First Observation of the Mucilage/Gelatinous Formation in the Sea of Marmara in October 2007

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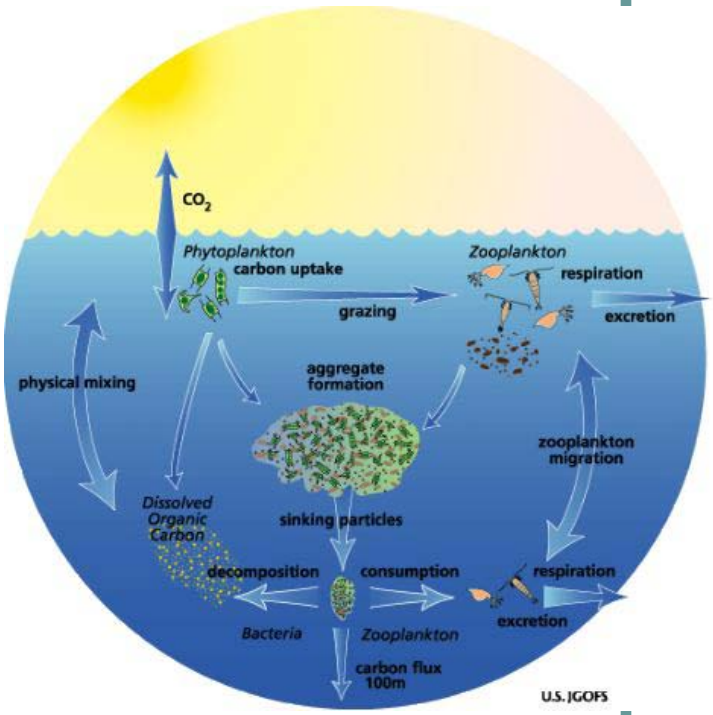
Global problem

Formation of mucilage has been reported from many world seas (Pompei et. al., 2003, Cozzi et al 2004, Precali et. al., 2005; Najdek 2005).

The first record of this phenomenon dates back to 1729 in Adriatic Sea, and episodes which occurred in the 19th century and in the first-half of the 20th century (Cozzi et. al., 2004) were reported from New Zealand (MacKenzie, 2002) to Mexico Gulf.



Causes

There is a general consensus that the mucilage phenomenon is generated by synergic combinations of several factors (Degobbis et al., 1999; Precali, et. al., 2005).

Some studies point out that mucilage formation originates from phytoplankton as a consequence of high chlorophyll a, and high density of phytoplankton besides its formation is not completely understood (MacKenzie, 2002).

Significant changes of nutrient concentrations and ratios, various perturbations in the organic carbon flow through planktonic food webs may cause the production and accumulation of mucilage (Malej, 1995; Azam et al., 1999).

Particularly climatic and oceanographic conditions also seem to have an important role in triggering the phenomenon (Degobbis et al.,1995; Ed.,2005).

Researchers initial findings (Project TCP/TUR/3201)

- Phytoplankton blooms and mucilage formation became a global concern,
- Mucilage can not be attributed to plankton blooms related to pollution and dissolved oxygen deficiency,
- Mucilaginous aggregates have been detected in many locations of the Mediterranean Sea, besides the Adriatic.

- Researchers studying the factors lying beneath mucilage formation in the Sea of Marmara in 2007 reported different species as responsible from the phenomenon:

Istanbul University-Institute of Marine Sci.: *Liriope tetraphylla*

TUBITAK: *P. micans, Skeletonema* sp. and *Gonyaulax fragilis*

I**stanbul University-Department of Biology and Faculty of Fisheries**: *Gonyaulax fragilis, Cylindrotheca closterium, Chaetoceros costatum and Thalasiosira rotula, Thalasiosira hyalina*

İnönü Foundation: *Rhizosolenia calcaravis*

First observations

Beginning period of aggregate formation: **Replies of fisherman to questionnaires which were designated to find out information on the mucilage formation in the Sea of Marmara show that no obvious change was occurred on the sea surface in the autumn 2006. These replies also show that the aggregate formation was first encountered by fishermen through smeared fishing nets which became heavier due to the mucilage aggregation. Purse seiners also reported that they realized thick gelatinous formation while setting around the fish although this formation was not detected by equipped echo sounders. Questionnaires results showed that fishermen associated this phenomenon with the invasive species Mnemiopsis leidyi which caused a very significant damage and sharp decline on fisheries in the Sea of Marmara in 1994.**

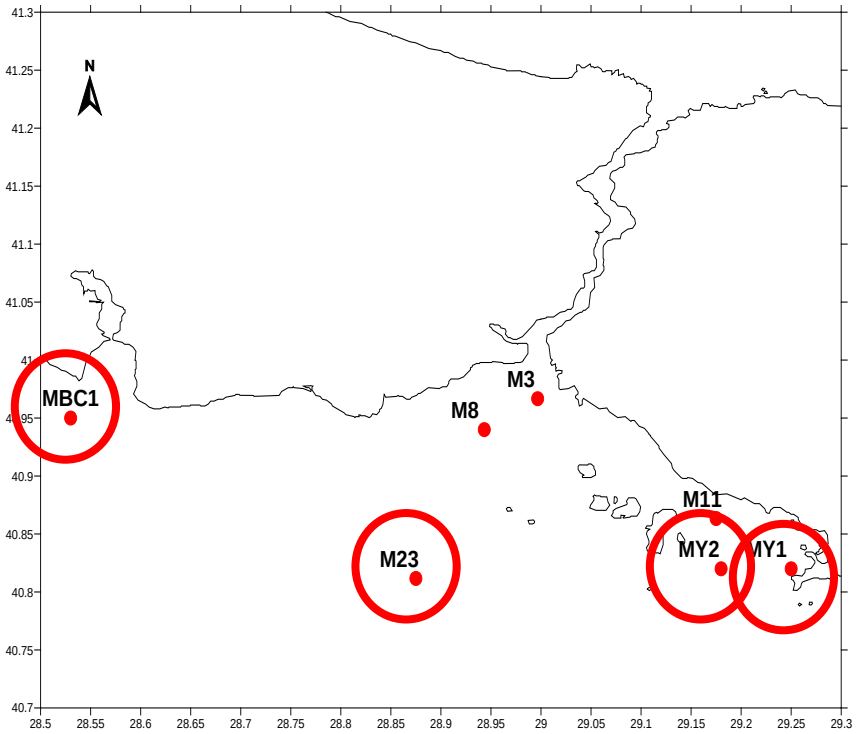
In August 2007, abnormal conditions were gradually observed by fishermen as fishing nets became extremely heavier. Aggregate formation took place in whole Sea of Marmara in late October 2007 and fishing had serious problem following the formation.

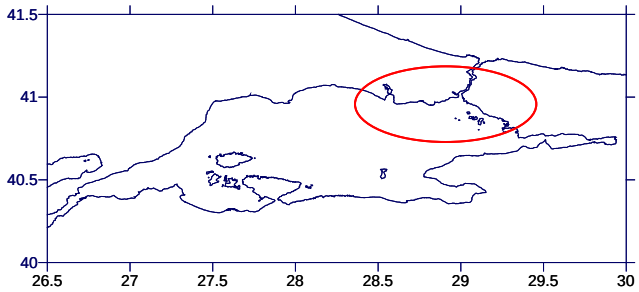
2007 ?

Dense mucilage/gelatinous matter production significantly affected fishing, as derived from the results of “Socio-economical status of Marmara Sea fishermen” project. Fishermen faced serious economic losses due to both damage in their fishing gear and decrease in fishing efficiency. This was particularly pronounced in October-December of 2007 and continued in 2008 and following years in smaller dimensions.

So what happened before and after 2007?

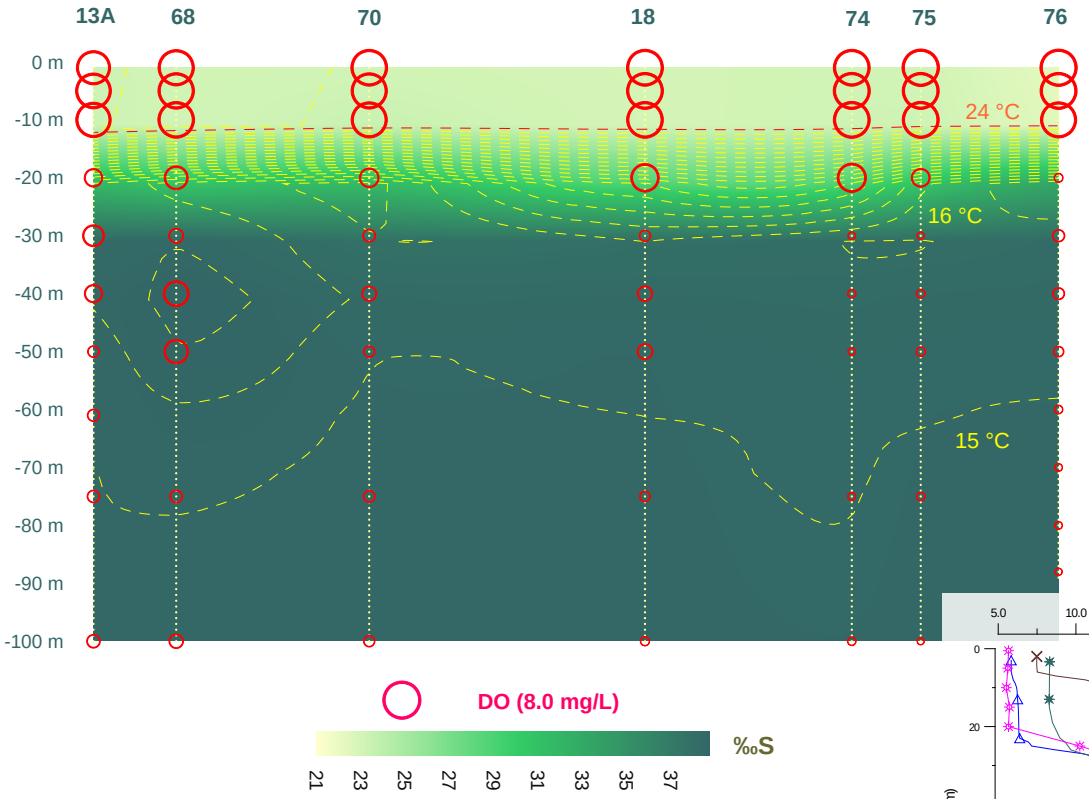
Monitoring stations

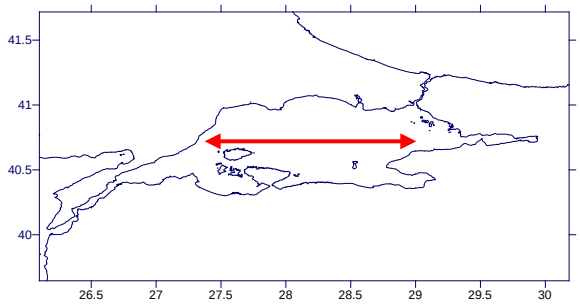


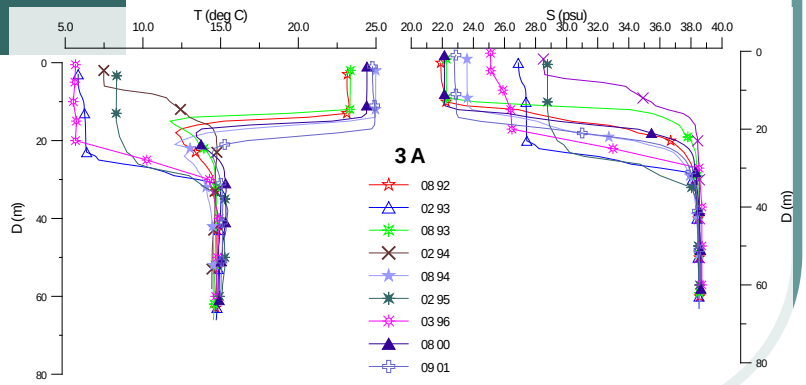


Locations of monthly monitoring stations in 1996-2009 period

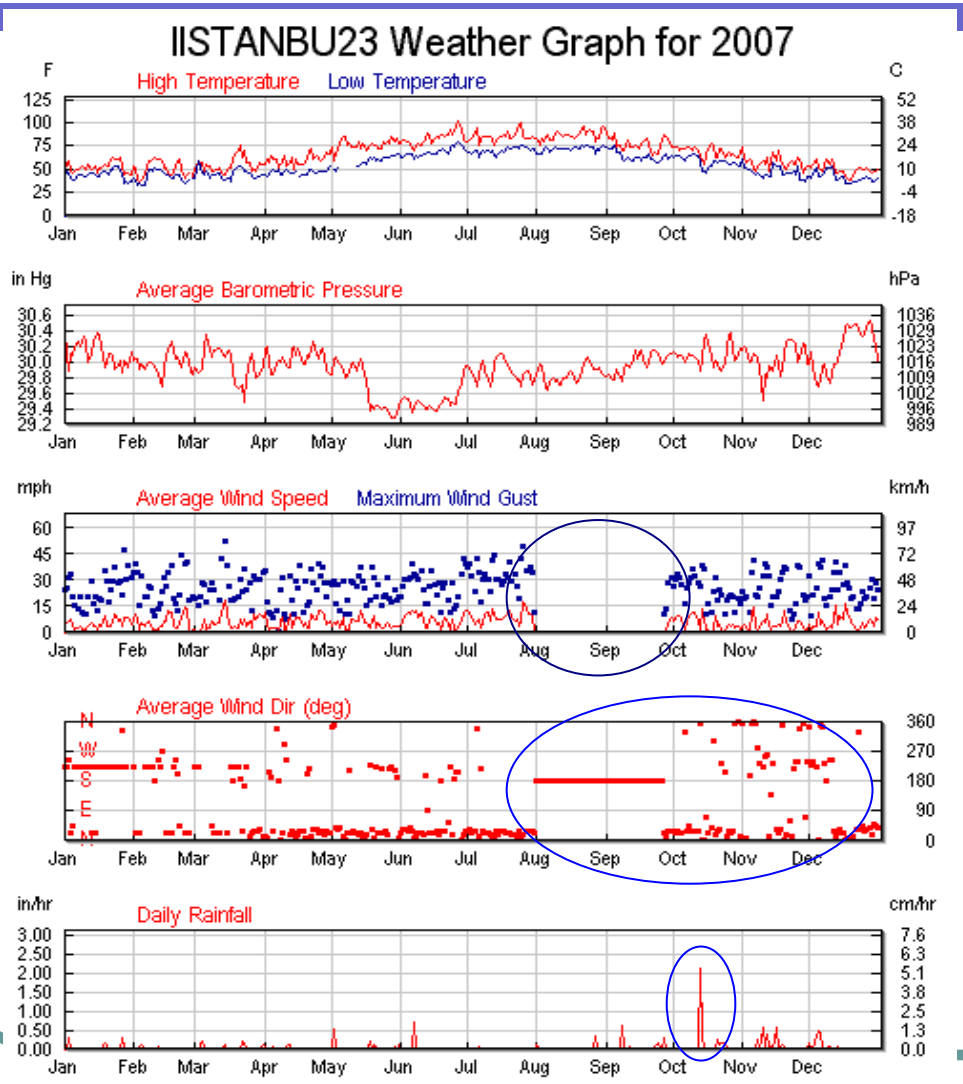
Sea of Marmara is a stratified basin







Weather conditions



Weather was stable in August and September before the aggregate formation occurred, afterwards strong northerly wind occurred and weather temperature sharply declined in October.

The amount of rainfall falling on unit area was reported 97 mm with the highest amount within 2 years

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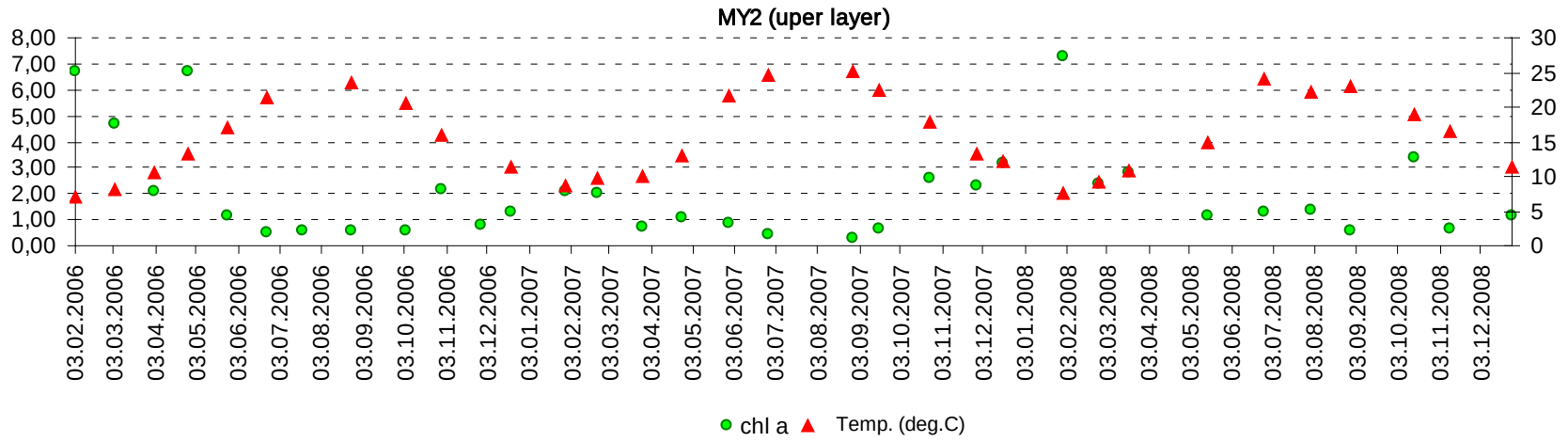
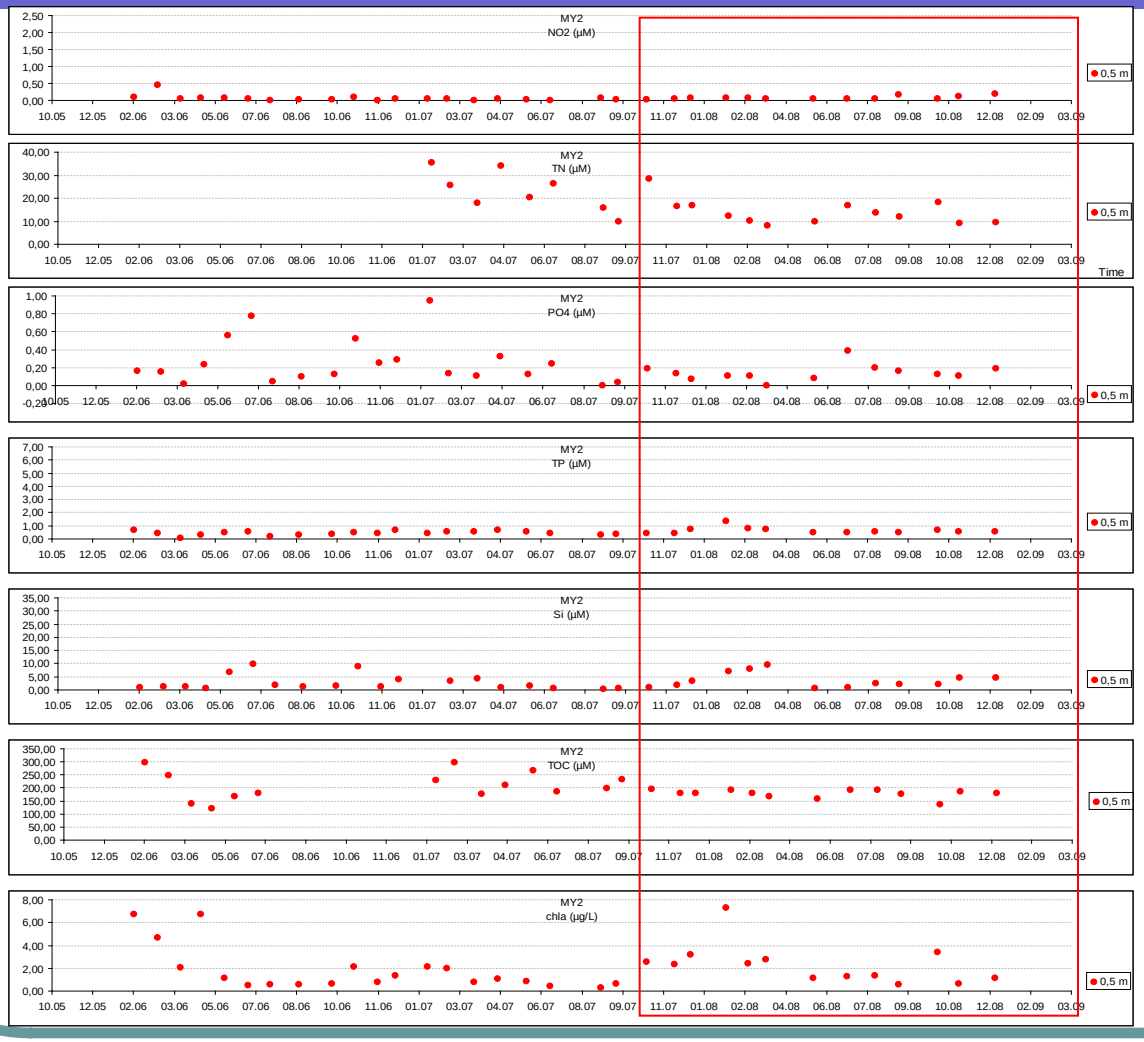
Sea surface temperature and Chlorohyl a



Sea surface temperature increased ~0.5 degC
before mucilage formation in 2007

Nutrients



There was no significant rise in the nutrients

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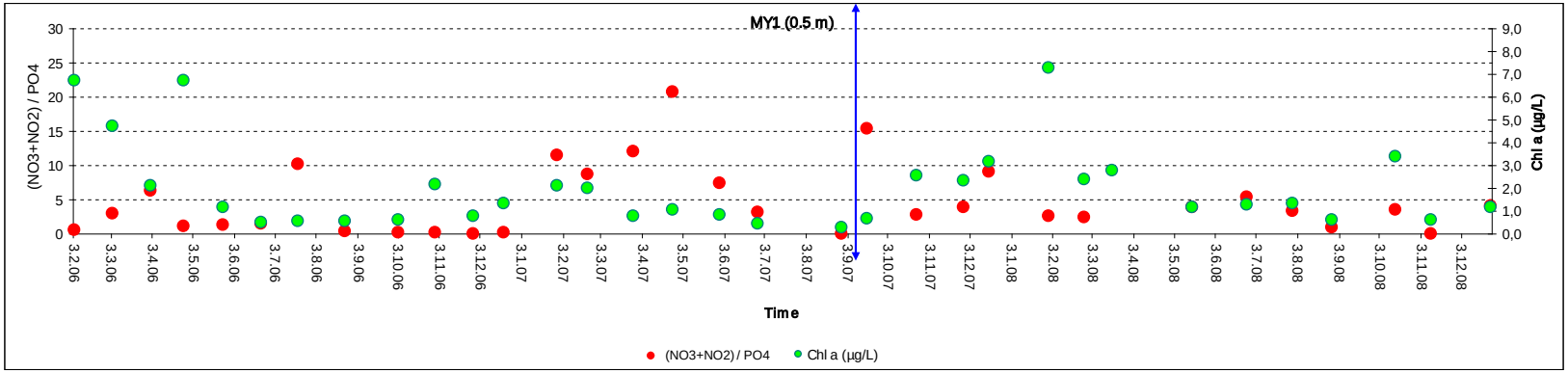
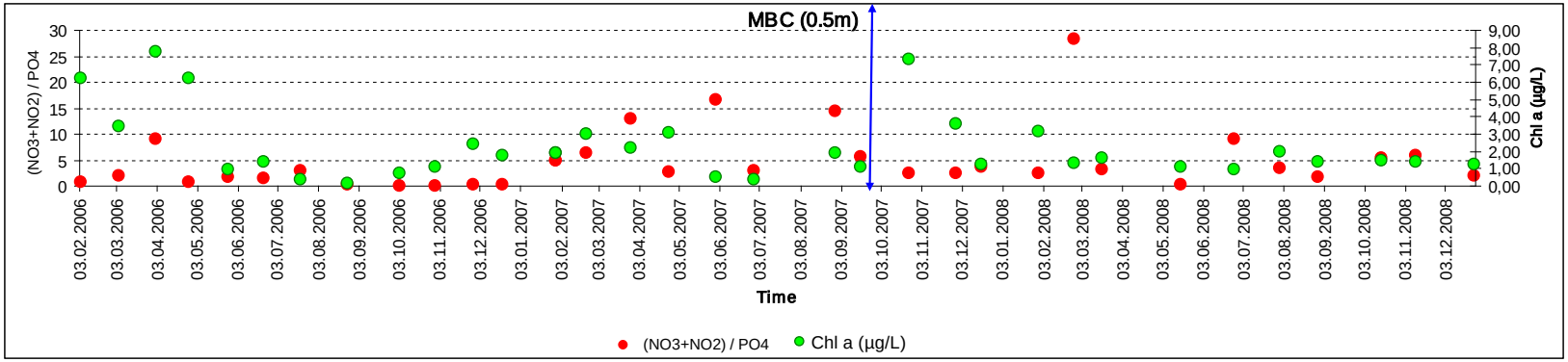
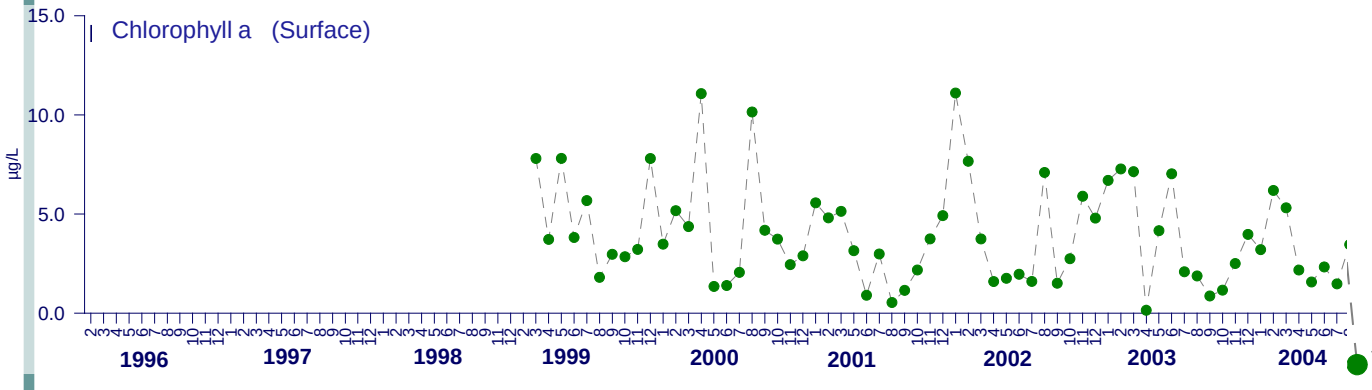
(NO3+NO2) / PO4 ratio, and Chlorophyll a

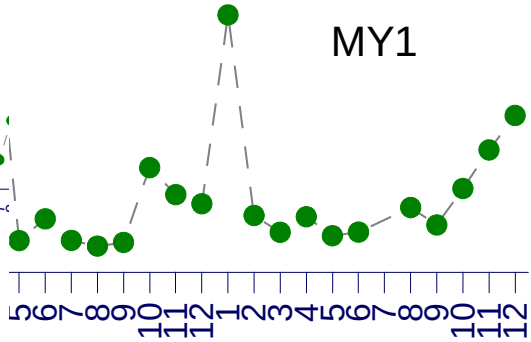


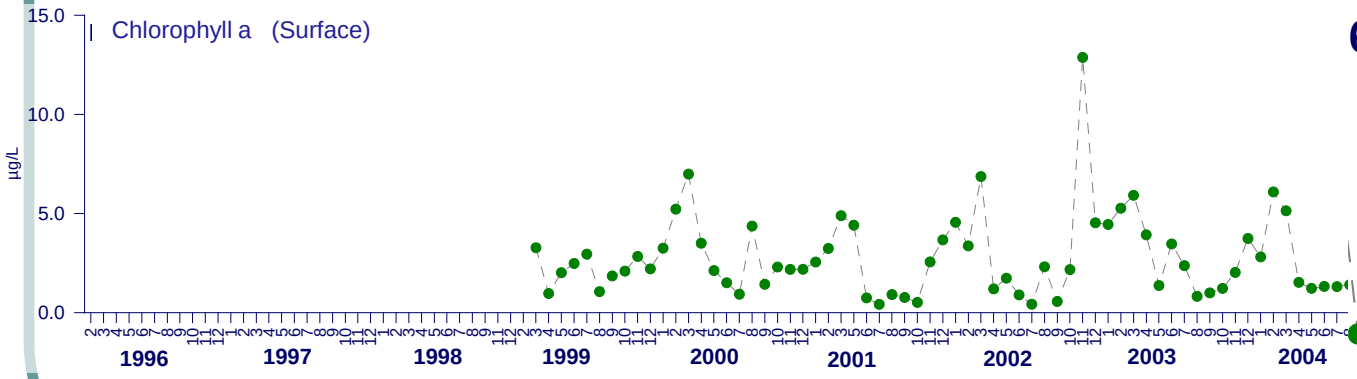


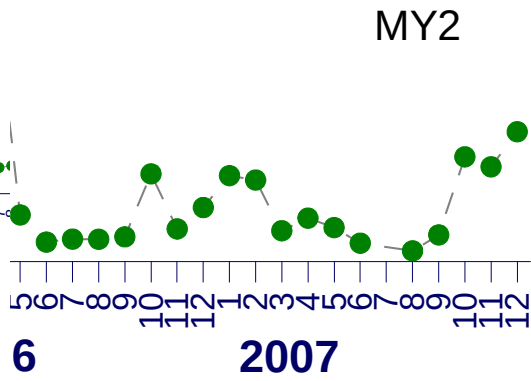
Before mucilage formation,
NOx increased but Chl a decreased (NOx was not utilized)

Chlorophyll a time series



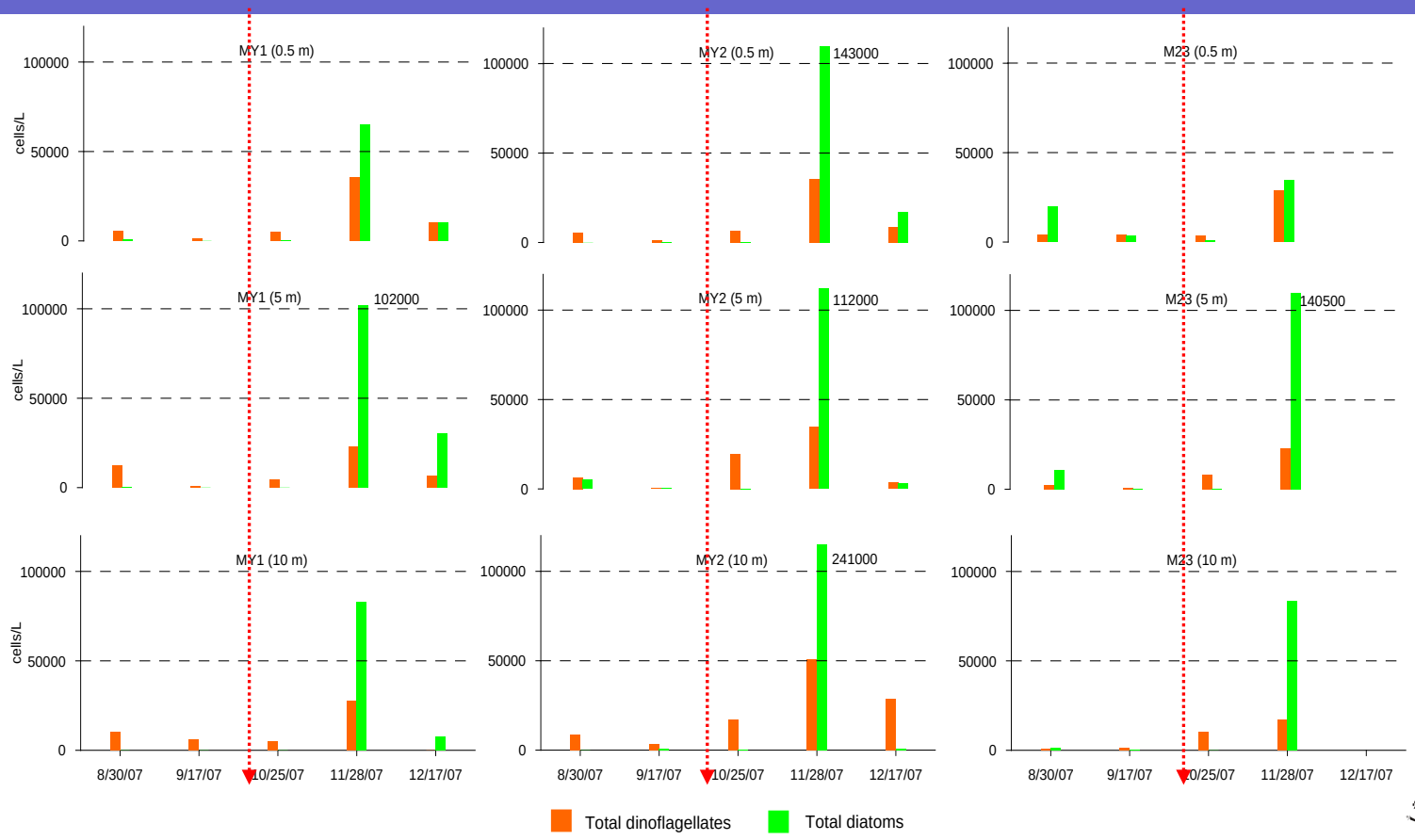






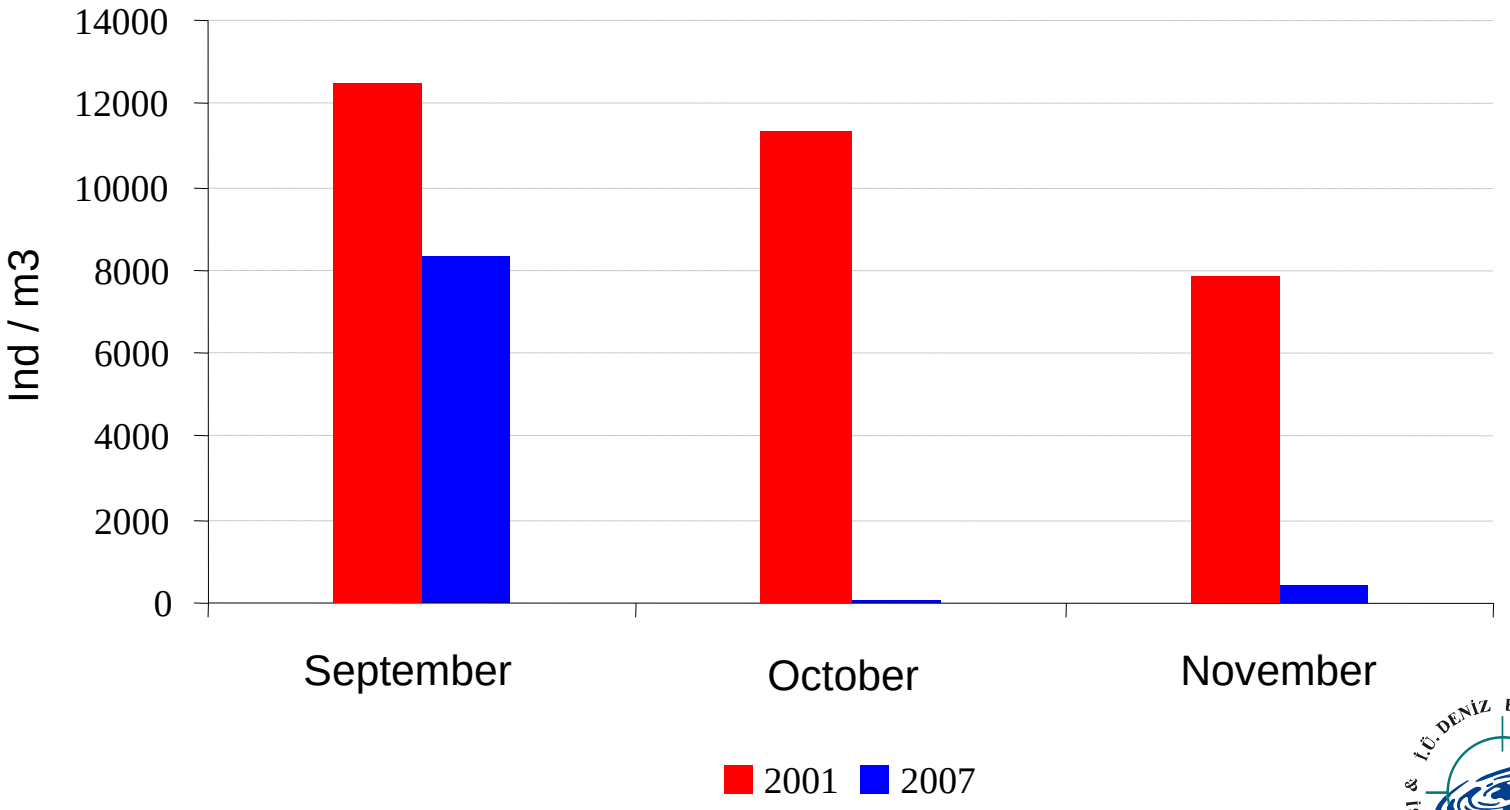
Chl a decreased significantly before mucilage formation

Phytoplankton abundance in 2007



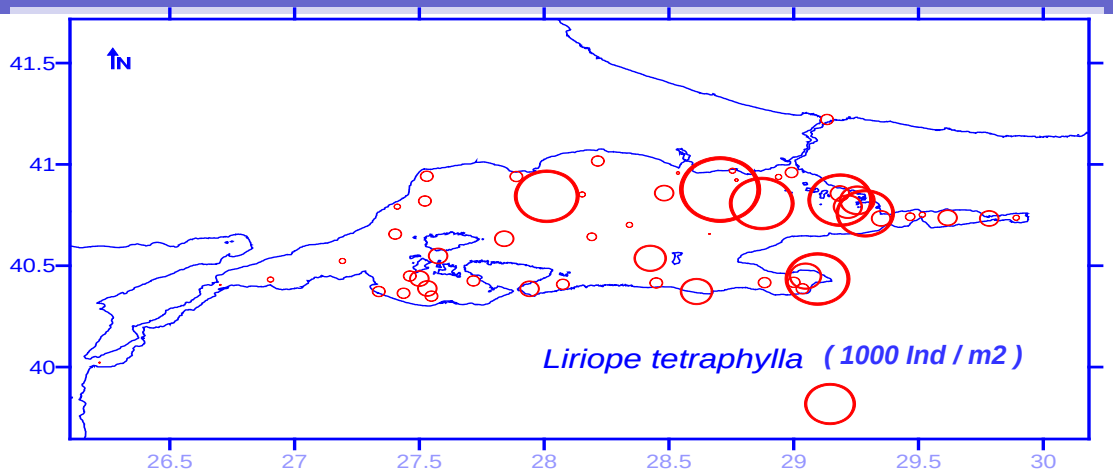
Most important finding was that phytoplankton was nearly absent before and after mucilage formation

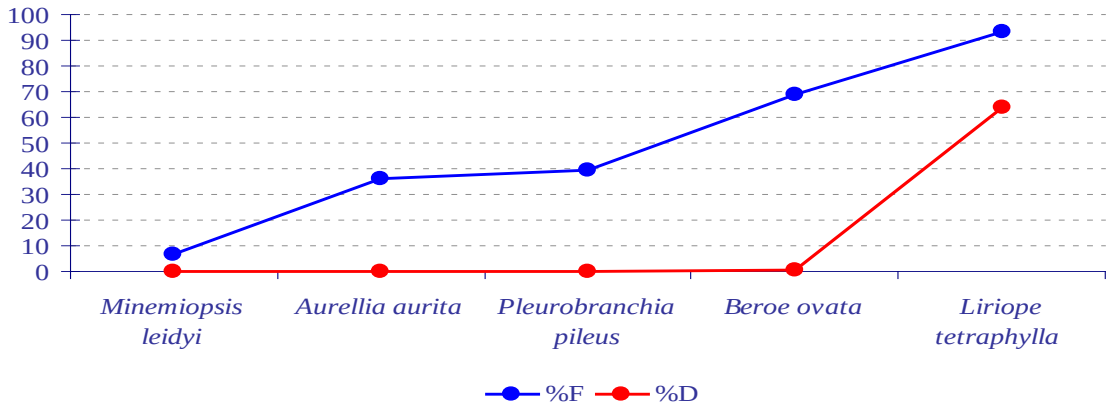
Zooplankton abundance



Zooplankton decreased in comparison to previous years and disappeared after mucilage formation since it was aggregated in the gelatinous

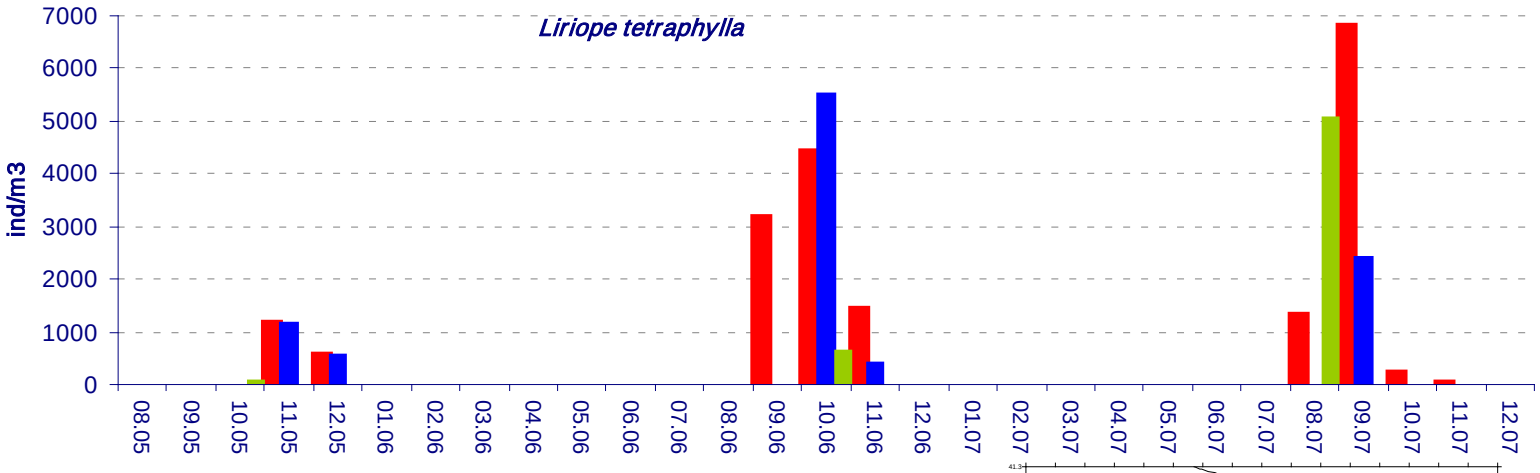
Liriope tetraphylla abundance in 2005

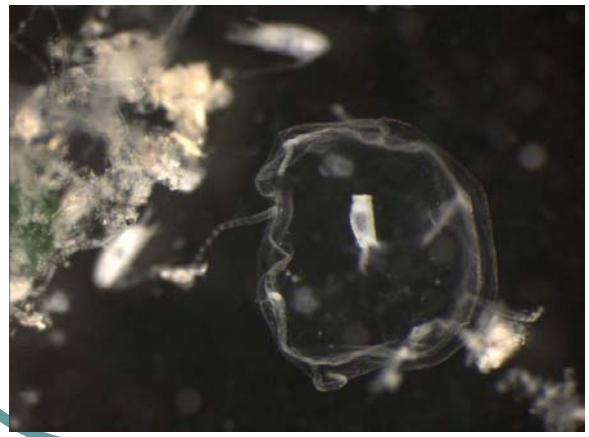


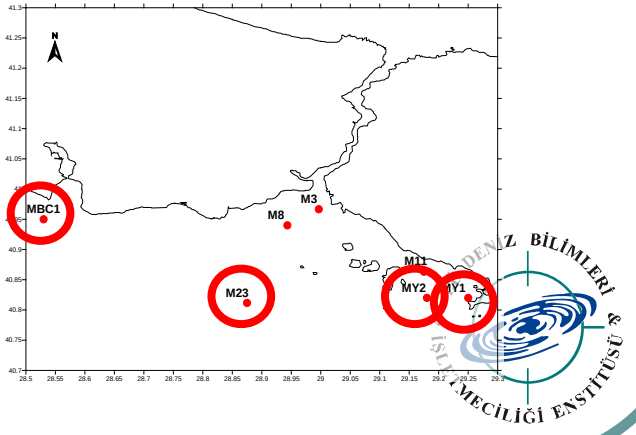


Before mucilage formation, only noticeable change was in the Liriope tetraphylla abundance which increased excessive amount in Marmara Sea not recorded in the literature

Dominance of *L. tetraphylla* in gelatinous material

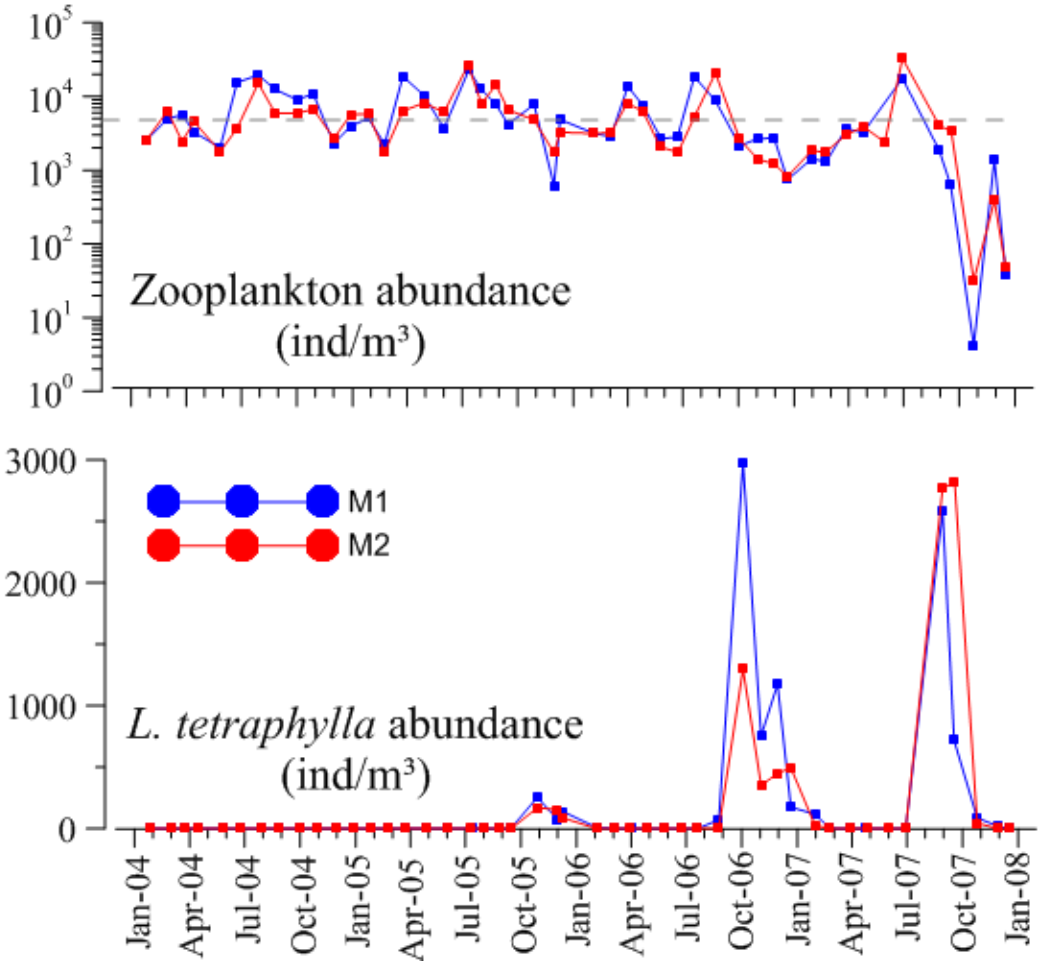


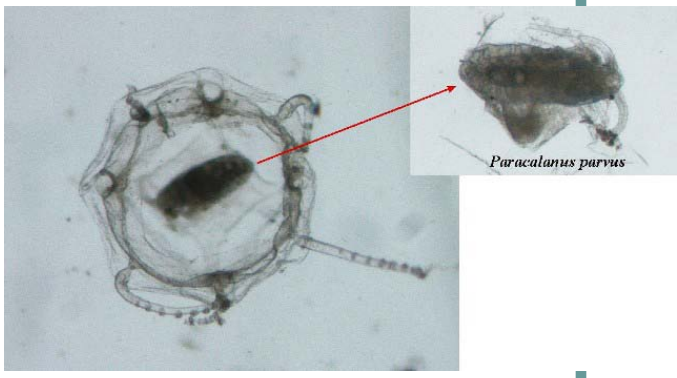




YILMAZ , I. N.,YÜKSEK A., (2009)

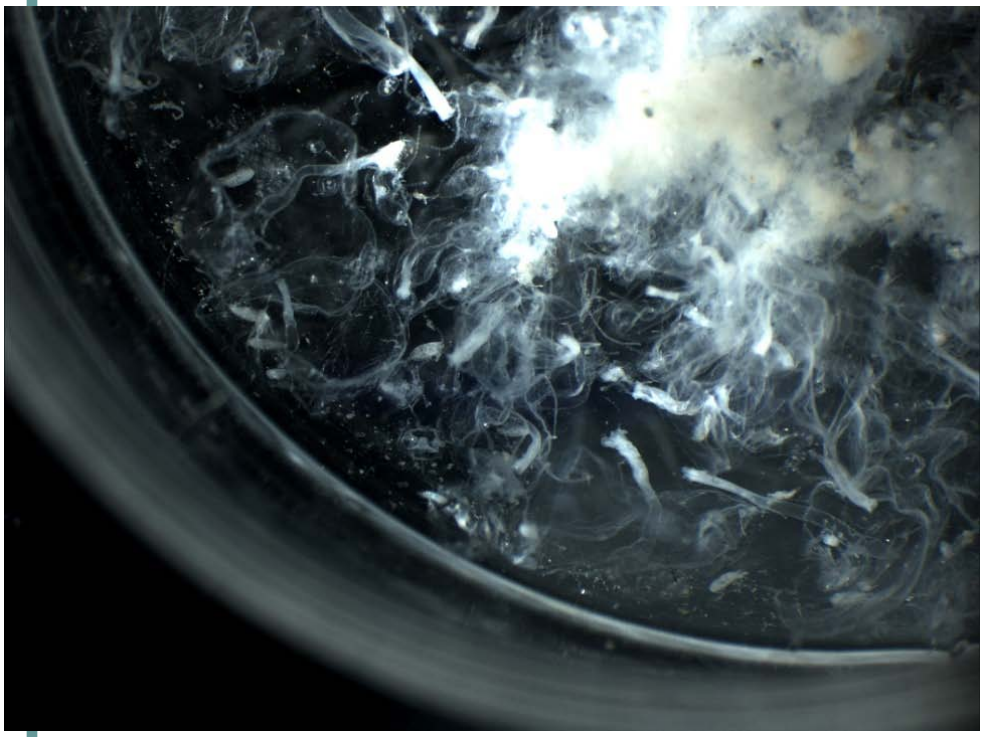
Influence of the recent *Liriope tetraphylla* (Trachymedusae) invasion on zooplankton community structure of the highly stratified Marmara Sea. **ASLO** Aquatic sciences Meeting **2009 ,** Nice, France

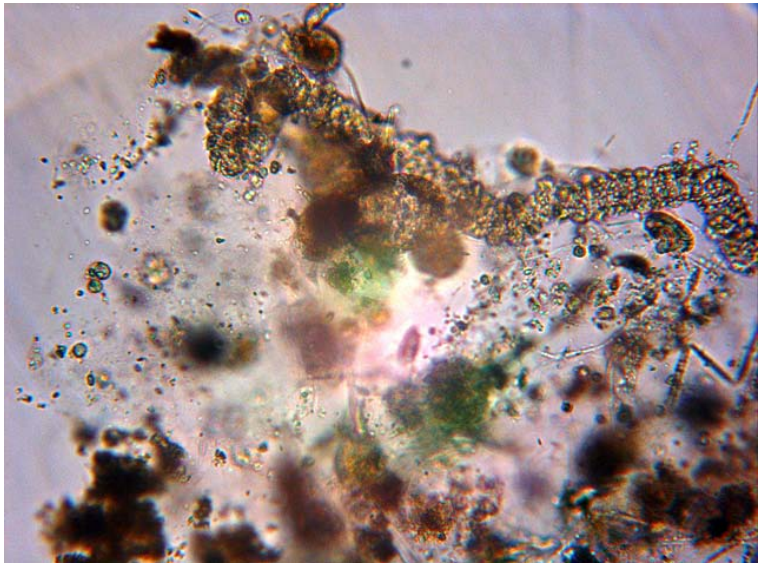


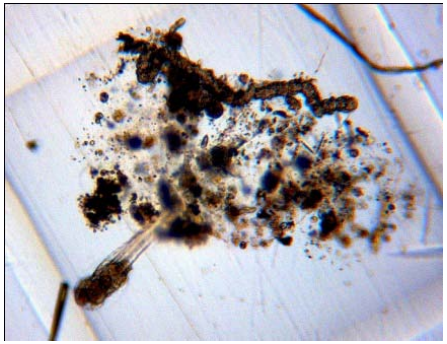


Zooplankton disappeared in the Marmara Sea which was not happened before

Liriope tetraphylla

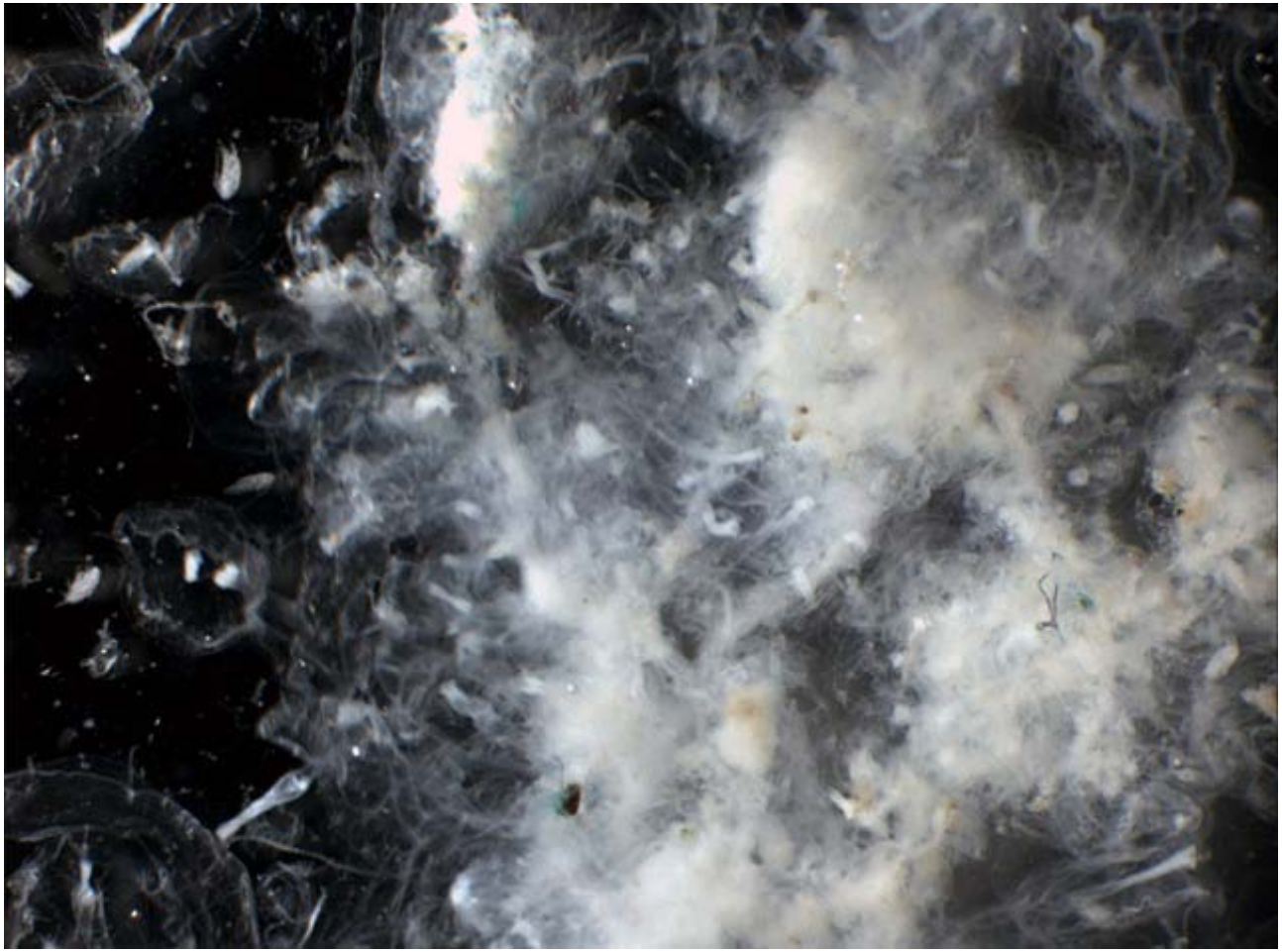




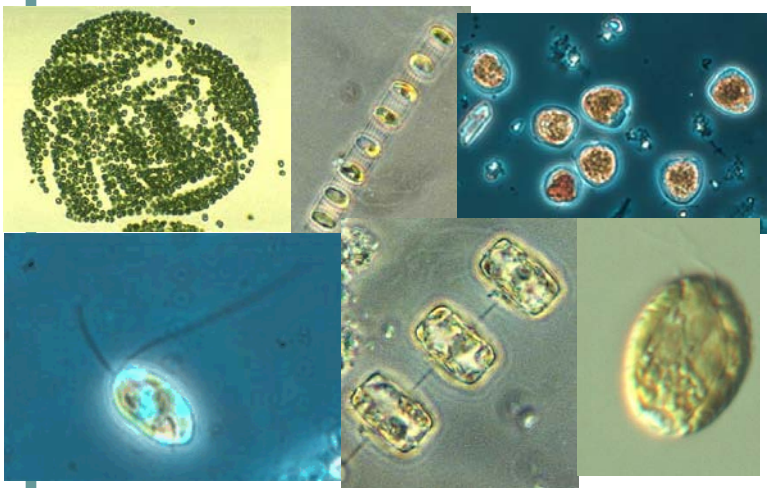


Liriope tetraphylla in September 2007

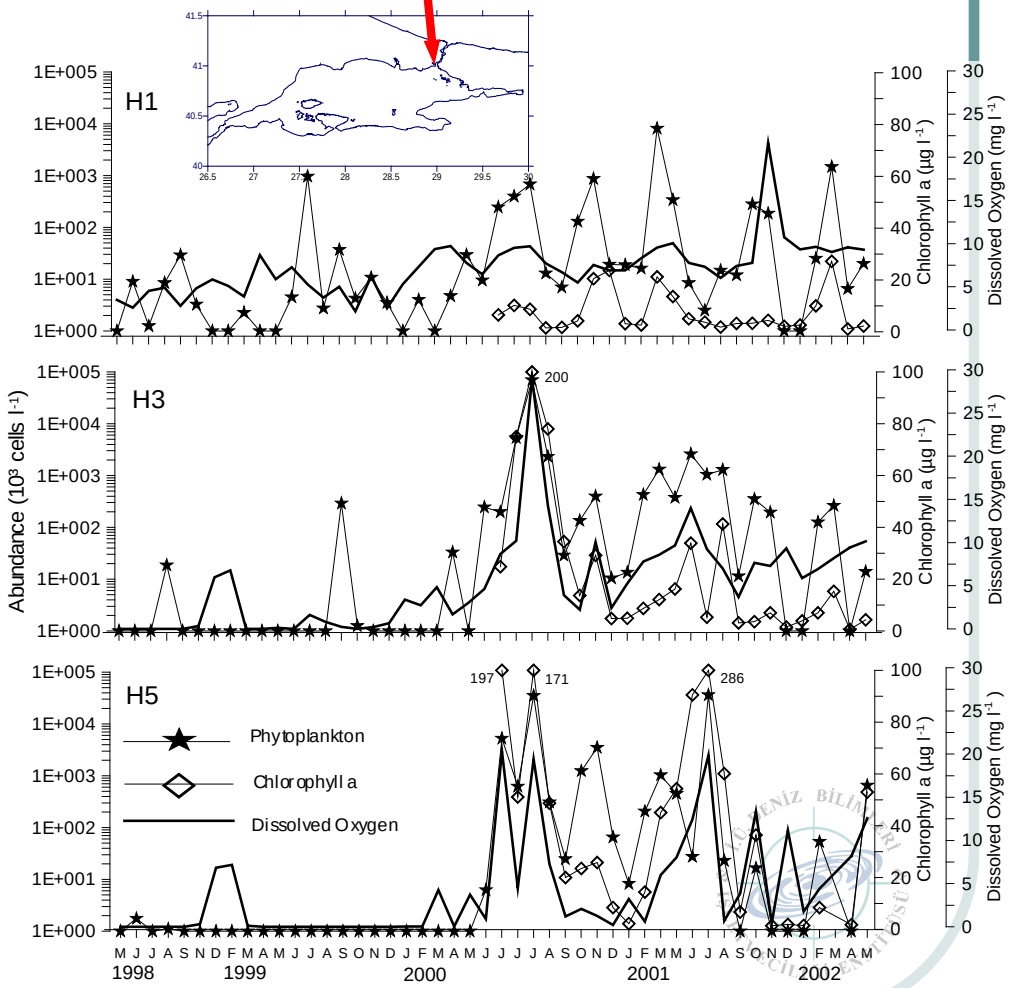
Liriope tetraphylla in September 2007



S. Tas, N. Yilmaz, E. Okus (2009). Phytoplankton as an incator of improving water quality in the Golden Horn Estuary. *Estuaries and Coasts,* 32,1205–1224.



25.12.1998	*Microcystis* sp.*
09.02.1999	*Microcystis* sp.*
13.07.1999	*Skeletonema costatum*
23.06.2000	*Skeletonema costatum*
26.07.2000	*Prorocentrum minimum*
08.08.2000	*Eutreptiella* sp.
24.10 2000	*Eutreptiella* sp.
14.11.2000	*Skeletonema costatum*
27.02.2001	*Eutreptiella* sp.
28.03.2001	*Skeletonema costatum*
20.06.2001	*Thalassiosira allenii*
10.07.2001	*Prorocentrum minimum*
23.10.2001	*Microcystis* sp.*
28.11.2001	*Fibrocapsa* sp.
25.03.2002	*Skeletonema costatum*



Mucilage producing phytoplankton blooms were observed in earlier years in the Golden Horn but no gelatinous matter formed

2007 ?
Phytoplankton

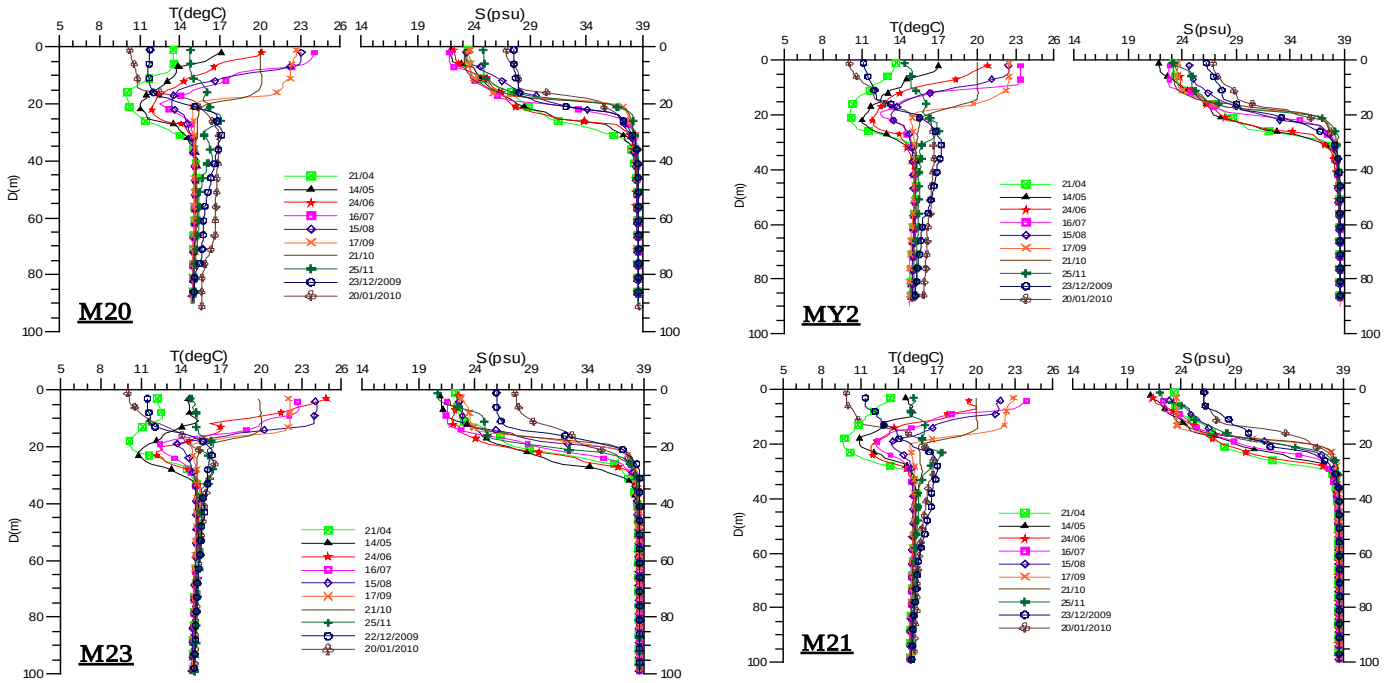
No significant increase in phytoplankton abundance was detected during the mucilage formation in October 2007, while abundance of potentially mucilage causing species, *Gonyaulax fragilis* reached only 19 500 cells/L. But later on, in November 2007, G. fragilis reached 49 000 cells/L and dominated in dinoflagellates, while Thalassiosira rotula appeared as the most important diatom species (240 000 cells/L).

In December 2007, a decrease in phytoplankton abundance was observed and abundance of dominant dinoflagellate Gonyaulax fragilis was 28 000 cells/L, while diatom *Thalassiosira rotula* was 14 000 cells/L, *Ditylum brightwelli* was 10 500 cells/L and *Pseudo-nitzschia* sp. was 5 000 cells/L.

It must be noted that no *Gonyaulax fragilis* was encountered in the Sea of Marmara in 2004, 2005 and 2006. On the other hand, in August and September 2007, before the mucilage phenomenon, phytoplankton abundance was very low and *Gonyaulax fragilis* was not encountered in samples.

Change in the structure of mucilage

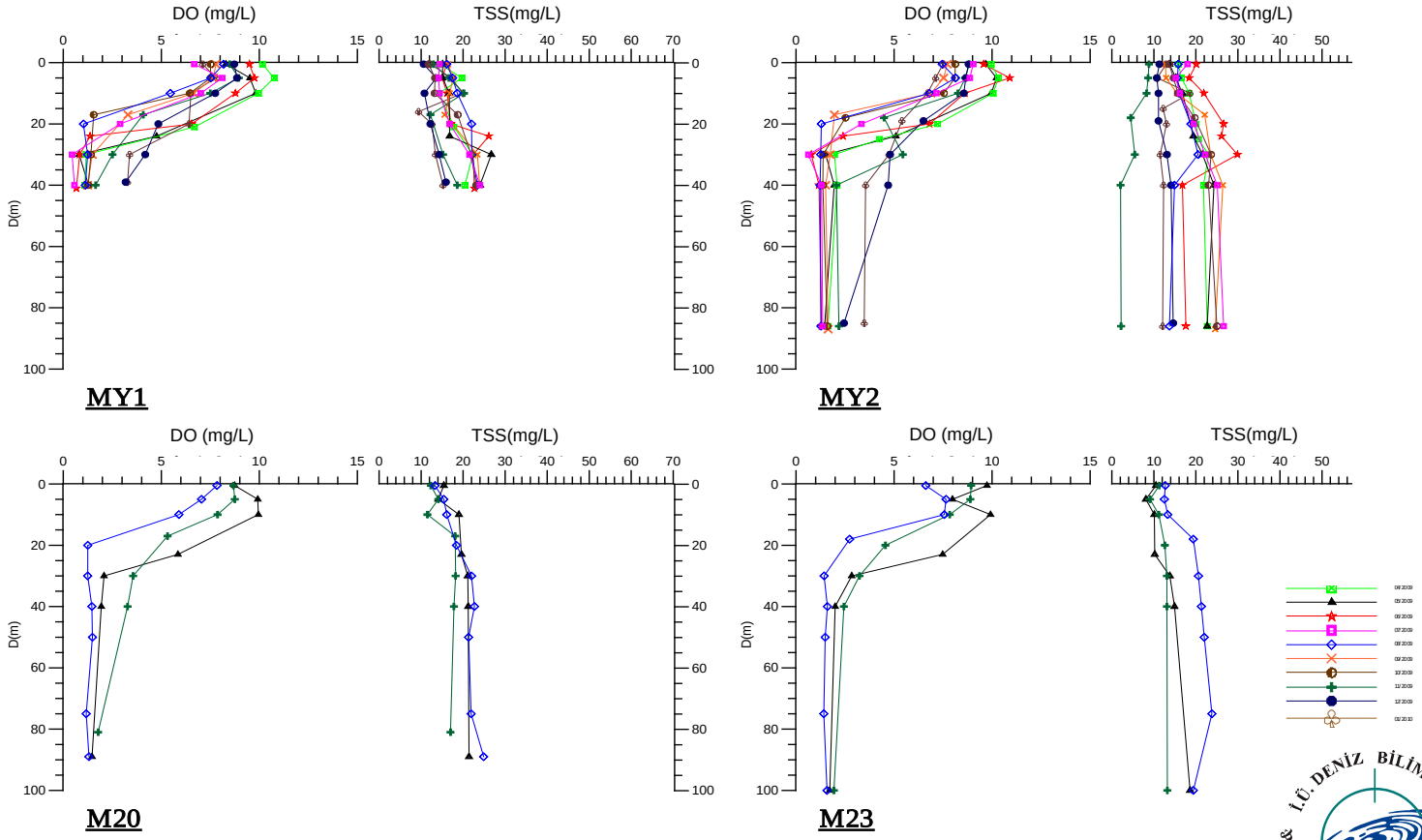
2009
Temperature and salinity



Stratified structure is always preserved

Change in the structure of mucilage

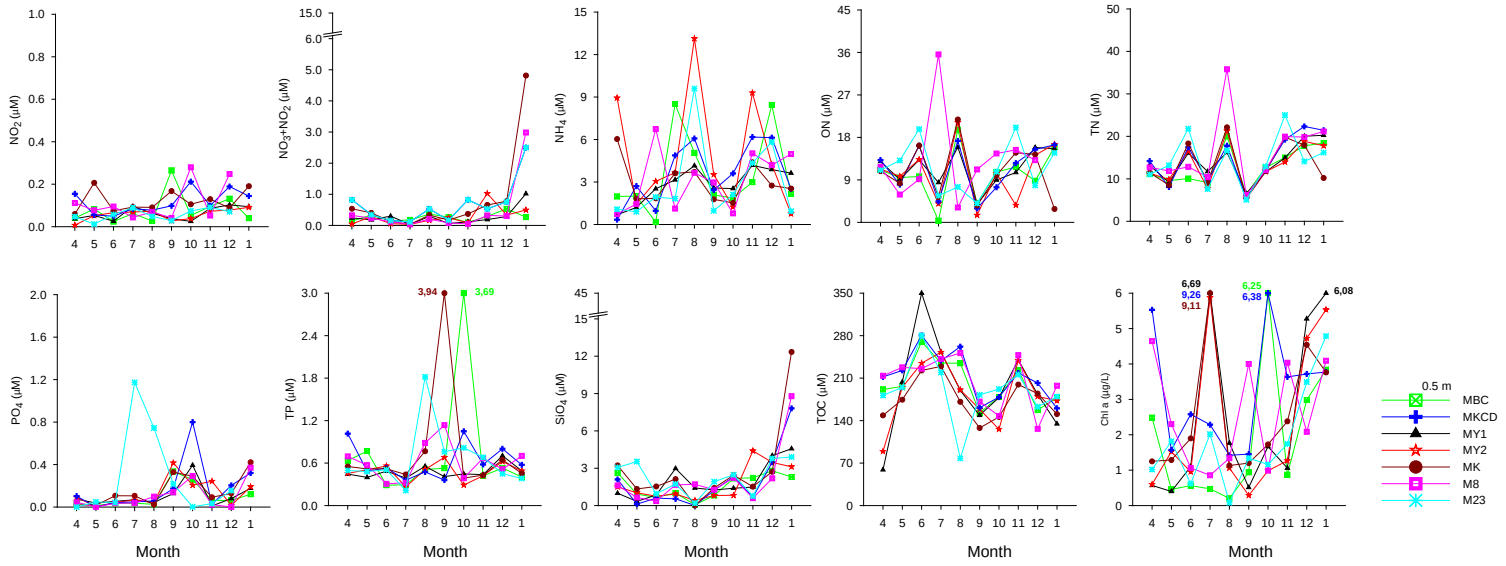
2009
Dissolved oxygen (DO) and TSS



No significant change is observed in DO and TSS

Change in the structure of mucilage

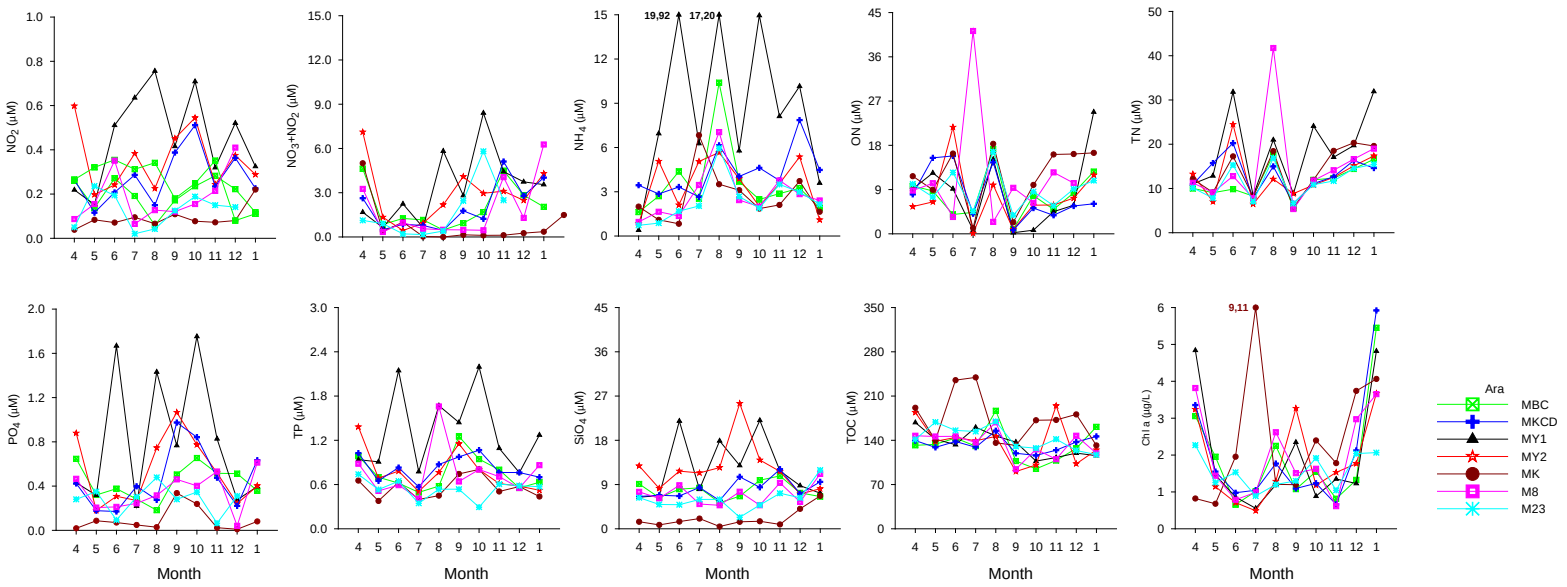
2009 ?
Nutrients (surface values)



No significant change is observed in nutrients

Change in the structure of mucilage

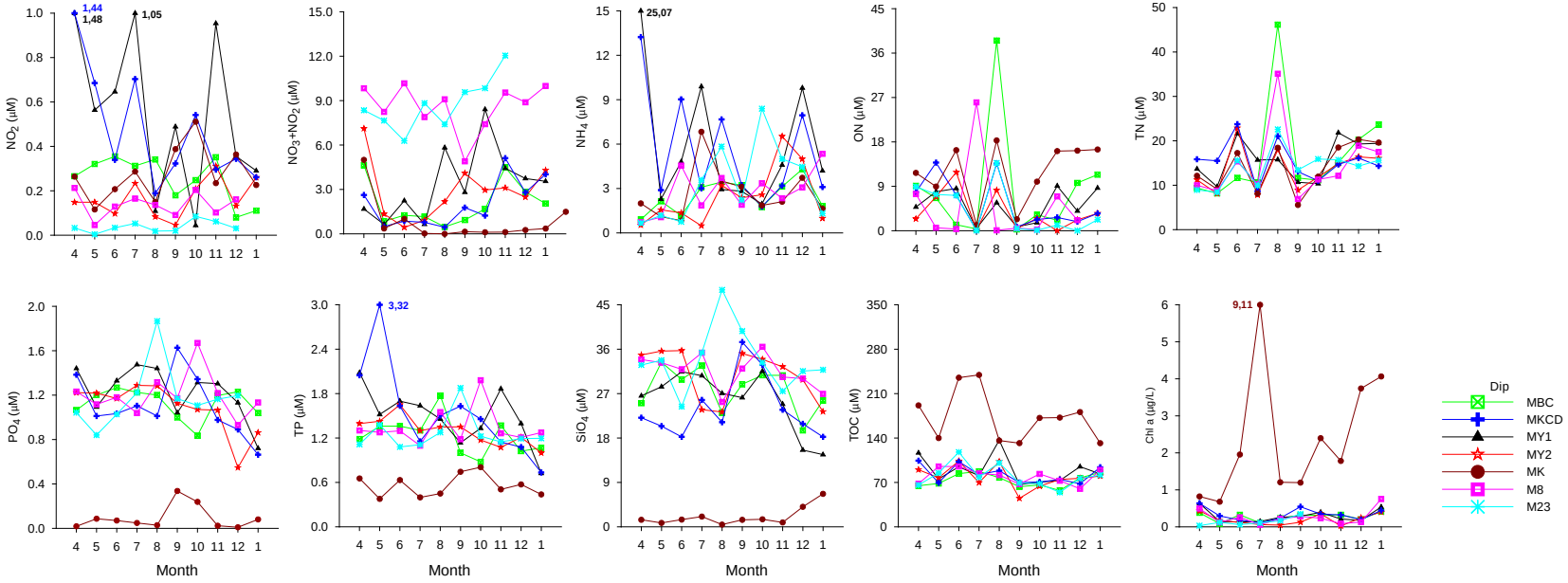
2009 ?
Nutrients (intermediate layer)



No significant change is observed in nutrients

Change in the structure of mucilage

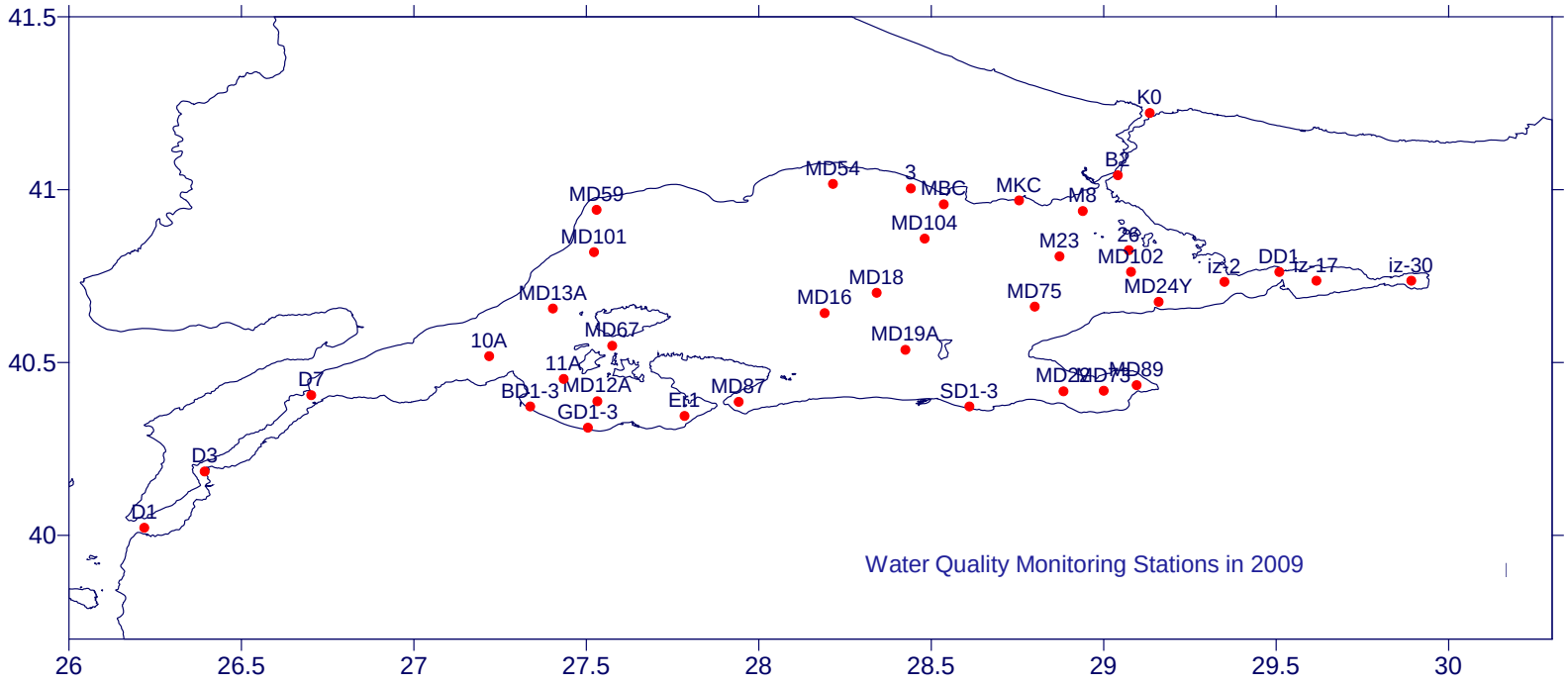
2009 ?
Nutrients (bottom)



No significant change is observed in nutrients

Change in the structure of mucilage

Sea of Marmara



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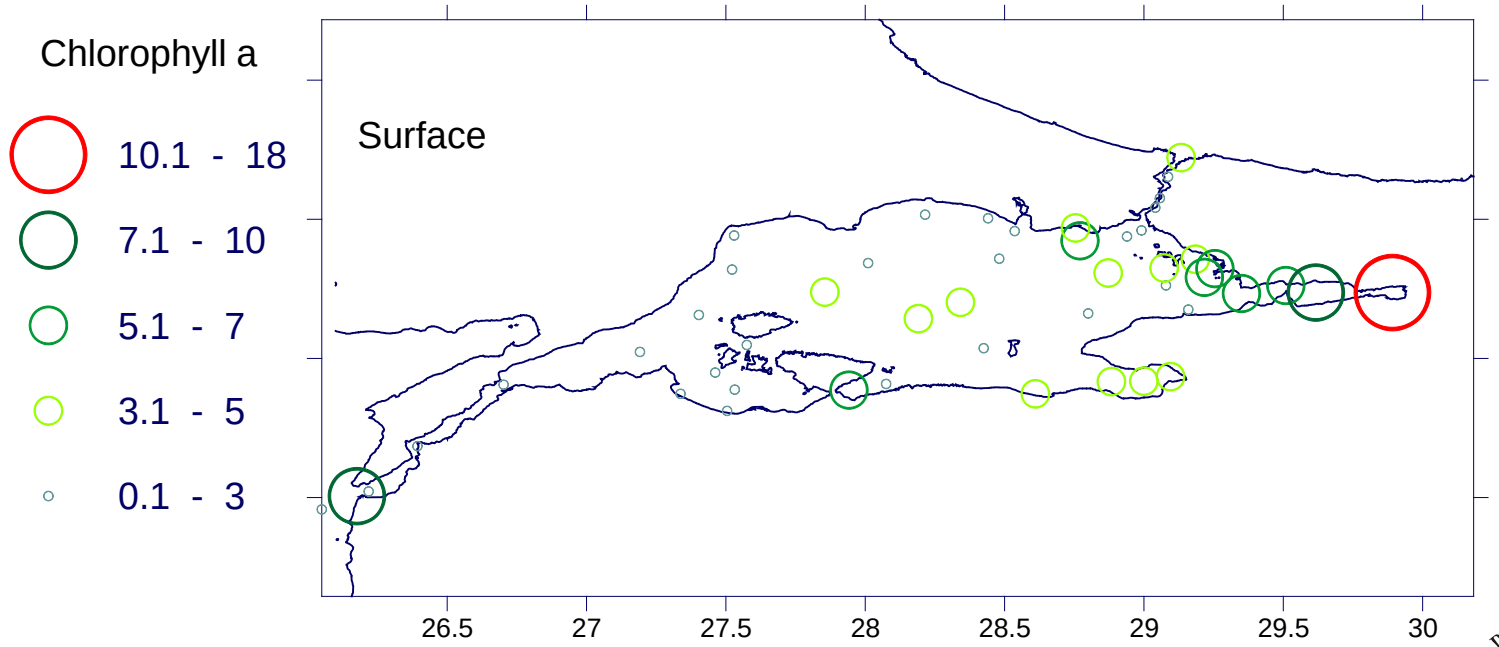
Change in the structure of mucilage

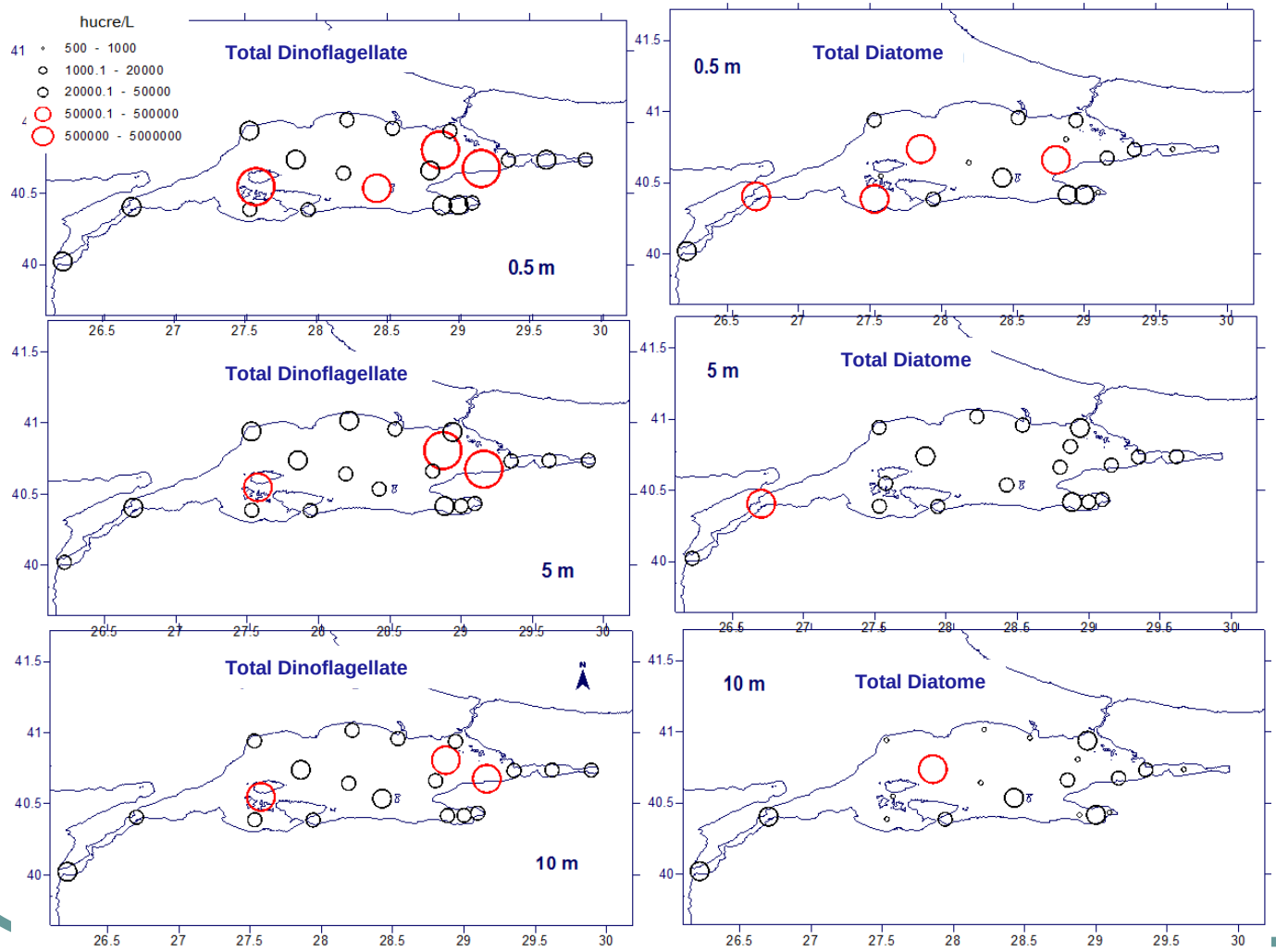
Sea of Marmara, 2009



Chlorophyl a was higher mainly in bays and river influenced regions

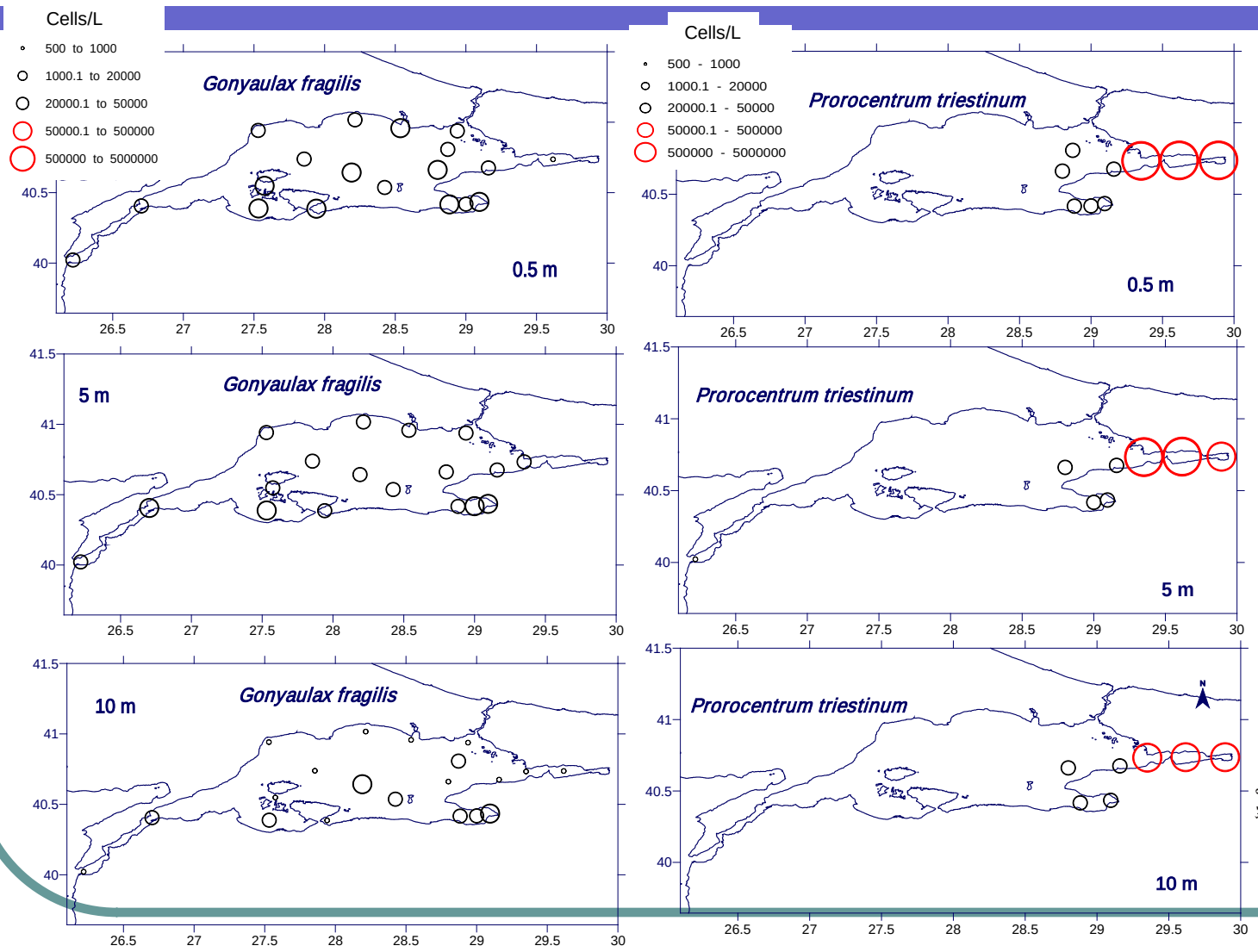
Change in the structure of mucilage

Sea of Marmara, 2009



Dinoflagellate was dominant and frequent

Sea of Marmara
phytoplankton in winter 2009

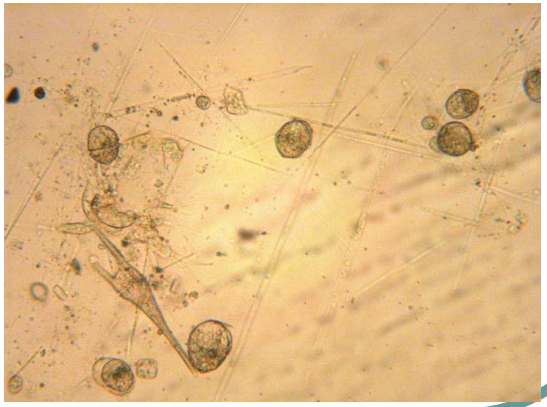


Gonyaulax was frequent

Sea of Marmara phytoplankton in winter

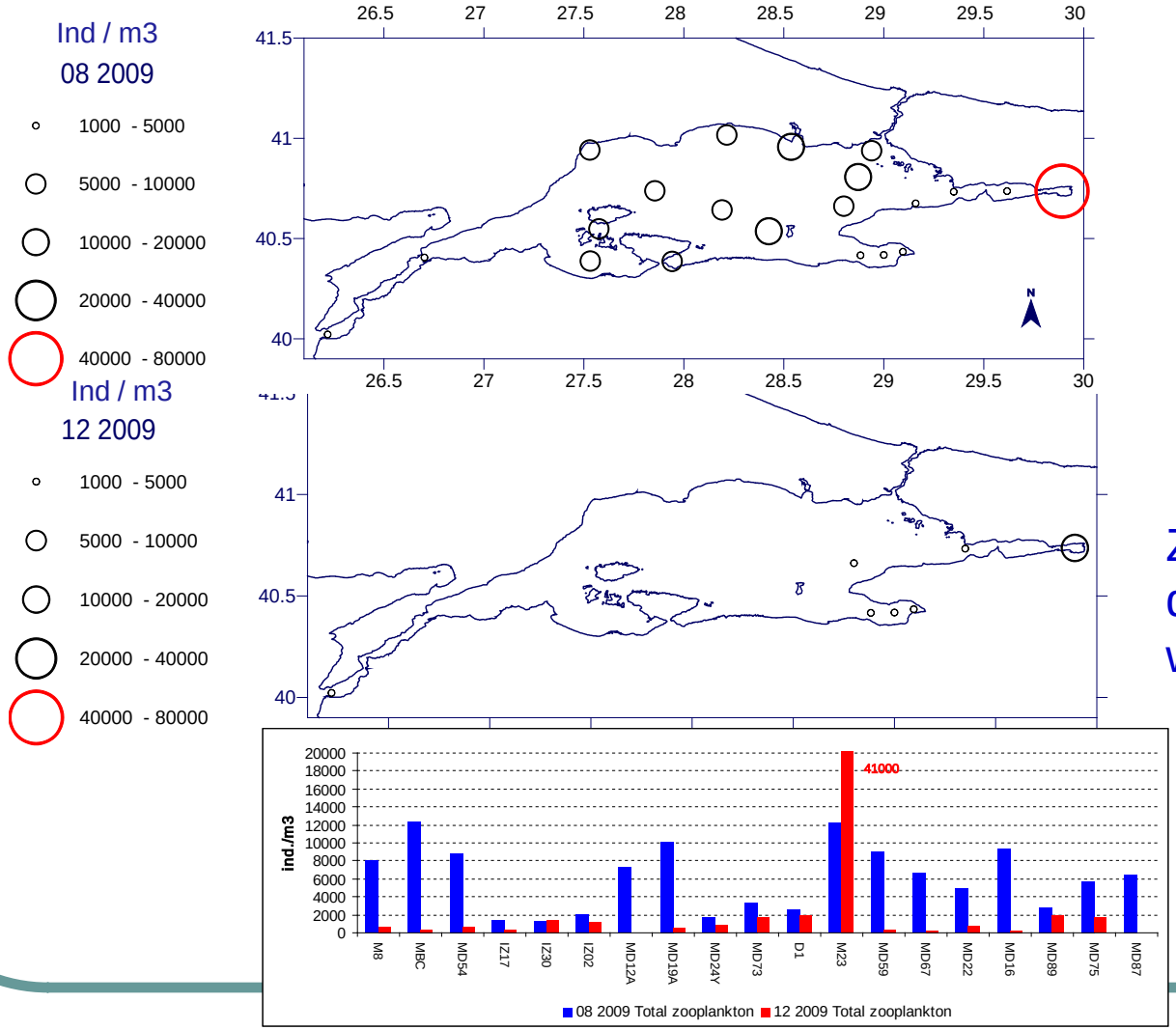
During August 2009 sampling no Gonyaulax fragilis was observed, while in December 2009 samples the species was frequent and reached 42 000 cells/L in MD22.

On the other hand in the İzmit Bay, dinoflagellate Prorocentrum triestinum bloomed and reached 4.5 x 10^6 cells/L. Cylindrotheca closterium, Proboscia alata, Pseudo-nitzschia delicatissima and Skeletonema costatum were the frequent diatom species.



Change in the structure of mucilage

Zooplankton distribution in 2009



Zooplankton nearly disappeared in winter 2009

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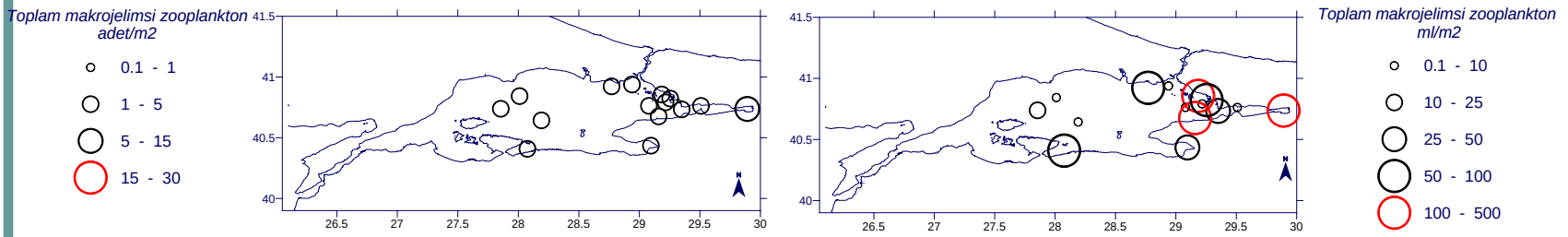
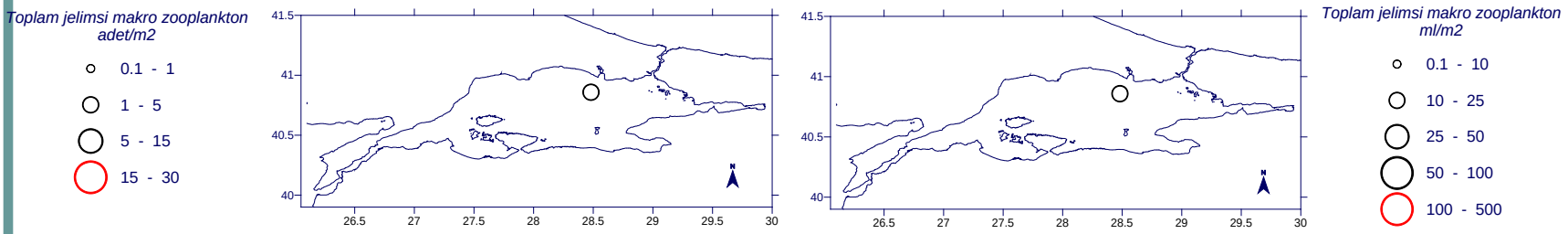
Change in the structure of mucilage

Total jellyfish

08 2009



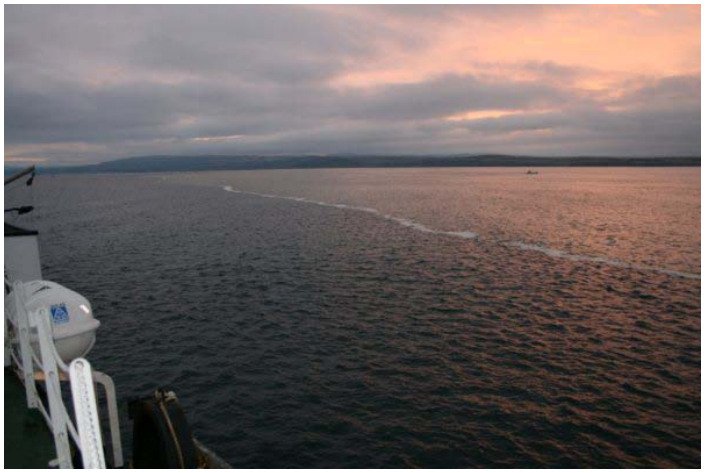
12 2009



Jellyfish was nearly vanished in winter 2009

Change in the structure of mucilage

Offshore of the K.menderes Stream, winter 2009



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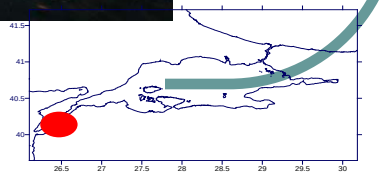

With 200m difference, sampling were performed in the area of frontal structure and outside of the frontal structure

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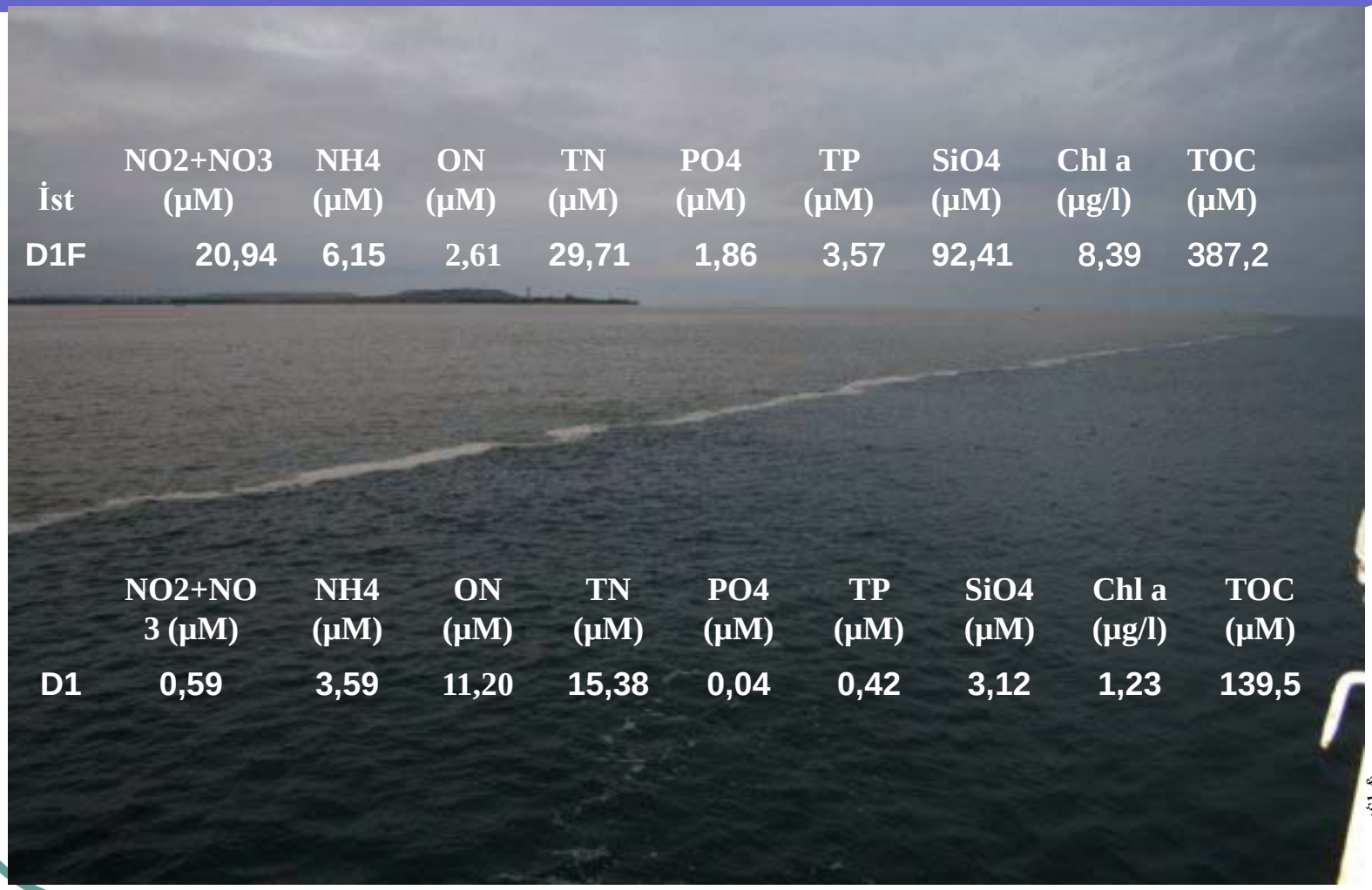
Offshore of the K.menderes Stream, winter 2009



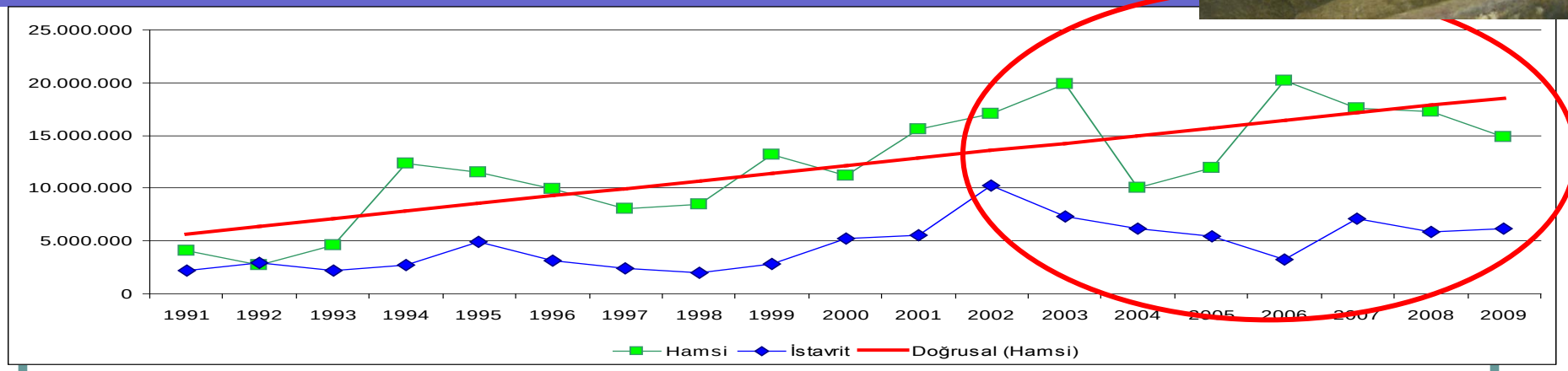
İst	NO2+NO3 (µM)	NH4 (µM)	ON (µM)	TN (µM)	PO4 (µM)	TP (µM)	SiO4 (µM)	Chl a (µg/l)	TOC (µM)
D1F	20,94	6,15	2,61	29,71	1,86	3,57	92,41	8,39	387,2

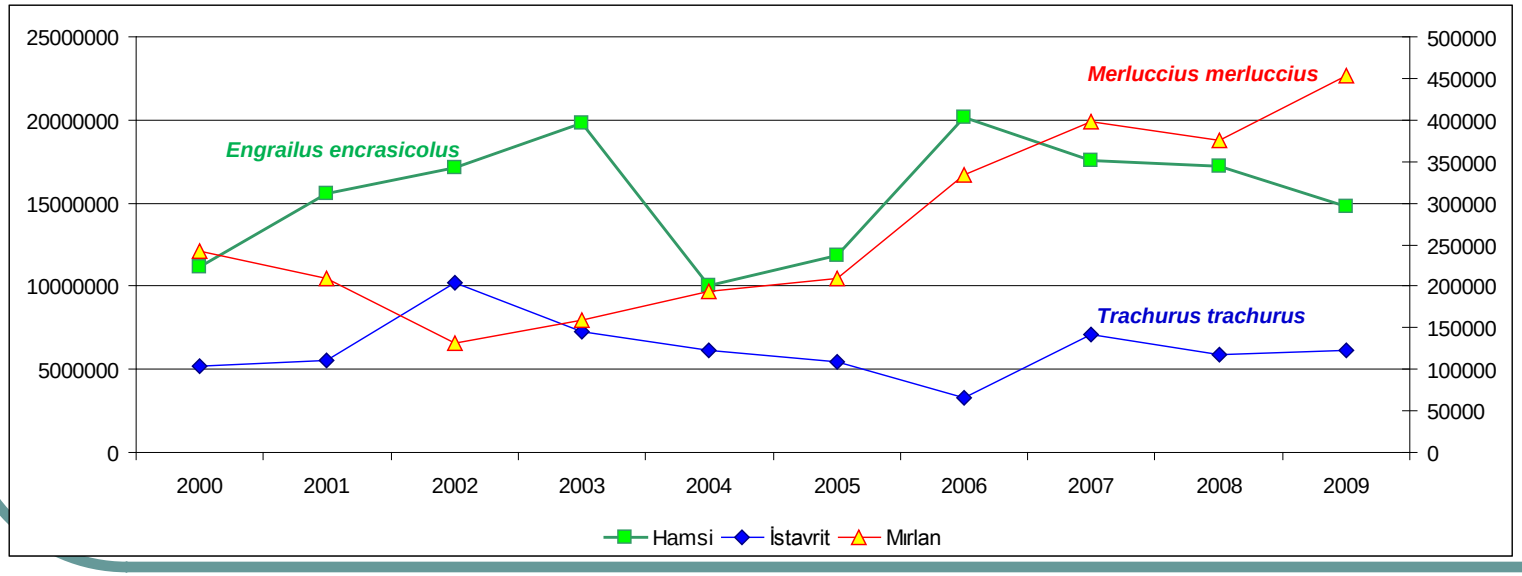
	NO2+NO 3 (µM)	NH4 (µM)	ON (µM)	TN (µM)	PO4 (µM)	TP (µM)	SiO4 (µM)	Chl a (µg/l)	TOC (µM)
D1	0,59	3,59	11,20	15,38	0,04	0,42	3,12	1,23	139,5

Significant differences observed at the surface values in the area of frontal structure and outside of the frontal structure

Change in the structure of mucilage

Fisheries in the Sea of Marmara

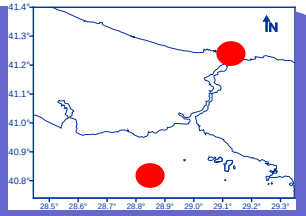


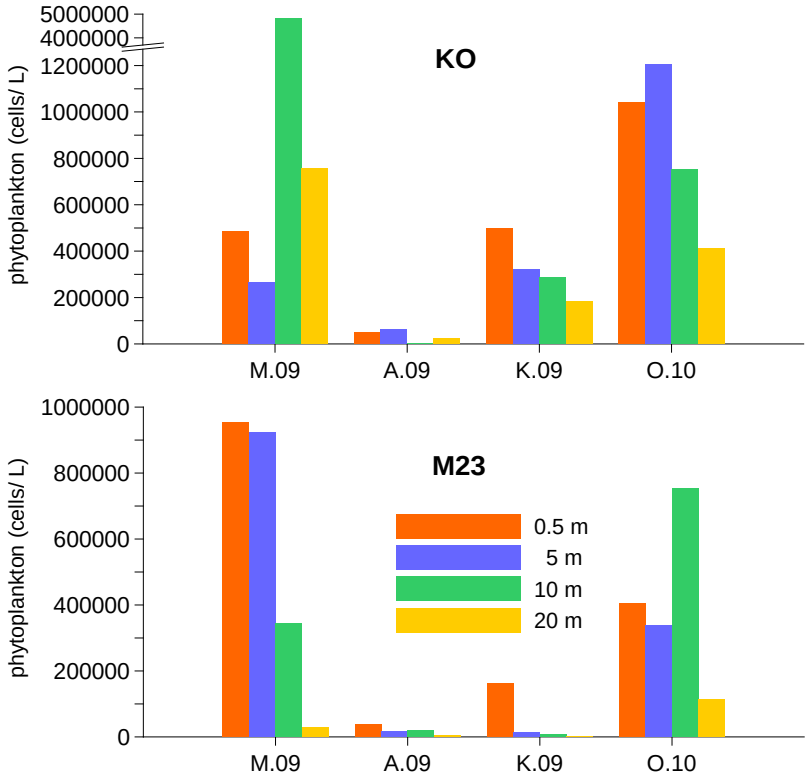


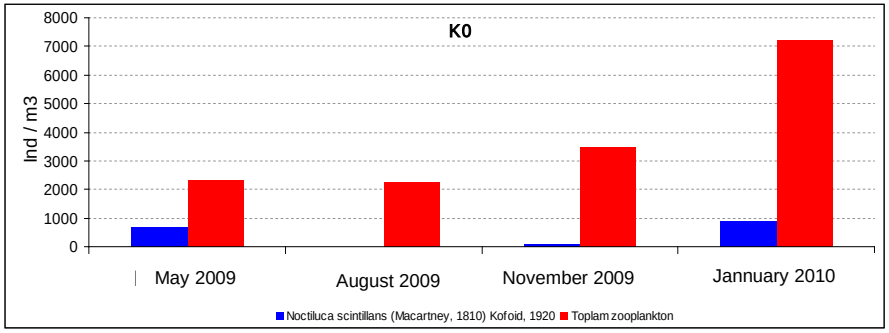
Overfishing was apparent in the Sea of Marmara

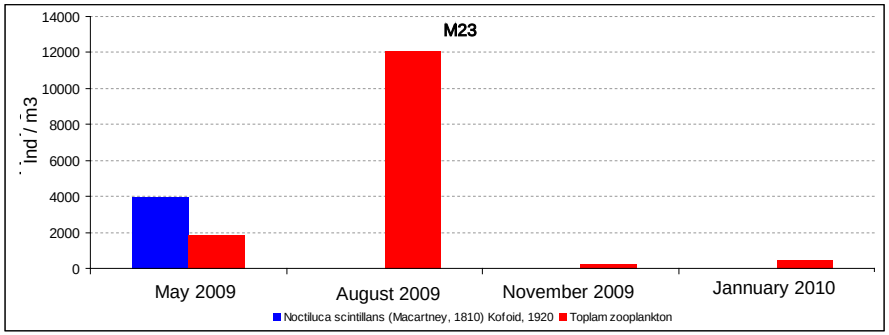
Change in the structure of mucilage

2009 ? Phytoplankton and zooplankton









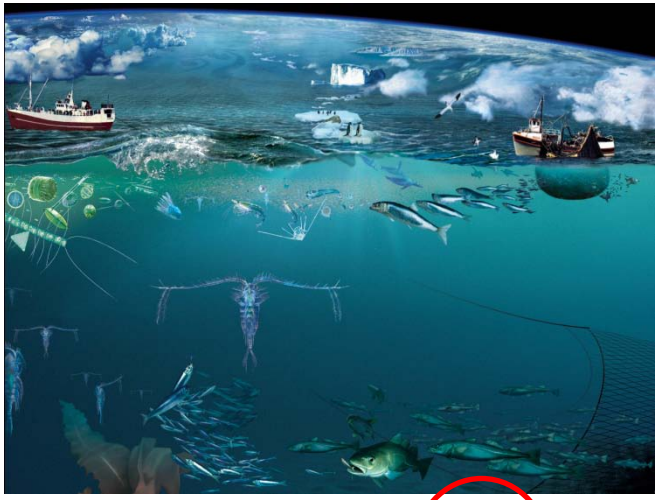
In 2009; phytoplankton dominated while zooplankton decreased and jellyfish disappeared during the mucilage formation which appeared in the deeper layers while it was observed at the surface in 2007. Therefore, phytoplankton may be one of the reason of gelatinous matter formations in 2009.

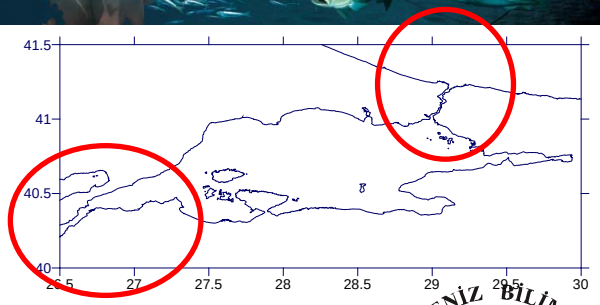
Results

- Fishermen of the Marmara Sea recognized the problem 2 months prior to the surface aggregations through increase in fishing effort due to heavier nets,
- Most important problems were faced in small pelagic fisheries, although there was no significant differences related to pollution parameters observed in Marmara Sea,
- Nitrogen/phosphate ratio increased prior to the aggregations and phytoplankton abundance decreased significantly, together with a drastic reduction in zooplankton abundance. Invasive *Liriope tetraphylla* abundance increased exponentially in August and died in masses as a result of starvation and meteorological / oceanographic conditions,
- In October, following the mucilage/gelatinous matter production another new species for the region Gonyaulax fragilis was observed through the basin. The species was a frequent member of phytoplankton in December 2009, however its abundance was relatively lower.
- Present work linked mucilage production to the breakdown of food chain. Overfishing in the Sea of Marmara provided a ground for invasive and/or opportunistic species increase in abundance of planktivorous species,
- Nutrient concentrations are generally high in the Sea of Marmara as a result of the surface inputs but mucilage\gelatinous formation is not very frequent phenomenon, therefore, one can say that it occurs as a result of not exactly known processes in a highly productive system,

Radical implementations are needed!

- Radical measures to protect planktivorous small pelagic species stocks (such as anchovy, mackerel, sardine and sprat) should be implemented immediately. As an example, fishing should be banned 10 miles around the entrances and exists of Çanakkale and İstanbul straits.
- Biological and chemical treatment of domestic and industrial wastewater input to the Sea of Marmara may be an important step in preventing these kind of outcomes that may be linked to pollution,
- A nation-wide monitoring network should be established to understand and prevent mucilage formation in the feature.





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THANK YOU!

Mucilage scenes from the Sea of Marmara in 2007