

OCEANOGRAPHIC RESEARCH AND RECORDINGS MADE ON THE NORTH-WEST COAST OF THE BLACK SEA

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Abstract

The aim of this paper is to provide an overview of general underwater circulation features in the Nord-West coast of Black Sea basin. In order to achieve this, during one year were analyzed data coming from different station near the coast. First is presented a general description of circulation patterns in Black Sea area. All the reference points have registered during one year data information about the water current amplitude, and water current direction and water pressure. The graphic present the average parameters in every month during one year. This data were analyzed and compared with in-situ data obtained using current metter along the Black Sea. The current velocity depends mostly on the point's location.

Keywords: *Direction and current value; Temperature, Conductivity, Density abnormality*

Introduction

The Black Sea represent an inland sea situated between Europe, Anatolia and Caucasus named in oceanographic literature “a small scale model of the ocean”. In the southwest, it connects with the Marmara Sea using the Bosphorus Strait through a 0.7-3.5 narrow channel with 31km in length and a depth between 39-100m [1] . In the northeast shelf, the Black Sea is connected with the Sea of Azov through the Kerch Strait which has 4.5-15km width and a depth up to 18m [2]. The basin of the sea is located at the edge of the European and the Asian continents between the southeastern part of Europe, Asia Minor and the Caucasus (Figure 1).

The topography and morphology of the basin determine the major characteristics of water circulation [3]. The depth water masses in the basin are caused by the depth of sea and determined the atmospheric impact. Configuration of bathymetric line, the presence of depressions and canyons has an important influence on the distribution of water masses, direction and speed of currents.

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The information regarding the Black Sea coastline, without estuaries, we can find in nautical charts 1:200 000 scale and represent 4125km between Turkey and Ukraine [4].

The surface layer which is located on the sea surface over 50 m depth represent the area with the most active water layer. This area is strongly influenced by the seasonal temperature variations and wind [5]. Another area, the second known as cold layer is a sub-surface water mass located at depth that varies from 50 to 180m. In this area, the temperature is constant, between 6°C and 8°C which is a result of the winter convective mixing in the centers of cyclonic gyres and in shelf areas. The outcome temperature does not influence the actual temperature in this area. Below the cold layer area [6], the water are most of the time stagnant with reduce changes in properties and this is the reason that area is not an individual water mass.

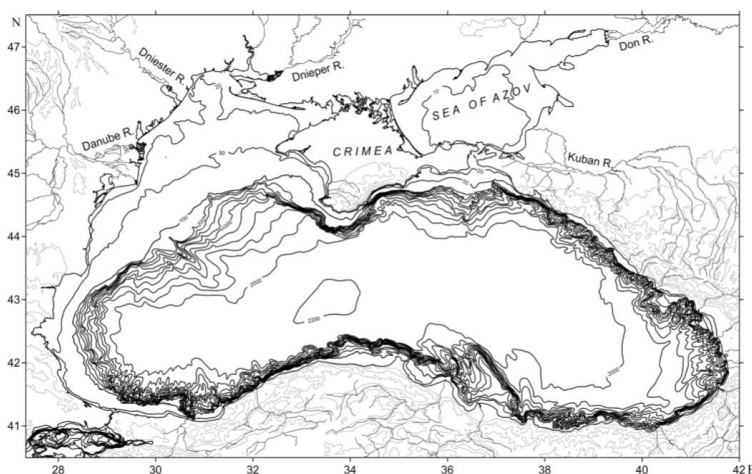


Fig. 1. Map of Black Sea based on the international Bathymetric Chart of the Mediterranean Sea (IBCM)

Regarding the depth, the Black Sea have an average depth of 1271m with a maximum depth of the Black Sea is 2588m recorded between latitude of 40°54' și 46°38' N and longitude 27°27' și 41°42' E.

The salinity of Black Sea is determined by the balance between the fresh water and water exchange through the Bosphorus Strait [7]. Another reason for excess of freshwater is the discharges of high river and precipitation over evaporation. In Black Sea was recorded an average surface layer salinity of 17.85PSu. This registration is two times less the salinity of the World Ocean surface waters. The bottom value salinity increases an average entire volume of 21.96PSU. Isolated volumes of fresh water are observed near the mouths of rivers. The difference is caused due to the fact that the surface and bottom waters do not mix, and high salinity water from Mediterranean origin penetrates into the sea along the Bosphorus Strait.

The Black Sea water temperature varies from the freezing temperature point along the coastal area in the north part of sea (0.97°C at salinity of 18PSU, -0.54°C at salinity of 10PSU) to higher value of 28-29°C in the middle of summer. Making a calculation, the average over the entire volume of sea is 8.96°C. This result is above the average temperature in the oceans and below Mediterranean Sea. The north- west part of Black Sea is characterized by temperate climate, while in the eastern part of sea is found a subtropical climate.

Experimental

The objective of this paper is to convey an image of general underwater circulation of masses features in the Nord-West coast of Black Sea basin [8]. Oceanographic in-situ research and recordings were made on the North-Western coast of the Black Sea from Constanta harbor to Eforie harbor. In order to achieve this, during one year were analyzed data coming from different station near the coast. First is presented a general description of circulation patterns in Black Sea area. All the reference points have registered during one year data information about the water current amplitude, and water current direction and water pressure. The graphic present the average parameters in every month during one year. Furthermore, during 2018, we made two measurements using CurrentMeter Model 106. Also, the paper present an overview of different characteristics of underwater environment, such as determinations of direction and current value, temperature, conductivity, pH, REDOX, density abnormality, profile salinity on water columns between coastal area from Constanta harbor to Eforie harbor, in the North-West coast of Black Sea basin.

In order to achive a comprehensive understanding on the direction and current velocities, temperature, conductivity, density different in-situ data were analyzed. In this study, the information regarding sea parameters was recorded in August.

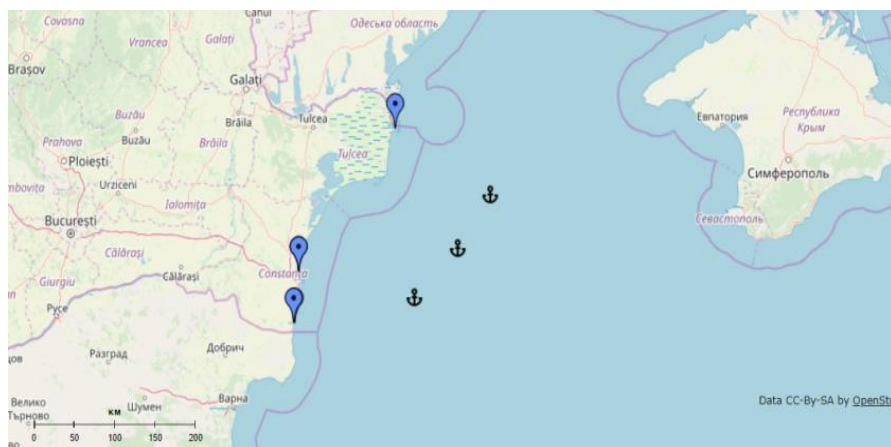


Fig. 2. Position of each buoy

The position for each station (each buoy) is presented in Table 1 and Figure 2. Each station belongs to Research and Development of Marine Geology and Geoecology, a Romanian institute of geology and geo-ecology.

In august, the stations have registered the folowing data presented in Table 2.

According to Table 2, the average water current amplitude was recorded in August, at Station 2. This station is situated at the highest depth compared to the other two, even though the maximum value was registered on Station 3. Regarding the water current direction, this is around 171-224°N.

Table 1. Position of buoy in Black Sea

Station	Latitude	Longitude	Alitude
Station 1	$\varphi=44^{\circ}42'28.92''N$	$\lambda=030^{\circ}46'46.80''E$	-100[m]
Station 2	$\varphi=44^{\circ}19'37.40''N$	$\lambda=030^{\circ}25'30.63''E$	-128[m]
Station 3	$\varphi=43^{\circ}58'51.14''N$	$\lambda=029^{\circ}56'12.15''E$	-115[m]

Table 2. Data according to GeoEcoMar

	Water Current Amplitude	Water Current Direction	Water Pressure	Water Temperature
Station 1				
Average	125.83478	188.3348	2615.8381	25.87861
Max	224.79999	347.80002	2649.223	26.104002
Min	45.1	104.6	2592.1187	25.669
Sum	2894.2	4331.7	60164.28	595.208
Valid %	100	100	100	100
Variation	2871.9949	3004.4045	319.05704	0.024303049
Station 2				
Average	175.2087	224.5087	2616.0156	-4
Max	333.6	314.2	2643.1045	-4
Min	22.8	132	2597.2173	-4
Sum	4029.8	5163.7	60168.355	-92
Valid %	100	100	100	100
Variation	12787.922	2159.5981	215.79381	0
Station 3				
Average	169.43478	171.99565	0	25.801044
Max	375.8	345.2	0	26.004002
Min	13.5	55.3	0	25.628002
Sum	3897	3955.9001	0	593.424
Valid %	100	100	100	100
Variation	13505.741	4784.5	0	0.017743737

Furthermore, during 2018, we made two measurements on Black Sea coast. The measurements made during 2018, executed on two decks along the Romanian seaside. One of them was made during the summer at the coordinate point $44^{\circ}13'54.5'' N$, $28^{\circ}38'03.1'' E$. The second measurement was carried out in winter at $44^{\circ}09'21.0'' N$, $28^{\circ}39'54.0'' E$. For both measurements was used CurrentMeter Model 106 (Fig. 3).



Fig. 3. CurrentMeter Model 106

The instrument used for both measurements is designed to determine real-time water parameter values. It works at every 1 second cycle, at which time only one compass path value is recorded. To do this, the eastern and northern speeds are calculated, and then summed for an average period. Additional parameters that it offers are temperature and pressure. Each measurement started at a depth of 2 meters and ended at 6 meters, except for the first measurement where the depth of the sea was 3.25 meters (Fig. 4).

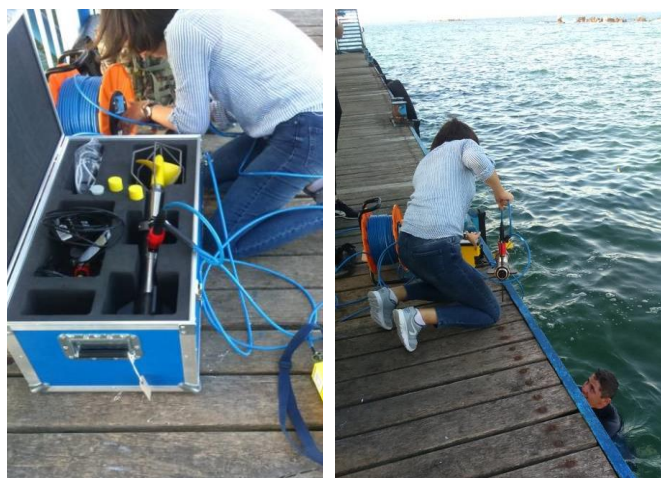


Fig. 4. Measurements made in the Black Sea

Depending on the depth at which the simulation is executed, the Current meter Model 106 has different values of the direction and velocity of the current. Measurements made with the flow meter took place in two stages: the first stage during the summer, when according to figure 5 the current velocity is relatively small, about 0.02m/s. The second stage of the recordings was carried out during the winter, when the current speed reaches a maximum of 0.08m/s.

The device recorded data from a depth of 2 meters to about 6.5 meters.

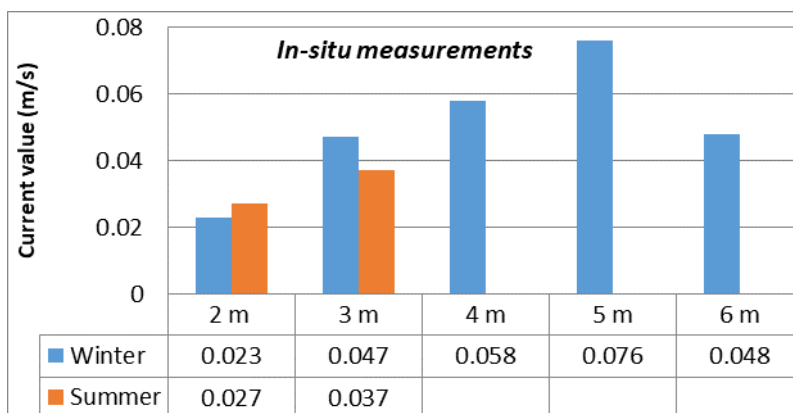


Fig. 5. Measurements with CurrentMeter Model 106

Third phrase from experimental

This measurements were, in the end, compared with the measurements from GeoEcoMar [9] and measurements from Maritime Hydrographic Directorate [10, 11].

The Maritime Hydrographic Directorate, use to measure oceanographic parameters, oceanographic sensors like: CTD 600+ VALEPORT , Current metter ECM Valeport, Magnetometru Sea Spy MarineMagnetics.

Also, the Maritime Hydrographic Directorate performed 10 ECM station and 4 CTD stations for which were determinated different characteristics of the marine environment (the position for each station is presented in Table 3 and Fig. 6). We determinate the directions and current value, temperature, conductivity, pH, REDOX, density anomaly, salinity on water columns with a height of between 5 and 25 meters.

Table 3. Position of stations

CTD+ECM 1-5	$\varphi=44^{\circ}02'52.2695''N$	$\lambda=28^{\circ}55'56.3762''E$
CTD+ECM 2-5	$\varphi=44^{\circ}00'10.1975''N$	$\lambda=28^{\circ}55'51.1589''E$
ECM 2-4	$\varphi=44^{\circ}00'13.9339''N$	$\lambda=28^{\circ}52'06.7297''E$
ECM 1-3	$\varphi=44^{\circ}02'59.5159''N$	$\lambda=28^{\circ}48'27.2789''E$
ECM 1-4	$\varphi=44^{\circ}02'55.9458''N$	$\lambda=28^{\circ}52'11.8443''E$
ECM 2-3	$\varphi=44^{\circ}00'17.5594''N$	$\lambda=28^{\circ}48'22.3181''E$
CTD+ECM 1-1	$\varphi=44^{\circ}03'06.3777''N$	$\lambda=28^{\circ}40'58.0523''E$
ECM 1-2	$\varphi=44^{\circ}03'03.0351''N$	$\lambda=28^{\circ}44'42.6676''E$
CTD+ECM 2-1	$\varphi=44^{\circ}00'24.3996''N$	$\lambda=28^{\circ}40'53.7485''E$
ECM 2-2	$\varphi=44^{\circ}00'21.0617''N$	$\lambda=28^{\circ}44'37.9439''E$

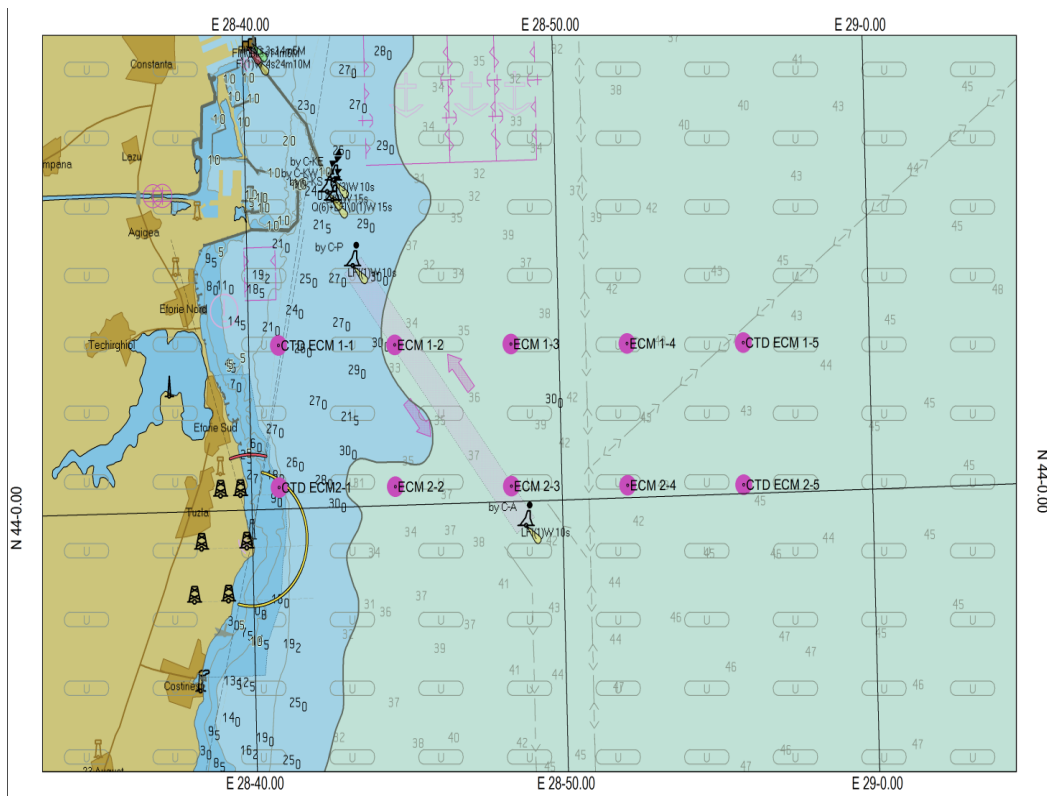


Fig. 6. Stations where the measurements take place

In this case, we analyse only the station which are situated near the coast (ECM 1-1, ECM 1-2, ECM 2-1, ECM 2-2). The information obtained are presented in figure 7.

In the case presented in Figure 6, the measurements were performed in $\varphi = 44^{\circ}03'06.3777''N$, $\lambda = 28^{\circ}40'58.0523'' E$. In this point, the velocity varies between 0.04 to 1.54m/s, the salinity between 16.1 to 18.1PSU, and the water temperature varies between 5.56°C (at the bottom) to 16.56°C at the sea surface.

In $\varphi = 44^{\circ}03'03.0351'' N$, $\lambda = 28^{\circ}44'42.6676'' E$, from Station ECM 1-2, the velocity varies between 0.10 to 1.20m/s, with a general current direction of 183°.

The characteristics of the data recorded by Station ECM 2-2 situated at $\varphi = 44^{\circ}00'21.0617'' N$ and $\lambda = 28^{\circ}44'37.9439'' E$ are: velocity varies between 0.10 m/s to 1.20 m/s, with a general current direction of 183°.

In case of Station CTD and ECM 2-1, the measurements were performed in $\varphi = 44^{\circ}00'24.3996'' N$ and $\lambda = 28^{\circ}40'53.7485'' E$. Were obtained the following data: velocity varies between 0.04 to 1.54m/s, salinity between 15.64 to 18.24PSU, water temperature varies between 5.41°C (bottom) to 17.91°C (at the surface).

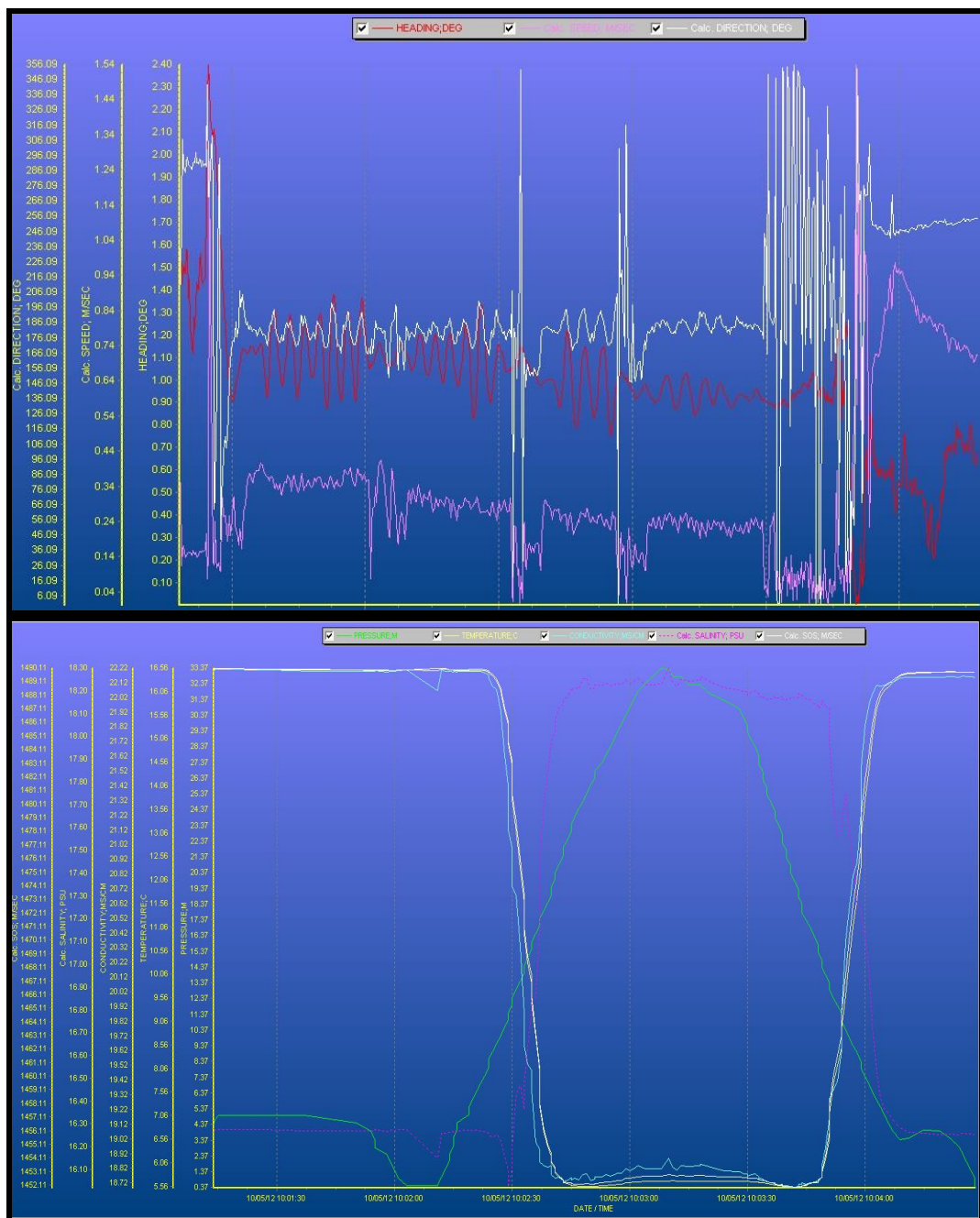


Fig. 6. Station CTD and ECM 1-1

Conclusions

The currents in the Black Sea ensure a renewal of the waters and are responsible for the distribution of nutrients in time and space. It also conditions the fertility of the marine environment and the activity of fishing.

Nordic winds generate southern currents, so it speeds up general circulation, thus bringing water masses from the continental area where the flow of fresh water is lower, so salinity is lower. In contrast, the currents generated by the weak and moderate winds from the south in the first phase will diminish or even prevent the south, thus reducing the diffusion area and then transporting the salty waters from the south to the central part of the continental shelf.

The way of depositing the alluviums in the spout is the result of the combined action of the Danube spill stream (the E-SE direction) and the specific marine current (N-S direction). Through the study of currents in the area, it was possible to predict how the deposits occur in the mouth, which was subsequently demonstrated by the hydrographic measurements.

It can be concluded that during the summer months there is a strong stratification of the active layers from the sea and that the surface layer is very sensitive to the speed, direction and duration of the winds in the Romanian seaside.

According to different data recorded by DHM, GeoEcoMar and data gathered using the Current Meter Model 106, the current patterns in the northwestern Black Sea basin has values ranged from 0.04 m/s to 1.5m/s. The velocity depends on different depth ranges. The salinity is between 16.1 to 18.1PSU, and the water temperature varies between 5.56°C (at the bottom) to 16.56°C at the sea surface.

This measurement helps us to provide an overview of general circulation features in the Nord-West of Black Sea basin.

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