THE ECOSYSTEMS OF THE DANUBE DELTA BIOSPHERE RESERV STATE-OF-THE-ART

P. GÂȘTESCU[1]

Abstract. The Ecosystems of the Danube Delta Biosphere Reserve state-of-the-art. Taking into account the morphologic-hydrographic configuration of natural ecosystems or ecosystems partly modified by man the area, its flora and fauna communities and the long-term human impact, the two main categories of Danube Delta ecosystems associated with Razim-Sinoie lake complex, coastal marine waters and the Danube flood plain between Isaccea and Tulcea, as part of Danube Delta Biosphere Reserve, have been delimited: natural ecosystems or ecosystems partly modified by man; anthropic ecosystems. To identify and characterize ecosystems, there have been analysed the data on hydrography, morphology, biodiversity, human settlements, types of land use, spatial changes through the construction of agricultural, fisheries, forestry polders, modification of the network of channels and canals with consequences on the water circulation system inside the delta. The first category, of natural and partly modified by man ecosystems comprises 23 types (water bodies: running waters-Danube and its main branches, channels and canals; standing freshwater-lakes; standing brackish and salt waters-coastal lagoons, coastal, marine zones; wetlands: water fringe vegetation-flooded reed beds, floating reed beds <plaur>, riparian willow formations, frequently flooded river levees; forests, shrubs and herbaceous vegetation: temperate riverine forests-mixed oak woods, shrubs and herbaceous vegetation, steppe meadows, meadows on low marine levees; dunes, beaches).The second category, of anthropic ecosystems includes 7 types (agricultural lands, forest areas-plantation on the river banks, fish farms, settlements-villages, towns). With the establishment of the Danube Delta Biosphere Reserve in 1990, with the statutory provisions on the protection and conservation of biodiversity, the deltaic landscape, some of the previous pressures were reduced, but the pollution of the Danube waters less consolidated beaches (Sulina, Sfântu Gheorghe, Chituc) and related with touristic activities, on ecosystems as a whole. The tourism activities also must represent not only a positive and dynamic development factor but also a practical solution to keeping the environment unaltered. These aspects were mentioned in the characterization of the ecosystems presented in this article.

Keywords: Danube Delta, natural, modified ecosystems, anthropic ecosystems.

[1] gastescu_petre@yahoo.com, Geography Institute of Romanian Academy.

I. GENERAL CONSIDERATIONS

The differentiation of the deltaic space from the ***Danube River*** to the ***seashore of the Black Sea,*** and from the main branches of the inside Delta area, which developed on sandbanks, lakes, streams, wetlands, and the ecosystems are the result of the evolution in time. Because all the deltaic ecosystems are closely interacting, the entire biotic gear of the Danube Delta can be considered a ***system***, a super-***ecosystemic*** organization level of the matter.

The caloric energy has the highest value (135.86 kcal/cm²/year) comparing to other regions of the Romanian territory. At this value the global caloric energy arrived on the delta surface in one year is 4,508.1 x 10^{12} kcal, from which 53.2% is consumed by evaporation and evapo-perspiration (2,396.2 x 10^{12} kcal), 16.5% is reflected (744.2 x 10^{12} kcal) and only 30.3% (1,367.8 x 10^{12} kcal) is retained and conveyed into system during the biological processes.

The amount of water transported by Danube is 204.5 km³/year at Ceatalul Chiliei (according to the average multi-annual flow of 6,495 m³/s), plus 69.7 mil. tons/year of dissolved salts, 53,0 mil. tons of alluvia, and 2,576.1 x 10^{12} kcal heat energy (at an average annual temperature of 12.6ºC).

Only a small part (about 5-7%) of these quantities of substance and energy can pass from branches through the stream and canal system into the lacustrine and wetlands areas inside the delta. Thus, in natural and non-dammed conditions, at the hydrograde 9 in the delta there can be accumulated 5.8 km³, representing 2.8% of the water volume conveyed on the Danube branches.

The polders and dammed settlements are out of the flood effect (about 1,000 km², which is 30% of the delta surface), the volume which can be possibly accumulated in the areal left in natural regime could be 3.3 km³ of water, representing 1.6% of the entire Danube water flow.

The amount of dissolved salts, the alluvia volume in suspension and the total quantity of caloric energy should also be taken into consideration. Those quantities of substances and energy constitute the material basis in the delta system, differentiated in numerous biotopes and biocoennosis, in one word – ecosystems.

The Danube flowing regime presents high waters in spring and at the beginning of winter and with small waters in summer – autumn period. This water flow pattern determines some of the specific features of the ecosystem abiotic fund by some particularities, as follows:

- the flooding process produces the renewal of the entire water volume and, at the same time, the withdrawal of important quantities of nitrogen, phosphor and sulphuretted hydrogen, that contribute to water eutrophication and the deposition of suspended load;

- depending on the duration of the flooding period, temporary changes of terrestrial and paludous biotops into lacustrian biotops occur, and finally, the change of the organizing way of biocoenosis.

As result of these changes, the flooded terrestrial and palustrine ecosystems take over the primary production function of the lacustrine ecosystems. Then, after the water withdrawal, the secondary production of the terrestrial and palustrine ecosystems depends on the primary and secondary production in the flooding period. This characteristic of function taking over within ecosystems during floods is a basic characteristic of the deltaic system, called completeness.

It is certain that these interrelations between ecosystems during floods influence less the areas of the Letea and Caraorman sandbanks, situated at altitudes higher than 4-5 m, compared to the sea level, or the Chilia field in the north part. Floods do not influence the dammed precincts either, though some influence could occur by means of the phreatic waters.

Regarding the human settlements in the delta, which are ***anthropic ecosystems*** like the ***arranged precincts (farming, pisciculture, forestry***), they are integrated, being adapted to the major manifestation phases of the Danube River and to the specific character of the deltaic system. In view of it, we can point out the following aspects:

- the settlements have a lengthened morphological structure on the fluvial sandbanks (Crișan, Gorgova, Partizan) and concentrated one on occur along river banks (C. A. Rosetti, Letea);

- the traditional basic occupation of the active population is fishing, associated with farming on small plots, with limited cultures during the period between flood phases;

- the connection between different places, and also the travel to and from work are made on water, on the main Danube branches, on streams and canals, and on lakes.

Taking into account the morpho-hydrographic configuration, the floristic and faunistic associations, the impact of the anthropic activity in the course of time, in the Danube Delta, the Razim-Sinoie lacustrine area and the Danube meadow between Isaccea and Tulcea, as component parts of the ***Danube Delta Biosphere Reserve (DDBR), two big categories of ecosystems*** have been delimited on the 1:50,000 map, as follows: ***natural ecosystems or partly modified by man, and anthropic ecosystems.***

The first category includes 23 ecosystems, beginning with the Danube branches and ending with the less consolidated seashore beaches.

The second category contains 7 types of ecosystems: arrangement types (farming, pisciculture and forestry), complex arrangements, isolated farming

cultures which are little extended, poplar plantations on the fluvial sandbanks, human settlements (urban and rural).

Canals hold a special position, actually being created by man, and, therefore, they should belong to the anthropic ecosystems. However, because they are integrated in the sub-system of the hydrographic network, they have abiotic and biotic characteristics (similar to those of streams and natural oxbows) decided to list them into the first ecosystem category.

A number of 314 areas fall into 30 types of ecosystems, marked out on the ***Map Ecosystems of Romanian Danube Delta Biosphere Reserve***. A brief characterisation of these types with emphasis on major abiotic (biotopes) and biotic (biocoenosis) particularities is given in the following chapters (Fig. 1).

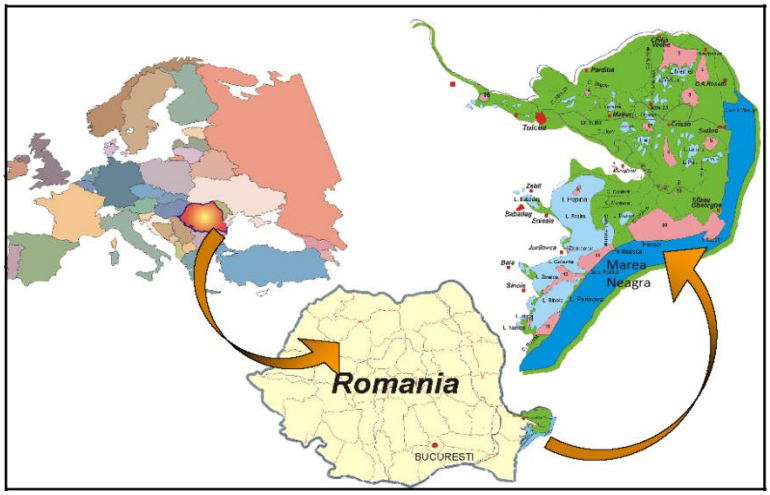

Fig.1. The position of the Danube Delta Biosphere Reserve

Among the main objectives of the Danube Delta Biosphere Reserve (DDBR) since its establishment in 1990 was the development of a monographic paper and thematic maps especially for vegetation, soils and ecosystems.

To identify and characterize ecosystems, have been analysed the data on hydrography, morphology, biodiversity, human settlements, types of land use, spatial changes through the construction of agricultural, fisheries, forestry polders, modification of the network of channels and canals with consequences on the water circulation system inside the delta.

The team of researchers who participated in the elaboration of the map of deltaic ecosystems consisted of Petre Gâștescu, Institute of Geography, of the Romanian Academy; Mircea Oltean, Institute of Biology of the Romanian Academy; Iulian in those fields. The ecosystem map was printed at the Institute

for Inland Water Management and Waste Water Treatment (RIZA), The Netherlands (Ecosystems map in the Romanian Danube Delta Biosphere Reserve, scale 1:175,000, 1998).

The Danube Delta Biosphere Reserve contains a greater range of habitat types, lower and higher plants, invertebrates and vertebrates. Many of the species that live within the delta are unique, including plants and animals. The floristic and faunistic inventory will enriched ongoing research developed by some profile programmes. So far now have been inventoried 2,380 flora species and 4,030 fauna species, of which around 2,260 insect species, 84 molluscs species, 135 fish species, 11 reptiles species, 8 frog species, 331 bird species, (10 species monuments of nature and 224 species protected under the Berna Convention) and 44 mammalian species (Fig. 2).

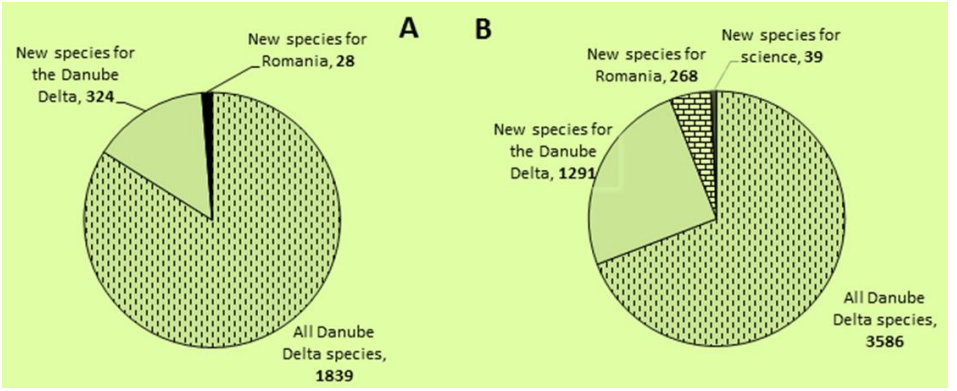

Fig. 2. Flora (A) and fauna (B) species inventoried in Danube Delta Biosphere Reserve

Obviously, in the period that followed, after 1990 through the statute of the Danube Delta Biosphere Reserve, within the extended limits (5800 km²) which included, in addition to the deltaic area itself, the Razim-Sinoie lake complex and the adjacent coastal marine waters up to -20 m isobat, were carried out different activities, according to three categories, namely of areas with integral protection protected) in an area of 506 km², buffer zones - 2233 km², and transition zones (economic) - 3061 km² (Fig. 3).

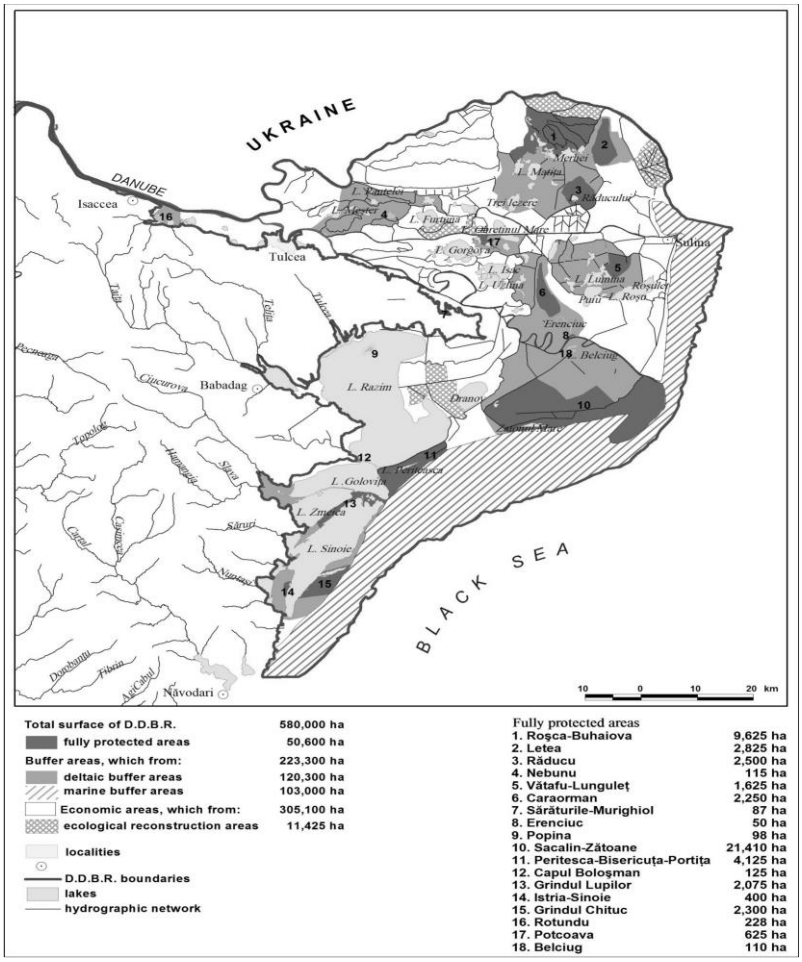

Fig.3. The structure of the Danube Delta Biosphere Reserve

II. NATURAL ECOSYSTEMS OR PARTIALLY MAN-MODIFIED

2.1. Running waters

The Danube and its main arms. In this type of ecosystem we include the 3 main arms (Chilia, Tulcea-Sulina and Sfântu Gheorghe), to which are added the secondary arms of Chilia (Tătaru, Cernovca, Babina and Musura), and Sfântu Gheorghe). These represent the main hydrographic arteries through which the waters of the Danube River from Ceatalul Chiliei are distributed. A series of hydrological parameters, such as flow rate (0.3 - 0.5 m/s in low water and 0.6 - 1.2 m/s in high water), turbidity given by suspended alluvium (approx. 290

gr/m3), uniformity of dissolved oxygen distribution (10 - 11 mg/l), mineralization (about 340 mg/l), hydro chemical type (calcium bicarbonate), are good conditions for the development of primary producers (plankton consisting of phyto- and zooplankton) which serve as food for many animals such as worms, molluscs, larvae, ephemeris, sponges, bryozoans, coelenterates and even fish, all representing the first link in the food chain. The dominant and permanent group of phytoplankton is composed of diatoms, followed by chlorophytes and then cyanophyceae. The most common of the diatoms are: Melosira granulata, M. granulata var. angustissima, Cyclotela meneghiniana, Stephanodiscus hantzschii, S. astrea, Fragilaria crotonensis, Asterionella sp., Tabellaria fenestrata, T. fenestrata var. asterionelloides, Synedra acus., S. acus var. angustissima, S. ulna etc. Among the most common chlorophytes are: Scenedesmus quadricauda, S. obliguua, Pediastrum duplex and Actinastrum hantzschii, and among the most common cyanophyceae are: Anabaena spiroides and Oscillatoria agardhii.

The maximum development of phytoplankton is registered in summer and autumn months due to the hydrological factors, such as: the decrease of the water current speed, the low turbidity, the decrease of the water level and, therefore, the delta waters' contribution. The large number of phytoplankton species is due to the mass development of the Metozira diatom. Regarding the quantitative distribution at the shore and in the water's middle section, the large number of phytoplankton species is observed with small exceptions, at the shores, due to the weaker water current.

The ichthyofauna dominates this ecosystem and is represented by carp (Cyprinus carpio), pikeperch (Lucioperca sandra), catfish (Silurus glanis), asp (Aspius rapax), moray eel (Vimba vimba carinata), oblet seedlings and adults (Alburnus alburnus, Chalc danubicus), swordfish (Pelecus cultratus), freshwater sturgeon - starlet (Acipenser ruthenus), bastard sturgeon (Acipenser nudivendtris), Danube mackerel (Alosa pontica), migratory sea sturgeons – mullet (Huso huso), sturgeon (Acipenser güldenstaedti), trout (Acipenser stellatus). This ichthyological picture changes depending on the change in the degree of water quality.

On the main arteries, for the distribution of water flows, especially on the Sulina and Sfântu Gheorghe arms, there were some changes of the abandoned meanders as a result of the rectification of the minor riverbed, the first on Sulina from 83.4 to 62.6 km to build the navigable marine artery – Sulina Canal, completed in 1902, and on Sfântu Gheorghe between 1985-1990, five meanders shortening the artery from 108.2 to 69.7 km (fig.4).

Channels and canals with active water circulation. This ecosystem is represented by abandoned arms of the Danube such as the Old Danube, on Sulina arm and those on Sfântu Gheorghe arm, some important canals such as Mila 35, Sireasa – Şontea, Crânjeală, Eracle, Căzănel, Bogdaproste, Litcov, Crişan - Caraorman, Dunavăţ, Dranov and others.

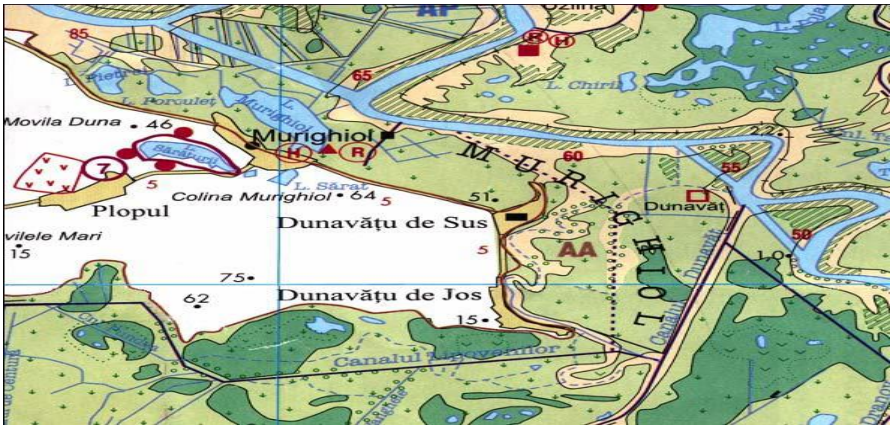

Fig. 4. Sfântu Gheorghe arm-five meanders cuted

These canals, as important connecting arteries between the main arms and the lake complexes, present a variable speed and reversible flow directions compared to the hydrological regime phase (high spring waters, small summer – autumn waters), decreasing inwards turbidity of the arms. Turbidity gradually decreases from detachment from the arms of the Danube to the interior of the delta, due to the settling (deposition) of alluvium.

As for the chemistry (mineralization), it also changes gradually through an enrichment in salts, as a result of the intensification of the evaporation process as the speed decreases and the water temperature increases. As for phyto- and zooplankton, it has a fluvial character during high waters, after which it acquires the features of semi-stagnant waters with the presence of lake forms. In terms of quantity, the plankton of this ecosystem is higher than in the waters of the Danube.

A more stable character are the epibionts that live here, such as: freshwater sponges (Ephydatia fluviatilis, Spongilla lacustris, Trochospongilla horridaceus), hydrozoans (Hydra and Cordylophora) and Dreissena lamellibranch. At the edge of canals and ravines, where the water flow and the alluvial substances are lower, hard flora biocenoses develop, consisting mainly of reeds (Phragmites australis), accompanied by rushes (Typha latifolia, Typha angustifolia) and some species of sedge (Carex dioica, C. stricta).

Among the fish species, apart from the species mentioned in the arms of the Danube, predators such as pike (Esox lucius), and perch (Perca fluviatilis) develop.

Channels and canals in natural areas with free regime circulation. This ecosystem, which represents an atrophy of rheophilic conditions and an accentuation of the slow ones, is well marked in the Danube Delta. Among these gorges and canals, we mention: Arhipenco - Păpădia, Stipoc - Pardina, Dovnica, Magearu, Sulimanca, Perivolovca, Imputita (blocked since 1990 by

the construction of the Sulina-Sfântu Gheorghe coastal dike), Sonda Canal, Puiu-Erenciuc, Ivancea, C Tărâța – Belciug, Lejai, Palade, Buhaz – Zăton etc. Many these canals were modified until their disappearance as a result of the production of the agricultural arrangements, the largest being Pardina of 27,000 ha (fig.4a, fig.4b).

Fig.4a. Canal with free circulation of water

Fig.4b.Channel without change of water

The water circulation is much lower, their function being, for the most part, reversible, the turbidity low due to the greater distance from the arms of the Danube. As the water circulation decreases, especially during low waters, these gorges and canals are largely covered by floating vegetation, which also causes a high degree of organic matter decomposition and therefore become harmful to those biocenoses.

Here species of floating vegetation develop, such as: pond thistle (Trapa natans); submerged vegetation, such as: Potamogeton crispus, Potamogeton perfoliatus, dill or fennel pondweed (Potamogeton pectinatus), watermilfoil (Myriophyllum sp.), Ceratophyllum sp., Elodea canadensis, etc. The ichthyofauna preserves the common features of both the canals and ravines with active water circulation, and of the lake complexes (perhaps even more by the latter).

2.2. Standing freshwater

Lakes with a large surface area/or active change of waters. This category includes the most important lakes and lake complexes in the Danube Delta, such as: Furtuna, Matiţa, Babina, Trei Iezere, Căzănel, Bogdaproste, Obretin, Gorgova, Isac, Puiu, Lumina, Roşu, Roşuleț, Razim, Zmeica etc. It is known that the morphohydrographic features of the Danube Delt differ from lakes from those of lakes based in river floodplains. The shore of the delta lakes are not morphological, they consist of red belt.Morphological depressions are much larger and within them

are several lakes that associate in complexes. Apart from the direct connection through gorges and canals, the lakes in these depressions communicate through the vegetation mass and under the plaur, even in the phase of the small summer-autumn waters. The depth varies depending on the level on the main arms.Thus, during the high spring waters, the depth is 2-3 m in the lake complexes in the river-marine delta (Iacob, Lumina, Roşu, Roşuleț, Puiu lakes) and 3-4 m in the river (Furtuna, Băclănești, Furtuna, Babina, Matița, Trei Iezere, Bogdaproste, Gorgova, Isacea).

During the small summer-autumn waters, the depth is reduced by 1 m in the fluvial-marine delta and by 1.5 - 2 m in the fluvial delta. The degree of transparency is also depending on the phase of hydrological regime on the arms because during the floods when waters with turbidity of 250 - 359 gr/m3 enter, its value decreases to 0.3 - 0.5 m, and in the autumn-winter waters increases reaching the bottom of the lakes when the suspensions more of an organic nature (detritus lifted from the bottom by the agitation of the water) are insignificant (15 - 20 mg/l). The reduction in transparency is also due to the explosive development of phytoplankton.

The change in transparency and affected water colour, depending on the direction of water flow has led yellow water, when there is a penetration of cloudy water from the arms into lakes, and black water, when the water is clean, but which reflects the water colourvegetation submerged by green-brown, they flow from the lake complexes to the collecting network.

Hydro-chemically, these ecosystems differ from those of running water by the fact that the total mineralization is slightly higher (300 - 500 mg/l), due to the accumulation of nitrogen and phosphorus nutrients, both from the washing of chemical fertilizers in the Danube basin, as well as from the fish pools arranged in the delta. The increase is also due to chlorine and sulphate compounds that come from the wastewater discharged into the Danube (mineralization on the river has increased from 292 mg/l in 1946 to 400 mg/l in recent years). Dissolved oxygen, another important parameter of the abiotic support in the ecosystem, varies in very large limits both during the year and from one lake basin to another, reflecting the level of activity of producers (phytoplankton, macrophytes), the intensity of the decomposition processes of organic matter and the degree of agitation of the water mass by the wind. Due to these various conditions, dissolved oxygen can be supersaturated (usually in summer) or deficient (all summer), on the same lake and even on the same vertical (measuring station). At the contact between the water mass and the detritus on the bottom (lake sediment), oxygen deficits are registered, as a result of the oxidation process (mineralization), and at the surface, where the water flowering process is highlighted, the dissolved oxygen is supersaturated due to the intensity of photosynthesis.

The phytocenoses of these ecosystems are represented, first of all, by phytoplankton from which have been identified so far as 300 species of algae

belonging to the groups of diatoms, chlorophylls (green algae), cyanophyceae (blue algae), euglenophytes, dinoflagellates, chrysophytes, by submerged vegetation so-called „soft flora", such as bark, fir, pasha or floating pondweed, „moţ", dill, „sârmuliţa" or „vâjoaica" (eel grass) (Vallisneria spiralis), spiny naiad (Najas major), Canadian waterweed, which is formed under normal abiotic conditions in green, a tangle in which animal species develop. At the lake surface, usually at the edge, where there are shelter conditions from the wind, where the water current and the boat traffic is missing, floating vegetation develops, fixed to the bottom, which through some species, creates the characteristic delta landscapes.

The zoocenoses are representative of zooplankton, which uses as food source (energy) smaller algae, bacteria and various organic particles, appreciated in about 80 species belonging mainly to rotifers, crustaceans (cladocers and copepods), testes, cilia etc.; phytophilic fauna that feeds on submerged, floating and epiphytic vegetation consisting of worms (oligochaetes, hirudines), molluscs (bivalves, gastropods), crustaceans (gamarids, corophids), insect larvae (chironomids, trichoptera); benthic fauna (bottom) that feeds on organic substances accumulated in the surface of lake sediments (detritus) of which more common are worms (about 6 species of oligochaetes), larvae of chironomid insects (about 12 species), bivalve molluscs etc.

Ichthyofauna is represented by species that also live in the ecosystem of running waters, such as carp, willow, pike, zope, perch, catfish, to which is added flax (Tinca tinca), bream (Abramis brama), common rud (Scardinius erytrophthalmus), crucian carp (Carassius auratus gibelio), white bream (Blicca bjoerkna), roach (Rutilus rutilus sp. carpathorossicus) and others.

In this ecosystem, too, there have been many changes in the relationship between species as a result of the increase over normal limits of nutrients ad the process of eutrophication ("water flowering"). Thus, carp and pike are diminished in favour of crucian, red species, roach with a high adapting capacity to the new ecological conditions, but with low economic value. Regarding the Razim - Sinoie Lake complex, due to the isolation works from the marine waters, on the one hand, and from the southern compartment (Sinoie, Istria, Nuntaşi - Tuzla) from the northern one, important changes in fauna. Due to the increased contribution of fresh water from the Danube and the closure of the connection with the Black Sea (Gura Portiţei), Razim, Goloviţa, Zmeica and other satellite lakes have the same ichthyofaunal picture as the delta lakes. Sinoie Lake in the southern compartment, although it did not withstand the same rate of sweetening, the closure, but not firm, of the periboines led to the limitation of water exchange with the sea basin, and through the dam on Canal V, between Sinoie and Goloviţa, allowing a freshwater runoff from the north, and it has undergone faunal changes to the slightly fresh (Fig. 5). Lakes with low change of water, partially covered with floating vegetation. This ecosystem

includes the lakes Merheiul Mare, Merheiul Mic, Roşca, Poleacova, Nebunu, Ligheanca, Dovnica, Răducu, Porcu, Tătaru, Obretinciuc, Cuibul cu Lebede, Isăcel, Uzlina, Murighiol etc. and is characterized by a reduced water exchange, which has led to an advanced degree of clogging, not so much by the alluvial processes, but especially by the amount of organic material deposited on the bottom.

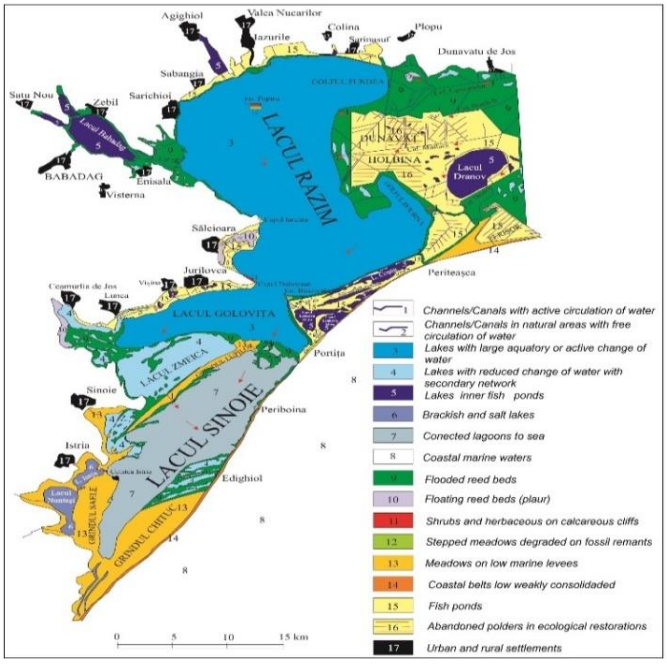

Fig. 5.The Razim-Sinoie Lake complex-ecosystem types

The landscape of these lakes is usually known for the presence of white water lily (Nymphea alba) and at the edge by yellow water lily (Nuphar luteum). Along with these pleasant-looking plants, other species coexist, such as the fringed water lily (Nymphoides peltata), water caltrop (Trapa natans), water-plantain (Alisma plantago-aquatica), arrowhead (Sagittaria sagittifolia), common frogbit (Hydrocharis morsus ranae), which sometimes cover the lake aueface the entire surface of small lakes and make them unsuitable for fishing and other economic uses. On the surface of the lakes, also more sheltered from the wind, but where the depth is greater, develops several species of floating plants, but not fixed to the bottom, such as: four species of duckweeds (Lemna sp.) With leaves like some pennies covering large areas, floating fern (Salvinia natans), bladderwort (Utricularia sp.), water silk (Spirogyra sp.), which generally do not give a pleasant appearance to these aquatic objectives. In the

heavily clogged lakes and ravines, a forage-growing plant called water pineapple (Stratiotes aloides) develops, which at first has a fixed root, but later detaches, becoming free, and the female flowers sink after fertilization, so that the seeds form new plants on the bottom (6a, 6b.).

Fig.6a. Nuphar luteum

Fig.6b. Nymphae alba

These lakes have been further affected by the eutrophication process in the last 15 years, which has led to a radical change in biotic structures. Thus, the most important change is the restriction up to extinction (in some cases) of submerged and sometimes emerged macrophytes, which were the habitat of a large number of organisms starting with epiphytic bacteria, epiphytic algae (periphyton), many invertebrates and ending with ichthyofauna. It is emphasized that the macrophyte horizons represent in a lake the regeneration background of delta's ichthyofauna.

The acceleration of the eutrophication process is due to the contribution of nutrients (nitrogen and phosphorus) from the Danube waters, the quantities coming from local agriculture and from ponds. The large amount of nutrients has favoured the explosive development of phytoplankton, the disappearance of macrophytes, the reduction of populations specific to these biocenoses and benthic fauna.

The energy accumulated by the primary phytoplankton is transferred, mainly, in the suspended detritus and in the sedimentary one, determining the intensification of bacterial metabolic processes and the storage of energy in the detritus. Under these conditions, organic substances exceed 30 mg of carbon per litter, and detritus in suspension varies between 3 - 30 mg of carbon per litter.

In order to restore the state of these ecosystems, it is necessary to reduce the amount of nutrients and achieve an efficient hydrological regime. Regarding the structure of ichthyofauna, it is very close to that of lakes with active water exchange. Lakes inside polders, with controlled water change. This category consists of lakes as Obretinul Mare, Dranov, Babadag, Coșna, Leahova Mare and Leahova Mică. Because water circulation between these lakes and the active hydrological network was barred and these lakes were turned into fish farms, both the living and non-living compartments of these systems have

changed. The structure of fish populations was affected most by introduction of allochthonous or exotic species.

2.3. Standing brackish and salt waters

Isolated lakes. This type of ecosystem includes the Istria and Nuntaşi (Tuzla) lakes located in the southern part of the Razim – Sinoie Lake Complex, between the Dobrogean Plateau and the Saele sand ridge. There is a narrow connection between these lakes, through a channel, first between Istria Lake and Sinoie, and then between Nuntaşi Lake with Istria. The semi-arid climatic conditions that determine a higher evaporation associated with the lack of underground and shallow fresh water supply, led in time to the accumulation of salts – peloid formation with balneary-therapeutic qualities. The most representative, in this sense, is Nuntaşi Lake, which is used quite modestly, currently, in balneary-therapeutic treatment. In prolonged dry periods the water volume evaporates leaving only the lake deposit, the most recent event being in the summer of 2020.

Lagoons connected to the sea. Two lakes are included in this ecosystem – Sinoie and Zătonul Mare. Due to their geographical position and the different degree of anthropogenic impact, the two lakes differ essentially. Sinoie Lagoon, by transforming Razim Lake into a freshwater basin for irrigation and transiting a significant volume of water to the sea, through Periboina, has greatly contributed to changing biotic conditions. Thus, Sinoie Lagoon evolved from a mesohaline to an oligohaline environment. The connection with the marine environment through the Periboina is semi-directed through a fence/dam type construction. In order to preserve and mud lagoon to a mesohaline environment. Zătonul Mare, with a much smaller aquarium and a larger and undirected opening to the marine environment, is a much more characteristic environment of this type of coastal ecosystem. Important morphological changes with consequences on biodiversity occur along the fragile marine bank between Gura Portiței and Grindul Chituc.

2.4. Coastal marine zones

Semi-enclosed bays. The two bays – Musura and Sfântu Gheorghe – have small depths, with fresh water inputs, which is in lacustrine-marine ecosystems with important biocenotic structures composed of planktonic and benthic biocenoses, ichthyofaunistic freshwater and marine. Benthos reaches 200 - 300 kg/ha, and plankton records the highest values in the Black Sea (up to 4 gr/m3 for phytoplankton, up to 1 gr/m3 for zooplankton). During the summer, a number of marine fish migrate to these bays, such as blue mackerel (Scomber scomber), anchovy (Engraulis encrasicholus), and sardines (Clupeonella sp.) (Fig. 7).

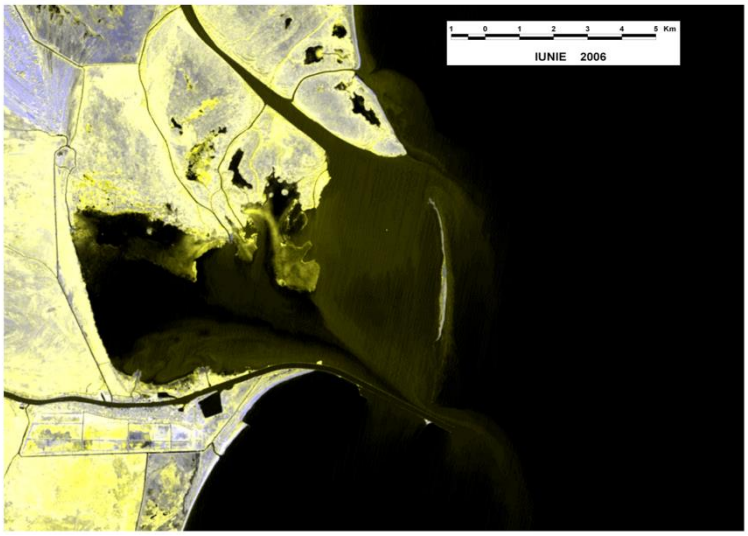

Fig.7. Golful Musura, semi-enclosed bay- ecosystem type

Coastal marine waters. Except of the Musura and Meleaua - Sfântu Gheorghe Golf, of the above mentioned, the coastal marine ecosystems have their eastern limit at the 200 m deep isobaths which simultaneously is the border of the Danube Delta Biosphere Reserve. The main characteristic bottom is it slight bending and the occurrence of a fluvial sediment layer running from the N-W to S-E. This is carried by the Danube River and the mud layer deposited on the sand facies is hiding the initial relief of the marine bottom.

Because of its large contact zone with the open marine waters,the coastal zone is subjected to the activedynamics of sea waters.This means mainly to the wind: waves stirred by the wind – 46%, by swell – 23%, mixed waves – 28% and quit sea – only 3%.The Danube has a major influence on the coastal marine waters, resulting in a certain degree of mineralisation (brackish waters), in tu mixed with pollutants have turbidity and polluting substances.The high quantities of nutrients (phosphates and nitrates) mixed with pollutants have accelerated eutrophication, causing the gradual decrease of biodiversity from primary producers to fish.

The marine flora is relatively reduced, being represented mainly by species of algae - Enteromorpha spp. The ichthyofauna comprises andromous species like Huso huso, Acipenser stellatus, A. guldenstaedti, Alosa pontica, A.caspia nordmanni, Salmo trutta labrix and species that are not migratory as Syngnathus typhle, Liza aurata,Atherina boyeri, Percarina demidofii, Potamotus saltator, Trachurus ponticus, Potamoschistus marmoratus, Gobius niger, Sloea

nasuta and Platichthisys flesus luscus. Squalus acanthias are often formed in these areas. The mammals are represented largely by Delphinus delphis and Turosiops tursio.

2.5. Wetlands

Water fringe vegetation/flooded reed beds. Is represented by frequently flooded depression areas, covered with fixed hygrophilous vegetation (reeds, rushes, sedges). This ecosystem with a large surface development is a continuation of those with stagnant water (lakes), within the vast morphological depressions limited, either by the riverbanks, or by them and the marine ones. These surfaces are under water, but shallow (less than 1 m, even 0.3 – 0.5 m) in summer – autumn and quite deep (over 1 m) during high spring and early summer waters. These areas, which occupied a very high percentage in the delta before being used as agricultural, fishing or forestry areas these had covered a large part of the delta. Now they still dominate the Matiţa – Merhei – Trei Iezere – Bogdaproste, Roşu – Puiu – Lumina, Isac – Uzlina – Gorgova depressions. The area of these marshy lands also includes part of the river and sea banks, even the southern part of the Chilia Field, lying one meter below the 0 sea level.

By raising the water level during floods (spring - early summer) these wetlands are expanding covering, temporarily, usually to the detriment of terrestrial ecosystems (sand ridges and plains). These temporary flooded areas are suitable for spawning (water table) or for the nesting of bird species.

The dominant vegetation species is the reed (Phragmites australis), which also gave the name of these lands, reeds, although inside them the floristic spectrum is very rich. Briefly analysing a profile of vegetation between an arm of the Danube and a lake within these marshy lands, the following sequence of associations can be noticed: at the edge of the depression on the river bank, on the highest part, there is the Salicaetum, then Typhaetum-Caricetum, Scirpo - Phragmitetum, Phragmitetum natans (“plaur”) and then passes to Nymphaetum-Potametum, respectively to the shore of the lake. In these reeds, as accompanying species, we mention: rush (Typha latifolia and T. angustifolia), bulrush (Scirpus radicans, S. lacustris), sedge (Carex pseudocyperus, C. dioica, C. stricta), horsetail grass (Equisetum marshes), arrowhead (Sagittaria sagittifolia), yellow iris (Iris pseudacorus), brook grass (Glyceria aquatica), pond mint (Mentha aquatica), grey sallow (Salix cinerea) and others. These lands are the best places for spawning, breeding and breeding of carp, catfish, bream, perch, pike, crucian carp, etc., for nesting many species of birds.

In addition to the mentioned flora and microscopic planktonic fauna, birds and mammals find an ideal place, as food and refuge. In the reeds, in the clusters of nearby willows, the reed nightingale (Locustella luscinioides), the

bearded reedling (Panurus biarmicus russicus), the Eurasian penduline tit (Remiz pendulinus), the warbler (Acrocephalus sp.). In the thickets of the reeds, where it is difficult to penetrate, nest the tufted duck (Aythya fuligula), the red or gypsy duck (A. nyroca), the red-crested pochard (Netta rufina), the brown-headed duck (Aythya ferina), mallard (Anas platyrhynchos), summer goose (A.anser), dwarf cormorant (Phalacrocorax pygmaeus), red heron (Ardea purpurea), great egret (Egretta alba), little egret (E. garzetta), yellow heron (Ardeola ralloides), spoonbill (Platalea leucorodia), glossy ibis (Plegadis falcinellus), gray heron (Ardea cinerea), night heron (Nycticorax nycticorax), common pelican (Pelecanus onocrotalus), curly pelican (P. crispus), mute swan (Cygnus olor). Over the reed and plaur come in flight for food Eurasian marsh harrier or reed jay (Circus aeruginosus), osprey (Pandion haliaetus), white-tailed eagle (Haliaeetus albicilla) of which there are only a few specimens in the entire delta. This bird has an important role in maintaining the faunal balance, prevents the outbreak of fish epidemics and regulates the number of respective populations (fig. 8a, 8b.).

Fig.8a. Pelecanus onocotalus

Fig.8b. Cygnus olor

Mammal fauna is represented by species that have become extinct in other European countries and have adapted to the specific conditions of the delta. The most precious for their fur are the otter (Lutra lutra), the mink or the cloud (Mustela lutreola), the weasel (Mustela nivalis), the ermine (M. erminea aestiva), the black-bellied fox (Vulpes melanogaster), the wild cat (Felis silvestris). In recent decades, the raccoon dog (Nyctereustes procyonoides) and the bison (Ondatra zibethica) have immigrated to reeds and plaur, coming from the southern parts of Ukraine. The otter (Myocastor coypus) is also less common, which is also acclimatized, and the wolf (Canis lupus) and the fox (Vulpes. vulpes) are on the verge of extinction. In these mammals we also mention, for their meat, the wild boar (Sus scrofa) and the rabbit (Lepus capensis europaeus), the latter is common in winter, when it can move on the ice bridge.

Floating reed beds (reed peat moor/ floating bridge). They are the floating reed beds (Romanian „plaur") formations inside the depression areas and around the lakes. The plaur, a real floating bridge, consists of reed rhizomes, interwoven with the rhizomes of other plants, with a thickness of 0.5 – 1.5 m, loaded with humus and untransformed organic matter. In addition to the reed, which is the main component, in the plaur are also found: rush (Typha latifolia and T. angustifol ia), bulrush (Scirpus radicans, S. lacustris), sedge (Carex pseudocyperus, C. dioica, C. stricta), horsetail grass (Equisetum marshes), arrowhead (Sagittaria sagittifolia), water arrow, water fern (Nephrodium thelypteris), water sorrel (Rumex hydrolapathum), rush, mace (Sparganium ramosum), sedge (Carex sp.), marsh woundwort (Stachys palustris), fineleaf water dropwort (Oenanthe aquatica), water hemlock (Ciucuta virosa), dragonfly (Gallium palustre), watercress (Rorippa amphibia), purple loosestrife (Lythrum salicaria), yellow melilot (Melilotus officinalis), grey willow etc. Many small, microscopic animals live in the soil of the plaur that results from the transformation of organic waste.

Thus, in 1 dm^3 of plaur soil were identified about 30,000 specimens of mites, Colembola, Ostracoda, larvae of files Diptera, adults of bugs Heteroptera, Lepidoptera, Coleoptera, Hymenoptera, Pseudoscorpiones, Isodopa,Oligochaeta, Gastropoda. Rotifera specimens are the most common organisms, hundreds of thousands of individuals are living in that soil volume.

The plaur, as it is loaded with a layer of soil and organic debris, is fixed on the depression's substrate, being raised only at very high waters. From the surfaces of are similar to those of the plaur islands, smaller pieces break, which are carried by winds and water currents to the mouths of ravines and canals, blocking the circulation of boats and dinghies. These situations are frequently encountered in Matiţa - Merhei - Trei Iezere - Bogdaproste and Roşu - Puiu - Lumina lake complexes (Fig. 9a, Fig. 9b).

Fig.9a. Floating bridge (plaur)-ecosystem

Fig.9b. Riparian willow on sand ridge-cosystem

In the action of arranging the premises for agriculture and fish farming, plaur is an impediment and at the same time a harmful source, because it interrupts the circulation of water and the removal of hydrogen sulphide. At the same time, as we have seen, the plaur is a good winter shelter for fish. In summer, the juvenile fish finds a safe place from predators. Critical situations also arise here when the water under the plaur is not sufficiently primed and, therefore, oxygenated. The large amount of hydrogen sulphide, resulting from the decomposition of organic substances, causes asphyxiation of fish. In the toponymy of the delta, there are hydroniums that reflect this state of the biotope, such as the Gârla Împuţita (Stinking Channel) that drains the waters under the plaur between the lakes Lumina, Puiu and Roşu, these being loaded, especially in spring, with large amounts of hydrogen sulphide, where it comes from and name.

During summer, the plaur becomes a favourable shelter for fish. Mammals often choose the habitats of plaur edges, because they prove even better than those of reed cover in the inside areas. The species of birds and mammals mentioned in the reed ecosystem are about the same, moreover, due to its consistency, mammals find a better habitat.

Riparian willow formation - mixed willow forests ("zavoi") on river levees and islands. This ecosystem occupies the river sand banks along the main arms and at the bifurcations, where, by extension, it acquires the appearance of alluvial plains with heights of up to 3 m. The sand levees are also subject to the flood process, but differentiated according to the height of the sand levee and the water level on the Danube. On these levees are also located the main rural settlements of the delta (Pătlăgeanca, Sălceni, Ceatalchioi, Plauru, Pardina, Tudor Vladimirescu, Ilganii de Sus, Ilganii de Jos, Partizani, Vulturu, Gorgova, Mila 23, Băltenii de Jos) most of them erected on some higher places to be protected from flooding.

The transition from these sand levees to depressions is smooth, so that the phytocenoses are difficult to delimit. However, the river leaves in the first half of the delta were, before the organized human intervention, the domain of willow forests with a rather rich floristic spectrum. Among the tree species, we mention several species of willows (Salix alba, S. fragilis, S. pentandra, S. purpurea, S. aurita, S. cinerea, S. rubra), the white poplar (Populus alba), in association with sea buckthorn red (Tamarix gallica), blackberry bushes (Rubus caesius), Alnus glutinosa, Fraxinus angustifolia, in association with the species Amorpha fruticosa Rubus caesius.

The grassy layer is represented by: Equisetum palustre, Poetrivialis sp., Polygonum hydropiper, Stellaria aquatica, Raphanus raphanistrum, Rorippa palustris, Potentilla reptans, Symphytum officinale, Solanum dulcamara a.s.o. This herbaceous layer consists of pastures used for grazing cattle and sheep

after the withdrawal of flood waters. On the flooded levees for a longer period of time, the willows develop – a group of clusters of small willow (Salix cinerea), the marshy vegetation is the one mentioned in the marshland ecosystem.

The zoocenoses consist of sharp-nosed mice (Neomys fodiens), rabbits (Lepus europaeus), woodpeckers (Gryllotalpa gryllotalpa), and among the birds – the reed warbler (Panurus biarmicus russicus), the European penduline tit (Remiz pendulinus).For the most part, willow forests have been replaced by Canadian poplar plantations or arable land by embankment, deforestation and drainage.

2.6. Forests, shrubs and herbaceous vegetation.

Mixed oak forests on high sea sand banks. This category includes two ecosystems on the Letea and Caraorman banks, which are characterized by a much more complex and interesting floristic and faunal picture compared to those on the river banks and on the continental fields (Chilia and Stipoc).

This complexity is given by the lithological constitution (sands of organic and mineral origin), by the wind modelling (dune relief), by the play of the groundwater level in relation to the hydrological regime of the Danube, by the high evapotranspiration. The variation of biotopes – high mobile and semi-mobile dunes, depressions with clayey sands subject to groundwater level fluctuations – determines a heterogeneity of ecosystems that is quite difficult to outline on small and medium scale maps (Fig. 9).

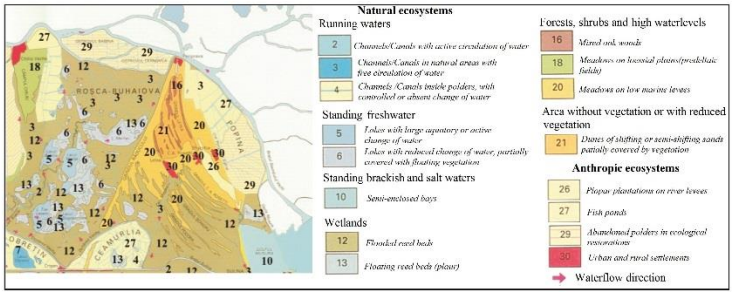

Fig. 9. The Letea levee and Merhei Lake complex- ecosystem types

The forests on the two sand banks are representative for pedoclimatic conditions and develop in the depressions between the dunes in form of elongated clusters like Letea sand bank, "hasmacuri" (Hasmacul Mare, Hasmacul Mic). These forests are composed of oak (Quercus robur, Q. pedunculiflora), ash (Fraxinus angustifolia, F. pallisae), elm (Ulmus foliacea), white, gray and aspen

poplar (Populus alba, P. canescens, P. tremula), white willow, linden (Tilia sp.), hazel (Corylus avellana), wild apple (Malus sylvestris), wild pear (Pyrus pyrastes); coppice like, blackthorn (Prunus spinosa), hawthorn (Crataegus monogyna), rosehip (Rosa canina), alder buckthorn (Rhamnus fragula), common buckthorn (R. cathartica), creeper vine (Euonymus vulgare), cherry dogwood (Cornus mas), bloody dogwood (C. sanguine), guelder rose (Viburnum opulus), sea buckthorn (Hippophaë rhamnoides) and French tamarisk (Tamarix gallica). All these are invaded by hanging plants, such as: wild vine (Vitis silvestris), ivy (Hedera helix), hops (Humulus lupulus), stalk (Clematis vitalba), and large weevil (Calystegia sp.) The most interesting and with lengths of 25 m is Periploca graeca, a liana of Mediterranean origin which, here, reaches the northern European limit. All these phytocenoses form a hard-to-penetrate hedge, especially in summer (Fig. 10).

The fauna of these sea banks is represented by the steppe viper (Vipera ursinii) from the southern steppes of Ukraine, the water snake (Natrix tessellata), which comes out of the water in autumn and sits on the dunes, the sand lizard (Eremias arguta deserti) and others. In winter, the wild boar, the wild cat and the wolf (the last one on the verge of extinction) come to the forest. In the crowns of the trees, the few specimens of the white-tailed eagle (Haliaetus albicella) and the great owl (Bubo bubo) make their nests, and in the passage stop the osprey (Pandion haliaetus), the little eagle (Aquila pomarina). Among the insects, very varied and numerous, we mention the tuna with 7 species (Tabanus sp.), Harmful for cattle and even for humans, in July and August.

Fig.10. The Letea – dunes, forest, liana (Periploca graeca) – ecosystem types

Shrub and herbaceous vegetation on calcareous cliffs. Due to the specific morpholithological conditions this type of ecosystem is limited to the

steep northern part of Popina Island and Cape Dolosman where Cretaceous limestones are largely devoid of soil cover, except for viruses where vegetal associates adapted to semi-arid conditions and well sunny (xerophilous); also a specific fauna. Thus, on the steep island of Popina is found the endemic plant Ornithogallum oreoides and among the animals the orthopteric endemism Isophya dobrogensis regent discovered, the venomous spider Latrodectus tredecimguttatus (black widow), the giant myriapod (17 cm) – Scolopendra tessata. On the fossil cliff of Cape Dolosman we mention the endemic plant Centauraea jankae, the endemic beetle Prosocuris phelandrii, on shrubs and grasses the striped lizard (Lacerta trilineata dobrogica) in the crevices of the cliff the large whipsnake (Columber caspius), the common swift (Apus apus), the white common shelduck (Tadorna tadorna), marbled polecat (Vormela peregusna).

Steppe meadows, strongly degraded on predeltaic outliers. This ecosystem with a small extension refers to the islands Popina, Grădiştea and Bisericuţa from the perimeter of Razim Lake.

Of these witnesses of erosion, best represented is Popina Island, with an area of 90 ha, consisting of Mesozoic limestone and partially covered by loessoid deposits, rises above the lake level by 48 m. The island's vegetation follows from the shore of the lake where finds the reed (southern part), the shrub also called the field elm (Ulmus minor), which grows on the calcareous cliff from the northern part, to the one on the upper, high surface, such as sea buckthorn (Tamarix ramosissima), thyme (Thymus zygoides), the colour is given by the hollyhock (Althea rosea), the buckthorn (Melica ciliata), the dwarf morning glory (Convolvulus cantabrica) etc., fescue (Festuca callieri).

Among the fauna species we mention those on the land or on the shore, such as: mallard (Anas platyrhynchos), summer goose (Anser anser), silver gull (Larus argentatus), woodpecker (Recurvirostra avosetta), white caliph (Tadorna tadorna) nests at the mouths of fox burrows, the red caliph (T. ferruginea), the shore swallow that makes its nest in the loessoid shore. The giant myriapod (17 cm) (Scolopendra cingulata) also lives here.

Meadows on low marine levees with sandy and halophile vegetation. This ecosystem includes most of the low sea banks belonging to the Letea, Caraorman, Sărăturile, Crasnicol – Frasin – Flamânda, Lupilor – Chituc – Saele bank complexes, with heights that are up to a maximum of 2 m above sea level. Usually, these banks are covered with grassy associations, being flooded, for the most part, during the high spring waters. The soil is medium sandy soil, strongly humidified on sandy deposits, with the groundwater horizon at depths of 0.5 - 1.5 m depending on the phase of the hydrological regime.

Plant associations differ significantly from one bank to another by the seashore and, therefore, by the influence of seawater. In addition, in the case of higher parts of the banks, such as Chituc, where sand is semi-fixed, sandstone associations appear predominantly compared to the halophilic ones.

The sandy vegetation is represented by associations of Festucetum arenicolae, Ephedro-Caricetum colchicae, Elymetum gigantei, Bromo-Cynodontetum, Aperetum maritimae, Holoschoeno-Calamagrostetum epigeios, Scabioso (argentae) – Artemisietum campestri, Koelerio (Glaucae)-Stipetum borysthenicae, important in fixing sands and their soil formation. An important role it also has the association ot Dauco (guttati) – Chrysopogonetum gryli in which coexist many xerophilous species such as Medicago falcata, Plantago lanceolata, Crepis rohoeadifolia, Bromus tectorum, Poa bulbosa, Inula salicina, Euphorbia sequerana, Holosch Cent, Dianthus polymorphus var. bassarabicus et al.

Halophile vegetation develops in close connection with the degree of mineralization of groundwater. In micro depressions, depending on the salinity of the sands, a certain succession is observed. Thus, in the depressions, where the highest concentration of salts is, it is occupied by associations of Salicornietum europaeae, followed to the periphery by Aeluropo-Salicornietum, Plantaginetum maritimae, Aeluropetum littoralis, Puccinellietum limosae, Agropyretum elongati and Spergulari.

As the waters of the Black Sea approach, the sands' salinity increases and, therefore, the vegetation's disposition is influenced in this respect. Under these conditions are the associations of Bassietum sedoides, Juncetum maritimi, Suaedetum maritimae, Salicornietum europaeae.

2.7. Open places with little or no vegetation

Dunes with shifting or partially shifting sands, covered with vegetation. The extension area of this type of ecosystem is reduced to two large banks - Letea and Caraorman, in which high dunes consisting of sandy deposits of medium and coarse texture are subjected to deflation process, which causes vegetation to be insular. The groundwater horizon is found at great depths, between 3-10 m, depending on the dunes' height and the thickness of sandy deposit.

The floristic spectrum is given by spear grass (Stipa joannis), convolvulus (Convolvulus persicus), sand carnation (Dianthus polymorphus), catchfly (Silene pontica), wheatgrass (Elymus sabulosus), cheatgrass (Bromus tectorum), "sadina" (Chrisopogon gryllus), couch grass (Agropyrum junceum), sand willow (Salix rosmarinifolia), desert madwort (Alyssum desertorum), sand plantain (Plantago arenaria), Carex ligerica, all of which are psammophilous or sandy (sandy) vegetation.

Weakly consolidated coastal sand-belts covered with halophile and buckthorn vegetation. This type of ecosystem differs significantly from that of well-established marine banks, in that it is frequently subject to marine storms and, therefore, has a high instability. In addition to a number of species of halophiles and psammophilous plants, which have been mentioned, specific to them are: sea kale (Crambe maritima), sand plantain (Plantago arenaria), sand wormwood (Artemisia arenaria), goatsbeard (Tragopogon floccosus) etc. In some coastal areas, such as those in Cardon and, especially, in the north of

Sfântu Gheorghe-Sărăturile levee, there are areas covered with sea buckthorn (Hyppophaë rhamnoides).

Among the birds, we mention the European herring gull (Larus argentatus cachinans), black-winged stilt (Himantopus himantopus), pied avocet (Recurvirostra avosetta), seagulls - pomarine jaeger (Stercorarius pomarinus) and parasitic jaeger (S. parasiticus Ch), marsh tern (Chlidonias sp.) etc.

Slightly consolidated coastal beaches. Integrated in the coastal cordons, these are parts that are mostly devoid of vegetation or with sparse vegetation in the form of clumps, bushes. The coastal beach develops on most of the coast between Midia Cape and Sulina, except for the sectors where the marine abrasion directly affects the reeds or deltaic plaur, as is the case of the sector near Zătonului Mic, Grindul Mocirla and the mouths of the secondary arms Gârla de Mijloc and Gârla Turcească (behind the Sacalin Peninsula), between the banks Cazacului and Gârla Împuţita and in the Gulf of Musura. The width of the coastal beach varies from 5 – 10 m to 60 – 100 m. The real sectors of the beach, used as such in the heliomarine cure are found at Gura Portiţei, Sfântu Gheorghe and Sulina. For the most part, the narrow coastal beach is washed by the waves, being made up of sandy material of organic origin and shells in different degrees of grinding (Fig. 11).

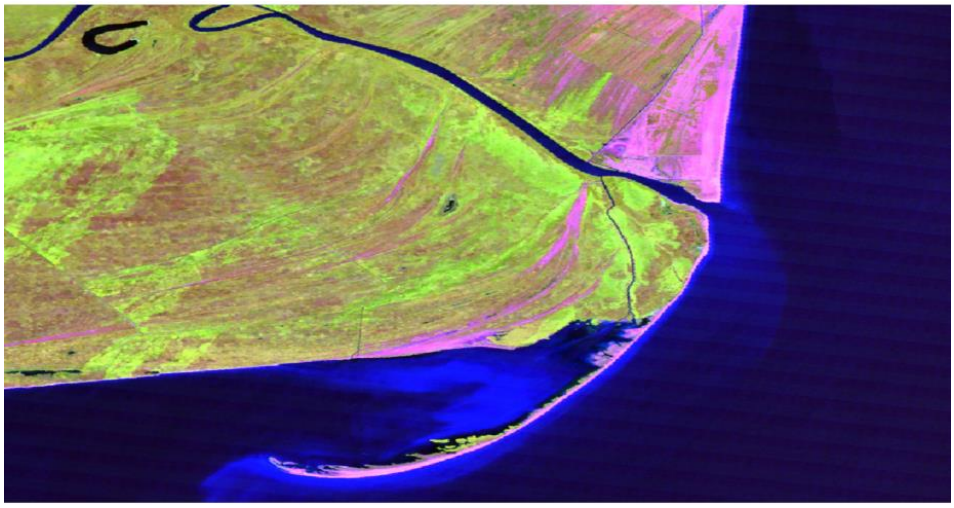

Fig.11. Sacalin peninsula-slightly consolidated levee- ecosystem type

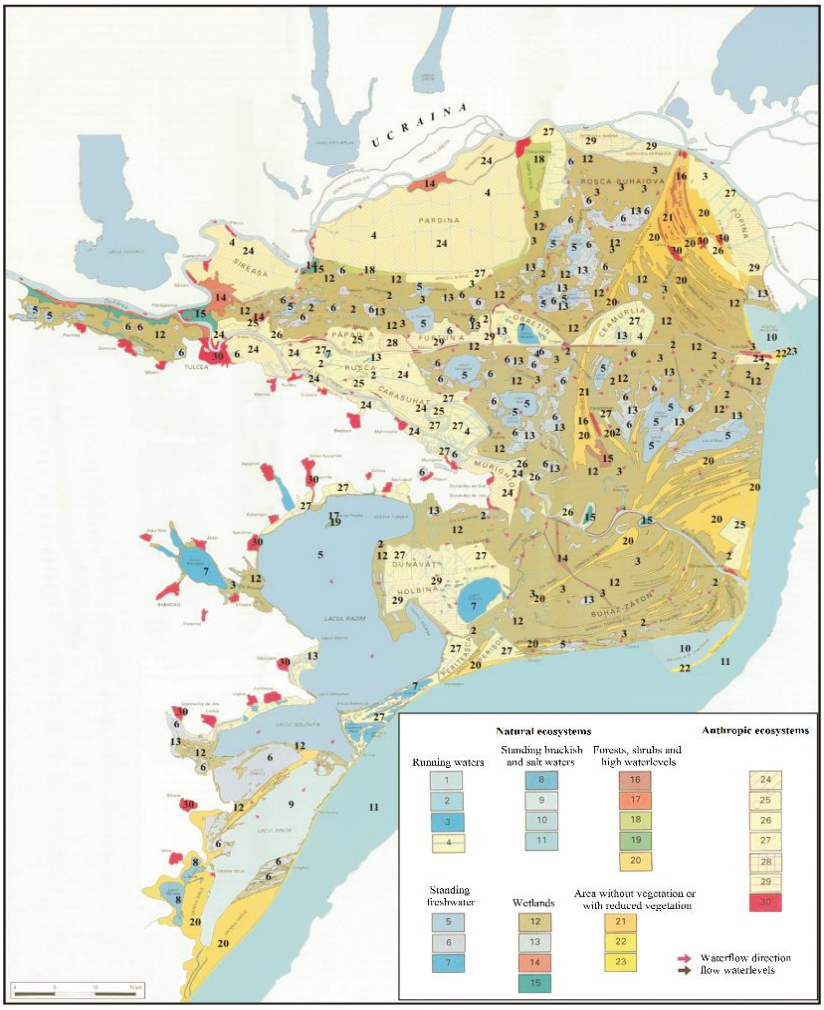

Fig.12.The ecosystems of the Danube Delta Biosphere Reserve

III. ANTHROPIC ECOSYSTEMS

3.1. Agricultural polders

This type of development, started before the Second World War through the Tătaru Ostrove (1939), continued after the 1960s by draining and damming large areas, which in 1990 had reached about 53000 ha distributed in several arrangements. Of this area, due to unsuitable conditions for agriculture, only 39,000 ha remain in operation. Among the most important agricultural

arrangements we mention, in order of their size, the following: Pardina 27 000 ha, Sireasa 7550 ha, Ostrovul Tătaru 2600 ha, Murighiol – Dunavăţ 2540 ha, Tulcea – Nufăru 2350 ha, Popina I 640 ha, Beştepe – Mahmudia 560 ha, Sulina 500 ha, Nufăru – Victoria 310 ha etc. We emphasize the fact that in the perimeter of these arrangements removed from the effect of floods there are important areas that are not cultivated, but which have not been returned to the natural deltaic regime.

Agricultural arrangements, like the others (fish and forestry), are ecosystems that function, more or less, according to the purpose for which they were made. In this sense, the drainage works carried out led to the disappearance of the previous natural ecosystems and the creation of anthropogenic ecosystems. Depending on the level of organization, maintenance and amendment of fertilizers and pesticides, these ecosystems can be considered as areas removed from the action of the laws of operation of the deltaic system as a whole (Fig. 12)

Agricultural productivity and negative consequences of these ecosystems are discussed and experimental studies are made to establish their opportunity in the initial conception or their reorganization in the context of reducing the ecological impact they have on ecosystems left in the natural regime.

3.2. Forestry polders

Unlike agricultural arrangements, forests appeared after 1960 through damming, deforestation of spontaneous forest vegetation and planting Euro-American willow and poplar species that occupy 97% of the total species, followed by ash, white, black and grey poplar – only 3%. Of the 97% of Euro-American willow and poplar, poplar occupies an area of 62%.

These forest arrangements were made for economic purposes and, as such, their ecological role was not taken into account in the sense of creating a diversified floristic spectrum that would provide biotopes for deltaic fauna. For these reasons, it is estimated that these forest arrangements are harmful to the ecological balance and lead to the impoverishment of the biodiversity potential of the Danube Delta.

The only forest management that aims to achieve forest associations that consolidate and protect the deltaic territory is the one on the Sărăturile bank near the Black Sea coast. Among the forest facilities with productive purpose we mention: Păpădia 2,000 ha, Rusca 1,200 ha, Carasuhat 620 ha, Pardina 425 ha, Murighiol 400 ha.

Poplar plantations on river levees. Between the main arms of the Danube and the longitudinal dams, which are usually found from a few tens of meters to 100 - 200 m, Euro-American poplar is planted both for protection and for economic recovery. These strips of plantations were made by deforestation

of willow branches that better protected the banks of the arms through their root system. At the same time, spontaneous willow galleries were biotopes for a wide range of living things, with numerous links in the food chain. Unfortunately, Euro – American poplar plantations meet only one requirement – economic, because ecologically they are quite poor in the diversification of biotopes.

3.3. Fish ponds

This type of facility, if the operating norms had been observed and the appropriate food had been provided, would have been the most adequate in the perimeter of the Danube Delta. Some negative aspects can be revealed in this direction. Thus, their location was not made in the most favourable conditions. This is the case of the Stipoc facility, which was made in the highest part where the loess deposits are also found close to the surface, dismantling an area suitable for grazing and even the cultivation of indigenous vines. The development of Popina to the east of the Letea bank, first for agricultural purposes, and after salting, the northern part was reshaped as a fishing facility, and the southern one was alternatively agricultural-fishing facility. In reality, Popina II in the south, in the area of 3,600 ha, is not used in any way, and its isolation from the normal annual flood processes has led to the salinization and expansion of sea buckthorn (Tamarix gallica).

In another situation are the Holbina I and II facilities located between Razim, to the west, and Dranov lakes, to the east, in the substrate of which there are peat deposits which, due to the generated acidity, damage the development of the fish fauna. In similar situations there are other fishing facilities, which due to inefficiency are proposed to be returned to the free circuit of water (regeneration), but quite difficult to achieve.

The fishing facilities in the Danube Delta, without the Razim – Sinoie lake complex, occupied at the beginning of 1990 about 37,800 ha, so an appreciable area that is removed from the deltaic system and works (or not) according to their requirements.

3.4. Abandoned facilities in ecological reconstruction

Some fishing (Dunavăţ, Holbina I, Holbina II), agricultural (Babina, Cernovca), ad forest facilities (Furtuna – south) that did not give economic results were selected and ecological reconstruction procedures are applied. Good results were obtained in the Babina and Chernovka islets, in which these procedures were applied.

The hearths of human settlements with spaces cultivated in and out of the built-up areas. It is an accepted fact, already, that the human settlements

and, especially, in the Danube Delta, represent an obvious discontinuity, true enclaves, the first to appear and modify the natural ecosystems here.

3.5. Human settlements

In generally, the human settlements in the Danube Delta are isolated from one another. They represent the first human impact on the natural ecosystems of this wetland. Depending on their position, the place occupied, also differ greatly as such and economic functions (fishing, agricultural, agricultural-fishing). Thus, the settlements located along the main arms have an elongated, linear shape (Crișan, Gorgova, Partizani, also Sulina town.), those on the Chilia Field – Chilia Veche, sea bancs-Letea, C.A.Rosetti, Caraorman, Periprava, have a scattered and polygonal shape. If the settlements along the arms have limited agricultural lands (behind the house), those on the Letea, Caraorman banks, obviously Chilia Veche, have larger areas on which to practice a traditional agriculture (Fig. 13).

Fig.13. Traditional house on the Sulina arm-ecosystem type

IV. CONCLUSIONS

The morpho-hydrographic configuration and, respectively, the landscape evolved in natural conditions until the second half of the 19th century. Under natural conditions, the predominant processes in the deltaic space were those of clogging inside the delta, through the transported Danube alluvial material and decomposed organic remains, in situ, by wind modelling on sandy sea ridges, by the formation of coastal cordons and secondary deltas at

the outflow of Chilia and Sfântu Gheorghe arms, resulting in the special mosaic of the ecosystems of the Danube Delta.

In addition to constructive processes, there have been negative processes such as clogging of lakes and abrasion processes on the sea shore by increasing sea level and waves, reducing the intake of Danube alluvium and prolonging jets at the mouth of the Sulina arm, the dam at Midia Cape that alters coastal marine currents.

The establishment of the European Commission of the Danube (CED) in 1856 triggered modifications, especially on the Sulina arm, to be arranged for the purpose of fluvio-maritime navigation. For this purpose, the meander cutting works were carried out (Maliuc, „Big M" = Old Danube), which shortened the waterway from 83.4 km to 62.6 km, deepening the riverbed to a minimum of 7.9 m (24 feet), started in 1858 and ended in 1902. The Sfântu Gheorghe arm it was also the objective of rectifying the five meanders, between 1985 and 1990, which led to its shortening from 108.2 km to 69.7 km.

Within the Danube Delta there were most changes in the river network, respectively canals and channels, which were determined by the use of natural resources (fish, reeds, wood, etc.), to shorten of the waterways and for other local interests.

Among the most important canals were: Dunavăț (originally called the King Carol I Canal, in 1907); Enisala (originally the Elizabeth Canal, inaugurated on October 12, 1913); Dranov (Ferdinand Canal, between 1912 – 1914), which connects the Sfântu Gheorghe arm with Lake Razim; Litcov (Carol II Canal, between 1929 and 1932); Crasnicol (Voievodul Mihai Canal, in the period 1930 – 1934); Sireasa, parallel to the Sulina arm, which ensures the access of fishing and tourist boats in the Şontea canal; Furtuna lake complex. All these aimed at achieving the circulation of water inside the delta to the lake complexes and improving the fishing potential.

The most important changes of the deltaic landscape, respectively of the deltaic ecosystems took place after 1950 in order to capitalize on all natural resources like reed (1960-1970), fish (1970-1980), agricultural (1980-1989), forests (since 1970). These activities disrupted the normal hydrological cycles and it will take years to reverse harmful effects. An important emphasis on human interventions in deltaic weighing is that they removed 30% of the delta surface, respectively the natural ecosystems spectrum and natural evolution and ecological balance.

With the establishment of the Danube Delta Biosphere Reserve in 1990, the statutory provisions on the protection and conservation of biodiversity, the deltaic landscape were reduced, but the pollution of the Danube waters less consolidated beaches (Sulina, Sfântu Gheorghe, Chituc) and related with touristic activities, on ecosystems as a whole. The tourism activities, represent

not only a positive and dynamic development factor, but also a practical solution to keeping the environment unaltered. These aspects were mentioned in the characterization of the ecosystems presented in this article.

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