## Exchanges between Cretan and Levantine Seas inferred from neutral surface analysis

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The water-mass exchanges between Cretan and Levantine Seas have been broadly known for some time, see inter alios MALANOTTE - RIZZOLI and HECHT (1988).

This work is based on analysis of CTD data collected by R.V."AEGAION" at 63 stations in the Cretan Sea and its environs (Fig. 1), during POEM-2-1986 Cruise (11 March -10 April 1986), and aims at delineating these exchanges during this period.

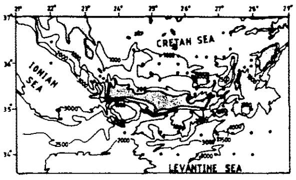


Fig. 1. Study area showing bathymetry and station network

To this end, "neutral surface analysis" (THEODOROU, 1983) a technique to infer the qualitative features of a flow pattern, on the basis of hydrographic data. will be employed. In brief, the outline of the technique is as follows:

Spreading of water masses in the ocean interior is generally assumed to occur predominantly along "neutral surfaces"; the latter can be defined as normal at every point to the gradient of potential density which is referenced to the pressure at the point in question, and thus along which water parcels can be interchanged without any work being done against buoyancy forces. To start a set of neutral surfaces any set of water parcels with observed temperatures and salinities can be used. Based on the "central-reference-pressure" method (THEODOROU, 1991) of approximating neutral surfaces, the levels at which the adiabatic density gradients for each of these water parcels intersect the corresponding adiabatic density profile at each station in a data set determine the levels of each of the neutral surfaces at that station.

Salinity is believed to be a conservative water-mass characteristics. Thus, the spreading of salinity on a neutral surface, coupled with the three-dimensional depth configuration of the latter, indicates patterns of spreading and flow of a water from a particular source; and they constitute together the essence of the "neutral surface analysis".

Our analysis rests on three neutral surfaces, which have been chosen so that to cover spatially the entire range of water-mass exchanges between the Cretan and the Levantine Seas.

The results revealed some interesting features, among which the following stand out:

1. A broadly defined cyclonic flow, which occupies the maior part of the Cretan Sea.

2. A north-eastward flow, which occurs at the easternmost part of the Cretan Sea.

3. Surface inflows are evident at the Kassos and Antikythira Straits.

4. However, at both these Straits, and at intermediate levels, the flows are reversed with respect to the surface ones, indicating general outflows of Cretan sea water through these Straits into the Levantine and southeasternmost Ionian Sea respectively.

5. Thus, at intermediate levels tongues of Cretan Sea water extend from the Cretan Sea, through the Kassos and Antikythira Straits westwards, spreading along the southern Crete and southernmost Peloponnisos respectively.

6. An anticyclone is evident, tied to the bottom topography, at the southwesternmost part of the study area.

7. A cyclonic eddy-like feature occupies the Karpathos Strait.

8. A cyclonic region occurs in the southeasternmost part of the study area.

9. Whilst, at the southernmost part thereof a meandering eastward flow is evident.

10. Except the uppermost one, the topographies of all neutral surfaces reflect broadly the bottom bathymetry.

### REFERENCES

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## Heat exchange processes at the surface of Elefsis Bay, Greece

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This work aims at determining the fluxes due to heat exchange processes at the surface of Elefsis Bay (Fig. 1), in Saronikos Gulf, Greece. Knowledge of these processes is fundamental, not only for understanding several important oceanographic features of the Bay -such as, inter alia. the seasonal balance of salt and heat, the stratification and the thermohaline circulation- but also for the analysis of the ecosystem of this polluted semi-enclosed shallow coastal embayment.

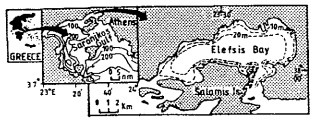


Fig. 1.- Elefsis Bay

The oceanographic data were obtained during twelve monthly cruises, between January and December 1987, by the Greek National Centre for Marine Research. The meteorological data for the same period, were collected at the Elefsis Station of the Greek Meteorological Service; daily mean values, based on three-hourly observations, were used.

The flux of heat across the surface of the sea, Q ($Wm^{-2}$. positive downwards), is given by:

$$Q = Q_{s-r} + Q_b + Q_e + Q_h$$

where $Q_{s-r}$ is the net shortwave radiation. $Q_b$ is the net longwave radiation, $Q_e$ is the latent or evaporative heat flux, and $Q_h$ is the sensible heat flux or turbulent heat conduction. To estimate these fluxes empirical formulas were employed.

The seasonal variations of the surface heat fluxes are displayed graphically in Figure 2, whilst their annual mean values (all in $Wm^{-2}$) are given below, and represent the annual heat budget for Elefsis Bay :

| Solar shortwave radiation | | Net longwave radiation | | Evaporative heat transfer | | Sensible heat transfer | | Total heat flux |
|---|---|---|---|---|---|---|---|---|
| 199 | - | 68 | - | 124 | - | 14 | = | -7 |

Our results show (Fig. 2) that during 1987, the most important heat loss mechanism, from the surface of Elefsis Bay, was evaporation (c), followed by longwave back radiation (b), whilst sensible heat loss was much smaller (d) the total heat loss, from September through February (e), and within the errors involved, was balanced, by the total heat gain, from March through August (e) of that year.

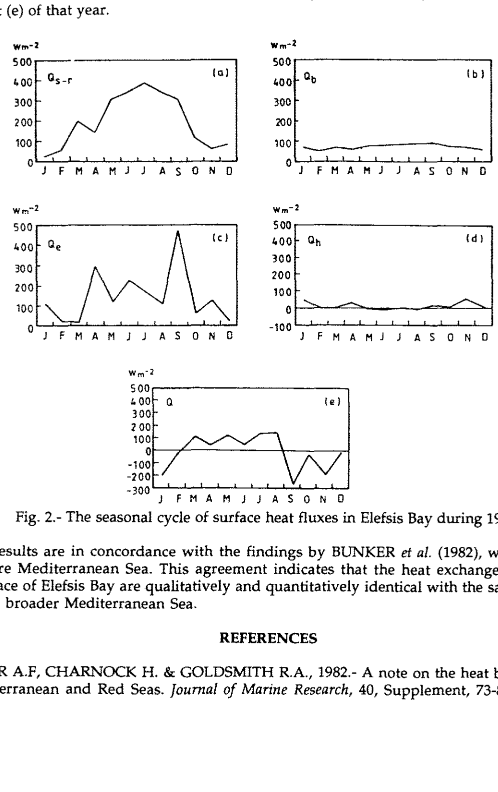


Fig. 2.- The seasonal cycle of surface heat fluxes in Elefsis Bay during 1987.

Our results are in concordance with the findings by BUNKER *et al.* (1982), which hold for the entire Mediterranean Sea. This agreement indicates that the heat exchange processes at the surface of Elefsis Bay are qualitatively and quantitatively identical with the same processes over the broader Mediterranean Sea.

### REFERENCES

BUNKER A.F, CHARNOCK H. & GOLDSMITH R.A., 1982.- A note on the heat balance of the Mediterranean and Red Seas. *Journal of Marine Research,* 40, Supplement, 73-84.



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