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MONITORING OF COASTAL EVOLUTION IN CONSTANTA AND EFORIE NORTH AREAS

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ABSTRACT

Following research carried out by research institutes as well as other institutions and international agencies which concluded that the southern part of the Romanian shoreline is constantly under attack by erosion, reaching measured land loss rates of up to 2 meters per year which in turn impacts litoral ecosystems, overall safety, businesses, livelihood and living quality. In the direction of harmonizing the erosion condition, the Dobrogea-Litoral Water Basin Administration (D-L WBA) contracted technical assistance to develop a coastal zone management strategy (Halcrow, 2012).

The whole coastal area between the Chilia branch of the river Danube to the north and the Vama Veche locality to the south was analyzed, studies in multiple fields were carried out including hydraulic modelling and a diagnostic analysis of the erosion process, including its effects on the environment. The results of these studies laid the base for a coastal zone management strategy over the span of the following 30 years. The masterplan's conclusions were that the northern unit was not an immediate priority in terms of socio-economic impact. The southern unit, however, was classified as being under the intense influence of coastal erosion and thus determined the introduction of short-term structural measures materialized through the completion of the first phase of the "Reduction of Coastal Erosion" major project. Total length of protected coastline is 7.3 kilometers, and the works were finalized in 2015. Since then, we have been investigating the evolution of the morphology of the coast area (shoreline) and modifications due to natural and human factors by means of photogrammetry and GNSS on a UAV and underwater echo-sounders. In addition, other factors such as water biology, chemistry and beach sand grain size were also monitored to create a better image of the coastline evolution's features.

Keywords: Romanian shoreline, coastal zone management strategy, master plan, erosion

AIMS AND BACKGROUND

"States with a maritime tradition consider that coastal areas are fundamental for the development of the national economy. But the effects of the interaction of socio-economic activities with the coastal areas are beginning to become

obvious as a result of globalization and climate change. Maritime spaces (coastal areas) represent the base of development for maritime states and constitutes the area of overlapping of factors for potential progress: sailing routes-climate timing-energy-resources-recreational space." (Hagi *et al*., 2020). One of the contributing factors to local as well as national instability is coastal erosion as it impacts two of the five main action domains of the EU integrated maritime policy (COM 2007), namely: Ensuring of the best living conditions in the coastal areas and Maximization of sustainable utilization of the seas and oceans. In addition, plainly said, coastal erosion represents the loss of national territory of Romania. As a point of reference, it was estimated that between 1962 and 2003, about half the total area of emerged beaches in Romania has been lost due to erosion at an average rate of about 85 hectares per year (Sâmbotin *et al.,* 2003). By comparison, the entire surface of beaches available for tourism in the year 2014 was little over 160 hectares although we must mention the fact that the coastal length where touristic beaches are is roughly 70 kilometers long, or less than 30% of the Romanian coastline.

The Romanian coastline at the Black Sea has a total length of 245 kilometers and throughout time has been subject to a continuous process of coastal erosion of different intensities from the northern (Chilia Branch, Musura bay) to the southern limit (Vama Veche, border with Bulgaria). Although coastal erosion is a common natural phenomenon, the rate of erosion varies in accordance with multiple environmental factors, such as water currents, wave intensity, direction and duration, sediment transport, etc., as well as human influence that may interfere with the environmental factors (JICA, 2007). One substantial example of human intervention is the building of the „Porțile de fier" (Iron Gates) dam on the river Danube which blocks the solid flow that would normally nourish the beaches. In was estimated that more than 70% of the sediments that would be carried down the river Danube each year are stopped by the dam and end up in its reservoir. It`s effects were felt immediately as erosion became more rampant and rapid stabilization works had to be carried out, especially in the southern sector. One of the major milestones accomplished by the Dobrogea-Litoral Water Basin Administration has been the establishment of a coastal zone management strategy (Post *et al.* 1996) and as a consequence, the promotion of the national project "Reduction of Coastal Erosion" of which the first phase was completed (works were taken over) in 2015. The general construction layout consisted of hydrotechnical works, respectively a system of groins linked to the shore and detached breakwaters parallel to the shore, creating what we refer to as "beach cells". Once the hydrotechnical works were completed, the "beach cells" would get a sand nourishment, creating new beaches or extending the existing ones.

EXPERIMENTAL

The study area of the present paper is situated in the southern unit of the Romanian littoral at the Black Sea with a northern limit at the Midia Cape and as a southern limit the Vama Veche, as it was defined in the “Protection and Rehabilitation of the Coastal Area” Master Plan.

This general layout was implemented in five areas in the first phase, respectively: Mamaia South, Tomis North, Tomis Centre and Tomis South, in the municipality of Constanta and Eforie North in the locality of Eforie, spanning a total coast length of 7.3 kilometers. In the present, the second phase of the project is ongoing with 11 areas in different stages of completion, from some still being tendered to one that was taken over after completion in June 2021 (Mamaia - which spans 6,95 kilometers). There is a difference between the way coastal protection was treated in the two successive phases, respectively in the first phase, the focus was entirely on the best protection methods to be applied considering human interactions, tourism and livelihoods, while in the second phase, the environment and biodiversity were another point of the measures proposed. As such, in the second phase contracts a substantial environmental section comprised firstly of dedicated biodiversity and environment monitoring before the execution, in the execution period and for 5 years after the execution is completed.

The region has low average precipitation (between 383 and 531mm/m^2/year), but on the shore there can be torrential rains that have a significant impact over the dunes and the soft loess cliffs situated along the length of the southern sector which is particularly affected by runoff and as a consequence by minor landslides (especially in the early winters when high levels of precipitation coincide with winter storms). Average humidity values along the Romanian coast ($\geq$ 9g/m^3) are much higher than any other inland area of the country. Along the whole length of the study area (Fig. 1) there is a lot of human touristic, residential and industrial structures, socio-economic activities, etc. (Dobrogea-Litoral Water Basin Administration, Integrated Coastal Monitoring Report 2016-2020).

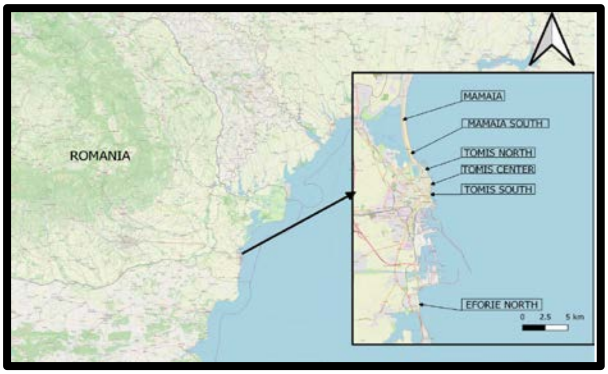

Fig. 1. Study locations

Mamaia sector stretches over a length of 6.95 kilometers spanning over the territory of 2 localities (Constanta and Navodari). The beach was nourished with over 4 million cubic meters of sand and as a result it has a newly created surface of 89.7 hectares. The Mamaia area is a sandbar that closed an ancient golf and has no cliffs and very little elevation over the sea level. The area is a dedicated touristic resort and as such the specific is mainly focused on touristic buildings and infrastructure although in the past years, the residential sector began to increase in the area as more and more residential buildings are constructed.
Mamaia South sector stretches over 1.2 kilometers and is characterized by the absence of cliffs and the presence of wide beaches, the newly created surface (2015) being 10.19 hectares, as a result of the execution of the protection and rehabilitation works in the first phase. The main activity in the area is tourism in the summer season and connected activities (hotels and lodging, restaurants, catering, entertainment, clubs, etc).
Tomis North, Tomis Center and **Tomis South sectors** stretch over a combined length of 4.7 kilometers and are characterized by the presence of cliffs which have beach at their base with a combined surface of the newly created (2015) beach of 36.22 hectares. Although these areas are located alongside the city of Constanta which has a mostly residential specific, in the years following the beach nourishment, they have seen a positive evolution regarding the development of the touristic sector which is no-longer limited to the "traditional" touristic resort of Mamaia.

Eforie North sector stretches over 1.4 kilometers and has a newly created beach surface of 14.24 hectares (2015). This area is also characterized by the presence of cliffs. This area has a combined specific, both touristic (summertime tourism) and residential.

RESULTS AND DISCUSSION

The same activities were used for the bathymetry section where a single beam sonar sensor was used for the underwater measurements. The sensor was mounted on a RIB (rigid inflatable boat) and sections were traced out according to the sensor`s scanning width. The bathymetry covered the section between 0,00 mdMN and -2,50mdMN. The mapping process is carried out twice every year for all the above-mentioned areas and is set in order to investigate the influence of the cold and warm seasons and general evolution of the shoreline (Dobrogea-Litoral Water Basin Administration, Integrated Coastal Monitoring Report 2016-2020).

The bathymetry has been added to the monitoring process in the year 2021 and as a result DTM`s were generated. The Digital Terrain Model (DTM) or Digital Elevation Model (DEM) is a graphical, digital representation of the ground topography and can be presented as a raster (a network of squares or pixels) or as an irregular vector-based network (TIN). TIN`s are a form of geographic digital data based on vectors and are connected to a series of images in order to form a network of triangles. The DTM is a representation of the continuous surface of the terrain with x and y coordinates as well as height (elevation) z. The land surface is represented through a mathematical surface that approximates the topographic surface of the terrain. For the five coastal protection areas: Mamaia South, Tomis North, Tomis Center, Tomis South and Eforie North, 2 sets of Digital Terrain Models were generated for the years 2021 and 2022, through the interpolation of TIN based on the measurements carried out by the Constanta Water Management System in GNSS/RTK system, as well by depth measurements with the single beam sonar in 2021 and 2022.

Mamaia South sector

In the Mamaia South beach cell the shoreline dynamics were analyzed by means of georeferenced orthophoto plans and satellite imagery. The seasonal dynamic of the shoreline was calculated by processing the differences between the base line (As Built) and the temporal series of the georeferenced shoreline position measured over 25 transects spaced 50m apart along the length of the beach cell. Through the Net Shoreline Movement method (NSM) values for the seasonal movement of the shoreline were identified in the overlapped transects. In the Mamaia South beach cell the shoreline dynamics were analyzed by means of georeferenced orthophoto plans and satellite imagery. The seasonal dynamic of the shoreline was calculated by processing the differences between the base line (As Built) and the temporal series of the georeferenced shoreline position measured over 25 transects spaced 50 m apart along the length of the beach cell (Fig. 2).

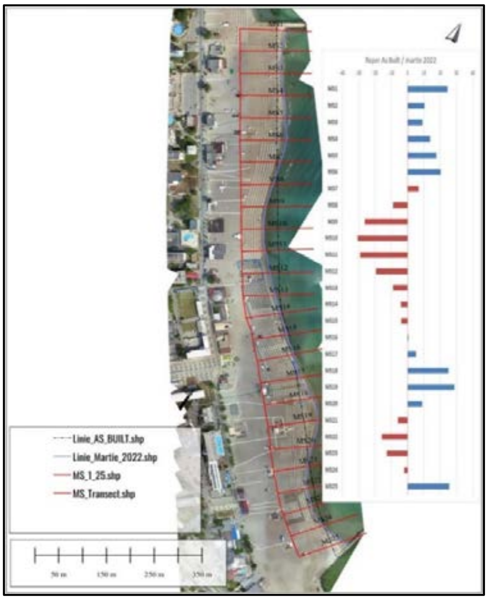

Fig. 2. Mamaia South evolution from completion in 2015 to March 2022

Through the Net Shoreline Movement method (NSM) values for the seasonal movement of the shoreline were identified in the overlapped transects. Thus, by analysis of the shoreline in the 2015-2022 interval (Table 1), we can see a redistribution of the sedimentary material and the shoreline takes on a concave aspect in the northern part where we identify accretion and a convex erosion zone in the center between the breakwater structures (MM2 and MM3).

Table 1. Surface variation measurements in the Mamaia South beach cell (2016-2022)

Survey date		Sediment deposit (accretion) from completion (As Built) to the survey date (sq.m)	Surface difference between survey date and previous survey (sq.m)	Average deposit (accretion) along the nourished area compared to the previous season (meters)
2016	February	4203	-	3.69
	November	8248	4045	3.32
2017	March	4731	-3517	-2.96
	October	6057	1326	1.34
2018	January	2008	-4049	-4.17
	May	-6643	-8651	-6.41
2019	January	-13	6630	5.31
	October	9027	9040	7.67
2020	January	3766	-5261	-4.88
	August	-1659	-5425	-4.14
2021	March	8481	10140	9.57
	July	-2917	-11398	-10.05
2022	March	1025	3942	2.88
	July	-2146	-3171	-2.5

A seasonal pattern of change of the shoreline, more cyclic rather than linear in nature were noticed. The sediment transport within the coastal protection cell is made by deposits and redistribution towards the northern extremity in the shadow of the RJ1/RJn1 groyne as well as in the “shadow” of the detached breakwaters MM1 and MM2 resulting in a concave and geometry of the shoreline.

In contrast, the area between the breakwaters and close to the CS1 groyne (in the south) show a convex geometry corresponding to the effects of erosion. As a conclusion all these deposits and erosion represent the redistribution of sedimentary material within the Mamaia South beach cell. Human influence is quite heavy in this beach cell which is almost closed, surrounded on 3 sides by groynes and breakwaters (CS1 to the south, RJn1 to the north and MM2/MM3 breakwaters on the east side), defined by a sand nourishment up to a width of 100 meters along the whole length as well as nourishment of the submerged beach (for the creation of a stable, close to natural, profile).

Tomis North Sector

In the Tomis North beach cell the shoreline dynamics (Fig. 3) were analyzed by means of georeferenced orthophoto plans and satellite imagery. The seasonal dynamic of the shoreline was calculated by processing the differences between the base line (As Built) and the temporal series of the georeferenced shoreline position measured over 22 transects spaced 50m apart along the length of the beach cell.

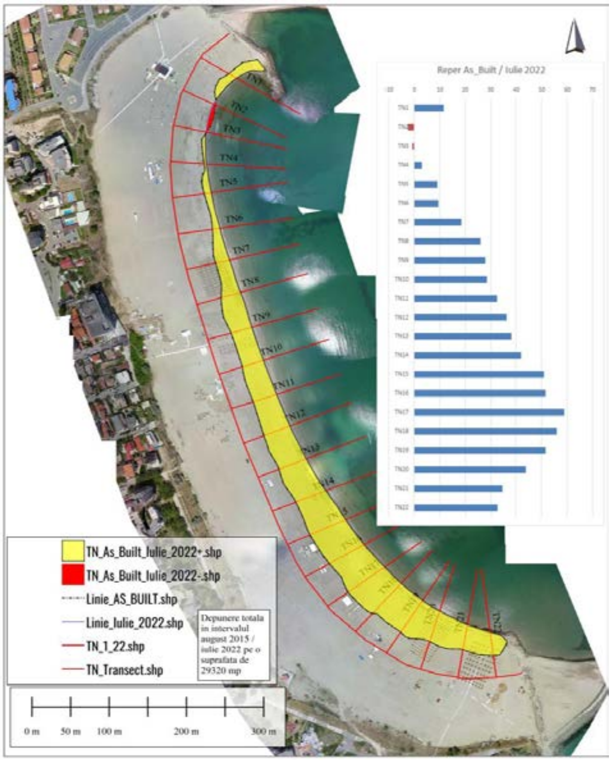

Fig. 3. Tomis North evolution from completion in 2015 to July 2022

Through the Net Shoreline Movement method (NSM) values for the seasonal movement of the shoreline were identified in the overlapped transects (Table 2). The monitoring in the above-mentioned time interval has shown a trend of slight loss of sediment within the Mamaia South beach cell and small seasonal fluctuation. Analysis of the transversal profiles extracted from transects and the DTM has shown a tendency to stabilize naturally in an equilibrium profile. The long-term behavior points towards the development of a stable beach contour while the short-term response is focused on the evolution of beach transversal profiles when influenced by storm conditions.

Tomis North is a beach cell with heavy human influence as well and is almost closed having groynes and breakwaters on 3 sides (T8 to the north, T6_2 to the south and DS_01 submerged breakwater to the east) and sand nourishment of 100 meters in width for the emerged beach and 400 meters for the submerged beach.

Table 2. Surface variation measurements in the Tomis North beach cell

Survey date		**Sediment deposit (accretion) from completion (As Built) to the survey date (sq.m)**	**Surface difference between survey date and previous survey (sq.m)**	**Average deposit (accretion) along the nourished area compared to the previous season (meters)**
2016	February	14243	-	13.2
	November	25086	10843	11.37
2017	March	28445	3359	3.8
	October	32229	3784	3.82
2018	January	26813	-5416	-5.41
	May	22022	-4791	-4.59
2019	January	32819	10797	10.32
	October	39585	6766	7.9
2020	January	40460	875	0.87
	August	31908	-8552	-9.49
2021	March	38225	6317	7.5
	July	35971	-2254	-2.6
2022	March	32622	-3349	-3.2
	July	29320	-3302	-3.4

An interesting observation is the creation of a new beach surface between the T6_02 groyne (new groyne) and the old groyne T6. A new beach surface of 7810 square meters "grew" between the completion date (2015) and the last measurement in 2022. This area was outside the pre-set transects but was observed and attributed to the proper functioning of the coastal protection system which is supposed to capture and retain sediment within the beach cell. As was expected since the design phase, the distribution of sediment is more substantial in the northern and southern extremities, more so in the southern part, resulting in a general convex shoreline geometry. The analysis of the transversal profiles from transects and the DTM show an evolution towards the establishment of a natural equilibrium profile. All sections seem relatively stable.

As was expected since the design phase, the distribution of sediment is more substantial in the northern and southern extremities, more so in the southern part, resulting in a general convex shoreline geometry. The analysis of the transversal profiles from transects and the DTM show an evolution towards the establishment of a natural equilibrium profile. All sections seem relatively stable.

Tomis Center Sector

In the Tomis Center beach cell the shoreline dynamics (Fig. 4) were analyzed by means of georeferenced orthophoto plans and satellite imagery. The seasonal dynamic of the shoreline was calculated by processing the differences between the base line (As Built) and the temporal series of the georeferenced shoreline position measured over 20 transects spaced 50m apart along the length of the beach cell (Table 3).

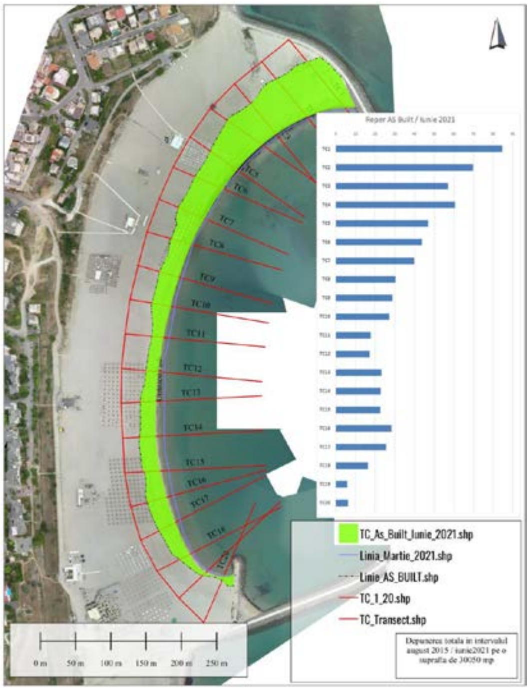

Fig. 4. Tomis Center evolution from completion in 2015 to July 2022

Through the Net Shoreline Movement method (NSM) values for the seasonal movement of the shoreline were identified in the overlapped transects. emerged beach and 400 meters for the submerged beach. As was expected since the design phase, the distribution of sediment is more substantial in the northern and southern extremities, more so in the northern part, resulting in a general convex shoreline geometry. The analysis of the transversal profiles from transects and the DTM show an evolution towards the establishment of a natural equilibrium profile.

Table 3. Surface variation measurements in the Tomis Center beach cell

Survey date		Sediment deposit (accretion) from completion (As Built) to the survey date (sq. m)	Surface difference between survey date and previous survey (sq. m)	Average deposit (accretion) along the nourished area compared to the previous season (meters)
2016	January	9947	-	10.98
	September	21064	11117	11.78
2017	May	23088	2024	2.88
	October	27176	4088	5.2
2018	March	21146	-6030	-7.22
	October	27075	5929	6.5
2019	January	28020	945	0.76
	October	33375	5355	6.41
2020	January	33889	514	0.61
	July	30596	-3293	-3.83
2021	March	35178	4582	-3.8
	June	30050	-5128	4.9
2022	March	30314	264	-5.23
	June	28181	-2133	-0.02

Tomis South Sector

In the Tomis South beach cell the shoreline dynamics were analyzed by means of georeferenced orthophoto plans and satellite imagery. The seasonal dynamic of the shoreline was calculated by processing the differences between the base line (As Built) and the temporal series of the georeferenced shoreline position measured over 34 transects spaced 50m apart along the length of the beach cell.

The Tomis South coastal protection scheme is divided into 3 beach cells (Fig. 5):

- *North beach cell* (between the T5 groyne to the north and T4 groyne to the south).
- *Central beach cell* (between the T4 groyne to the north and T3 groyne to the south).
- *South beach cell* (between the T3 groyne to the north and T1 groyne to the south).

In this sector, the north and center cells show stability while the south cell is characterized by a strong sediment redistribution from the north to the south, the shoreline showing a general orientation repositioning in a counterclockwise direction. The Tomis South sector shows a seasonal change pattern for the shoreline which is cyclic rather than linear with deposits and redistribution being detected towards the southern extremity for the north and center beach cells, with a very strong redistribution in the south beach cell, all resulting in convex shoreline aspect (Fig. 6).

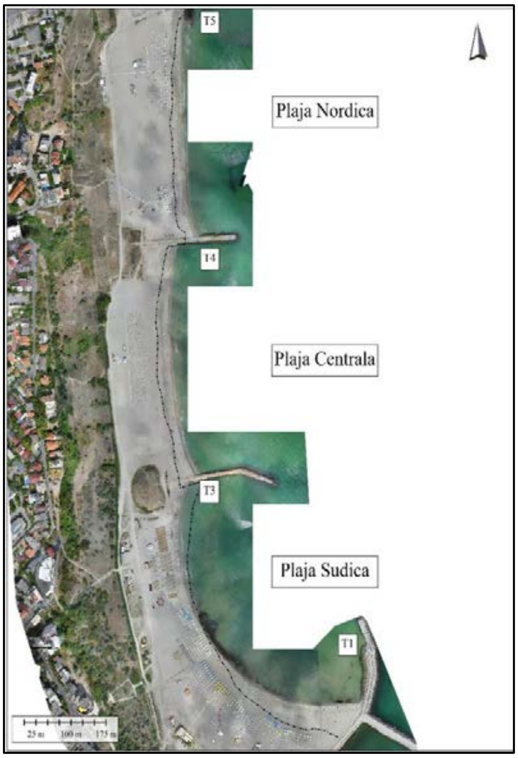

Fig.5. The 3 beach cells in the Tomis South sector

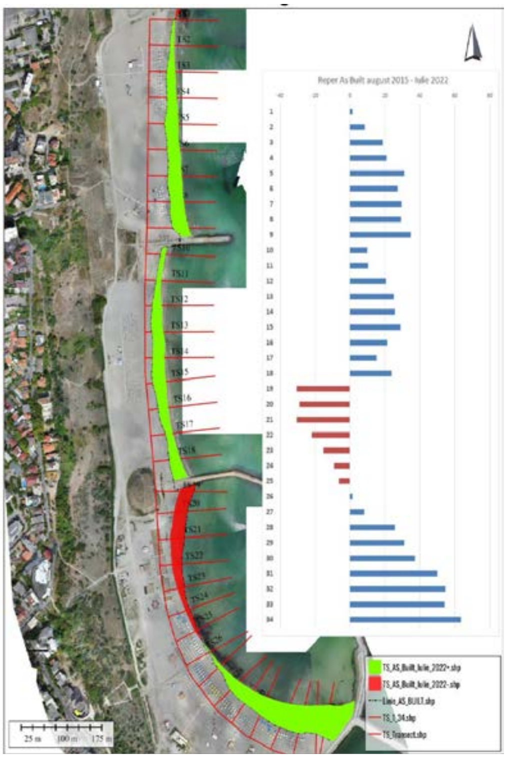

Fig.6. Tomis South evolution from completion in 2015 to July 2022

Tomis South sector comprised of the 3 beach cells has heavy human influence as well having groynes on 2 sides (T5 to the north, T1 to the south and T4 and T3 in between separating the 3 beach cells) and sand nourishment of 100 meters in width for the emerged beach and 400 meters for the submerged beach. The distribution of sediment is more substantial in the northern and southern extremities, more so in the northern part, resulting in a general convexe shoreline geometry. Slight influence can be observed from old submerged structures still present in the area of the north and center beach cells (Table 4).

The analysis of the transversal profiles from transects and the DTM show an evolution towards the establishment of a natural equilibrium profile. All sections seem relatively stable in the north and center beach cells while the south beach cell shows material loss in the northern part and gain in the southern part, a movement which is still not stabilized. In the Tomis South beach cell the shoreline dynamics were analyzed by means of georeferenced orthophoto plans and satellite imagery. The seasonal dynamic of the shoreline was calculated by processing the differences between the base line (As Built) and the temporal series of the georeferenced shoreline position measured over 24 transects spaced 50 m apart along the length of the beach cell.

Table 4. Surface variation measurements in the Tomis South beach sector

Survey date		Sediment deposit (accretion) from completion (As Built) to the survey date (sq. m)	Surface difference between survey date and previous survey (sq. m)	Average deposit (accretion) along the nourished area compared to the previous season (meters)
2016	January	18356	-	10,56
	September	34695	16339	10,74
2017	May	27723	-6972	-4,27
	October	29731	2008	1,35
2018	March	21867	-7864	-4,59
	October	20305	-1562	-1,22
2019	January	26438	6133	4,31
	October	35825	9387	5,99
2020	January	33669	-2156	-1,3
	July	29869	-3800	-2,54
2021	March	34623	4754	2.87
	June	34329	-294	-0.32
2022	March	31338	-2991	-1.6
	June	26270	-5068	-3.31

Eforie North Sector

The Eforie North coastal protection scheme is divided into 3 beach cells:

- *North beach cell* (between the J1 groyne to the north and EN7 groyne to the south);
- *Central beach cell* (between the EN7 groyne to the north and J2 groyne to the south);
- *South beach cell* (between the J2 groyne to the north and northern groyne of the Eforie Marina to the south).

Eforie North sector comprised of the 3 beach cells has heavy human influence as well having groynes and breakwaters on 3 sides (T5 to the north, T1 to the south and T4 and T3 in between separating the 3 beach cells closed to the east by the B-1, B-1` and B-2 submerged breakwaters) and sand nourishment of 100 meters in width for the emerged beach and 400 meters for the submerged beach. Following analysis of the costal dynamic in the 2015 to 2022 interval, we can identify that within the Eforie North coastal protection scheme, the northern, central and southern beach cells have relatively stable shorelines (Fig. 7). The central cell presents a substantial redistribution of sedimentary material from south to north. We also notice a seasonal changing pattern for the shoreline, more cyclic than linear with the north cell having overall accretion, the center cell displaying a redistribution of sediment from south to north, and the southern cell showing overall accretion (Table 5).

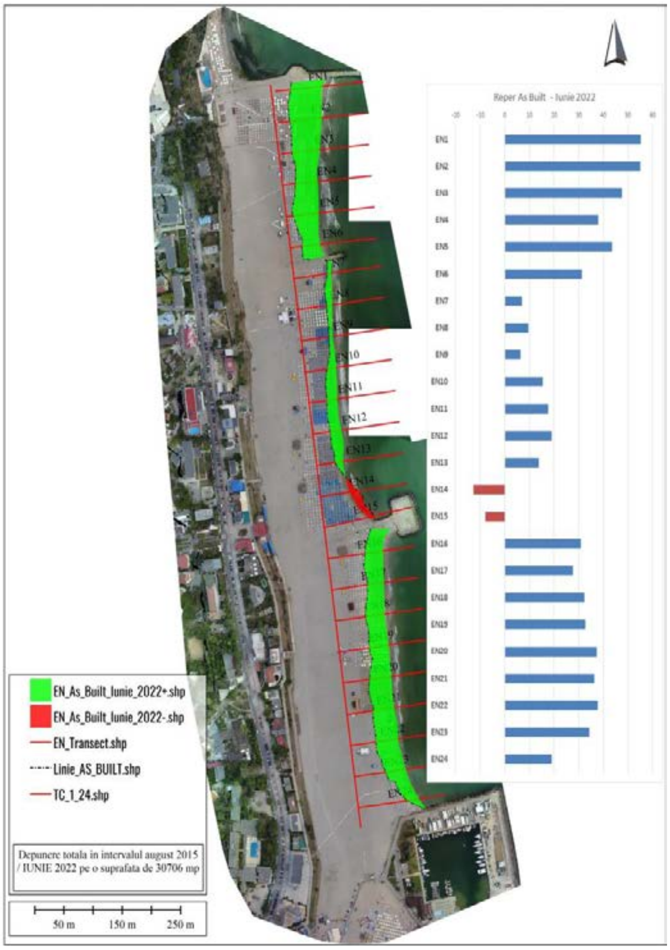

Fig.7. Eforie North evolution from completion in 2015 to July 2022

Table 5. Surface variation measurements in the Eforie North beach sector

Survey date		Sediment deposit (accretion) from completion (As Built) to the survey date (sq. m)	Surface difference between survey date and previous survey (sq. m)	Average deposit (accretion) along the nourished area compared to the previous season (meters)
2016	May	36693	-	20.2
	November	34130	-2563	9.4
2017	March	30566	-3564	-3.7
	October	33340	2774	2.7
2018	January	28791	-4549	-4.3
	May	27757	-1034	-1.2
2019	January	35376	7619	6.9
	November	40705	5329	4.7
2020	January	38566	-2139	-2.8
	August	33067	-5499	4.2
2021	March	31931	-1136	1.5
	July	31258	-673	-2.6
2022	March	31274	16	0.5
	July	30706	-568	0.9

Mamaia Sector

In the Mamaia sector the shoreline dynamics were analyzed by means of georeferenced ortophotoplans and satelite imagery. In operation, considering the large length of surveyed shoreline (6950 meters) for ease of analysis and plotting, the sector was divided in 3 areas: MM_N (Mamaia North), MM_C (Mamaia Center), MM_S1 (Mamaia South 1) (Fig.8-9-10).

The seasonal dynamic of the shoreline was calculated by processing the differences between the base line (As Built) and the temporal series of the georeferenced shoreline position measured as follows:

- MM_N (Mamaia North) where 27 transects were traced along the studies shoreline, spaced 100 meters apart.
- MM_C (Mamaia Center) where 25 transects were traced along the studies shoreline, spaced 100 meters apart.
- MM_S1 (Mamaia South 1) where 47 transects were traced along the studies shoreline, spaced 50 meters apart.

Through the Net Shoreline Method, we identified the seasonal movements of the shoreline by overlapping transects. Following the analysis of the dynamics of the coastline in the interval between 2021 and 2022 a redistribution of the sedimentary material was identified in the southern part (Table 6), MM_S1 where the influence of the MM4, MM5, MM6 and MM7 detached breakwaters is substantial generating a sinuous shoreline with deposits in the "shadow" of the breakwaters and erosion between them (Fig. 11).

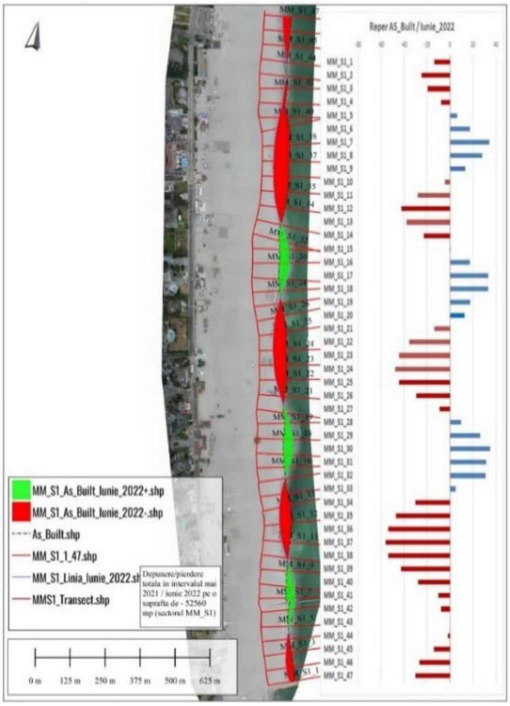

Fig. 8. Mamaia South 1 from completion in 2021 to 2022

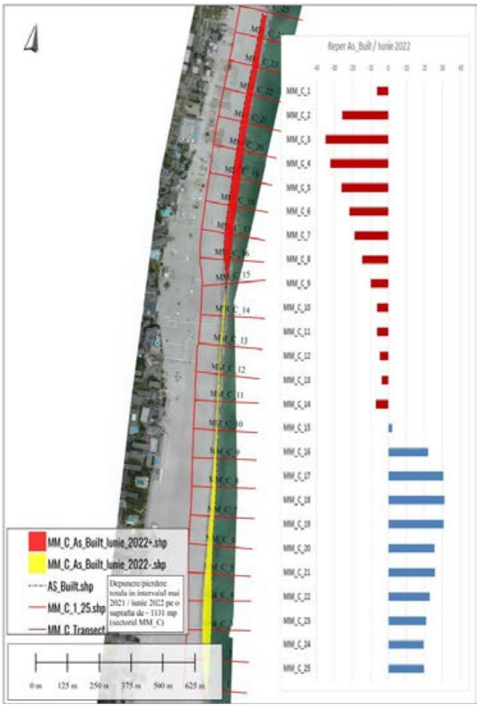

Fig. 9. Mamaia Center from completion in 2021 to 2022

Table 6. Surface variation measurements in the Mamaia beach sector

Survey date		Sediment deposit (accretion) from completion (As Built) to the survey date (sq. m)	Surface difference between survey date and previous survey (sq. m)	Average deposit (accretion) along the nourished area compared to the previous season (meters)
MM_S1	September 2021	-8532	-8532	-2,57
	June 2022	-52560	-61092	-7,56
MM_C	September 2021	5926	5926	4,22
	June 2022	1131	-4795	-2,78
MM_N	September 2021	91695	91695	33,43
	June 2022	82888	-8807	-1,1

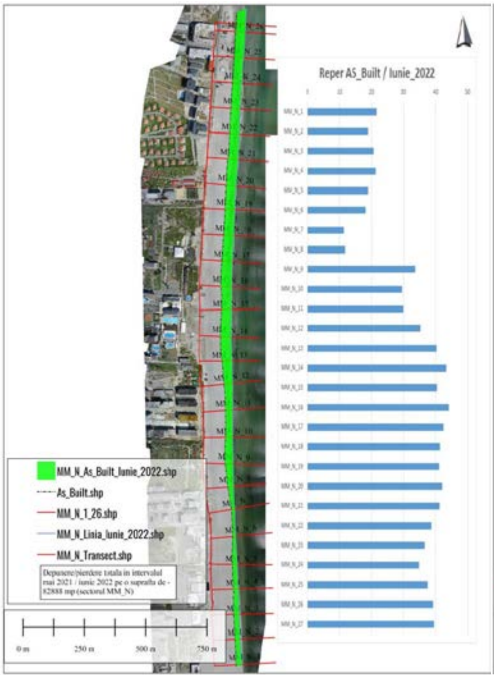

Fig. 10. Mamaia North from completion in 2021 to 2022

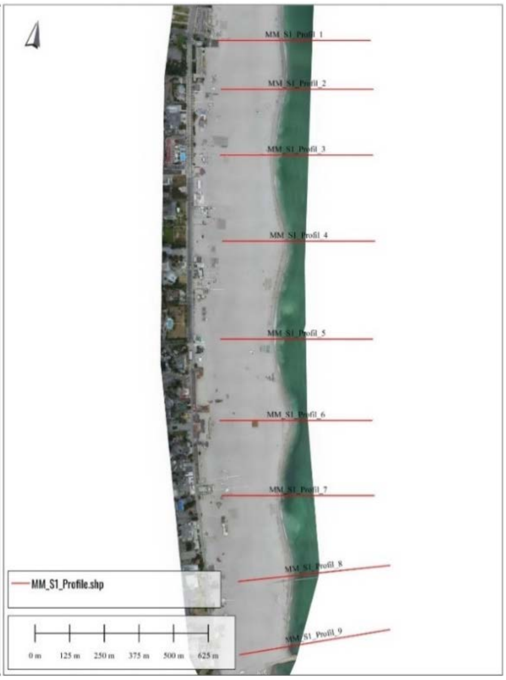

Fig. 11. cross-sections in the MM_S sector (DTM 2021-2022)

Granulometry (Grain Size analysis)

Unconsolidated sediment granulometry represents the study of grain fractions from sedimentary deposits (beaches) since their formation monitoring their evolution from the point of view of dynamics under the influence of external hydro-meteorological factors (wind, waves, marine currents) as well as human intervention. In order to fulfill this task, the granulometry activity implies a rhythmic and in-depth survey of beach sediment in areas of distinct behavior from a hydro-meteorological conditions point of view as well as local morphology. Water and wind will induce a sorting phenomenon on the unconsolidated sediment that helps us understand the transport process in the sense of accumulation or reduction of sedimentary material.

First phase of the granulometric study is represented by the grain size analysis, as in the totality of the processes that contribute to the dimensions of the particles. In the end, the analytical phase of the granulometry provides data that indicate the frequency of different dimensional categories of grains - the granulometric distribution of the studied sediments.

The second phase aims to interpret the frequency data that grain size measurement has provided. Description of grain size will remain an important preoccupation for the future as well, but this will not be the only contribution of the granulometric analysis to the overall sediment study. A series of sampling stations has been set ahead of starting the monitoring activity in accordance with beach cell division and different potential external influence from physical factors (the collection of samples from the base of the cliff the median line of the beach and the shoreline for example), as well as different depths.

The samples have been collected, prepared, and analyzed using established and proven techniques (Table 7). The grain size determination was done by using standardized sieves (screens) laid in a screening column. The study also analyzed the grain shapes (symmetry) in order to determine morphological tendencies. The Wentworth scale was used as granulometric scale and the graphic representation of the granulometric data was done in accordance with Folk and Ward parameters.

Table 7. Example of grain size distribution according to weight percentage from the sample (MSN1 sample from May 2021) (Dobrogea-Litoral Water Basin Administration, Integrated Coastal Monitoring Report 2021-2022)

Size (mm)	**Sample wgt.**	**Beaker wgt.**	**Net wgt.**	**%gr**	**Σ%gr**
2	36,556	28,254	8,302	3,833	3,833
1	73,593	30,343	43,25	19,97	23,803
0,5	106,815	50,053	56,762	26,209	50,012
0,25	123,273	50,3	72,973	33,69	83,702
0,125	102,167	69,179	34,988	16,155	99,857
0,0625	28,297	28,02	0,277	0,127	99,984
0,031	29,048	29,026	0,022	0,010	99,994
Total			**216,574**		

CONCLUSIONS

As years of research concluded, action had to be taken in order to control the erosion process, and the Dobrogea-Litoral Water Basin Administration (D-L WBA), with the aid and assistance of several other institutions and consultants has been at the forefront of this matter for over 20 years.

One of the major milestones accomplished by the D-L WBA has been the establishment of a coastal zone management strategy (Coastal Zone Master Plan) and therefore, the promotion of the national project “Reduction of Coastal Erosion” of which the first phase was completed (works were taken over) in 2015. The general construction layout consisted of hydrotechnical works, respectively a system of groynes linked to the shore and detached breakwaters parallel to the shore creating what we refer to as “beach cells”. Once the hydrotechnical works were completed, the “beach cells” would get a sand nourishment, creating new beaches or extending the existing ones. This general layout was implemented in 5 areas in the first phase, respectively: Mamaia

South, Tomis North, Tomis Centre and Tomis South, in the municipality of Constanta and Eforie North, spanning a total coast length of 7.3 kilometers. In the present, the second phase of the project is ongoing with 11 areas in different stages of completion, from some still being tendered to one that was taken over after completion in June 2021 (Mamaia - which spans 6,95 kilometers). There is a difference between the way coastal protection was treated in the two successive phases, respectively in the first phase, the focus was entirely on the best protection methods to be applied considering human interactions, tourism and livelihoods, while in the second phase, the environment and biodiversity were another focal point of the measures proposed.

As such, in the second phase contracts we have a substantial environmental section comprised firstly of dedicated biodiversity and environment monitoring before the execution, in the execution period and for 5 years after the execution is completed. The first phase had environmental monitoring, as in bio-chemical markers relevant to the area, pollution, etc, but the second phase is focused on the impact of works on different local species and their evolution following the execution of the works. In addition to monitoring, active measures have been requested to stimulate biodiversity through the creation of man-made habitats, planting of marine plants and algae, bio-structures and artificial reefs. Many of those measures are a first for our country, the only local experience in such matter being very small-scale experimental, but only for some species. This shows the growing experience and the improvement in inter-disciplinary and inter-institutional collaboration resulting in a much better understanding of the important aspects of coastal protection.

From experience we know that it does not suffice to implement measures that promise a lot and no matter how well executed, they need to be properly monitored in order to understand firstly that the initial estimates and goals are accomplished and secondly that we may understand the evolution of complex interactions between coastal morphology, human socio-economic activities, biology and environment in order to detect the need for intervention, correction or fine-tuning of future similar projects with the aim of achieving similar or better results.

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