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THE CHEMICAL CHARACTERISTICS AS CIRCULATION TRACERS IN THE SURFACE AND ATLANTIC WATER MASSES IN THE LEVANTINE SEA

KEMIJSKA SVOJSTVA KAO INDIKATORI CIRKULACIJE U POVRŠINSKIM I ATLANTSKIM VODENIM MASAMA LEVANTINSKOG MORA

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The chemical data of nitrite, nitrate, phosphate, oxygen and pH taken during the hydrographic cruises in the Eastern Mediterranean, during the period (1948—1972), which are collected by the IODC, are used to study the spatial distributions in the different seasons and to find out the correlation between these distributions and the horizontal dynamic strukture. The results indicate that, in the Levantine Sea, there is a core of maximum nitrite, consistent all the year around, and associated with maximum nitrate and phosphate. The areas rich in nutrient salt are often found in the regions of the cyclonic eddies.

The comparison between the different patterns of the chemical parameters and the dynamic topography shows that the most convenient circulation tracers in the Levantine Sea are nitrite, phosphate and pH values.

INTRODUCTION

The circulation pattern in the Eastern Mediterranean was studied, using hydrographic data, by different authors (Ovchinnikov, 1966, Lacombe and Tchernia, 1972, Gerges, 1976, El Gindy, 1983, and Sharaf El Din and El-Gindy 1986, and others). Intensive modelling activites are also done under the umbrella of the Project of Physical Oceanography of the Eastern Meditteranean (POEM), and the general features of the circulation are now developing in this area. One of the objectives of these studies is the prediction of the biological and chemical characteristics and their distributions. On the other hand chemical properties could be used as tracers for the circulation pattern.

In this paper, ist is intended to deal with two problems:

a — What are the major chemical characteristics of the surface water (at 10 m. depth) and at the core of minimum salinity, related to the Atlantic water mass in the Levantine Sea?

b — What are the most appropriate chemical characteristics to be used as circulation tracers?

MATERIALS AND METHODS

The source of the used data is the International Oceanographic data centre (IODC), which provides depth, temperature, salinity, density, sound velocity, and the concentrations of nitrite, nitrate, phosphate, dissolved oxygen and silicate in addition to the pH values, for the period from 1948 to 1972. The chemical data, for each of the four seasons, were taken at 10 meters depth, to represent the surface, and at the level of minimum subsurface salinity corresponding to the core of the Atlantic water mass. In winter, when the vertical convection in the Levantine Sea is active, the latter core cannot be detected and therefore, no winter pattern was obtained. The silicate concentration has been discarded since it has very low values. These date are presented seasonally on horizontal charts.

Since these data are collected during differents years, it is expected to give only climatological characteristics.

The patterns of the chemical components are to be compared with the dynamic height patterns, given by Sharaf-El Din and El-Gindy 1986, and El-Gindy (1983), to investigate the utility of some chemical tracers in the circulation studies.

RESULTS

Chemical characteristics of the surface water:

Nitrite distributions

In winter (Fig. 1-A) the concentration of nitrite lies between 0 and 0.36 μmol/dm^3. In this season, two high concentration regions could be shown, the first maximum is found in the north and the central parts of the basin and the second region exists east of 34°E and south of 33°30'N near Senai Coast.

In spring (Fig. 1-B) the range of concentration is from zero to 0.22 μ mol/dm^3 with maximum concentration in the area between Rhodes and Crete Islands as well as west of Cyprus Island.

In summer (Fig. 1-C) where the range is between zero and 0,19 μ mol/dm^3 there are high concentrations in the north between 35—36°N, west of 29°E, and along a core between 33°N and 35°N.

West of Cyprus is included in the second high concentration area.

In autumn (Fig. 1-D) the concentration is between zero and 0,13 μ mol/dm^3 The spatial distribution confirms the existence of the high concentration in the

central part of the Levantine Sea shown by summer situation.

From the nitrite distributions, it can be concuded that:

1 — The range of concentration in the Levantine Sea becomes narrower from winter to next autumn, with maximum in winter when the vertical overturn of waters is more active.

2 — The area of west Cyprus has high nitrite concentrations in spring, summer and autumn.

Nitrate distributions

In winter (Fig. 2-A), the range of nitrate was between zero and 0.24 μ mol/dm^3 an the maximum values are found in the NW of Leventine Sea (near Cretan Sea straits) as well as in the east of the basin.

In spring (Fig. 2-B) the range is limited between 0 and 0.05 μ mol/dm^3 with highest value in the north and around Cyprus.

In summer (Fig. 2-C) the situation is similar to that in spring.

In autum no enough data are available.

Therefore, higher nitrate concentration always exists around Cyprus Island.

Phosphate distributions

In winter (Fig. 3-A), the concentration range is about 0.01—0.49 μ mol/dm^3 with minimu values less than 0,04 μ mol/dm^3 west and south of Cyprus. This minimum is surrounded by high concentrations especially at Cretan Sea strait from Kapathos to Crete Island.

In spring (Fig. 3-B), the range is (0—0.36) μ mol/dm^3. High phosphate concentration is found north of 34°N and east of 33°E.

In summer (Fig. 3-C), where the range is (0—0.43 μ mol/dm^3), the lower concentrations are found in the central zone.

In autumn (Fig. 3-D), the range is smaller (0—0,22 μ mol/dm^3) continuous minimu core between 33° and 35°N.

From the Fig. 3, it can be concluded that there is a core of minimum concentration in the central part of Levantine Sea, but the shape of this core is seasonally variable.

Dissolved oxygen distribution

In winter no enough data are available.

In spring (Fig. 4-A), although few data are found north of 35°N, a high oxygen core, originating from the Cretan Sea straits and going eastward, can be noticed. The range of the concentration is 4.1 to 6.0 (ml/l).

In summer (Fig. 4-B), then range lies between 3.87 and 5.5 ml/l. It can also be shown that a zone with minimum oxygen exists in a central region with high concentrations in the north and south. The high oxygen is also comnig from Cretan Sea straits.

In autumn (Fig. 4-C) a quite different pattern is obtained with a range of 4.4—5.5 ml/l.

pH distribution

The pH ranges are 8—8.2, 8—8.28 and 7.9—8.12 in winter spring and summer respectivelly. The spatial distributions in winter, (Fig. 5-A) and summer (Fig. 5-C), exhibit a core of maximum walue originating from the Cretan

Sea. In spring (Fig. 5-B), the core of the maximum is replaced by minimum pH values. In autumn (Fig. 5-D) the few available data indicate the increase of pH in the northward.

Chemical characteristics of Atlantic water mass

Nitrite distribution

The ranges of the nitrite in the core of the Atlantic water are 0—0.23 and 0—0.31 μ mol/dm^3 in spring, summer and autumn respectively.

The horizontal distributions in these seasons (Fig. 6-A, B and C), have certain common features: there is a maximum concentration in the north and the south, while in the middle part there is a core with minimum concentration. The area occupied by the latter core is wider in summer (Fig. 9-B).

Nitrate distribution

The few available data of the nitrate concentration are in summer and autumn (Fig. 7-B). The range of the concentration is between 0 and 0.11 μ mol/dm^3 in summer, and between 0 and 0.08 μ mol/dm^3 in autumn.

Two areas with high concentrations are found east and south of Cyprus and in the SE Cretan Sea straits.

Phosphate distribution

The ranges of concentration are 0—0.31, 0—0.33 and 0—0.30 μ mol/dm^3 in spring, summer and autumn respectivelly. The most obvious common feature of the spatial distributions (Fig. 8-A, B and C), is the existence of low concentrations in the north and the south with maximum values in the middle parts.

Dissolved oxygen distribution

The range of oxygen is 4.8—5.8 m/l (Fig. 9-A & B). The summer pattern (Fig. 9-A) shohws a core of minimum oxygen delineated by high concentration in the north and the south.

pH distribution

The pH values in the Levantine Sea at the Atlantic water core lies between 7.8 and 8.2 (Fig. 10-A, B and C). The spatial distribution of this property indicates a core of minimum pH in the middle part of the basin.

The relation between the circulation and the chemical factors distributions:

The general circulation patterns in the surface layer, given by the different authors in the Levantine Sea manifest a cyclonic gyre in the north and the central parts of thhe basin, while in the souther part, an anticyclonic eddy is detected. According to El-Gindy (1983) and Sharaf El-Din and El-Gindy (1986), the autumn pattern has cyclonic eddies in the north and south with anticyclonic gyre in the central part.

The circulation patterns at surface and at the Atlantic water immersion are similar although the current magnitude decreases with depth, Gerges (1976).

Therefore, the surface circulation pattern is four seasons given by the geostrophic calculations (Fig. 11) will be compared with the spatial distributions of chemical tracers represented by Figs. 1 to 10 over which the expected current directions are indicated by arrows. This comparison leads to the following deductions:

1 — There is a good qualitative agreement between the chemical tracer patterns and the dynamic topography at the surface.
The direction of the geostrophic current is nearly parallel to the lines of equal concentration.

2 — The best agreement with the dynamic topography is given in the cases of nitrite, phosphate, and pH, while the nitrate and the dissolved oxygen are less correlated with the current pattern. The latter two tracers could be more affected by biochemical processes.

DISCUSSION AND CONCLUSIONS

The core of the maximum nitrate concentation which is consistent in different seasons, is correlated with the distributions of the other chemical tracers as follows:

a — In winter in the surface layer, the high concentration of nitrite is associated with high concentration of nitrate, phosphate and pH.

b — In spring, the core of maximum nitrite in the surface layer has high nitrate, high phosphate and low pH values, while the Atlantic water has high phosphate and high pH values.

c — In summer, in the surface layer the maximum nitrite has a maximum pH while no clear association is found with the other tracers.

d — In Atlantic water core, the high nitrite has high nitrate, high oxygen and low phosphate.

d — In autumn, in the surface layer, the high nitrit has high phosphate and low oxygen, while in the Atlantic water, this core has a high pH and a low phosphate.

Therefore the most correlated chemical tracers are nitrite, nitrate and phosphate.

The areas rich in nutrient salts are often found in the regions of the cyclonic eddies.

On the basis of the comparison between the spatial patterns of the chemi-
pH values, whose isolins are nearly parallel to the lines of equal dynamic height which are in turn, parallel to the current direction.
cal tracers, the best recommended circulation tracers are nitrite, phosphate and

In spring and summer there is an indication of an outflow from SE Cretan Sea straits to the east, characterized by high oxygen, high pH and high nitrite concentration.

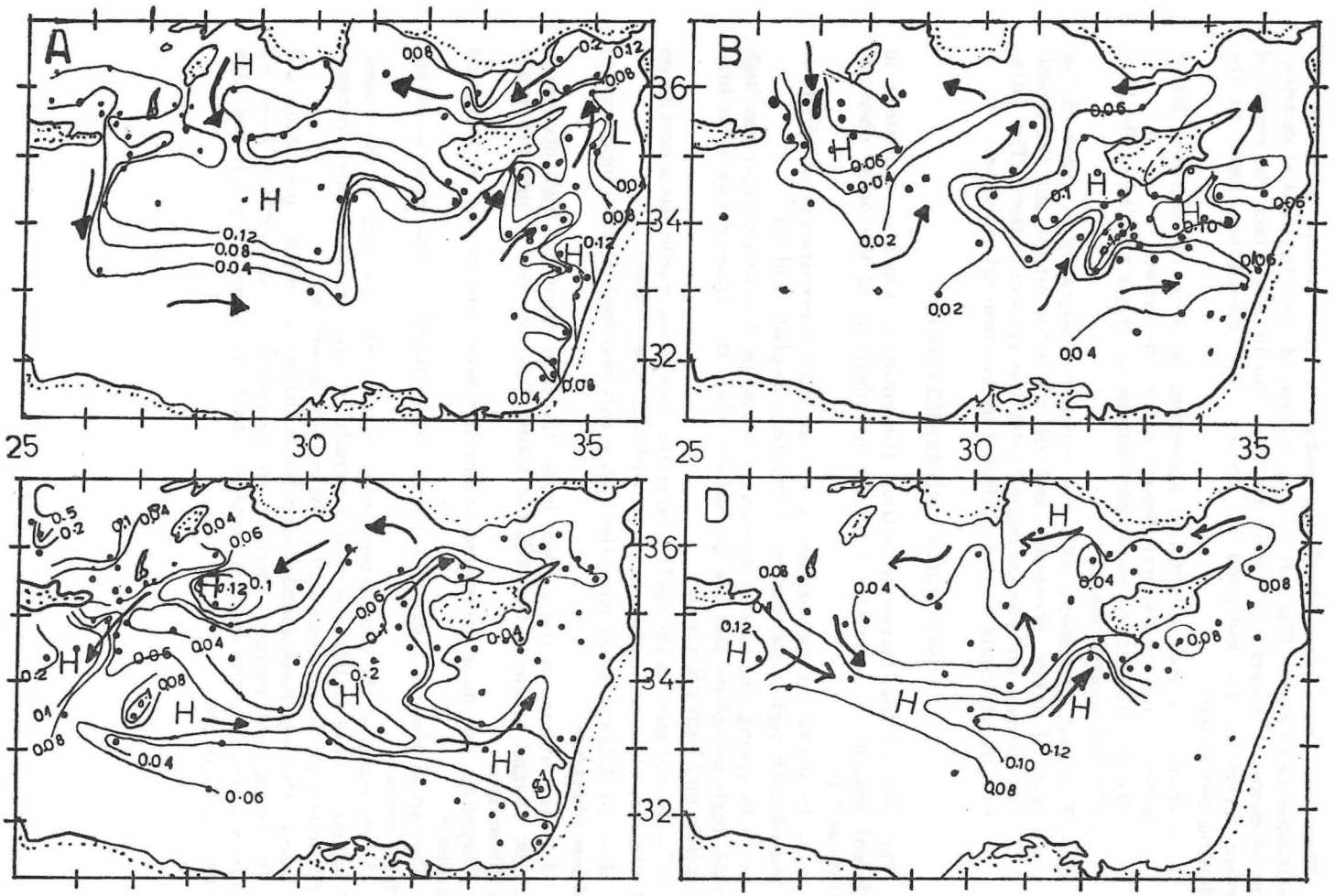

Fig. 1. The surface horizontale distributions of the concentration of nitrites, in (μ mol/dm^3), in the Levantine Sea, during A — Winter, B — Spring, C — Summer, D — Autumn. Arrows indicate expected circulation pattern.

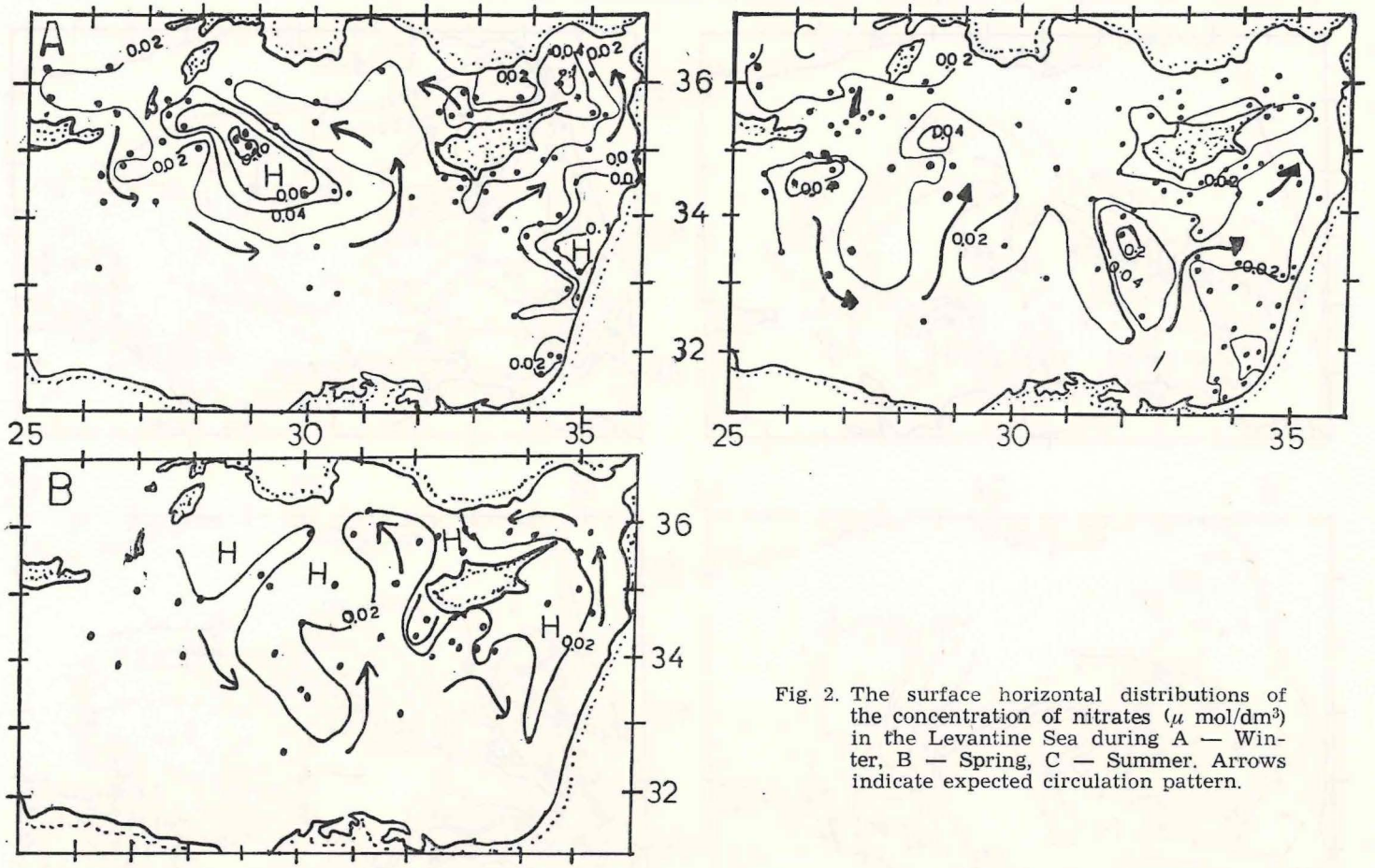

Fig. 2. The surface horizontal distributions of the concentration of nitrates (μ mol/dm^3) in the Levantine Sea during A — Winter, B — Spring, C — Summer. Arrows indicate expected circulation pattern.

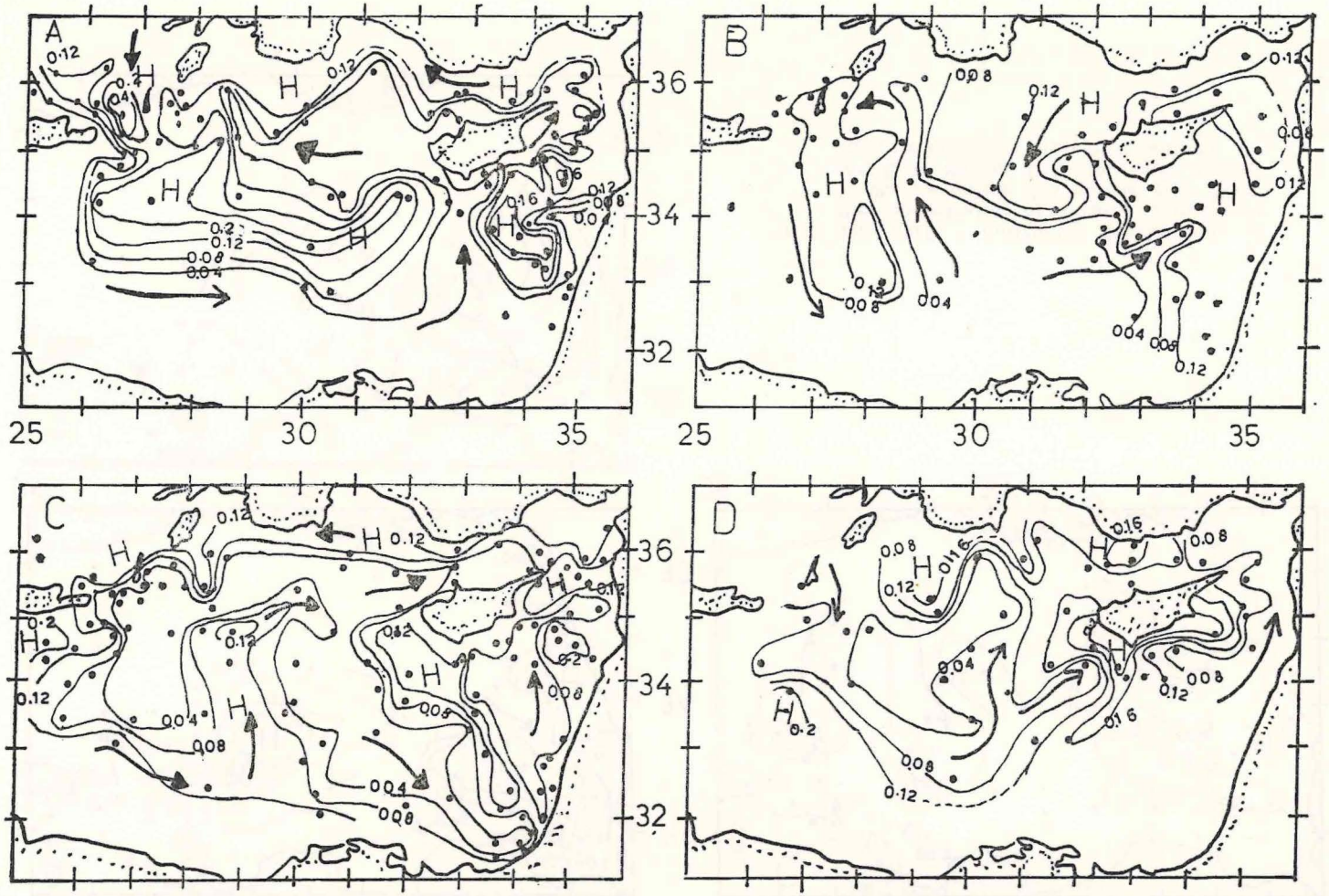

Fig. 3. The surface horizontal distributions of the concentration of phosphates (μ mol/dm^3) A — Winter, B — Spring, C — Summer, D — Autumn. Arrows indicate expected circulation pattern.

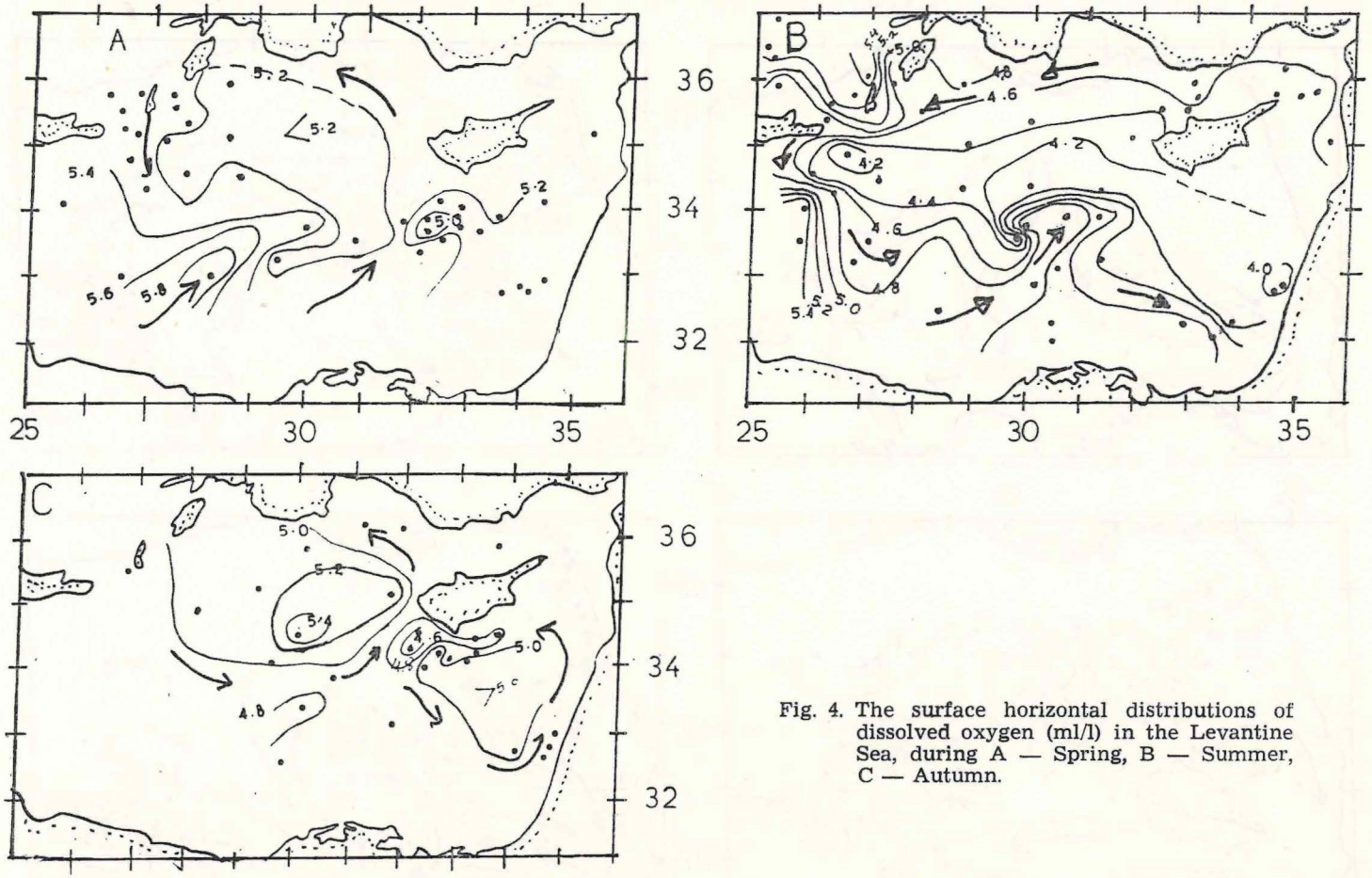

Fig. 4. The surface horizontal distributions of dissolved oxygen (ml/l) in the Levantine Sea, during A — Spring, B — Summer, C — Autumn.

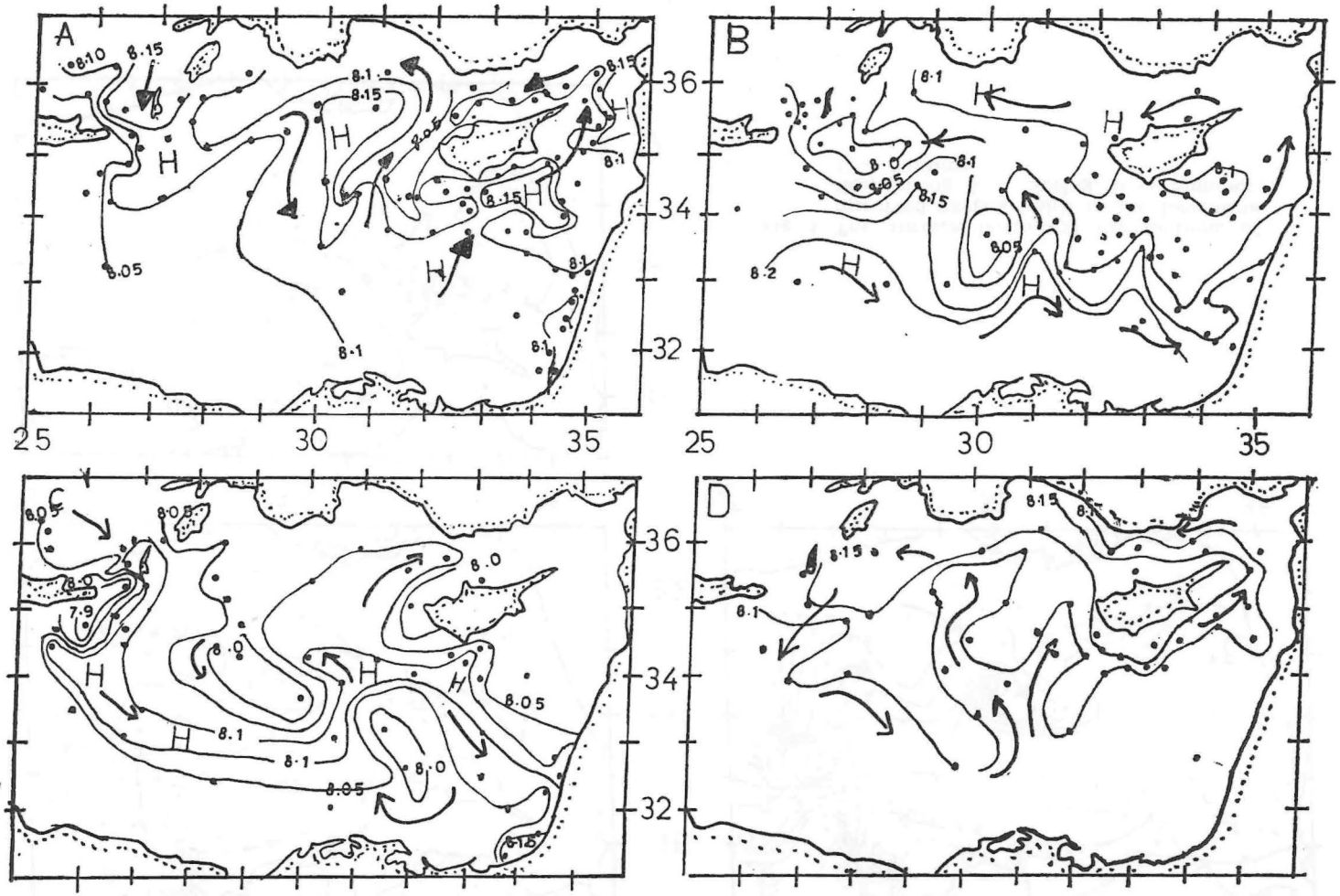

Fig. 5. The surface horizontal distributions of the pH in the Levantine Sea during A — Winter, B — Spring, C — Summer, D — Autumn. Arrows indicate expected circulation pattern.

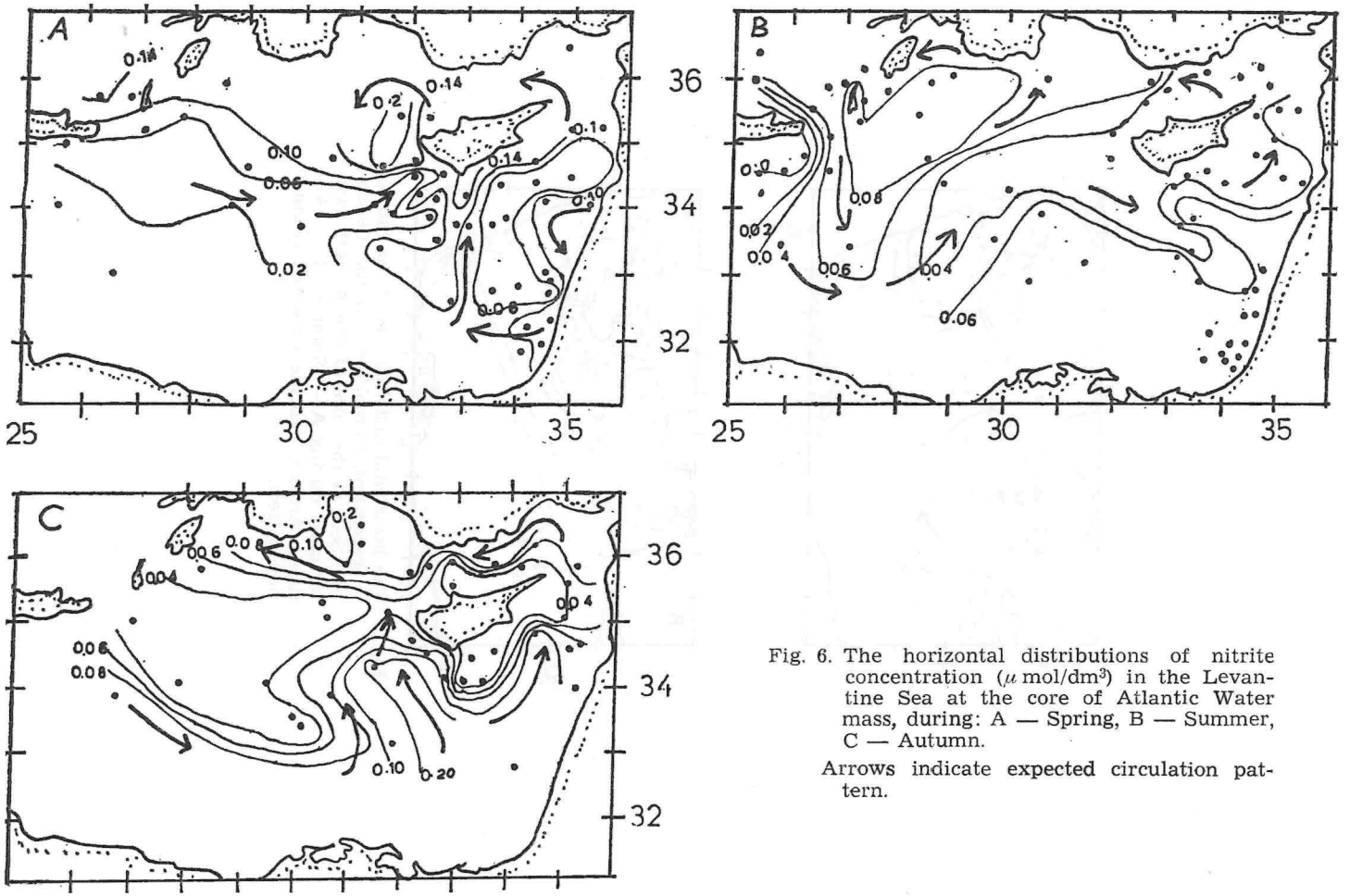

Fig. 6. The horizontal distributions of nitrite concentration (μ mol/dm^3) in the Levantine Sea at the core of Atlantic Water mass, during: A — Spring, B — Summer, C — Autumn.

Arrows indicate expected circulation pattern.

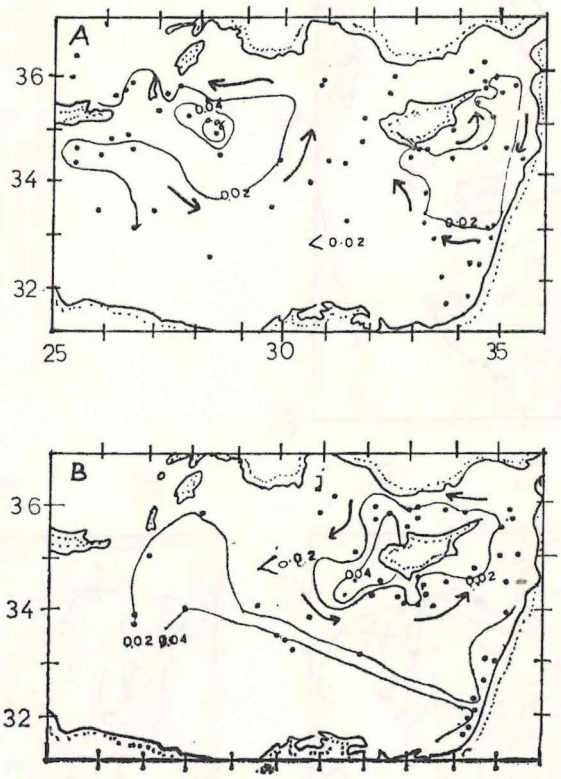

Fig. 7. The horizontal distributions of the nitrate concentration (μ mol/dm^3) in the Levantine Sea, at the core of the Atlantic water mass during A — Summer, B — Autumn. Arrows indicate expected circulation pattern.

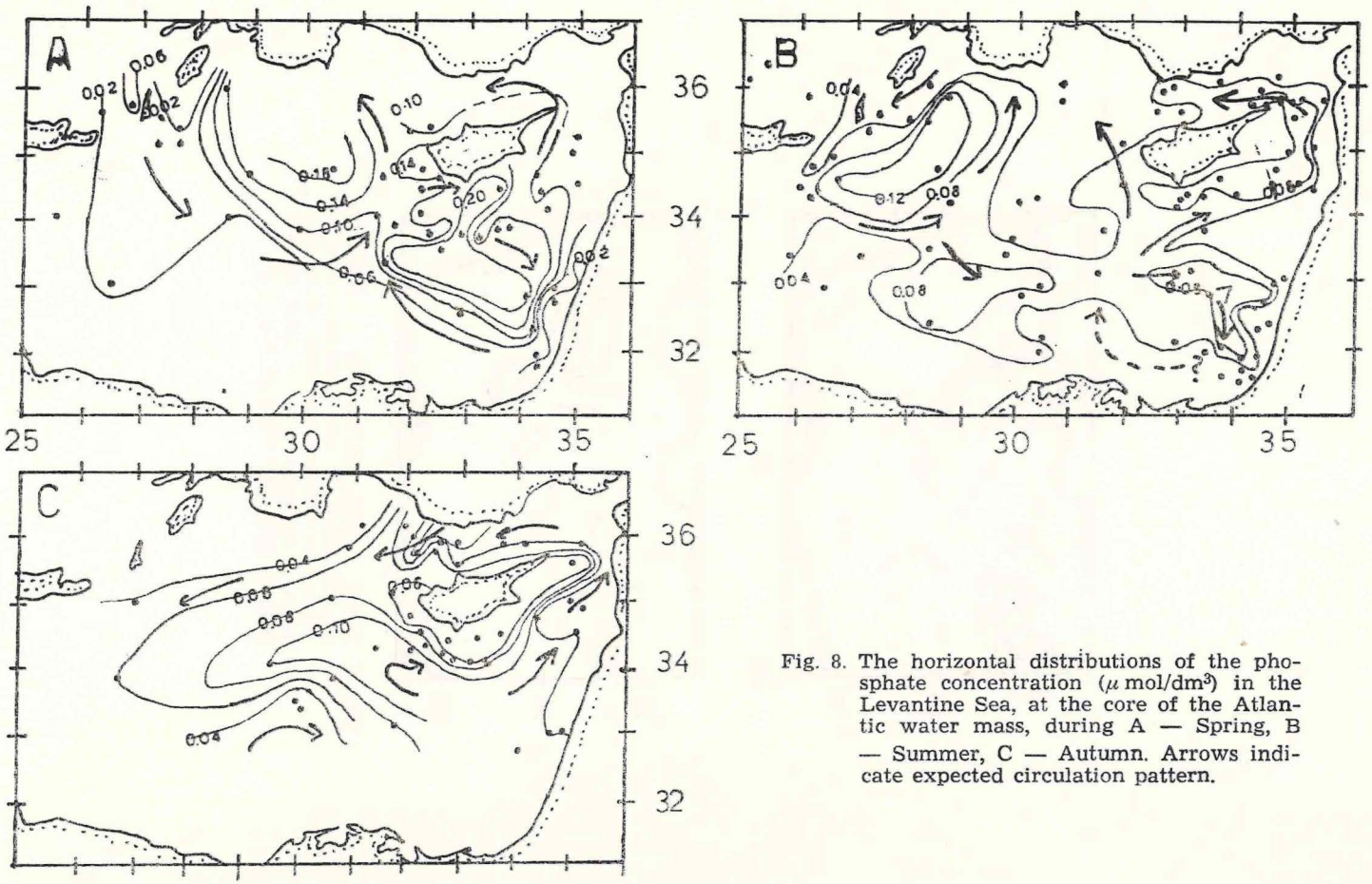

Fig. 8. The horizontal distributions of the phosphate concentration (μ mol/dm^3) in the Levantine Sea, at the core of the Atlantic water mass, during A — Spring, B — Summer, C — Autumn. Arrows indicate expected circulation pattern.

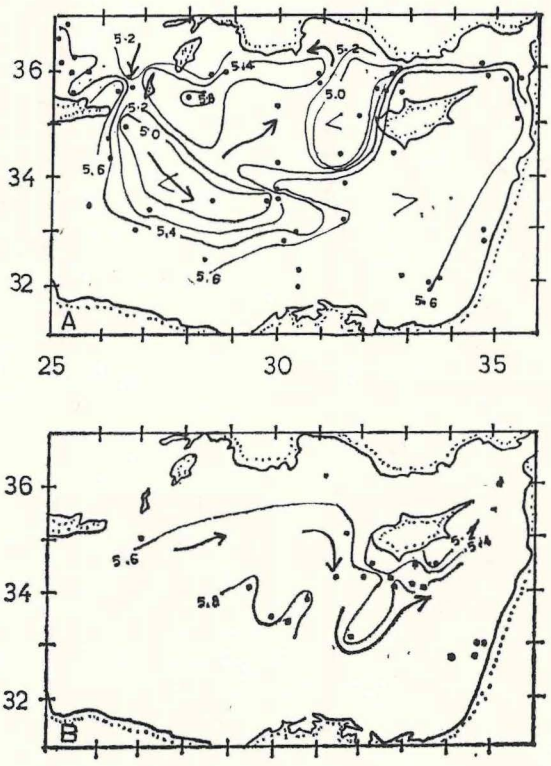

Fig. 9. The horizontal distributions of dissolved oxygen (ml/l) in the Levantine Sea, at the core of the Atlantic water mass, during A — Summer, B — Autumn. Arrows indicate expected circulation pattern.

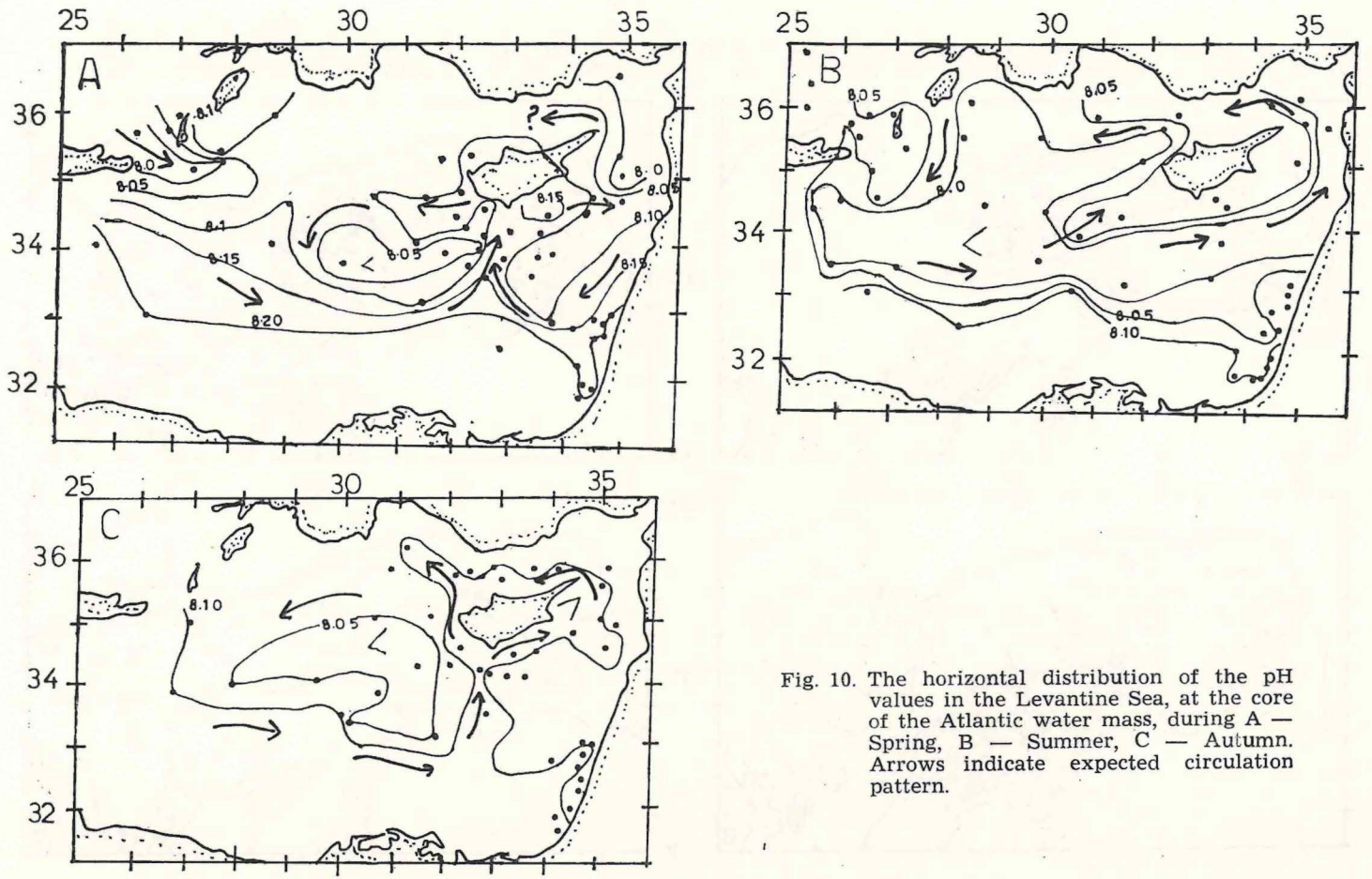

Fig. 10. The horizontal distribution of the pH values in the Levantine Sea, at the core of the Atlantic water mass, during A — Spring, B — Summer, C — Autumn. Arrows indicate expected circulation pattern.

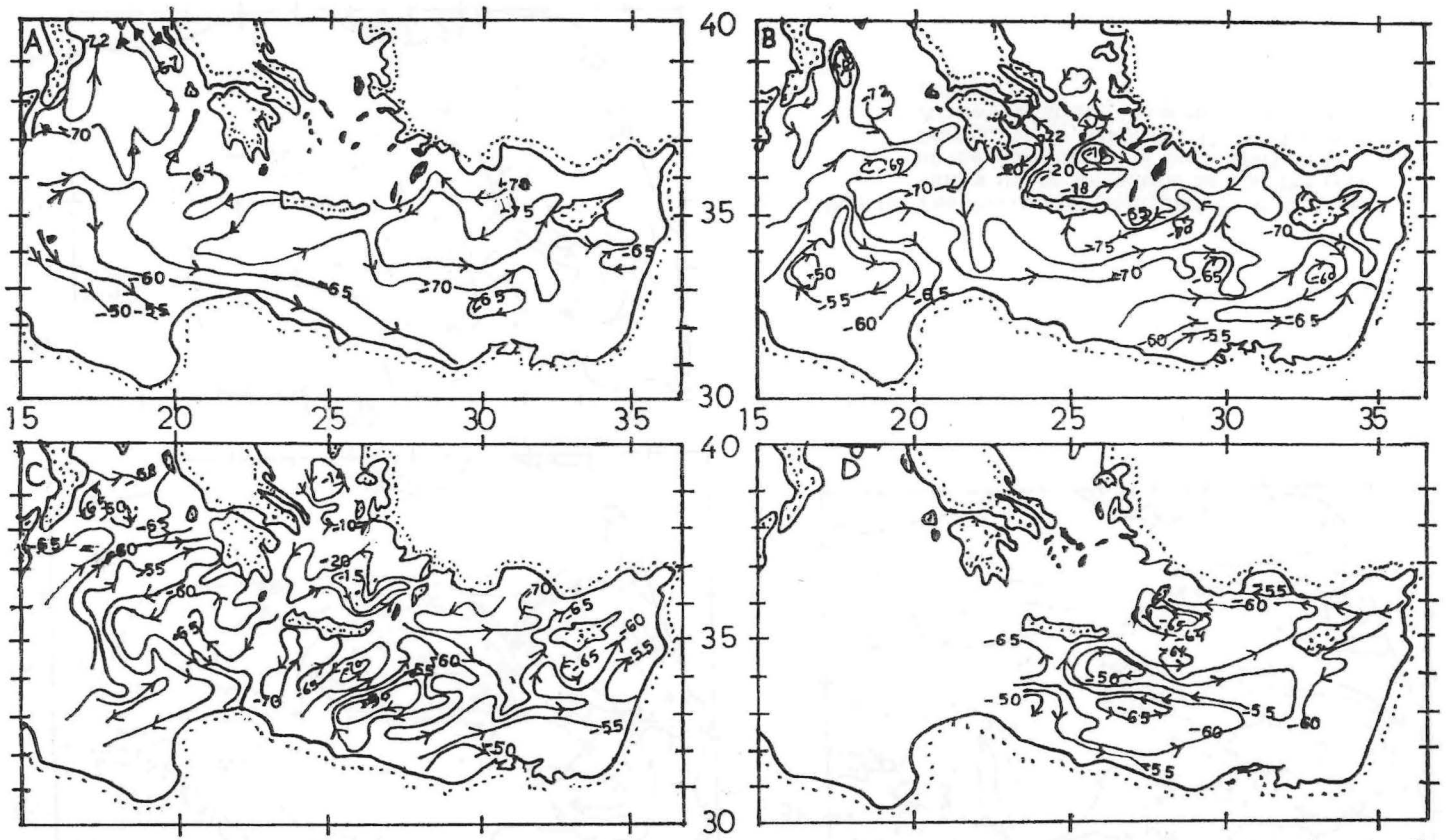

Fig. 11. The dynamic heights (r.t. 1000 d.b. in the Aegan Sea r.t. 300 d.b.) and the circulation patterns at surface in the Eastern Mediterranean, during A — Winter, B — Spring, C — Summer and D — Autumn (Sharaf El Din and El-Gindy, 1986).

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KEMIJSKA SVOJSTVA KAO INDIKATORI CIRKULACIJE U POVRŠINSKIM I ATLANTSKIM VODENIM MASAMA LEVANTINSKOG MORA

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Oceanološki odsjek, Odjel za znanstvena istraživanja Sveučilišta u Aleksandriji, Egipat

KRATKI SADRŽAJ

Kemijski parametri (nitriti, nitrati, fosfati, sadržaj kisika i pH) analizirani u periodu 1948—1972. u istočnom Mediteranu, korišteni su za izučavanje njihove prostorne raspodjele u nekoliko različitih sezona u odnosu prema horizontalnoj dinamičkoj strukturi. Dobiveni rezultati su pokazali da se maksimalne količine navedenih hranjivih soli nalaze u Levantskom moru, odnosno u područjima ciklonalnih vrtloga.

Ustanovljena korelacija s dinamičkom topografijom pokazala je da su nitrati, fosfati i PH najprikladniji pokazatelji cirkulacija vodenih masa u Levantinskom moru.