MACROBENTHIC COMMUNITY RESPONSE TO LONG-TERM CLIMATE CHANGE IN THE ADRIATIC SEA (ITALY)

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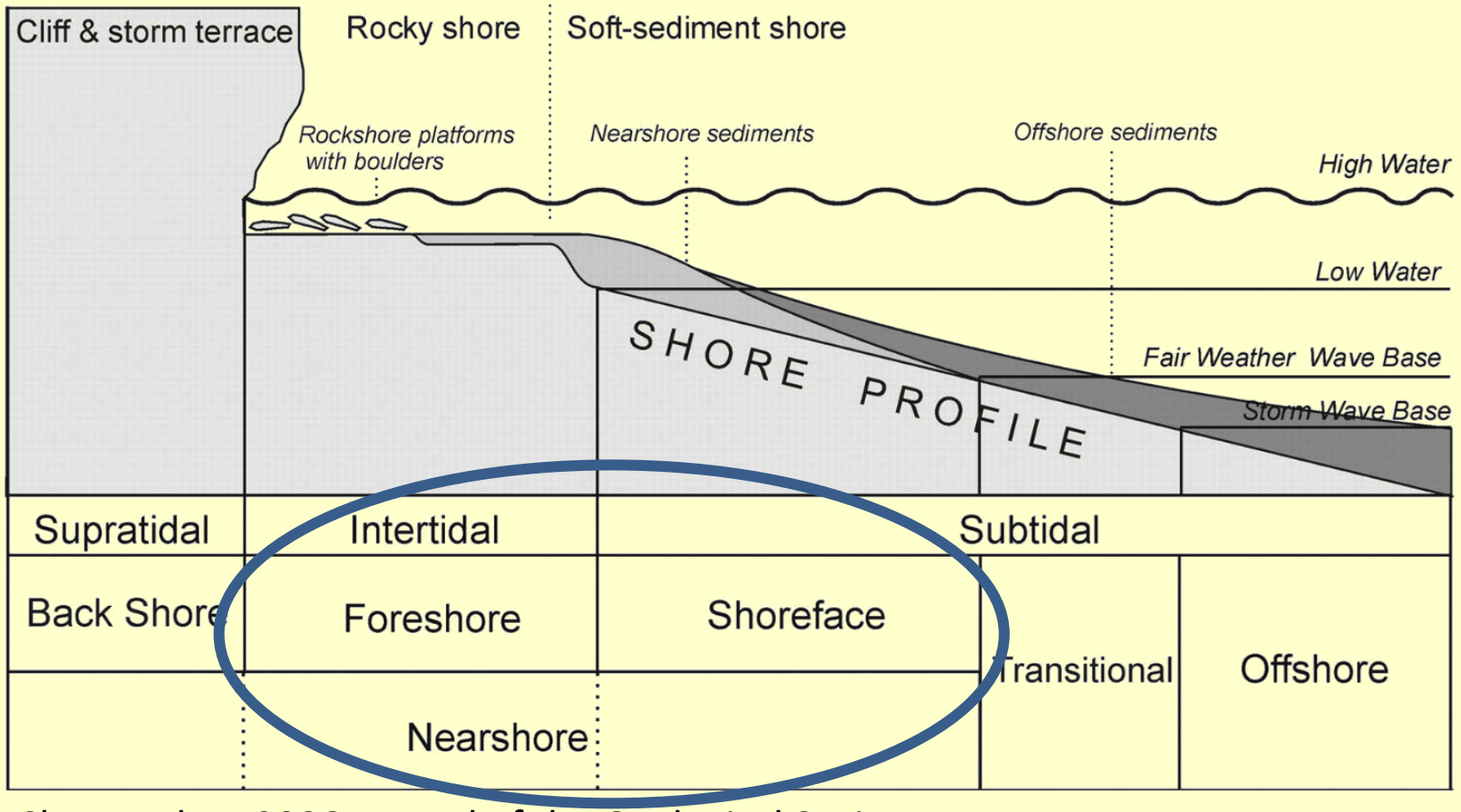
GOAL: To provide empirical insights into glacial-interglacial community assembly dynamics of mollusk assemblages in the Adriatic Sea.

Focus on nearshore mollusk associations from key time periods



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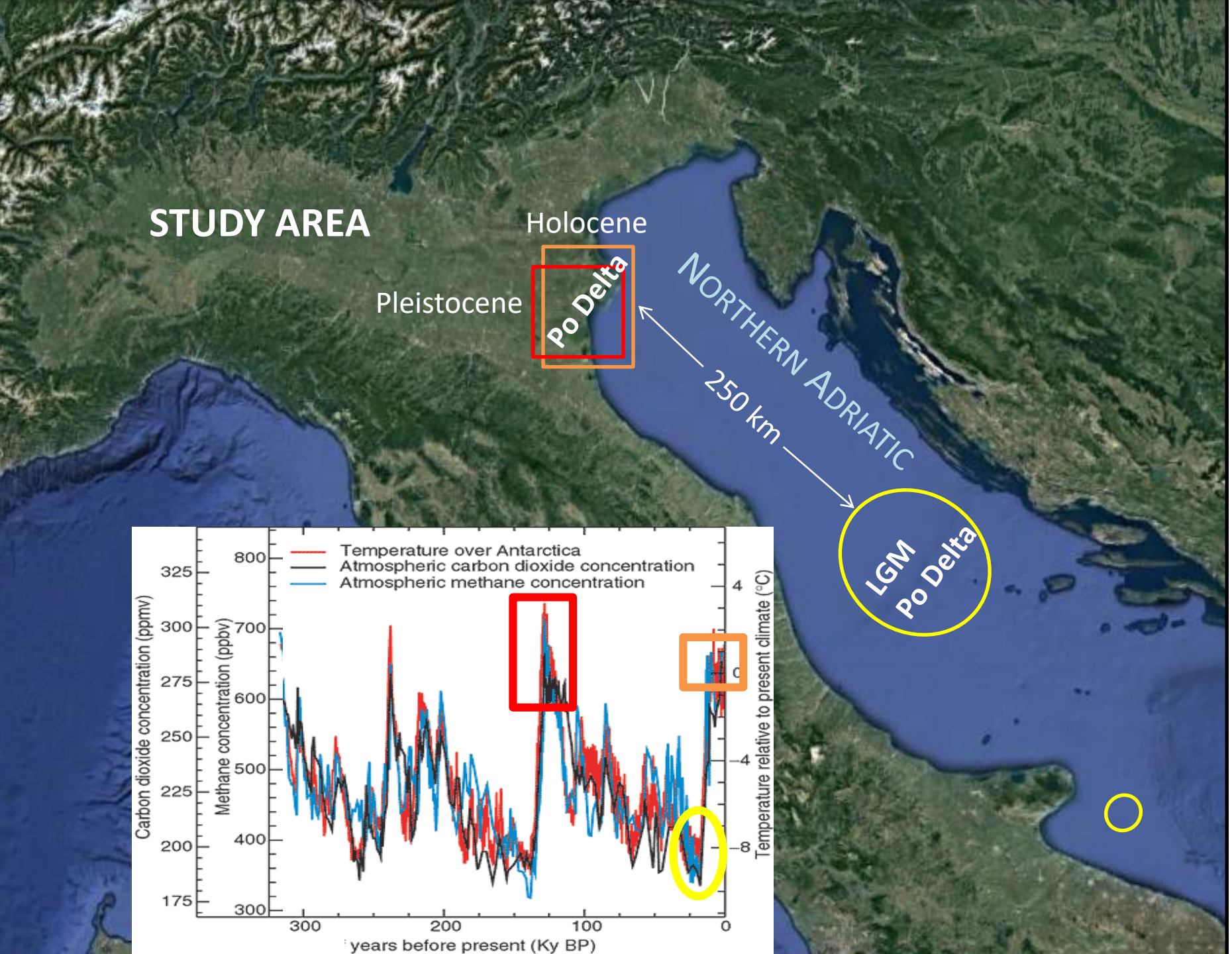
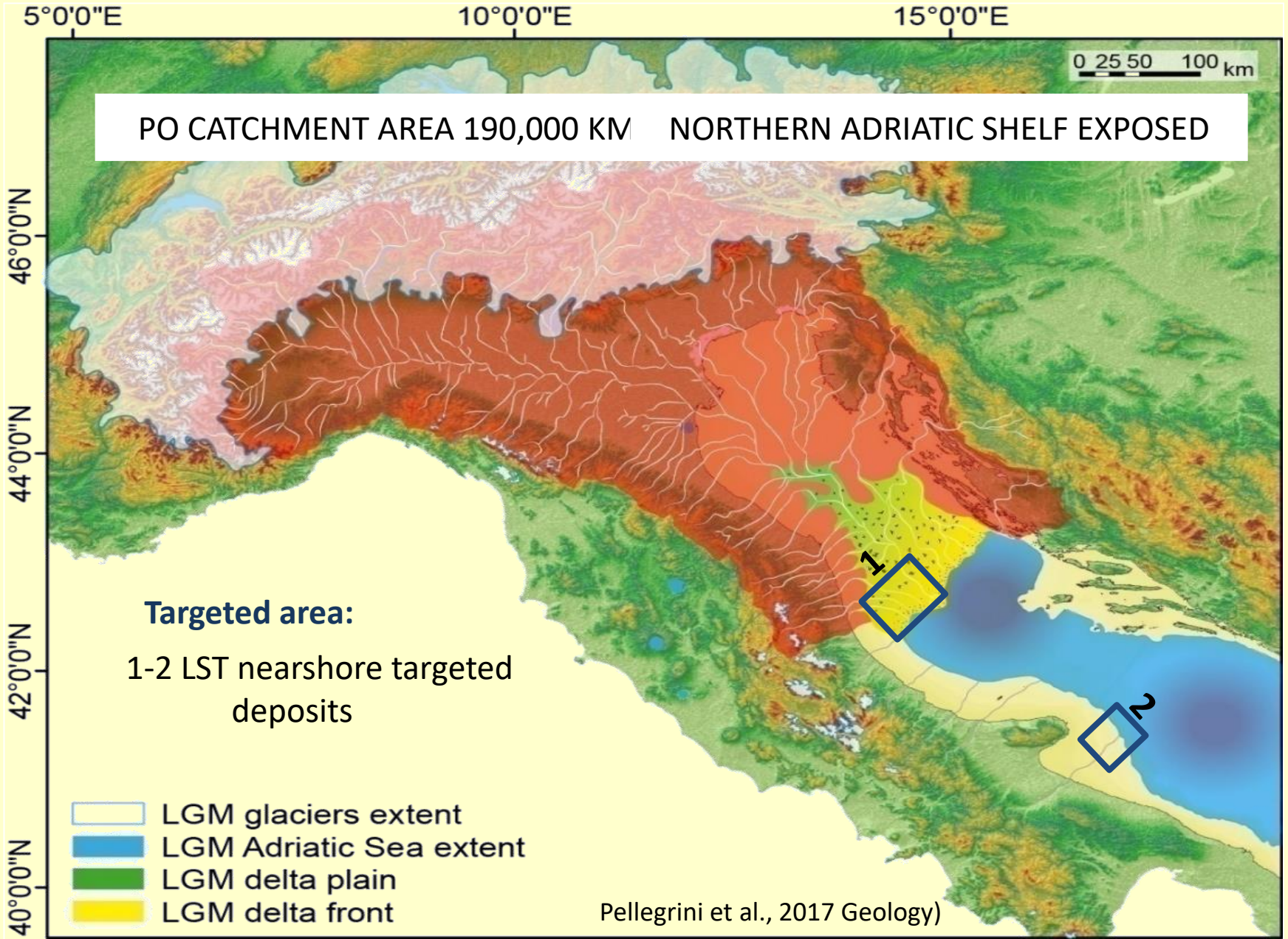
A case study targeting the latest Quaternary nearshore sedimentary successions of Italy.

Here with nearshore we mean shallow marine coarse-grained substrata situated above fair weather wave base.



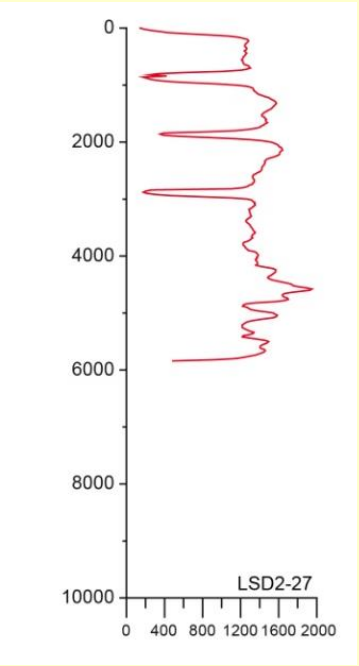
The study area is the Po-Adriatic deltaic system examined at three key-time periods during the latest 130 ka BP. This is a time span characterized by strong variations in sea level in the investigated area. The key periods are the late Pleistocene interglacial (MIS 5.5), last glacial (MIS 2) and present interglacial (MIS 1). Here the location of the Po deltaic system during the investigated time-intervals: last interglacial (red rectangle), present interglacial (orange square) and last glacial (yellow ellipse).

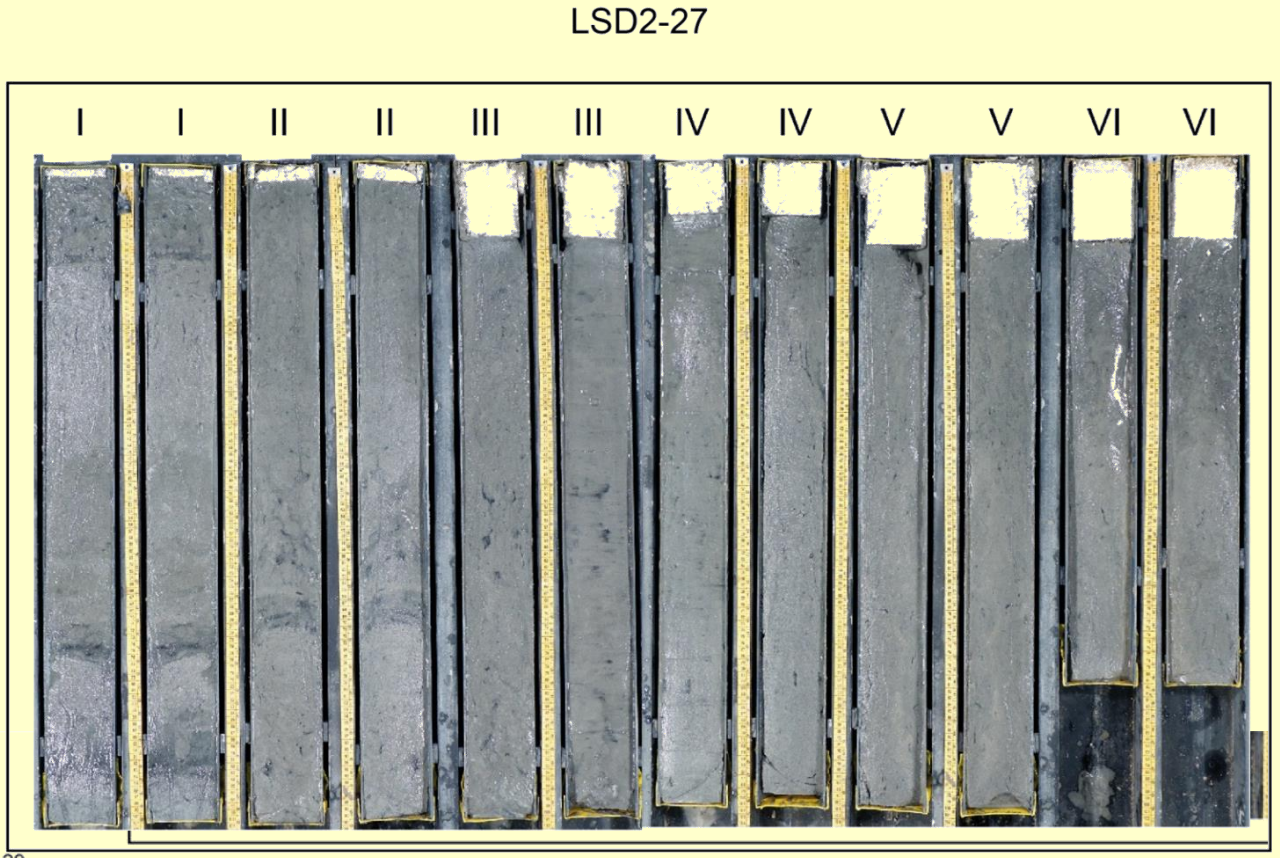
Physiographic Setting Northern Adriatic-Po Delta – Last Glacial Maximum

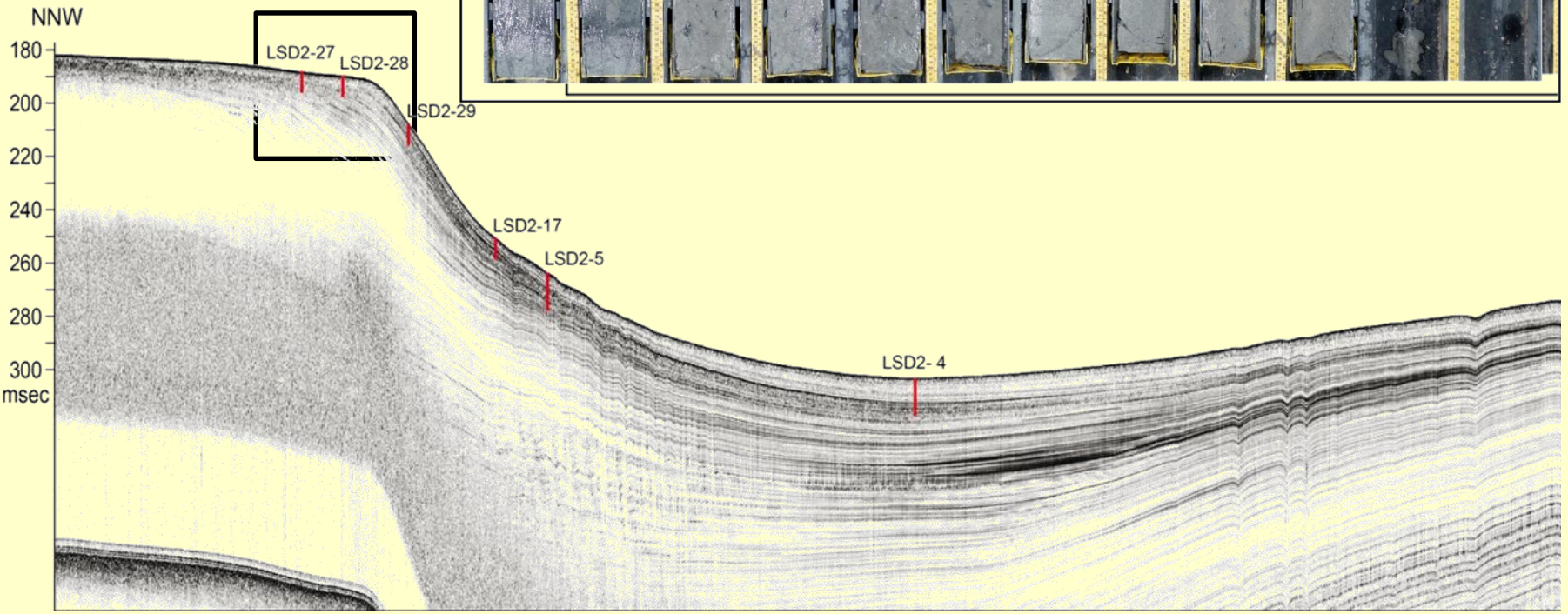


During the Last Glacial Maximum (~20 ka BP), the Adriatic sea level was approximately 130 m lower than present day, and the northern Adriatic Sea, that is a shallow epicontinental sea, was entirely subaerially exposed.

Note the location of the Po Delta of lowstand (LST), approximately 250 km southeastward of its present-day position.





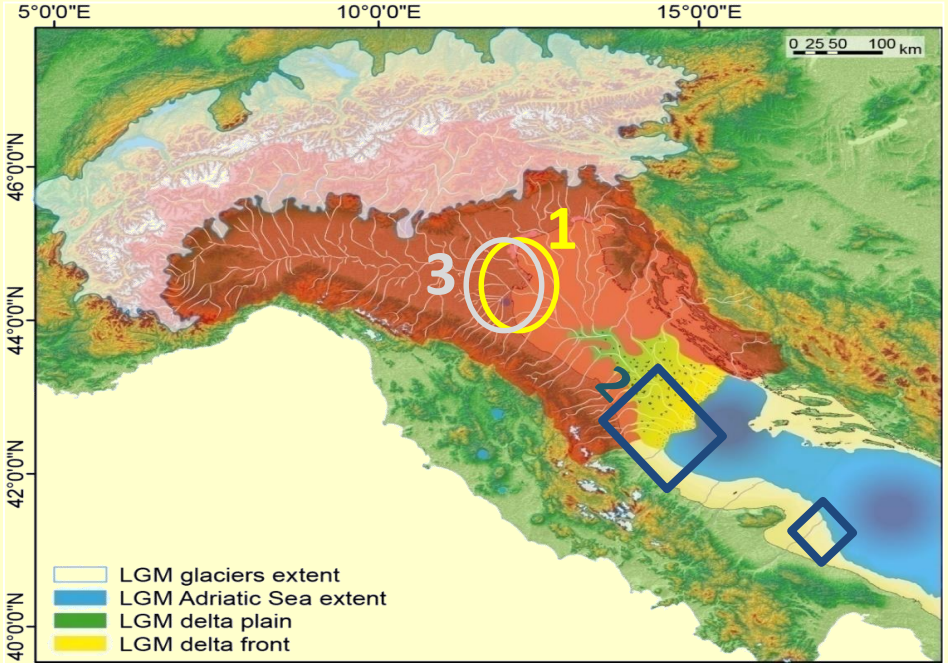


This study is based on samples from cores. Here, an example of cores and seismic lines from the Po Delta of Lowstand. Cores from the Central Adriatic Sea are between 5 and 10 m long and allowed us to investigate the latest Glacial interval (i.e., 18.0 to 14.5 ka BP after 14 ka BP, the deltaic system was drowned and the shoreline started backstepping toward its present-day position. In this study nearshore environments where mainly defined by means of integrated grain-size, sedimentary structures, microfaunal inferences and, when available, high-resolution seismic profiles.

Po Delta – Restricted Dataset

TARGETED NEARSHORE DEPOSITS:

	Cores	*Samples*	*Specimens*
Area 1 (Interglacial HST - H)	**7**	**181**	**29917**
Area 2 (Glacial LST - LGM)	**7**	**20**	**1739**
Area 3 (Interglacial HST – P5.5)	**6**	**18**	**5866**
	18	**219**	**37522**



Methods

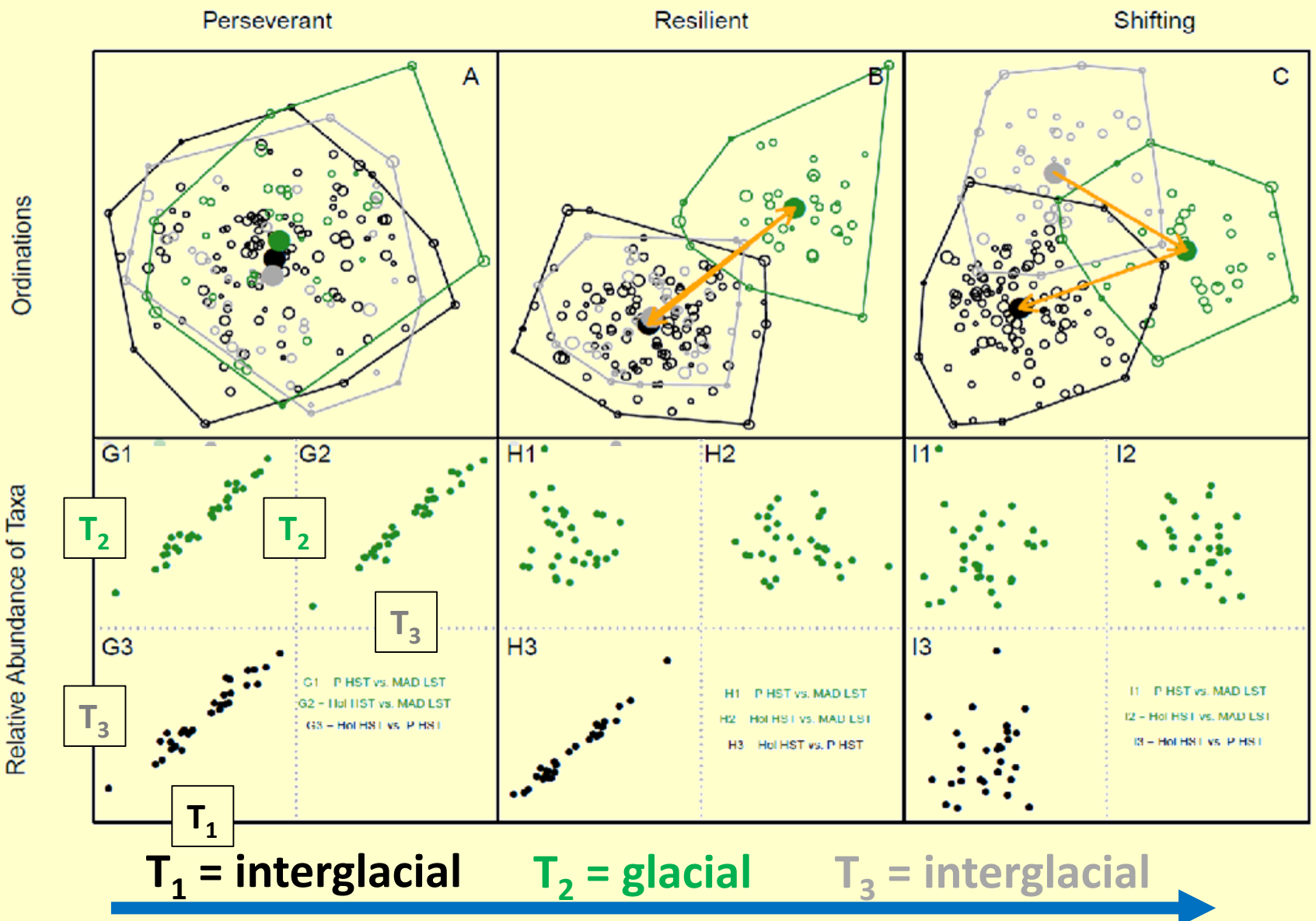
Ordination (NMDS)

Multiple Pairwise Comparisons

We quantified responses of nearshore marine benthic communities to long-term climate and sea-level changes using 219 core samples (37522 mollusk specimens) extracted from sediments of the Po-Adriatic deltaic system.

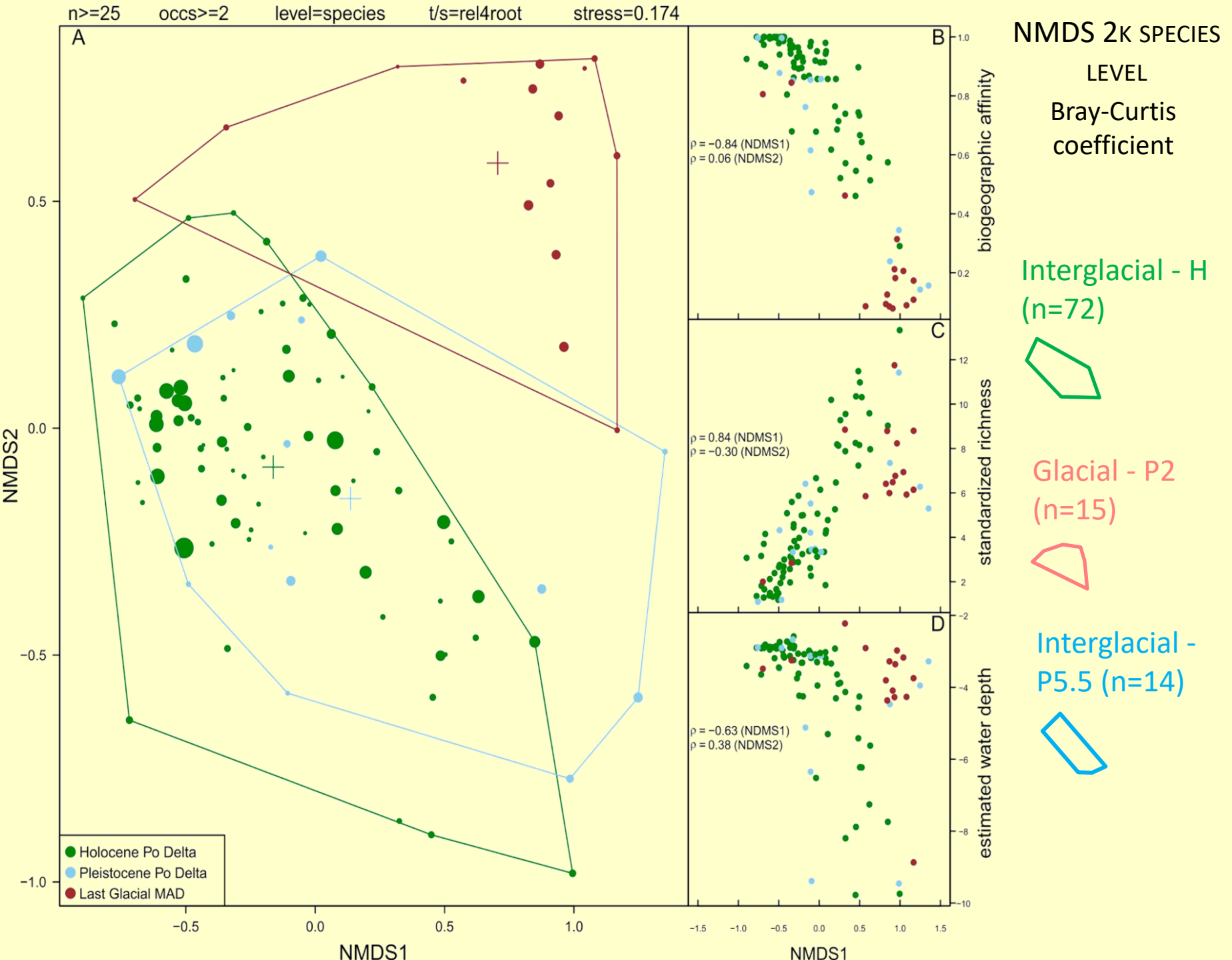
To evaluate metacommunity assembly dynamics, we employed NMDS and multiple pairwise comparisons of relative abundance distribution of species

CONCEPTUAL FRAMEWORK



Our conceptual framework concerning models of metacommunity dynamics in relation to climate-driven changes: Persistent, Resilient or Stochastic and the expected output based of the methods employed (i.e., NMDS and pairwise comparisons).

For example: ordination output (A) depicting a persistent response to climate change should show all samples groups strongly overlapping each other, and good to strong correlations in all 3 pairwise comparisons.



NMDS 2K SPECIES LEVEL

Bray-Curtis coefficient

Interglacial - H (n=72)

Glacial - P2 (n=15)

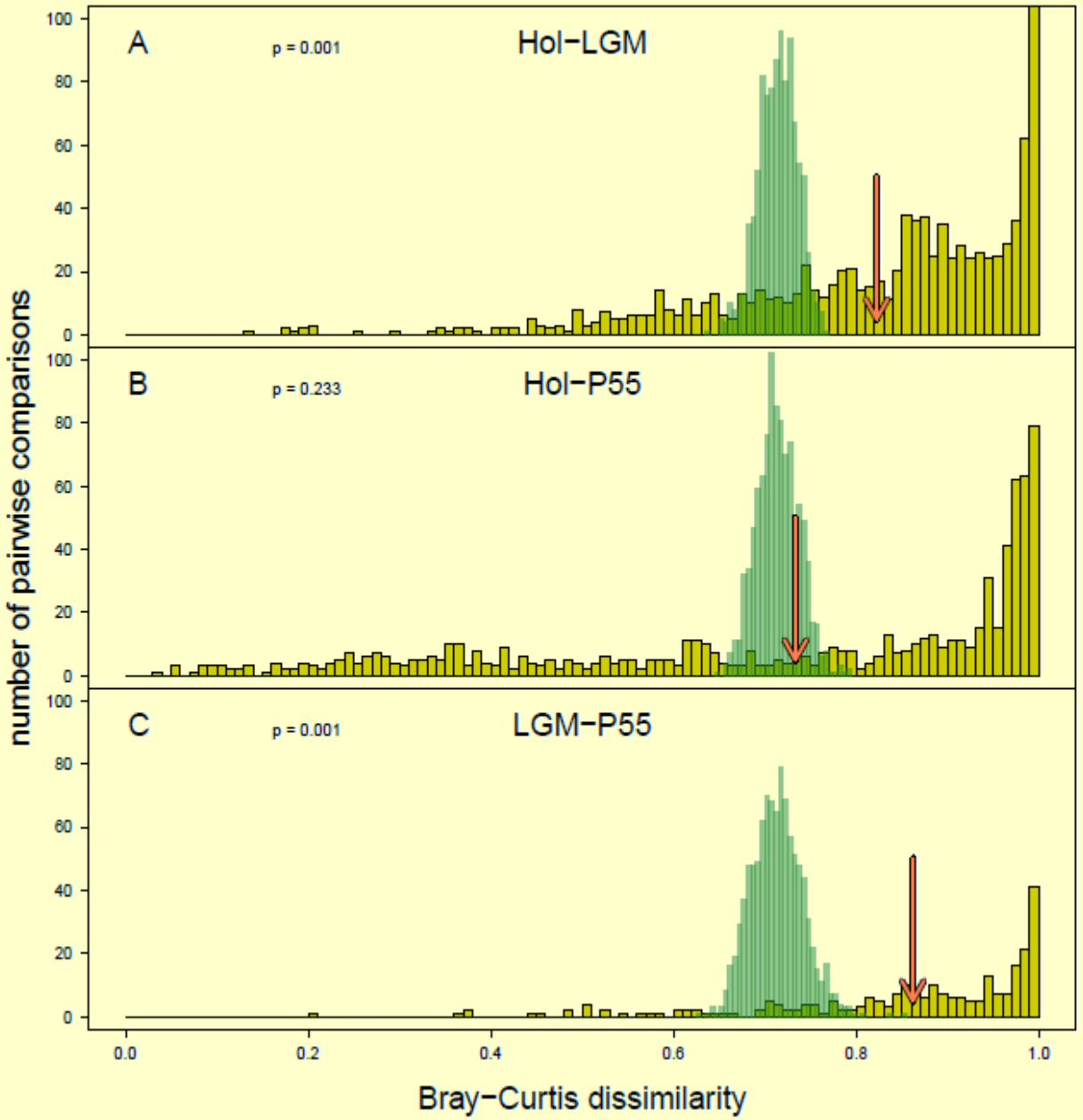
Interglacial - P5.5 (n=14)

Non-Metric Multidimensional Scaling (NMDS) at species level for visualization of relations among the investigated groups. Interglacial sample groups overlap strongly and Late Glacial samples plot separately in the NMDS space. Therefore **NMDS comparison points toward a resilient behavior of mollusk nearshore metacommunities of the Po-Adriatic system**. On the right, plots illustrating drivers of samples turnover along NMDS axis 1 and 2. Here, estimated water depth of samples (D, derived by averaging present-day depth distribution of mollusk species retrieved in that specific sample), support the definition of nearshore based on previously mentioned proxies (slide 5).

GLACIAL *VS* INTERGLACIALS: BC PAIRWISE DISTANCES

Higher similarity between samples from interglacial comparison

Randomization model supports Hol *vs.* P5.5 samples from same nearshore species pool



Time periods

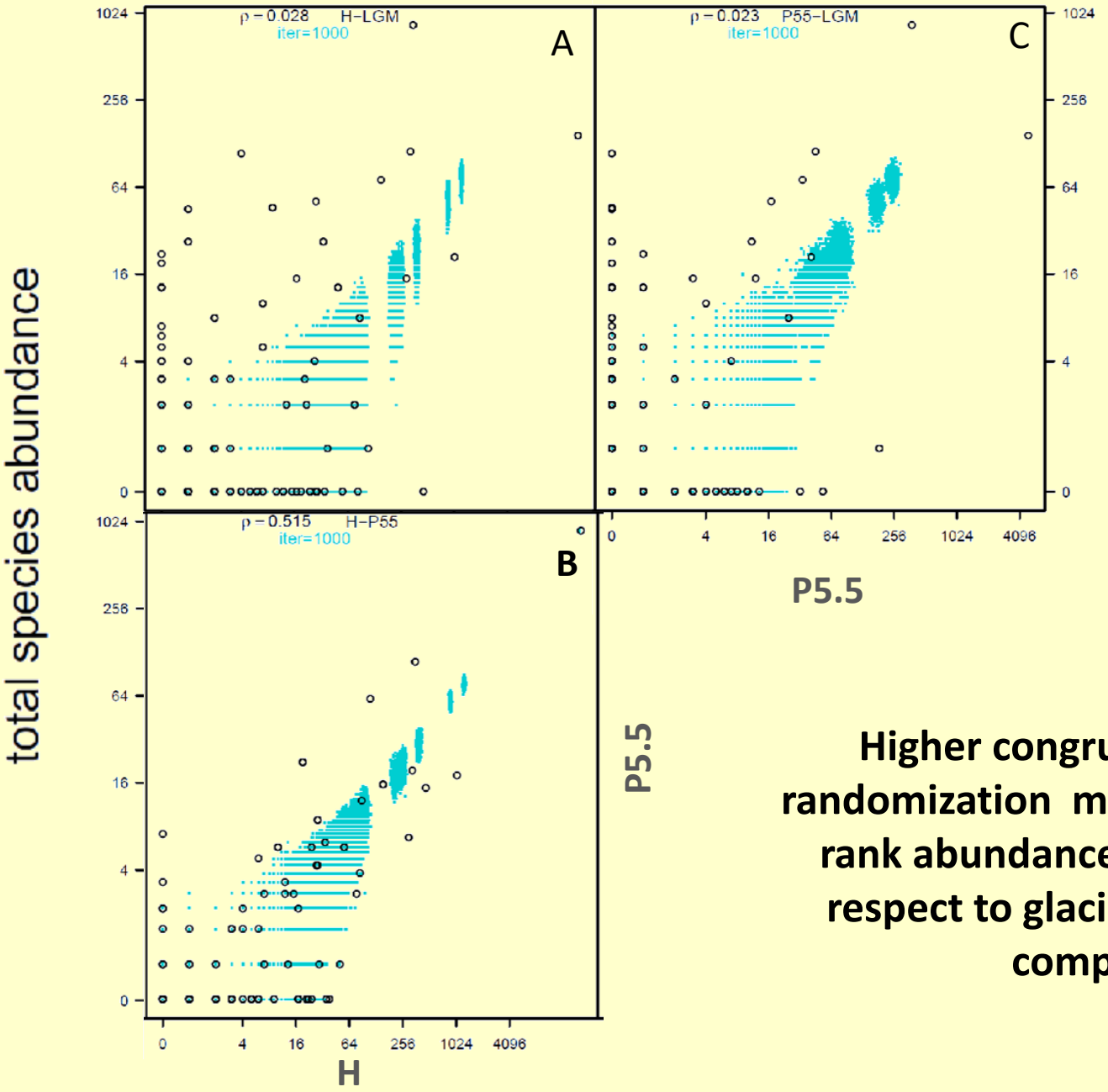
Hol = Holocene interglacial

LGM = Pleistocene glacial

P5.5 = Pleistocene interglacial

Pairwise comparisons of samples. Bray-Curtis dissimilarity was employed to evaluate similarity between nearshore assemblages from investigated pairs of targeted periods. Red arrows mark the location of the observed mean values of Bray Curtis (BC) distances for each frequency distribution of the three pairwise comparisons. The x-axis reports BC dissimilarity range, 0 value the two samples have the same faunal composition, 1 no species in common. In green sampling distributions of means based on randomization model (resampling without replacement, 1000 iterations) under the null model that the samples came from the same system.

GLACIAL *vs* INTERGLACIAL: RANK ABUNDANCE COMPARISONS



Time periods

Hol = Holocene interglacial

LGM = Pleistocene glacial

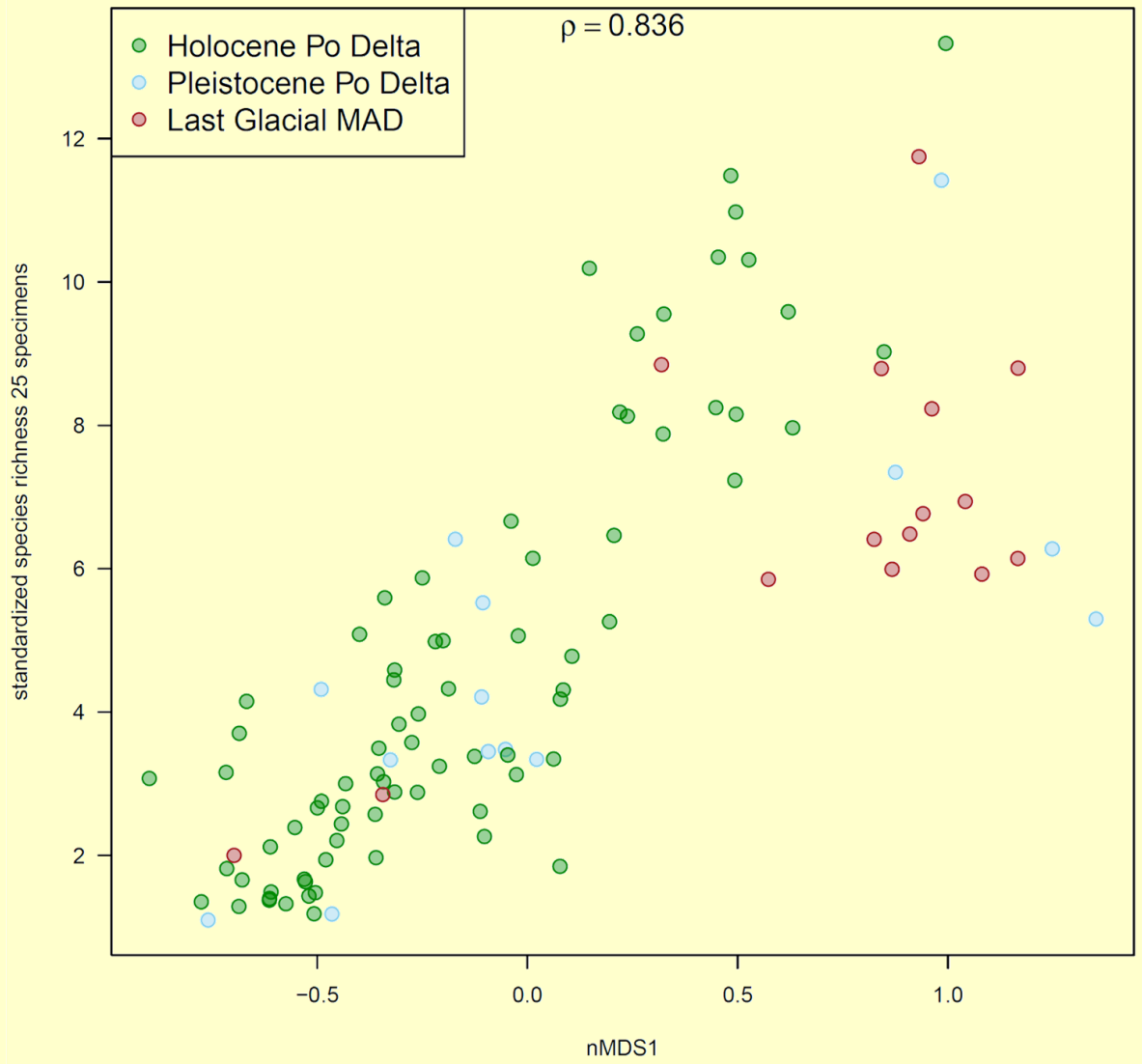
P5.5 = Pleistocene interglacial

Higher congruence between randomization model and H *vs.* P5.5 rank abundance comparison (B), respect to glacial *vs.* interglacial comparison

Pairwise comparisons of species total abundance (pooled data from targeted intervals). Holocene interglacial and Late glacial (A); Holocene and Pleistocene interglacial (B); and Late glacial and Pleistocene interglacial (C).

Species total abundance has been standardized by decostand function, method logarithmic base 2 in R software. The output of the randomization model based on 1000 iterations highlight in blue the portion of two-dimensional space in which the points should fall in case they were from a system with comparable species abundance.

GLACIAL AND INTERGLACIALS: STANDARDIZED SPECIES RICHNESS



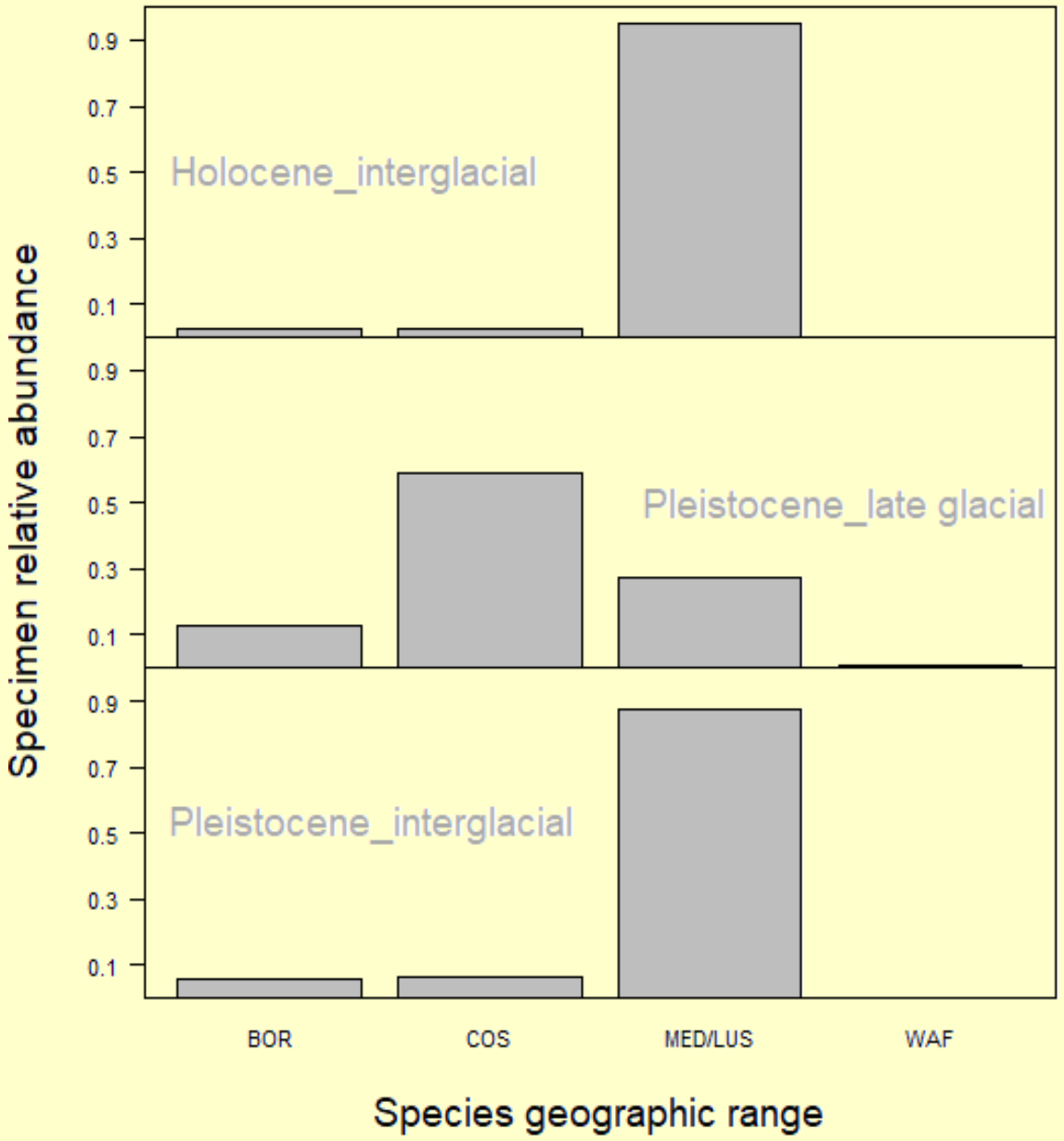
LGM Nearshore Deposits → Higher Standardized Diversity

Diversity drives similarity or dissimilarity between investigated time periods.

This graph shows a high spearman rank correlation between NMDS axis 1 sample scores and standardized (25 specimens) species richness of the investigated samples.

In detail, Holocene and Pleistocene nearshore deposits are both characterized by samples with low standardized diversity, whereas last glacial nearshore deposits show higher diversity.

GLACIAL AND INTERGLACIALS: BIOGEOGRAPHY



Species Biogeography

BOR= Mediterranean to Boreal

COS= Cosmopolitan

MED/LUS= Mediterranean to Lusitanian

WAF= Mediterranean to West African

Comparisons of specimens relative abundance coded by their geographic range (after Poppe and Goto 1991).

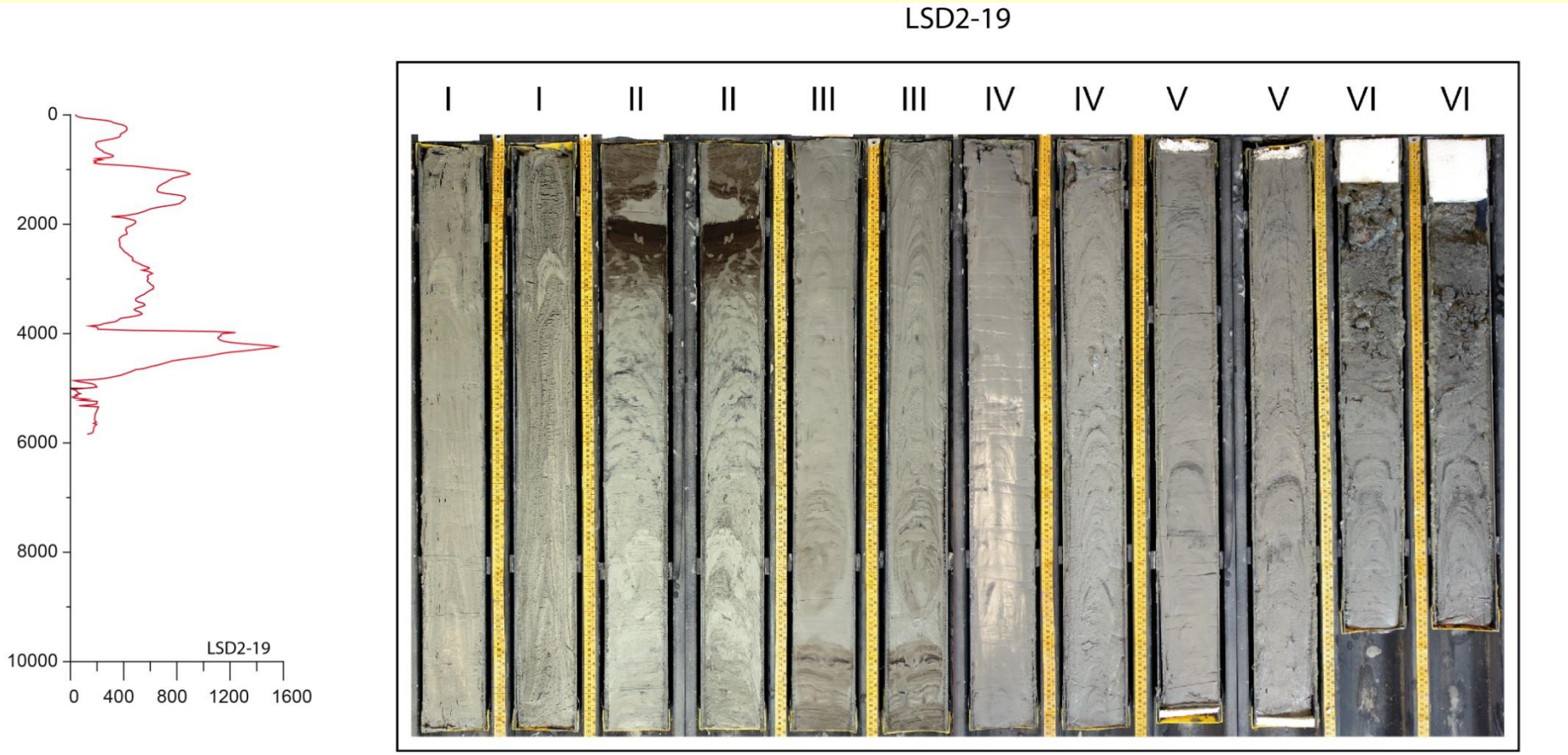
Both interglacial periods show a very similar distribution and are dominated by specimens of Mediterranean/Lusitanian affinity. Whereas in the glacial period, specimens are more evenly distributed among Cosmopolitan, Mediterranean and Boreal categories.

CONCLUSIONS

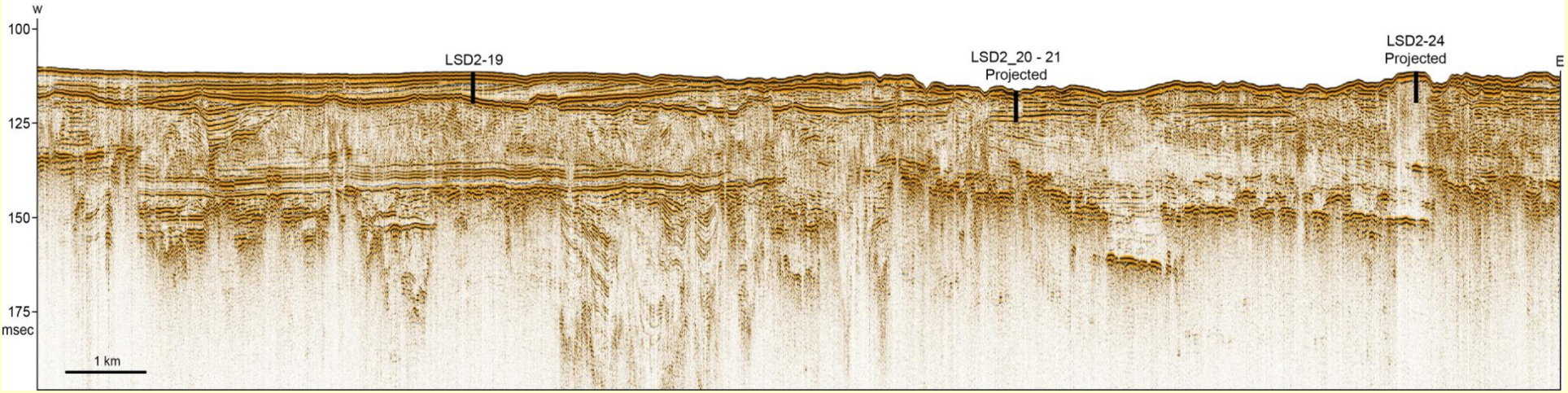
Pairwise distances, rank abundance comparisons and biogeographic patterns indicate a higher similarity between the interglacial nearshore communities (P5.5 *vs.* Hol) than between the glacial and interglacial nearshore communities (P5.5 *vs.* LGM and Hol *vs.* LGM).

When compared to the interglacial nearshore mollusk samples, the Glacial nearshore mollusk samples are characterized by higher equitability and elevated abundance of cosmopolitan specimens.

The coordinated response to climate change reported here indicates that the targeted benthic communities have been resilient to major, long-term environmental perturbation driven by natural processes.



Core from near Mid-Adriatic Deep



High resolution seismic profile

WESTERN MAD: CORE & SEISMIC LINES