MIDDLE EAST TECHNICAL UNIVERSITY
INSTITUTE OF MARINE SCIENCES

Response of the Black Sea ecosystem to the anthropogenic driver river nutrient loads

Bettina A. Fach[1], Heather Cannaby[1], Viktor L. Dorofeyev[2], Alexander I. Kubryakov[2], Baris Salihoglu[1*], Gennady K. Korotaev[2], Temel Oguz[1]

1. Institute of Marine Sciences, Middle East Technical University, Turkey

2. Marine Hydrophysical Institute NAS, Sevastopol, Ukraine

PERSEUS
POLICY-ORIENTED MARINE ENVIRONMENTAL RESEARCH IN THE SOUTHERN EUROPEAN SEAS

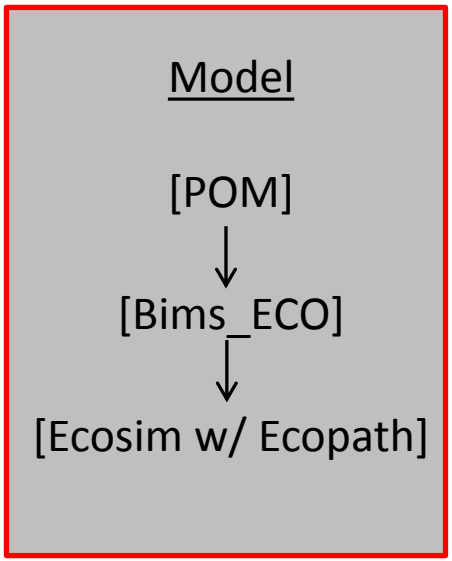
MEECE
Marine Ecosystem Evolution in a Changing Environment

Black Sea Integrated Modeling System (BIMS)

End-to-end model of the Black Sea:

- Circulation model (Princeton Ocean Model - pom2k)
- Ecosystem Model (BIMS_Eco)

→ 20-year model run for the years 1980-1999 forced with ERA40 atmospheric forcing fields



Princeton Ocean Model (pom2k)

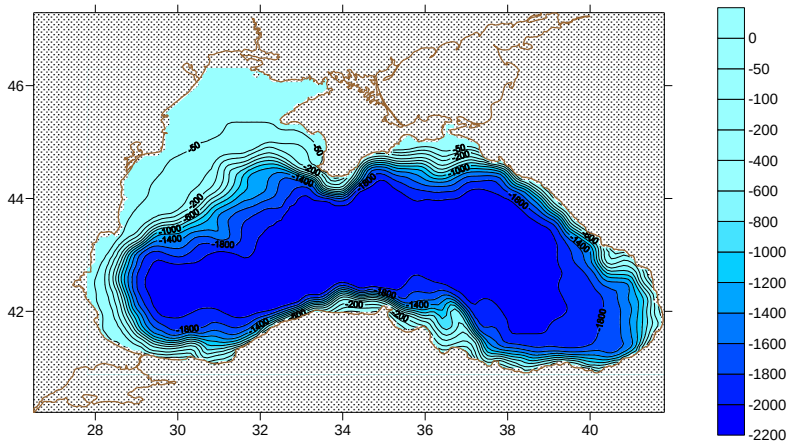
Horizontal grid ~ 8km regular array (141x88)

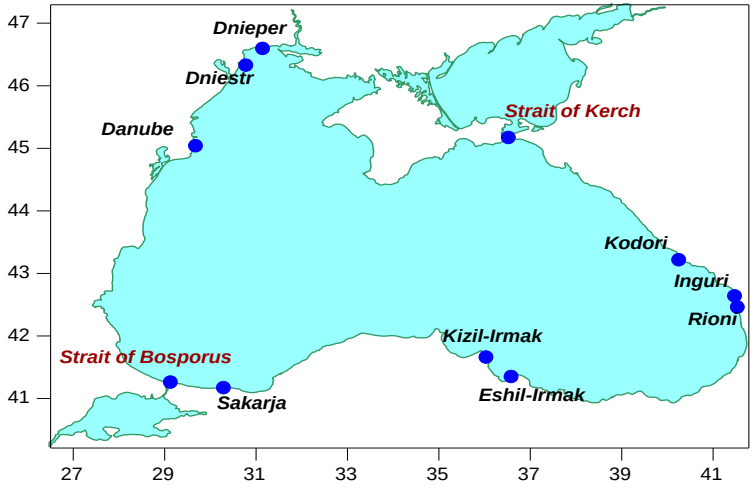
Vertical grid: 26 sigma levels, compressed towards upper 200 m

Initialisation: Spun up from climatology using atmospheric climatological forcing

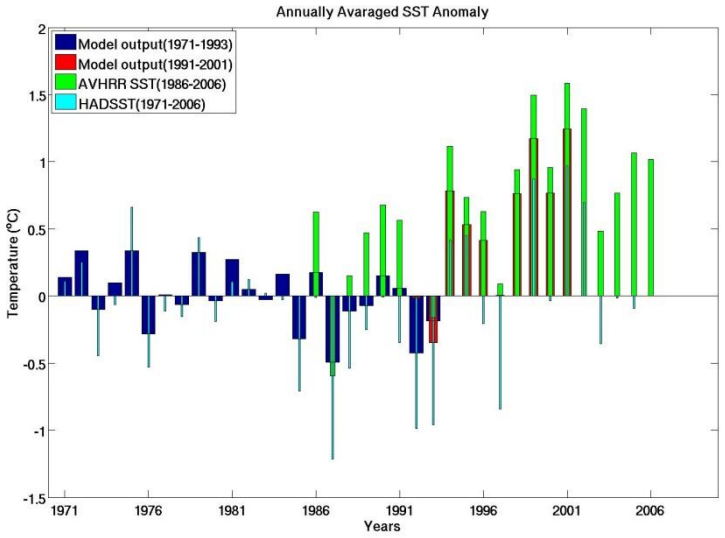
Forcing:

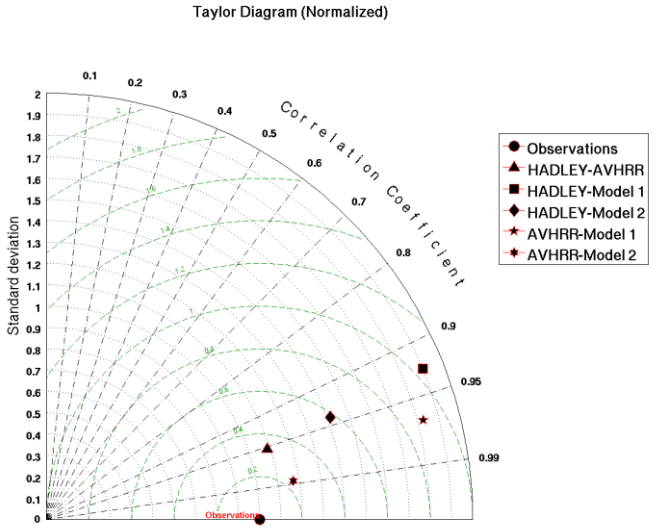
- ERA40 atmospheric (6-hours data)
- Climatic river input (9 in total)
- Straits discharges (Bosporus/Kerch)



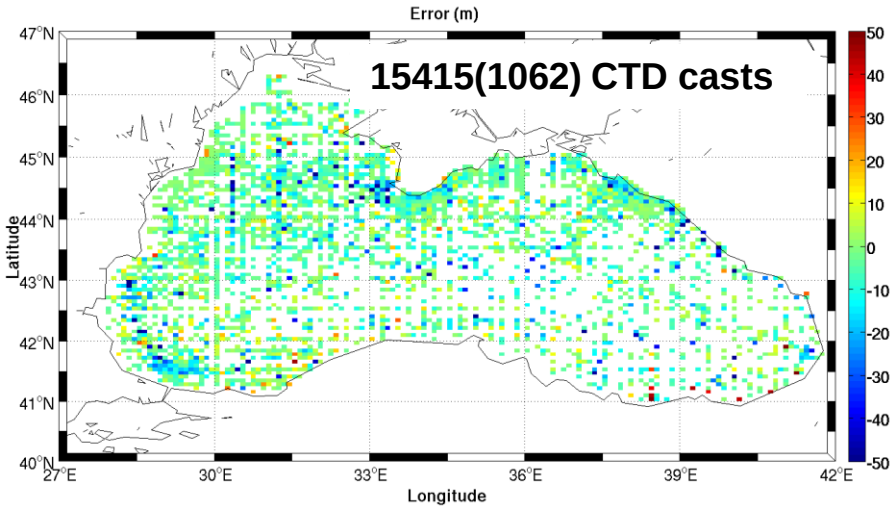


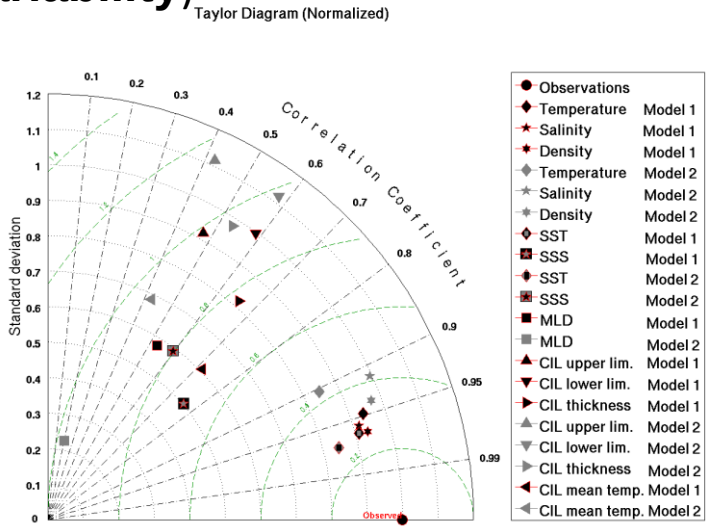
Physical model Validation (temporal variability)





Physical model Validation (accuracy/spatial variability)





BIMS_ECO

- Pelagic food web model
- Nutrient cycling (nitrogen)
- Vertical grid extends to 150 m (23 z-levels with 2 m resolution near the surface and 20 m near the lower boundary).
- Horizontal grid as in Circulation model.

Tropic level-0

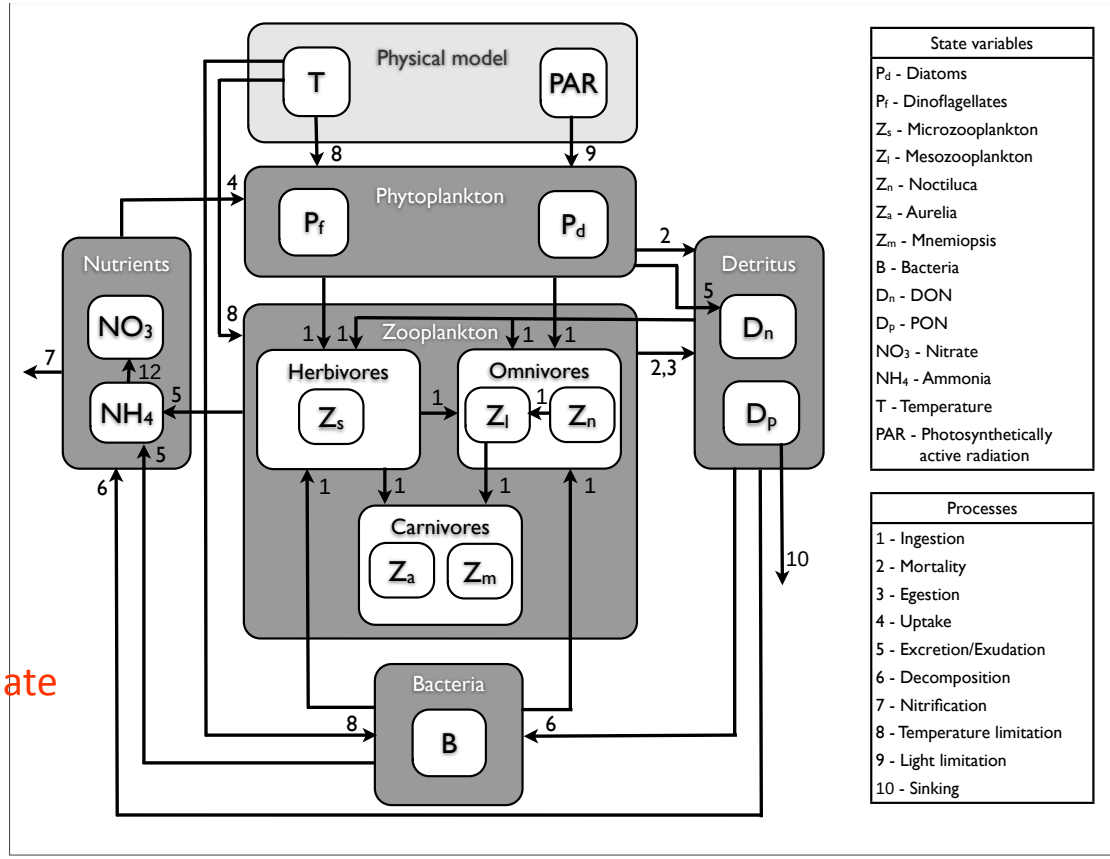
NO_3 - nitrate
NH_4 - ammonium
DON - Dissolved organic nitrogen
PON - Particulate organic nitrogen

Tropic level-1

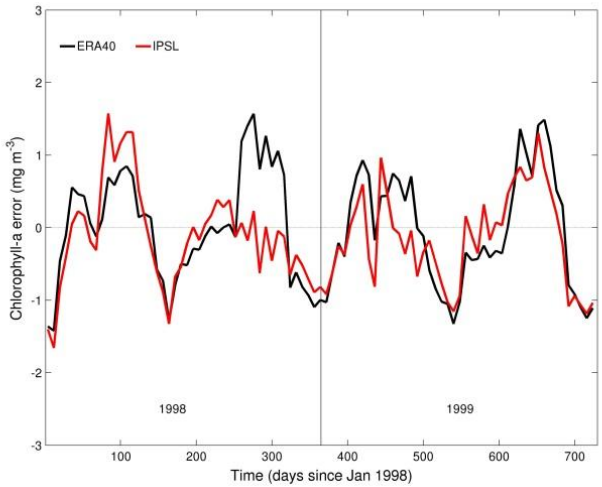
P_f - small (<10 µm) phytoplankton
P_d – large (> 10 µm) phytoplankton

Tropic level-2

Z_s – microzooplankton
Z_l – mesozooplankton
Z_n - opportunistic heterotrophic dinoflagellate *Noctiluca scintillans*
Z_a - gelatinous carnivore *Aurelia aurita*
Z_m - gelatinous carnivore *Mnemiopsis leidyi*



Ecosystem Model Validation

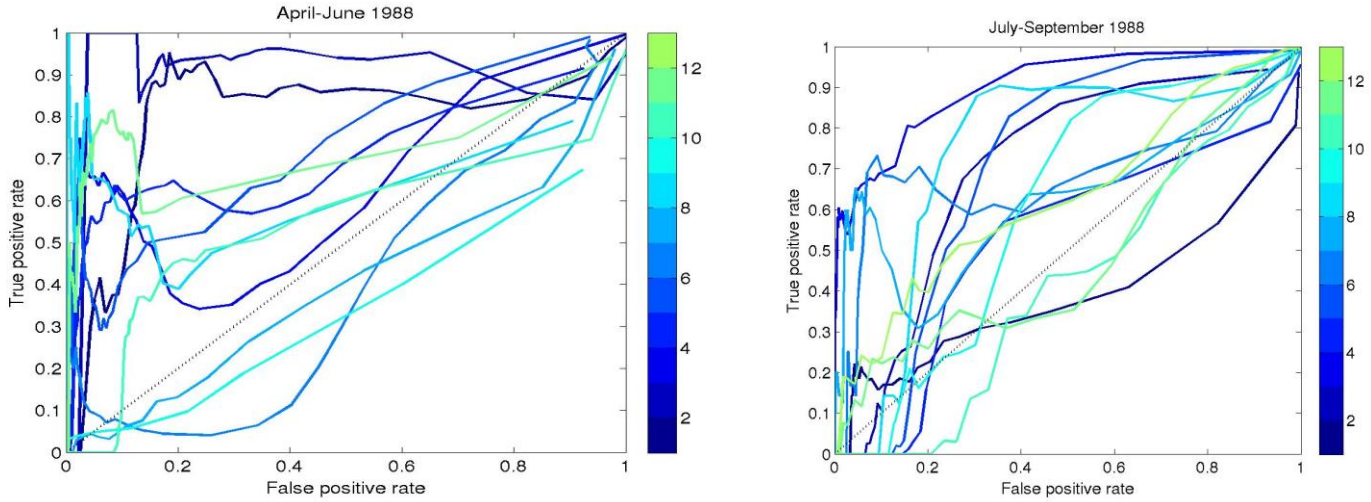


- Mean error between -1.42 to 1.5 mg m^{-3} (ERA40)
- Largest errors during spring and autumn bloom seasons
- Model tends to overestimate chlorophyll concentrations during blooms, underestimate during no-bloom times.

Wavelet Analysis

- The model performs well at intermediate chlorophyll exceeding 0.5 at all spatial scales and exceeding 0.8 in 90% of cases at spatial scales of more than 120 km.
- This suggests that much of the incurred error in the model representation of phytoplankton blooms results from a temporal rather than a spatial mismatch in bloom dynamics.

Ecosystem Model Validation cont.

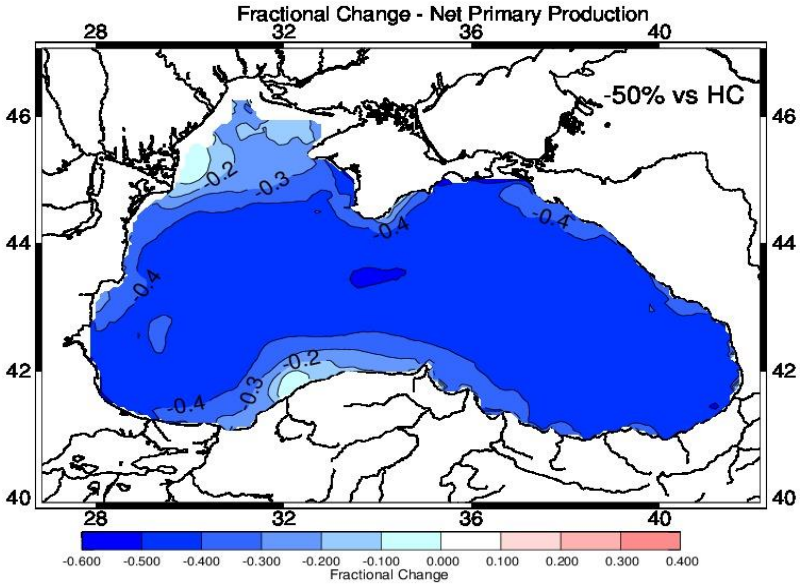


Receiver Operator Curves (ERA40 forcing)

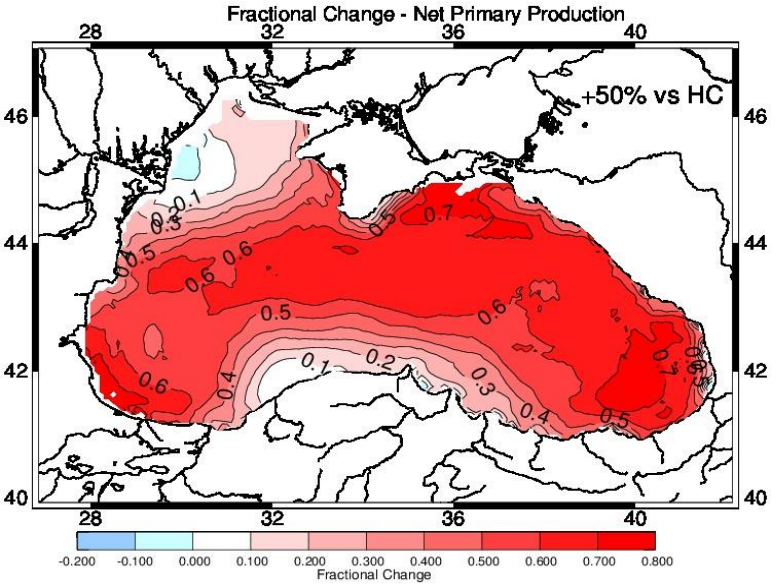
- 75% of the 8-day composite comparisons demonstrate a level of model skill in simulating remotely-sensed surface chlorophyll distributions.
- Model performance fluctuates throughout the year decreasing during the bloom seasons

Net primary production changes through river nutrient loading

- 50% nutrient load



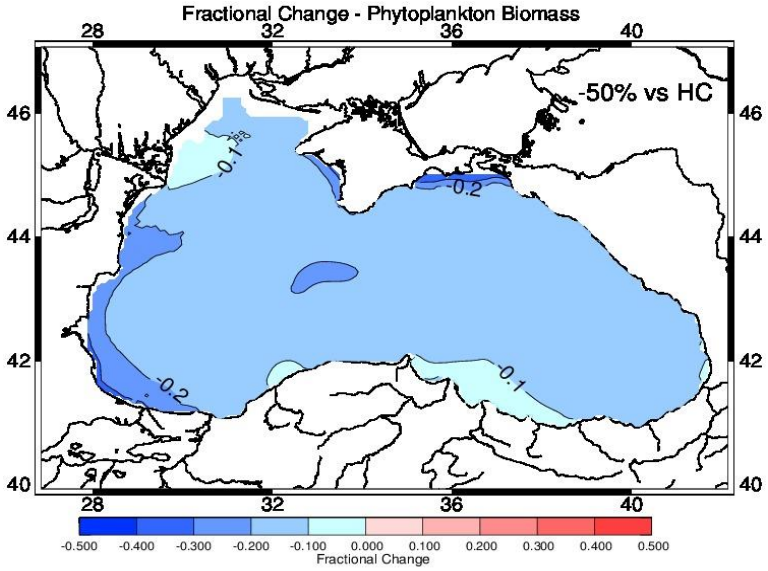
+ 50% nutrient load



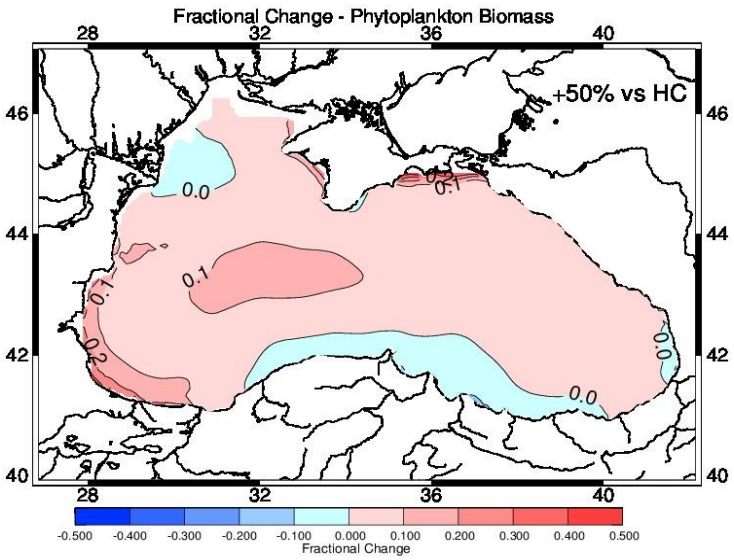
- Net PP decreases by 40% when the nutrient load is cut in half.
- Net PP increases up to 60% over much of the Black Sea inner basin when nutrient load is doubled.
- The eastern regions of the Black Sea react stronger to this increase, while on the north-western shelf the change is more moderate.

Changes in phytoplankton biomass

- 50% nutrient load



+ 50% nutrient load

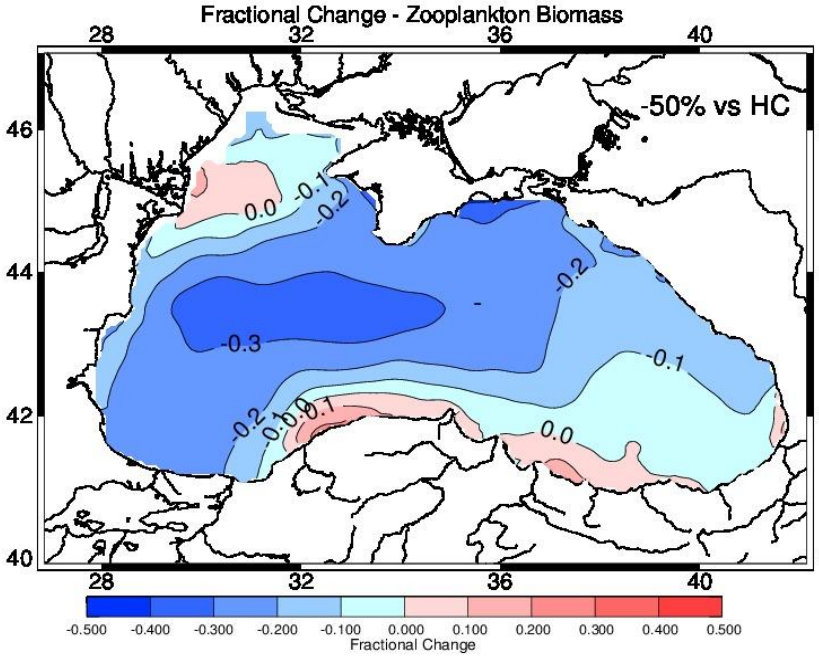


- Despite the strong in/decrease in primary production, chlorophyll-a concentrations typically respond weakly to changes in nitrate availability.

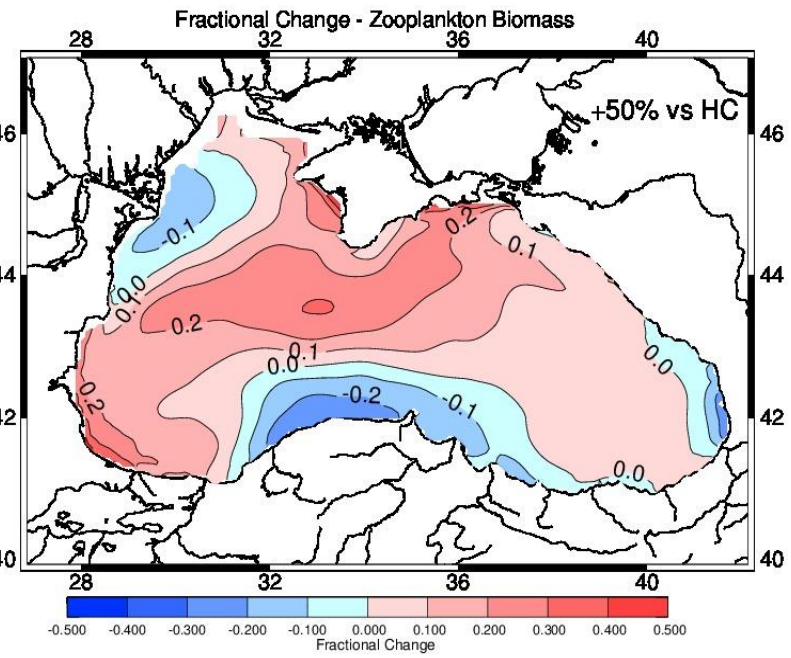
→ This indicates that increased grazing closely mirrors an increase in productivity, which is confirmed by changes in zooplankton biomass.

Changes in zooplankton biomass

- 50% nutrient load



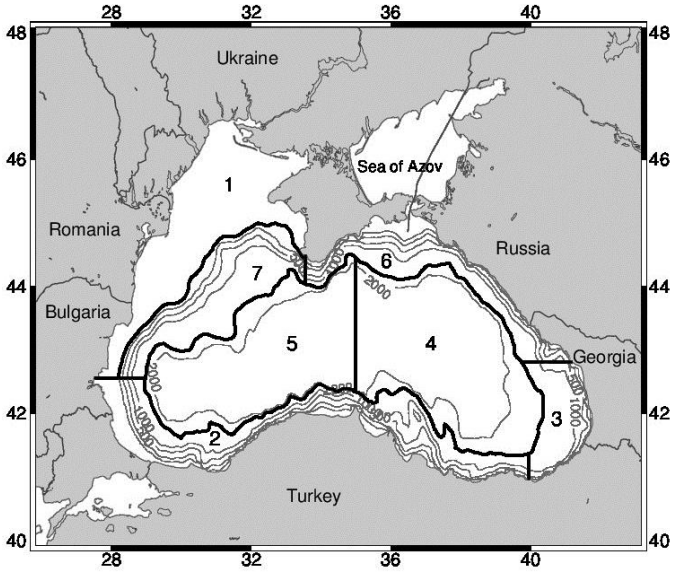
+ 50% nutrient load



- Zooplankton biomass shows more regional variability in response to changing nutrient loads.
- On decreasing the nutrient load by 50%, zooplankton in the deep basin decrease by 30%, while an increase of biomass is observed on the north-western shelf and near the south coast

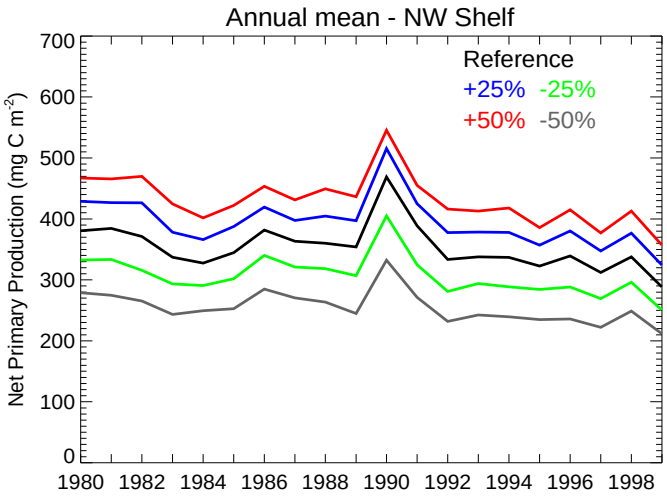
→ It is important to note that because of the strong influence of grazing on phytoplankton biomass, simulated chlorophyll concentration is not a good indicator of eutrophication in the Black Sea.

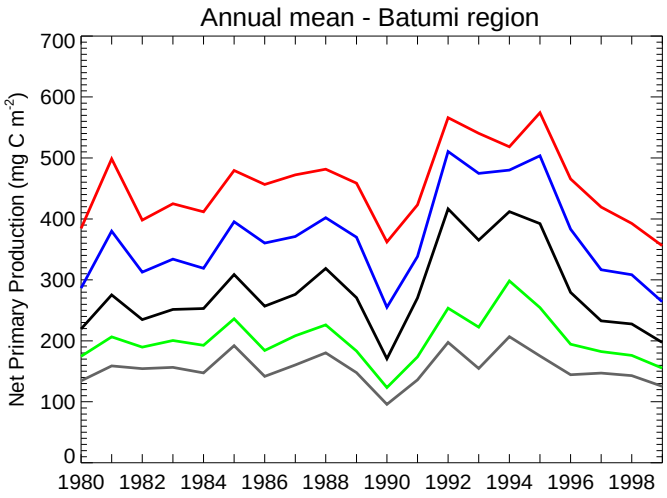
Regional Differences



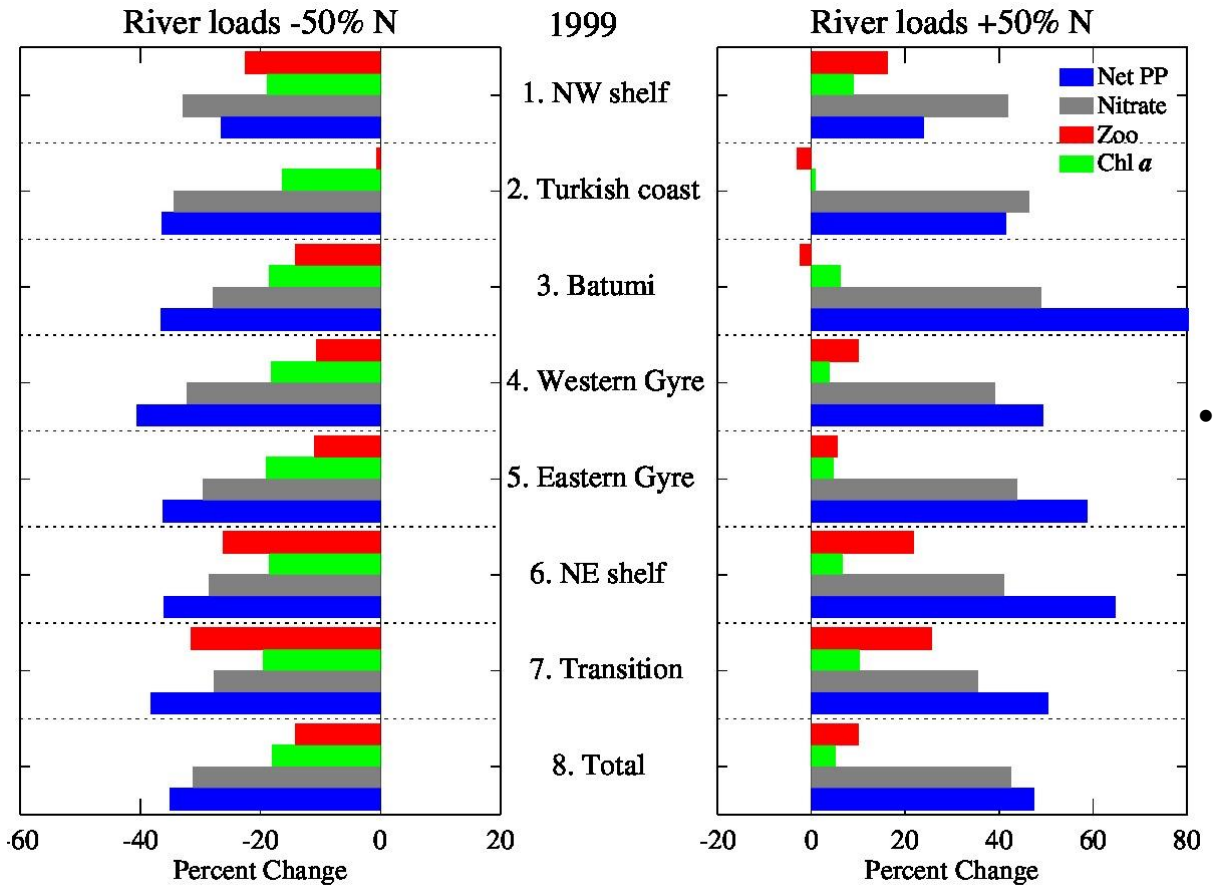
Different regions of the Black Sea react very differently to simulated eutrophication:

- Increased sensitivity of the open sea regions away from the north-western shelf to eutrophication and/or nutrient load reduction (example: Batumi region vs. North-west shelf)





Regional Differences



- The north-western shelf region, where 85% of the river load enters the Black Sea, is less sensitive to eutrophication in terms of net primary production. Rather, nutrients accumulate and are not used by the system.
- Primary production in the open ocean regions which are currently less impacted react strongly to increased eutrophication. The Batumi region with three rivers (Rioni, Kodori, Chorokhi) entering from Georgia seems especially sensitive to nutrient changes.

Conclusions

- **Model results indicate strong regional nitrate limitation, and high sensitivity to changes in river nutrient loading.**

- regions close to the Danube delta and other major river outflows within the NE basin are already highly impacted by eutrophication and consequently show a weaker response to an additional increase in nutrient loads.

- The southwest, near Batumi where the system is currently less impacted, the system is more sensitive to changes in nutrient loads.

- A 50% reduction in riverine nutrient loading has a greater impact on primary production than the increase in productivity associated with an 50% increase.

- biomass chlorophyll concentration is not a good indicator of eutrophication in the Black Sea because of the strong influence of grazing on phytoplankton

→ model simulations represent a Black Sea ecosystem, which is highly sensitive to a reduction in nutrient loadings, suggesting management of river water quality is vital for the improvement of the ecosystem state of the Black Sea.

Institute of Marine Sciences,
Middle East Technical University,
Turkey

THANK YOU FOR YOUR ATTENTION!