Effect of small seagrass *Zostera noltei* on tidal asymmetry in a semi-enclosed shallow lagoon: the Arcachon Bay (SW France)

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Context and Objectives

- The Arcachon Bay (Bay of Biscay, French Atlantic Coast)
- Dominated by tides and wind-waves (semi-diurnal tidal range from 1 to 5 m)
- Intertidal flats extensively colonized by seagrass meadows of *Zostera noltei*
- Drastic regression of meadows since 20 years (Fig. 1)
- Infilling of Eastern shallow channels observed simultaneously to seagrass decline

The seagrass *Zostera noltei*: a well known ecosystem engineer

 Results and Discussion

- Spatio-temporal variability of water level tidal asymmetry ($\psi$)
  - Similar patterns of $\psi$ for all runs generally flood-dominated
  - Seagrass seasonality causes changes in $\psi$ by up to 100 %
  - Variation of seagrass extent (1989, 2008 or without seagrass) causes changes in $\psi$ by up to 300%
  - $\psi$ patterns more complex compared with the South-East and North-East of the Bay, where flood dominance is significantly increased by seagrass meadows

- Seasonality and recent decline of *Z. noltei* meadows have significant but complex impacts on current asymmetry, due to the modifications of the general tidal circulation in the inner parts of the Bay.

- Comparison with decadal tidal gauge data
  - Significant decrease of $\psi$ from 2001 to 2014 (p<0.001) in agreement with model results
  - Double-cycle of $\psi$ within a year:
    - October's peak (flood-dominated): maximum seasonal development of *Z. noltei*
    - The rest of the double-cycle cannot be easily related to seagrass stage of development

Seagrass variability may contribute to long-term and seasonal changes of tidal asymmetry, among other factors (sea-level, wave setup, inlet migration...).

Conclusions and Perspectives

Our model shows that the modification of bottom friction induced by the presence of *Zostera noltei* meadows, the seasonality of their development as well as their change in extent have significant impact on tidal propagation within the Arcachon Bay. The seasonal variation of the seagrass meadows is linked with changes in water level tidal asymmetry, mainly in central/inner parts of the Bay when tidal flats are colonized. Regarding the current asymmetry, seagrass meadows also tend to enhance flood dominance, and to modify tidal circulation in the inner part of the Bay with possible substantial effects on sediment transport. Decadal tidal gauge data analysis also show a significant decrease of flood dominance with time, as well as an important seasonality of water level asymmetry which may be partly attributed to variation of seagrass development and extent. Various external factors such as sea level rise, wave-induced setup and morphological changes of the inlet may also significantly contribute to observed long-term changes. The relative impact among all these environmental factors remains to be quantified by new complete measurements of sediment erodibility, J. Coastal Res., SI, 64-65, 2000.

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Methodology

- **3D numerical modelling**
  - MARS3D model developed by Ifremer (Lazure and Dumais, 2008)
  - 3 runs with increasing spatial resolution
  - Effects of seagrass on hydrodynamics explicitly calculated by source terms in momentum and turbulence closure equations (Kombaudo et al., 2014)

- **Tidal asymmetry analysis**
  - Method by Nidzieko and Raistion (2012) over the last 29 days of simulation, for both water levels ($\psi$) and depth-averaged velocities ($\psi^*$)
  - For water level asymmetry ($\psi$), $\psi = \frac{\Delta h}{H}$, where $H$ is the mean water level, and $N$ is the number of samples $n$
  - For velocity asymmetry ($\psi^*$), $\psi^* = \frac{\Delta u}{\bar{u}}$, where $\Delta u$ are across-shore tidal velocities
  - $\psi$ also quantified for decadal data from Arcachon’s tidal gauge: running window (29 days length), linear trend tested for significance using Mann-Kendall test (95% confidence level), and seasonality computed and displayed as a box plot

Table 1: Characteristics of the five seagrass situations used for the simulations

<table>
<thead>
<tr>
<th>Simulation ID</th>
<th>Coverage</th>
<th>Leaf length (cm)**</th>
<th>Leaf width (mm)**</th>
<th>Leaf density (n.m-2)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unvegetated</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Winter</td>
<td>89 &gt;75%</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

May the spatio-temporal variability of *Z. noltei* meadows substantially modify tidal propagation and asymmetry within the Arcachon Bay?