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Some results of current measurements in the area of the Otranto Strait

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Short-period current measurements collected on seasonal basis at two locations in the Otranto Strait are discussed. Two-layer circulation was observed. Measurements in June 1988, March and May 1990 confirm known water exchange structure with inflowing northward current along the eastern coast and outflowing southward current along the western coast. August 1990, however, displays a different exchange scheme with inflowing northward current along the western and outflowing southward current along the eastern coast. The most intensive flow is usually between 500 and 800 m. Inertial oscillations were observed frequently and their generation is discussed like: a) wind generated inertial oscillations and b) oscillations due to northward propagating cyclonic eddies formed in a shear zone between the northward and southward flow.

INTRODUCTION

The Adriatic Sea, as a part of the Mediterranean, communicates with it across the 72 km wide and 800 m deep Otranto Strait. Expected exchange of water between the South Adriatic Pit and the Ionian Sea is disturbed by the underwater sill (Fig. 1). Situated deeply in the continent, the Adriatic Sea displays proper continental characteristics, opposite to the rest of the Mediterranean (ZORE-ARMANDA, 1969). Therefore, the model of the exchange of water is an example of interaction between a small and cold and a large and warm basin.

Two processes have a strong influence on the exchange of a water between the Adriatic and the Mediterranean: a) formation of the high density water mass in the Adriatic (Adriatic Deep Water - ADW) and b) formation of the Levantine intermediate high salinity water in the area between Rhodos and Cyprus (at depths from 200 m to 600 m). Because of the generally cyclonic current system, Levantine Intermediate Water (LIW) was regist-ered frequently in the Adriatic Sea, and Adriatic boreal water in the Ionian Sea (BULJAN and ZORE-ARMANDA, 1976). The formation of these water masses and advection from origin area depends on season, meteorological conditions, river outflow and characteristics of the sea bed.

Exchange of water masses in the Otranto Strait is a part of the general cyclonic current gyre of the Mediterranean. Previous investigations of currents in that area were performed by different methods with quite contrary conclusions.

First investigations were based on geostrophic currents calculations (WÜST, 1961; OVCHINNIKOV, 1966; ZORE-ARMANDA, 1969). These results indicated a three layer structure:

a) a surface layer down to 200 m with inflowing (northward) current along the east coast and outflowing (southward) current along the west coast; b) an intermediate layer between 200 m and 600 m, with inflowing (northward) current and c) a bottom layer with the prevailing outflowing (southward) current. Intensity of current varied seasonally.

Recent investigations were performed by direct current measurements in the Otranto Strait (VUČAK and ŠKRIVANIĆ, 1986; MICHELATO, 1986; FERENTINOS and KASTANOS, 1988; MICHELATO and KOVČEVIĆ 1991). The results indicated a two layer structure. The longest period of measurement was 32 days at five stations (FERENTINOS and KASTANOS, 1988). The results confirmed a two layer circulation: stable and intensive northward advection in the surface and intermediate layer and outflowing weaker advection along the Greek continental slope. Outflowing currents were also registered along the Italian continental shelf and continental slope.

This paper will deal with the analysis of current measurements at two stations in the area of the Otranto Strait (Fig. 1), performed during

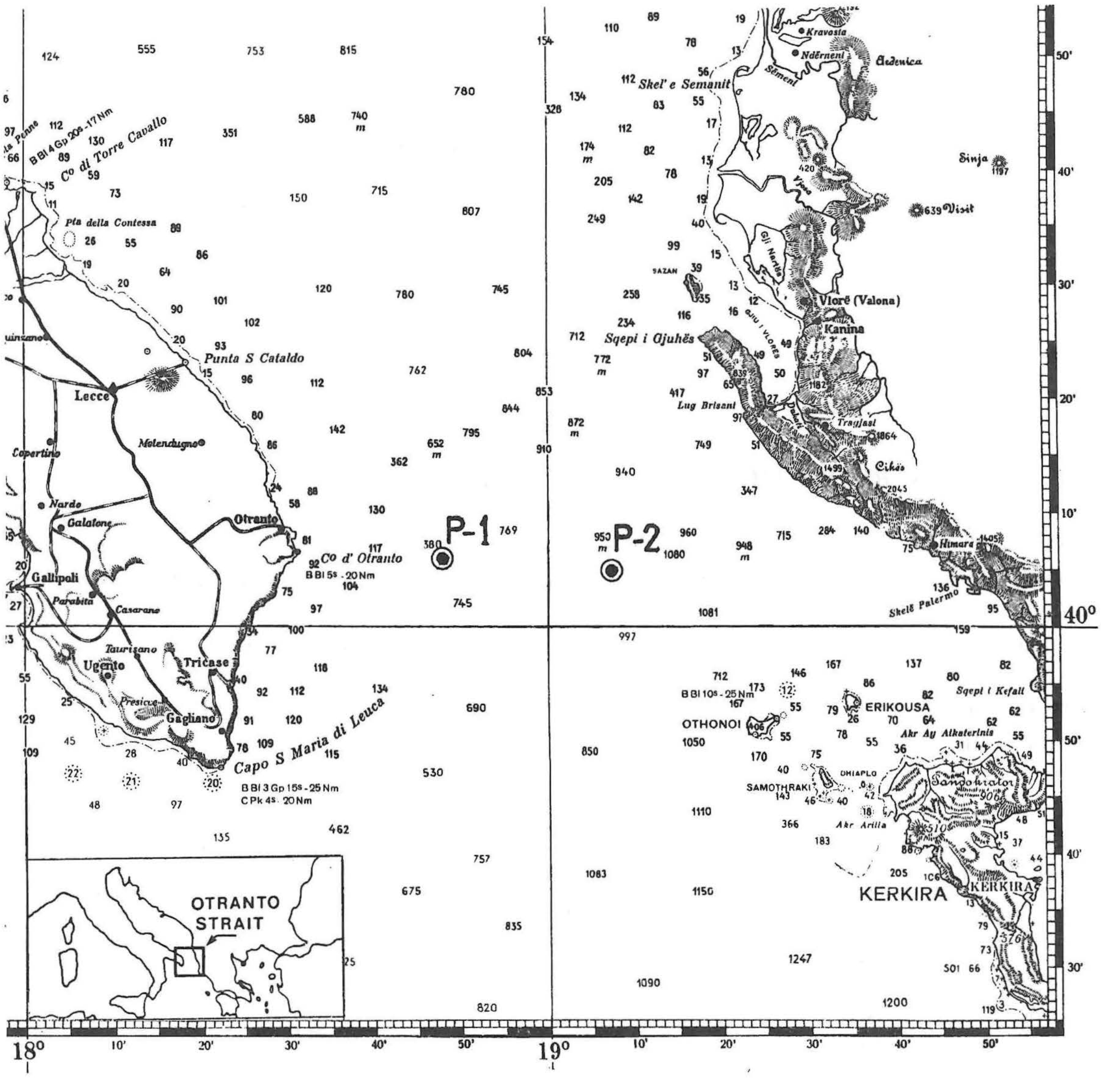

Fig. 1. Mooring locations P-1 and P-2 in the Otranto Strait

the surveying expeditions "Andrija Mohorovičić" The results obtained from these measurements will be compared with the known results.

MATERIALS AND METHODS

Five seasonal current measurements were realised in the Otranto Strait (Table 1) as parts of two projects: "Study, exploitation and protection of the Adriatic Sea" and "P. O. E. M.". Two current meter arrays were moored in the Strait: the first one near the west coast and the second one near the east coast at the positions:

P-1	P-2
$\varphi = 40^{\circ}$ 0,6.0' N	$\varphi = 40^{\circ}$ 04.7' N
$\lambda = 18^{\circ}$ 48.5' E	$\lambda = 19^{\circ}$ 06.5' E
d = 690 m	d = 970 m

The following statistical parameters were used to describe current field characteristics: minimum, mean and maximum current speeds,mean hourly vectors, resultant vectors, stability factor, progressive vector diagram, as well as rotary spectral analysis (Gonella, 1972).

RESULTS

June 1988

The results of current measurements in June 1988 were in harmony with the previous knowledge about the mass exchange in the Otranto Strait. The situation with outflowing water mass along the west coast (P-1) and inflowing water mass along the east coast (P-2) suggests a "typical" current field in the Otranto Strait.

Table 1. Positions of current meter stations, measurement intervals and nominal depths of current meters

	STATION P-1			STATION P-2		
POSITION	$\varphi = 40^{\circ}$ 06.0' N $\lambda = 18^{\circ}$ 48.5' E d = 690 m			$\varphi = 40^{\circ}$ 04.7' N $\lambda = 19^{\circ}$ 06.5' E d = 970 m		
MEASUREMENT INTERVALS	18-21	JUNE	1988	22-25	JUNE	1988
		- - -		23-28	SEPTEMBER	1988
	22-23	MARCH	1990	18-22	MARCH	1990
	17-19	MAY	1990	15-17	MAY	1990
	17-21	AUGUST	1990	15-17	AUGUST	1990
NOMINAL DEPTHS OF CURRENT METERS	5, 50, 100, 200, 500, and 650 m			5, 100, 200, 500, 800, and 930 m		

Aanderaa RCM-4 current meters, with 5 minutes sampling interval, were moored at the nominal depths of 5, 50, 100, 200, 500, 650 m (station P-1), and 5, 100, 200, 500, 800, 930 m (station P-2). Wind velocity measurements were registered onboard ship at one hour interval. Time-series of current data have been short, from one to five days. Current meter stations were anchored by 300 kg anchor, with surface buoy.

The location of the station P-1 was in the area where southward current outflow prevailed, and the station P-2 was situated in the area where northward current inflow prevailed.

The resultant vectors of the current stream for the Otranto Strait profile are shown in Fig. 16.

Main statistical parameters are presented in Table 2.

At the station P-1, southward current prevails along the whole water column. Different directions of current appear at 500 m (Fig.2). Maxima current speeds were registered from 17.0 cm/s (650 m) to 45 cm/s (50 m). Minimum (2 cm/s) was registered along the whole water column. Mean speeds indicate irregular distribution of speed along the water column. An increase of the mean speed was registered twice

Table 2. Statistical parameters of the current measurements (cm/s) in Otranto Strait in June 1988.

STATION P - 1						
DEPTH (m)	5	50	100	200	500	650
MAXIMUM SPEED	43.0	45.0	35.0	24.0	37.0	17.0
MEAN SPEED	14.5	15.5	13.0	9.3	33.6	6.4
MINIMUM SPEED	2.0	2.0	2.0	2.0	2.0	2.0
RESULTANT VECTOR (cms^{-1}/deg)	11. 9 / 163	14. 4. / 151	11. 8. / 146	7. 7 / 133	5. 7 / 131	4. 3 / 166
STABILITY FACTOR (%)	82	92	91	82	17	66
STATION P - 2						
DEPTH (m)	5	100	200	500	800	930
MAXIMUM SPEED	44.0	45.0	39.0	45.0	37.0	44.0
MEAN SPEED	23.3	29.7	25.1	31.0	36.5	25.3
MINIMUM SPEED	2.0	7.0	13.0	21.0	14.0	16.0
RESULTANT VECTOR (cms^{-1}/deg)	17.5 / 334	25. 4 / 358	21. 1 / 354	25. 0 / 353	23. 5 / 349	19. 7 / 342
STABILITY FACTOR (%)	75	85	84	80	64	78

at station P-1 (depths of 50 m and 500 m). Stability of outflowing flow of the water mass was confirmed by the resultant vectors and stability factors of currents. Stability factors were higher than 80 % for most of the water column. Exceptions are at 500 m (17 %) and at bottom (66 %)

Wind vector characteristics were: on 18th and 19th June variable wind directions, mainly from the southern quadrant (speed near 6 m/s); on 20th June the north wind with a constant speed 10-14 m/s; on 21th June the north and northwest wind, not more than 7 m/s. It is interesting to point out that southerly wind didn't influence the change of southward flow, although being in opposite directions, while northerly and northwesterly winds intensified the current speed (Fig. 2).

Analysing the results, it is very difficult to explain higher current speeds at P-1 at the depth of 500 m. Exchange of current direction in 24 hours period (12 hours outflow, 12 hours inflow) is difficult to explain, too. Significant peak in total power spectrum at 500 m at 23.8 hours period (Fig. 3), coincides with the peaks in the rest of water column. It seems to be the period of diurnal tidal oscillations, but it is in discrepancy with the tide-gauge measurements in Brindisi (Tavole di marea, 1988) which indicate semidiurnal tidal oscillations. Obviously, the current speeds indicate another kind of oscillations.

At station P-2 inflowing flow prevailed with very small oscillations in current directions (Fig. 4) along the whole water column. This was confirmed by the resultant vectors and stability factors higher than 75 %, with the exception at 800 m where the corresponding stability factor was 64% (Table 2). Maxima speeds were from 37 cm/s (800 m) to 45 cm/s (100 m and 500 m), mean from 23.3 cm/s at the surface to 36.5 cm/s at 800 m, and minima from 2 cm/s at the surface to 21 cm/s at 500 m. It is interesting to notice that the mean and maximum speed values at 800 m were similar (36.5 and 37.0 cm/s) thus indicating a high stability of speed and variability of direction (stability factor 64 %). Furthermore, the discrepancy between the wind and current directions at the surface (always in opposite directions) should be pointed out, although the wind was strong for the first two days: on 22th and 23th June the N and NNW wind speed was 8-12 m/s, while on 24 th June the N wind speed was 2-3

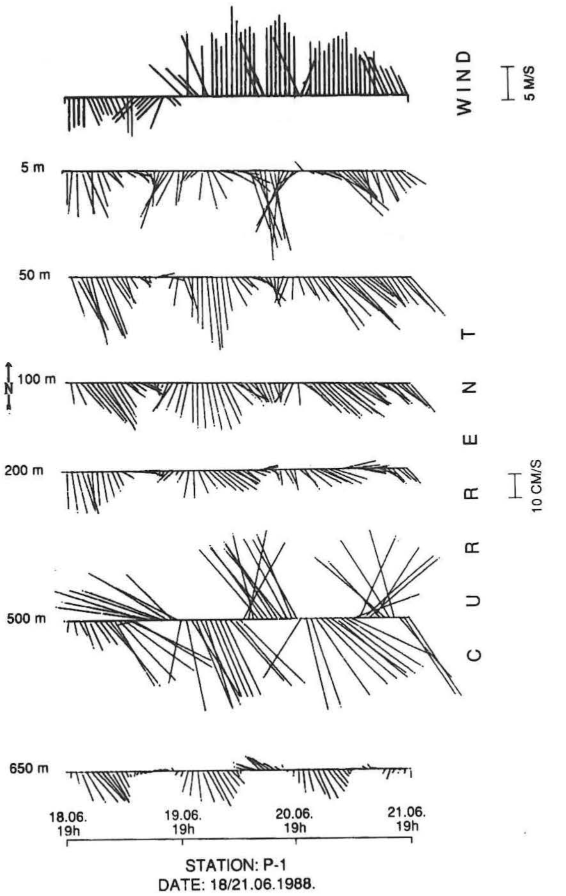

Fig. 2. Mean hourly wind and current vector timeseries for the period from June 18 to June 21, 1988 - mooring P-1

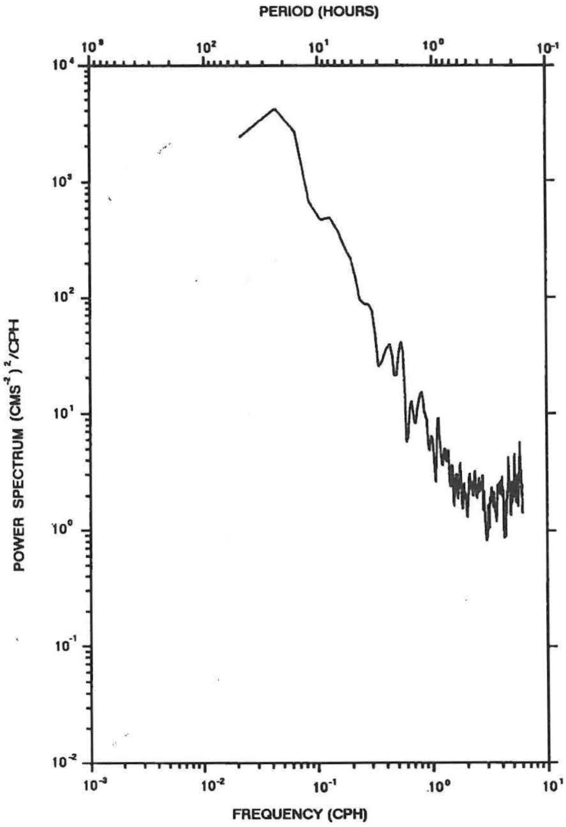

Fig. 3. Total spectrum for current time-series shown in Fig. 2 at the depth of 500 m

m/s. In the whole water column the current direction turned to the left on 24th June. Although the generating force for such change of current direction has not been known, it is difficult to suppose that it was because of starting of the SE wind (Fig. 4).

The vertical profile of a mean current speed was very complex - there were 3 increasings of a mean speed with depth. The most intensive flow was in 500-800 m layer. Intensity of the bottom flow is surprisingly high: maximum 44 cm/s, mean 25.3 cm/s and minimum 16 cm/s.

September 1988

Because of bad weather conditions, measurements were performed only at station P-2, with good results achieved using current meters at 100 m and 500 m. These measurements were characterized by the inertial-period oscillations at 100 m and prevailing southward outflowing current at 500 m, which is not typical for the area of the station P-2 (Fig. 5).

Rotatory motion at 100 m, with the period of 18 hours, was superimposed on the northward translatory advection (Fig. 6). Total power spectrum shows a peak at 18.1 hours period (Fig. 7) what is very close to the theoretical value of inertial period in the area of the Otranto Strait ($T = 2\Pi / 2\Omega \sin \phi = 18.6$ hours, where Ω is angular speed of Earth and ϕ is latitude).

Wind characteristics were: 23-25th September the NW and N wind 8-12 m/s, 26-27th September the N, NW and NNE wind 14-18 m/s, and than wind speed decreased to 5 m/s. Although the wind oscillations can generate inertial oscillations, it is difficult to explain their spreading to 100 m with so high intesity (current speed 45 cm/s Table 3). This will be subsequently discussed.

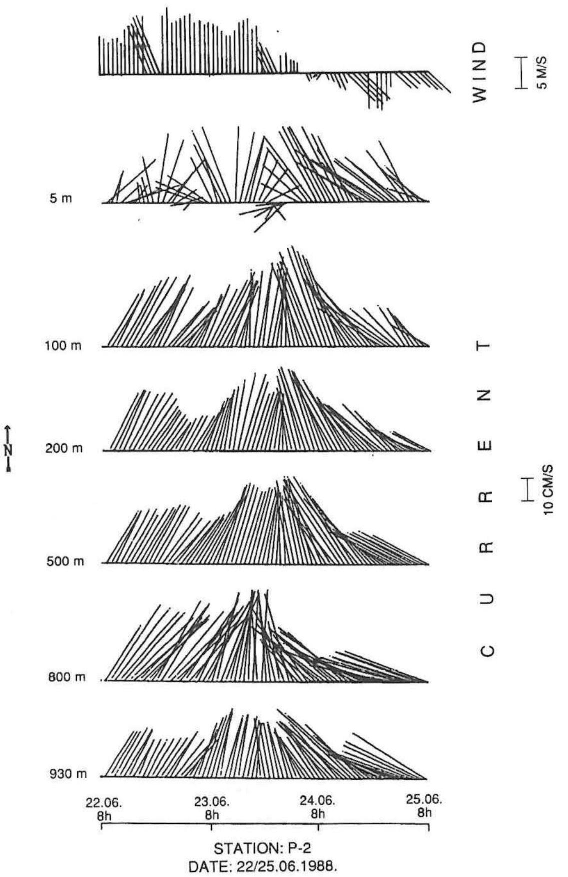

Fig. 4. Mean hourly wind and current vector time-series for the period June 22 to June 25, 1988 - mooring P-2

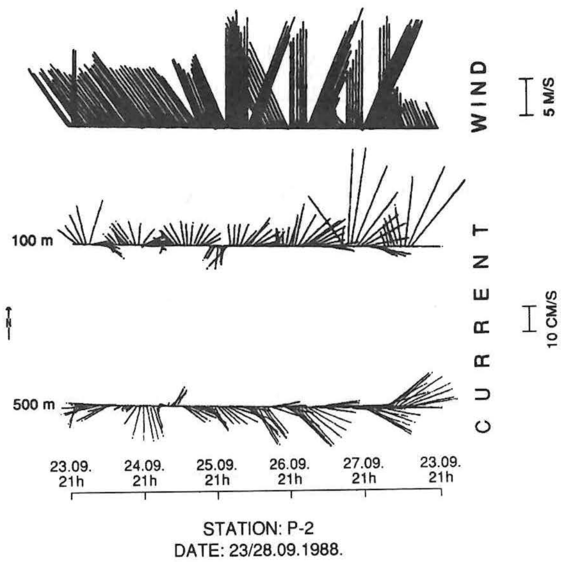

Fig. 5. Mean hourly wind and current vector time-series for the period September 23 to September 28, 1988 - mooring P-2

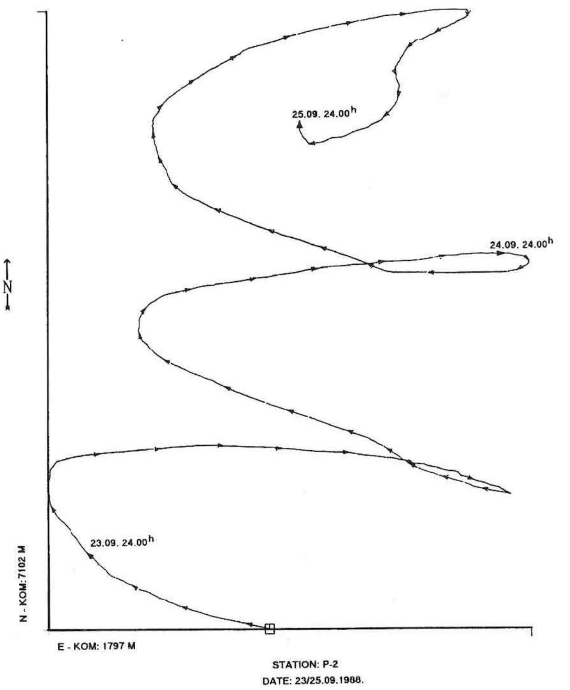

Fig. 6. Progressive vector diagram at the depth of 100 m for the period September 23 to September 25, 1988 - mooring P-2

Table 3. Statistical parameters of the current measurements (cm/s) in the Otranto Strait in September 1988.

STATION P - 2		
DEPTH (m)	100	500
MAXIMUM SPEED	45.0	21.0
MEAN SPEED	10.8	12.7
MINIMUM SPEED	2.0	2.0
RESULTANT VECTOR (cms^{-1} / deg)	6. 6. / 30	8. 6. / 114
STABILITY FACTOR (%)	61	68

At the depth of 500 m currents were more intensive than at 100 m (Table 3). Outflowing currents are not typical. According to the geostrophic current calculations (BULJAN and ZORE-ARMANDA, 1976) the inflow of Levantine Intermediate Water (LIW) is typical for this layer at station P-2. Because of missing/too short lasting measurements it is not possible to give an explanation of this nontypical situation.

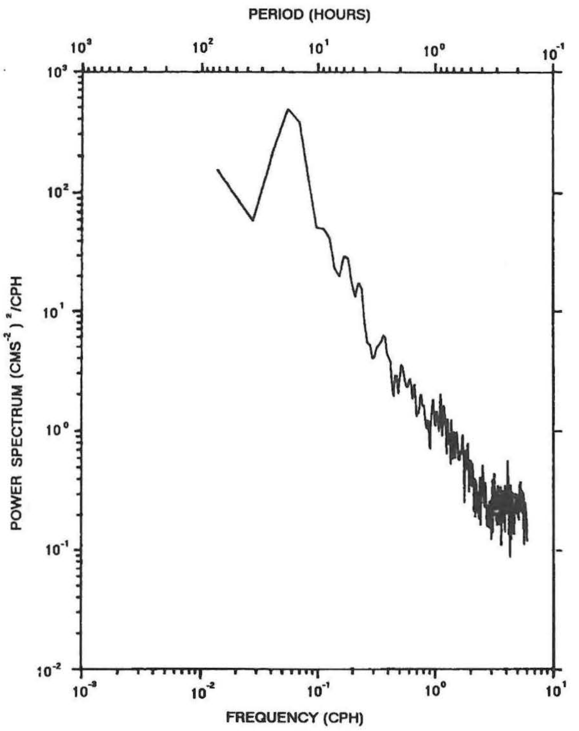

Fig. 7. Total spectrum for current time-series shown in Fig. 5 at the depth of 100 m

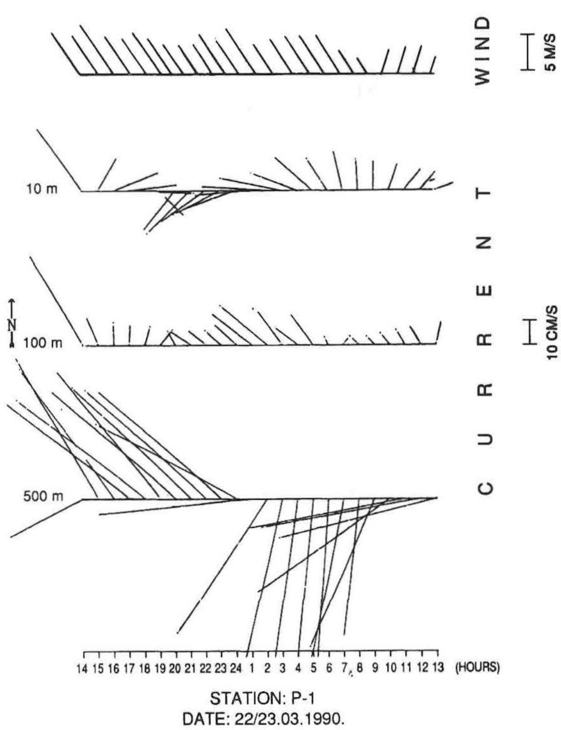

Fig. 8. Mean hourly wind and current vector time-series for the period March 22 to March 23, 1990 - mooring P-1

March 1990

Current measurements in March were not completed because of the instrument malfun-ctioning. At station P-1 there was no data from 200 m and 650 m depth and at station P-2 from 800 m and 930 m.

The resultant vectors of current for P-1 and P-2 are shown in Fig. 16.

Measurements at station P-1 were not representative, because of a short measurement period (1 day), but will be presented with a few interesting results.

At the depths of 10 m and 100 m prevailed inflowing N and NW current (Fig. 8), quite contrary to the typical outflowing southward current. At the depth of 500 m intensive currents of 55-64 cm/s were registered with a 24 hours period oscillation (Fig. 8). Mean speed was six times higher at 500 m, than at 100 m. Similar situation was registered in the area of the station P-1 at 500 m depth in June 1988. Main statistical current parameters are presented in Table 4. The speed of the NW wind was lower than 7 m/s (Fig. 8).

More representative measurements were performed at station P-2. Inflowing N and NE currents dominated along the whole water column (Fig. 9), as usual for the station P-2. The most intensive flow was at 200 m with a mean speed three times higher than at other depths (Table 4). Stability factors were higher than 80% what indicates stability of direction.

Main statistical parameters for station P-2 are shown in Table 4. During these measurements from 18th to 22th March the NNW wind blew, with a speed ranging from 5-16 m/s, demonstrating opposite direction of current and wind (Fig. 9).

May 1990

In May 1990 measurements were performed only two days at each station, without bottom current data.

The resultant current vectors presented along the Otranto cross section (Fig. 16) indicate a typical situation with outflowing current at the station P-1 and inflowing current at the station P-2.

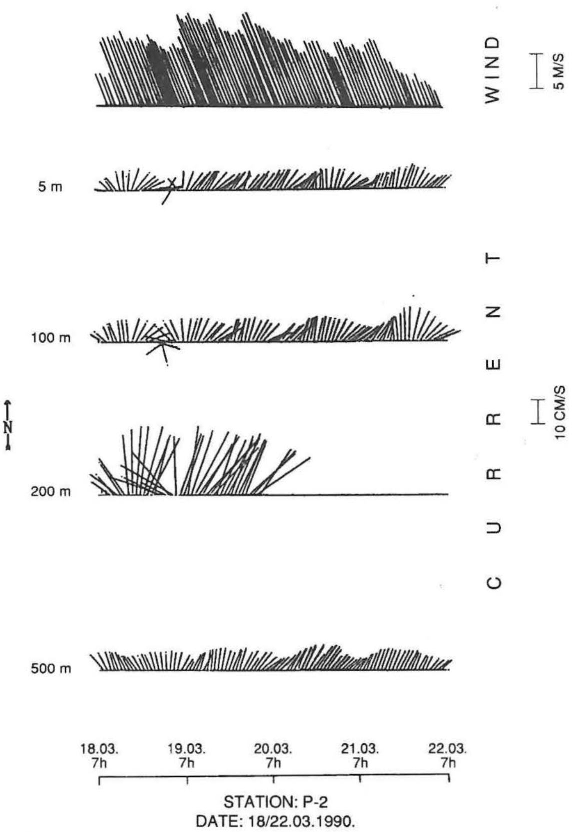

Fig. 9. Mean hourly wind and current vector time-series for the period March 18 to March 22, 1990 - mooring P-2

Because of a short measurement period and missing of the bottom data, current characteristics will not be analyzed in detail and the results are presented in Table 5.

The main characteristics of current field, evident from the Table 5, as well as from Figs. 10 and 11 are the following: at station P-1, the current flow was more intense (maximum speed was recorded at 100 m depth) and more persistent, with prevailing outflowing current in the intermediate and bottom layers (below 100 m), than in the surface layer (5 and 50 m), where the speeds were lower and directions were more variable; at station P-2, the current flow was more intense in the first 100 m (maximum speed was recorded at 5 m depth), with pronounced inertial oscillations, than in the intermediate and bottom layers, which were characterized by more persistent inflow of minor intensities. The wind of NW and NNW directions (7-10 m/s) was a probable generator of inertial oscillations at station P-2 (Fig. 11).

August 1990

During August 1990 a different pattern of current field was registered. The inflowing NW current prevailed along the west coast (P-1), while the outflowing SE current existed along the east coast (P-2), which could be regarded as a nontypical situation.

Table 4. Statistical parameters of the current measurements (cm/s) in the Otranto Strait in March 1990.

STATION P - 1			
DEPTH (m)	10	100	500
MAXIMUM SPEED	38.0	54.0	64.0
MEAN SPEED	17.6	10.3	63.8
MINIMUM SPEED	7.0	2.0	55.0
RESULTANT VECTOR (cms^{-1} / deg)	5.0 / 299	8.6 / 329	39.3 / 296
STABILITY FACTOR (%)	29	83	61

STATION P - 2				
DEPTH (m)	5	100	200	500
MAXIMUM SPEED	26.0	16.0	40.0	29.0
MEAN SPEED	8.1	9.5	23.0	8.1
MINIMUM SPEED	2.0	4.0	2.0	5.0
RESULTANT VECTOR (cms^{-1} / deg)	6.8 / 33	7.7 / 27	19.2 / 13	7.0 / 20
STABILITY FACTOR (%)	84	81	83	87

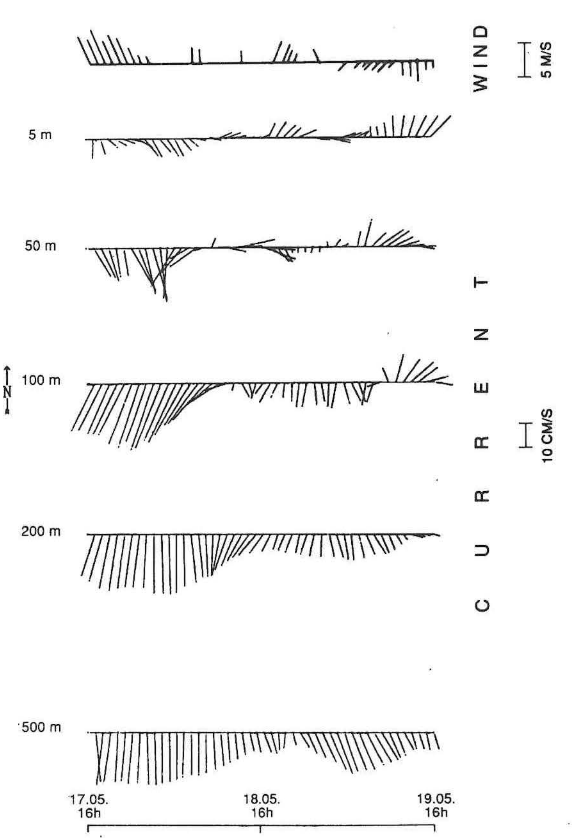

Fig. 10. Mean hourly wind and current vector time-series for the period May 17 to May 19, 1990 - moorning P-1

Main statistical parameters of currents are presented in Table 6.

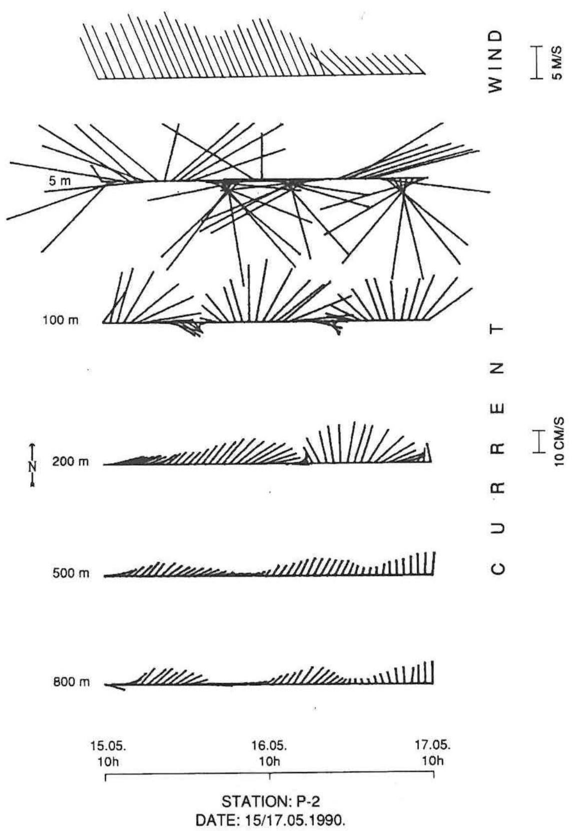

Fig. 11. Mean hourly wind and current vector time-series for the period May 15 to May 17, 1990 - moorning P-2

Inflowing NW current prevailed at station P-1, down to 500 m. Outflowing current prevailed near the bottom (Fig. 12). Progressive

Table 5. Statistical parameters of the current measurements (cm/s) in the Otranto Strait in March 1990.

STATION P - 1					
DEPTH (m)	5	50	100	200	500
MAXIMUM SPEED	20.0	23.0	29.0	25.0	25.0
MEAN SPEED	7.4	9.6	13.3	12.8	13.8
MINIMUM SPEED	3.0	2.0	2.0	2.0	5.0
RESULTANT VECTOR (cms^{-1} / deg)	4.9 / 76	5.5 / 138	10.2 / 201	12.1 / 184	13.5 / 171
STABILITY FACTOR (%)	66	57	76	95	98

STATION P - 2					
DEPTH (m)	5	100	200	500	800
MAXIMUM SPEED	49.0	30.0	19.0	11.0	10.0
MEAN SPEED	48.6	16.9	11.5	6.4	6.4
MINIMUM SPEED	12.0	2.0	2.0	2.0	2.0
RESULTANT VECTOR (cms^{-1} / deg)	5.6 / 210	10.6 / 38	9.7 / 44	5.6 / 39	5.3 / 45
STABILITY FACTOR (%)	12	63	84	88	82

Table 6. Statistical parameters of the current measurements (cm/s) in the Otranto Strait in August 1990.

STATION P - 1						
DEPTH (m)	5	50	100	200	500	650
MAXIMUM SPEED	26.0	14.0	21.0	16.0	22.0	22.0
MEAN SPEED	11.2	7.4	13.8	6.4	13.5	11.0
MINIMUM SPEED	2.0	2.0	5.0	2.0	3.0	7.0
RESULTANT VECTOR (cms^{-1} / deg)	8.1 / 306	5.5 / 290	10.3 / 306	3.9 / 299	8.3 / 297	7.2 / 207
STABILITY FACTOR (%)	72	74	74	61	61	66

STATION P - 2						
DEPTH (m)	5	100	200	500	800	930
MAXIMUM SPEED	11.0	8.0	14.0	6.0	16.0	10.0
MEAN SPEED	8.3	5.4	11.3	5.0	12.4	8.0
MINIMUM SPEED	4.0	3.0	9.0	2.0	9.0	5.0
RESULTANT VECTOR (cms^{-1} / deg)	7.8 / 4	5.1 / 110	11.0 / 109	4.8 / 93	11.9 / 104	7.5 / 121
STABILITY FACTOR (%)	94	95	97	97	96	94

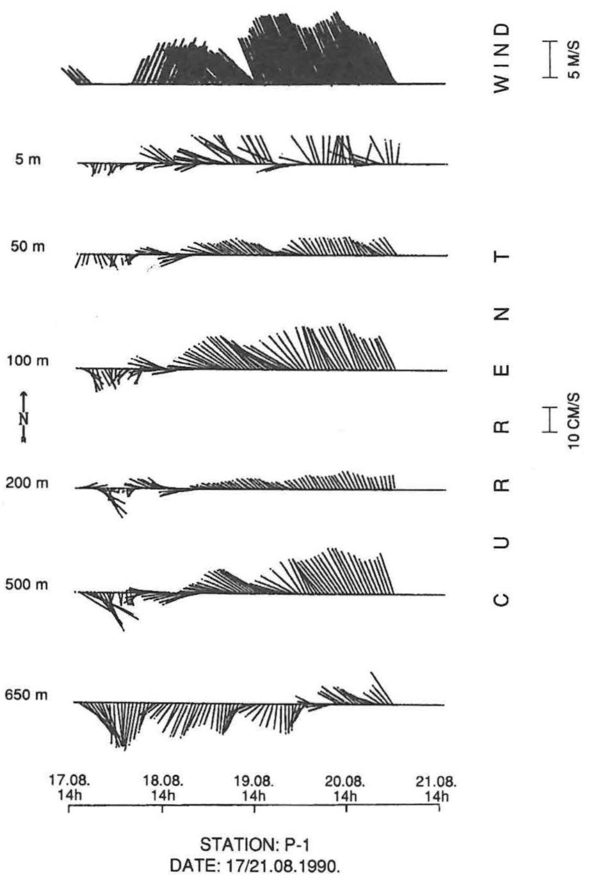

Fig. 12. Mean hourly wind and current vector time-series for the period August 17 to August 21, 1990 - moorning P-1

vector diagram of currents at 500 m is presented in Fig. 13, being similar to progressive vestor diagrams at the smaller depths, and different from those near the bottom. Maxima speeds were in the range from 14 cm/s (50 m) to 26 cm/s (surface) and mean values from 6.4 cm/s (200 m) to 13.5 cm/s (500 m). The highest minimum was registered near the bottom (7 cm/s - Table 6). The mean current speeds indicate an irregular distribution of current intensity. The most intensive currents were at 100 m and 500 m.

Stability factors were lower, between 60 % and 75 %, as a consequence of exchange of current regime at the beginning of the measurement period.

In spite of the strong NNW wind (10-15 m/s on 19th and 20th August), current direction was opposite to the wind in the major part of the water column (Fig. 12).

The outflowing SE current of negligible intensity prevailed at station P-2 (Fig. 14). Current speeds were lower than 16 cm/s (Table 6) and stability factor higher than 90 % along the whole water column. The progressive vector diagram of currents at 200 m is shown in Fig. 15.

The most intensive currents were at 200 m and 800 m, and the lowest at 500 m, quite

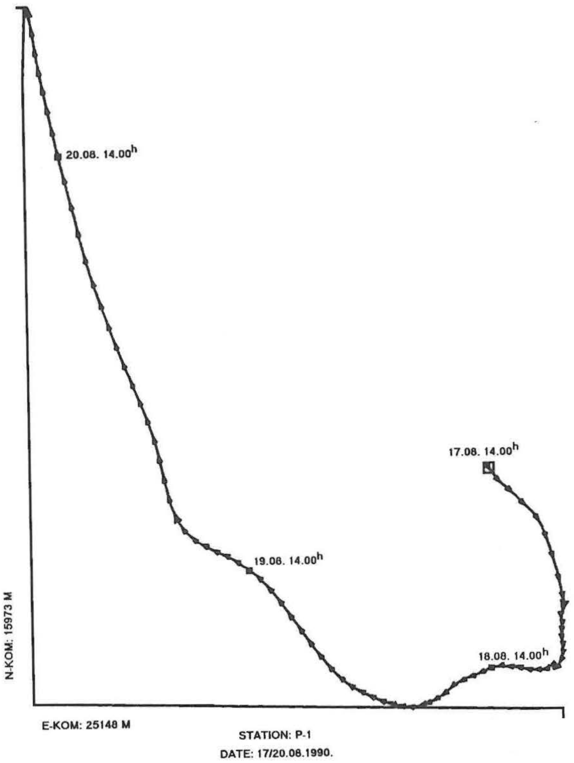

Fig. 13. Progressive vector diagram at the depth of 500 m for the period August 17 to August 20, 1990 - mooring P-1

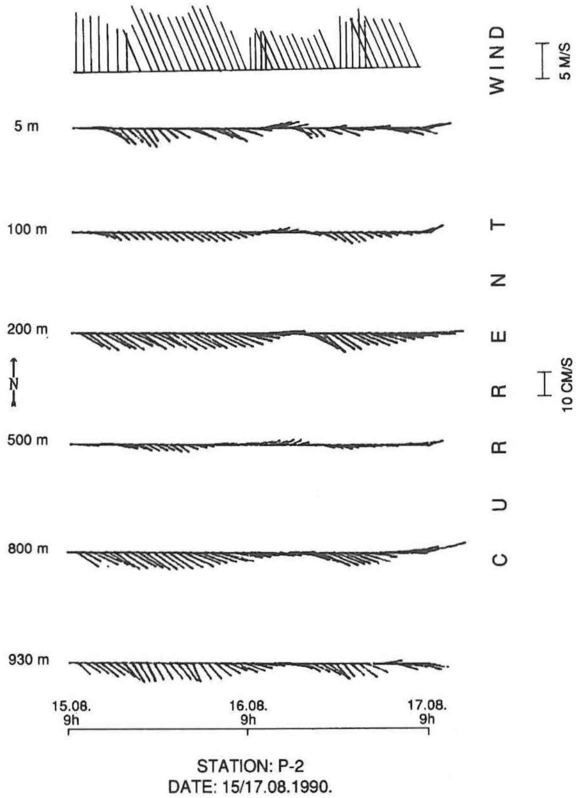

Fig. 14. Mean hourly wind and current vector time - series for the period August 15 to August 17, 1990 - mooring P-2

contrary to the typical situation when at 500 m the prevailing inflowing currents were of maximum intensity. The N and NW wind (5-10 m/s) had the same direction as the surface current (Fig. 14).

In meteorological situation without wind, or when the wind speed was negligible, one-layer flow existed, especially in the area of the station P-2.

DISCUSSION

Seasonal short-period current measurements at two stations in the Otranto Strait indicate mainly two-layer circulation, sometimes with only one layer especially at station P-2 (Fig. 16). The results are in agreement with VUČAK (1978), VUČAK and ŠKRIVANIĆ (1986), FERENTINOS and KASTANOS (1988) and MICHELATO and KOVAČEVIĆ (1991) results, obtained also by direct current measurements. The results are in collision with three-layer model obtained by calculating of geostrophic currents (WÛST, 1961; OVCHINNIKOV, 1966; ZORE-ARMANDA, 1969).

Geostrophic currents, being caused by the horizontal difference of density between water masses of the Adriatic Sea at the Ionian Sea are dominant signal in the current field. The current field was slightly modified by tidal currents; wind influence was located in the surface layer, in connection with the wind force and season.

Geostrophic currents were sometimes so strong at the surface, so that a strong wind in opposite direction didn't change the current direction.

The wind often generated oscillations of inertial period, what have concluded FERENTINOS and KASTANOS (1988) and MICHELATO and KOVAČEVIĆ (1991), as well.

Measurements in June 1988, March and May 1990 supported the well known structure of exchange of the water mass in the Otranto Strait, with inflowing northward currents along the Albanian coast, and outflowing southward

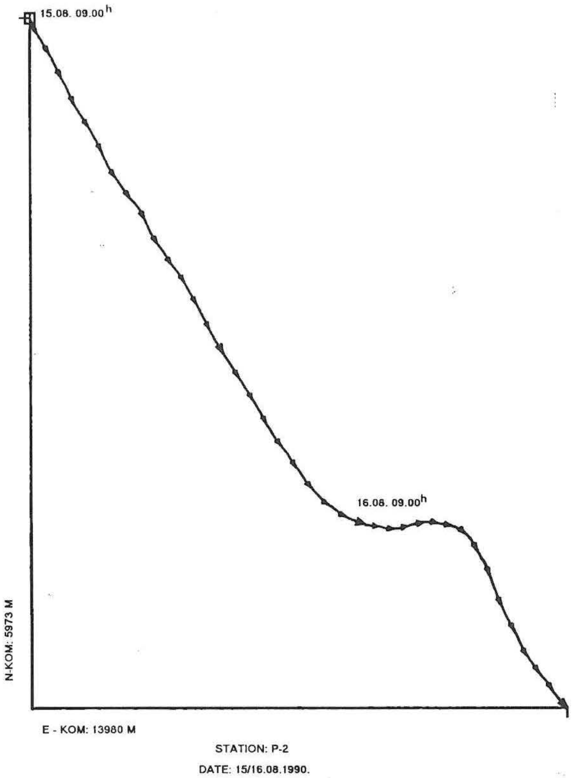

Fig. 15. Progressive vector diagram at the depth of 500 m for the period August 15 to August 16, 1990 - mooring P-2

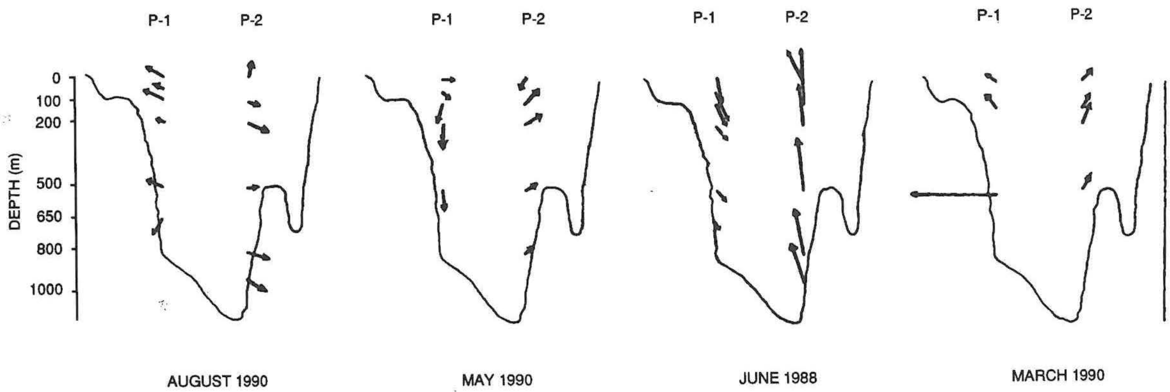

Fig. 16. Resultant currents in the Otranto Strait profile for March, May and August, 1990 and June, 1988.

currents along the Italian coast. Such current regime can be called a "typical situation".

Meanwhile, in August 1990, the opposite nontypical exchange of water masses was registered, with outflowing current along the Albanian coast and inflowing current along the Italian coast. In typical situation inflowing current were more intensive and stable than outflowing, while in nontypical situation inflowing currents along the Italian coast were more intensive and unstable than outflowing currents along the Albanian coast. At both stations currents were stronger in typical, than in nontypical situations.

It is interesting that VUČAK (1978) registered in July 1975 outflowing currents at both stations on the basis of one day measurements.

According to the accessible data set, it is impossible to conclude which mechanism is responsible for change of the current regime in the Otranto Strait.

Vertical profile of the current speed is complex, with a few disturbances along the water column. At station P-1 currents intensified at 500 m, while at station P-2 at 500 m and 800 m.

Outflowing currents near the bottom were not registered in all measurements what is contrary to the results of VUČAK and ŠKRIVANIĆ (1986), FERENTINOS and KASTANOS (1988) and MICHELATO and KOVAČEVIĆ (1991).

A regular exchange of the inflow-outflow currents at station P-1 at 500 m, with 24 hours period, was registered in June 1988 and March 1990, but not at other depths. This phenomenon is difficult to explain on the basis of the available data set. The tidal effect, however, can be ruled out.

Missing of data at four depths in September 1988 has provoked another dilemma. Oscillations of inertial period at 100 m can be explained as a result of variable wind influence (strong to storm wind). However, it is real to suggest that intensity of inertial oscillations decreases with depth (POLLARD, 1980), which cannot be seen from our measurements.

Another possible generator of inertial oscillations would be explained, as a consequence of the existence of cyclonic gyre in shear zone. Existence of gyres in the Otranto Strait area was registered by FERENTINOS and KASTANOS (1988) from direct current measurements and from satellite photos.

A few cyclonic gyres, with radius of 10-15 km, were registered in the shear zone. Direction of translation was toward the north,with speed similar to geostrophic currents. Physical explanation of generating currents of inertial period during translation of gyres was given by FERENTINOS and KASTANOS (1988). In the shear zone some parcels of the water mass can be detached from the general flow, causing inertial movement. During passive movement Coriolis force caused inertial oscillations. The resultant current field was performed by inertial oscillations and translation. This resultant motion is shown on the progressive vector diagram of currents (Fig. 6).

CONCLUSIONS

The results obtained by the present study show the following:

1. Current measurements indicate two-layer circulation;

2. Two main types of water exchange structure between the Adriatic and the Ionian Sea were observed:

a) "typical situation" - the northward flow along the eastern coast and the southward flow along the western coast of the Otranto Strait. The northward flow is more intensive and stable than the southward flow;

b) "nontypical situation" - an opposite flow than in the typical situation in the Otranto Strait. Inflowing currents along the western coast are more intensive and unstable than outflowing currents along the eastern coast;

3. At both stations currents were stronger in typical than in nontypical situation;

4. Geostrophic currents are a dominant feature in a two-layer outflow-inflow water exchange structure;

5. The most intensive flow is usually between 500 m and 800 m;

6. Surface current vector and wind vector can be in opposite direction although the wind is strong;

7. Inertial-period oscillations were observed frequently;

8. Better understanding of water circulation in the Otranto Strait requires additional longer-term current measurements together with temperature, salinity, density, wind, air pressure and sea level measurements.

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REFERENCES

BULJAN, M. and M. ZORE-ARMANDA. 1976. Oceanographical properties of the Adriatic Sea. Oceanogr. Mar. Biol. Ann. Rev., 14: 11-98.

FERENTINOS, G. and N. KASTANOS. 1988. Water circulation patterns in the Otranto Straits, eastern Mediterranean. Continental Shelf Research, 8: 1025-1041.

GONELLA, J. 1972. A rotary-component method for analysing meteorological and oceanographic vector time series. Deep-Sea Research, 19: 833-846.

MICHELATO, A. 1986. Current meter observations in the Strait of Otranto during POEM-0 85. Congress-Assemblee de la CIESM, Palma de Majorque, Spain, 20-25 October, Vol. 30, pp 158.

MICHELATO, A. and V. KOVAČEVIĆ. 1991. Some dynamic features of the flow through the Otranto Strait. Boll. Oceanol. Teor. Appl., 9, 39-51.

OVCHINNIKOV, I.M. 1966. Circulation in the surface and intermediate layers of the Mediterranean. Oceanology, 11: 524-528.

POLLARD, R.T. 1980. Properties of near surface inertial oscillations. J. Phys. Ocean., 10: 385-398.

Tavole di marea Mediterraneo - Mar Rosso. 1988. Istituto Idrografico della Marina, Genova, 1987.

VUČAK, Z. 1978. Current measurements in the area of Otranto Strait. M. Sc. Thesis, 104 pp.

VUČAK, Z. and A. ŠKRIVANIĆ 1986. Oceanographic properties of the Adriatic Sea - multidiscipline research by m/v "Andrija Mohorovičić". Hidrografski godišnjak 1984-1985: 85-102.

WÛST, G. 1961. On the vertical circulation of the Mediterranean Sea. J. Geoph. Res.,60: 3261-3271.

ZORE-ARMANDA, M. 1969. Water exchange between the Adriatic and Eastern Mediterranean. Deep-Sea Research, 16: 171-178.

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Neki rezultati mjerenja morskih struja u Otrantskim vratima

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KRATKI SADRŽAJ

Za vrijeme oceanografskih krstarenja i/b "Andrija Mohorovičić" mjerene su morske struje u Otrantskim vratima. Mjerenja su bila organizirana po sezonama na dvije postaje: P-1 uz zapadnu obalu i P-2 uz istočnu obalu Otrantskih vrata. Na svakoj postaji je bila usidrena strujomjerna stanica sa 6 strujomjera Aanderaa RCM-4 s intervalom mjerenja 5 minuta.

Na obje postaje je uočena dvoslojna cirkulacija. Mjerenja u lipnju 1988. godine, ožujku i svibnju 1990. godine potvrđuju do sada poznatu strukturu izmjene vodenih masa u Otrantskim vratima s ulaznim sjevernim strujanjem uz istočnu obalu i južnim izlaznim strujanjem uz zapadnu obalu. Međutim, mjerenja u kolovozu 1990. godine pokazuju sasvim suprotnu shemu izmjene vodenih masa s ulaznim sjevernim strujanjem uz zapadnu obalu i izlaznim južnim strujanjem uz istočnu obalu Otrantskih vrata.

Oscilacije inercijalnog perioda česta su pojava u Otrantskim vratima. Njihova pojava se pokušava objasniti djelovanjem dva fizikalna procesa: jakim oscilirajućim vjetrom i formiranjem ciklonalnih vrtloga u zoni smicanja između sjevernog i južnog strujanja.