Synthesis of Studies Conducted to Reveal the Impact of the Bastroe Canal on the Physico-Chemical Conditions and Biodiversity in Danube Delta Biosphere Reserve (DDBR)

Edward Bratfanof¹, Deak György², Georgeta Tudor³, Tiberius Dănălache²,³, Elena Holban² and Mădălina Boboc³

¹Dunărea de Jos University of Galați, Romania
²National Institute for Research and Development in Environmental Protection Bucharest, Romania
³University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania

E-mail: gyorgy.deak@incdpd.ro

Abstract. This paper aims to identify the impact of anthropogenic changes caused by the construction of the Bastroe Canal on the hydrology, hydrochemistry and biodiversity of the Danube Delta Biosphere Reserve (DDBR). The paper wants to provide a knowledge tool that can be a working basis for government and local decision-makers due to the special importance of conserving the biodiversity of this area. The impact of the Bastroe Canal will be revealed through a synthesis of the conclusions of the main studies carried out by institutes in Romania in the period 2004 - 2020.

1. Introduction
The extensive hydrotechnical works built by Ukraine, complemented by additional maintenance works for the new waterway, generated from the very beginning negative reactions at the national and international levels. Both the potential local and cross-border impact, as well as non-compliance with the conventions to which Ukraine and Romania are parties, of which we mention the Espoo and Berne conventions, posed a serious difficulty.

In order to establish the environmental consequences in the Danube Delta Biosphere Reserve (DDBR) and the adjacent coastal area, determined by the Bastroe project, the current state of the physico-chemical and biological components of the Danube Delta and the adjacent coastal area was analysed. Research was also conducted for the dynamics of fish populations with impact factors and with reference to the delta area adjacent to the Chilia branch. Emphasis was put on migration, migratory behaviour of fish species, relationship with connectivity, and the state of fishery resources in the delta area adjacent to the Bastroe Canal. The conservation status of the species' habitats (feeding places, breeding places, etc.) was established, due to the disturbing factors in the study area. Sturgeons were analyzed since 2013, both juveniles and adults, all ultrasonically tagged to determine migration routes which are most often Chilia branch – Old Istanbul – Black Sea.
1.1. The importance of DDBR in the context of Bastroe Canal

The DDBR has an inestimable value for the universal heritage, being an area of great ecological significance that includes a wide variety of habitats and species, many of them threatened in the rest of Europe. According to specialized literature, the Danube Delta represents the territory between the first bifurcation of the Danube, bordered on the east by the Black Sea coast, on the north by the Chilia branch and on the south by the Razim-Sinoe lake complex.

The global value of the DDBR was recognized by its inclusion in the international network of biosphere reserves (1990), within the “Man and the Biosphere” Program (MAB), launched by UNESCO. The Danube Delta was recognized (Sept. 1990) as a wetland of international importance by the Ramsar Convention (Iran). Also, the value of the universal natural heritage of the Reserve was recognized by its inclusion (Dec. 1990) in the List of World Cultural and Natural Heritage. DDBR is home to very rare or endangered species of fish and birds and is the most important water purification system on the European continent. DDBR ranks 8th out of over 600 Ramsar wetlands as waterfowl habitat, is the largest compact reedbed on the planet and includes the northernmost tropical forest. It is a living museum of biodiversity including 30 types of ecosystems, over 9,500 species of plants and animals (by 2019) including the largest colony of pelicans in Europe, 60% of the world's dwarf cormorant population and 50% of the world's population of red-necked geese. DDBR is recognized as having high density of specimens in many species, which today are rare or absent from other regions of the continent. Although the anthropogenic influences in recent decades (water pollution, the transformation of natural surfaces into forests, fishing and agricultural practices, etc.) have intensified, they have not yet led to the complete extinction of plant and animal species.

1.2. Short description of Bastroe Canal works

There have been changes in the secondary delta of the Chilia branch (in Ukraine), by recalibrating the Bastroe Canal in order to facilitate maritime navigation. The hydrotechnical works, which started in 2004, deepened and widened this canal on a length of 8.4 km, being continued on Old Istanbul towards the Black Sea, and on Chilia branch towards Romania. Carrying out these works affects in the secondary delta of Chilia the strictly protected area on the Ukrainian part and affects the DDBR on the territory of Romania. These works generated numerous reactions both in Romania and internationally (figure 1).

![Figure 1](image)

**Figure 1.** Location of the execution works of the navigable canal, phase I and II [1].

2. Results and Discussions

2.1. Hydrology
The level regime on the Chilia branch (duration curves) was analysed, by comparing the period 1995-2002 with 2004-2012. The hydrographs of the analysed liquid flows, for the two periods 1995 - 2012 and 2004 - 2012 (2004 - starts the deepening of the Danube riverbed and the recalibration of the Bastroe Canal), mostly reflect a decreasing value, more accentuated especially after 2004 (figure 2 - figure 9).

In the graphs, the years with minimum regime phase were highlighted with yellow, the years with maximum regime phase with coral, and the rest being medium regime phase years. This evolution can be correlated with the increased absorption of the water mass by the Bastroe Canal from the Chilia branch, after the recalibration of the riverbed (its widening) and a substantial increase of the slope. After 2004,
especially on the Bastroe Canal, the decrease of suspended alluvium flows is kept within variable limits depending on the extent of the annual works performed by the Ukrainian side.

2.2. Hydrochemistry of Chilia branch – Bastroe Canal – Old Istanbul – coastal Black Sea

The water chemistry in the Danube Delta and the adjacent coastal area was analysed, the values determined downstream and upstream of Bastroe Canal presented in the decisional matrix variations of ± 5%, ± 10%, respectively ± 20% of the concentrations of the indicators (IC):

- IC increase > 5% (biochemical oxygen consumption, chemical oxygen consumption, ammonium nitrogen, dissolved phosphorus, total phosphorus, chlorides, sodium, zinc, cadmium, phenols and detergents) and IC decrease <5% (permanganate index, nitrogen from nitrates, nitrogen from nitrates, fixed residue, mercury and manganese);
- IC increase > 10% (biochemical oxygen consumption, chemical oxygen consumption (potassium dichromate method), ammonium nitrogen, dissolved phosphorus, total phosphorus, phenols and detergents) and IC decrease <10% (permanganate index, nitrogen from nitrates, fixed residue, and mercury);
- IC increase > 20% (biochemical consumption of oxygen, ammonium nitrogen, dissolved phosphorus, total phosphorus and phenols) and IC decrease <20% (nitrogen from nitrates and fixed residue).

Overall, both upstream and downstream of the Bastroe Canal, the surface water falls into the third quality class, which represents a moderate ecological status. The analysis of the obtained information volume, correlated with the historical information volumes, led to the elaboration of a decisional matrix (table 1) by the experts from INCDPM Bucharest and INHGA [5], based on three categories of parameters/indicators used in hydrological, morpho-hydraulic and physico-chemical studies of the water in the analysed area.

The table shows that out of the total parameters analysed regarding the water condition in the Bastroe Canal area, 31% are subject to a major risk of impact on the Danube Delta, and 22% of them on the Black Sea coastal area, due to the construction and its subsequent maintenance. In the Danube Delta a share of 69% of the analysed parameters can be improved by applying risk mitigation measures. Especially morphohydraulic parameters are of concern because more than half of them present a major risk of impact.

Regarding the coastal area of the Black Sea, a smaller proportion, only 33%, of the total parameters analysed requires risk mitigation measures. From the hydromorphological point of view, the possible impact given by the Bastroe Canal is more accentuated and requires more expensive mitigation measures for the coastal area compared to the Danube Delta area.

| Parameters / indicators | Risk of impact Danube Delta | Parameters / indicators | Risk of impact Coastal area |
|-------------------------|-----------------------------|-------------------------|-----------------------------|
| Hydrological parameters | Physico-chemical water quality parameters |

Table 1. Qualitative decisional analysis from the hydrological, morpho-hydraulic and physico-chemical point of view regarding the impact of the Bastroe Canal [5].
2.3. **Hydrobiology**

Research was performed on the state of habitats in the adjacent delta and marine area, on biological components: phytoplankton, macrophytes, zooplankton and aquatic macroinvertebrates. Following the analysis of zoobenthos in the marine area in autumn 2012 [5] it was observed that the diversity of species changed, registering in autumn 2012, 28 species of invertebrates, most being polychaetes (50%), followed by bivalves (36%) and crustaceans (14%), as opposed to 36 species in the fall of 2011.

2.4. **Deltaic and marine ichthyofauna**

The dredging and deepening of the Bastroe Canal activate the water circulation on the former Bastroe gorge and practically increases the migration routes of Danube mackerel and sturgeons, suggesting an apparently positive impact on migratory species. With the intensification of the naval traffic, this impact will become negative with major risk on the sturgeon migration routes. Maintaining the functionality of the Bastroe Canal through periodic dredging can locally and temporarily affect water turbidity and benthos, with a possible negative impact on sturgeon feeding. Juveniles of mackerel being pelagic will probably not be affected by these dredging works carried out during the maintenance of the canal. A possible progressive clogging of the Old Istanbul branch and especially of the Musura branch will have a major negative effect on the upstream sturgeon migration at risk of decrease with 67%.

2.5. **The avifauna**

DDBR shelters in the Romanian part over 100 colonies of aquatic species from the orders Pelecaniformes, Ciconiiformes and Charadriiformes (figure 10). 25 colonial species nest in mono or polyspecific colonies. Of these, 4 polyspecific colonies were and will be monitored on a long-term basis by ornithologists from INCDDDD Tulcea [5]. The colonies are investigated on land and water routes and, if the level of funding will allow it, aero-evaluations will continue to be performed.

### Table: Water Level and Flow Impact

| Parameter                  | Major | Medium | Reduced |
|----------------------------|-------|--------|---------|
| Water level                |       |        |         |
| Water flow                 | Medium|        | Reduced |
| Solid flow                 | Reduced|       | Major   |

### Table: Physical and Chemical Parameters Impact

| Physical parameters          | Medium | Reduced |
|------------------------------|--------|---------|
| Oxygen regime                |        |         |
| Chemical parameters - Heavy metals |        |         |
| Chemical parameters - Other indicators | |       |

### Table: Morpho-hydraulic Parameters Impact

| Parameter                  | Medium | Reduced |
|----------------------------|--------|---------|
| Section                    | Not the case |         |
| The width of the riverbed  | Medium | Not the case |
| Average speed              | Major  | Not the case |
| Average depth              | Major  | Not the case |
| Geomorphological processes | Major  | Major   |

### Risk Analysis

| Risk Category                  | Major | Medium | Total |
|--------------------------------|-------|--------|-------|
| Total major risk               | 31 %  | 22 %   | 69 %  |
| Total medium risk              | 38 %  | 11 %   | 49 %  |
| Total risk that requires mitigation measures | 69 % | 33 % | 102 % |

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**Note:** The total risk exceeds 100% due to overlapping impacts and considerations.
Figure 10. Pelecanus onocrotalus [5].

From long-term monitoring, it turned out that the main causes of the major decline in the number of pairs in the colonies on Musura Island are direct anthropogenic disturbances and the reduction of the island's surface due to hydromorphological factors. From the 9 species of birds that have nested in recent years, 7 species have had a variable reduction in the number of pairs (from mild to drastic or even complete). This is distressing because 5 species (Recurvirostra avosetta, Himantopus himantopus, Charadrius dubius, Sterna sandvicensis, S. hirundo) are included in Annex II (strictly protected wildlife species) of the Bern Convention. Therefore, out of the total species of birds that nested on Musura Island, 78% suffered an impact. The impact of hydrotechnical activities and the disturbance caused by the movement of ships [2] on populations of endangered species (some larval species) have also affected avifauna in Ukraine, especially bird species that use the area along the banks of the Danube and the Black Sea coast for food, shelter, reproduction, rest, moulting, circadian or seasonal movements. These species were especially affected during both initial and maintenance hydrotechnical activities. Due to the scale of the initial hydrotechnical works in the area of the Bastroe Canal, of the maintenance works but also of the naval traffic, from an ecological point of view, we can speak of a significant transboundary impact on the endangered ornithofauna.

3. Conclusions
Research was conducted on population dynamics, adaptation to disturbing factors in the study area and the conservation status of migratory fish, bird and mammal habitats as a result of disturbing factors in the study area. Taking into account all the information we have on the impact of the construction of the Băstroe Canal, a series of ecological effects can be anticipated in the Romanian sector of the Danube Delta Biosphere Reserve, but also in the neighbouring coastal marine region. Therefore, the induction of regional socio-economic mutations and implications in the prospective sustainable development of the region will need to be closely monitored. The sustainable management of the entire area requires a solid scientific basis using updated data and risk mitigation measures in order to maintain the sturgeon migration routes on the Chilia branch – Old Istanbul – coastal Black Sea.

References
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