MIDDLE EAST TECHNICAL UNIVERSITY
INSTITUTE OF MARINE SCIENCES

Eutrophication and its implications on the ecosystem/food web current state, challenges and gaps

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General overview

- In the pre-anthropogenic and pre-dammed period before the 1960's when the nitrate-laden major rivers and wet deposition fed the system with **high N/P ratios (>25-50).**

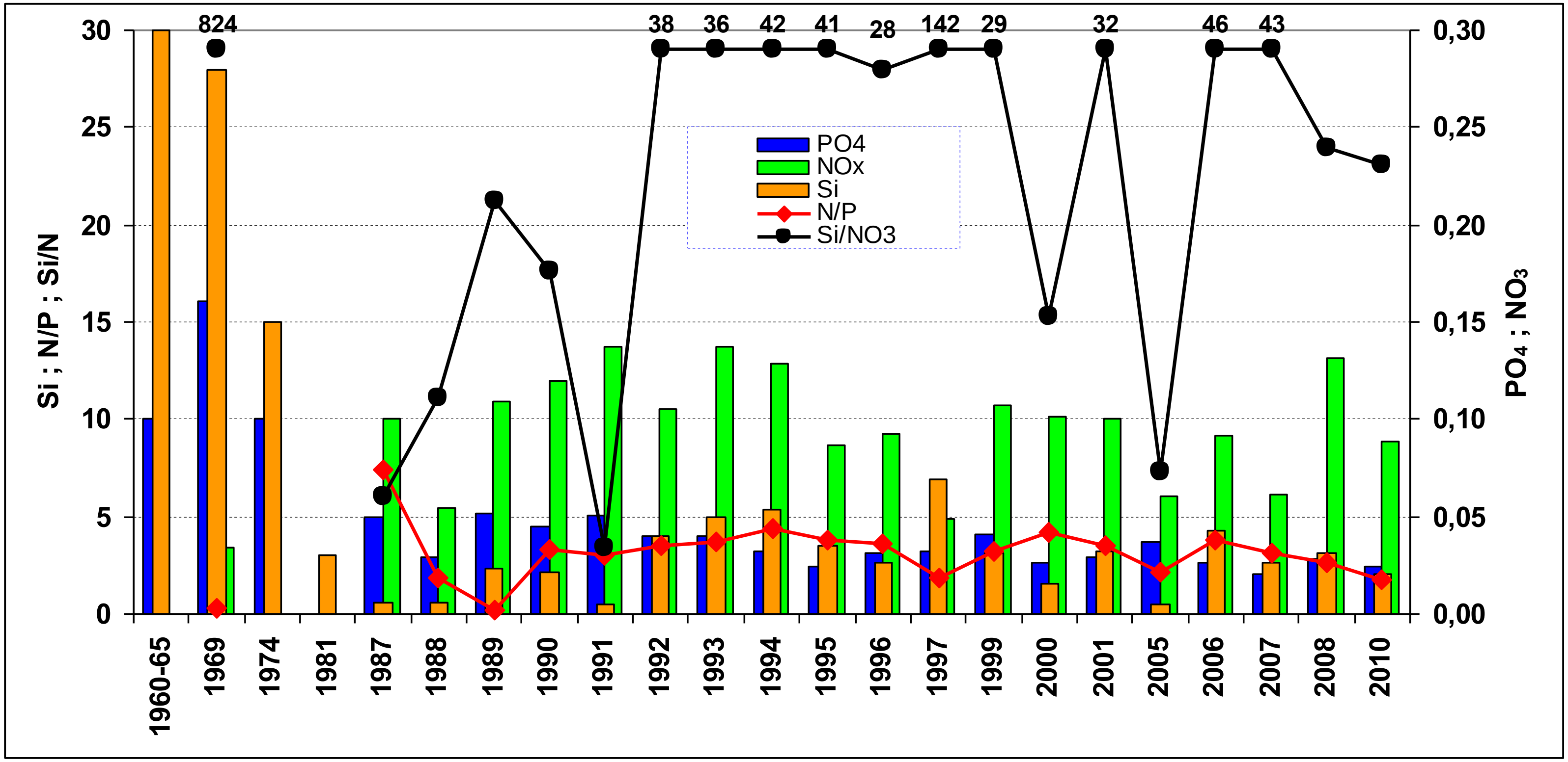
In the surface waters of Black Sea deep basin:

- Silicate: 30-70 µM
- Phosphate: 0.1-0.3 µM but
- Nitrate : < 0.1 µM,

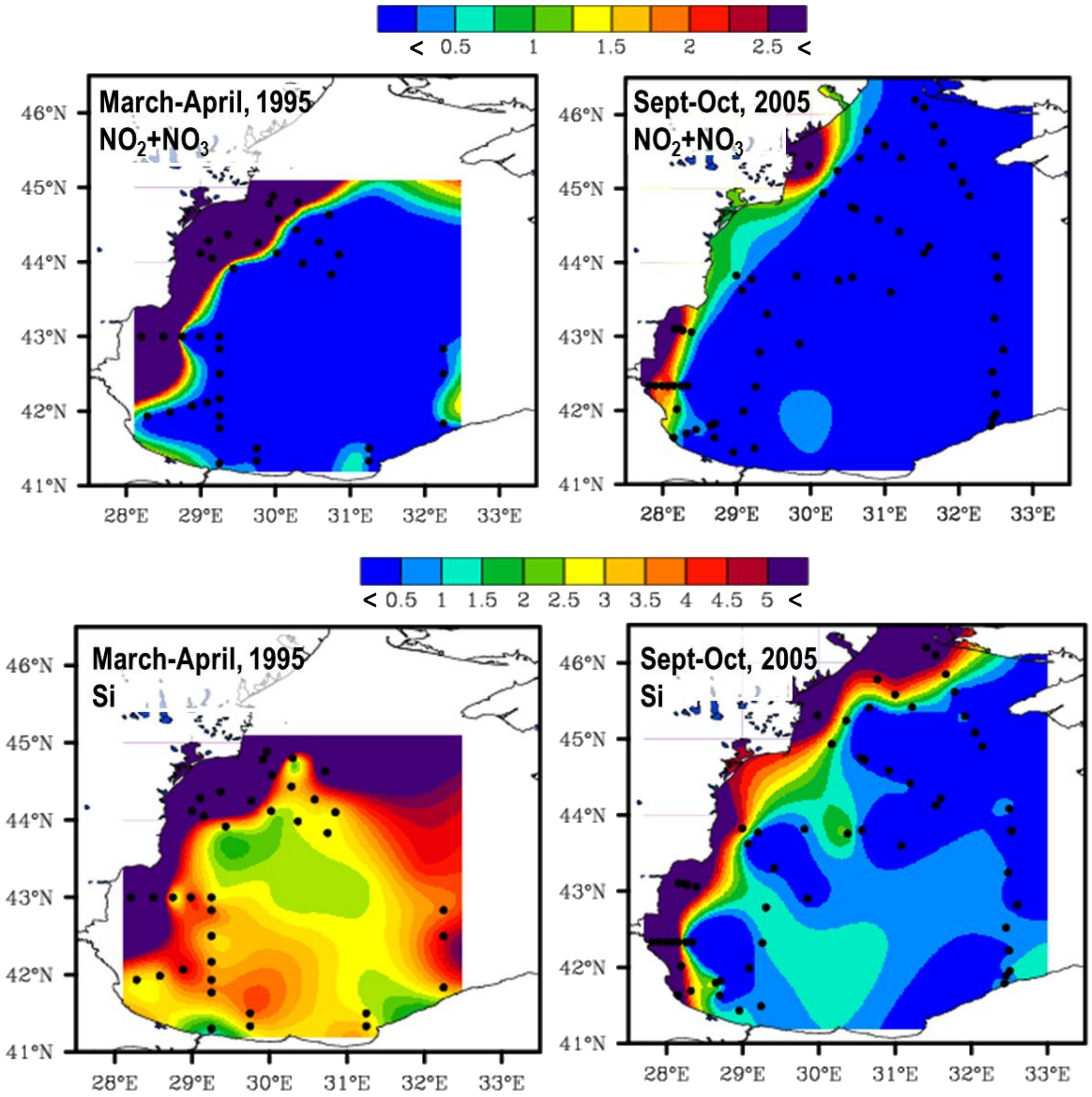
Thus,

- Si/NO_3 ratio: very high (>> 100)
- NO_3/PO_4 ratio: very low (N/P<1.0)

Long-term changes in nutrient concentrations



Long-term changes in nutrient concentrations and their ratios in the surface layer of the central basin, showing drastic decreases in the reactive Si content of the surface waters due to large nitrate and phosphate inputs by the major rivers and intense eutrophication (Tugrul et al., in press).



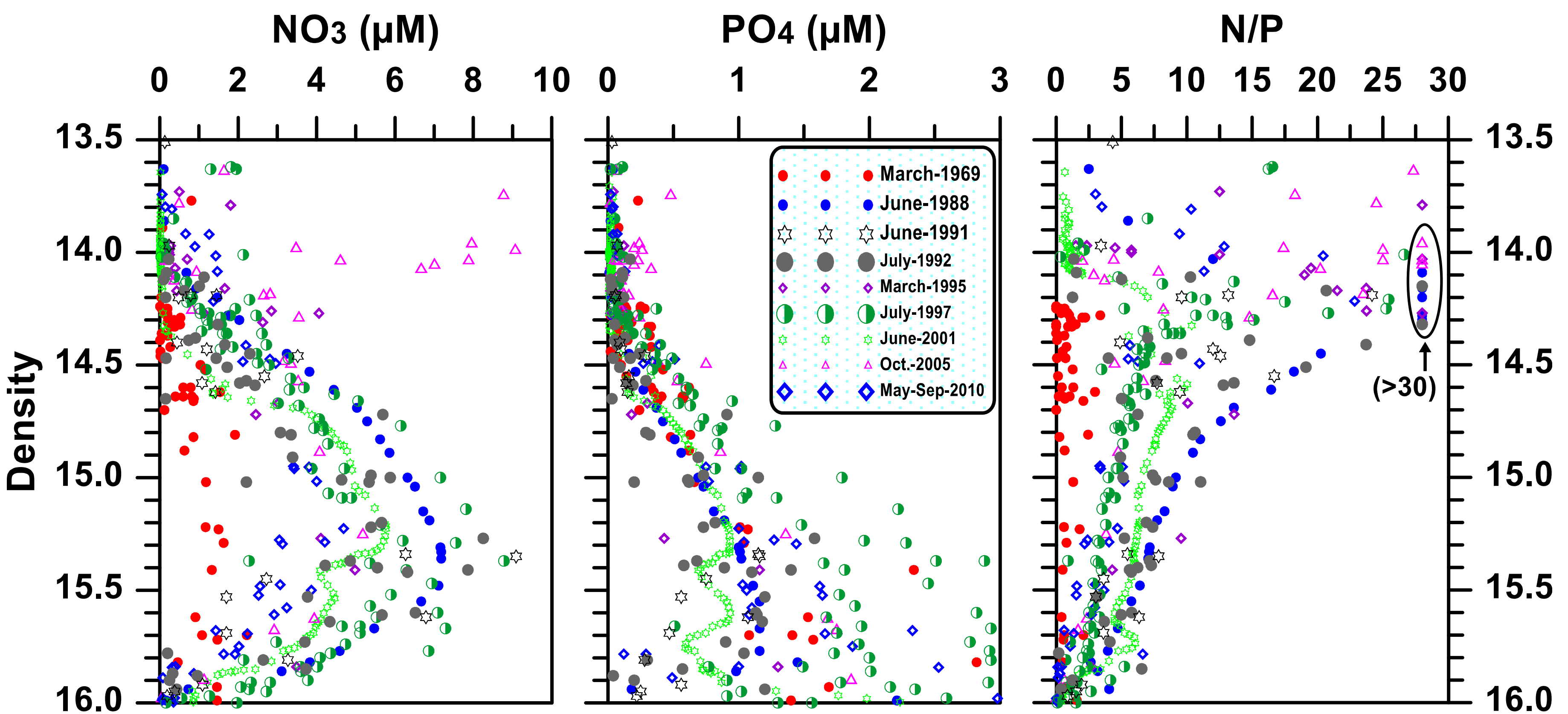
Effect of Danube on the surface nutrient distributions in western basin, decreasing markedly in autumn when the river discharges were at minimal levels in the 1990's (Tugrul et al., in press).

Before 1970’s

- The terrestrial inputs of DIN (nitrate+ ammonia) inputs were not sufficient for consumption of the excess inventories of reactive Si and P in the euphotic zone of the coastal and central gyres due to sufficient supply from the halocline depths in winter months before the 1970’s.

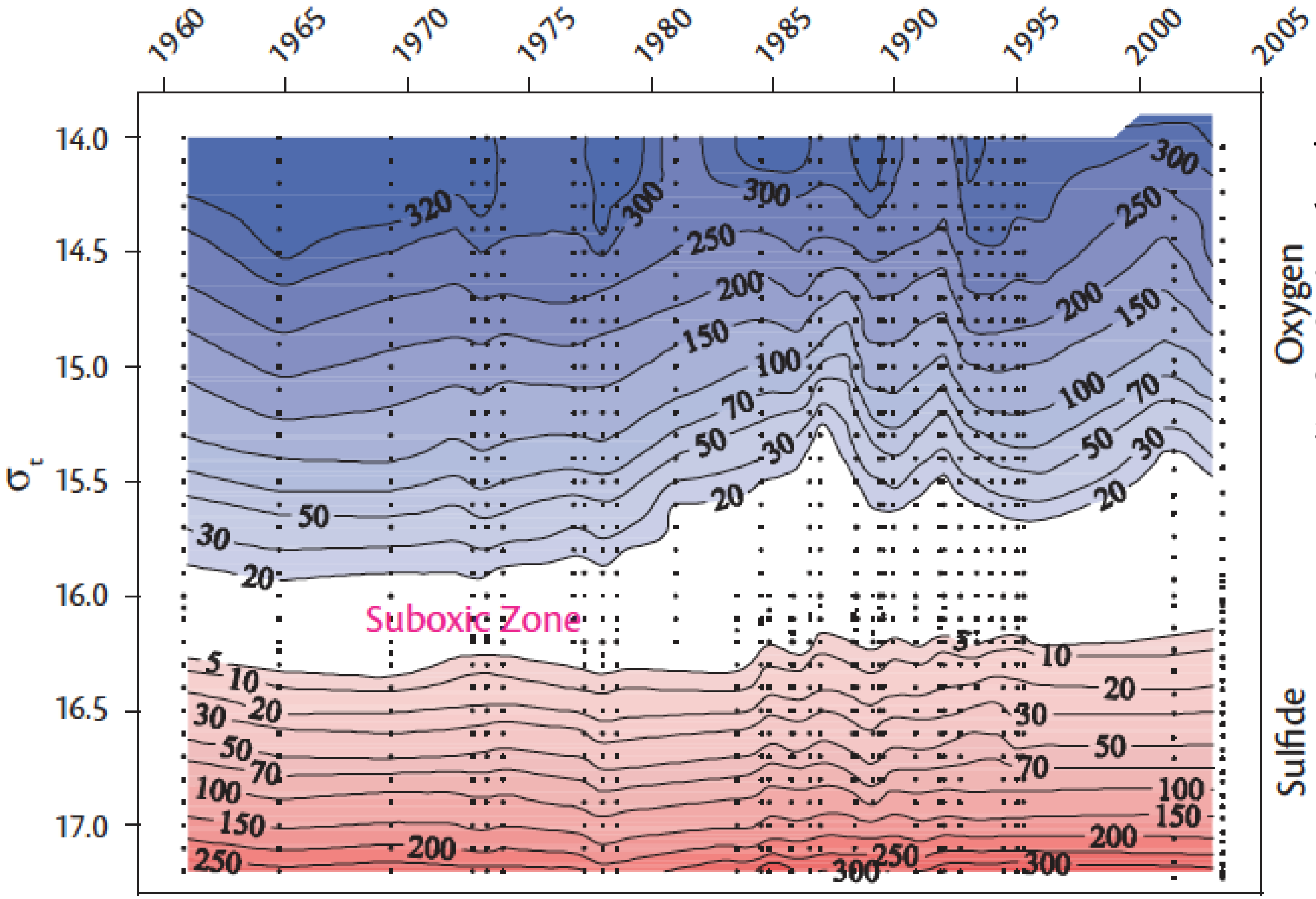
After 1970’s

- The enhanced DIN and P inputs by the major rivers with high N/P ratios (>25) but lower Si concentrations and thus lower Si/DIN (<1) in the polluted rivers resulted in the utilization of excess Si and reactive phosphate stocks in the near surface waters during the 1980’s
- The surface Si/N ratio declined drastically (<1) after late 1970’s as N/P ratios exhibited the opposite trend.
- The enhanced eutrophication increased the DIN inventory of the upper layer markedly in the 1980’s and then decreased gradually due after decreases in the nutrient loads of the River Danube, resulting in apparent increases in the Si/N ratio in the oxic upper layer.
- Silicate stock of the upper oxic-suboxic layer decreased markedly, equivalent to about an increase of 20-year DIN inputs by major rivers + precipitation.
- The increased POM export below the euphotic zone (20-30 m) has altered both the boundaries and thickness of the chemocline in the permanent halocline
- Moreover, the N/P ratio increased in the CIL and oxycline, which is still much lower than in the adjacent Marmara Sea and the classical Redfield ratio.



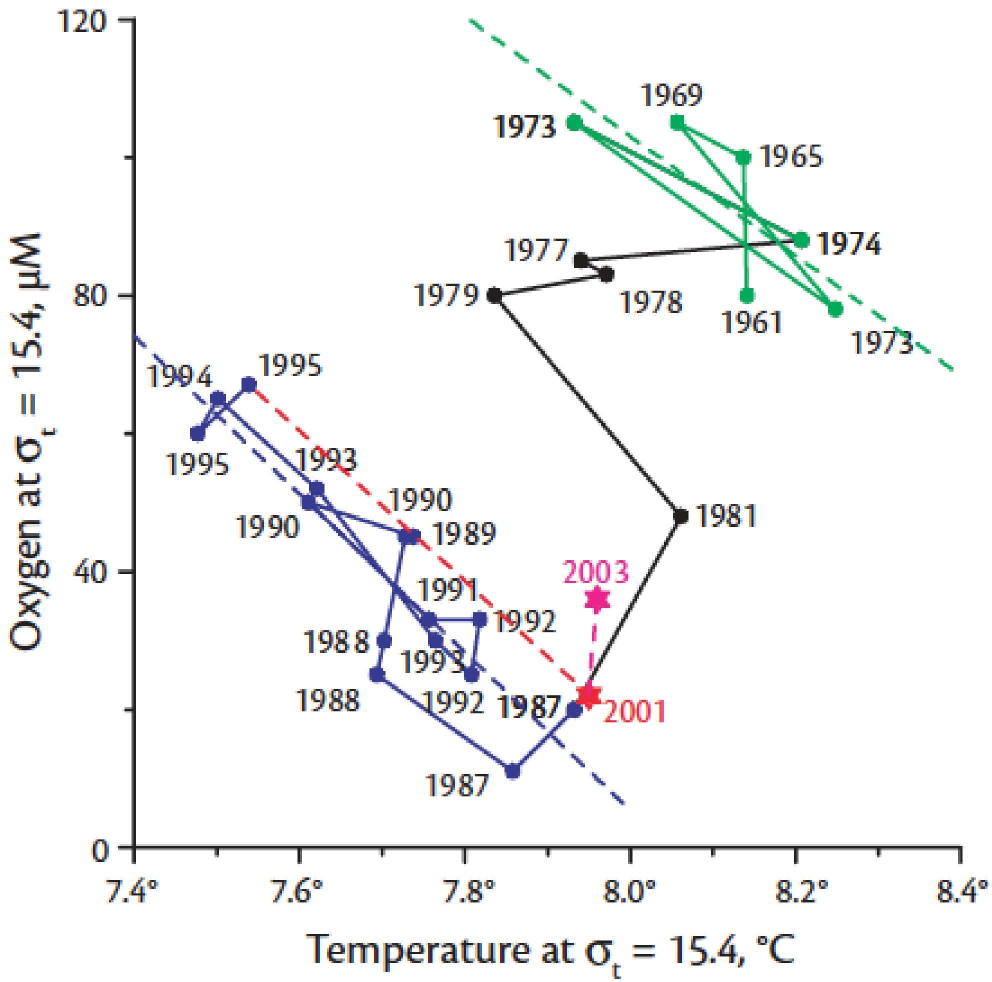
Density-dependent vertical distributions of nitrate, phosphate and their ratios (N/P) in the upper layer down to the suboxic/anoxic interface of the WS shelf and Rim Current in 1969 and between 1988-2010.

Long term oxygen dynamics



Temporal variations in the average distribution of oxygen (blue) and sulfide (red). (Konovalav 2005)

Long term oxygen dynamics



Variations in oxygen vs. temperature in the middle pycnocline (t=15.4) from 1961 to 2003 reveal two periods (before the middle 1970s in green and after the middle of 1980s in blue) of linear correlation. (Konovalav 2005)

GAPS

- The current ecological conditions and expected future trends in nutrient inputs strongly suggest that the “reference conditions” of pre-anthropogenic and pre-damming period in the Black Sea before the 1960’s can not be reached in the future. Therefore new reference conditions for “good environmental status” should be defined for the 2020 GES targets in the Black Sea.
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- The “new” reference values for reactive Si and the Si/DIN ratio should remain high; (Si>2.0 μM) and Si/DIN ratio (>10) in the near surface waters (salinity >17) during the more productive period even under changing climatic (warming/cooling) conditions.

- The upward shift of the O_2 boundary ≈ 5.0 μM within the enlarged SOL can increase the catalyzing role of Mn species and oxygen input by the Bosporus plume in maintaining the boundary of the hydrogen sulfide layer.

Outlook

- Under the present conditions, the Si and PO_4 deficiencies in the surface mixed layer can only be compensated by winter inputs from the upper halocline.

- To achive GES, DIN and reactive-P inputs from both rivers and precipitation should be reduced to threshold levels that can only be estimated by N-P-Si coupled ecosystem models.
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- These changes can be expected to increase the thickness of the euphotic zone, modify algae composition, resulting in enlargement of the oxycline to greater depths by the penetration of more oxygen into the halocline depths.
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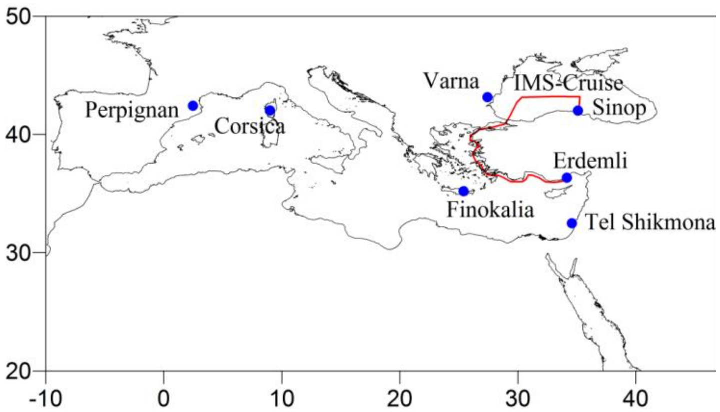
- Moreover, more oxygen will be injected into the suboxic/anoxic interface by the Bosphorus Plume, which compensates nearly %50 of annual oxygen utilized in sulfide oxidation.

Joint cruises

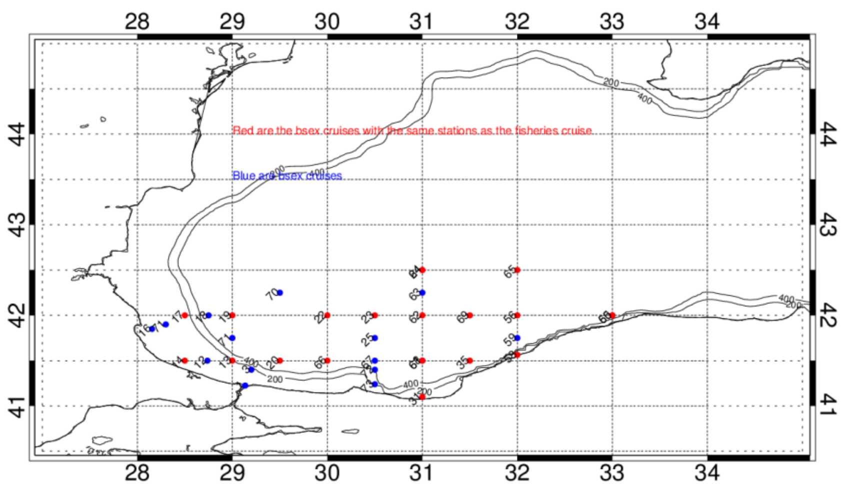
- Joint cruises (during June-August) to study the level of eutrophication and distribution of phytoplankton, zooplankton and impact of gelatinous zooplankton.
- With respect to decreased concentrations of certain micronutrients (such as silica and phosphorus), changes in the phytoplankton composition also can be addressed with joint cruises.
- Inputs for D2, D5, D7.

IMS-METU cruise measurements:



Measurement atmospheric nutrient deposition in southern Black Sea, DIN, DIP, DOC, DON, and DOP, as well as selected anthropogenic trace metals. METU, ECPL-UoC, IO-BAS. D5 and D1

One main (joint) cruise in 2013 (July)



- Eutrophication O2, nutrients, pH, chl, PAR
- Biodiversity phyto fractional change
- Bacterial biomass/production, PP
- Phyto-species level
- Zooplankton-higher taxons, group level/jellyfish (IU)
- Fish acoustics/zooplankton, jellfish (biomass, species level)
- Food web PP vs fish biomass
- Box corer/corer sample
- Eggs/Larvae + Noctiluca
- Atm deposition
- TOC, TN
- Gelatinous
- Eggs and larvae

Atmospheric Inputs

Institute of Marine Sciences, Middle East Technical University
(by Dr. Mustafa Koçak)

SCOPE and PURPOSE

Atmospheric inputs of the macro and micro nutrients to the coastal and open ocean have now been recognised as one of the major external sources.
Its contribution may exceed riverine inputs even in the region of freshwater influence (*e.g.,* North-eastern Levantine Basin).

There are few publications focusing on the atmospheric inputs in the Black Sea (Kubilay *et al.,* 1995, Medinets and Medinets, 2012; Theodosi *et al.,* 2013) and handful of research has been done on marine aerosols over the Eastern Mediterranean and the Black Sea (Chester and Bradshaw, 1991; Hacısalihoğlu et al., 1992; Kubilay et al., 1995; Medinets, 1995).

I) The main aim of the BSEX study is to enhance our knowledge of atmospheric deposition fluxes for a number of macro nutrients and trace metals.

II) The present study also aims to calculate more realistic dry deposition settling velocities, evaluate and compare the atmospheric and riverine inputs.

PROGRESS

To date, dry deposition settling velocities for North-eastern Levantine Basin and Central Black Sea have been calculated applying two-stage aerosol samples (see Figure 1).

Nitrate and phosphate in NLB are primarily associated with (> 70 %) the coarse particles whereas these species in **Central Black Sea are found to be evenly distributed between coarse and fine fractions.** Ammonium at both sites is mainly found in fine particle (> 85 %).

However, it should be highlighted that there is a considerable difference between two sites respect to size distribution (NLB> 97 %; CBS > 88 %).
In parallel with size distributions, Vds demonstrate great variability between two different regions.

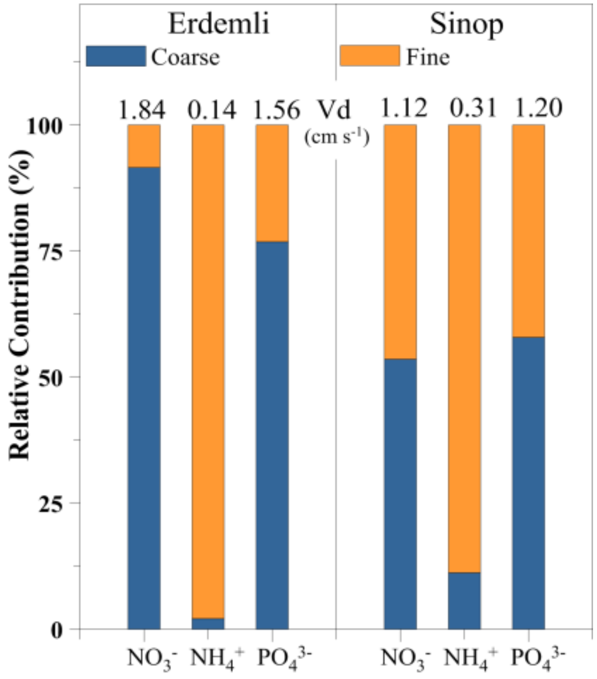


Figure 1. Relative contribution of nutrients in fine and coarse aerosol fraction along with corresponding settling velocities (Vd).

GAPS and FUTURE PLANS

a) On-board aerosol sampling has just been carried out (Perseus Marex, Bsex cruises).

b) Analysis of aerosol samples will be accomplished in the second phase of the project.

c) Source apportionment analysis will be applied in order to identify origin of the aerosols.

d) Air-masses trajectory analysis will be used to determine possible source areas.

e) Atmospheric inputs will be calculated for NLB and CB. Consequently, comparison will be made for nutrient and trace metal inputs from the atmosphere and river.

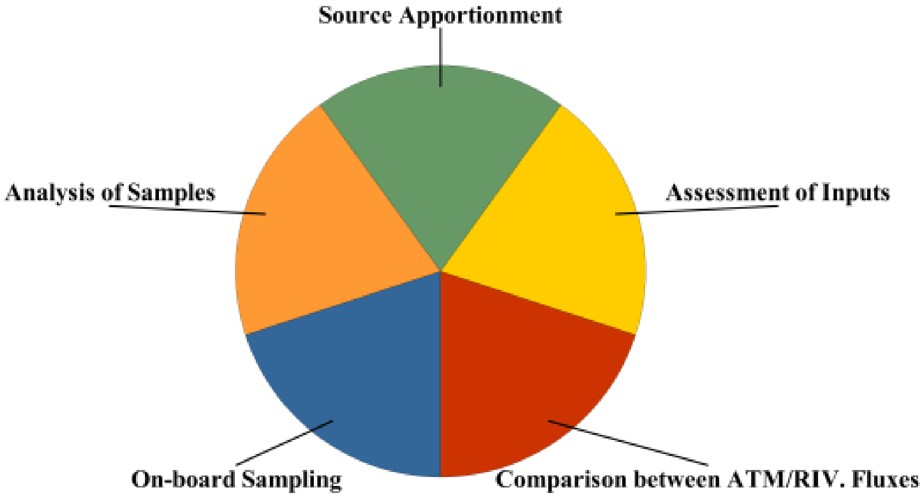
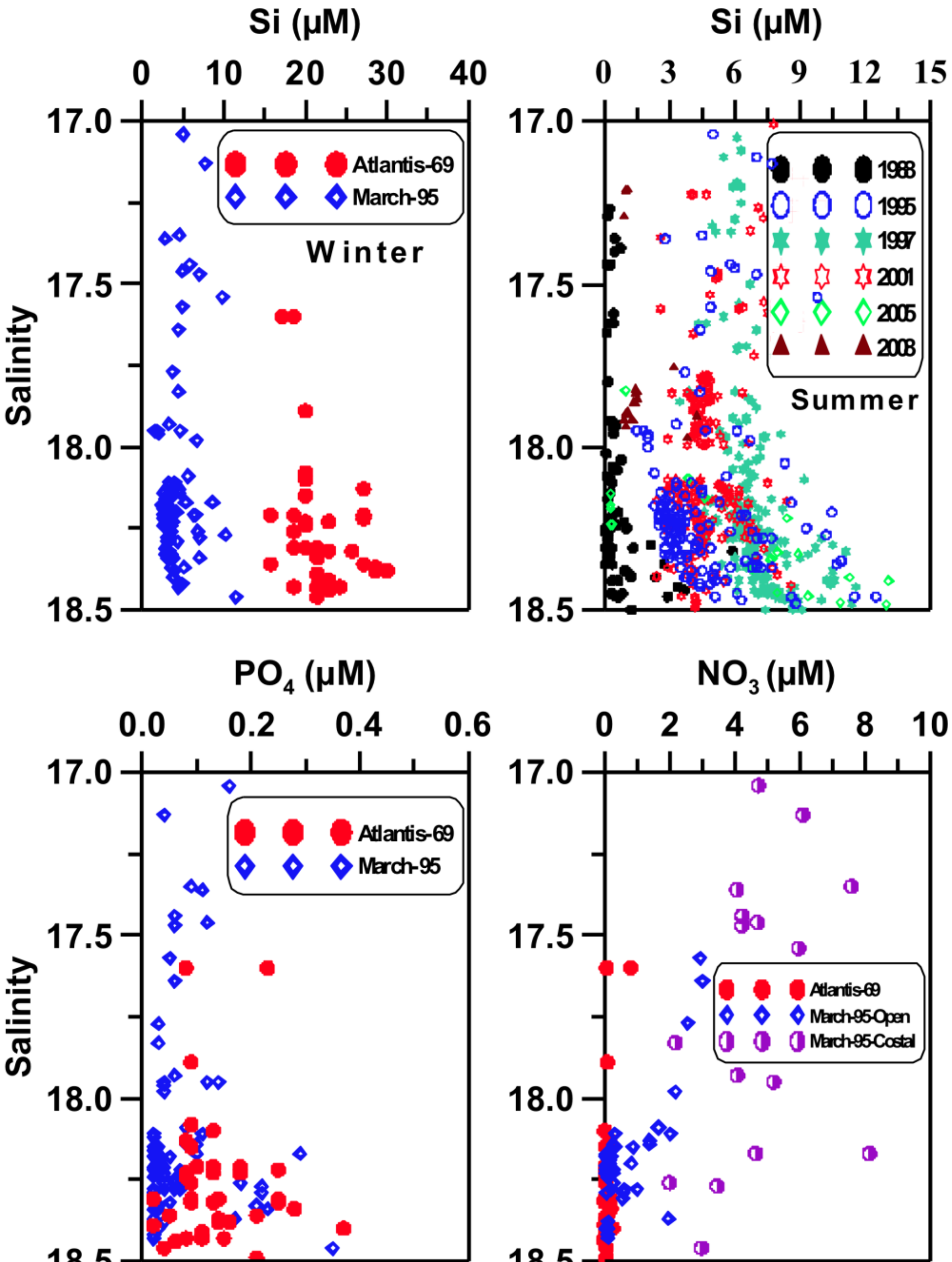
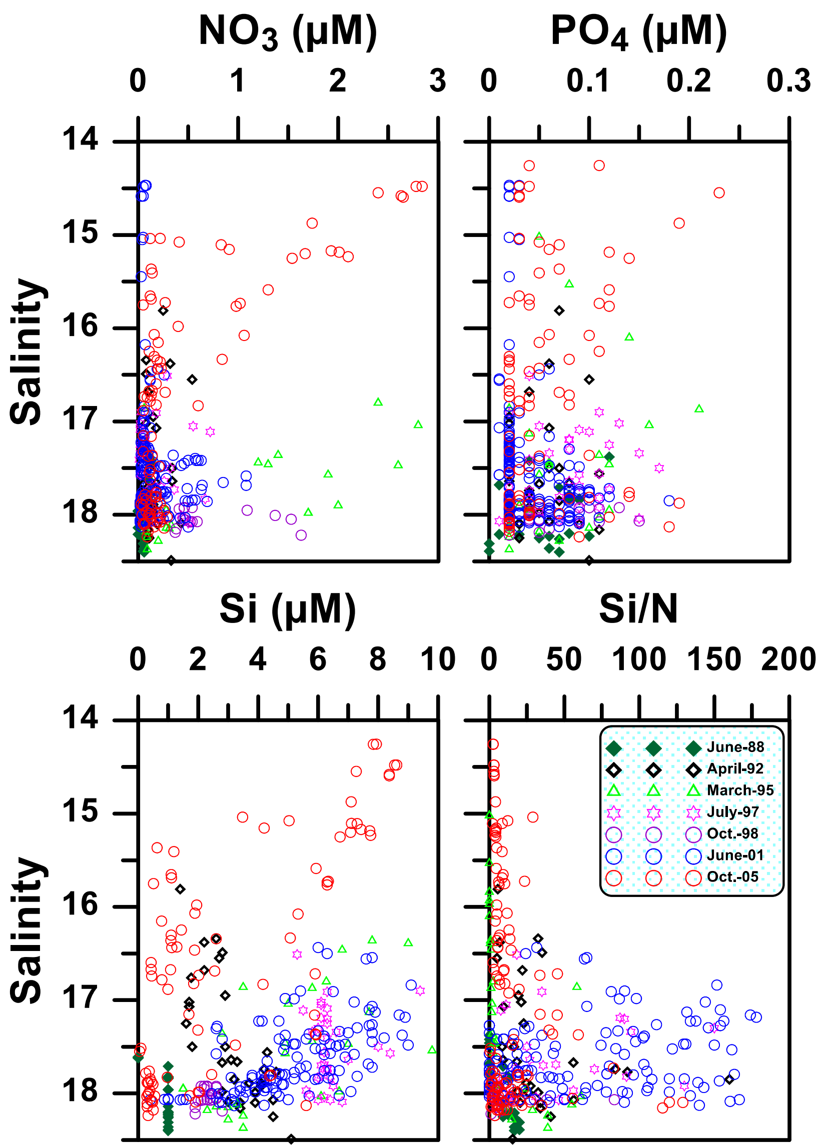


Figure 2. Future plans

Long term variability



Salinity-dependent variations of surface nutrient concentrations in the western Black Sea in March 1969 and in the recent decades.



Salinity-dependent distributions of silicate, phosphate and nitrate in the surface layer waters (0-10 m) of the NW shelf and SW Rim Current between1988-2005.

- Winter ventilation provides the fl ux of
- oxygen to the CIL (Figure 3) and the
- fl ux of nutrients from the CIL to the
- euphotic zone (Figure 5).
- • Climate-dependent variations in the
- intensity of winter ventilation result
- in interannual oscillations in the fl ux
- and concentrations of oxygen in the
- main pycnocline (Figure 6) and in the
- position of the upper boundary of the

Baris asagidaki yayından 2 sekli pinoklin tabakasının oksijen dusunun eutrophikasyonla dogrudan
sikisni gosteriyor. Soguk donemde dahi SOL tabakasina O_2 tasınımı yetersiz kaliyor. Doğagal
olarak 5 uM sınırıda derinden 15.9 densitiye tasınımıs, orada PO_4 minimum ve particulate Mn
max olusuyor. Bu da H_2S tabakasının muhtemelen namolar seviyede yukari kaymıs olmasi demek
ama biz bunu mevcut yontemlerle goremiyoruz. Yeni in situ (pump cast) calismalar ile gormek
mumkun olabilir. O da bzi de yok.

Otrofikasyonun ve iklim degsikliginin O_2 uzerinde eksinin tersine donmesi icin asagidaki sekil 10
da yapının dogal halini gelmesi gerekir. YAni soguk donemde daha fazla O_2 haloklin icinde
tutulabilmelidir (O_2 input> POM export on the annula basis)

Suleyman

Variations in the chemistry of the Black Sea on a time scale of decades (1960–1995)

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