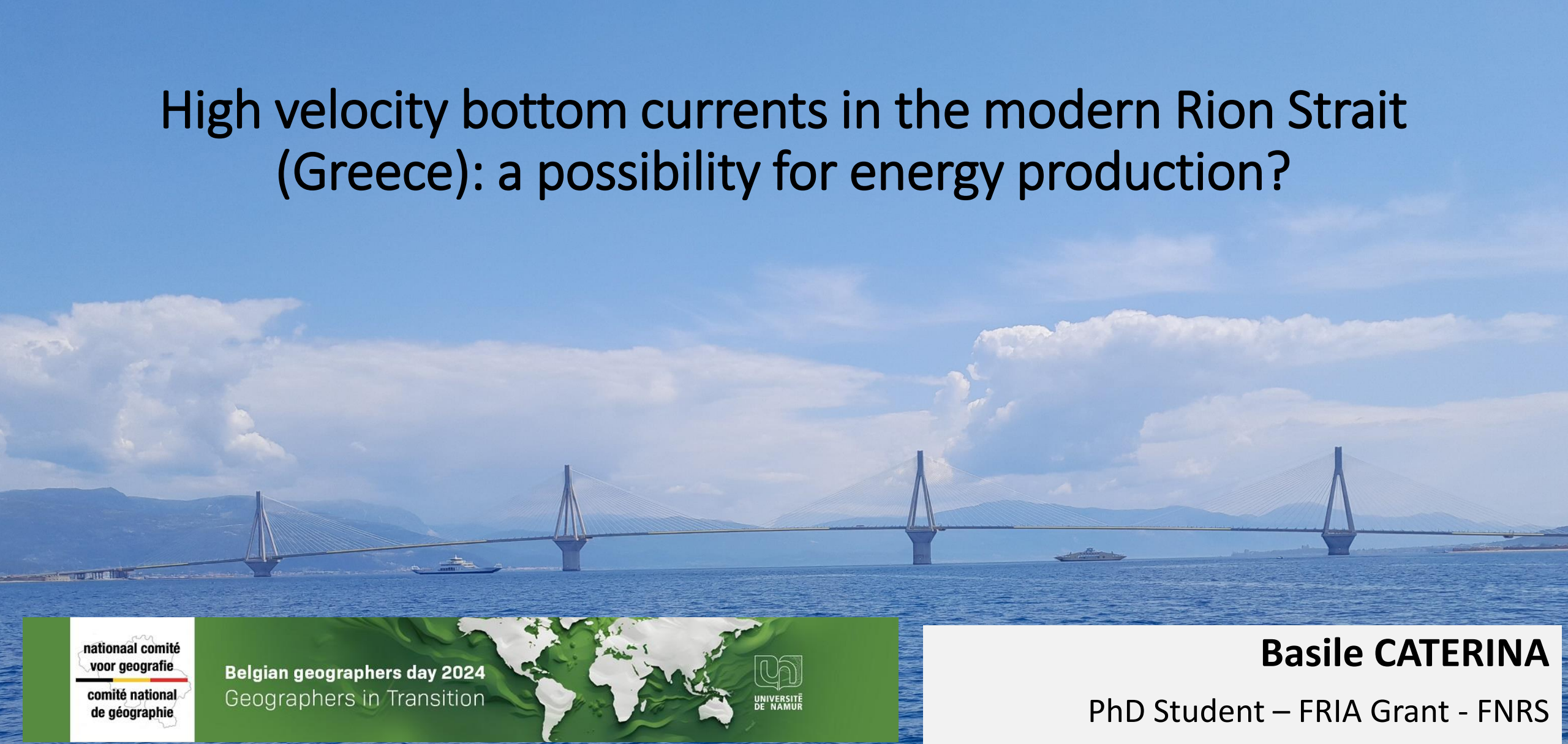
High velocity bottom currents in the modern Rion Strait (Greece): a possibility for energy production?



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BGEODAY 2024

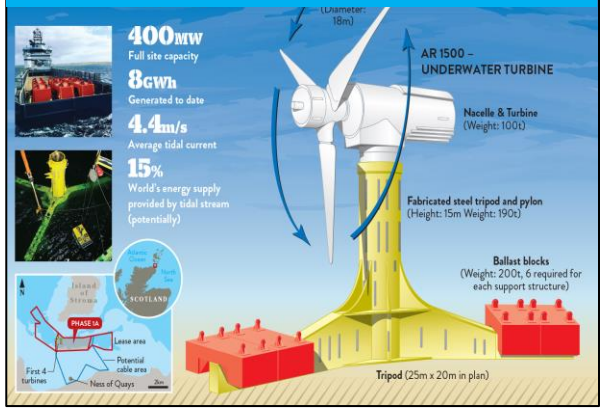
A new renewable energy flow

- Increasing demand for renewable energy -> seek sustainable solutions
- Solar or wind power are champions of green energy, but challenging to set up in some locations
- → Frontier of sustainable power awaiting exploration : ocean currents
- → Currents are mostly untapped power and

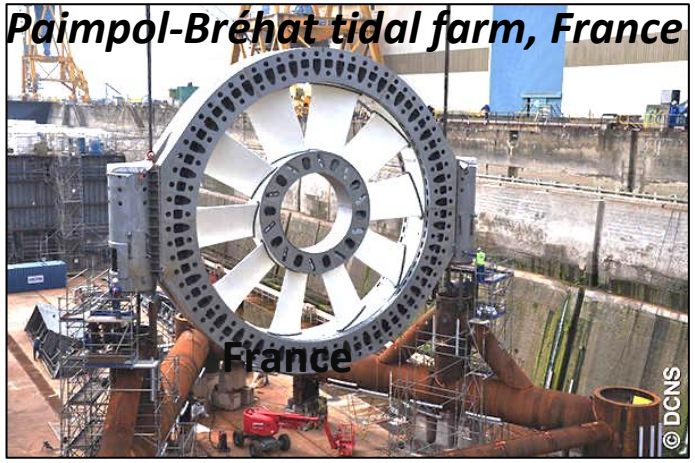
can provide sustainable energy

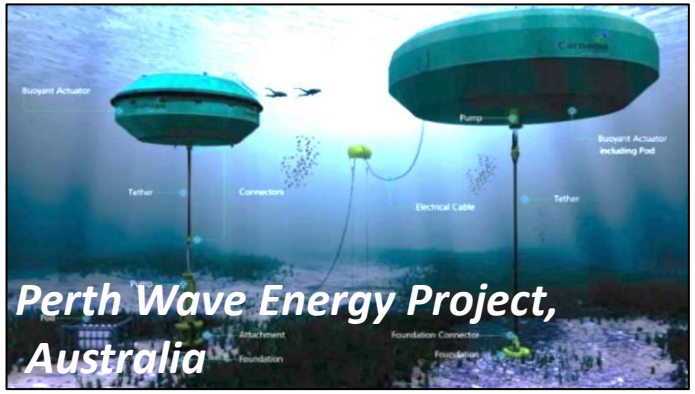
2021 2030 United Nations Decade of Ocean Science for Sustainable Development

MeyGen project, Scotland



Paimpol-Bréhat tidal farm, France





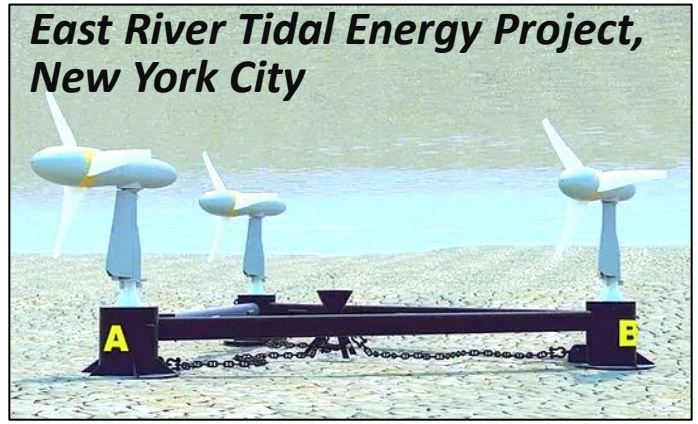
Perth Wave Energy Project, Australia

Existing marine tidal currenst energy projects

Other currents are exploitable in microtidal environment

Cape Sharp Tidal project, Canada

East River Tidal Energy Project, New York City



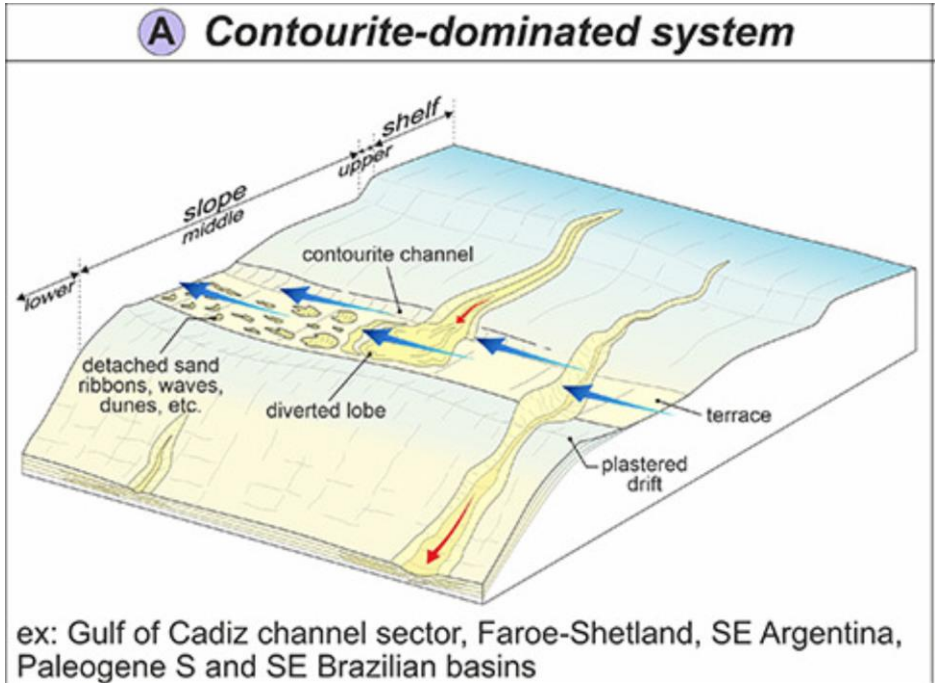
Uldolmene project, Kvalsundet Strait, Norway

Bottom currents energy exploitation near coast

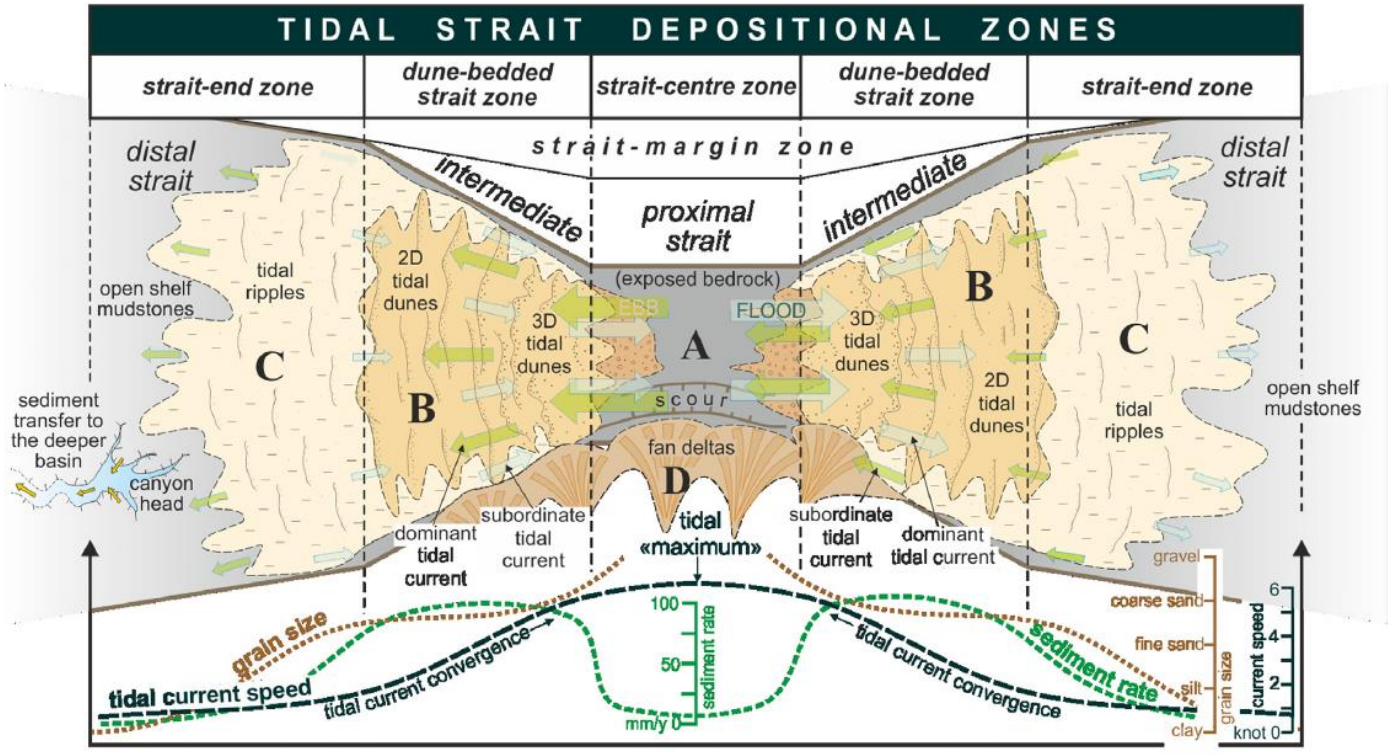
- The Mediterranean Sea is a microtidal environment => low tidal currents below 1-2 m/s, exception at strait locations

- Marine current energy exploitation near straits is good
  - Amplification
  - Close to the coasts and cities (strategic location)
  - Shallow enough for an easy access of the seafloor

- In strait, complex dynamics => need for current characterization and hydrodynamic modelling to develop proper turbines (presented here)

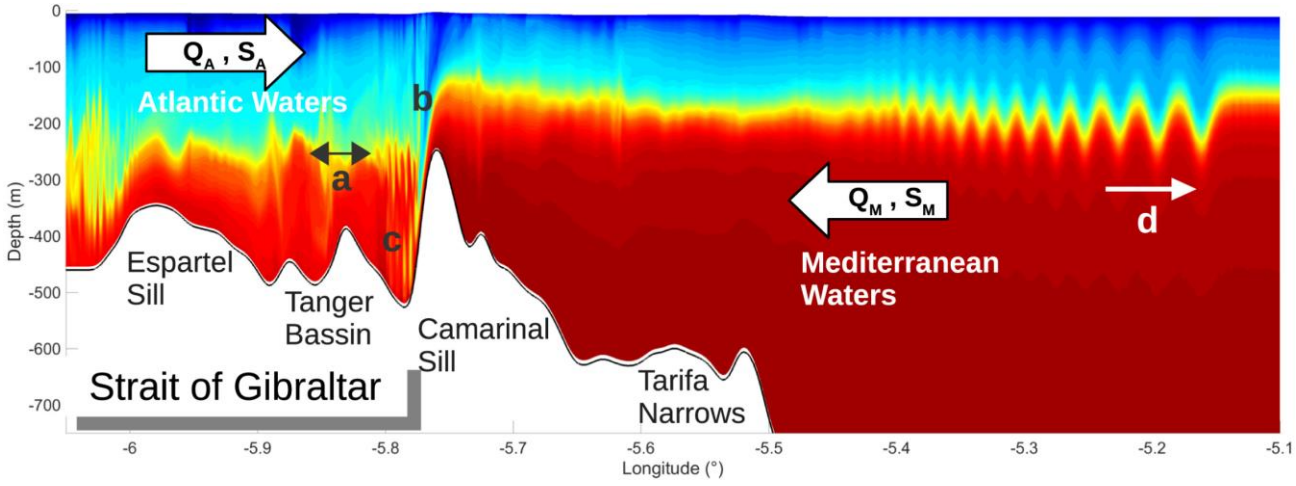


Complex hydrodynamic & sedimentation pattern



Theoretical depositional model in a tidal strait from Longhitano et al., 2013

- Spatial change in dynamics evidenced in depositional model: dunes near the sill and erosion in the sill
- Internal tide and internal waves with bathymetric thresholds



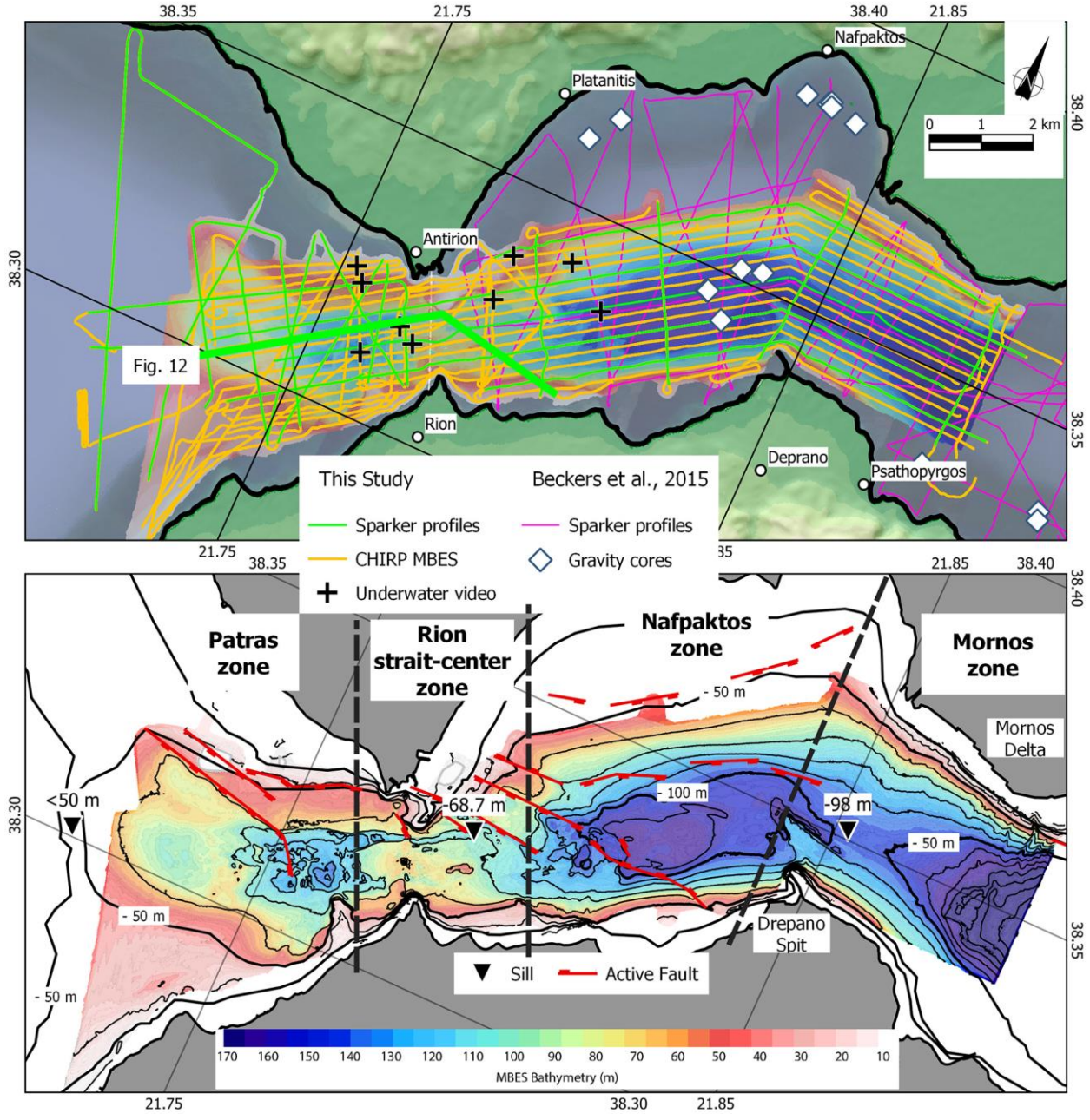
Internal wave in Gibraltar Strait (Hilt et al., 2022)

Study : The Rion-Antirion Strait

- Close to Patras city, third-most populous city in Greece
- Patras Gulf: “wide” and shallow (~150 m depth)
- Corinth Gulf: “narrow” and deep (~900 m depth)
- High dynamics in a microtidal context

Localization of the study area

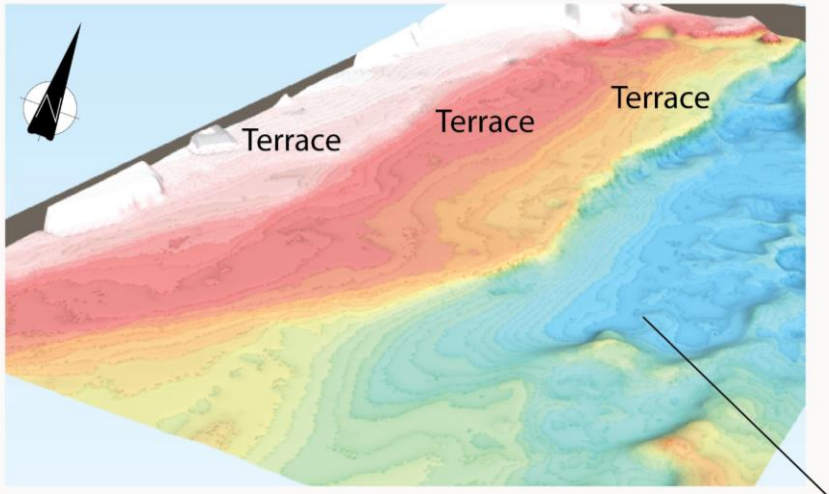
Measure currents and link them to morphologies



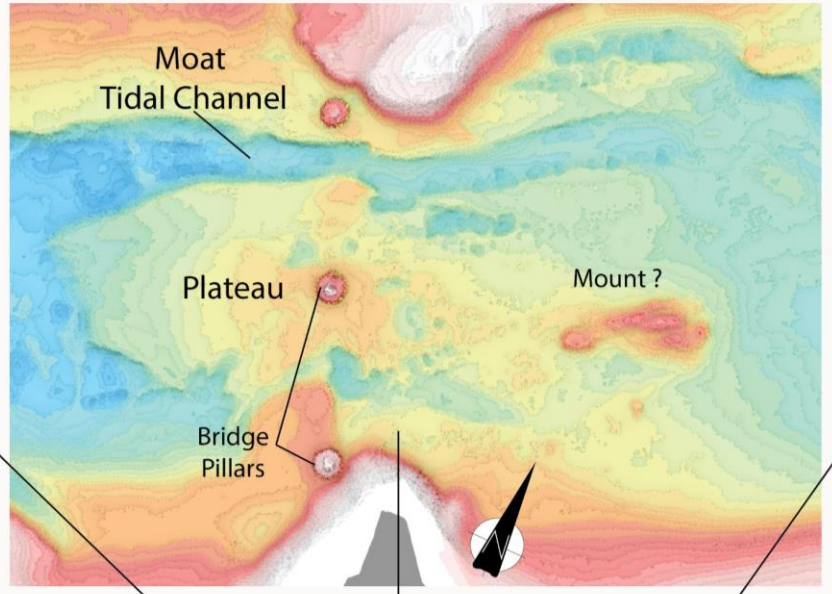
- Currents:
  - In-situ: CTD, ADCP
  - Remote sensing: CMEMS database, Landsat
- Morphologies:
  - Seismic profiles (CHIRP and Sparker)
  - MBES (High resolution bathymetry)

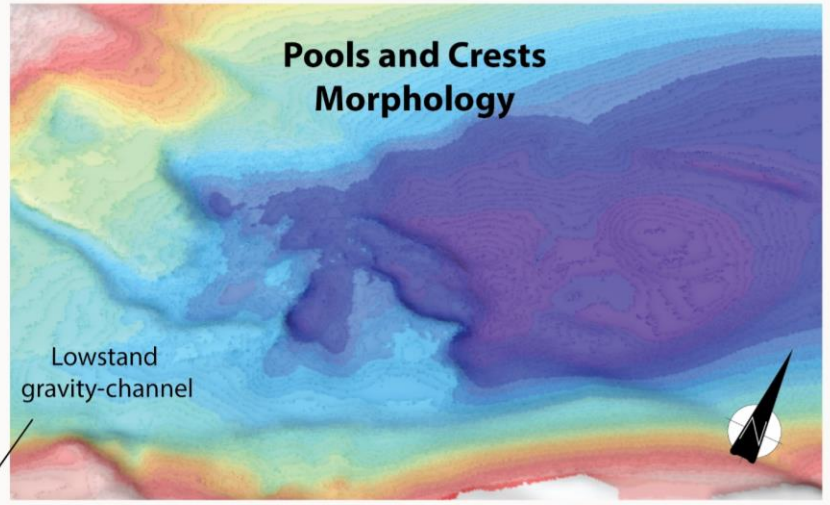
Map of all the transects with seismic and ADCP data. Fault and high-resolution bathymetry map of the Rion-Antirion strait (Rubi et al., 2022)

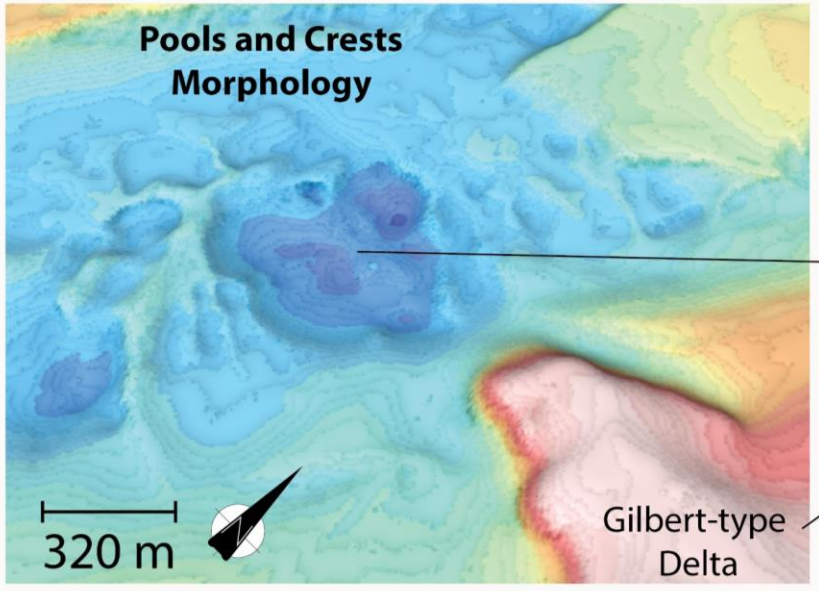
No dunes… too much erosion

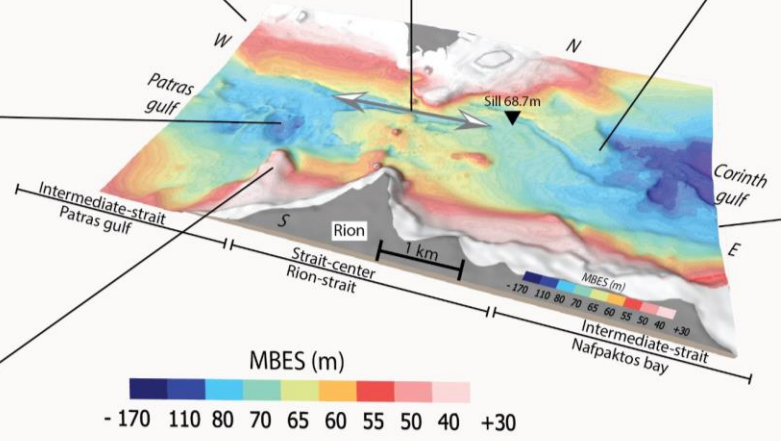


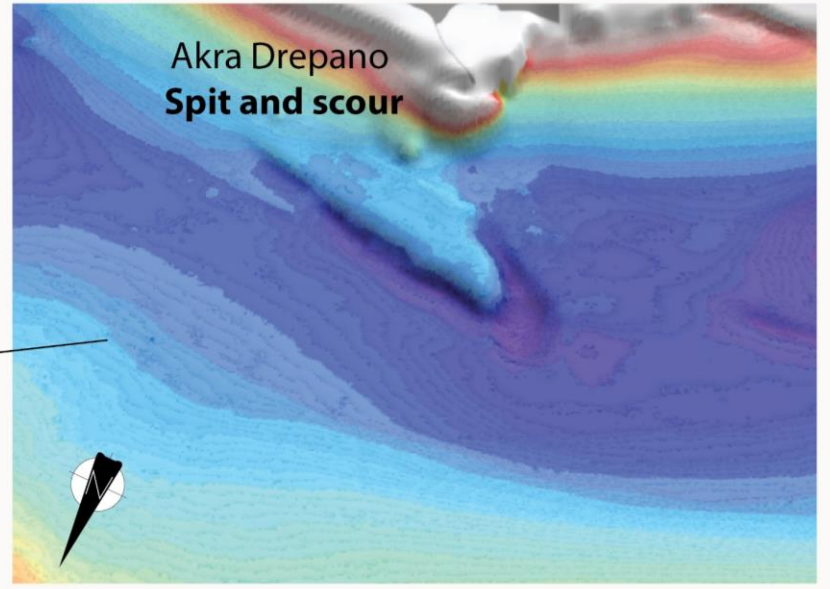
West Patras Gulf
Intermediate Strait









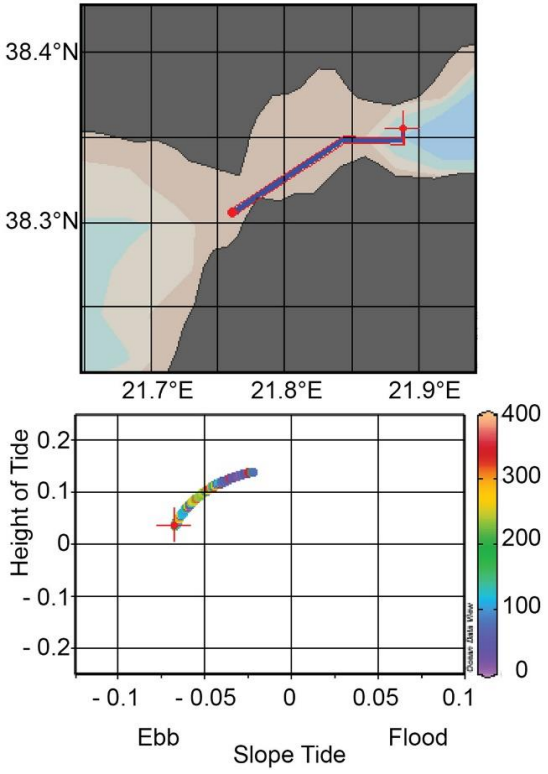


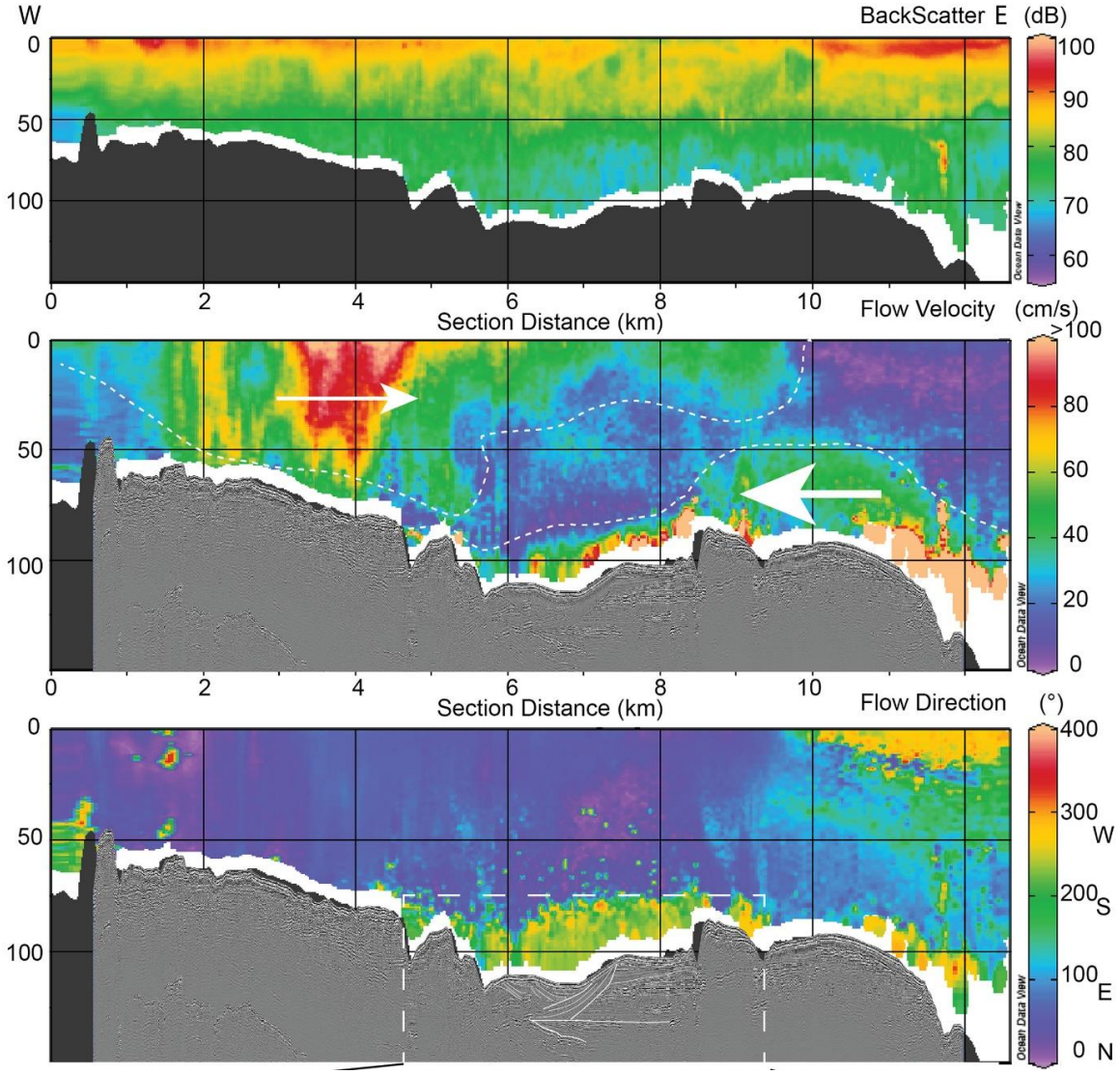
Evidence of an internal tide

Ebb tide

- Surface: towards Corinth Gulf

- Bottom:
  - internal tide due to a bathymetric threshold
  - High-velocity flow (up to 4m/s)

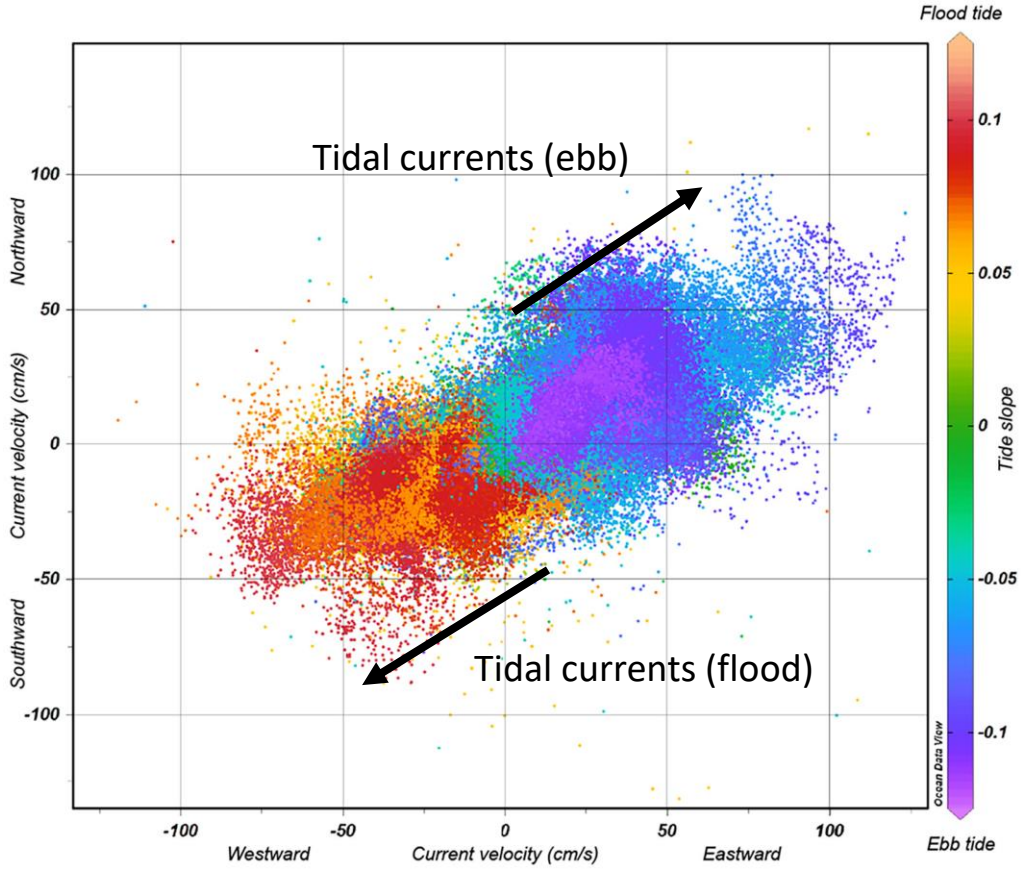




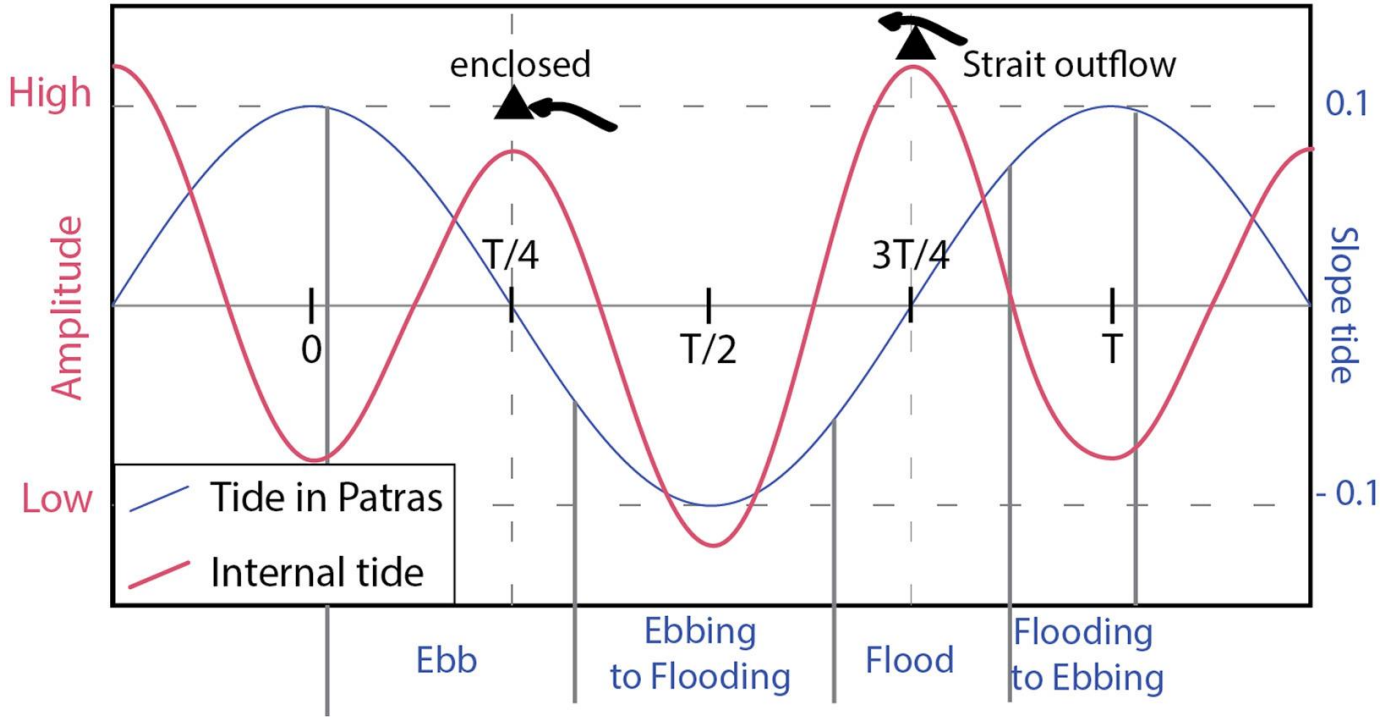
ADCP measurements during ebb tide on a longitudinal section in the Rion-Antirion Strait (Rubi et al., 2022)

Tidal amplitude and direction

- 2 different frequencies in the tides: surface vs bottom



Main surface current direction & velocity vs tide slope based on ADCP data (Rubi et al., 2022)



Tidal amplitude and direction of the currents (Rubi et al., 2022)

Regional Oceanographic Modelling System

- Forcings: Bathymetry (GEBCO), Oceanography (CMEMS), Winds (ECMWF), Tides (TPXO)
- Actual conditions verified through satellite data/in-situ measurements

Technical details

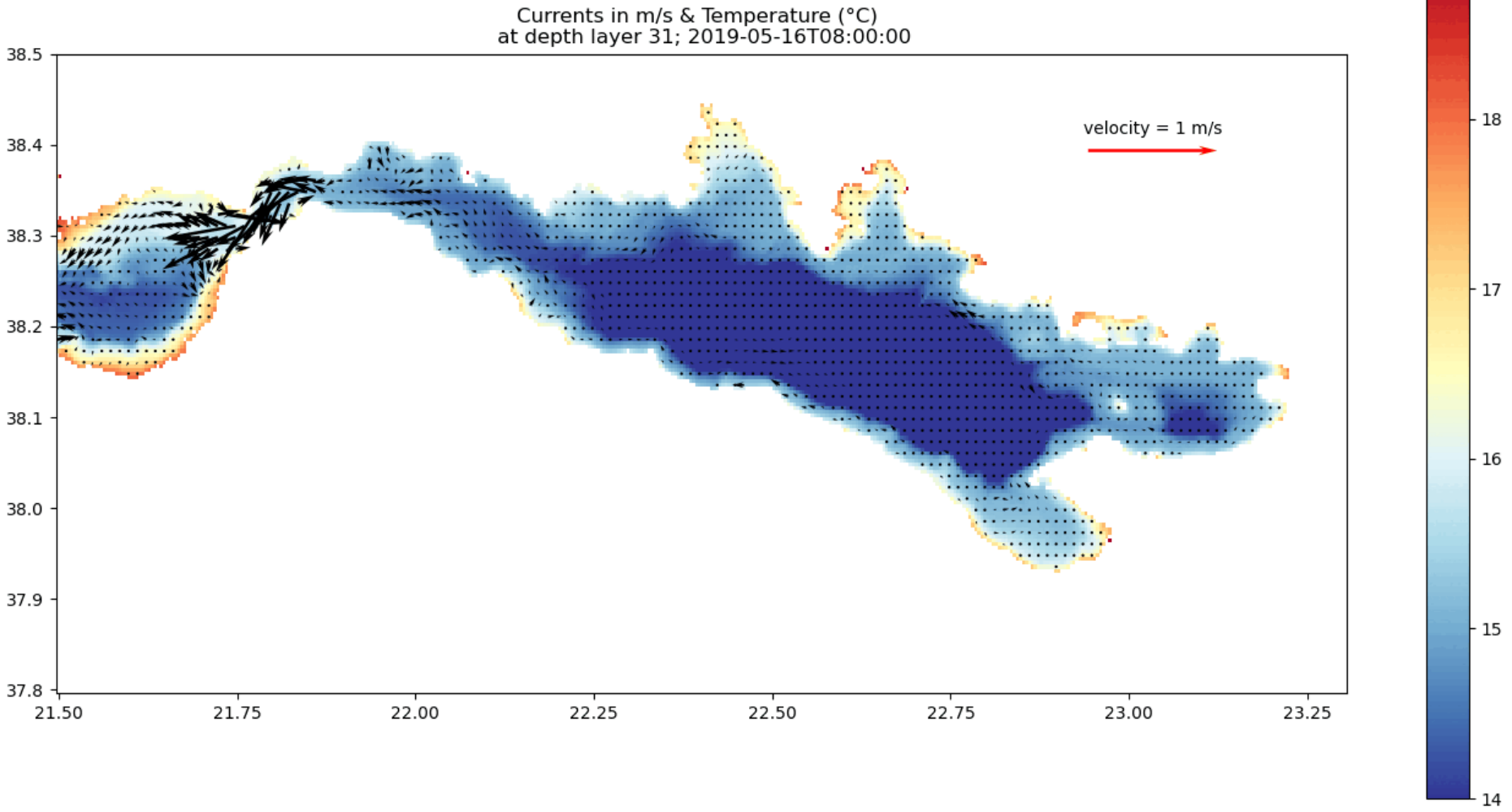
- High Resolution bathymetry for the strait (1,1) ~450 m
- Corrected bathymetry (HR bathymetry)
- Forcing at the boundaries; the rest is calculated
- Masks : lakes, small bays and Aegean Sea
- May 2019 and 1 year (01/01/2019 to 01/01/2020)
- Adaptative depth: 32 layers

Tidal currents at depth: funnel effect

- From bottom to top

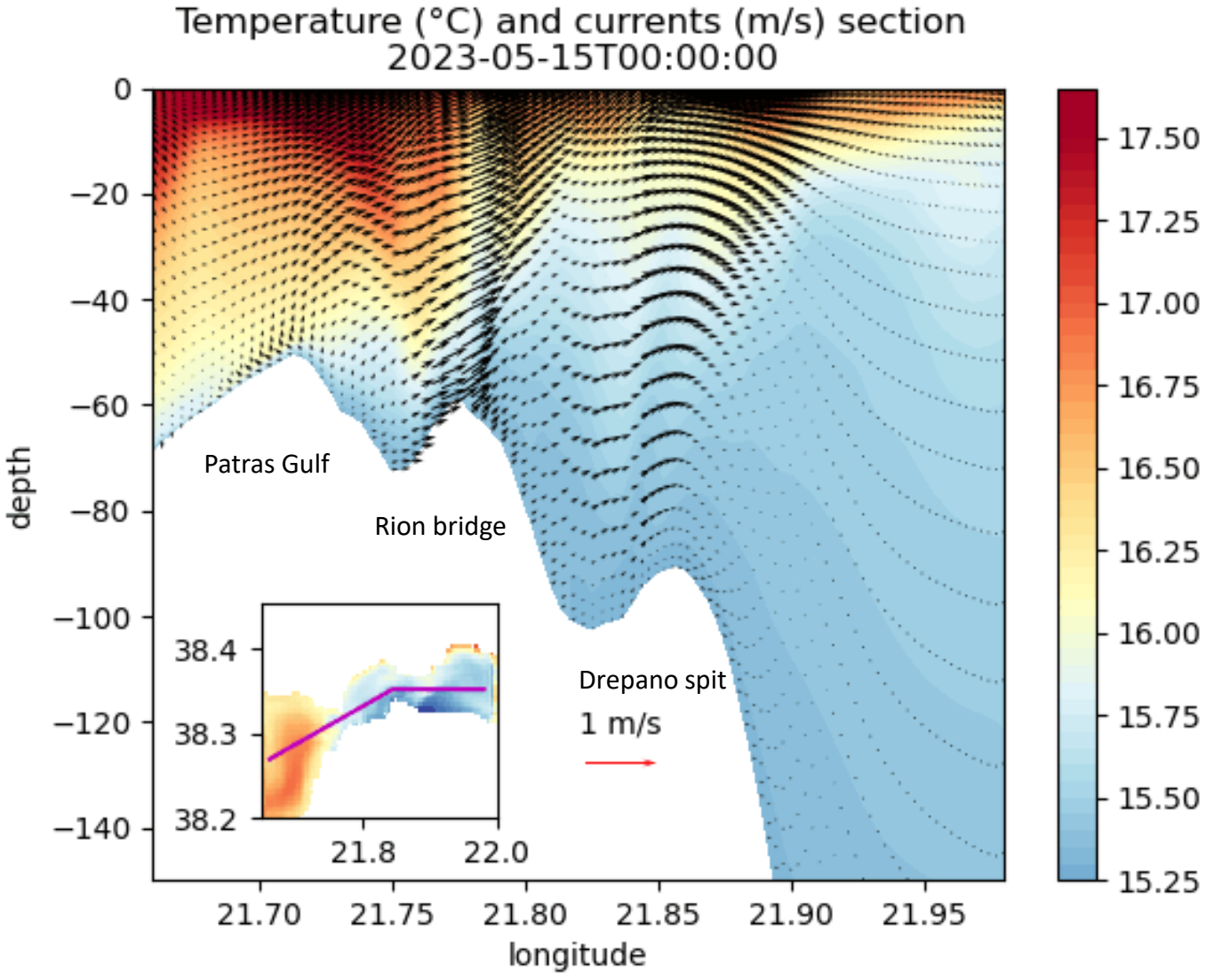
→Stronger currents appear at the bottom of the strait !

→Funnel effect from the shape of the 2 Gulfs



Tidal currents in the strait

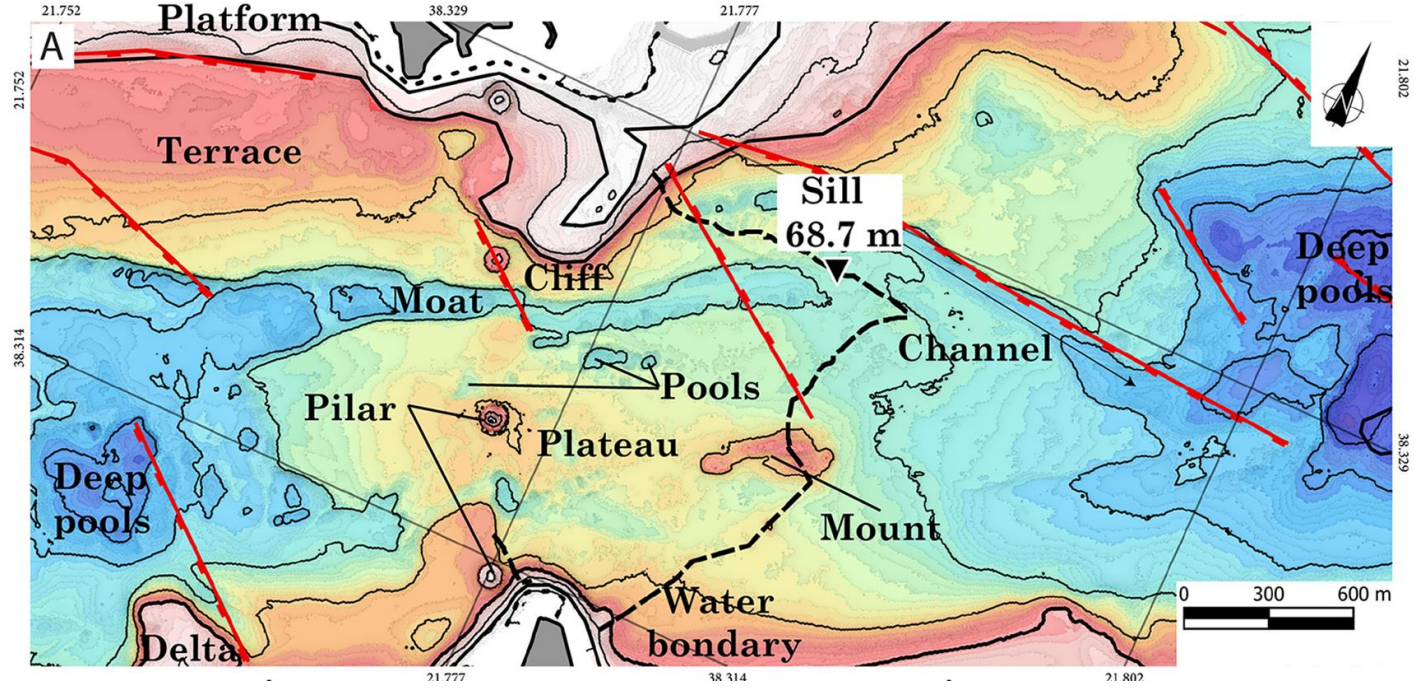
- “High” resolution bathymetry (~450 m/pixel)
- Funnel effect
- Strongest currents at the bottom of the Rion-Antirion bridge
- Differences in phases between surface and bottom tidal currents

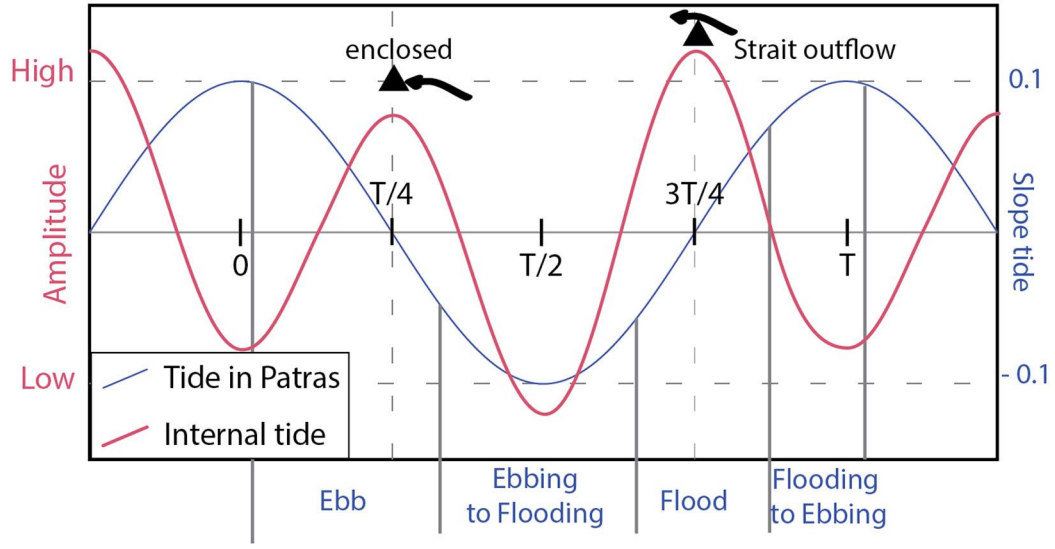


Erosion & internal tides

Conclusions:

- No dunes but **erosive** features
- Active hydrodynamism & funnel effect: velocities > **1m/s**
- **Internal tides** frequency ≠ tide frequency
- Space for possible water turbines (!! Needs adaptations !!)





Interpreted bathymetry around Rion-Antirion strait & Amplitude of the tide and internal tide in the Strait (Rubi et al., 2022)

Usefulness as source of renewable energy

Marine Current Energy:

- Continuous, highly predictable, abundant, flows of water in oceanic regions => stable source of energy
- Underwater turbines or rotors can be deployed in these currents to capture kinetic energy and convert it into electricity.
- Similar to tidal energy, marine current energy is renewable, reliable, and produces minimal greenhouse gas emissions.

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Thank you for your attention

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