

Invasive tunicates on Zeeland and Prince Edward Island mussels, and management practices in The Netherlands

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Abstract

In the Dutch province of Zeeland, fouling species on a mussel line form a diverse assemblage of mainly exotic invertebrate species. This differs strikingly from the situation in the estuaries of eastern Prince Edward Island, Canada. Despite the fact that about the same species are present, monocultures of exotic tunicate species dominate there. The import of mussels has been strictly regulated in The Netherlands, aiming at a reduction of the introduction of invasive species among which tunicates.

Key words: mussels, tunicates, invasive, *Ciona*, *Didemnum*, *Styela*, *Botrylloides*, management

During the years 2005 and 2006, sixteen non-native marine species were recorded as new to the Dutch fauna and flora (Figure 1). Never before have so many invasive species been recorded in such a short time span. These invaders are a nuisance and sometimes even a threat to the native ecosystems and commercial activities in the marine environment. In The Netherlands, the small number of tunicate species, together with molluscan species, for example the Japanese oyster *Crassostrea gigas* (Thunberg, 1793) and the Slipper limpet *Crepidula fornicata* (Linnaeus, 1758) have caused significantly more economical and ecological damage than non-native crustaceans, which constitute the largest number of invaders

(Figure 2). The introduced colonial sea-squirt *Didemnum* sp. (Figure 3) has expanded its populations in recent years, outcompeting many native Dutch species for space (Gittenberger 2007). The mussel industry has also been affected by *Didemnum* sp., which is commonly found on mussel lines together with other invasive tunicates like *Aplidium glabrum* (Verrill, 1871), *Botrylloides violaceus* Oka, 1927, *Diplosoma listerianum* (Milne Edwards, 1841), *Molgula manhattensis* (De Kay, 1843), *Styela clava* Herdman, 1881 (Figure 3), *Perophora japonica* Oka, 1927, as well as the native *Asciidiella aspersa* (Müller, 1776), *Botryllus schlosseri* (Pallas, 1766) and *Ciona intestinalis* (Linnaeus, 1758) (Figure 4).

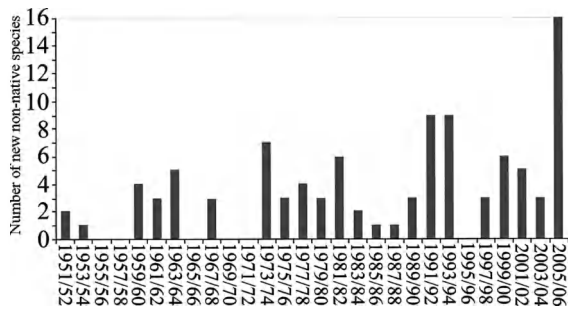


Figure 1. Number of non-native species recorded in the literature as new to the Dutch flora and fauna since 1951

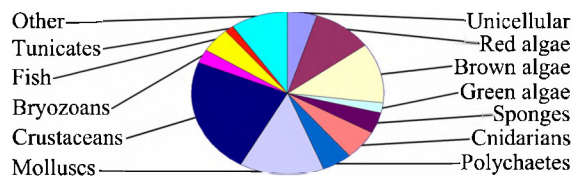
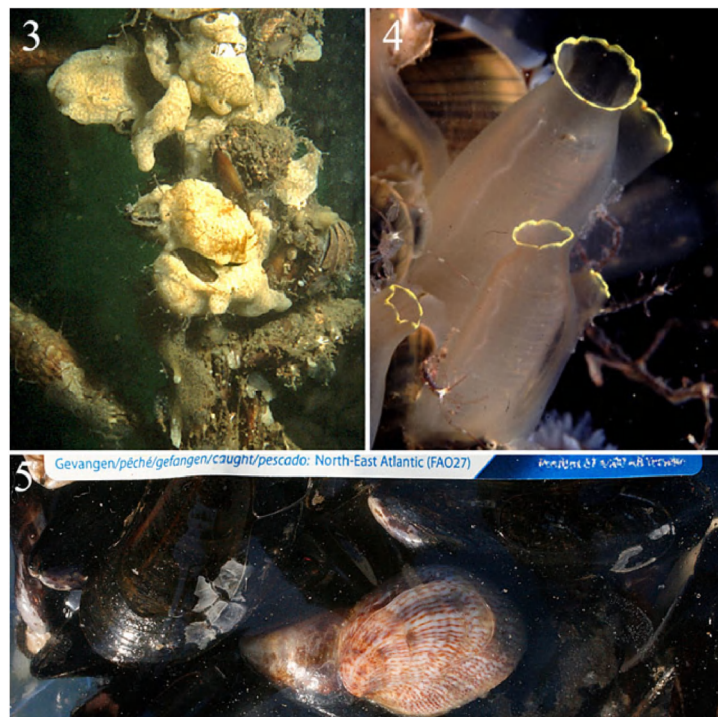


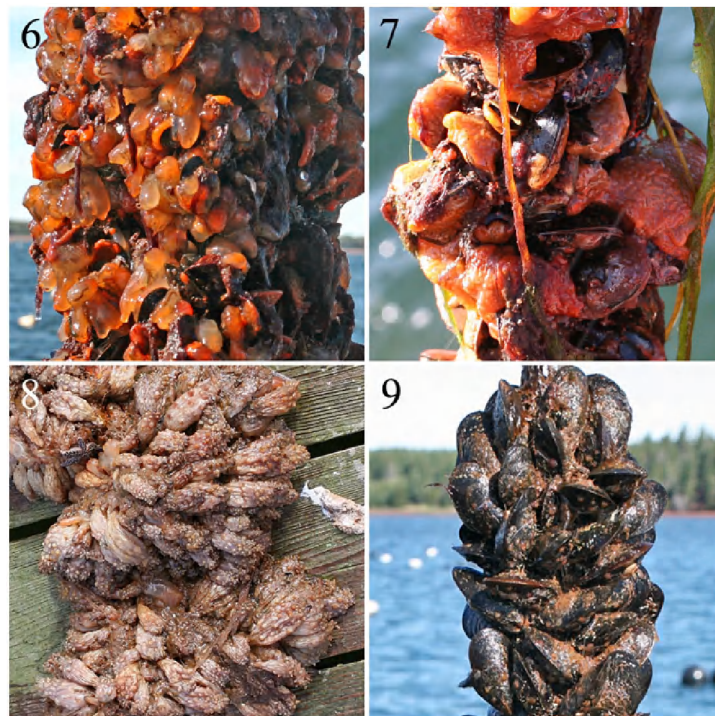
Figure 2. Relative number of non-native marine and brackish water faunal groups recorded in The Netherlands. Modified after Gmelig-Meyling and Gittenberger (2006: 243, Figure 1d)

Typically, the fouling species communities on mussel lines in The Netherlands consist of a mixture of tunicate, bryozoan, sponge, and sea-anemone species, without clear dominance of a single species. This differs strikingly from what is found in the estuaries of eastern Prince Edward Island, Canada (e.g., Locke et al. 2007). There, fouling communities on mussel lines are usually dominated by a single tunicate species. High numbers of solitary tunicates such as the Vase tunicate *Ciona intestinalis* (Figures 4, 6) and the Clubbed tunicate *Styela clava* (Figure 8) can make the mussels very heavy (compare Figures 8 and 9), causing part of the yield to fall off when the lines are pulled out of the water. The colonial tunicates, i.e., the Violet tunicate *Botrylloides violaceus* (Figure 7) and/or the Golden star tunicate *Botryllus schlosseri*, do not substantially increase the mussel weight, and cause only minimal loss during harvesting (local mussel fisherman, personal communication).

In The Netherlands, the import of mussel spat from Ireland and the transport of mussels within the country, from Zeeland to the Waddenzee, were temporarily halted in 2007, pending research results on the potential of the spat and



Figures 3-5. Overgrown mussels in The Netherlands. 3, mussel line overgrown by the colonial tunicate *Didemnum* sp. (yellow colonies) and the solitary *Styela clava* (bottom left). 4, specimens of the native *Ciona intestinalis* on a mussel line. 5, mussels in a sealed package imported from the "North-East Atlantic" with a live specimen of *Crepidula fornicata*



Figures 6-9. Mussel lines, eastern part of Prince Edward Island, Canada. 6-8, mussels overgrown by non-native tunicates. 6, *Ciona intestinalis*. 7, *Botrylloides violaceus*. 8, *Styela clava*. 9, mussel line without overgrowth by invasive species

mussels to harbor risky invasive species*. The reasons for this ruling were the increasing number of invaders in recent years, the high diversity of non-native species found on mussels, and the likely significant role of shellfish-transport as a distribution vector (Wolff 2005). The restrictions applied only to mussels that were imported for growing to maturity in open Dutch waters and not to mussels imported from the British Islands, Greece and Canada that were to be sold directly to consumers. These mussels are required to be cleaned before packing and transport but this is not always done carefully, and living *Crepidula fornicata* (Figure 5), barnacles and possibly tunicates might therefore still be imported into the Netherlands. However, these individuals will most probably not be able to reach a suitable habitat unless they are carelessly discarded alive.

* While this paper was in press, Dec. 4th 2008, the EU Court of Justice ruled against the Kingdom of the Netherlands and its restrictions system of prohibiting the import of mussels, without prior authorization, from other Member States. This would impede intra-Community trade for mussels from other EU Member States (Case C-249/07).

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