ATMOSPHERIC DEPOSITION CONTROLS ON THE EAST MEDITERRANEAN MARINE ECOSYSTEM

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Well defined decreasing trend in Chl from the West to the East

N:P ratio has been measured to increase in the same direction with the oligotrophic character of the sea

*Redfield, A. C., University of Liverpool, 1934*
Questions to be addressed

Can N and P atmospheric deposition explain the unusually high N/P sea water ratio?

How important is atmospheric deposition for the marine ecosystem?
Approach

Sea Water Observations are coupled with Atmospheric Deposition Measurements by means of 1-D Ocean Physical Biogeochemical Model.
Nitrogen and Phosphorus Fluxes in The Eastern Mediterranean Basin

Preferential P remineralization in oligotrophic marine ecosystems

The 1-d Model

Christodoulaki et al., Journal of Marine Systems, 2012

Clark et al., Nature, 1998

Physical Model 5-1000m

Pelagic Model

Benthic Model

Pref. P Remin.

PO₄³⁻

N:P=16

N:P>16

C,N,P, Si Sedimentation

Sub-surface Outflow

Surface Inflow

Sicily Straits Fluxes

Rivers

Atmospheric Deposition
Primary Biomass (mgC/m²) | Bacterial Biomass (mgC/m²)
---|---
March | 1488 ± 364 | 1620-1830 | 1423 ± 43 | 1060 - 1100 |
September | 645 ± 81 | 666-675 | 1505 ± 432 | 1190 - 1210 |
Annual | 600 – 1830 | 600 – 1850 (960) | 870 - 1055 | 1060-1210 (1142) |
Scenarios

- Reference simulation with atmospheric deposition fluxes
  \textit{Model +atm.dep.2000}

- Simulation with reduced atmospheric deposition fluxes
  \textit{Model +atm.dep.1860}

- Simulation with increased atmospheric deposition fluxes
  \textit{Model +atm.dep.2030}
Atmospheric Deposition Input

1860
Reduced Atmospheric Deposition Run:
Duce et al., GBC, 2008;
Mahowald et al., GBC, 2008

2000
Reference Run:
Kouvarakis et al., GBC, 2001;
Markaki et al., LImn. Ocean., 2003

2030
Increased Nitrogen Atmospheric Deposition Run:
Duce et al., GBC, 2008
Atmospheric Deposition Impact on DIN/DIP

Integrated in the first 200 m

Increase 20-45%

Further increase 4 - 9%

DIN/DIP

T0

T0+25yr

T0+50yr

1860

2000

2030

Integrated in the first 200 m
Reference run (2000)

Annual carbon fluxes (mg C m\(^{-2}\) yr\(^{-1}\)) and biomasses (mg C m\(^{-2}\)) (integrated within the top 100m)
Atmospheric Deposition Impact on Eastern Mediterranean marine ecosystem

## Changes due to anthropogenic inputs to the ocean

<table>
<thead>
<tr>
<th></th>
<th>1860</th>
<th>2000</th>
<th>2030</th>
<th>Difference(%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>(2000–1860)/</td>
<td></td>
<td>(2030-2000)/</td>
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<tr>
<td></td>
<td>2000</td>
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<td>2000</td>
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<tr>
<td>Phyto Biomass (mg C/ m²)</td>
<td>548 - 1750</td>
<td>600 - 1850</td>
<td>690 - 1850</td>
<td>4 - 20</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.1 – 2.1</td>
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<tr>
<td>Primary Production</td>
<td>150 750</td>
<td>200-890</td>
<td>200 - 890</td>
<td>7 - 26</td>
</tr>
<tr>
<td>(mg C/ m²/ d)</td>
<td></td>
<td></td>
<td></td>
<td>0.2 – 2.6</td>
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<tr>
<td>Bacterial Biomass</td>
<td>1040 - 1210</td>
<td>1040-1220</td>
<td>1040 - 1220</td>
<td>-2.5 to 4.5</td>
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<tr>
<td>(mg C/ m²)</td>
<td></td>
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<td>-0.25 to +0.25</td>
</tr>
</tbody>
</table>

Monthly mean values -variability
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Main conclusions

Anthropogenic atmospheric deposition inputs to the marine ecosystem in the East Mediterranean can explain the high N/P ratio in the seawater

They increased PP to 26% (since 1860)

They are expected to further increase it to 2.6% (2030)

Need for better understanding of

Ecosystem functioning (including the role of bacteria)

Atmospheric deposition (changes + bioavailability)
Thank you for your attention!

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