Extreme velocities at the bottom of a tidal Mediterranean strait: case of the Rio-Antirio strait

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Introduction & Settings: High velocity flows, a result of a funnel effect

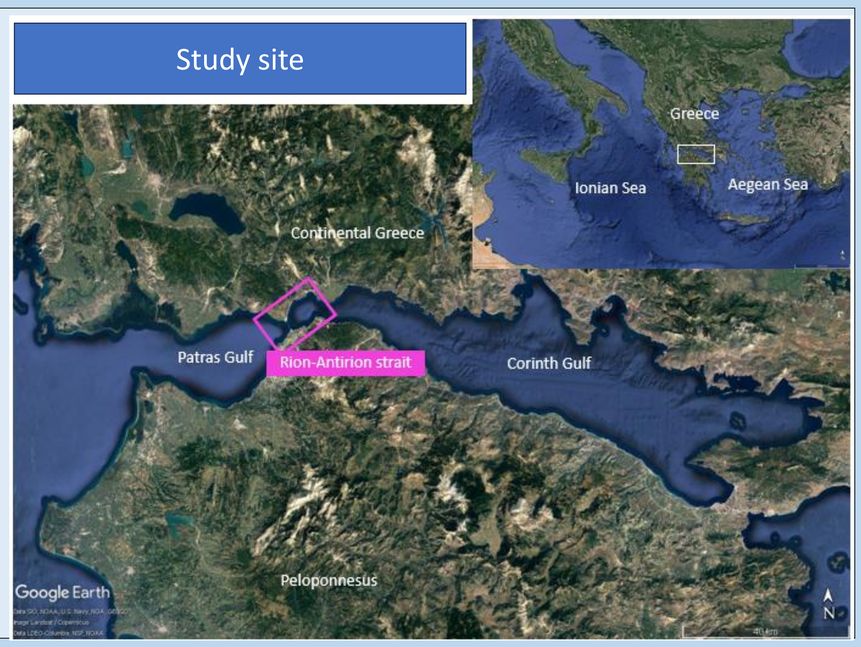
The **Rio-Antirio** strait links the "shallow" (150 m) and "wide" **Patras** Gulf with the "deep" (900 m) and "narrow" **Corinth** Gulf.

Oceanography:

- High dynamics in a **micro-tidal** context; 85 cm max. for the tidal amplitude near the strait.
- Influence of a **3D funnel effect** on the surface and bottom currents.
- Up to **4 m/s bottom currents** near the sill of the strait.

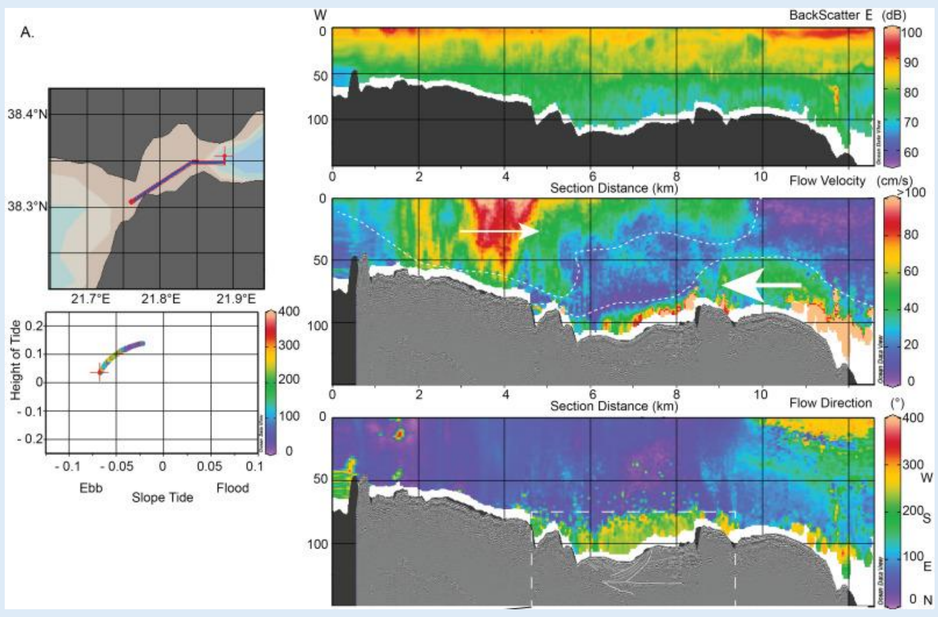
Geology

- Data on sedimentological morphologies in the Gulf through **seismic profiles** (Beckers *et al.*, 2016; Rubi *et al.*, 2022).
- Evidence of **erosion** in the strait due to high velocity instead of deposition (Rubi *et al.*, 2022).
- Some **sedimentological morphologies** cannot be explained yet due to the paucity of oceanographic data.
- Evidence of an **ancient strait** in the Corinth Canal location (**Caterina** *et al.*, 2022).

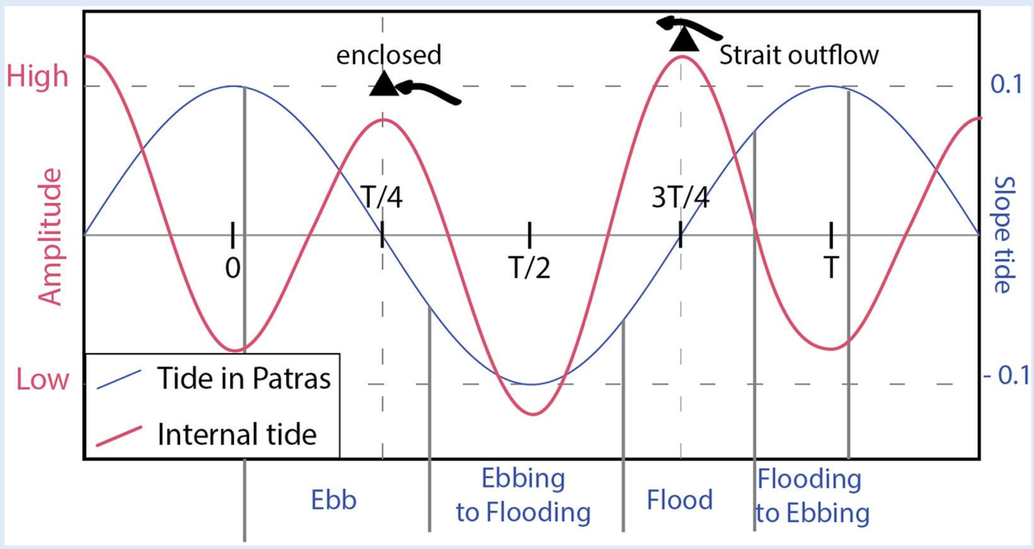


Internal tide: amplification of velocities

- **Stratification** in the Corinth Gulf leads to an **internal tide** with a higher frequency than the astronomic tide (2 times faster; Rubi *et al.*, 2022).
- **High velocities** (up to 4 m/s) reached at the **bottom** of the Rion-Antirion strait.
- **Same phase tides** amplifies velocities and allows overflow over the sill from Corinth to Patras while **opposite phase tides** restricts bottom waters to the Corinth Gulf.



*West-East longitudinal section along the Rion-Antirion strait during **ebb** tide with back scatter, current velocity and current direction on the right, and on the left the location of the profile and the slope tide vs height of tide. The **internal tide/wave** is visible in the strait sill (Rubi et al., 2022).*

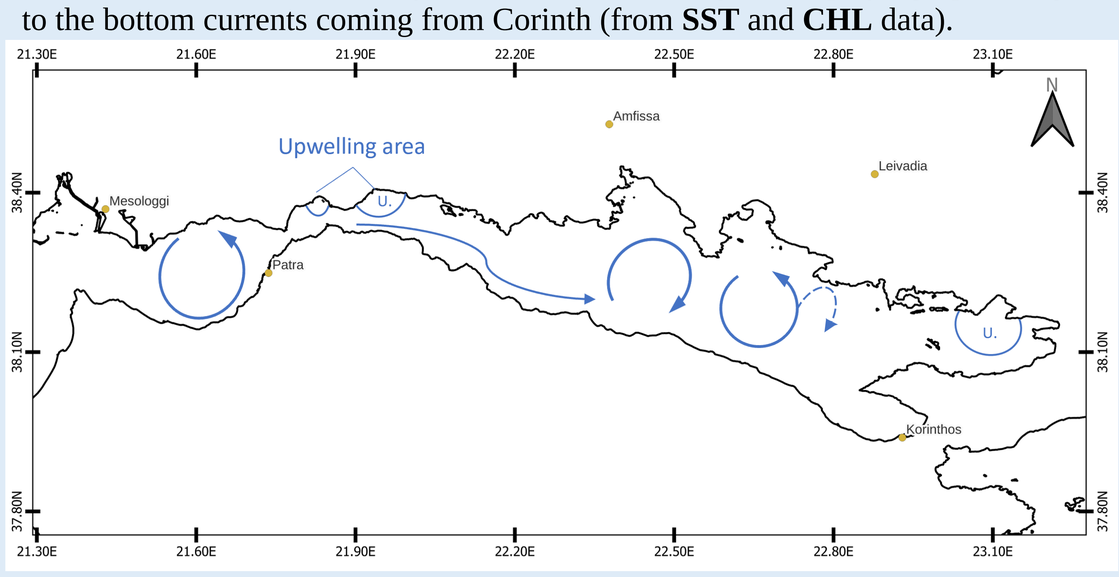


***Amplitude** of the surface tide and the internal tide in the Rio-Antirio Strait. Timings of **outflow** and **enclosure** are displayed on the graph. From Rubi et al., 2022.*

Impacts of the high velocity currents over local ocean dynamics

With Satellite data:

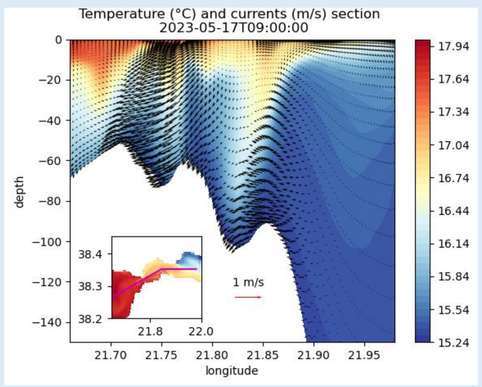
- The **strait area** is the most **dynamic** area of the Region, displaying upwellings due to the bottom currents coming from Corinth (from **SST** and **CHL** data).



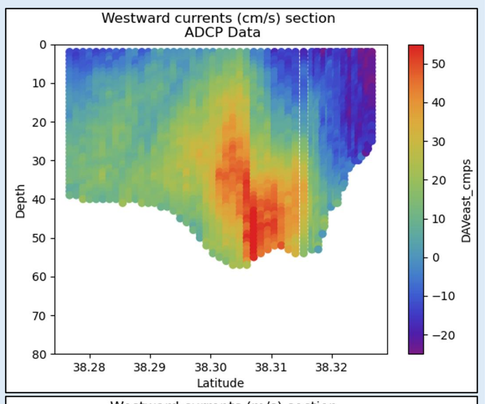
Synthetic map of the main surface dynamics of the Patras and Corinth Gulf. The high velocity flows at the strait location might be the trigger for the upwellings along the north coast of the Strait Region.

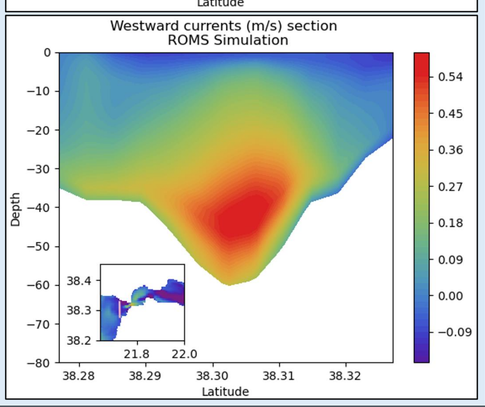
With ROMS:

- Modelling of the area since there are **no *in-situ* data** gives numerical values to phenomena
- The **tides** are the main forcing through the simulations, then the **bathymetry**.
- Validation with satellite and self-acquired **ADCP** data.



*(↑) Section through the Rio-Antirio Strait displaying the high velocity flows at the bottom. (→) Comparison between **ADCP** and **ROMS**. Here the **velocity** of the **Westward currents** at the Patras exit of the Rio-Antirio Strait is compared.*



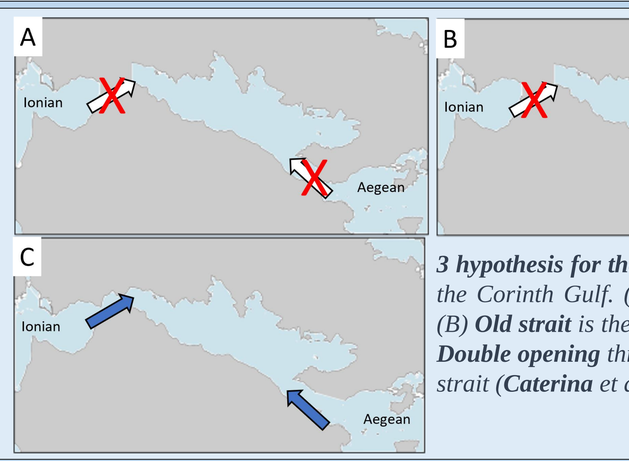


Further research:

It clearly appears that the **Rio-Antirio** strait plays a **crucial role** in the general **hydrodynamics** of the Corinth Gulf and that it is responsible for the **high erosion** found in the area due to **high velocity bottom currents**.

Getting to unravel the impacts of the **internal tide** over the dynamics of the Rio-Antirio Strait leads to several questions:

- What is the **extent** of the internal tide towards the Corinth Gulf?
- On which distance does the extreme velocities propagates? On which extent does it affect the geomorphology?
- Are these **velocities consistent trough geological times**?
- Through **paleogeographic** reconstruction of the Corinth Gulf, is a **double opening** of the Gulf increasing these velocities or reducing them?



***3 hypothesis for the paleogeography** of the Corinth Gulf. (A) **Lacustrine** case. (B) **Old strait** is the only one active. (C) **Double opening** through actual and old strait (**Caterina** et al., 2022)*

Bibliography:

Beckers, A., Beck, C., Hubert-Ferrari, A., Tripsanas, E., Crouzet, C., Sakellariou, D., Papatheodorou, G., & De Batist, M. (2016). Influence of bottom currents on the sedimentary processes at the western tip of the Gulf of Corinth, Greece. Marine Geology, 378, 312–332. https://doi.org/10.1016/j.margeo.2016.03.001

Beckers, A., Hubert-Ferrari, A., Beck, C., Bodeux, S., Tripsanas, E., Sakellariou, D., & De Batist, M. (2015). Active faulting at the western tip of the Gulf of Corinth, Greece, from high-r esolution seismic data. Marine Geology, 360, 55–69. https://doi.org/10.1016/j.margeo.2014.12.003

Caterina, B., Rubi, R., & Hubert-Ferrari, A. (2022). Stratigraphic architecture, sedimentology and structure of the middle Pleistocene Corinth canal (Greece). Geological Society, London, Special Publications, SP523-2021–2143. https://doi.org/10.1144/SP523-2021-143

Collier, R. (1990). Eustatic and Tectonic controlsupon Quaternary coastal sedimentation in the Corinth Basin, Greece. Journal of the Geological Society, 147, 301–314.

Fourniotis, N. T., & Horsch, G. M. (2015). Baroclinic circulation in the Gulf of Patras (Greece). Ocean Engineering, 104, 238–248. https://doi.org/10.1016/j.oceaneng.2015.04.080

Friglios, N., Theocharis, A., & Georgopoulos, D. (1985). Preliminary chemical and physical observations during summer 1980 on a silled embayment in the Ionian Sea. Vle Milieu, 35(2), 115–125.

Lascaratos, A., Salusti, E., & Papageorgaki, G. (1989). Wind-induced upwellings and currents in the gulfs of Patras, Nafpaktos and Korinthos, western Greece. Oceanologica Acta, 12(3), 159– 164.

Papailiou, D. D. (1982). Oceanographical study in Patras Gulf waters for pollution managment. University of Patras, Dept of Mechanical Engineering. Patras, Greece (in Greek).

Poulos, S. E., Collins, M. B., Pattiaratchi, C., Cramp, A., Gull, W., Tsimplis, M., & Papatheodorou, G. (1996). Oceanography and sedimentation in the semi-enclosed, deep-water Gulf of Corinth (Greece). Marine Geology, 134(3–4), 213–235. https://doi.org/10.1016/0025-3227(96)00028-X

Rubi, R., Hubert-Ferrari, A., Fakiris, E., Christodoulou, D., Dimas, X., Geraga, M., Papatheodorou, G., & **Caterina**, B. (2022). Hydrodynamics and sedimentary processes in the modern Rion strait (Greece): Interplay between tidal currents and internal tides. Marine Geology, 446, 106771. https://doi.org/10.1016/j.margeo.2022.106771

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