Ocurrence of Pennant's swimming crab, Portumnus latipes, *along the German North Sea coast*

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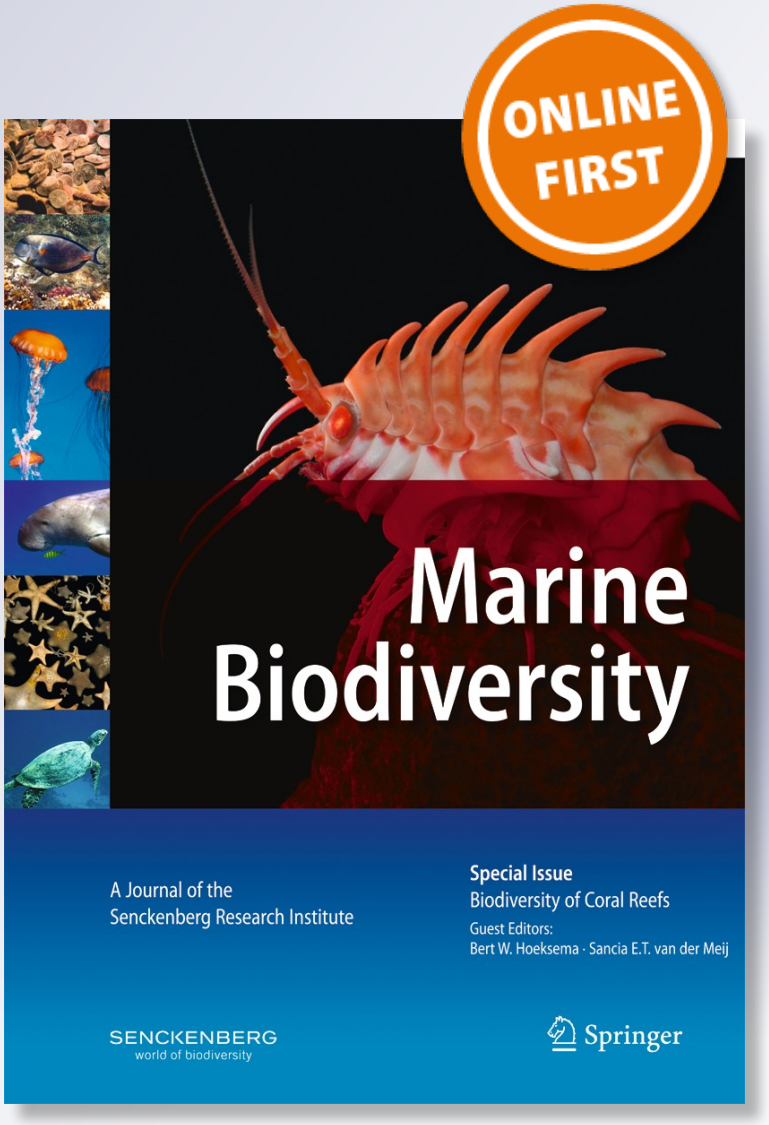

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Ocurrence of Pennant's swimming crab, *Portumnus latipes*, along the German North Sea coast

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Abstract Pennant's swimming crab (*Portumnus latipes*) was rarely recorded from the German North Sea coast, until it became a steady faunistic element from 1992. The occurrences show that the species has always been found in warmer periods and, thus, is a good indicator for warming of North Sea coastal waters.

Keywords Crustacea · Decapoda · Portunidae · North Sea · German Bight · Water temperature

Introduction

Pennant's swimming crab (*Portumnus latipes*) is a typical element of the surf zone and foreshore of sandy beaches of the temperate northeast Atlantic and the Mediterranean Sea. Usually, it buries itself in the sand and is therefore hidden when the tide is out and the habitat is therefore drained. Presumably, activity (including feeding) revives when water returns. The species is recorded down to 30 m depth (Adema 1991), but such maximum values could be accidental. Moreover, it seems that wave action and disturbance are critical in the life of this crab, as shown for this and the related species *P. lysianassa* (Chartosia et al. 2006; Chartosia and Koukouras 2009, 2010). Floating algae and pelagic crustaceans (e.g. *Gastrosaccus mediterraneus*) emerging from the sediment and floating at night (see Macquart-Moulin 1977) are present in the gut contents of both *Portumnus* species and might suggest that the species of this genus live on organic material brought in on the tide or washed from the beach sediments. A similar strategy of "catching" organic material from the water column in the surf zone has been reported for *Ashtoret lunaris* by Seiler (1976). This assumption fits well with the specific abundance of *P. latipes* in the zone strongly influenced by wave action. However, direct observations and experimental work are largely lacking to date.

The distribution of the present species is clearly southern and characteristic of temperate areas of the northeast Atlantic including the Mediterranean Sea. In the North Sea, it is more abundant in the Southern Bight (i.e. southeast British, Belgian and Dutch coasts) than farther north and east (Christiansen 1969; Adema 1991; d'Udekem d'Acoz 1999). Adema (1991) stated that, in the Netherlands, the species disappears after hard winters and repopulates the area after some time.

Along the more easterly situated German coast, *P. latipes* has been recorded for a long time, but it was neither of stable occurrence nor was it as common as further west and south. The very first mention of the species is by Hartmann (1855), a zoologist from Berlin (see Ciz 1984), in one of his first popular publications. In this scarcely available work, he lists the known species of the Eastern Frisian Islands without referring to any specific localities. The present species is recorded under the name *Portumnus variegatus* as a rare species ["somewhat rarer than the shore crab *Cancer maenas*" (= *Carcinus maenas*)]. Riefkohl (1861) in his book on the Eastern Frisian Island, Norderney, repeats the text of Hartmann, so that it cannot be concluded that the species was specifically recorded from this island. Also, Metzger (1871) lists the species (under *Portumnus variegatus*) nonspecifically from the Eastern Frisian Islands, stating that the crab is commonly washed ashore in summer and that it was found in the stomach of haddock ("*Gadus aeglefinus*"). In a subsequent paper (Metzger 1875), he repeats his earlier

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statements, but more specifically states that the haddock from the stomach of which "*Platyonychus latipes*" was removed was caught off Norderney at a depth of 10–20 fathoms. This, therefore, is the first specific German locality. The aforementioned records were repeated in subsequent compilations, such as Blohm (1913), Balss (1926), and Schellenberg (1928). Only Schellenberg (1928) added the new information that, according to Arthur Hagmeier (*1886–†1957) the crab was also at times common on the dune island of Helgoland, but without any reference to the years. A. Hagmeier, after earning his doctorate in Heidelberg, went first to Sylt in 1911 and then to Helgoland (Bückmann 1957; Bietz 2004). Thus, the statement of Schellenberg must mean that Hagmeier observed the crab at Helgoland between 1911 and 1927. Sebastian Müllegger (*1886–†1965), founder and head of the former Zoological station of Büsum, recorded the species from the coast of Schleswig Holstein (presumably close to Büsum, as he had received the specimens from local shrimp fishers): 1 specimen caught in the autumn of 1935 and 9 specimens caught in the summer of 1936, the largest one, a male, having a carapace breadth of 11 mm and a carapace-length of 12 mm (Müllegger 1937). Further, a screening of old German collections revealed a small number of specimens:

- 1 dry specimen (ZMB 213) in the Herbst-Collection in the Museum für Naturkunde (Berlin). In Herbst (1790), the origin of the figured specimen is referred to as "Das Vaterland ist der Ocean". In fact, the original label says "Mare Germanicum" which can be translated as either "German seas" or "North Sea", as "Mare Germanicum" was used for the North Sea in the Ptolemean world map and at least into the 1830s (Harper 2001–2012);
- 1 male (ZMB 21970) from the Eastern Frisian Island of Juist collected by Dr. Adolf Fritze of the Provincial Museum of Hannover (today, Landesmuseum Hannover) on July 28, 1905 (see Fritze 1905);
- 1 male (SMF 3673) from the Island of Langeoog, collected in July 1910 by Paul Prior, a member of the Senckenberg Natural Research Society (Mertens 1951);
- 1 male (ZMB 3654) from Helgoland, presumably from the beach of the Dune Island, collected by Magnus. This collector was presumably Paul Wilhelm Magnus, Professor of Botany in Berlin since 1880. Magnus participated in the 1872 North Sea cruise of R/V "Pommeriana" (Lindau 1914). On August 31, 1872, the crew landed at Helgoland for shore collection (Magnus 1875). Later, his student Paul Kuckuck was working at Helgoland after 1892 when the "Biologische Anstalt" was founded (Mollenhauer and Lüning 1988). Most probably the specimen was collected either in August 1872 or during a visit of Magnus to the station between 1892 and 1914 (Magnus died in 1914).
- 2 males (ZMH 25261) from around Büsum, collected by shrimp fishers and received in the collection of the Zoological Museum of Hamburg University in 1936. These might be two of the specimens mentioned by Müllegger (1937, see above). However, slight doubts remain, as Müllegger noted that his largest specimen, a male, had a carapace breadth of 11 mm, whereas the Hamburg specimens measure 18 and 20 mm, respectively.

Since these past times, *P. latipes* has not been recorded from the German coast. Also, the senior author has not personally seen this species during long years of excursions since the early 1970s along the coast of the island of Wangerooge. It became more regular in the early 1990s and has recently been a normal, though not always common, element of the fauna. This development stopped with the hard winter of 2009/2010. In the summers of 2010–2012, no specimens, nor casts, could be found on the sandy beaches of the Eastern Frisian Islands. It therefore seems timely to compile the data gathered during the last 40 years in order to have them as a reference basis for future observations. This is the main aim of the present study.

Materials and methods

All our offshore surveys were conducted on board R/V "Senckenberg", which allowed us to access environments that are otherwise virtually unreachable, the only limit being the vessel's draught of 2.5 m.

Sampling in the ebb delta of Otzumer Balje between the Eastern Frisian Islands, Spiekeroog and Langoog (Fig. 1), occurred between 1990 and 1992. A 0.2-m^2 Van Veen grab and a 0.054-m^2 Reineck type Box corer were used on the ebb delta lobe.

On the central swash bar (Mittelplate) that was directly accessible during low tide, a 0.2-m^2 metal cylinder corer was pushed 30 cm into the sediment, and then removed with the help of a shovel. All gathered sediments were sieved over a minimal mesh size of 500 μ.

Additionally, at each station of the "Mittelplate", tube-shaped filtering devices with a diameter of 110 mm were used to record the drift-fauna within the water column. This newly developed gear was called a "MeroPlankton-Tube" (MPT) ("Meroplankton-Rohr" in German; see Stecher 1999). Both tubes were oriented in a horizontal direction and were attached 50 cm above the bottom to a rod anchored in the sediment. At each station, two MPT units were used and their openings were manually adjusted to the main flood- and ebb-current directions; thus, they caught fauna drifting in or out, respectively. The macrofauna obtained through both methods was preserved in 4 % formalin-

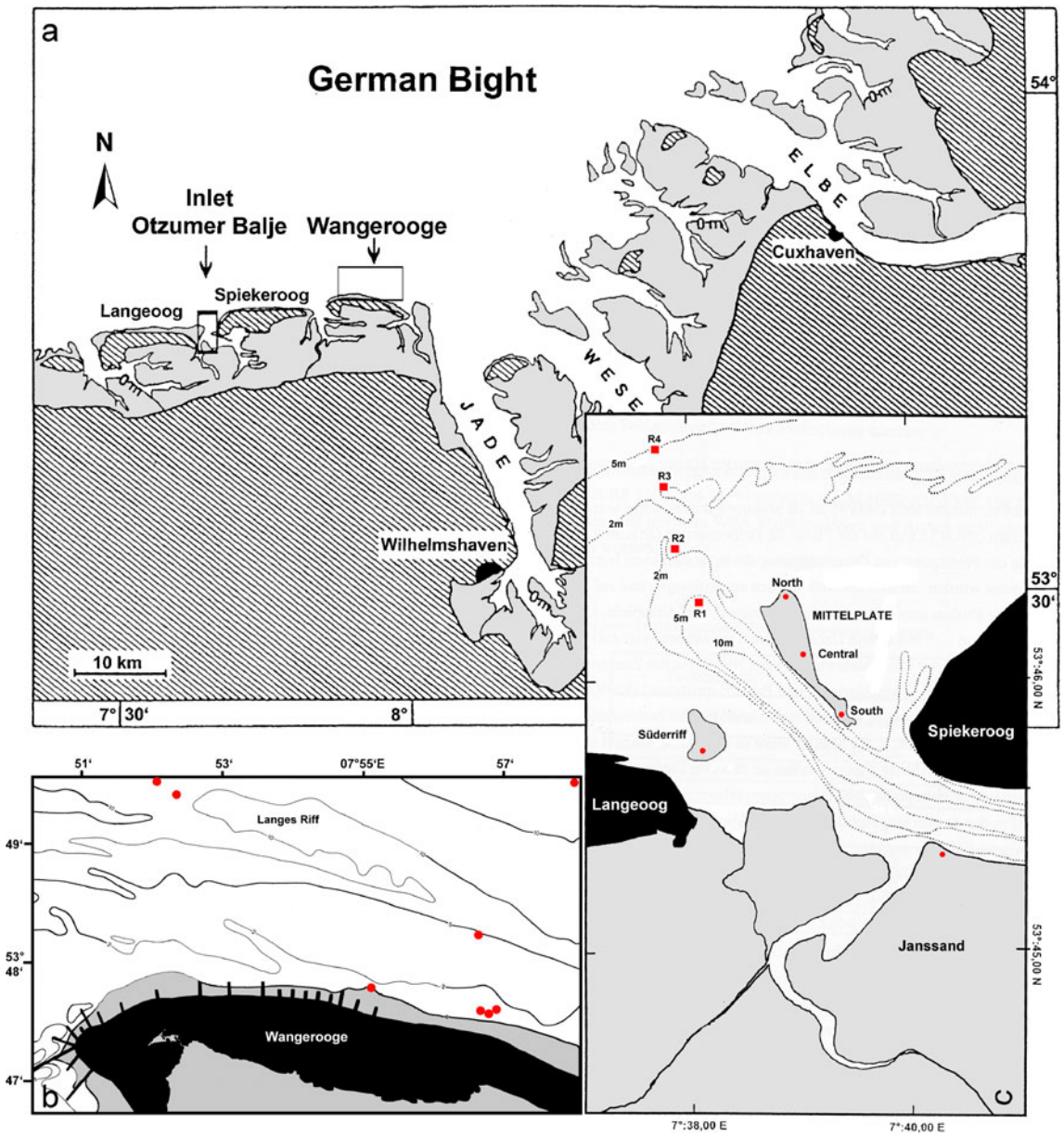

Fig. 1 Position of research stations. **a** Geographical setting of research area (from Stecher 1999, modified); **b** research area around Wangerooge with position of respective research stations; **c** detail of Otzumer Balje with position of the respective collecting stations (from Stecher 1999, modified)

seawater and taken back to the laboratory for further analysis (Stecher 1999).

In the area of Wangerooge (Fig. 1), beach collecting has been regularly undertaken since the 1980s with occasional sampling in the 1970s. The offshore stations have been sampled since 2002 with either a 2-m beam trawl with a minimum mesh size of 1 × 1 cm in the cod end (stations on Langes Riff) or with a ring dredge (remaining stations) as described by Gustafson (1934). The specific method of our sampling has been described by Türkay (2011). All the collected specimens were preserved in buffered 4 % formalin–seawater and taken back to the laboratory for further analysis.

All specimens were sexed and their carapace length (CL) and width (CB) were measured.

Results

As can be seen from the list of the collected specimens (Table 1), there was a regular offshore occurrence of the crab in the early 1990s. In this period, the species did not reach the beaches. An onshore expansion can be observed since at least 2003 when the first specimen was collected on the beach of Wangerooge. Since then, the number of

Table 1 The Pennant's swimming crab (*Portumnus latipes*) material examined

SMF	Number	Locality	Latitude	Longitude	Depth (m)	Gear	Date
3673	1 ♂	Langeoog			Beach		07.1910
30664	1 ♂	Norderney, off N-coast	53° 43.858′N	7° 13.716′E	1.2	RD	23.05.2005
22152	1 ♂	S'oog, NE part of Jahnssand	53°44.2′N	7°41.7′E	4.5	BMT	17.03.1993
21154	1 ♂; 1 ♀	S'oog, OB, MP, N-profile	53° 46.68′N	7° 38.89′E	Intertidal	CY	15.08.1991
21155	1 juv	S'oog, OB, MP, N-profile	53° 46.68′N	7° 38.89′E	Intertidal	CY	21.08.1991
21156	3 juv	S'oog, OB, MP, N-profile	53° 46.68′N	7° 38.89′E	Intertidal	CY	21.08.1991
21157	1 ♂	S'oog, OB, MP, S-profile	53° 45.72′N	7° 39.34′E	Intertidal	CY	14.08.1991
21159	1 ♀	S'oog, OB, MP, S-profile	53°45.72′N	7° 39.34′E	Intertidal	CY	19.05.1991
28072	1 ♂ cast	S'oog, OB, MP North	53° 46.68′N	7° 38.89′E	Intertidal	CY	03.06.1992
28066	3 juv	S'oog, OB, MP North 1	53° 46.68′N	7° 38.89′E	Intertidal	CY	19.07.1992
28067	1 juv	S'oog, OB, MP North 1	53° 46.68′N	7° 38.89′E	Intertidal	CY	16.12.1992
28068	1 juv	S'oog, OB, MP North 1	53° 46.68′N	7° 38.89′E	Intertidal	CY	22.07.1993
28069	1 juv	S'oog, OB, MP North 2	53° 46.68′N	7° 38.89′E	Intertidal	CY	03.06.1992
28070	1 juv	S'oog, OB, MP North 2	53° 46.68′N	7° 38.89′E	Intertidal	CY	16.12.1992
28071	1 juv.	S'oog, OB, MP North 2	53° 46.68′N	7° 38.89′E	Intertidal	CY	19.07.1993
	1♀ 1 cast	S'oog, OB, MP, South	53° 45.72′N	7° 39.34′E	Intertidal	CY	19.07.1993
28086	1 Larve	S'oog, OB, MP	53°46.19′N	7°39.09′E	Intertidal	MPT	04.06.1993
28087	1 juv	S'oog, OB, MP	53°46.19′N	7°39.09′E	Intertidal	MPT	19–20.7.1993
28088	1 cast	S'oog, OB, MP North	53° 46.68′N	7° 38.89′E	Intertidal	CY	20.07.1993
28073	11 casts	S'oog, OB, MP, Central	53° 46.19′N	7° 39.09′E	Intertidal	CY	03.06.1992
28074	1 cast	S'oog, OB, MP, Central	53° 46.19′N	7° 39.09′E	Intertidal	CY	05.06.1992
28075	1 ♂; 2 ♂ casts	S'oog, OB, MP, Central	53° 46.19′N	7° 39.09′E	Intertidal	CY	24.06.1992
28080	35 casts	S'oog, OB, MP, Central	53° 46.19′N	7° 39.09′E	Intertidal	CY	20.07.1993
28081	2 juv	S'oog, OB, MP, Central 1	53° 46.19′N	7° 39.09′E	Intertidal	CY	22.07.1993
28079	1 juv	S'oog, OB, MP, Central Ma3	53° 46.19′N	7° 39.09′E	Intertidal	CY	12.08.1992
28076	1 ♀	S'oog, OB, MP, Central Mb1	53° 46.19′N	7° 39.09′E	Intertidal	CY	02.07.1992
28077	1 ♀	S'oog, OB, MP, Central Mb2	53° 46.19′N	7° 39.09′E	Intertidal	CY	31.08.1992
28078	1 Larve	S'oog, OB, MP, Central Mb2	53° 46.19′N	7° 39.09′E	Intertidal	CY	31.08.1992
28082	1 juv	S'oog, OB, MP, South 1	53° 45.72′N	7° 39.34′E	Intertidal	CY	22.07.1993
28081	2 juv	S'oog, OB, MP, Central	53° 46.19′N	7° 39.09′E	Intertidal	CY	22.07.1993
28070	1 juv	S'oog, OB, MP North	53° 46.68′N	7° 38.89′E	Intertidal	CY	22.07.1993
28083	1♀, 1 cast	S'oog, OB, MP, South 2	53° 45.72′N	7° 39.34′E	Intertidal	CY	19.07.1993
28084	1 ♀	S'oog, OB, MP, South 3	53° 45.72′N	7° 39.34′E	Intertidal	CY	02.07.1992
28085	1 ♀ cast	S'oog, OB, MP South	53° 45.72′N	7° 39.34′E	Intertidal	CY	20.07.1993
28089	1 juv	S'oog, OB, Riffbogen 2a	53° 47′N	7° 37.9′E	4.5	BC	18.09.1992
28090	1 juv	S'oog, OB, Riffbogen 3c	53° 47.45′N	7° 37.85′E	4.5	BC	10.08.1992
28091	1 juv.	S'oog, OB, Riffbogen 3c	53° 47.45′N	7° 37.85′E	4.5	BC	10.09.1992
21158	1 juv	S'oog, OB SR,S-profile	53°45.4′N	7°38.3′E	Intertidal	CY	26.07.1991
33387	4 ♂	W'ooge, Langes Riff	53° 49.454′N	7° 52.087′E	12.4–15.4	BMT	29.07.2008
38282	1 ♀ ovig.	W'ooge, Langes Riff	53° 49.673′N	7° 51.737′E	11.5–13.7	BMT	02.07.2010
29346	1 ♂	W'ooge, N coast	53°47.46′N	7°55.09′E	Beach		22.05.2003
31837	7 ♂; 3 ♀; 2 ov. ♀	W'ooge, N coast	53°47.46′N	7°55.09′E	Beach		09.06.2007
31842	2 ♂	W'ooge, N coast	53°47.46′N	7°55.09′E	Beach		02.09.2006
30682	1 ♂	W'ooge, off N-coast	53° 47.494′N	7° 56.901′E	0.3	RD	30.05.2005
30683	1 ♂	W'ooge, off N-coast	53° 47.444′N	7° 56.998′E	0.6	RD	30.05.2005
30684	2 ♂	W'ooge, off N-coast	53° 47.444′N	7° 56.998′E	0.6	RD	30.05.2005
30732	1 ♀; 1 fragm.	W'ooge, off N-coast	53° 47.5′N	7° 56.86′E	0.5	RD	30.05.2005
30733	5 ♂; 4 fragm.	W'ooge, off N-coast	53° 47.444′N	7° 56.998′E	0.6	RD	30.05.2005
41048	1♀	W'ooge, off N-coast	53° 49.64′N	7° 57.66′E	6.8	RD	12.08.2004
41049	1♀	W'ooge, off N-coast	53° 48.23′N	7° 56.8′E	9.8	RD	12.08.2004

BC Box-corer, *BMT* beam trawl, *CY* cylinder corer, *MP* Mittelplate, *MPT* Meroplankton-Tube, *OB* Otzumer Balje, *RD* ring dredge, *S'oog* Spiekeroog, *SMF* Senckenberg-collection catalogue number (if missing, specimens have not been preserved), *SR* Süderriff, *W'ooge* Wangerooge; for the geographical terms, refer to Fig. 1

specimens has been increasing, and casts have also been frequently found. This development stopped after the severe winter of 2008/2009. However, this did not seem to affect the offshore populations, as specimens could be collected after that on Langes Riff.

Sexes are evenly distributed within the samples. The correlation between the carapace length and carapace breadth is linear so that no allometric growth seems to occur in this species (Fig. 2). An analysis of the size differences in males and females yielded no significant results. The box-whisker plot (Fig. 2) shows a slight difference in the medians and the size range, suggesting that males might be larger than females. A *t* test, however, resulted in no significant differences (0.128 for the probability assuming the null hypothesis). Ovigerous females are among the largest females (minimum ovigerous female size: CB: 19.3 mm, largest ovig. female with a CB of 21.9 mm, non-ovigerous females having a CB of 10.2–23.4 mm).

Discussion

The present records of Pennant's swimming crab along the German North Sea coast confirm the environmental preferences published in the former literature. All locations are high-energy sandy beaches and foreshores strongly influenced by surf and tidal currents. It seems that, in winter, and especially in cold winters, the species migrates offshore and comes back in spring when and if the environmental conditions allow. However, there has been no detailed study of this behaviour or the exact conditions under which the movements occur.

Much clearer is the correlation with temperature. Loewe et al. (2009) have described the temperature shift in the southern North Sea as discontinuous process, characterised by warm and cold periods. This is well illustrated in their fig. 3–23, where the sudden move towards a warm regime is illustrated for the period following 1990 and a next step is taken in 2000. The 1990 regime shift, also well documented in other parts of the North Sea, starting earlier in more southern and western areas (see Weijerman et al. 2005), agrees perfectly with our results, revealing high abundances of the species in the ebb delta Otzumer Balje and the subsequent movement towards the shore after 2000.

It is not only this coincidence that confirms the temperature-driven occurrence of the species on the German coast. Temperature regime changes, although not as dramatic as the recent ones, seem to have also governed the past development at least since the late nineteenth century when measurements exist. Wiltshire and Manly (2004) have published curves of the past temperature series of Helgoland Roads from the late 1870s on. Here, also, clear ups and downs can be seen and, thus, the existence of earlier pulses of regime shifts are evident. According to this presentation, temperatures were dropping from the 1870s, coming from an earlier unknown higher level. The first records of *Portumnus* by Hartmann (1855) and Riefkohl (1861) are in the period at and after 1855 and presumably come from this warm period, as does that of Metzger (1871). Again, a temperature rise (from an unknown lower level) is seen in the years before and around WW1. This coincides with the records of Arthur Hagmeier from Helgoland and the specimens collected by Magnus at Helgoland (see above), but also with the specimens from Juist (Fritze 1905) and from Langeoog in the Senckenberg Collection (see above). A next temperature high roughly between 1932 and 1939 coincides with the records of Müllegger (1937). These highs and lows of temperature, corresponding to the occurrence of *P. latipes*, are also evident in the surface temperature curves of the Mars Diep at the southern end of the Dutch Wadden Sea published by van Aken (2008). Slight differences may be due to the much more southern location as compared to Helgoland, resulting in a more steady influence of English Channel water.

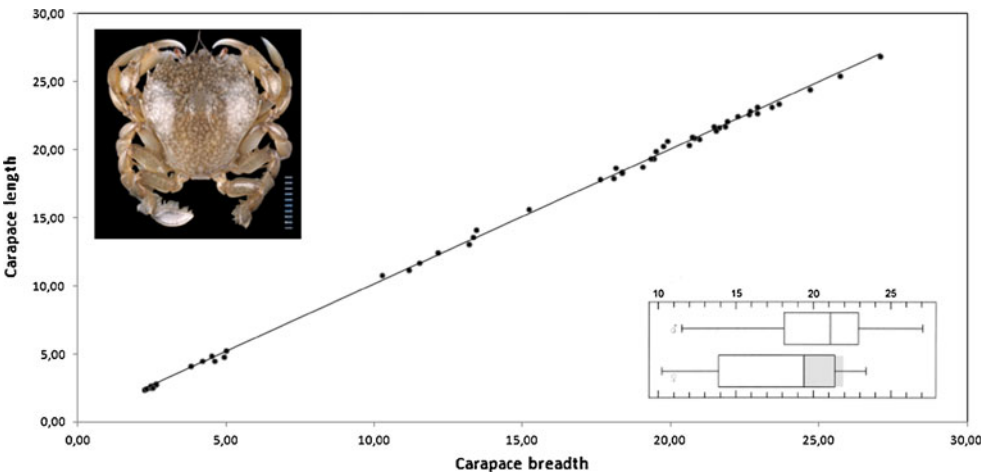

Fig. 2 Carapace breadth versus carapace length in the Pennant's swimming crab (*Portumnus latipes*) material examined (see Table 1), *upper left* a specimen from Langes Riff (off Wangerooge); *lower right* box-whisker plot of carapace breadth comparing males and females of the material examined (see Table 1), with size range of ovigerous females *shaded*

These rough correlations suggest that the appearance of *P. latipes* on the German coast is temperature driven and can be used as a further indication for maritime climate change processes. It is also clear that exact knowledge and detailed monitoring of the marine fauna is far from being just a matter of basic knowledge, it is in contrast necessary for understanding environmental change processes and their effect on the biosphere.

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