Available online http:/amq.aiqua.it
ISSN (print): 2279-7327, ISSN (online): 2279-7335

Alpine and Mediterranean Quaternary, 25 (1), 2012, 15-23

SEA LEVEL CHANGE IN WESTERN-CENTRAL MEDITERRANEAN SINCE 300 KYR: COMPARING GLOBAL SEA LEVEL CURVES WITH OBSERVED DATA

Fabrizio Antonioli
ENEA - UTMEA, Casaccia, Roma, Italy
Corresponding author: <fabrizio.antonioli@enea.it>

ABSTRACT: In this study, we used published sea level markers to provide a review of observational data for the Western-Central Mediterranean during the last 300 kyr. For the last interglacial (MIS 5.5, 125 kyr BP) and Holocene (10 kyr cal BP) periods, hundreds of data have been observed, measured, and dated using ^{14}C, U/Th, amino acid racemization (AAR), and electron spin resonance (ESR) methods. The maximum highstand for a MIS 5.5 sea level is normally set at 7±2 m. This altitude remains a key value for the Mediterranean Sea and is often used to establish the neotectonic stability of coastal areas or to uplift/downlift rates in a tectonically active coast.

Information on MIS 9 is available only from cores or terraces in tectonically active coastal areas. Knowledge on MIS 7 was recently improved by papers reporting precise sea level data from submerged speleothems in a stable coastal area: the Argentarola cave (Tyrrhenian Sea, Italy). These data (highstand duration and sea level) agree with global eustatic sea level curves. On the contrary, few observed data are available for MIS 3, 5.1, and 5.3. Moreover, most of these data disagree with global sea level curves. Only one recorded and dated observational datum for MIS 2 was published for the Late Glacial Maximum (LGM) lowstand (-129.5 m in Sicily). This datum agrees with global sea level curves and predicted sea level data from glacio-hydro-isostatic models.

With regard to the Holocene period, it can be assumed that sea level changes along the Mediterranean coasts are the sum of eustatic, glacio-hydro-isostatic, and tectonic factors. The first is only time dependent, while the latter two also vary with location, which means that at the same time slices the sea level (the sum of three different movements) may be different in different coastlines.

Keywords: Western-Central Mediterranean, global sea level change curves, observational data, last 300 kyr.

1. INTRODUCTION

This paper tries to use state-of-the-art methods in determining the observational points well connected to sea levels, comparing them with global sea level curves. This review constitutes a starting point for improving the observational data required for the projection of future coast scenarios. In some periods, such as MIS 9 and 3, no observed data are available in stable coastal areas: for completeness of information, data are reported also in tectonically active areas, corrected with tectonic rates.

The largest uncertainty in future sea level rise stems from our lack of a clear understanding of the dynamic response of ice sheets to anthropogenic climate change. The paleo records of sea level changes are potential resources to better constrain estimated future sea level rise (IPCC, 2007). Sea level (hereafter, sl) variations during the last 300 kyr were caused by solar insolation (Fig. 1) and ice melting, and they vary between +7 and -135 m in stable coastal areas in the Western-Central Mediterranean Sea (Waelbroek et al., 2002). Global sl curves are generally constrained by analyzing the δ^{18}O ratio in the fossil foraminifera series, sampled on either the shelf edge or the ocean floor. Changes in the δ^{18}O ratio show a direct correlation with sl variations, allowing a quantitative estimate of sl changes. These curves do not take into account any isostatic or tectonic component. The global sl curves reported by Waelbroek et al. (2002) (Fig. 2) and Siddal et al. (2003) were used in the present study. These authors show that robust regressions can be established between the relative sea level data and the oxygen isotope ratios of benthic foraminifera from the North Atlantic Ocean and the Equatorial Pacific Ocean over the last climatic interglacial cycle. Sea level predictions for the last 20 kyr using isostatic models are accepted worldwide. These models are often tested with observational data in tectonically stable areas. The isostatic contribution for MIS 5 has been the subject of recent publications (Potter & Lambeck, 2004, for MIS 5.3 and 5.1 and Lambeck et al., in press, for MIS 5.5), but for the Mediterranean Sea, the geophysical data are still lacking. Completing these data will be the main challenge in sea level studies in the next years.

2. DATA

MIS 9

Waelbroek et al. (2002) and Siddal et al. (2003) indicated that during MIS 9.1, the sl stand was at -17 and -38 m, respectively (Table 1). No observational data are reported for stable coastal areas of the Western-Central Mediterranean Sea during MIS 9. With regard to tectonically active coasts (either subsiding or uplifting), in a core drilled in the Fondi plain (Antonioli et al., 1988, a slightly subsided coastal area, Tyrrhenian Sea, Central Italy), sediments containing marine fossils found at -32 m were dated using amino acid racemization (AAR) at aminozone G (MIS 9). In the core “Venezia 1,” Kent et al. (2002) indicated the presence of marine sediments

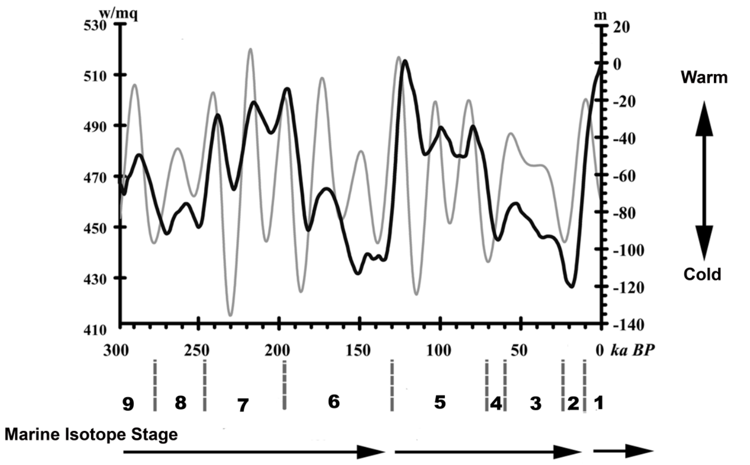

Fig. 1 - Summer insolation at 65°N, from Berger 1978. Global Sea-level curve from Imbrie et al., 1984.

during MIS 9 at about -200 m. This area indicates a negative downlift of about -0.6 mm/year for the last 125 kyr and a mean of 0.36 mm/year for the last 700 kyr. In southern Calabria, Italy, Miauyci et al. (1994) correlated MIS 9 with terrace VIII at about +300 m and indicated a mean of about +1 mm/tear for the last 125 kyr, in agreement with the data of Westaway (1993).

MIS 7

For MIS 7.1, 7.3, and 7.5, Waelbroek et al. (2002) indicated that the sl was located at -10, -4, and -9 m, respectively, below the present sea level. In Siddal et al. (2003), on the other hand, the sl is at -5, -29, and -3 m, respectively (Table 1). In Italy, a MIS 7 record was found and dated in a submerged cave. The cave is located in a coastal area (in the Argentarola Island, Central Italy) that can be considered tectonically stable (Bard et al., 2002).

Some speleothem samples from the cave are peculiar because they recorded several continental marine transitions. During lowstands, when the cave was emerged, dense sections of speleothem calcite were formed. During highstands, on the other hand, the Argentarola cave was flooded and stalagmites were covered by colonies of the marine worm *Serpula massiliensis*.

In the same cave, Bard et al. (2002) and Dutton et al. (2009) determined that the sea level elevation peaked at -18 m during the MIS 7.3 highstand and was between -18.5 and -21.0 m during the MIS 7.2 lowstand. In contrast, the peak sea levels during MIS 7.5 and 7.1 were above the highest reference point in the cave (-18 m). The observed lower peak sea level during MIS 7.3 relative to MIS 7.5 and 7.1 agrees with sea level reconstructions of global sl curves that are based on seawater $\delta^{18}O$ determinations and with the flowstone DWBAH sampled in submerged cave in Bahamas (Richards et al., 1994).

Underwater investigations along Italian coasts (Antonioli & Ferranti, 1994; Rovere et al., 2011) have shown a recurrent paleo-sea level from -15 to -20 m. Geomorphological evidence of this sea level remains at subhorizontal abrasion surfaces, which are visible on a cliff bordering some carbonate promontories. Antonioli & Ferranti (1994) related the submerged terraces to MIS 3, but I agree with Rovere et al. (2011) that these submerged terraces could be related to MIS 7 or, alternatively, to lower MIS 5 stages.

Tectonically active coastal areas: Using AAR methods, De Santis et al. (2010) found and dated MIS 7 marine sediments at -32 m in a core in a slowly downlifting area in the Apulia coast. On the other hand, using

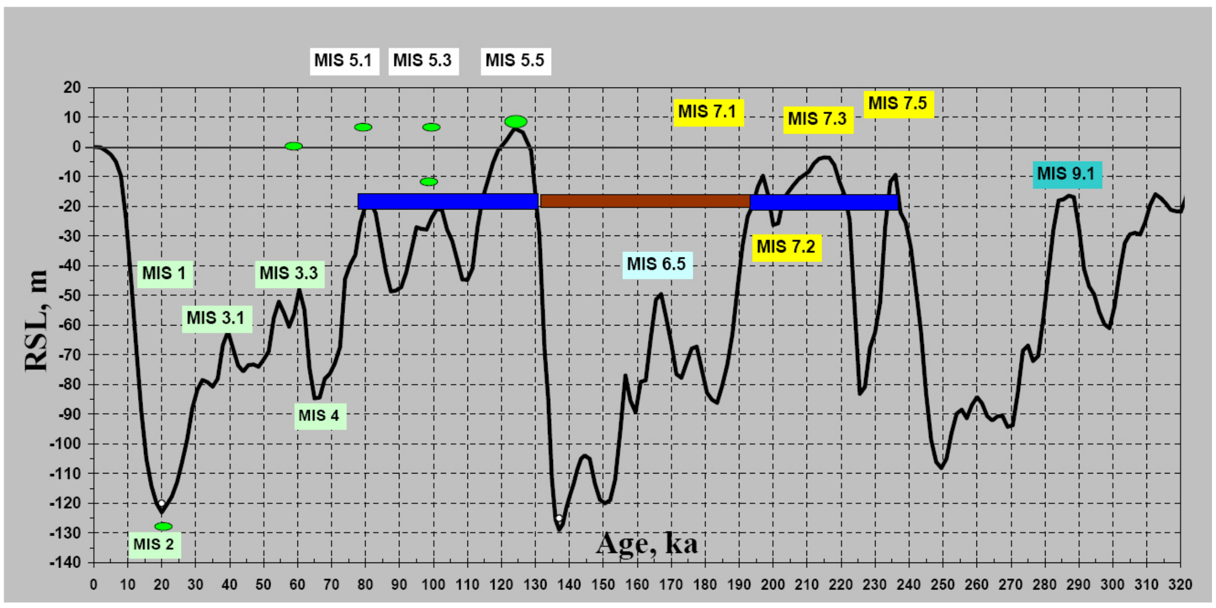

Fig. 2 - Global sea level curve from Waelbroek et al. (2002) with observational data in stable areas quoted in this paper (green ballon) and Argentarola marine (blue) continental Brown) layers.

Global sea level curve	MIS age	metres	Age Ka	Observed sea level	MIS / age	metres
	1	-		Lambeck et al., 2011 predicted s.l for Trieste	8 ka cal BP	-11.2 m
	1	-		Lambeck et al., 2011predicted s.l for Nora	8 ka cal BP	-18.7 m
Lambeck et al, 2011	2	-		predicted s.l for Termini Imerese (Sicily, Italy)	20 ka cal BP	-127 m
Waelbroek et al., 2002	2	-123	20	Caruso et al., 2011, observed on Termini Imerese continental shelf	21.8 ka cal BP	-129.5 m
Siddal et al 2003	2	-115	19.5			
Waelbroek et al., 2002	3.1	-62	39.5	Carboni et al., 2010, Amorosi et al 2004,	3.1	Not present at -60 m
Siddal et al 2003	3.1	-74	33.6	Belluomini et al., 2002	3.1	+1
Waelbroek et al, 2002	3.3	-48	60.5	Antonioli et al., 2004	3.3	deeper than -21
Siddal et al 2003	3.3	-53	66	Iannace et al., 2003		3-4
Waelbroek et al, 2002	5.1	-19	81.5	Dorale et al., 2010	81 ka	+1
Siddal et al 2003	5.1	-28	82.9	Riccio et al., 2001, 2003; Iannace et al., 2003, Mastronuzzi 2007, Hearty 1986, Rodriguez Vidal et al 2004	5.1	+1 and +5
Waelbroek et al, 2002	5.3	-21	102	Amorosi et al., 2004	5.3	-12
Siddal et al 2003	5.3	-27	107	Riccio et al., 2001; Iannace et al., 2003, Zazo et al 2009, Rodriguez Vidal et al 2004	5.3	between +6 and +2 m
Waelbroek et al, 2002	5.5	7	124	Lambeck et al 2004, Ferranti et al. 2006, 2010	5.5	between +6 and +8 m
Siddal et al 2003	5.5	17	123			
Waelbroek et al, 2002	6.5	-50	167	Bard et al 2002	6.5	Deeper than -22 m
Siddal et al 2003	6.5	-32	177			
Waelbroek et al, 2002	7.1	-10	189.7-201.5*	Bard et al., 2002, Dutton et al., 2009*	7.1	Above -18 m
Siddal et al 2003	7.1	-5				
Waelbroek et al, 2002	7.3	-4	206.0-217.2*	Dutton et al., 2009*	7.3	-18 m
Siddal et al 2003	7.3	-29				
Waelbroek et al, 2002	7.5	-9	231.0 – 248.9*	Dutton et al., 2009*	7.5	Above -18 m
Siddal et al 2003	7.5	-3				
Waelbroek et al, 2002	9.1	-17	288			
Siddal et al 2003	9.1	-24	287			

Tab. 1 - Global sea level curves compared with predicted and observed sea level data in stable areas for Western-Central Mediterranean sea.

TIMS U/Th, Antonioli et al. (2009) found and dated a MIS 7.1 (197 kyr BP) sample of *Cladocora caespitosa* at -72 m in the ENEA core in Versilia, Central Italy. In southern Calabria, Miauyci et al. (1994) correlated a terrace located at about +250 m to MIS 7.

MIS 6-5.5

Few observational records show a very rapid oscillation of sl, named Termination II, at about 135 kyr BP, which cannot be explained by the Milankovitch theory in its simplest form. After tectonic corrections, data show that sl reached -18 m around 135.8 kyr BP on the Barbados coral reefs (Gallup et al., 2002) considered slowly uplifting. At Huon Peninsula (Papua New Guinea), Esat et al. (1999) dated some corals from the "Aladdin's cave" evaluating a sl of -14 m at 135 kyr BP and a drop in sl of -80\60 at 130 kyr BP after tectonic corrections. No *in situ* observational data have been found in the Mediterranean Sea, but Capozzi & Negri (2009), and references therein, observed Termination II in an isotopic study of planktonic and benthic foraminifera.

MIS 5

MIS 5.5

The last interglacial (LIg) shoreline coincides with MIS 5.5, which occurred between 132 and 116 kyr BP (Stirling et al., 1998; Shackleton et al., 2003). The global sl curves (Waelbroek et al., 2002; Siddal et al., 2003) indicated sl at +7 and +17 m, respectively (Table 1).

A statistical approach on a worldwide compilation of data was published by Kopp et al. (2009), who determined the posterior probability distribution of LIg sl and ice volume through time, concluding that the high-

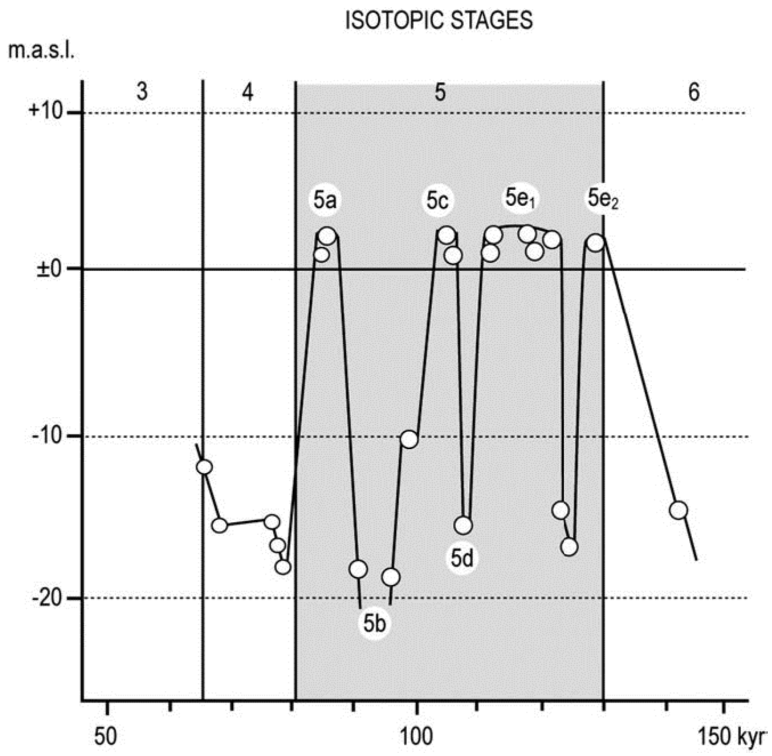

Fig. 3 - Eustatic sea level curve for the Last Interglacial using Mallorca data (Gines et al., 2001), from Bardaji et al. (2009).

stand peak was very likely to have exceeded 6.6 m and was likely to have been above 8.0 m although it is unlikely to have exceeded 9.4 m.

According to Siddal et al. (2010), the palaeosealevel data from far- and medium-field sites for the LIg period suggest that sl is attained close to its peak of 3–6 m above the modern sl by 126 kyr BP. Pedoja et al. (2011) provided a compilation of 890 records of paleo-shoreline sequences for MIS 5.5. They showed that "most coastal areas have risen relative to sea level with a mean uplift rate higher than 0.2 mm/a, more than four times, faster than the estimated eustatic drop in sl." The study concludes that plate-tectonic processes affect all margins and emphasizes the fact that the notion of a stable platform is unrealistic. These results, therefore, "seriously challenge the evaluation of past sl from the fossil shoreline record."

In a recent paper, Lambeck et al. (in press) demonstrated that "like their Holocene counterparts, sl during earlier interglacials can be expected to exhibit considerable spatial variability that depends on the location of a site relative to ice margins of both the immediately preceding glacial maximum and of the last glacial maximum, and on the earth's rheological response function response functions".

Their data show impressive differences (up to 15 m) for the LIg highstand in stable coastal areas, such as Australia, the Caribbean, and Red Sea. In southern Spain, Zazo et al. (1999) found and studied many sites between +20 and +1.5 m sl, dated MIS 5.5.

For the Italian coast, Lambeck et al. (2004) assumed a "nominal" age of 124±5 kyr and an elevation, in the absence of tectonics, of 7±3 m above the present sl. This elevation is higher than global estimates of this level because "the Italian sites lie relatively close to the former ice margins and the present MIS 5 shorelines in the Mediterranean may lie a few meters higher than for localities much further from the former ice margins" (Potter & Lambeck, 2004). These values are consistent with observations of tidal notches from Sardinia, Southern Lazio, Campania, and Western Sicily, which are believed to have been tectonically stable during the recent glacial cycles. Tidal notches, due to the low amplitude of tides in Italy (a mean of about 40 cm, with the exception of NE Adriatic and the Gulf of Gabes in Tunisia), are considered the best sl markers.

A recent compilation of MIS 5.5 sea level markers on 246 sites spanning the coastline of Italy (Ferranti et al., 2006) allows the distinction between stable and tectonically active coastal areas since the Late Pleistocene (Fig. 13 of this paper). Figure 1 of Ferranti et al. (2006) shows the distribution of MIS 5.5 markers in the whole Mediterranean Sea that vary between -125 m (Po Plain, Italy) and +190 m Corinth, Greece). This paper was implemented by new findings on the altitude of MIS 5.5 highstand in Tuscany and NE Adriatic Sea (Antonioli et al., 2009; Ferranti et al., 2010). Data from tectonically stable sites confirm that the highstand altitude reached by the sea in Italy during MIS 5.5 was 7±2 m above the present sl. A compilation of new and published evidence related to MIS 5 in southern Spain (considered stable since 125 kyr BP) was published by Bardaji et al. (2009), The authors concluded that "the palaeontological, sedimentological and geomorphological records of MIS 5 deposits in the Western Mediterranean, allows the proposal of a model for the connections between this basin and high latitude climatic changes in the Northern Hemisphere, in comparison with modern analogues, in this paper Authors published an eustatic curve for the LIg" (Fig. 3).

MIS 5.3

The global eustatic curves (Waelbroek et al., 2002; Siddal et al., 2003) indicate that the sea level during MIS 5.3 was located respectively at -18.7 and -28 m (Table 1). For MIS 5.3, there are some observational data in the Mediterranean in southern Spain (Zazo et al., 1999), which attribute to MIS 5.3 some deposits (dated using the U/th method) at altitudes between +6 and 0 m. In the vicinity of Gibraltar, considered stable since 125 ka, Rodriguez-Vidal et al. (2004) found deposits dated MIS 5.3 at +5 m.

In Italy, a flowstone covering a marine conglomerate and lying a few meters above the present sl was attributed to MIS 5.3 on the basis of U/Th ages (Riccio et al., 2001; Iannace et al., 2001, 2003). Transgressive lagoonal facies from the Po Plain (see core 240-S8 in Amorosi et al., 2004) were assigned a MIS 5.3 using the electron spin resonance (ESR) method on MIS 5.5

lagoonal deposit (Ferranti et al., 2006). Taking into account the present altitude of this deposit and the subsidence rates calculated using MIS 5.5 (about 1 mm/yr), a relative sl of -12 m can be established for MIS 5.3. The sediments of MIS 5.3 (and 5.1) were not found in the Veneto and Friuli Plain cores (North Adriatic Sea, Antonioli et al., 2009; Ferranti et al., 2010) affected by a negative tectonic between -0.6 and -0.4 mm\a. The authors interpreted this lack for the low seabed bathymetry of the North Adriatic Sea (about -10 m, some kilometres from the Present coastline): a confirmation that the altitude of these MIS was not higher than -15 m.

MIS 5.1

Waelbroek et al. (2002) and Siddal et al. (2003) indicated for MIS 5.1 a sl located at -21.2 and -26.7 m, respectively (Table 1). The observational data of MIS 5.1 deposits from coral reefs in the Caribbean Sea seem to disagree with the g.slc. In particular, discrepancies are found in transects in stable areas for the coast of Haiti, Bermuda, Bahamas, South Carolina, and Florida, with altitudes varying between -20 and +5 m. These controversial observations, however, are reconciled, taking into account the isostatic response of the Earth due to the North American ice sheets melting during the last glacial cycle (Potter & Lambeck, 2004). In the vicinity of Gibraltar, considered stable since 125 kyr, Rodriguez-Vidal et al. (2004) reported that deposits of MIS 5.1 are found between +2 and +1.5 m.

A MIS 5.1 sea level at about +1 m was recorded using phreatic speleothem sampled in a partially submerged cave at Mallorca in the Western Mediterranean (Dorale et al., 2010). In Southern Italy, a marine deposit located a few meters above the present sea level and attributed to MIS 5.1 based upon AAR was reported by Hearty (1986). In the Grotta del Diavolo (Apulia, considered a stable coastal area) (Ferranti et al. 2006, Mastronuzzi et al. 2007) studied and dated some marine deposits covered by flowstone. The U/th age calculated for the continental deposit allowed us to establish that MIS 5.1 is marked by a sea level position slightly higher than the present one. In the Argentarola cave, the $\delta^{18}O$ series on MIS 5 of a marine layer (serpulids) conserved in a speleothem at -18.5 m shows a continued deposition during MIS 5 (Antonioli et al., 2004). The lack of any hiatuses on the marine layer allows us to establish that the sea level never fell below -22 m during MIS 5.2 and 5.3.

The presence of two closely spaced tidal notches, both attributed to MIS 5.5, has been reported by Antonioli et al. (2006) in Sardinia (Orosei Gulf), a stable coastal area in Italy. There is no evidence in these studied sites for tidal notches at altitudes lower than MIS 5.5 (Fig. 4). The observational altitude of MIS 5.1 in the Mediterranean Sea sometimes disagrees with global sea level curves and remains a debated problem, which is also due to the lack of reliable isostatic models for MIS 5.

MIS 3

For MIS 3.3 and 3.1, Waelbroek et al. (2002) indicated that the sea level was located at -39.5 and -60.5 m,

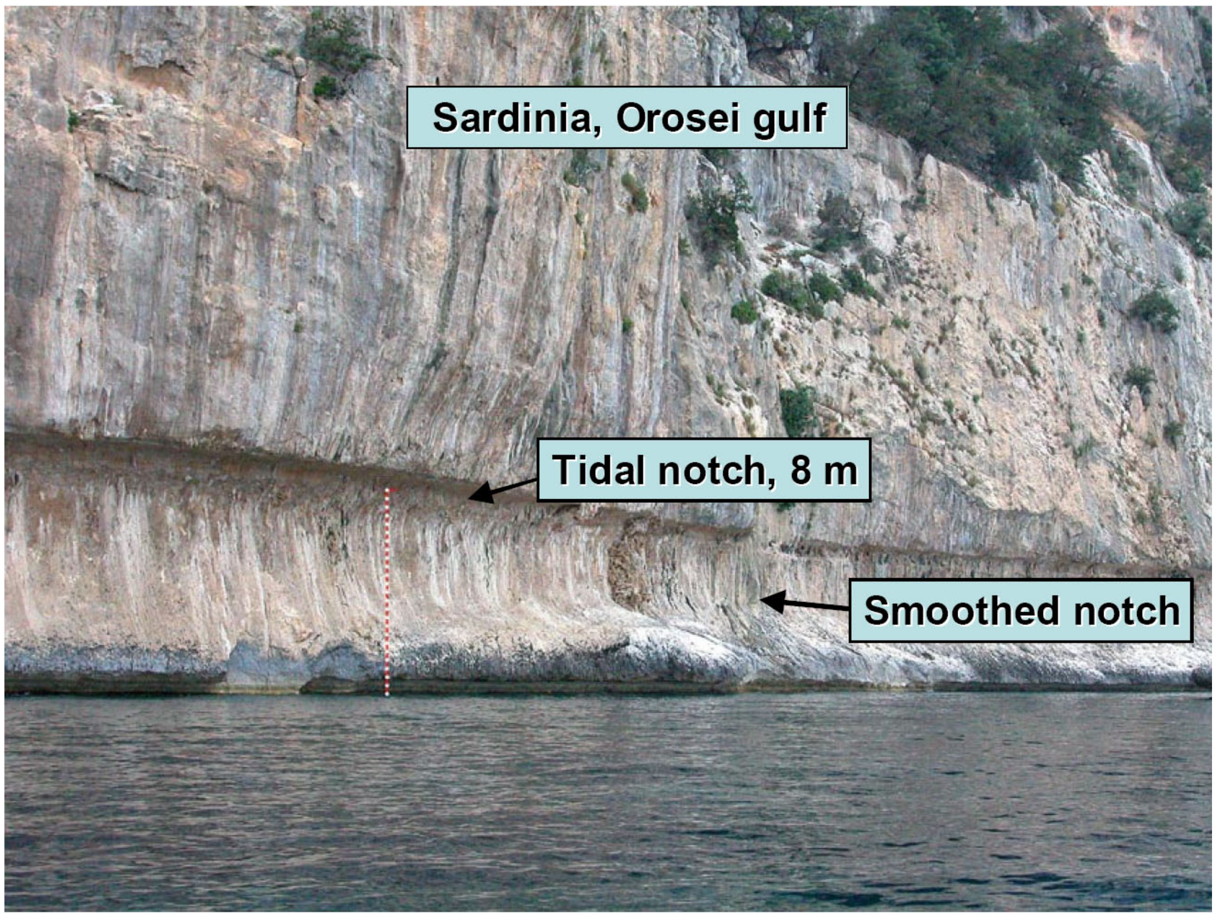

Fig. 4 - Orosei Gulf, Sardinia, Italy the tidal and smoothed notches of the MIS 5.5 highstand (see also Antonioli et al., 2006).

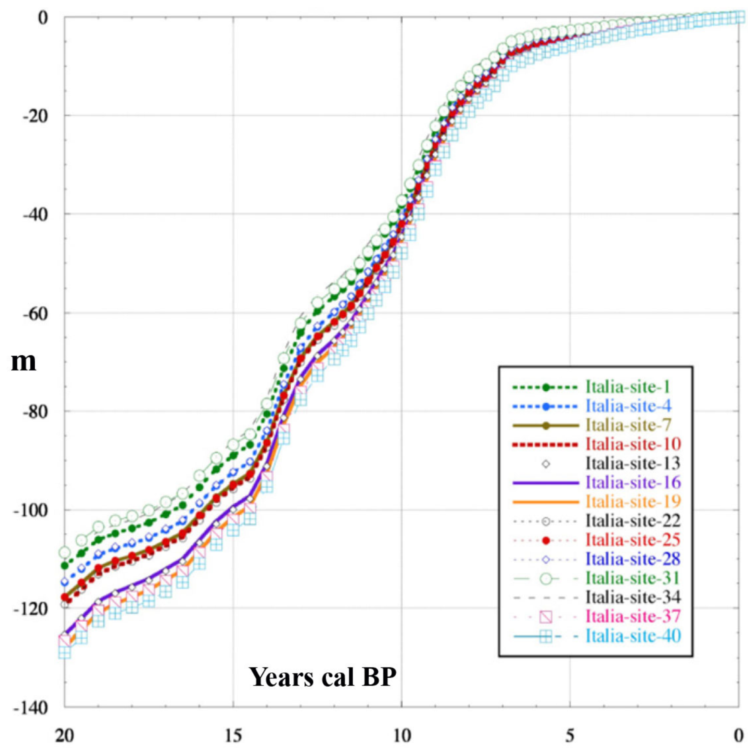

Fig. 5 - Eustatic and glacio-hydro-isostatic prediction for selected sites in Italy for the past 20 ka cal BP from Lambeck et al.(2011).

respectively, whereas Siddal et al. (2003) calculated the values -33.6 and -53 m for the same time intervals (Table 1). Data from the Mediterranean Sea are scarce for France. Lambeck & Bard (2000) wrote: "During stage 3, sea levels do not appear to have risen locally above about -60 m."

A marine deposit close to the present sea level was found in the Taranto Gulf (MIS 5.5 between 3 and 20 m (Ferranti et al., 2010) and dated to MIS 3 using the AAR method (Belluomini et al., 2002). U/Th dating of a flowstone overlying a marine conglomerate a few meters above sl allowed a correlation of the marine deposit to MIS 3 (Iannace et al., 2003) in Campania in a stable coastal area. Both findings disagree with global sea level curves. Subsurface data from the Po Plain (cores published by Amorosi et al., 1999, 2004) document that MIS 3 is represented by paludal and alluvial facies, with no intervening marine deposits. The same occurs in the Versilia Plain (Tyrrhenian Sea, Central Italy) where Carboni et al. (2010) studied the ENEA core up to -75 m.

MIS 2

For MIS 2 (LGM), Waelbroek et al. (2002) and Siddal et al. (2003) located the sea level at -123 and -114 m, respectively (Table 1). For the Mediterranean side of France, LGM shorelines are reported between -105 and -115 m below the present level. This range reflects the importance of the isostatic contributions for southern France.

Predicted sl values for Italy (Lambeck et al., 2011), which take into account the effects of glacio-hydro-isostatic movements, range between -130 and -108 m. LGM transgressive deposits recovered in a vibrocore sample on the shelf edge of Sicily (Termini Imerese) at -129.5 m furnished an age of 21.8 kyr cal BP (Caruso et al., 2011). These data agree with the local predicted sl curve by Lambeck et al. (2011).

MIS 1

Some paintings in the Cosquer cave (Marseille, France) aged 19 kyr cal BP, contained in the final portion of a flooded cave, demonstrate that the seal level maximum highstand was the present sl. (Clottes et al., 1997; Lambeck & Bard, 2000): The legs of horses are painted at tide level, and the bottom was eroded by sea water. On the contrary, the remaining top is perfectly preserved.

The Holocene sea level change along the Mediterranean coast during Holocene is the sum of eustatic, glacio-hydro-isostatic, and tectonic factors. The first is global and time dependent, while the latter two also vary with location. Large collections of Holocene data for France and Italy, using different markers well connected with sl, were published by Lambeck & Bard (2000) and by Lambeck et al. (2004). This large observational data set was compared with the predicted curves, leading to quantitative estimates of vertical tectonic movements (if present), identification of tectonically stable coastal areas, and paleogeographic reconstructions for the Central Mediterranean Sea at different epochs. These predictions were then extended to the whole Mediterranean Sea (Lambeck & Purcell, 2005). A complete review of the Holocene data, including the raw data files of the predicted sl data for 40 Italian sites, has been published recently [see the supplementary material in Lambeck et al. (2011)]. Significant differences can be observed in stable coastal areas if different sites are considered: As an example, the sea level at 10 kyr cal BP varies along the Italian coasts between -48 and -35 m, whereas at about 8 kyr cal BP, it ranges between -19 and -11 m (Fig. 5). In a recent paper, Pavlopulos et al. (2011) provided an extensive Holocene data from the coast and islands of Greece using archaeological and geomorphological markers. These observational data compared with predicted sea level curves (Lambeck & Purcell, 2005) allowed us to establish where the coast is stable, uplifting and downlifting, and to provide the tectonic rates.

3. DISCUSSION AND CONCLUSION

We compared eustatic curves presenting different data with different accuracies (i.e., sea level during MIS 3.3 set by Waelbroeck at -39 m and by Siddal at -33 m). There are uncertainties and error margins in the global eustatic sea level curves. Figure 6 show the error bar of Waelbroek et al. (2002).

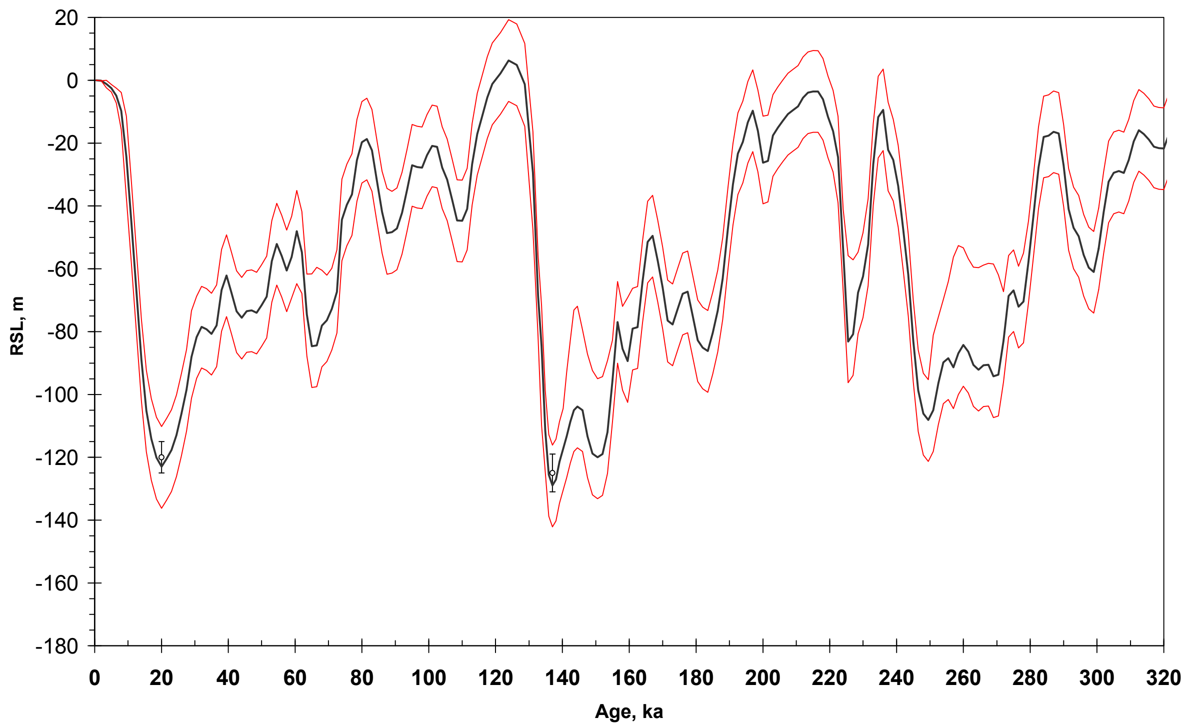

Fig. 6 - Global sea level curve from Waelbroek et al. (2002) with error bars (in red).

In stable coastal areas, data fit global curves in most cases, but there is a need for more reliable observational data sets in the Mediterranean. Also highlighting and resuming the efforts made in glacio-hydro–isostatic, modeling can be a good thing to remember, along with what is needed (i.e., modeling of MIS 5).

For MIS 9, no data are published for coastal areas stable in Western-Central Mediterranean. With regard to MIS 7.1, 7.3, and 7.5, data on age, duration, and elevation of the sea level are disposable for the Central Tyrrhenian Sea. MIS 7 appears to be below modern sea level, in agreement with global sea level curves.

Many observational data have been collected for MIS 5.5 (Ferranti et al., 2006). In Sardinia, Central Mediterranean, well preserved tidal notches provide evidence that MIS 5.5 highstand should be considered at 7±2 m. However, after the first published data (Lambeck et al., in press) on isostasy during MIS 5, it is possible that this is an average value for the Central Mediterranean Sea and that models that take into account the effect of isostatic could modify this altitude in the near future, especially between North and South Mediterranean.

With regard to MIS 5.3 and 5.1, data show in some coastal areas an altitude a few meters above sea level (southern Spain Mallorca, Apulia, Campania). On the contrary, with evidence in a core in the Po Plain, in the North Adriatic Sea cores, and in tidal notches of Sardinia (Antonioli et al., 2006), MIS 5.3 seems to agree with global sea level curves. At present, it is not possible to determine if the discrepancies are linked to isostasy differences (as observed in other areas, see Potter & Lambeck, 2004), problems in the interpretation of markers, or problems in dating.

MIS 3 observational data are scarce and disagree with global sea level curves. For MIS 3 the site in Apulia is slight uplifting the sites in Campania are stable could be possible some aging techniques problems. For MIS 2, the predictions of the position of the lowstand for Italy (Lambeck et al., 2011) and Central Mediterranean (Lambeck & Purcell, 2005) were published. The only observational data (Caruso et al., 2011) on the north Sicilian continental shelf agree with the predictions (Table 1). Many data about Italian Continental shelves (Chiocchi et al., 2004) described the lgm position at altitude compraised between -95 and -160 m, but these deposits are not radiocarbon aged. Much work should be done especially to, *i*: retrieve observational data older than MIS 7, *ii*: introduce isostasy during and after MIS 5 in order to explain the disagreement found for MIS 5.3 and 5.1, *iii*: provide tectonic ratea comparing the observational data to local sea level curves as clearly recomended by Caputo (2007), on a paper for the use of global sea level curves.

Acknowledgements

The author is grateful to L. Ferranti and A. Rovere for useful comments and revisions.

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Ms. received: January 22, 2012
Final text received: February 21, 2012