SEDIMENT TRANSPORT IN A TIDAL INLET: THE CASE OF THE LIDO INLET, VENICE, ITALY

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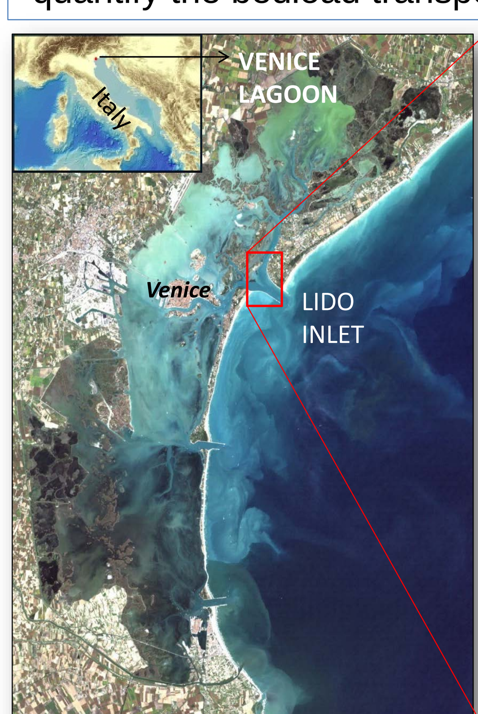
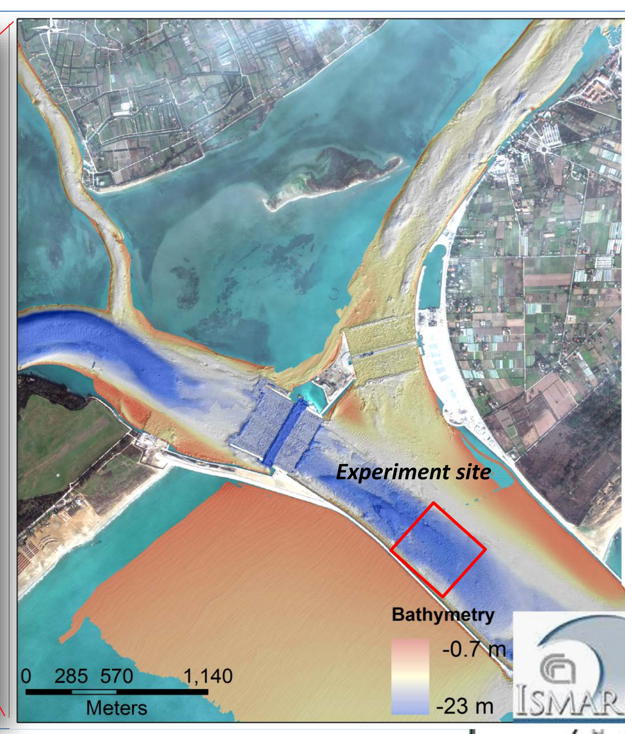
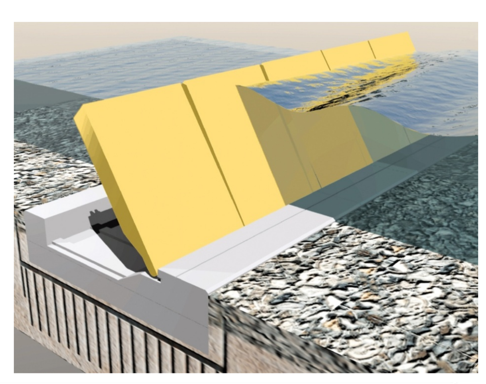
INTRODUCTION

Tidal inlets provide a connection between the ocean and bays, lagoons, marshes, and tidal creek systems. Two hydrodynamic factors are dominant in the long term evolution of a tidal inlet: wind waves, that are mainly responsible for re-suspending sediments, and tidal currents, that maintain the main inlet channel by advecting sediments away from the inlets. These two factors determine to a large extent the direction and magnitude of sediment transport. Tidal inlets, however, are often radically modified by human-driven intervention (for example for navigation or protection purposes).

This is the case of the three inlets of the Venice Lagoon, Italy, that are now the main construction site of a mobile barrier system for the protection of the historical city of Venice from floods. In September 2014, an experiment was set up in one of the lagoon inlets aimed to quantify the bedload transport inside the inlet channel over a tidal cycle.

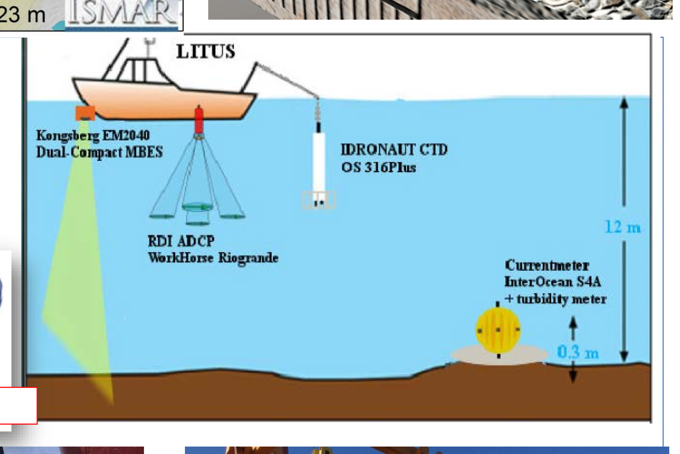


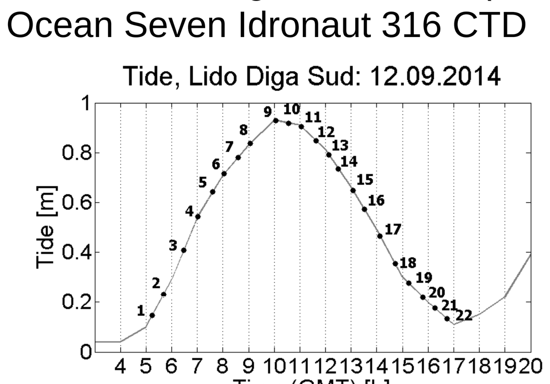




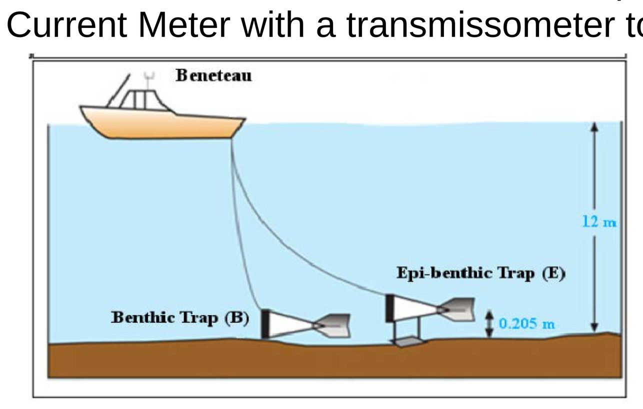
INSTRUMENTAL SET UP

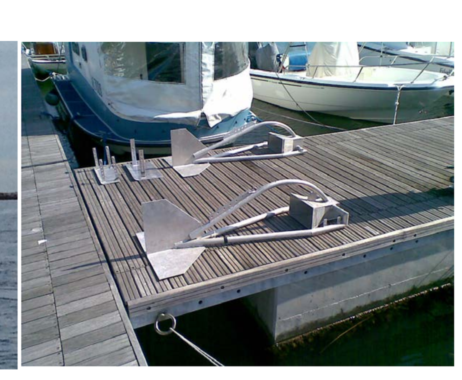
- Multibeam System Kongsberg EM 2040D-C (360 kHz)
- Positioning system Kongsberg Seapath 300 with DGPS correction
- Motion sensor Kongsberg Seatex MRU 5
- Valeport Mini SVS
- AML Ocenographic SV Profiler
- Workhorse Riogrande ADCP (1200 kHz)
- Ocean Seven Idronaut 316 CTD





A rectangular area of about 260m x 400m (0.1 km^2) was explored through 22 surveys over 12 hours during a tidal cycle. The first survey started at 05:15 , while the last survey started at 16:44 in Coordinated Universal Time (UTC). For every survey we collected 5 lines of raw MBES data and 5 co-located ADCP transect, for a total of 110 transects. Other 11 ADCP transects and MBES water column data were collected for the ADCP calibration.
In order to calibrate the ADCP backscatter we collected 11 CTD profiles with the Ocean Seven Idronaut 316 CTD exported downcast every 25 cm. Moreover, to measure in one fixed point the current close to the bottom, we deployed at about 0.3 m from the bottom an Interocean S4 Current Meter with a transmissometer to measure turbidity.





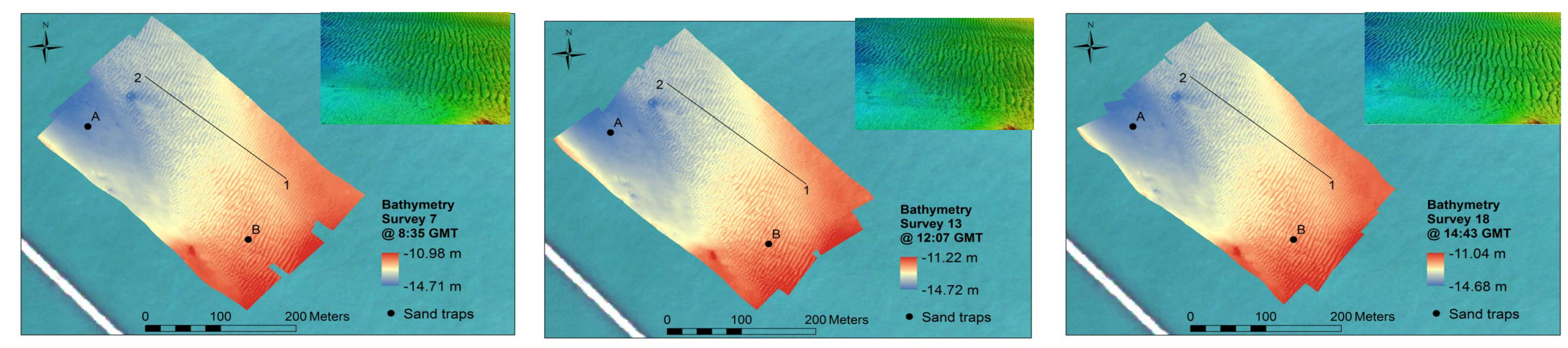
Two sand traps were deployed to the seabed for periods (Δt) of around 15 minutes (left). The traps had a sample mouth of 0.12 x 0.12 m and were equipped with a sample net mesh size of 60 microns. The benthic trap collected sand in motion from 0 > z > 0.12 m (where z is the height above the bed). The second (epi-benthic trap) was deployed synchronously with the benthic trap. This trap was equipped with a foot that elevated the sampling mouth the 0.12 > z >0.24 m. A trap efficiency of 4% was assumed based upon data collected by Amos *et al*. (2010). The traps were deployed from an anchored boat (BENETAU) approximately hourly for the duration of the survey.

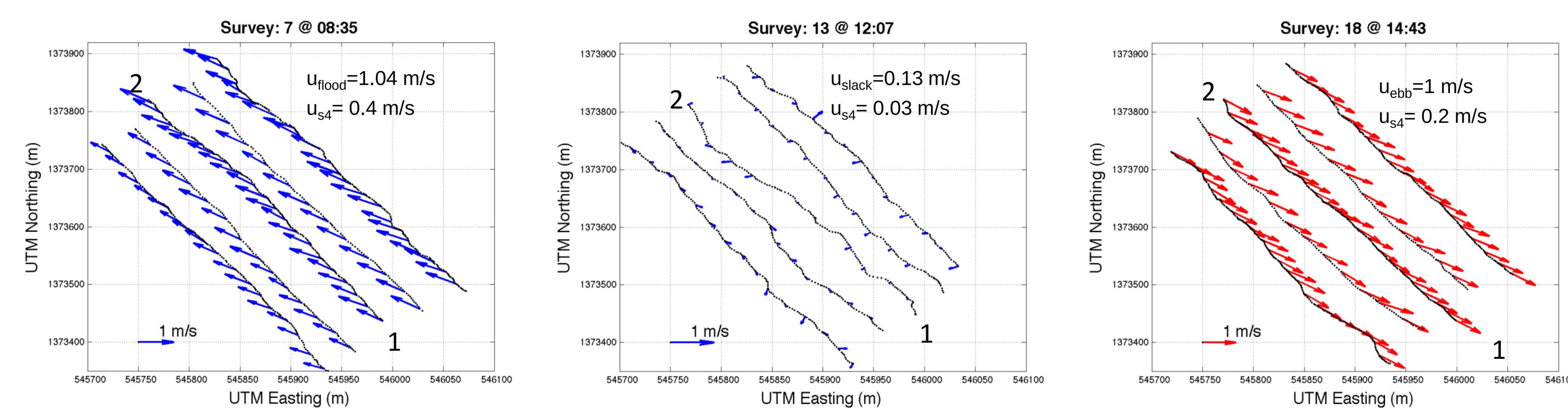
DUNE MOPHOLOGY, MIGRATION AND SEDIMENT TRANSPORT RATES

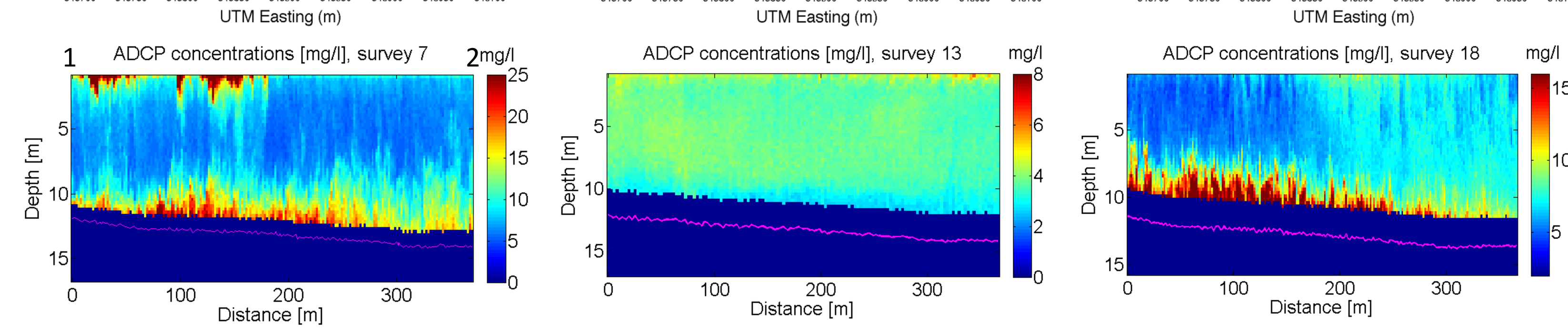
•The average dune height *h* was calculated by extracting the standard deviation of the detrended bathymetry multiplied by 4 for each survey (Masselink et al. 2003).
•The wavelength *λ* was determined from the peak of the 2DFFT of the bathymetry for each survey (Cazenave et al 2013)
•The migration distance was detrmined carrying out a cross-correlation between bathymetric profiles extracted from successive DTMs.
•The bed load transport rate Q_b can be related to the bedform migration rate $Q_b = 0.32 h \rho V_{mig}$ with V_{mig} is the migration speed of the bedform (Williams et al, 2003) and *ρ*:is the sediment density.
•The potential bedload transport rates were computed by the SEDTRANS05 model (Neumeier et al., 2008) using near bed (0.19 mab) velocity measured by S4 and considering: water column depth of 13.5 m, mean sediment grain size of 0.18 mm, dune height of 0.57 m, dune length of 5.2 m. Sand fluxes at the bottom were estimated following the methods of Engelund & Hansen (1967) and Einstein-Brown (1950).

RESULTS

- Averaging over the surveys we found that wave length *λ*= 5.2±0.5m and height *h*= 0.57±0.1m.
- Both *λ* and *h* did not change significantly over time.
- From the comparison of bathymetric surveys, we find a net migration of the dunes inwards the inlet, with a migration velocity of about 0.0001 m/ s.

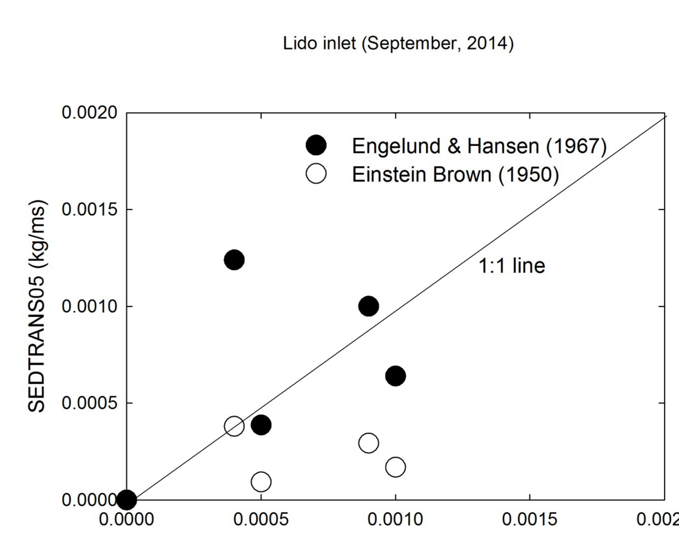






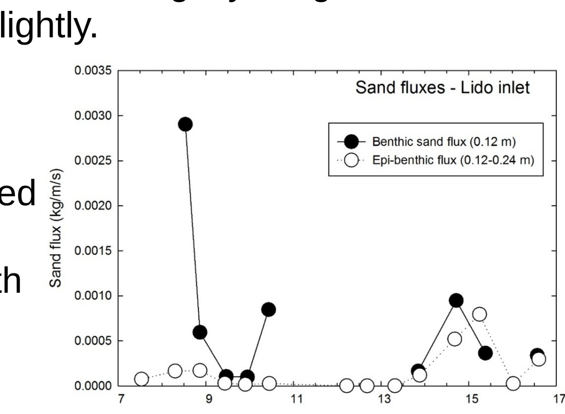
SEDIMENT TRANSPORT RATES

•The bed load transport rate Q_b obtained from the bedform migration is maximum in ebb tide Q_b=0.25 kg/m/s for the considered bathymetry proflie.

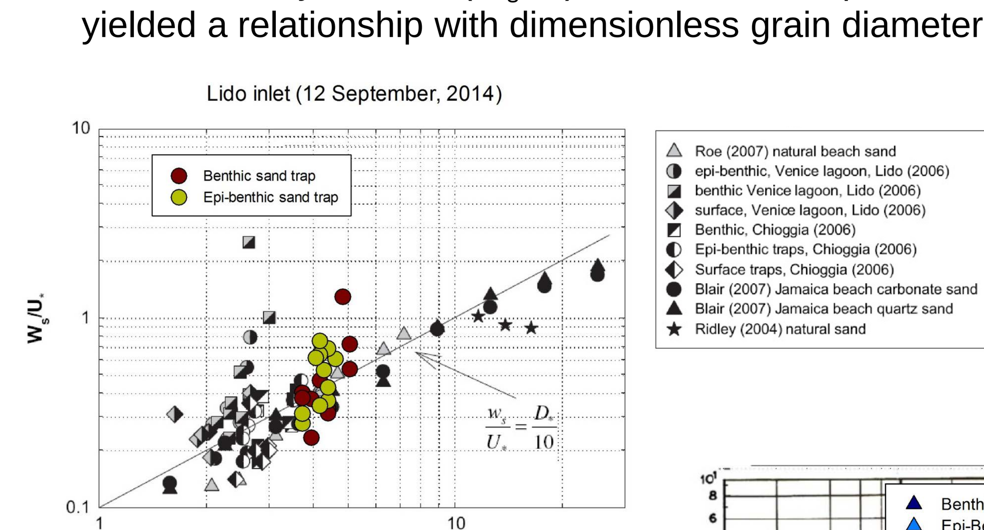


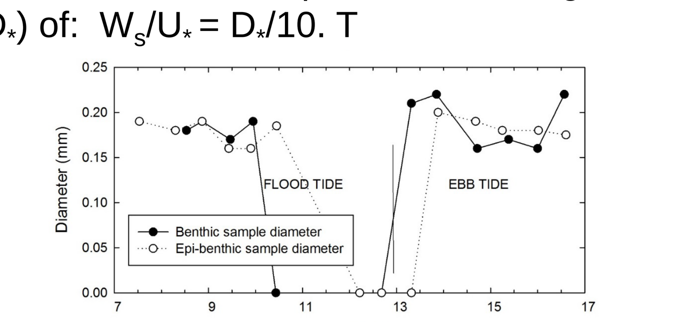
•The potential bedload transport rate computed by the SEDTRANS05 model was in reasonable agreement.
•Einstein-Brown under-predicted slightly; Engelund-Hansen over-predicted slightly.

•The flux of sand measured with the sand traps was maximum in flood tide with a peak of 0.003 kg/m/s



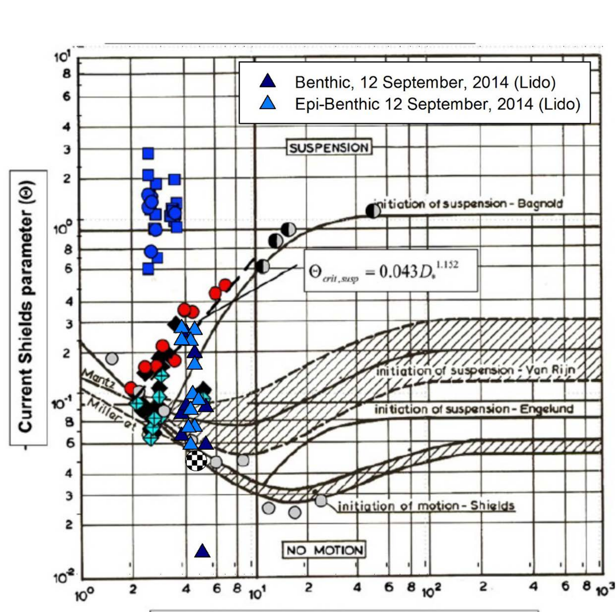
- Fine sand (d_{50} = 0.18 mm) was measured in transport for much of the flood and ebb tide in both the benthic and epi-benthic traps.
- The sand diameter was largely constant with time and current speed
- The threshold current speed at a height of 1 m above bed (U_1) for onset of motion of this fine sand as bedload was 0.18 m/s, which corresponds to a threshold Shields parameter of 0.046.
- The movability number (W_s/U_*) was in line with previous studies of sand transport in Venice lagoon and yielded a relationship with dimensionless grain diameter (D_*) of: $W_s/U_* = D_*/10$. T

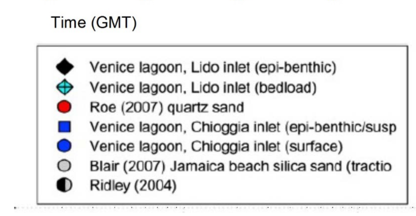




The ratio of still water settling rate (W_s) to friction velocity (U_*) plotted against dimensionless grain diameter (D_*).

•The results cluster about the line from previous studies in Venice lagoon.
•Benthic and epi-benthic samples show the same trend.





The extracted Shields parameters (van Rijn, 1993) plotted with similar data for Lido and Chioggia inlets collected during 2006 (Amos *et al*., 2010)

Most samples fall within the region defined as bedload/initiation of suspension (saltation) and are below the full suspension line defined by the red data points.

CONCLUSIONS

•Bedload transport rates were estimated using three different methods: from the dune migration extracted from bathymetry, from the SEDTRANS05 model and from sand traps.
•The transport estimated from bedform migration was about an order of magnitude higher than other methods.
•The transport estimated from the sand traps was in general agreement with SEDTRANS05 output.
•The threshold for transport as bedload and suspension appear accurate.
•Sands from the inlets of Venice lagoon show trends which appear to agree between inlets, between varying sites, and between years.

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