

## References

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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 Bahia 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

Annex). Temperature and salinity profiles were recorded at each sampling station using an SBE-19plus.

**Results**

In 2009, we had the surprise to discover numerous individuals (up to 782 in one trawl) of *M. leidy* in Midwater Ring Net samples that were sorted alive on board immediately after sampling for fish larvae study. Since then, recurrent patches of *M. leidy* were observed off the Danish and the Netherlands coasts and in the German bight during winter IBTS surveys (Figure 2). Few individuals were also recorded in the central region of the southern North Sea, but never off the English coast and in the eastern English Channel. Genetic analysis carried out since 2011 on some stations confirmed the morphological identification of the ctenophores as *M. leidy*. The abundance of *M. leidy* ranged from 0.12 to 456.13 ind.·1000m<sup>3</sup> over the six years. At stations where *M. leidy* occurred, temperature ranged between 1.2 and 7.5°C and salinity between 27.1 and 35.1 (Figure 2).

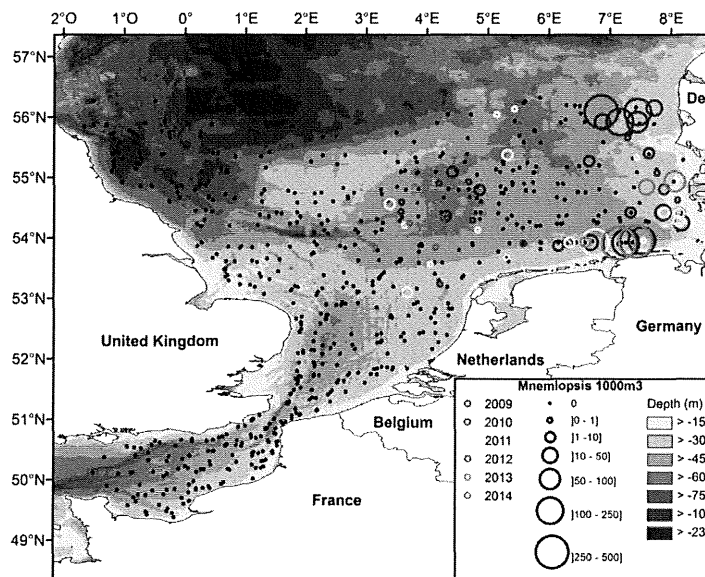


Figure 1. Distribution of *Mnemiopsis leidy* (ind. 1000 m<sup>3</sup>) overwintering in the southern North Sea from 2009 to 2014 and bathymetry of the studied area.

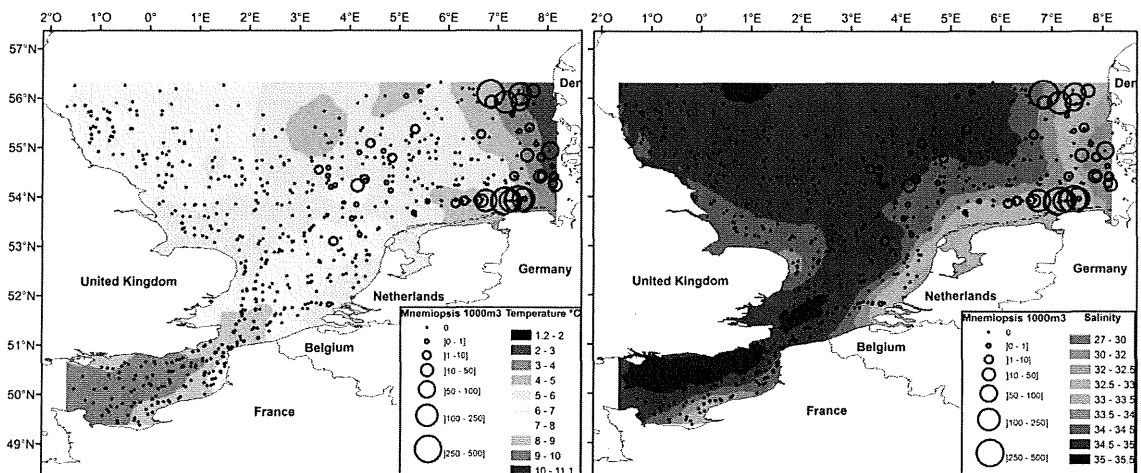


Figure 2. Interpolated temperature (left) and salinity (right) during January-February from 2009 to 2014 in the southern North Sea with distribution of *Mnemiopsis leidyi* (ind. 1000 m<sup>-3</sup>).

All *M. leidyi* collected were lobate individuals, and their oral-aboral length was most often of 2 or 3 cm, even though some individuals could reach 7 cm (figure 3).

### Discussion

The present study demonstrated that *M. leidyi* is capable of surviving off shore in the North Sea during winter even at temperatures less than 2°C. Highest densities (> 100 ind.·1000m<sup>3</sup>) were clearly observed in the colder and desalinated waters off the Wadden Sea and induced mainly by the Rivers Rhine and Elbe run-off which are the most relevant sources of freshwater for the German bight. However the densities observed were much lower than what could be observed in the Wadden Sea (up to 500 ind. m<sup>-3</sup> in summer, van Walraven *et al.*, 2013). In 2012 and 2014, few individuals were observed, and many seemed much degraded (comb-rows of cilia and lobes damaged), while other years individuals were in good state with sometime visible prey in their gut. Additional studies are needed to understand in what physiological state are individuals observed in winter, if they are food-limited and if they are able to survive winter conditions in the North Sea.

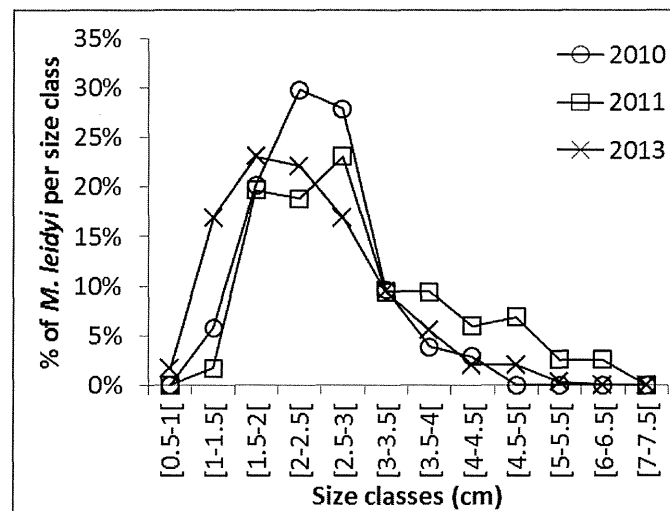


Figure 3. Percentage of *Mnemiopsis leidyi* per size classes (cm) and per year in the southern North Sea in winter.

The Midwater Ring Net was particularly useful as it allows filtering a large amount of water (about 4000 m<sup>3</sup>) to observe the presence of isolated ctenophores. The downside is that *M. leidyi* can be badly damaged after a tow of 10 minutes or more, and it is not always easy (even impossible) to rinse a net of 13 m length once on board. The result is an underestimation of the *M. leidyi* abundance that it must be corrected by using other type of plankton nets, such as WP2 or WP3 nets. Preliminary comparisons on few stations during IBTS 2014 have shown that the Midwater Ring Net may underestimates *M. leidyi* abundances by 30% compare to a WP3 net that was also towed for ten minutes (1 m. s<sup>-1</sup>).

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### 3.5 Distribution and size structure of comb jellyfish, *Mnemiopsis leidyi* (Ctenophora) in Izmit Bay during mucilage event

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**Keywords:** *Mnemiopsis leidyi*, mucilage, Izmit Bay, the northeastern Marmara Sea

#### Abstract

The Marmara Sea has a rather complex hydrological system, in a zone of transition between dense (salinity 37–38.5 ‰) and warmer waters originating in the Mediterranean Sea, and cold, lower-salinity water (20–22 ‰) coming from the Black Sea and