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Short communication

Distribution and abundance of the American comb jelly (*Mnemiopsis leidyi*) – A rapid invasion to the northern Baltic Sea during 2007

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Abstract

The invasive ctenophore *Mnemiopsis leidyi* is expanding its range in the Baltic Sea. It was observed in the Landsort Deep in March 2007 and in the western part of the Gulf of Finland, Åland and Bothnian Seas in August 2007. In September the abundances were several times higher in the Gulf of Finland and the Åland Sea than in August, maximum abundances being 694 ind m^{-2}, and densities 24 ind m^{-3}. In December *M. leidyi* was observed also in the eastern Gulf of Finland at low abundances. Eggs and newly hatched larvae as well as juvenile stages were observed during autumn, indicating efficient reproduction and establishment of the species in the northern Baltic Sea.

Key words: *Mnemiopsis leidyi*, Baltic Sea, range expansion, reproduction, invasive species

Aquatic invasive species (AIS) have been identified globally as one of the major threats to marine ecosystems, causing biodiversity loss and adverse environmental, economic and social impacts (Leppäkoski et al. 2002b). The ecosystem of the Baltic Sea is young and simple, hence vulnerable to ecological changes. For invasive species this provides an opportunity to find a vacant ecological niche and consequently establish permanent populations (Leppäkoski et al. 2002a).

A recent invader to the Baltic Sea is the American comb jelly, *Mnemiopsis leidyi* A. Agassiz 1865. This species originates from the estuaries and coastal regions of the east coast of North, Central and South America (Purcell et al. 2001). It is known to have wide tolerance for environmental conditions, including 2–38 ‰ salinities, 2–32 ºC temperatures and low oxygen, which enables effective spreading to new areas (Purcell et al. 2001). *M. leidyi* has been unintentionally introduced with ballast water to the Black Sea in 1982 (Vinogradov et al. 1989) and later, in 1999, to the Caspian Sea (Ivanov et al. 2000). The first records of *M. leidyi* in northern European waters were made in 2005 from Oslofjorden, Norway (Oliveira 2007), then later in the North Sea, off the western coast of the Netherlands (Faasse and Bayha 2006), and from the Swedish west coast, in the Kattegat region and the southern Baltic Sea in autumn 2006 (Javidpour et al. 2006, Hansson 2006). In 2006-2007 it was widely distributed in the Danish waters (Tendal et al. 2007).

M. leidyi is a simultaneous hermaphrodite capable of self-fertilization. Thus, under suitable conditions its abundance may increase rapidly, forming mass occurrences usually in late summer and autumn (reviewed by Purcell et al. 2001, Shiganova et al. 2001). *M. leidyi* was able to overwinter in low abundances (1-4 ind m^{-3}) in the southern Baltic at temperatures below 10 ºC (Kube et al. 2007). It has extended its distribution range from the south-western to the central Baltic Sea (the Gotland Basin) between summer 2006 and spring 2007 (Kube et al. 2007).

Here we report on the further spread of *M. leidyi* from the central to the northern Baltic Sea during spring, summer and autumn 2007. In March 2007 samples were taken using a WP-2 net (mesh size 90 µm) in vertical hauls from 100 to 60 m, 60 to 30 m and 30 to the surface in the Landsort Deep (Swedish National Monitoring Program). Further sampling was undertaken on a regular HELCOM monitoring cruises at R/V Aranda (Finnish Institute of Marine Research, FIMR) in August, September and December 2007. The samples were taken by vertical hauls using a WP-2 net (mesh size 500 µm) from the bottom to the halocline and from the halocline to the surface, according to the temperature and salinity profiles measured by CTD casts at each sampling site. At the stations where oxygen was depleted in deeper waters, the vertical tows were taken only from well-oxygenated water, from 50 m to the surface. In December the tows were taken from the bottom to the surface. At stations where *M. leidyi* was most abundant in September, additional vertical tows (WP-2 net, mesh size 100 µm) were taken in order to assess the abundance of eggs.

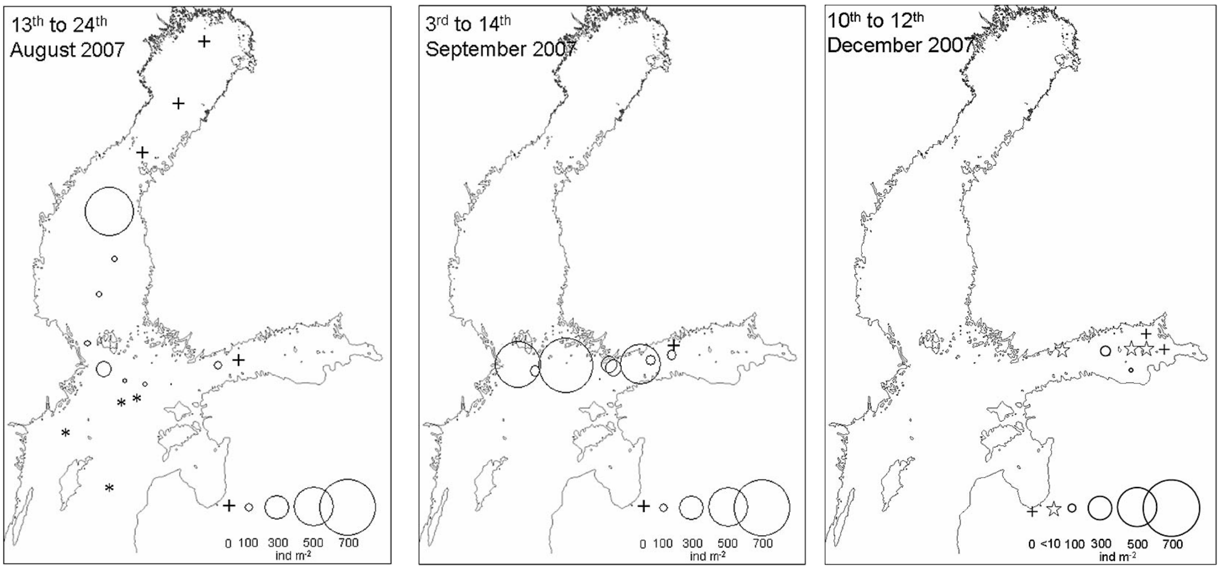

Figure 1. Occurrence and abundance of *Mnemiopsis leidyi* in a) August, b) September and c) December 2007 in the northern Baltic Sea during cruises of R/V Aranda (Finnish Institute of Marine Research). * no observations in net tows taken from 50-0 m. In September no data were collected from the Bothnian Sea. December cruise covered only the eastern part of the Gulf of Finland

Mnemiopsis leidyi was found in the Landsort Deep at abundances of 200 ind m^{-2} in March and in the western Gulf of Finland, Åland and Bothnian Seas in August. However, it was not found in the central Baltic around Gotland in summer or in the Bothnian Bay. In August the abundances were highest in the Bothnian Sea (max 619 ind m^{-2}) and lower in the Åland Sea (max 197 ind m^{-2}) and the Gulf of Finland (max 103 ind m^{-2}) (Figure 1a). The increase in *M. leidyi* abundance was observed one week later (at the beginning of September). The maximum abundances of 508 ind m^{-2} and 694 ind m^{-2} were then observed in the western part of the Gulf of Finland and the Åland Sea, respectively (Figure 1b). In December *M. leidyi* was observed at low abundances in the eastern Gulf of Finland (Figure 1c, see Annex for sampling and abundance details).

M. leidyi was most abundant in deep waters near the halocline. Densities ranged from 4 to 24 ind m^{-3} in 50-80 m depths at stations where the abundances were highest. The bulk of the population remained below the thermocline (~below 30 m) with densities above it always being <1 ind m^{-3}. The most abundant stages were cydippid larvae (Figure 2), which occurred higher in the water column than adults. The largest individuals recovered were 15 mm long indicating early reproduction. In December only larvae (1-2 mm long) were found. Eggs were found in the Åland Sea in September from depths of 155 to 50 m, with the highest abundances (90 egg m^{-3}) occurring around the halocline at 80-60 m (temperature 4.5-5ºC). Eggs at different developmental stages were present and hatching of the final stage, i.e. embryo with tentacles still within the egg envelope, was observed (Figure 2).

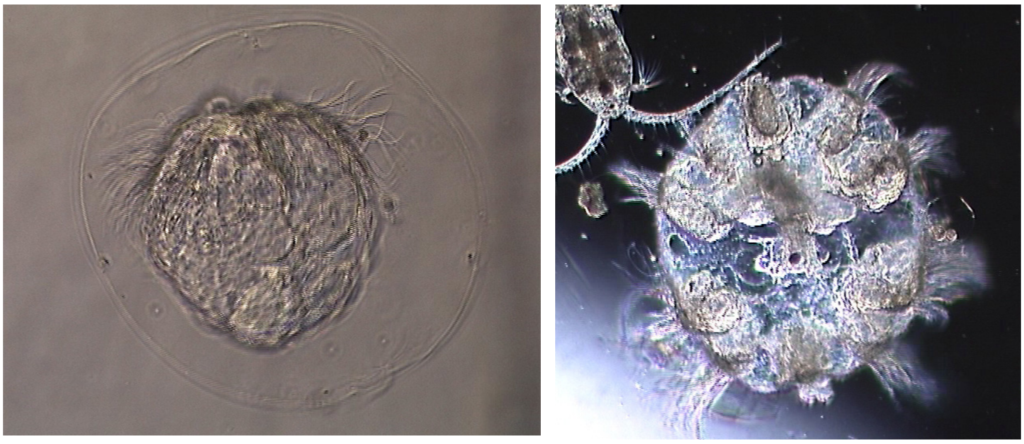

Figure 2. *Mnemiopsis leidyi* in the northern Baltic proper in September. Embryo within the egg envelope, 300 µm (left), cydippid stage larva (ventral view), 500 µm (right). Photos by Maija Huttunen, Finnish Institute of Marine Research

The distribution of *M. leidyi* in the northern Baltic Sea seems to be limited either by low salinity (no observations below 5 PSU) or low deep water oxygen levels (no observations at stations where oxygen was depleted below 60-70 m). Based on our data, it seems that *M. leidyi* has established populations in the northern Baltic Sea and will survive winter in water layers around the halocline. This assumption is based on observations that the species reproduced at low salinities (6.5-9 PSU) and temperatures (4-7 ºC) in the northern Baltic Sea, and was collected from the thermally stable part of the water column (i.e. the main part of the population was at 4-5 ºC), where temperature does not decrease much even during winter. The December observations of small individuals at low abundances also indicate overwintering as shown in the southern Baltic Sea (Kube et al. 2007). Earlier studies in other areas show that *M. leidyi* requires temperatures over 12 ºC to reproduce (Purcell et al. 2001), which are much higher than in this study. In its native areas and in the Black Sea and adjacent waters, population density seems not to be limited by salinity, but does decrease towards winter due to temperature decline (Purcell et al. 2001). In the northern Baltic, the most important factor reducing its abundance is probably decreasing food availability due to cooling of surface waters and decreasing plankton productivity towards late autumn and winter (Viitasalo 1992, Johansson et al. 2004).

The Black Sea was the first example of the damaging impact of *Mnemiopsis leidyi* on an ecosystem in general, especially on the pelagic community. The accidental introduction and subsequent outbreak of *M. leidyi* in late 1980s resulted in a dramatic decrease in abundance of almost all prey species of pelagic fish, and also in the disappearance of some zooplankton species (e.g. Vinogradov et al. 1989, Purcell et al. 2001). In the Caspian Sea, where individuals were mostly small, indicating early reproduction, the species invaded almost the entire sea in less than a year (Ivanov et al. 2000, Finenko et al. 2006). The rapid expansion of this invader in the Baltic Sea is similar to the invasion of the Caspian Sea. The high abundances observed and, especially, the high numbers of larval stages indicate establishment of the species. The magnitude of the effect of this species on the Baltic ecosystem has yet to be established but in similar eutrophic systems where similar prey taxa (e.g. *Centropages* spp., *Acartia* spp., *Eurytemora affinis* and cladocerans) are present, invasion by this ctenophore has profoundly changed the ecosystem (reviewed by Purcell et al. 2001).

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References

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

Finenko GA, Kideys AE, Anninsky BE, Shiganova TA, Roohi A, Tabari MR, Rostami H and Bagheri S (2006) Invasive ctenophore *Mnemiopsis leidyi* in the Caspian Sea: feeding, respiration, reproduction and predatory impact on the zooplankton community. Marine Ecology Progress Series 314: 171-185

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

Ivanov VP, Kamakin AM, Ushivtzev VB, Shiganova T, Zhukova O, Aladin N, Wilson SI, Harbison GR and Dumont HJ (2000) Invasion of the Caspian Sea by the comb jellyfish *Mnemiopsis leidyi* (Ctenophora). Biological Invasions 2: 255-258

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

Johansson M, Gorokhova E and Larsson U (2004) Annual variability in ciliate community structure, potential prey and predators in the open northern Baltic Sea proper. Journal of Plankton Research 26: 67-80

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: 137-145

Leppäkoski E, Gollasch S, Gruszka P, Ojaveer H, Olenin S and Panov V (2002a) The Baltic—a sea of invaders. Canadian Journal of Fisheries and Aquatic Sciences 59:1175-1188

Leppäkoski E, Gollasch S and Olenin S (eds) (2002b) Aquatic Invasive Species of Europe - Distribution, Impacts and Management. Kluwer Academic Publishers

Oliveira OMP (2007) The presence of the ctenophore *Mnemiopsis leidyi* in the Oslofjorden and considerations on the initial invasion pathways to the North and Baltic Seas. Aquatic Invasions 2 (3): 185-189

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

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 in other seas of the Mediterranean basin. Marine Biology 139:431-445

Tendal OS, Jensen KR and Riisgård HU (2007) Invasive ctenophore *Mnemiopsis leidyi* widely distributed in Danish waters. Aquatic Invasions 2 (4): 455-460

Viitasalo M (1992) Mesozooplankton of the Gulf of Finland and northern Baltic Proper – a review of monitoring data. Ophelia 35:147-168

Vinogradov ME, Shushkina EA, Musayeva EI and Sorokin PY (1989) A new exotic species in the Black Sea: the ctenophore *Mnemiopsis leidyi* (Ctenophora: Lobata). Oceanology 29: 220-224

Annex

Sampling stations and abundance of *Mnemiopsis leidyi* in the central and northern Baltic Sea. GoF = Gulf of Finland, SESU = Systems Ecology, Stockholm University, FIMR = Finnish Institute of Marine Research. Salinity and temperature ranges are shown for the water column part where *M. leidyi* occurred (thermocline-bottom). * indicates stations where oxygen was depleted from bottom to 60-70 m

Station	Location	Location coordinates		Date	Salinity	Temperature	Ind m^{-2}	Collector
		Latitude ºN	Longitude ºE		PSU	°C		
BY31	Baltic Proper	58°35.90'	18°14.21'	28.3.2007	-	-	200	SESU
LL13	Baltic Proper	59°22.00'	22°27.81'	9.8.2007	7-10.5	4-7	12	SESU /FIMR
LL7	GoF	59°50.79'	24°50.27'	13.8.2007	6-8.5	4-7.5	0	FIMR
LL17*	Baltic Proper	59°02.00'	21°04.77'	14.8.2007	6.5-11.5	6-7.5	0	FIMR
BA82*	Baltic Proper	58°58.60'	20°34.71'	14.8.2007	-	-	0	FIMR
LL23*	Baltic Proper	58°35.00'	18°14.00'	15.8.2007	7-11	4.5-5.5	0	FIMR
BY15*	Baltic Proper	57°19.20'	20°03.00'	16.8.2007	8-12.5	4-7	0	FIMR
F69	Åland Sea	59º46.99'	19º55.80'	17.8.2007	6-9	4.5-7	56	FIMR
F64	Åland Sea	60º11.34'	19º08.55'	18.8.2007	6-7	4.5-7	72	FIMR
SR5	Bothnian Sea	61°05.00'	19°35.00'	19.8.2007	5.5-6.5	3-5	68	FIMR
MS8	Bothnian Sea	61º51.00'	20º03.32'	19.8.2007	-	-	68	FIMR
F16	Bothnian Bay	63º31.00'	21º03.78'	20.8.2007	-	-	0	FIMR
BO3	Bothnian Bay	64º18.30'	22º21.50'	20.8.2007	3-4	3-7	0	FIMR
F2	Bothnian Bay	65º23.02'	23º27.76'	21.8.2007	3-3.5	2-7	0	FIMR
US5b	Bothnian Sea	62º35.17'	19º58.13'	22.8.2007	5.5-6.5	3-5	619	FIMR
F69	Åland Sea	59º46.99'	19º55.80'	23.8.2007	6-9	4.5-7	197	FIMR
F71	Baltic Proper	59º30.06'	20º23.26'	23.8.2007	6.5-10	4-7.5	53	FIMR
TPDEEP1	GoF	59º22.69'	21º26.41'	23.8.2007	7-11	5.5-8	85	FIMR
LL9	GoF	59º42.01'	24º01.81'	24.8.2007	6-7.5	4-8	103	FIMR
KASUUNI	GoF	59º55.01'	24º54.81'	24.8.2007	6-7	3.5-12	40	FIMR
LL7	GoF	59º50.79'	24º50.27'	3.9.2007	6-8.5	4.5-6.5	120	FIMR
AJAX1	GoF	59º42.01'	23º10.81'	3.9.2007	6.5-7	4.5-7	201	FIMR
F69	Åland Sea	59º47.00'	19º55.80'	4.9.2007	6.5-9	4.5-8.5	580	FIMR
ROOPE2	Baltic Proper	59º36.64'	20º38.94'	4.9.2007	7-9.5	4.5-6.5	126	FIMR
IU7	Baltic Proper	59º48.90'	21º20.19'	5.9.2007	6.5-7.5	4.5-6.5	694	FIMR
LL12	GoF	59º29.01'	22º53.81'	6.9.2007	-	-	14	FIMR
KLHAKK1	GoF	60º06.92'	25º32.18'	10.9.2007	5.5-5.7	10.5-12	0	FIMR
TRO0701	GoF	59º58.93'	25º34.56'	10.9.2007	5.5-6.5	4.5-9	115	FIMR
LL8	GoF	59º46.01'	24º25.80'	11.9.2007	6-7	4-9.5	508	FIMR
TRO0510b	GoF	59º39.00'	23º14.01'	11.9.2007	6.5-7.0	5.5-9	204	FIMR
39A	GoF	60°04.01'	24°58.81'	10.12.2007	5	4	1	FIMR
LL3a	GoF	60°04.03'	26°20.80'	10.12.2007	5-7	5-5.5	115	FIMR
F42	GoF	60°08.04'	27°27.94'	11.12.2007	4-6	4-5.5	7	FIMR
F41	GoF	60°07.04'	28°03.55'	11.12.2007	4.5-5	3.5-4.5	3	FIMR
F40	GoF	60°06.43'	28°48.30'	11.12.2007	3.5-4	3.5	0	FIMR
GF6	GoF	60°20.31'	28°00.11'	11.12.2007	3-4.5	3-4.5	0	FIMR
NAR3	GoF	59°44.13'	27°22.88'	12.12.2007	5-7	4-5	45	FIMR