Native and non-native species of the Dutch Wadden Sea in 2018

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Poles in the littoral zone near Moddergat (location 286)

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1.1 Samenvatting

In het voorjaar en in de zomer van 2018 werden inventarisaties uitgevoerd van de mariene flora en fauna in het Nederlandse gedeelte van de Waddenzee, met de focus op exoten. Hierbij werden zowel inheemse als uitheemse soorten gescoord op 570 verschillende tijdstippen en/of locaties. Om zoveel mogelijk soorten vast te kunnen stellen werden verschillende bemonsteringsmethoden gebruikt. Zo werden soorten op drijvende steigers snorkelend bemonsterd, werd aangroei vastgesteld op in zee uitgehangen pvc platen en werden stenen en rotsen in de litorale zone omgedraaid bij laag water. Verder werden ook sublitorale locaties zoals schelpdierbanken bemonsterd vanaf een schip met een kor. Voor het monitoren van soorten in zachte substraten, werden bodemmonsters genomen in het litoraal binnen het SIBES-project, en in het sublitoraal met een Petite Ponar of een Van Veen-happer. Wat pelagische organismen betreft, is vooral onderzoek gedaan naar het voorkomen van uitheemse kwallen met behulp van een 500µm zoöplanktonnet. Tenslotte zijn er monsters genomen van de drijvende steigers, vanuit de waterkolom en van de bodem in de haven van Oudeschild, om te onderzoeken in hoeverre metabarcoding / e-DNA analyses effectief gebruikt kunnen worden binnen soorten-inventarisaties. De monsters voor e-DNA analyse werden in het voorjaar genomen en geanalyseerd vóór de tweede onderzoeksperiode in de nazomer. Zo kon tijdens de tweede onderzoeksperiode specifiek gezocht worden naar soorten die op het zicht niet waren vastgesteld, maar waarvan het genetisch materiaal wel was aangetoond binnen de DNA-analyses. In totaal werden er met alle methodes gezamenlijk 226 soorten gevonden, waarvan er 51 vermoedelijk uitheems zijn voor Nederland. Voor zeven van deze soorten blijft dit onduidelijk aangezien het onbekend is wat het natuurlijke verspreidingsgebied van deze "cryptogene" soorten is. In vergelijking met de uitheemse soorten die al bekend waren voor de Waddenzee na de voorgaande exoten-inventarisatie in 2014, zijn er zeven "nieuwe" uitheemse soorten in 2018 waargenomen: de zeewiersoorten *Caulacanthus okamurae*, *Ceramium sungminbooi*, *Dasya sessilis*, *Polysiphonia senticulosa* en *Ulvaria splendens*, het mosdiertje *Schizoporella* cf. *japonica* en de twee-kleppige *Mulinia lateralis*. In aanvulling op de inventarisatie is een literatuurstudie uitgevoerd en werd gekeken naar nog ongepubliceerde waarnemingen van uitheemse soorten in de Nederlandse Waddenzee. In combinatie met de huidige inventarisatie resultaten konden hiermee in het totaal elf nieuwe uitheemse soorten voor de Waddenzee worden geregistreerd. Hoewel een deel van deze soorten zich vermoedelijk pas na 2014 heeft weten te vestigen in de Waddenzee, valt niet uit te sluiten dat enkele van deze soorten bij eerdere inventarisaties zijn gemist, en mogelijk dus al langer aanwezig zijn. In totaal zijn er in de Nederlandse Waddenzee tot en met de inventarisaties in 2018, 93 uitheemse mariene soorten waargenomen. Uit de exoten-inventarisaties die in de Waddenzee zijn uitgevoerd in 2009, 2011, 2014 en 2018 blijkt dat het aantal uitheemse soorten dat zich in de Waddenzee weet te vestigen gestaag blijft toenemen. Zo werden tijdens deze inventarisaties respectievelijk 11, 8, 9 en 7 uitheemse soorten gevonden die als nieuw werden geregistreerd voor de Nederlandse Waddenzee. Drie van deze soorten in 2018 waren ook nieuw waren voor Nederland. Nieuw waren: de zeewiersoort *Ulvaria splendens*, het mosdiertje *Schizoporella* cf *japonica* en de tweekleppige *Mulinia lateralis* (sinds 2017 in de Nederlandse Waddenzee). In 2018 was Texel de voornaamste "hotspot" wat betreft nieuwe introducties. Vier van de zeven "nieuwe" uitheemse soorten werden rondom Texel gevonden. Naast deze "nieuwe" soorten kon in 2018 voor meerdere uitheemse soorten die voor het eerst in de Waddenzee waren waargenomen tijdens de exoten-inventarisaties in 2009, 2011 en 2014, worden vastgesteld dat deze

zich sindsdien sterk verspreid hebben over het gebied. Zo werd de zeewiersoort *Dasysiphonia japonica* bijvoorbeeld voor het eerst aangetroffen in 2014. Toen werd deze soort alleen in de haven van Den Helder vastgesteld. In 2018 werd hij daar ook gevonden, en bleek hij zich bovendien gevestigd te hebben op verschillende locaties rond Texel en Terschelling. Ook het in 2014 voor het eerst in de Nederlandse Waddenzee aangetroffen mosdiertje *Tricellaria inopinata* had zijn verspreidingsgebied uitgebreid. Terwijl deze soort in 2014 alleen in de westelijke Waddenzee was gevonden, bij Den Helder, Texel, Vlieland en Terschelling, bleek hij in 2018 ook wijd verspreid in het oostelijke gedeelte aanwezig te zijn op locaties bij Ameland, Holwerd en de Eemshaven. Het is onduidelijk in hoeverre deze distributie uitbreidingen in relatie staan tot het feit dat de zomer van 2018 de warmste zomer was in de afgelopen drie eeuwen, zoals aangegeven door het KNMI. Voor sommige soorten, zoals het mosdiertje *Smittoidea prolifica*, is dit mogelijk juist een reden geweest van de afname in de verspreiding. Deze exoot werd in 2014 op diverse plekken in de centrale Waddenzee en bij Texel en Terschelling aangetroffen, maar kon in 2018 alleen nog maar worden vastgesteld bij Terschelling en een enkele plek nabij Delfzijl. Hoewel het, gezien de warme zomer, de verwachting was dat vooral uitheemse soorten gevestigd ten zuiden van Nederland gevonden zouden worden, bleek dit niet het geval te zijn. Zo is de “nieuw” aangetroffen uitheemse zeewiersoort *Ulvaria splendens* oorspronkelijk beschreven uit Alaska, en vooral bekend van noord Europese wateren. Ook het mosdiertje *Schizoporella* cf. *japonica* was in de Noordzee voorheen alleen bekend van noordelijke locaties voor de kusten van de Britse eilanden en Noorwegen. Aangezien de reststroom langs de west Europese kust een noordelijke richting heeft, is het niet mogelijk dat deze soorten zich via natuurlijke verspreiding hebben uitgebreid naar de Nederlandse kust. Beide soorten zouden in principe vanuit de noordelijke Noordzee in de Nederlandse Waddenzee geïntroduceerd kunnen zijn als aangroei op schepen, wat een bekende verspreidingsvector van deze soorten is. Een andere mogelijke vector betreft het transport van 80000 platte oesters, Ostrea edulis, die voor de kust van Noorwegen zijn verzameld en in mei 2018 in Nederlandse wateren zijn uitgezet in een gebied ten noorden van Schiermonnikoog met als doel daar de platte oester te herintroduceren. Bij deze transporten werd een protocol gevolgd dat specifiek gericht is op het minimaliseren van de kans dat uitheemse soorten mee zouden worden ingevoerd. Het blijft daarom onduidelijk wat de introductievector is geweest van deze nieuw in de Waddenzee aangetroffen “noordelijke” uitheemse soorten. Het achterhalen van dergelijke importvectoren wordt verder bemoeilijkt doordat mosdiertjes en zeewieren in geen van de standaard monitorings-programma’s langs de Nederlandse kust specifiek worden onderzocht. Daarom is het onduidelijk in hoeverre deze soorten al vóór 2018 aanwezig waren in de Waddenzee. Voor een uitheemse soort zoals het zeewier *Polysiphonia senticulosa*, dat voor het eerst in de Waddenzee werd aangetroffen in 2018, is het waarschijnlijk dat deze bij de voorgaande exoten-inventarisaties in de Waddenzee gemist is, aangezien die altijd alleen in de zomer plaats vonden. In 2018 werd daarom ook een voorjaars-inventarisatie uitgevoerd, met als resultaat dat deze soort werd aangetroffen. *Polysiphonia senticulosa* is uit Zeeland bekend als een soort die vooral in de winter en het voorjaar in hoge aantallen aanwezig is, terwijl hij moeilijk tot niet te vinden is in de zomer. Zo illustreren de resultaten dat, hoewel de meeste soorten in de zomer worden vastgesteld, een additieve voorjaars-inventarisatie kan resulteren in de detectie van uitheemse soorten die in de zomer worden gemist.

1.2 Summary

In the spring and summer of 2018, a rapid assessment was done of the marine algae and macrofauna of both the hard substrata and soft substrata in the Dutch Wadden Sea. The diversity of native and non-native species was assessed 570 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 hereby used ranging from snorkelling, deploying settlement plates and using gelatinous zooplankton nets, to turning over rocks at low tide, and dredging shellfish beds. For assessing species in soft substrata, bottom samples were taken with a hand corer as part of the SIBES project, a petit ponar and a van Veen-grab. In the harbour of Oudeschild, as a pilot for the application of metabarcoding / e-DNA analyses, additional samples for DNA-extraction were taken from the floating docks, the water column and from the bottom. These samples were taken in spring and analysed before the second survey period in late summer with the aim of increasing the chance of detecting additional alien species during that second survey.

In total 226 species were found of which 51 are probably non-native to the Netherlands. For seven of these species it remains uncertain whether they are non-native as their native range is unknown in literature, i.e. they are considered cryptogenic.

In comparison with the list of alien species known for the Dutch Wadden Sea after the previous alien species focused survey in 2014, seven species were recorded in 2018 for the first time: the algal species *Caulacanthus okamurae*, *Ceramium sungminbooi*, *Dasya sessilis*, *Polysiphonia senticulosa* and *Ulvaria splendens*, the bryozoan *Schizoporella* cf. *japonica* and the bivalve *Mulinia lateralis*. 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 2018 inventory, in total eleven species were added to the list of non-native species known for the Dutch Wadden Sea. This raised the total number of alien species on this list to 93 in 2018. Although some of the "new" non-natives may have been missed in prior monitoring efforts, others may concern recent introductions.

The number of alien species that is recorded for the Wadden Sea is steadily increasing, as is illustrated by the alien species focused inventories that were conducted in the region in 2009, 2011, 2014 and 2018. During these surveys respectively 11, 8, 9 and 7 new alien species to the region were found. Of the species recorded as new to the region in 2018, three are new for the Netherlands, i.e. the macro-algal species *Ulvaria splendens*, the bryozoan *Schizoporella* cf. *japonica* and the bivalve *Mulinia lateralis* (since 2017 in the Wadden Sea). In 2018, Texel concerned the main alien species hotspot as four of the seven of new species for the Wadden Sea were first found off Texel, i.e. the macro-algal species *C. okamurae*, *D. sessilis*, and *U. splendens*, and the bryozoan *Schizoporella* cf. *japonica*.

Some species have substantially expanded their range within the Wadden Sea after they were initially recorded during the inventories of 2009, 2011 and 2014. For example, the algal species *Dasysiphonia japonica* was first recorded for the Wadden Sea in 2014. It was then only found in Den Helder. In 2018 this species was also recorded in the port of Den Helder but additionally at several locations off Texel and Terschelling. Similarly the alien bryozoan *Tricellaria inopinata* has expanded its range. When it was first recorded in 2014, it was only recorded for the western part of the Wadden Sea including sites off Terschelling, Vlieland, Texel and Den Helder. In 2018 the species was found at the same localities but also in the eastern part including locations off Ameland, Holwerd and Eemshaven. It is unclear to what degree the range expansions

of these non-native species may have to do with the fact that the summer of 2018 was the warmest in three centuries (www.knmi.nl). For some alien species, like the bryozoan *Smittoidea prolifica*, this warm summer may have caused a decline in its population. In 2014 it was recorded from the central Wadden Sea, off Texel and off Terschelling. In 2018, however, its range appeared to have declined as it was only recorded off Terschelling and at one site off Delfzijl.

In 2018 the settlement of alien species coming from the south of the Netherlands was expected, because of the relatively warm summer. However, the species that were recorded in 2018 as new to the Wadden Sea do not specifically concern species with preferences for warm waters. The macro-algal species *Ulvaria splendens* for example, concerns a species originally described from Alaska. It is mostly known from northern European countries with colder waters relative to the Netherlands. Its record in the Wadden Sea concerns the first record of a settled specimen in Dutch waters. For the Pacific bryozoan *Schizoporella* cf. *japonica*, known records of settled colonies in the North Sea, concern a large number of sites to the north, i.e. off northern Great Britain and off Norway. As the residual sea currents along the western European mainland coast are directed to the north, it is unlikely that these species have reached the region by their natural dispersal. Both species are known from hull-fouling communities, indicating that they may have been introduced by ships and pleasure crafts, possibly coming from the north. Another potential vector may have been oyster imports as in May of 2018 about 80,000 oysters from Norway were placed in outer waters above the Wadden Sea island Schiermonnikoog aiming at promoting the recovery of native flat oyster populations along the Dutch coastline. For these oysters a treatment protocol was followed, which was specifically focused on minimizing the chance of importing alien species. The introduction vector of these newly recorded alien species therefore remains uncertain. Identifying the introduction vector of such species is further complicated by the fact that the last alien species focused survey in the Wadden Sea was conducted in 2014, and small bryozoans and macro-algae are not the focus of any of the ongoing monitoring programs in the region. It therefore remains unclear whether these species were not already present in the Wadden Sea prior to 2018. For example, for a species like the newly recorded macro-algae *Polysiphonia senticulosa*, it is very likely that it was missed during the previous alien species focused inventories, which were conducted in mid to late summer. An additional survey period in spring was included in the 2018 survey for recording also alien species that are not abundant in summer time, like *P. senticulosa*. This species is known to occur in high densities from about winter to spring in for example Zeeland, while being hard to impossible to find in summer. This illustrates that although most alien species are found during a summer survey, including also a spring survey can result in the discovery of additional alien species.

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, German and Danish parts of the Wadden Sea, on the World Heritage List. This inscription of the Danish-German-Dutch Wadden Sea on the UNESCO World Heritage List has further strengthened combined efforts to protect, conserve and manage this area. To support trilateral discussions on managing the risk of alien species within the Wadden Sea, the Dutch Office for Risk Assessment and Research (BuRO) of the Netherlands Food and Consumer Product Safety Authority, has issued a marine alien species focused survey of the Dutch Wadden Sea in 2018. This concerns a follow up study of three similar inventories done in 2009, 2011 and 2014 (Gittenberger *et al.*, 2010; Gittenberger *et al.*, 2012; Gittenberger *et al.*, 2015). The focus of the 2009 and 2011 inventories was on species that live in association with hard substrates only, 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 and 2018 inventories have focused additionally on species that live in and on the sandy bottoms of the Wadden Sea. For an even more complete overview of alien species present, the 2018 surveys were done both in spring and in summer while during previous surveys only a (late) summer survey was included. The spring survey was included to record alien species that may occur mainly in winter to spring, while being absent or rare in summer. Another optimization of the survey in 2018 in comparison to previous years, concerns the addition of two sampling methods, which may increase the detection chance of alien species present, i.e. the deployment of settlement plates and the use gelatinous zooplankton nets. Locally, in the harbour of Oudeschild, as a pilot the application of eDNA/metabarcoding analyses were tested on the basis of samples taken from the bottom, water column and floating docks. By doing these analyses on samples taken in spring, the results could be used in support of the survey done in late summer, for example by searching more specifically for alien species identified by the DNA-analyses.

The main goals of the alien species focused inventory of the Wadden Sea in 2018 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 in the Dutch Wadden Sea.

[4] To make comparisons with the results of the inventories of 2009, 2011 and 2014, where it concerns the spread of these alien species over the Wadden Sea.

[5] To assess and discuss which alien species were recorded in previous inventories, but not in the 2018 inventory.

[6] To assess and discuss which species were first recorded in the Wadden Sea during the 2018 inventory.

3 Materials and methods

3.1 Locations

For assessing the species communities, 573 samples were taken and/or local species assessments were done at different times and from different habitats (Figs 1-2; Appendix II). To assess the water parameters pH, salinity and turbidity, 111 surface water samples were taken. In the analyses of the data, eleven regions within the Wadden Sea were distinguished, as was also done by Gittenberger *et al.* (2010, 2012, 2015), 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).

To make comparisons between the inventory in 2018 and the inventories in 2009, 2011 and 2014 (Gittenberger *et al.*, 2010, 2012, 2015) the same locations or locations close by were searched for species (Figs 1-2). Where it concerns hard subatratum related 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 also sampled intensively. This was done because shellfish aquacultural activities in general are often linked to the dispersal of non-native species (Gittenberger *et al.*, 2017). In total 319 samples were taken to assess the diversity in the hard substrates of the Wadden Sea (Fig. 1; Table 1; Appendix II).

Soft substratum assosiated species were sampled in both the littoral and sublittoral zones of the Wadden Sea (Fig. 2). The selection of locations for assessing soft substrate related species, was done on the basis of the “sof substrate” locations included in the alien species focused survey of 2014 (Gittenberger *et al.*, 2015: Fig. 2). Hereby the same locations or locations close by were selected. Most of these locations are more or less randomly spread over the entire Wadden Sea. A selection of locations was not randomly spread however: As was also done during the survey in 2014, harbour areas and areas with mussel beds and oyster reefs were specificallty included as sampling locations as they are known as potential places where non-native species may be imported by shipping and aquaculture activities. In total 197 bottom samples were taken to assess the diversity in the soft substrates of the Wadden Sea (Fig. 2; Table 1; Appendix II).

For also assessing the presence of pelagic gelatinous alien species, in total 54 gelatinous zooplankton net samples were taken to assess the diversity of gelatinous zooplankton (Table 1; Appendix II). These samples were taken in harbours as gelatinous organisms tend to be “caught” within the relatively sheltered habitats present there.

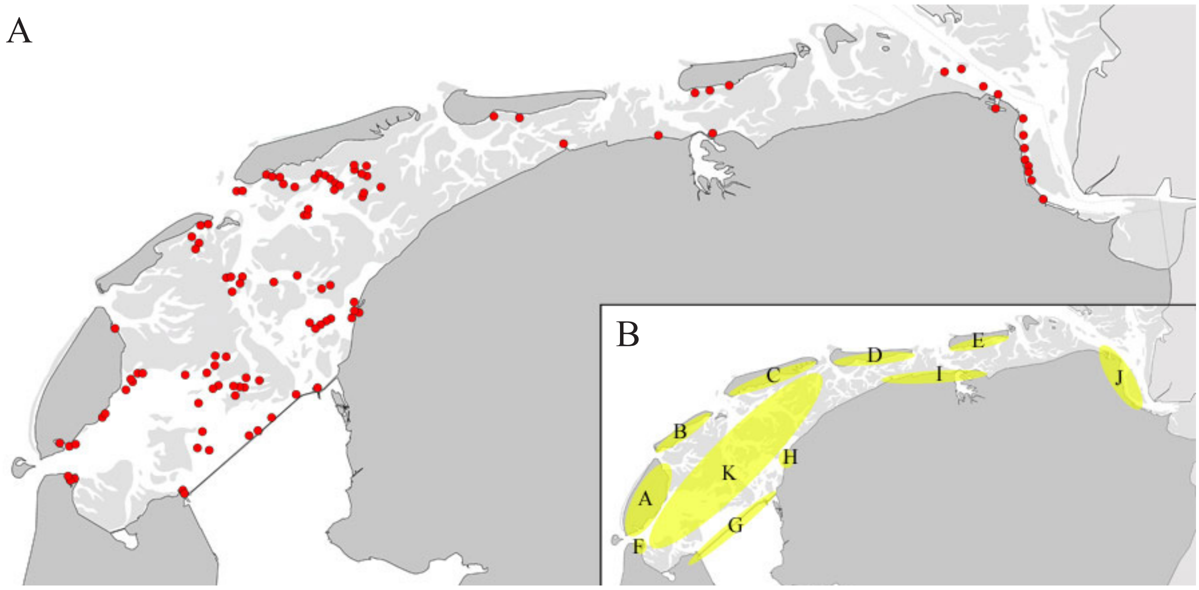

Fig. 1. A, Locations with hard substratum that were searched during the Dutch Wadden Sea inventory in 2018; B, Regions [A] Texel; [B] Vlieland; [C] Terschelling; [D] Ameland; [E] Schiermonnikoog; [F] Den Helder; [G] Afsluitdijk; [H] Harlingen; [I] Holwerd-Lauwersoog; [J] Eems; [K] Wadden Sea (open water). Appendix I provides more detailed information on the habitats, sampling dates, sampling methods, and GPS-coordinates.

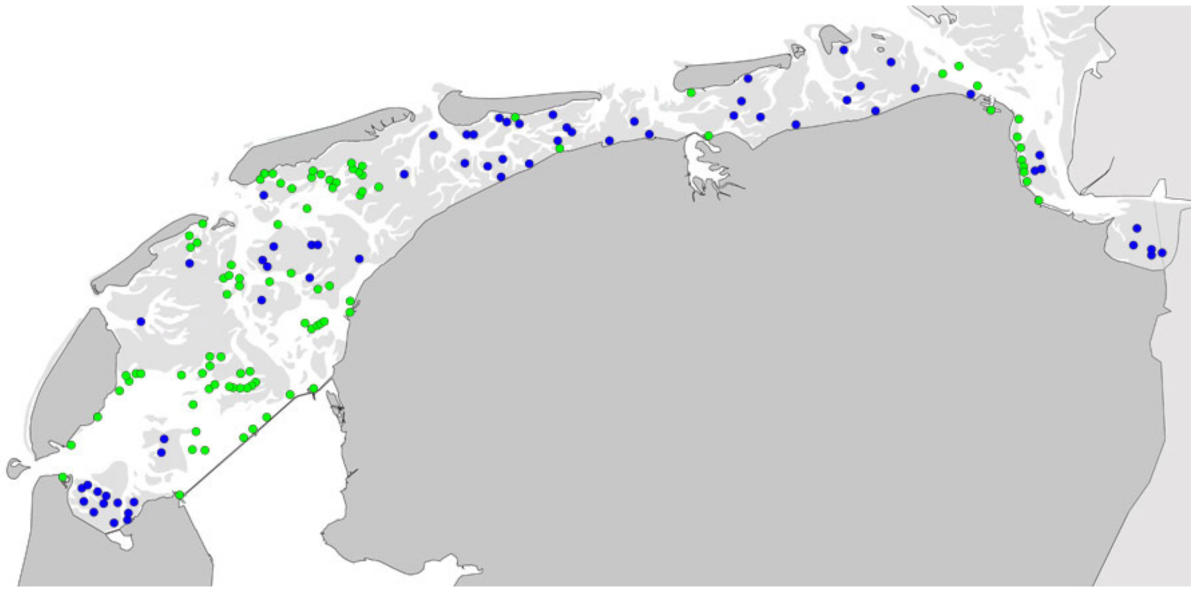

Fig. 2. Locations with soft substratum that were sampled during the Dutch Wadden Sea inventory in 2018; Littoral bottom samples taken with a Hand corer (blue dots) and sublittoral bottom samples taken with a Petit ponar or a Van Veen grab (green dots). Appendix I provides more detailed information on the habitats, sampling dates, sampling methods, and GPS-coordinates.

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, 2015). These methods are similar to those used by the Naturalis Biodiversity Center (NBC), described with the OSPAR-HELCOM Port Survey Protocol (HELCOM/OSPAR, 2013), and conducted during rapid assessments of harbours along the American east coast as described by McIntyre *et al.* (2013), and Wells *et al.* (2014) .

Where possible each locality was searched with the same method that was used during the previous non-native species focused inventories in the Wadden Sea (Gittenberger *et al.*, 2010, 2012, 2015). For each locality these methods were origionally chosen 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, 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 sampling methods that were used are described in more detail in the following paragraphs.

3.2.1 Hard substrate sampling

Visual inspection of the inside, base and outside of floating objects and of non-floating objects at low tide. Sampling techniques concerned:

• Snorkelling: Floating objects mainly concerned floating docks. These were searched for species while snorkelling, if permission was granted by the harbourmaster, or else from shore by looking over the edge of the floating dock.

• Usage of a net (aluminium scrape net) and grabbing devices (Petit Ponar) to collect material from under the low tide water line.

• Turning over rocks, oysters and other hard substrata during low tide, to access 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.

• Analysing settlement plates. Per location three settlement plates constructions (with plates on several depths) were deployed in the water in March 2018 in the harbours of Den Helder, Oudeschild (Texel), Terschelling and Harlingen. These 14x14 cm grey PVC plates were hung at depths of 1, 3 and 7 meter, where the water depth allowed it. In shallower waters plates were only deployed at 1, or 1 and 3 meter of depth. The plates deployed in March were checked after 3 months in June, and after 6 month in September 2018. In addition to these 12 plate constructions, the 14x14 cm grey PVC plates that were already present in the harbours of Den Helder and Eemshaven, as a part of the continuous monitoring program SETL, were also analysed for this report. This concerned respectively 19 and 23 plates in Den Helder and Eemshaven, of which the oldest ones were deployed respectively in March 2009 and June 2009. On these plates fouling species communities could be assessed in relatively much later succession stages than the communities that were recorded on the settlement plate constructions deployed in March 2018.

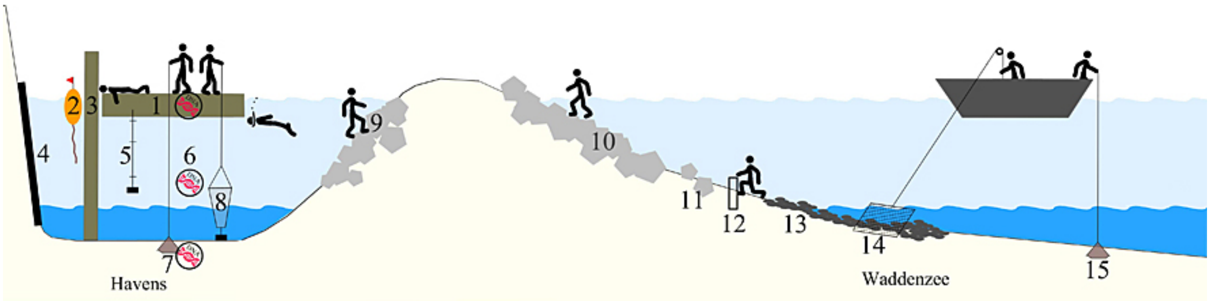

Fig. 3. Sampling methods used during the Wadden Sea inventory 2018; Hard substrate habitats were searched with visual inspections from the water surface, while snorkelling, or in the littoral zone during low tide. Hard substrate samples in the sublittoral zone were taken with a mussel dredge from a boat. 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] Settlement plates, e-DNA from the [6] watercolumn and [7] bottom, [8] gelatineus zooplankton, [9] the sheltered sides and the [10] exposed sides of dikes, [11] rocks, [13] shellfish reefs in the littoral zone and [14] shellfish reefs in the sublittoral zone. Soft substrate habitats in [12] the littoral zone were sampled with a hand corer, in the [15] the sublittoral zone, they were sampled from a floating dock or from a boat with a bottom grab, i.e. a Petit ponar or a Van Veen grab.

• Searching off-shore locations in the central Wadden Sea with a mussel dredge from the vessels 'De Asterias', the "Phoca" and "De Harder" of the Waddenunit of the Ministry of Agriculture Nature and Food Quality. These localities included subtidal mussel beds and oyster reefs, whereby locations were chosen as close as possible to the ones sampled during the 2014 survey (Gittenberger *et al.*, 2015). The boat was also used to check off-shore floats from which ropes were hanging for catching mussel spat.

3.2.2 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) program. 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 shore and from the vessels 'De Asterias. the "Phoca", and "De Harder" of the Waddenunit of the Ministry of Agriculture Nature and Food Quality. The bottom samples were sieved using a sieve with a mesh size of 1 mm.

3.2.3 Gelatinous zooplankton sampling

Samples of larger gelatinous zooplankton organisms have been obtained using a net with an opening of 50 cm, length of 2 meter and a mesh size of 500 µm, following the specifications indicated in the HELCOM/OSPAR port survet protocol (HELCOM/OSPAR, 2013). The net was towed vertically from just above the bottom to the surface. The tow rate was approximately 1 m/s. These samples were taken in the harbours of Den Helder, Oudeschild (Texel), Terschelling and Harlingen in both spring and summer. Species were examined immediately after collection without preservation. They were digitally photographed in the field and/or in the laboratory in a tray with seawater, while still alive.

3.2.4 e-DNA / Metabarcoding sampling

During the inventory in June 2018, samples were taken for DNA analysis from three habitats in the harbour of Oudeschild, Texel (Fig. 3: methods [5], [6] and [7]): [5] from the fouling communities on the floating docks, [6] from the water column in between the floating dock and [7] from the bottom sediment underneath the floating docks. A fouling community sample of about 1 kg was taken from the floating dock with an aluminium scrape net. A sediment sample of about 1 kg from the bottom was taken with a Petit ponar bottom grab. Three water samples of about 1/3 liter were taken with a Van Dorn Water sampler from KC Denmark, i.e. from the water surface, just above the bottom, and in the middle of the water column, in between the floating dock and the bottom. These three samples were then mixed together into a 1 liter bottle for eDNA analyses. All samples were transported in a coolbox and directly placed in the -20°C freezer in the lab for further analyses. The eDNA analyses were done at the Naturalis laboratories in triplicate for each sample, i.e. nine analyses were done in total. For identifying the species the recently developed “Leray-XT primers“ were used to assess the DNA-barcode marker CO-I. The resulting DNA sequences were compared with BoLD (The Barcode of Life Data System www.boldsystems.org) and the NIH genetic sequence database “GenBank”. Based on these comparisons a species list was constructed of species with a DNA match of at least 98%. These results of the DNA-studies based on the samples taken in June, were used for the second fieldwork period in late summer. They made it possible to specifically search in the harbour of Oudeschild for settled individuals of species that were recorded within these DNA studies, thereby increasing the detection chance of alien species. As the DNA studies could not distinguish between genetic material from living and dead organisms, only alien species of which individuals were found alive, were included in the final alien species list of the Dutch Wadden Sea. The remaining species that were recorded in the DNA-analyses are presented in a separate table.

3.2.5 Physical parameters

In total 111 water samples were taken to assess the waterparameters pH, salinity and turbidity throughout the Wadden Sea. Measurements were based on surface water samples taken with a bucket during the monitoring in both spring and summer. The pH and salinity (in ppt) measurements were done with the multimeter HI9829 from Hanna instruments. The turbidity was measured with the portable turbidity meter HI 93414 from Hanna instruments.

3.2.6 Species accumulation curves

Species accumulation curves were calculated separately for hard substrate and soft substrate samples. These accumulation curves give a rough indication of the numbers of species that could have been found with the methods used if an indefinite number of samples would have been taken. The calculations were conducted with the program Primer 6.1.10. They were conducted in the same manner as was done for the 2014 alien species survey in the Dutch Wadden Sea (Gittenberger *et al.*, 2015), so that comparisons could be made.

3.3 Fieldwork schedule

The fieldwork was conducted during a spring survey between 11 and 29 June 2018, a summer survey focused on taking the SIBES samples (soft sediments in the intertidal) between 23 July and 14 August, a late summer survey between 10 August and 21 September, and a short survey with 22 students of the Institute of Biology of Leiden University between 8 and 11 October.

During the spring survey in June and the late summer survey in August-September, teams of two or three 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, 2011 and 2014 (Gittenberger *et al.*, 2010, 2012, 2015). 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, 2014). This team also took bottom samples with a petit ponar at most of these sites. In addition in the late summer period, four days were spend on the western Wadden Sea with the ships the Phoca and the Asterias of the Waddenunit, focusing on taking samples with a mussel dredge on 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, bottom grab samples were taken, usually directly after the mussel dredge came out of the water. Finally the boat was used to visit and search floating mussel spat collectors in the central Wadden Sea. At the start of October four researchers and 22 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. Only species of which the identification was checked by one of the GiMaRIS supervisors, were included in the results of the present 2018 alien species survey of the Dutch Wadden Sea.

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

4.1 General results and discussion

In table 1 a summary is given of the results of the species inventory conducted in 2018, which was focussed on the detection of marine alien species. For comparison, results of similar inventories conducted in 2009, 2011 and 2014 in the Dutch Wadden Sea are also provided in this table. In 2018 in total 684 samples were taken for analyses or sites were searched for species (Appendix II). Using 111 water samples taken throughout the Dutch Wadden Sea during the sampling (Appendix II), 333 water parameter measurements were done with a Hanna instruments multimeter HI 9829 and a HI 93414 turbidity meter (Table 2). Hereby it was found that the waters at the research sites that were searched for species had a salinity between 7.0 and 25.6 ppt, an acidity between a pH 6.8 and 8.4, and an turbidity between 1.4 and 281.0 NTU.

In total 226 species were found of which 51 are probably non-native to the Netherlands (Table 3; Appendix I). For seven of these species it remains uncertain whether they are non-native as their native range is unknown in literature, i.e. they are considered cryptogenic. Within the present report it is assumed that they are non-native in the Netherlands. Of all 226 species recorded 194 species (including 48 non-natives) and 89 species (including 22 non-natives) were found during the monitoring efforts that focused

Table 1. Wadden Sea inventories totals. * Seven of these species were recorded during the 2018 inventory. Records of the other four species as new to the region were done separately from this inventory (Table 4). Abbrev. MM = Michaelis Menten.

Total Dutch Wadden Sea inventory	**2009**	**2011**	**2014**	**2018**
# Total samples taken / analyses done	147	167	492	684
# Total species found during the inventory	138	159	254	226
# Total non-native species recorded during the inventory	28	35	48	51
# New non-natives since previous Wadden Sea inventory	12	10	10	11*
# Non-native or crytogenic species recorded in the Dutch Wadden Sea (Table 4)	62	72	82	93
Hard substratum samples / local species assessments				
# Hard substratum locations	83	96	183	319
# Species found on hard substratum during the inventory	129	159	201	194
Maximum # species expected based on MM (S_{max})	150	168.6	211.2	195.6
# Non-native species recorded on hard substratum during the inventory	28	35	44	47
Soft substratum samples				
# Soft substratum locations			241	197
# Species found in soft substratum during the inventory			128	89
Maximum # species expected based on MM (S_{max})			136.7	92.1
# Non-native species recorded in soft substratum during the inventory			20	22
Gelatineus zooplankton net samples (GZP)				
# Gelatineus zooplankton locations				54
# Species found in GZP samples during the inventory				22
# Non-native GZP species recorded during the inventory				7
eDNA samples (Oudeschild, Texel)				
# eDNA Samples				3
Water samples (for waterparameter measurements)				
# Locations	64	71	68	111

respectively on hard substrates (Fig. 5) and soft substrates (Fig. 6) in the Dutch Wadden Sea. Respectively 1.6 and 3.1 more species were 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 that respectively 188.1 and 86.0 were expected to be found with double the research effort. These estimates should be considered very rough indications, especially because of the variety of sampling methods that was used. As these statistical estimations are slightly lower than the numbers of species recorded, they illustrate that if the number of samples would have been doubled, this probably would not have resulted in many additional species records.

The highest diversity of non-native species within one habitat was found on the floating dock in the marina of Oudeschild, Texel. There, 26 species of non-native or unknown origin were recorded. Of all regions searched during the survey in 2018, Texel, was the island where most non-

Table 2. Different localities in the Dutch Wadden Sea that were sampled during the inventory in 2018. For each locality the location numbers of the surface water samples (Appendix I) in that locality and the region (Fig. 1) in which it lies, is given. The minimum, mean and maximum measured turbidity, salinity and pH are provided where more than one water sample was taken. In total 333 measurements were done on water samples collected at 111 locations.

Region	**location / Sample number**	**Locality**	**Turbidity (NTU)**			**Salinity (ppt)**			**pH**		
			min	mean	max	min	mean	max	min	mean	max
A	1, 3, 9	Texel, ‘t Horntje	4.4	5.2	5.9	23.7	24.0	24.2	7.6	7.7	7.8
A	12	Texel, arrival ferry	-	25.0	-	-	24.2	-	-	7.5	-
A	15	Texel, Molwerk	-	4.9	-	-	24.9	-	-	8.5	-
A	16, 20, 25, 26	Texel, Oudeschild, marina	3.2	5.6	8.0	24.0	24.4	24.6	6.8	7.2	7.5
B	70, 72, 74	Vlieland, marina	3.1	4.2	4.8	23.5	23.8	24.0	7.9	7.9	7.9
C	106, 108, 110, 112	Terschelling, marina	3.1	4.2	6.9	23.9	24.1	24.3	8.0	8.1	8.2
D	123, 125, 127	Ameland, marina	2.8	4.8	6.2	23.4	23.4	23.5	7.6	7.7	7.7
E	139-141	Schiermonnikoog, marina	5.8	15.9	29.4	23.9	24.2	24.5	7.3	7.5	7.5
F	184-197	Den Helder, marine marina	2.9	5.5	8.6	20.4	21.8	22.7	7.8	7.9	7.9
G	216, 220	Den Oever, fishing harbour	4.9	11.1	17.4	7.0	13.3	19.6	7.3	7.6	7.9
G	227	Breezandijk	-	3.8	-	-	19.5	-	-	7.7	-
G	234	Kornwerderzand	-	17.6	-	-	18.3	-	-	7.5	-
H	271-273	Harlingen, Nieuwe Voorhaven	6.0	8.8	10.4	17.0	17.1	17.3	7.7	7.8	7.9
H	278	Harlingen, Nieuwe Willemshaven	-	4.0	-	-	16.3	-	-	7.3	-
H	281	Harlingen, Noorderhaven	-	3.3	-	-	16.0	-	-	7.5	-
I	285	Holwerd	-	132.0	-	-	23.1	-	-	7.7	-
I	287	Lauwersoog, marina	-	3.7	-	-	24.2	-	-	7.6	-
I	298-302	Lauwersoog, fishing harbour	1.4	3.7	7.9	24.1	24.1	24.1	7.5	7.5	7.6
I	306	Lauwersoog, arrival ferry	-	5.5	-	-	24.2	-	-	7.6	-
J	362-364	Eemshaven	2.6	97.2	281.0	21.6	22.4	23.2	7.0	7.4	7.6
J	374-378	Delfzijl, marina	2.3	3.6	5.8	19.9	20.0	20.1	7.2	7.3	7.3
K	380 - 594 (* see below)	Wadden Sea, sublittoral	1.4	8.6	42.9	21.9	23.8	25.6	7.3	7.9	8.4
* 380, 382, 384, 387, 390, 393, 396, 399, 402, 405, 408, 411, 414, 417, 420, 423, 426, 429, 432, 435, 438, 441, 443, 445, 448, 451, 454, 458, 459, 462, 465, 468, 471, 474, 477, 480, 483, 486, 489, 492, 495, 498, 501, 505, 508, 511, 514, 517, 520, 523, 526, 529, 532, 535, 538, 541, 544, 547, 550, 553, 556, 559, 561, 564, 567, 570, 573, 576, 579, 582, 585, 588, 591, 594											

Table 3. The 51 species of non-native origin and species of unknown origin that were found during the Dutch Wadden Sea inventory in 2018. * Cryptogenic species, i.e. species of unknown origin. ** Species that was first recorded within sediment samples taken in the intertidal in 2017 and 2018 within the SIBES project (Klunder *et al.,* 2019).

	Species	Group
1	*Antithamnionella spirographidis*	Algae
2	*Caulacanthus okamurae*	Algae
3	*Ceramium sungminbooi*	Algae
4	*Ceramium tenuicorne*	Algae
5	*Codium fragile*	Algae
6	*Colpomenia peregrina*	Algae
7	*Dasya sessilis*	Algae
8	*Dasysiphonia japonica*	Algae
9	*Gracilaria vermiculophylla*	Algae
10	*Melanothamnus harveyi*	Algae
11	*Polysiphonia senticulosa*	Algae
12	*Sargassum muticum*	Algae
13	*Ulva australis*	Algae
14	*Ulvaria splendens*	Algae
15	*Undaria pinnatifida*	Algae
16	*Aphelochaeta marioni* *	Annelida
17	*Ficopomatus enigmaticus*	Annelida
18	*Marenzelleria viridis*	Annelida
19	*Neodexiospira brasiliensis*	Annelida
20	*Aplidium glabrum* *	Ascidiacea
21	*Botrylloides violaceus*	Ascidiacea
22	*Didemnum vexillum*	Ascidiacea
23	*Molgula manhattensis*	Ascidiacea
24	*Styela clava*	Ascidiacea
25	*Amathia* cf. *gracilis* *	Bryozoa
26	*Bugulina stolonifera*	Bryozoa
27	*Schizoporella* cf. *japonica*	Bryozoa
28	*Smittoidea prolifica*	Bryozoa
29	*Tricellaria inopinata*	Bryozoa
30	*Diadumene cincta* *	Cnidaria

	Species	Group
31	*Nemopsis bachei*	Cnidaria
32	*Amphibalanus improvisus* *	Crustacea
33	*Austrominius modestus*	Crustacea
34	*Caprella mutica*	Crustacea
35	*Eriocheir sinensis*	Crustacea
36	*Hemigrapsus sanguineus*	Crustacea
37	*Hemigrapsus takanoi*	Crustacea
38	*Jassa marmorata*	Crustacea
39	*Palaemon macrodactylus*	Crustacea
40	*Mnemiopsis leidyi*	Ctenophora
41	*Telmatogeton japonicus*	Insecta
42	*Crepidula fornicata*	Mollusca
43	*Ensis leei*	Mollusca
44	*Magallana gigas*	Mollusca
45	*Mulinia lateralis* **	Mollusca
46	*Mya arenaria*	Mollusca
47	*Petricolaria pholadiformis*	Mollusca
48	*Stylochus* cf. *flevensis*	Platyhelminthes
49	*Haliclona (Soestella) xena* *	Porifera
50	*Hymeniacidon perlevis*	Porifera
51	*Leucosolenia somesii* *	Porifera

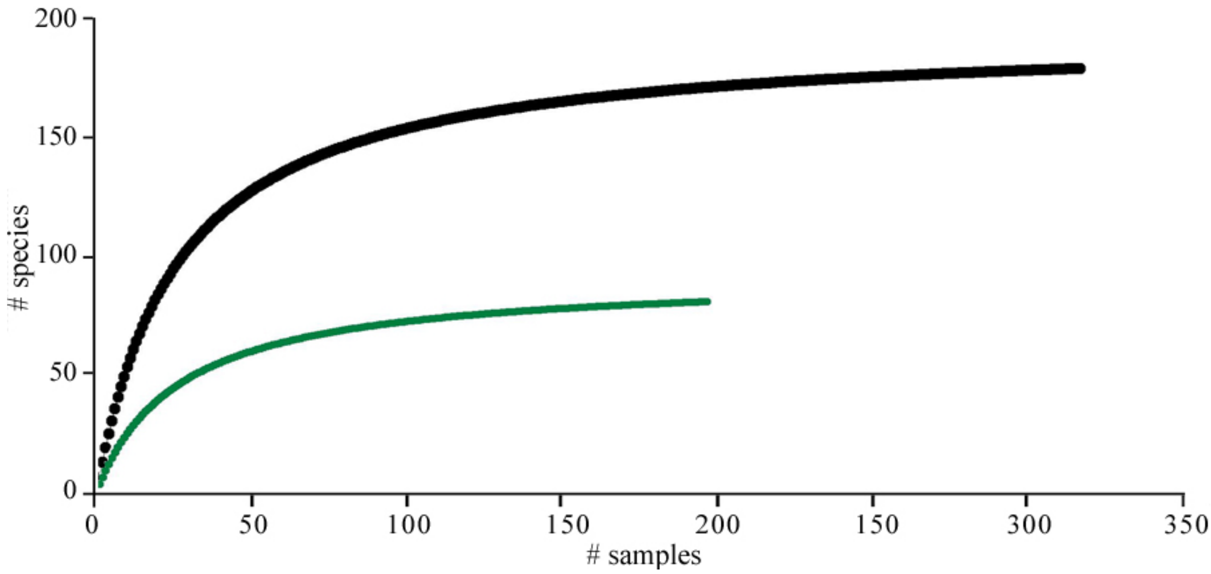

Fig. 4. Michaelis Menten species accumulation curves concerning the monitoring focused on hard substratum (black) and soft substratum (green) related species.

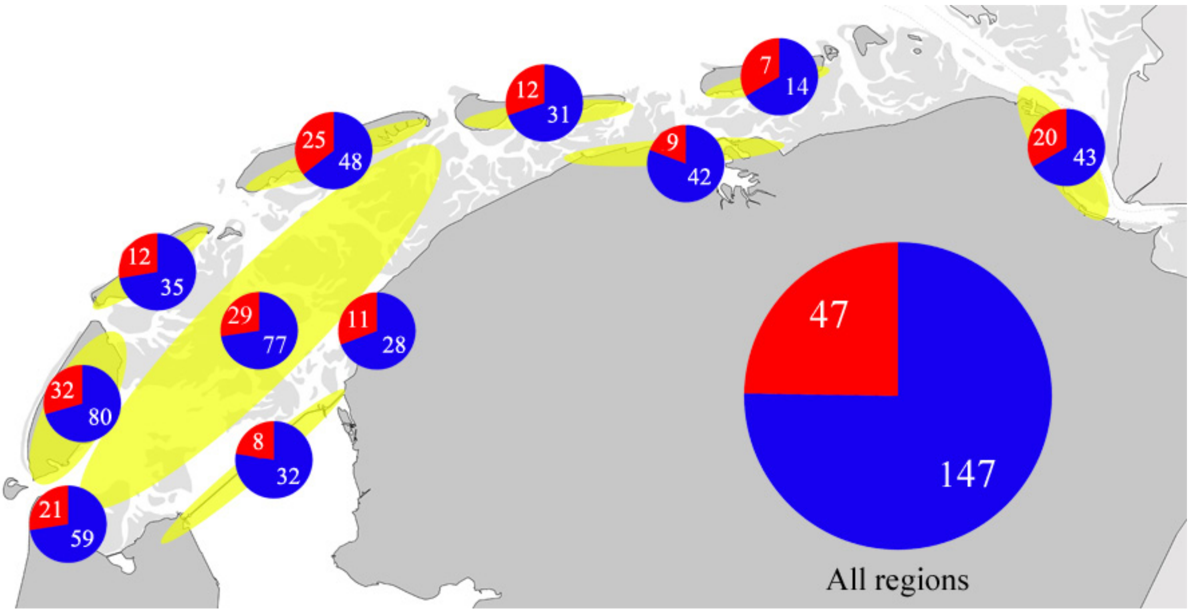

Fig. 5. Species diversity recorded during the monitoring focusing on hard substratum related species, per region (Fig. 1). [Red] number of species of non-native or unknown origin; [Blue] number of native species for the Dutch Wadden Sea.

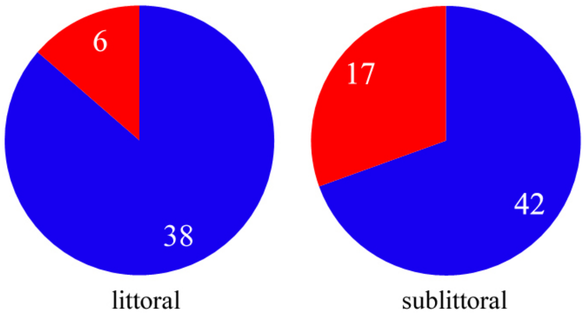

Fig. 6. Species diversity recorded during the monitoring in 2018 focusing on soft substratum related species throughout the entire Dutch Wadden Sea, separately for the sublittoral and littoral zones (Fig. 2) respectively. [Red] number of species of non-native or unknown origin; [Blue] number of native species for the Dutch Wadden Sea.

native species were found and the region where most non-native species new to the Dutch Wadden Sea were first recorded (Figs 1, 5).

Seven alien species were scored as new to the Dutch Wadden Sea, in comparison to the list of aliens species for the Dutch Wadden Sea that resulted from the 2014 survey (Gittenberger *et al.*, 2015). The number of alien species that is recorded for the Wadden Sea is steadily increasing, as is illustrated by the alien species focused inventories that were conducted in the region in 2009, 2011, 2014 and 2018. During these surveys respectively 11, 8, 9 and 7 new alien species to the region were found. Of these seven species three are new for the Netherlands, i.e. the macro-algal species *Ulvaria splendens*, the bryozoan *Schizoporella* cf. *japonica* and the bivalve *Mulinia lateralis*. Four of the seven species that were recorded in the present survey as new for the Wadden Sea, were first found off Texel, i.e. the macro-algal species *Caulacanthus okamurae*, *Dasya sessilis* and *Ulvaria splendens*, and the bryozoan *Schizoporella* cf. *japonica*. The other three species that were recorded during the survey and were scored as new for the Dutch Wadden Sea in 2018, concerned the macro-algal species *Ceramium sungminbooi* and *Polysiphonia senticulosa* and the bivalve *Mulinia lateralis*. The latter was already first recorded for the Wadden Sea within SIBES sediment samples taken in 2017 (Klunder *et al.,* 2019). The "new" macro-algal species *Ceramium sungminbooi* may have been present for much longer. This species, which closely resembles the native species *Ceramium cimbricum*, was described as new to science in 2016 and therefore missed in previous surveys. Re-examination of *C. cimbricum* material collected and preserved during the survey in 2014 (Gittenberger *et al.*, 2015) showed that both *C. cimbricum* amd *C. sungminbooi* were already settled in the Wadden Sea at that time.

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 2018 survey results, a total of eleven species were added to the list of non-native species recorded in the Dutch Wadden Sea that was presented by Gittenberger *et al.* (2015) after the last alien species focused survey in 2014. This raised the total number of species on this list to 93 in 2018 (Table 4). Although some of the "new" non-natives may have been missed in prior monitoring efforts, others may concern recent introductions. A large number of the 93 alien species that are known in 2018 is assumed to have been missed in monitoring efforts prior to 2009 as no alien species focused survey had ever been conducted. At that time, only 50 non-native species were known to the Dutch Wadden Sea (Wijsman & De Mesel, 2009). As four alien species focused surveys, i.e. in 2009, 2011, 2014 and 2018, have been conducted since then, it is assumed that alien species that are scored as new to the Dutch Wadden Sea in 2018, are likely to concern species that have been introduced recently, and do not concern species missed in prior monitoring.

Some species have substantially expanded their range within the Wadden Sea after they were initially recorded during the inventories of 2009, 2011 and 2014. The algal species *Dasysiphonia japonica* for example, was first recorded for the Wadden Sea in 2014. It was then only found in

Den Helder. In 2018 this species was also recorded in the port of Den Helder but additionally at several locations off Texel and Terschelling. Similarly the alien bryozoan *Tricellaria inopinata* has expanded its range. When it was first recorded in 2014, it was only recorded for the western part of the Wadden Sea including sites off Terschelling, Vlieland, Texel and Den Helder. In 2018 the species was found at the same localities but also in the eastern part including locations off Ameland, Holwerd and Eemshaven. It is unclear to what degree the range expansions of these non-native species may have to do with the fact that the summer of 2018 was the warmest in three centuries (www.knmi.nl). For some alien species, like the bryozoan *Smittoidea prolifica*, the warm summer in 2018 may have caused a decline in its population. In 2014 it was recorded from the central Wadden Sea, off Texel and off Terschelling. In 2018, however, its spread appeared to have declined as it was only recorded off Terschelling and at one site off Delfzijl. Another alien species of which the range appeared to have significantly declined concerns the macro-algal species *Gracilaria vermiculophylla*, with plants up to at least a meter long. Although it was found to be widespread throughout the Dutch Wadden Sea in 2009, 2011 and 2014, it occurred more restricted to the western part of the Dutch Wadden Sea in 2018.

Because of 2018 being the warmest summer in three centuries (www.knmi.nl), one may expect the settlement of alien species coming from the more southern coasts of Europe to the Netherlands. The species that were recorded in 2018 as new to the Wadden Sea do not specifically concern species that prefer warm waters however. The macro-algal species *Ulvaria splendens,* for example, concerns a species originally described from Alaska (www.algaebase.org). It is mainly known from northern European countries with colder waters relative to the Netherlands. Its record in the Wadden Sea concerns the first record of a settled specimen in Dutch waters. For the Pacific bryozoan *Schizoporella* cf. *japonica*, the European record of settled colonies closest by, also lies to the north, i.e. off Norway (Loxton *et al.*, 2017). As the residual sea currents along the western European mainland coast are directed to the north, it is unlikely that these species have reached the region by their natural dispersal. Both species are known from hull-fouling communities, indicating that they may have been introduced by ships and pleasure crafts, possibly coming from the north. Another potential vector may have been oyster imports as in May of 2018 about 80,000 oysters from Norway were placed in outer waters to the north of the Wadden Sea island Schiermonnikoog, aiming at promoting the recovery of native flat oyster populations along the Dutch coastline (Didderen *et al.*, 2019). "For these oysters a treatment protocol was used, which specifically focused on minimizing the chance that alien species are imported (Van den Brink, A. & T. Magnesen, 2018; Van der Have & Schutter, 2018). The introduction vector therefore remains uncertain. Further complicating the identification of a potential vector of introduction, is the fact that the last alien species focused survey in the Wadden Sea was conducted in 2014 and alien species like small bryozoans and macro-algae are not the focus of any of the ongoing monitoring programs. It is therefore not unlikely that these alien species were already present in the Wadden Sea prior to 2018. For a species like the newly recorded macro-algae *Polysiphonia senticulosa*, it is for example very likely that it was missed during previous monitoring efforts in the Dutch Wadden Sea. While alien species focused surveys in the Wadden Sea up to 2018 were done in mid to late summer, an additional survey period in spring was included in the 2018 survey. By doing so also alien species like *P. senticulosa* can be recorded. This species is known to occur in high densities from about winter to spring in for example Zeeland, while being hard to impossible to find in summer (Stegenga, *pers. obs.*). This illustrates that although most alien species are found during a summer survey, including also a spring survey can result in the discovery of some additional alien species, providing a more accurate view of what is there.

Table 4. Review of all 93 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 as presented by Gittenberger *et al.,* 2015, 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 / Author	Source of occurrence in the Dutch Wadden Sea	Origin and remarks
	ALGAE		
1	*Acrochaetium densum* (K.M.Drew) Papenfuss	Stegenga, 2002	Pacific (Stegenga & Vroman, 1976)
*	*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	*Alexandrium tamarense* (Lebour)	Wijsman & Mesel, 2009	Cryptogenic (Wolff, 2005)
3	*Antithamnionella spirographidis* (Schiffner) E.M.Wollaston	This species inventory; Gittenberger *et al*., 2010, 2012, 2015	N Pacific (Maggs & Stegenga, 1999)
4	*Biddulphia sinensis* Greville	Leewis, 1985	Indian Ocean (Eno *et al.,* 1997)
5	*Botrytella* sp.	Stegenga & Mol, 1996	Crytogenic (Wolff, 2005)
6	*Caulacanthus okamurae* Yamada	This species inventory;	NE Pacific (Yamada, 1933)
7	*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.
8	*Ceramium botryocarpum* A.W.Griffiths ex Harvey	Gittenberger *et al.,* 2012, 2015	NE Atlantic (Maggs & Hommersand, 1993)
9	*Ceramium cimbricum* H.E.Petersen	Gittenberger *et al.,* 2010, 2012	Crytogenic; probable non-native for NW Europe
10	*Ceramium sungminbooi* Hughey & Boo	This species inventory;	(Hughey & Boo, 2016)
11	*Ceramium tenuicorne* (Kützing) Waern	This species inventory; Gittenberger *et al.,* 2012, 2015	NE Atlantic (Maggs & Hommersand, 1993)
12	*Chattonella marina* (Subrahmanyan) Hara & Chihara	Vrieling *et al.,* 1995	Crytogenic (Wolff, 2005)
13	*Chattonella marina var. antiqua* (Hada) Demura & Kawachi	Vrieling *et al.,* 1995	Crytogenic (Wolff, 2005)
14a	*Codium fragile subsp. fragile* (Suringar) Hariot	This species inventory; Gittenberger *et al.,* 2015; Stegenga & Prud'homme and Reine, 1998	NW Pacific (Chapman, 1999)
14b	*Codium fragile subsp. atlanticum* (A.D.Cotton) P.C.Silva	Gittenberger *et al*., 2010, 2012; 2015	NW Pacific (Silva, 1955)
15	*Colpomenia peregrina* Sauvageau	This species inventory; Gittenberger *et al.,* 2015; 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*.
*	*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.

	Species / Author	Source of occurrence in the Dutch Wadden Sea	Origin and remarks
16	*Coscinodiscus wailesii* Gran & Angst	Edwards *et al.,* 2001	N Pacific (Edwards *et al.,* 2001)
17	*Dasya sessilis* Yamada	This species inventory	(Yamada, 1928)
18	*Dasysiphonia japonica* (Yendo) H.-S.Kim	This species inventory; Gittenberger *et al.,* 2015	NW pacific (Sjøtun *et al.,* 2008)
19	*Fibrocapsa japonica* S.Toriumi & H.Takano	Vrieling *et al.,* 1995	Crytogenic (Wolff, 2005)
20	*Gracilaria vermiculophylla* (Ohmi) Papenfuss	This species inventory; Gittenberger *et al.,* 2010, 2012, 2015	Pacific (Gollasch & Nehring, 2006)
21	*Heterosigma akashiwo* (Y.Hada) Y.Hada ex Y.Hara & M.Chihara	Wijsman & Mesel, 2009	Pacific? (Minchin, 2007)
*	*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).
22	*Mediopyxis helysia* Kühn, Hargreaves & Halliger	Loebl *et al.,* 2013	Kuehn *et al.,* 2005
23	*Melanothamnus harveyi* (Bailey) Díaz-Tapia & Maggs	This species inventory; Gittenberger *et al.,* 2010, 2012, 2015 Maggs & Stegenga, 1999; Wijsman & Mesel, 2009	N Pacific (Maggs & Stegenga, 1999)
24	*Pleurosigma simonsenii* Hasle	Kat, 1982	Indian Ocean (Eno *et al.,* 1997)
25	*Polysiphonia senticulosa* Harvey	This species inventory	N Pacific (Stegenga *et al.,* 1997)
26	*Prorocentrum triestinum* J.Schiller	Wijsman & Mesel, 2009	Crytogenic (Wolff, 2005)
27	*Sargassum muticum* (Yendo) Fensholt	This species inventory; Gittenberger *et al.,* 2010, 2012, 2015 Prud'homme Reine & Nienhuis, 1982;	NW Pacific (Wallentinus, 1999)
28	*Ulva australis* Areschoug	This species inventory; Gittenberger *et al.*, 2010, 2012, 2015; Stegenga & Mol, 2002	N Pacific (Stegenga & Mol, 2002)
29	*Ulvaria splendens* (Ruprecht) Vinogradova	This species inventory	North Pacific (Guiry & Guiry, 2019).
30	*Undaria pinnatifida* (Harvey) Suringar	This species inventory; Gittenberger *et al.*, 2010, 2012, 2015 De Ruijter, 2008	NW Pacific (Stegenga, 1999)
		ANNELIDA	
31	*Alitta virens* (M. Sars, 1835)	Gittenberger *et al.,* 2015; Horst, 1920	N Atlantic or N Pacific (Nehring & Leuchs, 1999)
32	*Aphelochaeta marioni* (Saint-Joseph, 1894)	This species inventory; Gittenberger *et al.,* 2015; Wijsman & Mesel, 2009	Crytogenic, probably native (Wolff, 2005)
33	*Ficopomatus enigmaticus* (Fauvel, 1923)	This species inventory; Gittenberger *et al.,* 2010, 2015	SW Pacific (Grosholz & Ruiz, 1996)
34	*Marenzelleria viridis* (Verrill, 1873)	This species inventory; Gittenberger *et al.,* 2015; Dekker, 1991	W Atlantic (Bick & Zettler, 1997)
35	*Neodexiospira brasiliensis* (Grube, 1872)	This species inventory; Gittenberger *et al.,* 2010, 2015	Tropics, including Brasil (Eno et al. 1997)
36	*Streblospio benedicti* Webster, 1879	Gittenberger *et al.,* 2015; Sebesvari *et al.,* 2006	North America (Carlton, 1979; Wolff, 2005).

	Species / Author	Source of occurrence in the Dutch Wadden Sea	Origin and remarks
		ASCIDIACEA	
37	*Aplidium glabrum* (Verrill, 1871)	This species inventory; Gittenberger *et al.,* 2010, 2012, 2015	Cryptogenic, possibly native to NE Atlantic (Wolff, 2005)
38	*Botrylloides violaceus* Oka, 1927	This species inventory; Gittenberger *et al.,* 2010, 2012, 2015	NW Pacific (Minchin, 2007)
39	*Didemnum vexillum* Kott, 2002	This species inventory; Gittenberger *et al.,* 2010, 2012, 2015	NW Pacific (Stefaniak *et al.,* 2009)
40	*Diplosoma listerianum* (Milne Edwards, 1841)	Gittenberger *et al.,* 2015	The origin of this cosmopolitan species, which was described in 1871 from the Mediterranean, is unknown.
41	*Molgula manhattensis* (De Kay, 1843)	This species inventory; Gittenberger *et al.,* 2012, 2015	NW Atlantic (Haydar *et al.,* 2011)
42	*Molgula socialis* Alder, 1863	Gittenberger *et al.*, 2010, 2012, 2015	NE Atlantic (Monniot, 1969)
43	*Styela clava* Herdman, 1881	This species inventory; Gittenberger *et al.,* 2010, 2012, 2015Huwae, 1974	NW Pacific (Lützen, 1999)
		BRYOZOA	
44	*Amathia imbricata* (Adams, 1798)	Wijsman & Mesel, 2009	Crytogenic (Wolff, 2005)
45	*Amathia gracilis* (Leidy, 1855)	This species inventory; Wijsman & Mesel, 2009	Crytogenic (Wolff, 1999)
46	*Bugulina stolonifera* (Ryland, 1960)	This species inventory; Gittenberger *et al.,* 2010, 2012, 2015 D'Hondt & Cadée, 1994	NW Atlantic (Cohen & Carlton, 1995)
47	*Schizoporella* cf. *japonica* Ortmann, 1890	This species inventory;	NW Pacific (Loxton *et al.*, 2017)
48	*Smittoidea prolifica* Osburn, 1952	This species inventory; Gittenberger *et al.,* 2015; Dekker & Drent 2013	Pacific coast of north America (Faasse *et al.,* 2013)
49	*Tricellaria inopinata* d'Hondt & Occhipinti Ambrogi, 1985	This species inventory; Gittenberger *et al.,* 2015	Probably NE Pacific (Cook *et al.,* 2013)
		CNIDARIA	
50	*Cordylophora caspia* (Pallas, 1771)	Gittenberger *et al.*, 2010, 2012, 2015	Ponto-Caspian (Nehring & Leuchs, 1999)
51	*Diadumene cincta* Stephenson, 1925	This species inventory; Gittenberger *et al.,* 2010, 2012, 2015 Pax, 1936	Crytogenic (Den Hartog & Ates, 2011) or Pacific (Gollasch & Nehring, 2006).
52	*Diadumene lineata* (Verrill, 1869)	Gittenberger *et al.,* 2012, 2015; Van Urk, 1956	NW Pacific (Gollasch &Riemann-Zürneck, 1996)
53	*Gonionemus vertens* A. Agassiz, 1862	Gittenberger *et al.,* 2012	NW Atlantic (Werner, 1950) or N Pacific (Edwards, 1976).
54	*Mitrocomella polydiademata* (Romanes, 1876)	Van Walraven, *in prep*	Atlantic
55	*Nemopsis bachei* L. Agassiz, 1849	This species inventory; Wijsman & Mesel, 2009	NW Atlantic (Faasse & Ates, 1998)

	Species / Author	Source of occurrence in the Dutch Wadden Sea	Origin and remarks
		CRUSTACEA	
56	*Amphibalanus improvisus* (Darwin, 1854)	This species inventory; Gittenberger *et al.,* 2010, 2012, 2015 Huwae, 1985;	Crytogenic, probably native for NE Atlantic (Gollasch, 2002)
57	*Austrominius modestus* (Darwin, 1854)	This species inventory; Gittenberger *et al.,* 2010, 2012, 2015 Huwae, 1985	SW Pacific (Harms, 1999)
58	*Callinectes sapidus* Rathbun, 1896	Wijsman & Mesel, 2009; Wolff, 2005	NW Atlantic (Christiansen, 1969)
59	*Caprella mutica* Schurin, 1935	This species inventory; Gittenberger *et al*., 2010, 2012; 2015	Pacific (Schrey & Buschbaum, 2006)
60	*Eriocheir sinensis* H. Milne Edwards, 1853	This species inventory; Gittenberger *et al*., 2010, 2012; 2015 Adema, 1991	NW Pacific (Adema, 1991)
61	*Hemigrapsus sanguineus* (De Haan, 1835)	This species inventory; Gittenberger *et al*., 2010, 2012; 2015 Wijsman & Mesel, 2009	NW Pacific (Breton *et al.,* 2002)
62	*Hemigrapsus takanoi* Asakura & Watanabe, 2005	This species inventory; Gittenberger *et al*., 2010, 2012; 2015 Wijsman & Mesel, 2009	NW Pacific (Asakura & Watanabe, 2005)
63	*Jassa marmorata* Holmes, 1905	This species inventory; Gittenberger *et al*., 2010, 2012; 2015 Dankers & van Moorsel 2001	NW Atlantic (Conlan, pers comm; Conlan, 1990)
64	*Leptomysis lingvura* (G.O. Sars, 1866)	Gittenberger *et al.,* 2015	NE Atlantic (Tattersall & Tattersall, 1951)
65	*Limnoria lignorum* (Rathke, 1799)	Hubrecht *et al.,* 1893; Wijsman & Mesel, 2009	Crytogenic, probably native for NE Atlantic (Wolff, 2005)
66	*Melita nitida* Smith, 1873	Gittenberger *et al.,* 2015	N America (Faasse & van Moorsel, 2003).
67	*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.
68	*Mytilicola orientalis* Mori, 1935	Thieltges et al. 2013	Pacific (Thieltges et al. 2013)
69	*Palaemon macrodactylus* Rathbun, 1902	This species inventory; Gittenberger *et al.,* 2015; Faasse, 2005; De Ruijter, 2007; Schrieken, 2008; Tulp, 2006a	NW Pacific (d'Udekem d'Acoz et all., 2005)
70	*Platorchestia platensis* (Krøyer, 1845)	Den Hartog, 1961; Wijsman & Mesel, 2009	Crytogenic (Wolff, 2005)
71	*Rhithropanopeus harrisii* (Gould, 1841)	Gittenberger *et al.,* 2012; Tesch, 1922;	W Atlantic (Eno *et al.,* 1997)
72	*Sinelobus stanfordi* (Richardson, 1901)	Gittenberger *et al.,* 2010	Cryptogenic (Haaren & Soors, 2009)
		CTENOPHORA	
73	*Mnemiopsis leidyi A. Agassiz, 1865*	This species inventory; Gittenberger *et al*., 2010, 2012; 2015 Gittenberger, 2008; Tulp, 2006b	W Atlantic (Gittenberger, 2008)
		INSECTA	
74	*Telmatogeton japonicus* Tokunaga, 1933	This species inventory; Gittenberger *et al.,* 2012	Pacific (Raunio *et al.,* 2009)

	Species / Author	Source of occurrence in the Dutch Wadden Sea	Origin and remarks
		MOLLUSCA	
75	*Corambe obscura* (A. E. 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).
76	*Crepidula fornicata* (Linnaeus, 1758)	This species inventory; Gittenberger *et al.*, 2010, 2012; 2015 Korringa, 1942	NW Atlantic (Nehring & Leuchs, 1999)
77	*Ensis leei* M. Huber, 2015	This species inventory; Gittenberger *et al.,* 2015; Essink & Tydeman, 1985	NW Atlantic (De Bruyne & De Boer, 1984)
78	*Crassostrea gigas* (Thunberg, 1793)	This species inventory; Gittenberger *et al.*, 2010, 2012; 2015 Drinkwaard, 1999	NW Pacific (Eno *et al.,* 1997)
79	*Mulinia lateralis* (Say, 1822)	This species inventory; Klunder *et al.,* 2019	W Atlantic (Brunel et al. 1998)
80	*Mya arenaria* Linnaeus, 1758	This species inventory; Gittenberger *et al.,* 2015; Wijsman & Mesel, 2009	NW Atlantic& N Pacific (Cohen & Carlton, 1995)
81	*Mytilopsis leucophaeata* (Conrad, 1831)	Van Benthem Jutting,1943; Wijsman & Mesel, 2009	NW Atlantic (Gittenberger & Janssen, 1998)
82	*Petricola pholadiformis* Lamarck, 1818	This species inventory; Van Benthem Jutting, 1943; Wijsman & Mesel, 2009	NW Atlantic (Eno *et al.,* 1997)
83	*Rangia cuneata* (G. B. Sowerby I, 1832)	Luijten, 2014	Gulf of Mexico and maybe the NW Atlantic (Gittenberger et al, 2015b)
84	*Teredo navalis* Linnaeus, 1758	Van Benthem Jutting,1943; Wijsman & Mesel, 2009	Crytogenic (Wolff, 2005)
		NEMATODA	
85	*Anguillicoloides crassus* (Kuwahara *et al.,* 1974)	Wijsman & Mesel, 2009; Wolff, 2005	NW Pacific (Minchin, 2007)
		PISCES	
86	*Atherina boyeri* Risso, 1810	Kloosterman & Schrieken, 2003; Wijsman & Mesel, 2009	NE Atlantic (Wolff, 2005)
87	*Neogobius melanostomus* (Pallas, 1814)	waddenzeevismonitor.nl, 2015	http://www.waddenzeevismonitor.nl/nieuws/nieuwe-vis-in-de-waddenzee-8946.html
88	*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.
		PLATYHELMINTHES	
89	*Stylochus* cf. *flevensis* Hofker, 1930	This species inventory; Tulp 2005;	Cryptogenic (Faasse, 2003)
		PORIFERA	
90	*Haliclona xena* De Weerdt, 1986	This species inventory; Gittenberger *et al.,* 2012, 2015; Van Soest *et al.,* 2007	Crytogenic (Van Soest *et al.,* 2007)
91	*Hymeniacidon perlevis* (Montagu, 1814)	This species inventory; Gittenberger *et al.,* 2012, 2015	NE Atlantic (Van Soest *et al.,* 2007)
92	*Leucosolenia somesii* (Bowerbank, 1874)	This species inventory; Gittenberger *et al.,* 2012, 2015	Crytogenic (Van Soest *et al.,* 2007)
		VIRUS	
93	*Ostreid herpesvirus-1 µvar*	Gittenberger & Engelsma, 2013; Gittenberger *et al*, 2016	NW Pacific (Mineur *et al.,* 2014)

4.2 e-DNA & metabarcoding analyses in the harbour of Oudeschild

Start of August 2018, the results became available of the e-DNA and metabarcoding analyses done on the basis of scrape samples from the floating dock, a mixed water sample and bottom sediment samples, taken in June 2019 in the harbour of Oudeschild, Texel. During the late summer survey in September 2019, (non-native) species of which these analyses indicated that their genetic material was present in the harbour, were specifically searched for to check whether living individuals of these species were present in the harbour of Oudeschild. The DNA-sequences that resulted from PCR analyses using Leray-XT primers to assess the DNA-barcode marker CO-I, were matched with the DNA-barcode databases BoLD (Barcode of Life Database: www.barcodinglife.com) and GenBank (NIH genetic sequence database : https://www.ncbi.nlm.nih.gov/genbank/). For 91 species DNA-sequences were recorded, which matched for at least 98% with the COI sequences of these species in the DNA-barcode databases BoLD or GenBank.

Of these 91 DNA-matches, 21 concerned non-marine species (Table 5). The genetic material detected of these species probably belongs to dead material, including pieces of tissue but also e-DNA, drifting in the waters of the harbour. These 21 species include humans (*Homo sapiens*), but also a large number of insect species, a bird (the Eurasian coot *Fulica atra*), several fresh water dinoflagellates and several freshwater shrimp species. Although some of these species, like the Eurasian coot and humans, are known to occur in the vicinity of the harbour of Oudeschild, the genetic material of some of the scored species clearly originates from further away. The three freshwater shrimp species scored for example, all concern non-native species that are known to be kept in freshwater aquaria.

Table 5. Non marine species of which the DNA-barcodes in the databases BoLD or GenBank matched for at least 98% with the COI sequences resulting from the e-DNA and metabarcoding analyses that were done based on samples collected in the harbour of Oudeschild in June 2018.

Species	**Group**	**Not a marine species:**
Fulica atra	Aves	Bird
Neocaridina davidi	Crustacea	Fresh water shrimp, commonly sold in aquarium trade
Neocaridina denticulata	Crustacea	Fresh water shrimp, commonly sold in aquarium trade
Neocaridina ketagalan	Crustacea	Fresh water shrimp, commonly sold in aquarium trade
Acanthoscelides obtectus	Insecta	Beetle
Agrilus suvorovi	Insecta	Beetle
Arantia congensis	Insecta	Grasshopper
Bruchus pisorum	Insecta	Beetle
Carpophilus halli	Insecta	Beetle
Dinoderus bifoveolatus	Insecta	Beetle
Euwallacea interjectus	Insecta	Beetle
Lasioderma serricorne	Insecta	Beetle
Megatoma graeseri	Insecta	Beetle
Neocondeellum brachytarsum	Insecta	Insect
Parorphula graminea	Insecta	Grasshopper
Prostephanus truncatus	Insecta	Beetle
Xyleborus emarginatus	Insecta	Beetle
Xyleborus semiopacus	Insecta	Beetle
Homo sapiens	Mammalia	Humans do not breath well under water
Parvodinium inconspicuum	Myzozoa	Fresh water dinoflagellates
Peridinium willei	Myzozoa	Fresh water dinoflagellates

Of the remaining 70 DNA-matches, 28 species concerned marine phytoplankton species of which 12 probably concern non-native species for Europe (Table 6). Of the 28 phytoplankton species scored, 14 concerned species that were not on the TWN list (Taxa Waterbeheer Nederland) of the Dutch Ministry of Water Management. As phytoplankton species that are scored during the ongoing phytoplankton monitoring program run by this Ministry in the Netherlands, get assigned a TWN code, having no TWN code may indicate that they have never been recorded. Sampling of phytoplankton with plankton nets was not included as a sampling method in the 2018 late summer survey. It therefore remains uncertain if living individuals of these 14 species occur in the harbour of Oudeschild.

Table 6. Phytoplankton species of which the DNA-barcodes in the databases BoLD or GenBank matched for at least 98% with the COI sequences resulting from the e-DNA and metabarcoding analyses that were done based on samples collected in the harbour of Oudeschild in June 2018. Based on the TWN list (http://ipt.nlbif.nl/ipt/resource?r=checklist-twn) it is assumed that species have been recorded in the Netherlands, or not. To assess whether phytoplankton species are non-native to Europe: *, Streftaris et al. (2005) is followed taking the remarks of Gomez (2008) into account; **, Algaebase.org is followed assuming that species not mentioned from Europe, should be considered non-native to the region.

Species	**Group**	**Non Native in NW Europe**	**Recorded in the Netherlands (based on TWN-list)**
Alexandrium catenella	Myzozoa	*	-
Alexandrium concavum	Myzozoa		-
Alexandrium minutum	Myzozoa	*	1
Alexandrium ostenfeldii	Myzozoa		1
Alexandrium pseudogonyaulax	Myzozoa	*	-
Alexandrium tamarense	Myzozoa	*	1
Alexandrium tamiyavanichii	Myzozoa	**	-
Azadinium caudatum var. margalefii	Myzozoa		1
Azadinium dalianense	Myzozoa	**	-
Azadinium obesum	Myzozoa		-
Azadinium poporum	Myzozoa		-
Azadinium spinosum	Myzozoa		1
Bellerochea polymorpha	Ochrophyta		-
Cryptoperidiniopsis brodyi	Myzozoa	**	-
Ethmodiscus punctiger	Ochrophyta	**	-
Fibrocapsa japonica	Ochrophyta	*	1
Heterocapsa rotundata	Myzozoa		1
Karlodinium veneficum	Myzozoa		1
Leucocryptos marina	Cryptophyta		1
Lingulodinium polyedra	Myzozoa		1
Micromonas pusilla	Chlorophyta		1
Pfiesteria piscicida	Myzozoa	*	-
Protoceratium reticulatum	Myzozoa	*	1
Protoperidinium depressum	Myzozoa		1
Pseudo-nitzschia delicatissima	Ochrophyta		1
Scrippsiella lachrymosa	Myzozoa		-
Scrippsiella precaria	Myzozoa	**	-
Thoracosphaera heimii	Myzozoa		-

Of the remaining 42 DNA-matches (Table 7), living individuals of 15 species were found during the surveys in spring and summer in the harbour of Oudeschild. Of the remaining 27 DNA-matches, 5 species were found in the Wadden Sea, but not in the harbour of Oudeschild. It is therefore understandable that genetic material of these species is found in the harbour.

Where it concerns the remaining 22 DNA-matches, for a selection of species the match appears to be found due to DNA-marker used not being specific enough. DNA-matches were for example found with four mussel species, i.e. *Mytilus chilensis, M. edulis, M. galloprovincialis* and *M. trossulus*. Probably only the common mussel *Mytilus edulis* is present in the harbour. Molecular markers have specifically been designed for distinguishing between these mussel species as it is known that they cannot be distinguished on the basis of the COI marker (Inoue *et al.*, 1995). This may also be the case for the closely related barnacle species *Balanus crenatus* and *Balanus balanus*, explaining why both species were recorded on the basis of the DNA-analyses while only *B. crenatus* specimens were recorded alive. It is also possible that living individuals of both species were present however, as *Balanus balanus* barnacles are occasionally found in Dutch waters, mostly on washed ashore debris. Knowing that the species was recorded within the DNA-analyses on the basis of samples taken in June, the species was specifically searched for, but not found, during the survey in September.

The September survey was also specifically focused on finding two non-native sponge species that were recorded in the DNA analyses, i.e. the yellowish sponge *Protosuberites mereui* and the bright blue sponge *Terpios gelatinosus*. Living individuals were not found however. As *P. mereui* is a cave dwelling Mediterranean species, its settlement would be unlikely. The settlement of *Terpios gelatinosus* would have been more likely as it is a western European species (Hayward & Ryland, 2017). It was not found however, although its bright blue appearance should not have made it difficult to detect. Both species may have been present on the hull of a pleasure craft in the marina of Oudeschild, explaining their detection in the DNA-analyses.

In conclusion, although no additional non-native species were recorded in the marina of Oudeschild with the aid of the DNA-analysis results, the eDNA and metabarcoding analyses did indicate the potential presence of several non-native species for which the environment in the marina appears to be suitable for their settlement. It may therefore proof to be a valuable tool for the early detection of such species. However, the majority of species living in the marina of Oudeschild was not detected within the present eDNA study, i.e. 81 species of which the presence of living individuals was confirmed during the surveys, were not detected in the eDNA and metabarcoding analyses.

Table 7. Species recorded in the harbour of Oudeschild during the surveys in 2018, distinguishing between those of which living individuals were detected during the surveys (based on their morphology) and those of which the COI sequences that were found matched for at least 98% with the DNA-barcodes in the databases BoLD or GenBank (excluding those species already included in tables 7-8). * Species of which living individuals were recorded in 2018 in the Wadden Sea, but not in the harbour of Oudeschild. Blue highlighted species concen species only recorded on the basis of DNA analyses. Of the green highlighted species, both living individuals were found (based on morphology) and COI sequences were found that matched for at least 98% with the DNA-barcodes in the databases BoLD or GenBank.

Accepted name	Oudeschild	DNA analyses
ALGAE		
Acinetospora crinita	1	
Aglaothamnion pseudobyssoides	1	
Antithamnionella spirographidis	1	
Ascophyllum nodosum	1	
Blidingia minima	1	
Bryopsis plumosa	1	
Ceramium cimbricum	1	
Ceramium sungminbooi	1	
Ceramium virgatum	1	
Chondrus crispus	1	
Cladophora liniformis	1	
Cladophora vagabunda	1	
Colpomenia peregrina	1	
Elachista fucicola	1	
Erythrotrichia carnea	1	
Fucus vesiculosus	1	1
Fucus virsoides		1
Gaillona hookeri	1	
Gracilaria vermiculophylla	1	
Hincksia sandriana		1
Leathesia marina		1
Mastocarpus stellatus	1	1
Melanothamnus flavimarinus		1
Melanothamnus harveyi	1	1
Melanothamnus japonicus		1
Polysiphonia elongata	1	
Polysiphonia stricta	1	
Pylaiella littoralis	*	1
Rhizoclonium riparium	1	
Sargassum muticum	1	
Stylonema alsidii	1	
Ulva australis	1	
Ulva clathrata	1	
Ulva compressa	1	
Ulva flexuosa	1	
Ulva intestinalis	1	
Ulva linza	1	
Ulva prolifera	1	
Ulva ralfsii	1	
Ulva rotundata	1	
Ulva torta	1	
ANNELIDA		
Alitta succinea	*	
Alitta virens		1
Dodecaceria concharum		1
Harmothoe imbricata	1	1
Hediste diversicolor	*	1
Marenzelleria viridis	*	1
Nereis pelagica	1	
Serpula vermicularis	1	
Spirobranchus triqueter	1	
Trypanosyllis zebra		1
Tubificoides benedii		1
ASCIDIACEA		
Aplidium glabrum	1	
Ascidiella aspersa	1	
Botrylloides violaceus	1	1
Botryllus schlosseri	1	1
Ciona intestinalis	1	
Molgula manhattensis	1	
Styela clava	1	
BRYOZOA		
Alcyonidioides mytili	1	
Bowerbankia cf. Gracilis	1	
Bugula neritina		1
Bugulina stolonifera	1	1
Conopeum reticulum	1	
Crisularia plumosa	1	
Cryptosula pallasiana	1	1
Electra pilosa	1	
Tricellaria inopinata	1	

Accepted name	Oudeschild	DNA analyses
CNIDARIA		
Aurelia aurita	*	1
Haliclystus tenuis		1
Metridium senile	1	
Obelia dichotoma	1	
Obelia longissima	1	
Rhizostoma pulmo	1	
Sagartia troglodytes	1	
Urticina felina	1	
CRUSTACEA		
Acartia (Acanthacartia) bifilosa		1
Amphibalanus improvisus	1	
Austrominius modestus	1	
Balanus balanus		1
Balanus crenatus	1	1
Caprella mutica	1	1
Carcinus maenas	1	1
Copilia quadrata		1
Corophium arenarium	1	
Gammarus locusta	1	1
Hemigrapsus sanguineus	1	
Hemigrapsus takanoi	1	
Idotea balthica	1	
Jassa marmorata	1	
Lekanesphaera rugicauda	1	1
Melita palmata	1	
Microprotopus maculatus	1	
Monocorophium acherusicum	1	
Neomysis integer	1	
Onychocorycaeus catus		1
Palaemon elegans	1	
Praunus flexuosus	1	
Semibalanus balanoides	1	
Tachidius discipes		1
ECHINODERMATA		
Asterias rubens	1	
INSECTA		
Telmatogeton japonicus	1	

Accepted name	Oudeschild	DNA analyses
MOLLUSCA		
Littorina littorea	1	
Littorina obtusata	1	
Littorina saxatilis	1	
Magallana gigas	1	
Mya arenaria	1	
Mytilus chilensis		1
Mytilus edulis	1	1
Mytilus galloprovincialis		1
Mytilus trossulus		1
Peringia ulvae	1	
PISCES		
Atherina presbyter		1
Gobius niger	1	
Pomatoschistus microps	1	
Syngnathus acus	1	
PORIFERA		
Halichondria (Halichondria) panicea	1	1
Haliclona (Soestella) xena	1	
Leucosolenia somesii	1	
Leucosolenia variabilis	1	
Protosuberites mereui		1
Sycon ciliatum	1	
Terpios gelatinosus		1

4.3 Species of non-native or unknown origin

4.3.1 Algae

4.3.1.1 *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 the non-native species focused inventory of the Dutch Wadden Sea in 2009 it was first recorded for the Dutch Wadden Sea (Gittenberger *et al.*, 2010), i.e. off the Wadden Sea Islands Texel and Terschelling. Based on the inventories in 2011, 2014 and 2018 it can be concluded that the *A. spirographidis* is steadily becoming more abundant and widespread throughout the Wadden Sea. At first, in 2009, 2011 and 2014, it occurred solely within habitats in and around harbours (Gittenberger *et al.*, 2012, 2015; Fig. 8). In 2018 however, it was additionally found more offshore in the Dutch Wadden Sea (Fig. 8). Although most individuals were still recorded on floating docks, in 2018 specimens were also recorded in littoral and sublittoral zones on dikes and mussel beds. The salinities at the locations where the species was found in 2018, varied from 20.4 to 25.6 ppt (Fig. 8; Table 2; Appendix III).

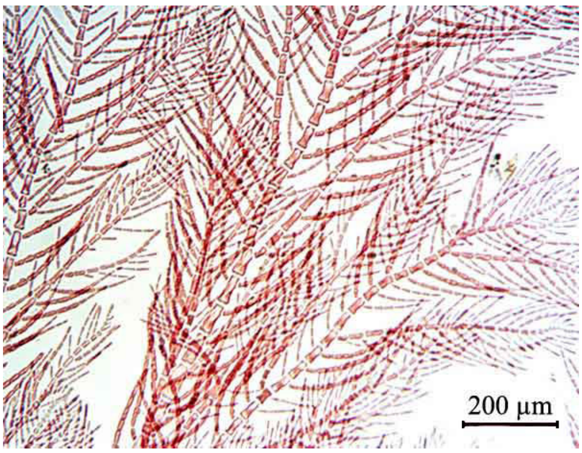

Fig. 7. *Antithamnionella spirographidis* detail *in vitro*. Specimen collected in June 2018 from a floating dock in Terschelling.

Impact:
Antithamnionella spirographidis (Fig. 7) is a relatively small red alga, which only occurs on hard substrata. Although the species has become more widespread in the Wadden Sea over the years (Fig. 8), it was not found in high abundances. It is therefore not expected to have a large impact on the Wadden Sea ecosystem (Gittenberger *et al.*, 2010).

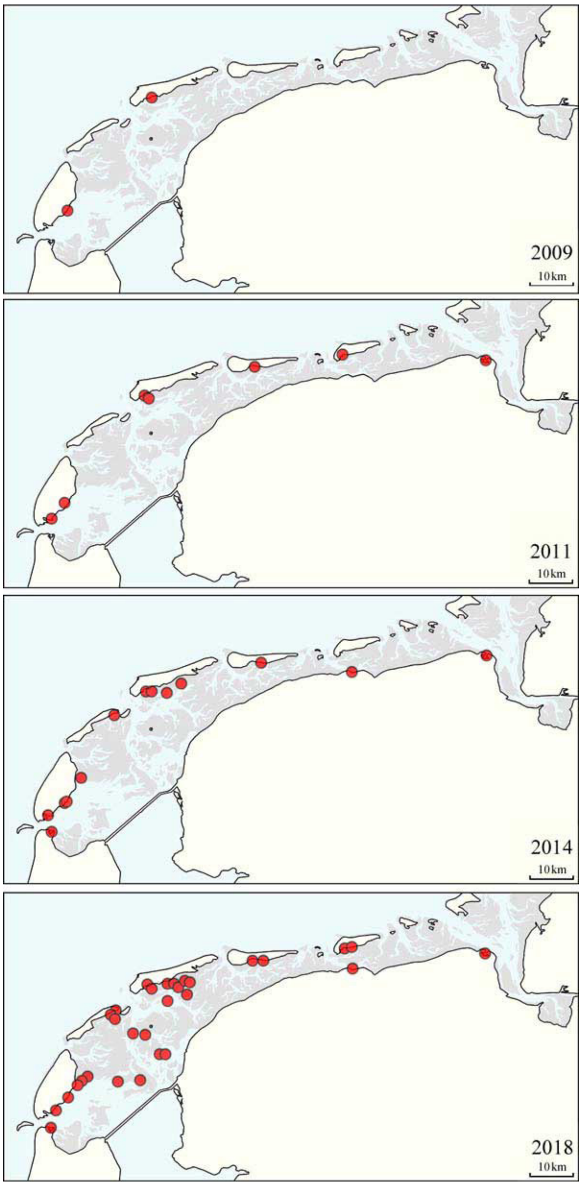

Fig. 8. Locations where *Antithamnionella spirographidis* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.1.2 *Caulacanthus okamurae* Yamada (Figs 9-10)

Origin:
NE Pacific (Yamada, 1933)

Distribution:
For the Dutch Wadden Sea this concerns the first record of *Caulacanthus okamurae*. In 2018 it was found locally in the littoral zone of the exposed side of the dike next to the harbour 't Horntje, Texel (Fig. 10; Table 2; Appendix III). In the Netherlands *C. okamurae* was first recorded in the Dutch Delta area in 2005 where it quickly became widely distributed (Stegenga & Karremans, 2014).

Impact:
Caulacanthus okamurae was first recorded for the Netherlands in 2005 when the alien was noticed due to its rapid spread in the province of Zeeland. There it was and is mainly found on the exposed side of the dike near Neeltje Jans, where it covers a large percentage of the dike. As a locally dominating species in Zeeland, it may also locally have a distinct impact in the Wadden Sea, especially in the littoral zone on dikes.

Fig. 9. *Caulacanthus okamurae in situ* on the exposed side of the dike of 't Horntje, Texel, in August 2018

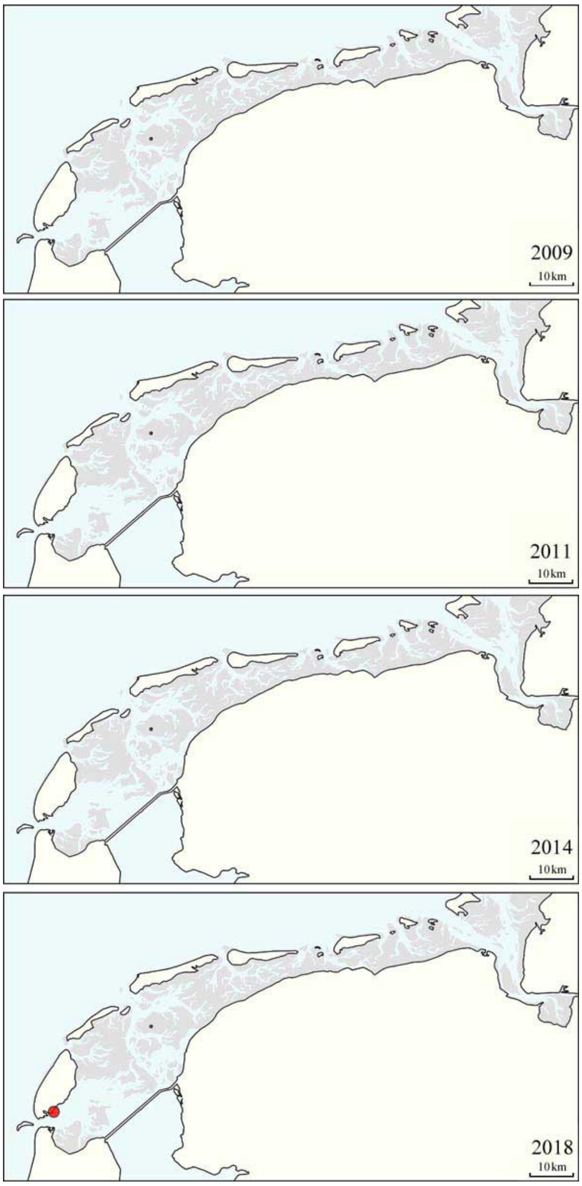

Fig. 10. Locations where *Caulacanthus okamurae* was found during The Wadden Sea inventory in 2018.

4.3.1.3 *Ceramium sungminbooi*

Hughey & Boo (Figs 11-12)

Origin:

NE Pacific (Hughey & Boo, 2016)

Distribution:

Ceramium sungminbooi was found at various locations during the 2018 Wadden Sea inventory (Fig. 12). The species, which closely resembles the native species *Ceramium cimbricum*, was described as new to science in 2016 by Hughey & Boo. It is therefore possible that *C. sungminbooi* may have been present during the previous inventories in 2009, 2011 and 2014, but was then mistakenly identified as *C. cimbricum* (Gittenberger *et al.*, 2010, 2012, 2015). This hypothesis is supported by the re-analysis of *C. cimbricum* material collected in 2014 in the port of Den Helder. Those specimens turned out to be *C. sungminbooi*. In 2018 both *Ceramium* species were recorded, whereby *C. cimbricum* appears to be distributed more locally close to the Texelse stroom in the west and close to the Eemshaven in the east of the Wadden Sea. The alien *C. sungminbooi* occurs much more widespread throughout the whole Wadden Sea. In what year it originally established itself in the Wadden Sea remains uncertain as it has probably been misidentified in the past.

Fig. 11. *Ceramium sungminbooi* detail *in vitro*. Specimen collected in June 2018 from a floating dock in Oudeschild, Texel.

Impact:

Although *C. sungminbooi* is found to be widespread, the small specimens of this red algal species do not appear to outcompete any native species for space and may therefore not have a large impact.

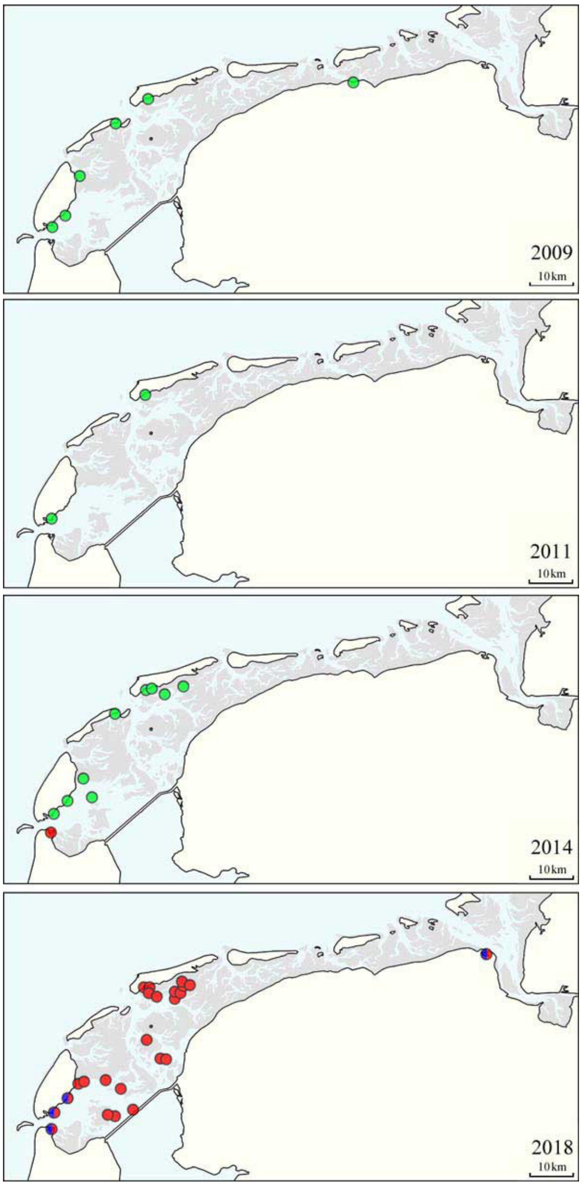

Fig. 12. Locations where *Ceramium sungminbooi* (red dots) and *C. cimbricum* (blue dots) were found during the Wadden Sea inventory in 2018. *C. sungminbooi* was described as new for science in 2016. In the past the species was probably already present in the Wadden Sea, but identified at the time as *C. cimbricum* (green dots). One sample, collected in Den Helder in 2014, was reassesed in 2017 and proven to be *C. sungminbooi* (red dot in 2014).

4.3.1.4 *Ceramium tenuicorne* (Kützing) Waern (Figs 13-14)

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 (Gittenberger *et al.*, 2012). In 2014 it was found in five harbours spread over the whole Dutch Wadden Sea. There it was solely recorded on floating docks (Fig. 14; Gittenberger *et al.*, 2012, 2015). In 2018 it was found at two sites, again solely on floating docks in harbours. The salinities at the locations where the species was found in 2018, varied from 17.0 to 24.2 ppt (Table 2; Appendix III).

Fig. 13. *Ceramium tenuicorne* detail *in vitro*. Specimen collected in October 2018 from a floating dock in Lauwersoog.

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

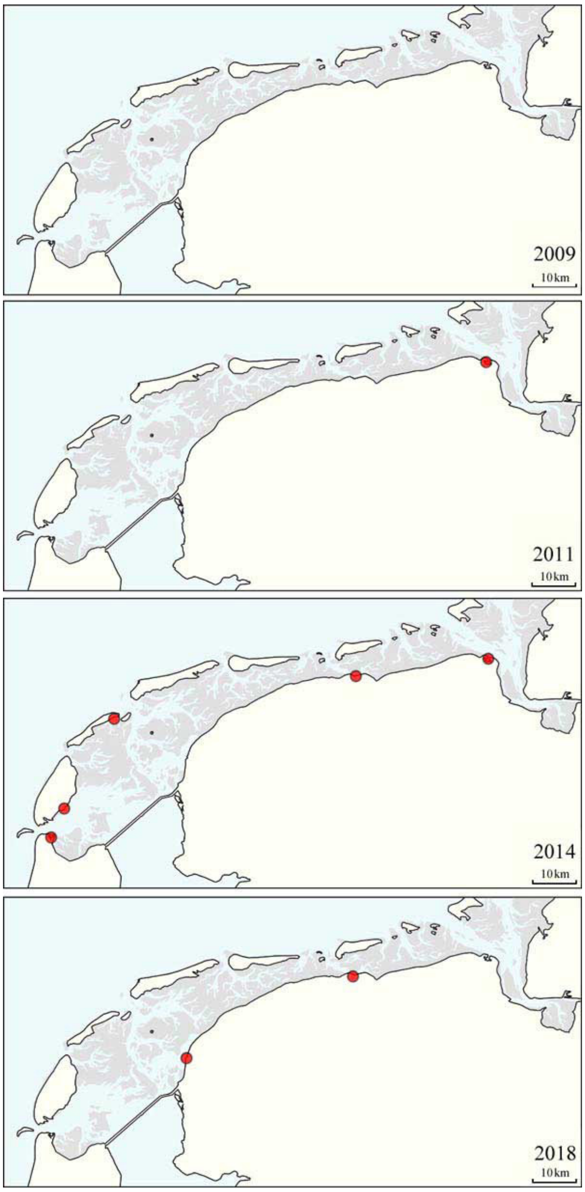

Fig. 14. Locations where *Ceramium tenuicorne* was found during the Wadden Sea inventories in 2011, 2014 and 2018.

4.3.1.5 *Codium fragile*
(Suringar) Hariot (Figs 15-16)

Origin:
Although Silva (1955) indicates that *Codium fragile* originates from the NW Pacific, Brodie *et al.* (2007) indicate that *Codium fragile atlanticum* is a native species for NW Europe, while *Codium fragile fragile* is a non-native (sub)species.

Distribution:
Although the "non-native" subspecies *Codium fragile fragile* was first recorded in the Dutch Wadden Sea more than a century ago, settled individuals of the "native" subspecies *Codium fragile atlanticum* were first recorded in the Wadden Sea during the alien species focused inventory in 2009 (Gittenberger *et al.*, 2010). During that inventory in 2009 *Codium fragile atlanticum* was only found on a floating dock on Terschelling. In 2011 the species was additionally found on Vlieland and Texel. In 2014 both subspecies were found in the harbour of Oudeschild, Texel, whereby *Codium fragile fragile* was also found on a floating dock in the marina of Terschelling (Fig. 16; Gittenberger *et al.*, 2010, 2012, 2015). In 2018 the two subspecies were recorded on the floating docks in the harbour Terschelling and on an oyster reef off Terschelling. The salinities at the locations where the species was found in 2018, varied from 23.9 to 24.2 ppt (Table 2; Appendix III).

Fig. 15. *Codium fragile atlanticum in situ* on a floating dock in the harbour of Terschelling in September 2018.

Impact:
Codium fragile fragile 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 Dutch Wadden Sea ecosystem since then. It is therefore unlikely that *Codium fragile fragile* or *Codium fragile atlanticum* will have an impact on the Wadden Sea ecosystem.

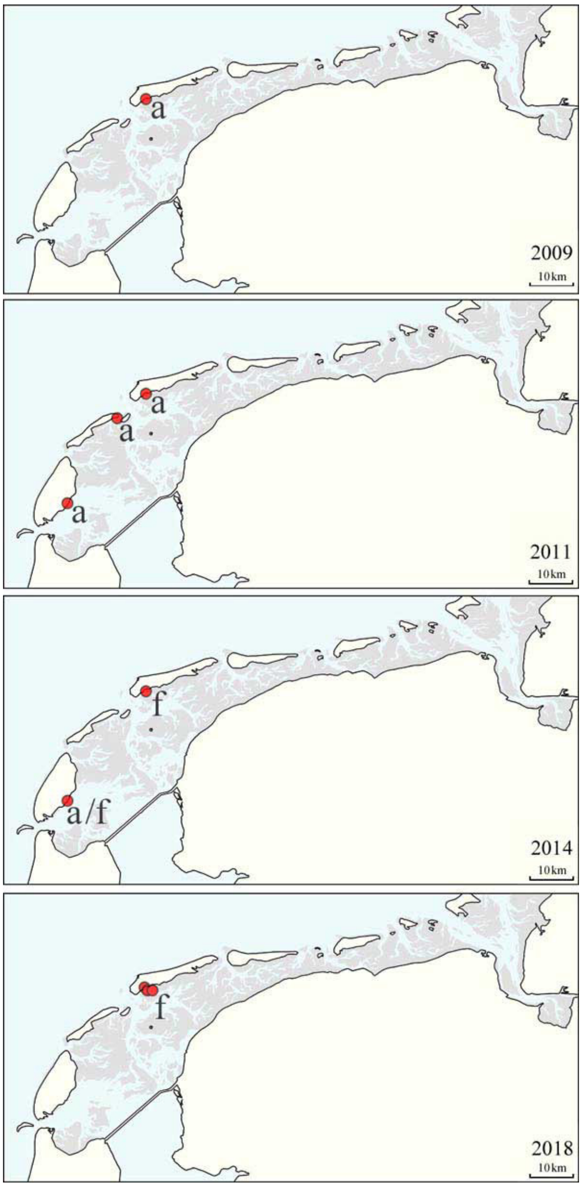

Fig. 16. Locations where *Codium fragile* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018. Subspecies: a = C. f. atlanticum, f = C. f. fragile.

4.3.1.6 *Colpomenia peregrina* (Sauvageau) Hamel (Figs 17-18)

Origin:
NW Atlantic Ocean (Wolff, 2005)

Distribution:
Van Goor (1923) first recorded *Colpomenia peregrina* as the synonym *C. sinuosa* in the Dutch Wadden Sea in May 1921 (Wolff, 2005). *Colpomenia* was not found during the species inventories in 2009 and 2011. In 2014 it was found, but only in the harbour of Oudeschild, Texel (Gittenberger *et al.*, 2015). In 2018 it was also found on the floating docks in Oudeschild, and additionally in the marina of Terschelling (Fig. 17). The salinities at the locations where the species was found in 2018, varied from 23.9 to 24.6 ppt (Table 2; Appendix III).

Impact:
The vernacular name "oyster thief" of this species refers to individuals that have settled on oysters. As they can form large "bladders" with high buoyancy, these algae can pull oysters away from the bottom in strong currents or storms. In the Wadden Sea this is not expected to happen often as *Colpomenia peregrina* is found in the Dutch Wadden Sea for almost a century (Van Goor, 1923), and it still does not seem to be widely distributed. It appears to be rare and occurring mostly on floating docks. In 2018 it was found at two locations, both floating docks, i.e. in the harbour of Oudeschild and the marina of Terschelling. It is therefore unlikely that the species will have a large impact on the Wadden Sea ecosystem.

Fig. 17. *Colpomenia peregrina in vivo* collected in October 2018 from a floating dock in the harbour of Oudeschild, Texel.

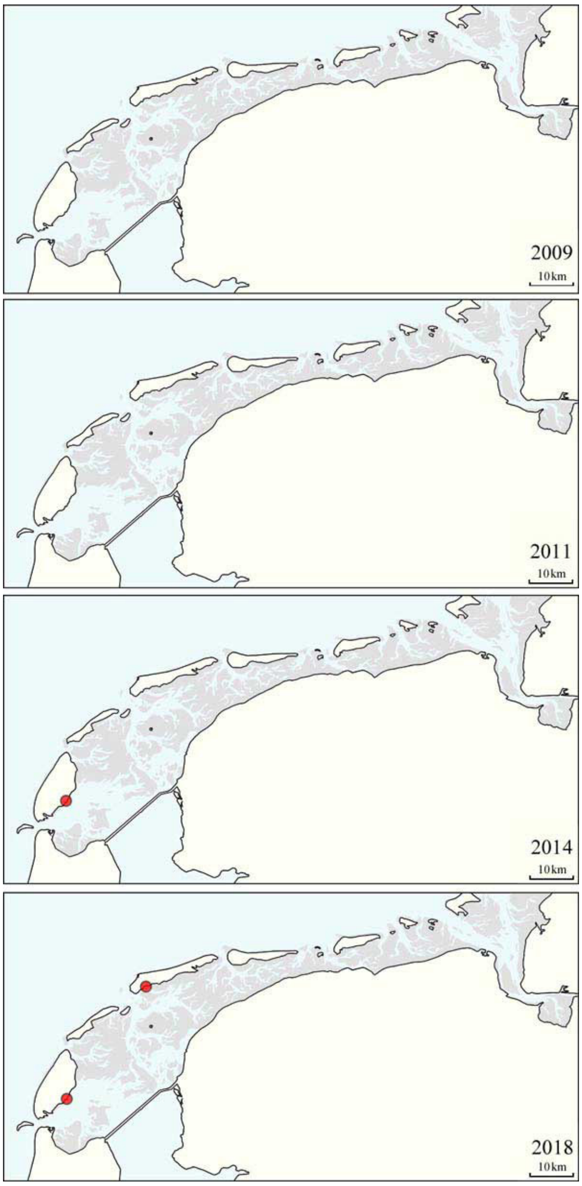

Fig. 18. Locations where *Colpomenia peregrina* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.1.7 *Dasya sessilis*
Yamada (Figs 19-20)

Origin:
NE Pacific (Yamada, 1928)

Distribution:
This concerns the first record of *Dasya sessilis* for the Wadden Sea. *D. sessilis* was not found during the non-native species inventories in the region in 2009, 2011 and 2014 (Gittenberger *et al.*, 2010, 2012, 2015). In 2018 it was found in a tidal pool on the exposed side of the dike of 't Horntje, Texel and in a sublittoral dredge sample off the northeast side of Texel (Fig. 20). The salinities at the locations where the species was found in 2018, varied from 23.9 to 24.6 ppt (Table 2; Appendix III). *Dasya sessilis* was first recorded for the Netherlands in 2003, in the Oosterschelde (Stegenga & Karremans, 2013).

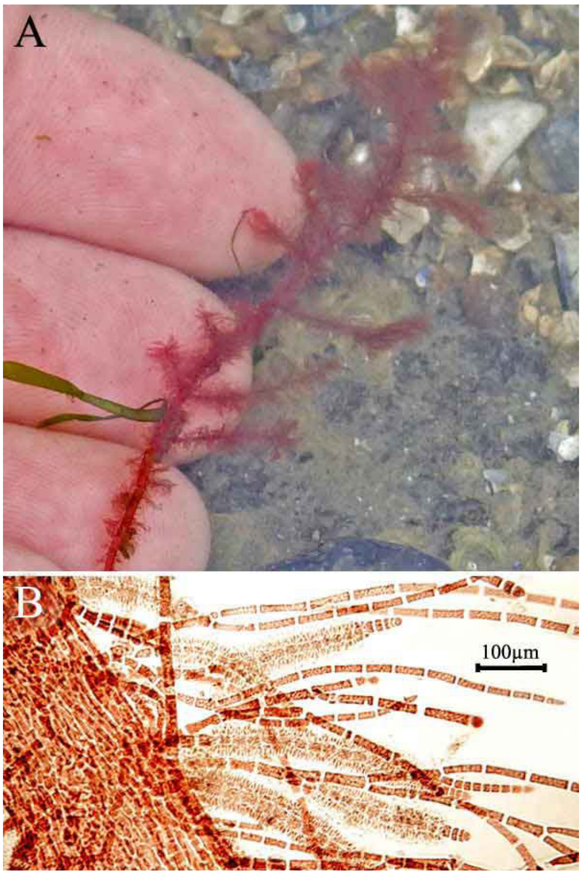

Fig. 19. *Dasya sessilis* [A] *in situ* [B] detail *in virto*. Specimen collected on the exposed side of the dike of 't Horntje, Texel, in August 2018

Impact:
After being sighted for the first time in the Netherlands in the Oosterschelde in 2003, *Dasya sessilis* has slowly expanded its range throughout Zeeland (Stegenga & Karremans, 2014). As no dense populations were formed, its impact on the local ecosystem has probably remained minimal. Although the two sighting off the east coast of Texel do indicate that the species may establish itself in the Wadden Sea, there is no reason to assume that this species will have a significant impact on the Wadden Sea ecosystem.

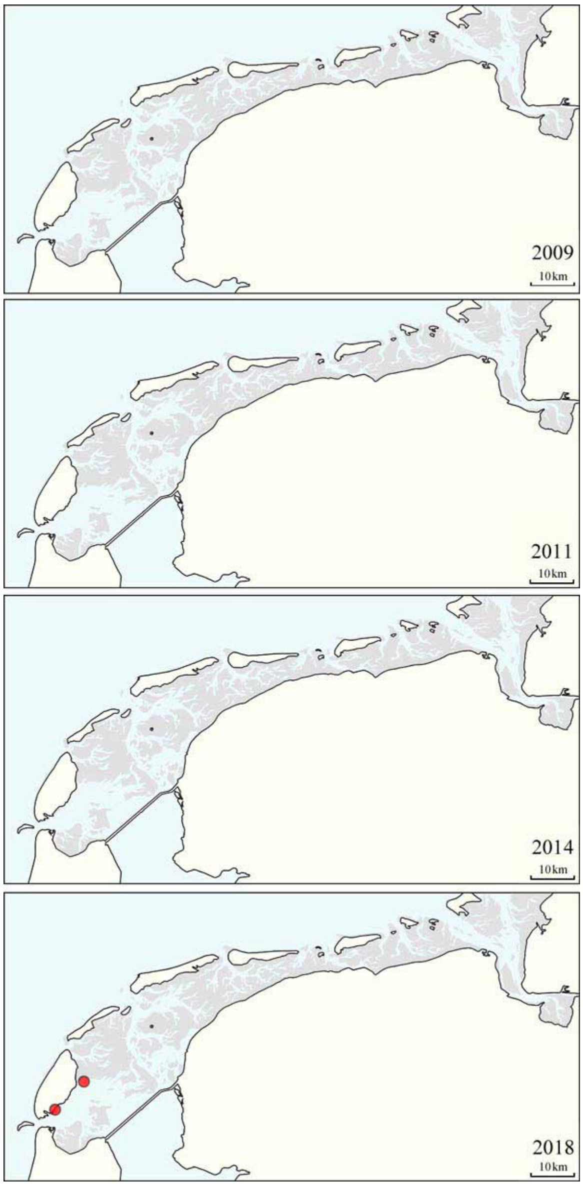

Fig. 20. Locations where *Dasya sessilis* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.1.8 *Dasysiphonia japonica* (Yendo) H.-S. Kim (Figs 21-22)

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

Distribution:
Dasysiphonia japonica was first recorded in the Netherlands in 1994 in the province of Zeeland (Maggs & Stegenga, 1999 as *Heterosiphonia japonica*). In 2014 *D. japonica* was recorded for the first time for the Wadden Sea. It was then only found on a floating dock in the harbour of Den Helder (Fig. 22, Gittenberger *et al.*, 2015). In 2018 *D. japonica* has expanded its range throughout the more saline regions of the western Dutch Wadden Sea. There it was found multiple times in harbours and on sublittoral mussel parcels. The salinities at the locations where the species was found in 2018, varied from 23.7 to 24.6 ppt (Table 2; Appendix III). Nowadays *D. japonica* is distributed along the entire European coastline from Spain to Norway (Sjotun *et al.*, 2008; Gittenberger *et al.*, 2012).

Impact:
As *Dasysiphonia japonica* does not grow well at salinities lower than 15 ppt (Bjærke & Rueness, 2004), it has significantly expanded its range since its discovery in 2014 to relatively saline habitats in the western Wadden Sea. Because of its small size and the need for constantly submerged hard substrata to settle on, it is unlikely that this algal species will have a distinct impact on the Wadden Sea ecosystem. It rapid range expansion since 2014, does indicate that it may be found even more widespread in the Wadden Sea within the coming years.

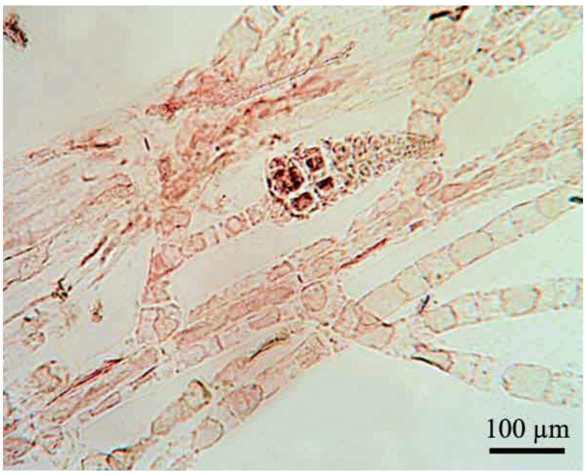

Fig. 21. *Dasysiphonia japonica in vitro* detail with tetrasporangia. Specimen collected from a musseldregde sample south off Terschelling in August 2018.

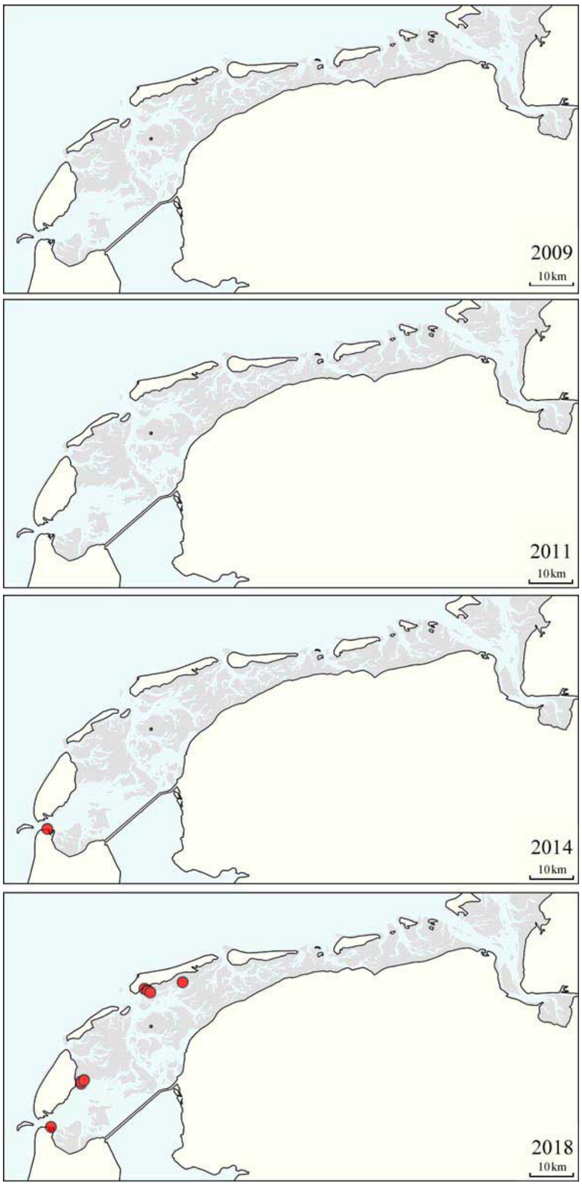

Fig. 22. Locations where *Dasysiphonia japonica* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.1.9 *Gracilaria vermiculophylla*
(Ohmi) Papenfuss (Figs 23-24)

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

Distribution:
In the Netherlands *Gracilaria vermiculophylla* was first recorded in the Dutch Delta area, close to Yerseke in 1994 (Stegenga *et al.*, 2007). In the Wadden Sea it is known since the inventory in 2009 (Gittenberger *et al.*, 2010). During the alien species focused inventories in 2009, 2011 and 2014 *G. vermiculophylla* was found wide-spread throughout the Wadden Sea, usually in the littoral zone on sand, on oyster reefs and/or on mussel beds (Fig. 24; Gittenberger *et al.*, 2010, 2012, 2015). In 2018 it was also found in these habitats, but only in the western part of the Wadden Sea. The salinities at the locations where the species was found in 2018, varied from 20.4 to 24.6 ppt (Table 2; Appendix III).

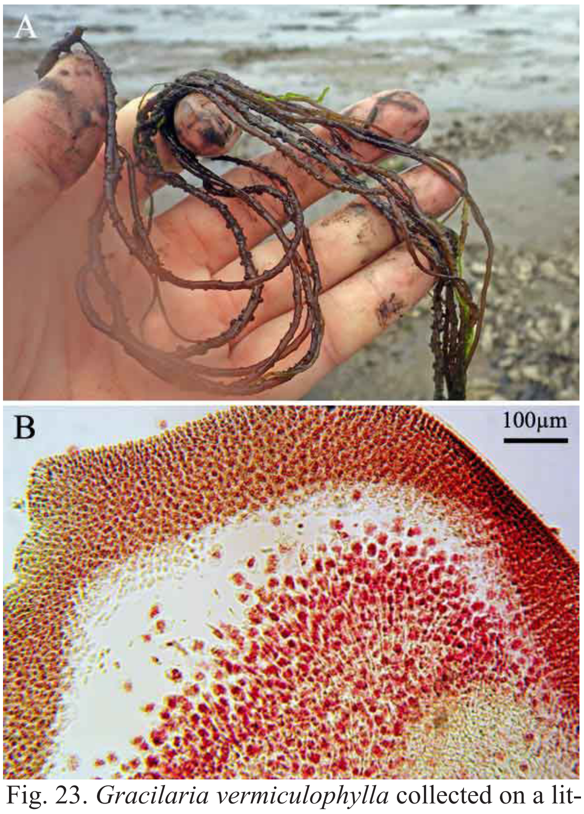

Fig. 23. *Gracilaria vermiculophylla* collected on a littoral oyster reef off Texel in September 2018 [A] *in situ* [B] *in vitro* detail of on a carposporophyt.

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 marcoalgal species present covering large areas of the surface (Thomsen *et al.* 2007). Although *G. vermiculophylla* may have a similar impact on the Dutch Wadden Sea ecosystem, the 2018 survey indicated that its

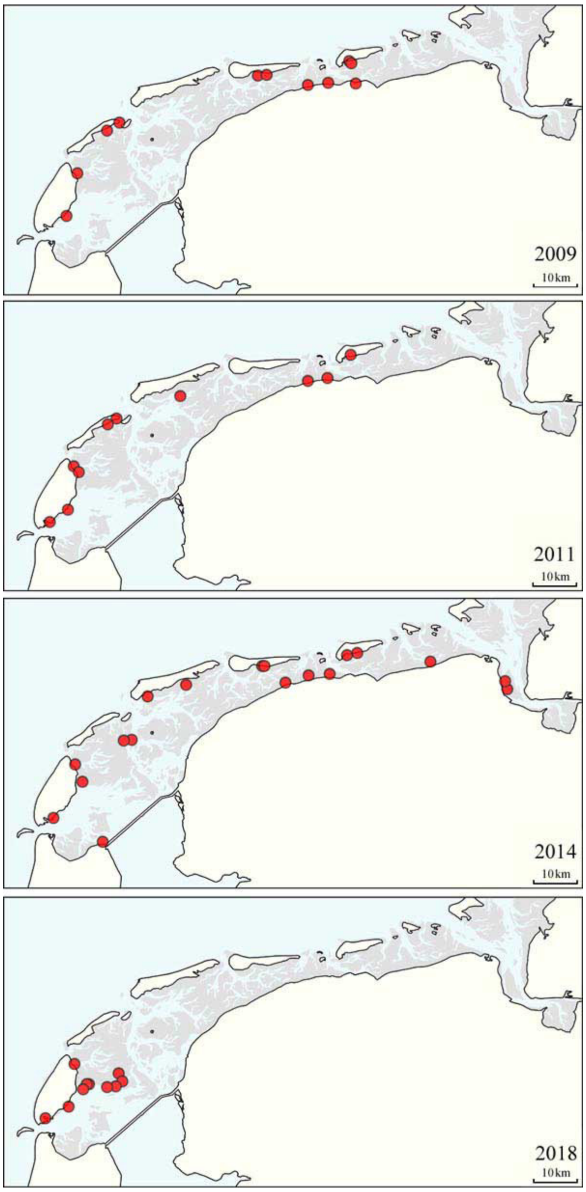

Fig. 24. Locations where *Gracilaria vermiculophylla* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

spread had distinctly declined. It was found restricted to the western part of the Dutch Wadden Sea only, while it was known to be more widely distributed from the west to the east in 2009, 2011 and 2015 (Gittenberger *et al.*, 2009, 2011, 2015; Fig. 24). As it is a species that is mainly found in the littoral zone where it lies directly exposed to the sun, the warm summer of 2018 may have caused its population decline. It was the warmest summer in the Netherlands in three centuries (www.knmi.nl).

4.3.1.10 *Melanothamnus harveyi*

(Bailey) Kim, Choi, Guiry & Saunders (Figs 25-26)

Origin:
N Pacific (Maggs & Stegenga 1999).

Distribution:
Melanothamnus harveyi was first recorded in the Netherlands in 1960 in the Canal through Zuid-Beveland in the Dutch Delta area (Maggs & Stegenga 1999 as *Polysiphonia harveyi*), where it is at present a widespread and common species. In the Wadden Sea it was first discovered in 1972 at Balgzand (Stegenga & Mol, 1983). Since then it has expanded its range. During the species inventories in 2009, 2011, 2014 and 2018 *M. harveyi* was found widespread throughout the entire Wadden Sea (Fig. 26; Gittenberger *et al.*, 2010, 2012, 2015). The individuals recorded in 2018 came from a wide variety of habitats in harbours and in the sublittoral. The salinities at the locations where the species was found in 2018, varied from 7.0 to 25.6 ppt (Table 2; Appendix III).

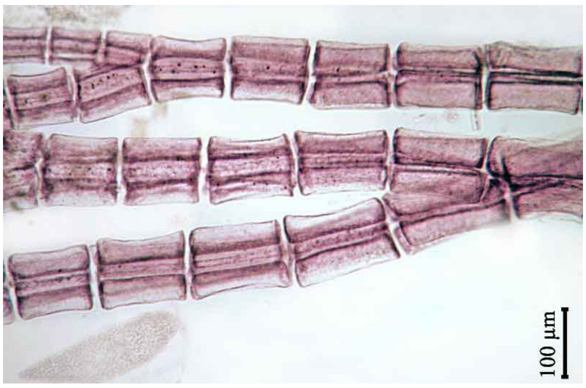

Fig. 25. *Melanothamnus harveyi in vitro.* Specimen collected from a floating dock on Vlieland, in August 2018

Impact:
Although *Melanothamnus harveyi* was found almost completely restricted to floating docks during the inventory in 2009 (Gittenberger *et al.*, 2010), it was also found more offshore in the central Wadden Sea in 2011, 2014 and 2018. There, it may have a more direct impact on the ecosystem of the Wadden Sea.

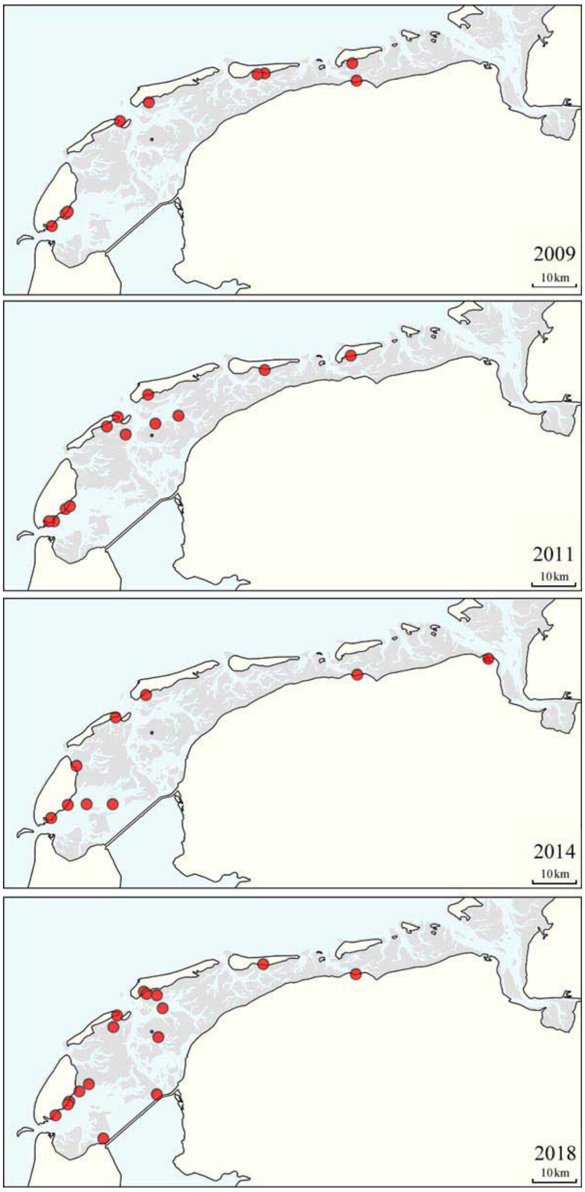

Fig. 26. Locations where *Melanothamnus harveyi* has found during The Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.1.11 *Polysiphonia senticulosa*
Harvey (Figs 27-28)

Origin:
N Pacific (Stegenga *et al.*, 1997)

Distribution:
This concerns the first record of *Polysiphonia senticulosa* in the Dutch Wadden Sea, i.e. on a floating dock in the harbour of Terschelling (Fig. 28). The salinity at this location was 24.3 ppt (Table 2; Appendix III). It was not found during the non-native species inventories in the region in 2009, 2011 and 2014 (Gittenberger *et al.*, 2010, 2012, 2015). Those inventories did not include a spring survey however, which may explain why the species may have been missed. In 2018 it was found in the June survey, but not during the summer survey in August-October 2018. This is consistent with the situation in the Oosterschelde where the species is common during winter time, while being virtually absent in summer (Stegenga & Karremans, 2014). The species was first recorded for the Netherlands in 1993, i.e. in the Oosterschelde (Stegenga, 1998).

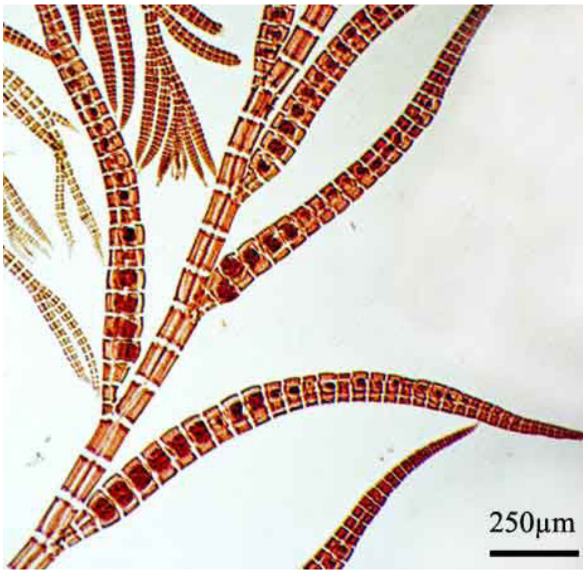

Fig. 27. *Polysiphonia senticulosa* in vito detail. Specimen collected from the floating dock of Terschelling in June 2018.

Impact:
Polysiphonia senticulosa is a relatively small red alga, which has only been found once in the Wadden Sea, i.e. in the spring period survey of 2018 on floating docks. Although it may occur more commonly in winter time as it does in the Dutch province of Zeeland (Stegenga & Karremans, 2014), it is not expected to have a large impact on the Wadden Sea ecosystem.

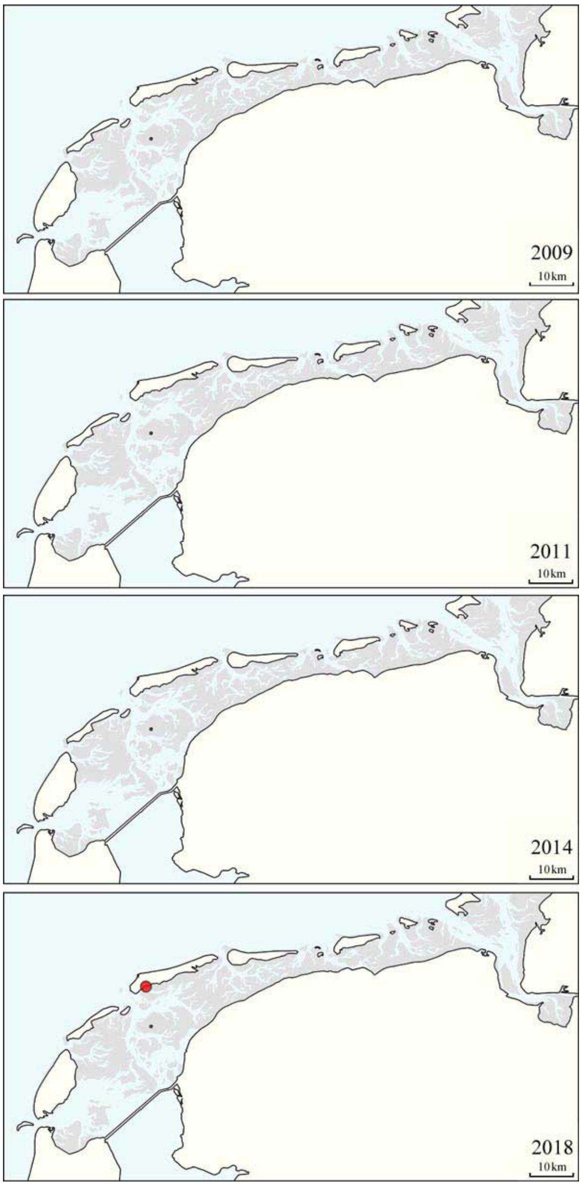

Fig. 28. Locations where *Polysiphonia senticulosa* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.1.12 *Sargassum muticum*
(Yendo) Fensholt (Figs 29-30)

Origin:
NW Pacific (Silva 1955).

Distribution:
Attached thalli of the Japanese Sargasso weed *Sargassum 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). During the species inventories in 2009, 2011, 2014 and 2018 the algal species *S. muticum* was found widespread throughout the western Dutch Wadden Sea in various habitats (Fig. 30; Gittenberger *et al.*, 2010, 2012, 2015). The salinities at the locations where the species was found in 2018, varied from 16.3 to 25.6 ppt (Table 2; Appendix III).

Fig. 29. *Sargassum muticum in situ* in a tidal pool in an oyster reef off Terschellling.

Impact:
At none of the localities *Sargassum muticum* (Fig. 29) was found as a dominant species during the species inventories in 2009, 2011, 2014 and 2018. Instead, it was usually rare. Therefore, *S. muticum* does not seem to have a large impact on the Wadden Sea ecosystem. In other regions in especially southern Europe the specimens of this species tend cover large areas having a distinct impact on their surroundings (Ribera & Boudouresque, 1995).

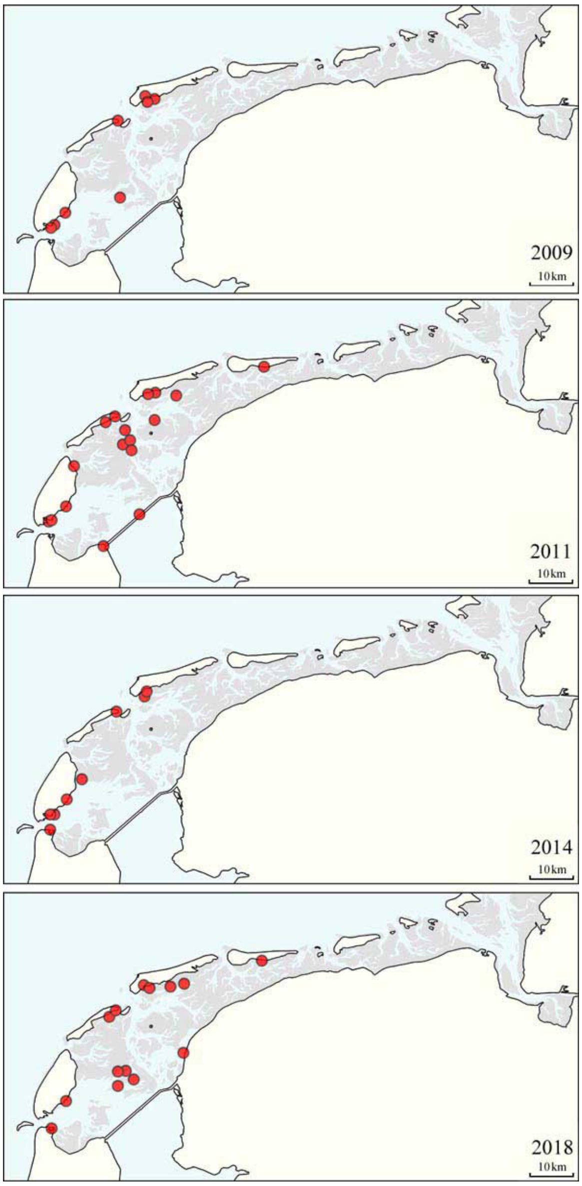

Fig. 30. Locations where *Sargassum muticum* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.1.13 *Ulva australis*
Kjellman (Figs 31-32)

Origin:
NW Pacific (Silva 1955).

Distribution:
The first record of *Ulva australis* in the Netherlands was done in the Dutch Delta region in 1993 (Stegenga & Mol, 2002 as *Ulva pertusa*). Since then, the species has quickly spread throughout the Netherlands from the Delta region up to the Wadden Sea (Stegenga & Mol, 2002). During the species inventories in 2009, 2011, 2014 and 2018 Ulva australis was found widespread throughout the Dutch Wadden Sea (Fig. 32; Gittenberger *et al.*, 2010, 2012, 2015).

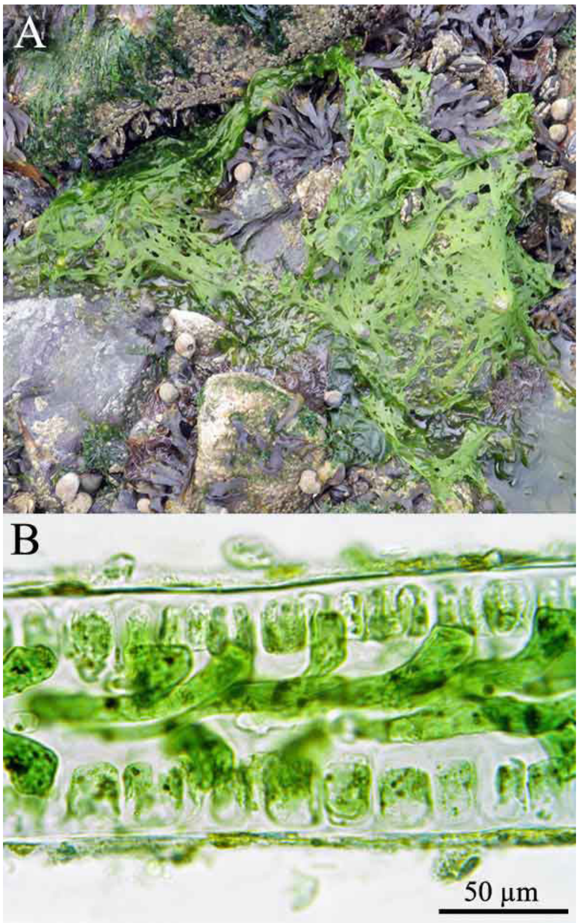

Fig. 31. *Ulva australis* [A] *in situ* on the exposed side of the dike in 't Horntje, Texel; [B] specimen collected from the sheltered side of the dike in Oudeschild, Texel *in virto*.

The salinities at the locations where the species was found in 2018, varied from 19.5 to 25.6 ppt (Table 2; Appendix III).

Impact:
This sea lettuce species is locally very abundant, having a distinct impact. Because it is hard to distinguish *Ulva australis* in the field (Fig. 31A) from native *Ulva* species (Koeman & Van den Hoek 1981), its overall impact on the Wadden Sea ecosystem remains uncertain.

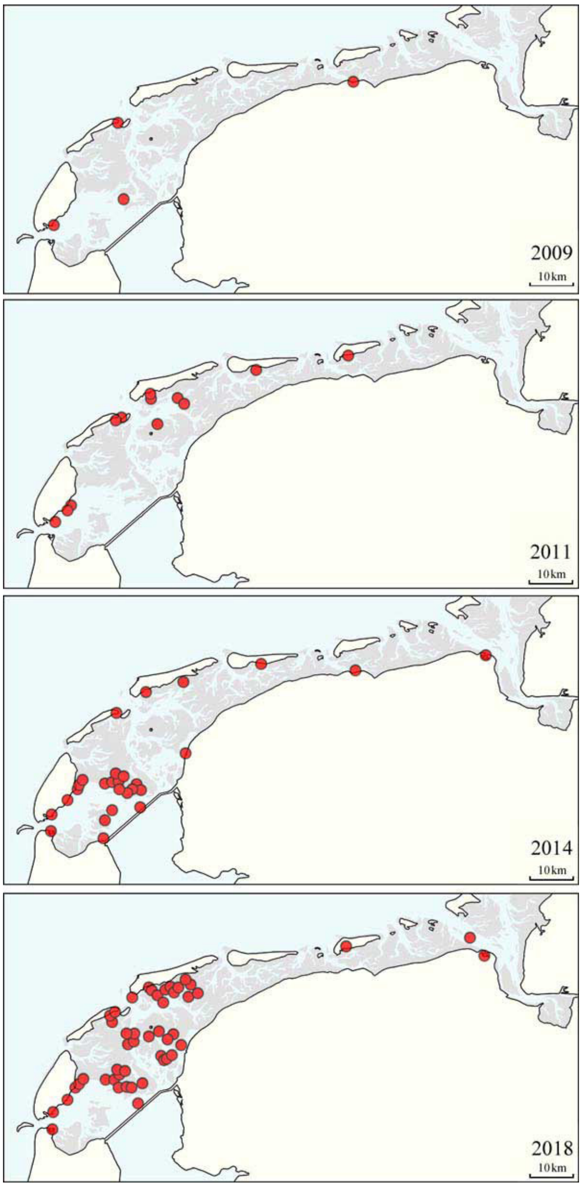

Fig. 32. Locations where *Ulva australis* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.1.14 *Ulvaria splendens*
(Ruprecht) Vinogradova (Figs 33-34)

Origin:
Possibly North Pacific, but present especially in Northern Europe, e.g. in Norway for over a century (Guiry & Guiry, 2019).

Distribution:
This concerns the first record of *Ulvaria splendens* in the Wadden Sea and the Netherlands. It was not found during the non-native species inventories in the region in 2009, 2011 and 2014 (Gittenberger *et al.*, 2010, 2012, 2015). In 2018 it was found only once in August 2018 on a floating dock in the harbour of ‘t Horntje, Texel (Fig. 34). The salinity at this location was 23.7 ppt (Table 2; Appendix III).

Impact:
This sea lettuce species was found at one location, where it was not very abundant. Because it is hard to distinguish *Ulva splendens* in the field from native *Ulva* species (Koeman & Van den Hoek 1981), its overall impact on the Wadden Sea ecosystem remains uncertain however.

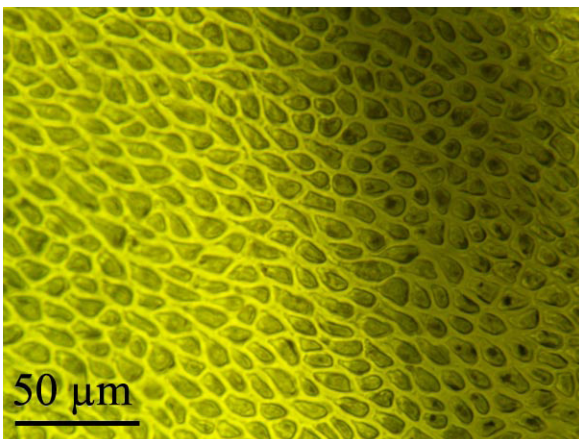

Fig. 33. *Ulvaria splendens* detail *in vitro*. Specimen collected in August 2018 from a floating dock in ‘t Horntje, Texel.

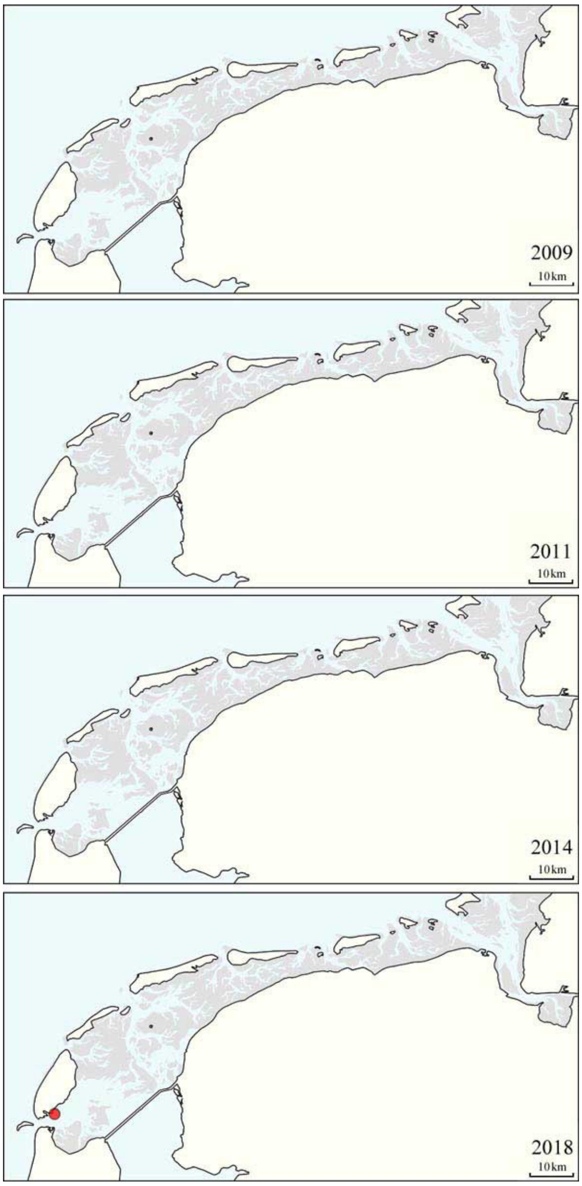

Fig. 34. Locations where *Ulvaria splendens* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.1.15 *Undaria pinnatifida*
(Harvey) Suringar (Figs 35-36)

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. Additionally one specimen was recorded in the Wadden Sea in 2014, just south off Terschelling, on a sublittoral oyster reef (Gittenberger *et al.*, 2010, 2012, 2015). In June and August 2018 *U. pinnatifida* was found at the same locations as in 2014 (Fig. 36), but only a few individuals were found. This could be related to relatively warm summer, i.e. the warmest in three centuries (www.knmi.nl), considering that U. pinnatifida is a winter species. The salinities at the locations where it was found in 2018 varied from 23.9 to 24.3 ppt (Table 2; Appendix III).

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). Possibly very locally, Wakame may be able to establish itself. The small oyster reef south of Terschelling for example, lies relatively sheltered, which may have enabled its local settlement (Fig. 36).

Fig. 35. *Undaria pinnatifida in vito*, cellected from a floating dock in the harbour of Terschelling.

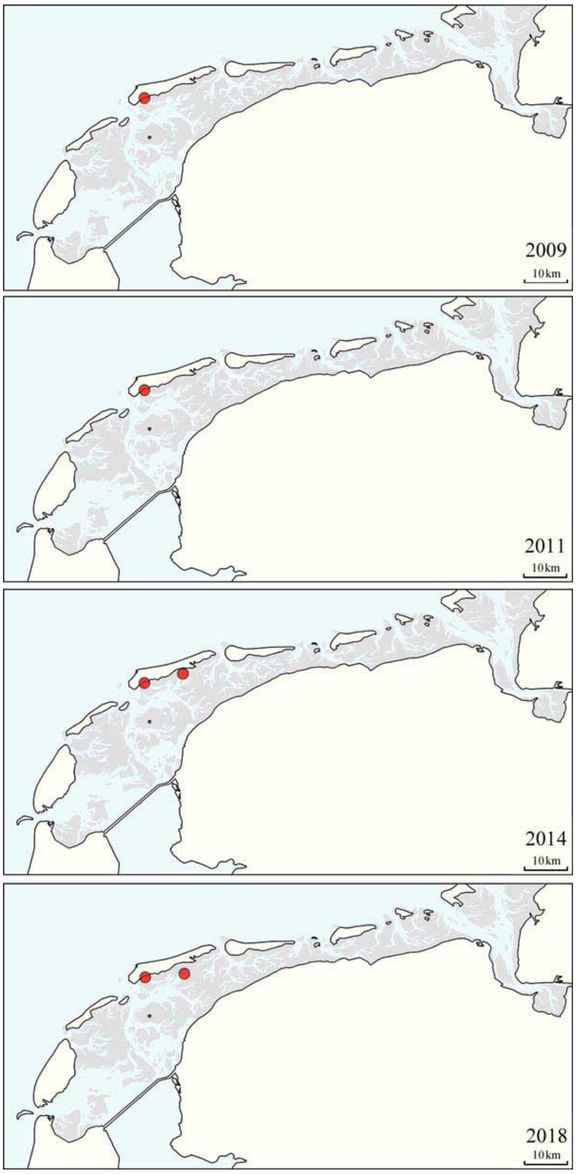

Fig. 36. Locations where *Undaria pinnatifida* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.2 Annelida

4.3.2.1 *Aphelochaeta marioni*
(Saint-Joseph, 1894) (Figs. 37-38)

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 inventories in 2014 and 2018 *A. marioni* was commonly found, being widespread in soft sediment "SIBES" samples taken in the intertidal. It has been common in the Dutch Wadden Sea 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). Figure 38 only includes the records made during the inventories in 2014 and 2018 and soft sediment samples were included in these surveys (Gittenberger *et al.*, 2015).

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

Fig. 37. *Aphelochaeta marioni.*

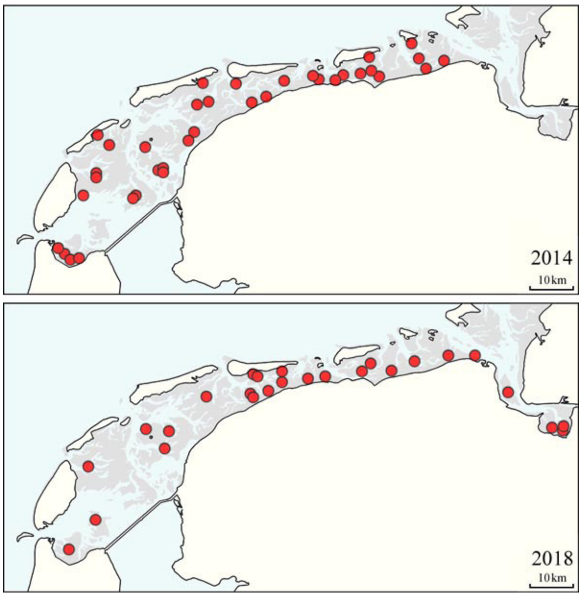

Fig. 38. Locations where *Aphelochaeta marioni* was found during The Wadden Sea inventory in 2014 and 2018.

4.3.2.2 *Ficopomatus enigmaticus*
(Fauvel, 1923) (Figs 39-40)

Origin:
SW Pacific (Grosholz & Ruiz, 1996)

Distribution:
In 1967 the calcareous tube worm *Ficopomatus enigmaticus* was first recorded in the Netherlands in the Westerschelde (Wolff, 1968). Since then, it became widespread in the Netherlands, occurring mainly in brackish waters. In the Wadden Sea it was first recorded in the harbour of Harlingen in 2009 (Gittenberger *et al.*, 2010; Fig. 40). Although it was not recorded during the surveys in 2011 and 2014, it was found during the non-native species inventory in 2018 (Fig. 40). In 2018 it was recorded on floating docks and SETL-plates in the harbours of Harlingen and Den Helder. The salinities of these locations, varied from 16.0 to 20.4 ppt in 2018 (Table 2; Appendix III).

Impact:
With its tubes this worm (Fig. 39) can build relatively large, up to at least 20-30 cm, and strong cal-careous 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 open waters of the Wadden Sea, but it may do so more inland in stream and canals with relatively low salinities (Gittenberger *et al.*, 2010).

Fig. 39. Three individuals of *Ficopomatus enigmaticus* (white arrows) on a SETL plate in the harbour of Den Helder in September 2018.

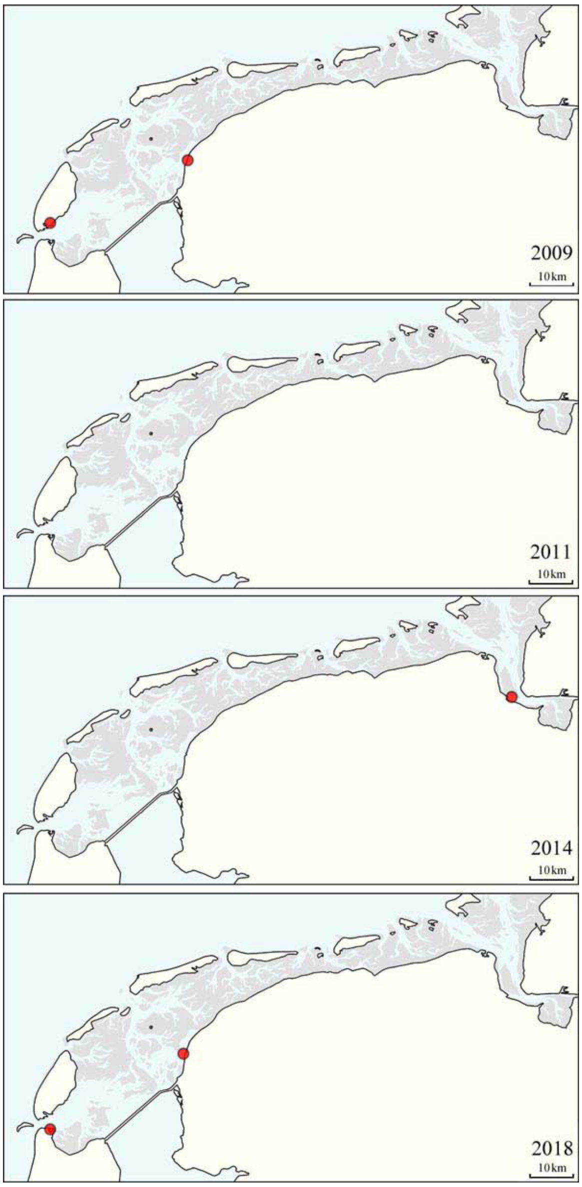

Fig. 40. Locations where *Ficopomatus enigmaticus* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.2.3 *Marenzelleria viridis*
(Verrill, 1873) (Figs 41-42)

Origin:
NW Atlantic (Barnes, 1994).

Distribution:
Marenzelleria viridis wasfirst 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 and 2018 it was found widespread in bottom samples throughout the entire Wadden Sea (Gittenberger *et al.*, 2015; Fig. 42). 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:
As *Marenzellaria viridis* is a common, widespread species in the more brackish parts of the Wadden Sea (Dekker & Drent, 2013). It therefore probably has a distinct impact on the local ecosystem (Essink & Dekker, 2002), for example by competing for food and space with other polychaetes.

Fig. 41. *Marenzellaria viridis.*

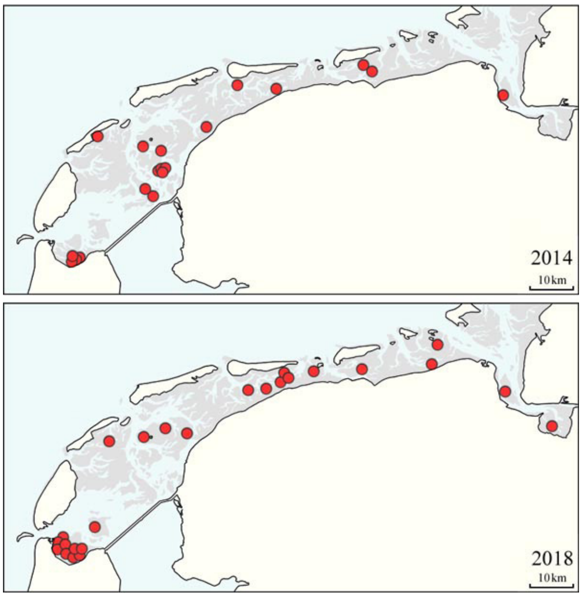

Fig. 42. Locations where *Marenzelleria viridis* was found during The Wadden Sea inventories in 2014 and 2018.

4.3.2.4 *Neodexiospira brasiliensis*
(Grube, 1872) (Figs 43-44)

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

Distribution:
In the Netherlands *Neodexiospira brasiliensis* was first recorded in 1982, i.e. at Goessche Sas in the Eastern Scheldt (Critchley & Thorp, 1985). In the Wadden Sea *N. brasiliensis* was first recorded in 2009 in the harbour ‘t Horntje, Texel (Fig. 44), where the minute spiral calcareous tubes were found on the alga *Mastocarpus stellatus* in the littoral zone on the dike. In 2014 it was found on the same location (Gittenberger *et al*., 2010, 2015) and in 2018 the species was again recorded in the same harbour, growing on algae on the floating dock.

Impact:
The small calcareous tubes of *Neodexiospira brasiliensis* are several millimetres in diameter (Fig. 43). They were recorded in the harbour ‘t Horntje, Texel, during the surveys in 2009, 2014 and 2018 (Gittenberger *et al*., 2010, 2012, 2015; Fig. 44), but nowhere else in the Wadden Sea. This species is therefore not expected to have any impact on the ecosystem.

Fig. 43. *Neodexiospira brasiliensis in situ* on macro algea on the floating dock of ‘t Horntje, Texel, August 2018.

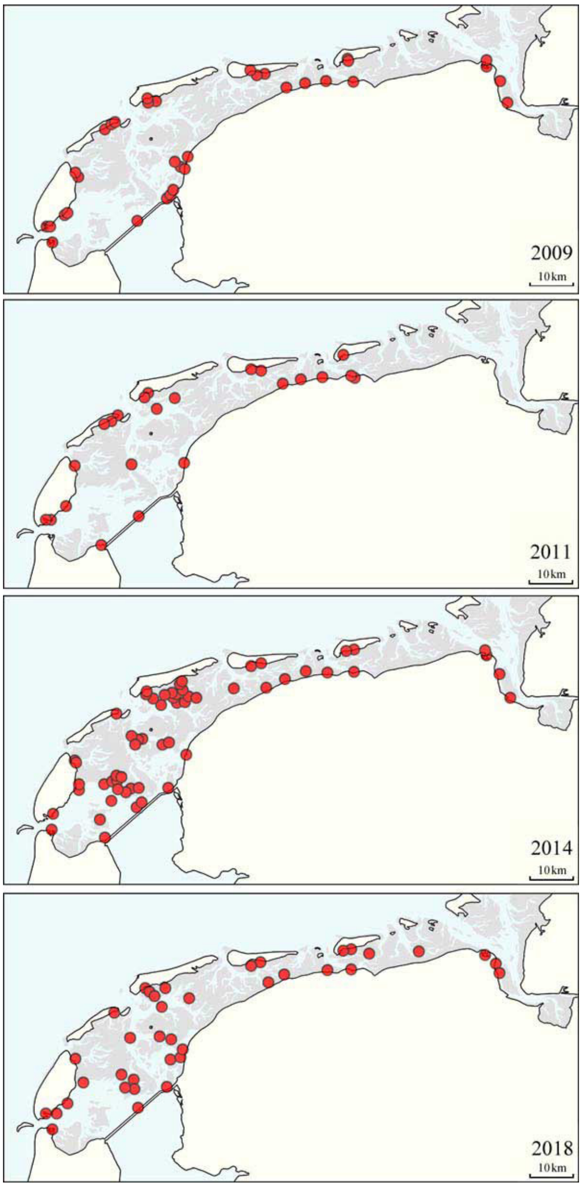

Fig. 44. Locations where *Neodexiospira brasiliensis* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.3 Ascidiacea

4.3.3.1 *Aplidium glabrum*
(Verrill, 1871) (Figs 46, 49A)

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

Distribution:
In the Netherlands *Aplidium glabrum* was first recorded in the Dutch Delta region in 1977 (Buizer, 1983). During the non-native species focused inventory in 2009 it was first recorded for the Wadden Sea in the marina of Terschelling. There it was also found during the inventories in 2011, 2014 and 2018 (Gittenberger *et al.*, 2010, 2012, 2015; Fig. 46). In 2014 the species was additionally found off Terschelling, Vlieland and Schiermonnikoog (Gittenberger *et al.*, 2015) and in 2018 it was found on floating docks in the harbours of Terschelling, Vlieland and Texel (Fig. 46). The salinities at the locations where it was found in 2018 varied from 23.5 to 24.6 ppt (Table 2; Appendix III).

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 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.

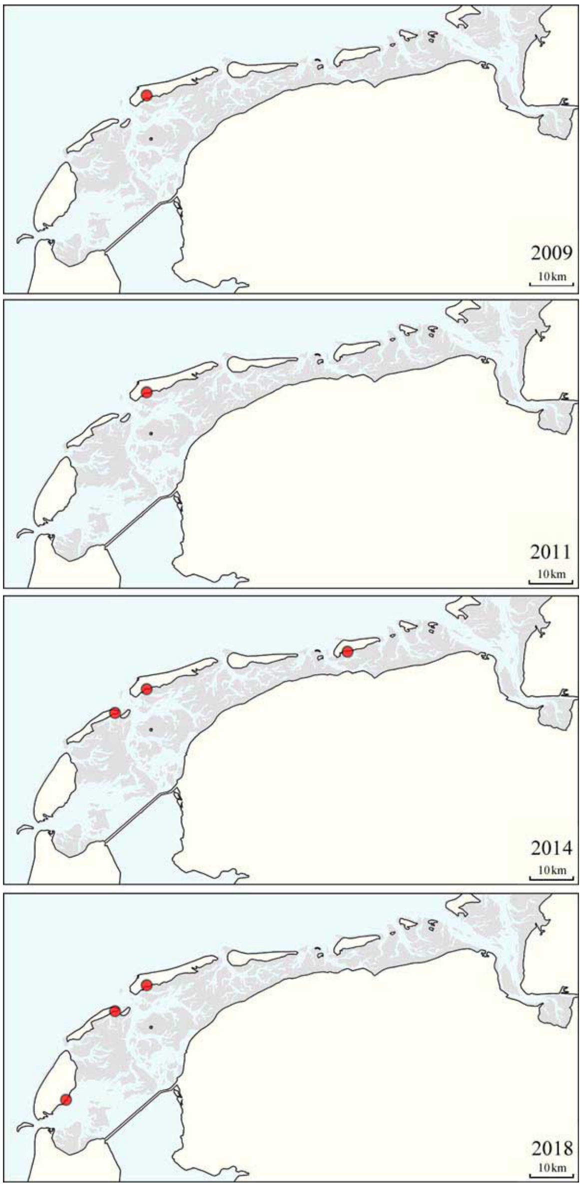

Fig. 46. Locations where *Aplidium glabrum* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.3.2 *Botrylloides violaceus*
Oka, 1927 (Figs 47, 49C)

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 *B. violaceus* like colonies were already sighted in the NIOZ harbour (Gittenberger *et al.*, 2014). It occurred abundantly on the floating docks in virtually all the harbours of the Wadden Sea islands in 2009 (Fig. 47). There it was also found during the inventories in 2011, 2014 and 2018 (Gittenberger *et al.*, 2012, 2015; Fig. 47). Although *B. violaceus* was only found in the marinas and harbours of the Wadden Sea islands in 2009 and 2011, it was also found in harbours of the main land from Den Helder to Eemshaven in 2014 and 2018 (Gittenberger *et al.*, 2010, 2012, 2015; Fig. 47). Although some colonies occurred on harbour walls and jetties, most records are from floating docks and SETL plates. The salinities at the locations where the species was found in 2018, varied from 20.4 to 24.6 ppt (Table 2; Appendix III).

Impact:
This abundant and very distinctly coloured species (Fig. 49C) 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.

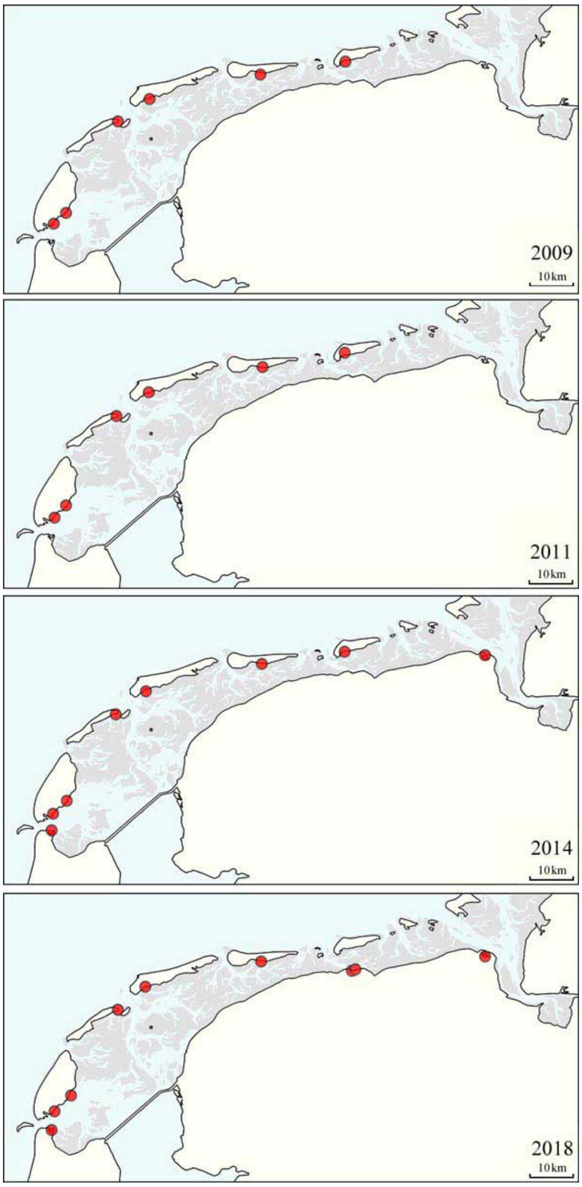

Fig. 47. Locations where *Botrylloides violaceus* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.3.3 *Didemnum vexillum*
Kott, 2002 (Figs 48, 49B)

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 detected 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 further into the more saline areas of the Wadden Sea, also being present in sublittoral habitats off Texel and Terschelling (Gittenberger *et al.*, 2015), where it was again found in 2018 (Fig. 48). The salinities at the locations where the species was found in 2018, varied from 21.8 to 25.6 ppt (Table 2; Appendix III).

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 the organisms present. *D. vexillum* is mainly found on hard substrata, but has also shown the ability to overgrow sandy bottoms (Gittenberger, 2007). Gittenberger (2010) has done a risk analysis focused on this species, for the Wadden Sea. As was predicted *Didemnum vexillum* has expanded its population within the Wadden Sea to the more saline areas. There it is especially dominant on 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 more saline areas of the Wadden Sea.

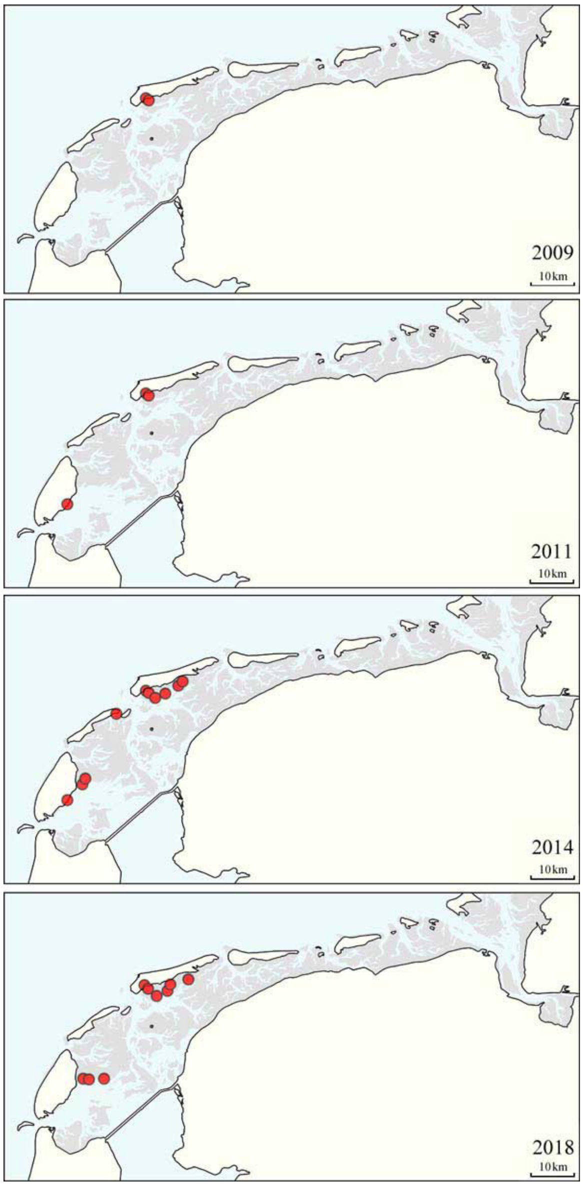

Fig. 48. Locations where *Didemnum vexillum* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

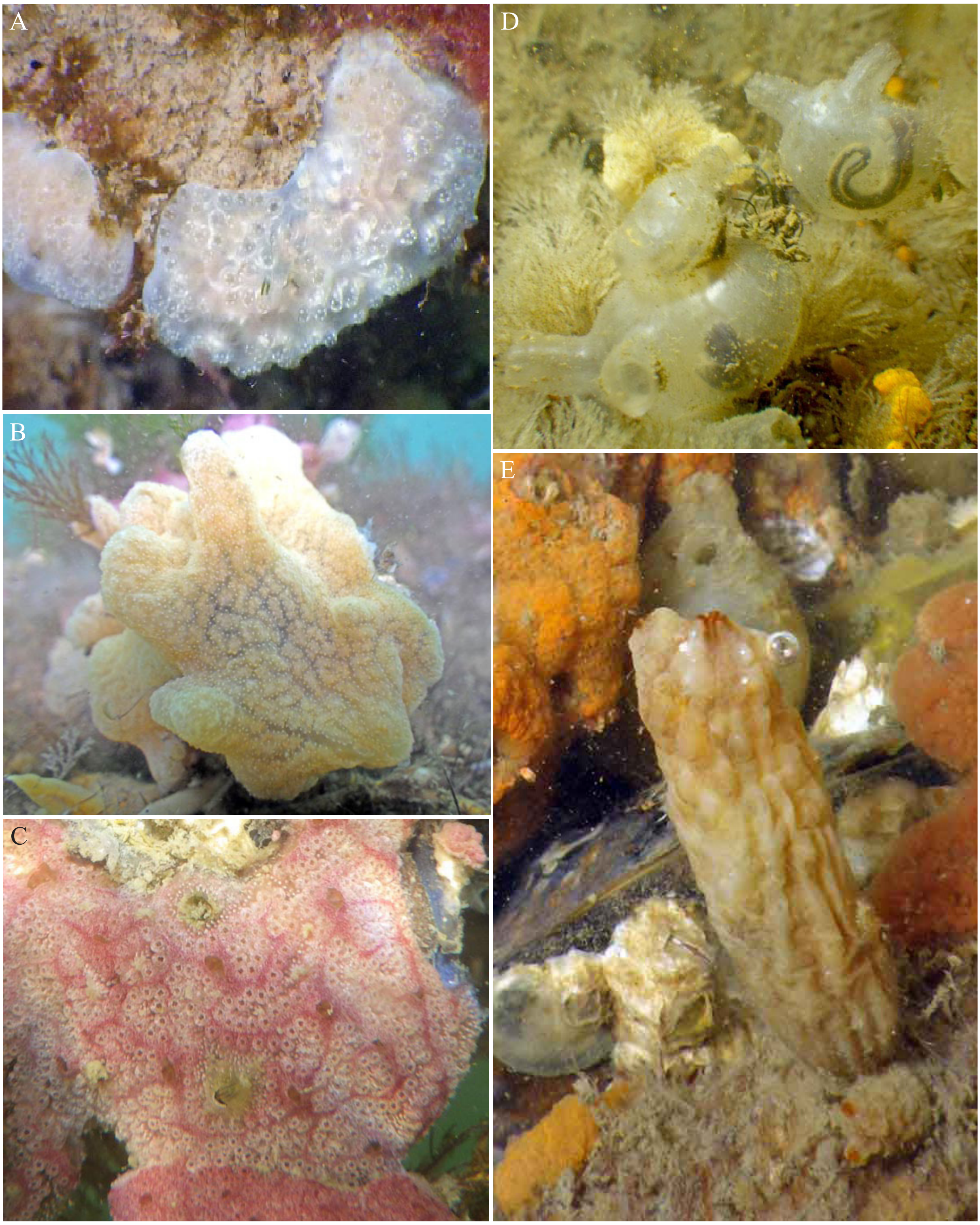

Fig. 49. Ascidians *in situ* in the Dutch Wadden Sea in 2018. A-C, Colonial ascidians: A, *Aplidium glabrum,* B, *Didemnum vexillum* and C, *Botrylloides violaceus;* [D]-[E], Solitary ascidians: D, *Molgula manhattensis* and E, *Styela clava.* Floating dock in marina of Terschelling: A-B; Floating dock in the harbour of 't Horntje, Texel: C-D; SETL plate in the port of Eemshaven: E.

4.3.3.4 ***Molgula manhattensis*** (De Kay, 1843)
Molgula socialis Alder, 1863
(Figs 49D, 50)

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 *Molgula* 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, which can only be identified by molecular analyses and/or the time-consuming anatomical dissection of adult specimens. It is therefore uncertain where and since when each of these species occurred in the Netherlands and in the Wadden Sea. Based on the anatomical analysis of a selection of specimens it could be concluded that both species in 2018 occur in the Dutch Wadden Sea (Fig. 50), as was also concluded in a similar manner during the previous inventories in the Dutch Wadden Sea in 2009, 2011 and 2014 (Gittenberger *et al.*, 2010, 2012, 2015). The salinities at the locations where these Molgula individuals were found in 2018, varied from 7.0 to 25.6 ppt (Table 2; Appendix III).

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, especially on hard substrata. Their impact on the ecosystem remains unknown (Gittenberger *et al.*, 2012).

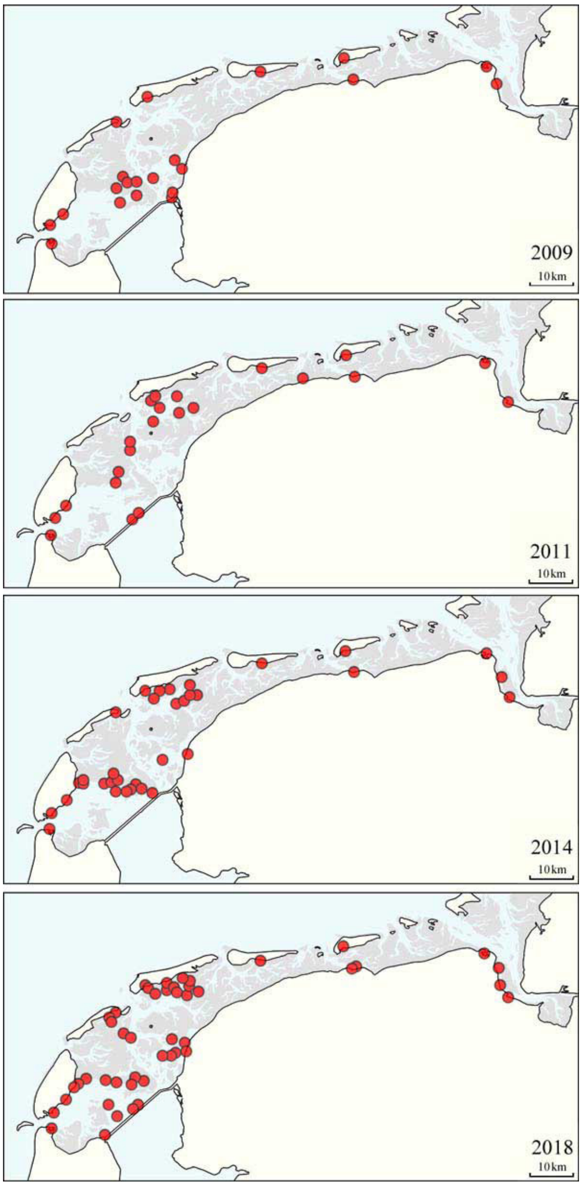

Fig. 50. Locations where *Molgula manhattensis/ socialis* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.3.5 *Styela clava*
Herdman, 1881 (Figs 49E, 51)

Origin:
NW Pacific (Lützen 1999).

Distribution:
In the Netherlands the club tunicate *Styela clava* was first found in 1974, in the Dutch Wadden Sea in the harbour of Den Helder (Huwae & Lavaleye, 1975). During the non-native species inventories in the Wadden Sea in 2009, 2011 and 2014 it was found widespread throughout the whole Wadden Sea both in the harbours and more offshore in the Wadden Sea (Gittenberger, 2010, 2012, 2015; Fig. 51). In 2018, it was still recorded widespread, but all individuals were recorded in harbours and close to shore (Fig. 51). The salinities at the locations where the species was found in 2018, varied from 20.4 to 25.6 ppt (Table 2; Appendix III).

Impact:
Over the years *Styela clava* has become part of the Dutch Wadden Sea ecosystem. Although it was also found in the central Wadden Sea during previous surveys in 2009, 2011 and 2014, *S. clava* becomes particularly abundant in harbours, having a distinct impact on its surroundings there.

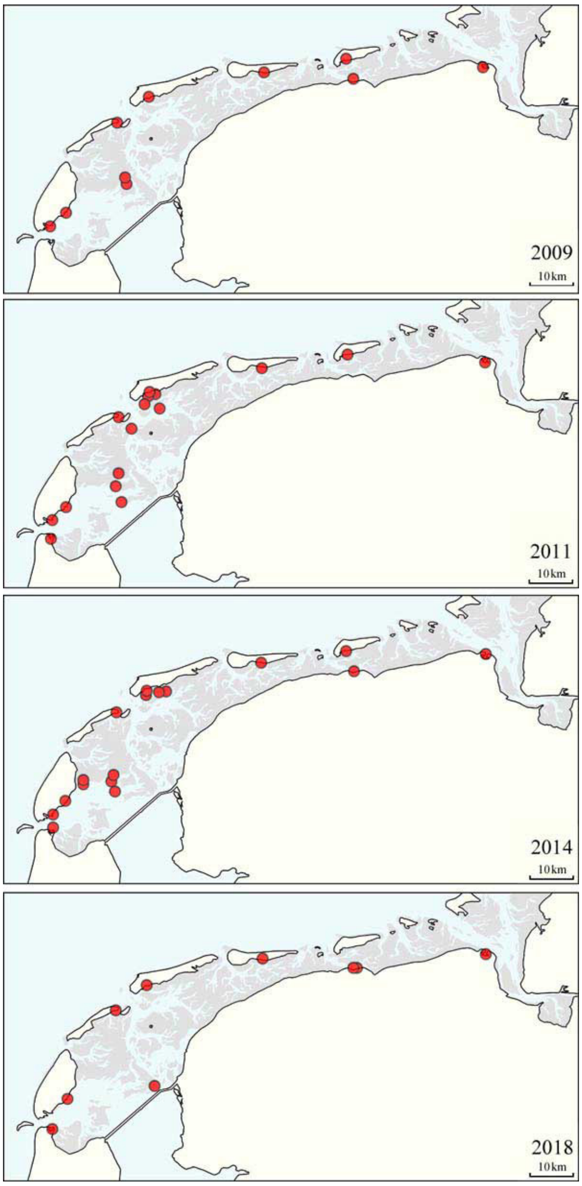

Fig. 51. Locations where *Styela clava* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.4 Bryozoa

4.3.4.1 *Amathia* cf. *gracilis*
(Leidy, 1855) (Figs 52-53)

Origin:
Although *Amathia* cf. *gracilis* is generally considered a cosmopolitan species (Faasse & De Blauwe, 2004; Wolff, 2005), which may be considered native to the Netherlands, some authors indicate that its origin is unknown and it should therefore be considered a cryptogenic species, possible non-native to the Netherlands (Wolff, 2005).

Distribution:
Amathia cf. *gracilis* is an established species in the Netherlands (Faasse & De Blauwe, 2004; Wolff, 2005). It was recorded for the Wadden Sea by Faasse & De Blauwe (2004) referring to a student report of T. Mulder in 1983, indicating its presence in the harbour and on the dike of Oudeschild on Texel, where the species was also recorded during the present study in 2018 (Fig. 53). While the species was not recorded during the alien species focused surveys in 2009, 2011 and 2014, it was recorded 17 times in 2018, i.e. in the harbours of Oudeschild, Harlingen and Eemshaven on various SETL-plates. The SETL fouling plate methodology was not used during the previous assessments in 2009, 2011 and 2014, explaining why the species may have been missed during those inventories. *Amathia*

Fig. 52. *Amathia* cf. *gracilis* overgrowing an ascidian on a SETL plate in Eemshaven in June 2018.

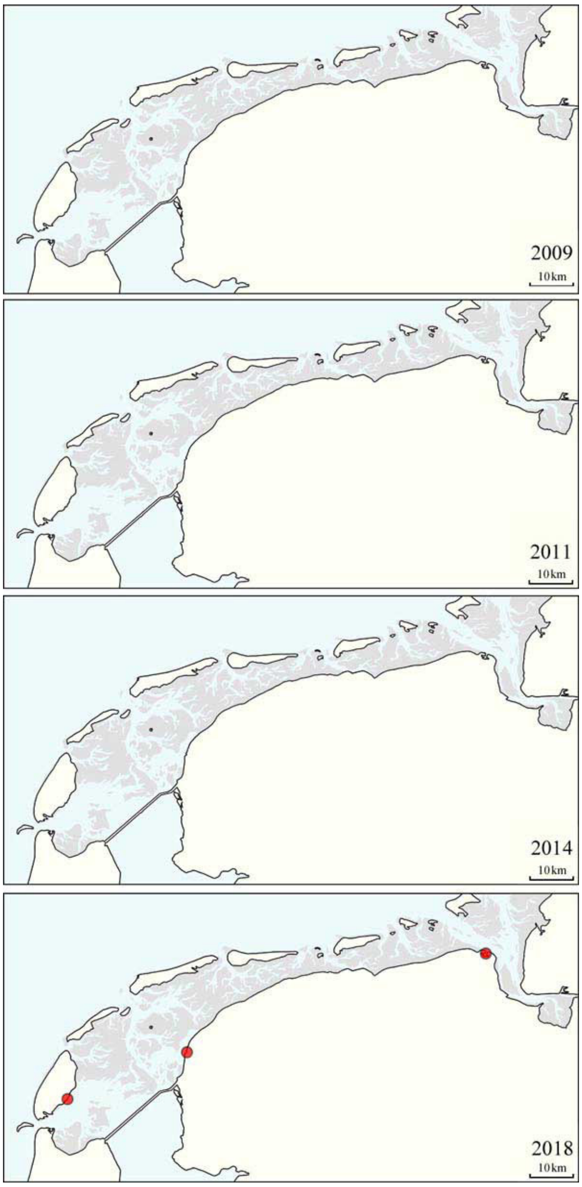

Fig. 53. Locations where *Amathia* cf. *gracilis* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

cf. *gracilis* probably concerns a pioneer species, which is therefore mainly recorded on hard substrates that have recently been deployed, like fouling plates. In comparison it is probably relatively rare on floating docks as the fouling species communities on those docks tend to be in later succession stages. The salinities at the locations where the *Amathia* cf. *gracilis* was found in 2018, varied from 17.0 to 24.6 ppt (Table 2; Appendix III).

Impact:
Amathia cf. *gracilis* concerns an established species in the Netherlands. As it is potentially a native species, which is only recorded in the Dutch Wadden Sea in the vicinity of harbours, its impact on the Wadden Sea ecosystem is probably minimal.

4.3.4.2 *Bugulina stolonifera*
(Ryland, 1960) (Figs 54AB, 55)

Origin:
NW Atlantic (Cohen & Carlton 1995).

Distribution:
In the Netherlands *Bugulina stolonifera* was first found in 1993 in the NIOZ harbour, Texel (D'Hondt & Cadée 1994), During the species inventories in 2009 and 2011 the bryozoan *Bugula stolonifera* was only found in harbours of the Wadden Sea islands, but not in the mainland harbours (Fig. 55; Gittenberger *et al.*, 2010, 2012). In 2014 it was also found in a harbour mainland, i.e. the marine pleasure craft harbour of Den Helder (Gittenberger *et al.*, 2015; Fig. 55). In 2018 it had spread even further as it was additionally found in the eastern Dutch Wadden Sea in the harbour of Eemshaven (Fig. 55). Of the 16 locations where it was recorded in 2018, 15 concerned floating docks or SETL (fouling) plates deployed from these docks. Only one individual was found settled on the sublittoral part of the dike. The salinities at the locations where the species was found in 2018, varied from 20.4 to 24.6 ppt (Table 2; Appendix III).

Impact:
Bugula stolonifera was only found in marinas and there it was mainly found on floating docks. Although the species can be locally abundant on these docks, it seems unlikely that the species will have a large impact on the Wadden Sea ecosystem outside of the harbours.

4.3.4.3 *Tricellaria inopinata*
d'Hondt & Occhipinti Ambrogi, 1985
(Figs 54AC, 56)

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

Distribution:
In 2000 *Tricellaria inopinata* was first recorded for the Netherlands in the Dutch Delta region (Blauwe & Faasse, 2001). 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 *T. 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). *Tricellaria inopinata* was first recorded for the Dutch Wadden Sea during the 2014 alien species focused inventory (Gittenberger *et al.*, 2015), but 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.). During the survey in 2014 it was only recorded in the western part of the Dutch Wadden Sea in harbours of Terschelling, Vlieland, Texel and Den Helder (Gittenberger *et al.*, 2015; Fig. 56). In 2018 this alien species has extended its range to the east (Fig. 56). It was found within the same harbours in the west, but additionally also in the harbours of Ameland, Holwerd and Eemshaven in the east. Most of the records concern floating docks and SETL plates, but it has also been spotted in the sublittoral part on dikes. The salinities at the locations where the species was found in 2018, varied from 20.4 to 24.6 ppt (Table 2; Appendix III).

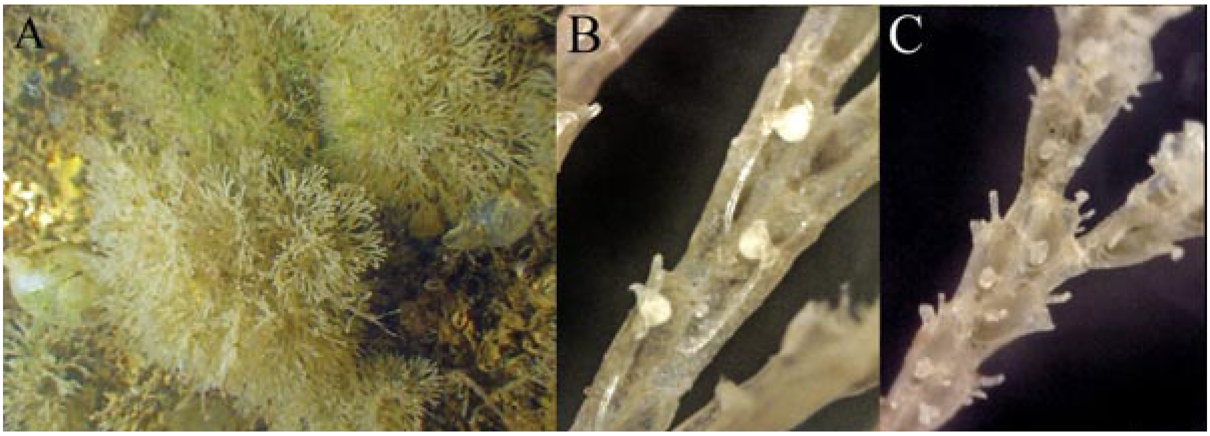

Fig. 54. [A] *Bugulina stolonifera* and *Tricellaria inopinata in situ* on a floating dock in Oudeschild in September 2018. Preserved specimens from this floating dock of [B] *B. stolonifera* and [C] *T. inopinata*, Scale bars are 0.2 mm.

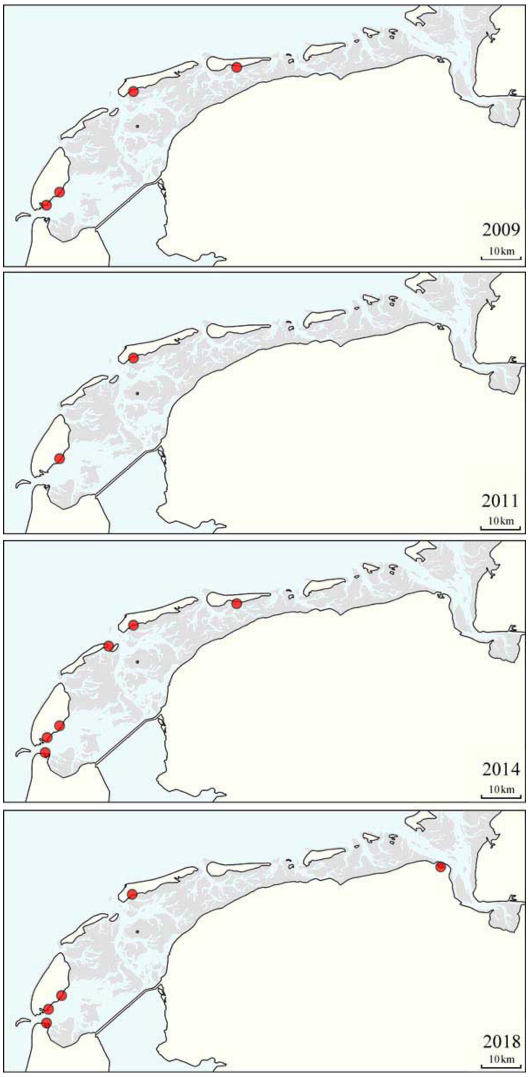

Fig. 55. Locations where *Bugula stolonifera* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

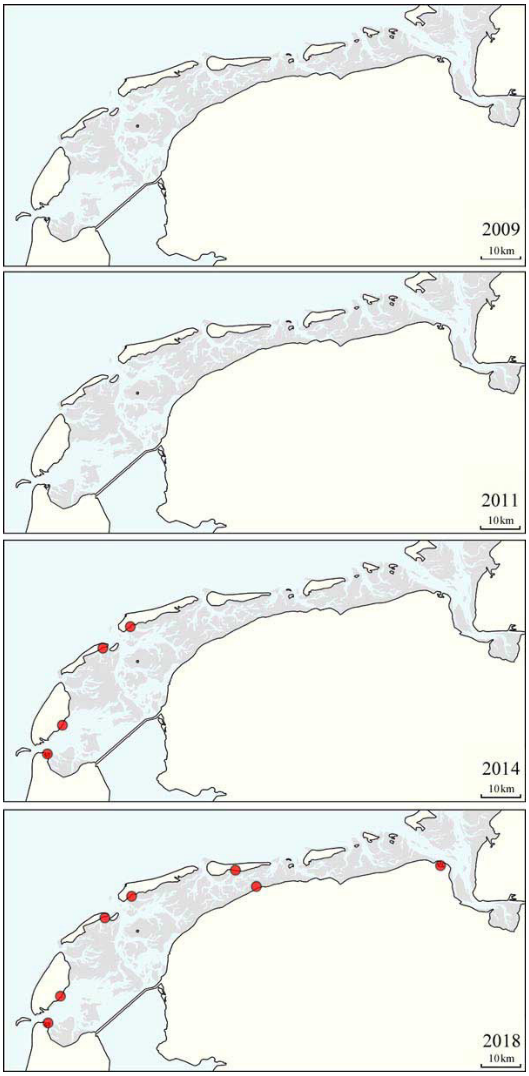

Fig. 56. Locations where *Tricellaria inoptata* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

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). After the 2014 survey it was therefore predicted by Gittenberger *et al.* (2015) that *T. inopinata* will only establish itself in the harbours of the Dutch Wadden Sea, and will therefore not have a distinct impact on the Wadden Sea ecosystem as a whole. Although *T. inopinata* was recorded much more widespread in Dutch Wadden Sea in 2018, the additional records since 2014 all concerned harbours. Regardless of its rapid spread, it therefore remains unlikely that the species will have a distinct impact on the Dutch Wadden Sea ecosystem.

Fig. 57. *Schizoporella cf. japonica* on an oyster that was collected from a sublittoral oyster reef off Texel, in August 2018.

4.3.4.4 *Schizoporella* cf. *japonica*
Ortmann, 1890 (Figs 57-58)

Origin:
NW Pacific (Loxton *et al*., 2017)

Distribution:
This concerns the first record of a settled colony of *Schizoporella* cf. *japonica* in the Wadden Sea and in the Netherlands. The colony was growing on the inside of an old oyster shell fished up in September 2018 NE off Texel with a mussel dredge from a sublittoral shellfish bed consisting mainly of Pacific oysters, i.e. *Magallana gigas* (Fig. 58). The salinity at this location was 25.6 ppt (Table 2; Appendix III). Within Europe the species was first recorded in 2009 in a marina in Plymouth in the south of Great Britain (Ryland *et al.,* 2014). A recent study of Loxton et al. (2017) focused on assessing the distribution of the species in Europe, illustrated however that the species mainly occurs in northern Europe, including in the North Sea a large number of sites off Norway (Porter *et al.,* 2015) and northern Great Britain. Records were included in this study from GB and Norway in addition to specifically checking 231 harbours and marinas across GB, Ireland, Isle of Man, France and Portugal, for the presence of the species. On the basis of these records Loxton et al. (2017) conclude that it seems likely that *S. japonica* may be a rare example of a southward-spreading species in GB, assuming that the species first established itself in Scotland.

Impact:
Although *Schizoporella* cf. *japonica* in Europe has mainly been recorded from marinas and harbours, the species record in Dutch Wadden Sea off NE Texel was not done in the vicinity of any harbour. Loxton et al. (2017) consider this bryozoan invasive in Western Europe as their studies have shown its capability for long-distance salutatory spread and potential for negative impact on native ecosystems and economic activity.

This impact is mainly linked to the fact that the species can form red calcareous colonies over hard substrata. If the species would expand its population within the Dutch Wadden Sea, it may therefore have a distinct impact on fouling communities as are found in for example subtidal shellfish beds.

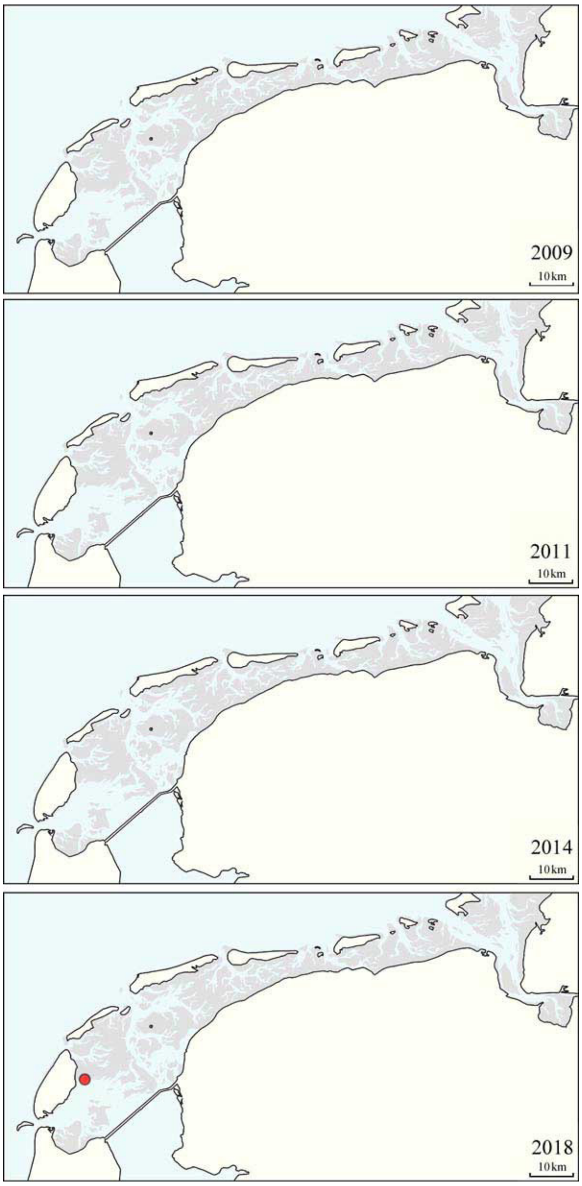

Fig. 58. Locations where *Schizoporella* cf. *japonica* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.4.5 *Smittoidea prolifica*
Osburn, 1952 (Figs 59-60)

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

Distribution:
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). *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 (Dekker & Drent 2013). Since 2008 the species was not found any more in the Dutch Wadden Sea until the alien species focused inventory in 2014 during which it was found widespread in the western Wadden Sea off Terschelling and off Texel on mostly sublittoral mussel and oyster banks (Gittenberger *et al.*,

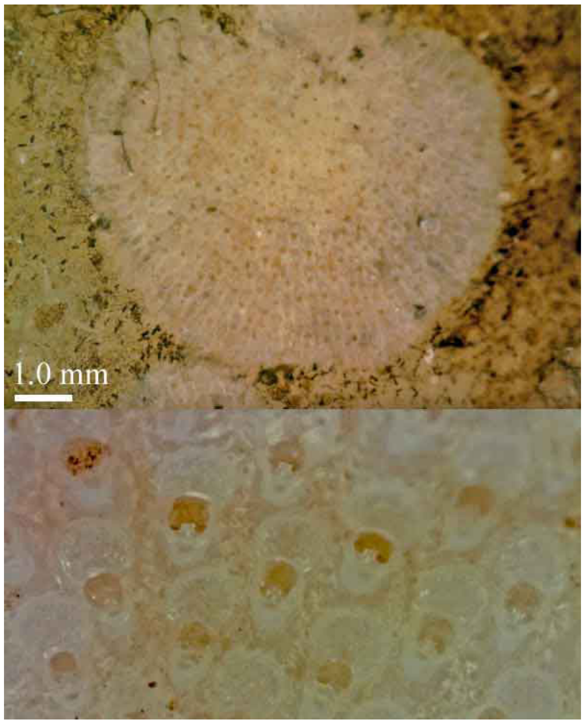

Fig. 59. *Smittoidea prolifica* on an oyster that was collected from a sublittoral oyster reef off Terschelling, in August 2018.

2015). In 2018 the species was less common, not recorded off Texel anymore as in 2014 (Fig. 60). In addition to locations off Terschelling *S. prolifica* was found much further to the east on a sublittoral Pacific oyster reef off Delfzijl. The salinities at the locations where the species was found in 2018, varied from 21.8 to 25.6 ppt (Table 2; Appendix III).

Impact:
While *Smittoidea prolifica* was found widespread at various localities in the western Dutch Wadden Sea in 2014, the species appeared to be less common in 2018. Taking this into account and the fact that the small encrusting calcareous patches of *S. prolifica* are mainly found on the insides of empty oyster, mussel and razor shells, it is considered to be unlikely that this species will have a distinct impact on the Wadden Sea ecosystem.

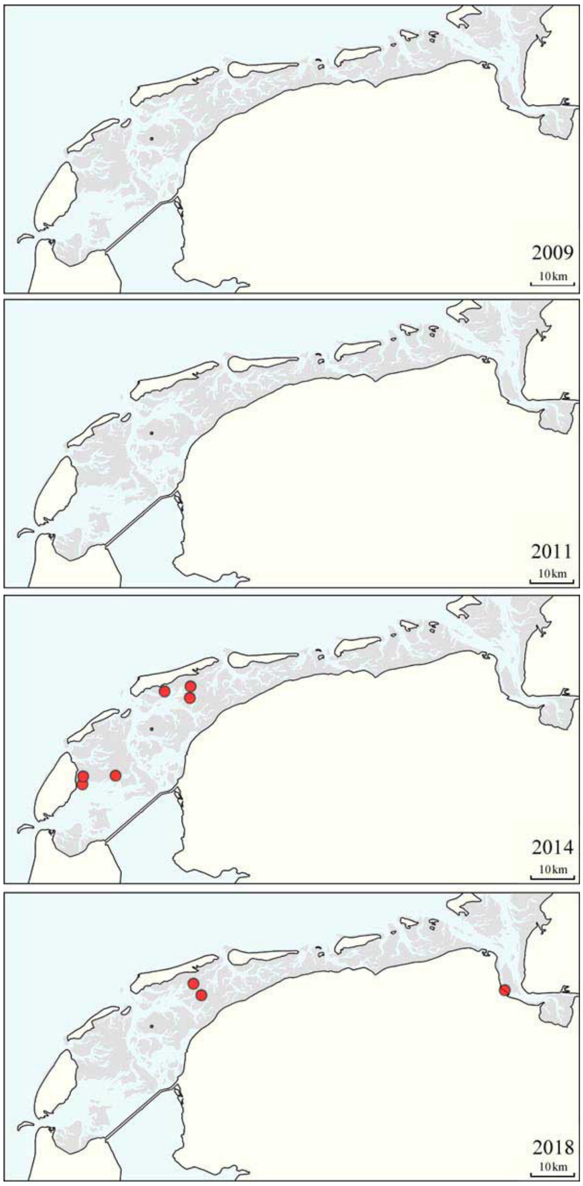

Fig. 60. Locations where *Smittoidea prolifica* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.5 Cnidaria

4.3.5.1 *Diadumene cincta*

Stephenson, 1925 (Figs 61-62)

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, 2011 and 2014 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 (Gittenberger *et al.*, 2010, 2012, 2015; Fig. 62). In 2018 the species was additionally detected in the harbour of 't Horntje on Texel (Fig. 62). The salinities at the locations where *D. cincta* was found in 2018, varied from 20.4 to 24.6 ppt (Table 2; Appendix III).

Fig. 61. *Diadumene cincta in situ* on the floating dock of the marine in Den Helder in October 2018.

Impact:

Diadumene cincta (Fig. 61) 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, 2015). It is therefore unlikely that the species will have a large impact on the Wadden Sea ecosystem.

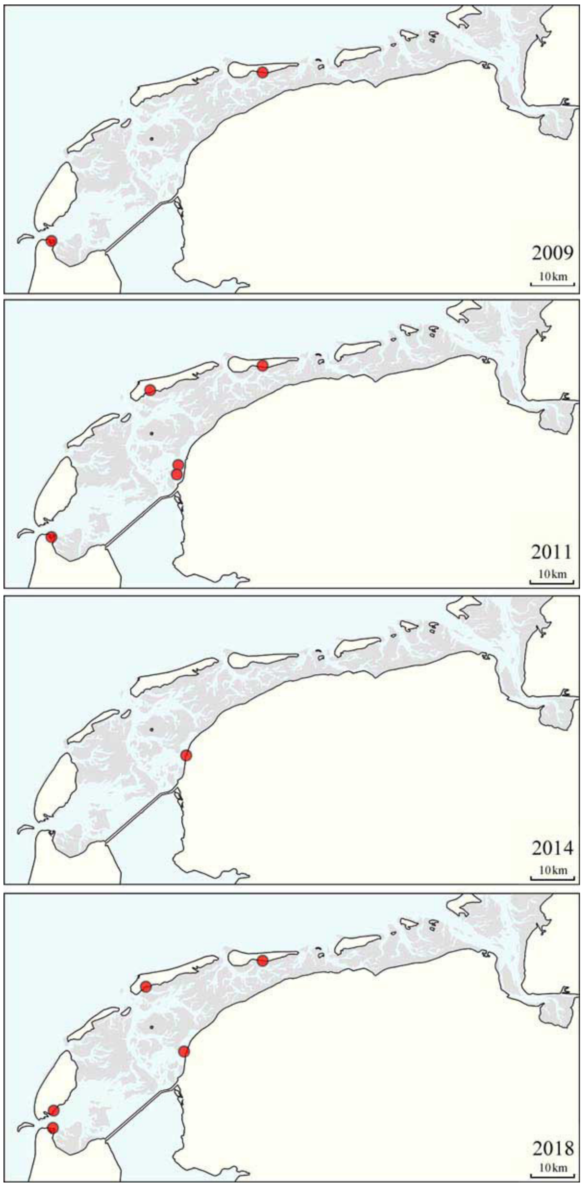

Fig. 62. Locations where *Diadumene cincta* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.5.2 *Nemopsis bachei*

L. Agassiz, 1849 (Figs 63-64)

Origin:

Although *Nemopsis bachei* may concern a non-native species from NW Atlantic species, this is uncertain (Vervoort & Faasse, 2009). Specimens in the NE Atlantic may have been misidentified in the past. The specimens of *N. bachei* morphologically strongly resemble those of various other species, mainly of the genus *Bougainvillia* (Faasse & Ates, 1998; Vervoort & Faasse, 2009). The presence of two small tentacles with a bulbous like ending within each of the four groups of tentacles along the margin, is distinct for Nemopsis (Vervoort & Faasse, 2009). Although this was visible through a dissecting microscope in specimens swimming in a petridish with seawater within the present study, it is a character that is easily overlooked.

Distribution:

At the start of the 20th century *Nemopsis bachei* used to be an abundant species in the Netherlands in the Zuiderzee, but it disappeared when this water body was isolated from the Wadden Sea, becoming a freshwater lake (Vervoort & Faasse, 2009). In recent years it is more rarely recorded in mostly brackish waters from the Dutch Delta to the Wadden Sea (Vervoort & Faasse, 2009; Gittenberger *et al.*, 2014). In the Dutch Wadden Sea it was first recorded in 1998 off Den Helder (Dekker, 1998) and later in the harbour of Lauwersoog (Tulp, 2002). During the non-native species inventory of 2018 *N. bachei* was found in a gelatinous zooplankton net sample taken in the port of Den Helder. The species may have been missed in the previous inventories in 2009, 2011 and 2014 as gelatinous zooplankton net samples were not taken during those surveys (Gittenberger *et al*., 2010; 2012; 2015; Fig. 64).

Impact:

Although locally *Nemopsis bachei* specimens have been found in high densities, records of this species, which may be native to the NE Atlantic, remain rare. It is therefore unlikely that this species has a distinct impact on the Wadden Sea ecosystem.

Fig. 63. *Nemopsis bachei in vivo* collected in June 2018 with a gelatineus zooplankton net in the harbour of Den Helder.

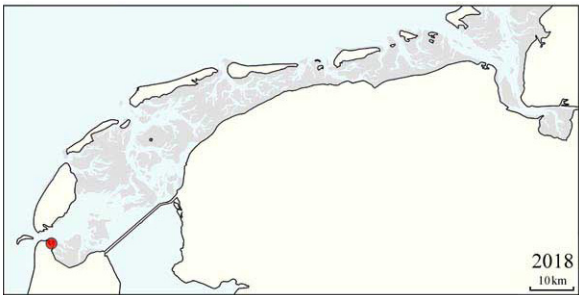

Fig. 64. Locations where *Nemopsis bachei* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.6 Crustacea

4.3.6.1. *Amphibalanus improvisus*
(Darwin, 1854) (Fig. 65-66)

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

Distribution:
Waardenburg (1827) first recorded *Amphibalanus improvisus* in the Netherlands (as *Balanus ovularis*) (Wolff, 2005), whereby the species was already recorded in the 19th century form the Zuiderzee (Wolff, 2005). At present the species is widespread throughout the Netherlands, especially occurring in brackish waters. During the non-native species inventories in 2009, 2011 and 2014 *A. improvisus* was found widespread and especially abundant in the sublittoral in brackish waters close to the mainland on floating docks, dikes and mussel beds (Gittenberger *et al.*, 2010; 2012; 2015). This was also the case in 2018, as its distribution did not differ much from previous years (Fig. 66). The salinities at the locations where the species was found in 2018, varied from 16.3 to 25.6 ppt (Table 2; Appendix III).

Fig. 65. *Amphibalanus improvisus* collected in a sublitoral dredge sample off Delfzijl.

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* probably does not compete much with native barnacle species for space. Its impact on the ecosystem therefore remains limited.

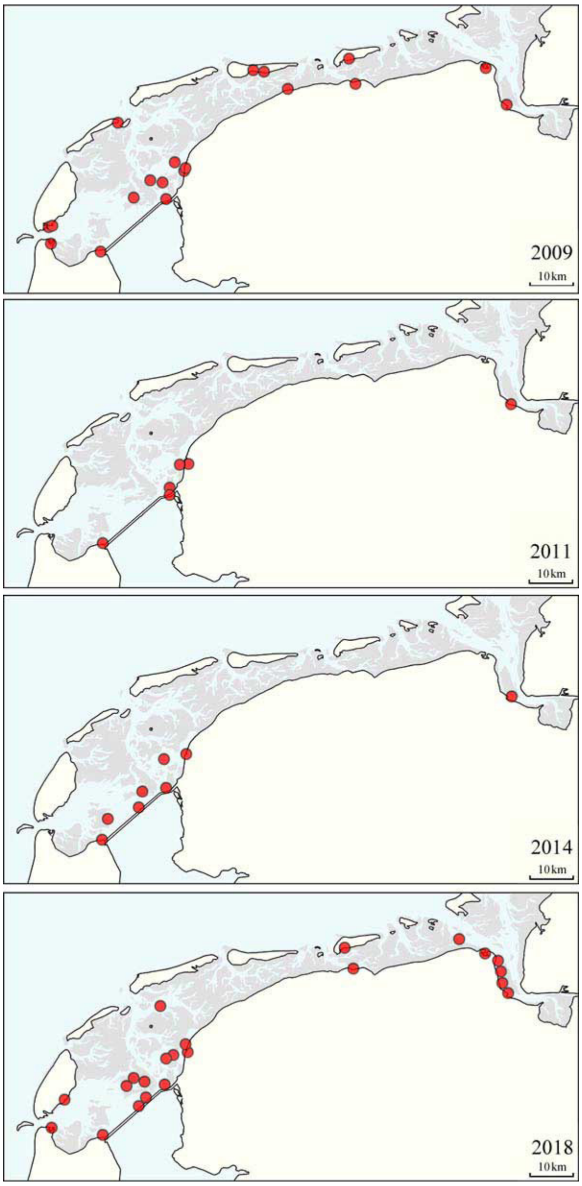

Fig. 66. Locations where *Amphibalanus improvisus* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.6.2. *Austrominius modestus*
(Darwin, 1854) (Figs 67-68)

Origin:
SW Pacific (Harms 1999)

Distribution:
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. During the non-native species inventories in 2009, 2011, 2014 and 2018 *A. modestus* was found widespread in both the more saline and the brackish waters of the Wadden Sea (Gittenberger *et al.*, 2010; 2012; 2015; Fig. 68). It was recorded both in the littoral and sublittoral zones, whereby it was found in virtually all habitats with hard substrates (Table 2; Appendix III). The salinities at the locations where the species was found in 2018, varied from 16.3 to 25.6 ppt (Table 2; Appendix III).

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). Because *A. modestus* is often the most dominant barnacle species present, it probably has a distinct impact on the flora and fauna living on hard substrata in the Wadden Sea.

Fig. 67. *Austrominius modestus in situ* in the harbour of Eemshaven.

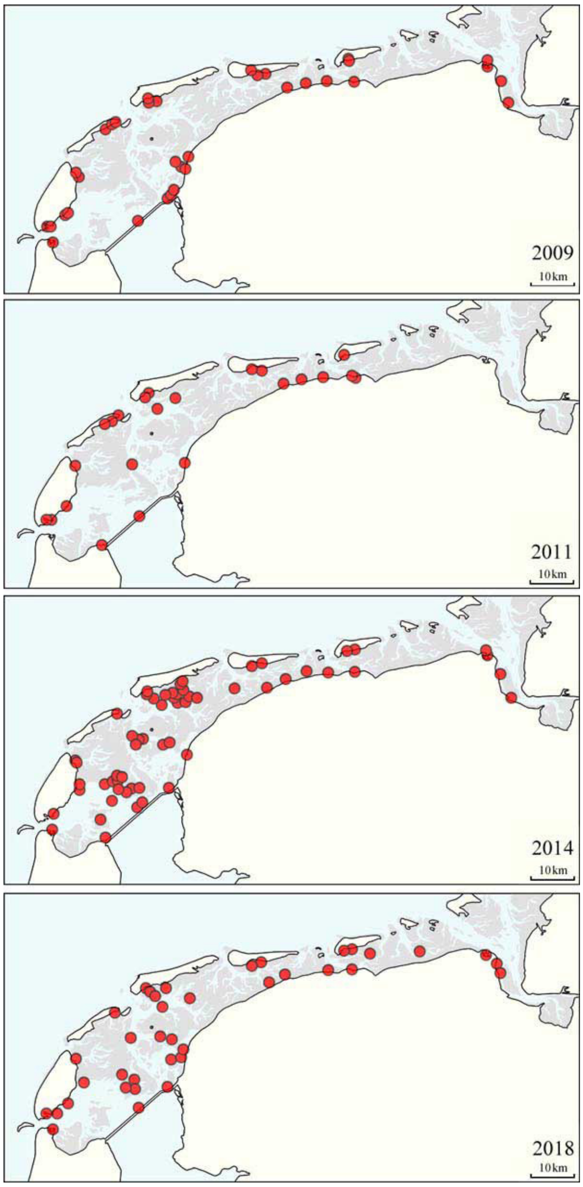

Fig. 68. Locations where *Austrominius modestus* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.6.3 *Caprella mutica*
Schurin, 1935 (Figs 69-70)

Origin:
Pacific (Schrey & Buschbaum 2006)

Distribution:
Caprella mutica was first recorded in Europe in 1994 in the Delta area of the Netherlands (Cook *et al.* 2007), after which it quickly became abundant and widespread. In the Dutch Wadden Sea it was first recorded in 2005 off the island Texel (Cook *et al.* 2007). While *C. mutica* was found throughout the whole 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 (Gittenberger *et al.*, 2010; 2012; 2015). In 2018 it was found more widespread again, occurring at locations off Texel and Den Helder in the west up to the port of Eemshaven in the east of the Dutch Wadden Sea (Fig. 70). Locally it was found to be very abundant, mainly on floating docks at salinities between 6.98 to 24.6 ppt in 2018 (Table 2; Appendix III).

Fig. 69. *Caprella mutica in vitro.* Specimen collected in June 2018 from the floating dock in the harbour of Oudeschild, Texel.

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) indicate that it may be able to outcompete at least the native caprellid species in the Dutch Wadden Sea. This hypothesis did not appear to be supported by the survey in 2014 during which C. mutica was only found in the western part of the Wadden Sea (Gittenberger *et al.*, 2015). In 2018 however, *C. mutica* had become more widespread again indicating that it is likely that this alien species will have a distinct impact on the native flora and fauna in the Wadden Sea.

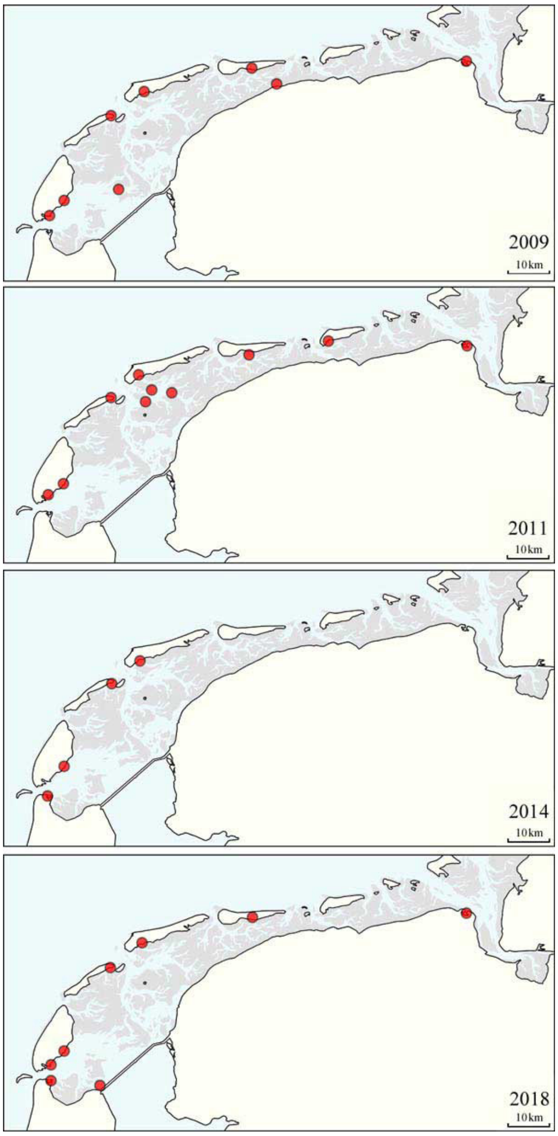

Fig. 70. Locations where *Caprella mutica* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.6.4 ***Eriocheir sinensis***
H. Milne Edwards, 1853 (Figs 71-72)

Origin:
NW Pacific (Adema, 1991).

Distribution:
After first being sighted in the Netherlands in 1930, i.e. in the eastern Dutch Wadden Sea at the sluices of Termunterzijl, the Chinese mitten crab *Eriocheir sinensis* quickly spread. Since 1935 it was present in almost any part of the Netherlands suitable for its establishment (Wolff, 2005). In the Dutch Wadden Sea it is mainly found along the mainland in waters with a relatively low salinity (Wolff, 2005), where it was also recorded during the non-native species inventory in 2009, 2014 and 2018 (Gittenberger *et al.*, 2015; Fig. 72). The salinities at the locations where the species was found in 2018, varied from 16.0 to 22.7 ppt (Table 2; Appendix III).

Fig. 71. *Eriocheir sinensis* juvenile *in vitro.* Specimen collected in September 2018 from the floating dock in the harbour of Harlingen.

Impact:
Chinese mitten crabs live most of their life in fresh to slightly brackish waters. Only for their reproduction they need to return to more saline waters. In the more saline waters of the Wadden Sea this species is therefore not expected to have a distinct impact (Gittenberger *et al.*, 2010).

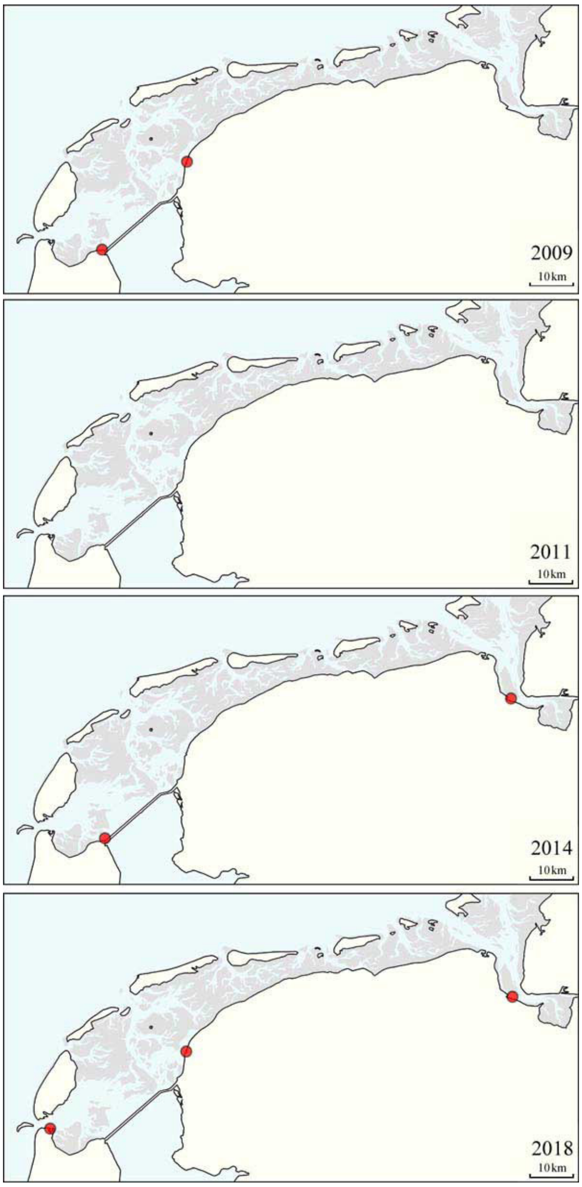

Fig. 72. Locations where *Eriocheir sinensis* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.6.5 *Hemigrapsus sanguineus*
(De Haan, 1835) (Figs 73-74)

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

Distribution:
Hemigrapsus sanguineus was first sighted in the Netherlands in 1999, i.e. in the Dutch Delta area (Wolff, 2005). In 2004 it was found for the first time in the Dutch Wadden Sea (Gittenberger *et al.* 2015). During the non-native species inventories in 2009, 2011, 2014 and in 2018 *H. sanguineus* was found widespread in the Wadden Sea (Gittenberger 2010; 2012; 2015; Fig. 74), usually hiding below rocks, boulders and Pacific oysters. In its distribution it appeared to show a preference for the more saline waters and sites that lie relatively exposed to the open Wadden Sea. In 2018 it was mainly found in the littoral zones of dikes. The salinities at the locations where the species was found in 2018, varied from 18.3 to 25.6 ppt (Table 2; Appendix III).

Impact:
Regardless of their small size of usually about 2 cm, Pacific shore crabs are relatively aggressive crabs that 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 during 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 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, 2014 and 2018 (Fig. 70), it is noted that these Pacific crab species were relatively hard to find and rare at most locations in 2014 and 2018, while they were abundant at most locations where they were found in 2009 and 2011. To what degree the numbers of crabs have decreased cannot be specified as species abundances were not scored during these inventories.

Fig. 73. *Hemigrapsus sanguineus* at the harbour wall near the ferry arival on Texel.

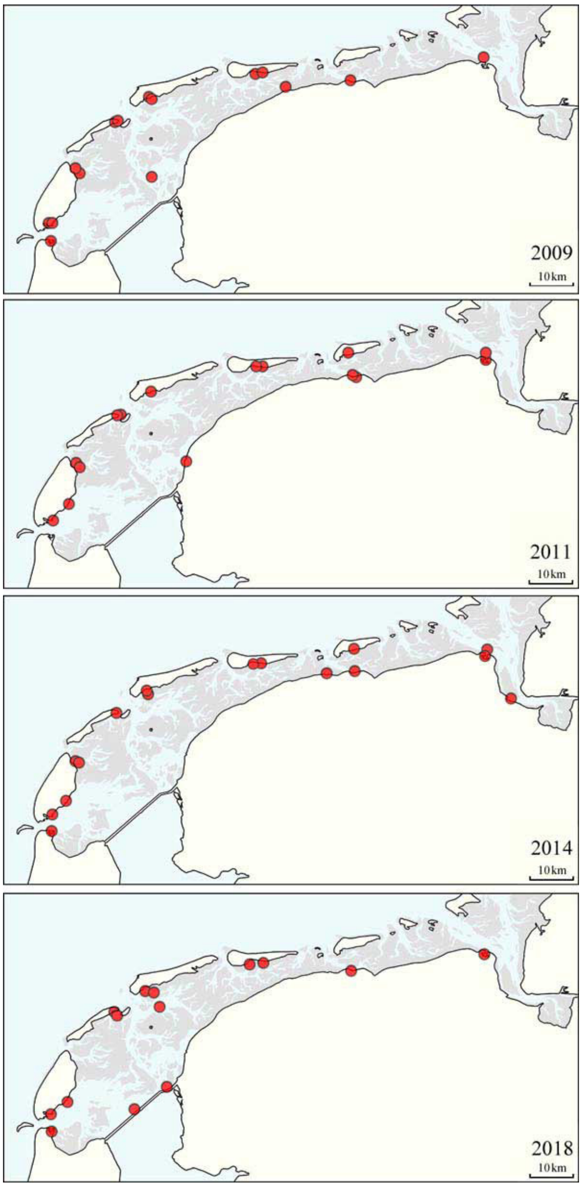

Fig. 74. Locations where *Hemigrapsus sanguineus* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.6.6 *Hemigrapsus takanoi*

Asakura & Watanabe, 2005 (Figs 75-76)

Origin:
NW Pacific (Asakura & Watanabe, 2005)

Distribution:
In the Netherlands *Hemigrapsus 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 (Gittenberger *et al.* 2015). During the non-native species inventories in 2009, 2011 and 2014 and 2018 *H. takanoi* was found widespread in the Wadden Sea (Gittenberger et al 2010; 2012; 2015; Fig. 76), usually hiding below rocks and boulders, and in between Pacific oysters. In its distribution it appeared to show a preference for sites that lie relatively sheltered to the open Wadden Sea like the sheltered side of a harbour dike. In 2018 it was mainly recorded in the littoral zones of dikes at salinities between 18.3 to 25.6 ppt (Table 2; Appendix III).

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 also 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 and 2018 equally widespread throughout the Wadden Sea as in 2009 and 2011. They were much harder to find in 2014 and 2018 however as they appeared to occur in much lower numbers 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. 75. *Hemigrapsus takanoi* collected from the dike in Eemshaven.

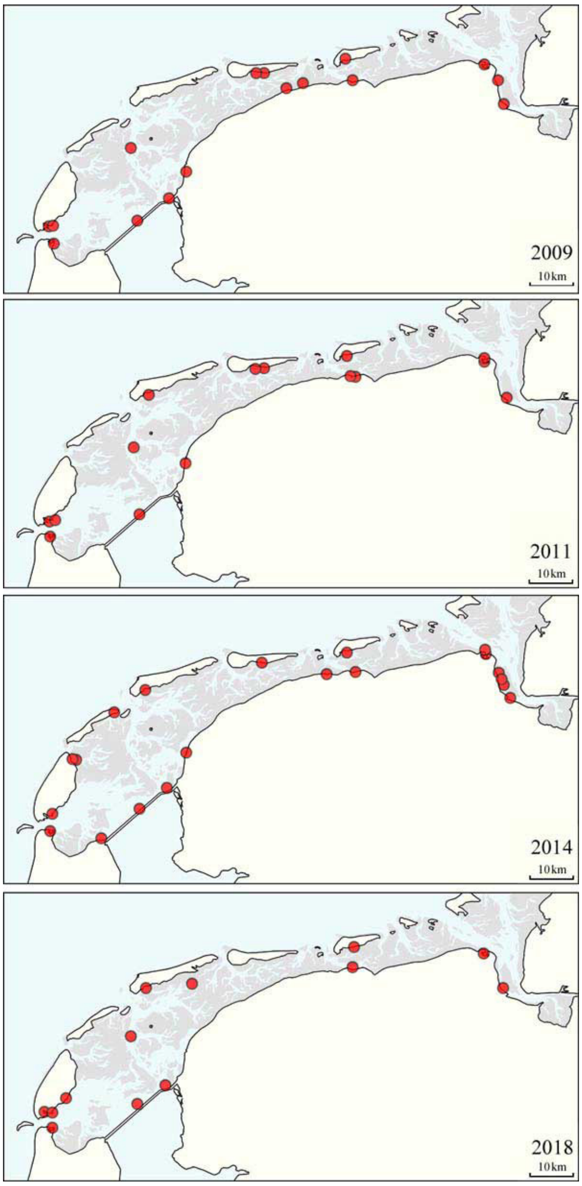

Fig. 76. Locations where *Hemigrapsus takanoi* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.6.7 *Jassa marmorata*
Holmes, 1905 (Figs 77-78)

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

Distribution:
It is unknown since when *Jassa 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). As was also the case during the inventory in 2009, 2011, and 2014 (Gittenberger *et al.*, 2010; 2012; 2015) *J. marmorata* was found especially abundant in 2018 on the ropes of mussel spat collectors, which floated in the middle of the Dutch Wadden Sea (Fig. 78; Table 2; Appendix III). Additionally specimens were recorded on floating docks in harbours of Den Helder, Texel, Terschelling and Ameland. The salinities at the locations where the species was found in 2018, varied from 20.4 to 25.6 ppt (Table 2; Appendix III).

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 on floating structures (Gittenberger *et al.*, 2015). *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 by functioning as a food source for fishes (Gittenberger *et al.*, 2015). For as long as *J. marmorata* remains dominant on artificial structures only, like floating mussel collectors, buoys and pontoons, the negative impact of this species on the Wadden Sea ecosystem will remain limited (Gittenberger *et al.*, 2010).

Fig. 77. *Jassa marmorata in vitro* collected from mussel spat collector in the Wadden Sea in August 2018.

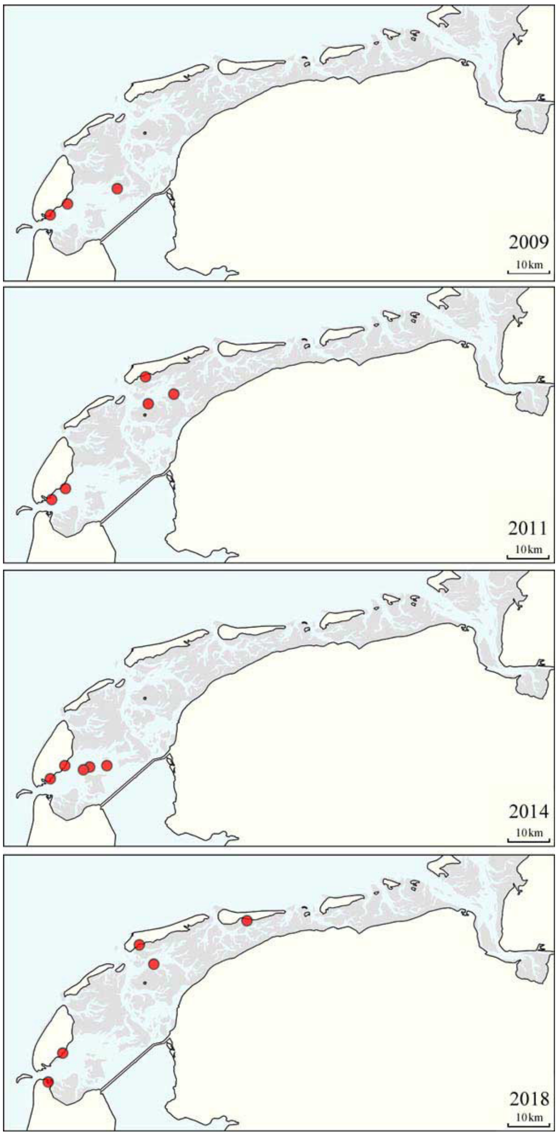

Fig. 78. Locations where *Jassa marmorata* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.6.8 *Palaemon macrodactylus*
Rathbun, 1902 (Figs 79-80)

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

Distribution:
In the Netherlands *Palaemon macrodactylus* was first recorded in 1999 in the Westerschelde (d'Udekem d'Acoz et ai, 2005), after which the species quickly spread and was recorded from the Westerschelde and the Oosterschelde up to the Noordzeekanaal in the north of Holland (d'Udekem d'Acoz *et al.*, 2005). In the Dutch Wadden Sea it was first recorded one year later, i.e. in 2005 in the port of Eemshaven (Faasse, 2005). Since then it was recorded along the mainland coast of the complete Dutch Wadden Sea from west to east including sites off Oudeschild, Texel (de Ruijter, 2007), off Den Oever (Schrieken, 2008), in the harbours of Harlingen and Lauwersoog (Tulp, 2006a) and in the port of Eemshaven (Faasse, 2005). Regardless of its wide distribution the prawn *P. 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 harbours from west to east in the Dutch Wadden Sea (Gittenberger *et al.*, 2015). In 2018 it was only found to be common in the east from Eemshaven down to Delfzijl (Fig. 80). There it was recorded within dredge samples taken from sublittoral Pacific oyster reefs and within a gelatinous plankton net sample taken from a floating dock in the marina of Delfzijl . The salinities at the locations where the species was found in 2018, varied from 19.6 to 21.6 ppt (Table 2; Appendix III).

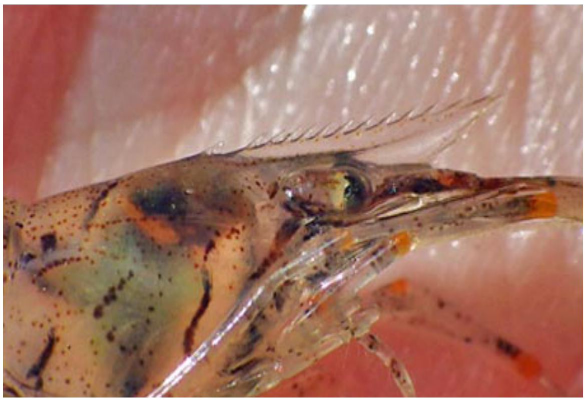

Fig. 79. *Palaemon macrodactylus in vivo*, collected in Eemshaven.

Impact:
Over the years the prawn *Palaemon macrodactylus* has expanded its population over the Wadden Sea, where it is mainly found in the mainland

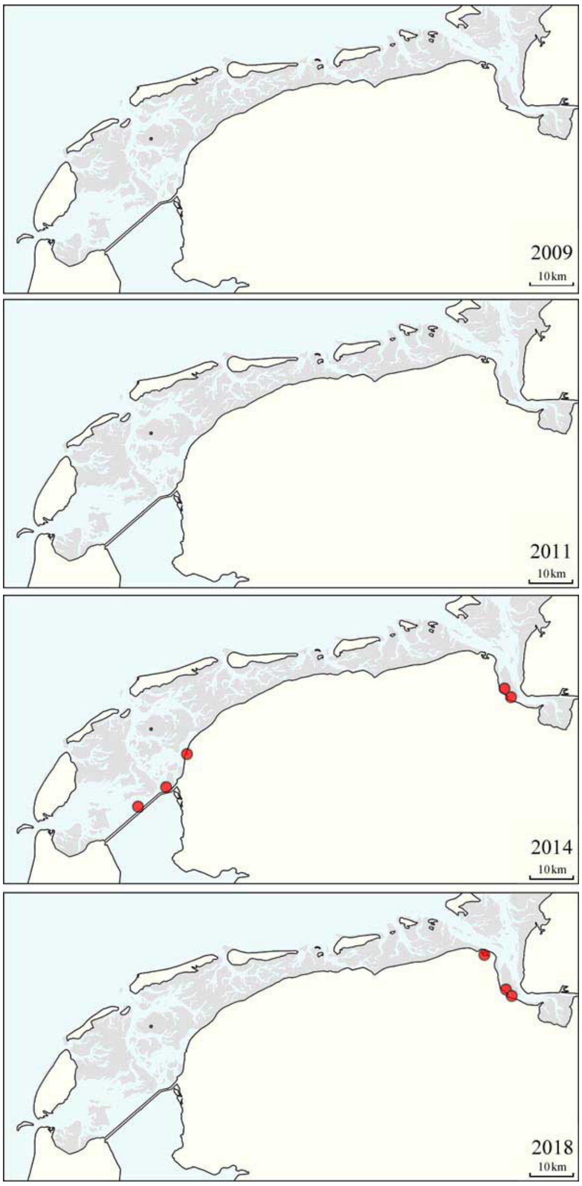

Fig. 80. Locations where *Palaemon macrodactylus* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

harbours. The fact that it was not found during the inventories in 2009 and 2011, widespread found 2014 and more restricted to the east in 2018, make it difficult to predict whether this will have a distinct impact on the Wadden Sea ecosystem.

4.3.7 Ctenophora

4.3.7.1 *Mnemiopsis leidyi*
A. Agassiz, 1865 (Figs 81-82)

Origin:
W Atlantic (Kideys, 2002).

Distribution:
Mnemiopsis leidyi was first recorded in the Netherlands in 2006, in both the Delta area and in the Wadden Sea (Faasse & Bayha 2006, Tulp 2006b). Since then it was recorded annually in most inland saline waters of the Netherlands. Although pelagic species were not specifically sampled during the inventories in 2009, 2011 and 2014, *M. leidyi* was recorded in these years as occurring widespread in the Dutch Wadden Sea as it was abundantly present in the harbours and was scored when sighted (Gittenberger *et al.*, 2010; 2012; 2015). In 2018 gelatinous zooplankton net samples were taken specifically for pelagic alien species like *M. leidyi*. Mainly based of these samples, it could be concluded that *M. leidyi* in 2018 still occurred widespread throughout the whole Dutch Wadden Sea. The salinities at the locations where it was found in 2018, varied from 7.0 to 25.6 ppt (Table 2; Appendix III).

Fig. 81. *Mnemiopsis leidyi in vivo,* collected from a gelatineus zooplankton sample in Terschelling in August 2018.

Impact:
Mnemiopsis leidyi, which feeds on zooplankton, has the potential to cause extreme ecological and

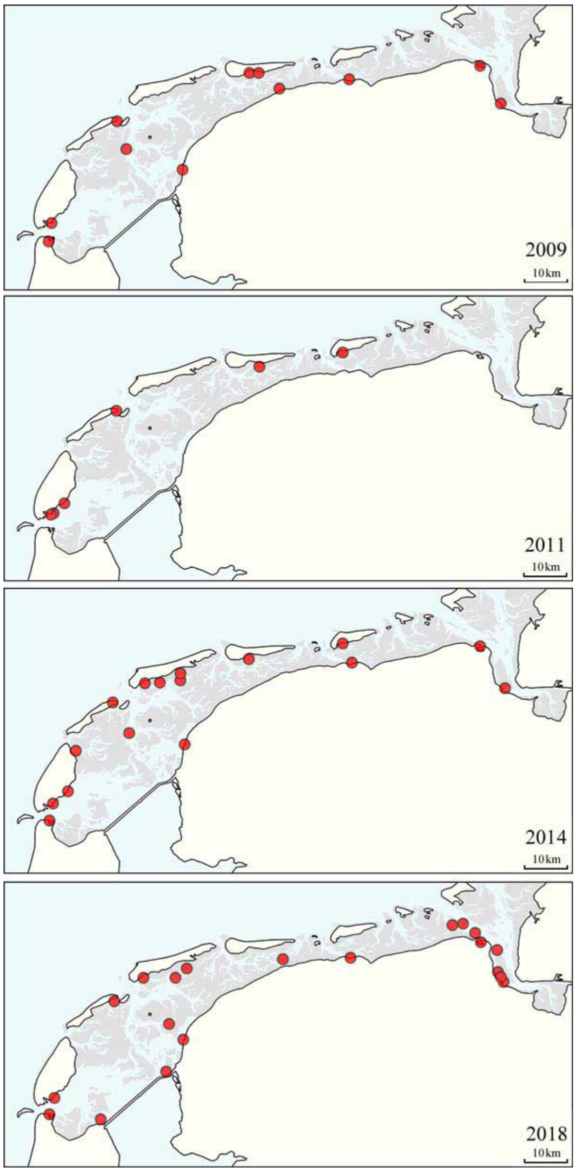

Fig. 82. Locations where *Mnemiopsis leidyi* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

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* probably already had a major influence on the ecosystem. This is confirmed by a study in the western Dutch Wadden Sea by Van Walraven *et al.* (2013).

4.3.8 Insecta

4.3.8.1 Telmatogeton japonicus
Tokunaga, 1933 (Figs 83-84)

Origin:
Pacific Ocean (Raunio *et al.*, 2009)

Distribution:
In 1993 *Telmatogeton japonicas* was first recorded in the Netherlands, i.e. in the Noordzeekanaal (Klink *et al.*, 1997). In 2011 it was first discovered in the Wadden Sea by Floris Bennema on a floating dock in the harbour of Harlingen (Gittenberger *et al.*, 2012). Although it was not recorded during the alien species survey in 2014, it was found to be widespread in the Dutch Wadden Sea in 2018 from Den Helder and Oudeschild in the west to Terschelling and Lauwersoog in the east (Fig. 83). The salinities at the locations where it was found varied from 20.4 to 25.6 ppt (Table 2; Appendix III). Specimens were recorded on floating docks and settlement plates in marinas, and on mussel spat collectors in the central Wadden Sea.

Fig. 83. *Telmatogeton japonicus in vito* collected in the harbour of Ameland in September 2018. Scale bar is 1 mm.

Impact:
T. japonicus was recorded by Boudewijn & Meijer (2007) to form an important food source, especially during winter, for various birds off the coast of IJmuiden. On buoys and wind turbines on the North Sea it was found to form monocultures by Kerckhof *et al.* (2009). Although T. japonicus was recorded much more widespread in 2018 than during the previous surveys (Gittenberger *et al.*, 2015), it remains uncertain to what degree this species may have an impact on the natural environment in the Wadden Sea. It has only been found on artificial floating objects.

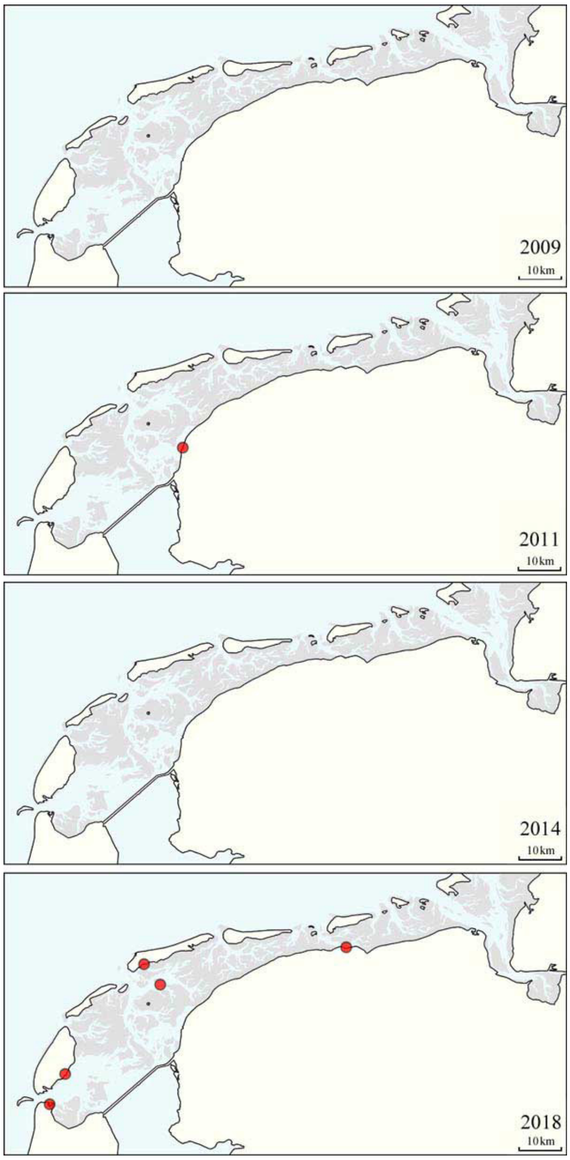

Fig. 84. Locations where *Telmatogeton japonicus* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.9 Mollusca

4.3.9.1 *Crepidula fornicata*
(Linnaeus, 1758) (Figs 85-86)

Origin:
NW Atlantic (Nehring & Leuchs 1999).

Distribution:
Living specimens of *Crepidula 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). During the non-native species inventories in the Dutch Wadden Sea in 2009, 2011, 2014 and 2018 the species was found to be widespread (Gittenberger *et al.*, 2010, 2012, 2015; Fig. 86). In comparison to the high densities that are found in the Dutch province of Zeeland (Wolff, 2005), the densities of *C. fornicata* in the Wadden Sea appear relatively low however. During the various surveys *C. fornicata* was mainly found in the Wadden Sea in the harbours and on shellfish beds. The salinities at the locations where it was found in 2018, varied from 21.5 to 25.6 ppt (Table 2; Appendix III).

Fig. 85. *Crepidula fornicata* collected from a sublittoral dredge sample in the Wadden Sea in September 2018.

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

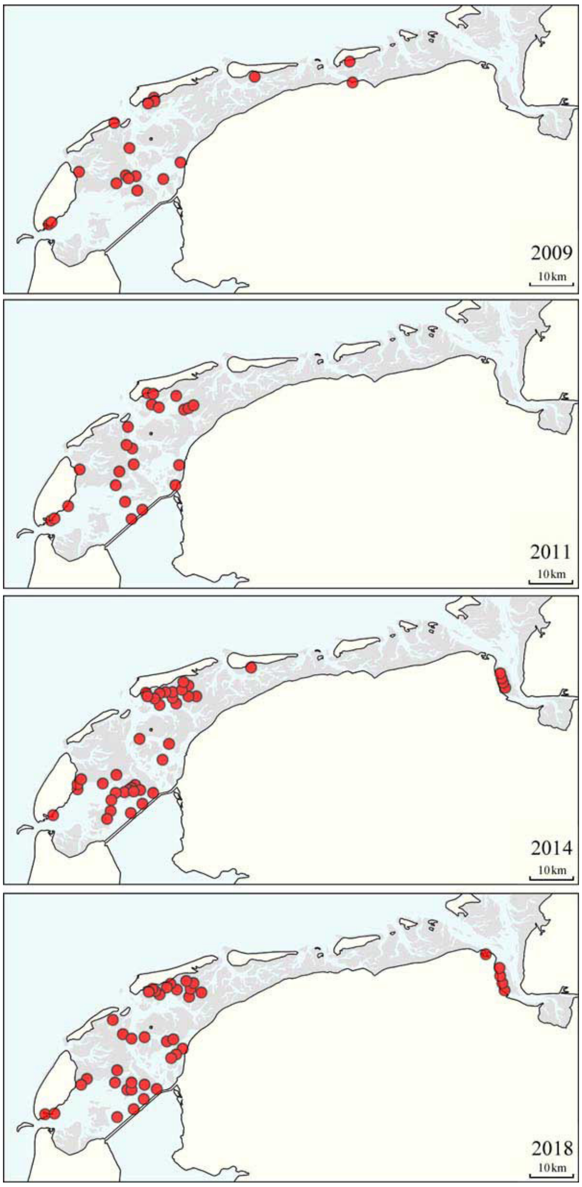

Fig. 86. Locations where *Crepidula fornicata* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.9.2 *Ensis leei*
(Conrad, 1843) (Figs 87-88)

Origin:
NW Atlantic (Wolff, 2005)

Distribution:
Ensis leei was first observed in the Netherlands in 1977 in the Wadden Sea south off Terschelling (Dekker & Beukema, 2012). A few years later it was recorded from nearly the entire Wadden Sea (Essink, 1984; Wolff, 2005). As the non-native species inventories in 2009 and 2011 focused on habitats with hard substrates, it was not recorded during those inventories (Gittenberger *et al.*, 2010, 2012). During the 2014 survey it was scored as soft substrata were specifically sampled during that survey (Gittenberger *et al.*, 2015). Although the American razor shell was already found to be widespread in 2014, in 2018 it was recorded to be much more abundant (Fig. 88). It is uncertain to what degree these records all concern established populations however, as many of the 2018 records concerned juvenile specimens only (Fig. 87). The salinities at the locations where the species was found in 2018, varied from 21.8 to 25.6 ppt (Table 2; Appendix III).

Fig. 87. *Ensis leei in vivo* juvenile, collected in a grab sample in the Wadden Sea in September 2018.

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

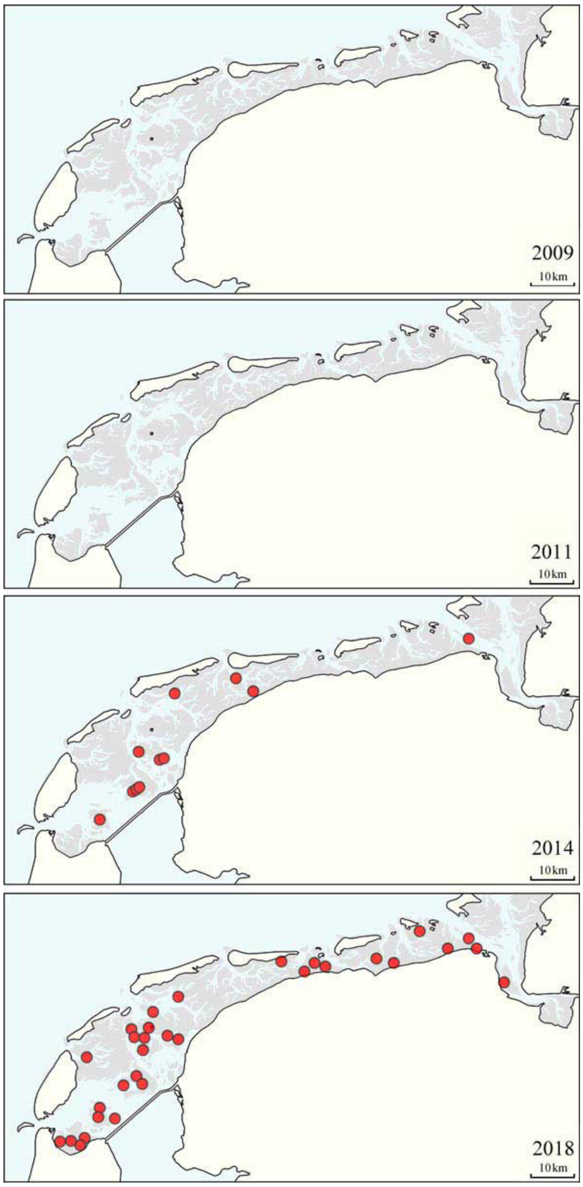

Fig. 88. Locations where *Ensis directus* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.9.3 *Magallana gigas*
(Thunberg, 1793) (Figs 89-90)

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

Distribution:
The first autochthonous Pacific oyster *Magallana gigas* in the Netherlands was recorded in 1928 (Wolff, 2005), but reproduction at that time remained rare. Since then and especially in the 1970-80's Pacific oysters were repeatedly imported until it suddenly started to rapidly reproduce and expand its populations in the inland saline waters along the Dutch coastline in 1975 (Wolff, 2005). From 1976 on, specimens were also recorded in the Dutch Wadden Sea (Wolff, 2005). During the non-native species inventories in 2009, 2011, 2014 and 2018 *M. gigas* was found widespread in the Wadden Sea (Gittenberger *et al.*, 2010, 2012, 2015; Fig. 90). Hereby it was found forming reef-like structures in the littoral and sublittoral on sandy bottoms, on dikes, and on floating docks. The salinities at the locations where the Pacific oyster was found in 2018, varied from 17.0 to 25.6 ppt (Table 2; Appendix III).

Impact:
The extended reefs of the invasive Pacific oyster *Magallana 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.

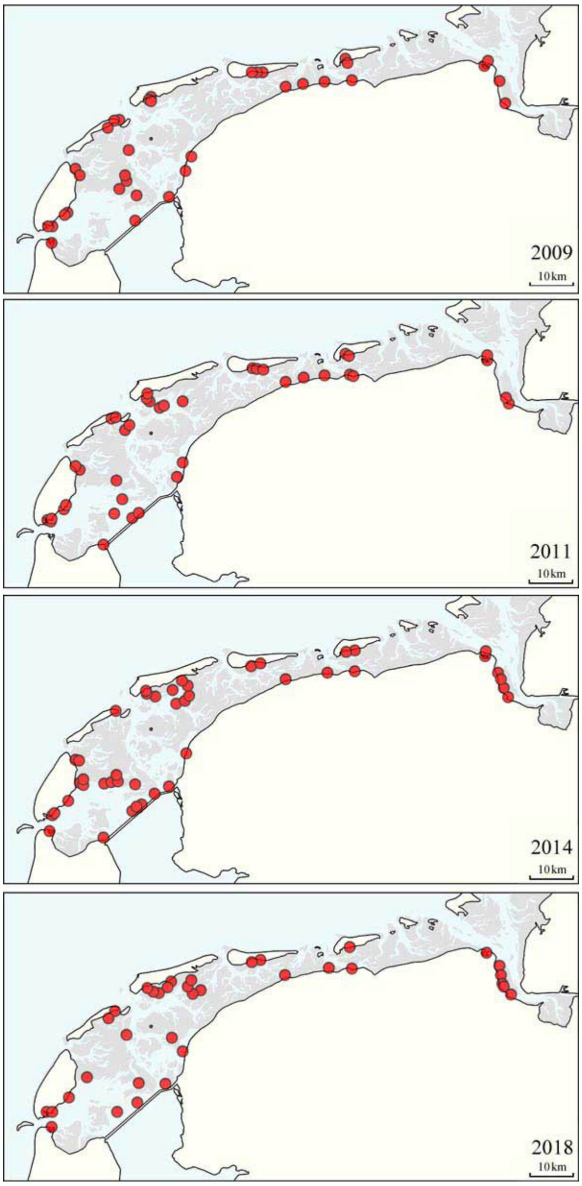

Fig. 90. Locations where *Magallana gigas* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

Fig. 89. *Magallana gigas* reef off Terschelling.

4.3.9.4 *Mulinia lateralis*
(Say, 1822) (Figs 91-92)

Origin:
W Atlantic (Brunel *et al.* 1998)

Distribution:
In August 2017, the dwarf surf clam *Mulinia lateralis* was found in bottom sediment samples taken within the "SIBES" program in the intertidal zone of the Dutch Wadden Sea in the Dollard, and just across the German border in the Eems (Fig. 92; Klunder *et al.,* 2019). These records concern the first for the Netherlands, Germany and Europe. About a month later, i.e. in September or October 2017 in the Voordelta, the species was additionally recorded more to the south, off the coast of Zeeland in the Netherlands, where Craeymeersch *et al.* (2019) found densities of up to 5872.4 specimens/m2. In 2018 the dwarf surf clams were again found within SIBES sediment samples in the Wadden Sea, i.e. in the Eems, Dollard and more centrally in the Dutch Wadden Sea off Engelmansplaat. Based on these records and records more to the west by Craeymeersch *et al.*, (2019) one can conclude that *M. lateralis* occurred widespread in the Dutch Wadden Sea in 2018 (Fig. 92). DNA studies confirmed the identification of the species in both the SIBES samples (Klunder *et al.,* 2019) and the samples of Craeymeersch *et al.* (2019). For accuracy figure 92 is based on all SIBES samples that have been analysed up to date. As in total ~5600 regular grid samples are taken throughout the Wadden Sea within the SIBES program (Klunder *et al.,* 2019), not all SIBES samples of 2018 have been analysed yet. It is therefore expected that the species in 2018 may occur even more widespread in the Wadden Sea than is presented. In the Dutch Wadden Sea M. lateralis occurs mainly in intertidal soft sediment habitats (Craeymeersch *et al.*, 2019; Klunder *et al.,* 2019).

Fig. 91. *Mulinia lateralis*.

Impact:
The impact of the dwarf surf clam *Mulinia lateralis* on the Wadden Sea ecosystem may be severe, as it was found to be widespread in the Dutch Wadden Sea in 2018 and densities of almost 6000 individuals per square meter were recorded in the Voordelta of the Netherlands by Craeymeersch *et al.* (2019). Additionally, as can be concluded from the SIBES data (Klunder, 2019) and Craeymeersch *et al.* (2019), the species appears to disperse rapidly, making it an even more successful invasive alien species.

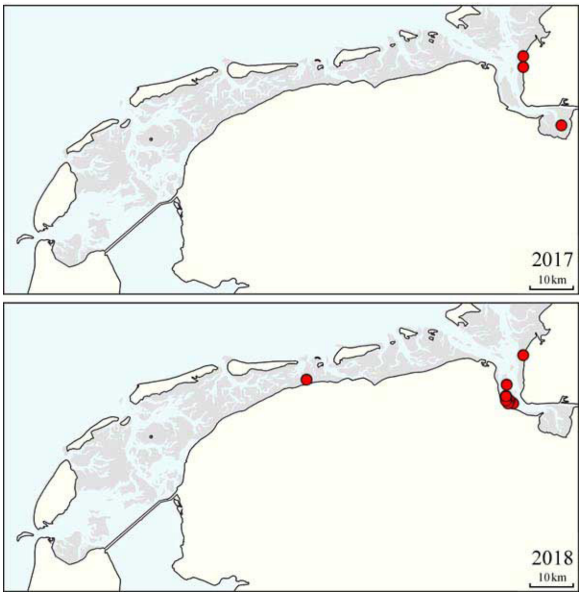

Fig. 92. Locations where *Mulinia lateralis* was found in soft sediment samples taken within the SIBES program in 2017 and 2018 (Klunder, 2019) (red dots). As not all ~5600 SIBES samples taken in 2018 were analyzed up to date, the species may be even more widespread than presented here. This is supported by the records made in 2018 by Craeymeersch *et al*. (2019) (blue dots).

4.3.9.5 *Mya arenaria*
Linnaeus, 1758 (Figs 93-94)

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

Distribution:
The first record of *Mya arenaria* in the Netherlands is by Baster (1765) but it was probably introduced earlier (Wolff, 2005). When exactly it established itself in the Wadden Sea remains unknown. At present it is a common species in Dutch marine waters (Wolff, 2005), which shows a preference for nearshore and brackish soft sediments within the Wadden Sea (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). In 2014 and especially in 2018 *Mya arenaria* was found widespread in bottom sediment samples taken in the intertidal throughout the Dutch Wadden Sea (Gittenberger *et al.*, 2015; Fig. 94).

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.

Fig. 93. *Mya arenaria* collected in a sublittoral dregde sample in the Wadden Sea in August 2018.

4.3.9.6 *Petricolaria pholadiformis*
(Lamarck, 1818) (Figs 95-96)

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

Distribution:
The false angel wing *Petricolaria pholadiformis* was first recorded from the Belgian-Dutch coast in 1899 (Schlesch, 1932). In the Wadden Sea *P.*

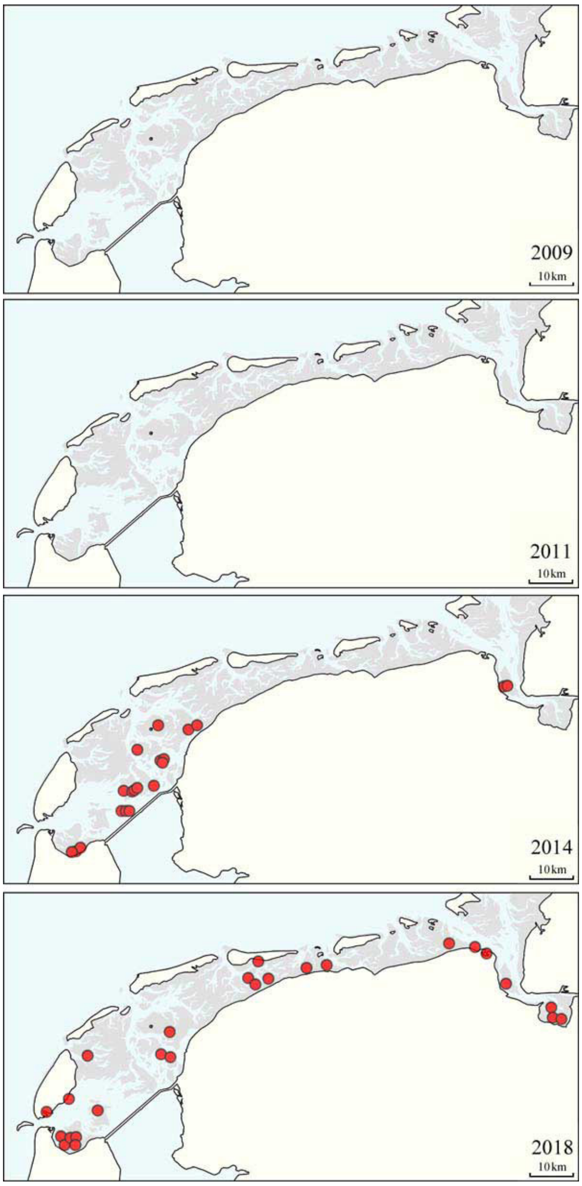

Fig. 94. Locations where *Mya arenaria* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

pholadiformis was first recorded off Den Helder in 1908 (Denker, 1908). Subsequently Dorsman (1919) already recorded this species from the entire Dutch coast (Wolff, 2005). That fact that *P. pholadiformis* was not recorded during the non-native species inventories in 2009, 2011 and 2014, does not indicate that the species was not commonly present in the Wadden Sea at that time. It may have been missed because of the habitat it lives in, which was not specifically targeted within these surveys. This bivalve bores and burrows itself in peat and wood. During the 2018 survey it was found in a piece of wood that was collected from the bottom off Vlieland with a dredge. The salinity of the water at the time of sampling was 24.0 ppt.

Impact:

Locally *Petricolaria pholadiformis* can be present in high densities within peat and wood on the bottom. There is no reason to assume that its presence will have any distinct impact on the Wadden Sea ecosystem however.

Fig. 95. *Petricolaria pholadiformis* collected in a sublittoral dregde sample off Vlieland.

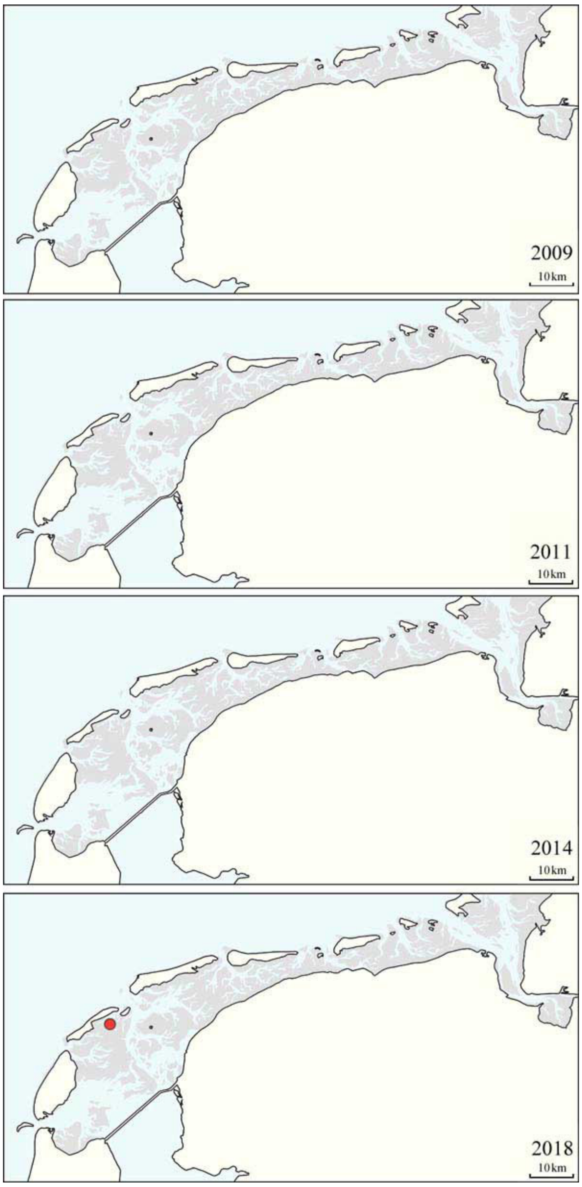

Fig. 96. Locations where *Petricolaria pholadiformis* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.10 Platyhelminthes

4.3.10.1 *Stylochus* cf. *flevensis*

Hofker, 1930 (Figs 97-98)

Origin:

Although the flatworm *Stylochus flevensis* was originally described from the Zuiderzee, and was never recorded outside of the Netherlands, Faasse (2003) indicates that it is probably non-native. He considers it a cryptogenic species, i.e. a species of which the origin is unknown.

Distribution:

In the Netherlands, *Stylochus flevensis* was first recorded in 1921, i.e. in its pelagic larval stage (Faasse, 2003). In 1928 the first adult specimens were found in the Zuiderzee (Hofker, 1930). After the Zuiderzee was closed the species was recorded in the south of the Netherlands in the Veerse Meer and more central in the Noordzeekanaal (Faasse, 2003). In 2004 the species was first recorded for the Dutch Wadden Sea in the harbour of Lauwersoog (Tulp, 2005). The record of *S. flevensis* in the port of Harlingen on a floating dock during the alien species focused survey in 2018, appears to concern the second sighting of the species in the Wadden Sea. The salinity of the water in the port of Harlingen at the site where the flatworm was collected, was 16 ppt.

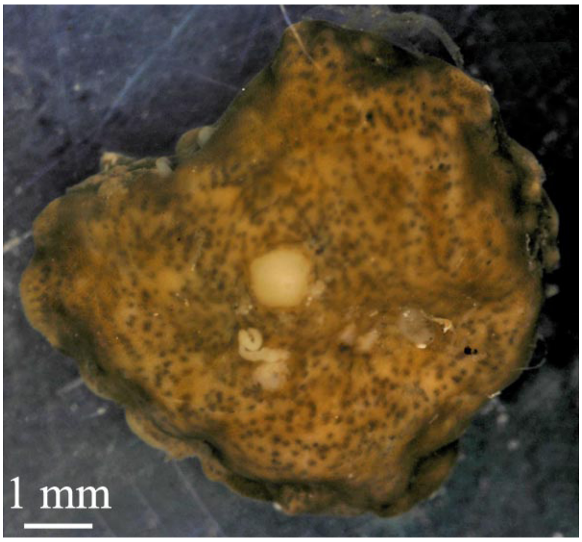

Fig. 97. *Stylochus* cf. *flevensis in vitro* collected from the floating dock in the Noorderhaven, Harlingen.

Impact:

As *Stylochus flevensis* occurs in relatively brackish waters, it is only expected to be present in or surrounding the mainland ports and sluices of the Wadden Sea. It is therefore not expected to have any distinct impact on the Wadden Sea ecosystem.

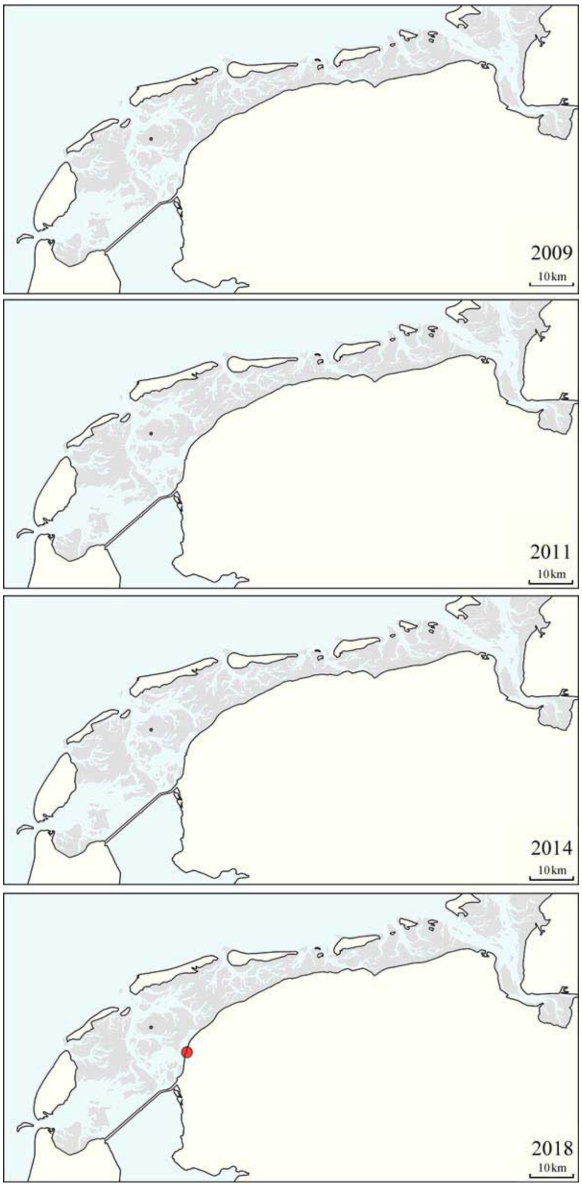

Fig. 98. Locations where *Stylochus* cf. *flevensis* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.11 Porifera

Fig. 99. *Haliclona* cf. *xena in situ* on a floating dock in the harbour of ‘t Horntje, Texel.

Fig. 100. *Leucosolenia somersi in situ* on a floating dock in the harbour of Oudeschild, Texel.

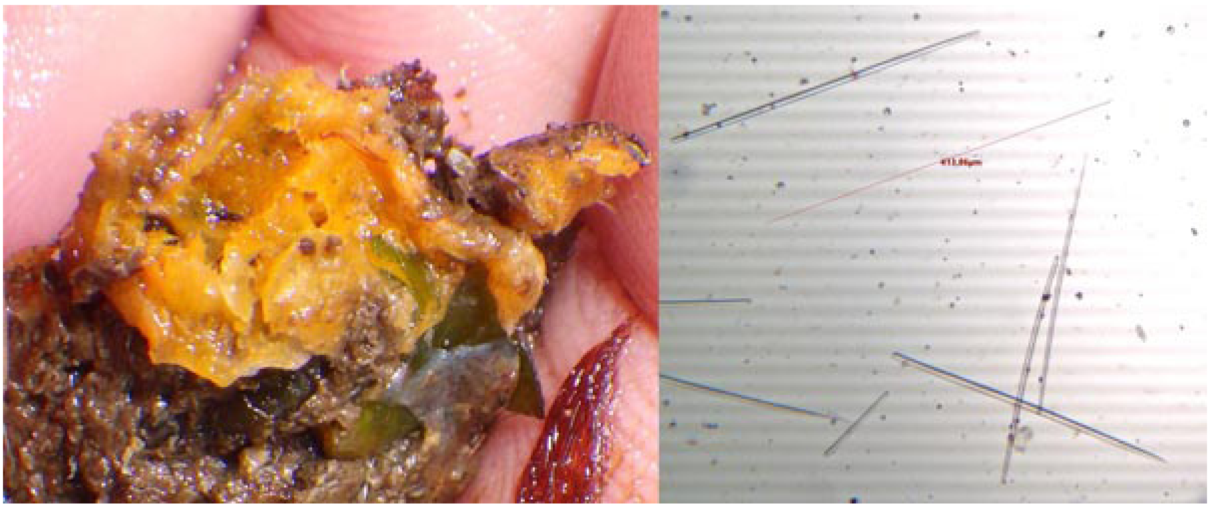

Fig. 101. *Hymeniacidon perlevis* collected from [A] a floating dock of the harbour in Terschelling and [B] a sublittoral oysterreef off Texel.

4.3.11.1 *Haliclona xena*
De Weerdt, 1986 (Fig. 99, 102)

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 Dutch Wadden Sea is was first recorded during the inventory in 2009, off Texel (Gittenberger *et al.*,2010). Since then *Haliclona xena* has remained relatively rare and was mainly recorded in the harbour of ‘t Horntje in Texel (Gittenberger *et al.*, 2010, 2012, 2015; Fig. 102). In 2018 it was found twice, i.e. on the floating docks in the harbour of ‘t Horntje and the marina of Oudeschild, Texel. The salinities measured during the surveys in 2018 at these two locations varied from 23.7 to 24.6 ppt (Table 2; Appendix III).

Impact*:*
Even though *Haliclona (Soestella) xena* is one of the more common sponge species in the Delta region of the Netherlands (van Soest *et al.*, 2007), it is rare in the Dutch Wadden Sea. It is therefore unlikely that it has or will have a significant impact on the Dutch Wadden Sea ecosystem.

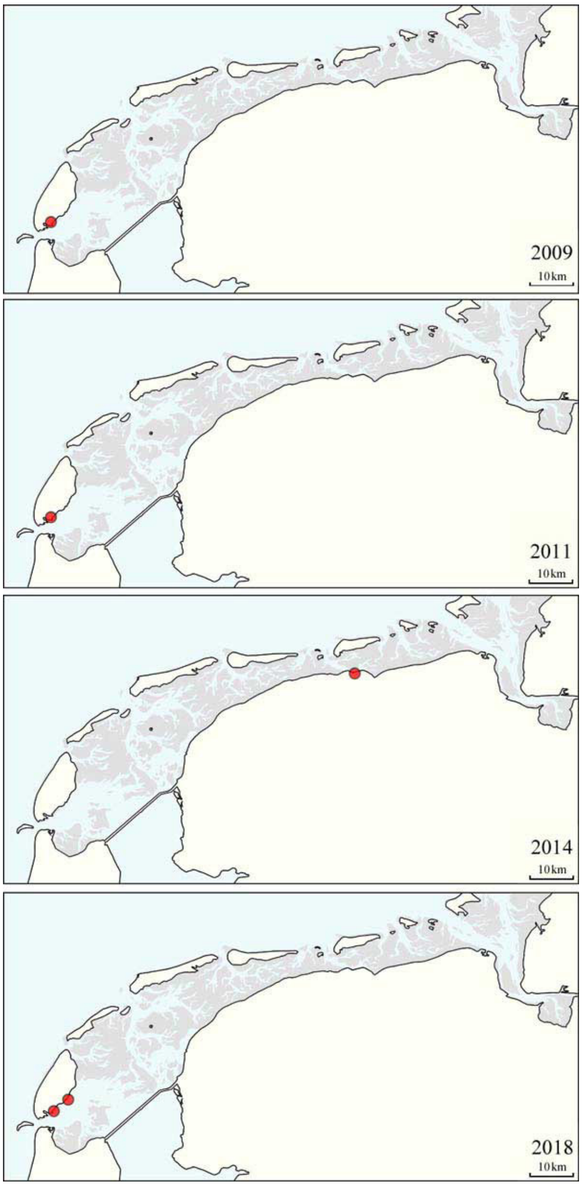

Fig. 102. Locations where *Haliclona* cf. *xena* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.11.2 *Hymeniacidon perlevis*
(Montagu, 1814) (Figs 101, 103)

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 the Netherlands *Hymeniacidon perlevis* was first recorded in 1951 in the province of Zeeland (Van Soest, 1977). In 2011 it was first recorded for the Dutch Wadden Sea in the harbour of Terschelling (Gittenberger *et al.*, 2012). In 2014 it was again recorded solely in the harbour of Terschelling (Gittenberger *et al.*, 2015). In 2018 however it had extended its range from Terschelling to Texel in the west and the port of Eemshaven in the east of the Dutch Wadden Sea (Fig. 103). It was recorded from floating docks and sublittoral shellfish beds with Pacific oysters at locations where the salinities varied from 21.5 to 25.6 ppt (Table 2; Appendix III).

Impact:
Hymeniacidon perlevis is common in the Delta region of the Netherlands where it probably, at least locally, impacts the ecosystem. Although *H. perlevis* does seem to have extended its range in the Wadden Sea in 2018, it was mainly found in between Pacific oysters and on artificial structures like floating docks. It therefore does not seem to have any distinct impact on the Wadden Sea ecosystem.

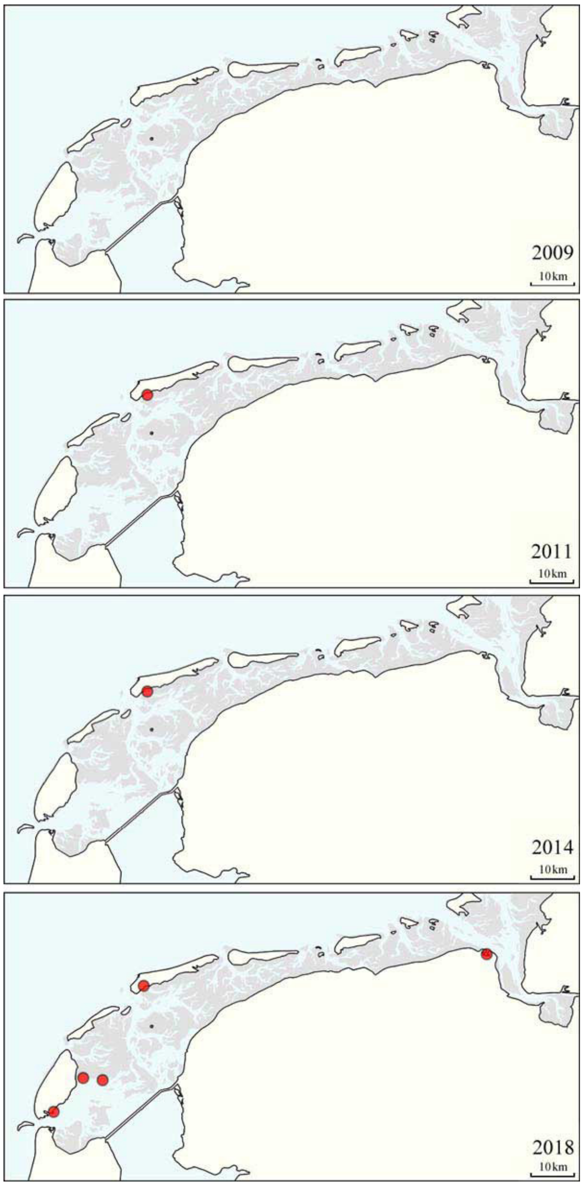

Fig. 103. Locations where *Hymeniacidon perlevis* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

4.3.11.3 *Leucosolenia somesi*
(Bowerbank, 1874) (Figs 100, 104)

Origin:
The origin of *Leucosolenia somesi* is unclear. Although it may not be native to the Netherlands it is a species that is native to northwestern Europe (Van Soest *et al.*, 2007).

Distribution:
It was first recorded of *Leucosolenia somesi* 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 *Leucosolenia variabilis* in the past, a native species that morphologically closely resembles *L. somesi*. 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 the species appeared to have extended its range in the Wadden Sea as 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 (Gittenberger *et al.*, 2015; Fig. 104). In 2018 however *L. somesi* was solely found on the floating docks of the marina of Oudeschild, where it was also solely recorded during the inventory of 2011 (Gitteneberger *et al.*, 2012; Fig. 104). The salinities measured at the locations where the species was found in 2018 in the marina of Oudeschild, varied from 24.0 to 24.6 ppt (Table 2; Appendix III).

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.

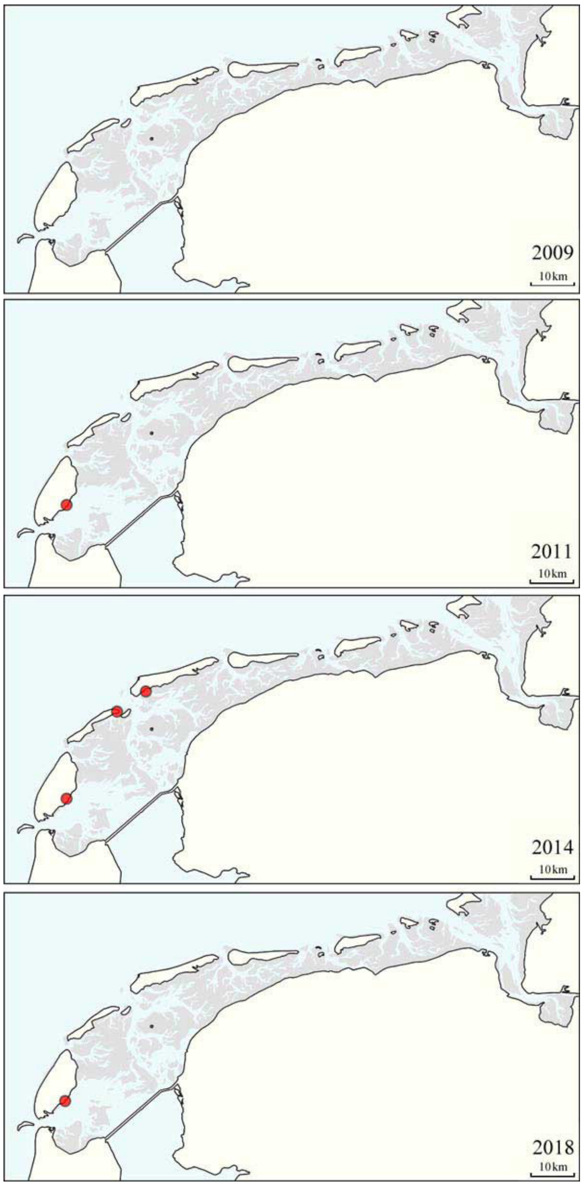

Fig. 104. Locations where *Leucosolenia somersi* was found during the Wadden Sea inventories in 2009, 2011, 2014 and 2018.

5. General conclusions and recommendations

In the spring and summer of 2018, a rapid assessment was done of the marine algae and macrofauna of both the hard substrata and soft substrata in the Dutch Wadden Sea, with a focus on recording alien species. During this survey a total of 226 species was recorded of which 51 are assumed to be non-native to the Netherlands. Eleven new alien species were added to the total list of marine alien species known for the Dutch Wadden Sea as presented after the previous alien species focused survey in 2014 (Gittenberger *et al*., 2015). Similar numbers of new introductions were recorded in the surveys of 2009, 2011 and 2014 (Gittenberger *et al*., 2010; Gittenberger et al., 2012; Gittenberger *et al*., 2015), indicating that there is a continuous increase of alien species establishing themselves in the region. As 2018 concerned the warmest summer in three centuries (www.knmi.nl) more southern European species were expected to be found. This hypothesis was not supported however by newly recorded alien species like the macro-algal species *Ulvaria splendens* and the bryozoan *Schizoporella* cf. *japonica*. These species are especially known from the northern North Sea. Taking into account the south-north residual current along the mainland of Western Europe, it is unlikely that they arrived in the Wadden Sea by natural distribution. It appears more likely that they were imported within fouling communities on ship and pleasure craft hulls or on the flat oysters that were recently transported from Norway to a region just north of the Dutch Wadden Sea. As these oyster imports took place by following a protocol minimizing the chance that alien species travel along, this may not be the case however. Based on the alien species focussed surveys that are repeated in the region since 2009 every 3 to 4 years, it remains difficult to conclude with certainty through what vector such an alien species was introduced. This could probably be done more accurately if surveys would be done on an annual basis, possibly by focusing on a selection of alien species hotspots that are related to certain pathways, vectors, and stepping stones. Hereby alien species management in the Wadden Sea could be done more focused preventing new introductions and limiting the spread of already settled alien species. The survey results could then effectively be incorporated in the recently developed Trilateral Wadden Sea Management and Action Plan for Alien Species, i.e. MAPAS (WG-AS & Gittenberger, 2019).

What the four surveys since 2009 have illustrated is that one can identify the main introduction sites in the Dutch Wadden Sea, i.e. the sites and habitats where the settlement of new alien species is first recorded. In addition one can find hotspots of alien species settlement, which usually concern the main stepping stones that most newly introduced alien species use in their further spread. Although this does not account for all newly introduced species, it does for most. For example, the four surveys have shown that most alien species settle first in the Dutch Wadden Sea in marinas or subtidal oyster reefs off the islands of Terschelling and Texel. From there they tend to extend their range within several years to the more eastern Wadden Sea islands and the mainland port of Den Helder. Subsequently they are found in the other mainland ports and marinas up to Eemshaven in the east. Alien species that are first recorded off Terschelling and Texel are usually also found in subsequent surveys, i.e. they tend to establish themselves. Additional sites of entry appear to be the naval port of Den Helder and the port of Eemshaven. Alien species that were first recorded in Eemshaven, are not always recorded again in subsequent surveys however, indicating that they may not establish themselves. These examples illustrate that ongoing monitoring may also give an indication of the potential impact of newly introduced alien species in time and space. The 2018 survey has for example shown that alien species like the algal species *Dasysiphonia japonica* and the bryozoan *Tricellaria inopinata* have substantially expanded their range within the Wadden Sea since 2014. Other species, like the alien bryozoan *Smittoidea prolifica* have shown a significant decline since 2014. Although these findings are supported by the surveys done, they cannot take into account annual fluctuations. They can therefore only be used as a first year of record and not to identify the exact years or sites of introduction, because these surveys were done once every 3 to 4 years only. The results of the surveys can and were used to identify more in general the main vectors and pathways of introduction and subsequent spread of newly introduced alien species. This should form the basis of the further development and optimisation of the Trilateral Wadden Sea Management and Action Plan for Alien Species, i.e. MAPAS (WG-AS & Gittenberger, 2019).

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Appendix I

All species that were found during the Dutch Wadden Sea inventory in 2018. Cryptogenic species and species of non-native origin are highlighted.

Species	Author	Group	Origin
Acinetospora crinita	(Carmichael) Sauvageau	Algae (Ochrophyta)	Native
Acrochaetium secundatum	(Lyngbye) Nägeli	Algae (Rhodophyta)	Native
Acrosiphonia arcta	(Dillwyn) Gain	Algae (Chlorophyta)	Native
Aglaothamnion pseudobyssoides	(P.L.Crouan & H.M.Crouan) Halos	Algae (Rhodophyta)	Native
Antithamnionella spirographidis	(Schiffner) E.M.Wollaston	Algae (Rhodophyta)	Non native
Ascophyllum nodosum	(Linnaeus) Le Jolis	Algae (Ochrophyta)	Native
Blidingia marginata	(J.Agardh) P.J.L.Dangeard	Algae (Chlorophyta)	Native
Blidingia minima	(Nägeli ex Kützing) Kylin	Algae (Chlorophyta)	Native
Bryopsis hypnoides	J.V.Lamouroux	Algae (Chlorophyta)	Native
Bryopsis plumosa	(Hudson) C.Agardh	Algae (Chlorophyta)	Native
Callithamnion corymbosum	(Smith) Lyngbye	Algae (Rhodophyta)	Native
Caulacanthus okamurae	Yamada	Algae (Rhodophyta)	Non native
Ceramium botryocarpum	A.W.Griffiths ex Harvey	Algae (Rhodophyta)	Native
Ceramium cimbricum	H.E.Petersen	Algae (Rhodophyta)	Native
Ceramium diaphanum	(Lightfoot) Roth	Algae (Rhodophyta)	Native
Ceramium pallidum	(Nägeli) Maggs & Hommersand	Algae (Rhodophyta)	Native
Ceramium sungminbooi	Hughey et Boo	Algae (Rhodophyta)	Non native
Ceramium tenuicorne	(Kützing) Waern	Algae (Rhodophyta)	Non native
Ceramium virgatum	Roth	Algae (Rhodophyta)	Native
Chaetomorpha linum	(O.F.Müller) Kützing	Algae (Chlorophyta)	Native
Chondrus crispus	Stackhouse	Algae (Rhodophyta)	Native
Cladophora albida	(Nees) Kutzing	Algae (Chlorophyta)	Native
Cladophora hutchinsiae	(Dillwyn) Kützing	Algae (Chlorophyta)	Native
Cladophora laetevirens	(Dillwyn) Kützing	Algae (Chlorophyta)	Native
Cladophora liniformis	Kützing	Algae (Chlorophyta)	Native
Cladophora sericea	(Hudson) Kützing	Algae (Chlorophyta)	Native
Cladophora vagabunda	(Linnaeus) Hoek	Algae (Chlorophyta)	Native
Codium fragile	(Suringar) Hariot	Algae (Chlorophyta)	Non native
Colpomenia peregrina	Sauvageau	Algae (Ochrophyta)	Non native
Dasya sessilis	Yamada	Algae (Rhodophyta)	Non native
Dasysiphonia japonica	(Yendo) H.-S.Kim	Algae (Rhodophyta)	Non native
Derbesia marina	(Lyngbye) Solier	Algae (Chlorophyta)	Native
Ectocarpus siliculosus	(Dillwyn) Lyngbye	Algae (Ochrophyta)	Native
Elachista fucicola	(Velley) Areschoug	Algae (Ochrophyta)	Native
Erythrotrichia carnea	(Dillwyn) J.Agardh	Algae (Rhodophyta)	Native
Fucus spiralis	Linnaeus	Algae (Ochrophyta)	Native
Fucus vesiculosus	Linnaeus	Algae (Ochrophyta)	Native
Gaillona hookeri	(Dillwyn) Athanasiadis	Algae (Rhodophyta)	Native
Gayralia oxysperma	(Kützing) Vinogradova ex Scagel	Algae (Chlorophyta)	Native
Gracilaria gracilis	(Stackhouse) Steentoft et al.,	Algae (Rhodophyta)	Native
Gracilaria vermiculophylla	(Ohmi) Papenfuss	Algae (Rhodophyta)	Non native

Species	**Author**	**Group**	**Origin**
Hincksia fuscata	(Zanardini) P.C.Silva	Algae (Ochrophyta)	Native
Hypoglossum hypoglossoides	(Stackhouse) F.S.Collins & Hervey	Algae (Rhodophyta)	Native
Mastocarpus stellatus	(Stackhouse) Guiry	Algae (Rhodophyta)	Native
Melanothamnus harveyi	(Bailey) Díaz-Tapia & Maggs	Algae (Rhodophyta)	Non native
Polysiphonia denudata	(Dillwyn) Greville ex Harvey	Algae (Rhodophyta)	Native
Polysiphonia elongata	(Hudson) Sprengel	Algae (Rhodophyta)	Native
Polysiphonia senticulosa	Harvey	Algae (Rhodophyta)	Non native
Polysiphonia stricta	(Dillwyn) Greville	Algae (Rhodophyta)	Native
Porphyra purpurea	(Roth) C.Agardh	Algae (Rhodophyta)	Native
Porphyra umbilicalis	Kützing	Algae (Rhodophyta)	Native
Prasiola stipitata	Suhr	Algae (Chlorophyta)	Native
Pterothamnion plumula	(J.Ellis) Nägeli	Algae (Rhodophyta)	Native
Pylaiella littoralis	(Linnaeus) Kjellman	Algae (Ochrophyta)	Native
Rhizoclonium riparium	(Roth) Harvey	Algae (Chlorophyta)	Native
Sargassum muticum	(Yendo) Fensholt	Algae (Ochrophyta)	Non native
Stylonema alsidii	(Zanardini) K.M.Drew	Algae (Rhodophyta)	Native
Ulva australis	Areschoug	Algae (Chlorophyta)	Non native
Ulva clathrata	(Roth) C.Agardh	Algae (Chlorophyta)	Native
Ulva compressa	Linnaeus	Algae (Chlorophyta)	Native
Ulva curvata	(Kützing) De Toni	Algae (Chlorophyta)	Native
Ulva flexuosa	Wulfen	Algae (Chlorophyta)	Native
Ulva intestinalis	Linnaeus	Algae (Chlorophyta)	Native
Ulva lactuca	Linnaeus	Algae (Chlorophyta)	Native
Ulva linza	Linnaeus	Algae (Chlorophyta)	Native
Ulva prolifera	O.F.Müller	Algae (Chlorophyta)	Native
Ulva pseudocurvata	Koeman & Hoek	Algae (Chlorophyta)	Native
Ulva ralfsii	(Harvey) Le Jolis	Algae (Chlorophyta)	Native
Ulva rigida	C.Agardh	Algae (Chlorophyta)	Native
Ulva rotundata	Bliding	Algae (Chlorophyta)	Native
Ulva torta	(Mertens) Trevisan	Algae (Chlorophyta)	Native
Ulvaria splendens	(Ruprecht) Vinogradova	Algae (Chlorophyta)	Non native
Undaria pinnatifida	(Harvey) Suringar	Algae (Ochrophyta)	Non native
Vertebrata fucoides	(Hudson) Kuntze	Algae (Rhodophyta)	Native
Alitta succinea	(Leuckart, 1847)	Annelida	Native
Ampharete acutifrons	(Grube, 1860)	Annelida	Native
Aphelochaeta marioni	(Saint-Joseph, 1894)	Annelida	Non native
Arenicola marina	(Linnaeus, 1758)	Annelida	Native
Capitella capitata	(Fabricius, 1780)	Annelida	Native
Eteone longa	(Fabricius, 1780)	Annelida	Native
Eunereis longissima	(Johnston, 1840)	Annelida	Native
Ficopomatus enigmaticus	(Fauvel, 1923)	Annelida	Non native
Harmothoe imbricata	(Linnaeus, 1767)	Annelida	Native
Hediste diversicolor	(O.F. Müller, 1776)	Annelida	Native
Heteromastus filiformis	(Claparède, 1864)	Annelida	Native
Hypereteone foliosa	(Quatrefages, 1865)	Annelida	Native
Lagis koreni	Malmgren, 1866	Annelida	Native
Lanice conchilega	(Pallas, 1766)	Annelida	Native

Species	**Author**	**Group**	**Origin**
Lepidonotus squamatus	(Linnaeus, 1758)	Annelida	Native
Marenzelleria viridis	(Verrill, 1873)	Annelida	Non native
Neoamphitrite figulus	(Dalyell, 1853)	Annelida	Native
Neodexiospira brasiliensis	(Grube, 1872)	Annelida	Non native
Nephtys cirrosa	Ehlers, 1868	Annelida	Native
Nephtys hombergii	Savigny in Lamarck, 1818	Annelida	Native
Nereis pelagica	Linnaeus, 1758	Annelida	Native
Phyllodoce mucosa	Örsted, 1843	Annelida	Native
Polydora cornuta	Bosc, 1802	Annelida	Native
Pygospio elegans	Claparède, 1863	Annelida	Native
Scoloplos armiger	(Müller, 1776)	Annelida	Native
Serpula vermicularis	Linnaeus, 1767	Annelida	Native
Spio martinensis	Mesnil, 1896	Annelida	Native
Spiophanes bombyx	(Claparède, 1870)	Annelida	Native
Spirobranchus triqueter	(Linnaeus, 1758)	Annelida	Native
Streblospio shrubsolii	(Buchanan, 1890)	Annelida	Native
Aplidium glabrum	(Verrill, 1871)	Ascidiacea	Non native
Ascidiella aspersa	(Müller, 1776)	Ascidiacea	Native
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
Molgula manhattensis	(De Kay, 1843)	Ascidiacea	Non native
Styela clava	Herdman, 1881	Ascidiacea	Non native
Alcyonidioides mytili	(Dalyell, 1848)	Bryozoa	Native
Amathia cf. *gracilis*	(Leidy, 1855)	Bryozoa	Non native
Bugulina stolonifera	(Ryland, 1960)	Bryozoa	Non native
Conopeum reticulum	(Linnaeus, 1767)	Bryozoa	Native
Crisularia plumosa	(Pallas, 1766)	Bryozoa	Native
Cryptosula pallasiana	(Moll, 1803)	Bryozoa	Native
Einhornia crustulenta	(Pallas, 1766)	Bryozoa	Native
Electra pilosa	(Linnaeus, 1767)	Bryozoa	Native
Schizoporella cf. *japonica*	Ortmann, 1890	Bryozoa	Non native
Smittoidea prolifica	Osburn, 1952	Bryozoa	Non native
Tricellaria inopinata	d'Hondt & Occhipinti Ambrogi, 1985	Bryozoa	Non native
Aurelia aurita	(Linnaeus, 1758)	Cnidaria	Native
Bougainvillia muscus	(Allman, 1863)	Cnidaria	Native
Clytia hemisphaerica	(Linnaeus, 1767)	Cnidaria	Native
Diadumene cincta	Stephenson, 1925	Cnidaria	Non native
Ectopleura larynx	(Ellis & Solander, 1786)	Cnidaria	Native
Eucheilota maculata	Hartlaub, 1894	Cnidaria	Native
Hartlaubella gelatinosa	(Pallas, 1766)	Cnidaria	Native
Hydractinia echinata	(Fleming, 1828)	Cnidaria	Native
Metridium senile	(Linnaeus, 1761)	Cnidaria	Native
Nemopsis bachei	L. Agassiz, 1849	Cnidaria	Non native
Obelia dichotoma	(Linnaeus, 1758)	Cnidaria	Native
Obelia geniculata	(Linnaeus, 1758)	Cnidaria	Native

Species	Author	Group	Origin
Obelia longissima	(Pallas, 1766)	Cnidaria	Native
Rhizostoma pulmo	(Macri, 1778)	Cnidaria	Native
Sagartia troglodytes	(Price in Johnston, 1847)	Cnidaria	Native
Sagartia elegans	(Dalyell, 1848)	Cnidaria	Native
Sagartiogeton undatus	(Müller, 1778)	Cnidaria	Native
Sertularia cupressina	Linnaeus, 1758	Cnidaria	Native
Urticina felina	(Linnaeus, 1761)	Cnidaria	Native
Amphibalanus improvisus	(Darwin, 1854)	Crustacea	Non native
Aora gracilis	(Bate, 1857)	Crustacea	Native
Apohyale prevostii	(Milne Edwards, 1830)	Crustacea	Native
Austrominius modestus	(Darwin, 1854)	Crustacea	Non native
Balanus crenatus	Bruguière, 1789	Crustacea	Native
Bathyporeia sarsi	Watkin, 1938	Crustacea	Native
Calliopius laeviusculus	(Krøyer, 1838)	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
Eriocheir sinensis	H. Milne Edwards, 1853	Crustacea	Non native
Gammaropsis nitida	(Stimpson, 1853)	Crustacea	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
Idotea linearis	(Linnaeus, 1766)	Crustacea	Native
Jassa marmorata	Holmes, 1905	Crustacea	Non native
Lekanesphaera rugicauda	(Leach, 1814)	Crustacea	Native
Liocarcinus depurator	(Linnaeus, 1758)	Crustacea	Native
Melita palmata	(Montagu, 1804)	Crustacea	Native
Microprotopus maculatus	Norman, 1867	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 elegans	Rathke, 1837	Crustacea	Native
Palaemon longirostris	H. Milne Edwards, 1837	Crustacea	Native
Palaemon macrodactylus	Rathbun, 1902	Crustacea	Non native
Praunus flexuosus	(Müller, 1776)	Crustacea	Native
Semibalanus balanoides	(Linnaeus, 1767)	Crustacea	Native
Urothoe poseidonis	Reibish, 1905	Crustacea	Native
Beroe gracilis	Künne, 1939	Ctenophora	Native
Mnemiopsis leidyi	A. Agassiz, 1865	Ctenophora	Non native
Amphipholis squamata	(Delle Chiaje, 1828)	Echinodermata	Native
Asterias rubens	Linnaeus, 1758	Echinodermata	Native

Species	Author	Group	Origin
Echinocardium cordatum	(Pennant, 1777)	Echinodermata	Native
Ophiura ophiura	(Linnaeus, 1758)	Echinodermata	Native
Telmatogeton japonicus	Tokunaga, 1933	Insecta	Non native
Abra tenuis	(Montagu, 1803)	Mollusca	Native
Cerastoderma edule	(Linnaeus, 1758)	Mollusca	Native
Crepidula fornicata	(Linnaeus, 1758)	Mollusca	Non native
Ensis leei	M. Huber, 2015	Mollusca	Non native
Lepidochitona cinerea	(Linnaeus, 1767)	Mollusca	Native
Limecola balthica	(Linnaeus, 1758)	Mollusca	Native
Littorina fabalis	(W. Turton, 1825)	Mollusca	Native
Littorina littorea	(Linnaeus, 1758)	Mollusca	Native
Littorina obtusata	(Linnaeus, 1758)	Mollusca	Native
Littorina saxatilis	(Olivi, 1792)	Mollusca	Native
Magallana gigas	(Thunberg, 1793)	Mollusca	Non native
Mulinia lateralis	(Say, 1822)	Mollusca	Non native
Mya arenaria	Linnaeus, 1758	Mollusca	Non native
Mytilus edulis	Linnaeus, 1758	Mollusca	Native
Ostrea edulis	Linnaeus, 1758	Mollusca	Native
Peringia ulvae	(Pennant, 1777)	Mollusca	Native
Petricolaria pholadiformis	(Lamarck, 1818)	Mollusca	Non native
Retusa obtusa	(Montagu, 1803)	Mollusca	Native
Scrobicularia plana	(da Costa, 1778)	Mollusca	Native
Tergipes tergipes	(Forsskål in Niebuhr, 1775)	Mollusca	Native
Gobius niger	Linnaeus, 1758	Pisces	Native
Myoxocephalus scorpius	(Linnaeus, 1758)	Pisces	Native
Pholis gunnellus	(Linnaeus, 1758)	Pisces	Native
Platichthys flesus	(Linnaeus, 1758)	Pisces	Native
Pleuronectes platessa	Linnaeus, 1758	Pisces	Native
Pomatoschistus microps	(Krøyer, 1838)	Pisces	Native
Pomatoschistus minutus	(Pallas, 1770)	Pisces	Native
Pomatoschistus pictus	(Malm, 1865)	Pisces	Native
Scophthalmus maximus	(Linnaeus, 1758)	Pisces	Native
Solea solea	(Linnaeus, 1758)	Pisces	Native
Syngnathus acus	Linnaeus, 1758	Pisces	Native
Stylochoplana maculata	(Quatrefage, 1845)	Platyhelminthes	Native
Stylochus cf. *flevensis*	Hofker, 1930	Platyhelminthes	Non native
Cliona celata	Grant, 1826	Porifera	Native
Halichondria bowerbanki	Burton, 1930	Porifera	Native
Halichondria panicea	(Pallas, 1766)	Porifera	Native
Haliclona xena	De Weerdt, 1986	Porifera	Non native
Hymeniacidon perlevis	(Montagu, 1814)	Porifera	Non native
Leucosolenia somesii	(Bowerbank, 1874)	Porifera	Non native
Leucosolenia variabilis	Haeckel, 1870	Porifera	Native
Sycon ciliatum	(Fabricius, 1780)	Porifera	Native

Appendix III

The research locations searched during the Wadden Sea inventory in 2018.

Loc.	Habitat	Method	Coordinates	Date
Region A (Fig. 1): Texel, 't Horntje				
1	Floating dock (synthetic)	Snorkling	N53 0.3188, E4 47.7548	14/08/2018
2	Poles, littoral zone	Visual inspection	N53 0.3100, E4 47.7550	12/08/2018
3	Dike, exposed side, littoral zone	Visual inspection	N53 0.2906, E4 47.8263	12/08/2018
4	Dike, sheltered side, littoral zone	Visual inspection	N53 0.3170, E4 47.7840	12/08/2018
5	Dike, sheltered side, littoral zone	Visual inspection	N53 0.3100, E4 47.7550	12/08/2018
6	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 0.3336, E4 47.7868	14/08/2018
7	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 0.3301, E4 47.7751	14/08/2018
8	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 0.3196, E4 47.7640	14/08/2018
9	Water column	Gelatinous zooplankton net	N53 0.3196, E4 47.7640	14/08/2018
10	Water column	Gelatinous zooplankton net	N53 0.3301, E4 47.7751	14/08/2018
11	Water column	Gelatinous zooplankton net	N53 0.3336, E4 47.7868	14/08/2018
Region A (Fig. 1): Texel, arrival ferry				
12	Dike, sheltered side, littoral zone	Visual inspection	N53 00.255, E4 46.912	12/08/2018
13	Harbour wall, littoral zone	Visual inspection	N53 00.230, E4 46.883	12/08/2018
Region A (Fig. 1): Texel, Molwerk				
14	Dike, sheltered side, littoral zone	Visual inspection	N53 0.4980, E4 45.6360	12/08/2018
15	Oyster reef, littoral zone	Visual inspection	N53 0.3980, E4 45.5810	12/08/2018
Region A (Fig. 1): Texel, Oudeschild, marina				
16	Dike, sheltered side, sublittoral zone	Visual inspection	N53 2.6040, E4 51.4000	12/08/2018
17	Dike, sheltered side, littoral zone	Visual inspection	N53 2.6040, E4 51.4000	12/08/2018
18	Dike, sheltered side, sublittoral zone	Visual inspection	N53 2.6500, E4 51.4830	12/08/2018
19	Dike, sheltered side, littoral zone	Visual inspection	N53 2.6500, E4 51.4830	12/08/2018
20	Dike, sheltered side, sublittoral zone	Visual inspection	N53 2.6590, E4 51.4540	12/08/2018
21	Dike, sheltered side, littoral zone	Visual inspection	N53 2.6590, E4 51.4540	12/08/2018
22	Dike, exposed side, littoral zone	Visual inspection	N53 2.8583, E4 51.7133	12/08/2018
23	Dike, exposed side, littoral zone	Visual inspection	N53 2.8988, E4 51.7261	12/08/2018
24	Dike, sheltered side, littoral zone	Visual inspection	N53 2.6978, E4 51.4216	12/08/2018
25	Floating dock (synthetic)	Snorkling	N53 2.6930, E4 51.5250	13/08/2018
26	Floating dock (wood)	Snorkling	N53 2.5970, E4 51.3890	13/08/2018
27	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 2.6802, E4 51.4189	13/08/2018
28	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 2.6899, E4 51.4333	13/08/2018
29	Bottom sample, soft substrate, sublittoral zone	Hand dredge	N53 2.6802, E4 51.4189	13/08/2018
30	Bottom sample, soft substrate, sublittoral zone	Hand dredge	N53 2.6899, E4 51.4333	13/08/2018
31	Dike, sheltered side, littoral zone	Visual inspection	N53 2.6858, E4 51.4074	13/08/2018
32	Harbour wall, littoral zone	Visual inspection	N53 2.6858, E4 51.4074	13/08/2018
33	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 2.7193, E4 51.4697	14/08/2018
34	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 2.7222, E4 51.4723	14/08/2018
35	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 2.6978, E4 51.4382	14/08/2018

Loc.	Habitat	Method	Coordinates	Date
36	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 2.6993, E4 51.4412	14/08/2018
37	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 2.7380, E4 51.4964	14/08/2018
38	Water column	Gelatinous zooplankton net	N53 2.6802, E4 51.4189	14/08/2018
39	Water column	Gelatinous zooplankton net	N53 2.6899, E4 51.4333	14/08/2018
40	Floating dock, submerged rope	Visual inspection	N53 2.7380, E4 51.4964	11/06/2018
41	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 2.7380, E4 51.4964	11/06/2018
42	Floating dock (synthetic)	Scrape sample	N53 2.7124, E4 51.4642	11/06/2018
43	Floating dock, submerged rope	Visual inspection	N53 2.7193, E4 51.4697	11/06/2018
44	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 2.7193, E4 51.4697	11/06/2018
45	Water column	Gelatinous zooplankton net	N53 2.6972, E4 51.4395	11/06/2018
46	Water column	Gelatinous zooplankton net	N53 2.7206, E4 51.4723	11/06/2018
47	Water column	Gelatinous zooplankton net	N53 2.7377, E4 51.4973	11/06/2018
48	Floating dock, submerged rope	Visual inspection	N53 2.7222, E4 51.4723	11/06/2018
49	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 2.7222, E4 51.4723	11/06/2018
50	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 2.7193, E4 51.4697	11/06/2018
51	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 2.7079, E4 51.4543	11/06/2018
52	Floating dock (wood)	Visual inspection	N53 2.5581, E4 51.3738	10/10/2018
53	Poles, littoral zone	Visual inspection	N53 2.7374, E4 51.4963	10/10/2018
54	Dike, exposed side, littoral zone	Visual inspection	N53 2.8098, E4 51.6953	10/10/2018
Region A (Fig. 1): Texel, Oudeschild, fishing harbour				
55	Poles, littoral zone	Visual inspection	N53 2.5991, E4 51.3581	12/08/2018
56	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 2.5991, E4 51.3581	13/08/2018
57	Bottom sample, soft substrate, sublittoral zone	Hand dredge	N53 2.5991, E4 51.3581	13/08/2018
58	Water column	Gelatinous zooplankton net	N53 2.5991, E4 51.3581	14/08/2018
Region A (Fig. 1): Texel, Cocksdorp				
59	Mussel beds, littoral zone	Visual inspection	N53 9.4918, E4 52.7108	13/08/2018
Region B (Fig. 1): Vlieland, marina				
60	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 17.8250, E5 5.2150	30/08/2018
61	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 17.8200, E5 5.3160	30/08/2018
62	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 17.7660, E5 5.4060	30/08/2018
63	Dike, exposed side, littoral zone	Visual inspection	N53 17.6790, E5 5.4750	30/08/2018
64	Dike, exposed side, littoral zone	Visual inspection	N53 17.6666, E5 5.4853	10/10/2018
65	Dike, sheltered side, littoral zone	Visual inspection	N53 17.7050, E5 5.4500	30/08/2018
66	Floating dock	Visual inspection	N53 17.8180, E5 5.3150	30/08/2018
67	Floating dock	Visual inspection	N53 17.8219, E5 5.1797	10/10/2018
68	Floating dock, buoy	Visual inspection	N53 17.8624, E5 5.2263	10/10/2018
69	Harbour wall, littoral zone	Visual inspection	N53 17.8463, E5 5.1911	10/10/2018
70	Water column	Surface water sample	N53 17.8240, E5 5.2160	30/08/2018
71	Water column	Gelatinous zooplankton net	N53 17.8240, E5 5.2160	30/08/2018
72	Water column	Surface water sample	N53 17.8200, E5 5.3160	30/08/2018
73	Water column	Gelatinous zooplankton net	N53 17.8200, E5 5.3160	30/08/2018
74	Water column	Surface water sample	N53 17.7660, E5 5.4060	30/08/2018
75	Water column	Gelatinous zooplankton net	N53 17.7660, E5 5.4060	30/08/2018

Loc.	Habitat	Method	Coordinates	Date
Region B (Fig. 1): Vlieland, arrival ferry				
76	Dike, exposed side and tide pool, littoral zone	Visual inspection	N53 17.7541, E5 4.4536	10/10/2018
Region C (Fig. 1): Terschelling				
77	Oyster Reef	Visual inspection	N53 21.5846, E5 13.9005	10/09/2018
78	Oyster Reef	Visual inspection	N53 21.5403, E5 13.9955	10/10/2018
79	Oyster Reef	Visual inspection	N53 21.5327, E5 13.9892	10/10/2018
80	Oyster Reef	Visual inspection	N53 21.5881, E5 13.8917	10/09/2018
Region C (Fig. 1): Terschelling, marina				
81	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 21.9200, E5 13.3590	30/08/2018
82	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 21.8310, E5 13.2640	30/08/2018
83	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 21.5930, E5 13.0570	30/08/2018
84	Floating dock	Visual inspection	N53 21.8950, E5 13.3310	10/09/2018
85	Floating dock	Scrape sample	N53 21.9022, E5 13.2863	29/06/2018
86	Floating dock	Scrape sample	N53 21.8660, E5 13.3717	29/06/2018
87	Floating dock, submerged rope	Visual inspection	N53 21.9040, E5 13.2870	10/09/2018
88	Floating dock, submerged rope	Visual inspection	N53 21.9040, E5 13.2870	10/09/2018
89	Floating dock, submerged rope	Visual inspection	N53 21.9050, E5 13.2860	10/09/2018
90	Floating dock, submerged rope	Visual inspection	N53 21.9050, E5 13.2860	10/09/2018
91	Floating dock, submerged rope	Visual inspection	N53 21.9050, E5 13.2860	10/09/2018
92	Floating dock, submerged rope	Visual inspection	N53 21.9050, E5 13.2860	10/09/2018
93	Floating dock, submerged rope	Visual inspection	N53 21.9270, E5 13.3890	10/09/2018
94	Floating dock, submerged rope	Visual inspection	N53 21.9022, E5 13.2863	29/06/2018
95	Floating dock, submerged rope	Visual inspection	N53 21.9022, E5 13.2863	29/06/2018
96	Floating dock, submerged rope	Visual inspection	N53 21.9022, E5 13.2863	29/06/2018
97	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 21.9040, E5 13.2850	10/09/2018
98	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 21.9040, E5 13.2870	10/09/2018
99	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 21.9050, E5 13.2860	10/09/2018
100	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 21.9050, E5 13.2860	10/09/2018
101	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 21.9050, E5 13.2860	10/09/2018
102	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 21.9050, E5 13.2860	10/09/2018
103	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 21.9022, E5 13.2863	29/06/2018
104	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 21.9022, E5 13.2863	29/06/2018
105	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 21.9022, E5 13.2863	29/06/2018
106	Water column	Surface water sample	N53 21.9200, E5 13.3590	30/08/2018
107	Water column	Gelatinous zooplankton net	N53 21.9190, E5 13.3590	30/08/2018
108	Water column	Surface water sample	N53 21.8310, E5 13.2640	30/08/2018
109	Water column	Gelatinous zooplankton net	N53 21.8300, E5 13.2610	30/08/2018
110	Water column	Surface water sample	N53 21.5930, E5 13.0570	30/08/2018
111	Water column	Gelatinous zooplankton net	N53 21.5920, E5 13.0560	30/08/2018
112	Water column	Surface water sample	N53 21.9040, E5 13.2870	10/09/2018
113	Water column	Gelatinous zooplankton net	N53 21.9022, E5 13.2863	29/06/2018

Loc.	Habitat	Method	Coordinates	Date
Region D (Fig. 1): Ameland, marina				
114	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 26.2720, E5 46.5200	20/09/2018
115	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 26.2460, E5 46.5200	20/09/2018
116	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 26.2060, E5 46.5200	20/09/2018
117	Dike, exposed side, littoral zone	Visual inspection	N53 26.2830, E5 46.4740	20/09/2018
118	Dike, sheltered side, littoral zone	Visual inspection	N53 26.2780, E5 46.4980	20/09/2018
119	Floating dock	Scrape sample	N53 26.2730, E5 46.5180	20/09/2018
120	Floating dock	Scrape sample	N53 26.2430, E5 46.5180	20/09/2018
121	Floating dock	Scrape sample	N53 26.2070, E5 46.5200	20/09/2018
122	Floating dock	Scrape sample	N53 26.2710, E5 46.5191	09/10/2018
123	Water column	Surface water sample	N53 26.2720, E5 46.5210	20/09/2018
124	Water column	Gelatinous zooplankton net	N53 26.2740, E5 46.5190	20/09/2018
125	Water column	Surface water sample	N53 26.2450, E5 46.5170	20/09/2018
126	Water column	Gelatinous zooplankton net	N53 26.2440, E5 46.5180	20/09/2018
127	Water column	Surface water sample	N53 26.2060, E5 46.5190	20/09/2018
128	Water column	Gelatinous zooplankton net	N53 26.2070, E5 46.5200	20/09/2018
Region D (Fig. 1): Ameland, KNRM dike				
129	Dike, exposed side, littoral zone	Visual inspection	N53 26.0630, E5 43.2780	20/09/2018
130	Dike, sheltered side, littoral zone	Visual inspection	N53 26.1110, E5 43.1730	20/09/2018
Region E (Fig. 1): Schiermonnikoog, arrival ferry				
131	Dike, exposed side, littoral zone	Visual inspection	N53 28.3353, E6 11.7624	21/09/2018
132	Dike, exposed side, littoral zone	Visual inspection	N53 28.1670, E6 12.0560	21/09/2018
Region E (Fig. 1): Schiermonnikoog, marina				
133	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 28.1910, E6 10.0010	21/09/2018
134	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 28.1900, E6 10.0130	21/09/2018
135	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 28.1930, E6 10.0310	21/09/2018
136	Dike, exposed side, littoral zone	Visual inspection	N53 28.2020, E6 9.9770	21/09/2018
137	Dike, sheltered side, littoral zone	Visual inspection	N53 28.1910, E6 10.0020	21/09/2018
138	Floating dock	Scrape sample	N53 28.1920, E6 10.0240	21/09/2018
139	Water column	Surface water sample	N53 28.1910, E6 10.0130	21/09/2018
140	Water column	Surface water sample	N53 28.1910, E6 10.0130	21/09/2018
141	Water column	Surface water sample	N53 28.1930, E6 10.0310	21/09/2018
142	Water column	Gelatinous zooplankton net	N53 28.1910, E6 10.0020	21/09/2018
143	Water column	Gelatinous zooplankton net	N53 28.1910, E6 10.0110	21/09/2018
144	Water column	Gelatinous zooplankton net	N53 28.1930, E6 10.0310	21/09/2018

Loc.	Habitat	Method	Coordinates	Date
Region F (Fig. 1): Den Helder, marine marina				
145	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N52 57.6972, E4 46.8479	07/09/2018
146	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N52 57.6901, E4 46.8661	07/09/2018
147	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N52 57.7802, E4 46.9134	07/09/2018
148	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N52 57.7684, E4 46.9423	07/09/2018
149	Floating dock	Scrape sample	N52 57.7802, E4 46.9134	07/09/2018
150	Floating dock	Scrape sample	N52 57.7684, E4 46.9423	07/09/2018
151	Floating dock	Scrape sample	N52 57.7514, E4 46.9441	07/09/2018
152	Floating dock	Visual inspection	N52 57.7616, E4 46.8392	11/10/2018
153	Poles, sublittoral zone	Visual inspection	N52 57.7616, E4 46.8392	11/10/2018
154	Harbour wall, littoral zone	Visual inspection	N52 57.7616, E4 46.8392	11/10/2018
155	Dike, sheltered side, littoral zone	Visual inspection	N52 57.7616, E4 46.8392	11/10/2018
156	Floating dock	Scrape sample	N52 57.6941, E4 46.8536	11/06/2018
157	Settlement plate (deployed: June 2014)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
158	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
159	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
160	Settlement plate (deployed: December 2017)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
161	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
162	Settlement plate (deployed: December 2017)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
163	Settlement plate (deployed: June 2016)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
164	Settlement plate (deployed: September 2009)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
165	Settlement plate (deployed: March 2009)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
166	Settlement plate (deployed: June 2016)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
167	Settlement plate (deployed: June 2018)	SETL plate (1m)	N52 57.6941, E4 46.8536	07/09/2018
168	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.6941, E4 46.8536	07/09/2018
169	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.6941, E4 46.8536	07/09/2018
170	Settlement plate (deployed: December 2017)	SETL plate (1m)	N52 57.6941, E4 46.8536	07/09/2018
171	Settlement plate (deployed: December 2017)	SETL plate (1m)	N52 57.6941, E4 46.8536	07/09/2018
172	Settlement plate (deployed: September 2009)	SETL plate (1m)	N52 57.6941, E4 46.8536	07/09/2018
173	Settlement plate (deployed: March 2009)	SETL plate (1m)	N52 57.6941, E4 46.8536	07/09/2018
174	Settlement plate (deployed: June 2014)	SETL plate (1m)	N52 57.6941, E4 46.8536	07/09/2018
175	Settlement plate (deployed: June 2018)	SETL plate (1m)	N52 57.6941, E4 46.8536	07/09/2018
176	Settlement plate (deployed: June 2018)	SETL plate (1m)	N52 57.6941, E4 46.8536	07/09/2018
177	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.6941, E4 46.8536	07/09/2018
178	Settlement plate (deployed: June 2016)	SETL plate (1m)	N52 57.6941, E4 46.8536	07/09/2018
179	Settlement plate (deployed: June 2016)	SETL plate (1m)	N52 57.6941, E4 46.8536	07/09/2018
180	Water column	Gelatinous zooplankton net	N52 57.7802, E4 46.9134	07/09/2018
181	Water column	Gelatinous zooplankton net	N52 57.6972, E4 46.8479	07/09/2018
182	Water column	Gelatinous zooplankton net	N52 57.6901, E4 46.8661	07/09/2018
183	Water column	Gelatinous zooplankton net	N52 57.7684, E4 46.9423	07/09/2018
184	Water column	Surface water sample	N52 57.6744, E4 46.8482	07/09/2018
185	Water column	Surface water sample	N52 57.7802, E4 46.9134	07/09/2018
186	Water column	Surface water sample	N52 57.7684, E4 46.9423	07/09/2018
187	Water column	Surface water sample	N52 57.7514, E4 46.9441	07/09/2018
188	Water column	Gelatinous zooplankton net	N52 57.6941, E4 46.8536	11/06/2018

Loc.	Habitat	Method	Coordinates	Date
Region F (Fig. 1): Den Helder, navy port				
189	Floating dock	Scrape sample	N52 57.5365, E4 46.8476	11/06/2018
190	Floating dock	Scrape sample	N52 57.2698, E4 47.1775	11/06/2018
191	Floating dock	Scrape sample	N52 57.6941, E4 46.8536	11/06/2018
192	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.2698, E4 47.1775	11/06/2018
193	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.2698, E4 47.1775	11/06/2018
194	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.2698, E4 47.1775	11/06/2018
195	Settlement plate (deployed: December 2016)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
196	Settlement plate (deployed: December 2016)	SETL plate (3m)	N52 57.6941, E4 46.8536	11/06/2018
197	Settlement plate (deployed: June 2016)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
198	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
199	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
200	Settlement plate (deployed: September 2016)	SETL plate (3m)	N52 57.6941, E4 46.8536	11/06/2018
201	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
202	Settlement plate (deployed: September 2016)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
203	Settlement plate (deployed: September 2016)	SETL plate (1m)	N52 57.6941, E4 46.8536	11/06/2018
204	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.5365, E4 46.8476	11/06/2018
205	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.5365, E4 46.8476	11/06/2018
206	Settlement plate (deployed: March 2018)	SETL plate (1m)	N52 57.5365, E4 46.8476	11/06/2018
207	Water column	Gelatinous zooplankton net	N52 57.5365, E4 46.8476	11/06/2018
208	Water column	Gelatinous zooplankton net	N52 57.6941, E4 46.8536	11/06/2018
209	Water column	Gelatinous zooplankton net	N52 57.2698, E4 47.1775	11/06/2018
Region G (Fig. 1): Den Oever, marina				
210	Floating dock (synthetic)	Visual inspection	N52 56.3723, E5 2.0387	10/08/2018
Region G (Fig. 1): Den Oever, fishing harbour				
211	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N52 56.0414, E5 2.3075	04/09/2018
212	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N52 56.0383, E5 2.3288	04/09/2018
213	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N52 56.0300, E5 2.3267	04/09/2018
214	Dike, sheltered side, littoral zone	Visual inspection	N52 56.2510, E5 2.1090	14/09/2018
215	Floating dock (wood)	Scrape sample	N52 56.0650, E5 2.3240	14/09/2018
216	Water column	Surface water sample	N52 56.0400, E5 2.3280	04/09/2018
217	Water column	Gelatinous zooplankton net	N52 56.0414, E5 2.3075	04/09/2018
218	Water column	Gelatinous zooplankton net	N52 56.0383, E5 2.3288	04/09/2018
219	Water column	Gelatinous zooplankton net	N52 56.0300, E5 2.3267	04/09/2018
220	Water column	Surface water sample	N52 56.0720, E5 2.3200	14/09/2018
Region G (Fig. 1): Breezandijk				
221	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 1.2176, E5 12.1593	10/09/2018
222	Dike, exposed side, littoral zone	Visual inspection	N53 1.2502, E5 12.0940	09/10/2018
223	Dike, sheltered side, littoral zone	Visual inspection	N53 1.2109, E5 12.1576	09/10/2018
224	Dike, sheltered side, sublittoral zone	Visual inspection	N53 1.2080, E5 12.1530	10/09/2018
225	Poles, sublittoral zone	Scrape sample	N53 1.2170, E5 12.1580	10/09/2018
226	Water column	Gelatinous zooplankton net	N53 1.2176, E5 12.1593	10/09/2018
227	Water column	Surface water sample	N53 1.2176, E5 12.1593	10/09/2018

Loc.	Habitat	Method	Coordinates	Date
Region G (Fig. 1): Kornwerderzand				
228	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 4.6346, E5 20.0776	10/09/2018
229	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 4.5961, E5 20.0949	10/09/2018
230	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 4.5217, E5 20.1241	10/09/2018
231	Dike, exposed side, littoral zone	Visual inspection	N53 4.5105, E5 20.3426	09/10/2018
232	Dike, sheltered side, littoral zone	Visual inspection	N53 4.5130, E5 20.1336	10/09/2018
233	Floating dock	Scrape sample	N53 4.5236, E5 20.1243	10/09/2018
234	Water column	Surface water sample	N53 4.5250, E5 20.1265	10/09/2018
235	Water column	Gelatinous zooplankton net	N53 4.6337, E5 20.0714	10/09/2018
236	Water column	Gelatinous zooplankton net	N53 4.5950, E5 20.0905	10/09/2018
237	Water column	Gelatinous zooplankton net	N53 4.5255, E5 20.1229	10/09/2018
Region H (Fig. 1): Harlingen, Nieuwe Voorhaven				
238	Floating dock	Scrape sample	N53 10.7144, E5 24.8596	29/06/2018
239	Floating dock, submerged rope	Visual inspection	N53 10.7144, E5 24.8596	29/06/2018
240	Floating dock, submerged rope	Visual inspection	N53 10.7144, E5 24.8596	29/06/2018
241	Floating dock, submerged rope	Visual inspection	N53 10.7144, E5 24.8596	29/06/2018
242	Floating dock, submerged rope	Visual inspection	N53 10.7144, E5 24.8596	29/06/2018
243	Floating dock, submerged rope	Visual inspection	N53 10.7144, E5 24.8596	29/06/2018
244	Floating dock, submerged rope	Visual inspection	N53 10.7144, E5 24.8596	29/06/2018
245	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 10.7144, E5 24.8596	29/06/2018
246	Settlement plate (deployed: March 2018)	SETL plate (3m)	N53 10.7144, E5 24.8596	29/06/2018
247	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 10.7144, E5 24.8596	29/06/2018
248	Settlement plate (deployed: March 2018)	SETL plate (3m)	N53 10.7144, E5 24.8596	29/06/2018
249	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 10.7144, E5 24.8596	29/06/2018
250	Settlement plate (deployed: March 2018)	SETL plate (3m)	N53 10.7144, E5 24.8596	29/06/2018
251	Water column	Gelatinous zooplankton net	N53 10.7144, E5 24.8596	29/06/2018
252	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 10.7110, E5 24.8710	31/08/2018
253	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 10.7110, E5 24.8710	31/08/2018
254	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 10.7110, E5 24.8710	31/08/2018
255	Floating dock	Scrape sample	N53 10.7160, E5 24.8610	31/08/2018
256	Floating dock, submerged rope	Visual inspection	N53 10.7160, E5 24.8620	31/08/2018
257	Floating dock, submerged rope	Visual inspection	N53 10.7160, E5 24.8630	31/08/2018
258	Floating dock, submerged rope	Visual inspection	N53 10.7150, E5 24.8640	31/08/2018
259	Floating dock, submerged rope	Visual inspection	N53 10.7150, E5 24.8640	31/08/2018
260	Floating dock, submerged rope	Visual inspection	N53 10.7150, E5 24.8640	31/08/2018
261	Floating dock, submerged rope	Visual inspection	N53 10.7150, E5 24.8650	31/08/2018
262	Floating dock, submerged rope	Visual inspection	N53 10.7150, E5 24.8650	31/08/2018
263	Floating dock, submerged rope	Visual inspection	N53 10.7150, E5 24.8650	31/08/2018
264	Floating dock, submerged rope	Visual inspection	N53 10.7150, E5 24.8650	31/08/2018
265	Settlement plate (deployed: March 2018)	SETL plate (3m)	N53 10.7160, E5 24.8620	31/08/2018
266	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 10.7150, E5 24.8640	31/08/2018
267	Settlement plate (deployed: March 2018)	SETL plate (3m)	N53 10.7150, E5 24.8640	31/08/2018
268	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 10.7150, E5 24.8650	01/09/2018
269	Settlement plate (deployed: March 2018)	SETL plate (3m)	N53 10.7150, E5 24.8650	31/08/2018
270	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 10.7150, E5 24.8650	31/08/2018

Loc.	Habitat	Method	Coordinates	Date
271	Water column	Surface water sample	N53 10.7070, E5 24.8480	31/08/2018
272	Water column	Surface water sample	N53 10.7070, E5 24.8480	31/08/2018
273	Water column	Surface water sample	N53 10.7080, E5 24.8490	31/08/2018
274	Water column	Gelatinous zooplankton net	N53 10.7120, E5 24.8770	31/08/2018
275	Water column	Gelatinous zooplankton net	N53 10.7120, E5 24.8770	31/08/2018
276	Water column	Gelatinous zooplankton net	N53 10.7120, E5 24.8770	31/08/2018
Region H (Fig. 1): Harlingen, Nieuwe Willemshaven				
277	Dike, exposed side, littoral zone	Visual inspection	N53 10.1650, E5 24.7950	10/09/2018
278	Dike, sheltered side, littoral zone	Visual inspection	N53 10.1620, E5 24.8920	10/09/2018
Region H (Fig. 1): Harlingen, Noorderhaven				
279	Floating dock	Scrape sample	N53 10.5580, E5 25.1730	10/09/2018
280	Poles, sublittoral zone	Scrape sample	N53 10.5580, E5 25.1730	10/09/2018
281	Water column	Surface water sample	N53 10.5580, E5 25.1730	10/09/2018
	Region I (Fig. 1): Holwerd			
282	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 23.7330, E5 52.6820	20/09/2018
283	Dike, exposed side, littoral zone	Visual inspection	N53 23.6899, E5 52.7350	09/10/2018
284	Water column	Gelatinous zooplankton net	N53 23.7330, E5 52.6820	20/09/2018
285	Water column	Surface water sample	N53 23.7230, E5 52.6830	20/09/2018
Region I (Fig. 1): Moddergat				
286	Poles, littoral zone	Visual inspection	N53 24.3847, E6 4.9069	09/10/2018
Region I (Fig. 1): Lauwersoog, marina				
287	Water column	Surface water sample	N53 24.4820, E6 11.9750	21/09/2018
288	Water column	Gelatinous zooplankton net	N53 24.4820, E6 11.9760	21/09/2018
289	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 24.4820, E6 11.9760	21/09/2018
290	Floating dock	Scrape sample	N53 24.4820, E6 11.9770	21/09/2018
291	Floating dock	Visual inspection	N53 24.4817, E6 11.9770	08/10/2018
Region I (Fig. 1): Lauwersoog, fishing harbour				
292	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 24.6150, E6 12.4660	21/09/2018
293	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 24.6020, E6 12.4740	21/09/2018
294	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 24.5930, E6 12.4830	21/09/2018
295	Dike, exposed side, littoral zone	Visual inspection	N53 24.6692, E6 12.0817	08/10/2018
296	Dike, sheltered side, littoral zone	Visual inspection	N53 24.5824, E6 12.0803	08/10/2018
297	Floating dock	Scrape sample	N53 24.6150, E6 12.4660	21/09/2018
298	Water column	Surface water sample	N53 24.6160, E6 12.4680	21/09/2018
299	Water column	Gelatinous zooplankton net	N53 24.6150, E6 12.4660	21/09/2018
300	Water column	Surface water sample	N53 24.6020, E6 12.4730	21/09/2018
301	Water column	Gelatinous zooplankton net	N53 24.6020, E6 12.4730	21/09/2018
302	Water column	Surface water sample	N53 24.5910, E6 12.4820	21/09/2018
303	Water column	Gelatinous zooplankton net	N53 24.5920, E6 12.4830	21/09/2018
Region I (Fig. 1): Lauwersoog, arrival ferry				
304	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 24.6060, E6 11.8570	21/09/2018
305	Floating dock	Scrape sample	N53 24.6050, E6 11.8560	21/09/2018
306	Water column	Surface water sample	N53 24.6060, E6 11.8580	21/09/2018
307	Water column	Gelatinous zooplankton net	N53 24.6050, E6 11.8580	21/09/2018

Loc.	Habitat	Method	Coordinates	Date
Region J (Fig. 1): Eemshaven				
308	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 26.6866, E6 49.3615	13/09/2018
309	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 26.6797, E6 49.4179	13/09/2018
310	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 26.6761, E6 49.5256	13/09/2018
311	Dike, exposed side, littoral zone	Visual inspection	N53 27.5040, E6 50.0220	12/09/2018
312	Dike, sheltered side, littoral zone	Visual inspection	N53 26.6480, E6 49.5250	13/09/2018
313	Floating dock	Visual inspection	N53 26.6899, E6 49.4606	13/09/2018
314	Floating dock	Scrape sample	N53 26.6857, E6 49.4898	19/06/2018
315	Harbour wall, littoral zone	Visual inspection	N53 26.6470, E6 49.5240	13/09/2018
316	Settlement plate (deployed: March 2016)	SETL plate (3m)	N53 26.6874, E6 49.4781	13/09/2018
317	Settlement plate (deployed: March 2016)	SETL plate (1m)	N53 26.6874, E6 49.4781	13/09/2018
318	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 26.6874, E6 49.4781	13/09/2018
319	Settlement plate (deployed: June 2018)	SETL plate (1m)	N53 26.6874, E6 49.4781	13/09/2018
320	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 26.6874, E6 49.4781	13/09/2018
321	Settlement plate (deployed: June 2018)	SETL plate (1m)	N53 26.6874, E6 49.4781	13/09/2018
322	Settlement plate (deployed: June 2018)	SETL plate (1m)	N53 26.6874, E6 49.4781	13/09/2018
323	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 26.6874, E6 49.4781	13/09/2018
324	Settlement plate (deployed: June 2012)	SETL plate (1m)	N53 26.6874, E6 49.4781	13/09/2018
325	Settlement plate (deployed: March 2016)	SETL plate (1m)	N53 26.6874, E6 49.4781	13/09/2018
326	Settlement plate (deployed: March 2013)	SETL plate (1m)	N53 26.6874, E6 49.4781	13/09/2018
327	Settlement plate (deployed: March 2016)	SETL plate (7m)	N53 26.6874, E6 49.4781	13/09/2018
328	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 26.6857, E6 49.4898	19/06/2018
329	Settlement plate (deployed: March 2016)	SETL plate (1m)	N53 26.6857, E6 49.4898	19/06/2018
330	Settlement plate (deployed: March 2016)	SETL plate (7m)	N53 26.6857, E6 49.4898	19/06/2018
331	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 26.6857, E6 49.4898	19/06/2018
332	Settlement plate (deployed: March 2018)	SETL plate (1m)	N53 26.6857, E6 49.4898	19/06/2018
333	Settlement plate (deployed: June 2016)	SETL plate (7m)	N53 26.6857, E6 49.4898	19/06/2018
334	Settlement plate (deployed: March 2016)	SETL plate (7m)	N53 26.6857, E6 49.4898	19/06/2018
335	Settlement plate (deployed: June 2012)	SETL plate (1m)	N53 26.6857, E6 49.4898	19/06/2018
336	Settlement plate (deployed: June 2012)	SETL plate (1m)	N53 26.6857, E6 49.4898	19/06/2018
337	Settlement plate (deployed: March 2013)	SETL plate (1m)	N53 26.6857, E6 49.4898	19/06/2018
338	Settlement plate (deployed: March 2016)	SETL plate (1m)	N53 26.6857, E6 49.4898	19/06/2018
339	Settlement plate (deployed: March 2016)	SETL plate (1m)	N53 26.6857, E6 49.4898	19/06/2018
340	Settlement plate (deployed: March 2016)	SETL plate (3m)	N53 26.6857, E6 49.4898	22/03/2018
341	Settlement plate (deployed: March 2016)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018
342	Settlement plate (deployed: June 2012)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018
343	Settlement plate (deployed: March 2013)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018
344	Settlement plate (deployed: June 2012)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018
345	Settlement plate (deployed: December 2017)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018
346	Settlement plate (deployed: March 2013)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018
347	Settlement plate (deployed: March 2016)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018
348	Settlement plate (deployed: March 2016)	SETL plate (7m)	N53 26.6857, E6 49.4898	22/03/2018
349	Settlement plate (deployed: March 2016)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018
350	Settlement plate (deployed: March 2016)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018

Loc.	Habitat	Method	Coordinates	Date
351	Settlement plate (deployed: March 2016)	SETL plate (7m)	N53 26.6857, E6 49.4898	22/03/2018
352	Settlement plate (deployed: December 2017)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018
353	Settlement plate (deployed: June 2012)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018
354	Settlement plate (deployed: June 2009)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018
355	Settlement plate (deployed: December 2017)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018
356	Settlement plate (deployed: September 2011)	SETL plate (1m)	N53 26.6857, E6 49.4898	22/03/2018
357	Settlement plate (deployed: March 2016)	SETL plate (3m)	N53 26.6857, E6 49.4898	22/03/2018
358	Settlement plate (deployed: March 2016)	SETL plate (7m)	N53 26.6857, E6 49.4898	22/03/2018
359	Bottom sample, soft substrate, sublittoral zone	Mussel dredge	N53 26.6866, E6 49.3615	13/09/2018
360	Bottom sample, soft substrate, sublittoral zone	Hand dredge	N53 26.6720, E6 49.5328	09/10/2018
361	Bottom sample, soft substrate, sublittoral zone	Hand dredge	N53 26.6869, E6 49.2868	09/10/2018
362	Water column	Surface water sample	N53 27.4940, E6 50.0240	12/09/2018
363	Water column	Surface water sample	N53 26.6520, E6 49.5250	13/09/2018
364	Water column	Surface water sample	N53 26.6866, E6 49.3615	13/09/2018
365	Water column	Gelatinous zooplankton net	N53 26.6819, E6 49.5231	13/09/2018
366	Water column	Gelatinous zooplankton net	N53 26.6837, E6 49.5104	13/09/2018
367	Water column	Gelatinous zooplankton net	N53 26.6905, E6 49.4703	13/09/2018
368	Water column	Gelatinous zooplankton net	N53 26.6857, E6 49.4898	19/06/2018
Region J (Fig. 1): Delfzijl, marina				
369	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 19.8600, E6 55.8700	12/09/2018
370	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 19.8620, E6 55.8700	13/09/2018
371	Bottom sample, soft substrate, sublittoral zone	Petite Ponar	N53 19.8700, E6 55.8700	13/09/2018
372	Floating dock	Scrape sample	N53 19.8620, E6 55.8650	13/09/2018
373	Water column	Gelatinous zooplankton net	N53 19.8584, E6 55.8719	12/09/2018
374	Water column	Surface water sample	N53 19.8600, E6 55.8720	12/09/2018
375	Water column	Gelatinous zooplankton net	N53 19.8640, E6 55.8700	12/09/2018
376	Water column	Surface water sample	N53 19.8630, E6 55.8700	12/09/2018
377	Water column	Gelatinous zooplankton net	N53 19.8720, E6 55.8750	12/09/2018
378	Water column	Surface water sample	N53 19.8740, E6 55.8740	12/09/2018
Region K (Fig. 1): Wadden Sea, sublittoral				
379	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 20.5540, E5 9.1650	30/08/2018
380	Water column	Surface water sample	N53 20.5480, E5 9.1710	30/08/2018
381	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 20.5490, E5 9.9830	30/08/2018
382	Water column	Surface water sample	N53 20.5480, E5 9.9890	30/08/2018
383	Bottom sample, mixed oyster/mussel reef, sublittoral zone	Mussel dredge	N53 21.6680, E5 14.8960	30/08/2018
384	Water column	Surface water sample	N53 21.7980, E5 14.6910	30/08/2018
385	Bottom sample, oyster reef, sublittoral zone	Petite Ponar	N53 21.7980, E5 14.6910	30/08/2018
386	Bottom sample, oyster reef, sublittoral zone	Mussel dredge	N53 21.7980, E5 14.6910	30/08/2018
387	Water column	Surface water sample	N53 21.1640, E5 15.4540	30/08/2018
388	Bottom sample, mussel parcel with oysters, sublittoral zone	Petite Ponar	N53 21.1550, E5 15.4550	30/08/2018
389	Bottom sample, mussel parcel with oysters, sublittoral zone	Mussel dredge	N53 21.1550, E5 15.4550	30/08/2018
390	Water column	Surface water sample	N53 20.6240, E5 16.9340	30/08/2018

Loc.	Habitat	Method	Coordinates	Date
391	Bottom sample, mussel parcel, mainly oysters, sublittoral zone	Petite Ponar	N53 20.6250, E5 16.9350	30/08/2018
392	Bottom sample, mussel parcel, mainly oysters, sublittoral zone	Mussel dredge	N53 20.6250, E5 16.9360	30/08/2018
393	Water column	Surface water sample	N53 22.0890, E5 20.2180	30/08/2018
394	Bottom sample, mixed oyster/mussel reef, sublittoral zone	Petite Ponar	N53 22.0720, E5 20.1620	30/08/2018
395	Bottom sample, mixed oyster/mussel reef, sublittoral zone	Mussel dredge	N53 22.0720, E5 20.1610	30/08/2018
396	Water column	Surface water sample	N53 21.5640, E5 20.0330	30/08/2018
397	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 21.6050, E5 19.9460	30/08/2018
398	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 21.6060, E5 19.9450	30/08/2018
399	Water column	Surface water sample	N53 21.8370, E5 20.9610	30/08/2018
400	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 21.8670, E5 21.0040	30/08/2018
401	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 21.8680, E5 21.0050	30/08/2018
402	Water column	Surface water sample	N53 21.5500, E5 21.9190	30/08/2018
403	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 21.5500, E5 21.9320	30/08/2018
404	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 21.5490, E5 21.9330	30/08/2018
405	Water column	Surface water sample	N53 22.7560, E5 24.6970	30/08/2018
406	Bottom sample, mixed oyster/mussel reef, sublittoral zone	Mussel dredge	N53 22.7220, E5 24.7610	30/08/2018
407	Bottom sample, mixed oyster/mussel reef, sublittoral zone	Petite Ponar	N53 22.7210, E5 24.7630	30/08/2018
408	Water column	Surface water sample	N53 22.3440, E5 24.9430	30/08/2018
409	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 22.3440, E5 24.9430	30/08/2018
410	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 22.3430, E5 24.9430	30/08/2018
411	Water column	Surface water sample	N53 22.6160, E5 26.2200	30/08/2018
412	Bottom sample, mussel parcel with oysters, sublittoral zone	Mussel dredge	N53 22.5350, E5 26.3990	30/08/2018
413	Bottom sample, mussel parcel with oysters, sublittoral zone	Petite Ponar	N53 22.5340, E5 26.4000	30/08/2018
414	Water column	Surface water sample	N53 22.0330, E5 25.6720	30/08/2018
415	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 22.0010, E5 25.7980	30/08/2018
416	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 21.9970, E5 25.8010	30/08/2018
417	Water column	Surface water sample	N53 21.9040, E5 26.1830	30/08/2018
418	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 21.8200, E5 26.2200	30/08/2018
419	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 21.8180, E5 26.2200	30/08/2018
420	Water column	Surface water sample	N53 20.7930, E5 28.3440	30/08/2018
421	Bottom sample, oyster reef, sublittoral zone	Mussel dredge	N53 20.8380, E5 28.4010	30/08/2018
422	Bottom sample, oyster reef, sublittoral zone	Petite Ponar	N53 20.8390, E5 28.4030	30/08/2018
423	Water column	Surface water sample	N53 20.1130, E5 25.8760	30/08/2018
424	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 20.1880, E5 25.8930	30/08/2018
425	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 20.1890, E5 25.8940	30/08/2018
426	Water column	Surface water sample	N53 20.3920, E5 25.8110	30/08/2018
427	Bottom sample, mixed oyster/mussel reef, sublittoral zone	Mussel dredge	N53 20.4490, E5 25.9710	30/08/2018

Loc.	Habitat	Method	Coordinates	Date
428	Bottom sample, mixed oyster/mussel reef, sublittoral zone	Petite Ponar	N53 20.4490, E5 25.9720	30/08/2018
429	Water column	Surface water sample	N53 21.2680, E5 22.1590	30/08/2018
430	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 21.2980, E5 22.2980	30/08/2018
431	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 21.2980, E5 22.3000	30/08/2018
432	Water column	Surface water sample	N53 21.2000, E5 22.6870	30/08/2018
433	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 21.2000, E5 22.6880	30/08/2018
434	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 21.2000, E5 22.6900	30/08/2018
435	Water column	Surface water sample	N53 20.7970, E5 22.2010	30/08/2018
436	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 20.8290, E5 22.2990	30/08/2018
437	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 20.8290, E5 22.2990	30/08/2018
438	Water column	Surface water sample	N53 19.1260, E5 18.5030	30/08/2018
439	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 19.1650, E5 18.6930	30/08/2018
440	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 19.1650, E5 18.6930	30/08/2018
441	Water column	Surface water sample	N53 18.5640, E5 18.1160	30/08/2018
442	Mussel spat collector	Scrape sample	N53 18.5640, E5 18.1160	30/08/2018
443	Water column	Surface water sample	N53 18.5650, E5 18.1170	30/08/2018
444	Mussel spat collector	Scrape sample	N53 18.6110, E5 18.2650	30/08/2018
445	Water column	Surface water sample	N53 18.5920, E5 18.4780	30/08/2018
446	Mussel spat collector	Scrape sample	N53 18.5920, E5 18.4770	30/08/2018
447	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 17.8570, E5 15.3020	30/08/2018
448	Water column	Surface water sample	N53 15.7830, E5 4.0660	30/08/2018
449	Bottom sample, oyster reef, sublittoral zone	Mussel dredge	N53 15.9790, E5 4.0340	30/08/2018
450	Bottom sample, oyster reef, sublittoral zone	Petite Ponar	N53 15.9790, E5 4.0340	30/08/2018
451	Water column	Surface water sample	N53 16.2190, E5 4.1420	30/08/2018
452	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 16.2290, E5 4.2060	30/08/2018
453	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 16.2290, E5 4.2080	30/08/2018
454	Water column	Surface water sample	N53 16.9920, E5 3.5670	30/08/2018
455	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 16.9160, E5 3.4010	30/08/2018
456	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 16.9160, E5 3.4000	30/08/2018
457	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 14.7360, E5 9.0110	31/08/2018
458	Water column	Surface water sample	N53 14.7440, E5 9.0150	31/08/2018
459	Water column	Surface water sample	N53 12.3510, E5 8.6910	31/08/2018
460	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 12.3690, E5 8.5140	31/08/2018
461	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 12.3690, E5 8.5130	31/08/2018
462	Water column	Surface water sample	N53 13.7020, E5 8.3650	31/08/2018
463	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 13.7570, E5 8.5750	31/08/2018
464	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 13.7560, E5 8.5760	31/08/2018
465	Water column	Surface water sample	N53 13.6430, E5 8.0060	31/08/2018
466	Bottom sample, mussel parcel, mainly oysters, sublittoral zone	Mussel dredge	N53 13.6390, E5 7.9340	31/08/2018
467	Bottom sample, mussel parcel, mainly oysters, sublittoral zone	Petite Ponar	N53 13.6390, E5 7.9340	31/08/2018
468	Water column	Surface water sample	N53 12.9670, E5 10.0930	31/08/2018

Loc.	Habitat	Method	Coordinates	Date
469	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 13.0990, E5 9.8580	31/08/2018
470	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 13.1000, E5 9.8580	31/08/2018
471	Water column	Surface water sample	N53 13.6550, E5 9.9980	31/08/2018
472	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 13.6550, E5 9.9970	31/08/2018
473	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 13.6550, E5 9.9970	31/08/2018
474	Water column	Surface water sample	N53 13.3130, E5 13.9990	31/08/2018
475	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 13.2600, E5 14.0210	31/08/2018
476	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 13.2590, E5 14.0210	31/08/2018
477	Water column	Surface water sample	N53 13.8840, E5 17.3040	31/08/2018
478	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 13.8700, E5 17.1740	31/08/2018
479	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 13.8700, E5 17.1740	31/08/2018
480	Water column	Surface water sample	N53 13.0630, E5 21.2350	31/08/2018
481	Bottom sample, mussel parcel with oysters, sublittoral zone	Mussel dredge	N53 13.0530, E5 21.5930	31/08/2018
482	Bottom sample, mussel parcel with oysters, sublittoral zone	Petite Ponar	N53 13.0520, E5 21.5950	31/08/2018
483	Water column	Surface water sample	N53 12.7540, E5 20.4660	31/08/2018
484	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 12.7500, E5 20.4230	31/08/2018
485	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 12.7500, E5 20.4220	31/08/2018
486	Water column	Surface water sample	N53 10.0160, E5 18.8020	31/08/2018
487	Bottom sample, mussel bank, sublittoral zone	Mussel dredge	N53 9.9740, E5 18.9250	31/08/2018
488	Bottom sample, mussel bank, sublittoral zone	Petite Ponar	N53 9.9740, E5 18.9260	31/08/2018
489	Water column	Surface water sample	N53 9.5190, E5 19.5760	31/08/2018
490	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 9.5190, E5 19.5760	31/08/2018
491	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 9.5190, E5 19.5760	31/08/2018
492	Water column	Surface water sample	N53 9.7930, E5 20.1530	31/08/2018
493	Bottom sample, mussel bank, sublittoral zone	Mussel dredge	N53 9.7930, E5 20.1540	31/08/2018
494	Bottom sample, mussel bank, sublittoral zone	Petite Ponar	N53 9.7900, E5 20.1680	31/08/2018
495	Water column	Surface water sample	N53 9.9690, E5 20.6730	31/08/2018
496	Bottom sample, mussel bank, sublittoral zone	Mussel dredge	N53 9.9240, E5 20.7420	31/08/2018
497	Bottom sample, mussel bank, sublittoral zone	Petite Ponar	N53 9.9230, E5 20.7420	31/08/2018
498	Water column	Surface water sample	N53 10.1730, E5 21.2340	31/08/2018
499	Bottom sample, mussel bank, sublittoral zone	Mussel dredge	N53 10.1650, E5 21.3500	31/08/2018
500	Bottom sample, mussel bank, sublittoral zone	Petite Ponar	N53 10.1640, E5 21.3510	31/08/2018
501	Water column	Surface water sample	N53 11.7120, E5 24.9750	31/08/2018
502	Bottom sample, mussel bank, sublittoral zone	Mussel dredge	N53 11.6140, E5 24.8350	31/08/2018
503	Bottom sample, mussel bank, sublittoral zone	Petite Ponar	N53 11.6140, E5 24.8340	31/08/2018
504	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 4.7730, E4 54.2600	04/09/2018
505	Water column	Surface water sample	N53 4.7740, E4 54.2610	04/09/2018
506	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 4.7750, E4 54.2610	04/09/2018
507	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 5.7040, E4 55.1390	04/09/2018
508	Water column	Surface water sample	N53 5.7040, E4 55.1380	04/09/2018
509	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 5.7030, E4 55.1390	04/09/2018
510	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 5.5110, E4 55.3530	04/09/2018

Loc.	Habitat	Method	Coordinates	Date
511	Water column	Surface water sample	N53 5.5110, E4 55.3540	04/09/2018
512	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 5.5110, E4 55.3550	04/09/2018
513	Bottom sample, mussel parcel, mainly oysters, sublittoral zone	Mussel dredge	N53 6.0760, E4 56.2950	04/09/2018
514	Water column	Surface water sample	N53 6.0770, E4 56.2960	04/09/2018
515	Bottom sample, mussel parcel, mainly oysters, sublittoral zone	Petite Ponar	N53 6.0770, E4 56.2960	04/09/2018
516	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 6.0510, E4 56.7250	04/09/2018
517	Water column	Surface water sample	N53 6.0520, E4 56.7240	04/09/2018
518	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 6.0520, E4 56.7240	04/09/2018
519	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 5.9790, E5 2.3260	04/09/2018
520	Water column	Surface water sample	N53 5.9800, E5 2.3250	04/09/2018
521	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 5.9800, E5 2.3240	04/09/2018
522	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 6.0340, E5 5.0090	04/09/2018
523	Water column	Surface water sample	N53 6.0340, E5 5.0080	04/09/2018
524	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 6.0340, E5 5.0080	04/09/2018
525	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 6.6550, E5 6.1080	04/09/2018
526	Water column	Surface water sample	N53 6.6550, E5 6.1080	04/09/2018
527	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 6.6550, E5 6.1090	04/09/2018
528	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 7.4240, E5 6.1430	04/09/2018
529	Water column	Surface water sample	N53 7.4240, E5 6.1430	04/09/2018
530	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 7.4240, E5 6.1430	04/09/2018
531	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 7.3700, E5 7.3760	04/09/2018
532	Water column	Surface water sample	N53 7.3700, E5 7.3760	04/09/2018
533	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 7.3700, E5 7.3770	04/09/2018
534	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 7.3700, E5 7.3780	04/09/2018
535	Water column	Surface water sample	N53 6.0220, E5 11.6420	04/09/2018
536	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 6.0230, E5 11.6430	04/09/2018
537	Bottom sample, mussel bank, sublittoral zone	Mussel dredge	N53 5.4070, E5 12.1750	04/09/2018
538	Water column	Surface water sample	N53 5.4070, E5 12.1750	04/09/2018
539	Bottom sample, mussel bank, sublittoral zone	Petite Ponar	N53 5.4070, E5 12.1750	04/09/2018
540	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 5.8940, E5 10.2060	04/09/2018
541	Water column	Surface water sample	N53 5.8940, E5 10.2060	04/09/2018
542	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 5.8940, E5 10.2060	04/09/2018
543	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 4.9510, E5 8.9360	04/09/2018
544	Water column	Surface water sample	N53 4.9510, E5 8.9350	04/09/2018
545	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 4.9510, E5 8.9350	04/09/2018
546	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 4.9810, E5 9.7340	04/09/2018
547	Water column	Surface water sample	N53 4.9810, E5 9.7340	04/09/2018
548	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 4.9810, E5 9.7340	04/09/2018
549	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 5.0030, E5 8.6450	04/09/2018
550	Water column	Surface water sample	N53 5.0030, E5 8.6460	04/09/2018
551	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 5.0030, E5 8.6450	04/09/2018
552	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 5.1250, E5 6.5750	04/09/2018

Loc.	Habitat	Method	Coordinates	Date
553	Water column	Surface water sample	N53 5.1240, E5 6.5750	04/09/2018
554	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 5.1240, E5 6.5750	04/09/2018
555	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 4.8610, E5 5.7860	04/09/2018
556	Water column	Surface water sample	N53 4.8610, E5 5.7850	04/09/2018
557	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 4.8600, E5 5.7850	04/09/2018
558	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 3.7080, E5 3.7900	04/09/2018
559	Water column	Surface water sample	N53 3.7080, E5 3.7900	04/09/2018
560	Bottom sample, mussel parcel, sublittoral zone	Petite Ponar	N53 3.7080, E5 3.7900	04/09/2018
561	Water column	Surface water sample	N53 29.8540, E6 42.5980	13/09/2018
562	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 29.7200, E6 42.8800	13/09/2018
563	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 29.7080, E6 42.9080	13/09/2018
564	Water column	Surface water sample	N53 29.9990, E6 45.5330	13/09/2018
565	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 30.1150, E6 45.2730	13/09/2018
566	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 30.1180, E6 45.2710	13/09/2018
567	Water column	Surface water sample	N53 28.5760, E6 47.7570	13/09/2018
568	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 28.5760, E6 47.7570	13/09/2018
569	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 28.5760, E6 47.7570	13/09/2018
570	Water column	Surface water sample	N53 24.7900, E6 53.3120	13/09/2018
571	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 24.7900, E6 53.3120	13/09/2018
572	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 24.7900, E6 53.3120	13/09/2018
573	Water column	Surface water sample	N53 24.0309, E6 53.4838	13/09/2018
574	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 24.0309, E6 53.4838	13/09/2018
575	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 24.0309, E6 53.4838	13/09/2018
576	Water column	Surface water sample	N53 22.8559, E6 53.6596	13/09/2018
577	Bottom sample, oyster reef, sublittoral zone	Mussel dredge	N53 22.8559, E6 53.6596	13/09/2018
578	Bottom sample, oyster reef, sublittoral zone	Petite Ponar	N53 22.8559, E6 53.6596	13/09/2018
579	Water column	Surface water sample	N53 22.5161, E6 53.8663	13/09/2018
580	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 22.4326, E6 53.8842	13/09/2018
581	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 22.4326, E6 53.8842	13/09/2018
582	Water column	Surface water sample	N53 22.0996, E6 53.9633	13/09/2018
583	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 22.0225, E6 53.9743	13/09/2018
584	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 22.0225, E6 53.9743	13/09/2018
585	Water column	Surface water sample	N53 21.3965, E6 54.1392	13/09/2018
586	Bottom sample, oyster reef, sublittoral zone	Mussel dredge	N53 21.3255, E6 54.1494	13/09/2018
587	Bottom sample, oyster reef, sublittoral zone	Petite Ponar	N53 21.3255, E6 54.1494	13/09/2018
588	Water column	Surface water sample	N53 21.1526, E6 54.3151	13/09/2018
589	Bottom sample, oyster reef, sublittoral zone	Mussel dredge	N53 21.1526, E6 54.3151	13/09/2018
590	Bottom sample, oyster reef, sublittoral zone	Petite Ponar	N53 21.1526, E6 54.3151	13/09/2018
591	Water column	Surface water sample	N53 26.1532, E6 53.1384	13/09/2018
592	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 26.0051, E6 53.1170	13/09/2018
593	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 26.0051, E6 53.1170	13/09/2018
594	Water column	Surface water sample	N53 21.3457, E6 54.1390	13/09/2018
595	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 21.1526, E6 54.3151	13/09/2018
596	Bottom sample, off the parcels, sublittoral zone	Petite Ponar	N53 21.1526, E6 54.3151	13/09/2018

Loc.	Habitat	Method	Coordinates	Date
597	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 1.3470, E5 4.3660	13/09/2018
598	Bottom sample, mussel parcel, sublittoral zone	Van Veen-Grab	N53 1.3470, E5 4.3610	13/09/2018
599	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N53 0.0370, E5 3.8250	13/09/2018
600	Bottom sample, mussel parcel, sublittoral zone	Van Veen-Grab	N53 0.0370, E5 3.8250	13/09/2018
601	Bottom sample, mussel parcel, sublittoral zone	Mussel dredge	N52 59.8380, E5 5.3790	13/09/2018
602	Bottom sample, mussel parcel, sublittoral zone	Van Veen-Grab	N52 59.8380, E5 5.3790	13/09/2018
603	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 0.7900, E5 10.8680	13/09/2018
604	Bottom sample, off the parcels, sublittoral zone	Van Veen-Grab	N53 0.7900, E5 10.8680	13/09/2018
605	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 2.3040, E5 13.8180	13/09/2018
606	Bottom sample, off the parcels, sublittoral zone	Van Veen-Grab	N53 2.3040, E5 13.8180	13/09/2018
607	Bottom sample, off the parcels, sublittoral zone	Mussel dredge	N53 4.2260, E5 16.8630	13/09/2018
608	Bottom sample, off the parcels, sublittoral zone	Van Veen-Grab	N53 4.2260, E5 16.8630	13/09/2018
609	Bottom sample, off the parcels, sublittoral zone	Van Veen-Grab	N53 5.1710, E5 11.5580	13/09/2018
610	Bottom sample, off the parcels, sublittoral zone	Van Veen-Grab	N53 5.2470, E5 11.8190	13/09/2018
611	Bottom sample, off the parcels, sublittoral zone	Van Veen-Grab	N53 4.9460, E5 10.7760	13/09/2018
612	Bottom sample, off the parcels, sublittoral zone	Van Veen-Grab	N53 5.0220, E5 11.0370	13/09/2018
613	Bottom sample, off the parcels, sublittoral zone	Van Veen-Grab	N53 5.0960, E5 11.2980	13/09/2018
614	Mussel spat collector	Scrape sample	N53 4.1330, E5 8.9142	13/09/2018
Region K (Fig. 1): Wadden Sea, littoral				
615	Bottom sample, soft substrate, littoral zone	Hand corer	N52 56.9399, E4 49.2400	23/06/2018
616	Bottom sample, soft substrate, littoral zone	Hand corer	N52 55.9099, E4 49.5000	25/06/2018
617	Bottom sample, soft substrate, littoral zone	Hand corer	N52 57.2200, E4 49.9600	26/06/2018
618	Bottom sample, soft substrate, littoral zone	Hand corer	N52 55.1299, E4 50.8900	29/06/2018
619	Bottom sample, soft substrate, littoral zone	Hand corer	N52 56.6800, E4 51.3600	29/06/2018
620	Bottom sample, soft substrate, littoral zone	Hand corer	N52 55.8599, E4 51.9199	17/07/2018
621	Bottom sample, soft substrate, littoral zone	Hand corer	N52 56.2699, E4 52.2900	17/07/2018
622	Bottom sample, soft substrate, littoral zone	Hand corer	N52 54.2400, E4 53.3800	17/07/2018
623	Bottom sample, soft substrate, littoral zone	Hand corer	N52 55.8599, E4 53.9400	17/07/2018
624	Bottom sample, soft substrate, littoral zone	Hand corer	N52 54.5099, E4 55.3500	18/07/2018
625	Bottom sample, soft substrate, littoral zone	Hand corer	N52 55.0499, E4 55.4599	18/07/2018
626	Bottom sample, soft substrate, littoral zone	Hand corer	N52 55.7100, E4 56.0200	19/07/2018
627	Bottom sample, soft substrate, littoral zone	Hand corer	N53 10.2499, E4 57.0700	21/07/2018
628	Bottom sample, soft substrate, littoral zone	Hand corer	N52 59.9100, E4 59.7499	23/07/2018
629	Bottom sample, soft substrate, littoral zone	Hand corer	N53 0.99000, E5 0.20999	30/07/2018
630	Bottom sample, soft substrate, littoral zone	Hand corer	N53 14.8500, E5 3.47999	30/07/2018
631	Bottom sample, soft substrate, littoral zone	Hand corer	N53 11.9399, E5 12.7999	31/07/2018
632	Bottom sample, soft substrate, littoral zone	Hand corer	N53 20.3100, E5 13.2300	31/07/2018
633	Bottom sample, soft substrate, littoral zone	Hand corer	N53 14.8799, E5 13.3900	31/07/2018
634	Bottom sample, soft substrate, littoral zone	Hand corer	N53 14.5999, E5 13.6600	01/08/2018
635	Bottom sample, soft substrate, littoral zone	Hand corer	N53 16.2299, E5 14.5399	01/08/2018
636	Bottom sample, soft substrate, littoral zone	Hand corer	N53 13.7899, E5 19.2700	01/08/2018
637	Bottom sample, soft substrate, littoral zone	Hand corer	N53 16.2299, E5 19.7899	02/08/2018
638	Bottom sample, soft substrate, littoral zone	Hand corer	N53 16.2299, E5 20.2500	02/08/2018
639	Bottom sample, soft substrate, littoral zone	Hand corer	N53 16.2100, E5 20.2500	02/08/2018

Loc.	Habitat	Method	Coordinates	Date
640	Bottom sample, soft substrate, littoral zone	Hand corer	N53 15.1499, E5 25.8400	03/08/2018
641	Bottom sample, soft substrate, littoral zone	Hand corer	N53 21.9400, E5 31.8300	03/08/2018
642	Bottom sample, soft substrate, littoral zone	Hand corer	N53 24.9300, E5 35.7700	05/08/2018
643	Bottom sample, soft substrate, littoral zone	Hand corer	N53 22.6900, E5 39.8200	05/08/2018
644	Bottom sample, soft substrate, littoral zone	Hand corer	N53 24.9400, E5 40.1599	05/08/2018
645	Bottom sample, soft substrate, littoral zone	Hand corer	N53 24.7999, E5 40.2799	05/08/2018
646	Bottom sample, soft substrate, littoral zone	Hand corer	N53 24.9400, E5 40.7500	05/08/2018
647	Bottom sample, soft substrate, littoral zone	Hand corer	N53 22.4899, E5 43.1800	06/08/2018
648	Bottom sample, soft substrate, littoral zone	Hand corer	N53 21.6599, E5 44.4799	06/08/2018
649	Bottom sample, soft substrate, littoral zone	Hand corer	N53 26.2900, E5 44.5300	06/08/2018
650	Bottom sample, soft substrate, littoral zone	Hand corer	N53 23.0299, E5 45.0499	07/08/2018
651	Bottom sample, soft substrate, littoral zone	Hand corer	N53 26.0200, E5 45.5500	07/08/2018
652	Bottom sample, soft substrate, littoral zone	Hand corer	N53 25.7500, E5 47.2800	07/08/2018
653	Bottom sample, soft substrate, littoral zone	Hand corer	N53 22.4899, E5 48.7099	08/08/2018
654	Bottom sample, soft substrate, littoral zone	Hand corer	N53 26.5699, E5 51.4200	08/08/2018
655	Bottom sample, soft substrate, littoral zone	Hand corer	N53 24.1200, E5 52.3800	08/08/2018
656	Bottom sample, soft substrate, littoral zone	Hand corer	N53 24.1200, E5 52.3999	09/08/2018
657	Bottom sample, soft substrate, littoral zone	Hand corer	N53 25.4700, E5 53.3400	09/08/2018
658	Bottom sample, soft substrate, littoral zone	Hand corer	N53 25.1500, E5 53.8000	09/08/2018
659	Bottom sample, soft substrate, littoral zone	Hand corer	N53 24.3900, E5 58.9300	09/08/2018
660	Bottom sample, soft substrate, littoral zone	Hand corer	N53 26.0200, E6 2.11002	09/08/2018
661	Bottom sample, soft substrate, littoral zone	Hand corer	N53 24.8599, E6 4.04999	09/08/2018
662	Bottom sample, soft substrate, littoral zone	Hand corer	N53 26.3800, E6 15.2400	16/08/2018
663	Bottom sample, soft substrate, littoral zone	Hand corer	N53 27.6499, E6 16.5600	16/08/2018
664	Bottom sample, soft substrate, littoral zone	Hand corer	N53 29.2900, E6 17.2900	16/08/2018
665	Bottom sample, soft substrate, littoral zone	Hand corer	N53 26.4300, E6 18.9700	16/08/2018
666	Bottom sample, soft substrate, littoral zone	Hand corer	N53 25.7500, E6 23.6299	20/08/2018
667	Bottom sample, soft substrate, littoral zone	Hand corer	N53 31.6600, E6 30.1500	20/08/2018
668	Bottom sample, soft substrate, littoral zone	Hand corer	N53 27.6599, E6 30.6100	20/08/2018
669	Bottom sample, soft substrate, littoral zone	Hand corer	N53 28.7400, E6 32.2099	20/08/2018
670	Bottom sample, soft substrate, littoral zone	Hand corer	N53 26.8200, E6 34.3399	20/08/2018
671	Bottom sample, soft substrate, littoral zone	Hand corer	N53 30.7200, E6 36.2100	21/08/2018
672	Bottom sample, soft substrate, littoral zone	Hand corer	N53 28.5199, E6 39.4699	21/08/2018
673	Bottom sample, soft substrate, littoral zone	Hand corer	N53 27.9299, E6 46.7599	21/08/2018
674	Bottom sample, soft substrate, littoral zone	Hand corer	N53 22.1899, E6 55.3099	21/08/2018
675	Bottom sample, soft substrate, littoral zone	Hand corer	N53 22.2499, E6 55.7800	22/08/2018
676	Bottom sample, soft substrate, littoral zone	Hand corer	N53 23.3200, E6 55.7800	22/08/2018
677	Bottom sample, soft substrate, littoral zone	Hand corer	N53 16.2400, E7 8.32001	22/08/2018
678	Bottom sample, soft substrate, littoral zone	Hand corer	N53 17.5999, E7 8.65002	23/08/2018
679	Bottom sample, soft substrate, littoral zone	Hand corer	N53 15.9799, E7 10.6900	23/08/2018
680	Bottom sample, soft substrate, littoral zone	Hand corer	N53 15.6300, E7 10.6900	24/08/2018
681	Bottom sample, soft substrate, littoral zone	Hand corer	N53 15.7300, E7 12.0900	24/08/2018

Appendix III

Species found during de Wadden Sea inventory in 2018, and the locations (Appendix I) were they were found.

Species	**Locations**
Abra tenuis	545; 617; 623; 639; 641; 671; 678
Acinetospora crinita	40-42; 80
Acrochaetium secundatum	149
Acrosiphonia arcta	290
Aglaothamnion pseudobyssoides	23; 42; 63; 129; 156; 190-191; 389; 395; 398; 401; 403; 406; 410; 412; 415; 439; 452; 455; 472; 510; 513; 515-516; 519; 521-522; 525; 528
Alcyonidioides mytili	25; 84; 121; 152; 165; 314; 316; 324-325; 327; 330; 333-342; 344; 346-351; 353-354; 356-358; 484; 502; 543; 571; 599
Alitta succinea	639; 642; 645; 647-648; 652; 657; 665; 672; 679
Ampharete acutifrons	636
Amphibalanus improvisus	26; 138; 150-151; 169-171; 173; 176; 193-194; 204-206; 210; 224-225; 228-230; 232-233; 238-250; 256-263; 265; 267-270; 277; 279-280; 289; 292; 305; 309; 311; 313; 316-327; 359; 372; 444; 493; 496-497; 499; 502; 537; 540; 543; 562; 574; 580; 583; 586; 589; 592; 605
Amphipholis squamata	383; 452; 469; 472; 475
Antithamnion densum	89; 100
Antithamnionella spirographidis	1; 5; 18; 33-34; 63; 66-67; 85; 89; 100; 117; 119-120; 129-132; 136; 138; 149; 151-152; 289-291; 297; 305; 313-314; 383; 389; 395; 398; 401; 403; 406; 410; 412; 415; 427; 433; 439; 452; 455; 469; 472; 475; 487; 493; 504; 507; 510; 513; 515-516; 537; 555
Aora cf. *gracilis*	151
Aphelochaeta marioni	620; 627; 629; 635-636; 638-639; 641; 647-649; 651; 653-655; 659; 661-663; 666; 668; 672-674; 677; 679-680
Aplidium glabrum	26; 44; 52; 66-67; 84; 85; 88; 92-93; 97
Apohyale prevostii	151
Arenicola marina	616-617; 621; 623; 626-629; 635; 639; 651; 654; 662-663; 666; 668-669; 676-680
Ascidiella aspersa	33; 67-68; 149; 160; 167; 169; 171-176; 179; 200; 297; 313; 317
Ascophyllum nodosum	3-5; 17-22; 24-25; 52; 65; 84; 222-224; 231-232; 278; 312-313
Asterias rubens	54; 88; 90; 105; 116; 122; 152; 334; 356; 359; 386; 389; 392; 398; 406; 410; 412; 418; 421; 427; 430; 436; 449; 452; 463; 464; 466-467; 469; 472; 475; 478; 484; 487; 496-497; 499; 502; 504; 507; 510; 513; 519; 522; 525; 534; 543; 546; 548; 555; 558; 568; 571; 574; 589; 595; 599
Aurelia aurita	167; 175-176
Austrominius modestus	1-4; 7; 12-15; 19; 22; 24; 26; 32-34; 37; 40; 44; 52-55; 59; 62-66; 68; 76-80; 98; 100; 102; 116-118; 120-121; 129-132; 136-137; 151; 153-154; 156; 164; 222-223; 231-232; 277; 283; 286; 289-292; 295-297; 305; 311-313; 315-318; 321-322; 324-325; 327; 330; 360; 385-386; 389; 392; 395; 427; 442; 444; 446; 469; 478; 499; 502; 507; 534; 540; 543; 546; 571; 574; 592; 653; 663; 668
Balanus crenatus	1; 3-5; 7; 14; 16-18; 20; 23-25; 33-34; 36-37; 41-42; 54; 63; 66-68; 77-79; 85; 88; 90; 96-98; 100-105; 116; 119-122; 138; 146; 149-152; 156-162; 164-166; 168; 174; 176; 178; 189-195; 197-198; 201; 203-206; 222-223; 244; 246; 260; 279; 283; 290-291; 295; 297; 314; 317; 324-325; 327-331; 333-344; 346-351; 353-354; 356; 358-359; 383; 385-386; 389; 392; 395; 398; 415; 427; 442; 455; 463-464; 469; 478; 484; 490; 496-497; 504; 507; 510; 513; 519; 524; 527-528; 531; 534; 537; 540; 546; 548; 552; 555; 565; 568; 571; 574; 597; 599; 601; 603; 605; 607; 609; 614; 618

Species	Locations
Bathyporeia sarsi	622; 626
Beroe gracilis	188; 207-208; 368
Blidingia marginata	117; 129; 130; 131; 132; 136; 215; 278; 283; 296; 297; 509; 513; 519
Blidingia minima	2; 5; 16; 19; 23-24; 64-65; 67; 117-118; 129; 222; 224-225; 277; 283; 311
Botrylloides violaceus	1; 18; 25-26; 33-37; 40-41; 43-44; 48-52; 66-67; 84-85; 87-90; 92; 94; 97-99; 101-102; 105; 119-122; 149; 152; 157; 196; 290-291; 297; 313-314; 316-329; 331-333; 335-338; 340; 341-344; 346-348; 350; 353-356; 358-359
Botryllus schlosseri	1; 25-26; 33-37; 41-42; 44; 49-50; 52; 66-68; 85; 87; 90; 97; 99; 101; 104-105; 119-121; 152; 157; 163-168; 170-179; 195-196; 200; 202; 290; 297; 313-314; 316-322; 324-325; 327-328; 331-332; 334-338; 353; 356; 359
Bougainvillia muscus	368
Amathia cf. *gracilis*	18; 240; 242-250; 326; 332; 351; 353; 357-358
Bryopsis hypnoides	84-85; 89; 91; 100; 102; 383; 389; 392; 403; 406; 412; 487
Bryopsis plumosa	42; 189; 531; 537; 565; 568
Bugulina stolonifera	1; 18; 25; 33-37; 50-52; 85-86; 167; 326
Calliopius laeviusculus	190
Callithamnion corymbosum	84; 89; 91; 100; 102
Cancer pagurus	452
Capitella capitata	616-617; 619-620; 623-624; 627-628; 631; 633; 640; 649; 651; 654; 659; 662; 665; 669-670; 672; 675-677
Caprella linearis	97; 150
Caprella mutica	1; 25-26; 35-37; 42-43; 45; 52; 58; 67; 84-85; 92-93; 97; 104-105; 119-122; 151; 207; 210; 314; 319; 322; 325; 332; 334; 336-338; 368
Carcinus maenas	1; 3-5; 7-8; 12-18; 20-26; 31; 35; 42; 52; 54; 63; 65; 69; 77-80; 85-86; 88; 90; 116-118; 120-121; 129-131; 137; 146; 149; 151-152; 154-156; 162; 190; 214; 222-224; 238; 246; 255-256; 258-259; 261; 264; 277; 283; 286; 290; 292; 296; 310-312; 314; 322; 333; 359; 386; 389; 392; 395; 397-398; 401; 403; 406; 410; 412; 415; 418; 421; 424; 427; 430; 433; 436; 444; 449-450; 452-453; 455; 460; 466; 469; 472; 475; 478; 484; 487; 499; 502; 504; 507; 510; 513; 515; 519; 522; 525; 527-528; 531; 534; 537; 540; 546; 548; 552; 555; 562; 565; 568; 571; 574; 577; 580; 583; 586; 592; 595; 609; 614; 616-617; 641; 651; 653; 657; 659; 667; 680
Caulacanthus okamurae	3
Ceramium cf. *virgatum*	222
Ceramium botryocarpum	190
Ceramium cimbricum	1; 26; 40-42; 145; 149-151; 191; 313-314; 359
Ceramium diaphanum	291
Ceramium cf. *pallidum*	288; 305
Ceramium sungminbooi	1; 40; 84; 149; 150; 312-314; 322; 383; 386; 389; 392; 403; 406; 410; 412; 433; 436; 475; 487; 493; 507; 513; 519; 552; 599; 601; 603
Ceramium tenuicorne	238; 291
Ceramium virgatum	1; 3; 22; 40; 42; 59; 77; 117; 119; 130; 190; 222*; 282; 290; 297; 314; 383; 398; 415; 418; 427; 433; 436; 463; 475; 510; 513; 515; 519; 525; 537; 540; 543; 546; 562
Cerastoderma edule	286; 397; 488; 490; 499; 616; 618; 622; 625; 628-629; 636; 639; 641; 647; 648; 649; 651; 652; 659; 661; 672-674; 678-679
Chaetomorpha linum	487
Chondrus crispus	3; 5; 12; 21; 25; 85-86; 117; 121; 129-130; 132; 134; 136-138; 152; 222-224; 297; 305; 311; 359; 583; 586; 589; 595; 599; 603

Species	Locations
Ciona intestinalis	25-26; 33; 37; 50; 52; 66-68; 84-85; 88; 90; 92; 97; 99; 101; 104-105; 167; 175; 195-196; 200; 314; 327; 340; 341-343; 348-351; 353; 357-358
Cladophora albida	84; 150
Cladophora hutchinsiae	238; 383; 389; 406; 466
Cladophora cf. *laetevirens*	507; 513; 519
Cladophora cf. *liniformis*	18
Cladophora sericea	84; 286; 313; 383; 389; 392; 403; 406; 412; 487
Cladophora vagabunda	25;
Cliona celata	513
Clytia hemisphaerica	168; 178
Codium fragile	79; 84; 383
Colpomenia peregrina	52; 84
Conopeum reticulum	1; 7; 18; 33-34; 36-37; 42; 44; 60; 67; 84; 103-105; 119-122; 146; 149; 150-152; 156; 164-165; 172-173; 176-178; 191; 195; 203; 223; 243; 255; 286; 290; 291; 313-314; 316-317; 319; 321-326; 329-331; 334-344; 346-347; 349-351; 353-354; 356-360; 381; 383; 385-386; 389; 392; 398; 401; 403; 406; 410; 412; 415; 418; 421; 427; 433-434; 436; 457; 460; 463-464; 466; 475; 478; 484; 487; 497; 499; 502; 504; 507; 510; 519; 521-522; 524-525; 527-528; 534; 537; 540; 543; 548; 555-565; 568; 571; 574; 577; 583-584; 589; 597; 599; 601; 604-605; 607-609
Corophium arenarium	25-26; 621; 669
Corophium volutator	1; 615; 622-623; 630; 632; 642-649; 652-653; 656-657; 661; 671
Crangon crangon	360-361; 389; 395; 398; 401; 406; 410; 412; 418; 427; 430; 436; 452-453; 463; 469; 472; 475; 487; 496; 499; 513; 519; 522; 525; 537; 540; 543; 568; 571; 574; 577; 586; 615; 617; 624; 642; 661
Crepidula fornicata	1; 15; 78-79; 309; 359-360; 383; 389; 392; 395; 398; 403; 406; 412; 415; 418; 421; 427; 430; 449; 452; 466; 469; 475; 484; 496; 497; 499; 502; 507; 510; 513; 516; 524; 528; 537; 540; 543; 546; 571; 574; 577; 586; 589; 601; 603; 605; 607
Crisularia plumosa	26; 42; 66; 68; 96; 105; 297; 313-314; 317-319; 321-322; 324-326; 329; 335-337; 343
Cryptosula pallasiana	25-26; 33-36; 42; 50; 52
Dasya sessilis	3; 507
Dasysiphonia japonica	80; 89; 91; 100; 102; 147; 180; 389; 406; 507; 510; 513
Derbesia marina	66; 80; 152; 513; 515
Diadumene cincta	1; 86; 116; 121; 146; 152; 172-173; 240; 242; 244; 267
Didemnum vexillum	84; 93; 383; 392; 395; 398; 406; 513; 515-516; 519
Echinocardium cordatum	631
Ectocarpus siliculosus	189*; 469
Ectopleura larynx	359; 595
Ectopleura larynx	444
Einhornia crustulenta	238; 279; 283; 401
Elachista fucicola	22-23; 63; 65; 386
Electra pilosa	25; 42; 68; 85; 156-158; 160-162; 165; 189-190; 192; 194; 199; 204-206; 231; 291; 332; 334-336; 398
Ensis leei	437; 447; 457; 472-473; 475-476; 536; 539; 554; 566; 602; 616; 620; 624; 626-629; 631; 633; 636; 654; 659-661; 665-667; 672-674
Eriocheir sinensis	156; 279; 372
Erythrotrichia carnea	1; 16; 18; 20; 22; 77; 80; 223; 291; 383; 389; 392; 403; 406; 412; 427; 430; 452; 469; 487; 543; 546; 592

Species	Locations
Eteone longa	615-617; 619; 621-624; 627-630; 634-635; 640; 654;-656; 658-665; 669-670; 675-677
Eucheilota maculata	368
Eunereis longissima	620; 679
Ficopomatus enigmaticus	121; 172; 174; 176; 178; 268; 279
Fucus spiralis	3; 64; 118; 223; 232; 278; 283
Fucus vesiculosus	1; 3; 5; 14; 16-17; 19-24; 53-54; 59; 63-65; 69; 77-80; 117-118; 129-132; 136-137; 155-156; 214-215; 222-224; 232-233; 278; 283; 291; 296; 311-314; 386; 389; 392; 395; 398; 403; 430; 463; 466; 475; 484; 513; 552; 565; 571; 580; 589; 592; 595
Gaillona hookeri	16; 18; 25; 149; 150; 222; 291
Gammaropsis nitida	156
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