar is 0.2 mm.

4.1.4.3 *Tricellaria inopinata*

d'Hondt & Occhipinti Ambrogi, 1985 (Figs 54-55)

Origin:

Probably NE Pacific (Cook *et al.*, 2013)

Distribution:

This concerns the first confirmed record of *Tricellaria inopinata* during an inventory in the Dutch Wadden Sea (Fig. 55). In the distribution map of this species in Europe in Cook *et al.* (2013) a dot in the Dutch Wadden Sea indicates the presence of *Tricellaria inopinata*. That record is not included in the list of all records in the supplementary material of the article however. That Dutch Wadden Sea record therefore probably concerns a mistake as is also confirmed by the Dutch co-author of the paper (Faasse, *pers comm*).

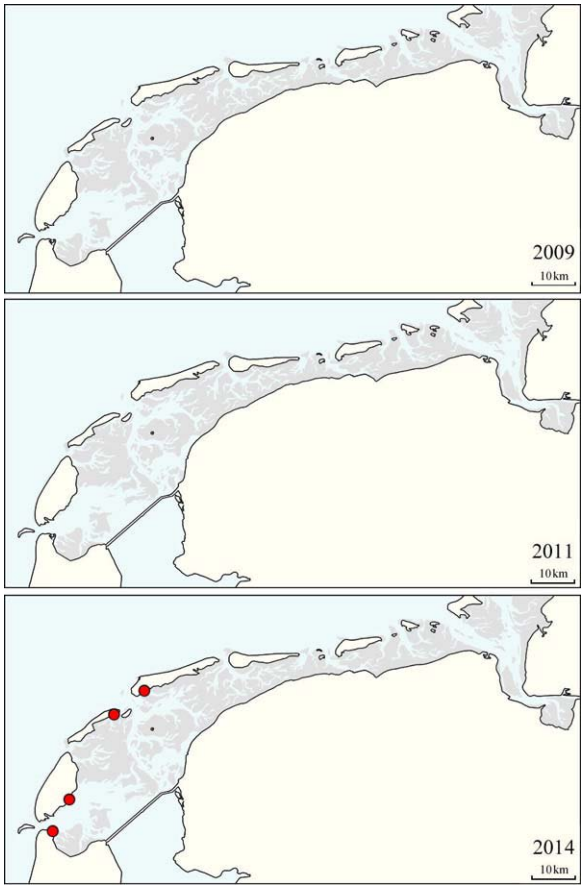

Fig. 54. Locations where *Tricellaria inoptata* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

T. inopinata was found widespread in the western Dutch Wadden Sea in 2014. It may have been present there for at least several years, as it was seen in the NIOZ harbour of Texel from 2012 onwards (Dekker, *pers. obs*.). In 2014 it occurred widespread in the marinas of Den Helder, Texel (Oudeschild), Vlieland and Terschelling (Fig. 54) where it was mainly found settled on floating docks, but also on the dike and the harbour walls at salinities between 17.91 and 20.52 ppt (Table 2; Appendix II). In 2000 *T. inopinata* was first recorded for the Netherlands in the Dutch Delta region (Blauwe & Faasse, 2001).

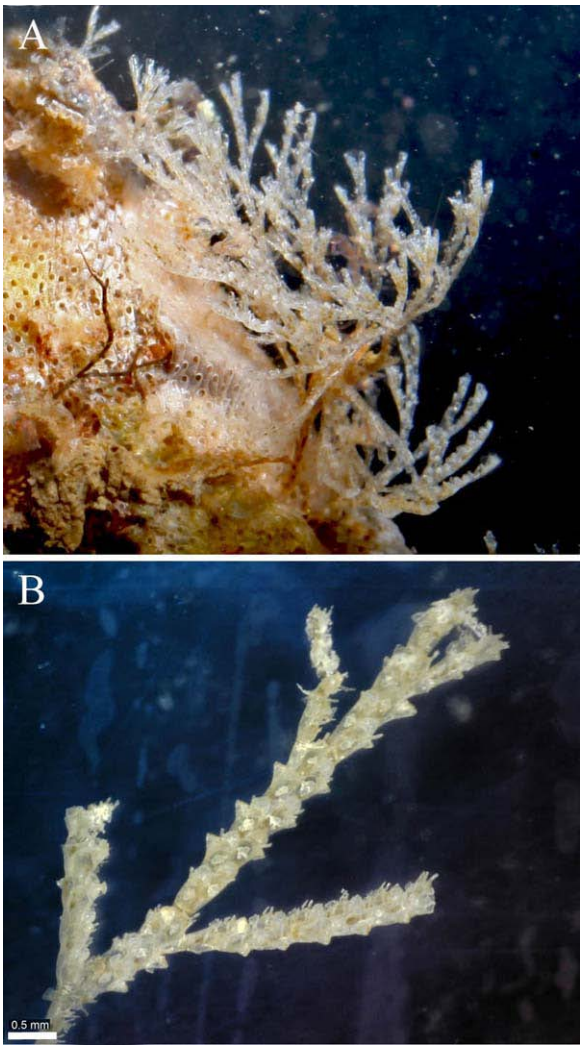

Fig. 55. *Tricellaria inoptata.* A: *in situ* on a floating dock in the harbour of Oudeschild, Texel; B; preserved specimen, scale bar is 0.5 mm.

Impact:
Throughout its distribution in Europe and also in the Dutch Delta region and in The Wadden Sea, the settlement of *Tricellaria inopinata* appears to remain almost completely restricted to marinas where it is mainly found on floating docks (Cook *et al.*, 2013). In the German Wadden Sea where the species had settled in marinas prior to 2010, the species disappeared after a particularly cold winter in 2009 and 2010 suggesting that *T. inopinata* is close to its physiological limits in this region (Cook *et al.,* 2013). Although *T. inopinata* may settle in the harbours of the Dutch Wadden Sea it therefore remains unlikely that the species will have a distinct impact on The Wadden Sea ecosystem as a whole.

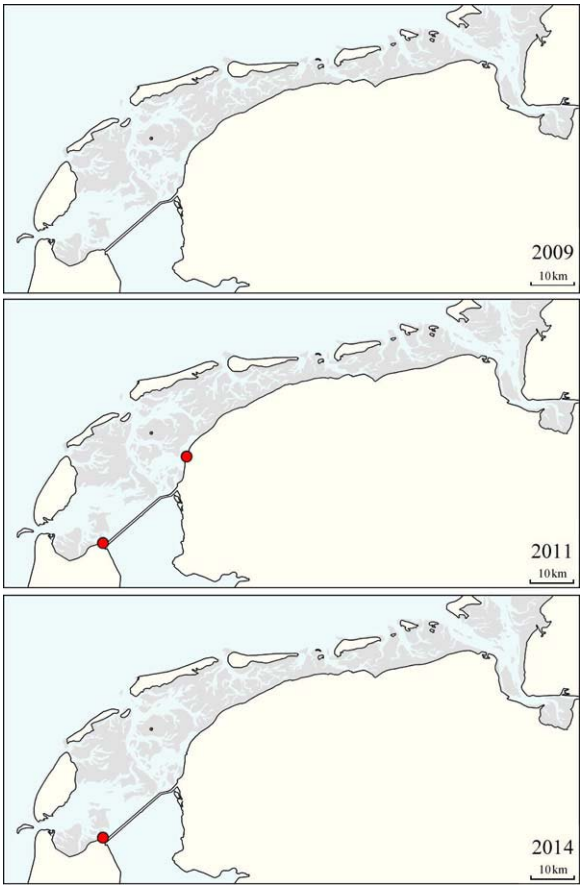

Fig. 56. Locations where *Cordylophora caspia* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

4.1.5 Cnidaria

4.1.5.1 *Cordylophora caspia*
(Pallas, 1771) (Fig. 56-57)

Origin:
Ponto-caspian region (Nehring & Leuchs, 1999)

Distribution:
Cordylophora caspia (Fig. 57) is widespread in western Europe including the whole of the Netherlands in fresh water and slightly brackish water. In 2010 and 2011 colonies were first found in more saline waters in The Wadden Sea, off Ameland (Tulp, 2010) and in the harbours of Harlingen and Den Oever at salinities up to 20 ppt (Gittenberger *et al.*, 2012). A recent molecular study of Folino-Rorem *et al.* (2009) indicates that *C. caspia* probably concerns a species complex including several species that each has

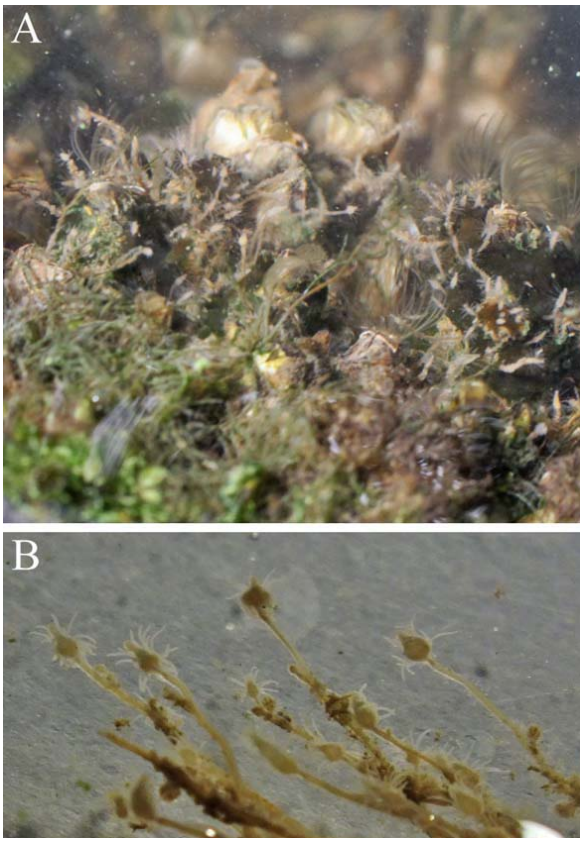

Fig. 57. *Cordylophora caspia* A: *in situ* in on a floating dock in the harbour of Den Oever; B: the collected specimen *in vivo*.

its own salinity preferences. These species still have to be described. It therefore remains uncertain which of these species occur in the Netherlands. In 2014 *C. caspia* was found only in the harbour of Den Oever (Fig. 56) on floating docks and boat hulls at salinities between 4.9 and 8.9 ppt (Table 2; Appendix II).

Impact:
In the Dutch Wadden Sea the distribution of *Cordylophora caspia* appears to remain restricted mainly to the mainland harbours with brackish water, where it is found to be abundant on the floating docks. Worldwide *C. caspia* is only known to become a dominating species in fresh to slightly brackish water having a distinct impact on its surroundings. Whether it will also have a distinct impact on the Dutch Wadden Sea ecosystem therefore remains uncertain (Gittenberger *et al.*, 2012).

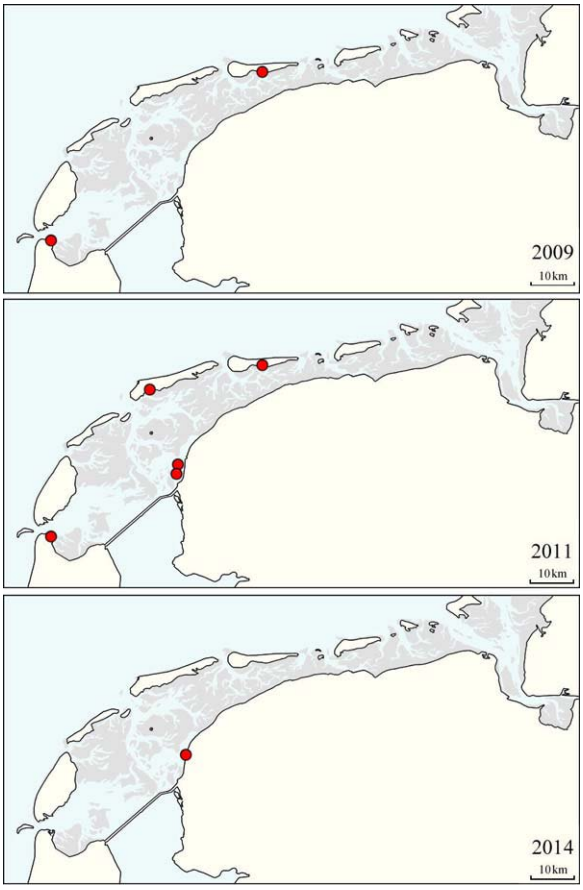

Fig. 58. Locations where *Diadumene cincta* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

4.1.5.2 *Diadumene cincta*
Stephenson, 1925 (Figs 58-59)

Origin:
Pacific (Gollasch & Nehring 2006), but its non-native origin has been questioned by Ates (2006).

Distribution:
During the non-native species inventories in 2009 and 2011 in the Dutch Wadden Sea *Diadumene cincta* was only found at a small selection of locations in the marinas of Ameland, Terschelling, Den Helder and Harlingen. In 2014 it was only recorded in the harbour of Harlingen at a salinity of 12.68 ppt (Fig. 58; Table 2; Appendix II).

Impact:
Diadumene cincta (Fig. 59) was first recorded in the Netherlands in 1925 off Den Helder (Pax, 1936). Since then the population of this species has not expanded much in the Dutch Wadden Sea (Gittenberger *et al.*, 2009, 2012). It is therefore unlikely that the species will have a large impact on The Wadden Sea ecosystem.

Fig. 59. *Diadumene cincta in vivo* collected in the Nieuwe Willemshaven in Harlingen.

4.1.5.3 *Diadumene lineata*
(Verrill, 1869) (Figs 60-61)

Origin:
Pacific Ocean (Eno *et al.*, 1997)

Distribution:
Although *Diadumene lineata* was already recorded from The Wadden Sea by Urk (1956) subsequent records are rare (Dekker, 1982). During the non-native species inventory in 2009 it was not found, and in 2011 only at two locations (Fig. 60). In 2014 *D. lineata* was recorded, very locally abundant, at four locations at salinities between 14.93 and 17.47 ppt on floating docks and in tidal pools in the littoral (Table 2; Appendix II).

Impact:
Since *Diadumene lineata* (Fig. 61) was first recorded in The Wadden Sea by Urk (1956) it has not expanded its population much. It is therefore unlikely that the species will have a large impact on The Wadden Sea ecosystem.

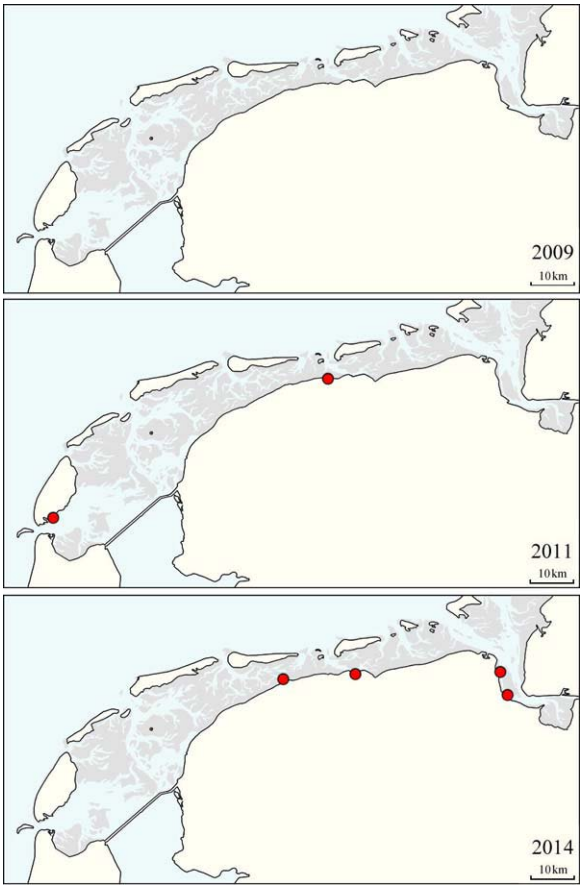

Fig. 60. Locations where *Diadumene lineata* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

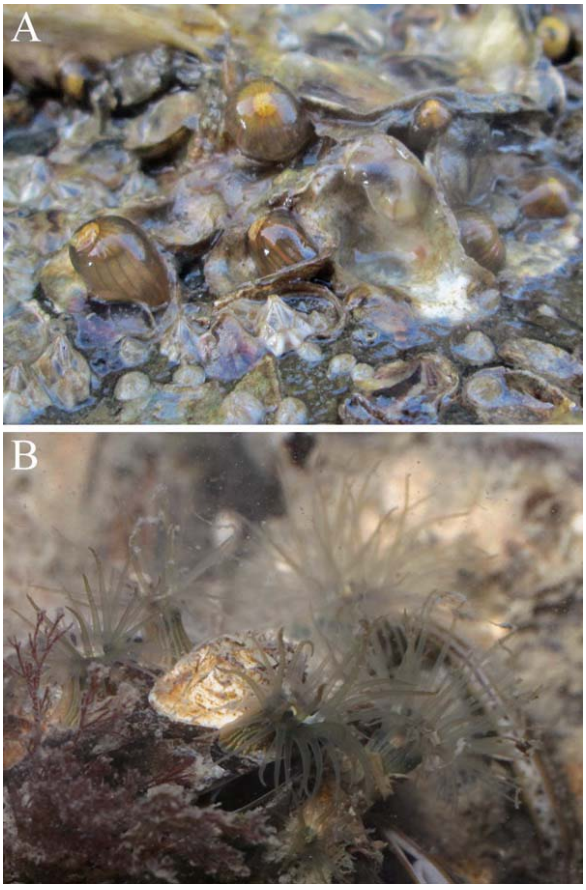

Fig. 61. *Diadumene lineata.* A: on a turned rock in the littoral zone in Nieuwstad; B: *in situ* on a floating dock in the fishery harbour of Lauwersoog.

4.1.6 Crustacea

4.1.6.1. *Amphibalanus improvisus* (Darwin, 1854) (Fig. 62-63)

Origin:
Cryptogenic, possibly native to NE Atlantic (Gollasch 2002).

Distribution:
During the non-native species inventories in 2009, 2011 and 2014 *Amphibalanus improvisus* was found widespread and especially abundant in the sublittoral in brackish waters close to the mainland (Fig. 62; Gittenberger *et al.*, 2010; 2012). In 2014 it was mainly recorded in the sublittoral; on floating docks, dikes and mussel beds (Fig. 63) at salinities between 5.5 and 18.13 ppt (Table 2; Appendix II). Waardenburg (1827) first recorded this species in the Netherlands (as *Balanus ovularis*) (Wolff, 2005).

Impact:
Especially in the less saline areas in The Wadden Sea this species is abundant. As native barnacle species prefer more saline habitats, they are rarely found there in mixed populations with *A. improvisus*. Therefore *A. improvisus* does not compete with the native barnacle species for space and its impact on the ecosystem remains limited.

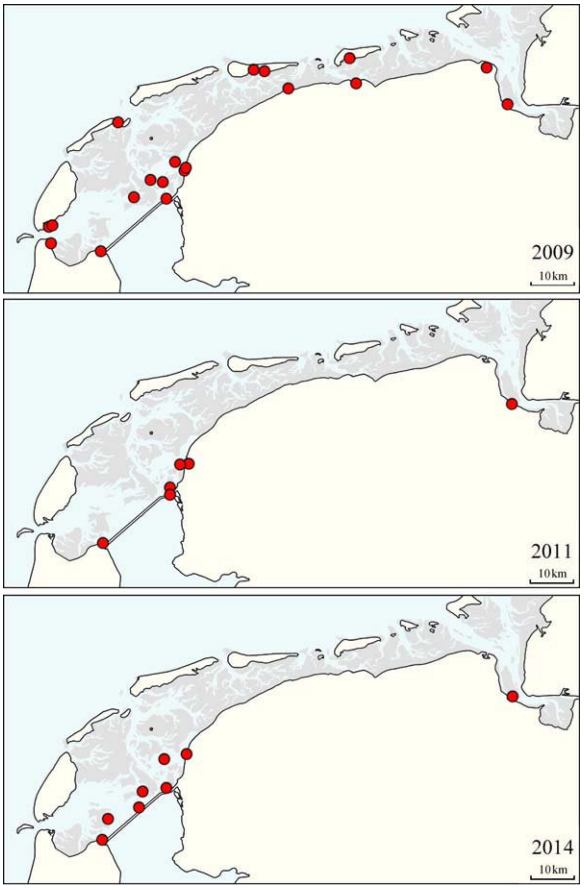

Fig. 62. Locations where *Amphibalanus improvisus* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

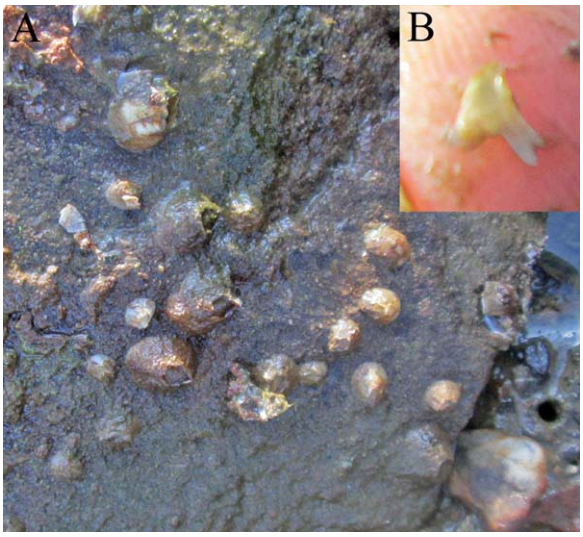

Fig. 63. *Amphibalanus improvisus in situ* on a dike in Breezanddijk.

4.1.6.2. *Austrominius modestus*
(Darwin, 1854) (Figs 64-65)

Origin:
SW Pacific (Harms 1999)

Distribution:
During the non-native species inventories in 2009, 2011 and 2014 *Austrominius modestus* was found widespread in both the more saline and the brackish waters of The Wadden Sea, both in the littoral and sublittoral zones. (Fig. 64; Gittenberger *et al.*, 2010; 2012) In 2014 it was found on virtually all hard substrates that were surveyed at salinities between 8.9 and 25.97 ppt (Table 2; Appendix II)). *Austrominius modestus* was first found in the Netherlands in 1946 at Wassenaarse slag and at Loosduinen-Kijkduin (Boschma 1948). After its introduction it rapidly expanded its population throughout the Netherlands.

Impact:
Because of its ability to live and become abundant in a relatively wide range of habitats it competes for space with several native species (Gittenberger *et al.*, 2010). In the littoral zone it competes mostly with the native barnacle *Semibalanus balanoides*, which is abundant there (Gittenberger *et al.*, 2010). In the sublittoral zone it competes with the native barnacle *Balanus crenatus* (Gittenberger *et al.*, 2010). It probably has a distinct impact on the flora and fauna living on hard substrata in The Wadden Sea.

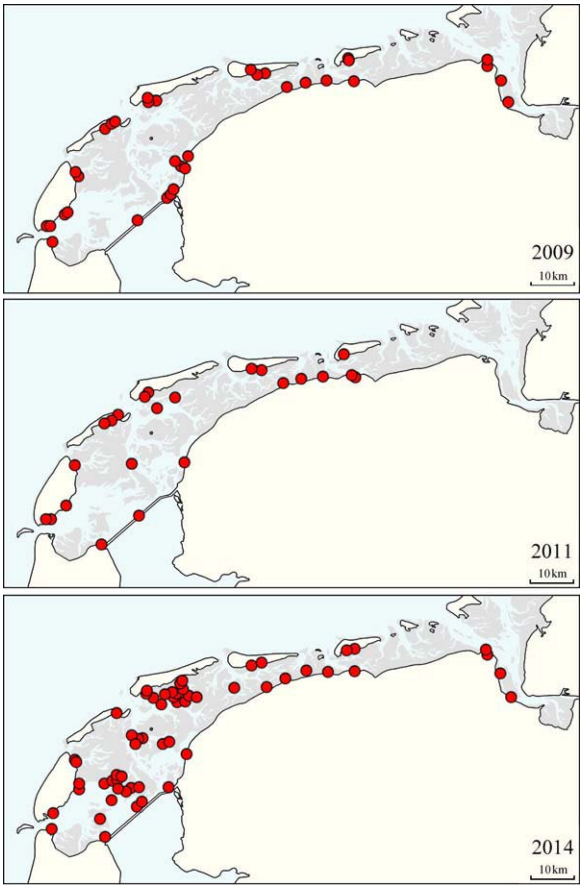

Fig. 64. Locations where *Austrominius modestus* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 65. *Austrominius modestus* on *Littorina* collected from a dike on Schiermonnikoog.

4.1.6.3 *Caprella mutica*
Schurin, 1935 (Figs 66-67)

Origin:
Pacific (Schrey & Buschbaum 2006)

Distribution:
While *Caprella mutica* was found widespread over the Dutch Wadden Sea during the non-native species inventories in 2009 and 2011, it was only found at a selection of locations in the western Wadden Sea in 2014 (Fig. 66; Gittenberger *et al.*, 2010; 2012). There it was found, locally very abundant, mainly on floating docks at salinities between 17.91 and 25.97 ppt (Table 2; Appendix II).

Impact:
As *Caprella mutica* can become very abundant locally and is one of the largest caprellid species found in the NE Atlantic, Gittenberger *et al.* (2010) indicates that it may be able to outcompete all native caprellid species in the Dutch Wadden Sea. This is not supported however by the fact that *C. mutica* was found in 2014 at a much lower number of locations than in 2009 and 2011, while the native species *Caprella linearis* was found to be more common. The impact that *C. mutica* may have on the native flora and fauna in The Wadden Sea therefore remains uncertain.

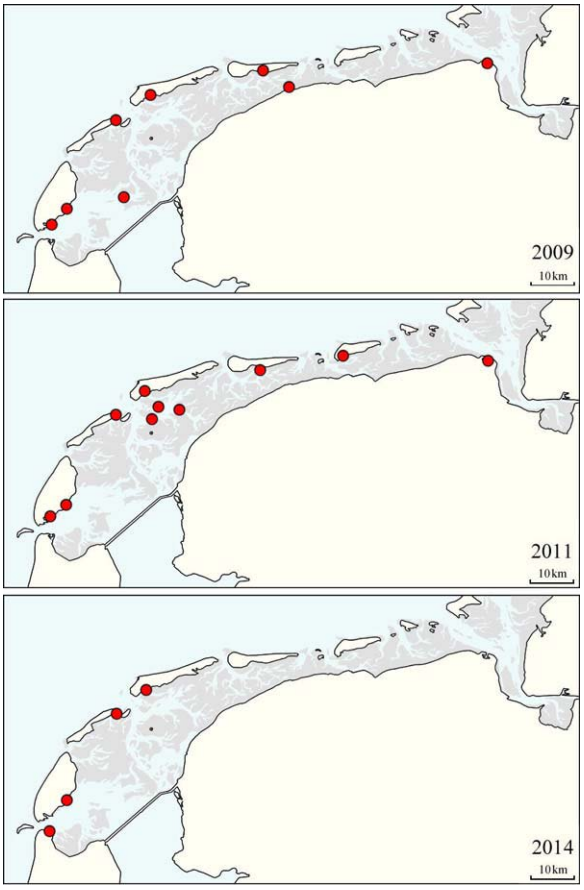

Fig. 66. Locations where *Caprella mutica* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 67. *Caprella mutica in situ* on *Botrylloides violaceus* in the harbour of Oudeschild, Texel.

4.1.6.4 *Eriocheir sinensis*
H. Milne Edwards, 1853 (Figs 68-69)

Origin:
NW Pacific (Adema, 1991).

Distribution:
Since the 1930s the Chinese mitten crab *Eriocheir sinensis* has expanded its populations along the mainland of the Dutch Wadden Sea in waters with a relatively low salinity (Wolff, 2005), where the species was also recorded during the non-native species inventory in 2009 (Fig. 68; Gittenberger *et al.*, 2010). Although *E. sinensis* was not recorded during the inventory in 2011 (Gittenberger *et al.*, 2012), it was again found in 2014 on floating docks in the harbours of Den Oever and Delfzijl at salinities between 5.5 and 14.93 ppt (Fig. 68; Table 2; Appendix II).

Impact:
The largest part of the Dutch Wadden Sea appears to be too saline for the Chinese mitten crab. This species therefore does not have a large impact (Gittenberger *et al.*, 2010).

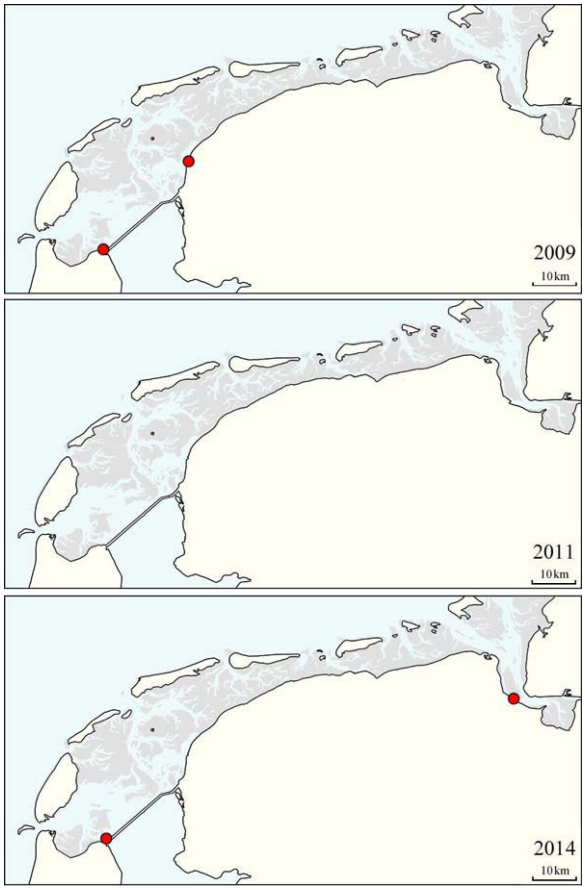

Fig. 68. Locations where *Eriocheir sinensis* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 69. *Eriocheir sinensis* collected from the foating dock in the harbour of Den Oever. Scale bar is 1.0 mm.

4.1.6.5 *Hemigrapsus sanguineus*
(De Haan, 1835) (Figs 70-71)

Origin:
NW Pacific (Breton *et al.*, 2002).

Distribution:
During the non-native species inventories in 2009, 2011 and 2014 *Hemigrapsus sanguineus* was found widespread in The Wadden Sea, usually hiding below rocks, boulders and Pacific oysters (Fig. 70; Gittenberger 2010; 2012). In its distribution it showed a preference for the more saline waters and sites that lie relatively exposed to the open Wadden Sea. In 2014 it was mainly recorded on floating docks, and in the littoral zones of dikes and oyster reefs at salinities between 17.91 and 25.97 ppt (Fig. 70; Table 2; Appendix II). *H. sanguineus* was first sighted in the Netherlands in 1999 in the Dutch Delta area (Wolff, 2005). In 2004 it was found for the first time in the Dutch Wadden Sea.

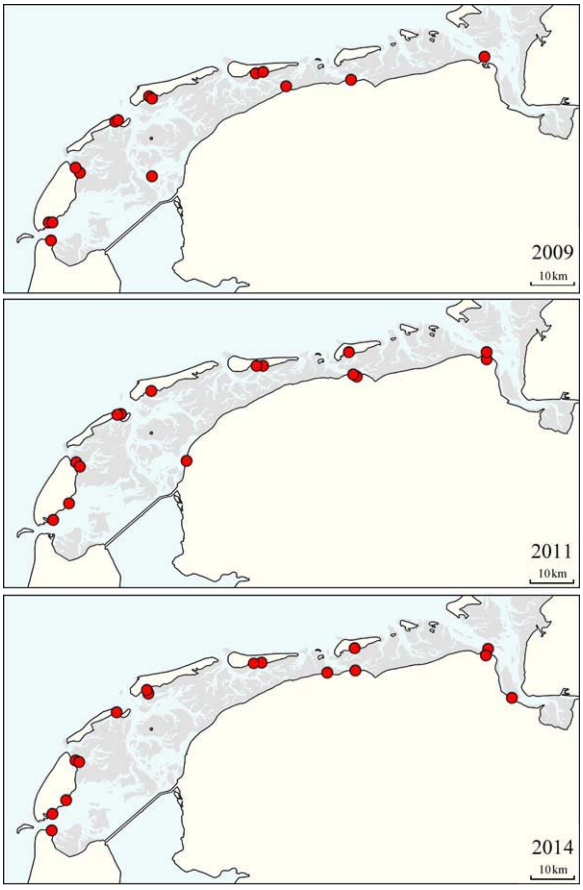

Fig. 70. Locations where *Hemigrapsus sanguineus* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Impact:
Regardless of their small size of usually about 2 cm, Pacific shore crabs are relatively aggressive crabs that usually occur in aggregations of at least 5-10 specimens underneath a boulder (Gittenberger *et al.* 2010). In areas where they occurred sympatrically with the native shore crab *Carcinus maenas* and/or the Pacific pencil crab *Hemigrapsis takanoi*, these species virtually never inhabited the same microhabitat, e.g. underneath the same rock. This supports the hypothesis that *H. sanguineus* is in strong competition for space with these species, as was also the conclusion of a recent study focusing on *H. sanguineus, H. takanoi* and the native shore crab *C. maenas* in the German Wadden Sea (Landschoff *et al.*, 2013). Although the distribution patterns of *H. takanoi* and *H. sanguineus* are very similar in 2009, 2011 and 2014 (Fig. 70), it is noted that these Pacific crab species were relatively hard to find and rare at most locations in 2014, while they were abundant at most locations where they were found in 2009 and 2011. To what degree the numbers of crabs have decreased since then cannot be specified as species abundances were not scored during these inventories.

Fig. 71. *Hemigrapsus sanguineus* in the harbour of Den Helder.

4.1.6.6 *Hemigrapsus takanoi*

Asakura & Watanabe, 2005 (Figs 72-73)

Origin:

NW Pacific (Asakura & Watanabe, 2005)

Distribution:

During the non-native species inventories in 2009, 2011 and 2014 *Hemigrapsus takanoi* was found widespread in The Wadden Sea, usually hiding below rocks and boulders, and between Pacific oysters (Fig. 72; Gittenberger et al 2010; 2012). In its distribution it showed a preference for sites that lie relatively sheltered to the open Wadden Sea like the sheltered side of a harbour dike. In 2014 it was mainly recorded on floating docks, and in the littoral zones of dikes and oyster reefs at salinities between 11.32 and 25.97 ppt (Fig. 72; Table 2; Appendix II). In the Netherlands *H. takanoi* was first recorded in the Dutch Delta in 1999 (Nijland & Beekman 1999). In 2006 it was found for the first time in the Dutch Wadden Sea.

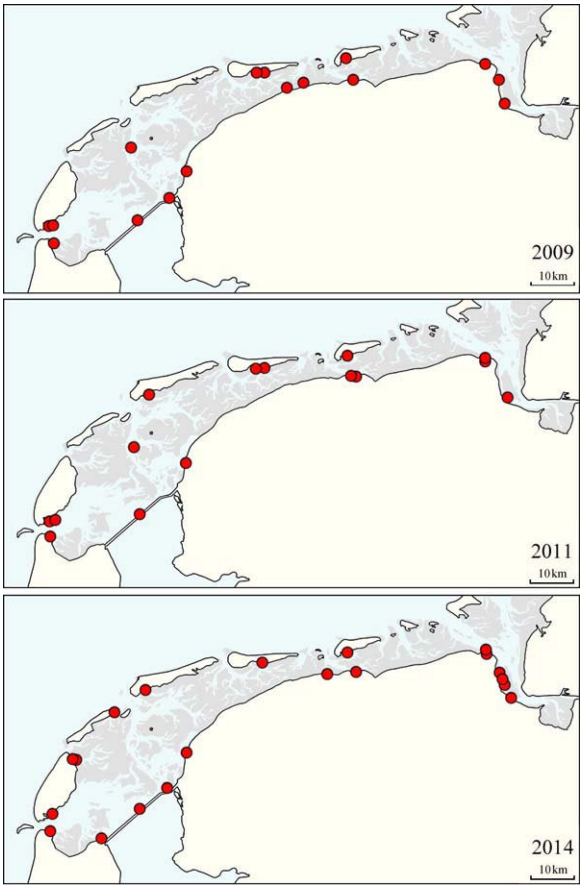

Fig. 72. Locations where *Hemigrapsus takanoi* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Impact:

Just like *Hemigrapsus sanguineus, H. takanoi* is also a relatively aggressive crab species that usually occurs in aggregations of at least 5-10 specimens underneath a boulder (Gittenberger *et al.* 2010). In areas where they occurred sympatrically with the native shore crab *Carcinus maenas* and/or *H. sanguineus*, these species virtually never inhabited the same microhabitat, e.g. underneath the same rock. This supports the hypothesis *that H. takanoi* is in strong competition for space with these species, as is concluded by Landschoff *et al.* (2013) based on a study of these species in the German Wadden Sea. As was also noted for *H. sanguineus, H. takanoi* specimens were found in 2014 equally widespread throughout The Wadden Sea as in 2009 and 2011. They were much harder to find in 2014 however and appeared to occur in much lower number at most of the locations. To what degree the numbers of *H. takanoi* specimens have decreased cannot be specified as species abundances were not scored during these inventories.

Fig. 73. *Hemigrapsus takanoi* collected from the dike in Breezanddijk.

4.1.6.7 *Jassa marmorata*
Holmes, 1905 (Figs 74-75)

Origin:
NW Atlantic (Conlan 1990; Gittenberger *et al.*, 2010). It is unclear whether this species is also native in the NE Atlantic.

Distribution:
As was also the case during the inventory in 2009 and 2011, *Jassa marmorata* was found especially abundant in 2014 on the ropes of mussel spat collectors, which floated in the middle of the Dutch Wadden Sea (Fig. 74; Table 2; Appendix II; Gittenberger *et al.*, 2010; 2012). Additionally some individual specimens were recorded on floating docks in the harbours of Texel. It is unknown since when *J. marmorata* occurs in the Netherlands as it probably has been misidentified in the past as the morphologically very similar native species *Jassa falcata* (Faasse & Van Moorsel, 2000).

Impact:
Jassa marmorata has spread worldwide in temperate areas from its native range in the NW Atlantic. It can be especially abundant in harbour systems. *J. marmorata* furthermore has a preference for areas with strong currents (Faasse & Van Moorsel, 2000). This may explain why it was found in high densities on the floating mussel spat collectors that are situated in the middle of the Dutch Wadden Sea where the currents can be very strong. Even though *J. marmorata* did not seem to be harmful to the mussel spat, high densities of *Jassa* species can have a distinct impact on an ecosystem as they form an important food source for fishes. For as long as *J. marmorata* remains dominant on the floating mussel collectors and other floating objects like buoys and pontoons only, the negative impact of this species on The Wadden Sea ecosystem will remain limited (Gittenberger *et al.*, 2010).

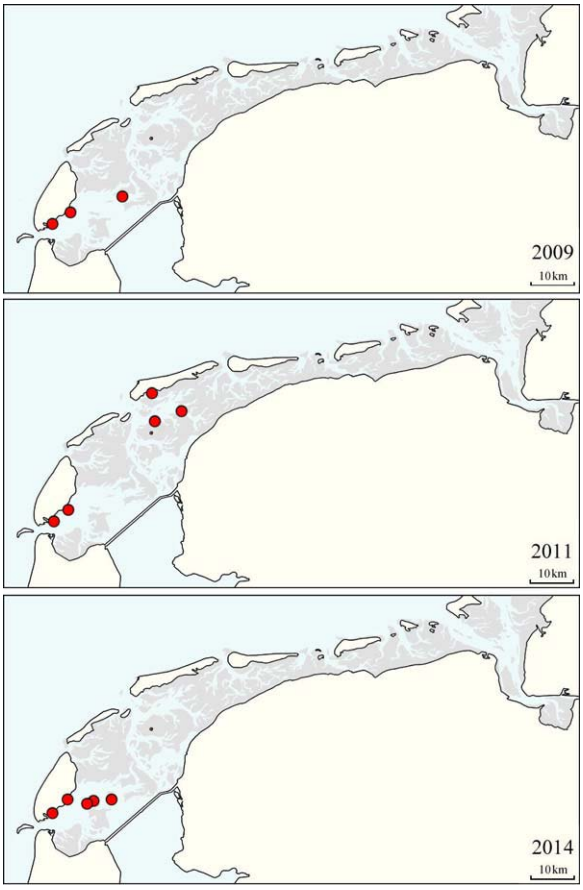

Fig. 74. Locations where *Jassa marmorata* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

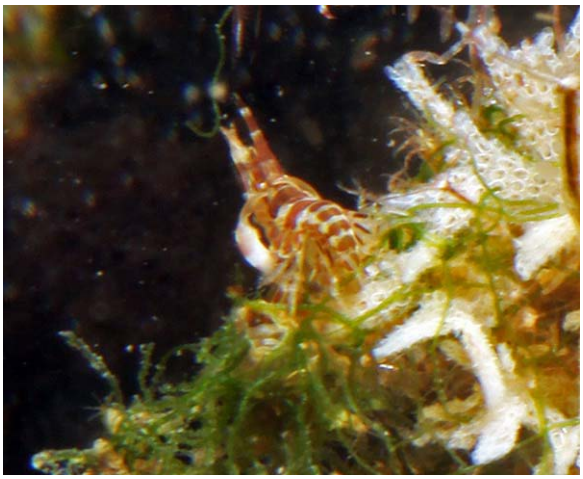

Fig. 75. *Jassa marmorata in situ* on a floating dock in Oudeschild, Texel.

4.1.6.8 *Leptomysis lingvura*
(Sars G.O., 1866) (Figs 76-77)

Origin:
NE Atlantic (Tattersall & Tattersall, 1951)

Distribution:
This is the first record of *Leptomysis lingvura* for The Wadden Sea (Fig. 76). Several specimens were found in a soft substratum sample from the sublittoral zone in front of the Afsluitdijk (Fig. 78). *L. lingvura* was first found in the Netherlands in 1994 in the Eastern Scheldt near Zierikzee (Faasse, 1995).

Impact:
The small mysid shrimp *Leptomysis lingvura* has only been recorded twice in the Netherlands, i.e. in 1994 in the Delta region and in 2014 during the Wadden Sea inventory. It is therefore unlikely that this rare species will have a distinct impact on The Wadden Sea ecosystem in the future.

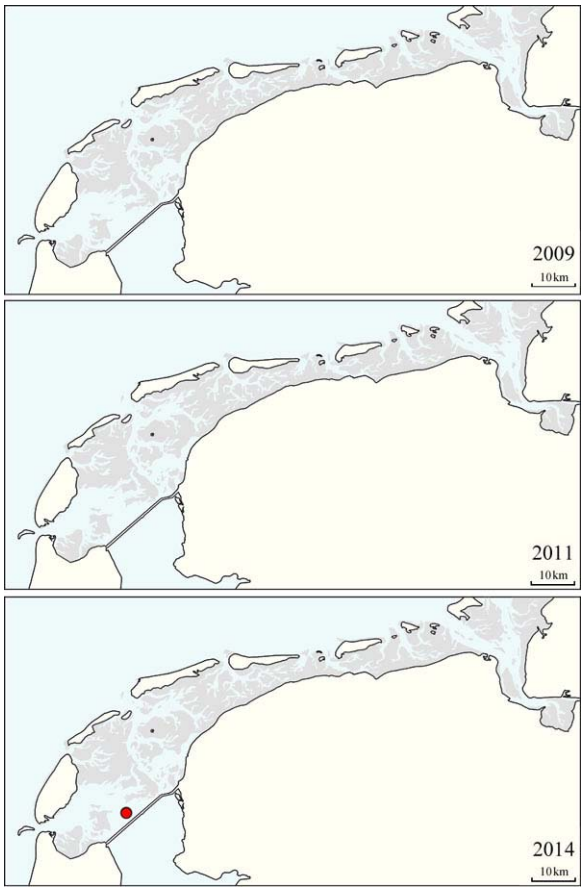

Fig. 76. Locations where *Leptomysis lingvura* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 77. *Leptomysis lingvura in vitro* collected in a sublittoral soft bottom sample. Scale bar is 1.0 mm.

4.1.6.9 *Melita nitida*
Smith, 1873 (Figs 78-79)

Origin:
North America: Its distributional area ranges from the south-western Gulf of St. Lawrence (Canada) to Yucatan (Mexico) on the Atlantic coast and from the Strait of Georgia (British Columbia, Canada) to Elkhorn Slough (California) on the Pacific coast (Faasse & van Moorsel, 2003).

Distribution:
This is the first record of *Melita nitida* for The Wadden Sea (Fig. 78). Several specimens were found on a dike and on a floating dock in the harbour of Harlingen (Fig. 78) at a salinity of 12.79 ppt (Table 2; Appendix II) in mixed populations with the native *Melita* species *M. palmata*. The specimens were identified by M.A. Faasse. *M. nitida* was first found in the Netherlands in 1998 in the Western Scheldt (Faasse & van Moorsel, 2003). Since then it has spread having a preference for mesohaline regions like the River Rhine connecting Rotterdam to the North Sea, the North Sea Canal to Amsterdam, and the Kiel Canal in Germany (Reichert & Beermann, 2011).

Impact:
Although *Melita nitida* may compete with other amphipod species in the same "brackish water" habitat like *Melita palmata* (Faasse & van Moorsel, 2003; Reichert & Beermann, 2011), there has been no evidence yet that this has happened. If *M. nitida* will have an impact in The Wadden Sea region, it is most likely that this will be concentrated in the relatively brackish waters of the mainland harbours.

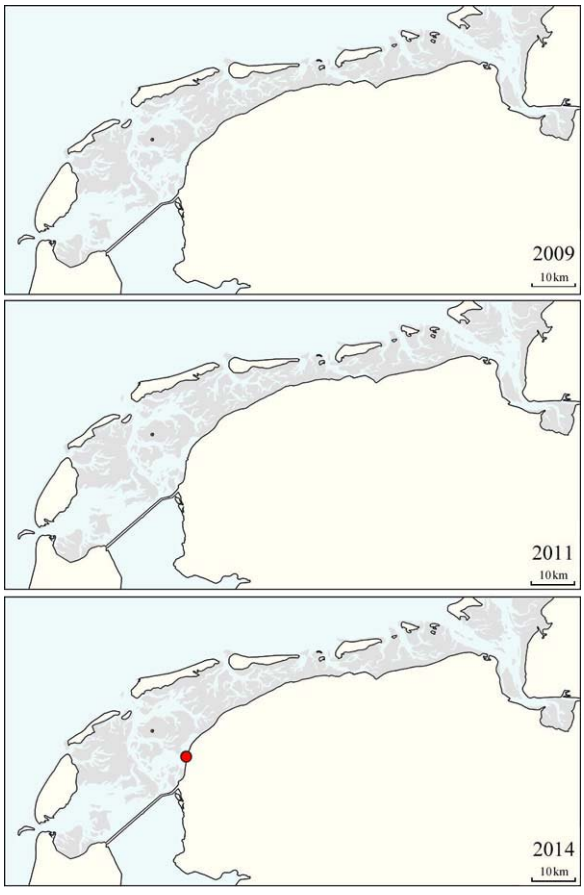

Fig. 78. Locations where *Melita nitida* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

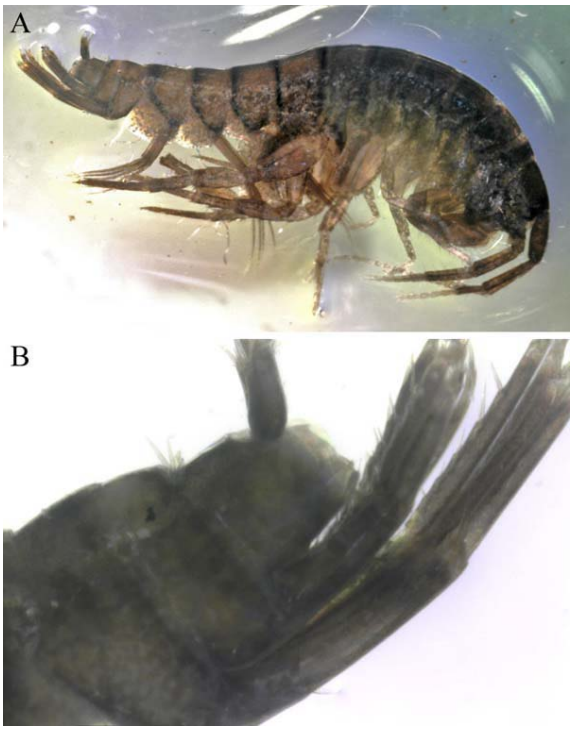

Fig. 79. *Melita nitida.* A: complete specimen collected in the harbour of Harlingen, B: Typical spines on the urosome.

4.1.6.10 *Palaemon macrodactylus*
Rathbun, 1902 (Figs 80-81)

Origin:
NW Pacific (d'Udekem d'Acoz *et al.*, 2005)

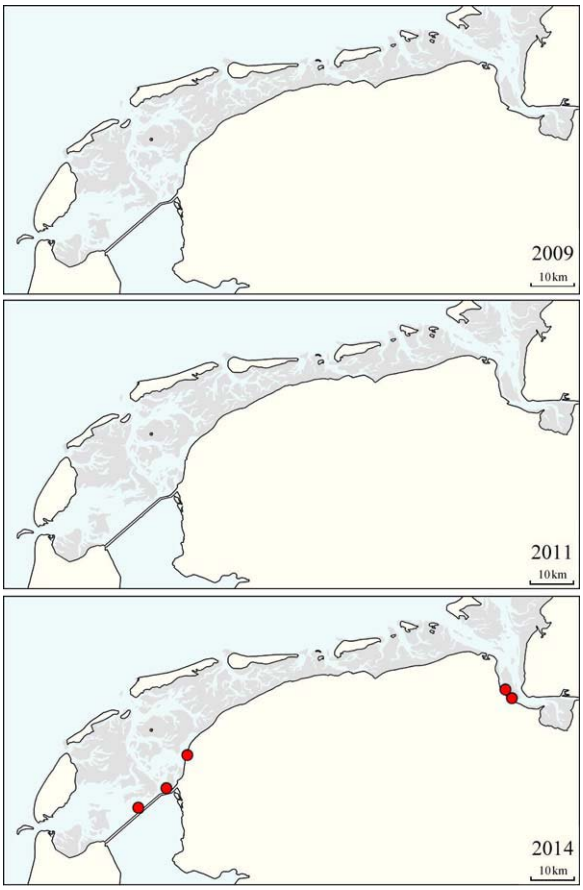

Fig. 80. Locations where *Palaemon macrodactylus* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Distribution:
Palaemon macrodactylus has been recorded in The Wadden Sea during various monitoring efforts from west to east in the Dutch Wadden Sea off Oudeschild, Texel (de Ruijter, 2007), off Den Oever (Schrieken, 2008), in the harbours of Harlingen and Lauwersoog (Tulp, 2006) and in Eemshaven (Faasse, 2005). Regardless of its wide distribution the prawn *Palaemon macrodactylus* was not encountered during the non-native species inventories in 2009 and 2011 in The Wadden Sea (Gittenberger *et al.*, 2010, 2012). In 2014 however, the species was commonly recorded in various harbour from west to east in the Dutch Wadden Sea (Fig. 80). There it was found in harbours mostly on and underneath floating docks at salinities between 8.74 and 14.93 ppt (Table 2; Appendix II).

Impact:
Over the years the prawn *Palaemon macrodactylus* has expanded its population over The Wadden Sea, where it is mainly found in the mainland harbours. Although it may have been relatively rare at these localities until recently, the fact that it was not found during the inventories in 2009 and 2011, and was commonly found at various locations in 2014, may indicate that it is becoming more abundant. To what degree it will compete with the native prawn species and thereby have an impact on The Wadden Sea ecosystem remains uncertain however.

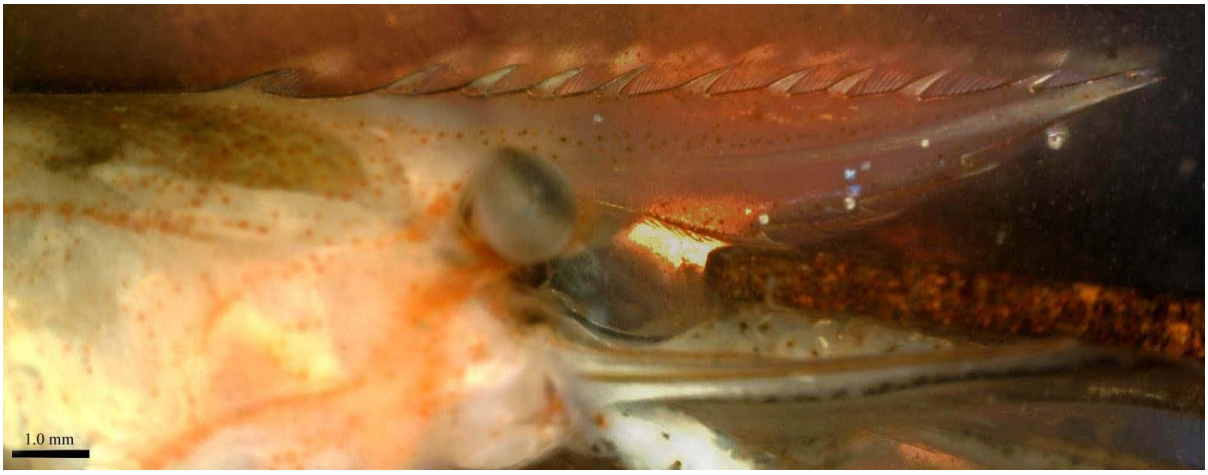

Fig. 81. Conserved *Palaemon macrodactylus*, collected from a jetty in Breezanddijk. Scale bar is 1.0 mm.

4.1.7 Ctenophora

4.1.7.1 *Mnemiopsis leidyi*
A. Agassiz, 1865 (Figs 82-83)

Origin:
W Atlantic (Kideys, 2002).

Distribution:
Although *Mnemiopsis leidyi* is a pelagic species and hence does not live in association with hard or soft substrata, it is usually abundantly found in harbours and was scored during the present species inventory when sighted. Similar to the previous non-native species inventories in The Wadden Sea in 2009 and 2011, *M. leidyi* was recorded throughout the entire Dutch Wadden Sea in 2014 (Fig. 82; Gittenberger *et al.*, 2010; 2012).

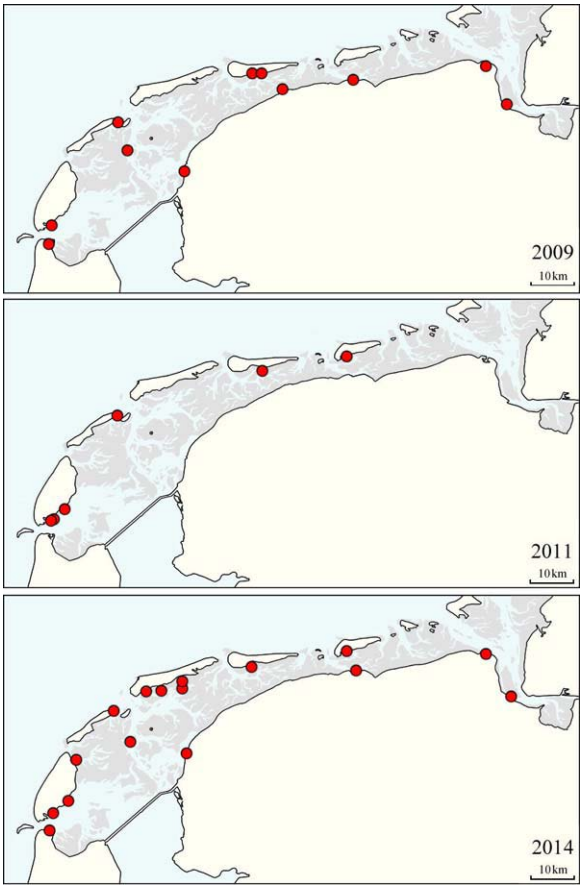

Fig. 82. Locations where *Mnemiopsis leidyi* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Impact:
Mnemiopsis leidyi, which feeds on zooplankton, has the potential to cause extreme ecological and economical damage in areas where it is introduced. In the Black Sea, it devastated the anchovy stock and consequently the fisheries (Kideys 2002). Risks for the Dutch waters including The Wadden Sea are described in detail in the risk assessment by Gittenberger (2008). The high numbers that were recorded throughout The Wadden Sea indicate that *M. leidyi* may already have a major influence on the ecosystem as is confirmed by a recent study in the western Dutch Wadden Sea by Van Walraven *et al.* (2013).

Fig. 83. *Mnemiopsis leidyi* in the harbour of Vlieland.

4.1.8 Mollusca

4.1.8.1 *Crassostrea gigas*
(Thunberg, 1793) (Figs 84-85)

Origin:
NW Pacific (Eno *et al.*, 1997).

Distribution:
During the non-native species inventories in 2009, 2011 and 2014 *Crassostrea gigas* was found widespread in The Wadden Sea (Fig. 84; Gittenberger *et al.*, 2010, 2012). In 2014 it was found forming reef-like structures in the littoral and sublittoral on sandy bottoms, the dikes, and floating docks at salinities between 5.53 and 25.97 ppt (Fig. 84; Table 2; Appendix II). The first autochthonous (born in the Netherlands) Pacific oyster was recorded in 1928 (Wolff, 2005), but reproduction remained rare. In the 1970-80's Pacific oysters were repeatedly imported. In 1975 it suddenly started to reproduce and rapidly expand its populations in the Netherlands (Wolff, 2005).

Impact:
The extended reefs of the invasive Pacific oyster *Crassostrea gigas* have considerably changed the Wadden Sea ecosystem by competing with native filter feeding bivalves like *Mytilus edulis* and *Cerastoderma edule* and by increasing the amount of hard substrate in the area.

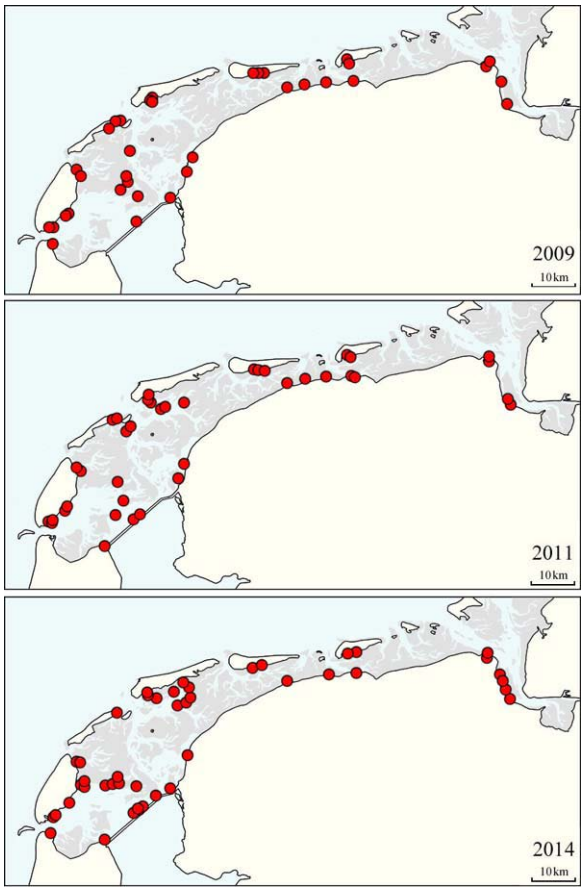

Fig. 84. Locations where *Crassostrea gigas* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 85. *Crassostrea gigas* reef off Terschelling.

4.1.8.2 *Crepidula fornicata*
(Linnaeus, 1758) (Figs 86-87)

Origin:
NW Atlantic (Nehring & Leuchs 1999).

Distribution:
During the non-native species inventories in 2009, 2011 and 2014 *Crepidula fornicata* was found widespread in The Wadden Sea (Fig. 86; Gittenberger *et al.*, 2010, 2012). In comparison to the high densities that are found in the Dutch province of Zeeland, the densities of *C. fornicata* in The Wadden Sea are relatively low however. In 2014 it was mainly found in the harbours and on shellfish beds at salinities between 8.74 and 25.97 ppt (Table 2; Appendix II). Living specimens of *C. fornicata* were first recorded in the Netherlands in 1926, where they washed ashore at Zandvoort and a few years later in the Dutch Wadden Sea (Korringa, 1942).

Impact:
At most localities, only a few specimens were found. Although *Crepidula fornicata* is widespread in the Dutch Wadden Sea it probably does not have a distinct impact on the ecosystem.

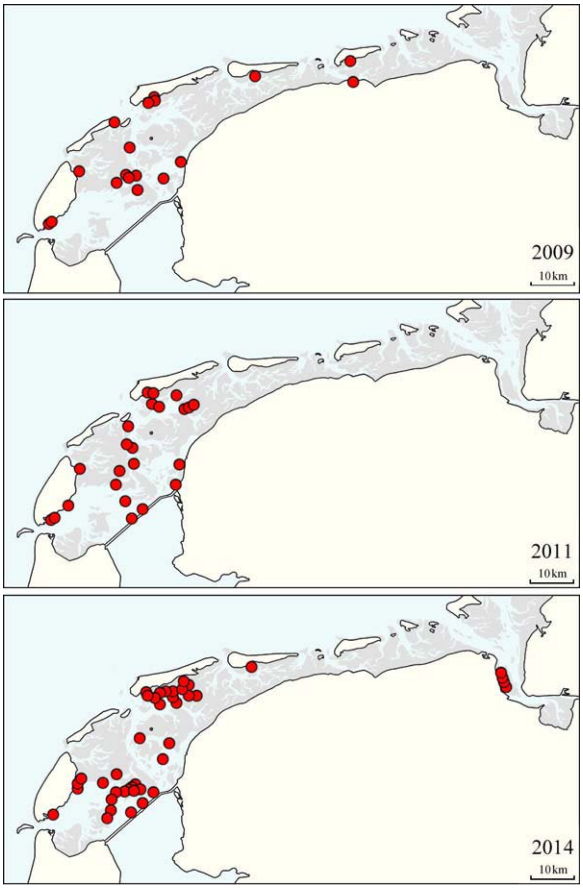

Fig. 86. Locations where *Crepidula fornicata* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 87. *Crepidula fornicata* collected from a sublittoral oyster reef.

4.1.8.3 *Ensis directus*
(Conrad, 1843) (Figs 88-89)

Origin:
NW Atlantic (Wolff, 2005)

Distribution:
In 2014 the American razor shell *Ensis directus* was found widespread in the bottom samples that were taken (Fig. 88). As the non-native species inventories in 2009 and 2011 focused on the hard substrates present, it was not recorded during those inventories (Gittenberger *et al.*, 2010, 2012). *E. directus* was first observed in the Netherlands in 1977 in The Wadden Sea south off Terschelling (Dekker & Beukema, 2012). Within the next few years it was recorded from nearly the entire Wadden Sea (Essink, 1984; Wolff, 2005).

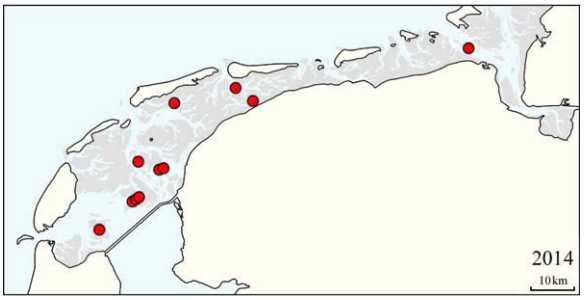

Fig. 88. Locations where *Ensis directus* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 89. *Ensis directus* collected in a sublittoral dregde sample.

Impact:
Ensis directus is widespread in the Wadden Sea, predominantly in subtidal seaward soft sediments (Dekker & Drent, 2013) and is usually found in high densities, indicating that this species must have a considerable impact on the ecosystem (Dekker & Beukema, 2012).

4.1.8.4 *Mya arenaria*
Linnaeus, 1758 (Figs 90-91)

Origin:
NW Atlantic and N Pacific (Wolff, 2005)

Distribution:
During the inventory in 2014 *Mya arenaria* was found widespread in the bottom samples in the western of The Wadden Sea and more locally off Delzijl in the eastern part (Fig. 90). As the non-native species inventories in 2009 and 2011 focused on the hard substrates present, it was not recorded during those inventories (Gittenberger *et al.*, 2010, 2012). The first record of *Mya arenaria* in the Netherlands is by Baster (1765) but it was probably introduced earlier (Wolff, 2005). It is a common species in the Netherlands (Wolff, 2005). It shows a preference for more nearshore and brackish soft sediments in The Wadden Sea (Dekker & Drent, 2013).

Impact:
Mya arenaria is a common species that has become part of the Dutch ecosystem. As it can be found in high densities and is widespread, its impact on The Wadden Sea ecosystem is probably considerable in areas influenced by freshwater discharge.

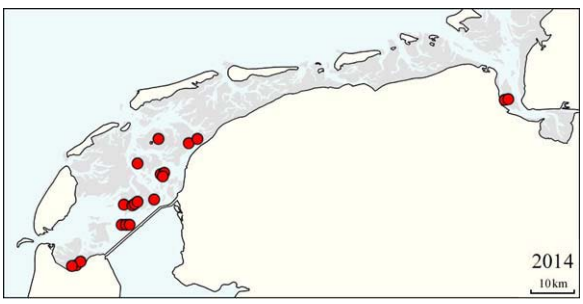

Fig. 90. Locations where *Mya arenaria* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 91. *Mya arenaria* collected in a sublittoral dregde sample.

4.1.9 Porifera

4.1.9.1 *Haliclona cf xena*
De Weerdt, 1986 (Fig. 92-93)

Origin:
Cryptogenic (Van Soest *et al.*, 2007)

Distribution:
After this sponge species was first recorded in 1977, it has become one of the more common species in the Netherlands (Van Soest *et al.* 2007). In the previous non-native species inventories in The Wadden Sea in 2009 and 2011 *Haliclona xena* was only recorded in 't Horntje, Texel (Fig. 92). In 2014 several sponges, resembling *H. xena*, were found in the marina of Lauwersoog at a salinity of 20.9 ppt (Table 2; Appendix II). Although these sponges did form the typical tubes known for *H. xena*, the spicules (skeletal parts) were slightly larger than one would expect (Van Soest *et al.*, 2007). The specimens were therefore identified provisionally as *Haliclona* con forma *xena*.

Impact:
Even though *H. (Soestella) xena* is one of the more common sponge species in the Netherlands, it was found to be rare in the Dutch Wadden Sea. It is therefore unlikely that it has or will have a significant impact on The Wadden Sea ecosystem (Gittenberger *et al.*, 2010, 2012).

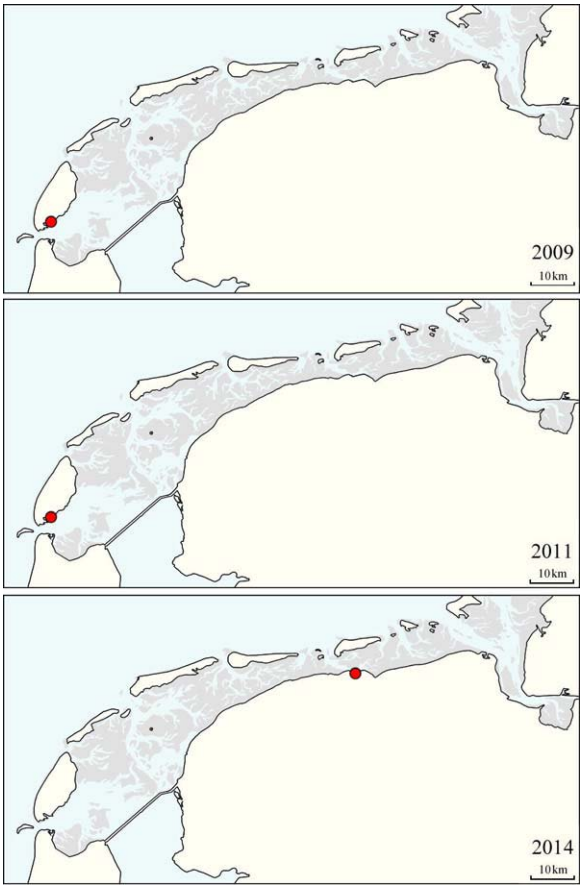

Fig. 92. Locations where *Haliclona* cf *xena* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 93. *Haliclona* cf *xena in situ* on a floating dock in the harbour of Lauwersoog.

4.1.9.2 *Hymeniacidon perlevis*
(Montagu, 1814) (Figs 94-95)

Origin:
In the NE Atlantic this species is considered to be native in countries that lie to the south of the Netherlands (Van Soest *et al.*, 2007).

Distribution:
In 2011 this species was first recorded for the Dutch Wadden Sea in the harbour of Terschelling (Gittenberger *et al.*, 2012). In 2014 it was again recorded in the harbour of Terschelling (Fig. 94). There it was found on a floating dock at a salinity of 20.56 ppt (Table 2; Appendix II). In the Netherlands *Hymeniacidon perlevis* was first recorded in 1951 in the province of Zeeland (Van Soest, 1977).

Impact:
Hymeniacidon perlevis is common in the Delta region of the Netherlands where it probably, at least locally, impacts the ecosystem. In The Wadden Sea *H. perlevis* was only found in the harbour of Terschelling in 2011 and in 2014. It therefore does not seem to have any impact on The Wadden Sea ecosystem.

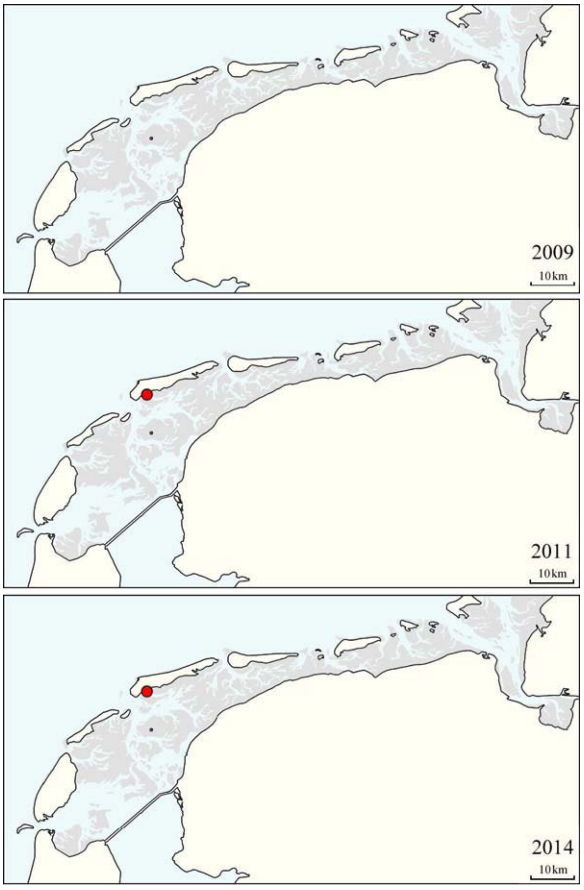

Fig. 94. Locations where *Hymeniacidon perlevis* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

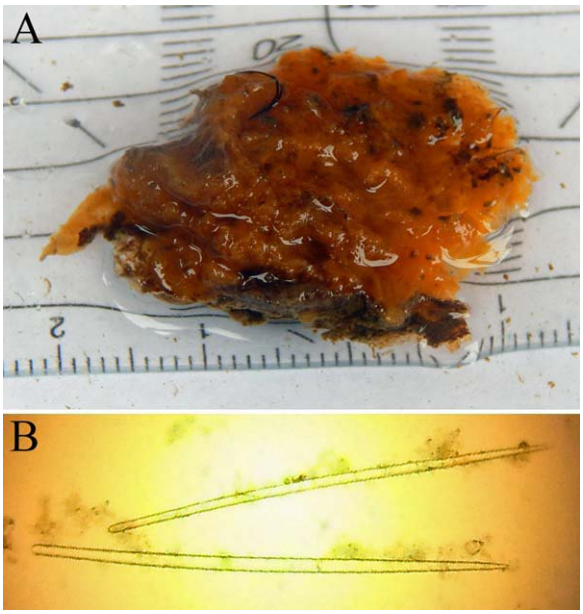

Fig. 95. *Hymeniacidon perlevis*. A: *in vivo* from a floating dock of the harbour in Terschelling; B: spicules.

4.1.9.3 *Leucosolenia somesi*
(Bowerbank, 1874) (Figs 96-97)

Origin:
The origin of *Leucosolenia somesi* is unclear. It was first recorded in the Netherlands in 1996 in the Dutch Delta (Van Soest *et al.*, 2007) but it may have been present for much longer as it may have been misidentified as *L. variabilis* in the past, a native species that morphologically closely resembles *L. somesi.*

Distribution:
In 2011 *Leucosolenia somesi* was first recorded for The Wadden Sea in the harbour of Oudeschild, Texel. This sponge species may have occurred for much longer being misidentified as the native species *L. variabilis* however (Gittenberger *et al.*, 2012). The colonies of that species in general stay much smaller however (up to about 2 cm) and do not have the V shaped spicules that are typical for *L. somesi*. In 2014 typical *L. somesi* colonies, which can easily reach 10 cm or more, were found on the floating docks of the marinas of Oudeschild, Vlieland and Terschelling at salinities between 17.91 and 25.97 ppt (Fig. 96; Table 2; Appendix II).

Impact:
Leucosolenia somesi was only found growing on floating docks in marinas. It is therefore unlikely that this species will have a distinct impact on The Wadden Sea ecosystem.

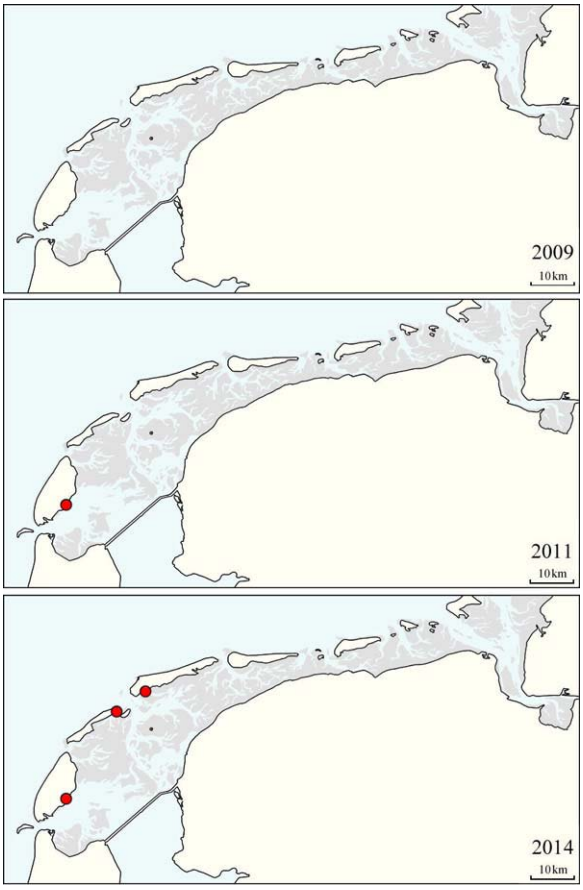

Fig. 96. Locations where *Leucosolenia somersi* was found during The Wadden Sea inventories in 2009, 2011 and 2014.

Fig. 97. *Leucosolenia somersi in situ* on a floating dock in the harbour of Oudeschild, Texel.

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Appendix I

The research locations searched during The Wadden Sea inventory in 2014.

Location	Habitat	Method	Coordinates	Date
Region A (Fig. 1): Texel, 't Horntje				
1	Floating dock	Snorkelling	N53 0.324 E4 47.769	15-09-14
2	Floating dock	Visual inspection	N53 0.324 E4 47.769	06-10-14
3	Floating dock	Visual inspection	N53 0.324 E4 47.769	06-10-14
4	Floating dock, buoy	Visual inspection	N53 0.324 E4 47.769	06-10-14
5	Jetty	Visual inspection	N53 0.329 E4 47.706	06-10-14
6	Dike, sheltered side, littoral zone	Visual inspection	N53 0.326 E4 47.797	06-10-14
7	Dike, sheltered side, littoral zone	Visual inspection	N53 0.326 E4 47.797	06-10-14
Region A (Fig. 1): Texel, arrival ferry				
8	Dike, sheltered side, littoral zone	Visual inspection	N53 0.251 E4 46.912	21-09-14
9	Dike, sheltered side, littoral zone	Visual inspection	N53 0.251 E4 46.912	06-10-14
10	Dike, sheltered side, littoral zone	Visual inspection	N53 0.251 E4 46.912	06-10-14
Region A (Fig. 1): Texel, Oudeschild, marina				
11	Floating dock (wood)	Snorkelling	N53 2.602 E4 51.402	15-09-14
12	Floating dock (metal)	Snorkelling	N53 2.700 E4 51.445	15-09-14
13	Floating dock (wood)	Visual inspection	N53 2.602 E4 51.402	10-09-14
14	Floating dock (metal)	Visual inspection	N53 2.700 E4 51.445	10-09-14
15	Floating dock (wood)	Visual inspection	N53 2.602 E4 51.402	10-09-14
16	Floating dock (metal)	Visual inspection	N53 2.700 E4 51.445	10-09-14
17	Floating dock (metal), buoy	Visual inspection	N53 2.700 E4 51.445	10-09-14
18	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 2.694 E4 51.420	21-09-14
19	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 2.691 E4 51.428	21-09-14
20	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 02.685 E4 51.416	21-09-14
21	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 02.672 E4 51.413	21-09-14
22	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 02.663 E4 51.454	21-09-14
23	Harbour wall	Visual inspection	N53 2.684, E4 51.408	10-09-14
24	Dike, exposed side, littoral zone	Visual inspection	N53 2.882 E4 51.693	15-09-14
25	Dike, sheltered side, littoral zone	Visual inspection	N53 2.676, E4 51.401	10-09-14
26	Jetty	Visual inspection	N53 2.597, E4 51.257	10-09-14
Region A (Fig. 1): Texel, Cocksdorp				
27	Oyster reef, littoral zone	Visual inspection	N53 8.998, E4 54.026	06-10-14
28	Dike, litoral zone, near fresh water outlet	Visual inspection	N53 09.454 E4 52.682	15-09-14
29	Dike, exposed side, littoral zone	Visual inspection	N53 09.356 E4 53.121	15-09-14
Region B (Fig. 1): Vlieland, marina				
30	Floating dock	Visual inspection	N53 17.769, E5 5.409	07-10-14
31	Floating dock	Visual inspection	N53 17.769, E5 5.409	07-10-14
32	Boat hulls	Visual inspection	N53 17.769, E5 5.409	07-10-14
33	Floating dock	Visual inspection	N53 17.769, E5 5.409	07-10-14
34	Floating dock, submerged rope	Visual inspection	N53 17.769, E5 5.409	07-10-14
35	Floating dock, submerged rope	Visual inspection	N53 17.769, E5 5.409	07-10-14
36	Floating dock, buoy	Visual inspection	N53 17.769, E5 5.409	07-10-14
37	Dike, exposed side, littoral zone	Visual inspection	N53 17.675, E5 5.467	07-10-14
38	Dike, sheltered side, littoral zone	Visual inspection	N53 17.746, E5 5.398	07-10-14
39	Dike, sheltered side, littoral zone	Visual inspection	N53 17.746, E5 5.398	07-10-14
40	Dike, exposed side, littoral zone	Visual inspection	N53 17.675, E5 5.467	07-10-14

Location	Habitat	Method	Coordinates	Date
Region C (Fig. 1): Terschelling				
41	Oyster reef, littoral zone	Visual inspection	N53 21.539 E5 14.017	18-09-14
Region C (Fig. 1): Terschelling, marina				
42	Floating dock	Visual inspection	N53 21.894 E5 13.538	18-09-14
43	Floating dock	Visual inspection	N53 21.881 E5 13.506	08-10-14
44	Floating dock	Visual inspection	N53 21.881 E5 13.506	08-10-14
45	Floating dock, buoy	Visual inspection	N53 21.881 E5 13.506	08-10-14
46	Dike, sheltered side, littoral zone	Visual inspection	N53 21.898 E5 13.581	08-10-14
47	Dike, sheltered side, littoral zone	Visual inspection	N53 21.898 E5 13.581	08-10-14
48	Dike, exposed side, littoral zone	turning rocks	N53 21.860 E5 13.317	08-10-14
49	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 21.909 E5 13.539	18-09-14
50	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 21.936 E5 13.537	18-09-14
51	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 21.934 E5 13.503	18-09-14
52	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 21.911 E5 13.503	18-09-14
53	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 21.912 E5 13.502	18-09-14
54	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 21.881 E5 13.506	18-09-14
55	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 21.933 E5 13.469	18-09-14
56	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 21.903 E5 13.474	18-09-14
57	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 21.928 E5 13.407	18-09-14
58	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 21.914 E5 13.334	18-09-14
Region D (Fig. 1): Ameland, marina				
59	Floating dock	Visual inspection	N53 26.232, E5 46.552	07-10-14
60	Floating dock	Visual inspection	N53 26.232, E5 46.552	07-10-14
61	Floating dock, rope	Visual inspection	N53 26.232, E5 46.552	07-10-14
62	Dike, sheltered side, littoral zone	Visual inspection	N53 26.276 E5 46.561	23-08-14
63	Dike, sheltered side, littoral zone	Visual inspection	N53 26.276 E5 46.561	07-10-14
64	Dike, sheltered side, littoral zone	Visual inspection	N53 26.218, E5 46.579	07-10-14
65	Dike, exposed side, littoral zone	Visual inspection	N53 26.275 E5 46.471	23-08-14
66	Dike, exposed side, littoral zone	Visual inspection	N53 26.275 E5 46.471	07-10-14
67	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.216 E5 46.556	24-08-14
68	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.197 E5 46.557	24-08-14
69	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.194 E5 46.574	24-08-14
70	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.223 E5 46.571	24-08-14
71	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.241 E5 46.554	24-08-14
72	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.258 E5 46.551	24-08-14
73	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.215 E5 46.519	24-08-14
74	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.230 E5 46.518	24-08-14
75	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.247 E5 46.522	24-08-14
Region D (Fig. 1): Ameland, KNRM dike				
76	Oyster reef, littoral zone	Visual inspection	N53 25.885 E5 43.913	23-08-14

Location	Habitat	Method	Coordinates	Date
Region E (Fig. 1): Schiermonnikoog, arrival ferry				
77	Dike, exposed side, littoral zone	Visual inspection	N53 28.126 E6 12.045	03-09-14
78	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 28.095 E6 12.119	03-09-14
79	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 28.097 E6 12.133	03-09-14
80	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 28.103 E6 12.105	03-09-14
Region E (Fig. 1): Schiermonnikoog, marina				
81	Dike, exposed side, littoral zone	Visual inspection	N53 28.085 E6 09.998	03-09-14
82	Dike, sheltered side, littoral zone	Visual inspection	N53 28.172 E6 09.990	03-09-14
83	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 28.122 E6 10.032	03-09-14
84	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 28.121 E6 10.013	03-09-14
85	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 28.158 E6 10.032	03-09-14
86	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 28.156 E6 10.013	03-09-14
87	Floating dock	Scrape sample	N53 28.155 E6 10.011	03-09-14
88	Floating dock	Visual inspection	N53 28.153, E6 10.021	07-10-14
89	Floating dock	Visual inspection	N53 28.153, E6 10.021	07-10-14
90	Floating dock, buoy	Visual inspection	N53 28.153, E6 10.021	07-10-14
91	Floating dock, buoy	Visual inspection	N53 28.153, E6 10.021	07-10-14
92	Harbour wall	Visual inspection	N53 28.207, E6 9.995	07-10-14
93	Harbour wall	Visual inspection	N53 28.207, E6 9.995	07-10-14
Region F (Fig. 1): Den Helder, marine marina				
94	Floating dock	Visual inspection	N52 57.759, E4 46.881	09-10-14
95	Floating dock	Visual inspection	N52 57.759, E4 46.881	09-10-14
96	Floating dock, buoy	Visual inspection	N52 57.759, E4 46.881	09-10-14
97	Harbour wall	Visual inspection	N52 57.759, E4 46.881	09-10-14
98	Harbour wall	Visual inspection	N52 57.759, E4 46.881	09-10-14
99	Dike, sheltered side, littoral zone	Visual inspection	N52 57.782, E4 46.846	09-10-14
Region G (Fig. 1): Den Oever, marina				
100	Floating dock	Visual inspection	N52 56.455 E5 1.872	09-10-04
101	Floating dock	Visual inspection	N52 56.455 E5 1.872	09-10-14
102	Boat hulls	Visual inspection	N52 56.360 E5 1.976	09-10-14
103	Floating dock, submerged rope	Visual inspection	N52 56.360 E5 1.974	09-10-14
104	Poles, sublittoral zone	Visual inspection	N52 56.353 E5 2.004	09-10-14
105	Floating dock	Visual inspection	N52 56.345 E5 2.017	09-10-14
106	Bottom sample soft substrate, sublittoral zone	Petit ponar	N52 56.342, E5 2.028	09-10-14
107	Floating dock, submerged bucket	Visual inspection	N52 56.442 E5 1.859	09-10-14
108	Dike, sheltered side, littoral zone	Visual inspection	N52 56.344, E5 1.973	09-10-14
109	Bottom sample soft substrate, sublittoral zone	Petit ponar	N52 56.350, E5 2.016	09-10-14
110	Bottom sample soft substrate, sublittoral zone	Petit ponar	N52 56.357, E5 2.000	09-10-14
111	Dike, sheltered side, littoral zone	Visual inspection	N52 56.342 E5 2.069	09-10-14
112	Dike, exposed side, littoral zone	Visual inspection	N52 56.570 E5 01.820	16-08-14
113	Bottom sample soft substrate, sublittoral zone	Petit ponar	N52 56.363, E5 1.983	09-10-14
114	Bottom sample soft substrate, sublittoral zone	Petit ponar	N52 56.372, E5 1.993	09-10-14
115	Dike, exposed side, littoral zone	Visual inspection	N52 56.333 E5 2.092	09-10-14
116	Bottom sample soft substrate, sublittoral zone	Petit ponar	N52 56.387, E5 2.013	09-10-14
117	Bottom sample soft substrate, sublittoral zone	Petit ponar	N52 56.421, E5 1.945	09-10-14
118	Bottom sample soft substrate, sublittoral zone	Petit ponar	N52 56.411, E5 1.932	09-10-14
119	Bottom sample soft substrate, sublittoral zone	Petit ponar	N52 56.401, E5 1.920	09-10-14

Location	Habitat	Method	Coordinates	Date
Region G (Fig. 1): Den Oever, fishing harbour				
120	Floating dock	Visual inspection	N52 56.283 E5 2.013	09-10-14
121	Harbour wall	Visual inspection	N52 56.289 E5 2.018	09-10-14
122	Boat hulls	Visual inspection	N52 56.291 E5 2.013	09-10-14
123	Poles, sublittoral zone	Visual inspection	N52 56.361 E5 2.010	09-10-14
RegionG (Fig. 1): Breezanddijk				
124	Dike, sheltered side, littoral zone	Visual inspection	N53 01.211 E5 12.152	16-08-14
125	Poles, sublittoral zone	Scrape sample	N53 01.215 E5 12.154	16-08-14
126	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 01.217 E5 12.162	16-08-14
127	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 01.220 E5 12.159	16-08-14
Region G (Fig. 1): Kornwerderzand				
128	Dike, sheltered side, littoral zone	Visual inspection	N53 04.596 E5 20.113	16-08-14
129	Jetty	Scrape sample	N53 04.567 E5 20.114	16-08-14
130	Floating dock	Scrape sample	N53 04.525 E5 20.125	16-08-14
131	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 04.596 E5 20.090	16-08-14
132	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 04.567 E5 20.115	16-08-14
133	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 04.564 E5 20.112	16-08-14
134	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 04.525 E5 20.125	16-08-14
Region H (Fig. 1): Harlingen, Nieuwe Willemshaven				
135	Floating dock RWS	Visual inspection	N53 10.243 E5 24.803	08-10-14
136	Dike, sheltered side, littoral zone	Visual inspection	N53 10.413 E5 24.461	08-10-14
137	Dike, exposed side, littoral zone	Visual inspection	N53 10.563 E5 24.193	08-10-14
138	Floating dock RWS	Visual inspection	N53 10.243 E5 24.803	08-10-14
139	Dike, sheltered side, littoral zone	Visual inspection	N53 10.413 E5 24.461	08-10-14
140	Dike, exposed side, littoral zone	Visual inspection	N53 10.563 E5 24.193	08-10-14
Region I (Fig. 1): Holwerd				
141	Floating dock	Scrape sample	N53 23.710 E5 52.825	23-08-14
142	Dike, exposed side, littoral zone	Visual inspection	N53 23.710 E5 52.825	24-08-14
Region I (Fig. 1): Wierum				
143	Mussel beds, littoral zone	Visual inspection	N53 24.099 E5 58.471	24-08-14
Region I (Fig. 1): Moddergat				
144	Wadpaaltje, littoral zone	Visual inspection	N53 24.346 E6 04.685	24-08-14
Region I (Fig. 1): Lauwersoog, fishing harbour				
145	Dike, exposed side, littoral zone	Visual inspection	N53 24.593, E6 12.161	08-10-14
146	Floating dock	Visual inspection	N53 24.571, E6 12.349	08-10-14
147	Dike, sheltered side, littoral zone	Visual inspection	N53 24.576, E6 12.739	08-10-14
148	Floating dock, submerged rope	Visual inspection	N53 24.571, E6 12.349	08-10-14
149	Floating dock	Visual inspection	N53 24.571, E6 12.349	08-10-14
150	Floating dock, buoy	Visual inspection	N53 24.571, E6 12.349	08-10-14
151	turning rocks, littoral zone	Visual inspection	N53 24.593, E6 12.161	08-10-14
152	Bottom sample soft substrate, sublittoral zone	Visual inspection	N53 24.576, E6 12.739	08-10-14
153	Poles, sublittoral zone	Visual inspection	N53 24.599, E6 12.403	08-10-14
154	Poles, sublittoral zone	Visual inspection	N53 24.599, E6 12.403	08-10-14
155	Bottom sample soft substrate, sublittoral zone	Visual inspection	N53 24.593, E6 12.161	08-10-14
156	Dike, exposed side, littoral zone	Visual inspection	N53 24.593, E6 12.161	08-10-14
157	Dike, exposed side, bottom sample soft substrate, littoral zone		N53 24.593, E6 12.161	08-10-14

Location	Habitat	Method	Coordinates	Date
Region J (Fig. 1): Eemshaven				
158	Oyster reef, littoral zone	Visual inspection	N53 27.703 E6 49.916	19-09-14
159	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.703 E6 49.381	19-09-14
160	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.700 E6 49.398	19-09-14
161	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.694 E6 49.430	19-09-14
162	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.688 E6 49.467	19-09-14
163	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.682 E6 49.499	19-09-14
164	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.678 E6 49.524	19-09-14
165	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.675 E6 49.555	19-09-14
166	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.669 E6 49.589	19-09-14
167	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.663 E6 49.622	19-09-14
168	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 26.651 E6 49.702	19-09-14
169	Floating dock	Visual inspection	N53 26.684 E6 49.487	06-10-14
170	Floating dock	Visual inspection	N53 26.684 E6 49.487	06-10-14
171	Dike, sheltered side, littoral zone	Visual inspection	N53 26.635 E6 49.562	06-10-14
172	Dike, sheltered side, littoral zone	Visual inspection	N53 26.635 E6 49.562	06-10-14
Region J (Fig. 1): Nieuwstad				
173	Oyster reef, littoral zone	Visual inspection	N53 24.207 E6 53.108	19-09-14
Region J (Fig. 1): Delfzijl				
174	Oyster reef, littoral zone	Visual inspection	N53 20.577 E6 55.108	19-09-14
Region J (Fig. 1): Delfzijl, marina				
175	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 19.888 E6 55.912	19-09-14
176	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 19.883 E6 55.919	19-09-14
177	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 19.874 E6 55.930	19-09-14
178	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 19.868 E6 55.938	19-09-14
179	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 19.854 E6 55.947	19-09-14
180	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 19.840 E6 55.937	19-09-14
181	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 19.827 E6 55.926	19-09-14
182	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 19.806 E6 55.914	19-09-14
183	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 19.778 E6 55.898	19-09-14
184	Bottom sample soft substrate, sublittoral zone	Petit ponar	N53 19.744 E6 55.878	19-09-14
185	Floating dock	Visual inspection	N53 19.883, E6 55.864	06-10-14
186	Floating dock, buoy	Visual inspection	N53 19.763, E6 55.843	06-10-14
187	Dike, sheltered side, littoral zone	Visual inspection	N53 20.083, E6 56.234	06-10-14
188	Floating dock	Visual inspection	N53 19.883, E6 55.864	06-10-14
189	Floating dock, buoy	Visual inspection	N53 19.763, E6 55.843	06-10-14
190	Dike, sheltered side, littoral zone	Visual inspection	N53 20.083, E6 56.234	06-10-14
Region K (Fig. 1): Wadden Sea, sublittoral				
191	Sublittoral zone, mussel parcel	Mussel dredge	N53 12.670 E5 19.676	19-08-14
192	Sublittoral zone, mussel parcel	Petit ponar	N53 12.678 E5 19.667	19-08-14
193	Sublittoral zone, mussel parcel	Mussel dredge	N53 12.758 E5 20.579	19-08-14
194	Sublittoral zone, mussel parcel	Mussel dredge	N53 13.272 E5 14.043	19-08-14
195	Sublittoral zone, mussel parcel	Petit ponar	N53 13.333 E5 13.909	19-08-14
196	Sublittoral zone, mussel parcel	Mussel dredge	N53 13.457 E5 13.082	19-08-14
197	Sublittoral zone, mussel parcel	Petit ponar	N53 13.488 E5 12.996	19-08-14
198	Sublittoral zone, mussel parcel	Mussel dredge	N53 13.414 E5 12.383	19-08-14
199	Sublittoral zone, mussel parcel	Petit ponar	N53 13.420 E5 12.391	19-08-14
200	Sublittoral zone, mussel parcel	Mussel dredge	N53 13.611 E5 10.299	19-08-14
201	Sublittoral zone, mussel parcel	Petit ponar	N53 13.612 E5 10.298	19-08-14
202	Sublittoral zone, off the parcels	Mussel dredge	N53 13.050 E5 10.493	19-08-14
203	Sublittoral zone, off the parcels	Petit ponar	N53 13.051 E5 10.493	19-08-14

Location	Habitat	Method	Coordinates	Date
204	Sublittoral zone, off the parcels	Mussel dredge	N53 13.036 E5 10.069	19-08-14
205	Sublittoral zone, mussel parcel	Mussel dredge	N53 13.352 E5 08.855	19-08-14
206	Sublittoral zone, mussel parcel	Petit ponar	N53 13.479 E5 08.755	19-08-14
207	Sublittoral zone, mussel parcel	Mussel dredge	N53 13.619 E5 08.379	19-08-14
208	Sublittoral zone, mussel parcel	Petit ponar	N53 13.705 E5 08.325	19-08-14
209	Sublittoral zone, mussel parcel	Mussel dredge	N53 18.597 E5 16.473	19-08-14
210	Sublittoral zone, mussel parcel	Petit ponar	N53 18.598 E5 16.475	19-08-14
211	Sublittoral zone, mussel parcel	Mussel dredge	N53 19.193 E5 18.556	19-08-14
212	Sublittoral zone, mussel parcel	Petit ponar	N53 19.193 E5 18.556	19-08-14
213	Sublittoral zone, mussel parcel mainly oysters	Mussel dredge	N53 19.658 E5 23.472	19-08-14
214	Sublittoral zone, mussel parcel mainly oysters	Petit ponar	N53 19.658 E5 23.474	19-08-14
215	Sublittoral zone, mussel parcel (mussel seed and oysters)	Mussel dredge	N53 20.118 E5 25.919	19-08-14
216	Sublittoral zone, mussel parcel (mussel seed and oysters)	Petit ponar	N53 20.118 E5 25.919	19-08-14
217	Sublittoral zone, off the parcels, oyster reef	Mussel dredge	N53 20.848 E5 28.639	19-08-14
218	Sublittoral zone, off the parcels, oyster reef	Petit ponar	N53 20.848 E5 28.640	19-08-14
219	Sublittoral zone, off the parcels, mixed oyster/ mussel reef	Mussel dredge	N53 20.551 E5 26.413	19-08-14
220	Sublittoral zone, off the parcels, mixed oyster/ mussel reef	Petit ponar	N53 20.551 E5 26.415	19-08-14
221	Sublittoral zone, mussel parcel	Mussel dredge	N53 20.819 E5 22.219	19-08-14
222	Sublittoral zone, mussel parcel	Mussel dredge	N53 21.179 E5 22.560	19-08-14
223	Sublittoral zone, mussel parcel	Mussel dredge	N53 21.310 E5 22.292	19-08-14
224	Sublittoral zone, mussel parcel	Petit ponar	N53 21.311 E5 22.294	19-08-14
225	Sublittoral zone, mussel parcel with oysters	Mussel dredge	N53 22.519 E5 26.409	19-08-14
226	Sublittoral zone, mussel parcel with oysters	Petit ponar	N53 22.519 E5 26.409	19-08-14
227	Sublittoral zone, mussel parcel	Mussel dredge	N53 22.221 E5 25.273	19-08-14
228	Sublittoral zone, mussel parcel	Petit ponar	N53 22.221 E5 25.273	19-08-14
229	Sublittoral zone, off the parcels	Mussel dredge	N53 22.734 E5 24.576	19-08-14
230	Sublittoral zone, off the parcels	Petit ponar	N53 22.734 E5 24.575	19-08-14
231	Sublittoral zone, off the parcels, oyster reef	Mussel dredge	N53 22.937 E5 24.941	19-08-14
232	Sublittoral zone, off the parcels, oyster reef	Petit ponar	N53 22.938 E5 24.941	19-08-14
233	Sublittoral zone, off the parcels, mussel bank	Mussel dredge	N53 21.426 E5 20.078	19-08-14
234	Sublittoral zone, off the parcels, mussel bank	Petit ponar	N53 21.427 E5 20.079	19-08-14
235	Sublittoral zone, mussel parcel	Mussel dredge	N53 21.226 E5 18.313	19-08-14
236	Sublittoral zone, mussel parcel	Petit ponar	N53 21.225 E5 18.315	19-08-14
237	Sublittoral zone, mussel parcel with oysters	Mussel dredge	N53 20.602 E5 17.003	19-08-14
238	Sublittoral zone, mussel parcel with oysters	Petit ponar	N53 20.627 E5 17.047	19-08-14
239	Sublittoral zone, mussel parcel	Mussel dredge	N53 21.592 E5 14.515	19-08-14
240	Sublittoral zone, mussel parcel	Petit ponar	N53 21.592 E5 14.516	19-08-14
241	Sublittoral zone, off the parcels, oyster reef	Mussel dredge	N53 21.750 E5 14.710	19-08-14
242	Sublittoral zone, off the parcels, oyster reef	Mussel dredge	N53 21.749 E5 14.711	19-08-14
243	Sublittoral zone, mussel parcel	Mussel dredge	N53 05.597 E4 54.862	25-08-14
244	Sublittoral zone, mussel parcel	Petit ponar	N53 05.603 E4 54.873	25-08-14
245	Sublittoral zone, mussel parcel	Mussel dredge	N53 05.990 E4 55.173	25-08-14
246	Sublittoral zone, mussel parcel	Mussel dredge	N53 05.989 E4 55.177	25-08-14
247	Sublittoral zone, mussel parcel	Mussel dredge	N53 06.285 E4 55.930	25-08-14
248	Sublittoral zone, mussel parcel	Petit ponar	N53 06.522 E4 56.058	25-08-14
249	Sublittoral zone, mussel parcel	Mussel dredge	N53 06.522 E4 56.058	25-08-14
250	Sublittoral zone, mussel parcel	Petit ponar	N53 06.810 E4 56.395	25-08-14
251	Sublittoral zone, mussel parcel	Mussel dredge	N53 06.810 E4 56.396	25-08-14

Location	Habitat	Method	Coordinates	Date
252	Sublittoral zone, mussel parcel	Mussel dredge	N53 06.111 E5 02.276	25-08-14
253	Sublittoral zone, mussel parcel	Mussel dredge	N53 06.111 E5 02.276	25-08-14
254	Sublittoral zone, mussel parcel	Petit ponar	N53 06.111 E5 02.276	25-08-14
255	Sublittoral zone, mussel parcel	Mussel dredge	N53 06.344 E5 05.216	25-08-14
256	Sublittoral zone, mussel parcel	Petit ponar	N53 06.340 E5 05.245	25-08-14
257	Sublittoral zone, mussel parcel	Mussel dredge	N53 06.643 E5 06.455	25-08-14
258	Sublittoral zone, mussel parcel	Petit ponar	N53 06.643 E5 06.455	25-08-14
259	Sublittoral zone, mussel parcel	Mussel dredge	N53 07.237 E5 06.384	25-08-14
260	Sublittoral zone, mussel parcel	Petit ponar	N53 07.237 E5 06.384	25-08-14
261	Sublittoral zone, mussel parcel	Mussel dredge	N53 07.194 E5 07.114	25-08-14
262	Sublittoral zone, mussel parcel	Petit ponar	N53 07.182 E5 07.105	25-08-14
263	Sublittoral zone, mussel parcel	Mussel dredge	N53 05.603 E5 11.723	25-08-14
264	Sublittoral zone, mussel parcel	Petit ponar	N53 05.605 E5 11.723	25-08-14
265	Sublittoral zone, mussel parcel	Mussel dredge	N53 05.227 E5 12.716	25-08-14
266	Sublittoral zone, mussel parcel	Petit ponar	N53 05.226 E5 12.710	25-08-14
267	Sublittoral zone, mussel parcel	Mussel dredge	N53 05.093 E5 10.233	25-08-14
268	Sublittoral zone, mussel parcel	Petit ponar	N53 05.091 E5 10.234	25-08-14
269	Sublittoral zone, mussel parcel	Mussel dredge	N53 04.899 E5 09.306	25-08-14
270	Sublittoral zone, mussel parcel	Petit ponar	N53 04.899 E5 09.306	25-08-14
271	Sublittoral zone, mussel parcel	Mussel dredge	N53 04.857 E5 08.709	25-08-14
272	Sublittoral zone, mussel parcel	Petit ponar	N53 04.857 E5 08.709	25-08-14
273	Sublittoral zone, mussel parcel	Mussel dredge	N53 05.151 E5 06.490	25-08-14
274	Sublittoral zone, mussel parcel	Petit ponar	N53 05.151 E5 06.490	25-08-14
275	Sublittoral zone, mussel parcel	Mussel dredge	N53 04.725 E5 05.850	25-08-14
276	Sublittoral zone, mussel parcel	Petit ponar	N53 04.725 E5 05.849	25-08-14
277	Mussel spat collector	Visual inspection	N53 03.282 E5 04.567	25-08-14
278	Mussel spat collector	Visual inspection	N53 03.222 E4 58.766	25-08-14
279	Mussel spat collector	Visual inspection	N53 03.129 E4 58.202	25-08-14
280	Sublittoral zone, mussel parcel	Mussel dredge	N53 01.347 E5 04.366	25-08-14
281	Sublittoral zone, mussel parcel	Petit ponar	N53 01.348 E5 04.366	25-08-14
282	Sublittoral zone, mussel parcel	Mussel dredge	N53 00.037 E5 03.825	25-08-14
283	Sublittoral zone, mussel parcel	Petit ponar	N53 00.036 E5 03.825	25-08-14
284	Sublittoral zone, mussel parcel	Mussel dredge	N52 59.838 E5 05.379	25-08-14
285	Sublittoral zone, mussel parcel	Petit ponar	N52 59.838 E5 05.378	25-08-14
286	Sublittoral zone, off the parcels	Mussel dredge	N53 00.790 E5 10.868	25-08-14
287	Sublittoral zone, off the parcels	Petit ponar	N53 00.790 E5 10.868	25-08-14
288	Sublittoral zone, off the parcels	Mussel dredge	N53 02.304 E5 13.818	25-08-14
289	Sublittoral zone, off the parcels	Petit ponar	N53 02.304 E5 13.818	25-08-14
290	Sublittoral zone, off the parcels	Mussel dredge	N53 04.226 E5 16.863	25-08-14
291	Sublittoral zone, off the parcels	Petit ponar	N53 04.226 E5 16.864	25-08-14
292	sunlittoral zone oyster reef	Mussel dredge	N53 21.320 E6 54.160	30-10-14
293	sunlittoral zone oyster reef	Mussel dredge	N53 21.512 E6 54.039	30-10-14
294	sunlittoral zone oyster reef	Mussel dredge	N53 21.745 E6 53.902	30-10-14
295	sunlittoral zone oyster reef	Mussel dredge	N53 21.130 E6 54.280	30-10-14
296	Bottom sample soft substrate, sublittoral zone	Van Veen-Grab	N53 22.020 E6 53.960	30-10-14
297	Bottom sample soft substrate, sublittoral zone	Van Veen-Grab	N53 22.400 E6 53.860	30-10-14
298	Bottom sample soft substrate, sublittoral zone	Van Veen-Grab	N53 22.820 E6 53.680	30-10-14
299	Bottom sample soft substrate, sublittoral zone	Van Veen-Grab	N53 24.090 E6 53.410	30-10-14
300	Bottom sample soft substrate, sublittoral zone	Van Veen-Grab	N53 26.025 E6 53.160	30-10-14
301	Bottom sample soft substrate, sublittoral zone	Van Veen-Grab	N53 26.220 E6 53.160	30-10-14
302	Bottom sample soft substrate, sublittoral zone	Van Veen-Grab	N53 26.790 E6 52.660	30-10-14
303	Bottom sample soft substrate, sublittoral zone	Van Veen-Grab	N53 26.864 E6 52.697	30-10-14
304	Bottom sample soft substrate, sublittoral zone	Van Veen-Grab	N53 30.039 E6 42.400	30-10-14
305	Bottom sample soft substrate, sublittoral zone	Van Veen-Grab	N53 30.140 E6 44.940	30-10-14

Location	Habitat	Method	Coordinates	Date
Wadden Sea, littoral				
306	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 01.053 E5 08.992	20-08-14
307	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 01.033 E5 09.278	20-08-14
308	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 01.115 E5 08.135	20-08-14
309	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 01.094 E5 08.420	20-08-14
310	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 01.074 E5 08.706	20-08-14
311	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 05.171 E5 11.558	19-08-14
312	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 05.247 E5 11.819	19-08-14
313	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 04.946 E5 10.776	19-08-14
314	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 05.022 E5 11.037	19-08-14
315	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 05.096 E5 11.298	19-08-14
316	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 10.087 E5 19.278	19-08-14
317	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 09.480 E5 19.237	19-08-14
318	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 10.028 E5 18.418	19-08-14
319	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 10.048 E5 18.705	19-08-14
320	Bottom sample soft substrate, sublittoral zone	Van Veen-grab	N53 10.067 E5 18.992	19-08-14
321	bottom sample soft substrate, littoral zone	Hand corer	N53 10.250 E4 57.070	-
322	bottom sample soft substrate, littoral zone	Hand corer	N53 08.590 E4 58.350	-
323	bottom sample soft substrate, littoral zone	Hand corer	N53 10.530 E4 57.520	-
324	bottom sample soft substrate, littoral zone	Hand corer	N53 10.530 E5 00.520	-
325	bottom sample soft substrate, littoral zone	Hand corer	N53 15.380 E5 02.080	-
326	bottom sample soft substrate, littoral zone	Hand corer	N53 16.180 E5 07.200	-
327	bottom sample soft substrate, littoral zone	Hand corer	N53 12.610 E5 00.210	-
328	bottom sample soft substrate, littoral zone	Hand corer	N53 07.530 E4 59.440	-
329	bottom sample soft substrate, littoral zone	Hand corer	N53 07.530 E5 00.060	-
330	bottom sample soft substrate, littoral zone	Hand corer	N53 07.790 E4 56.950	-
331	bottom sample soft substrate, littoral zone	Hand corer	N53 07.620 E4 58.350	-
332	bottom sample soft substrate, littoral zone	Hand corer	N53 09.710 E5 00.820	-
333	bottom sample soft substrate, littoral zone	Hand corer	N53 16.230 E5 00.520	-
334	bottom sample soft substrate, littoral zone	Hand corer	N53 14.850 E5 03.480	-
335	bottom sample soft substrate, littoral zone	Hand corer	N53 14.560 E5 05.810	-
336	bottom sample soft substrate, littoral zone	Hand corer	N53 11.940 E5 04.870	-
337	bottom sample soft substrate, littoral zone	Hand corer	N53 19.770 E5 25.930	-
338	bottom sample soft substrate, littoral zone	Hand corer	N53 17.050 E5 28.210	-
339	bottom sample soft substrate, littoral zone	Hand corer	N53 12.160 E5 07.260	-
340	bottom sample soft substrate, littoral zone	Hand corer	N53 23.300 E5 25.330	-
341	bottom sample soft substrate, littoral zone	Hand corer	N53 25.250 E5 30.040	-
342	bottom sample soft substrate, littoral zone	Hand corer	N53 16.230 E5 26.970	-
343	bottom sample soft substrate, littoral zone	Hand corer	N53 15.690 E5 26.570	-
344	bottom sample soft substrate, littoral zone	Hand corer	N53 20.640 E5 33.770	-
345	bottom sample soft substrate, littoral zone	Hand corer	N53 22.690 E5 39.820	-
346	bottom sample soft substrate, littoral zone	Hand corer	N53 18.690 E5 34.700	-
347	bottom sample soft substrate, littoral zone	Hand corer	N53 24.800 E5 40.280	-
348	bottom sample soft substrate, littoral zone	Hand corer	N53 24.940 E5 40.160	-
349	bottom sample soft substrate, littoral zone	Hand corer	N53 25.150 E5 53.800	-
350	bottom sample soft substrate, littoral zone	Hand corer	N53 11.340 E5 02.260	-
351	bottom sample soft substrate, littoral zone	Hand corer	N53 22.760 E5 23.190	-

Location	Habitat	Method	Coordinates	Date
352	bottom sample soft substrate, littoral zone	Hand corer	N53 15.150 E5 25.690	-
353	bottom sample soft substrate, littoral zone	Hand corer	N53 16.510 E5 29.570	-
354	bottom sample soft substrate, littoral zone	Hand corer	N53 17.870 E5 31.820	-
355	bottom sample soft substrate, littoral zone	Hand corer	N53 28.740 E6 40.020	-
356	bottom sample soft substrate, littoral zone	Hand corer	N53 15.730 E7 12.090	-
357	bottom sample soft substrate, littoral zone	Hand corer	N53 15.980 E7 10.690	-
358	bottom sample soft substrate, littoral zone	Hand corer	N53 25.750 E5 47.280	-
359	bottom sample soft substrate, littoral zone	Hand corer	N53 27.580 E6 25.480	-
360	bottom sample soft substrate, littoral zone	Hand corer	N53 26.230 E6 13.840	-
361	bottom sample soft substrate, littoral zone	Hand corer	N53 24.890 E6 04.050	-
362	bottom sample soft substrate, littoral zone	Hand corer	N53 29.290 E6 17.290	-
363	bottom sample soft substrate, littoral zone	Hand corer	N53 26.230 E6 10.110	-
364	bottom sample soft substrate, littoral zone	Hand corer	N53 26.430 E6 18.970	-
365	bottom sample soft substrate, littoral zone	Hand corer	N53 21.660 E5 44.480	-
366	bottom sample soft substrate, littoral zone	Hand corer	N53 24.120 E5 52.380	-
367	bottom sample soft substrate, littoral zone	Hand corer	N53 24.120 E5 52.380	-
368	bottom sample soft substrate, littoral zone	Hand corer	N53 06.040 E5 16.060	-
369	bottom sample soft substrate, littoral zone	Hand corer	N53 27.650 E6 16.560	-
370	bottom sample soft substrate, littoral zone	Hand corer	N53 25.480 E6 21.100	-
371	bottom sample soft substrate, littoral zone	Hand corer	N53 20.310 E5 13.230	-
372	bottom sample soft substrate, littoral zone	Hand corer	N53 07.260 E5 13.830	-
373	bottom sample soft substrate, littoral zone	Hand corer	N53 25.470 E5 53.340	-
374	bottom sample soft substrate, littoral zone	Hand corer	N53 09.710 E5 04.250	-
375	bottom sample soft substrate, littoral zone	Hand corer	N53 16.230 E5 14.540	-
376	bottom sample soft substrate, littoral zone	Hand corer	N53 23.030 E5 45.050	-
377	bottom sample soft substrate, littoral zone	Hand corer	N53 26.290 E5 44.530	-
378	bottom sample soft substrate, littoral zone	Hand corer	N53 24.940 E5 40.750	-
379	bottom sample soft substrate, littoral zone	Hand corer	N53 22.490 E5 48.710	-
380	bottom sample soft substrate, littoral zone	Hand corer	N52 58.780 E4 59.750	-
381	bottom sample soft substrate, littoral zone	Hand corer	N53 19.770 E5 36.390	-
382	bottom sample soft substrate, littoral zone	Hand corer	N53 21.940 E5 43.160	-
383	bottom sample soft substrate, littoral zone	Hand corer	N53 26.290 E5 45.150	-
384	bottom sample soft substrate, littoral zone	Hand corer	N53 24.770 E6 09.180	-
385	bottom sample soft substrate, littoral zone	Hand corer	N53 26.380 E6 15.240	-
386	bottom sample soft substrate, littoral zone	Hand corer	N53 25.730 E6 18.500	-
387	bottom sample soft substrate, littoral zone	Hand corer	N53 27.100 E6 18.500	-
388	bottom sample soft substrate, littoral zone	Hand corer	N53 29.830 E6 20.530	-
389	bottom sample soft substrate, littoral zone	Hand corer	N53 15.630 E7 10.690	-
390	bottom sample soft substrate, littoral zone	Hand corer	N53 17.600 E7 08.650	-
391	bottom sample soft substrate, littoral zone	Hand corer	N53 28.740 E6 32.210	-
392	bottom sample soft substrate, littoral zone	Hand corer	N53 28.690 E6 31.080	-
393	bottom sample soft substrate, littoral zone	Hand corer	N53 26.020 E6 02.110	-
394	bottom sample soft substrate, littoral zone	Hand corer	N53 26.820 E6 34.340	-
395	bottom sample soft substrate, littoral zone	Hand corer	N53 28.520 E6 39.470	-
396	bottom sample soft substrate, littoral zone	Hand corer	N53 27.930 E6 46.760	-
397	bottom sample soft substrate, littoral zone	Hand corer	N53 16.240 E7 08.320	-
398	bottom sample soft substrate, littoral zone	Hand corer	N53 28.960 E6 32.940	-
399	bottom sample soft substrate, littoral zone	Hand corer	N53 14.600 E5 13.660	-

Location	Habitat	Method	Coordinates	Date
400	bottom sample soft substrate, littoral zone	Hand corer	N53 31.660 E6 30.150	-
401	bottom sample soft substrate, littoral zone	Hand corer	N53 00.180 E5 01.300	-
402	bottom sample soft substrate, littoral zone	Hand corer	N52 54.510 E4 55.350	-
403	bottom sample soft substrate, littoral zone	Hand corer	N52 55.050 E4 55.460	-
404	bottom sample soft substrate, littoral zone	Hand corer	N53 16.360 E5 18.390	-
405	bottom sample soft substrate, littoral zone	Hand corer	N53 24.590 E5 36.090	-
406	bottom sample soft substrate, littoral zone	Hand corer	N53 21.670 E5 28.180	-
407	bottom sample soft substrate, littoral zone	Hand corer	N53 21.800 E5 26.780	-
408	bottom sample soft substrate, littoral zone	Hand corer	N53 00.990 E5 00.230	-
409	bottom sample soft substrate, littoral zone	Hand corer	N52 59.950 E4 59.750	-
410	bottom sample soft substrate, littoral zone	Hand corer	N53 21.940 E5 31.830	-
411	bottom sample soft substrate, littoral zone	Hand corer	N53 27.660 E6 30.610	-
412	bottom sample soft substrate, littoral zone	Hand corer	N53 22.190 E6 55.310	-
413	bottom sample soft substrate, littoral zone	Hand corer	N53 22.250 E6 55.780	-
414	bottom sample soft substrate, littoral zone	Hand corer	N53 16.510 E5 19.990	-
415	bottom sample soft substrate, littoral zone	Hand corer	N52 56.130 E5 00.470	-
416	bottom sample soft substrate, littoral zone	Hand corer	N53 13.790 E5 19.270	-
417	bottom sample soft substrate, littoral zone	Hand corer	N52 55.860 E4 51.920	-
418	bottom sample soft substrate, littoral zone	Hand corer	N52 54.240 E4 53.380	-
419	bottom sample soft substrate, littoral zone	Hand corer	N52 54.510 E4 54.480	-
420	bottom sample soft substrate, littoral zone	Hand corer	N53 11.940 E5 12.800	-
421	bottom sample soft substrate, littoral zone	Hand corer	N53 11.880 E5 13.130	-
422	bottom sample soft substrate, littoral zone	Hand corer	N52 55.710 E4 56.020	-
423	bottom sample soft substrate, littoral zone	Hand corer	N52 55.860 E4 53.940	-
424	bottom sample soft substrate, littoral zone	Hand corer	N52 57.220 E4 49.960	-

Appendix II

Species found during de Wadden Sea inventory in 2014, and the locations (Appendix I) were they were found.

Species	Location
Algae	
Acinetospora crinita	1, 34
Acrochaetium secundatum	1, 241, 242
Aglaothamnion hookeri	46, 136
Aglaothamnion pseudobyssoides	27, 125, 148, 241, 242
Aglaothamnion roseum	88, 94, 145, 146
Aglaothamnion tenuissimum	11, 124, 128
Antithamnionella spirographidis	2, 14, 18, 19, 30, 31, 33, 34, 35, 37, 41, 59, 94, 145, 146, 148, 169, 170, 172, 229, 233, 241, 242, 249
Ascophyllum nodosum	6, 7, 25, 26, 39, 40, 46, 62, 124, 128, 136, 137, 138, 140, 171, 172, 174, 187, 190, 223
Blidingia marginata	19, 20, 22, 28, 31, 65, 112, 124, 128, 130, 141, 143, 144, 172, 187
Blidingia minima	6, 35, 136
Bryopsis hypnoides	30, 34, 42, 43
Bryopsis plumosa	6, 8, 11, 31, 39, 60, 95
Callithamnion corymbosum	43, 146, 169
Ceramium botryocarpum	245, 246, 251, 255
Ceramium cimbricum	1, 11, 12, 14, 18, 19, 26, 31, 34, 35, 41, 42, 43, 46, 229, 233, 249, 279
Ceramium deslongchampsii	37
Ceramium tenuicorne	12, 31, 94, 146, 169
Ceramium virgatum	1, 2, 11, 14, 37, 41, 59, 76, 200, 207, 217, 219, 231, 232, 239, 241, 242, 243, 246, 253, 277, 311
Chaetomorpha ligustica	246, 259, 261, 281
Chaetomorpha linum	65, 70, 71, 92, 144, 193, 196, 209, 422
Chondrus crispus	1, 2, 8, 11, 26, 46, 76, 99, 124, 158
Cladophora cf dalmatica	11
Cladophora hutchinsiae	245, 246
Cladophora laetevirens	249
Cladophora sericea	12, 14, 94, 143, 379
Cladophora vagabunda	14
Codium fragile atlanticum	14
Codium fragile fragile	26, 42
Colpomenia peregrina	14, 26
Dasysiphonia japonica	94
Ectocarpus siliculosus	241, 242
Elachista fucicola	145, 187
Erythrotrichia bertholdii	1, 146, 277, 279
Erythrotrichia carnea	1, 31, 34, 35, 41, 46, 63, 124, 145, 146, 241, 242, 245, 246, 311
Fucus spiralis	7, 41, 48, 66, 91, 94, 115, 145, 146, 147, 171, 187

Species	Location
Fucus vesiculosus	6, 12, 15, 16, 25, 26, 27, 28, 29, 31, 39, 40, 41, 42, 43, 44, 46, 47, 48, 60, 62, 63, 64, 65, 76, 77, 81, 82, 87, 95, 98, 108, 112, 124, 128, 133, 136, 137, 138, 141, 142, 143, 145, 147, 150, 151, 154, 155, 156, 158, 170, 171, 173, 185, 187, 188, 190, 193, 213, 223, 225, 227, 237, 259
Gracilaria gracilis	28, 29, 39, 40, 41, 63, 66, 73, 77, 81, 87, 112, 187, 200, 217, 232
Gracilaria vermiculophylla	6, 27, 63, 65, 76, 77, 81, 87, 92, 112, 142, 143, 144, 200, 207, 231, 239, 249, 292, 294, 394
Gracilariopsis longissima	27, 72, 241, 242, 245, 251, 253, 329
Hincksia granulosa	146, 277, 279
Hincksia sandriana	11, 241, 242
Hypoglossum hypoglossoides	231, 233, 243, 245, 247, 249, 251, 255, 278, 279
Mastocarpus stellatus	6, 8, 13, 46, 48, 99, 171, 172, 173
Neosiphonia harveyi	1, 2, 11, 12, 14, 15, 23, 26, 27, 29, 30, 31, 34, 35, 42, 43, 145, 146, 170, 277, 279
Polysiphonia fucoides	37, 41, 60, 61, 124, 241, 242, 277
Polysiphonia nigra	231, 245, 246, 251, 255, 277
Polysiphonia stricta	13, 14, 15, 16, 19, 108, 128, 130, 185
Porphyra purpurea	141
Porphyra umbilicalis	88, 142, 147, 158, 174, 187, 241, 242
Pterothamnion plumula	26, 30
Pylaiella littoralis	33, 46, 136, 145
Rhizoclonium riparium	27, 29, 30, 46, 108, 124, 249
Sargassum muticum	3, 5, 6, 10, 26, 30, 31, 40, 41, 43, 47, 95, 241, 242, 249
Spongonema tomentosum	37
Stylonema alsidii	37, 41, 145, 200, 207, 239, 241, 242, 245, 246, 249, 277, 311
Ulothrix flacca	124
Ulva cf lactuca	15, 26, 31, 39, 60, 64, 88, 174
Ulva clathrata	12, 15, 20, 21, 25
Ulva compressa	11, 14, 16, 31, 33, 34, 43, 46, 48, 63, 76, 125, 126, 145, 146, 200, 201, 203, 207, 210, 212, 225, 227, 228, 231, 239, 241, 242, 246, 259, 261, 281, 289, 351, 355, 360
Ulva curvata	27, 60, 75, 77, 81, 87, 88, 92, 126, 130, 141, 142, 143, 144, 147, 173, 191, 193, 194, 196, 198, 200, 202, 203, 204, 207, 208, 209, 211, 213, 217, 219, 221, 222, 223, 225, 229, 233, 235, 239, 398, 414
Ulva flexuosa	12, 23, 29, 34, 169, 245, 246, 253, 259, 261, 275, 278, 281, 283, 285, 340, 407
Ulva intestinalis	2, 12, 16, 26, 31, 35, 37, 40, 46, 81, 88, 92, 94
Ulva linza	1, 48, 87, 125, 130, 158, 328, 331, 334
Ulva pertusa	1, 2, 6, 14, 30, 31, 35, 42, 43, 46, 48, 62, 63, 65, 94, 112, 125, 135, 145, 169, 170, 231, 243, 244, 245, 246, 249, 251, 253, 255, 257, 259, 261, 263, 265, 267, 269, 273, 280, 282
Ulva prolifera	1, 27, 28, 29, 41, 66, 76, 77, 81, 87, 92, 100, 106, 128, 145, 200, 212, 227, 231, 237, 239, 277, 279, 322, 347, 353, 378, 391, 392, 410
Ulva pseudocurvata	37, 158, 187, 336
Ulva ralfsii	200, 207, 231, 233
Ulva rigida	8, 15, 16, 26, 31, 95, 237, 239
Ulva torta	35, 185, 200, 201, 207, 212, 227, 231, 239, 279, 371, 395
Undaria pinnatifida	42, 43, 44, 231
Urospora neglecta	124
Vertebrata lanosa	136

Species	Location
Annelida	
Alitta succinea	26, 28, 31, 135, 142, 211, 213, 215, 217, 219, 225, 227, 233, 246, 247, 255, 259, 263, 279, 284, 285, 318, 319, 356, 357, 363, 390, 397, 403, 412
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