

Invasive ctenophore *Mnemiopsis leidyi* widely distributed in Danish waters

Ole Secher Tendal^{1*}, Kathe R. Jensen^{1,2} and Hans Ulrik Riisgård³

¹Zoological Museum, SNM, University of Copenhagen, Universitetsparken 15, DK-2100 Copenhagen Ø, Denmark, E-mail: ostendal@snm.ku.dk

²Agency for Spatial and Environmental Planning, Haraldsgade 53, DK-2100 Copenhagen Ø, Denmark
E-mail: krjensen@snm.ku.dk

³Marine Biological Research Centre, University of Southern Denmark, Hindsholmvej 11, DK- 5300 Kerteminde, Denmark, E-mail: hur@biology.sdu.dk

*Corresponding author

Received 27 September 2007; accepted in revised form 22 October 2007

Abstract

Blooms of *Mnemiopsis leidyi* observed along the coast of The Netherlands in late 2006 have made the spreading of this invasive ctenophore to neighboring waters a topic of major concern. Here we report on recent occurrences of *M. leidyi* in Danish waters, observed partly by ourselves and other biologists, partly by beach guests, boat owners and amateur divers. The earliest record of *M. leidyi* is from August 2005 and the early summer of 2006, and in 2007, the earliest records are from February and March, from the northern Little Belt and Kerteminde Bay. In the period April to June, the density of *M. leidyi* remained very low in the Great Belt, but numerous reports indicate that the ctenophore in July to September was widely distributed in all inner Danish waters, and "mass occurrences" have been reported from certain areas.

Key words: invasive ctenophore, *Mnemiopsis leidyi*, Danish waters, first record, *Beroe*, *Bolinopsis*

The lobate ctenophore *Mnemiopsis leidyi* A. Agassiz, 1865 is indigenous to the east coast of the Americas, but in the early 1980s it was brought to the Black Sea with ballast water of cargo ships, and a few years later it exhibited mass occurrence (Waggett and Costello 1999, Purcell et al. 2001, Shiganova et al. 2001). In 1989 enormous mass occurrence of the ctenophore coincided with a breakdown of the important anchovy fishery in the Black Sea (Kideys and Romanova 2001). The collapse was

probably caused by a combination of over-fishing, food competition from the zooplanktivorous ctenophore, and predation of *M. leidyi* on fish eggs and larvae (Bilio and Niermann 2004). Later, the invasive ctenophore spread into the Azov, Marmara, Aegean and Caspian Seas where similar ecological impacts were recorded (Shiganova et al. 2001, Kideys and Romanova 2001, Bilio and Niermann 2004). More recently, during the late summer of 2006, large blooms of *M. leidyi* were observed in estuaries along the

coast of The Netherlands (Faasse and Bayha 2006). Presumably, *M. leidyi* found its way to the Dutch coast in ballast water, but it is likely that the ctenophore had been present in Dutch waters for several years before 2006 because it was probably misidentified as the morphologically similar cold-water ctenophore *Bolinopsis infundibulum* (O.F. Müller, 1776) (Faasse and Bayha 2006). Against this background, the spread of *M. leidyi* to neighboring waters is a topic of major concern.

In summer and autumn 2006 *Mnemiopsis leidyi* was observed in coastal and estuarine areas to both the north and south of Denmark (Norway: Oslo Fjord and near Bergen, Hansson 2006, Oliveira 2007; Sweden: Tjärnö Marine Biological Laboratory, and the Gullmarn Fjord, Hansson 2006, L. Friis Møller, pers. comm.; Germany: Helgoland, Sylt and western Baltic Sea, Boersma et al. 2007, Javidpour et al. 2006,

Kube et al. 2007, R. Asmus, pers. comm.). There are no official reports dealing with the occurrence of *M. leidyi* in Danish waters. It has been found in Kiel Bay in January-February 2007 (Kube et al. 2007) and in Oslo Fjord in March (Oliveira 2007). During the spring it was observed in Swedish waters off the Tjärnö Marine Biological Laboratory (H. G. Hansson, pers. comm.) and in the Gullmarn Fjord (L. Friis Møller, pers. comm.). In August and September it had spread through the Baltic Sea to the Åland Sea and the Gulf of Finland (Lehtiniemi et al. 2007).

In the present paper we report recent and some previous occurrences of *M. leidyi* in Danish waters, observed partly by ourselves and other biologists, partly by beach guests, boat owners and experienced amateur divers (Figure 1 and Annex)

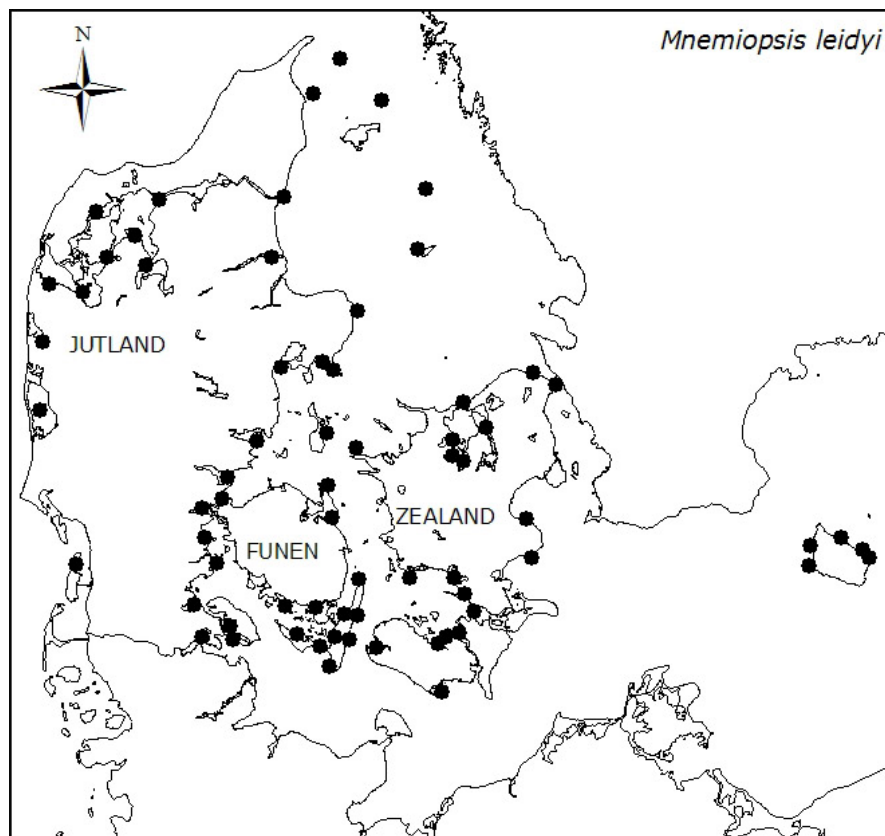


Figure 1. Observations of *Mnemiopsis leidyi* in Danish territorial waters 2005-2007 (see also Annex)

Mnemiopsis leidyi is fragmented beyond recognition by standard preservation methods. Accordingly, our results comprise reported live

observations, observations made in aquaria, and photographs. We have obtained the information from several sources. One is our own field

investigations (see below). Another is the members of a network of biologists interested in invading marine species, established during a meeting for Danish marine scientists held at the University of Southern Denmark in January 2007. In addition, we have made requests to the public through newspapers, television and radio. We received 150 reports, but the map only includes records where at least one of us has actually seen the specimens or photographs (Figure 1). However, when addressing the general distribution we consider all reasonable reports.

The earliest record of *Mnemiopsis* we could trace is from August 2005 from Felsted Kog, Nisum Fjord (western Jutland) where several specimens were observed and some were photographed (M. Lauersen, pers. comm.). The next record is from early summer 2006 where members of the staff of the Marine Biology Laboratory in Helsingør observed mass occurrence just off the harbor (J. P. Jeppesen, pers. comm.). In October 2006 *Mnemiopsis* was photographed in Kattegat near Hundested (D. Lisbjerg, pers. comm.). From late summer of 2006 we have unconfirmed reports by divers and fishermen that the 'strange medusa' was seen in Limfjorden (northern Jutland) and Isefjord (northern Zealand).

From February 2007 onwards reports are numerous, and in many cases the wording is indicative of a mass occurrence (Figure 1). The earliest records were from February and March, from the northern Little Belt (eastern Jutland) and Kerteminde Bay (Funen), and soon after specimens were collected in Kerteminde Fjord (Kertinge Nor) and the northern part of the Great Belt. The concentration of *Mnemiopsis leidyi* in the Great Belt remained very low, between 0.4 and 3.4 individuals per 100 m³ in the period 18 April to 18 June 2007, although the mean body length increased from 1.1 ± 0.4 to 4.6 ± 1.3 cm (unpublished data from ongoing jellyfish project conducted by H.U. Riisgård, C.-M. Vandt Madsen and L. Böttiger in co-operation with the Marine, Water and Nature Division, Danish Ministry of the Environment - Environment Centre Odense). In the same period between April and July 2007, numerous specimens were observed near the island of Mandø in the Danish Wadden Sea. In the middle of July a large number of 2-4 cm *M. leidyi* were observed in Limfjorden (Lemvig, Struer, Thisted, Glyngøre, Feggesund, Fursund, Hvalpsund, Løgstør). During the summer months reports came from all

along eastern Jutland and southern Funen to the Baltic. Again in June and July there were large numbers to be seen off Helsingør, and in July and August several observations came from the Isefjord, other parts of Zealand, Lolland and Bornholm. The concurrent reports indicate that from May to July 2007 the body length of *M. leidyi* increased from 2-3 to 8-11 cm. The maximum length reached so far (July) in the Sound is about 12 cm, in a single case 15 cm. From late June there was one observation in Sønderborg Bay of 'clouds' of hundreds of small 3 to 4 mm individuals together with somewhat larger ctenophores with lengths of 1 to 2 cm (K.B. Christensen, pers. comm.).

Some authors point out that low concentrations of *Mnemiopsis leidyi* may have been present in their areas for some years, taken for the native *Bolinopsis infundibulum* which is rather similar to *M. leidyi*, especially in the younger stages (Faasse and Bayha 2006, Boersma et al. 2007). The observation from Nisum Fjord show the species to be present in Danish waters as early as 2005. Likewise, photographs from Oslo Fjord taken in November 2005 shows *M. leidyi* (Oliveira 2007).

Considering previous observations of the occurrence of *Mnemiopsis leidyi* along the Dutch, German, Norwegian and Swedish coasts (Kube et al. 2007), it is not surprising that the ctenophore is now widely distributed through all inner Danish waters.

Although the registration of the scattered observations compiled here was neither planned nor done regularly it seems reasonable to suggest that the records actually reflect the history of the invasion of *Mnemiopsis leidyi* from Dutch into Scandinavian waters. Thus, during 2005 presumably rather few specimens were transported by currents along the west coast of Jutland into the Skagerrak and Oslo Fjord area. In 2006, the ctenophore subsequently turned up along the Swedish west coast, the Zealand north coast and in the Sound, later reaching the south-western Baltic Sea from where it has expanded its distribution into the central Baltic Sea between summer 2006 and spring 2007 (Kube et al. 2007). Promoted by the mild winter conditions, *M. leidyi* has been able to reproduce, and during 2007 it spread into all inner Danish waters.

The native habitats of *Mnemiopsis leidyi* are temperate to subtropical estuaries along the Atlantic coast of North and South America (Purcell et al. 2001), and here it is preyed upon by another ctenophore, *Beroe ovata* cf. Mayer,

1912 (Bilio and Niermann 2004). Although also introduced into the Black Sea and adjacent areas *B. ovata* has so far not been recorded in the NE Atlantic. *Beroe* species eat their prey by engulfing it if size allows or, if it is too large, by biting pieces out using macro cilia, compound ciliary-feeding organelles found inside the mouth opening. The macro cilia are different from one species of *Beroe* to another, seemingly adapted to a preferred prey (Tamm and Tamm 1993). It remains to be seen if the two species of *Beroe* occurring in Danish waters, *B. cucumis* Fabricius, 1780 and *B. gracilis* Künne, 1939 will take the role as predators of *M. leidyi*.

Acknowledgements

We gratefully acknowledge the following people for reporting on their observations of *Mnemiopsis leidyi*: Per Andersen, Line Bøttiger, Kim B. Christensen, Karsten Dahl, Tom Fenchel, Lene Friis Møller, Hans G. Hansson, Tomas Jensen, Jens P. Jeppesen, Martha Lauersen, Dennis Lisbjerg, Beth Søbørg Lundholm, Jens Tang Christensen, Caroline-Marie Vandt Madsen and students from DIS EHI class of spring 2007. We are thankful to Grete E. Dinesen for making the map and the table.

References

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

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: 270-277

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

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

Kideys AE and Romanova Z (2001) Distribution of gelatinous macrozooplankton in the southern Black Sea during 1996-1999. *Marine Biology* 139: 535-547

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

Lehtiniemi M, Pääkkönen J-P, Flinkman J, Katajisto T, Gorokhova E, Karjalainen M, Viitasalo S and Björk H (2007) Distribution and abundance of the American comb jelly (*Mnemiopsis leidyi*) – A rapid invasion to the northern Baltic Sea during 2007. *Aquatic Invasions* 2: 445-449

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: 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

Tamm SL, Tamm S (1993) Diversity of macrociliary size, tooth patterns, and distribution in *Beroe* (Ctenophora). *Zoomorphology* 113: 79-89

Waggett R and Costello JH (1999) Capture mechanisms used by the lobate ctenophore, *Mnemiopsis leidyi*, preying on the copepod *Acartia tonsa*. *Journal of Plankton Research* 21: 2037-2052

AnnexRecords of *Mnemiopsis leidyi* in Danish waters in 2005-2007

Location	Record coordinates (UTM32N WGS84)		Date of record	Collector
	Latitude, °N	Longitude, °E		
Mandø	469923,09	6120301,28	7 May 2007	T. Jensen
Nissum Fjord	452734,91	6239800,05	1 August 2005	M. Laursen
Lemvig harbor	456008,85	6270902,47	23 July 2007	H. U. Riisgård & B. F. Larsen
Struer harbor	474833,99	6265991,56	23 July 2007	H. U. Riisgård & B. F. Larsen
Thisted harbor	481381,87	6308552,76	26 July 2007	H. U. Riisgård & B.F. Larsen
Løgstør harbor	514939,75	6316737,61	27 July 2007	H. U. Riisgård & B. F. Larsen
Fursund	501843,99	6296275,49	20 July 2007	H. U. Riisgård
Sallingsund	487980,40	6285116,77	25 July 2007	H. U. Riisgård
Hvalpsund	508467,57	6280128,59	25 July 2007	H. U. Riisgård
Hals harbor	582142,23	6316233,52	25 July 2007	R. Borup
Hirsholmene	597661,02	6371657,77	5 August 2007	H. T. Christensen
Læsø Trindel	634067,50	6367715,86	1 September 2007	K. Dahl
Hertas Flak	611321,00	6390215,12	1 September 2007	K. Dahl
Kims Top	657555,74	6320986,63	1 September 2007	K. Dahl
Anholt harbor	653105,34	6288844,82	23 August 2007	K. Rasmussen
Grenå harbor	620963,54	6256208,53	13 August 2007	T. Jensen
Elsegårde	608106,82	6224993,56	7 August 2007	L. Otte
Æbeltoft Vig	601843,29	6229608,79	8 August 2007	M. Jeppesen
Århus Bay	581734,06	6226641,86	1 July 2007	P. Andersen
Ballen harbor	604480,56	6191368,29	21 July 2007	D. Jørgensen
Horsens Fjord	567558,70	6187412,38	19 August 2007	K. Balleby
Vejle Fjord	552064,70	6167962,47	15 July 2007	C. Stenberg
Little Belt	549097,76	6157083,70	15 February 2007	K. R. Jensen
Kolding Fjord	538219,00	6151479,49	20 September 2007	J. S. Laursen
Knuds Hoved	539867,30	6135985,5	1 July 2007	T. Jensen
Årøsund	546130,83	6122469,46	13 June 2007	B. Lange
Åbenrå Fjord	533933,43	6100711,93	29 July 2007	J. Varberg
Alssund	554483,34	6088844,19	6 August 2007	J. T. Christensen
Sønderborg Bay	554701,98	6081921,34	10 June 2007	K. B. Christensen
Flensborg Fjord	538548,66	6083239,97	12 June 2007	B. Testrup
Kerteminde Bay	607117,84	6146534,60	16 March 2007	H. U. Riisgård
Great Belt	605139,88	6163347,23	1 April 2007	H. U. Riisgård
Lohals habor	620963,64	6113568,65	20 July 2007	J. Laursen
Svendborgsund	598546,69	6098733,97	20 July 2007	J. Laursen

Annex (continued)Records of *Mnemiopsis leidyi* in Danish waters in 2005-2007

Location	Record coordinates (UTM32N WGS84)		Date of record	Collector
	Latitude, °N	Longitude, °E		
Avarnakø	583052,69	6100052,61	13 June 2007	F. Brandrup
Spodsbjerg	621622,86	6093789,08	20 June 2007	J. Laursen
Illebølle beach	616677,96	6081921,34	21 June 2007	J. Laursen
Siø Bridge	614040,69	6095767,04	21 June 2007	J. Laursen
Lindelse Nor	608106,82	6083899,29	14 August 2007	N. Holmboe
Bagenkop	606128,86	6067384,07	22 July 2007	J. Laursen
Ærø Hale	601183,97	6078262,83	4 August 2007	I. S. Pedersen
Revkrogen	588656,91	6085185,68	14 August 2007	"Skibet", Ærø
Nakskov Fjord	631182,98	6077603,51	10 August 2007	P. Fisher
Guldborgsund	675687,01	6085185,68	15 July 2007	L. Jørgensen
Viksø	668104,85	6083537,38	6 August 2007	A. Borre
Sakskøbing Fjord	663819,27	6079581,47	1 August 2007	H. Carl
Avnø Fjord	678324,29	6105624,57	5 August 2007	T. Pelle
Knudshoved Odde	683269,18	6096723,76	27 August 2007	B. Søbørg
Svinø	672060,76	6114855,03	8 August 2007	B. Thronsen
Rødvig harbour	713596,82	6125758,29	3 August 2007	O. Dreyer-Wågensen
Strøby Ladeplads	710959,55	6146197,18	1 August 2007	J. Jattu
Holdbæk Fjord	671400,41	6179822,45	15 June 2007	P. W. Henriksen
Ejby harbor	677334,28	6176855,51	20 July 2007	O. S. Tendal
Orø	671730,06	6188393,59	23 July 2007	P. Eldon
Hundested	677004,62	6207843,50	10 August 2007	P. R. Møller
Frederikssund	689531,68	6194327,46	18 August 2007	O. N. Andersen
Helsingør harbor	724805,24	6216744,31	1 June 2006	J. P. Jeppesen
N of Hornbæk	714585,80	6223667,16	7 August 2007	M. Branth
Salne Bay, Gudhjem	878735,91	6135528,55	15 August 2007	H. P. Jakobsen
Listed	889593,47	6129421,17	12 August 2007	M. Brix
Hulle harbor, Svaneke	892647,16	6125349,59	4 September 2007	E. Kure
Sorhat	861092,38	6121278,00	14 August 2007	M. Brix
Vang	861431,68	6131456,96	14 August 2007	M. Brix
Rødsand	665851,94	6053921,70	27 August 2007	B. Søbørg
Ringkøbing Fjord	451562,56	6204287,47	20 August 2007	R. V. Sams
Røsnæs	620371,09	6183705,06	18 August 2007	P. R. Møller
Karrebæksmind Bay	648975,04	6114535,51	27 August 2007	B. Søbørg
Mariager Fjord	574439,35	6285334,34	27 September 2007	J. S. Laursen