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A SHORT AND LONG TERM EVALUATION OF ALONG SHORE GEOMORPHOLOGICAL CHANGES IN THE DANUBE DELTA

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ABSTRACT

The Romanian coastline is constantly changing through the action of several factors such as wave height and direction, wind speed, water depth, sediment supply, removal and transport along the coast, strength of tides, rates of relative sea level change, as well as rainfall and the frequency and intensity of extreme meteorological and climate events, including storm surges.

Due to the general structural and geomorphological features and the Danube's influence, and also the morphodynamic and lithodynamic development of the coastal zone, the Romanian coast can be subdivided into thenorthern and southern parts, separated by a transitional part (between Midia Cape and Singol Cape):

The northern unit - Danube Delta and Razim (Razelm) - Sinoe lagoon shore, with low beaches in the deltaic / lagoon sector, height less than 2.00 m and smooth underwater slopes. It stretches from the Musura Bay to the Midia Cape and has a length of about 160 km, focused on the preservation of nature (Danube Delta Biosphere Reserve - DDBR)

For the better understanding of the short and long term shore evolution several methods were used:

- Analysis of cartographic data, including historical, topographical, hydrological, navigational maps, process that include geo-referencing and digitization;
- Analysis of aerial photos from AUVs and satellite images;

Profile topographic measurements carried out at the hydrographic landmarks and GPS measurements made in the last years during the NIRMD field campaign.

The surveillance of the shoreline evolution based on GPS and remote sensing techniques indicated the need to prioritize shoreline management coastal protection and rehabilitation. For visual representation in a referential plan/configuration and for spatial and temporal analysis , all available information was integrated in a ArcGIS system.

Key-Words: shoreline, morpho-dynamics, Danube Delta, coastal protection

AIMS AND BACKGROUND

In the past four decades, the increasing of environmental and other risks due to climate change and sea level rise and increasing number and frequency of extreme storms, coastal erosion have been registered.

The northern unit delimited north of the Musura lagoon and south of Midia Cape is defined by a lagoon and deltaic shore with marine and rivers accumulations that rarely exceed 2 m high. The shore consisting in sandbanks, coastal belts and lagoon barriers, is characterized by a pronounced dynamic, predominantly erosive processes.

The aim of the present paper is to evaluate the long and short-term geomorphological changes in the Danube Delta and Razim - Sinoe lagoon shore, using both "traditional" resources, such as maps, beach profiles, and "modern" tools, such as post-processed AUV images (orthopfotoplans and digital terrain model).

EXPERIMENTAL

The geospatial evaluation of the processes and phenomena underlying the hydro-geo-morphodynamic changes in the northern part of the Romanian littoral and the identification of vulnerable and risk areas are based on spatial data and information (maps, aerial images, topographic profiles of the beach, shoreline) existing in the NIMRD database.

The long and short term evaluation of coastal dynamic is based on historical shoreline data that have been digitized from pre-georeferenced maps (historical map State Country Committee maps, 1962, 1:25.000, 1975/1980 topographical maps, scale 1:25.000), beach profiles, bathymetric profiles on shallow water coastal area, aerial images, orthophotoplans and GPS measurements (2008 - present).

The aerial images (annually during 2016-2018, on 10-15 sections/year) were achieved using DJI Phantom Advance 3 quadcopter (12MP Sony camera) and DJI Phantom Professional 4 (21MP camera) with ground control points and post-processed with Agisoft Photo ScanPro software. The results were materilized in orthophotomaps with resolution of 2-4 cm and Digital Surface Models.

RESULTS AND DISCUSSION

The present evaluation is focused on sectors of the northern Romanian littoral, highlighting the sector with high vulnerability: Musura, the central part of Sulina - Sf. Gheorghe, Sahalin, Zaton, Portita - Periboina.

The Musura bay shore is swampy, with marsh vegetation that makes the delimitation land - water difficult to estimate. The Sulina dikes are the most important anthropogenic structures in the area, which have substantially altered the natural hydrodynamics both in the adjacent sectors and entire littoral. According to the initial project from year 1856, the dikes were designed to protect the waterway from clogging due to sediment transport on Chilia. The construction began in 1958, now

reaching 8 km in length. The sediment transport was diverted offshore with consequences in the distribution of sediments on the southern beaches (Coastal Zone Diagnosis, 2011).

The disrupting of sediment transport from the Chilia branch had as a consequence the intensification of sedimentation processes in the area, forming sandy barrier structures that tend to close the Musura Bay and clogging the sector behind. The new formed enclosing barrier has the tendency to elongate to the south and to translate westwards, the specific evolution of the Danube Delta sand features.

GPS measurements show that, in 2007-2009, the barrier island lengthened 180 m in the direction of WSW-ENE. In March 2010, the barrier integrity was severely affected as a result of the 8-9 March storm that occurred in a period of high sea level due to historical floods on the Danube (Fig. 1).

Thus, for a length of approximately 2 km of shore, in the period 2007-2018, there were average withdrawals / translations of 40-50 m year, the actual island being translated more than 500 m inland.

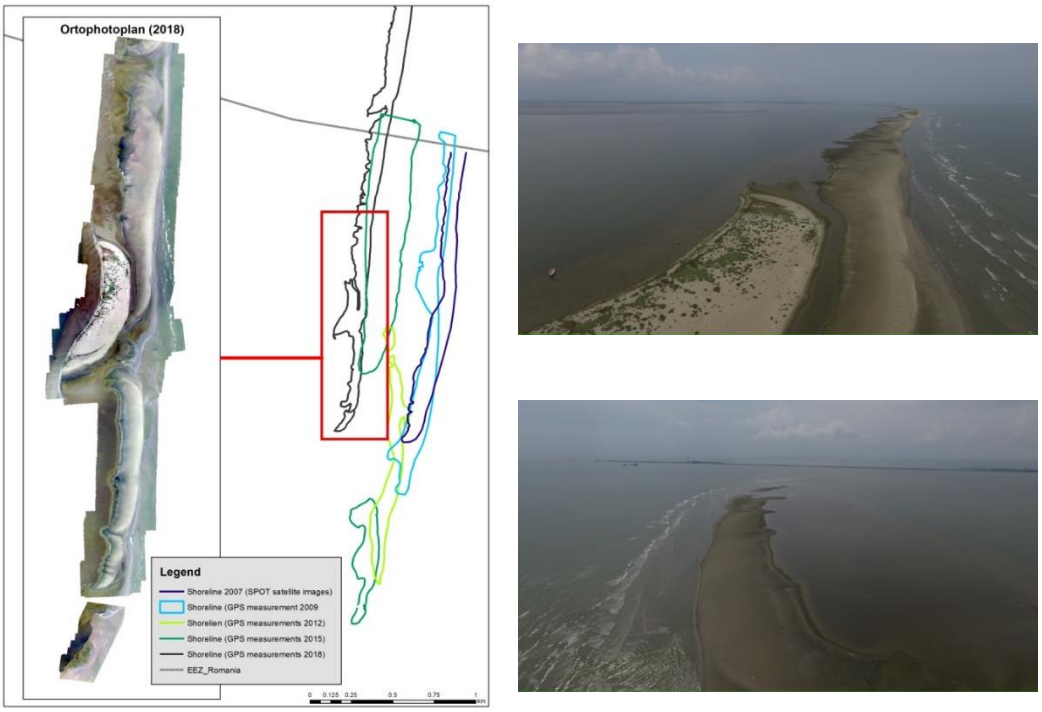

Fig. 1 Musura island (morphological evolution 2007-2018).

The Sulina beach is a complex beach barrier, supplied by the circular current generated by the Sulina dikes, being dominated by accumulation processes in the northern and central part of the sector.

Between Sulina and Sf. Gheorghe, on about 35 km, the shore is well defined. South from Sulina, the coastal belt becomes gradually thinner, from 200 m to 30-40 m at Garla Imputita, and the elevation decreases from 1-2.5 m at 0.5-0.6. In the center

of the sector, between Garla Imputita and the Cazacu sandbank, about 10 km, the shore is fragile, consisting of fragments of coastal belt with a height of 0.5-0.6 m and width not exceeding 30 m (Diaconeasa, 2009). In many sectors reeds and reed islets fixed to the ground get close to the shoreline, being washed away by the waves. In this sector, in periods with high levels of the Danube waters, forms the numerous breaches, the delta drainage into the sea (Fig. 2).

The annual erosion rates calculated showed an average of ~ 5-20 m/year. Between 1975 and present, the erosion process of the beach is particularly intense, the shore being over 600 m in certain sectors.

Fig. 2. Garla Împuțitei - Câșla Vădanei sector.

Between the Cazacu sandbank and Buival Cape the coast on about 13 km is well consolidated, the shore is represented by the succession of the Saraturi sandbanks cutback by the sea. The sandbank's level increases from north to south, from 0.4 to 1.9 m (Paraipan Mounds) and the beach gradually widens to 500-600 m at Sf. Gehorghe. The erosion processes predominate, with lower intensity than the previous sector, except the southern part, the Sf. Gheorghe branch shore, with dynamic balance.

The shallow water bars in front of Sf. Gheorghe mouth were highlighted on the maps at the end of the 19th century (Commander Catuneanu Map, 1898), the Sahalin Island appearing following the floods in 1897 (NIMRD project reports). The structure thus formed evolved in the peninsula by clinging to the shore in the north part. At present, it has an arched shape, with the general tendency of translation by successive retraction to the west, the clogging of the inner part and its extension to the southwest. The irregular evolutionary rhythms depend on the fluctuations in the solid flow on the Sfântu Gheorghe arm and the hydrological conditions (Fig. 3).

The erosion occurs on the entire sector, it is evident by the disappearance of the beach in many sectors (the sea come in direct contact with reeds) and the concave bathymetric profile near the shore. The accumulation is present only in the terminal sector by extending it to the south-west and west (Zaton lake area). The bathymetric profile shows shallow waters (up to 1.5 m) near the coast and the existence of several submersed bars a few hundred meters offshore (Fig. 3).

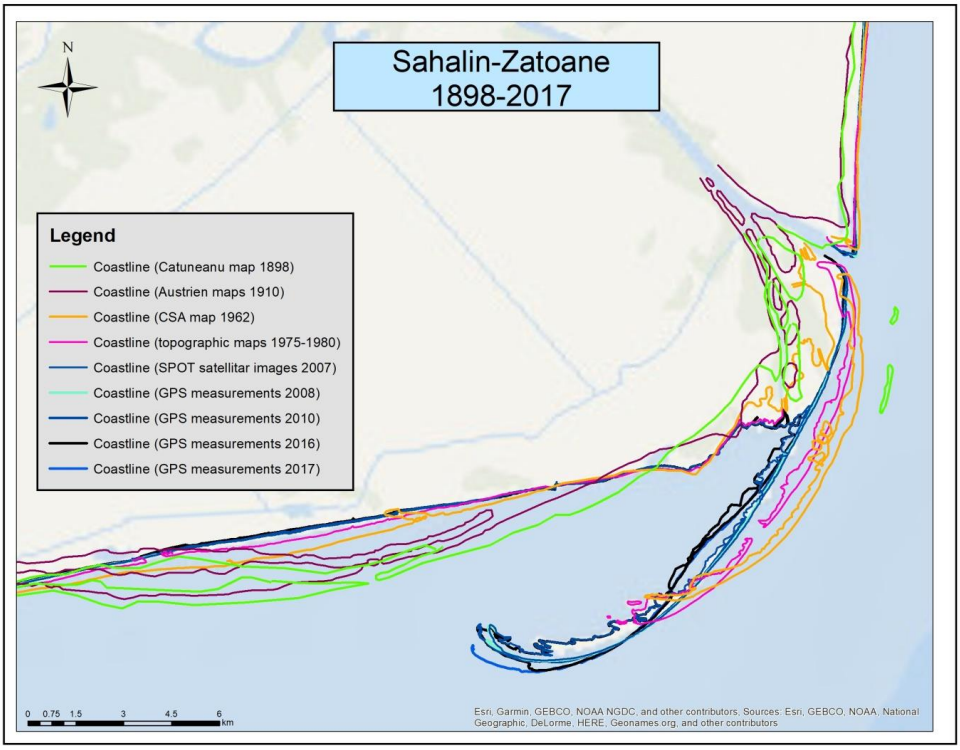

Fig. 3. Shore evolution in the Sahalin-Zatoane sector (1898-2017).

The sector is vulnerable from morphologically point of view, the shore on ~3 km being destroyed by extreme storms during the cold season in 2013, currently undergoing a recovery process (fig 4, fig. 5).

Fig. 4. Sahalin peninsula (aerial images, 2017).

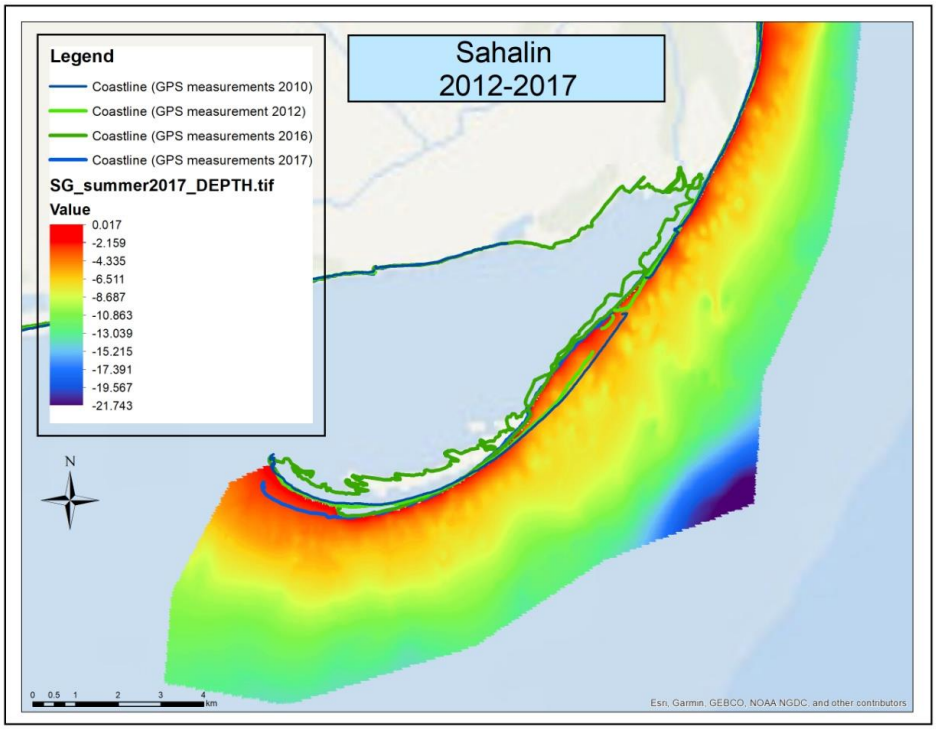

Fig. 5. Shore evolution Sahalin-Zatoane sector (2010-2017).

The Ciotic-Zaton-Perişor sector is affected by erosion for the most part. In the area of the Zaton Lake, the erosion process began to become particularly active since 1985 and continued at about the same rate until 2000. The analysis of data collected on the field (GPS measurements shoreline and aerial images) for 2004-2016 showed more than 50 m coastline retreat the last 12 years (Fig. 6). The erosional sector continues to the south of the Perisor fishing point.

The South Perişor-Periteaşca sector is about 25 km long, formed by the joining of succesive coastal belts; at present the shore is stable, covered with grassy and small tree vegetation. The beach is well developed with widths of 15 - 40 m and heights of 0.4 to 1.5 m. It is noticeable that the shoreline advanced until the ’80s, with an accumulation rate of 1 - 4 m/year. In the last 30 years, the shore has advanced ~ 60 m, currently being in dynamic balance, with variations in the annual rhythm up to 5 m.

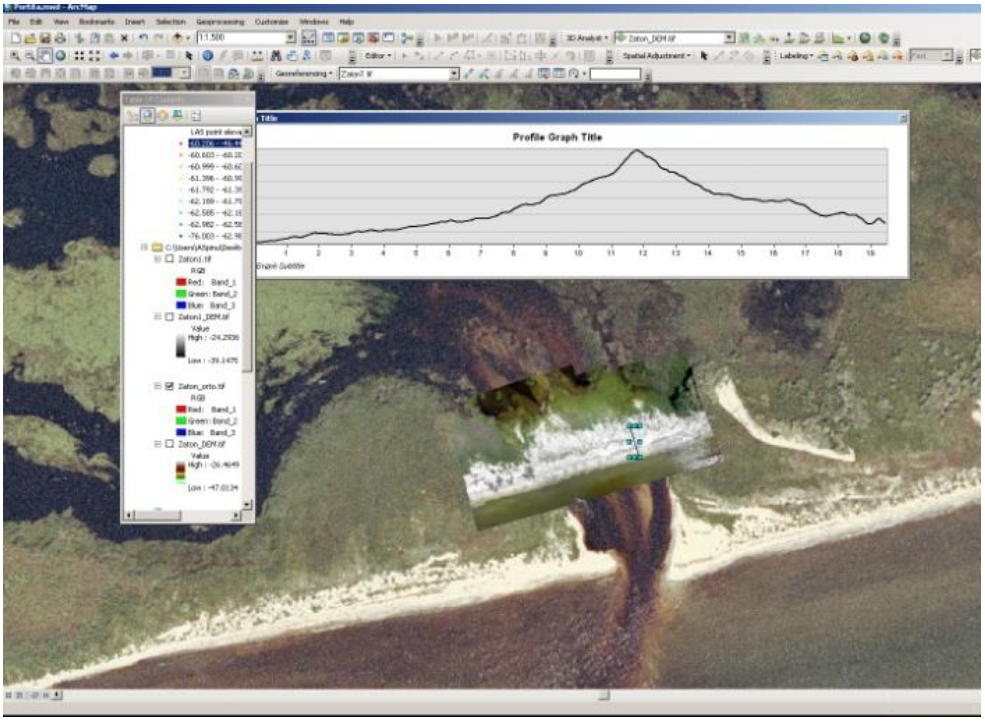

Fig. 6. Shore evolution (2004-2016, Zaton Lake).

The Portiţa - Periboina-Edighiol sector has a length of approximately 17 km and represents a barrier of the Razim - Sinoe lagoon, currently with a width of 30-50 m, maximum 300 m and a height of less than 1-1.5 m.

Along the Portita-Periboina-Edighiol lagoon barrier there were some sporadic shore protection works for stopping the sand transportation to the lake and the formation of breaks during strong storms. After 1970, the Portiţa mouth was artificially closed by the construction of a dam at the entrance of the Golovita chanel to stop the communication with the sea. In front of it, the mouth was naturally sanding, the shore line aligning with the general trend. Today, the only "break" is Periboina, artificially arranged to control the discharge flows from Lake Sinoe. Between 1972-1989, the internal shore to the lake was the subject of hydrotehnical works, being protected by stones to prevent the breakages (NIMRD project reports).

The lagoon barrier narrows and moves westwards in a translation movement over the old lacustral formations. The coastline withdrew ~ 250-500 m over the past 130 years at a rate of 5-10 m / year. The barrier has narrowed from 700-1000 m in the north to 50-200 m today, and from 400-600 m to 200-300 m in the southern part (Fig. 7) (Spînu, 2017).

The sector between the holiday village and the lighthouse ~ 2 km lenght (overlapping with the former connection between Razim Lake and the sea), the shore is fragile, the beach narrowing to a maximum of 5-20 m, the area behind the barrier being flooded.

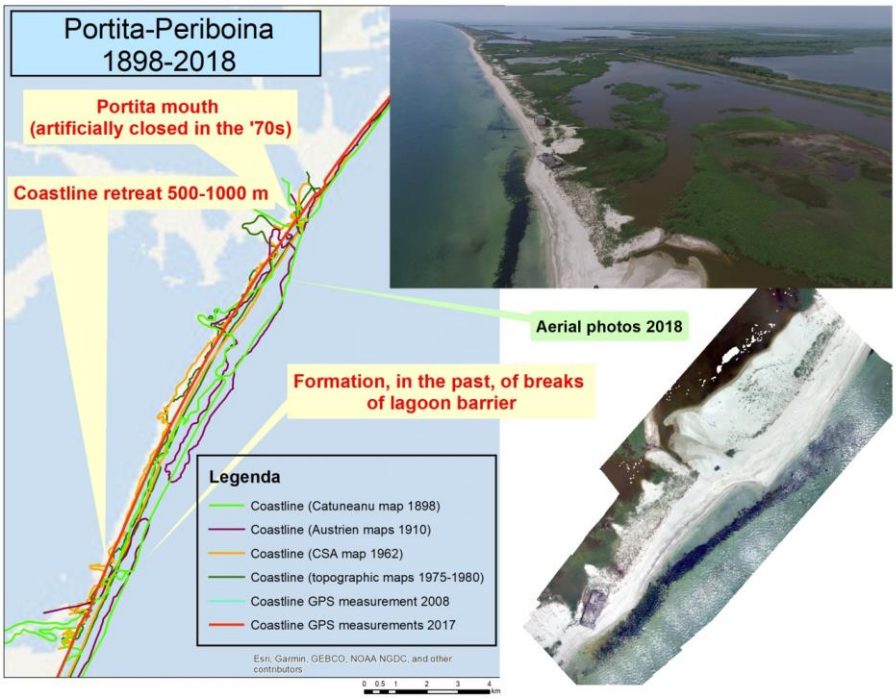

Fig. 7. Geomorphological evolution of Portița-Periboina lagoon barrier (1898-2018).

The Chituc sandbank (Fig. 8), with a length of approximately 20 km, was formed by the joining of several successive coastal belts in the direction of the ENE-WSW. The erosion occurs in the northern part of the sector, and continues ~10 km to th south (Spînu, 2017). In the southern part of the sector, the shore becomes typically accumulative, with broad beaches and sand dunes, the shoreline advancing between 1962-2017 with approx. 4-5 m/year.

Fig. 8. Photo of the Chituc sandbank.

CONCLUSIONS

The low accumulation shore that outlines the lagoon bay and deltaic shore consists of river-discharged sand and shell-bearing sand, reaching heights never exceeding 2 m is constantly reshaped by wind and waves.

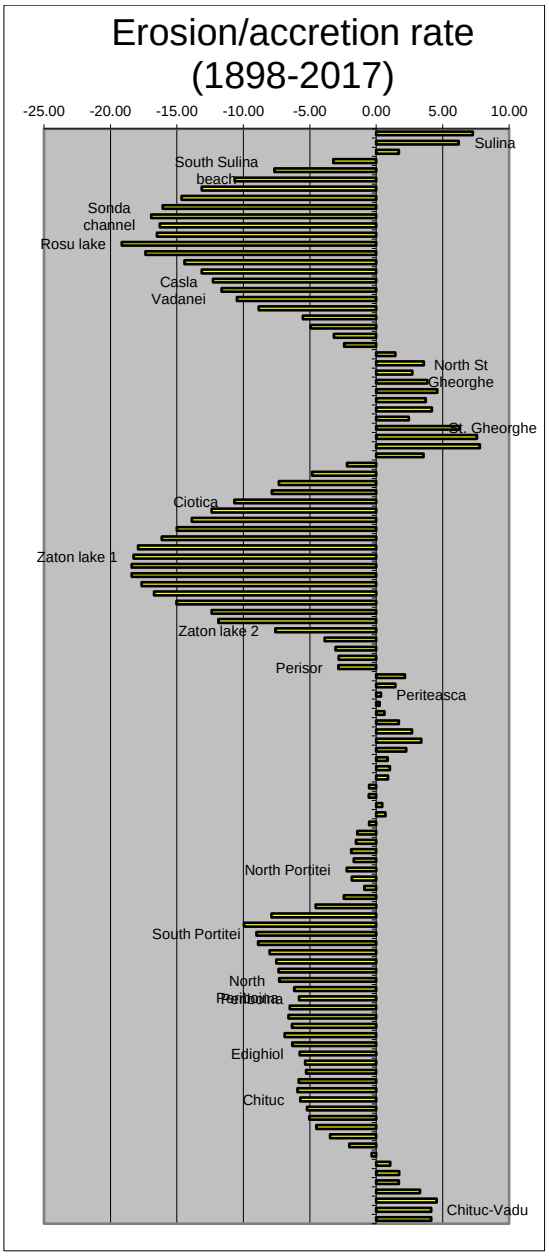

Fig. 9. Erosion/accretion rate (1898-2017).

Historical climate changes and especially recent changes induce important modifications in the shore configuration. Sea level rise and the intensification of meteorological and hydrological extreme phenomena due to climate change and in direct association with the decrease of sedimentary material transported by the Danube, coupled with modifications of sea currents, have resulted in pronounced erosion of the shores, the deltaic and lagoon sector being the most affected (Fig. 9).

The evolution of the shore varies according to the intensity of coastal processes, distinguishing distinct sectors:

- erosion sectors: southern Sulina - north Sf. Gheorghe, Zaton - Perisor sector, North Portita – Periboina - Edighiol sector.
- accumulative sectors: Sulina beach, Periteasca sector, Chituc sector.
- Narrow lagoon barriers with specific dynamics - bending and elongation to the southwest, accompanied by a translation movement to the west (Musura Bay Island, Sahalin Peninsula).

REFERENCES

Diaconeasa D. (2009), Geodynamics of Romanian Black Sea coast. Mamaia Bay sector, Ed. Universitara: 1-125;

Spinu A. (2017), Lagoon shore of the Black Sea between Perisor and Midia Cape. Coastal geomorphology Study: 1-142;

*** NIMRD project reports;

*** Coastal zone diagnosis (2011), Technical Assistance for the Preparation of Projects under Priority Axis 5. Implementation of adequate infrastructure of natural risk prevention in the most vulnerable areas. Major intervention domain 2 - Reduction of coastal erosion - report.