EVOLUTION OF OXYGEN AND NUTRIENTS DEEP CIRCULATION THROUGH THE STRAITS OF THE CRETAN ARC: IMPACT ON THE DEEP LAYERS OF THE EASTERN MEDITERRANEAN SEA

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Abstract
The intensive research during the past decade, revealed important changes in the deep and bottom layers of the Eastern Mediterranean. The increase of oxygen and the corresponding decrease of nutrient content in the deep and bottom layers of this sea, observed after 1987 is mainly due to the increased outflow of the Cretan Deep Water (CDW). This water outflows towards the Levantine and Ionian Seas through the deeper straits of the Cretan Arc and displaces upwards the old Eastern Mediterranean Deep Water of Adriatic origin .

Key-words: deep waters, oxygen, nutrients, Eastern Mediterranean

Introduction

The Cretan Sea occupies the southern and larger basin of the Aegean Sea. It communicates with the SE Ionian Sea through the straits of Elafonissos (sill depth: 200m, width: 11 km), Kithira (sill depth: 160m, width: 33 km) and Antikithira (sill depth: 700m, width: 31 km) and with the Levantine Sea through the straits of Rhodes (sill depth: 350m, width: 17 km), Karpathos (sill depth: 850m, width: 43 km) and Kassos (sill depth: 1000m, width: 67 km).

The Cretan Sea and the straits of the Cretan Arc have been sampled several times since March 1986 in the framework of the multinational research programme for the exploration of the Eastern Mediterranean, POEM-I (1985-1990), POEM-II-EPICS (1991-continued). The survey consisted of an extensive grid of stations shown in the Figure 1.

The general remarks for the distribution of oxygen and nutrients in the Cretan Sea, can be summarised to the relative decrease of nutrients and to the corresponding rise of oxygen concentrations in the intermediate and deep waters of this sea with regard to the Eastern Mediterranean for all the periods (summer-winter) of observation [1].

The deep layers of the Cretan Sea are occupied by the Cretan Deep Water (CDW) which outflows through the Straits of the Cretan Arc and after 1987 affects the structure and the characteristics of the water column in large areas outside the Cretan Sea [2] [3]. The increase of the oxygen content of the deep and bottom waters of the Eastern Mediterranean by about 0.3 ml/l, observed during the last few years, is mainly due to the increased outflow of the Cretan Deep Water (CDW) towards the Levantine and Ionian Seas through the straits of the Cretan Arc [4]. This water displaces upwards the old Eastern Mediterranean Deep Water of Adriatic origin.

Among the straits of the Cretan Arc three straits with sill depths deeper than 700 metres, namely Antikythira, Kassos and Karpathos, play an important role for the deep circulation between the Cretan Sea and the Eastern Mediterranean. In the present paper we follow the deep circulation of oxygen and nutrients, from 1987 to 1992, through the Antikythira and Kassos straits.

Antikythira Strait

Exchanges between the Cretan Sea and the Ionian Sea through Antikythira Strait in late winter and in late summer 1987 show a supply of nutrients in the Cretan Sea between 200 and 800 decibars [5]. The inflowing water originates from depths 500-1000 metres in the Ionian Sea; the maximum nitrate, phosphate, silicate and the minimum oxygen concentrations in late summer 1987 (3.5 μM, 0.17 μM, 4.6 μM and 4.8 ml/l, respectively) are found at about 500 m in the Antikythira Strait (Figure 2).

In the near bottom layer (below 400 dbars) an outflow of the oxygen rich-nutrient poor CDW towards the Ionian Sea is observed (Figure 2). During the late winter and late summer 1987 cruises, this saline and warm deep water with low nutrient and high oxygen content is detected in form of patches to the west of the Cretan Arc at a depth of 900 m [6]. Our results showed that this intermittent outflow of CDW towards the Ionian Sea can not affect the concentrations of the chemical parameters in the deep layers of the Eastern Mediterranean. During 1987, the deep layer below 1000 metres is rather homogeneous, with oxygen about 4.2 ml/l and nitrates higher than 5.0 μM (Figure 7).

The distribution of oxygen along the Antikythira Strait in autumn 1991 (Figure 3) shows that the outflow of CDW towards the Ionian Sea, occurs below 200 m down to the sill depth. On the same figure, the important

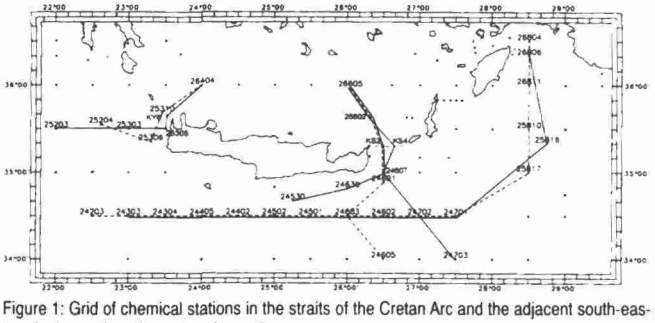

Figure 1: Grid of chemical stations in the straits of the Cretan Arc and the adjacent south-eastern Ionian and north-western Levantine seas.

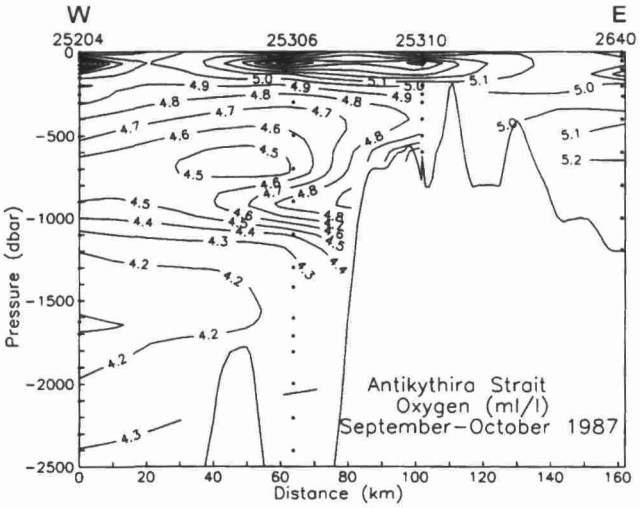

Figure 2: Vertical distribution of oxygen (ml/l) along the Antikythira Strait in late summer 1987.

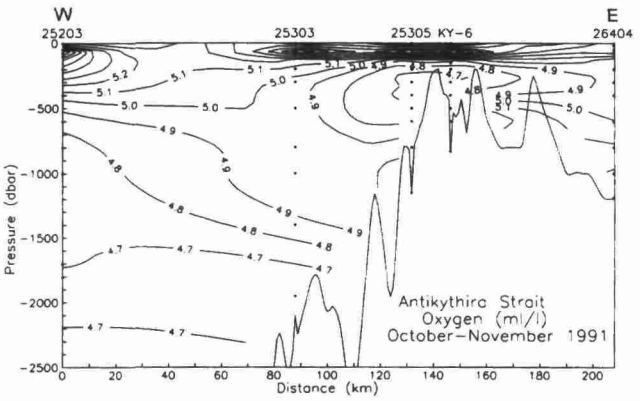

Figure 3: Vertical distribution of oxygen (ml/l) along the Antikythira Strait in autumn 1991.

increase of oxygen (about 0.5 ml/l) observed in the deep and bottom layers in the Ionian Sea, to the west of the Antikythira strait, led us to suppose that an important outflow of CDW towards the Ionian took place after 1987. The corresponding decrease of nutrients is about 1 μM for both nitrates and silicates. The intrusion of CDW has modified considerably the distribution of all properties in the Eastern Mediterranean affecting a large area around the island of Crete.

Kassos Strait

The distribution of oxygen and nitrates along a transect through the Kassos Strait in late summer 1987 (Figure 4) shows that the oxygen and nitrates concentrations below 1000 metres in the Cretan and the NW Levantine seas are considerably different. In the Cretan Sea below 1000 m the oxygen is higher than 5.2 ml/l while the nitrates are lower than 1.6 μM; considerably lower oxygen concentrations (O_2 ~ 4.1 ml/l) and higher nitrates concentrations (NO_3 ~ 5.2 μM) are found in the NW Levantine Sea indicating a very weak Aegean influence in the deep layers (>1500m) of the NW Levantine Sea during this period. The current meter measurements performed in the area during the same period [7] confirm our observations.

The important CDW outflow after 1987 is manifested in autumn 1991 by the important augmentation (~ 0.4 ml/l) of oxygen (Figure 5) and diminution of nutrients concentration in the layer below 800 metres in the NW Levantine Sea, in the viscinity of the strait.

Further increase of oxygen and decrease of nutrients concentrations in the deep layers of the NW Levantine Sea were observed during the late