3.3 Looking for *Mnemiopsis leidyi* in Dunkirk Harbour (Southern North Sea, France)

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Background

Dedicated efforts to investigate the presence of *Mnemiopsis leidyi* in the French harbours of the Eastern English Channel and Southern North Sea were initiated during the 2010–2013 MEMO Project funded by the EU Interreg-2seas- IVa programme. During this time period the presence of *M. leidyi* was confirmed in several locations (see Antajan *et al.*, 2014, and contribution in the present volume). In Dunkirk, the only French industrial harbour of the North Sea, the presence of the species was confirmed from September to November 2012 by weekly sampling efforts in a basin (Forme 4) from the eastern harbour. The presence of *M. leidyi* in this area and more specifically the perspective of possible bloom events, led local coastal industries to fund a dedicated environmental monitoring programme to assess the risk of water intake clogging by gelatinous plankton in Dunkirk industrial harbour (i.e. in the western harbour).

Methods

Since April 2013, three stations located within Dunkirk Western Harbour have been sampled twice a month from April to October and once a month from November to March. Station 1 is located at the entrance of the harbour (outer harbour) and allowed to consider species tidal introduction from the North Sea, station 2 is located at the limit between the outer and inner harbour so as to integrate possible mixing between inner and outer populations, and station 3 is located in the inner port, at the entrance of the canal linking the western and eastern harbours (Figure 1). Since May 2014, a fourth station has been added to the sampling programme to investigate the existence of possible retention zones in the most sheltered part of the harbour.

Gelatinous plankton and other macro-plankton are sampled using a WP3 plankton net (1m² opening, 1 mm mesh size) towed for 10 min from surface to near bottom depth in undulating movements. A WP2 plankton net (0.25 m² opening, 200 µm mesh size) towed from surface to near bottom depth in oblique tow is used to sample mesozooplankton and thus, to consider potential preys of gelatinous plankton.

WP3 samples are brought back alive to the lab 2–3 hours after sampling. At laboratory, gelatinous plankton is sorted, identified, counted and measured alive (umbrella diameter for cnidarians and oral-aboral length for ctenophores) under a stereomicroscope. The rest of the WP3 catch is fixed in 4% formalin and stored until analysed (i.e. sorting and counting of other macroplankton components). WP2 samples are visually inspected on board for the presence of ctenophores (especially *Mnemiopsis leidyi*) before being preserved in 4% formalin. All fixed samples are analysed within 9–12 months after collection.

A multiparametric probes (YSI 6600V2) is used to measure temperature, salinity, pH, turbidity, concentration of dissolved O_2, and *in-situ* fluorescence profiles at each sampling station. 2L of water are sampled within 2 m depth with a Niskin bottle for further chlorophyll *a* analyses.

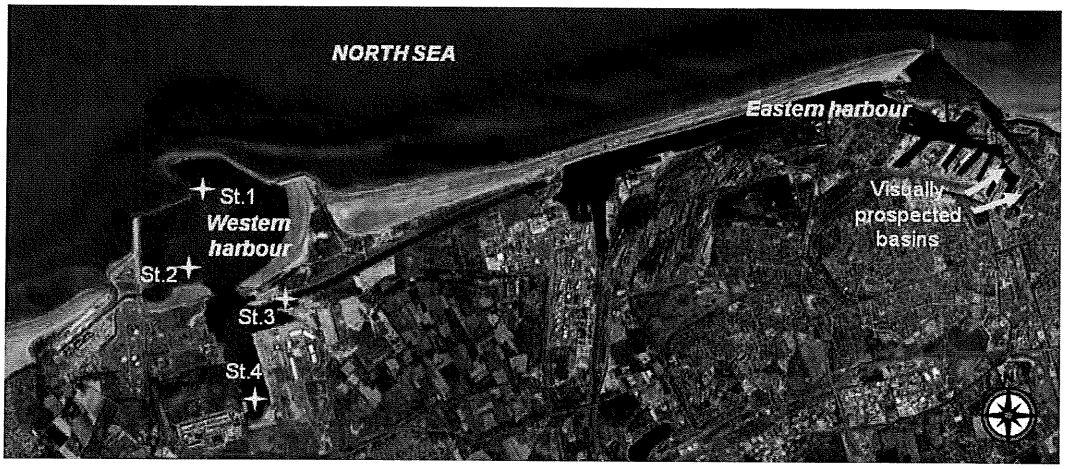

Figure 1. Location of sampling stations in Dunkirk (France) western harbour and of the visually prospected basins in Dunkirk eastern harbour.

Results

In 2013, *Mnemiopsis leidyi* has only been observed in Dunkirk Western Harbour from September to December. The first individuals observed already measured 32 mm (oral-aboral length). So far, only small abundances have been recorded (Table 1), with a maximum of 0.02 ind. m^{-3} corresponding to 6 individuals caught in a 10 min WP3 haul in mid-October 2013. The same day, 4 *Mnemiopsis leidyi* were caught in a single oblique WP2 haul, which led to an estimate abundance of 0.32 ind. m^{-3}, i.e. one order of magnitude higher, highlighting the difficulty to get reliable abundance estimates for low abundances.

Two other ctenophore species were present in Dunkirk Western Harbour: *Pleurobrachia pileus*, which is by far the most abundant one, and *Beroe* sp. which was infrequently present in samples, always at low abundance.

The environmental conditions between year 2013 and 2014 differed quite a lot, with a noticeably cold late winter-early spring in 2013 compared to 2014, leading to 5.6°C higher temperatures in late April 2014 compared to the same date in 2013. The presence of *Mnemiopsis* in autumn and early winter coincided with water temperature from 17.2 to 9.8°C and salinity from 34.5–33.5 (Figure 2).

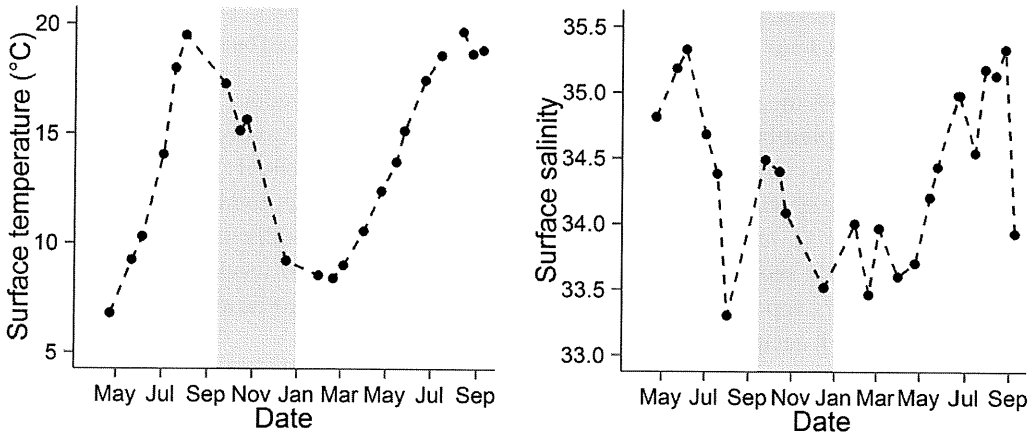

Figure 2. Seawater surface temperature and salinity in Dunkirk Western Harbour (Station 1) from April 2013 to September 2014. The shaded area indicates the period of *Mnemiopsis leidyi* presence.

Table 1. Abundance of *Mnemiopsis leidyi* and other ctenophore species in Dunkirk Western harbour in 2013 and 2014.

	Mnemiopsis leidyi			*Beroe sp.*			*Pleurobrachia pileus*		
	St.1	St.2	St.3	St.1	St.2	St.3	St.1	St.2	St.3
23-apr.-13	0.00	0.00	0.00	0.00	0.00	0.003	0.13	0.36	0.43
6-may-13	0.00	0.00	0.00	0.01	0.02	0.13	0.24	**0.46**	**1.15**
22-may-13	0.00	0.00	0.00	0.01	0.00	0.00	0.49	0.24	0.80
5-jun.-13	0.00	0.00	0.00	0.00	0.00	0.00	**0.88**	0.29	0.89
20-jun.-13	0.00	0.00	0.00	0.00	0.03	0.04	0.03	0.07	0.47
3-jul.-13	0.00	0.00	0.00	0.00	0.01	0.01	0.09	0.39	0.32
19-jul.-13	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.03
2-aug.-13	0.00	0.00	0.00	0.01	0.04	0.01	0.01	0.01	0.01
29-aug.-13	0.00	0.00	0.00	0.00	0.002	0.01	0.00	0.05	0.03
25-sep.-13	0.01	*	0.00	0.00	0.00	0.00	0.04	0.01	0.01
15-oct.-13	*	*	*	0.00	0.00	0.00	0.03	0.03	0.01
24-oct.-13	0.01	0.02	0.02	0.00	0.00	0.00	0.07	0.08	0.02
17-dec.-13	0.00	*	0.003	0.004	0.002	0.004	0.07	0.03	0.06
30-jan.-14	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.001	0.001
19-feb.-14	0.00	0.00	0.00	0.00	0.00	0.00	0.003	0.04	0.03
5-mar.-14	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.02
18-mar.-14	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.002	0.00
1-apr.-14	0.00	0.00	0.00	0.00	0.004	0.002	0.02	0.06	0.09
25-apr.-14	0.00	0.00	0.00	0.002	0.01	0.03	0.86	0.22	6.51
13-may-14	0.00	0.00	0.00	0.00	0.00	0.00	**10.67**	**53.30**	**12.88**
26-may-14	0.00	0.00	0.00	0.00	0.00	0.00	4.14	1.40	11.58
23-jun.-14	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.67	0.95
15-jul.-14	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.23	0.02
29-jul.14	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.23	0.36
13-aug.-14	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.23	0.55
26-aug.-14	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.16	0.21

9-sep.-14	0.00	0.00	0.00		0.00	0.00	0.00		0.62	0.13	0.17

*** *M. leidyi* not present in WP3 net (used to estimate abundances) but caught in WP2 net.**

Post-meeting addendum: *Mnemiopsis* was observed in Dunkirk West at the end of September 2014 by E. Antajan (0.04 to 0.09 ind. m^{-3}, corresponding to 9 and 2 individuals caught in a Bongo net and a WP2 net respectively), confirming the presence of the species in the area for the year 2014. The 30th September 2014, a visual prospection for *M. leidyi* was conducted in the basins of Dunkirk eastern harbour. No *M. leidyi* were seen despite good visibility conditions. Two weeks later, in early October, divers reported having observed the species in large numbers in the same area (Dunkirk eastern harbour).

Discussion

The temporary autumnal presence and the small abundances recorded in Western Dunkirk Harbour in 2013 and so far in 2014 contrasted with what was observed the same years in neighbouring regions of the North Sea (e.g. Spuikom at Oostende, Belgium) as well as in some regions of the Eastern English Channel (Le Havre Harbour and Bay of Seine, France) where the species was present throughout summertime and sometimes in very high numbers (L. Vanstenbrugge, *pers. comm.*). This logically raises questions on the origin of the animals observed in Dunkirk Harbour. As previously discussed by Antajan *et al.*, (2014) it is thought that Dunkirk Harbour *Mnemiopsis leidyi* population behaves as a sink population depending on seasonal re-inoculation. This is supported by the absence of organisms in the samples collected the rest of the year, including in areas of the inner harbour which were *a priori* identified as potential sheltered zones where *M. leidyi* could reproduce and maintain a permanent population. The hypothesis of re-inoculation may be further supported by the fact that the first recorded individuals measured >30 mm and >50 mm in 2013 and 2014 respectively (i.e. relatively big individuals). However, what is known from local current patterns would suggest that a spread of *M. leidyi* into Dunkirk Harbour from neighbouring areas is unlikely (Antajan *et al.*, 2014).

A serious limitation in the sampling protocol is the fact that plankton tows would not sample individuals that may form near-bottom discrete aggregations (Costello and Mianzan 2003). This question should be investigated with direct observations by divers or using imaging systems (video or camera).

A last point that deserves to be considered is the difficulty to reliably measure the abundance of the species when occurring in low numbers. As highlighted in results, sampling with Bongo, WP3 and WP2 nets lead to very different abundance estimates.

Conclusion

Mnemiopsis has been present for at least 3 consecutive years in Dunkirk harbour, but only during the autumn and early winter. Analysis of the rest of the data collected during the environmental monitoring program of the harbour (i.e. zooplankton abundance, chlorophyll *a* biomass, and abiotic parameters) should provide further insights into the environmental conditions favourable to the presence of this species.

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3.4 Recurrent winter observations of *Mnemiopsis leidyi* swarms in the Southern North Sea

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Introduction

Since the first records of the lobate ctenophore *Mnemiopsis leidyi* (A. Agassiz 1865) in the North Sea in summer 2005 (in Grevelingen, The Netherlands, reported by Faasse and Bahya 2006 and in Nissum Fjord, Denmark, as reported by Tendal *et al.*, 2007), large blooms were regularly observed in estuaries and along coastal regions of the eastern and southern North Sea. Most of these *M. leidyi* records occurred during summer and autumn when temperature was comprised between 10 to 23°C. Some authors pointed out that winter temperature conditions in the North Sea may not favour *M. leidyi* survival (Boersma *et al.*, 2007), even in a shallow seaway (Riisgård *et al.*, 2011). Whereas *M. leidyi* is found in an extremely wide range of environmental conditions in its native habitat of the Atlantic coast of North and South America (temperature of 2–32°C; Purcell 2001), the species does not survive at temperatures lower than 4°C in the Black Sea (Shiganova *et al.*, 2001) and lower than 2°C in the subarctic Baltic Sea (Viitsalo *et al.*, 2008). Faasse and Bayha (2006) suggested that estuaries may serve as temperature refuge areas allowing *M. leidyi* to over-winter in the North Sea. Here we report on the recurrent observations of *M. leidyi* swarms surviving off shore in the southern North Sea during winter.

Methods

The study was carried out on regular International Bottom Trawl Surveys (IBTS; ICES 2010) on board the R/V Thalassa in January and February from 2009 to 2014. Sampling effort extended from the eastern English Channel to latitudes up to 56°N. *Mnemiopsis leidyi* were identified, counted and measured alive from samples collected at night with a Midwater Ring Net designed for fish larvae sampling (black conical net of 13 m in length, opening diameter 2 m, mesh size 1.6 mm except the last meter and the cod-end for which the mesh size is 500 µm). The haul profile is oblique, and the fishing speed of 3 knots, for at least 10 minutes. *Mnemiopsis leidyi* were measured for length (aboral-oral dimension) and assigned to size classes to the closest 0.5 cm. Morphological identification of *M. leidyi* was based on the position of the oral lobes extending to the apical statocyst (sense organ) over nearly the entire body length (Antajan *et al.*, 2014). To confirm morphological identifications some ctenophore specimens were preserved in 99% alcohol every year since 2011 for further DNA analysis according to the method describe in Van Ginderdeuren *et al.*, (2012; see superscript in