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SOME PROPERTIES OF THE RESIDUAL CIRCULATION IN THE NORTHERN ADRIATIC

NEKE OSOBINE REZIDUALNOG STRUJANJA U SJEVERNOM JADRANU

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Large number of data collected from the northernmost Adriatic part, particularly those from oil-drilling platforms have been used to get a better insight into the current field of that area.

Effects of general Adriatic cyclonic circulation, topographic features and Po River on the mean current field are discussed. Seasonal variations and wind forcing are also considered.

INTRODUCTION

Large number of data on currents have recently been collected from the northern Adriatic. Since the properties of currents were less known in this area than in some other Adriatic parts these new data have contributed much toward better understanding of the current field in the Adriatic basin.

Data collected from oil-drilling platforms are of particular significance since they satisfy all the criteria of fixed stations.

Study area extends approximatively from the line Pescara—Dugi otok including the north Adriatic archipelago. Topography of the area is for the most part uniform with depths not exceeding 75 m and being reduced to the southwest (Fig. 1). Another property of the northern Adriatic is the fresh water discharge of the Po River and some other big rivers. The climate of this area is characterized by strong high-frequency bora wind.

The following aspects of the mean current field are considered:

1. General Adriatic cyclonic circulation and topography effects
2. Po River effects
3. Seasonal variations
4. Wind forcing

MATERIALS

Two distinct groups of data have been interpreted: data collected from oil-drilling platforms and seasonal measurement data from moorings at a series of stations along the western Istrian coast.

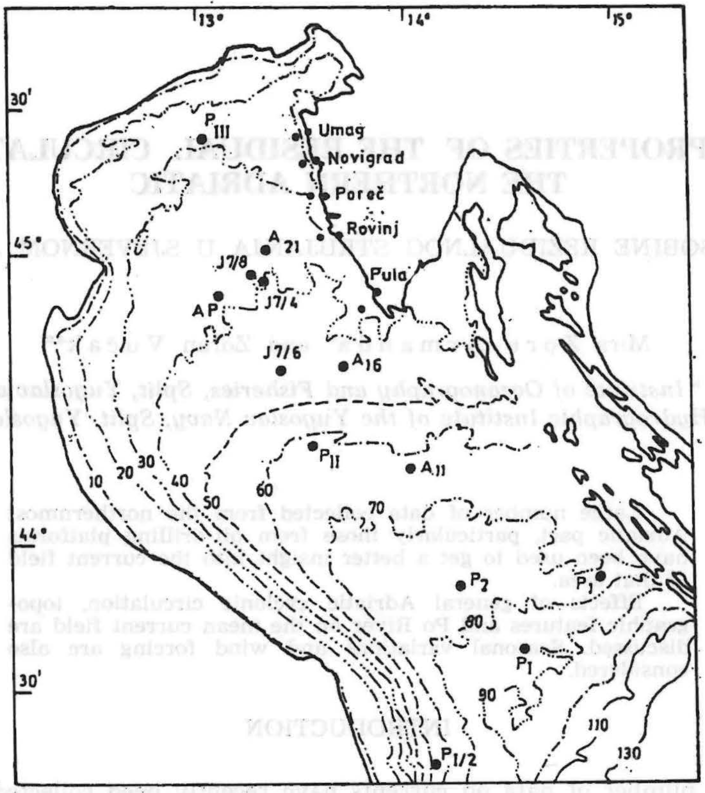

Fig. 1. The map of isobaths of the study area and current-meter stations.
»A«marked stations — MEDALPEX stations
»P« marked stations — oil-drilling platform stations
Stations along the western Istrian coast are named after the closest town

Material from the area along the western Istrian coast includes seasonal 24-hour series from 5 stations (Table 1) collected by moorings. Most of the material was collected from a total of 10 locations of oil-drilling platforms (stations marked P in Fig. 1). A part of this material was studied earlier (Zore-Armanda, et al., 1975) and somewhat larger part was studied in detail and presented in the paper by Vučak, MS. Data were statistically treated at the Hydrographic Institute of the Yugoslav Navy, Split. MEDALPEX data have also been included (Zore-Armanda, et al., 1983). The time and duration of measurements are shown in Table 2 as well as the basic data. Alexeev BPV—2r (mechanical) and Aanderaa RCM—4 (electronic) current meters were used.

Table 1. Current-meter data collected along the western Istrian coast by Alexeev BPV-2r current-meter at 5 minute intervals

Station	Position	Measurement depth (m)	Time of 24-hour series (months and years)
Umag	$\varphi = 45°27.1'$ $\lambda = 13°29.4'$	3	3/77, 6/77, 8/77, 9/77, 12/77, 3/78, 6/78, 8/78, 11/78, 12/78.
		25	3/77, 6/77, 8/77, 9/77, 12/77, 3/78, 6/78, 8/78, 12/78.
Novigrad	$\varphi = 45°19.8'$ $\lambda = 13°31.0'$	3 and 20	3/77, 6/77, 8/77, 9/77, 12/77, 3/78, 6/78, 8/78, 11/78, 12/78.
Poreč	$\varphi = 45°15.4'$ $\lambda = 13°31.5'$	3 and 20	8/76, 9/76, 12/76, 3/77, 6/77, 8/77, 9/77, 12/77, 3/78, 6/78.
Rovinj	$\varphi = 45°04.9'$ $\lambda = 13°36.0'$	3	3/78, 6/78, 8/78, 11/78, 12/78.
		23—26	3/78, 6/78, 11/78, 12/78,
Pula	$\varphi = 44°51.2'$ $\lambda = 13°46.0'$	3 and 32	6/77, 8/77, 10/77, 12/77, 4/78, 6/78.

Table 2. Data collected from oil-drilling platforms (stations marked P) and during MEDALPEX experiment as well as the basic data on residual circulation

Station	Position and type of current-meter	Depth (m)	Meas. depth (m)	Duration of records (10—20 min intervals)	Res. speed (cms^{-1})	Mean speed (cms^{-1})	Res. direction °azimuth
P_1	$\varphi = 42°55.2'N$	61	3	14. 1. 71—22. 2. 71	7.2	16	343
	$\lambda = 14°53.0'E$		20	14. 1. 71—22. 2. 71	4.3	9	339
			35	14. 1. 71—22. 2. 71	0.8	6	23
	Alexeev BPV — 2 r		60	12. 2. 71—22. 2. 71	0.6	5	355
P_2	$\varphi = 43°52.5'N$	71	3	27. 10. 70—11. 1. 71	6.1	13	3
	$\lambda = 14°12.8'E$		20	21. 11. 70—21. 12. 70	4.7	11	338
	Alexeev BPV — 2 r		65	27. 10. 70—10. 1. 71	2.8	5	357
PI	$\varphi = 43°38'30''N$	83	3	23. 11. 77—13. 5. 78	2.4	14.1	14
	$\lambda = 14°32'30''E$		50	23. 11. 77—13. 5. 78	1.8	10.2	5
	Alexeev BPV — 2 r		80	23. 11. 77—13. 5. 78	0.7	7.4	331
PI/2	$\varphi = 43°16'36''N$	61	5	3. 4. 80—14. 7. 80	10.6	17.3	176
	$\lambda = 14°05'51''E$		30	3. 4. 80—14. 7. 80	6.7	8.1	164
	Alexeev BPV — 2 r		57	3. 4. 80—14. 7. 80	4.6	6.2	158
P II_1	$\varphi = 44°21,29''N$	63	5	11. 8. 79—26. 3. 80 and 23. 7. 80—11. 1. 81	8.8	17.0	258*
	$\lambda = 13°32'40''E$		20—30	11. 8. 79—26. 3. 80 and 23. 7. 80—11. 1. 81	3.7	9.2	265
	Alexeev BPV — 2 r		60	11. 8. 79—26. 3. 80 and 23. 7. 80—11. 1. 81	2.7	7.7	249
P III_1	$\varphi = 45°24'45''N$	27	3	16. 11. 78—1. 8. 79	5.1	10.3	268
	$\lambda = 13°01'24''E$		15	16. 11. 78—1. 8. 79	3.2	7.6	257
	Alexeev BPV — 2 r		24	16. 11. 78—1. 8. 79	2.3	6.1	245
AP	$\varphi = 44°41'31''N$	38	8	24. 2. 82—12. 4. 82	3.4	10.8	19
	$\lambda = 13°07'31''E$		20	24. 2. 82—12. 4. 82	3.0	10.0	28
	Aanderaa RCM4		35	24. 2. 82—12. 4. 82	2.1	6.6	29
AP	Alexeev BPV — 2 r		5	15. 12. 81—26. 4. 82	1.9	9.8	10
			20	15. 12. 81—26. 4. 82	2.7	8.2	347
			39	15. 12. 81—26. 4. 82	1.2	5.4	340

Station	Position and type of current-meter	Depth (m)	Meas. depth (m)	Direction of records (10—20 min intervals)	Res. speed (cms^{-1})	Mean speed (cms^{-1})	Res. direction °azimuth
A_{11}	φ = 44°16'N	57	8	16. 3. 82—20. 4. 82	8.7	16.1	303
	λ = 14°00'E		20	16. 3. 82—20. 4. 82	6.3	9.5	309
	Aanderaa RCM4		54	16. 3. 82—20. 4. 82	5.2	8.4	300
A_{16}	φ = 44°37.2'N	47	8	15. 3. 82—23. 3. 82 and 19. 4. 82—15. 5. 82	5.0	13.8	265
	λ = 13°40.0'E		40	15. 3. 82—16. 4. 82 and 19. 4. 82—15. 5. 82	3.8	8.1	240
	Aanderaa RCM4						
A_{21}	φ = 45°02.2'N	37	8	16. 3. 82—15. 5. 82	2.8	11.9	61
	λ = 13°19.0'E		35	16. 3. 82—15. 5. 82	2.8	8.4	19
	Aanderaa RCM4						
$J_{7/6}$	φ = 44°35'28"N	44	5	18. 8. 81—6. 9. 81	7.1	19.0	233
	λ = 13°24'06"E		20	18. 8. 81—6. 9. 81	7.4	19.2	200
	Alexeev		40	18. 8. 81—6. 9. 81	5.3	11.4	186
	BPV — 2 r						
$J_{7/4}$	φ = 44°44'12"N	43	5	5. 11. 81—9. 12. 81	1.2	8.8	219
	λ = 13°19'10"E		25	5. 11. 81—9. 12. 81	1.0	8.4	282
	Alexeev		39	5. 11. 81—9. 12. 81	0.5	5.7	301
	BPV — 2 r						
$J_{7/8}$	φ = 44°45'46"N	40	5	18. 5. 82—20. 6. 82	2.0	13.0	4
	λ = 13°16'10"E		22	18. 5. 82—20. 6. 82	2.1	10.3	339
	Alexeev		37	18. 3. 82—20. 6. 82	1.0	6.3	346
	BPV — 2 r						

* Data on speeds of this series for the November 22 — January 1, 1891 are not reliable and therefore not included in the succeeding tables.

RESULTS AND DISCUSSION

General cyclonic circulation and effects of topography

Frequencies of daily mean resultant directions have been calculated for longer series to establish whether some directions show greater frequency of occurrence in the study area (Table 3). It has been observed that some directions occurring at stations closer to the coast are more frequent and those at Station P I in the middle of the basin are more dispersed (Fig. 9). However, the directions group to a certain extent at this station as well since the third quadrant directions, that is directions towards the western coast, are least present. The opposite is true for the area of P II station where records show that W and SW directions are most frequent. This station is apparently located within the transversal branch of the current from the eastern towards the western coast which may be taken as a part of the cyclonic circulation. Stations closer to the coast (P III and $P_{1/2}$) show more pronounced grouping of directions which is consonant with a cyclonic circulation (at P III — W and SW directions and at $P_{1/2}$ — S and SE directions).

Ever since the beginning of the investigations of the Adriatic currents it has been shown that the surface circulation is basically cyclonic (see e.g. Zore, 1956). Actual occurrence of this circulation in the northern Adriatic may be inferred from the frequency of respective directions at coastal stations.

Table 3. Frequency of daily mean directions (in %)

Station	Depth (m)	N	NE	E	SE	S	SW	W	NW	No. of days	Period
P I	3	21.2	11.5	14.1	14.7	5.1	7.7	7.7	18.0	156	25. 11. 77.
	50	23.0	18.4	4.6	14.9	4.6	8.0	18.4	8.1	87	to
	80	22.2	11.9	5.9	7.4	20.0	11.1	7.4	14,1	135	13. 5. 78.
P II	5	5.6	5.2	4.6	3.6	6.9	23.9	38.0	12.1	305	11. 8. 79.
	30	6.2	5.8	3.1	3.9	8.9	22.5	35.3	14.3	258	to
	Bott. layer	8,1	8.1	8.1	2.8	11.7	25.1	24.7	11.3	247	11. 1. 81.
P III	3	7.1	6.2	7.1	3.3	4.2	11.7	48.8	11.7	240	16. 11. 78.
	15	6.2	2.5	7.9	7.5	5.0	15.8	41.5	13.7	241	to
	24	8.7	6.9	5.8	5.2	11.6	33.5	18.5	9.8	173	1. 8. 79.
P I/2	5	5.6	0	4.5	16.9	60.7	11.2	1.1	0	89	3. 4. 80.
	30	0	1.0	1.0	25.0	72.0	1.0	0	0	100	to
	57	1.0	1.0	1.0	43.7	51.4	1.9	0	0	103	14. 7. 80.

Note: No measurements were taken from P II between March, 27 and July 22, 1980

Table 4. Direction frequencies (in %) which are consonant with cyclonic circulation according to daily resultants for the surface layer (frequency of daily resultants have been given for stations from Table 3 and direction frequencies of all records for the rest of stations)

Station/Direction	N	NW	W	SW	S	SE	Total
P_1	32,5	22.5					55.0
P II			27,8	19.4			47.2
A_{16}			28.9	17.5			46.4
Pula	11.7	21.6					33.4
Rovinj	16.5	12.0					28.5
Poreč	30.2	11.0					41.2
Novigrad	22.9	16.8					39.7
Umag	34.1	21.7					55.8
P III			48.8	11.7			60.6
P I/2					60.7	16.9	77.6

As shown in Table 4 the frequency of occurrence of cyclonic circulation expressed in percentages varies from about 30% to almost 80%. The prevalence of cyclonic circulation throughout the Adriatic and consequently in its northern part as well, has not yet been theoretically clarified. Earlier authors held it due to the Coriolis Force and topography. However, the distribution of masses and prevailing winds should also be taken into account. More denser water in the middle of the basin is associated with the cyclonic circulation. However, it is pretty difficult to distinguish whether this kind of distribution of masses is the result of or the cause of cyclonic circulation.

Stream lines are mainly aligned with the isobaths and encountering a topographic obstacle they show disturbances (Zore-Armanda and Bone, 1983).

Mean flow may be shown by residual vectors (Fig. 2). Prevailling W direction in the central part at stations A_{16}, P II and J 7/6 (Fig. 2) may also be affected by topography since the flow is here, as well, aligned with the isobaths. It may be of interest to mention that W flow is very stable at P II station unaffected by seasons or any other circumstances (Table 5).

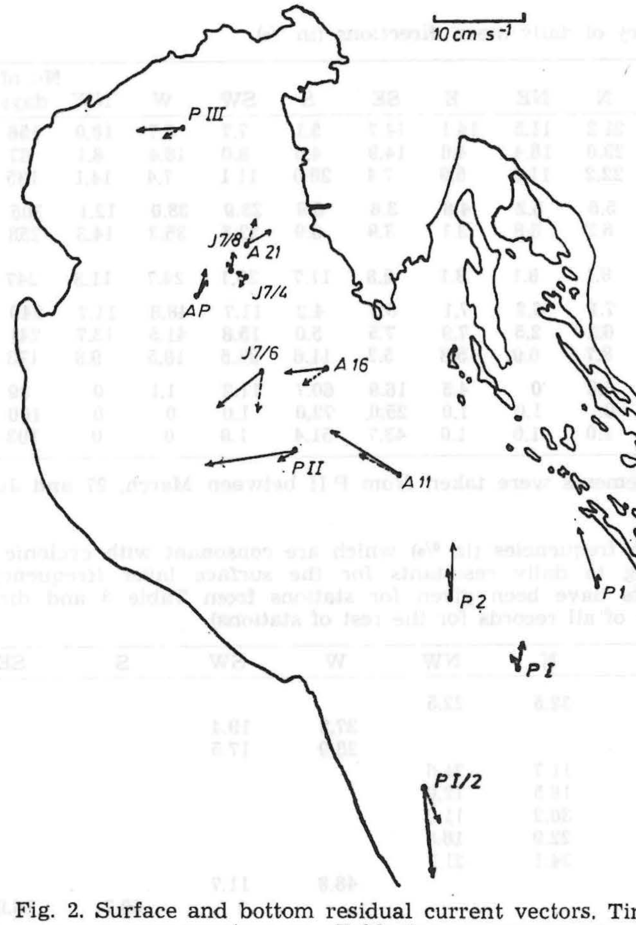

Fig. 2. Surface and bottom residual current vectors. Time of measurements — see Table 1

Table 5. Azimuth, speed and stability factor of monthly mean (resultant) currents for surface and bottom layers at P II station

	Surface layer			Bottom layer (50 m)		
Month and year	Azimuth°	Speed (cm/sec)	Stability factor (%)	Azimuth°	Speed (cm/sec)	Stability factor (%)
8/79	252	13.6	71	249	3.6	40
9/79	250	15.3	71	246	4.4	44
10/79	250	18.5	81	325	2.8	57
12/79	253	1.0	37	251	2.1	47
1/80	253	5.0	33	275	1.1	23
2/80	241	5.9	49	216	3.1	49
3/80	257	2.9	24			
7/80	223	3.0	22 (7 days)	32	1.5	22
8/80	273	5.4	40	60	0.8	15
9/80	238	9.2	68	320	0.8	13
10/80	246	5.7	31	227	5.3	54
11/80	290			257	5.6	52
12/80	256			249	3.9	46
1/81	258			254	5.1	56

Monthly mean direction is practically stable varying for not more than 67° in the surface layer. Month-to-month variations are of somewhat greater extent in the bottom layer even though W direction is prevalent.

Po River effects

The data collected show the Po River effects on the residual circulation. It is held that the Po River waters discharged into the sea partly turn right and are incorporated into the SE flow along the Italian coast and partly continue to the east forming two gyres: a cyclonic gyre north from the Po River mouth and an anticyclonic gyre south from the Po River mouth. This assumption may be proved by the following:

1. The analysis of current meter data collected along the western Istrian coast shows that the frequency of N direction exceeds that of S direction at more northern stations and that the frequency of S flow exceeds that of N flow at more southern stations.

Table 6. Relationship between the frequency of occurrence of N and S directions at stations along the western Istrian coast

Station	Entire layer		Surface layer		Bottom layer	
	N (%)	S (%)	N (%)	S (%)	N (%)	S (%)
Umag	32.3	15.8	35.2	11.9	29.4	19.7
Novigrad	26.4	18.1	24.2	20.8	28.6	15.4
Poreč	23.8	16.5	25.2	20.8	22.5	12.2
Rovinj	18.2	22.1	18.2	24.0	18.2	19.6
Pula*	16.4	29.2	18.3	37.4	14.5	21.0

* Relationship between the frequency of NW and SE directions is given for Pula instead of that between N and S directions due to the coastline curvatures.

It is apparent from Table 6 that the frequency of alongshore flow directions (N and S) exceeds 45% at all the stations, that is they practically occur half the time. This alongshore flow is characterized by the prevalence of S flow over the N flow in the entire water column in the areas of Umag, Novigrad and Poreč. However, the S flow prevails over the N flow in the areas of Rovinj and Pula. In addition, the frequency of N direction increases northward and that of S direction southward what means that the differences are least in the central part of the study area, near Rovinj and Poreč. These differences increase northward and southward from this area. Thus, just between Rovinj and Poreč the flow is separated into cyclonic and anticyclonic gyres as shown in Fig. 3.

2. The comparison of the data from the station P III and the group of stations AP, J 7/4 and J 7/8 taken together to obtain the desired series, with the Po River discharge shows that greater the Po River discharge the E flow is intensfied (Fig. 4). This is indicative of the direct influence of the Po River on the flow.

3. Results of the experiments with drift bottles (Feruglio and De Marchi, 1920) as well as preliminary synoptic current measurements (Zore-Armanda and Mladinić, 1974).

4. Distribution of bottom sediments (Fig. 5). An earlier map after van Straaten, 1965 has been reproduced here since currents which correspond to bottom sediment distribution were plotted. Some more recent maps of sediment distribution after Stipaničev (1981) and Istituto di Geologia

Fig. 3. Schematic plot of the northern Adriatic residual circulation

Marina (1981) show still better agreement of sediment distribution and schematically plotted flow (Fig. 3). This quite good agreement between sediment distribution and flow is indicative of the fact that residual flow is essentially single-layered. This is, further, quite in agreement with the map of residual vectors (Fig. 2) which shows that the vectors of surface and bottom flows are as a rule of either the same or similar direction.

Seasonal variations

It is well known that seasonal rhythm is particularly pronounced in the Adriatic mean current field (Zore-Armanda, 1956; 1968). Water predominantly leaves the Adriatic in the surface layer in summer and enters it in winter that is the outgoing flow component is intensified along the western coast in summer and the incoming one along the eastern coast in winter. In summer the flow is separated in three layers; the inflow in the intermediate layer being compensatory to the prevailing outgoing flow in the surface layer. In winter the water inflow prevails in the intermediate layer and the outgoing flow in the bottom layer is compensatory (Zore-Armanda, 1963). Three layers with clearly distinguished intermediate layer are easily identifiable only at station P I (Fig. 11).

Only the summer flow regime is distinguished from that of other seasons in the northern Adriatic. This may be illustrated for the western Istrian coast by the following table.

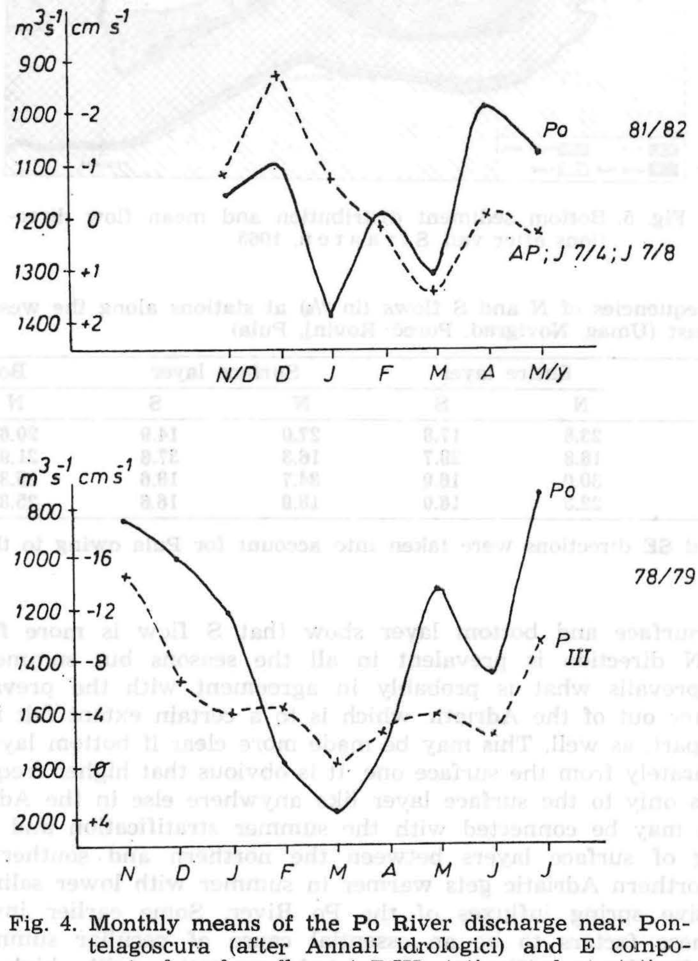

Fig. 4. Monthly means of the Po River discharge near Pontelagoscura (after Annali idrologici) and E component of surface flow at PIII station and at stations AP, $J_{7/4}$ and $J_{7/8}$ taken together since being close enough. Greater the Po River discharge the E flow component is greater

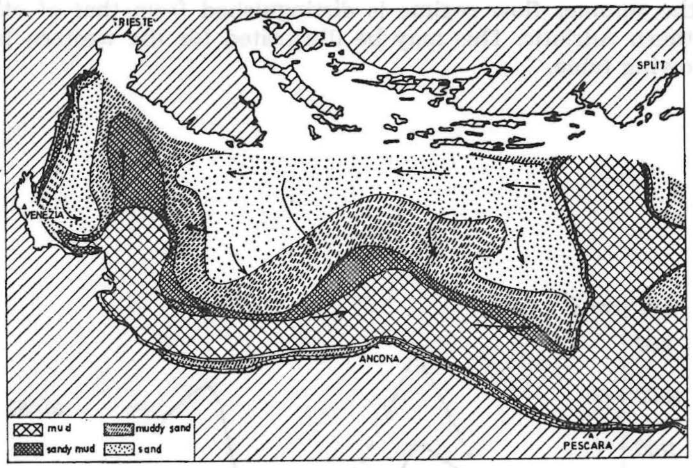

Fig. 5. Bottom sediment distribution and mean flow directions after van Straaten, 1965

Table 7. Frequencies of N and S flows (in %) at stations along the western Istrian coast (Umag, Novigrad, Poreč, Rovinj, Pula)

Season	Entire layer		Surface layer		Bottom layer	
	N	S	N	S	N	S
Spring	23.8	17.8	27.0	14.9	20.6	20.8
Summer	18.8	29.7	16.3	37.6	21.9	19.7
Autumn	30.0	16.0	34.7	18.6	25.3	13.3
Winter	22.3	16.0	18.9	16.6	25.8	15.4

NW and SE directions were taken into account for Pula owing to the coastline curvatures

Both surface and bottom layer show that S flow is more frequent in summer. N direction is prevalent in all the seasons but summer when S direction prevails what is probably in agreement with the prevailing flow of the water out of the Adriatic which is to a certain extent felt in its northernmost part, as well. This may be made more clear if bottom layer is considered separately from the surface one. It is obvious that higher frequency of S flow refers only to the surface layer like anywhere else in the Adriatic. This circulation may be connected with the summer stratification and differences in heating of surface layers between the northern and southern Adriatic. Shallow northern Adriatic gets warmer in summer with lower salinity due to the intensive spring influxes of the Po River. Some earlier investigations showed these factors to be an essential cause of peculiar summer regime affected also by specific summer wind properties with high frequency maestral (NW wind).

To get better insight into the seasonal variations in the central part of the study area and overall annual cycle the stations AP, $J_{7/4}$, $J_{7/6}$, and $J_{7/8}$ (Table 8) were observed together. Marked change in the regime is observed in August with prevailing S flow in the entire water column. This is much better illustrated by direction frequencies (Fig. 6).

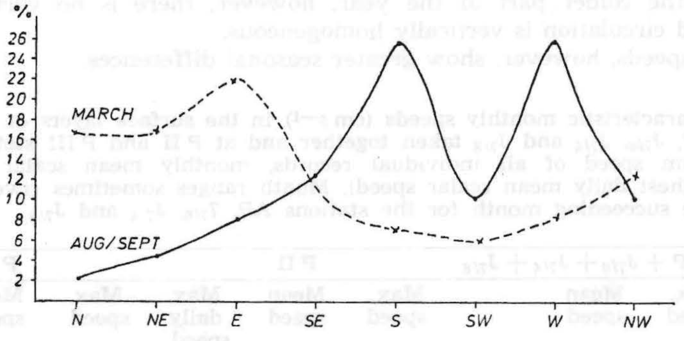

Fig. 6. Frequency of surface directions in the central part of the study area (AP and $J_{7/6}$ stations) in summer (August, 18 to September, 6) and winter (March)

W direction is premanently prevailing in the surface layer at stations P II and P III. However, during the warm period, that is from May to August, NW, N and NE direction (320 — 60°) occur in the intermediate and bottom layers as monthly mean directions. This may be understood as a compensatory flow to the intensified surface outgoing flow even though there are no changes in the mean direction of the surface flow. This is very likely since W flow at these stations may be a part of a general outgoing tendency.

Table 8. Monthly mean (resultant) directions at stations AP, $J_{7/4}$, $J_{7/6}$ and $J_{7/8}$ taken together and stations P II and P III. Month ranges sometimes cover a part of the succeeding month for the first group of stations

Month	$AP + J_{7/6} + J_{7/4} + J_{7/8}$			P II			P III		
	Surf.	Int.	Bott.	Surf.	Int.	Bott.	Surf.	Int.	Bott.
1	334	351	340	253	268	275	261	261	248
				258	260	254			
2	351	001	360	241	240	216	265	261	
3	039	012	020	257	251		215	258	233
4	353	352	356				295	262	250
5	004	339	346				271	079	027
6							263	255	
7				223	027	032	263	242	236
				252	239	249			
8	233	200	186	273	014	060			
9				250	265	246			
				238	215	320			
10				250	253	325			
				246	245	227			
11	219	282	301	290	297	257	260	253	237
12	315	310	279	253	275	251	267	260	252
				256	280	249			

Fig. 11 shows intensified SE component in the surface layer of P II station and compensatory flow in the bottom layer in July.

Accordingly, seasonal variations in the flow regime show in the first place a tendency of intensified outgoing flow in the surface layer during the warmer part of the year with possible compensatory counter flow in deeper layers. In the colder part of the year, however, there is no vertical stratification and circulation is vertically homogeneous.

Mean speeds, however, show greater seasonal differences.

Table 9. Characteristic monthly speeds (cm s^{-1}) in the surface layers of the stations AP, $J_{7/6}$, $J_{7/4}$ and $J_{7/8}$ taken together and at P II and P III stations (maximum speed of all individual records, monthly mean scalar speed and highest daily mean scalar speed). Month ranges sometimes cover a part of the succeeding month for the stations AP, $7_{7/6}$, $J_{7/4}$ and $J_{7/8}$

	$AP + J_{7/6} + J_{7/4} + J_{7/8}$		P II			P III		
Month	Max. speed	Mean speed	Max. speed	Mean speed	Max. daily speed	Max. speed	Mean speed	Max. daily speed
1	28	8.2	33	14.9	27.0	30	7.3	20.0
2	29	9.2	31	12.0	21.5	35	8.4	22.5
3	30	11.1	30	11.9	24.7	38	8.3	18.8
4	40	8.8				39	10.0	25.7
5	51	13.0				40	11.0	20.6
6						41	5.9	27.3
7			51	13.7	23.2	64	15.1	30.0
8	59	19.0	66	16.4	31.4			
9			61	17.5	41.6			
10			66	20.5	38.1			
11	27	8.8	84	18.7	39.7	60	17.4	48.9
12	34	13.1	37	4.6	27.3	50	13.0	46.4

Maximum mean speed was recorded from station P II in summer. Generally speaking all highest values were recorded in summer. This is to a certain degree a surprising result. However, it is well known that outgoing flow along the western coast reaches greatest speed in summer. It is therefore highly likely that this is the case of superimposing of this geostrophic component and wind forcing which is felt primarily in the surface layer (inertial oscillations) in summer due to stratification. Rather high speeds were also recorded from P III station in autumn. Maximum speeds were also recorded from the coastal area of the middle Adriatic in autumn (Zore-Armanda, 1980).

Wind forcing

Wind effects were observed in the open sea causing particularly inertial oscilations in the surface layer in summer. This was presented in the paper by Gačić and Vučak, 1982.

Mean flow is more affected by the wind in the coastal area.

Figs. 7 and 8 show current and wind roses for the surface layer in March. In March bora is the strongest and most frequent wind prevailing both in the coastal area and in the open sea. The direction of bora is changed from E (Trieste) to NE (Pula, Rijeka, Senj and the open sea). Along the western Istrian coast bora reaches peaks in Trieste and Pula, that is at the northernmost and southernmost points of the area. Its frequency and forcing is considerably reduced in the central part of the west Istrian coast near Rovinj. Sea response is easily identifiable. Bora affects most strongly the flow in the northernmost part (station P III) and the area south of Pula (stations A_{16}, A_{21} and P II). Flow counter to bora direction occurs in the central part (near

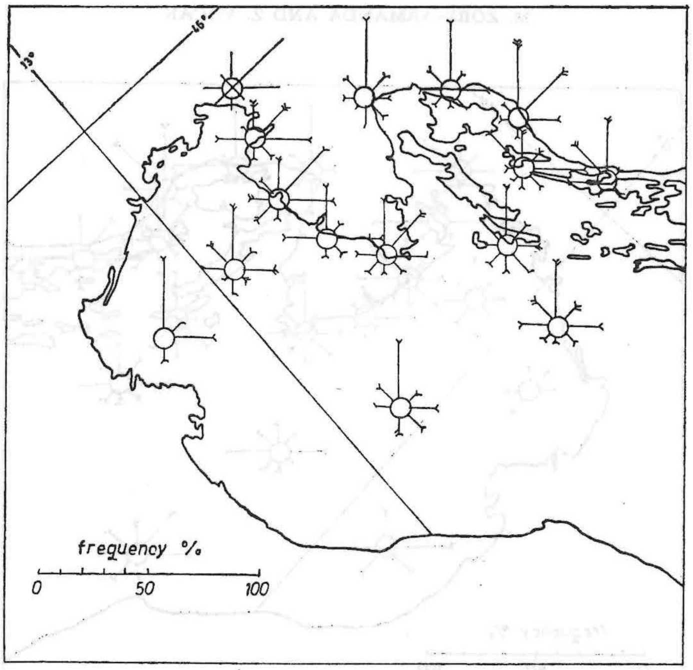

Fig. 7. Wind roses for March after Climatological Atlas of the Adriatic Sea (1979). Wind frequencies are given with the arrow length and wind force in B with a number of small tails. Wind frequencies for Trieste were determined after Polli, 1950

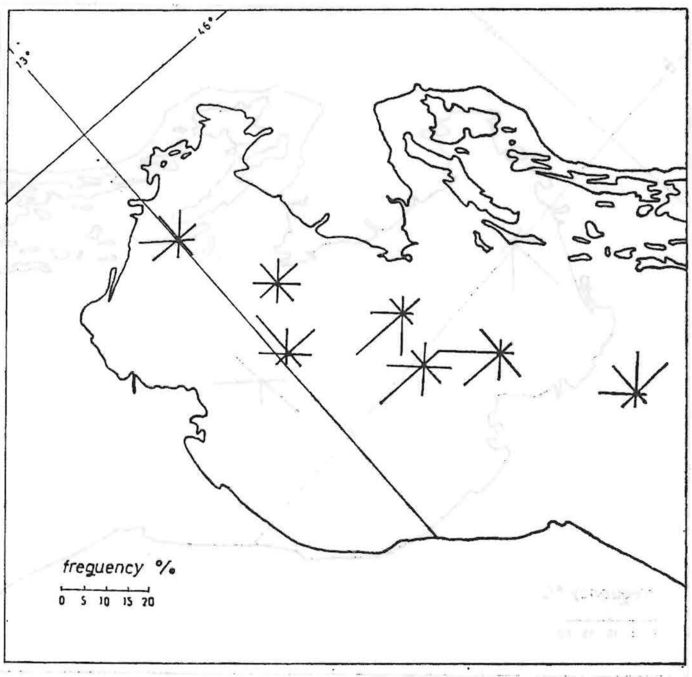

Fig. 8. Current rose for March (frequencies)

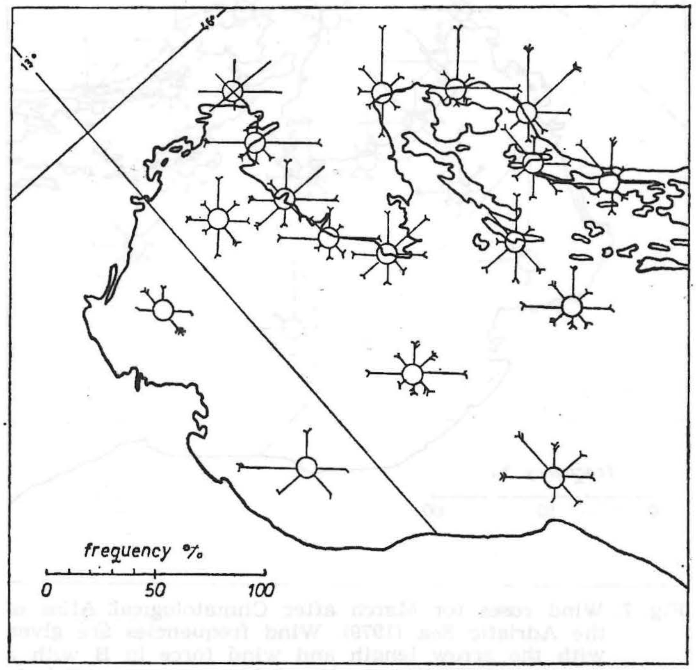

Fig. 9. Current roses for July like in Fig. 5

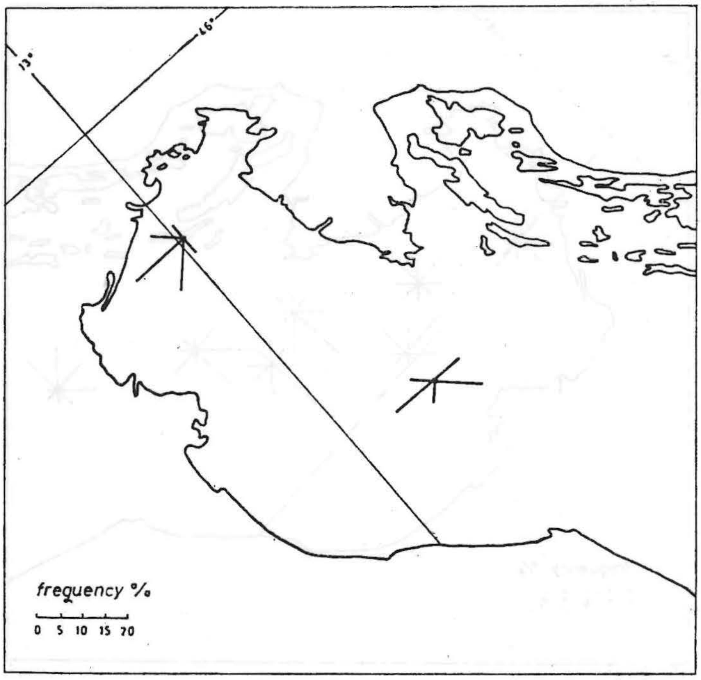

Fig. 10. Current roses for July like in Fig. 6

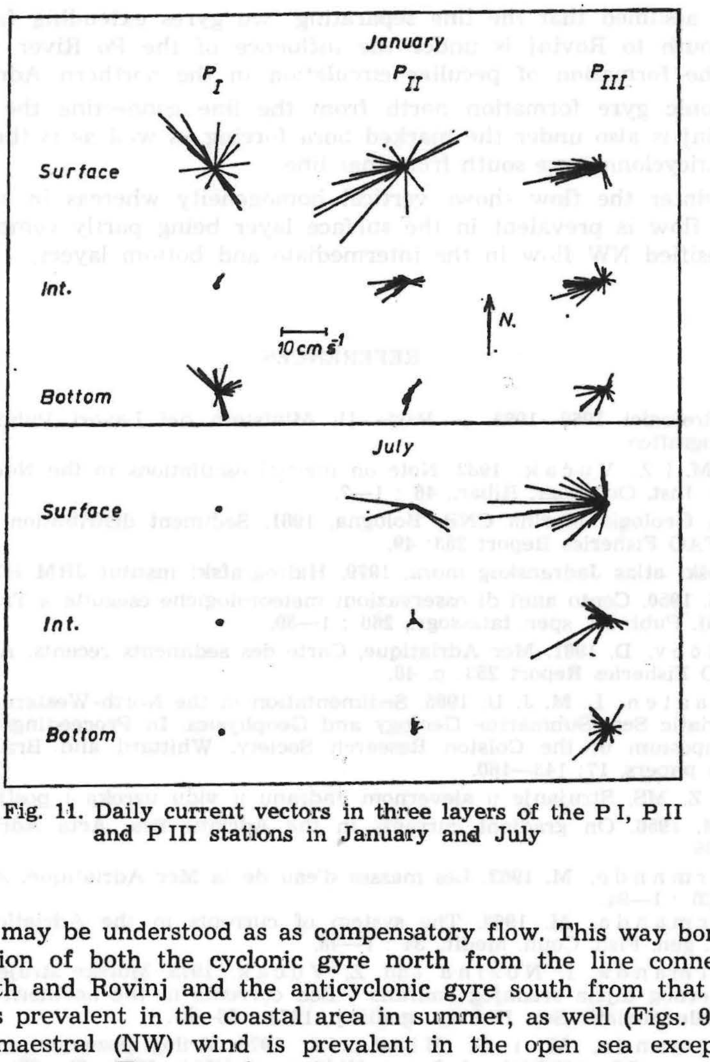

Fig. 11. Daily current vectors in three layers of the P I, P II and P III stations in January and July

Rovinj). It may be understood as as compensatory flow. This way bora affects the formation of both the cyclonic gyre north from the line connecting Po River mouth and Rovinj and the anticyclonic gyre south from that line.

Bora is prevalent in the coastal area in summer, as well (Figs. 9 and 10). However, maestral (NW) wind is prevalent in the open sea except in the northernmost part (Trieste) where bora is also prevailing. Sea response is consonant with this kind of wind distribution.

Bora driven flow is prevailing in summer in the northernmost part, as well, even though the SW component is rather pronounced. SE flow prevails south from Pula affected by maestral even though bora driven W direction occurs as well.

CONCLUSIONS

Two gyres occur in the northernmost Adriatic, the anticyclonic gyre south from the line connecting the Po River mouth and Rovinj and the cyclonic gyre north from that line. The cyclonic gyre is consonant with the general cyclonic circulation throughout the Adriatic.

It is assumed that the line separating two gyres extending from the Po River mouth to Rovinj is under the influence of the Po River which thus affects the formation of peculiar circulation in the northern Adriatic.

Cyclonic gyre formation north from the line connecting the Po mouth and Rovinj is also under the marked bora forcing as well as is the formation of the anticyclonic gyre south from that line.

In winter the flow shows vertical homogeneity whereas in summer the outgoing flow is prevalent in the surface layer being partly compensated by the intensified NW flow in the intermediate and bottom layers.

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NEKE OSOBINE REZIDUALNOG STRUJANJA U SJEVERNOM JADRANU

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KRATKI SADRŽAJ

Obrađen je velik broj strujomjernih podataka prikupljenih prvenstveno sa bušaćih platformi i u manjoj mjeri s oceanografskih plutača u najsjevernijem dijelu Jadrana. Ispitan je udio jadranske ciklonalne cirkulacije u strujnom polju, zatim utjecaj rijeke Po na rezidualno strujanje, sezonske promjene i utjecaj vjetra na rezidualno strujanje. Moglo se je zaključiti slijedeće:

U najsjevernijem dijelu Jadrana se osim ciklonalnog strujanja, koje inače prevladava u cijelom Jadranu, pojavljuje i anticiklonalni vrtlog južno od spojnice ušće Po—Rovinj.

Pretpostavljeno je da na strujnu granicu od ušća rijeke Po prema Rovinju utječe dotok rijeke Po i tako pridonosi formiranju specifične cirkulacije sjevernog Jadrana.

Formiranje ciklonalnog vrtloga sjeverno od spojnice delta Po—Rovinj kao i pojava anticiklonalnog vrtloga južno od te spojnice su ujedno pod izrazitim utjecajem bure.

Zimi je strujanje vertikalno homogeno dok se ljeti u površinskom sloju pojačava izlazno strujanje koje se dijelom kompenzira pojačanim sjeverozapadnim strujanjem u srednjem i pridnenom sloju.