

# THE DANUBE RIVER AND ITS MOUTH AREA AND COAST LINE (DELTA) IN DOCUMENTS AND MAPS FROM ANCIENT TIMES TO THE PRESENT

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**Abstract.** *The Danube River and its mouths area and coast line (delta) in documents and maps from the ancient times to the present.* The Danube mouth as reported in documents and maps from the Antiquity to date. This mouth of the Danube and its Delta in particular, where a topic interest for many classical scholars (Herodotus, Erathostenes, Polybus, Ptolemey, Strabo etc) and recent scientific researchers who focused their attention on the number of Danube arms and the evolution of the Delta realm from the moment of its formation to the present configuration. The second half of the 19<sup>th</sup> century witnessed the publication of Sir Ch. Hartley's map under the aegis of the Danube European Commission. The map was intended to help the selection of and correction works to one the arms in order to facilitate maritime navigation on it. Several other maps were printed in the 20<sup>th</sup> century by I. Vidrașcu, 1909-1911, the State Water Committee, 1964 and the Institute of Geography, 1983. In addition a series of topographical maps of Romania territory have also been produced.

This sector was created as a result of accumulation processes, the north-south coastal marine currents, moving the river alluvia blocked the river mouth forming the Danube Delta and Halmyris lagoon, the whole becoming Razim-Sinoie Lake Complex. This marine shore sector, due to the contribution of river alluvia, is characterized generally by the advance in the marine space, but the current conditions (reducing the volume of sediments from the Danube, marine minitransgression and anthropogenic interventions (by the dams raised at the mouth of the Sulina branch and Cape Midia) generate shoreline retreat in some areas. To identify portions of advancement and retreat, and setting the corresponding annual rates, existing topographic map series for a period of over 150 years, hydrographic measurements for 30 years and series of satellite images starting from 1975 were used.

**Keywords:** Danube mouth area, in documents, maps, from ancient times to present

## I. INTRODUCTION

Numerous mentions of the shores of the Black Sea (Pontus Euxinus) and the mouths of the Danube River (Istros) date back to at least 5-6 centuries

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BC, due to the existence of cities on these lands and the interest in mastering the riparian territories, which offered important natural resources (on land and on water).

In order to navigate along the western shore of Pontus Euxinus and to be able to enter Halmyris Bay at the fortresses of the time, the most important of which was Histria (founded in the first half of the 8th century BC) and at the mouth of the Istros, there was a need of information on sea currents and sandbanks, therefore a need to draw up sketches of maps.

## II. DATA AND SHORT HISTORIC

The first mention of the western shore of Pontus Euxinus and, especially, of the river, dates from the 5th century BC and belongs to Herodotus of Halicarnassus (ca. 484 - 425 BC), also called the father of history and geography. In the 9 books entitled "Histories", Herodotus, in addition to describing many inland waters, also refers to the expedition of Darius I, Persian emperor (522 - 486 BC), against the Scythians in 514 BC, who entering from the Black Sea on the Danube says "After walking for two days up the river, from the sea, people built a bridge over the river, where the mouths of the Istros are separated" (it is estimated that that place was at Noviodunum, today Isaccea). From the same work it results that the Istros flowed into the Pontus Euxinus in a bay where were the Histrians - settlers of Miletus (*Book II, 33*) - it is assumed that it is Halmyris Bay, the current Razim - Sinoie Lake Complex. It is also mentioned (*Book II, 47*) that the *Istros* River, which is navigable, has five mouths - a subject that has caused controversy until today.

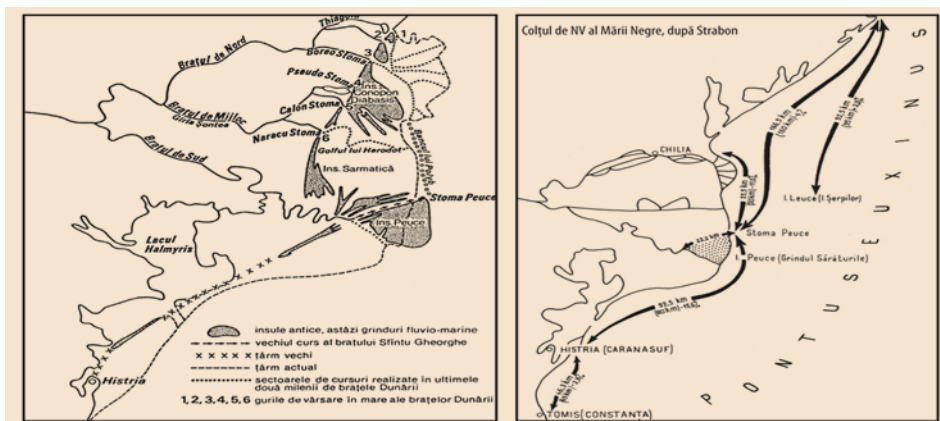


Fig.1. The Danube mouth mentioned in ancient documents

A little later, *Polybius* (c. 203 - 120 BC), a Greek politician and historian who lived for several years as a hostage in Rome, in his work "*Histories*", shows "*How the Istros comin--g from Europe flows in Pont through several mouths; from the mud brought by his arms a bank of sand was formed in Pont, almost 1,000 stadie away from the land, a day's journey. Those who float in Pont, being in full sea, reach this obstacle and they jam their ships there, during the night without noticing.*" (Book IV, 41, 1, 2). A very important information for this paper, together with the formation of more mouths of the Istros River, is the formation of sandbanks+, which by evolution reached today's coastal cordons, such as Chituc, eventually closing Halmyris Bay, transforming it into the Razim - Sinoie Lake Complex (Fig.1).

*Strabo* (63 BC - 19 AD), the greatest geographer, historian and ethnographer of antiquity, in his work "*Geographia*", brings valuable information on the issue under discussion: "*At the mouth of the Istros is a large island, Peuce. There are other islands - much smaller - some upstream, others to the sea. Istros River flows through seven mouths, the largest of which is called the Holy Mouth (Gura Sfântă), through which navigation is made near the Peuce Island, up the river, at a distance of 120 stadia, an island downstream, where landed Darius, although he could also land upstream of the Island, at the other end of it. That is the first mouth on the left that enters in the Black Sea, then the others, if you sail along the shore to Tyras (Dniester). From it to the seventh mouth there are about 300 stadie. Between the mouths are small islands. The three mouths following the Holy Mouth are smaller, the remaining are larger, and yet much smaller than the Holy Mouth ... From Istros to Tyras, another navigable river, there are 900 stadie*". Two pieces of information are noteworthy: the Danube flowed through seven mouths, compared to five, as mentioned by Herodotus; *Peuce Island* was located near *Holy Mouth* - today's Saint George (Sfântu Gheorghe) arm (Fig. 2.).

It should be mentioned that the geographical position at the mouth of St. George arm of the Peuce Island was also much commented on by Gr. Antipa (1914), C. Brătescu (1921), Gh. Năstase (1932), so that, at present, it is positioned on the right shore of the Danube at Ostrov, under the name "Păcuil lui Soare" where archeological vestiges were identified.

In the first century of our era, *Pliny the Elder* (23 - 79 AD), one of the illustrious scientists of the Roman era, in his work "*Naturalis historia*" makes a description of the mouths of the Danube and implicitly of its delta. The Danube flows into the sea through six arms: "*The first mouth is Peuce; it is situated immediately after the island of Peuce, beside which the so-called riverbed is lost in a vast pond, XIX thousand feet long. From the same riverbed and above Histropolis (Istria) it is formed a lake with a contour of LXIII thousand steps, called Halmyris. The second mouth is called Naracu Stoma (Narrow mouth),*

the third, *Calon Stoma* (Beautiful Mouth), near the Sarmatic Island, the fourth *Pseudo Stoma* (False Mouth) with *Conopon Diabasis Island* (Mosquito Ford), then *Boreo Stoma* (North Mouth) and *Psilon Stoma* (Thin Mouth). And all these mouths are so big that it is said that the sea is defeated and good drinking water on a distance of XL thousand steps longitude."

The most complete data on the estuaries of the Danube belong to *Ptolemy* (c. 90 - 168 AD), Greek astronomer and geographer, in his work "*Geographia*", a work par excellence cartographic - being mentioned geographical coordinates.

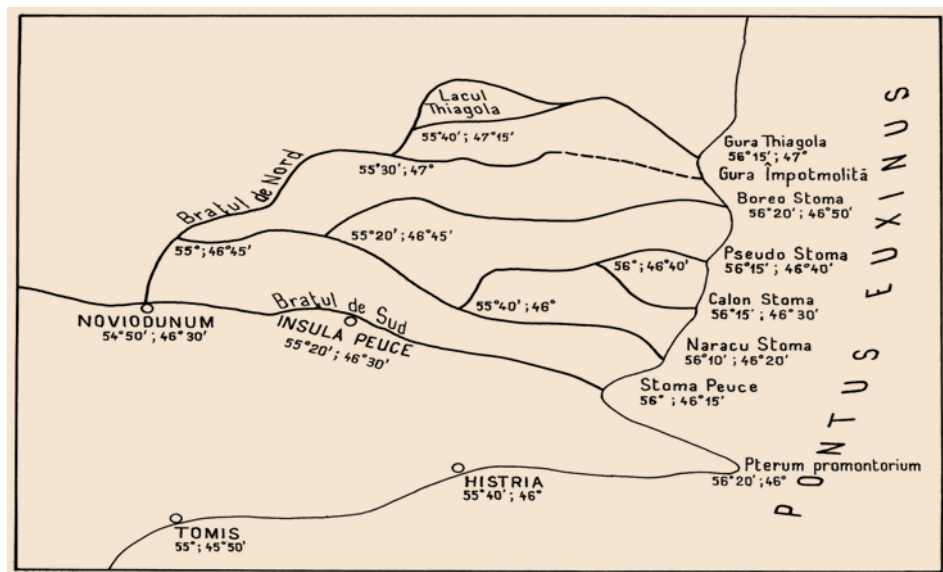


Fig.2. The Danube mouth after Claudiu Ptolomeu

Like Strabo, he mentions seven mouths, which from north to south were: the first - Pylon or Spiro or Thiagola Stoma, which ended in the lake of the same name and was of little importance; second mouth - insignificant and probably a stuffy arm; third mouth - Boreo Stoma, already indicates an exit from activity; mouth IV - Pseudo Stoma; the 5th mouth - Calon Stoma, was active with beautiful landscapes, which would be identified with the Sulina arm of today; 6th mouth - Naracu Stoma (Lazy, Sleepy Mouth), abandoned arm; mouth VII - Hiaron Stoma (Holy Mouth) also called Peuce, is the southernmost, intensely used for navigation in antiquity and corresponds to the St. George arm of today.

Also in antiquity, there were references to the Danube and its mouths: *Flavius Arrianus* (c. 95 - 175 AD) in the work "*Periplus Ponti Euxinus*"

describes the Island of Leuce (today's Snake Island) and gives some distances, including the one from the last mouth of the Danube to the Istria Fortress; *Pomponius Mela* (first half of the 1st century AD) in the work "De Chorographia" he writes that "there are six islands in the Mouths of the Istros, the best known and largest of which is Peuce"; *Eratosthenes* (ca. 275 - 195 BC), Greek mathematician, astronomer, geographer and philosopher from Alexandria, specified the triangular shape of Peuce Island (Fig.2).

According to the enumerated works of ancient scholars, the Danube Delta, at the beginning of the first millennium AD, was represented by several river arms, ravines, lakes and islands, and at the contact with the Black Sea were individual sandbanks, some emerged, and others submerged. The first water fork is located near Noviodunum (Isaccea).

The process of formation and expansion of the sea cords resulted in the contouring of the river delta through the alignment Jibrieni - Letea - Caraorman, and near the Gulf of Halmyris, its sealing completed with closure, leading to the decline of riparian cities.

In the Middle Ages, the information and, especially, the cartographic ones on the mouths of the Danube are less in number, poorer in content and more inaccurate.

In 950, the first mention of Sulina appears, under the name of *Selina*, in the work of the Byzantine emperor *Constantine VII Porphyrogenitus* (912 - 959) - "De administrando imperio", in which he draws attention to the strategic importance of the Carpatho-Danubian space. In the 14th century, Pietro Vesconti drew up a series of maps (1311, 1313 and 1318) on the mouths of the Danube and the nearby Black Sea coast, in which are known the known localities of the time.

In 1320, *Mario Sanudo's* portulan appears, which contains numerous localities on the Black Sea coast and near the Danube Delta, including the locality of Sollina, today's Sulina (Popescu-Spineni, 1978).

In the middle of the XIVth century, Georg de Reichersdorfer (c. 1495 - 1554), born in Transylvania, notary in Sibiu and later serving at the Hungarian court, is the author of the map "*Moldaviae finitimarum regionum typus*" published in Vienna in 1595, which shows the Danube in four-armed outflow area.

In the second half of the 18th century, more accurate maps were drawn up, regarding both the content of the information and the cartographic execution. Among them we mention the map of Moldavia, at a scale of 1: 288 000, drawn up by *Friederich Wilhelm von Bawr* and printed in 1781 in Amsterdam and in which the Danube - from Brăila to the outflow, including the delta - is very well rendered. The first more complete map of the Danube Delta dates from 1830 and was drawn up by the *Russian General Staff* and in 1856, *Captain Spratt* of the *British Navy Service* drew up a map in which the Chilia arm has five mouths.

### III. RESULTS AND DISCUSSION

The morphohydrographic configuration and the landscape one, respectively, evolved in natural conditions, the predominant processes being those of clogging inside the delta, through the Danube alluvial material and decomposed organic remains, in situ, by wind modeling on sandy sea ridges, by building coastal cordons and deltas secondary to the discharge of the waters of the Chilia and St. George arms

In 1857, after the establishment of the European Commission of the Danube, a first version of the map of the Danube's mouth was drawn up under the leadership of *Charles and they Hartley*, which was resumed in 1871 and in 1883, eventually printed in Vienna, with the aim of choosing one of the main arms for the maritime navigation purposes.

Between 1909 and 1911, the State Fisheries Service, under the leadership of Eng. *I. Vidrașcu*, draws up a map of the Danube Delta at a scale of 1: 50,000, in equal flood curves, in hydrogrades, but based on surveys at a scale of 1: 10,000, being the most complete map of the Danube Delta for that period. A 1: 150,000 scale variant was published by Grigore Antipa in the work "Scientific and Economic Problems of the Danube Delta" - 1917. This map revised in 1913, 1927 and 1935 was used in studies and works of the Delta Danube and Razim - Sinoie Complex until 1945 - 1950.

The topographic maps referring to the delta, executed in the last century, did not have a single cartographic projection, being used different projections depending on the historical period in which they were drawn up, the most frequent being Lambert, Gauss, stereographic.

The extensive research and development program of enclosures in the Danube Delta for agricultural, reed and forestry purposes after the 1960s, required the preparation of detailed maps of this region. Thus, the hydrotopographic map at the scale 1:25 000 by the *State Water Council* in 1962, the map of the land use categories at 1: 50 000 by IGFCOT - Bucharest in 1980.

After 1980, the application of extensive and even intensive exploitation policies of the natural resources available in the territory of the reservation, in addition to the previous arrangements (reed and abandoned), other arrangements were made, fish, agricultural and forestry, channels of economic interest, often unfounded. which the Crișan - Caraorman canal, the Mila 35 canal, etc. Through the extension of the arrangements in the delta, between the years 1960 - 1989, many imbalances occurred, a fact that negatively influenced the existing natural reserves.

Also in this context, the *Institute of Geography-Romanian Academy*, based on field investigations and aerial photographs from 1980, elaborated and printed the map of the Danube Delta at 1: 75 000 in 1983. Publishing House, later several editions 1992, 2000, 2002,2012 and in guides,

having texts with synthetic and complex characterizations, in Romanian, English and German (Gâțescu și colab.1983).

### 3.1. Genesis of the Danube Delta

The morphohydrographic configuration and the landscape one, respectively, evolved in natural conditions, the predominant processes being those of clogging inside the delta, through the Danube alluvial material and decomposed organic remains, in situ, by wind modeling on sandy sea ridges, by building coastal cordons and deltas secondary to the discharge of the waters of the Chilia and St. George arms (Fig., Panin,1974).

The genesis of the Danube Delta was favoured by existence of the large continental shelf of Black Sea, aliman-type gulf between the Dobrogean horst and the Bugeac Platform, the big volume of alluviadeposited by the Danube, the configuration of littoral sea currents, the low tides (7-11 cm) in the north-east of the Black Sea, together with the major climatic conditions which triggered the Black Sea level oscillations, and the tectonic(epirogenetic) movements suffered by the neighboring areas.

All the hypotheses on the genesis and evolution of the Danube Delta river sector fall into two large categories: one admitting the existence of a liman enclosed by littoral bars, pierce through in several points, and later evolving into the fluviatile delta; the other admitting the formation of the delta by gradual advance of the river levees as far as the littoral sea current, fact that led to the formation of coastal bar. The age of the Danube Delta is not older than 10,000-12,000 years( Fig.3.).

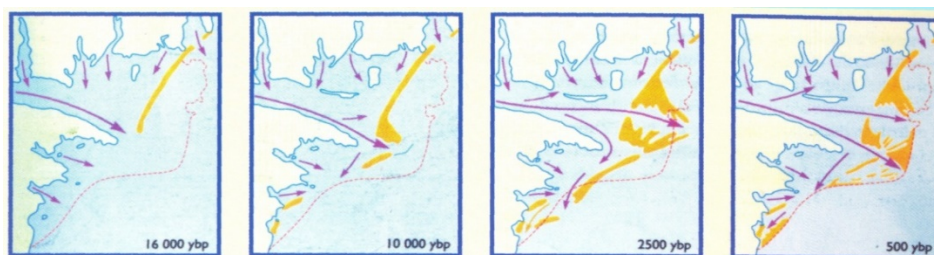


Fig. 3. The Danube Delta formation stages over the past 16,000 years (Panin, 1974)

### 3.2. Morphohydrographic units of the Danube Delta

The main morphohydrographic categories are: **predeltaic territories** are located in the Bugeac area to the north the Chila branch of river constituted from loess deposits were eroded by water from this area-Câmpul Chilieii and Stipoc; **river sandbanks** are located along the margins of the main branches and near cross ; **marine sandbanks** are formed and tend to lie parallel to the

line of coast; **initial banks** were formed in the Letea, Caraorman and Crasnicol areas; **network of river**, side channels and canals determines the way in which water is able to move through and around the delta; lakes the most important categories, but since 1980, reduced the total lake area in the delta from dry up; **swamps/marshes vegetation** surround lakes in the depression areas and still cover 143,500 ha(43% of the delta's area).

In terms of genesis, hypsometry, water relations between the Danube arms and inland areas, climatic conditions and landscape, two large sector delta can be distinguished: **the fluviale delta and fluviale-marine delta** with limit between is the Letea-Caraorman-Crasnicol marine levees (Fig.4.).



**Fig. 4.** The morphohydrographic pattern of the Danube Delta before management works started (1860)

#### IV. COASTAL MORPHOLOGY OF DELTA FRONT

The marine currents and waves, the sediment river branches fluxes generates a complex dynamics along the coast. The actual coast morphology is a result of natural factors in combination with human intervention. If the human

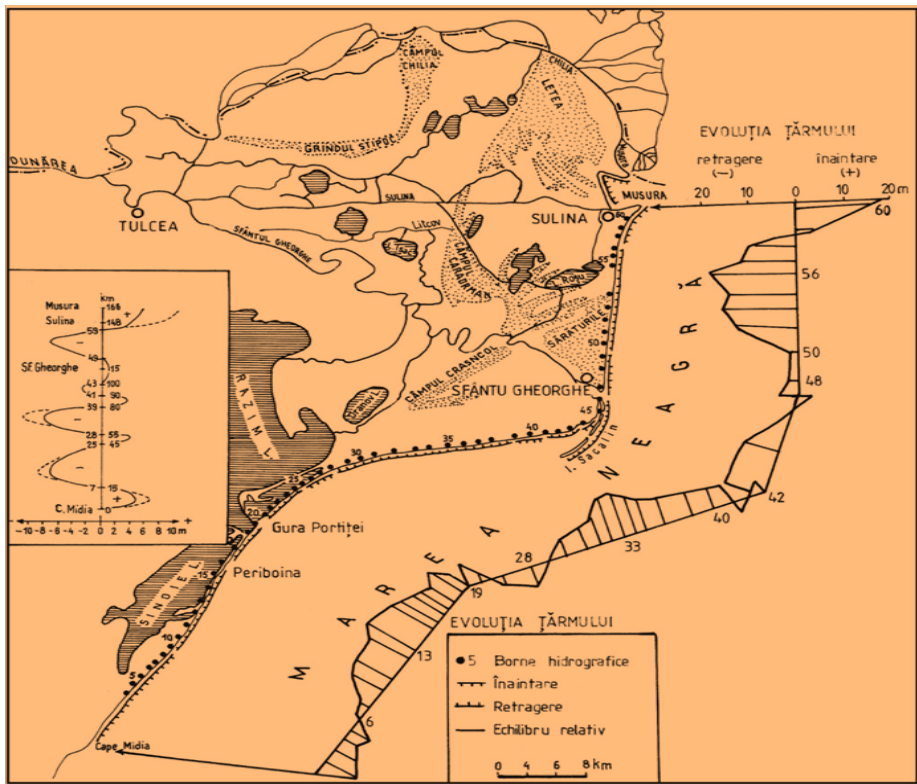


## THE DANUBE RIVER AND ITS MOUTH AREA AND COAST LINE

intervention in XIX centuries has small impact on coastal changes in the past period of XX centuries this impact become very important.

The **abrasion** is caused by marine transgression, drastic reduction of the sediments transported by the Danube and changes in the pattern of sea currents circulation in the wake of coastal engineering works.

Therefore, one can find abrasion retreating sectors alternating with sectors of reduced **accumulation (accretion)**. Sometime a relative temporal equilibrium between the two sets in. Accumulation sectors occur as a rule right south of the Danube arms (Fig.5. Gâtescu, Driga, 1995)



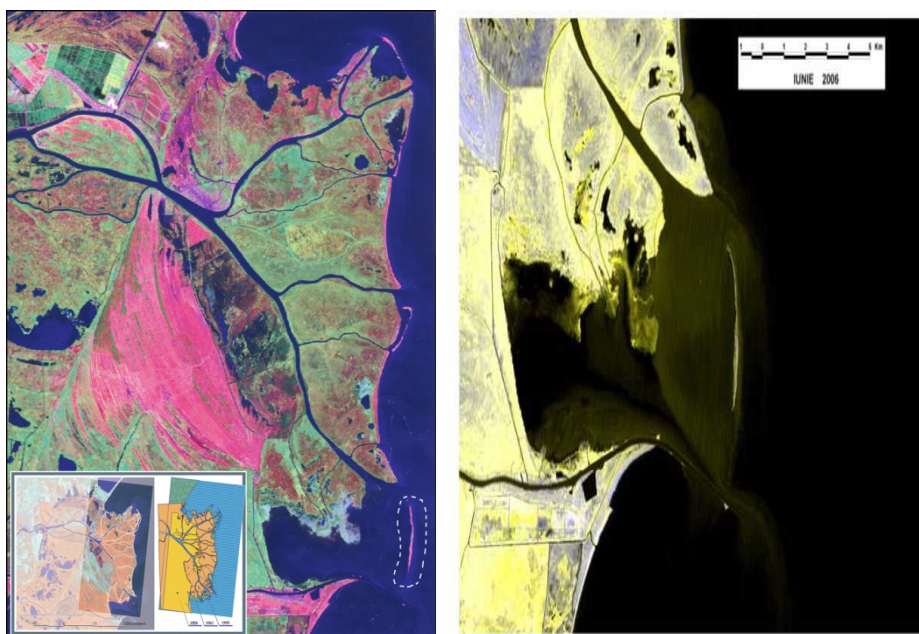
**Fig. 5.** Evolution of the accumulation Black Sea coast in front of the Danube Delta between Sulina and Midia over 1962-1985 period.

### 4.1. The coastal sectors with a special evolution

**4.1.1. Chilia Arm Secondary Delta.** Chilia Arm, the youngest and most active Danube branch in view of discharge and sediment transport (ca. 58 %), has in time built three successive up-to-downstream secondary deltas (Pardina, Roșca-Buhaiova, and the current, evolving delta).

The set of delta maps produced between the years 1830 and 1883 (Map of the Russian Military Headquarters, 1930; Hartley's Map, 1871; Lambert's Topographic Map Projection, 1883; Gauss-Krüger's Topographic Map Projection, 1971), have been used to determine the rate of delta accretion (m/year) along three main directions - Oceaov, Ankudenov and Staro Stambul, as well as the surface-area increase rate (sqkm/year).

In the last 200 years, there was an abundance of sediments on the Danube River and the secondary delta Chilia Delta increased from 78.7 km<sup>2</sup> in 1830 to 345.5 km<sup>2</sup> in 1971, therefore with 1.89 km<sup>2</sup>/year. After 1971 the sediment transported by Danube has been drastically reduced and on the Chilia Arm also has reduced (Fig.6).

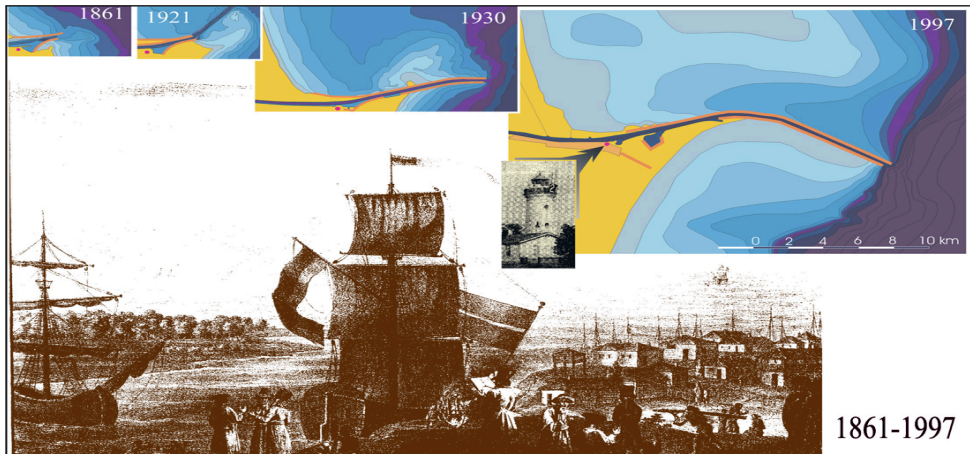


**Fig. 6. Evolution of the Chilia Arm-secondary delta over the 1830 - 1971 period and satellite image 2003**

**4.1.2. Sulina mouth/arm.** Reported problems in navigation on the Sulina Arm date back to the latter half of the 19th century, after the Paris Treaty of 1856, when the European Danube Commission (EDC) was established and assigned the surveillance of navigation along the Danube arms and the execution of works to enable high-tonnage sea vessels to reach the river ports of Galați and Brăila.

Ever since Sulina mouth was chosen as a route for maritime navigation, the alluvia that keep depositing are forming a submerged bar that necessitates a

lot of dredging and protection for that deep navigable channel flanked by two parallel piers; these piers have extended over 9 km if measured from the old lighthouse (Fig.7).



**Fig. 7.** Evolution of the Sulina Arm mouth over the 1861-1997 period

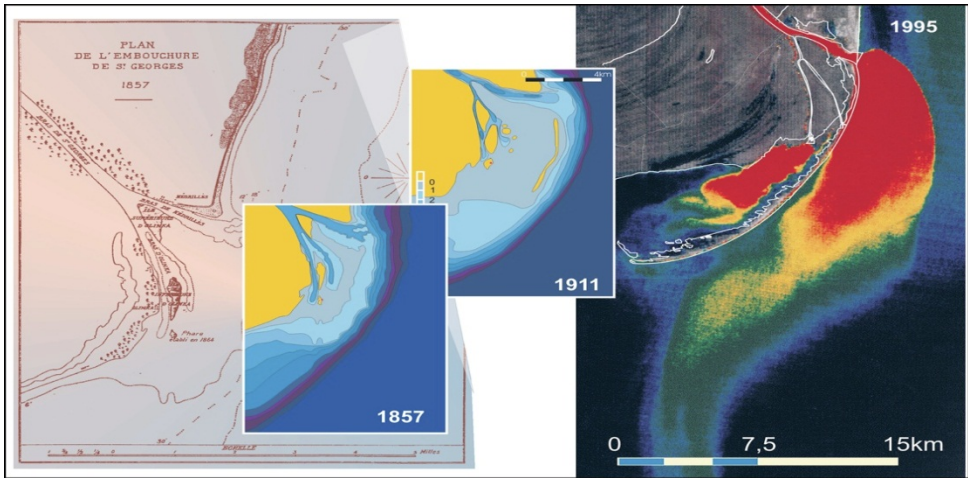
**4.1.3. Sfântu Gheorghe arm with the Scalin island/peninsula.** The birth of the Sacalin island dates back 1897, after the catastrophic flood of the Sfântu Gheorghe Arm. The island lengthened gradually only in the south-west direction having in 1995, 17 km long. The translation movement towards west with tendency to join delta area in the north-east extremity.

The changes in the natural processes tendencies became important after 1995, year when a big transportation project was finished, which consists in cutting six Saint George branch meanders. This works affect three closest deposit/erosion areas.

According to analyses, the Sacalin area till 1990 was an area where the deposit process was dominant. After this year, the dominant process was erosion.

If in 1990 the peninsula surfaces rich 670 ha in 1996 the surface decrease to 620 ha and in 2000 to 450 Ha. The erosion rate between 1990- 1996 was 8.3 ha/year. This rate is increasing between 1996- 2000 to 42.5 ha/year.

In the 1990 – 2000 interval, in the most active Sacalin area, the coast was retreating with 350 m. If the actual erosion rates remain, in 10 years this peninsula will disappear. It will remain a island in the south part where the deposit process is dominant (Fig.8).



**Fig. 8.** Evolution of the Sacalin Island over the 1857-1995 period (to day peninsula)

The fundamental changes that took place in Romania after 1989, through the concerted action of several scientific, political and environmental protection forums set up, managed to stop some landscaping works in the Danube Delta and prepare the documentation for its declaration as a Biosphere Reserve, made by *Romanian Government Decision no. 983 of August 1990*, the elaboration and approval by the *Romanian Parliament of Law no. 82/1993* regarding the *Danube Delta Biosphere Reserve*, which established the structure and the way of administration, protection and ecological reconstruction of some damaged areas.

## CONCLUSION

The satellite images processing techniques and GIS can be used for understanding the morphological natural processes. It is also useful in observing and quantifying the disturbance induced by human activity in this processes.

The study of the Danube Delta coast morphology is very important because here are the clean brackish water habitats. This habitat is essential for sturgeons and other endangered species survival. In the young stage these species live and feed here.

Now we have in Romanian Danube Delta Biosphere Reserve only two areas with brackish habitat: between Sacalin peninsula and Danube Delta coast; Musura bay.

Both of them are now in the process of changing their status. The Sacalin peninsula will disappear so the habitat will become a marine one.

Musura bay will be close by the island which is growing fast and become a fresh water habitat

Coast morphology is an important characteristic of deltas. The Danube Delta has a complex pattern of changes in time and space. The fluxes of marine and river branches generate a complex dynamics along the coast. The actual coast is the result of a combination between natural factors and human intervention. If human intervention in the 19th century had a small impact on coast changes, in the late 20th century this impact became very important. Satellite data available from 1975 cover the majority of hydrological works made in the Danube Delta Biosphere Reserve. Using these data, changes in costal morphology patterns were observed in correlation with major hydrological works.

Using remote sensing techniques morphological changes can be analysed at low cost and good accuracy. Analysing the current morphological processes of the Romanian Black Sea it appears that the coastal accumulation zone shows a slow sea level uplift at a rate of ca 2 mm/year; a sharp quantitative decrease of the Danube-derived sediments, deposited at the seaside; the dominance of wave action over current action; man's intervention on the coast by the construction and extension of the Sulina mouth piers.

As regards the Sacalin area, graphs show a change in the patterns of costal morphology. If until 1990, the dominant process was deposition, between 1990-2006 it was erosion. After 2006, deposition processes became again dominant. The lake-forming process, by the merging of the Sacalin Island with the coast, continues even if the island is now a peninsula (split). Morphological changes on the coast seem to indicate the possible location of the future junction. The high rate of morphological changes is related to the meanders cut in the Sfântu Gheorghe Arm, which was finished in 1990.

Therefore coastal abrasion in the studied area is by far more extended (109 km) than accumulation (57 km). Accumulation takes place largely in front of the three main Danube mouths: Chilia, Sulina and Sfântu Gheorghe.

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