The Danube Delta

back to nature through international cooperation

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Summary

Since the half of the XIXth Century, the Danube Delta has suffered significant changes from human interventions. Aiming first to solve navigation problems at the river mouths – and straightening the waterway, humans expanded and intensified their actions which altered the natural state of the delta. Most significant changes were made during the communist times, when the natural status of the delta itself was threatened. The change in the political regime has fortunately reversed the type of human interventions. After establishing the Biosphere Reserve status for the Danube Delta, significant international projects have been run for the restoration of the natural state and equilibrium in the delta area. The delta coast also suffered from intensified erosion phenomena due to human interventions.

New concepts of coastal dynamics, such as coastal sediment circulations cells, increase insight into coastal erosion processes and contribute to finding adaptive solutions.

Large scale international projects have brought best practice knowledge to the assessment of phenomena and ICZM plans for the Danube Delta coast.

The Danube Delta: *extended, natural fresh water wetlands, northern passage to Chilia-Veche. (photo: R.Misdorp)*

1. Introduction

Geography and history of human interventions disturbing the natural equilibrium of the Danube Delta

The Danube River is Europe's second longest river, after the Volga, with a total length of 2857 km. The source of the river lies in the Black Forest (Schwartzwald) Mountains in Germany, and the river flows into the North Western part of the Black Sea through three main channels. The Danube drainage basin covers 15 Central and Eastern European countries and has a total area of 817,000 km^2 (Figure 1). The Danube first divides into two deltaic tributaries: Kilia and Tulcea. The former bifurcates into a series of smaller branches, forming the Kilia Secondary Delta, situated in the Ukraine, whilst the latter splits into the Sulina (middle) and Sf. Gheorghe (southernmost) channels (Panin, 1998, Giosan et al., 1999, Stanica et al., 2007, Stanica & Panin, 2009).
The Delta (Figure2) is flat and low-lying and therefore susceptible to external changes such as human interventions and anticipated impacts of climate change including accelerated sea level rise.

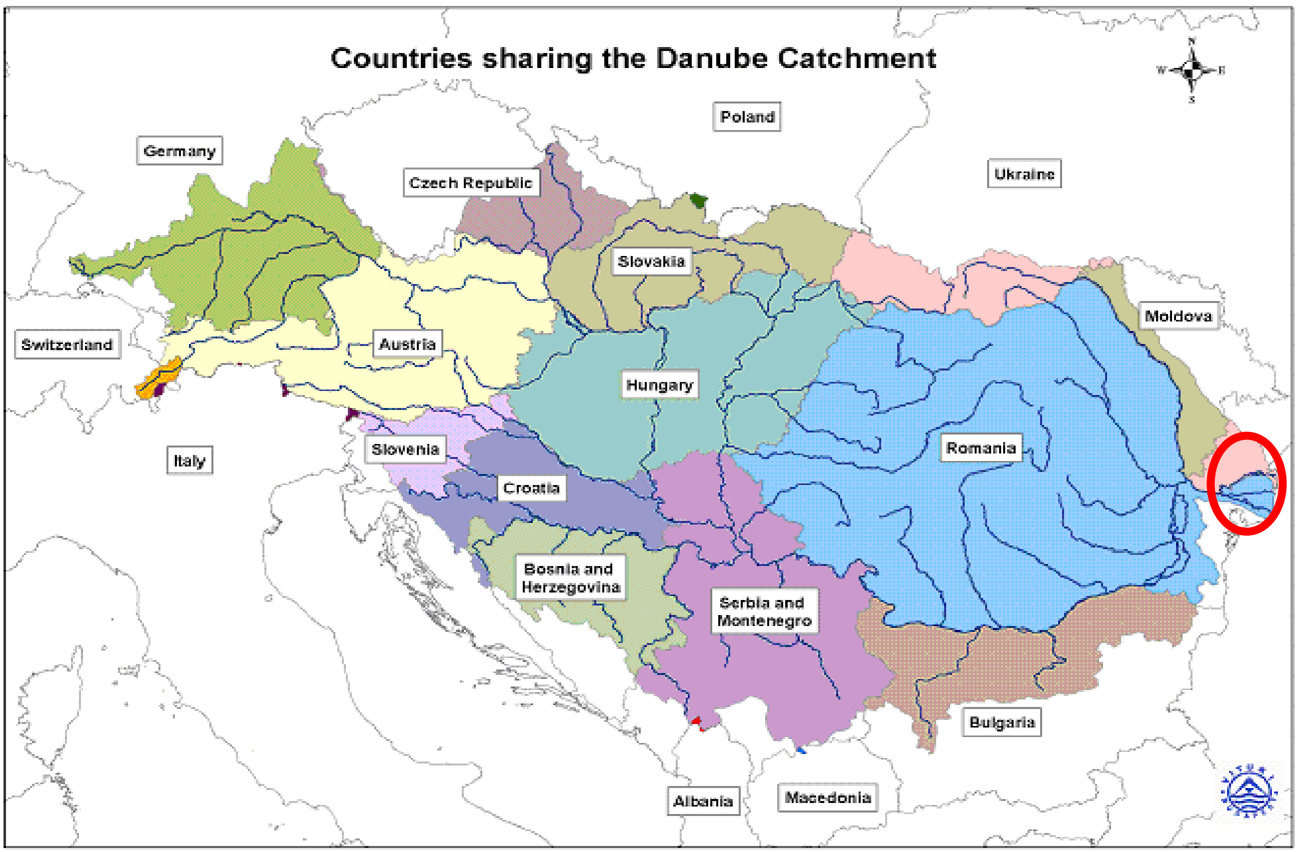
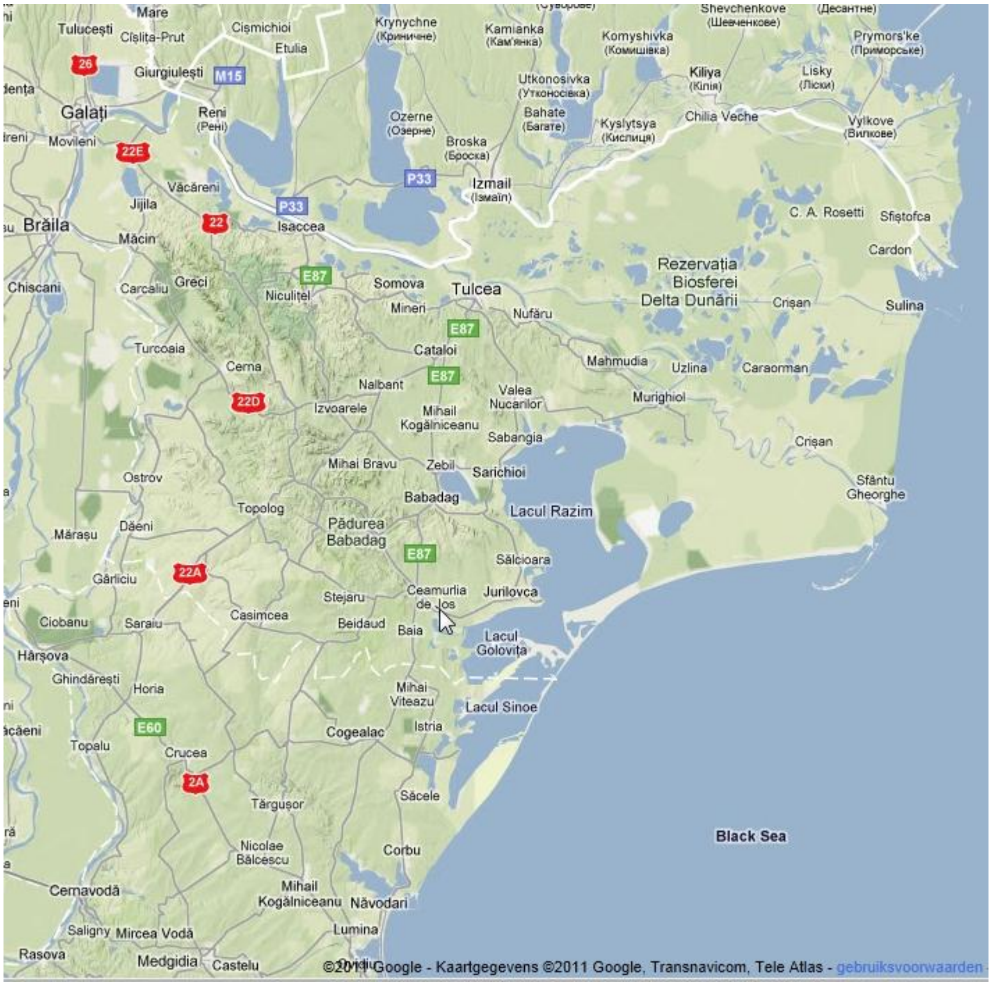


Figure 1. ***The Danube catchment, fifteen riparian countries and its delta*** *(circled in red). (source: Base map from the Hungarian Vituki Institute)*



→ Kilia Sub-Delta

→ Sulina Sub-Delta

→ Sf Gheorghe Sub-Delta

*Figure 2: T**he Danube Delta** displaying the three mouths and related sub-deltas and their channels, lakes and beach ridges. (source: Google Maps: ©2011 Google – Kaartgegevens ©2011Google, Transnavicon, Tele Atlas)*

The Danube Delta is located in the North Western part of the Black Sea. The coastline is about 240 kilometres, of which ca. 160 kilometres lies in Romania.
Under natural conditions, the Danube transported about 70 million tons/year of alluvial material to the delta, filling-up lakes and feeding the coast. The sandy bed load, which is the main source of sediment to the coastal zone is estimated at about 10% of the total alluvial discharge (Panin, 1996).

For more than 150 years, the area has been subjected to considerable human pressure along the upstream segment of the Danube River, in the Delta itself and along the Black Sea coast. There are three main categories of interventions:

Changes in the Danube River water and sediment discharges
The first changes to the natural flow of the Danube River dates back to the second half of the 19th Century. An engineer, Sir Charles Hartley, employed by the European Danube Commission, cut-off the natural meanders of the Sulina channel in order to shorten the distance between the Black Sea and the inland Danube harbours such in Braila and Galati (Figure 2) , thereby modifying water and sediment flux between the Sulina and Sf. Gheorghe tributaries. Furthermore dam constructions, acting as sediment traps, contributed to a 40% decrease in sediment discharge (Lepsi, 1942, Panin, 1976, 1998; Giosan et al., 1997; Ungureanu & Stãnicã, 2000). The most serious, affecting the northern part of the Romanian coastal zone, was the construction two hydroelectric dams Portile de Fier I (in 1970, 943 km from the coast) and Portile de Fier II (in 1983, 864 km from the coast).
During the 1980s, sandy sediments were dredged from the Sulina Free Zone Harbor and disposed on the Sulina Beach, immediately to the south of the jetties (Stanica & Panin, 2009).

Coastal engineering works (Stanica & Panin, 2009)

Two parallel jetties built at the end of the 19th Century at the Sulina mouth facilitated navigation at the entrance of the Sulina Canal. They are now approximately 8 km long due to incremental increases in length during the 20th Century. The jetties strongly influence the local circulation of near shore currents and related sediment transport and interrupt the dominant southward directed longshore sediment drift initiated by the Kilia tributary. This altered nearshore circulation has contributed to the increase of the coastal erosional trends. (Giosan et al., 1997).

Human interventions within the Danube Delta

These can be divided into:

a) The so called "reed period" (1960-1970): changes in the natural circulation pattern by digging canals;,

b) The "fish-period": 1970 – 1980: changes in land uses : creation of large fish ponds;

c) The "agriculture period" (1980 – 1990): transforming wetlands into agricultural polders (more than 35,000 ha).

These changes improved food production, navigation and industrial output, but negatively affected the functioning of the valuable, delta ecosystem through loss of tidal land, pollution and increased coastal erosion.

These interventions together with the ongoing sea level rise of about 3 mm/year (Giosan et al., 1997, Panin, 1999, Stanica & Panin, 2009) increased the rate of coastal erosion.

Furthermore, the construction of sluices which closed the Razelm – Sinoe former coastal lagoon system (Figure 2) changed its character. It transformed the lagoon system into a series of large coastal lakes and surrounding wetlands which salinity changed from brackish to freshwater. The aim of this change was to initiate more productive freshwater fishery and to create a reserve for irrigation water for the neighboring areas from Northern Dobrudja.

Activities in the Black Sea which impacting the natural evolution of the Danube Delta ecosystem are: fishing and the introduction of alien species.

2. Getting back to nature

Beginning international cooperation for nature restoration

In 1989, at the end of the communist period, the Danube Delta as a natural environment was on the verge of destruction because of the activities described above.

A transformation began in 1991, when the Romanian part of the Danube Delta (580,000 ha) became a UNESCO Biosphere Reserve.

This was one of the first and most significant international cooperative approaches to natural resources management, with the Netherlands Ministry of Transport Public Works and Water Management (RIZA/Min.V&W, 2003) assisting in capacity building, planning and organisation, exploration of vegetation and water quality and advising on ecological restoration of the former aquaculture ponds, right from the start (comm. Hans Drost -RIZA/Min.V&W). The World Bank (GEF-grant) and WNF/Auen Institut were also providing assistance during these first years.

The Danube Delta Biosphere Reserve is managed by the Danube Delta Biosphere Reserve Administration (DDBRA), under the authority of the Romanian Ministry for the Environment and Sustainable Development. The DDBRA has built up a large international network of cooperation (see DDBRA website).

Since the beginning, the primary aim is to achieve sustainable development in the area. The first steps comprised the restoration and maintenance of the natural equilibrium of the delta. Using mainly internationally funded projects, the Reserve Administration successfully restored several former agricultural polders to wetlands.

Restoring and sustainably managing the nature conservation values of the nature reserve raised several delicate issues, which can be grouped in two main categories:

- Retaining local communities and maintaining their traditional habits.
- Dealing with changes to the delta habitats and leaving nature to take its course, by mitigating adverse human impacts.

The DDBRA developed using spatial planning as a tool (see Figure 3 – land use map of the DDBRA). The entire area has been divided into three zones: strictly protected areas (50,600 ha) and areas of traditional, economic use (306,100 ha), which are separated by buffer zones (223,300 ha).

While access in the first category is strictly controlled, the areas of economic use have been regulated in plans, which establish a series of traditional activities (such as fishing and reed harvesting) with well established maximum quotas.

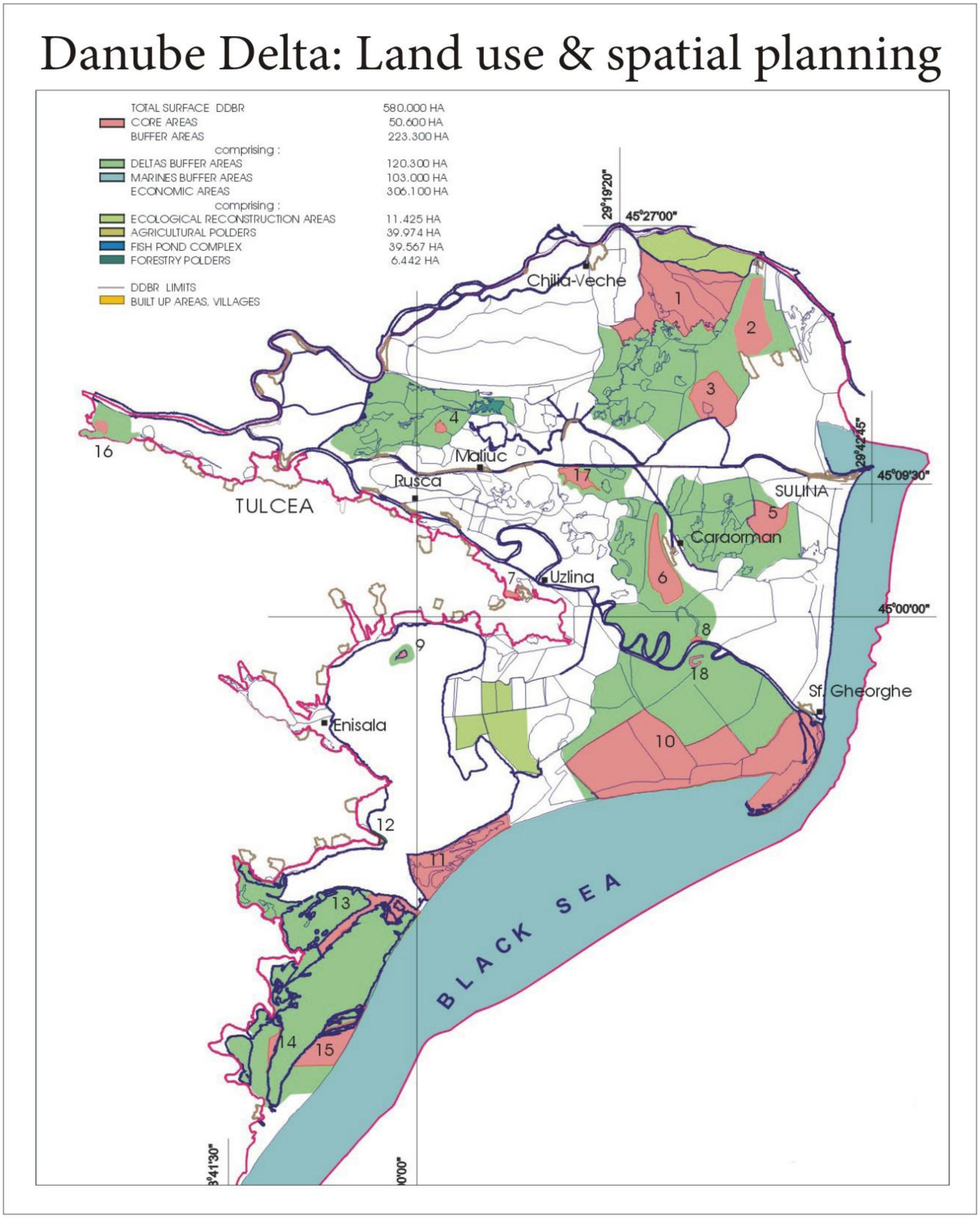


*Figure 3: **Land use map and spatial planning of the Danube Delta** Biosphere Reserve (580,000 ha), delimited by the red line. Pink/red – strictly protected areas (nature sanctuaries). Green – buffer zones. White – traditional economic use areas (for fisheries, reed harvesting, ecological tourism. Light green – areas in need of ecological reconstruction. The marine part of the Danube Delta coast is also recognised a buffer zone. (source: Danube Delta Biosphere Reserve Administration: www.ddbra.ro)*

3. Back to the coast

The Danube Delta coast – international cooperation for ICZM and spatial planning

Why are these natural resource management activities so important to the ICZM plans for the Danube Delta coast? There are several reasons:

- The large Danube Delta contains valuable wetlands, which have a vital influence on the Black Sea.
- Human pressures affect the entire Danube Delta, but are particularly important on the coast.
- The measures developed and implemented by the DDBRA also apply most significantly to the coast.

The implementation of ICZM in a particular area requires a vision for that area.

Does a vision for the Danube Delta coast exist? The answer is Yes – even though this has not yet been officially approved by the Romanian Parliament. This vision – in the form of an outline ICZM Strategy for the entire Romanian coast is one of the deliverables of a Dutch Government (MATO) funded project, executed by the Romanian Ministry of Environment and Sustainable Development and assisted by Royal Dutch Haskoning and EUCC (see CCC I-3-1). In the mean time a draft ICZM Strategy is made and stakeholders are being consulted.

What is the vision for the Delta – or what should the Danube Delta coast look like in the year 2025?
In brief - by 2025 the Danube Delta coast should be less polluted while natural coastal dynamics restored. Maintaining natural diversity should go hand in hand with promoting traditional activities by local communities that are sustainable both for the Danube Delta ecosystems and in providing good living standards. This includes eco-tourism, which has strongly increased over the last two decades.
If this is the vision for the Danube Delta coast – how can we achieve it?

The ICZM plans for the Danube Delta coast (still in progress) include the typical spatial planning of the DDBR territory, with the strictly protected areas and areas of economic use – separated by buffer zones.
Eco-tourism and some traditional activities are encouraged, by the provision of European Commission funds.

These EC structural funds are made available for the development of infrastructure for coastal settlements within the Danube Delta. Although the Danube Delta coast is sparsely populated, it must also be managed in a sustainable way. The settlements need urgent modernisation of their infrastructure (e.g. at Sulina see Coman et al., 2007). This needs to focus on combating poverty and covers a wide spectrum of restoration activities: renovation of 19th century residences and boulevards, improving sewage systems and introducing home sanitation units, generating electricity from solar energy, using solar desalination of sea water for drinking water (see also CCC III-3-3-5 & 6), repairing fishery and yachting harbours and wharfs, reintroducing controlled coastal fisheries and promoting dedicated coastal ecotourism. These activities will be evaluated by monitoring the natural coastal and socio-economic system before, during and after the rehabilitation of the Sulina coastal area. In this way, the city of Sulina could again become a gateway of Europe.

An important driving force for improving water networks is the European Water Framework Directive (60/2000) which seeks to improve water quality both in the freshwater areas and along the Black Sea coast.

4. Danube Delta coast shoreline erosion management

International cooperation for integrated planning and sustainable coastal development

The long term, natural evolution of the Danube Delta is characterised by a general growth during the Holocene and by regular shifts in activity of the main river channels. These shifts subsequently caused alternating natural phenomena of accretion and erosion of the various stretches of the Danube Delta coast (Panin, 1996, 1998, 1999).
During the last century however, coastal erosion has become a dominant, man induced and critical feature along large parts of the Danube Delta coast.

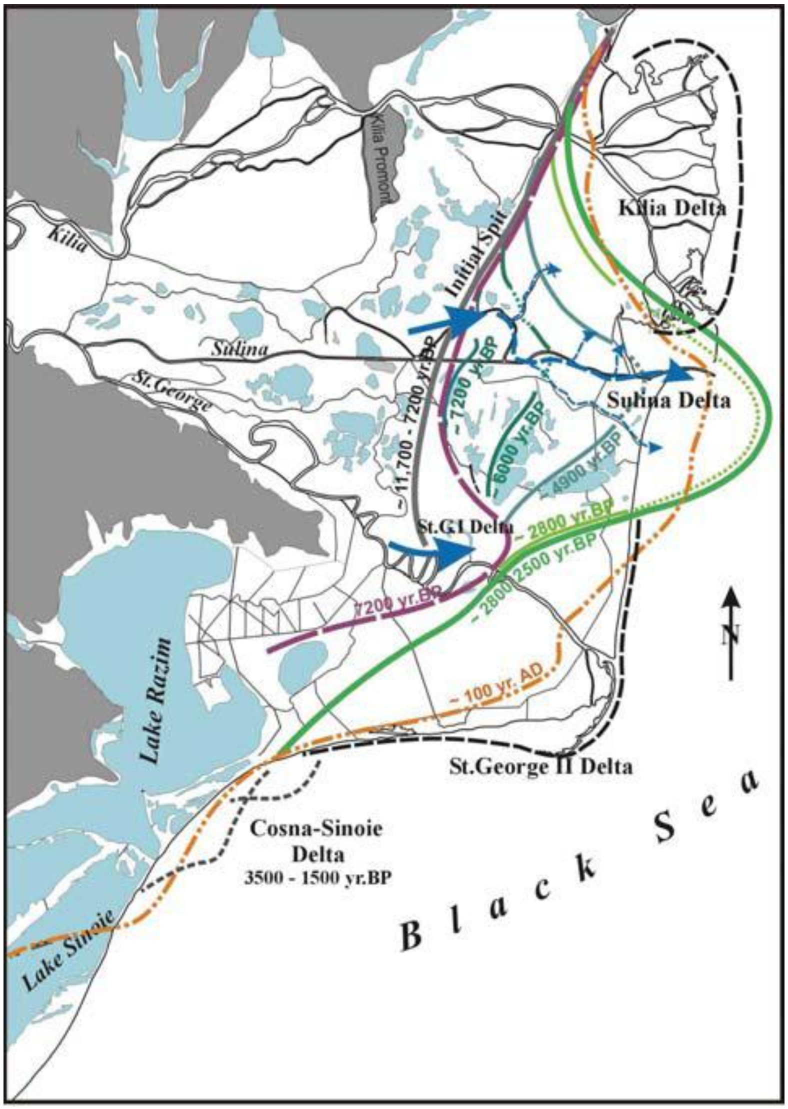


Figure 4: ***Long-term evolution of the Danube Delta.*** *(source: Panin, 1997)*
Legend:

1: Initial Spit 11,700-7,500 years.Before Present (BP)	:	*(grey line)*
2: St. George I Delta 9,000 -7,200 years.BP	:	*(purple line)*
3: Sulina Delta 7,200 -2,000 years BP	:	*(green lines)*
4: Coastline position at ~ 1,900 year BP (100 years AD	:	*(brown line)*
5: St.George II Delta and Kilia Delta 2,800 years.BP – Present	:	*(black hatch line)*
6: Cosna-Sinoie Delta 3,500 -1,500 years.BP.	:	*(black dotted line)*

Human interventions described above, abruptly changed the natural coastal evolution trends (Figure 4). This resulted in an average rate of shoreline retreat of 3.7 m/year, a loss of about 45 ha/year from the delta The maximum rate erosion of almost 25 m/year is recorded on Sahalin Island, see Figure 7 (Gastescu & Oltean, 1997, Panin, 1999, Vespremeanu-Stroe et al., 2007, Stanica & Panin, 2009).

The Danube Delta coast can be divided into two major sediment circulation cells (Figure 5), each with its specific characteristics.

The EC FP5 (5th Framework Programme) funded project EUROSION 2000 – 2004 (www.eurosion.eu), led by Dutch Min. V&W (RIKZ), and the EC – funded FP6 (6th Framework Programme) Project CONSCIENCE – Concepts and Science for Coastal Erosion Management, led by the Dutch Institute Deltares (2007 to 2010; www.conscience-eu.net) introduced the following key concepts:

- Dividing the coast into sediment cells;
- Recognising the value of coastal resilience;
- Identifying strategic sediment reservoirs.

The Danube Delta northern sedimentary cell, described above is one of the pilot sites for testing the CONSCIENCE key concepts concerned with controlling erosion by managing sediment movement.

The solutions from CONSCIENCE will be integrated and elaborated by the USA Government funded project COASTEROSION, into an ICZM strategy for the entire Danube Delta coast.

Figure 5: ***Two coastal sedimentary cells,***

1. *In yellow: the northern cell) along the Danube Delta coast between Sulina and Cape Media and*
2. *In orange: the southern cell;*

The concept of sedimentary cells contributes to searching for adaptive solutions - EU projects: EUROSION and CONSCIENCE. (source: Ministry of the Environment and Forest).

The Sulina – Sf. Gheorghe sediment circulation cell has a total length of the coast of about 60 kilometres. The general water circulation here, as in the entire NW part of the Black Sea, is North – South oriented. The Sulina navigation jetties induce an abrupt change reversing the near coast circulation, south of these obstacles, to a clockwise south to north direction.
The erosion rates here are greater than the natural trends.

Sahalin Island, the southern boundary of the Sulina – Sf. Gheorghe coastal cell, is a lateral curved bar, situated near front of the river mouth. The island is continuously shifting to the south east direction. The entire bar system is at the same time however migrating shorewards by overwashing and is thus retreating (Figure 6) due to reduced sediment supply.

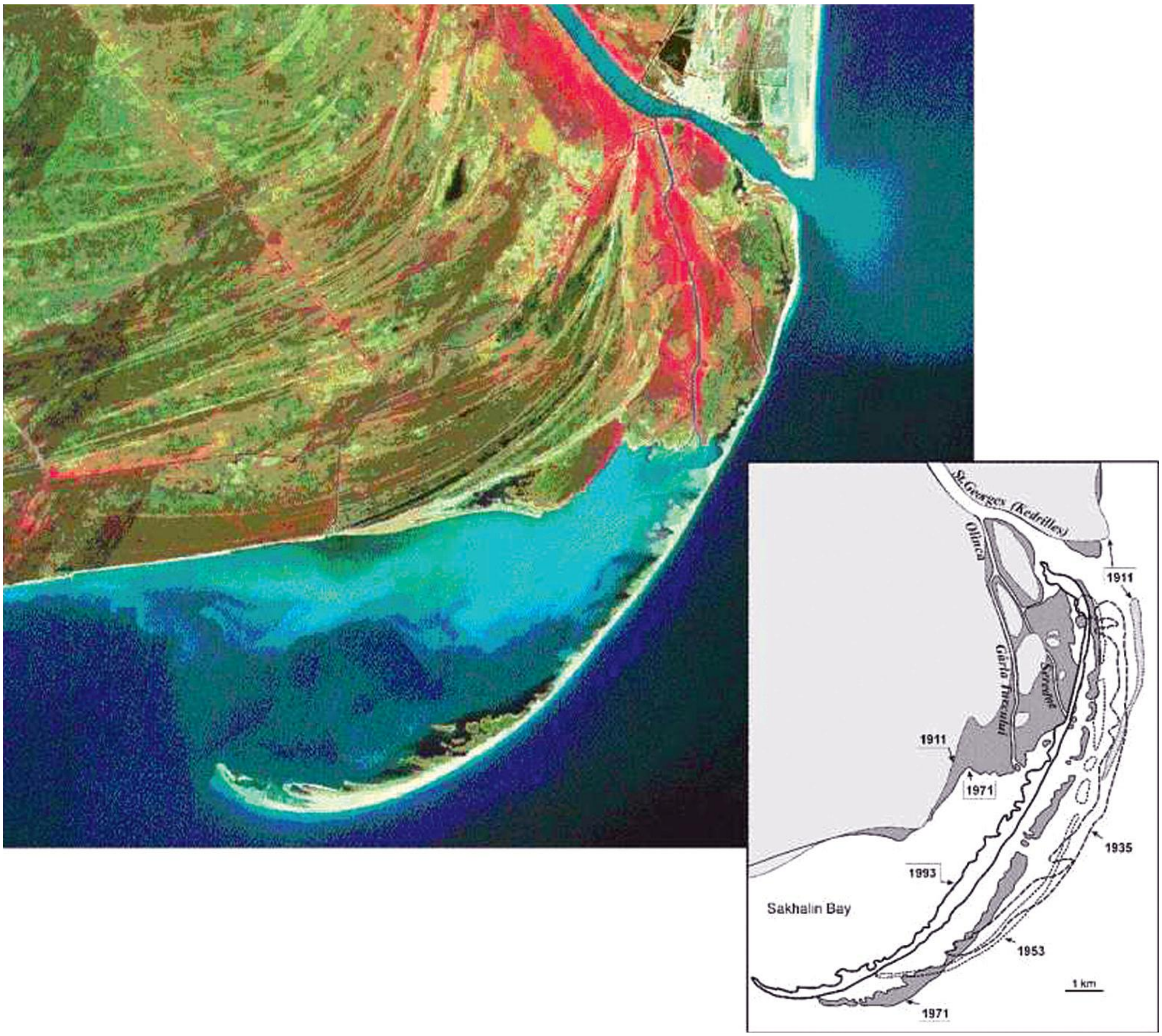


*Figure 6: **Sahalin spit island evolution** near St Gheorghe, during the period 1911-1993. The 13 km long spit is gradually enlarging towards the south west, but the entire system moves landward and is retreating. (source : Giosan et al., 1997 and Giosan in Jugaru et al., 2006, satellite photo: © Landsat 2000)*

The southern sediment circulation cell is about 100 kilometres long. The complex shoreline dynamics include sections with intense erosion, whilst others are stable or even advancing. Change in coastline orientation influences the circulation patterns. At Cape Midia, the Midia Harbour northern jetty, projecting 5 km offshore, effectively blocks all sediment transported by littoral drift.

Studies comparing annual erosion rates in both sedimentary cells show that shoreline retreat from the 1960s – 1980s was greater than in the next two decades (1990s-2000s). This change in erosion rate may be connected to the North Atlantic Oscillation (Vespremeanu-Stroe et al. (2007), although it was during the 1970s and 1980s that the big dam constructions had strong, initial impacts on the Danube River & Delta system. These dam constructions contribute to significant reductions in sediment supply to the Delta and its coast (Panin & Jipa, 1998, Ungureanu & Stanica, 2000).
Although erosion rates have adjusted and slowed during the last decades, erosion due to human activity is still ongoing, opposite to a growing delta under natural conditions.

The large erosion in the Danube Delta southern coastal cell is also strongly influenced by the human activities in the Danube river. Local intervention however, such as blocking the outlet of the former coastal lagoons of Razelm and Sinoe (for location see Figure 2) contribute to the high erosion rates observed.

An important decision must be taken here, whether to protect the beach or re-open the lagoon. A decision will be taken only after modelling shows what the different effects will be. The US funded COASTEROSION project is currently trying to find a solution within the Romanian ICZM framework, but it will be some time before a final decision is made.

Analysing the causes of coastal erosion contribute to sustainable solutions by choosing the economic and environmentally effective coastal measures. Soft coast protection measures such as sand nourishment can help control coastal erosion in a sustainable and resilient way (see CCC I-2-1 and I-2-5. the Netherlands).

5. Conclusions

Until the end of the Romanian communist regime in 1989, the Danube Delta was subject to damaging human activities. Two years later, the Delta became a Biosphere Reserve and restoration of the natural environment turned into a long term goal. Activities associated with this have been undertaken in cooperation with international institutes and organisation concerned with wetlands and coastal research, management and administration.
The Danube Delta coast has received international funding and expert assistance (Dutch, EU and USA) for projects dealing with critical issues such as coastal erosion. New comprehensive and integrated plans include the restoration of human coastal settlements, which will help fight poverty, create employment and sustainably develop coastal resources.
These ICZM efforts are being executed through national and international supported projects aiming to provide sustainable and long term solutions along the Danube Delta coast.

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