3.6 *Mnemiopsis* in the Berre Lagoon, what are the main triggers for its expansion?

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Introduction

Thousands of marine species are moved around yearly due to human activities either deliberately or not into areas where they are not indigenous. Among these introduced or alien species only a few, then called invasive species, thrive in their new environment, impacting biodiversity, ecosystem functioning and human activities (i.e. fisheries, industrial complex, and tourism). These invasive species see their population rapidly increase in their new habitat, where no or very little natural controls exist (i.e. predators, parasites), reaching densities out of control. Among invasive jelly species, the invasive success history of the ctenophore *Mnemiopsis leidyi* in most European waters since the 1980s offers a unique opportunity to study population dynamics and dispersal. Two main invasion pathways have been identified for *M. leidyi* introduction into Eurasia: the first via the Gulf of Mexico into the Black Sea; the second via the East Coast of the USA into the North and Baltic Seas. This particularly voracious predator reduces the amount of food available for other predators such as commercially important fish species, thus creating modifications in prey abundance, specific diversity and ecosystem functioning all the way down to bacteria and virus. Understanding the population dynamics of gelatinous zooplankton is thus mandatory to establish their actual role and potential threat in marine ecosystem.

Since 2005, this species has been a resident feature of several coastal lagoons along the French shore of the Mediterranean Sea. An extensive study in the Berre Lagoon has been conducted for the past 4 years on the impact of the environmental conditions on the success of this species. This lagoon is under strict regulation of freshwater and silt inputs going thru the hydro-electrical power plant in the North since 2006. Other limitations in the inputs of chemicals are in place.

Material and methods

Environmental conditions were recorded in continuous at several depths at three stations located in the upper middle and lower part of the main lagoon. Bi-weekly samplings were conducted, using a modified Nansen nets (700 μm mesh size, 2 m long and 75 cm opening area). Nets were towed horizontally for 2 to 5 min. Life stages, size (oral-aboral length) and total weight was recorded.

Results and discussion

Temperatures displayed a clear temperate pattern, with summer values around 26–28°C and winter ones down to 5°C (Figure 1). Regulation in the amount of freshwater inputs applied in 2006 showed a real impact on the salinity minimum of the lagoon, with an increase of about 4 units of salinity between 2009 and 2013. Maximum values varied between 26 and 30 (Figure 1). Winter conditions in 2011/12 and 2012/13 were harsher with lower temperature reaching 0°C and ice developing on the surface of the lagoon in 2011/12 and winter conditions lasting longer than usual in 2012/2013.

Mnemiopsis leidyi appeared in September 2005, but the monitoring started only in January 2010. The invasive species was present year around from 2010 to the beginning of 2012. Even if the lagoon is still showing large variations in salinity, temperatures seem to have a clear impact on the population dynamics. Inter-annual variability in the timing of the bloom of this species appeared strongly impacted by the length and strength of the winter conditions. Very cold winter conditions in early 2012 and 2013 clearly affected the population of *Mnemiopsis* (Figure 1) with no organisms recorded for several months.

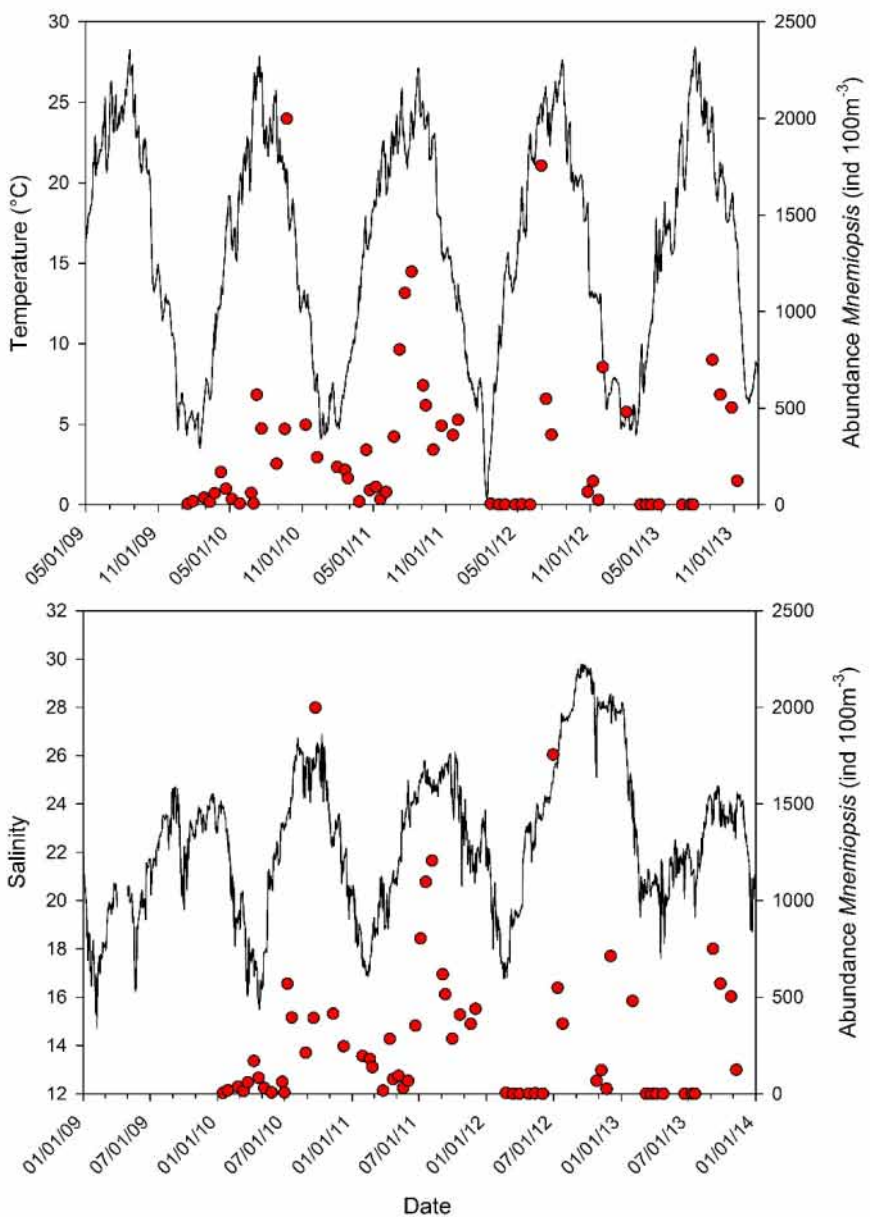

Figure 1. Temperature and salinity variations at Station SA2 from 2009 to 2013. In red circles, abundance (ind. 100m^{-3}) of *Mnemiopsis leidyi* (Thibault *et al.*, in prep).

Maximal abundance (up to 23 ind m^{-3}) of adults are observed at the end of summer (August/September) While several studies have shown that egg production is strongly correlated to temperature, salinity and food availability (Baker and Reeve 1974; Reeve *et al.*, 1989; Jaspers *et al.*, 2011) with optimal conditions: temperature >12°C (Purcell *et al.*, 2001, Costello *et al.*, 2006, van Walraven *et al.*, 2013), salinity 10–30 (Le-

thiniemi *et al.*, 2012) and food > 3 mg C m^{-3} (Kremer 1994; Purcell *et al.*, 2001). But high reproduction is taking place in Berre thru winter as highest numbers of juvenile have been recorded in January-February (Figure 2), when salinity and food availability are within the optimal ranges (Delpy *et al*., submitted).

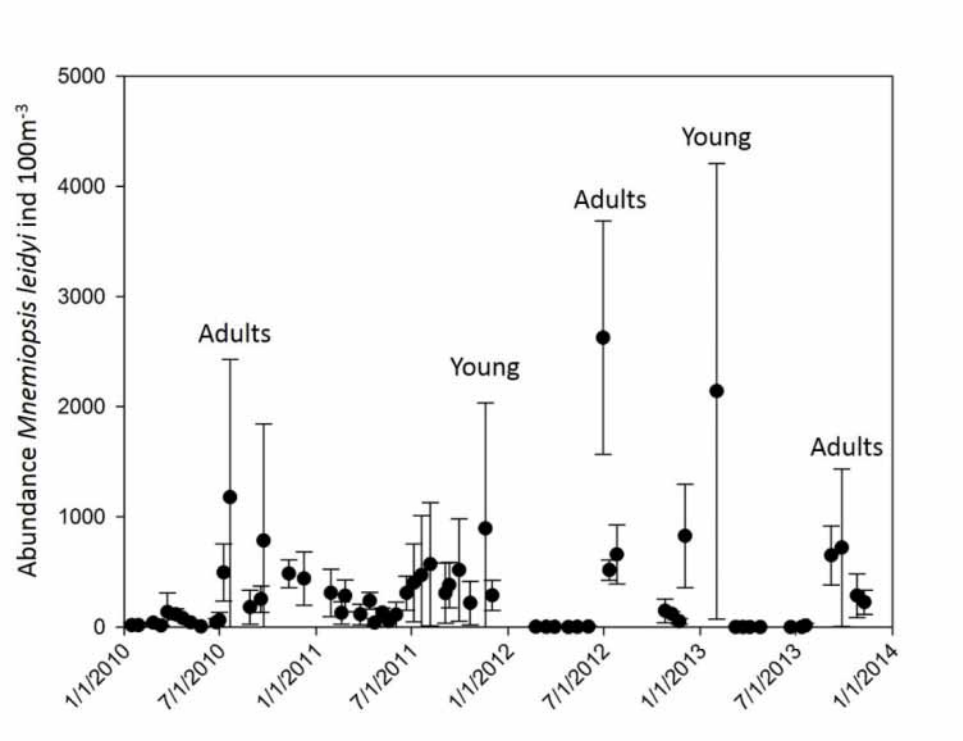

Figure 2. Distribution of *Mnemiopsis* (average +/- stdev) in the Berre Lagoon from 2010 to 2013 (Thibault *et al.*, in prep). Development of continuous massive gelatinous populations, like in Berre which presents a perennial *M. leidyi* population, might in the future transform the pelagic ecosystems functioning and benthic-pelagic interactions.

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3.7 The invasive ctenophore *Mnemiopsis leidyi* in the Spanish Mediterranean coast

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Introduction

The American comb jelly *Mnemiopsis leidyi* is native to estuaries and coastal regions of the Western Atlantic Ocean, from the United States to southern Argentina (Mianzan, 1999). Since the early 1980s, when it was first introduced into the Black Sea, and during the last three decades, it has invaded and expanded to almost all European waters, including the western basin of the Mediterranean Sea. The occurrence of the invasive ctenophore *Mnemiopsis leidyi* in the Spanish Mediterranean coast was reported and genetically confirmed in 2009 at several locations (Catalonia, Alicante, Valencia, Balearic Islands) but disappeared after that summer (Fuentes *et al.*, 2010). One year after, in 2010, the presence of this ctenophore was more evident, mainly in the southern limit of the Catalan coast in the Ebro River Delta, specifically in the Fangar and Alfacs bays, an area with high anthropogenic disturbance but also, with high socio-economic importance due to aquaculture and fishing, and ecological relevance as Natural Park, RAMSAR wetland and European site Natura 2000. The presence and abundance of *M. leidyi* in the Alfacs bay has been a constant since then, becoming more than just an isolated or seasonal fact. Additionally, in 2012, blooms of *M. leidyi* were reported in the Mar Menor lagoon, a hypersaline environment (42.3–45.6 psu). Only adults were registered and the abundance was significantly related to temperature (Marambio *et al.*, 2013a).

Materials and Methods

A monthly monitoring programme was established in the Alfacs Bay at the end of 2010 in order to determine the eco-physiology and population dynamics of the species. Field sampling includes abundance and distribution assessment of *M. leidyi*, analysis of the zooplankton community together with environmental parameters (i.e.: temperature, salinity, chlorophyll-a, dissolved oxygen, nitrate and phosphate). Environmental variables were correlated to the abundances of the species using GAM models. The data available of the occurrence in the Mediterranean Sea was used to predict potential establishment areas for *M. leidyi* in the whole Mediterranean basin, based on an Ensemble modelling approach.

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