



## **Mixed layer warming-deepening in the Mediterranean Sea and its effect on the marine environment**

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This work aims at investigating the evolution of the ocean mixed layer in the Mediterranean Sea and linking it to the occurrence of mass mortalities of benthic invertebrates. The temporal evolution of selected parameters describing the mixed layer and the seasonal thermocline is provided for the whole Mediterranean Sea for spring, summer and autumn and for the period 1945-2011. For this analysis all temperature profiles collected in the basin with bottles, Mechanical Bathy-Thermographs (MBT), eXpendable Bathy-Thermographs (XBT), and Conductivity-Temperature-Depth (CTD) have been used (166,990). These data have been extracted from three public sources: the MEDAR-MEDATLAS, the World Ocean Database 2013 and the MFS-VOS program. Five different methods for estimating the mixed layer depth are compared using temperature profiles collected at the DYFAMED station in the Ligurian Sea and one method, the so-called three-segment method, has been selected for a systematic analysis of the evolution of the uppermost part of the whole Mediterranean Sea. This method approximates the upper water column with three segments representing mixed layer, thermocline and deep layer and has shown to be the most suitable method for capturing the mixed layer depth for most shapes of temperature profiles.

Mass mortalities events of benthic invertebrates have been identified by an extensive search of all data bases in ISI Web of Knowledge considering studies published from 1945 to 2011. Studies reporting the geographical coordinates, the timing of the events, the species involved and the depth at which signs of stress occurred have been considered.

Results show a general increase of thickness and temperature of the mixed layer, deepening and cooling of the thermocline base in summer and autumn. Possible impacts of these changes are mass mortalities events of benthic invertebrates that have been documented since 1983 mainly in summer and autumn. It is also shown that most mass mortalities occurred in months with anomalously high mixed layer depth temperature leading to the conclusion that warming of upper Mediterranean Sea has allowed interannual temperature variability to reach environmental conditions beyond the thermal tolerance of some species.