Upstream control of the frontal jet regulating plankton production in the Alboran Sea (Western Mediterranean)

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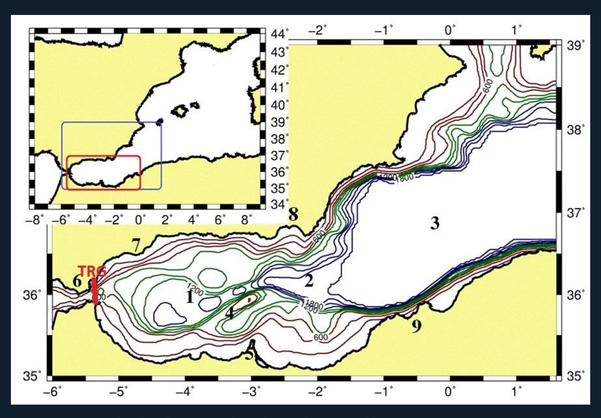
Using a coupled physical-biological model, we investigate the impact of the 40 km wide meandering jet on the biological production of the Alboran Sea (Western Mediterranean).

Our results suggest that the jet constitutes a major source of biological enrichment even in the absence of wind forcing and tidal dynamics. The level of enrichment is shown to vary markedly during the year depending on the upstream characteristics of the jet as it exits from the Strait of Gibraltar. The high production is shown to be supported by frontogenesis-driven ageostrophic cross-frontal circulation combined with eddy pumping within cyclonic eddies located on the outer periphery of the jet.

1 Study area and model description



Model domain in the Alboran Sea

➢ **Physical model:**

• POM, resolution ~3km

• surface forcings: climatological heat fluxes, no wind/tides

• western lateral boundary conditions: climatological temperature and seasonally varying 2-layer zonal velocities

➢ **Biological model:**

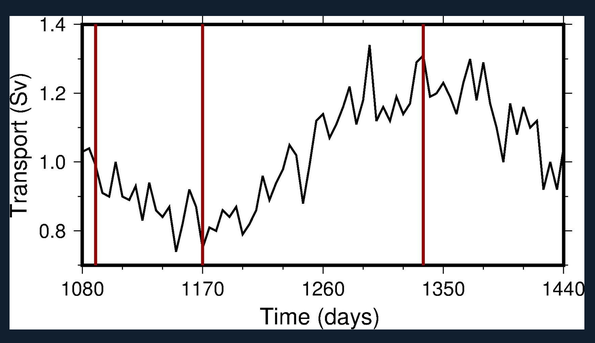
• NP2ZD

• on-line coupling

• 4 years of model integration

2 Results: seasonal variability

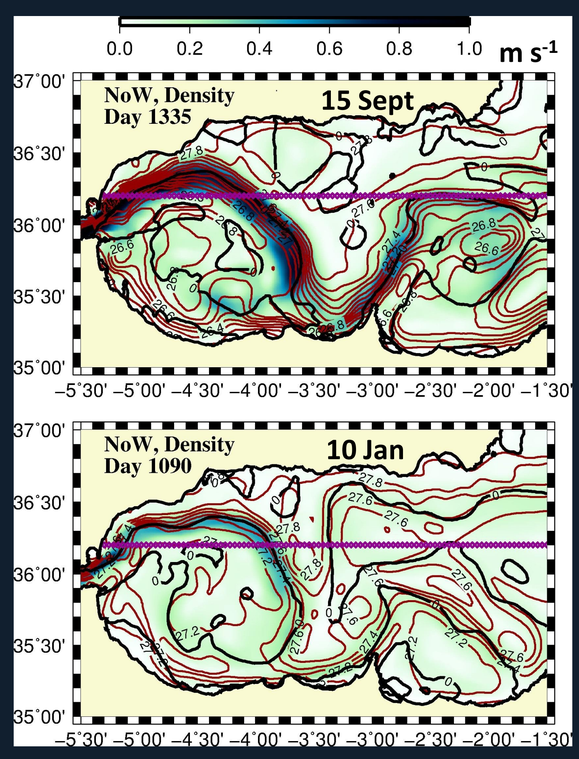
1 Physical



Annual variations of the Gibraltar Strait upper layer transport

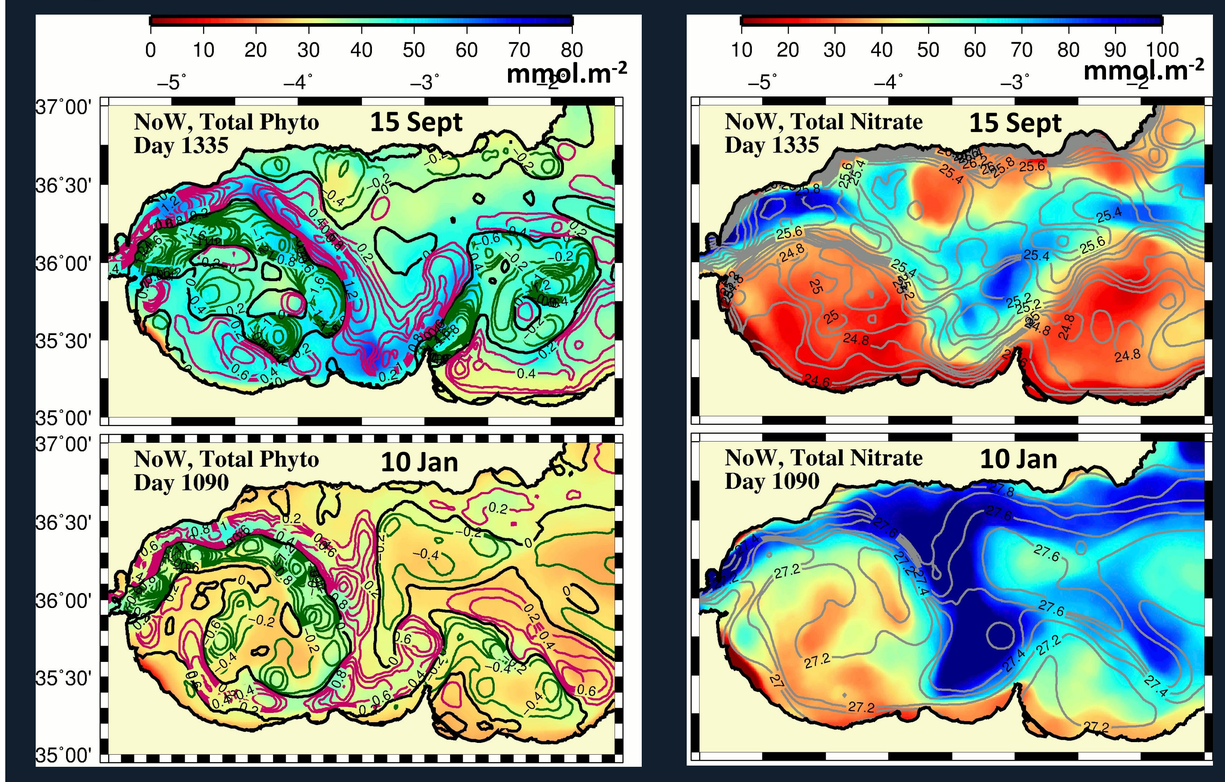
• Seasonal variability of the incoming Atlantic water mass transport

• Intensification of the cross-frontal density gradients in summer



Current speed and contours of density @25m for summer and winter periods

2 Biological

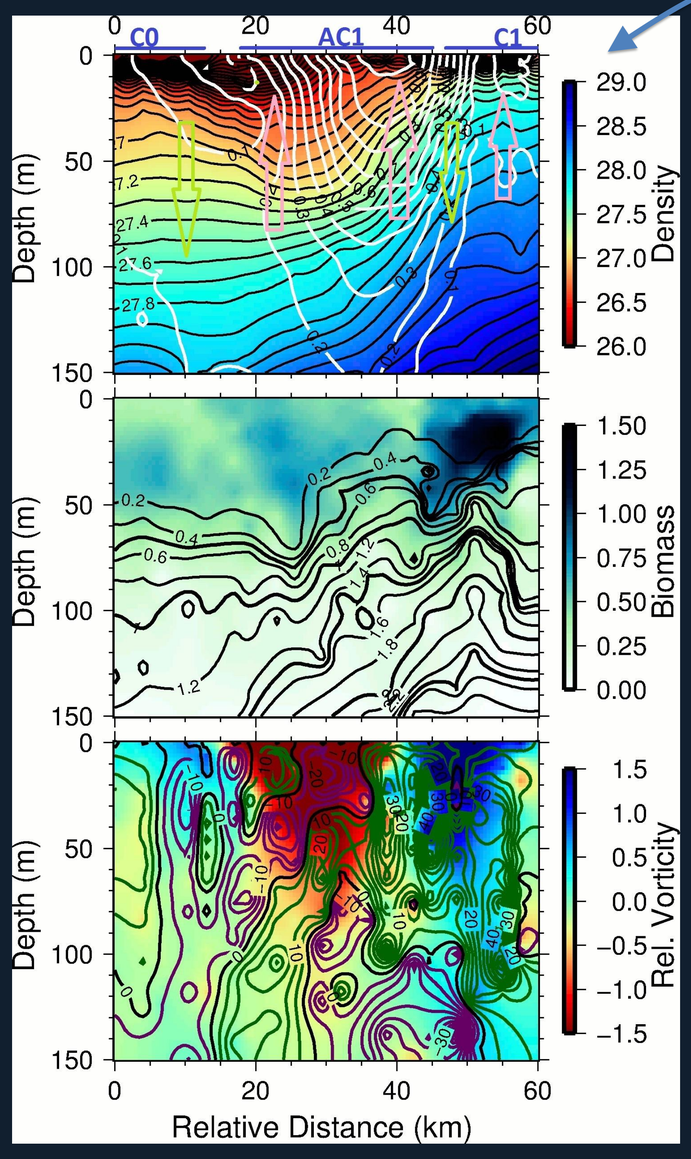


Left: Integrated phytoplankton biomass over the 100m water column for summer and winter periods; Right: integrated nitrate concentrations

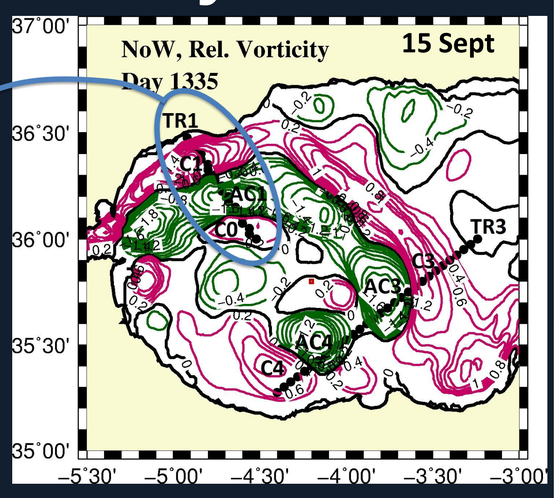
• Larger biomass along the jet trajectory, and higher production in summer.

• Light limitation in winter precludes subsurface nutrients to be consumed in the phytoplankton growth process.

3 Frontogenesis and eddy pumping



Vertical sections of 1) density (kg m^{-3}) and current speed (m s^{-1}); 2) phytoplankton biomass and nitrate concentrations (mmol N m^{-3}); 3) normalized relative vorticity and vertical velocity (m d^{-1}) along TR1.



• Upward velocities in cyclonic eddy C1 (eddy pumping) lead to upward rise of nutrients and high phytoplankton biomass

• Frontogenesis-driven ageostrophic cross-frontal circulation also leads to upward rise of nutrients in the anticyclonic side of the front (~km 40)

• Lateral advection of nutrients and phytoplankton along the jet trajectory

4 Conclusions

• The Atlantic Jet constitutes a major source of biological enrichment in the Alboran Sea with a marked seasonal variability.

• Cross-frontal ageostrophic circulation and eddy pumping mechanisms both support the production throughout the year, with an intensification in summer-autumn.