

Invasive ctenophore *Mnemiopsis leidyi* widely distributed in Danish waters

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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. leidy* to neighboring waters is a topic of major concern.

In summer and autumn 2006 *Mnemiopsis leidy* 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. leidy* 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. leidy* in Danish waters, observed partly by ourselves and other biologists, partly by beach guests, boat owners and experienced amateur divers (Figure 1 and Annex)

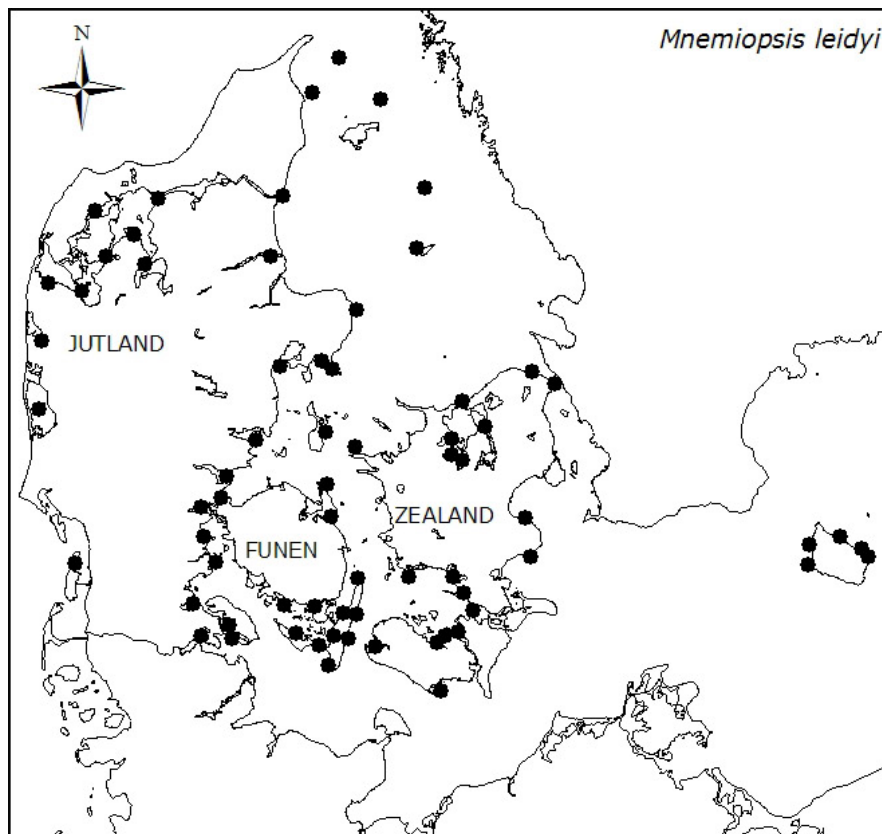


Figure 1. Observations of *Mnemiopsis leidy* in Danish territorial waters 2005-2007 (see also Annex)

Mnemiopsis leidy 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, Nissum 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 Kattgat 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 Nissum 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. leidy*.

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Mnemiopsis leidyi in Danish waters**Annex**Records 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. Søeborg |
| 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 |
| Sorthat | 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. Søeborg |
| Ringkøbing Fjord | 451562,56 | 6204287,47 | 20 August 2007 | R. V. Sams |
| Røsnæs | 620371,09 | 6183705,06 | 18 August 2007 | P. R. Møller |
| Karrebæksminde Bay | 648975,04 | 6114535,51 | 27 August 2007 | B. Søeborg |
| Mariager Fjord | 574439,35 | 6285334,34 | 27 September 2007 | J. S. Laursen |