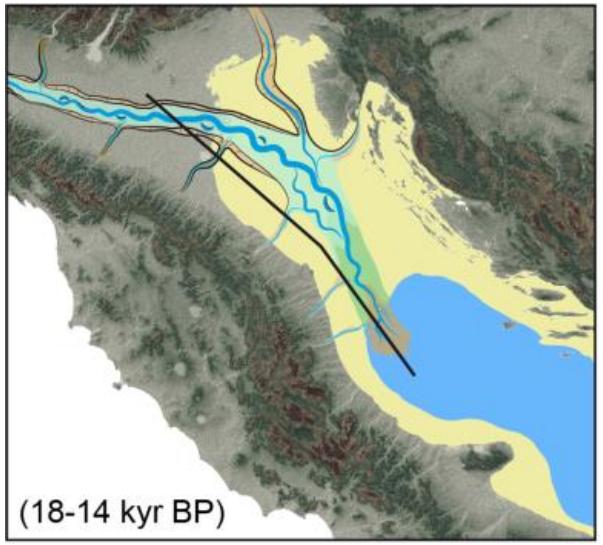
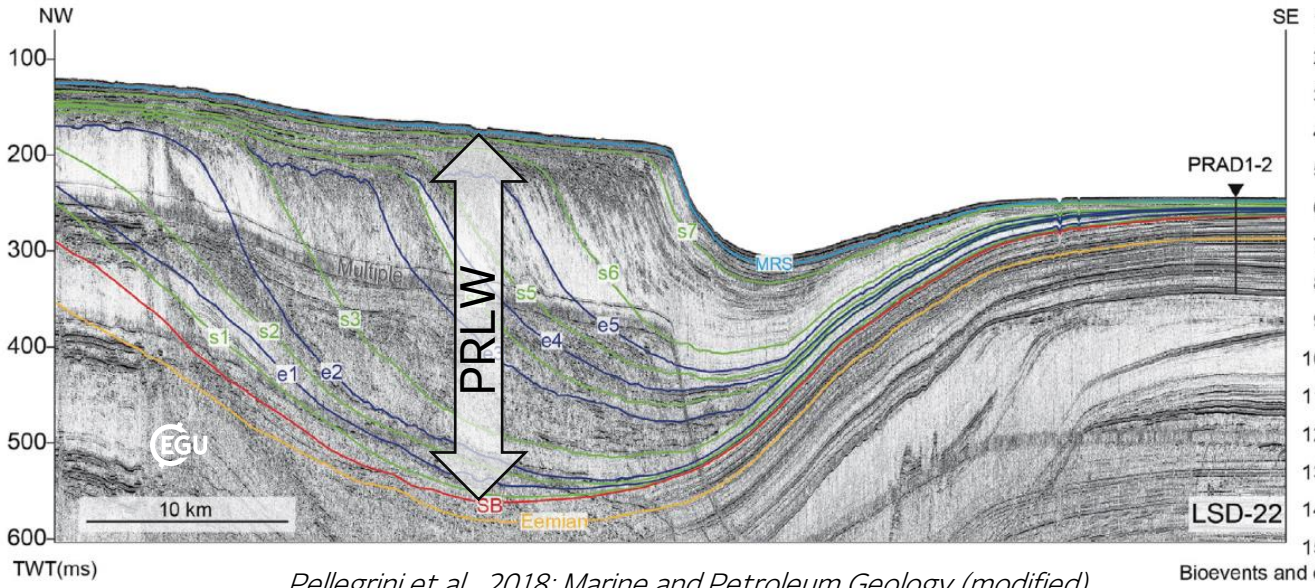
Linking benthic fauna and seismic facies to improve stratigraphic reconstructions: The case of the Mid-Adriatic Deep since the late glaciàl period (Central Adriatic Sea)

Azzarone M., Pellegrini C., Barbieri G., Rossi V., Gamberi F., Trincardi F. & Daniele Scarponi

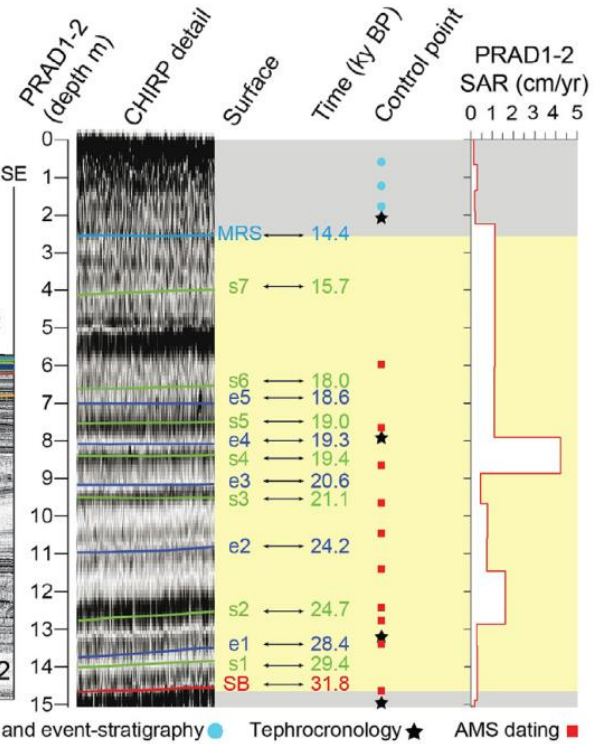
Geological setting



Amorosi et al., 2016; Earth Science Reviews

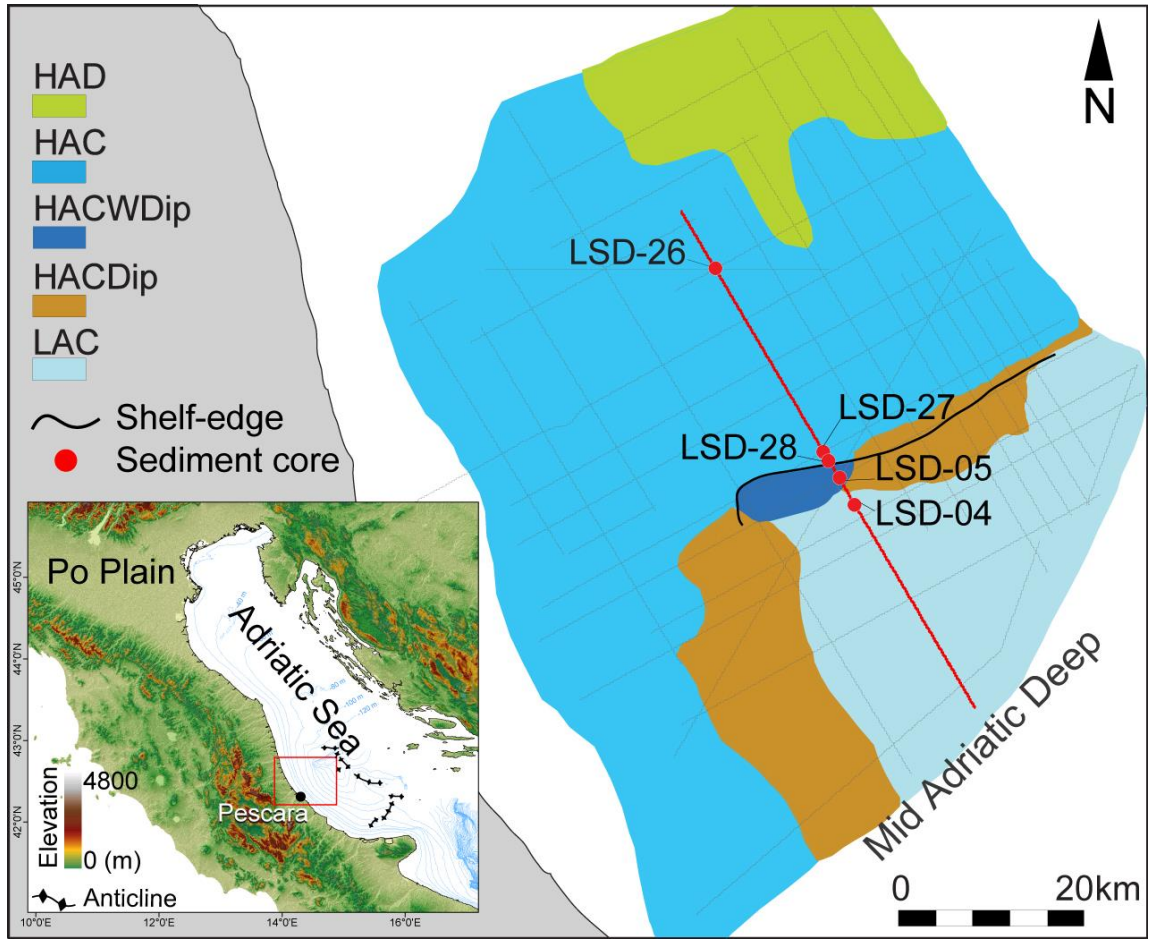


Pellegrini et al., 2018; Marine and Petroleum Geology (modified)



- Between the Eemian (MIS 5e) and the Last Glacial Maximum: reconfiguration of the N Adriatic basin → sea-level drop of ~135 m (Lambeck et al., 2014) and southward migration of shorelines of 300 km (Pellegrini et al., 2017a).
- Po River discharged into the Mid-Adriatic Basin → building of the Po River Lowstand Wedge (PRLW).
- The PRLW is constituted by 13 elemental clinothems (A_1 to C_2; Pellegrini et al., 2018), reaching a thickness of up to 350 m in 17 ky (Pellegrini et al., 2017a).

Study area



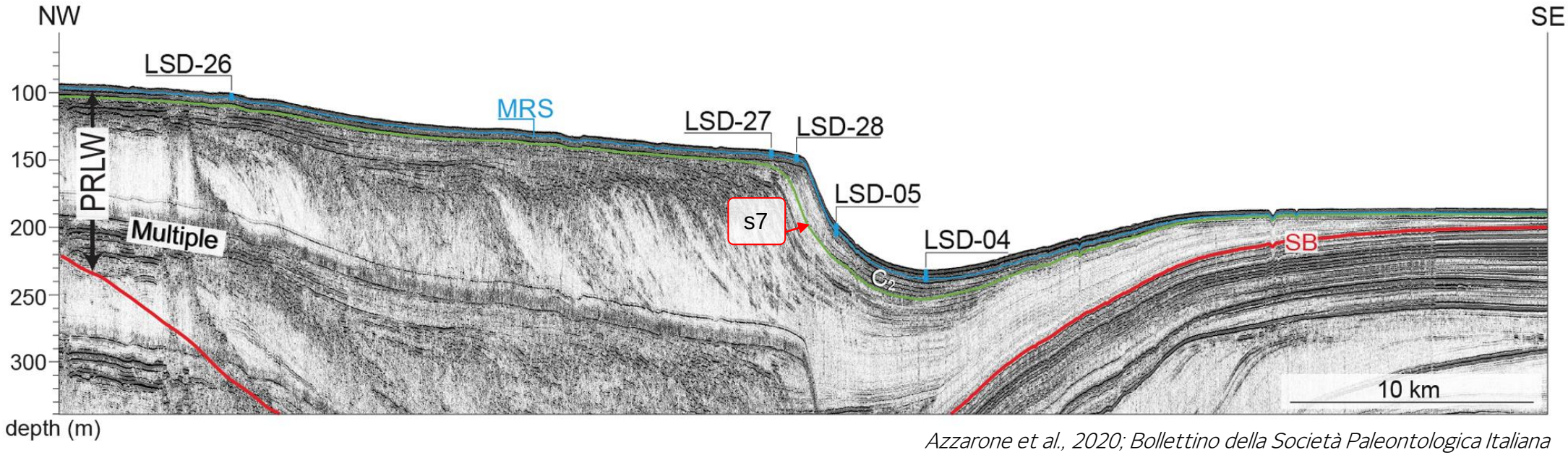
Azzarone et al., 2020; Bollettino della Società Paleontologica Italiana

Five cores investigated along a downdip gradient that intersect the most recent clinothem C_2:

- LSD-26
- LSD-27
- LSD-28
- LSD-05
- LSD-04

The Clinothem C_2

The multichannel seismic reflection profile used in this work was acquired with a mini water-gun source and a multichannel streamer during the oceanographic cruise Low Stand Delta (LSD) 2014.



Azzarone et al., 2020; Bollettino della Società Paleontologica Italiana

The C_2 clinothem is bounded at the base by the s7 surface (~15.7 ka BP; here in green), and at the top by the MRS (~14.4 ka BP). It recorded the last phase of deposition of the PRLW that resulted in > 20 m of shelf aggradation and in > 1 km of shelf-edge progradation (Pellegrini et al., 2017a).

The post-Last Glacial Maximum eustatic rise, with rates of up to 12 m/ky (Lambeck et al., 2014) led to the abandonment of the C2 clinothem close to the onset of Termination I, after ~14.4 ky BP.

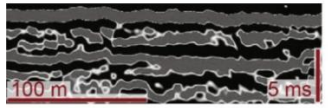
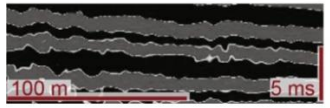
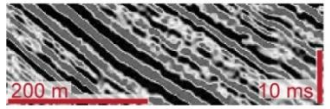
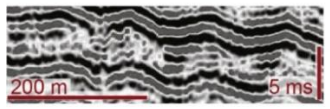
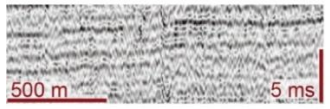
Targeted seismic facies

Pellegrini et al., 2018 recognized different seismic facies based on:

- Seismical amplitude
- Continuity and dip
- Internal reflection characters
- Nature of their boundaries
- Position in the depositional system

Seismic facies were used for a preliminary interpretation in terms of lithofacies and depositional environments.

Along the investigated downdip transect of the C_2 clinothem, we link the seismic interpretation with quantitative macro- and meiofaunal inferences. Based on core availability we analyzed three out of four seismic facies (i.e., HAC, HACWDip & LAC).

Seismic facies	Acronyms and colours	Internal reflections	Depositional environment
	HAD	High Amplitude Discontinuous	Lagoon
	HAC	High Amplitude Continuous	Delta plain/ subaqueous shelf
	HACDip	High Amplitude Continuous Dipping	Prodelta
	HACWDip	High Amplitude Continuous Wavy Dipping	Prodelta
	LAC	Low Amplitude Continuous	Distal Basin

Azzarone et al., 2020; Bollettino della Società Paleontologica Italiana

Material & Methods

- 41 mollusc samples investigated from regressive deposits and the lower part of the overlying transgressive unit.
- A suite of ostracod samples was analysed from selected stratigraphic intervals to improve the paleontological record and to constrain the position of the MRS.

The final dataset counts:

Molluscs			Ostracods			
Genera	Species	Total	Genera	Species	Group	Total
69	82	3555	39	76	1	2032

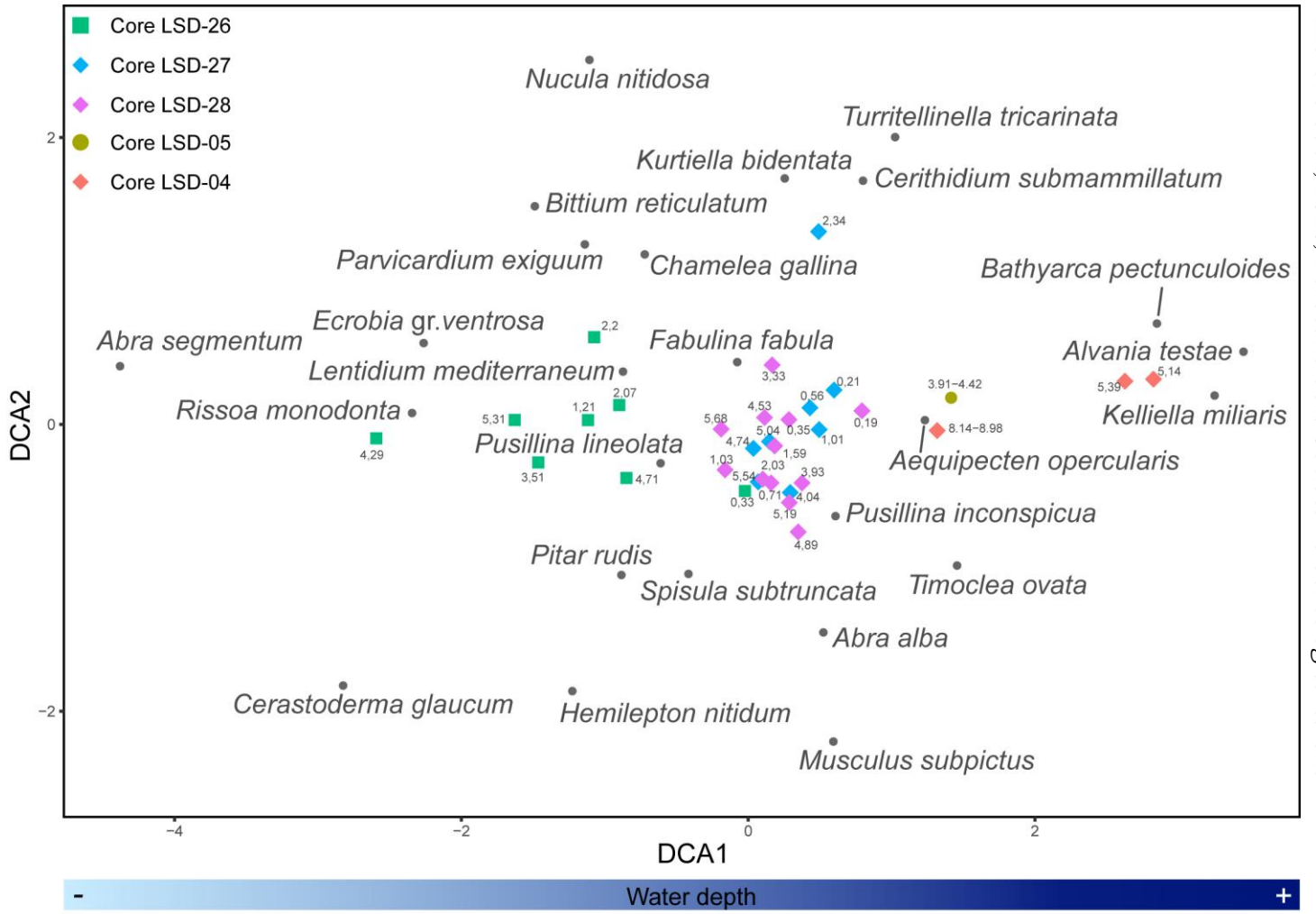
The culled molluscs dataset was separatedly investigated with a Detrended Correspondence Analysis (DCA) to identify key environmental drivers of molluscan assemblages.

On mollusc and ostracod datasets (transformed to relative abundance) was performed a R-mode cluster analysis using UPGMA and correlation as similarity coefficient.

Results - DCA

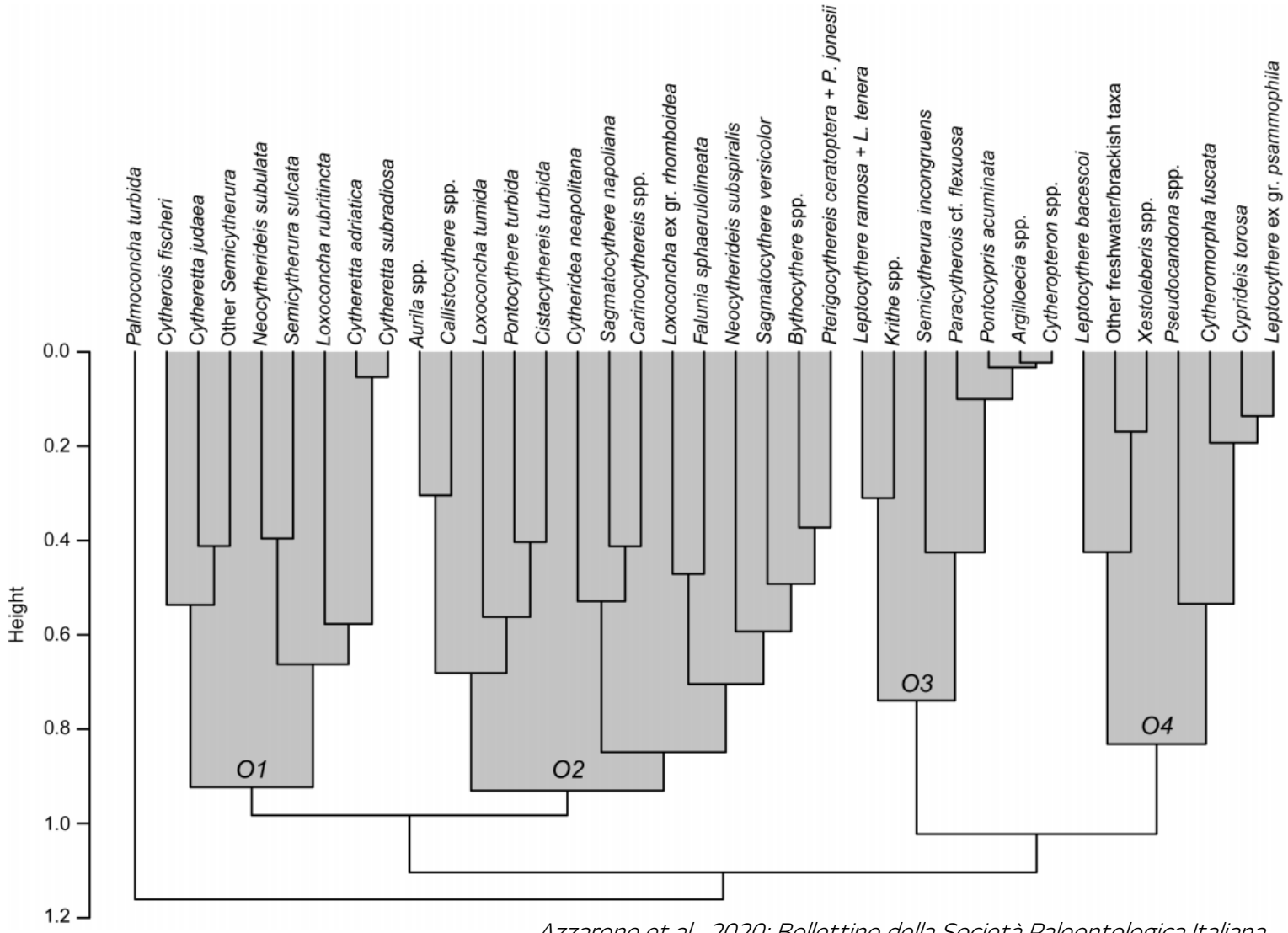
DCA results show that:

- Water depth and covariant salinity is associated with DCA axis 1 (DCA1)
- Samples rich in shallow water-brackish taxa show a lower DCA1 scores (left)
- Positive value of DCA axis 1 (right) are associated with samples bearing deeper taxa.
- Samples along DCA1 reflect the position of the cores along the depositional profile and morphological gradient.



Azzarone et al., 2020; Bollettino della Società Paleontologica Italiana

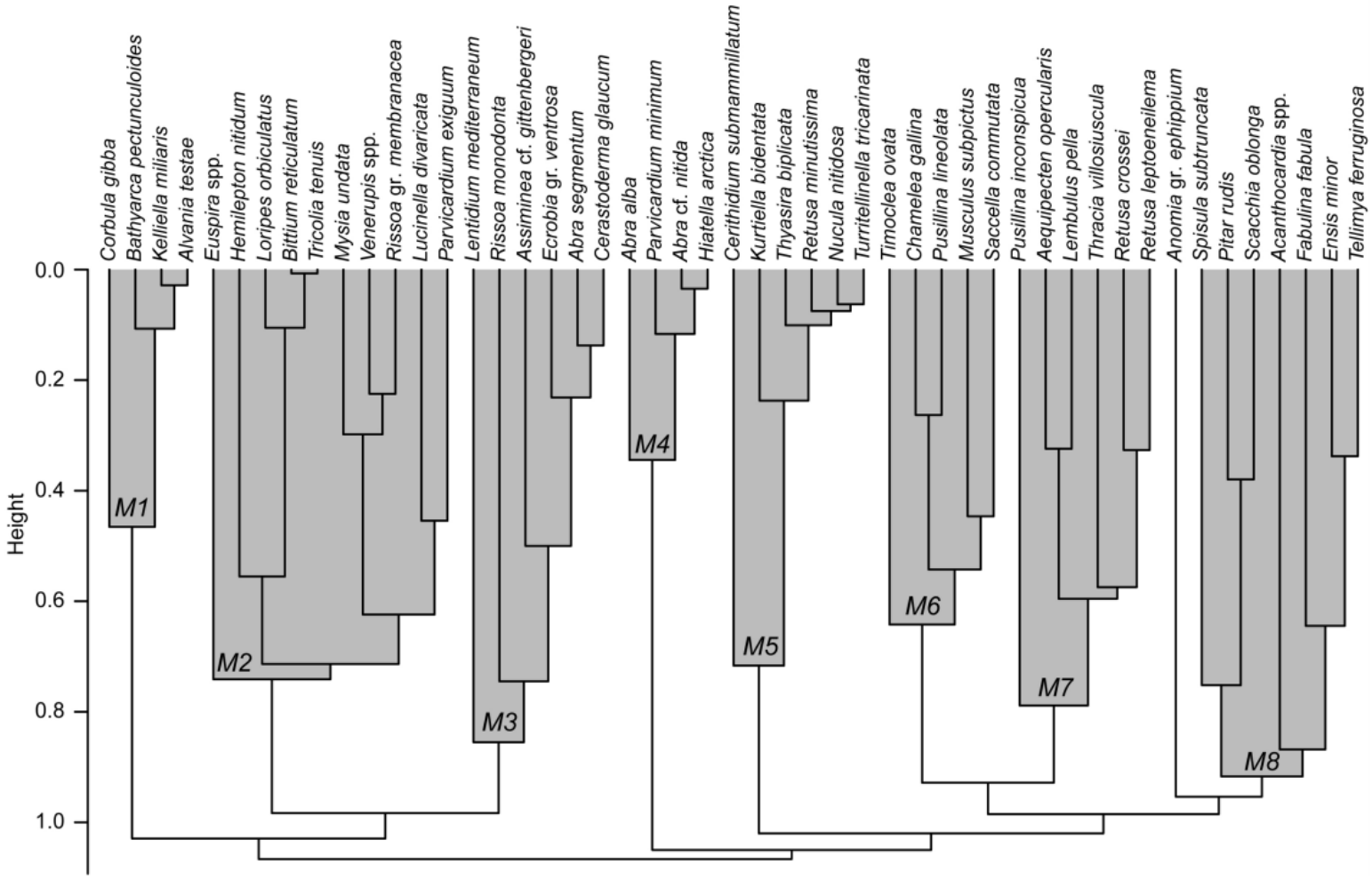
Results – Ostracod clusters



Cluster	Environment
O1	Nearshore-offshore transition
O2	Inner-middle shelf
O3	Mid-outer shelf
O4	Lower delta plain
P. turbida	Riverine-influenced, rich in organic matter

Azzarone et al., 2020; Bollettino della Società Paleontologica Italiana

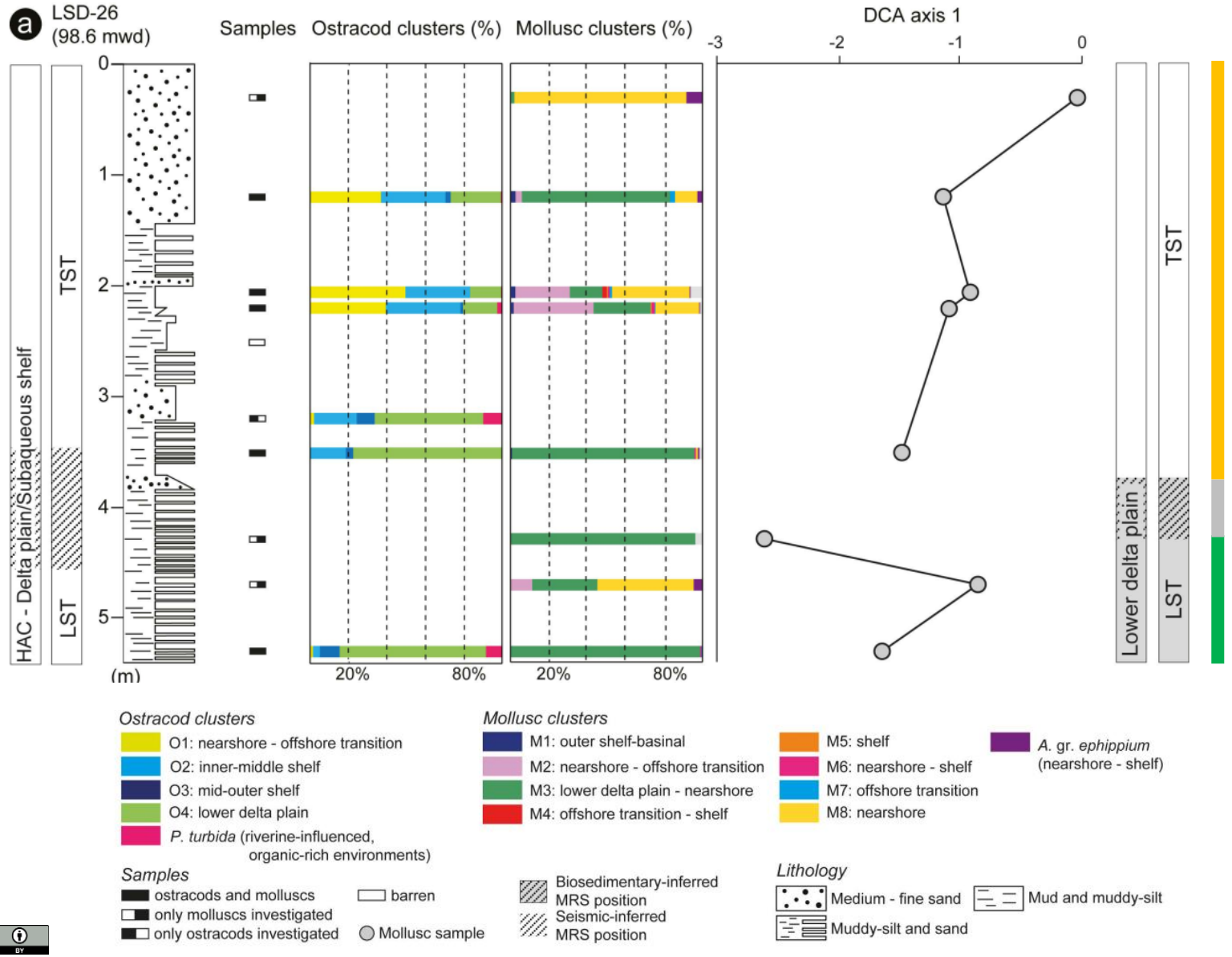
Results – Mollusc clusters



Name	Environment
M1	Outer shelf-basinal
M2	Nearshore-offshore transition
M3	Lower delta plain-nearshore
M4	Offshore transition-shelf
M5	Shelf
M6	Nearshore-shelf
M7	Offshore transition
M8	Nearshore
*A.*gr. *ephippium*	Nearshore – shelf (current swept)

Azzarone et al., 2020; Bollettino della Società Paleontologica Italiana

Core LSD-26. Faunal dynamics & sequence stratigraphy



Azzarone et al., 2020; Bollettino della Società Paleontologica Italiana

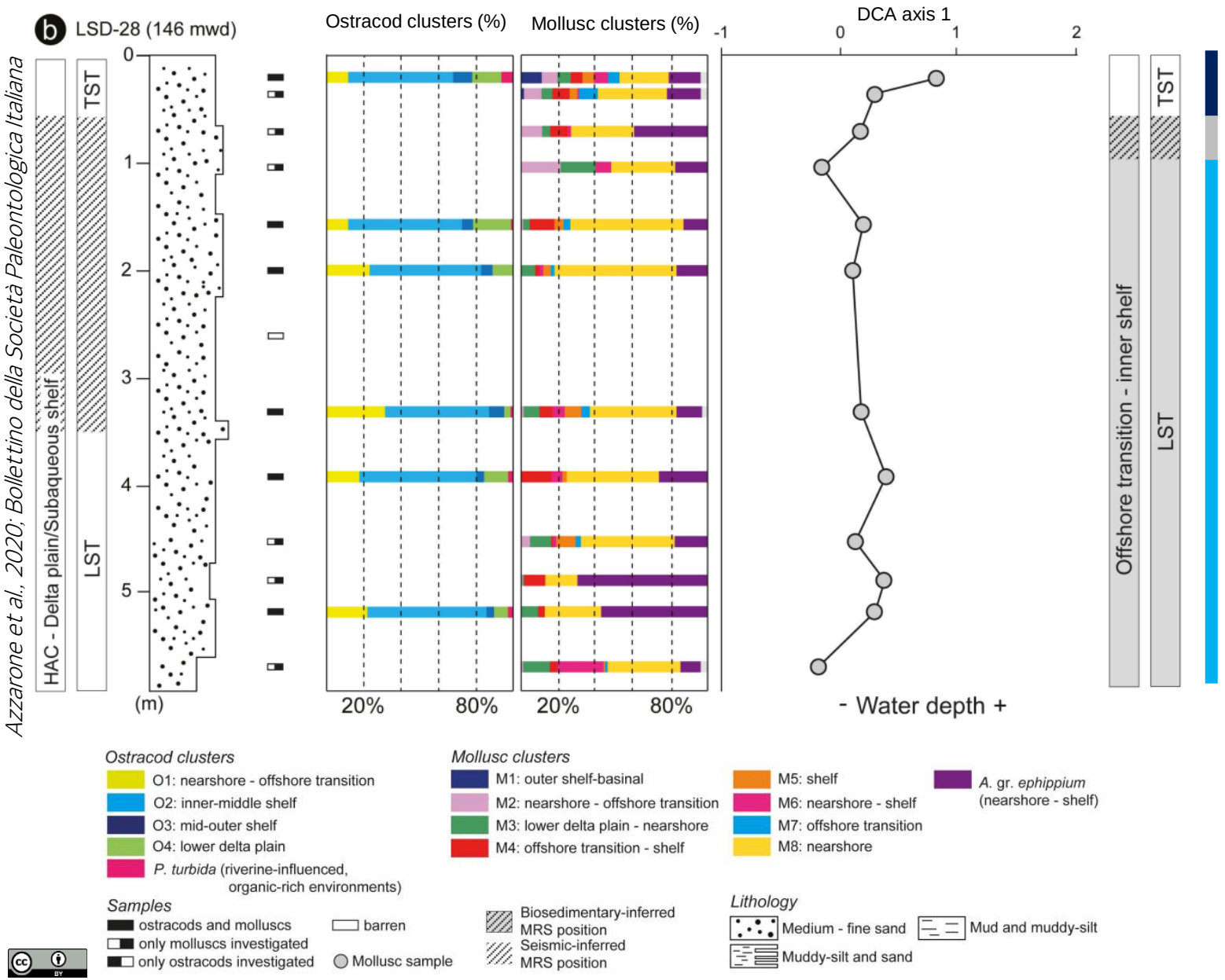
Paleontological inferred environments

Nearshore settings with vegetated substrates. DCA evidences increase in water depth and marine influence.

Strongly fluvial-influenced shallow coastal environments. DCA evidences shallowing upward trend.

Biosedimentary inferred position of the Maximum Regressive Surface ~4 m.

Core LSD-28



Azzarone et al., 2020; Bollettino della Società Paleontologica Italiana

Paleontological inferred environments

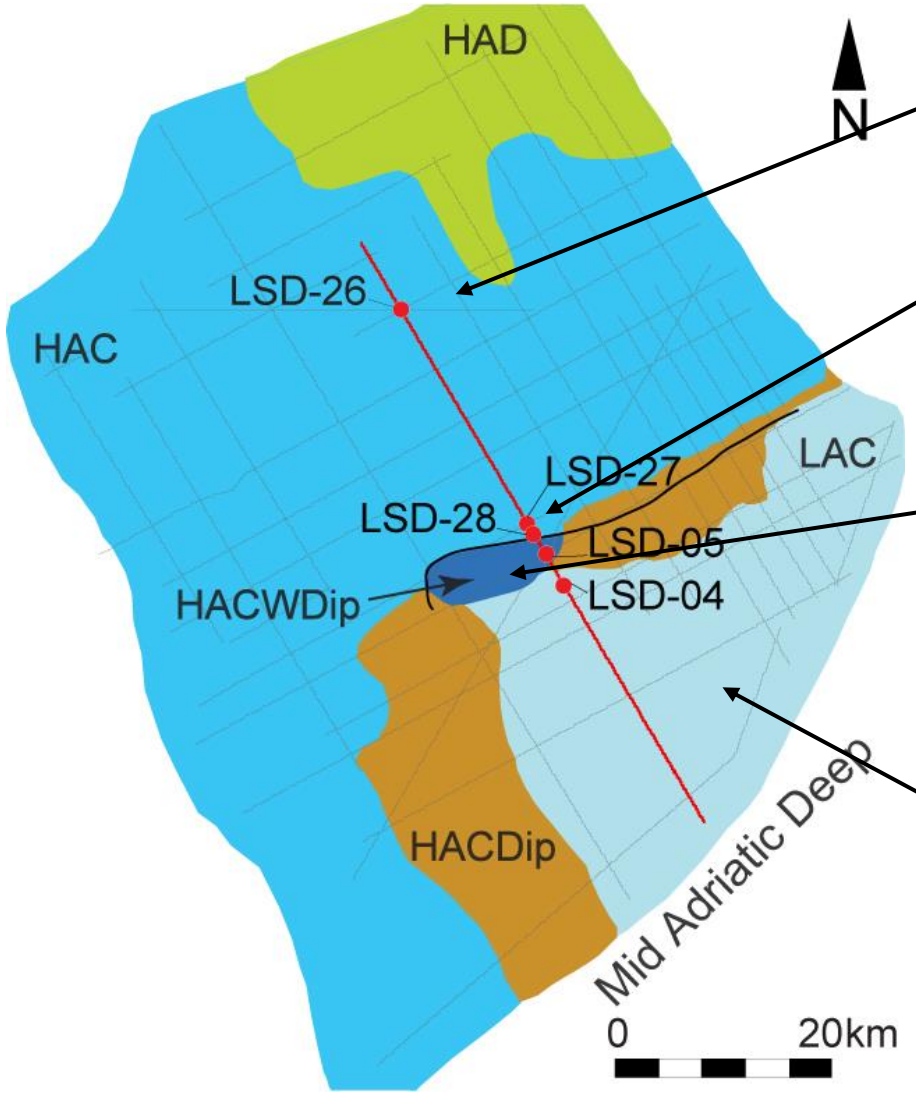
DCA evidences deepening upward trend. Topmost sample records appearance of outer shelf taxa along with nearshore taxa.

Offshore transition to inner shelf. High number of clusters with contrasting environmental significance suggest high bioturbation activity and/or offshore discharge.

Overall aggrading trend derived from DCA1 scores

Biosedimentary inferred position of the Maximum Regressive Surface between 0.30-0.90 m.

Paleobiological characterization of seismic-inferred facies



HAC proximal deposits record deltaic progradation into shallow brackish and protected settings with vegetated substrates and subject to frequent high energy events as inferred by the sedimentological evidences and by euryhaline benthic assemblages.

In the **distal HAC** groups of species with contrasting ecological characteristics pointing toward an offshore transition-inner shelf setting with intense bioturbation activity and high-energy conditions due to river activity and storms.

HACWDip analysed deposits are characterised by scarce macro and meiobenthic fauna, suggesting a (mid) shelf setting possibly subject to environmental instability.

LAC: the only datum available supports the deep marine muddy basinal environments of Pellegrini et al., 2018. *Anomia ephippium* suggests a recurrent remobilizations and transport of shelf deposits to the basinal sector.

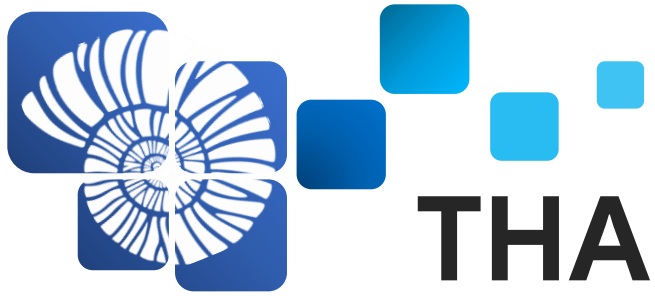
Azzarone et al., 2020; Bollettino della Società Paleontologica Italiana

Conclusions

- Paleontological inferences (DCA1-bathymetric trends and benthic faunal turnover) complement seismic-derived stratigraphic interpretations and allow to constrain the position of the Maximum Regressive Surface within the Mid-Adriatic Deep, Late Pleistocene sedimentary succession.

- The quantitative analysis of bio-sedimentary insights provides information on several environmental variables (e.g., energy levels, salinity, vegetation cover) and is thus a powerful tool to detail the variation of depositional settings and improve paleogeographic reconstructions of cored successions in connection with sea level variations.

- Our results provide a reference for future seismically based interpretations of sedimentary environments in similar geological settings while also testing the power of benthic fauna in seismically based stratigraphic reconstructions.



THANKS FOR THE ATTENTION!

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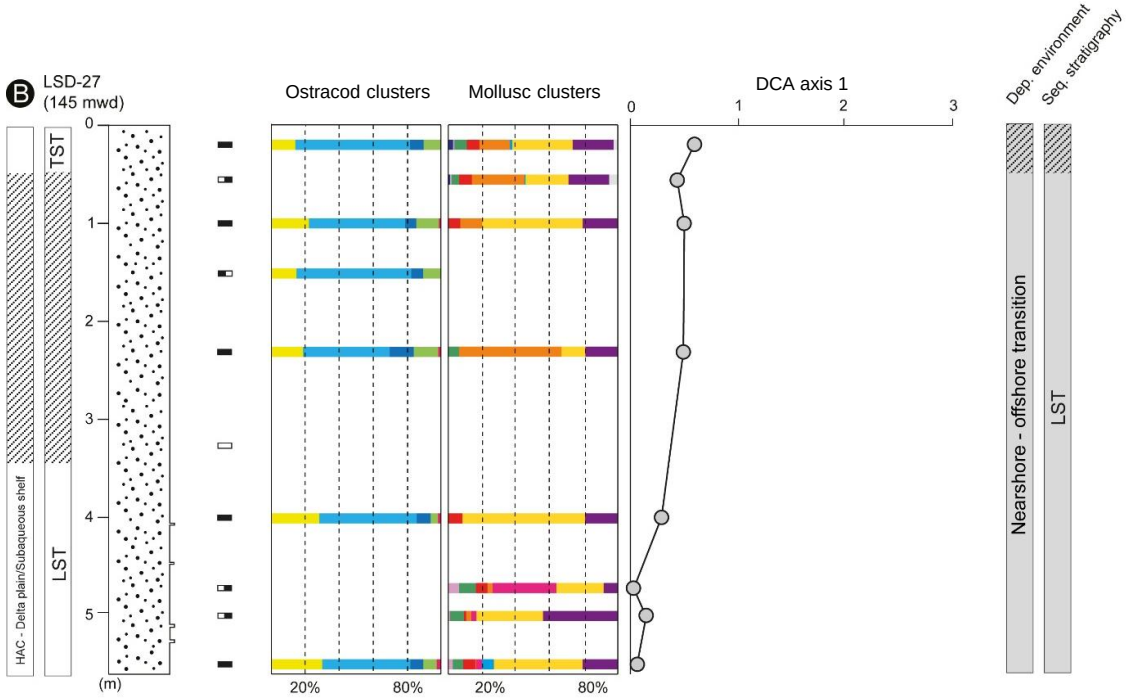
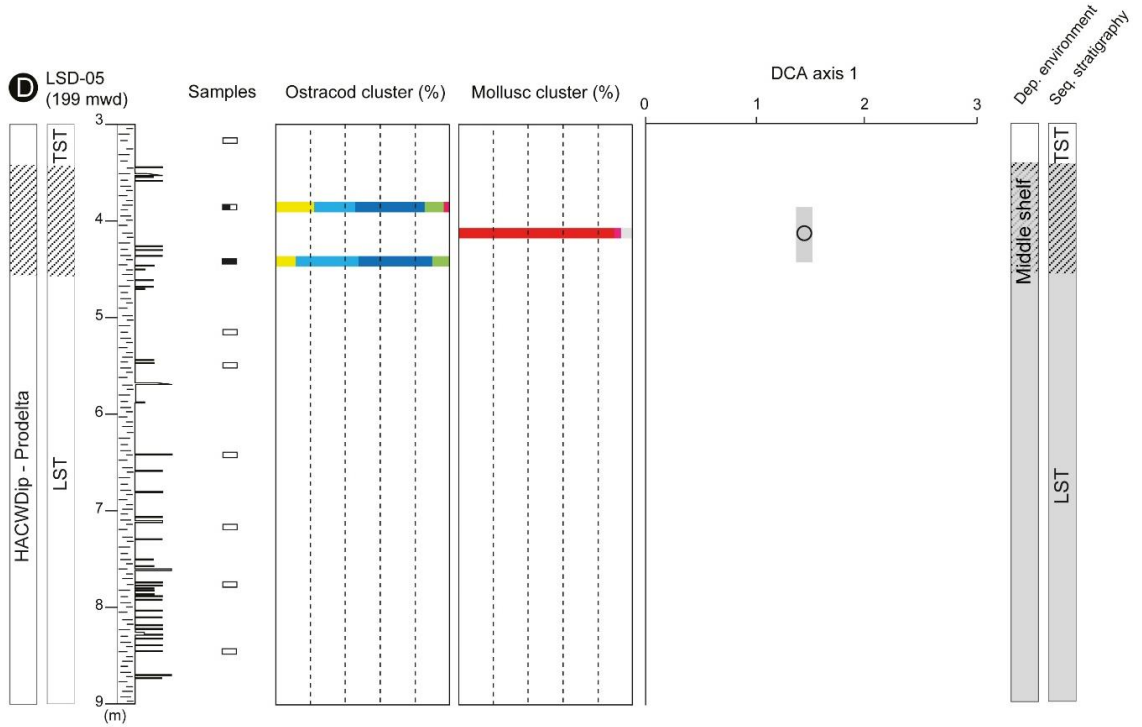
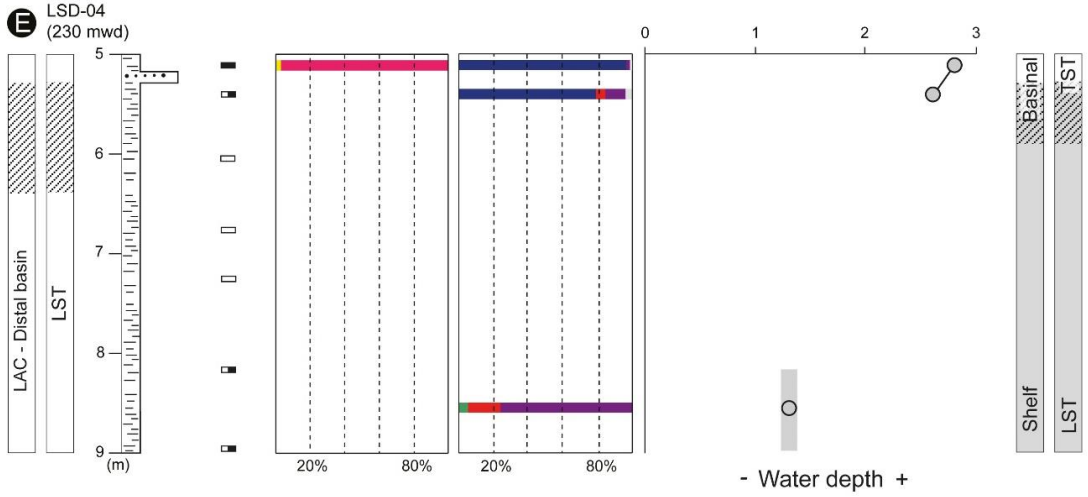
Supplementary Material

Cores LSD-27, 04 & 05







Ostracod clusters
- O1: nearshore - offshore transition
- O2: inner-middle shelf
- O3: mid-outer shelf
- O4: lower delta plain
- *P. turbida* (riverine-influenced, organic-rich environments)

Mollusc clusters
- M1: outer shelf-basinal
- M2: nearshore - offshore transition
- M3: lower delta plain - nearshore
- M4: offshore transition - shelf
- M5: shelf
- M6: nearshore - shelf
- M7: offshore transition
- M8: nearshore
- *A. gr. ephippium* (nearshore - shelf)

Lithology
- Medium - fine sand
- Mud and muddy-silt
- Muddy-silt and sand

Samples
- ostracods and molluscs
- only molluscs investigated
- only ostracods investigated
- barren
- Mollusc sample
- Seismic-inferred MRS position
- Biosedimentary-inferred MRS position

Azzarone et al., 2020; Bollettino della Società Paleontologica Italiana

Cores Data

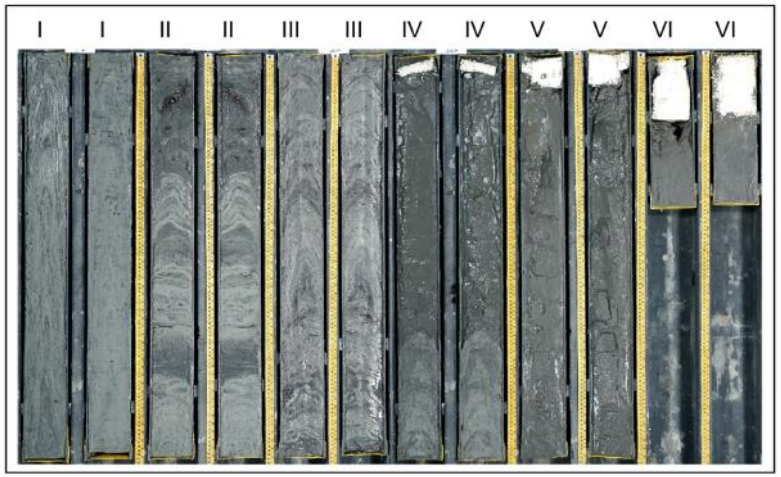
Core name	Latitude	Longitude	Device	Water depth (m)	Recovery (m)
LSD-04	42.856494°N	14.626905°E	PC 10 m	230	8.97
LSD-05	42.883066°N	14.602752°E	PC 10 m	199	8.33
LSD-26	43.081668°N	14.440637°E	VC 6 m	98.6	5.21
LSD-27	42.895910°N	14.592332°E	VC 6 m	146	5.40
LSD-28	42.896907°N	14.591559°E	VC 6 m	145	5.60

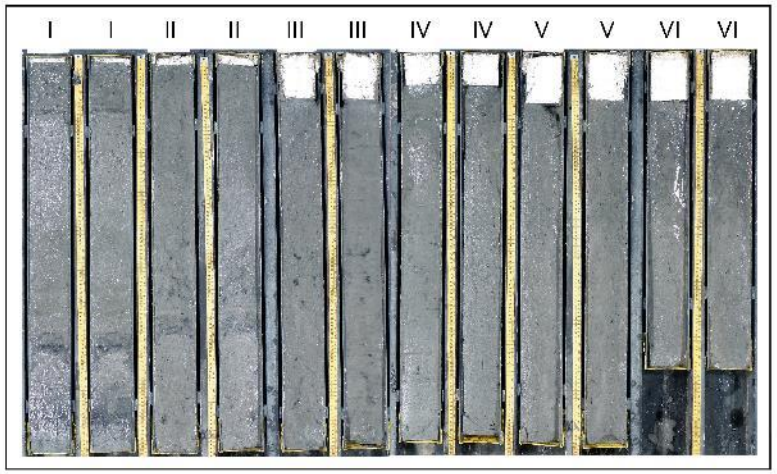
Core data of the five investigated cores in this work. PC = piston corer, VC = vibrocorer.

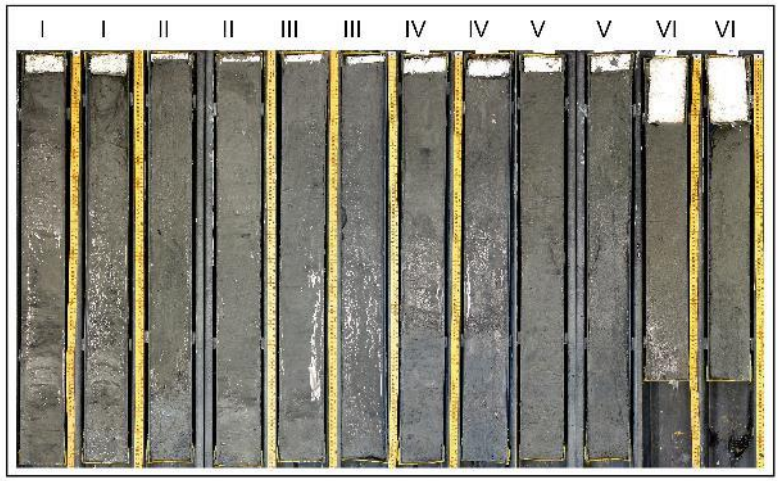
Azzarone et al., 2020; Bollettino della Società Paleontologica Italiana

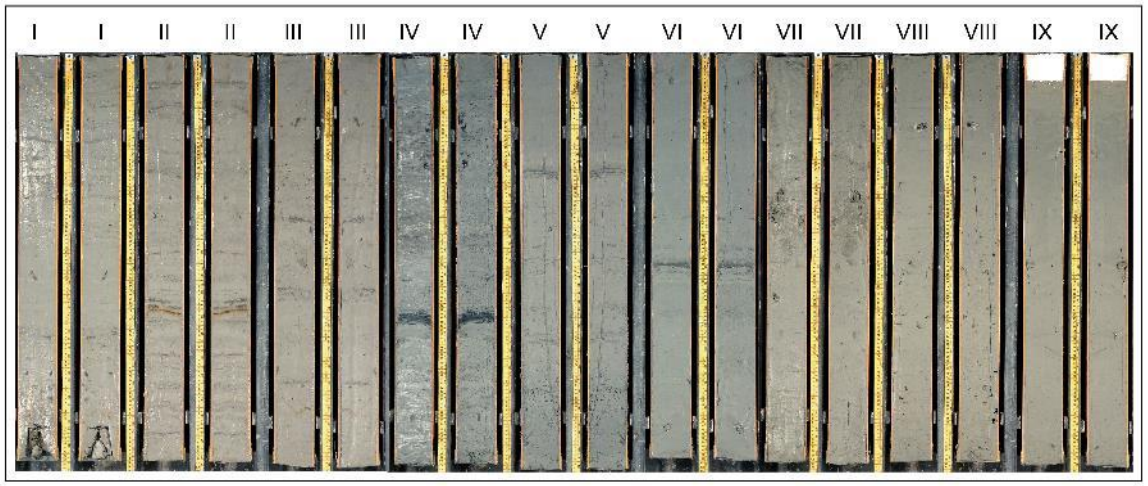
Investigated cores pictures

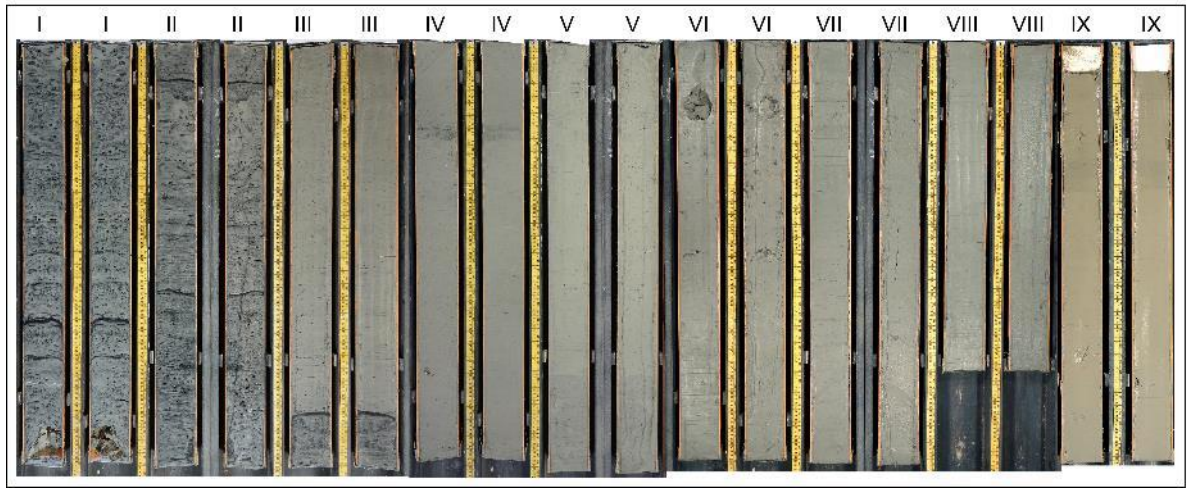
Azzarone et al., 2020; Bollettino della Società Paleontologica Italiana











Pictures of the five investigated cores along the downdip transect LSD-22. Each core is subdivided in 1 m-long sections. Cores are housed at the Consiglio Nazionale delle Ricerche – Istituto delle Scienze Marine in Bologna (Italy).