Phenology and Population Dynamics of the Invasive Ctenophore *Mnemiopsis leidyi* in Recipient Areas of the Eurasian Seas – Changes .Linked with Environmental Variability and Climate Forcing

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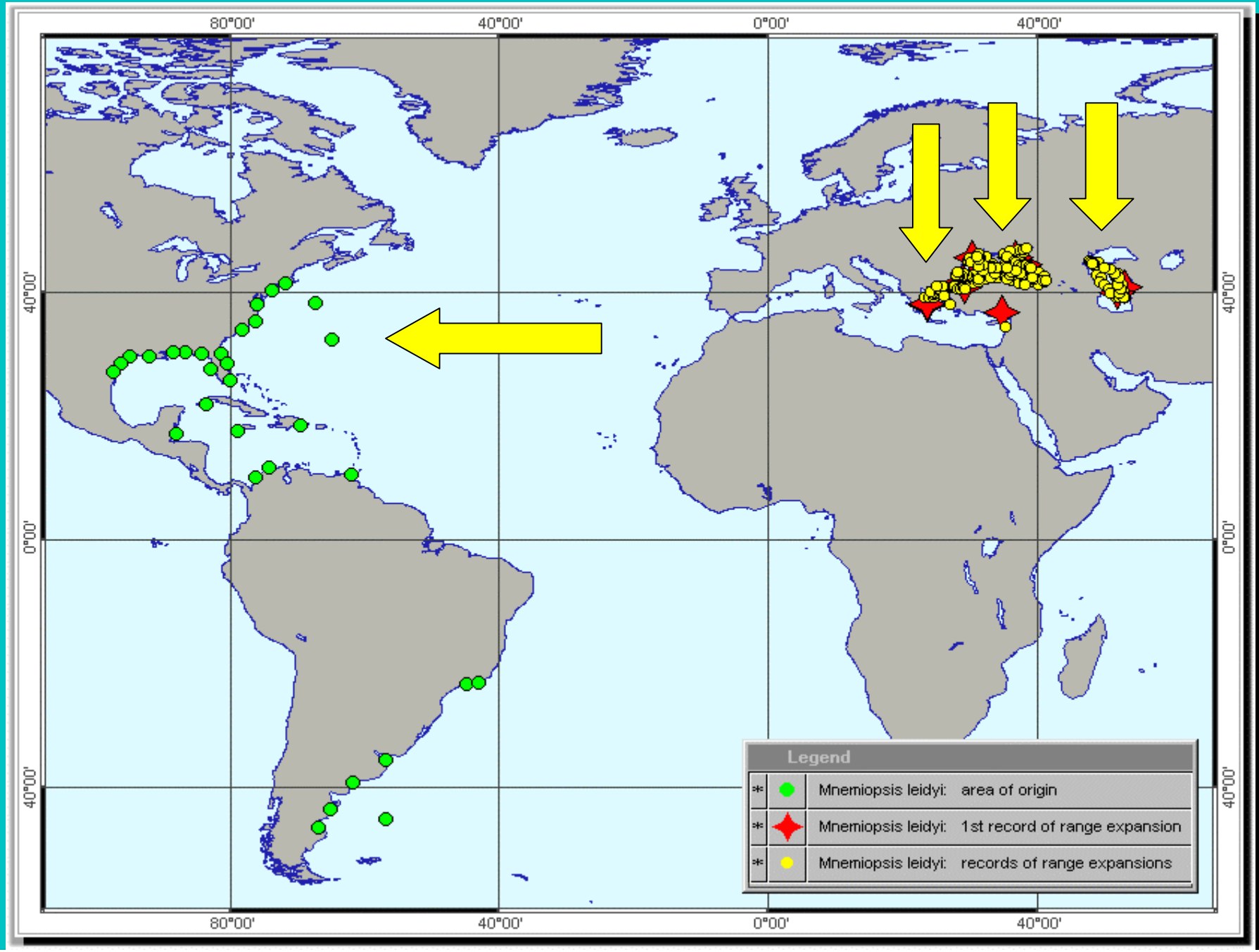
Ctenophore

Mnemiopsis leidyi A.Agassiz 1865


80°00'
40°00'
0°00'
40°00'
40°00'
0°00'
40°00'
Legend
Mnemiopsis leidyi: area of origin
Mnemiopsis leidyi: 1st record of range expansion
Mnemiopsis leidyi: records of range expansions

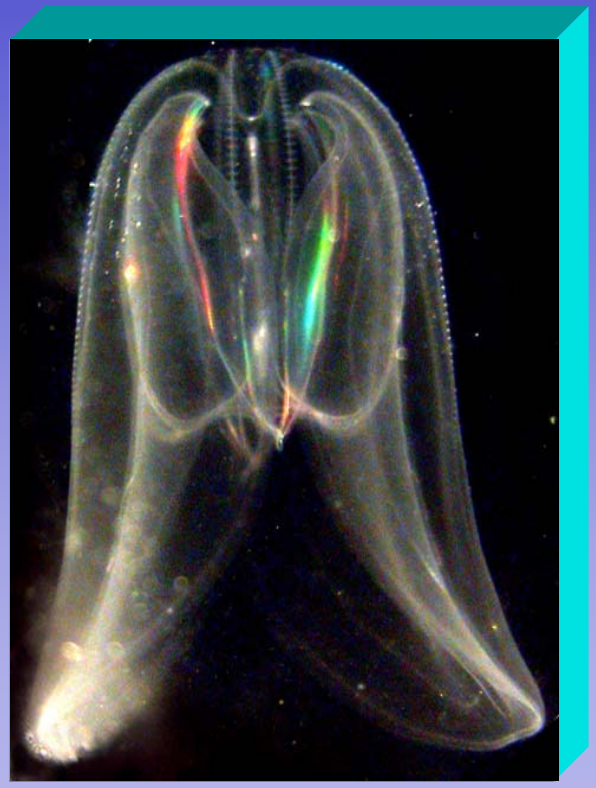

2006
2006
2005
1982
1988
1990
1990
1999
NORWAY
SWEDEN
FINLAND
Faroe Islands
Tórshavn
Oslo
Helsinki
Tallinn
St. Petersburg
Moscow
Nizhniy Novgorod
Yekaterinburg
MOUNTAINS
URAL
UNITED KINGDOM
Dublin
IRELAND
London
Amsterdam
Brussels
Berlin
Prague
Warsaw
POLAND
BELARUS
Minsk
Kiev
UKRAINE
Samara
KAZAK
Aral Sea
GERMANY
Luxembourg
Paris
FRANCE
Bern
Budapest
Belgrade
Sarajevo
Sofia
Black Sea
Marseille
Rome
Istanbul
Ankara
TURKEY
GEORGIA
Tbilisi
Yerevan
Baku
UZBEKISTAN
TURKMENISTAN
Ashgabat
Madrid
Barcelona
SPAIN
PORTUGAL
Lisbon
Algiers
Tunis
TUNISIA
MALTA
Valletta
Mediterranean Sea
Tripoli
Casablanca
Rabat
MOROCCO
ALGERIA
LIBYA
EGYPT
Cairo
Alexandria
SYRIA
Damascus
Beirut
IRAQ
Baghdad
IRAN
ISRAEL
JORDAN
Amman
KUWAIT
Kuwait
SAUDI ARABIA
Riyadh
BAHRAIN
Manama
QATAR
Doha
Abu Dhabi
UNITED ARAB EMIRATES
Muscat
OMAN
RUB' AL KHALI
SAHARA
MALI
NIGER
CHAD
Khartoum
Niamey
Bamako
ERITREA
Asmara
YEMEN
Sanaa

Geomorphological and hydrological characteristics of the seas

Location	Depth max. (mean) (m)	Winter, T0 (Co)	Summer, T0 (Co)	Salinity	Chlorophyll (mg/m3)
Black Sea	2245 (1271)Oxic layer 200(60)	0-8	24-27	17-22.3	0,47-1,9
Sea of Azov	14,.5 (7)	-08.- +1.2	24-30	0-14	2-6
Sea of Marmara	1335(10)	8-15	24-29	18-29	1-2,5
Caspian Sea (total) Northern Middle Southern	1025(208) 15-20 (4.4) 770 (192) 1025(345)	0-11 0-0.5 0-11 5.6-10.7	24-28 25-27 24-25 25-28	0.1-13 0.1-11 12.6-13 12.6-13	3,31±1,1 6.8± 2.09 2.1± 0.86 2.4± 1.59
North Aegean Sea	300 (30)	12 -18	24-27	36 - 39	0,02-0,5 (0,32)
Gulf of Trieste (North Adriatic)	33,5 (10)	<6	24-25	32,7-37,6	0,72-4,16
Baltic Sea (surface layer)	459 (56)	0-2	14-18	0,5-10 (25)	

Mnemiopsis leidyi

from the Black Sea

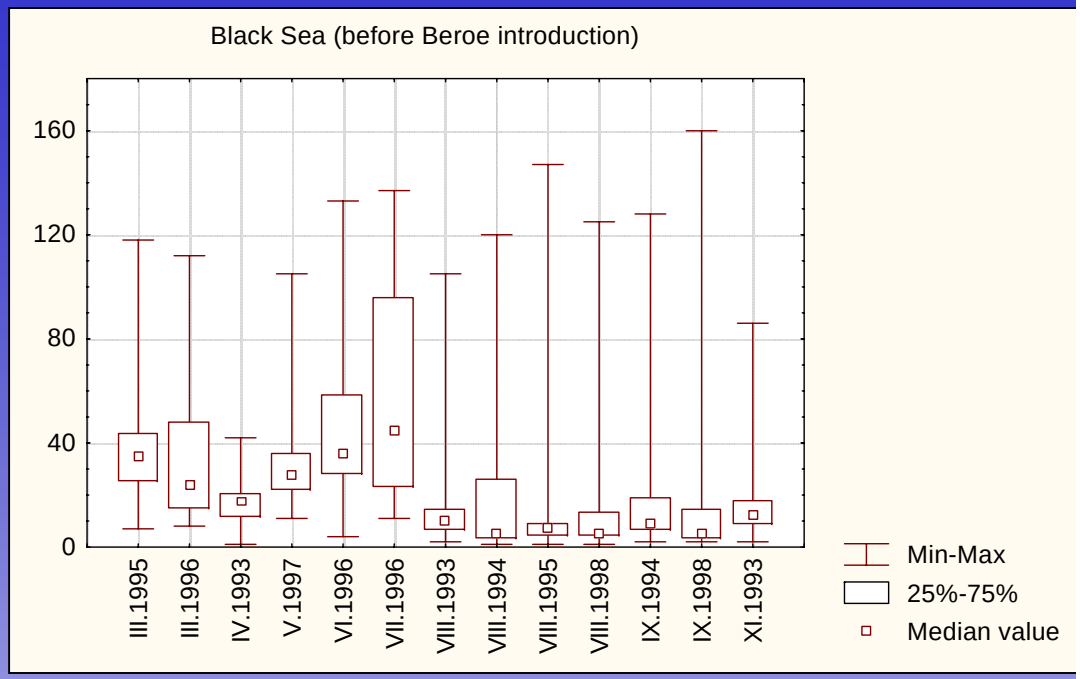


L=135 mm

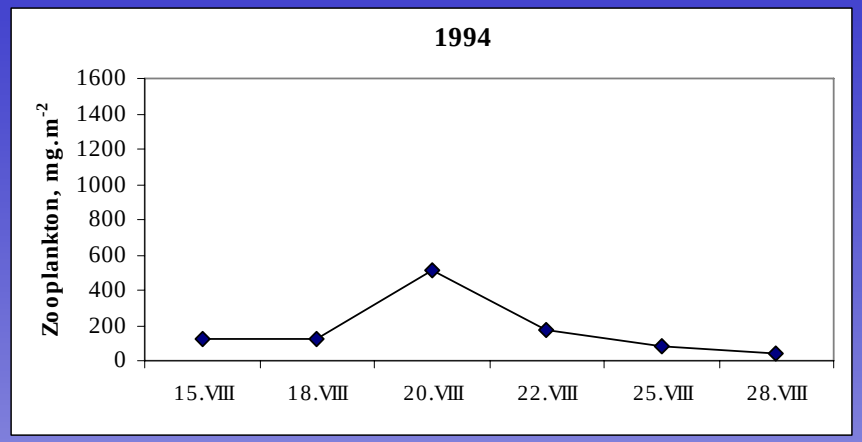
L=110 mm

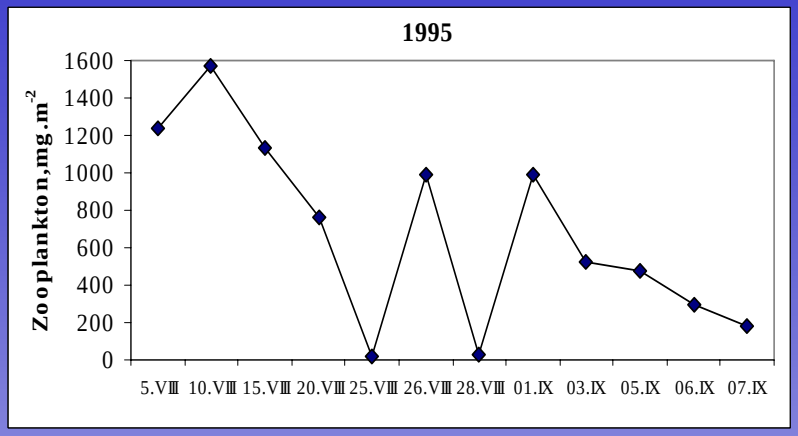
Mnemiopsis leidyi length (with lobbies) in the Black Sea

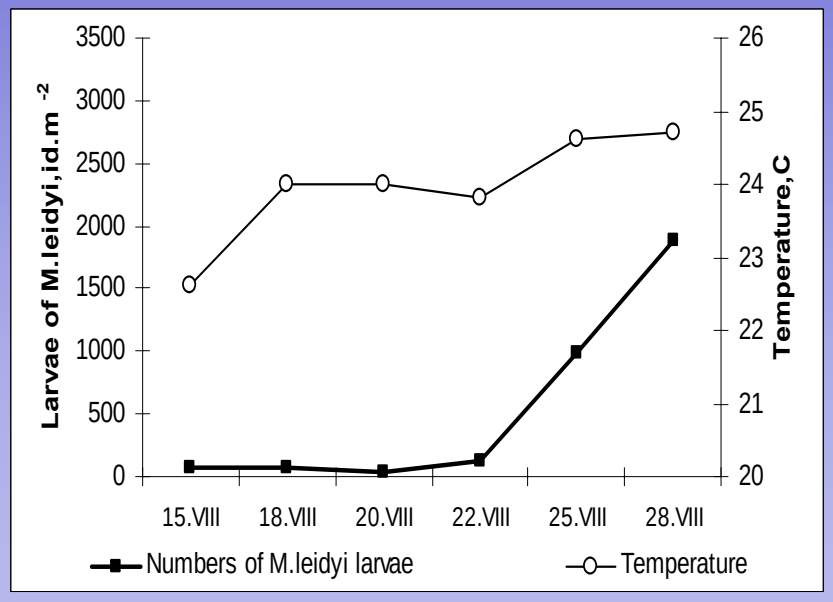
M. leidyi lives continuously and reaches the largest size in the Black Sea. It reproduces from the middle of July till late November. The environmental conditions of the Black Sea are optimal for *M.leidyi*. But due to short period of reproduction it can reach large size, growing with warming from early spring until middle of July. Its growth accompanies with growing long lobbies and auricles.

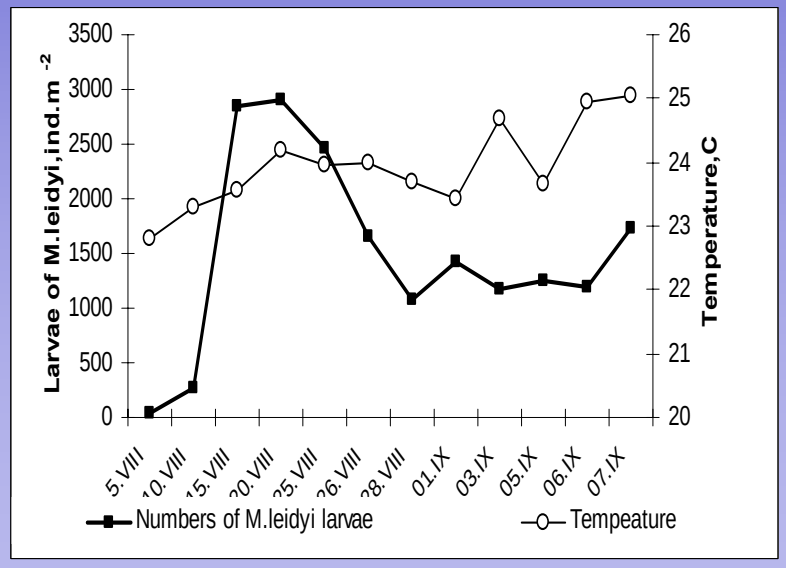


Phenology of *M.leidyi* in the Black Sea before *Beroe ovata* arrival

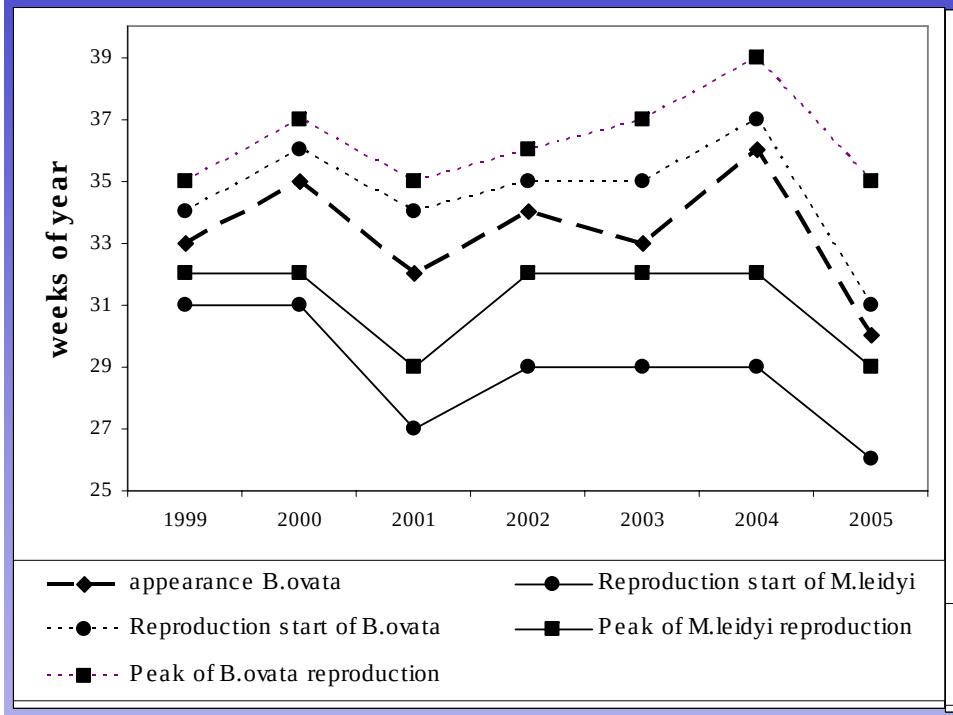


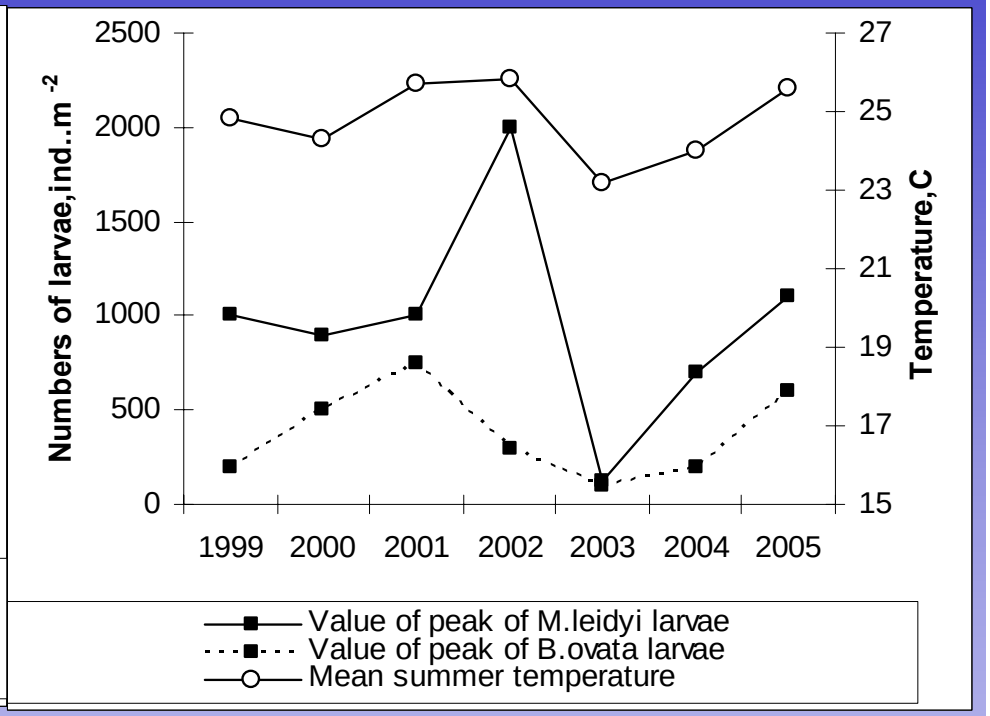






M.leidyi phenology after *Beroe ovata* arrival in the Black Sea

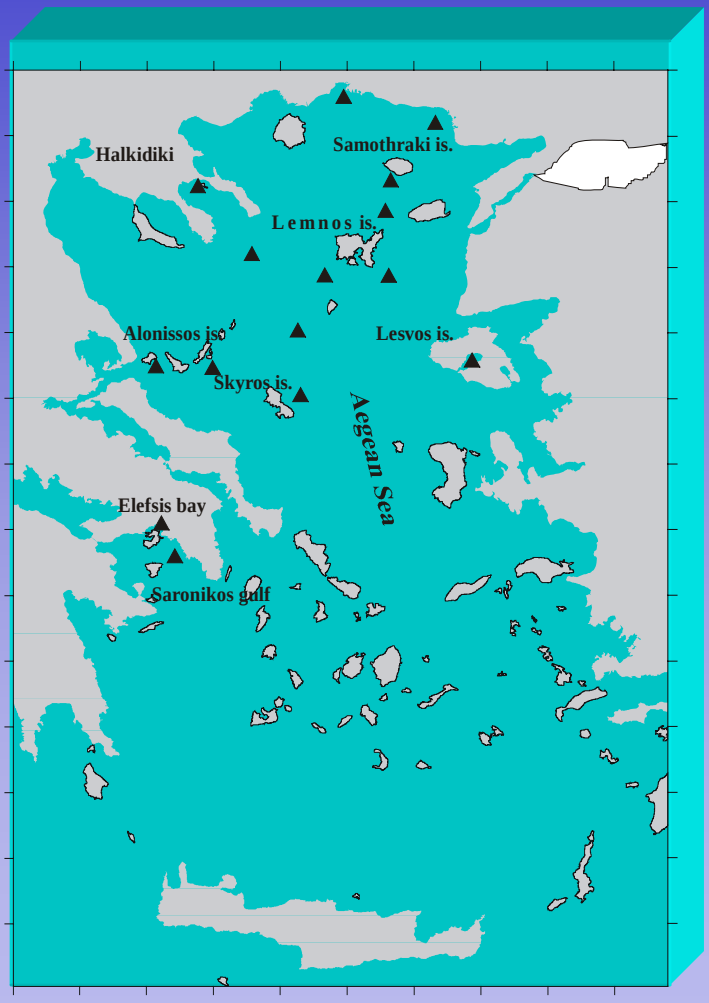




Mnemiopsis leidyi

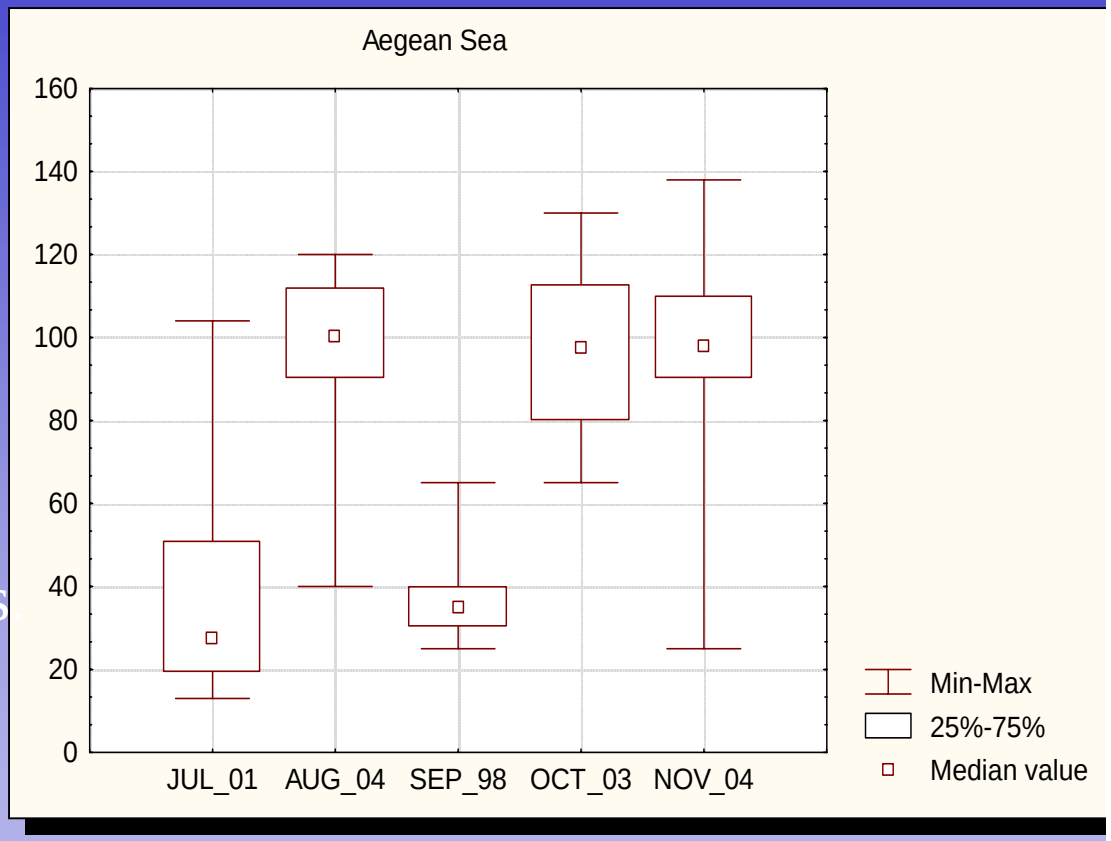
in the Aegean Sea

L=142 mm



Mnemiopsis leidyi length in the Aegean Sea

M.leidyi may reproduce only in some bays or coastal areas of the Aegean Sea, but it can not reproduce in most of the oligothrophic Aegean Sea. In some cases it can continue growing but its proportions change, auricles and oral lobbies grow much longer, papillae become bigger and cover most of body and lobbies.



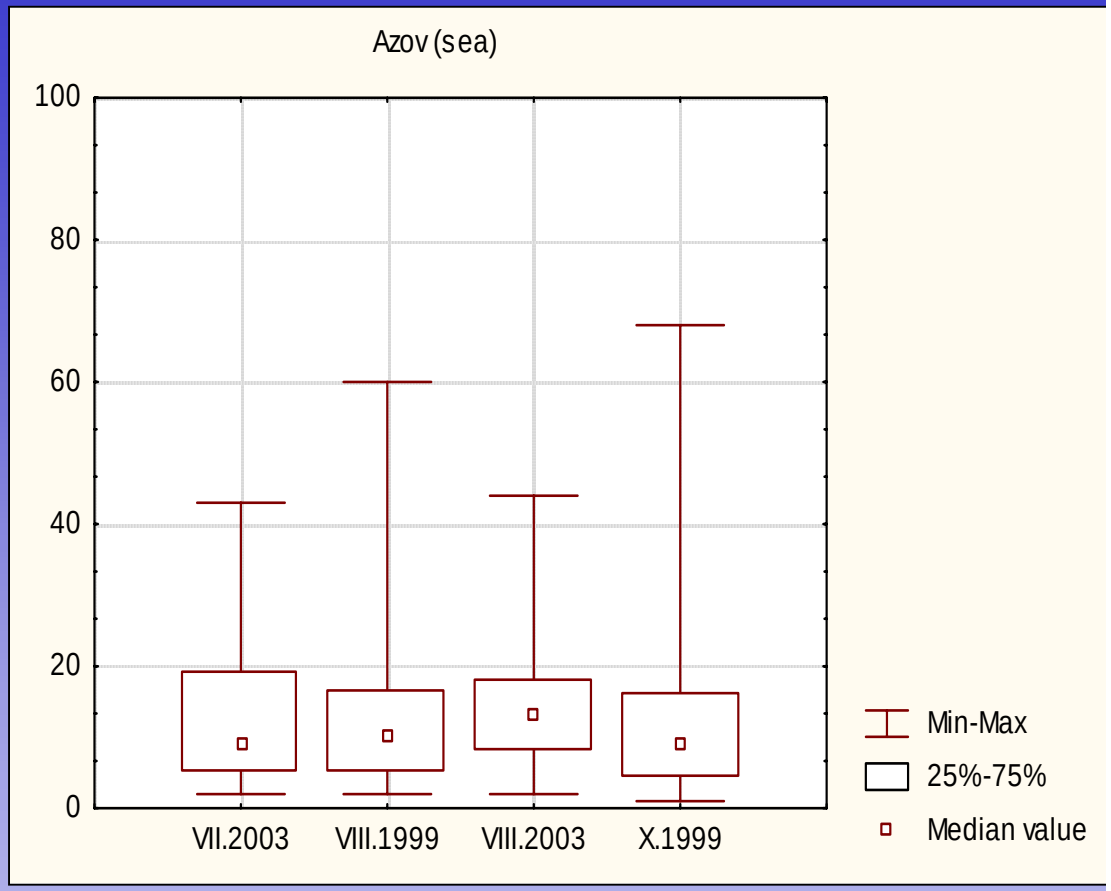
Mnemiopsis leidyi

from the Sea of Azov

L=46 mm

Mnemiopsis leidyi length in the Sea of Azov

M.leidyi can live in the Sea of Azov only during warm season, eliminating in autumn, when temperature reaches 4o and re-introduce every spring or early summer from the Black Sea. *M.leidyi* begins to reproduce soon after arrival in the Sea of Azov in June-early July in high prey (zooplankton) concentrations. The average size of *M.leidyi* in the Sea of Azov is about 20 mm, max 60 in the bays. *M.leidyi* has small round oral lobbies and short auricles.



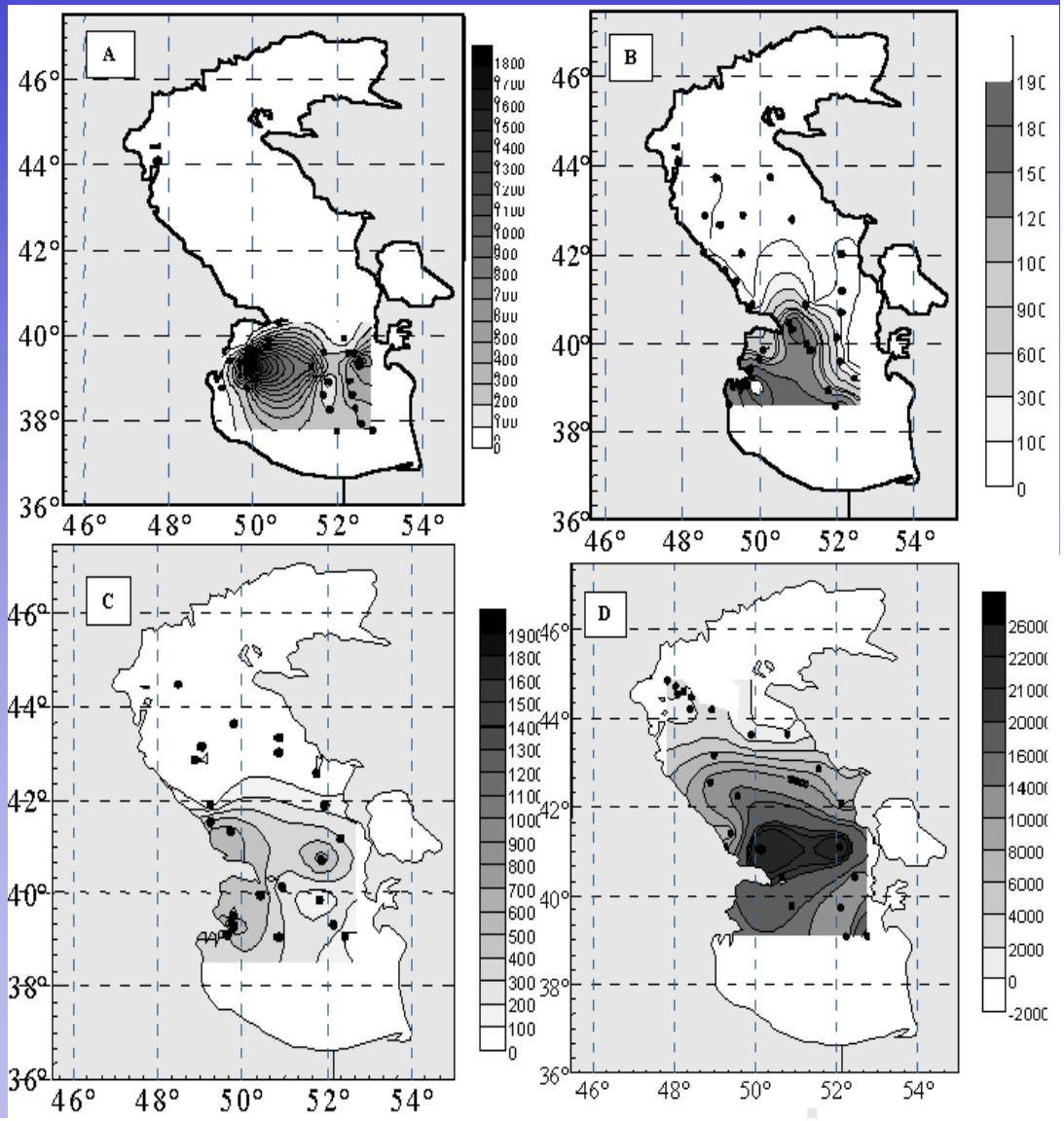
Mnemiopsis leidyi

from the Caspian Sea

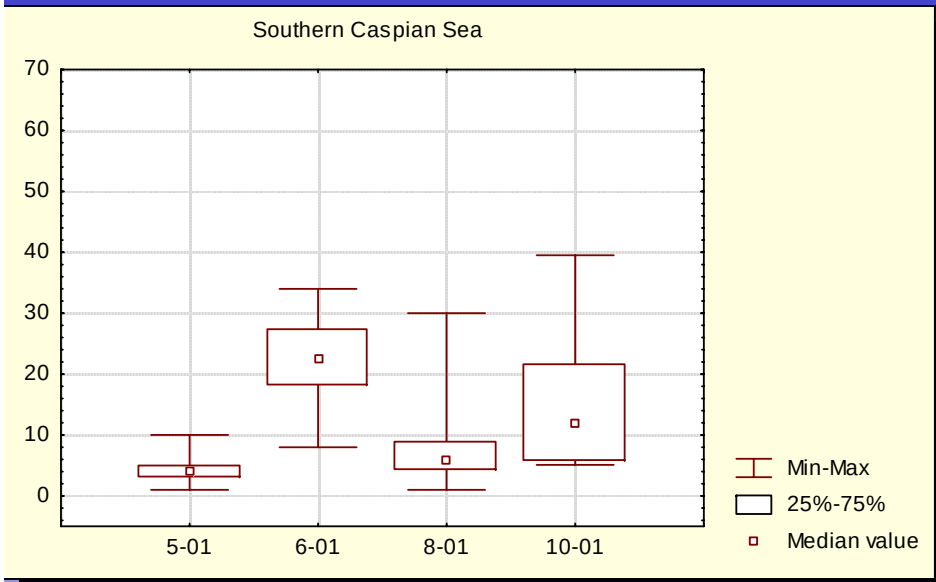
L=38 mm

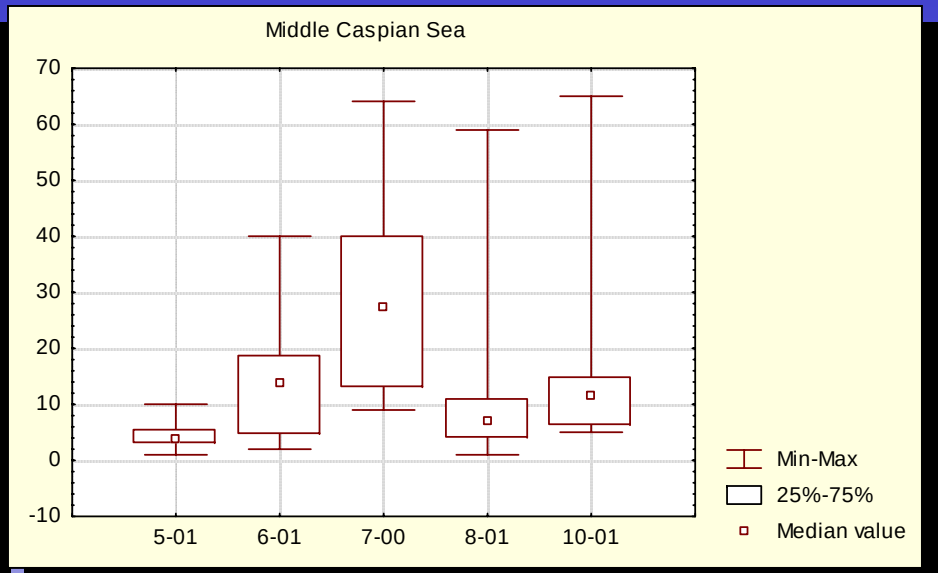
M.leidyi can live around a year only in the Southern Caspian. It spreads to the north with spring warming and reaches the Northern Caspian only in early August. *M.leidy*i starts actively to reproduce with spring warming, but reproduction was recorded even in winter in the Southern Caspian where temperature was >12º .

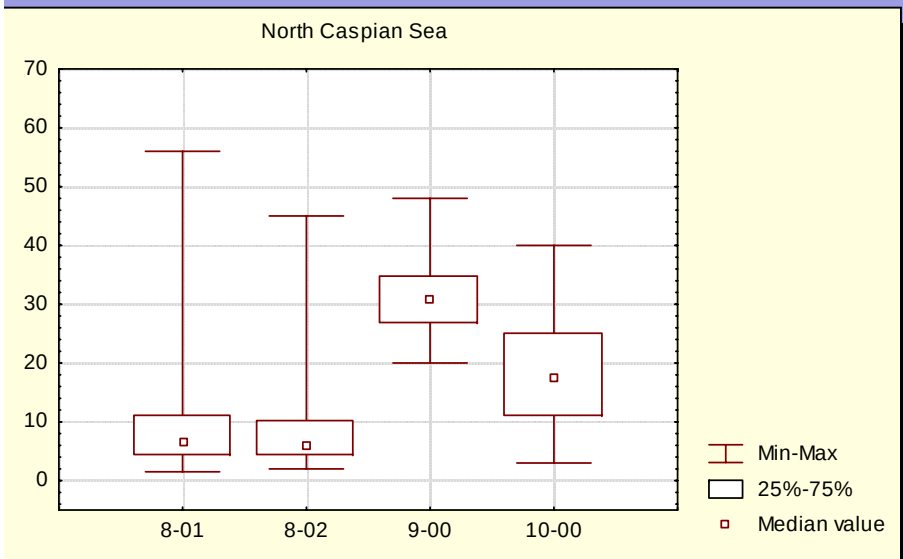
Pattern of seasonal distribution of *M.leidyi* in the Caspian Sea



Mnemiopsis leidyi length in the Caspian Sea



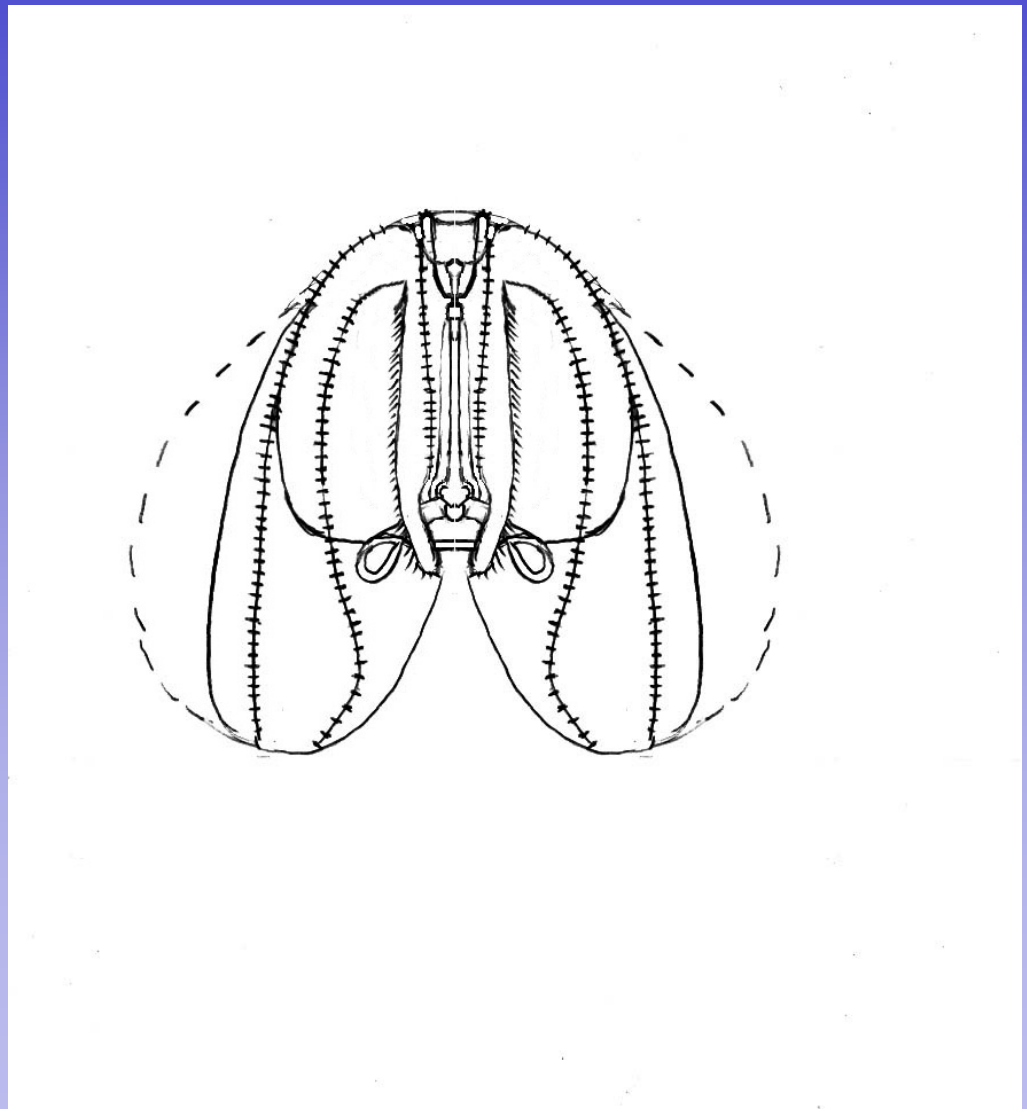




The size of the Caspian adult individuals *M. leidyi:* mean 20-30 mm, maximal 64 mm. Lobbies originate lower the level of the infundibulum. Oral lobbies short and round, auricles are also short.

Mnemiopsis leidyi

from the northern Caspian Sea



Mnemiopsis leidyi in the Baltic Sea

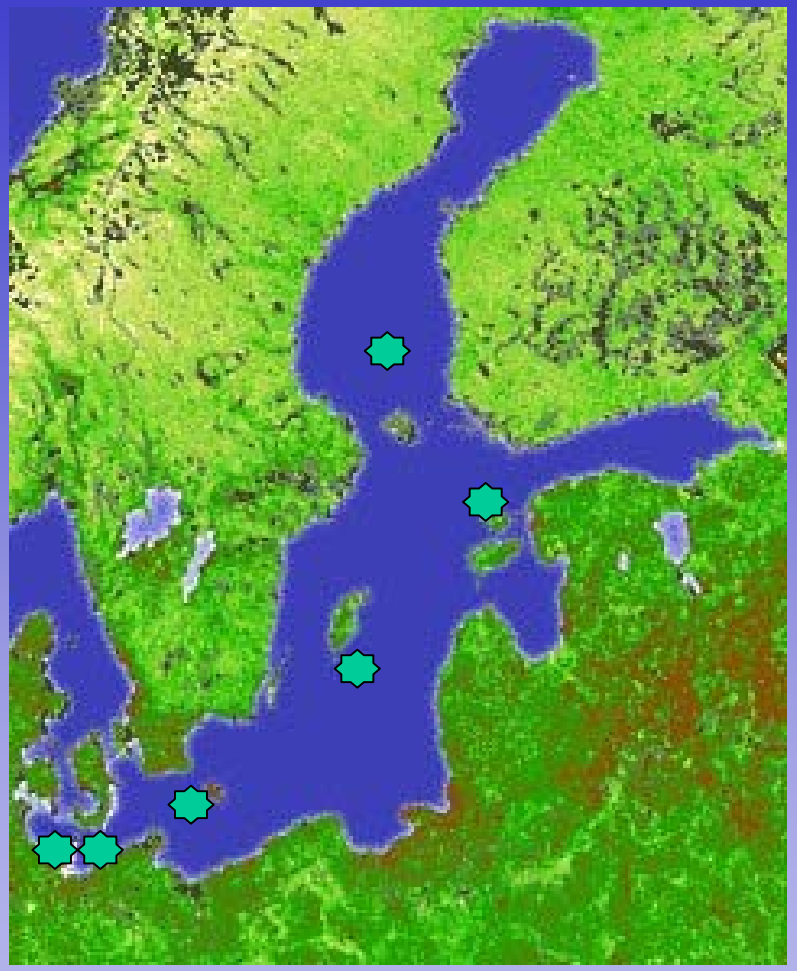
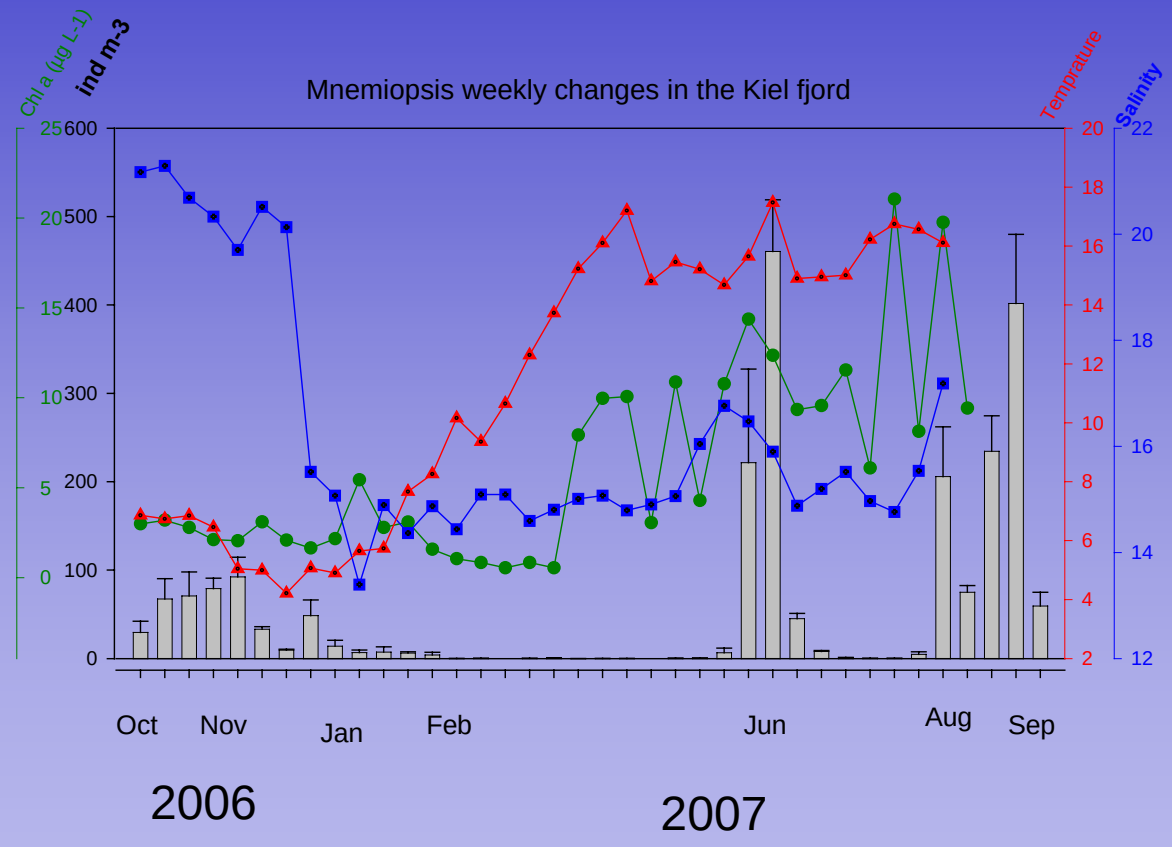


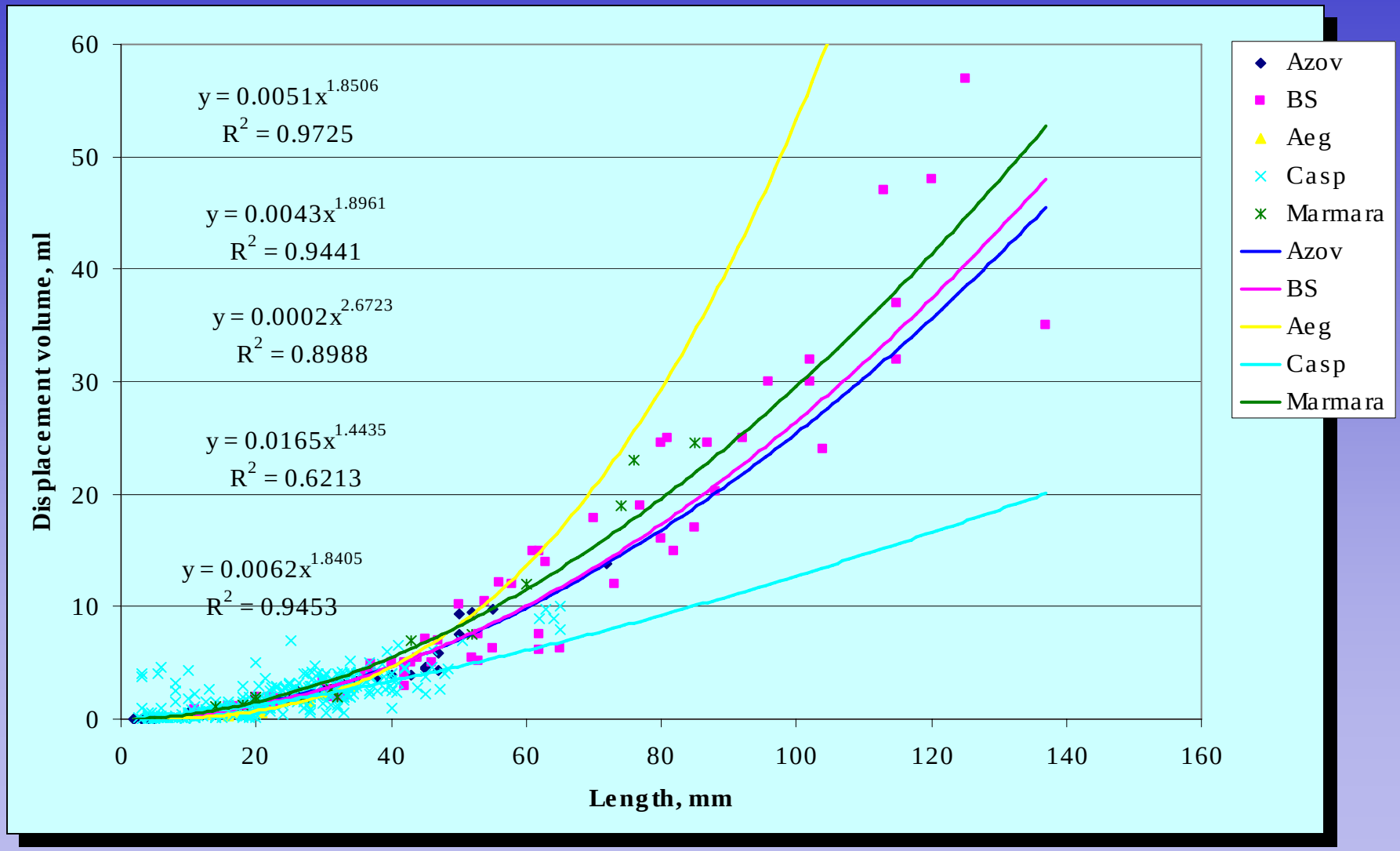
Photo J.Davidour

M.leidyi does not reach final size in the Baltic Sea as well. Oral lobbies short and round due to low salinity, low temperature. Maximal size 60 mm, mean 23 mm

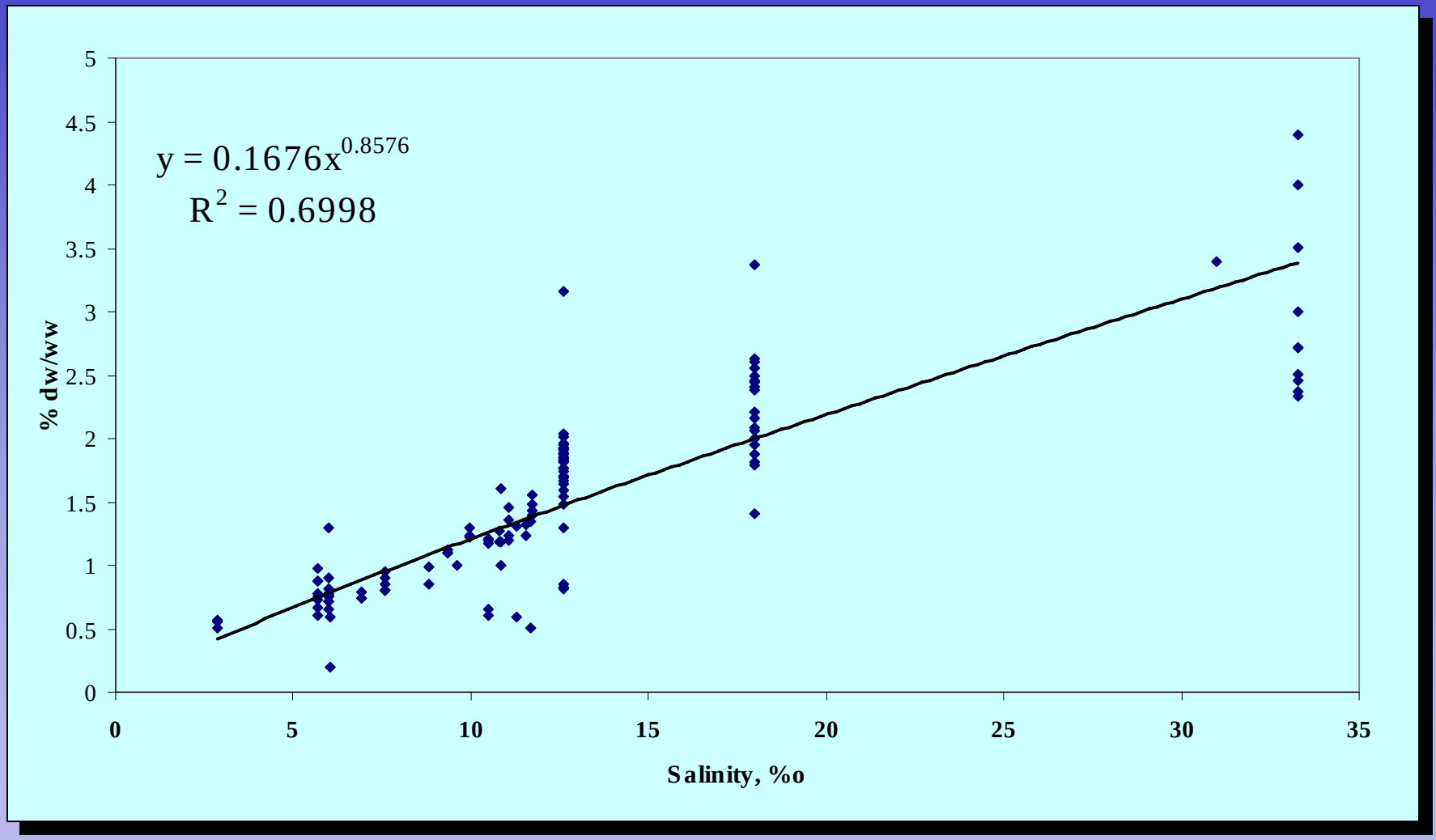
Seasonal development of *M.leidyi* in the Baltic Sea



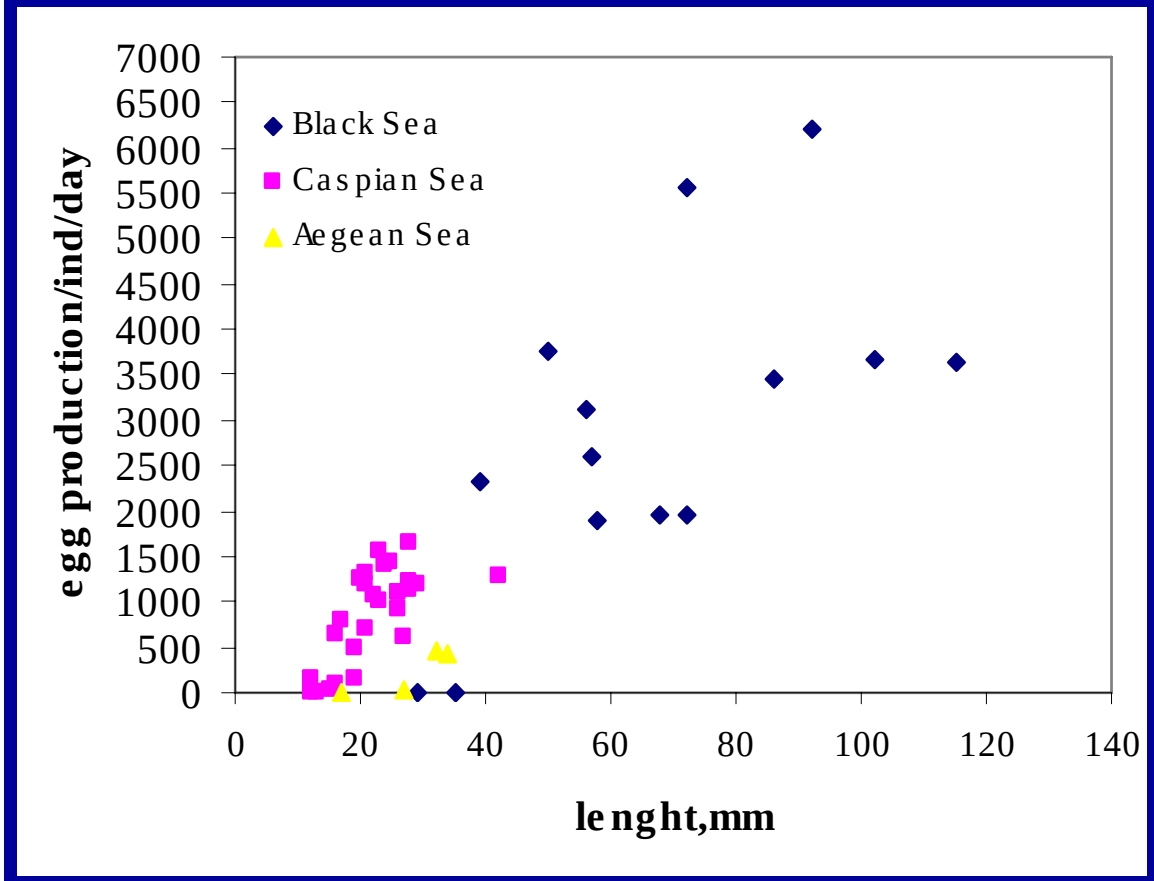
M.leidyi relationship between length and wet weight in the Azov, Black, Aegean, and Caspian Seas



Relationship between *M.leidyi* dry weight and salinity

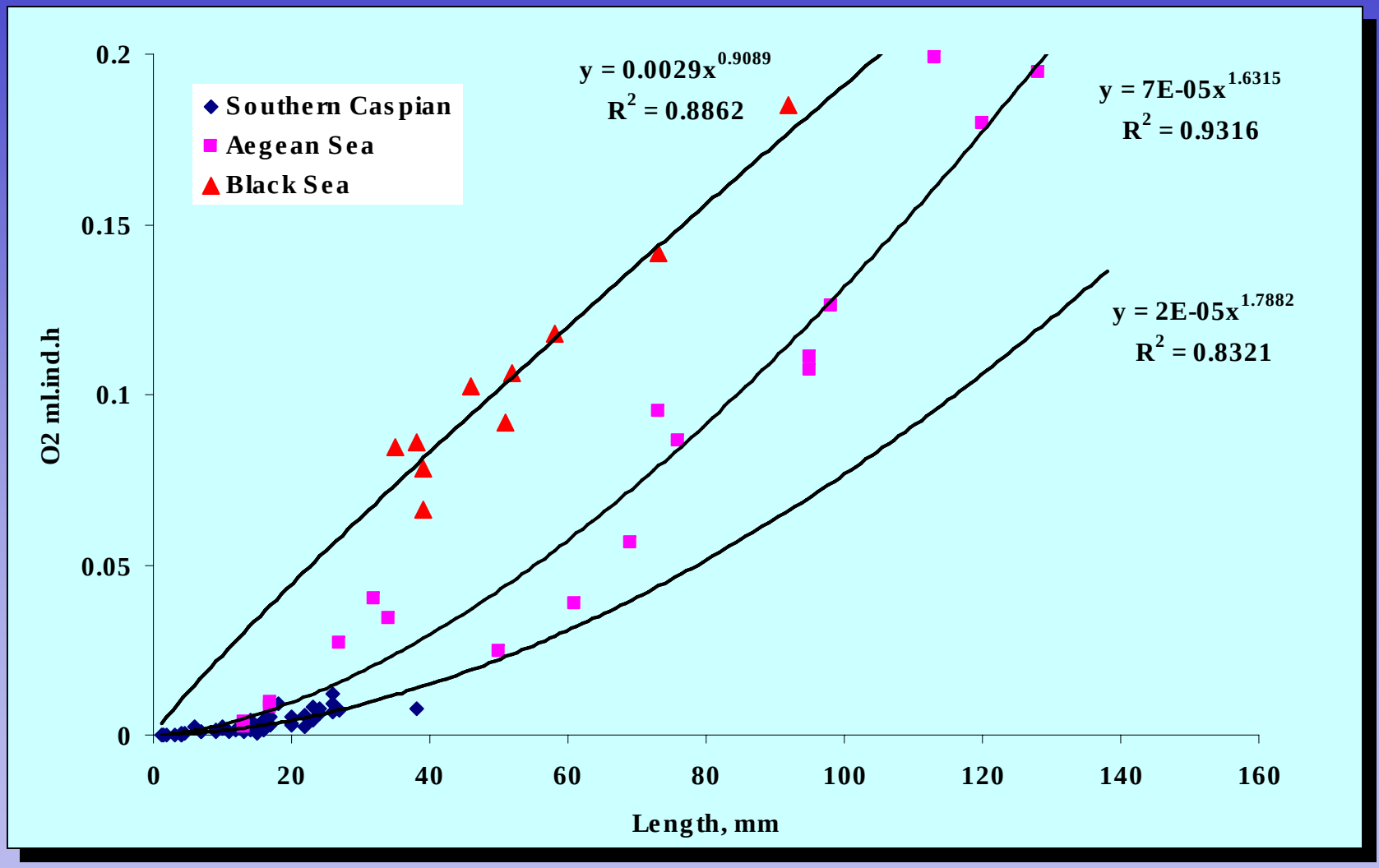


Fecundity of *M.ledyi* in different seas

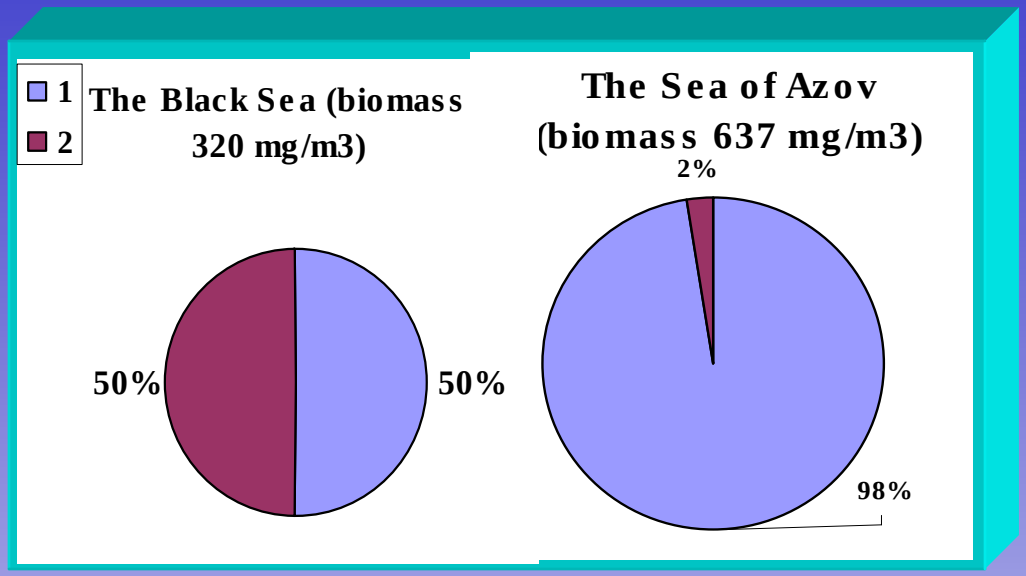


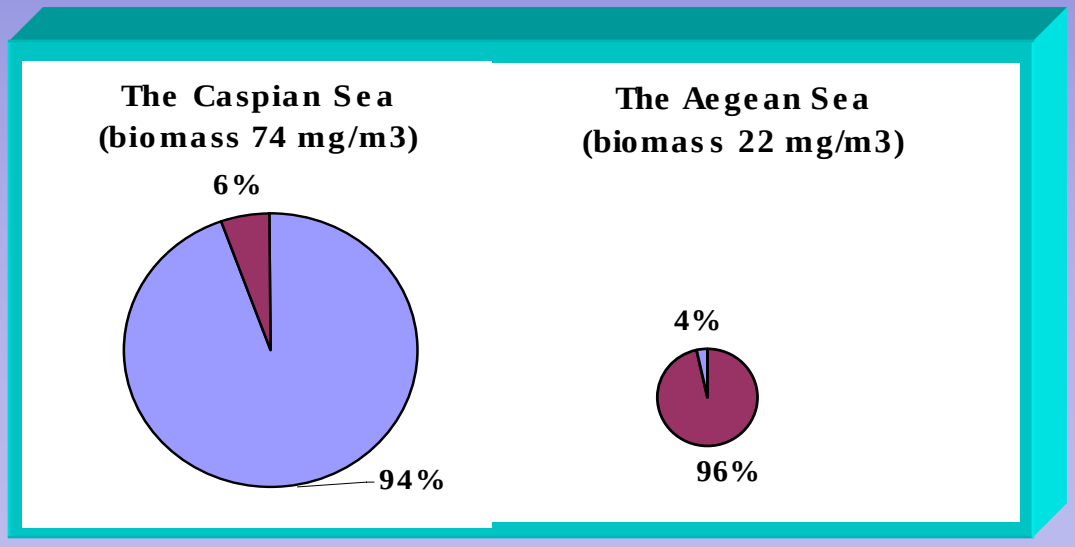
Reproduction rate of *M.leidyi* depends on temperature, salinity, and prey availability. The highest fecundity was found for the Black Sea *M.leidyi :* range 1900 - 6200, mean 3350±1380 ovae/ind, for the Caspian Sea *M.leidyi:* range 130- 1600, mean 937 ovae/ ind., for the Aegean Sea *M.leidyi*: range 24- 450, mean 250 ovae/ ind.Weight specific reproduction rate is the highes in the Caspian and Azov Seas lowest – in the Aegean Sea

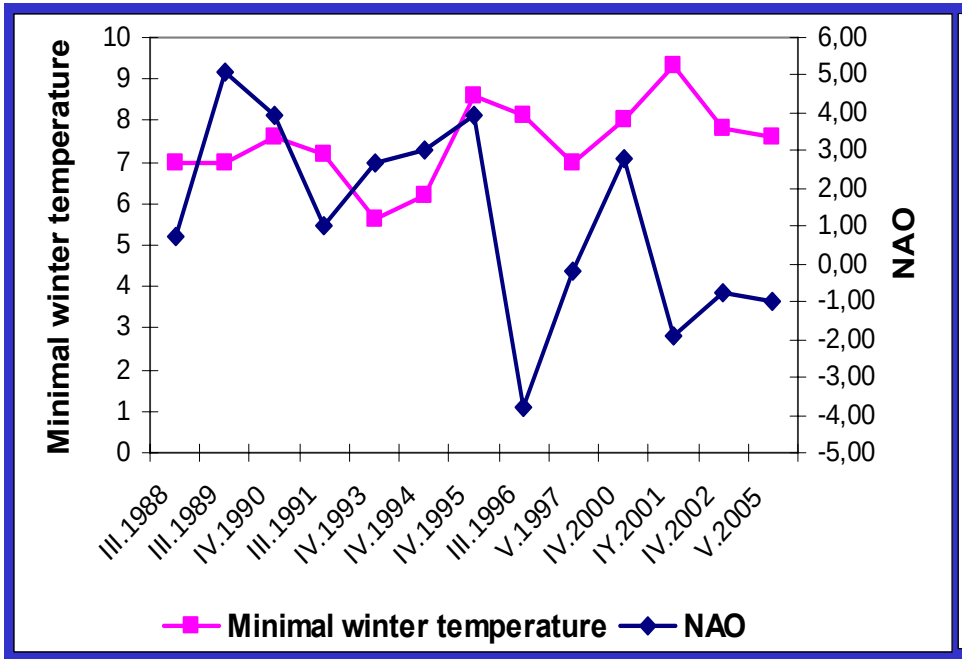
M.leidyi respiration rate (ml/ind./h) in the Aegean, Black and Caspian Seas

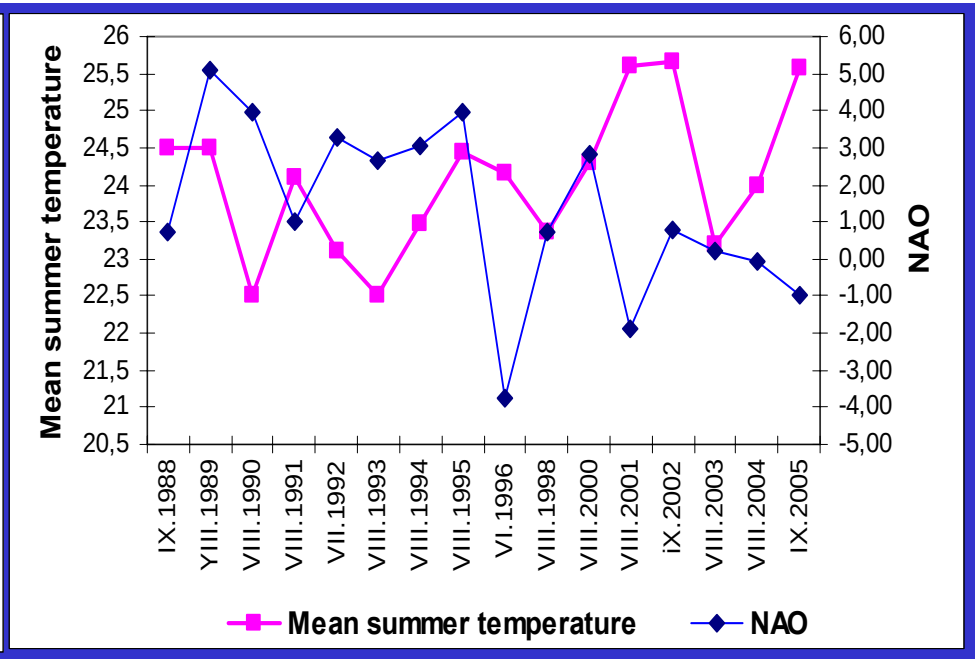


M.leidyi predation rate on zooplankton in the Black, Azov, Caspian and Aegean Sea



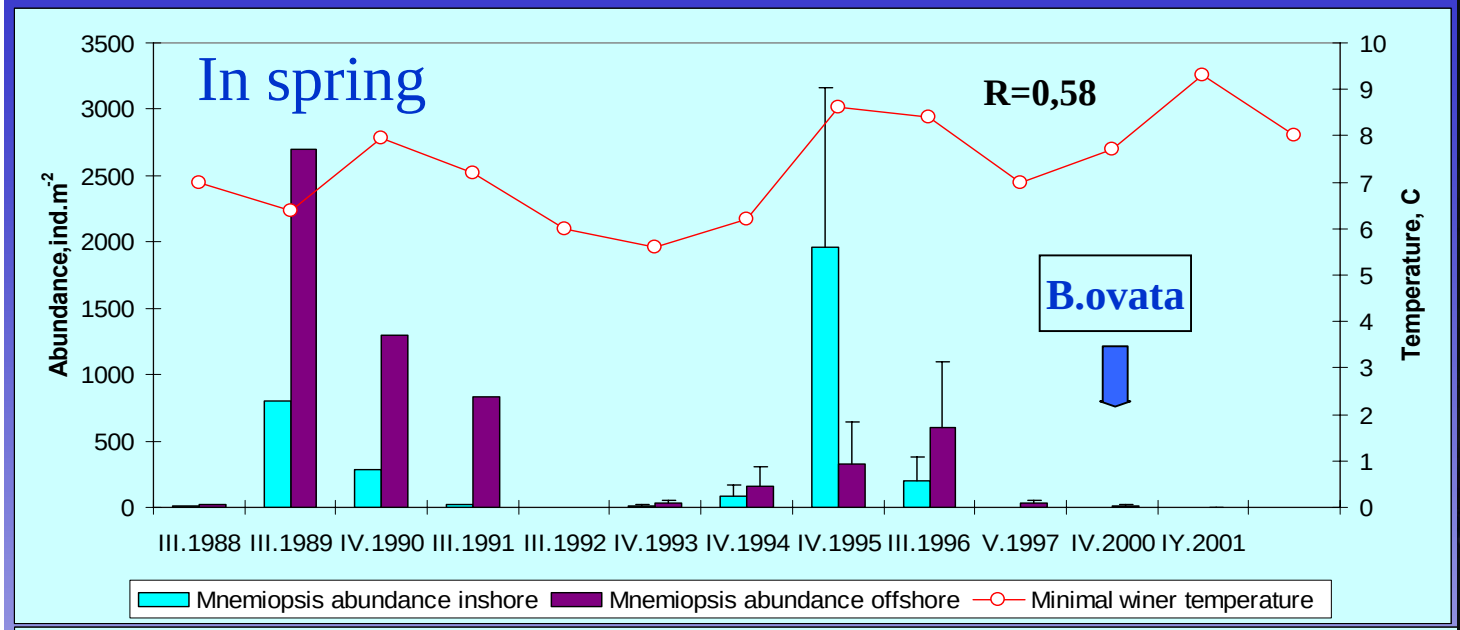


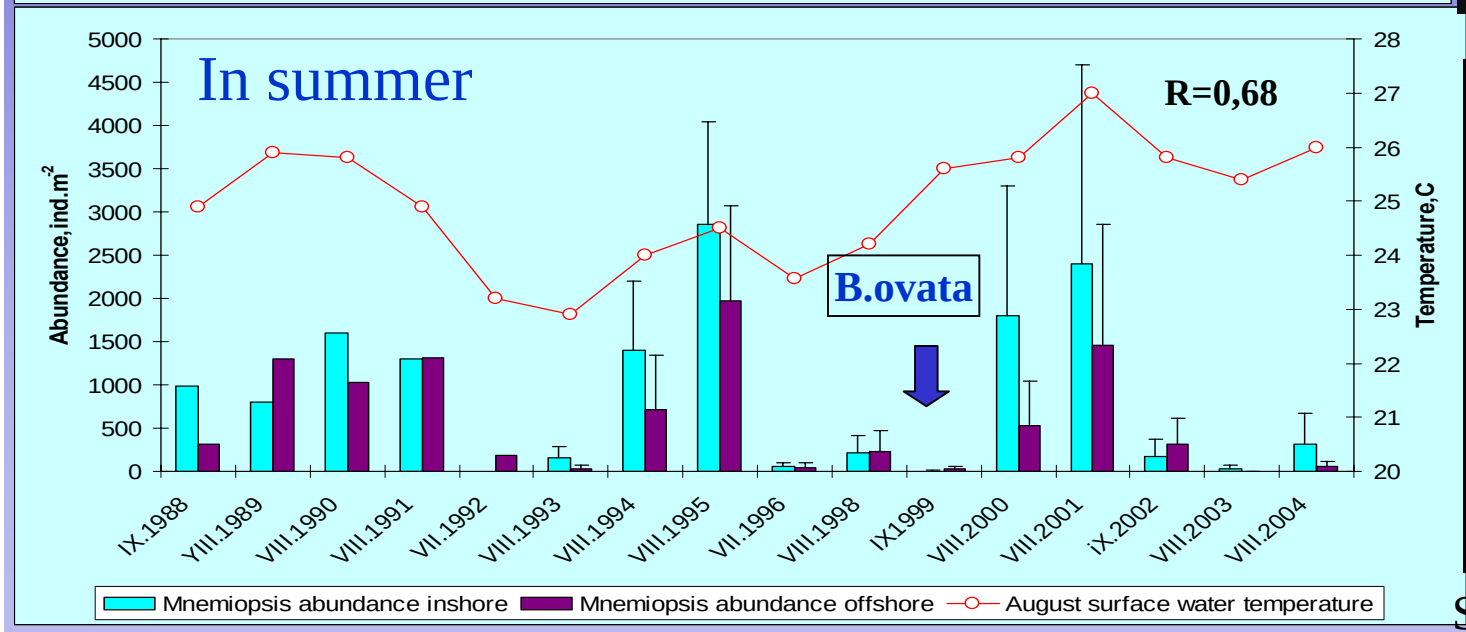


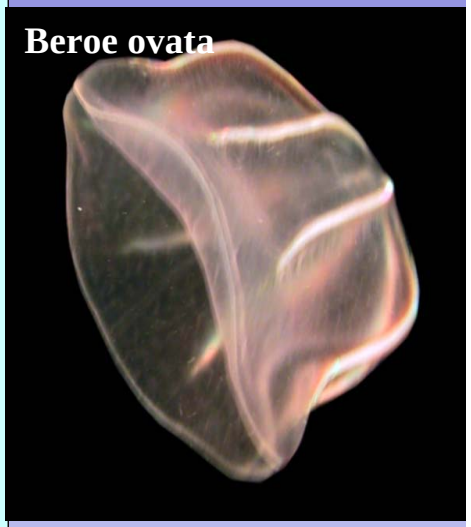


Interannual individual and population *M.leidyi* size, spatial distribution in spring and during a year are strongly control by SST, particularly by minimal winter SST. Minimal population size and absence in the inshore waters in spring occurs after cold winter, which are connected with positive NAO and EAWR indexes, affected the Eurasia region by cold and dry air masses. Under negative NAO and EAWR indexes – warm and wet air. After warm winter conditions for *M.leidyi* population growth are favorable.

Annual *M. leidyi* abundance and SST variability in the Black Sea

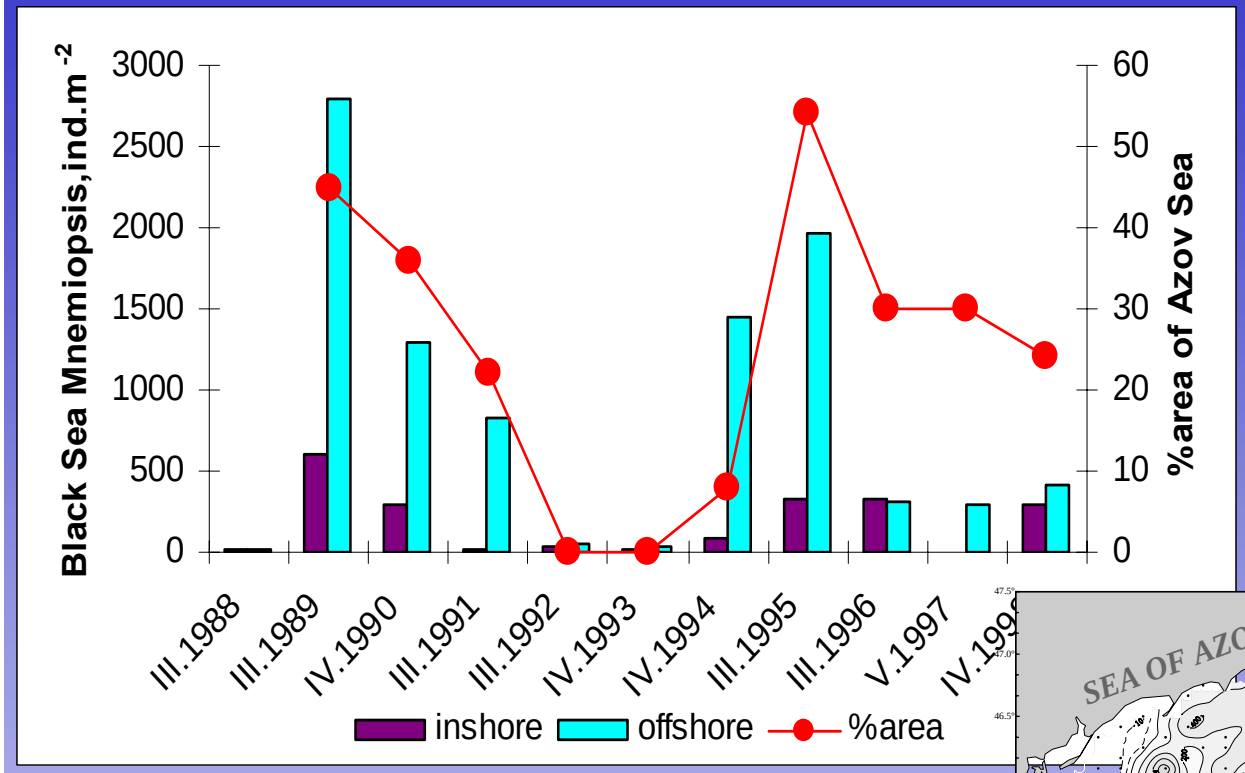






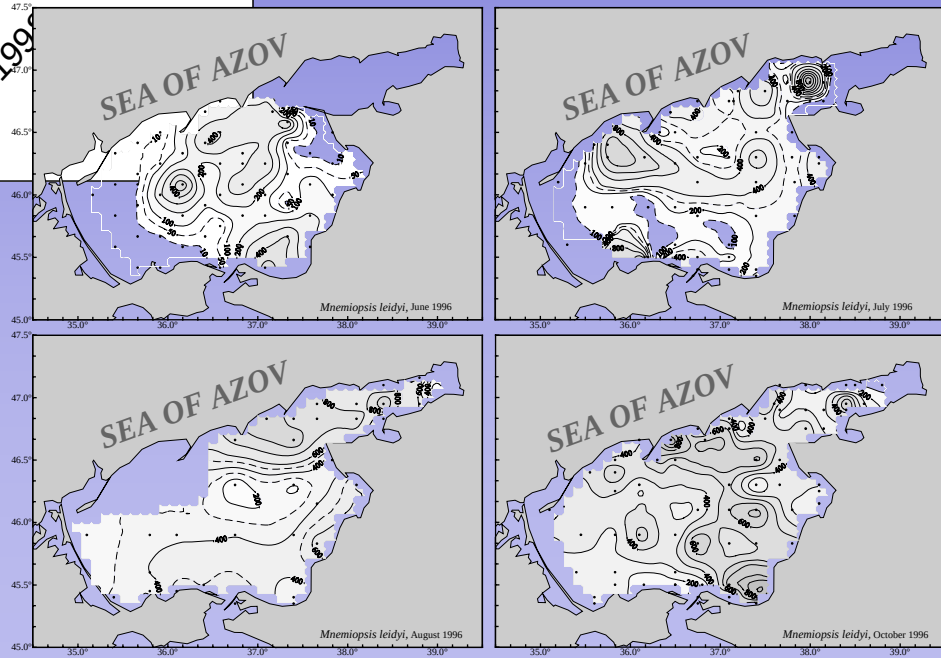
Shiganova et al., 2004

M.leidyi abundance in the Black Sea in spring and area occupied by *M.leidyi* in the Sea of Azov in June



NE **wind increase; air temp. and SST decrease**

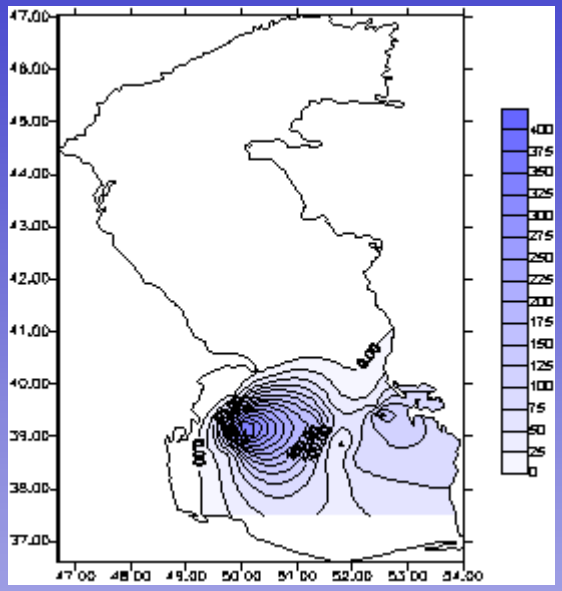
NAO becomes positive and system switches to SW wind regime

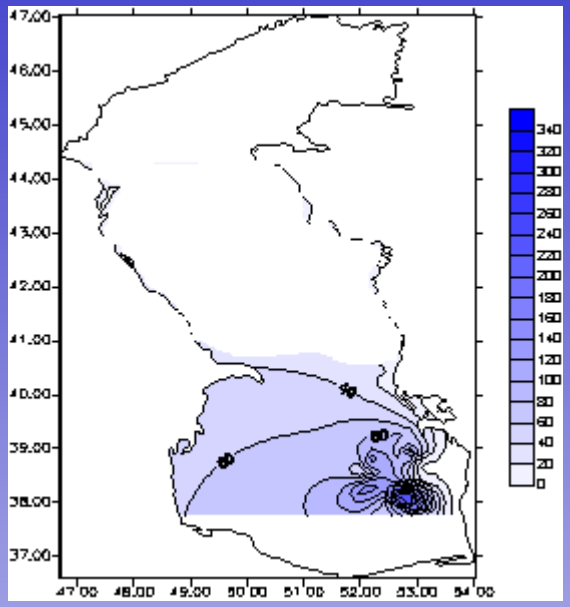


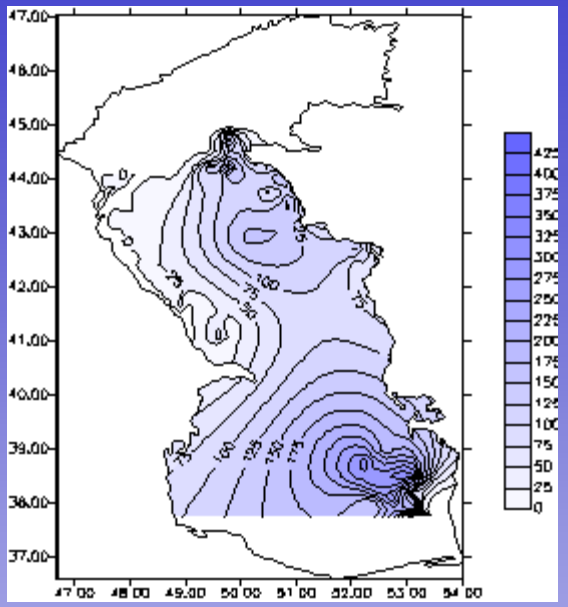
Shiganova et al,2001

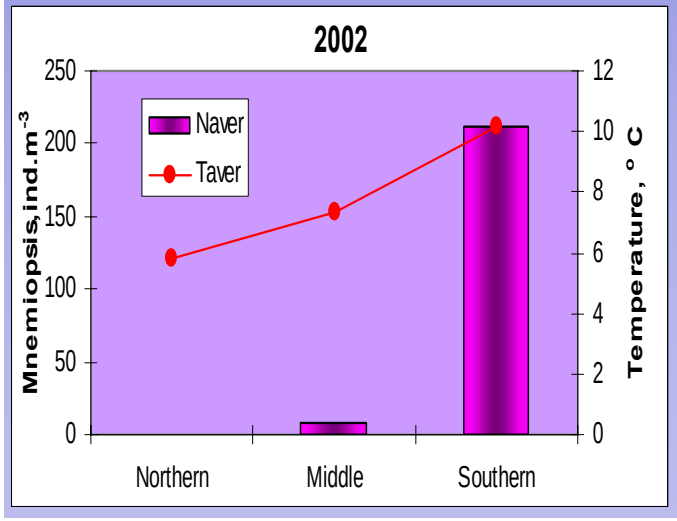
Pattern of *M.leidyi* distribution in winter

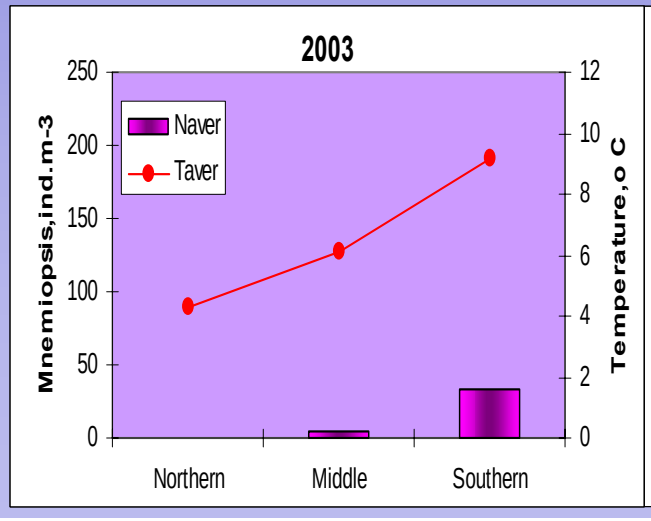
2002 2003 2004

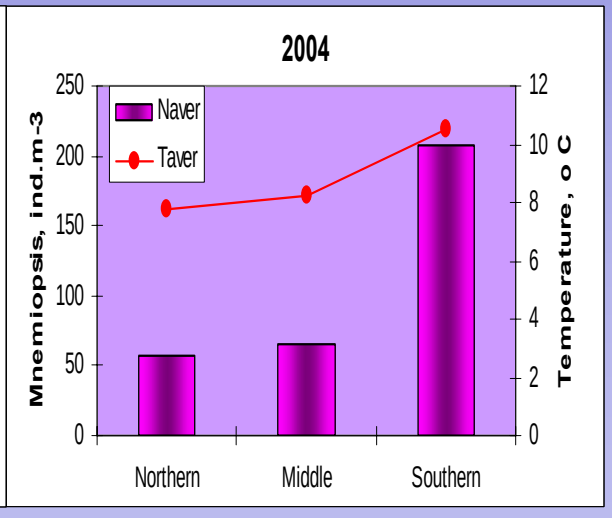




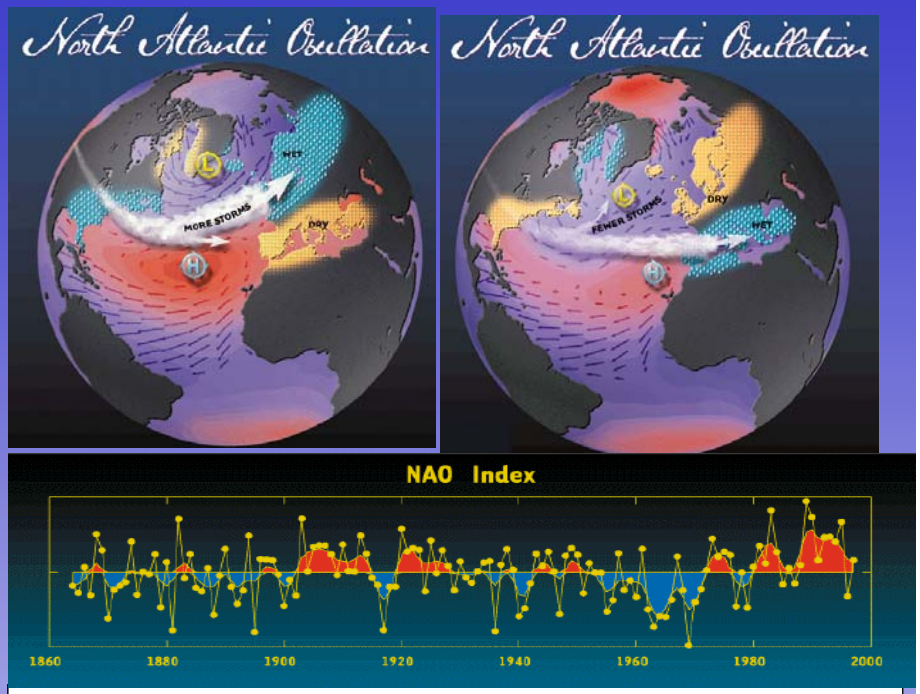


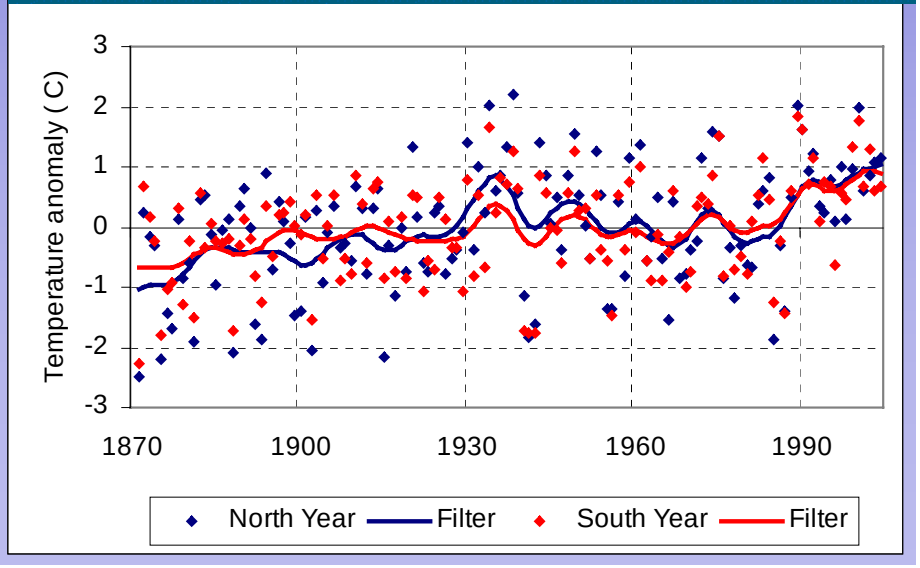


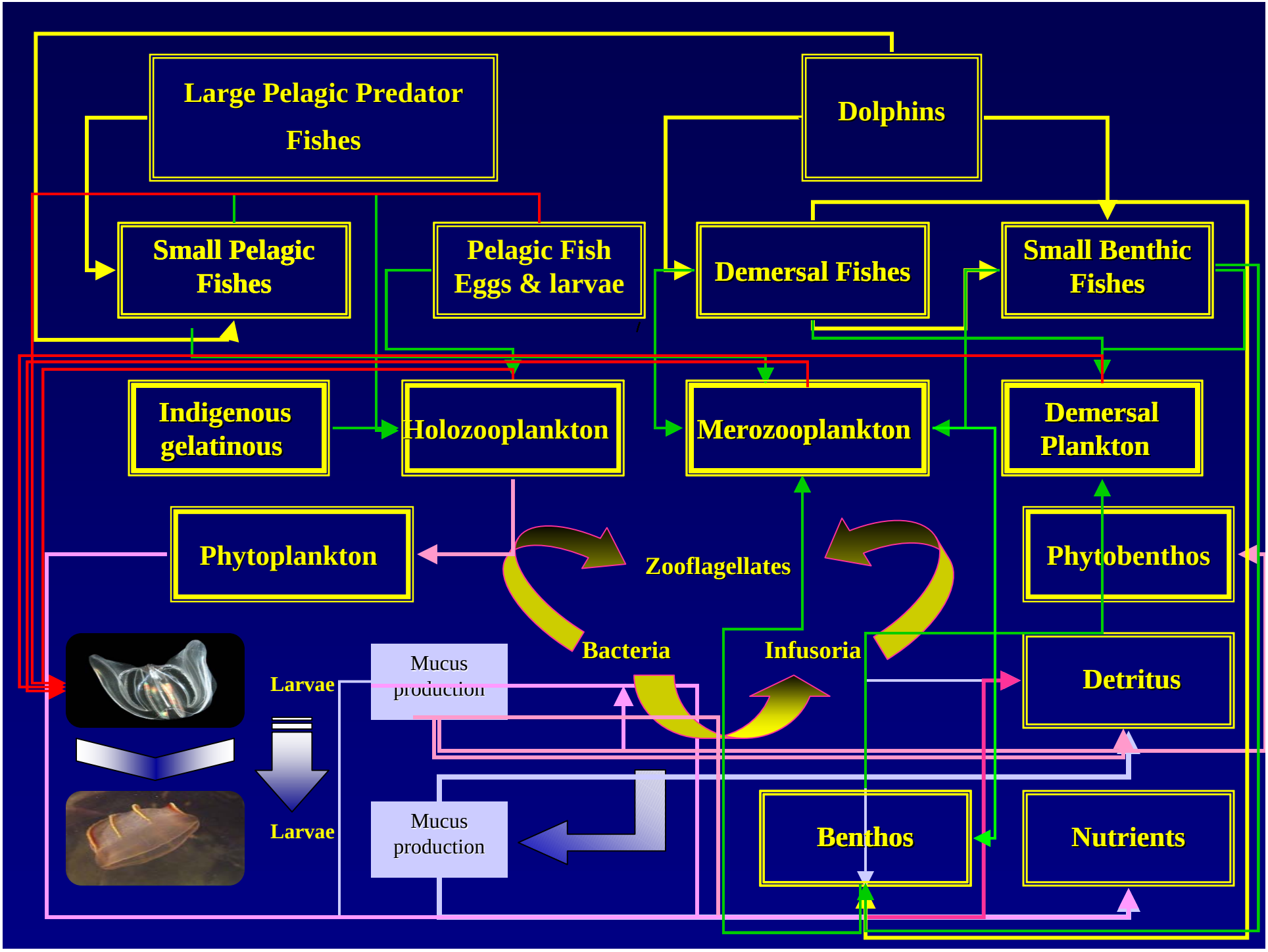




Annual anomaly temperature in the Baltic Sea






Large Pelagic Predator Fishes
Dolphins
Small Pelagic Fishes
Pelagic Fish Eggs & larvae
Demersal Fishes
Small Benthic Fishes
Indigenous gelatinous
Holozooplankton
Merozooplankton
Demersal Plankton
Phytoplankton
Zooflagellates
Phytobenthos
Bacteria
Infusoria
Detritus
Larvae
Mucus production
Larvae
Mucus production
Benthos
Nutrients

Beroe ovata Mayer, 1912

B.ovata was introduced in the Black Sea in 1997, spread around the Black Sea in 1999. *B.ovata* is specialized predator on planktivorous ctenophore like *M.leidyi*. It began to control *M.leidyi* population size and the Black Sea ecosystem started to recover.

Distribution of *B.ovata* in the Southern Seas

(a year is a first finding in the sea)

Conclusions

M.leidyi is a polymorphic species with wide environmental tolerance and high phenotypic variability. Therefore it could establish in different environmental conditions of the Eurasian Seas. And environmental conditions determined its morpho-physiological features in its possible range of phenotypic alternative development.

In their turn morpho-physiological features of *M.leidyi* in different environments determine seasonal cycle of life, which includes reproduction rate and time, population growth and size, pattern of seasonal distribution and finally population predation rate on zoo- and ichthyoplankton.

But interannual individual and population *M.leidyi* size, spatial distribution are control by SST. Minimal population size and absence in the inshore waters in spring occurs after cold winter, which are connected with positive NAO and EAWR indexes, affected the Eurasia region by cold and dry air masses. Under negative NAO and EAWR indexes – warm and wet air. After warm winter conditions for *M.leidyi* population growth are favorable.