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New crustacean invaders in the Schelde estuary (Belgium)

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ABSTRACT. This paper reports on the first records of three non-indigenous crustacean species in the Zeeschelde estuary (Belgium). All three species are native to the Western Pacific Ocean and are probably transported in ballast water or hull fouling. The isopod *Synidotea laevidorsalis* has been recorded earlier in Europe from two locations, in the south of France and in Spain. The present records constitute a range extension of more than 1000 kilometres to the north. The crab *Hemigrapsus takanoi* and the prawn *Palaemon macrodactylus* were found for the first time in the brackish reaches of the Schelde estuary. The finding of these species demonstrates the vulnerability of the estuarine system to the invasion of exotic species.

KEY WORDS: Schelde estuary, *Synidotea laevidorsalis*, *Hemigrapsus takanoi*, *Palaemon macrodactylus*, invasive species.

INTRODUCTION

Invasions of non-indigenous species are occurring throughout the world. However, the magnitude of the phenomenon is still underestimated (Ruiz et al., 1997). This is partly because exotic species are frequently misidentified during the first years after their arrival in the new habitat. Regions with harbours and shellfish culture are especially vulnerable to introductions of alien species. Brackish harbour regions in Western Europe are particularly susceptible to introductions (Ruiz et al., 1997). In low saline regions the diversity of native species is low (Remane, 1971) and the import rate of new species is high. The port of Antwerp (Belgium) is a large international port, mainly focussed on container transport and receiving ships from over 800 locations worldwide. The main port activities are situated in the brackish part of the Schelde estuary, between the Dutch-Belgian border and the city of Antwerp. The high loads of ballast water and the recent improvement of the water quality make the system vulnerable to introductions of non-indigenous species (Ysebaert et al., 1997, Stevens et al., 2004; Azémar et al., 2007). In the mesohaline part of the Schelde estuary, where the port of Antwerp is situated, the invertebrate fauna contains a high proportion of alien species. The invasion rate in the ecosystem has never been higher than during the last 20 years (Kerckhof et al., 2007).

The present paper reports on the first records of three crustacean species in the Zeeschelde, the Belgian part of the Schelde estuary. For the isopod *Synidotea laevidorsalis* (Miers, 1881) (Fig. 1) this is the first record of this species in north-west Europe, while the crab *Hemigrapsus takanoi* (Asakura & Watanabe, 2005) (Fig. 2) and the prawn *Palaemon macrodactylus* (Rathbun, 1902) (Fig. 3) were already known from Belgian coastal waters and from the Dutch part of the Schelde estuary (Westerschelde).

S. laevidorsalis is a large isopod from the Western Pacific Ocean (China, Japan, and the east coast of Russia). It has spread during the past 100 years to an almost cosmopolitan distribution in temperate regions (Chapman & Carlton, 1991; Chapman & Carlton, 1994; Bushek & Boyd, 2006). Before the records in the present note, the genus *Synidotea* had only been recorded in Europe from the Gironde estuary in France (Mees & Fockedey, 1993) and the Guadalquivir estuary in southern Spain (Cuesta et al., 1996). The species invaded the Gironde, more than 1000km south of the Schelde estuary, prior to 1975. The species was recorded for the first time in the Guadalquivir estuary in the early 1990's (Cuesta et al., 1996).

P. macrodactylus is native to the north-west Pacific, but has been introduced already to the west coast of North and South America, Australia and Europe (González-Ortegón & Cuesta, 2006). This species was first recorded in Belgium in June 2004 (De Blauwe, 2006) and was found in the Zeeschelde near Doel in 2005 (d'Udekem d'Acoz et al., 2005). However, the earliest specimen we found came from a sample from autumn 2003, which makes it the first observation of this species in Belgium.

The crab *H. takanoi* has much the same native distribution as *P. macrodactylus* (Western Pacific). The species invaded north-west Europe in the early 1990's, The Netherlands in 2000 (d'Udekem d'Acoz & Faasse, 2002) and the Belgian coast in 2003 (Dumoulin, 2004). This species was found already in 2003 in the Westerschelde near Baalhoek, but despite a search in the same period, it could not be found in the Zeeschelde (Dumoulin, 2004).

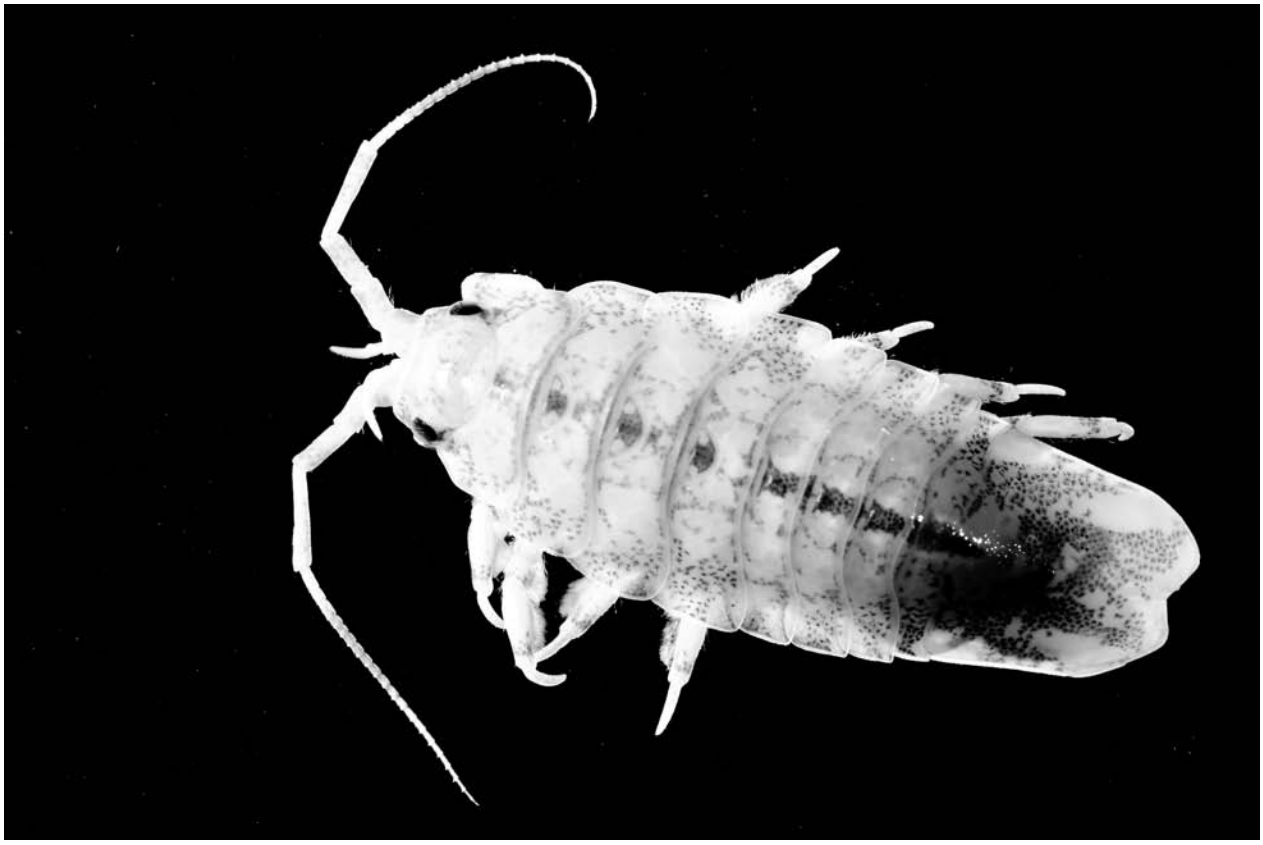

Fig. 1. – *Synidotea laevidorsalis* (Vilda/ Yves Adams)

Fig. 2. – *Hemigrapsus takanoi* (Vilda/ Yves Adams)

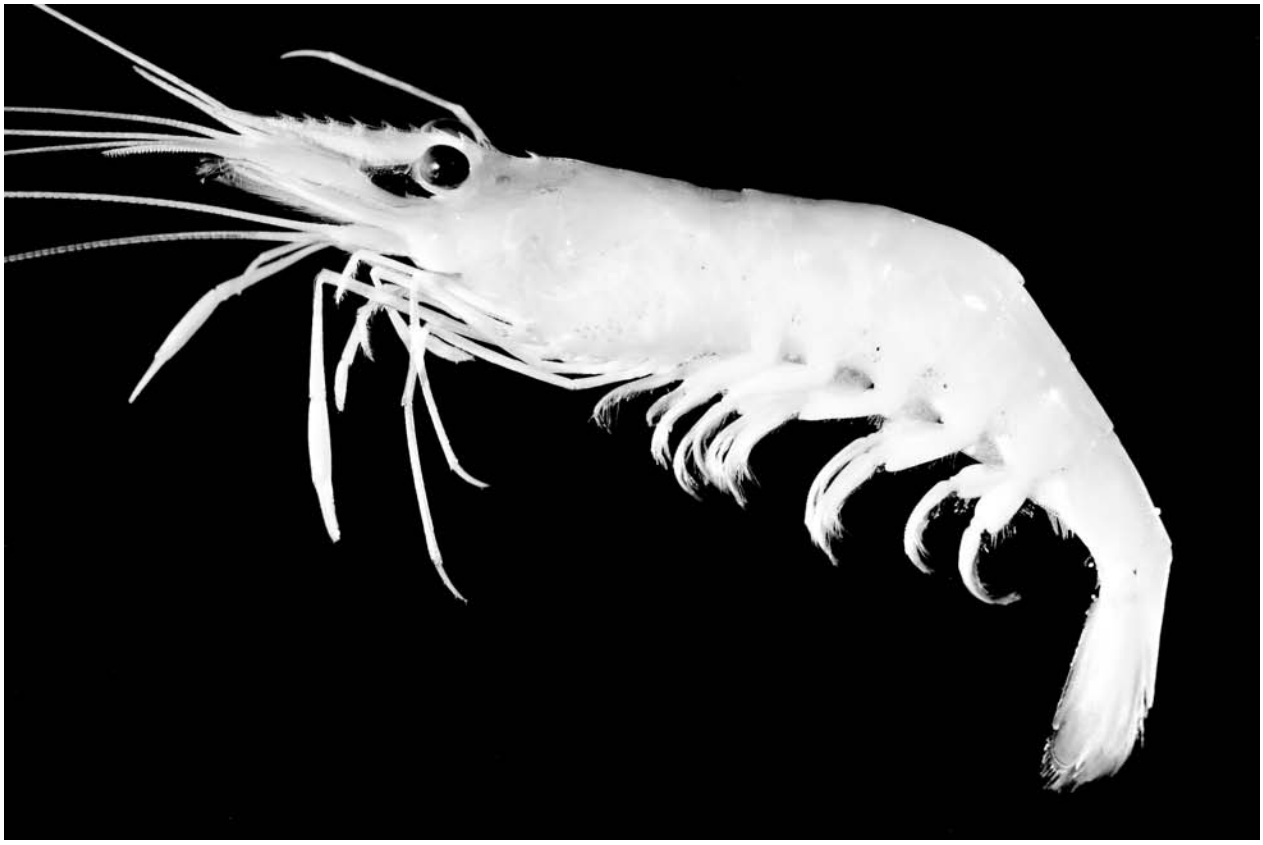

Fig. 3. – *Palaemon macrodactylus* (Vilda/ Yves Adams)

MATERIALS AND METHODS

Study area

The river Schelde rises in the north of France and flows into the North Sea near Vlissingen (The Netherlands). It is a lowland river with a total length of 355km and a fall of 100m at most. Its catchment area, approximately 21000km², has around ten million inhabitants. This study focuses on the estuary, which extends to Gent, 160km from the mouth, where tidal influence is stopped by sluices. The tributaries are also under tidal influence and are considered as a part of the estuary. The Dutch part of the estuary (Westerschelde) is characterised by flood and ebb channels, separated by intertidal sand- and mudflats. Upstream from the Dutch-Belgian border, it changes into a one channel system. The study area is situated in the mesohaline part of the estuary (Beneden-Zeeschelde), between the Dutch-Belgian border and Antwerp (Fig. 4). This part of the estuary is characterized by a steep salinity gradient, ranging between 17psu in summer near the border and 0.5psu in winter near Antwerp (Table 1). The oxygen concentration may be low near Antwerp in summer when river discharge is low and temperature high. Near the border the oxygen concentration is generally higher and varies between 3.5 and 10mg/L.

Data collection

The species were collected by various sampling techniques including sieving of cooling water, benthic soil samples, hand netting and analysis of fish stomach contents. Regular fish monitoring in the brackish part of the Schelde estuary started in 1991 using monthly cooling water samples from the nuclear power plant Doel (NPP Doel). The power plant is situated on the west bank of the Schelde estuary between Antwerp (Belgium) and the Dutch-Belgian border (Fig. 4). The main purpose of these surveys was to study seasonal trends in the estuarine fish and crustacean communities. Fish were collected from the intake screens of the NPP Doel. Cooling water is withdrawn through five intake apertures (25m^3/s) and filtered by two vertically-travelling screens with a mesh size of 4mm to prevent larger organisms and debris from obstructing the condensers. A full description of the sampling site and the methodology is given in Maes et al. (2001). Former catches of isopods in Doel were probably misidentified as the native harbour isopod (*Ligia oceanica*). In 2007, some isopods were taken to the laboratory and could be identified as *S. laevidorsalis*.

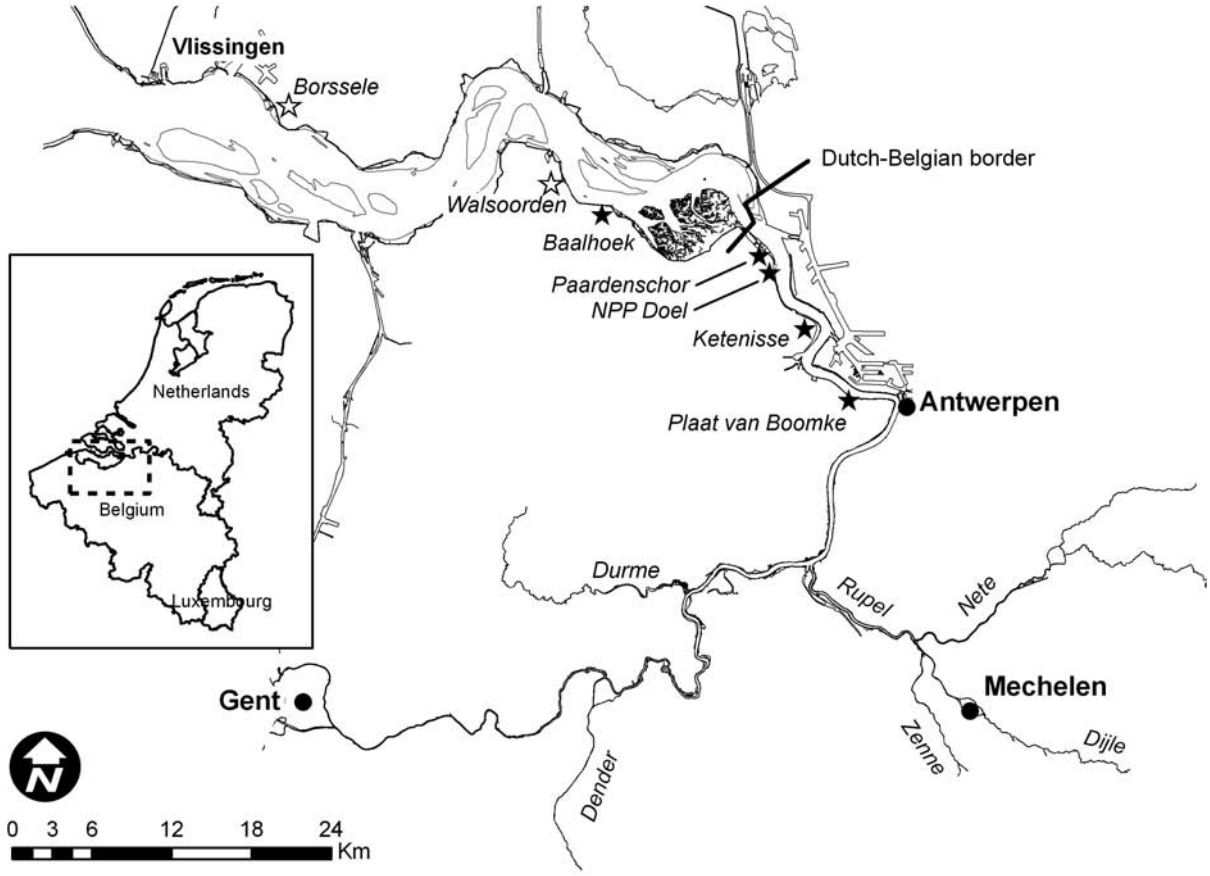

Fig. 4. – Map of the Schelde estuary. The lower part of the estuary (Westerschelde – downstream of the Dutch-Belgian border) consists of multiple channels and the upper part (Zeeschelde – upstream of the border) consists of a single channel.

TABLE 1

Water quality parameters in the study area (2002-2007).
Data were obtained from the Centre for Estuarine and Marine Ecology (CEME - NIOO).

	Salinity (psu)		Temperature (°C)		Dissolved oxygen (mg/L)	
	Border	**Antwerp**	**Border**	**Antwerp**	**Border**	**Antwerp**
average	9.0	4.6	13.6	13.5	6.9	4.5
max	16.8	11.3	24.0	23.6	10.0	9.1
min	1.2	0.4	4.2	2.9	3.3	0.3

The subtidal macrobenthic community of the mesohaline part of the Schelde is sampled three-yearly (autumn) since 1996. In 2003 an additional monitoring campaign was set up to evaluate the impact of dredging activities. On each location one Van Veen grab (0.105m²) was taken. The samples were sieved through a 1-mm mesh in the field and preserved in neutralized formalin (8%). In the laboratory the samples were sorted after staining with 0.02% Rose Bengal. When possible, the organisms were identified to species level and counted. With this method hyperbenthic organisms (such as *Synidotea* spec. and *Palaemon* spec.) are sampled only accidently. A few additional samples have been included in this study, i.e. two van Veen grab samples containing specimens of *S. laevidorsalis*, two samples from fykes containing *H. takanoi* originating from a local fisherman, stomach contents of fish caught near Doel and two samples collected under boulders in the littoral zone (Table 2).

TABLE 2

Catch results and site characteristics.

	Location	Date	Habitat	#
S. laevidorsalis	Near NPP Doel (Van Veen grab)	27/09/2005	Subtidal, >10m TAW	2
	D-B border near Prosperhaven (Van Veen grab)	27/09/2005	Subtidal, >10m TAW	1
	NPP Doel	17/08/2007	Water intake	>100
	NPP Doel	11/12/2007	Water intake	23
P. macrodactylus	Antwerp (Plaat van Boomke)	25/09/2003	Subtidal, soft	2
	Paardenschor	17/07/2007	Mudflat (Fish stomachs)	2
	NPP Doel	17/08/2007	Water intake	19
H. takanoi	Ketenisse	28/07/2007	Mudflat (fyke)	1
	NPP Doel	17/08/2007	Water intake	4
	Ketenisse	25/10/2007	Under boulders	2
	Ketenisse	12/11/2007(*)	Under boulders	1
	NPP Doel	11/12/2007	Water intake	2

(*) On 12/11/2007 together with *H. takanoi* the alien (American) amphipod *Crangonyx pseudogracilis* and the native amphipod *Corophium lacustre* were collected.

RESULTS

An overview of all specimens collected is given in Table 2. Since the isopods and prawns at the NPP Doel were picked out randomly, higher numbers of *S. laevidorsalis* were probably present. In the fish stomach samples of 17 July 2007, six specimens of the native prawn *Palaemon longirostris* (H. Milne Edwards, 1837) were present as well. In the August samples of Doel, species of Pacific origin predominated. A single specimen of the native prawn *Palaemon adspersus* (Rathke, 1837) (Fig. 5) was collected on the same date, constituting its first record from the Belgian part of the Schelde. On 11 December 2007 the crab *Rhithropanopeus harrissii* (Gould, 1841), another alien crustacean, originating from the north-west Atlantic and recorded from the Schelde since 1985 (MAES et al., 1998; YSEBAERT, 2000; WOUTERS, 2002; WOLFF, 2005) was found in the samples. Native species collected on the same date were *Palaemon longirostris* and *Crangon crangon* (Linnaeus, 1758). Pontoon scrapings and hand net catches near the low water mark in the mesohaline part of the Dutch Westerschelde did not yield any specimens of *S. laevidorsalis*. Also inspection of the cooling water inlet of the power plant in Borssele in the polyhaline part of the Westerschelde was not successful in detecting this species.

DISCUSSION

S. laevidorsalis is an invasive species that should be expected to arrive in several more temperate estuarine areas worldwide. It has been misidentified and/or redescribed erroneously in different parts of the world where it has been introduced (CHAPMAN & CARLTON, 1991; CHAPMAN & CARLTON, 1994). Ballast water or hull fouling is the most likely vector for the introduction of *S. laevidorsalis* in the Gironde, Guadalquivir and Schelde estuaries. All three estuaries have international ports and receive large amounts of ballast water (NIIMI, 2004). The tendency of *S. laevidorsalis* to cling to floating objects (CHAPMAN & CARLTON, 1994; BUSHEK & BOYD, 2006) increases the chance of it being introduced with ships.

S. laevidorsalis is mostly recorded from intertidal pilings, rock jetties or floats and buoys, among dense masses of hydroids or bryozoans in shallow brackish and marine waters (CHAPMAN & CARLTON, 1991). According to MEES & FOCKEDEY (1993) however, the species was never collected during the extensive macrobenthos surveys in the Gironde. They found the species by trawling the bottom of the Gironde with a hyperbenthic sledge in the main subtidal channel at a sampling depth between 6 and 14m. In the Gironde the species is found in salinities ranging from 0.1 to 24g/L with highest densities around 3g/L. The same authors mention that Hydrozoa and Bryozoa have not been reported to occur in important numbers in the brackish part of the estuary. They suggest that the animals crawl over the bottom and that at least a part of the Gironde population migrates into the water column, even during daytime. *S. laevidorsalis* is a typical estuarine species. The European finds are situated in three of the biggest European estuaries. The optimal salinity of 3g/L for *S. laevidorsalis* found in the Gironde corresponds well with the salinity range of the records in the Schelde (Table 1). In the Guadalquivir estuary, the species was found commonly in a salinity ranging from 16g/L to 24g/L (CUESTA et al., 1996). This makes it very likely that the species could also occur in the mesohaline part of the Westerschelde (The Netherlands). However, this could not yet be demonstrated.

Fig. 5. – *Palaemon adspersus* (Vilda/ Yves Adams)

The stations where this species is found correspond well with its ecological preferences. Since the current monitoring program is focussed on benthic organisms, we assume that the species is more common than the few observations suggest. Alternatively, it is possible that this species takes advantage of the locally higher water temperatures near the outflow of the NPP Doel.

P. macrodactylus tolerates a broad range of ecological conditions. It is known to occur in protected harbours, bays, ponds and tidal creeks (GONZALEZ ORTEGON & CUESTA, 2006). In the UK, this species has also been collected from the water intake of a power station (WORSFOLD & ASHELBY, 2006). The first observations of *P. macrodactylus* in (coastal) Belgium were in 2004 (DE BLAUWE, 2006). However, our own observation of two specimens in 2003 indicates that this species was already present in the Zeeschelde before that date. This is not very surprising considering that the first observation in the Westerschelde was in 1999 in Walsoorden (D'UDEKEM D'ACOZ et al., 2005). The Belgian observations show that this species has a broad salinity-tolerance. The species seems to be quite common and coexists with at least two other native *Palaemon* species. In the Thames, where the presence of this species has been demonstrated since 1992, it has become a common species, but has not outcompeted the native species *P. longirostris* (WORSFOLD & ASHELBY, 2006). BEGUER et al. (2007) consider it very likely that there is a significant competition for food between *P. macrodactylus* and native species such as *P. longirostris* and even *Crangon crangon*. In California, RICKETS et al. (1968) considered the species as responsible for the disappearance of a native *Crangon* species.

H. takanoi reached the Belgian part of the Schelde and can be considered as quite common on the stony banks of the brackish part of the Schelde. Since the species was already present close to the Belgian border in 2003, it is very likely that this species did arrive much earlier. No targeted research was undertaken between 2003 and 2007, when the species was accidentally found in the NPP Doel. In contrast with the other two exotic species, *H. takanoi* was not found in Gironde and Guadalquivir estuaries. *H. takanoi* often hides under boulders in intertidal areas of estuaries, lagoons, boulder beaches and wave sheltered rocky shores (ASAKURA & WATANABE, 2005), but occurs also on stony mediolittoral river banks or in association with mussels or oysters such as the Japanese oyster *Crassostrea gigas* (Thunberg, 1873) (DUMOULIN, 2004). This author found the species most numerously in sheltered places such as marinas and harbours, canals and coastal bays. The larvae of this crab are pelagic which means that it can easily colonize new areas. This species is a possible competitor with other crabs in the estuary such as the native *Carcinus maenas*, which has a similar habitat preference and which reaches its lower salinity limit in the estuary near the Dutch-Belgian border. Also competition with *Eriocheir sinensis* and *Rhitropanopeus harrisii* cannot be ruled out.

The coexistence of *S. laevidorsalis*, *P. macrodactylus* and *H. takanoi* in the basin of the NPP Doel may be explained by their habitat preferences. All three species are regarded as euryhaline and prefer shallow, often calm and protected waters with stones or other hard substrates such as harbour walls and pontoon floats. All three species take advantage of the human introduction of hard substrates in the Schelde-estuary where soft sediments

naturally prevail. It's very likely that *S. laevidorsalis*, *P. macrodactylus* and *H. takanoi* were already present in the Zeeschelde for several years in the period before 2003-2005. However, they were never found and/or identified as such, because a consistent monitoring programme for hyperbenthos in the Zeeschelde is lacking. The current benthos monitoring in the Schelde estuary is focussed on intertidal and subtidal sampling of sediments. As a result, hyperbenthic organisms are sampled only occasionally. Walk-over-surveys could make a difference for *H. takanoi*, since this species can be easily found under stones in the intertidal.

CONCLUSIONS

This article mentions three exotic crustacean species that have been collected in the Zeeschelde-estuary recently. *Synidotea laevidorsalis* is new to northwestern Europe. *Hemigrapsus takanoi* had never been found before in the Zeeschelde. *Palaemon macrodactylus* was present, but had not been recorded, as early as 2003 from Belgium. The presence of several large ports in the estuary makes the Zeeschelde very vulnerable to invaders. The transformation of the estuary by introduction of hard substrates has provided new niches that are now occupied by new, often exotic and opportunistic species. In addition, recent improvement of the water quality in the freshwater part of the estuary may facilitate the introduction and establishment of non-native species. Further research should focus on the impact of introduced species on the ecological functioning of the estuary. An adjusted monitoring programme for the hyperbenthos may reveal the presence of more exotic species.

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