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Journal
Biogeographia – The Journal of Integrative Biogeography, 24(1)

ISSN
1594-7629

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Publication Date
2003

DOI
10.21426/B6110126

Peer reviewed

Biogeographia vol. XXIV - 2003
(Printed October, 31st 2003)
Marine biogeography of the Mediterranean Sea: patterns and dynamics of biodiversity

Sea level change in Italy during last 300 ka. A review

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Key words: sea level, isostatic rebound, radiocarbon ages.

SUMMARY

This paper is a review about the sea level change in Italy during last 300 ka and the markers used to constrain the curves. In particular is underlined as it is important to distinguish between Global, Local and Predicted sea level curves.

INTRODUCTION

Sea level change can be reconstructed from dated fossil coral reef terraces, and these data are complemented by a compilation of global sea-level estimates based on deep-sea oxygen isotope ratios at millennial-scale resolution or higher. Because of the lack of coral reefs in the Mediterranean seas, results on late Quaternary sea-level changes have been difficult to obtain in comparison with typical sites such as Barbados, the Huon Peninsula, Tahiti and others. Otherwise, the very low tidal range of Italian seas offers a good opportunity to produce precise palaeo-sea level curves.

Sea level change along the Italian coast is the sum of eustatic, glacio-hydro-isostatic, and tectonic factors. The first is time-dependent while the latter two also vary with location. This wants to say that at the same time slices, the relative sea level (the sum of 3 different movements) should be different in different coastlines. For any palaeo reconstruction of ancient coastline it is necessary to take in account all components. It is important to distinguish between **Global** sea level curve (**s.l.c.**), **Local** s.l.c. or **Predicted** s.l.c., constrained using geophysical models.

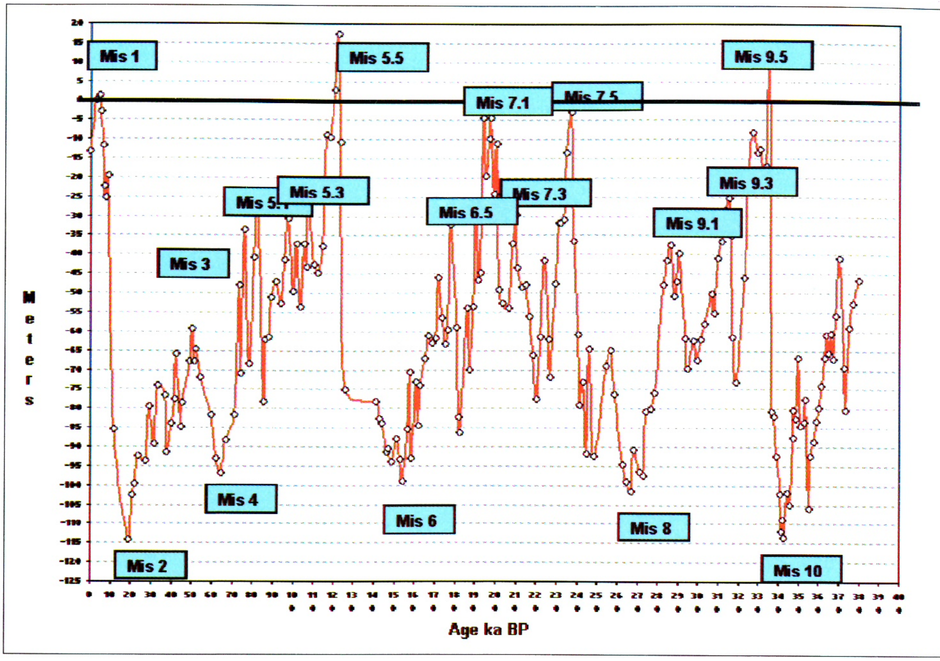


Fig. 1 - Siddal et al. (2003) Global sea level curve.

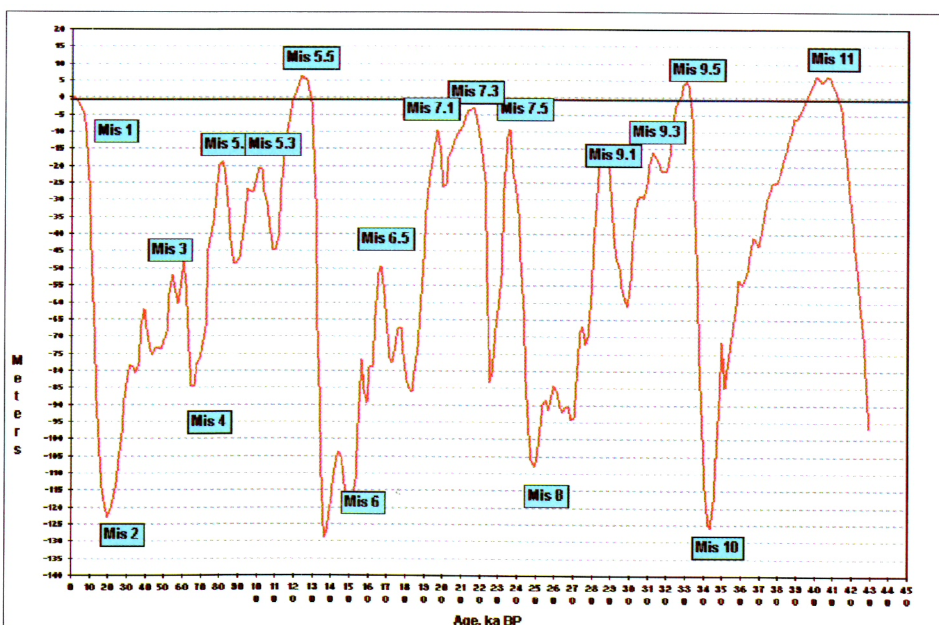


Fig. 2 - Waelbroeck et al. (2002) Global sea level curve.

Global

Global s.l.c. are generally constrained analyzing $\delta^{18}O$ ratio on Foraminifera series, sampled on mud core of Ocean bottom. The $\delta^{18}O$ ratio in facts, showing a direct correlation with sea level variations allows calculating the sea level changes. This kind of reconstruction does not take in account any isostatic component. Two s.l.c. recently published and often quoted on international journals, are here are exposed as examples: Woalbreak et al., 2002; Siddal et al., 2003 (Figs. 1 and 2).

Local

To constrain a Local s.l.c. it is necessary collect and date many fossils, well connected with sea, at different depths. Biological markers, living at intertidal environment (i.e. *Dendropoma* reef) are considered the best. Maximum error bars is in fact the mean annual tide (Fig. 3).

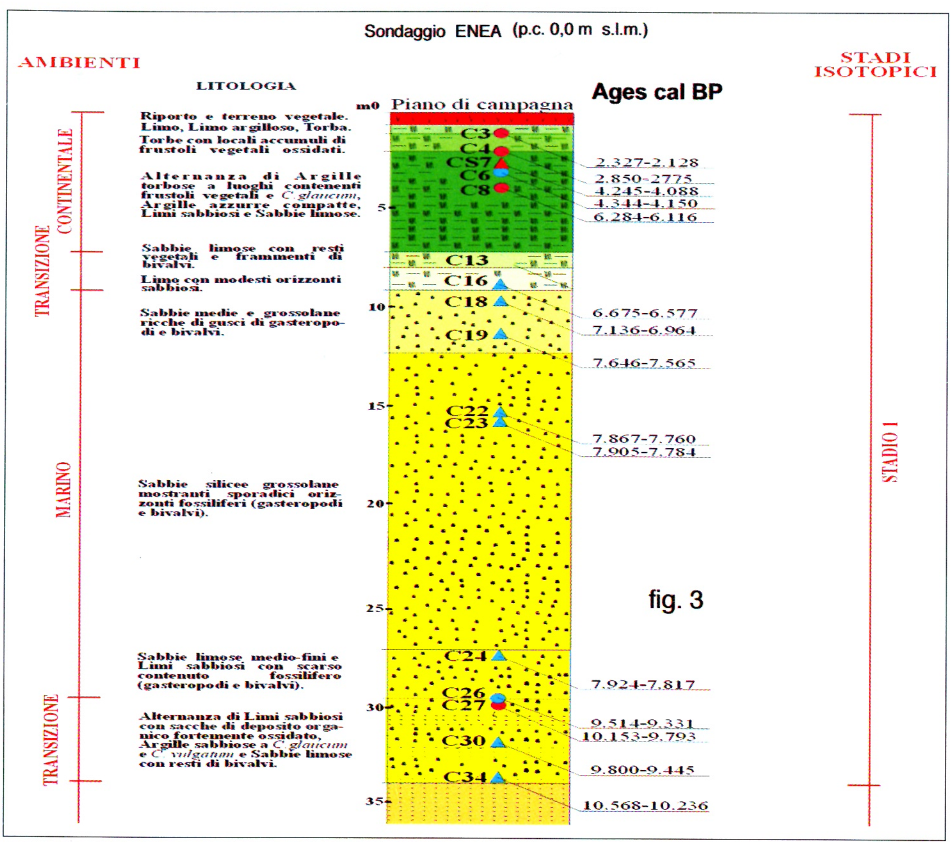
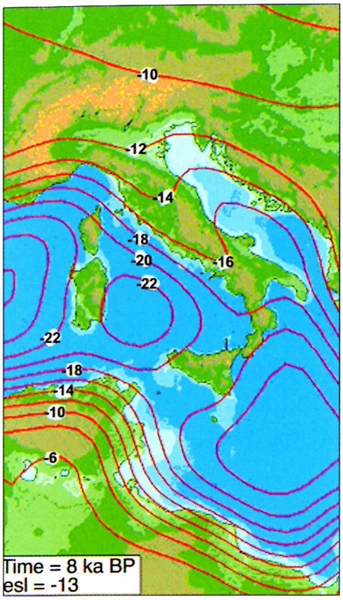


Fig. 3 - Detail of the core drilled on the stable coast of Versilia Plain (Central Italy), the first 34 m crossed Holocene deposits, the aged lagoon fossils constrain one of the best Local sea level curve of Italy.



Figs. 4 and 5 - After Lambeck et al. (in press). Palaeogeographic reconstructions at 8 and 20 ka for the central Mediterranean region. The red (negative) contours refer to the sea level change. The ice-volume-equivalent sea level (esl) values for each epoch are given in meters.

Predicted

Geophysical models predict sea level change (with glacio-hydro-isostatic rebound) taking in account, (*i*) the ice thickness during glacial stages, (*ii*) the distance of the coastal site from the ice sites during glacial period, (*iii*) the rhology of the earth, (*iiii*) the density of the mantle and, obviously, the eustatic component that must be the same. Discrepancies between observed Holocene sea levels and model predicted values provide the information for refining the model parameters, it is important to compare any predicted s.l.c.

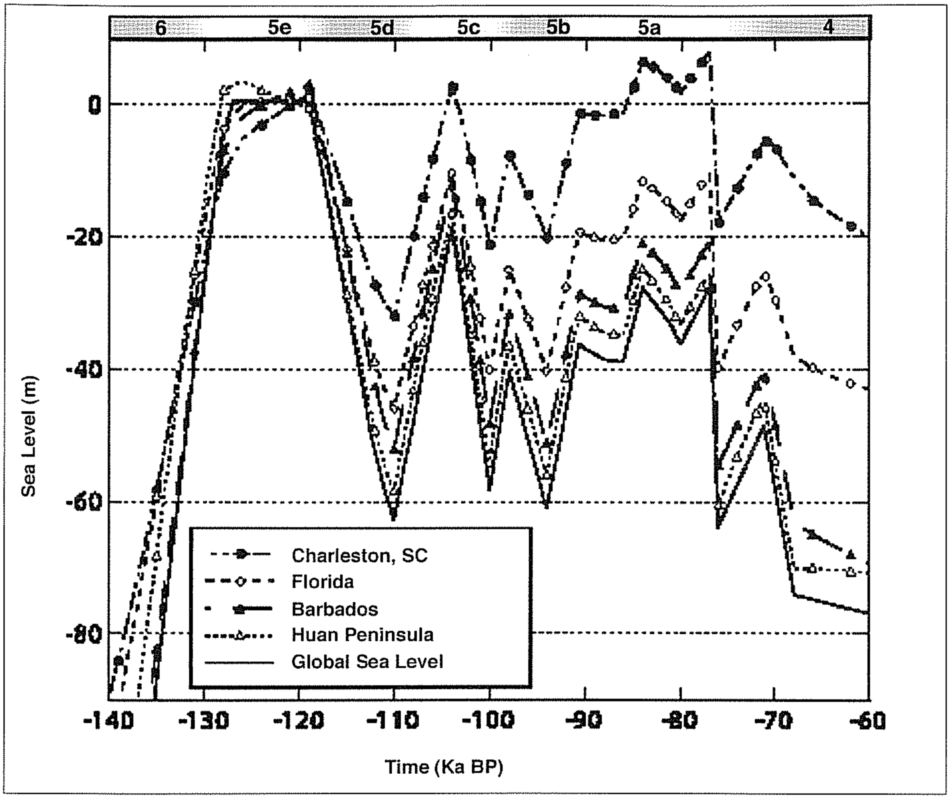


Fig. 6 - After Potter and Lambeck (2004). MIS-5 ice-equivalent sea-level model and Caribbean relative sea-level predictions. Note that there is a greater variation of predicted relative sea levels across the region for the MIS-5.1 and 5.3 highstand than for MIS-5.5.

with observed data. Models are based on palaeo-ice thickness, presently the information on ice thickness allows reconstructing LGM and older glacial time but for time periods prior to the last glacial maximum, the distribution and melting history of the global ice sheets are generally poorly constrained.

The relative sea levels in the Mediterranean regions are particularly sensitive to the melting history of the European and North American ice sheets respectively. These two ice bodies may also vary independently, thus producing additional complications for the comparison of the relative sea level at these sites. Data for MIS 6, 8, are scarce for the Mediterranean, thus, it is difficult to reconstruct sea level older than MIS 5.

It is important to note that for the same time slice relative sea level change could show large differences (due to the different isostatic rebound). For example 2000 years ago (during Roman age) sea level was eustatically 0.12 cm lower than Present but (for isostatic rebound) the relative sea level rise is 0.5 m in north

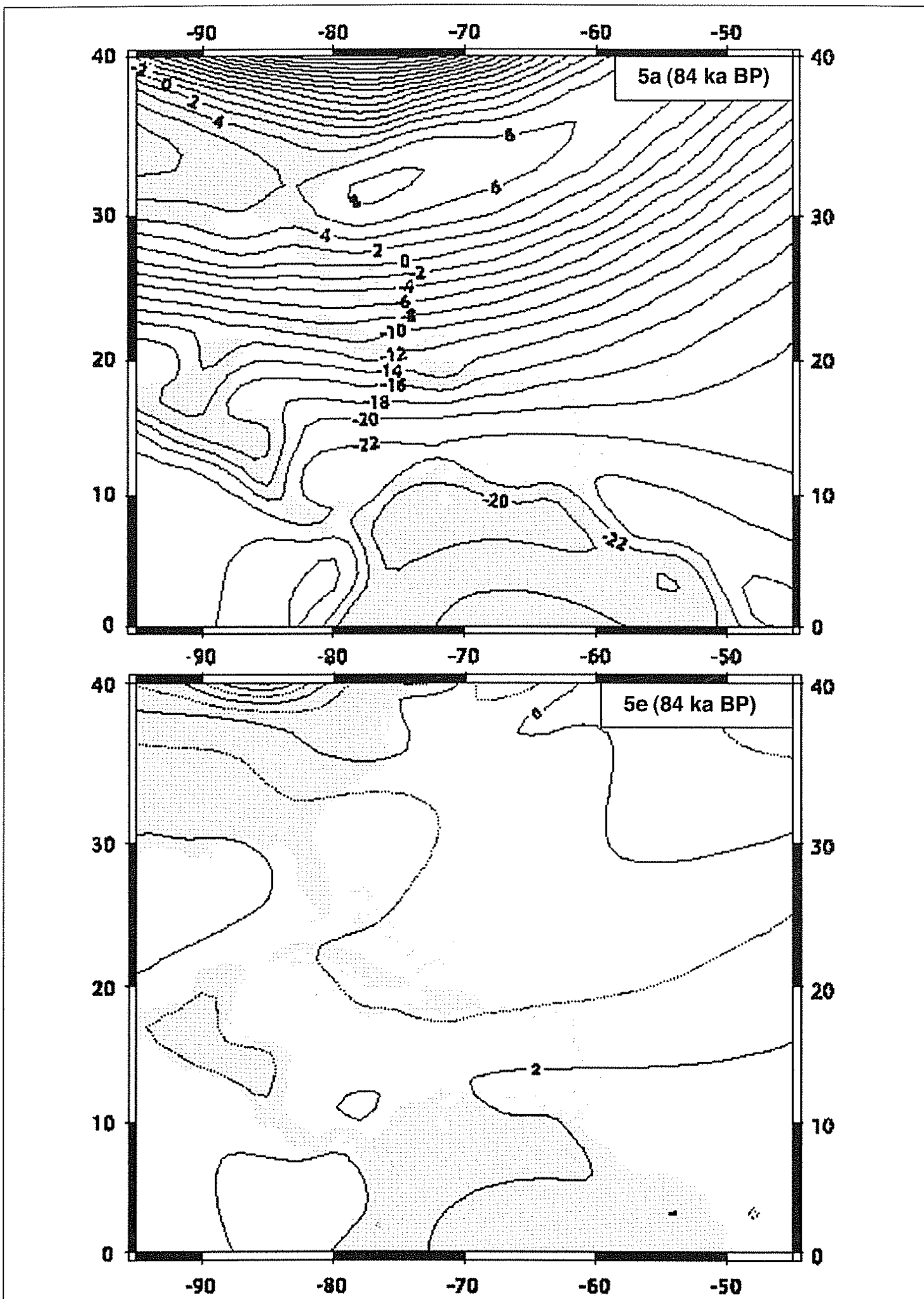


Fig. 7 - After Potter and Lambeck (2004). Spatial variability of MIS-5.1 and 5.5 relative sea levels across the Caribbean and West Atlantic region. There is a significant gradient in MIS-5.1 relative sea level across the region but a very little gradient in the MIS-5.5 relative sea level.

Adriatic Sea and about 2 m in Sardinia (Lambeck et al., 2004a). Larger discrepancies occur for older period as shown in Figs. 4 and 5.

Discrepancies in sea level observations can often be explained by the influences of glacio-hydro-isostasy, which describes the response of the Earth, and hence sea level, to changes in ice and water surface loading. For example, Potter and Lambeck (2004) compared the altitude of MIS 5.1 deposits (84 ka BP) at sites across the Caribbean region and US Atlantic Coast. These deposits form a roughly SE-NW transect of increasing MIS 5.1 sea level ranging from −19 m at Barbados to +3 m on the US Atlantic Coast. By taking into account the glacio-isostatic effects of the Laurentide ice sheet, these seemingly conflicting observations can be reconciled (Figs. 6 and 7).

These examples clearly show how it is very difficult to make land-sea changes reconstruction during Pleistocene only providing data on eustatic sea level changes.

ITALIAN DATA

The sea-level indicators widely used in Italy for studying sea-level change comprise: biological markers such as vermetids reefs (Antonioli et al., 1999), *Cerastoderma* sp. (Segre, 1967) or *Lithophaga* sp. (Rust and Kershaw, 2000), coastal plain and offshore cores containing biological sea level indicators (Blanc 1936; Marocco, 1991; Barra et al., 1996; Correggiari et al., 1996; Preti, 1999; Galassi and Marocco, 1999; Antonioli et al., 2001), submerged speleothems with marine overgrowths (Antonioli and Oliverio 1996, Antonioli et al., 2001; Antonioli et al., in press), phreatic speleothems (Tuccimei et al., 2000), archaeological remains (Smiedt, 1972; Pirazzoli, 1976; Antonioli and Leoni 1998; Lambeck et al., 2004b), beach-rock (Demuro and Orrù, 1998) as well as fossil beach and lagoonal deposits (Blanc, 1936; Hearty et al., 1986, Antonioli et al., 1988). Here a short review of the published data (and markers) used to calculate palaeosealevel change for *Italian stable* coastal area.

Holocene and MIS 5.5

An exhaustive review by Lambeck et al. (2004a) reports the whole available data on Holocene sea-level changes for the Italian seas, as well as the sea level indicators used and the associated error bars.

Many studies have focused on the dating of Italian landscapes and deposits related to MIS 5.5 highstand (also called *Tyrrhenian*, 124 ka BP): Carobene and Pasini (1982), Hearty and Dai Prà (1986), Cosentino and Gliozzi (1988), Bordoni and Valensise (1998). There is no doubt about the maximum highstand reached during Mis 5.5 in Italy, which seems to be between 6 and 8 m above sea level. On the other hand, sea-level data on other periods are scarce.

MIS 5.1-5.3 (80, 110 Ka)

Hearty and Dai Prà (1986), Mauz (1999), Iannace et al. (2001), Riccio et al. (2001), indicate elevations of 5-2 m higher than or close to present-day sea level. Antonioli et al. (in press), observed sea level during MIS 5.1-5.3 lower than −20 m, in agreement with global sea level curves. Two recent Regional sea level curves obtained from corals, Cutler at al. (2003: Barbados and Huon Peninsula) and Toscano and Lundberg (1999) from Florida put the highstand of these interstadial periods below sea level between −5 and −18 m.

MIS 6.5-7.1-7.3-7.5

The alpha counting age (165 ± 15 ka) provided on the top of a stalagmite (presently submerged by the sea) sampled in the Grotta di Nettuno together with $\delta^{18}O$ series (Antonioli et al., 2003) suggests that MIS 6.5 sea level peaked at a level lower than −52 m, in agreement with the Barbados corals analyzed by Gallup et al., 2003, the Global s.l.c. of Woalbreak et al. (2002). Tuccimei et al. (2000) sampled some phreatic speleothems (Vesica et al., 2000) in the Nettuno cave (Sardinia Italy) at +2.75 m and 1.85 m, obtaining ages of 195 ± 5 and 233 ± 18 ka (TIMS U-Th).

More recently, Bard et al. (2002) used TIMS U-Th methods to date a stalagmite sampled at −18.5 m in the Argentarola Cave, thus obtaining constraints on the timing and sea-level highstand for MIS 7.1 (from −18). Stalagmites studied in the Argentarola cave are of very special interest because they exhibit several continental layers (speleothems) corresponding to periods of low sea level. During highstands, the cave was flooded and the speleothems were covered by overgrowths formed by colonies of the marine worm *Serpula massiliensis.* This marine and continental archive, recording more than one climatic cycle, is particularly useful because it is directly linked with sea level. Antonioli et al. (in press) state that MIS 7.3 reached −21.5 m.

No data are published for Italian stable coast on older MIS, see on Tab 1 the global sea level data.

CONCLUSION

Discrepancies in sea level observations on stable area can often be explained by the influences of glacio-hydro-isostasy. Before operating reconstructions on land-sea changes during Pleistocene it is necessary to collect data on glacio-hydro-isostasy and tectonic movements. Reconstruction for the last glacial cycle (20 ka) is indeed possible due to last researches recently published for Italian coasts.

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