Aquatic Invasions (2007) Volume 2, Issue 3: 185-189
DOI 10.3391/ai.2007.2.3.5
© 2007 The Author(s)
Journal compilation © 2007 REABIC (http://www.reabic.net)
This is an Open Access article

**Research article**

# The presence of the ctenophore *Mnemiopsis leidyi* in the Oslofjorden and considerations on the initial invasion pathways to the North and Baltic Seas

Otto M. P. Oliveira
*Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, R. Matão, Trav. 14, 101, 05508-900, São Paulo, SP, Brazil and Centro de Biologia Marinha, Universidade de São Paulo, Rodovia Manoel H. do Rego km 131,5, 11600-000, São Sebastião, SP, Brazil*
*Email: ottompo@usp.br*

Received 22 May 2007; accepted in revised form 8 August 2007

## Abstract

The ctenophore *Mnemiopsis leidyi* is one of the most cited invasive species due to its ecological and economical impact that occurred in the Black and Caspian Seas in previous years. Recent reports on the species presence in the Baltic and North Seas alarmed the scientific community. While the earliest report of *M. leidyi* in the Baltic was spring 2006, this paper indicates of the presence of *M. leidyi* in the Oslofjorden as early as autumn 2005, and discusses the possible invasion routes from its native range along the eastern coast of the Americas.

*Key words:* Ctenophora, invasive species, ballast water, North Atlantic Current, transoceanic spread

## Introduction

*Mnemiopsis leidyi* A. Agassiz, 1865 is a lobate ctenophore, originally distributed along the American coast of the Atlantic, from Narragansett Bay, USA (41°N) to the Valdez Peninsula, Argentina (42°S) (GESAMP 1997). The species is a simultaneous hermaphrodite, able to perform self-fecundation (Oliveira and Migotto 2006) and can live and reproduce in a wide salinity and temperature range (Baker and Reeve 1974, GESAMP 1997), inhabiting both coastal and estuarine waters (GESAMP 1997). Feeding mainly on copepods, fish eggs and larvae (Burrell and Van Engel 1976), *M. leidyi* populations rapidly grow when food is abundant (cf. Purcell et al. 2001).

In the early 1980's, *M. leidyi* was introduced in the Black Sea, possibly transported from its native area in ships ballast water (cf. GESAMP 1997). Due to suitable living conditions in the receiving environment (food abundance and a physical environment similar to the estuaries in the native region), populations established and grew in the Black Sea (Purcell et al. 2001, Shiganova et al. 2001). The absence of potential predators and the favorable environmental conditions allowed *M. leidyi* to spread along the Black Sea and adjacent areas, as the Azov, Marmara and northeastern Mediterranean Seas (GESAMP 1997, Shiganova et al. 2001, Kideys 2002). The invasion of the Caspian Sea occurred in the mid of the 1990's. The species was likely transported in ballast water through the Volga-Don Channel (Kideys 2002, Bilio and Niermann

2004). Population explosions in the Black Sea were observed in 1989 and 1995 (Shiganova et al. 2001), a time period when fisheries of anchovies drastically decreased in the area, apparently due to trophic competition and feeding on eggs and larvae by *M. leidyi* (GESAMP 1997). Overfishing and increased water pollution have also contributed to the decline of the Black Sea fisheries.

In the late 1990's, another ctenophore, *Beroe ovata* Chamisso & Eysenhardt, 1821 (a natural predator of *M. leidyi*), was accidentally introduced to the Black Sea. Its predatory behavior resulted in a biological control of the *M. leidyi* population and an environmental equilibrium (Shiganova et al. 2001, Kideys 2002). Nowadays, *M. leidyi* populations are still affecting the environmental equilibrium in the Caspian Sea, due to the absence of the predator *B. ovata* there (Stone 2005).

The recent reports on the *M. leidyi* presence in the Baltic (Javidpour 2006, Hansson 2006, Kube et al. 2007) and North Sea (Faasse and Bayha 2006, Boersma et al. 2007) alarmed the scientific community, since those are some of the most productive fishery areas of the world. The region presents large rates of catch on planktotrophic fishes as herrings (Jansson 2003, Sea Around Us Project 2007), which were probably the most affected organisms by *M. leidyi* populations explosions in the Black Sea. Along the Dutch coast, sole and plaice fisheries are also potentially threatened during high abundances of *M. leidyi* (Faasse and Bayha 2006).

This study presents new records of *M. leidyi* for the Oslofjorden (Norway) and discusses possible invasion routes from its native range along the eastern coast of the Americas.

## Materials and Methods

*Mnemiopsis leidyi* specimens were photographed underwater by two divers in the Oslofjorden between November 2005 and March 2007 (see Annex). Photos were taken in dives up to 10 m depth. Most of the register locations are on the east side of the fjord (except for the Pumpehuset, Drøbak register), areas constantly affected by inflow streams with higher temperatures (see Meteorologisk Institutt 2007).

Water surface temperatures at the register locations were obtained from Bundesamt für Seeschifffahrt und Hydrographie (2007) and Meteorologisk Institutt (2007).

## Results

All *M. leidyi* specimens photographed were adults, with a least 40 mm in length, biggest up to 80 mm. The position of the lobes insertion, near the aboral end of the body, attests the identification of the species (see Figure 1).

One of the divers (Vidar Aas) goes into water weekly, from March to November, every year. He observed more specimens in each location and in other occasions than that when they were photographed. However, dense agglomerations of adult comb-jellies were never observed in those locations.

At the register moments, water surface temperatures ranged from 4–11°C (Annex).

## Discussion

Faasse and Bayha (2006) reported the presence of *M. leidyi* in the Netherlands estuarine regions and suggested that this species may have occurred in the area for several years, being misidentified as *Bolinopsis infundibula* (O.F. Müller, 1776), another lobate ctenophore. The authors also suggested that the resident population from Dutch estuaries could serve as a yearly supply of *M. leidyi* to the Baltic Sea, through Skagerrak and Kattegat or through the Kiel Canal, if the species was unable to overwinter in the Baltic (Faasse and Bayha 2006). Hansson (2006) agreed with the hypothesis of an annual reintroduction in the Baltic Sea originating from the North Sea. However, Kube et al. (2007) data suggested that *M. leidyi* survived the last winter in the southern Baltic Sea.

The specimens observed in the Oslofjorden in different localities and occasions (see Figure 1, Annex), are well developed adults, suggesting that reproduction could have been occurring in the Oslofjorden. However, I cannot infer that the Oslofjorden population of *M. leidyi* survived the winters, once temperature reached about 1°C or lower in these periods (Bundesamt für Seeschifffahrt und Hydrographie 2007). A low temperature of that magnitude kills the Azov Sea population of *M. leidyi* every winter and the sea is reinvaded by Black Sea specimens in spring (Studenikina et al. 1991). It is therefore possible that the Faasse and Bayha (2006) hypothesis of annual reintroduction is correct for the population in the Oslofjorden. However, it is unclear,

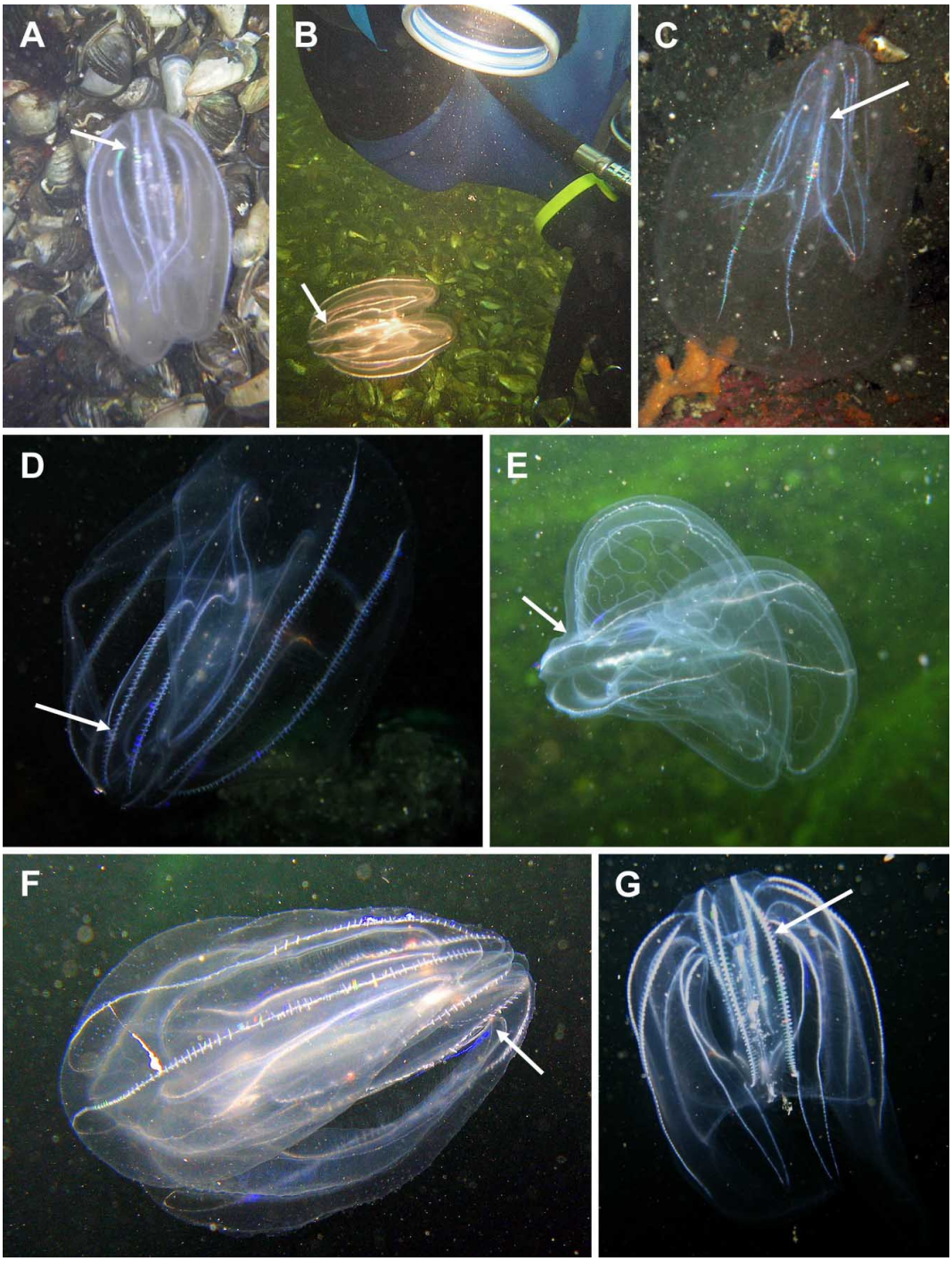


**Figure 1.** *Mnemiopsis leidyi* from the Oslofjorden, Norway. A-D, specimens observed in November, 2005; E, specimen observed in May, 2006; F, specimen observed in November, 2006; G, specimen observed in March, 2007. Arrows indicate the position of the lobes insertion, near the aboral end of the body in *M. leidyi*, a distinctive characteristic from *Bolinopsis infundibula* (other lobate ctenophore that also occurs in the Oslofjorden). Photos by Vidar Aas (A–B, E–G) and Asbjørn Hansen (C–D)

for instance, if the annual reinvasion of the Oslofjorden population originates from Baltic or the North Sea comb jelly populations.

Regarding the possible transport of *M. leidyi* from the native areas to the North and Baltic Seas, Faasse and Bayha (2006) suggest the possibility of the ballast water transfer once two of the largest European ports (Antwerp and Rotterdam), are near to the Dutch estuaries where they found *M. leidyi*. However, I believe that a discussion on natural oceanic transport, by the North Atlantic Current (NAC) should be considered. A recent study shows that surface water temperature of the North Atlantic, including the NAC, was more than 1°C warmer in the last five years than the historical means (cf. Hughes and Holliday 2006). The superficial waters of NAC arrive in the UK coast and in the North Sea with mean temperatures above 9°C (Hughes and Holliday 2006). The North Sea also presented an increase in mean water temperatures of more than 2°C in the last five years (Hughes and Holliday 2006). Possibly the low temperatures, a major factor against the transoceanic spread of *M. leidyi*, has not been the problem in recent years due to water temperature increase in NAC and in the recipient regions.

*Mnemiopsis leidyi* is known as a coastal ctenophore (GESAMP 1997, Mianzan 1999). However, there are some specimen records in oceanic waters (Harbison et al. 1978), including localities inside the inflow of the Gulf Stream (see collecting stations 509, 510 and 584 in Harbison et al. 1978). This certainly indicates the potential of transoceanic spreading of *M. leidyi*. The drifting from the northern Gulf Stream to the North Sea, through NAC, can least 15 to 60 days, depending on the season and wind oscillations (cf. Siedler et al. 2001). In a recent study, adult specimens were able to live up to 17 days under starvation in the laboratory (Oliveira 2007). In natural conditions of a transoceanic current, it is not expected that coastal species have an adequate food supply as natural coastal waters prey organisms are either absent or occur in much lower abundance. However, considering the *M. leidyi* predatory potential and trophic plasticity, I expect this ctenophore to be capable of such a way of dispersal. Furthermore, this transoceanic spread hypothesis needs to be tested.

The absence of *M. leidyi* records on the U.K. coast, as well as in the Atlantic coasts of France and Spain, are negative arguments for such hypothesis. However, the species could just have been misidentified as *Bolinopsis infundibula* in the area, as previously occurred in other European seas (Faasse and Bayha 2006, Boersma et al. 2007). Samplings on the NAC, associated with molecular identification of *M. leidyi* lineages should be of great value to elucidate this question.

The presence of *M. leidyi* have been recorded for several points along the North and Baltic seas (see Kube et al. 2007, Figure 3), proving once more the species great spreading potential. Now, studies on its trophic interaction with native plankton organisms of such regions are strongly needed to evaluate its possible ecological and economical impacts

## Acknowledgements

I gratefully acknowledge the two anonymous referees for their important suggestions and contributions, and two divers Asbjørn Hansen and Vidar Aas for allowing the use of their photos. This study was supported by FAPESP (Proc. 2004/15300-0).

## References

Baker LD and Reeve MR (1974) Laboratory culture of the lobate ctenophore *Mnemiopsis leidyi* with notes on feeding and fecundity. Marine Biology 26: 57–62

Bilio M and Niermann U (2004) Is the comb jelly really to blame for it all? *Mnemiopsis leidyi* and the ecological concerns about the Caspian Sea. Marine Ecology Progress Series 269: 173–183

Boersma M, Malzahn AM, Greve W and Javidpour J (2007) The first occurrence of the ctenophore *Mnemiopsis leidyi* in the North Sea. Helgoland Marine Research 61: 153–155

Bundesamt für Seeschifffahrt und Hydrographie (2007) Sea surface temperatures. http://www.bsh.de/en/Marine%20data/Observations/Sea%20surface%20temperatures/index.jsp (accessed July 2, 2007)

Burrell Jr VG and Van Engel WA (1976) Predation by and distribution of a ctenophore, *Mnemiopsis leidyi* A. Agassiz, in the York River estuary. Estuarine, Coastal and Shelf Science 4: 235–242

Faasse MA and Bayha KM (2006) The ctenophore *Mnemiopsis leidyi* A. Agassiz 1865 in coastal waters of the Netherlands: an unrecognized invasion? Aquatic Invasions 1(4): 270–277

GESAMP (IMO/FAO/UNESCO-IOC/WMO/WHOI/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution) (1997) Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* invasion in the Black Sea. GESAMP reports and studies No. 58. International Maritime Organization, London

Hansson HG (2006) Ctenophores of the Baltic and adjacent Seas – the invader *Mnemiopsis* is here! Aquatic Invasions 1(4): 295–298

Harbison GR, Madin LP and Swanberg NR (1978) On the natural history and distribution of oceanic ctenophores. Deep-Sea Research 25: 233–256

Hughes SL and Holliday NP (eds) (2006) ICES Report on Ocean Climate 2005. ICES Cooperative Research Report 280: 1–49

Jansson O (2003) Chapter 7. In: Sherman K, Hempel G (eds) Large Marine Ecosystems of the World: Trends in Exploitation, Protection and Research, Elsevier, Amsterdam

Javidpour J, Sommer U and Shiganova T (2006) First record of *Mnemiopsis leidyi* A. Agassiz 1865 in the Baltic Sea. Aquatic Invasions 1(4): 299–302

Kideys AE (2002) Fall and rise of the Black Sea ecosystem. Science 297: 1482–1483

Kube S, Postel L, Honnef C and Augustin CB (2007) *Mnemiopsis leidyi* in the Baltic Sea – distribution and overwintering between autumn 2006 and spring 2007. Aquatic Invasions 2(2): 137–145

Meteorologisk Institutt (2007) Havtemperatur og strøm i indre Oslofjord.http://met.no/kyst_og_hav/indreoslo_anim.html (accessed July 2, 2007)

Mianzan HW (1999) Ctenophora. In: Boltovskoy D. (ed.) South Atlantic Zooplankton. Backhuys, Leiden, The Netherlands, pp 561–573

Oliveira OMP (2007) Ctenóforos da costa brasileira: considerações taxonômicas e biológicas. Doctoral dissertation, University of São Paulo, Brazil

Oliveira OMP and Migotto AE (2006) Pelagic ctenophores from the São Sebastião Channel, southeastern Brazil. Zootaxa 1183: 1–26

Purcell JE, Shiganova TA, Decker MB and Houde ED (2001) The ctenophore *Mnemiopsis* in native and exotic habitats: U.S. estuaries versus the Black Sea basin. Hydrobiologia 451: 145–176

Sea Around Us Project, 2007. Large Marine Ecosystems - Marine landings in North Sea by taxa. Internet based text, available at http://www.seaaroundus.org (accessed May 20, 2007)

Shiganova TA, Mirzoyan ZA, Studenikina EA, Volovik SP, Siokou-Frangou I, Zervoudaki S, Christou ED, Skirta AY and Dumont HJ (2001) Population development of the invader ctenophore *Mnemiopsis leidyi* in the Black Sea and other seas of the Mediterranean basin. Marine Biology 139: 431–445

Siedler G, Church J and Gould J (eds) (2001) Ocean Circulation and Climate: Observing and Modelling the Global Ocean. Academic Press, San Diego, USA

Stone R (2005) Attack of the killer jellies. Science 309: 1805–1806

Studenikina YeI, Volovik SP, Mirzoyan IA and Luts GI (1991) The ctenophore *Mnemiopsis leidyi* in the Sea of Azov. Oceanology 31: 722–725

**Annex**

Records of the ctenophore *Mnemiopsis leidyi* in the Oslofjorden waters

| Location | Location coordinates | | Date of record | Water temperature* | Figure | Photographer |
|---|---|---|---|---|---|---|
| | Latitude,°N | Longitude,°E | | | | |
| Bjørnemyrdalen, Akershus | 59º50'40" | 10º38'40" | November 14, 2005 | ~10°C | 1A | Vidar Aas |
| Fjellstrand, Akershus | 59º48'18" | 10º36'24" | November 14, 2005 | ~10°C | 1B | Vidar Aas |
| Pumpehuset, Drøbak | 59º39'00" | 10º36'00" | November 17, 2005 | ~10°C | 1C | Asbjørn Hansen |
| Fabrikken, Hvitsten | 59º35'00" | 10º39'00" | November 20, 2005 | ~7°C | 1D | Asbjørn Hansen |
| Svestad, Akershus | 59º46'50" | 10º35'38" | May 5, 2006 | ~11°C | 1E | Vidar Aas |
| Alvern, Akershus | 59º49'06" | 10º36'04" | November 16, 2006 | ~9°C | 1F | Vidar Aas |
| Alvern, Akershus | 59º49'06" | 10º36'04" | March 20, 2007 | ~4°C | 1G | Vidar Aas |

* Approximated values for water surface temperature, based on Bundesamt für Seeschifffahrt und Hydrographie (2007)