

Bryozoan Studies 2013 - Antonietta Rosso, Patrick N. Wyse Jackson & Joanne Porter (eds)

Recent observations of the introduced *Fenestrulina delicia* Winston, Hayward & Craig, 2000 (Bryozoa) in Western Europe

Hans DE BLAUWE^{1*}, Britta KIND², Ralph KUHLENKAMP², Joël CUPERUS³, Babeth van der WEIDE³ & Francis KERCKHOF⁴

¹ Watergang 6, 8380 Dudzele, Belgium

² PHYCOMARIN, Bredenbergschweg 1, 21149 Hamburg, Germany

³ IMARES Wageningen UR, Ambachtsweg 8a, 1785 AJ Den Helder, The Netherlands

⁴ Royal Belgian Institute of Natural Sciences, Management Unit of the North Sea Mathematical Models, 3de en 23^{ste} Linie-regimentsplein, B-8400 Oostende, Belgium

* Corresponding author e-mail: deblauwehans@hotmail.com

SUMMARY - *Recent observations of the introduced Fenestrulina delicia Winston, Hayward & Craig, 2000 (Bryozoa) in Western Europe* - We detail the discovery of recently established immigrant populations and beached material of the encrusting bryozoan *Fenestrulina delicia* from the Atlantic coasts of Europe. This species of unknown origin is highly invasive and, in contrast to most other introduced bryozoans spreads along offshore natural and artificial hard substrates, rather than hopping from one marina to another. Part of the material, collected in situ, was found on empty shells at locations well known for their aquaculture of oysters and mussels. This suggests that the import of shellfish could be the vector of primary introduction. Beached material suggests that floating plastic debris might be a vector of transport for secondary introduction. The base of offshore wind turbines forms a supplementary substrate in the sandy southern North Sea and probably provides stepping stones for this exotic species.

RIASSUNTO - *Osservazioni recenti sull'introduzione di Fenestrulina delicia Winston, Hayward & Craig, 2000 (Bryozoa) in Europa occidentale* - Viene illustrata la scoperta di popolazioni di recente insediamento immigratorio e di materiale spiaggiato del briozoo incrostante *Fenestrulina delicia* proveniente dalle coste atlantiche europee. Questa specie di origine ancora ignota è particolarmente invasiva e, contrariamente alla maggior parte degli altri briozoi introdotti, si diffonde su substrati solidi in mare aperto di origine naturale o artificiale, invece di saltare da un porticciolo all'altro. Una parte del materiale raccolto in situ è stato trovato su conchiglie vuote in località ben note per la loro acquacoltura di ostriche e mitili. Ciò suggerisce che l'importazione di crostacei potrebbe essere il vettore dell'introduzione primaria. Il materiale spiaggiato indica che i detriti di plastica potrebbero essere un vettore di trasporto per l'introduzione secondaria. La base delle turbine eoliche offshore costituisce un substrato supplementare nell'area meridionale sabbiosa del Mare del Nord e probabilmente funziona da trampolino intermedio per questa specie esotica.

Key words: Invasive species, bryozoan, offshore wind turbines, Europe

Parole chiave: Specie invasive, briozoi, turbine eoliche offshore, Europa

1. INTRODUCTION

We describe the discovery of recently established immigrant populations and beached material of the encrusting bryozoan *Fenestrulina delicia* (Winston, Hayward & Craig, 2000) from the Atlantic coasts of Europe. This species, of an as yet unknown origin, is highly invasive and, in contrast to most other introduced bryozoans, spreads along offshore natural and artificial hard substrata, rather than hopping from one marina to another. Material collected in situ was found on empty shells and on boulders, suggesting that the import of shellfish for aquaculture, such as oysters and mussels, is an important vector of primary introduction. Beached material indicates that floating plastic debris might be a transport vector for the secondary introduction of colonies. Supplementary suitable substrates in the sandy

southern North Sea are provided by the scour protection of offshore wind turbines whose boulders probably act as stepping stones for this exotic species.

2. MATERIALS AND METHODS

Colonies were collected in France (HD) by exploring beaches at low tides and dedicated searching in fishing harbours; in Germany (BK, RK) by dredging; in wind farms in Belgium (FK) and in The Netherlands by scuba diving; and on the Borkumer reef by box core (JC, BW). Some of these records originate from different research programs. Material collected in situ is summarized in table 1.

Several naturalists collected beached material (plastics, seaweeds, et cetera) in order to find bryozoans and

Tab. 1 - Material of *Fenestrulina delicia* Winston, Hayward & Craig, 2000 collected in situ.Tab. 1 - *Materiale di Fenestrulina delicia* Winston, Hayward & Craig, 2000 raccolto in situ.

Location	Date ymd	Latitude	Longitude	Depth in meter	Nr of colonies	source
Pléneuf-Val-André	2008/05	48°35'58"N	2°33'28"W	lower shore	common	HD
Granville	20070222	48°50'06"N	1°37'02"W	lower shore	1	HD
Morgat	20100328	48°14'09"N	4°29'17"W	lower shore	1	HD
Lanvéoc	20130504	48°17'36"N	4°27'13"W	7 - 8	8	MF
Courseulles	20120408	49°20'N	0°27'W	harbour	1	HD
D5 in Wgs84	20100820	51°32'14"N	2°54'42"E	25	2	FK
D5 in Wgs84	20110113	51°32'14"N	2°54'42"E	25	2	FK
D5 in Wgs84	20120712	51°32'14"N	2°54'42"E	25	8	FK
Borkumer Stenen	20110511	53°53'N	6°17'E	30.9	4	JC, BW
Anna Frisopolder	20111001	51°36'02"N	3°42'02"E	5 - 10	1	MF
Anna Frisopolder	20111119	51°36'02"N	3°42'02"E	5 - 10	1	MF
Anna Frisopolder	20120824	51°36'02"N	3°42'02"E	5 - 10	2	MF
Goesse Sas	20050820	51°32'37"N	3°55'54"E	5 - 10	1	HD, MF
Goesse Sas	20050928	51°32'37"N	3°55'54"E	5 - 10	2	MF
Goesse Sas	20060722	51°32'37"N	3°55'54"E	5 - 10	5	MF
Goesse Sas	20061014	51°32'37"N	3°55'54"E	5 - 10	4	MF
Goesse Sas	20061125	51°32'37"N	3°55'54"E	5 - 10	1	MF
Goesse Sas	20091121	51°32'37"N	3°55'54"E	5 - 10	5	MF
Goesse Sas	20110903	51°32'37"N	3°55'54"E	5 - 10	1	MF
Zierikzee	20120707	51°37'46"N	3°54'27"E	10 - 15	30	MF
Zierikzee	20120907	51°37'46"N	3°54'27"E	10 - 15	20	MF
St. Annaland	20120623	51°36'36"N	4°06'15"E	10 - 15	3	MF
Zeelandbrug	20120630	51°37'44"N	3°54'44"E	10 - 15	15	MF
Zeelandbrug	20120728	51°37'44"N	3°54'44"E	10 - 15	5	MF
Zeelandbrug	20121027	51°37'44"N	3°54'44"E	10 - 15	30	MF
Helgoland, S	2011/08	54°08'48"N	7°53'00"E	40 - 50	59	BK
Helgoland, S	2012/08	54°08'48"N	7°53'00"E	40 - 50	ca 59	BK
Helgoland, NE	2012/08	54°13'30"N	8°02'30"E	10	2	BK
PAWP	20111029	52°34'N	4°13'E	19 - 24	2	MF

Tab. 2 - Beached material of *Fenestrulina delicia* Winston, Hayward & Craig, 2000.Tab. 2 - *Materiale spiaggiato di Fenestrulina delicia* Winston, Hayward & Craig, 2000.

Location	Date ymd	Latitude	Longitude	colonies	substrate	Source
Lombardsijde	20091229	51°10'N	2°45'E	2	lobsterpot	Verhaeghe, 2010
Goedereede	20110101	51°50'N	3°58'E		lobsterpot	KvdW
Goedereede	20110218	51°50'N	3°58'E		lobsterpot	KvdW
Bredene	20111221	51°15'N	2°59'E		plastic	HDB
Oostende	20120109	51°14'N	2°55'E	10+	lobsterpot	MD
Goedereede	20120128	51°50'N	3°58'E		lobsterpot	KvdW
Callantsoog	20120313	52°50'N	4°41'E	1	lobsterpot	RdR
Ouddorp	20120606	51°45'N	3°51'E	2	plastic	KvdW

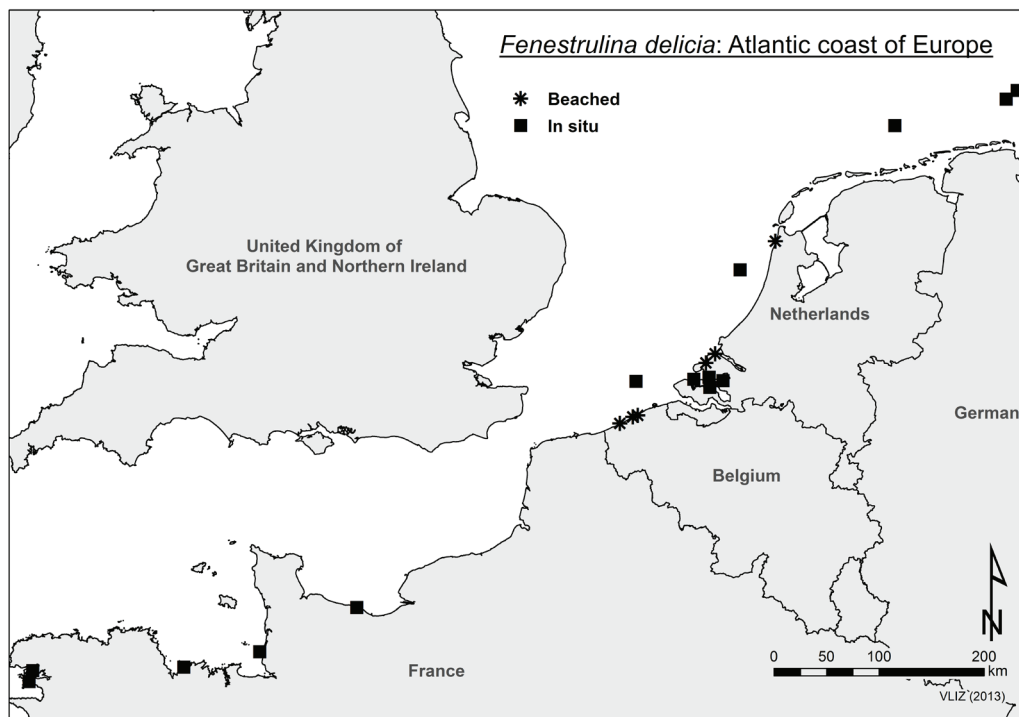


Fig. 1 - Locations of in situ collections and beached material of *Fenestulina delicia* Winston, Hayward & Craig, 2000 on the Atlantic coast of Europe.

Fig. 1 - Ubicazione dei campionamenti in situ e dei punti di raccolta di materiale spiaggiato di *Fenestulina delicia* Winston, Hayward & Craig, 2000, sulle coste atlantiche dell'Europa.

other marine fauna along French, Belgian and Dutch seashores. Beached material is summarized in table 2.

Samples were preserved dry or in 4% formalin/sea-water and later observed in ethanol or as dried specimens; voucher specimens are kept in the collection of each collector. A colony, collected at Goesse Sas in The Netherlands in 2006 and coated for SEM, is deposited in the RBINS: IG30.551/BRY.212 The first author has verified material of each locality, either by direct study of the material, which was returned to the collectors afterwards, or by study of high quality photographs.

3. RESULTS

3.1. The Netherlands - Eastern Scheldt (a North Sea tidal water body)

The first European records of *F. delicia* originate from the Eastern Scheldt in The Netherlands. A few colonies were discovered on empty mussel shells (*Mytilus edulis*) collected during SCUBA dives in 2005 and 2006, at depths between 5 and 10 m near Goesse Sas (De Blauwe 2008, 2009). Faasse (unpublished records) collected additional colonies in the Eastern Scheldt: in 2011 at similar depths near Anna Frisopolder and in 2012 between 10 and 15 m depth near Zierikzee and St. Annaland. One earlier record (de Kluijver 2006) of *Fenestulina malusii* (Audouin, 1826) probably refers to *F. delicia* (see Discussion). The Eastern Scheldt is the main area in the Southern Bight of the North Sea receiving shellfish imports.

3.2. France - littoral and shallow sublittoral

The second record originates from the Atlantic

coast of France. The first author has regularly surveyed the littoral bryozoan fauna of this region since 1999 and *F. delicia* was found neither in Brittany nor in Normandy until 2007. On February 22th 2007, a colony was collected at Granville (Normandy) on an oyster shell and in May 2008 (De Blauwe 2008) many colonies were collected at Le-Val-André (Brittany) on the inside of several bivalves. One colony was found on an empty shell of *Haliotis tuberculata* on the beach of Morgat (Brittany) on March 29th 2010 (De Blauwe 2010). On April 8th 2012, one colony was discovered in the fishing harbour of Courseulles-sur-Mer (Normandy) on an empty shell of *Aequipecten opercularis*. Eight colonies, some of them large, were collected on two empty valves of mussels (*Mytilus galloprovincialis*) near Lanvéoc (Brittany). The mussel valves were collected by SCUBA diving from 7-8 m depth near a pillar overgrown with mussels, about 20 m from the shore (M.A. Faasse, pers. comm.). Accompanying bryozoan species on the two mussel valves are *Tubulipora* sp., *Plagoecia patina* (Lamarck, 1816), *Callopora dumerilii* (Audouin, 1826), *Chorizopora brongniartii* (Audouin, 1826) and *Schizoporella unicornis* (Johnston in Wood, 1844). Shellfish culture is generally common throughout Brittany and Normandy.

3.3. Germany - offshore natural North Sea sediments

The first offshore record (JC, BW - 2011) came from an area north of the Islands Schiermonnikoog and Rottum in Germany called "Borkumer Reef Ground". Strong tidal currents exist in this area and the seabed is characterized by medium- to coarse-grained sandy sediments, which are sporadically interspersed with gravel and head-sized boulders. Four colonies were found on one stone collected by a box core at a depth of 30.9 m. There are no earlier reports of a *Fenestulina* species from this area. The nearest shellfish

culture is located in the Wadden Sea. Accompanying bryozoans on the stones are *Conopeum reticulum* (Linnaeus, 1767), *Electra pilosa* (Linnaeus, 1767), *Escharella immersa* (Fleming, 1828) and *Microporella ciliata* (Pallas, 1766).

A second record is situated in the south-eastern North Sea near Helgoland in the German Bight (Kuhlenkamp & Kind 2012). Fifty-nine colonies were collected in August 2011 by dredging at a depth of 40 - 50 m along different transects 2.5 km south of Helgoland in the Tiefe Rinne, a gully in the sandy sediment. A similar number of colonies was found in August 2012. All colonies were attached to empty shells of horse mussels, *Modiolus modiolus*, or locally extinct native oyster shells *Ostrea edulis*. The substratum consists of coarse shells with sand and mud, with the shells exposed at the surface of the sediments. Stones and gravel are mostly absent. The bottom substratum of the Tiefe Rinne might be best characterized as circalittoral (below the light zone) shell gravel. Earlier reports of *F. malusii* in 2008-2009 probably refer to *F. delicia* (see Discussion).

In August 2012, 6 km northeast of Helgoland, 2 colonies were observed at a depth of about 10 m on flint stones (Kind, pers. com.).

There never was an import of shellfish to Helgoland, only into nearby Wadden Sea areas, about 55 km away.

3. 4. Southern Bight of the North Sea - stones in offshore wind farms

During the spring of 2008, the first wind turbines of the C-Power wind farm were built on the Thorntonbank, some 30 km off the Belgian coast. A monitoring program was set up to sample the biofouling on the new hard substrata associated with the wind turbines (details see Kerckhof *et al.* 2009). Sampling by scuba diving of the boulders of the scour protection at a depth of ca 25 m of wind turbine D5 in the C-Power wind farm started in 2009 and *F. delicia* was detected for the first time in 2010 when on August 20th two colonies were present on two of three collected. During 2011 small colonies of *F. delicia* were again detected on January 31th (present on two of three collected stones) and again on November 22th (one small colony on one of the three collected stones). In 2012 the species was again found on July 12th, when several colonies were present on two of the three collected stones. While in 2010 and 2011 only small colonies were detected of which the living status was difficult to assess, the colonies found in 2012 were more extensive, covering up to 4 % of the surface of the stone. Accompanying bryozoans were *Conopeum reticulum*, *Electra pilosa* and *Callopora dumerilii*. *F. delicia* was not present in the scrape samples taken on the foundations of the wind turbines.

At present two wind farms are operational in the Dutch part of the North Sea. The construction of Offshore Wind farm Egmond aan Zee (OWEZ) 10-18 km off the coast near Egmond, owned by Shell and Nuon, was finished in August 2006. The foundations of the Prinses Amalia-windpark (PAWP) 23-26.4 km off the coast near IJmuiden, owned by Eneco, were finished in May 2007. During a monitoring project in October 2011 in the PAWP two colonies of *F. delicia* were collected from two out of sixteen scour protection boulders (Faasse *et al.*, in press). Accompanying

bryozoans on the same two boulders were *Conopeum reticulum*, *Electra pilosa*, *Callopora dumerilii*, *Celleporella hyalina*, *Schizomavella linearis*, *Microporella ciliata* and *Smittoidea prolifica*.

3. 5. Belgian and Dutch shores - beached plastic debris

The Belgian coast is regularly surveyed for beached bryozoans on plastic and algae since 1999 (HD) and *F. delicia* was never discovered on these substrates until the end of 2009 (Verhaeghe 2010). Since the publication of an identification key for Bryozoa in Belgium and The Netherlands (De Blauwe 2009), several naturalists were inspired to collect plastic debris and other material on local beaches in order to identify bryozoans. From then on, several colonies were found on beached plastic in Belgium and The Netherlands (table 2). Most of this plastic is debris of lobsterpots used in the English Channel, especially in Brittany and Normandy. Such fishing gear is not used in Belgium or in The Netherlands. We could not find any *Fenestrulina* spp. on beached algae.

4. DISCUSSION

4. 1. Identification of *Fenestrulina delicia* and *F. malusii*

Both species have a tatiform ancestrula, surrounded by about 10 spines. In *F. delicia*, the lateral pores are partly hidden by the smooth calcification of the zooidal border and the ovicell is transversally ridged (Fig. 1), in *F. malusii*, the lateral pores are free and the ovicells are not ridged.

F. delicia is very similar to *F. sinica* Liu & Liu, 2001 from China, except that the ancestrula of the latter resemble later autozooids, whereas that of *F. delicia* and *F. malusii* is tatiform. There is a morphologically similar population of uncertain identity found at Akkeshi, Japan (Dick *et al.* 2005) on which we do not have more information. It is, therefore, important to make identifications on colonies providing ancestrula and ovicells.

The identification guides to European bryozoans before 2009 (e.g. Hayward & Ryland 1999) refer exclusively to *F. malusii*. It is thus not surprising that *F. delicia* at first went undetected due to misidentifications as *F. malusii*, a species until recently incorrectly regarded as cosmopolitan (Dick *et al.* 2005).

In the area covered by this paper, *F. malusii* is the only native *Fenestrulina* species. It is found growing alive in the English Channel but in the Southern North Sea we only detected a few dead colonies, offshore and on beached plastic (De Blauwe 2009). Apart from beached material, probably originating from the English Channel, there is only one record from The Netherlands by de Kluijver (2006). He reported a colony from the Eastern Scheldt in 2002 near Wemeldinge. We could not trace this material but, regarding the location, we assume that this is the first European record of *F. delicia*, although misidentified.

In 2008 and 2009, results of sampling in the Tiefe Rinne near Helgoland reported a very high abundance of *F. malusii*, while *F. delicia* was not mentioned at all (Beermann *et al.* 2010). Again, we assume that *F. delicia*

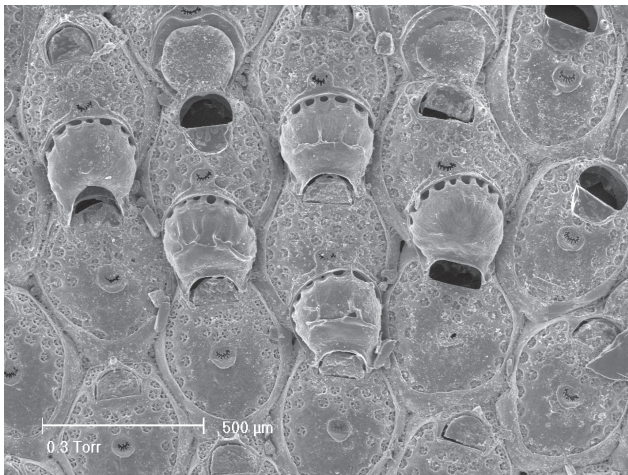


Fig. 2 - *Fenestulina delicia* Winston, Hayward & Craig, 2000, collected in Goesse Sas, the Netherlands in 2006. Sterile and ovicellate zooids.

Fig. 2 - *Fenestulina delicia* Winston, Hayward & Craig, 2000, raccolta a Goesse Sas, in Olanda nel 2006. Zooidi sterili e ovicezzati.

was misidentified as *F. malusii* in those samples, because *F. malusii* was completely absent in 2011, and in 2012 only 3 dead colonies were collected whereas about 60 live colonies of *F. delicia* were unambiguously identified. Unfortunately, the material of 2008-2009 is not available for revision (Kuhlenkamp & Kind 2012). It is noteworthy that on these stones, where competition amongst fouling species is heavy and earlier settlers may easily get smothered by new arrivals (Kerckhof unpublished), *F. delicia* was apparently able to maintain itself.

4.2. *Fenestulina delicia*, a cryptogenic species?

The first trace of *F. delicia* leads us to Craig (1994), who found this *Fenestulina* species in the Damariscotta Estuary, Maine (western Atlantic), near Walpole, heavily encrusting blades of the kelp *Agarum cribrosum* (Bory). *Fenestulina* colonies settled naturally on black Plexiglas settling plates at a depth of about 10 m in the Damariscotta River Estuary, near Hodgson Island (Craig 1994).

Winston *et al.* (2000) collected colonies on kelp and a *Mytilus* shell (30-43 m depth) from the same estuary on 29th July 1991 and described the species as *F. delicia*.

Shortly after, Dick *et al.* (2005) identified *F. delicia* on SERC settling plates from the following locations in the eastern Pacific: Valdez (retrieved in August 2000, 2001 and 2003) and Sitka in Alaska; Coos Bay (August 2000) in Oregon; and San Francisco (2000 till 2002). We could not find any records on natural substrata from the eastern Pacific.

The recent, nearly simultaneous, discoveries of *F. delicia* in boreal waters of the western Atlantic and eastern Pacific suggest that it might be a species introduced to one or both of these regions only within the past few decades (Dick *et al.* 2005). Finding the species at the same time in the eastern Atlantic strengthens that opinion. *F. delicia* was apparently absent before the 21st century at the European locations where it occurs today, suggesting that it is introduced to Europe.

4.3. Vectors of primary introduction

The first European specimen unequivocally identified as *F. delicia* was collected in The Netherlands in 2005 in the Eastern Scheldt, a semi-closed estuary known for its shellfish culture (De Blauwe 2008). The village of Yerseke on the coast of this estuary is the centre for the mussel and oyster trade in The Netherlands and Belgium. Pacific oysters *Crassostrea gigas* were and mussels still are imported from abroad, transporting also non-indigenous epifauna (e.g. Wijsman *et al.* 2006). Shellfish import is, therefore, the most likely vector of primary introduction to Europe. The coasts of Brittany and Normandy are also known for their considerable shellfish culture and provide a long stretch of coastline, where new species could be introduced with imported shellfish.

4.4. Secondary range expansion of *Fenestulina delicia*

It is quite surprising that *F. delicia* is reported simultaneously from two offshore wind farms in the Southern Bight of the North Sea, remote from the coast and from shellfish culture. Three potential vectors for secondary spread of *F. delicia* should be considered.

In Europe, some invasive bryozoans, e.g. *Tricelaria inopinata*, *Bugula simplex* and *Bugula stolonifera*, spread by hopping from one marina to another. They are mainly found in harbours and on ship's hulls, and ships are probably their main vector of secondary introduction. They settle also on plastics and algae but spreading outside the harbours happens slowly or fails. *Fenestulina delicia* has not been found on ship's hulls, nor in marinas along the Atlantic coasts of Europe.

Another vector of transport could be rafting on floating algae such as *Himantalia elongata*. The highly invasive bryozoan, *Watersipora subtorquata*, is established in the English Channel, but no populations has been found in the North Sea yet. *W. subtorquata* often enters the North Sea on *Himantalia* originating from the English Channel (De Blauwe 2001, 2012) and even reaches Helgoland (Kuhlenkamp & Kind in press), about 800 km from the nearest known population of this bryozoan. Although *F. delicia* heavily encrusts blades of the kelp *Agarum cribrosum* (Bory) in the western Atlantic, we have not yet found the species on any seaweed in the eastern Atlantic.

From 2009 on, colonies of *F. delicia* were found in Belgium and The Netherlands on plastic debris from lobsterpots used in Brittany and Normandy. This indicates that colonies settle on plastic in France and subsequently travel with their substrate into the North Sea. Fertile colonies can disperse their larvae close to suitable new substrates. Rafting on plastic could be an important vector of transport within and outward from the colonized area.

4.5. Natural and man-made stepping stones in the southern North Sea

During monitoring of bryozoans on empty shells and gravel within the Hinder Banks (Belgium) in 2004, not a single *F. delicia* colony was found (De Blauwe, un-

published). These gravel grounds, however, offer similar habitat conditions as the Borkumer Reef Grounds and are situated between the French population of *F. delicia* and the Belgian wind farm, thus colonization by *F. delicia* of this area is expected to happen in the near future or to have happened already. Hard substrates in the Borkumer Reef Grounds, in the Tiefe Rinne and other shell or gravel grounds can be well regarded as important natural stepping stones for *F. delicia* in the predominantly sandy North Sea.

It is very likely that the spread of *F. delicia* along the European coasts has been facilitated by the construction of wind turbine foundations in the several recently developed wind farms in the southern North Sea. Within the coming years, many more wind turbines will be constructed in a designated area of the Belgian part of the North Sea. With the construction of wind turbines, a new habitat of artificial hard substrate is being introduced in a region mostly characterized by sandy sediments. This will increase the habitat heterogeneity of the region and the effect of the introduction of these hard substrates - the so-called reef effect - is regarded as the most important change of the original marine environment caused by the construction of wind farms (Kerckhof *et al.* 2009). From the very beginning the newly available substrata were colonized by non-indigenous species. Both, introduced species and southern species expanding their range, took advantage of the increased availability of hard substrata, i.e. the wind turbine foundations, to settle and further spread into the North Sea or, if already present in the region, to expand their overall population range. This is particularly important for the obligate intertidal hard substrate species, for which offshore habitat was rare to non-existent (Kerckhof *et al.* 2011).

5. CONCLUSION

Presumably, *F. delicia* has invaded Europe in or prior to 2005 following its introduction with imported shellfish. Within a decade, several suitable habitats have been colonized along nearly a thousand kilometres of coastline. This species is not following the traditional pattern of colonization of harbours and ship's hulls to hop from one marina to another, as in most other introduced bryozoans along the Atlantic coast of Europe, but it colonizes boulders and shells tens of kilometres offshore, far away from marinas and shellfish farms. Rafting of colonies on plastic debris of lobsterpots originating from the English Channel occurs frequently, whereas the settlement on algae has not yet been demonstrated in Europe. The introduction of hard substrates in wind farms increases the habitat heterogeneity of the sandy North Sea bottom where native and non-indigenous fauna takes advantage of these man-made stepping stones.

ACKNOWLEDGMENTS

We like to thank the naturalists Floris Verhaeghe, Katie van der Wende, Michael Dekee and Rien de Ruijter, who collected plastics and seaweeds on the beach, reported *Fenestrulina* specimen to us and enabled us to study their material for confirmation of its identity. We are grateful to

VLIZ for drawing the distribution map. Stacey C. Havard from the Marine Invasions Lab at Smithsonian Environmental Research Center, for additional information about the settling plates used in the eastern Pacific. The work of Britta Kind and Ralph Kuhlenkamp (PHYCOMARIN) was performed as part of a long-term monitoring project under the European Water Frame Work Directive conducted and funded by the State Agency for Agriculture, Nature and Rural Areas (LLUR) of Schleswig-Holstein, Germany. We gratefully appreciate the scientific research service provided by the Alfred Wegener Institute for Polar and Marine Research in the Helmholtz Association at their Biological Institute Helgoland and appreciate the invaluable support by the staff and the research vessel Uthörn. The sampling of Bryozoa on the Borkum reef ground would not be possible without the help of the benthic group of IMARES. We gratefully appreciate their support. Special thanks to the crew of the VOS Satisfaction. The research in the Belgian wind farms was financed by C-Power NV, in fulfilment of the environmental monitoring requirements of their environmental permits. Fieldwork could not have been completed without the help and smooth operation provided by the officers and crew of the RV Belgica, operated by the Belgian Navy under charter of the RBINS and the RV Zeeleeuw, property of the Flemish government operated by the Flanders Institute of the Sea. The sampling could not have been completed without the help of a number of scientific divers.

REFERENCES

- Beermann J., Boos K., Reichert K., Haldin J. & Franke H., 2010 - Zeigereigenschaften Makrozoobenthos (MZB)-Helgoland 2009: MZB-Monitoring und Bewertung nach EU-WRRL. Report of the State Agency for Agriculture, Nature and Rural Areas (LLUR) of Schleswig-Holstein, Germany, 81p.
- Craig S.F., 1994 - Intraspecific fusion in the encrusting bryozoan *Fenestrulina* sp. In: Hayward, P.J. Ryland, J.S. and P.D. Taylor (eds), *Biology and Paleobiology of Bryozoans*, Fredensborg, Denmark: Olsen & Olsen: 51-54.
- De Blauwe H., 2008 - *Fenestrulina delicia* Winston, Hayward & Craig 2000, een nieuw mosdiertje (Cheilostomata, Bryozoa) in Europa. *De Strandvlo*, 28/4: 154-157.
- De Blauwe H., 2009 - *Mosdiertjes van de Zuidelijke bocht van de Noordzee: Determinatiewerk voor België en Nederland*. Vlaams Instituut voor de Zee (VLIZ): Oostende. ISBN 978-90-812-9003-6. 445 pp.
- De Blauwe H., 2010 - Bryozoa verzameld tijdens de SWG-reis naar Camaret en omgeving (Bretagne, Frankrijk) in 2010. *De Strandvlo*, 30/4: 112-118.
- De Blauwe H., 2011 - Riemwiervoetjes en hun begroeiing - eerste melding van *Watersipora subtorquata* (d'Orbigny, 1852) op het Belgische strand. *De Strandvlo*, 31/3-4: 93-9.
- De Blauwe H., 2012 - Riemwiervoetjes en hun begroeiing, een vergelijking. Influx van de invasieve exoot *Watersipora subtorquata* (Bryozoa, Cheilostomatida) op drijvende wieren. *De Strandvlo*, 32/4: 145-14.
- Dick M.H., Grischenko A.V. & Mawatari S.F., 2005 - Intertidal Bryozoa (Cheilostomata) of Ketchikan, Alaska. *Journal of Natural History*, 39/43: 3687-3784.
- Faasse M.A., van Moorsel G.W.N.M. & Tempelman D., (2013) - Bryozoa of the Dutch part of the North Sea and coastal

- waters of The Netherlands (in press).
- Hayward P.J. & Ryland J.S., 1999 - Cheilostomatous Bryozoa: 2. Hippothooidea - Celleporoidea: notes for the identification of British species. 2nd ed.. *Synopses of the British fauna (New Series)*, 10. Field Studies Council: Shrewsbury. ISBN 1-85153-263-3. VII, 416 pp.
- Kerckhof F., Norro A., Jacques T.G. & Degraer S., 2009 - Early colonisation of a concrete offshore windmill foundation by marine biofouling on the Thornton Bank (southern North Sea). In: Degraer, S. & Brabant, R. (Eds.) *Offshore wind farms in the Belgian part of the North Sea: State of the art after two years of environmental monitoring*. Royal Belgian Institute for Natural Sciences, Management Unit of the North Sea Mathematical Models. Marine ecosystem management unit, 287 pp. + annexes: 39-51.
- Kerckhof F., Degraer S., Norro A. & Rumes B., 2011 - Offshore intertidal hard substrata: a new habitat promoting non-indigenous species in the Southern North Sea: an exploratory study. In: Degraer S., Brabant R. & Rumes B. (Eds.) *Offshore wind farms in the Belgian part of the North Sea: Selected findings from the baseline and targeted monitoring*. Royal Belgian Institute of Natural Sciences, Management Unit of the North Sea Mathematical Models. Marine ecosystem management unit, 157 pp. + annex: 27-37.
- Kluijver de M.J., 2006 - Non-indigenous species in the Oosterschelde. In 'Wijsman, J.W.M. & Smaal, A.C. Risk analysis of mussel transfer. Wageningen IMARES, report C044/06: 130p.
- Kuhlenkamp R. & Kind B., 2012 - Makrozoobenthos Monitoring Helgoland 2011, Maßnahme im Rahmen der WRRL. Report of the State Agency for Agriculture, Nature and Rural Areas (LLUR) of Schleswig-Holstein, Germany, 55p.
- Kuhlenkamp R. & Kind B., in press - Arrival of the invasive *Watersipora subtorquata* (Bryozoa) at Helgoland (Germany, North Sea) on floating macroalgae (*Himantalia*). *Marine Biodiversity Records*.
- Verhaeghe F., 2010 - Het mosdiertje *Fenestrulina delicia* (Winston, Hayward & Craig, 2000) voor het eerst aangespoeld aan de Belgische kust, 29 december 2009, Lombardsijde. *De Strandvlo*, 30/2: 36-38.
- Wijsman J.W.M. & Smaal A.C., 2006 - Risk analysis of mussel transfer. Wageningen IMARES, report C044/06: 130p.
- Winston J.E., Hayward P.J. & Craig S.F., 2000 - Marine bryozoans of the Northeast Coast of the United States: new and problem species. In: Herrera Cubilla A. & Jackson J.B.C. (eds), *Proceedings of the 11th International Bryozoology Association Conference*. Balboa, Republic of Panama: Smithsonian Tropical Research Institute: 412-420.

