

RELATIVE SEA LEVEL DURING THE LAST MILLENNIUM ON THE BASIS OF ARCHEOLOGICAL MARKERS. NEW INFORMATION FROM TUSCANY AND NORTHERN SARDINIA

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ABSTRACT: Porqueddu *et al.*, Relative sea level during the last millennium using archeological markers. New information from Tuscany and northern Sardinia. (IT ISSN 0349-3356, 2011).

Preliminary results have been produced on a multi-disciplinary analysis about the opportunity to test paleo sea level on the basis of geo-archaeological signs. The study has concerned Tuscany and northern Sardinia sea coast, for the provinces of Livorno and Olbia. In order to decrease the error bar measurements was corrected for tide and atmospheric pressure using the same method of ANTONIOLI *et al.* (2007). The functionality of the archaeological marker was calculated on the basis of LAMBECK *et al.* (2004b) and AURIEMMA *et al.* (2009). Then the observed and corrected has been compared with the predicted sea level curve of LAMBECK *et al.* (2011).

RIASSUNTO: Porqueddu *et al.*, *Variazioni del livello del mare durante gli ultimi millenni sulla base di indicatori archeologici. Nuovi dati dalla Toscana e dalla Sardegna settentrionale.* (IT ISSN 0349-3356, 2011)

Vengono presentati i risultati preliminari di uno studio multidisciplinare sulla possibilità di misurare antichi livelli del mare sulla base di indicatori geo-archeologici. Lo studio ha interessato le coste della Toscana e della Sardegna settentrionale, con particolare attenzione per le province di Livorno e Olbia. Al fine di ridurre al minimo le incertezze altimetriche, gli indicatori sono stati misurati direttamente in situ e le relative quote sono state corrette per i valori di marea e pressione atmosferica registrati al momento della misurazione (ANTONIOLI *et al.*, 2007). A queste misure è stata poi apportata una correzione basata sull'altezza rispetto al livello medio del mare che, originariamente, doveva garantire la funzionalità del marker archeologico (LAMBECK *et al.*, 2004; AURIEMMA *et al.*, 2009). I dati ottenuti sono stati poi comparati con le previsioni dei più recenti modelli teorici di previsione validi per le stesse regioni (LAMBECK *et al.*, 2011).

Key words: *relative sea level*

Parole chiave: *livello relativo del mare*

The Soprintendenza per i Beni Archeologici and the Dipartimento di Scienze Storiche del Mondo Antico, University of Pisa, made some archaeological excavations and measurements on coastal archaeological markers in the site *Portus Pisanus* (Livorno). The 2004 excavation campaign (located in "Il Deserto") allowed to restore the stratigraphical sequence of the area from the late 7th- early 6th cent. BC to the 6th cent. AD (DUCCI *et al.*, 2006). The stratigraphical level included between -130 and 160 cm a.s.l., has been identified as the sandy floor of a marine gulf used as maritime trade from the 3rd cent. BC up to the 1st cent. BC. This stretch of water was progressively and rapidly silted up by alternate sand and posidonia layers since the mid 2nd cent BC. In the late 1st cent BC activities connected with navigation could no longer be performed in this area and were moved to the west (DUCCI *et al.*, 2005). This information has been improved by the analysis of the specimens of malacofauna using ¹⁴C, that were taken during the excavations from the same stratigraphical unit (US

23, -140 ± 5 cm a.s.l.). This has provided a date of 2071 ± 44 years cal BP. According to the excavation evidence, it has been supposed that this area had to be used by appropriate sheeps (so with a clearance value of 35 cm). We assume the chronological period of use was between 2210 ± 100 years BP. Adding to the medium bottom level (-145 ± 15 cm a.s.l.) correction for tide (about 20 cm) and the supposed functional depth (35 cm), we get a change of sea level of 90 ± 15 cm from 2210 ± 100 year BP.

Along the coast South of Livorno (at Calafuria and surroundings) the evidence interpreted as stone quarry si activities in antiquity marked on the flysch which is typical of the cliffs of Livorno's mountains (GALOPPINI *et al.*, 1994) has been measured *in situ*. Particular attention was given to the detaching surfaces of the blocks (certainly related to anthropic activity), today flooded by the sea. In the southern side of the quarry a small inlet has been identified. It is approximately rectangular-shaped, suited to hold medium size boats. Near it, a docking ring

has been supported, in the edge of the rock (at the moment at about 20 cm a.s.l.). The construction marks are still evident (it may be because of chiselling). It is unlikely to be of natural formation. The selected point for the measurement has been located on the surface of a removed block with dimensions of 60x215 cm, measured at a depth of -95 cm a.s.l. (corretto). According to previous studies (ANTONIOLI *et al.*, 2007; AURIEMMA *et al.*, 2009) we suppose that the quarry area had to be found at an altitude above the medium sea level so that it always had dry conditions, even in case of high tide (30 ± 30 cm above high tide level). The quarry level we propose, according to the chronology assigned in the bibliography (GALOPPINI *et al.*, 1994), is the hellenistic period. Therefore we propose a change of sea level of +148 ± 30 cm from 2300 ± 100 years BP.

Geomorphologic features of the Olbia Gulf are well known thanks to intense surveys which have been of interest outside the gulf (SEGRE, 1954; PORQUEDDU *et al.*, 2010). In 1999 the recovery of a few wrecks, due to the works for the implementation of the connecting tunnel between the extra-urban network and the modern seaport, has provided new data to determine sea level variations on the inland side of the gulf. The Soprintendenza per Beni Archeologici per le Province di Sassari e Nuoro (Olbia branch) excavated the remains of at least 24 boats of different sizes dated between the 1st and the 5th century AD and in the medieval period. Due to the particular features of positions and the chronologically homogeneous context where they were integrated, only the relics found in the northern area of the excavation have been considered. The ships, at the time of their destruction, must have been moored inside the harbour area with a low bottom (D'ORIANO, 2002). Therefore it was chosen to determine the paleo sea level starting from the level of the placement of the wrecks measured at the base of the keel.

To date this context the interpretations of the Soprintendenza have been followed. The event was first dated around the middle of the 5th century AD, during the period of the Vandal invasions. According to later theories, a date beyond 1560 ± 10 years BP is suggested. The height that the keel is positioned at with regard to the wreck has been measured at -145 cm a.s.l. (corretto).

To this data has been added the functional height of the harbour area, needed to warrant the ships floating (40 cm) and included the higher sea level in case of mistakes (because when dealing with wrecks it cannot be excluded, that particularly during low sea level phases, the keels could be based on the floor)(RICCARDI, 2002).

According to what has been changing of the relative sea level inside the Gulf of Olbia can be quan-

tified in +105 ± 23cm from 1560 ± 10 years BP (PORQUEDDU *et al.*, 2010).

Comparing observed data connected with the sea level at *Portus Pisanus* and Olbia, and the predicted sea level curves (LAMBECK *et al.*, 2011), the proposed working hypothesis, in addition to confirming the tectonic stability of the searched areas, expresses a substantial uniformity between the obtained results and what was predicted, including differences in the indicated visible margins of error. More distant from the model of prevision is the datum of Calafuria: this anomaly will be explained only with further researches *in situ*.

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