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THE POSITIVE EFFECTS OF CHANNELS RESTORATION IN THE DANUBE DELTA BIOSPHERE RESERVE

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Abstract

Ecological restoration in the Reservation of Danube Delta Biosphere is a method of sustainable development of nature and local communities, for the medium and long term. The topography and structural variety of bed channels influence the hydraulic network and ecological restoration processes. To understand the general comportment of ecological restoration processes it is important to survey the channel from a bathymetric and topographic point of view. Modeling the ecological restoration processes commonly includes measures of water level, discharge, and velocity of channel transect. The present study aims to collect and analyze the topo-bathymetric survey data obtained for two periods for the channel Ivancea and Cordon Litoral, from the Reservation of Danube Delta Biosphere. This area was come under an ecological restoration phase by dredging it. The first survey expedition was made before the dredging (august 2021), and the last expedition was made after the dredging (after august 2021). The result shows that the use of modern method and equipment for the survey, ensure the highest accuracy for water circulation system data analysis. The data analysis highlights that ecological restoration increases the discharge and the water velocity. In conclusion, the dredging process is important for ecological restoration, in the context of deltaic systems. Also, the time-to-time monitoring of this process, let us understand the sedimentation rate, and how it influences the hydraulics overall.

***Key words**: ecological restoration, discharge, water velocity, hydro morphological monitoring, ADCP survey.*

INTRODUCTION

At the confluence with the Black Sea, the Danube has built an area of 5,800 km^2, which is one of the most important deltas in Europe, namely the Danube Delta, a UNESCO World Heritage Site, and a biosphere reserve (Gâştescu, 2009). The Danube Delta Biosphere Reserve (DDBR) is situated between 44°25′ and 45°30′ North latitude and 28°45′ 'and 29°46′ East longitude.

The DDBR is located in the geological unit of the Pre-Dobrogean Depression (Vespremeanu-Stroe & Preoteasa, 2015), at the edge of the Scythian Platform, the boundary between the North Dobrogea orogen and the territory occupied by the delta is given by the Sfântu Gheorghe fracture zone. Delta is located in a mobile area of the earth's crust characterized by subsidence (1.5-1.8 mm/year) and sediment accumulations (Vespremeanu-Stroe & Preoteasa, 2015).

The lake complexes, which are a significant feature of the lakes in the Danube Delta, are delimited by morphological elements (ridges, depressions, stage of evolution) and hydrographic elements (connection through canals and under the plateau or vegetation) (Banescu et al., 2020). In the DDBR the following aquatic complexes were outlined, presented in Figure 1:

- Somova - Parcheş (A) (predeltaic area);
- Şontea - Furtuna (B);
- Matiţa - Merhei (C);
- Gorgova - Uzlina (D);
- Red - Chicken (E);
- Dunavăţ – Dranov (F);
- Razim - Sinoe (G).

The ecological restoration in the DDBR has a positive effect from hidromorphological point of view.

This study aims to show the positive effects of Ivancea and Cordon Litoral channels restoration, by dredging processes.

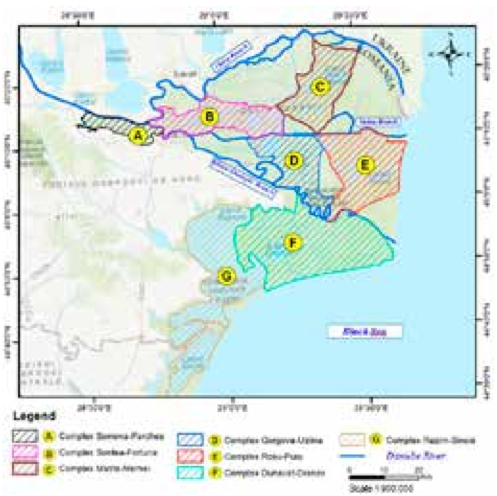

Figure 1. The map of main complexes of DDBR

MATERIALS AND METHODS

The study area is situated in the east part of Rosu-Puiu aquatic Complex, in the buffer zone of the confluence with the Black Sea. This area was supposed to a largeness process of ecological restoration, during the Operational Programme for Large Infrastructure (POIM), Project "Improving the hydrological conditions in the aquatic natural habitats of the DDBR for the conservation of biodiversity and fishery resources - Gorgova-Uzlina, Roșu-Puiu aquatic complexes" (*Operational Programme for Large Infrastructure - POIM*, 2016).

The main purpose of this restoration is to assess how the dredging processes of channel influence the sedimentation rate, discharge flow and water velocity flow, in context for improvement the hydrological condition for the aquatic natural habitats.

To understand these effects, we choose to compare two topo-bathymetric surveys for cross-section situated on Ivancea an Cordon Litoral channels. In this regard 5 cross-section was surveyed for the experimental analysis (Figure 2). The first survey was made in August-September 2020 period when the channels was not constrained to dredging processes. The last survey was taken in period of August-September 2021, when 3 of these 5 cross-sections was dredged.

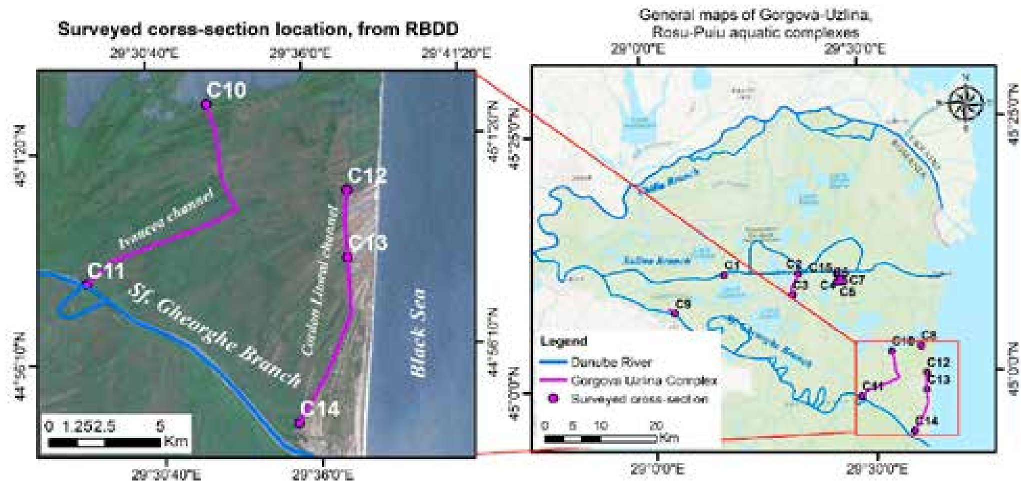

Figure 2. The geospatial position of surveyed cross-section: C10, C11, C12, C13 and C14

The survey of cross-sections was made in two phases: topographic survey for banks area, and bathymetric surveys for underwater areas (the riverbed part of channel, Figure 3 e).

The topographic surveys were made with Global Navigation Satellite System Receiver (GNSS) Topcon HiPer HR, produced by Topcon, and South S82-V GNSS equipment's (Figure 3 a, b).

The River Surveyor M9 ADCP, produced by Xylem was used for bathymetric measure-ments, especially for depth, discharge and water velocity data (Figure 3 c, d). The RiverSurveyor M9 the profiler module is mounted on a powerboat which resist at small waves, but is very adaptable for rapid and accurate discharge measurements in unsteady flow conditions (Turunen et al., 2020). The width of the river and the location of vertical water column velocity and discharge is also provided by ADCP device (Wosiacki et al., 2021). To determine the water level related to national Datum - Black Sea Sulina (BS Datum), was used two levelling equipment, with millimeter precision: Leica Sprinter 250 M, produced by Leica Geosystems and Topcon DL-501, produced by Topcon Positioning Systems (Figure 3 f, g).

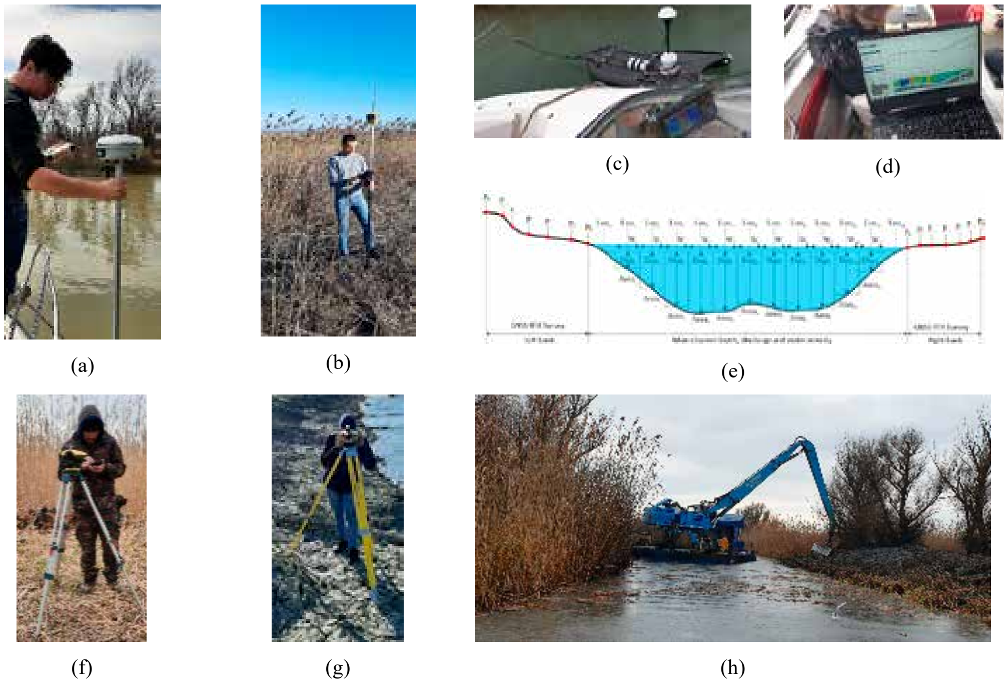

Figure 3. The main important instruments and methods used for survey campaigns, in order to assess the positive effects of channels restauration: (a) - GNSS receiver South S82-V; (b) - GNSS receiver Topcon HiPer HR; (c) - River Surveyor M9 ADCP; (d) - River Surveyor Live software for discharge and water velocity record; (e) - discharge and velocity values computing; (f) - Leica Sprinter 250 M levelling instrument; (g) - Topcon DL-501 levelling instrument; (h) - the dredging process on Ivancea channel

RESULTS AND DISCUSSIONS

The survey occurred in August-September period 2020 was limited due to the fact of accentuated sedimentation rate and the limitation of depth on the Ivancea channel. The discharge and water velocity on C11 cross-section was very reduced, caused by the high sedimentation rate and low water level in 2020 year. The abundance of vegetation and the depths between 0.5-0.15 cm cannot ensure surveys with River Surveyor M9 ADCP.

During the 2021 campaign the terrain elevations, depths, discharge and water velocity was surveyed for all five cross-sections.

The results of measured depth, discharge (Q) and water velocity survey parameters are presented in Figures 4-13.

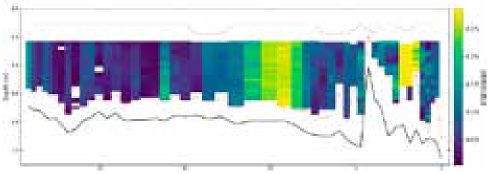

Figure 4. ADCP survey C10 cross-section (Ivancea channel) in 2020 campaign

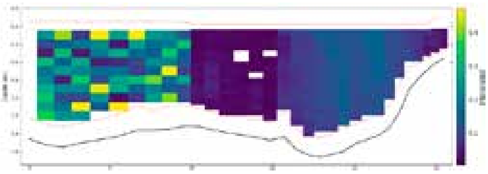

Figure 5. ADCP survey C10 cross-section (Ivancea channel) in 2020 campaign

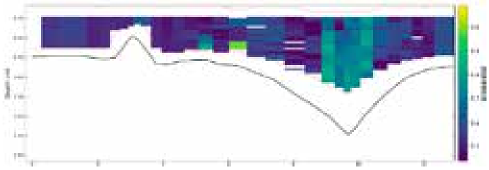

Figure 6. ADCP survey C11 cross-section (Ivancea channel) in 2020 campaign

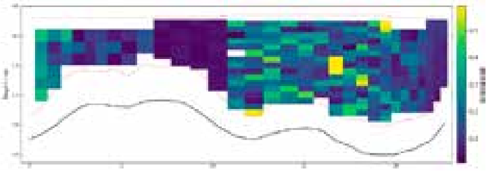

Figure 7. ADCP survey C12 cross-section (Ivancea channel) in 2021 campaign

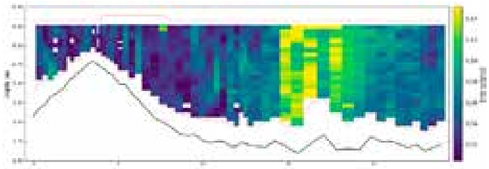

Figure 8. ADCP survey C12 cross-section (Cordon Litoral channel) in 2020 campaign

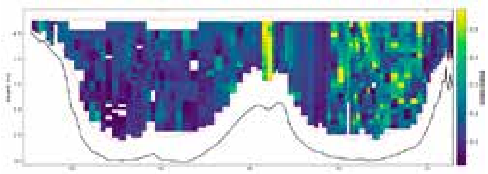

Figure 9. ADCP survey C12 cross-section (Cordon Litoral channel) in 2021 campaign

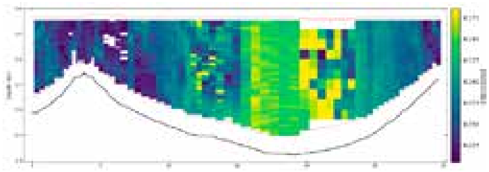

Figure 10. ADCP survey C13 (Cordon Litoral channel) cross-section in 2020 campaign

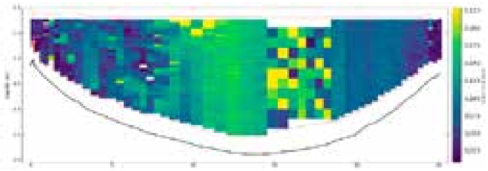

Figure 11. ADCP survey C13 cross-section (Cordon Litoral channel) in 2021 campaign

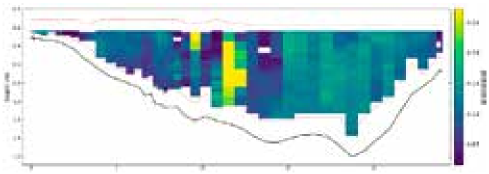

Figure 12. ADCP survey C14 cross-section (Cordon Litoral channel) in 2020 campaign

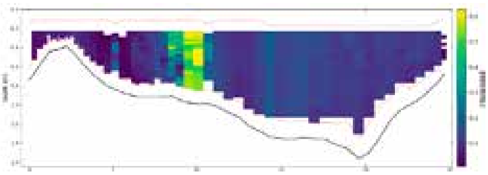

Figure 13. ADCP survey C14 cross-section (Cordon Litoral channel) in 2020 campaign

The results from ADCP survey show that the water velocity speed increase from $0.08 m \times s^{-1}$ to $0.11 m \times s^{-1}$ for C10 cross-section, from first to second survey. A significant difference for discharge and water velocity was identified for C11 cross-section. For this profile the discharge increase with 87%, and velocity with 18%. The C13 and C14 has the smallest difference between survey campaigns. The increase was less 10%.

To assess the difference between discharge and depth data, it was used the normalized distance from the streambed. Each segment was divided into 5 percent, from 0.05 to 1 (Figure 14).

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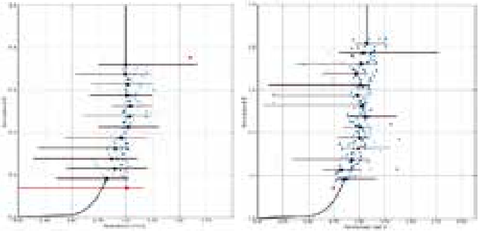
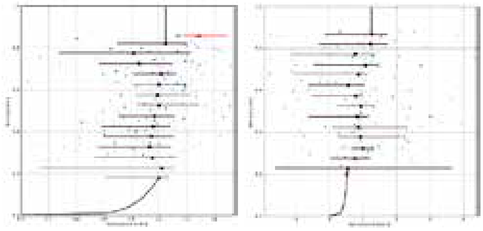
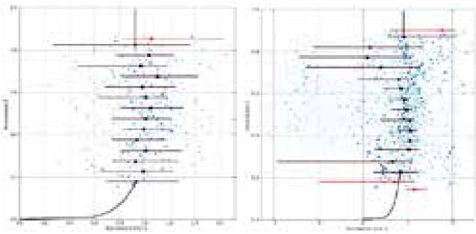
For each discharge segment was represented the median value.
All the obtained normalized value was assigned to depth data for corresponding column. All the number of points used for depth survey in cell column is reported by blue color (Figure 14). To compute the extrapolation for non-measured depth cells only the medians with sufficient points was used, by applying the 20% thresholds.



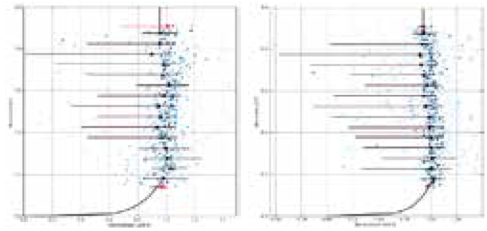
(a)



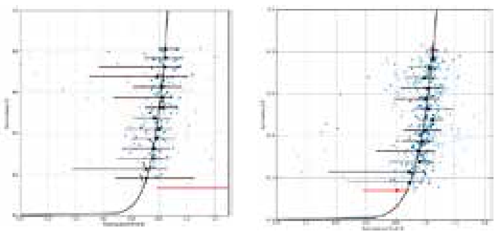
(b)



(c)



(d)



(e)

Figure 14. The extrapolation statistical analysis depending of medians for depth data of each beam cell, for cross-sections measured in 2020 survey campaign (left image) and 2021 survey campaign (right image): (a) - C10 cross-section; (b) - C11 cross-section; (c) - C12 cross-section; (d) - C13 cross-section; (e) - C14 cross-section

Figure 14 shows the medians points for an individual transect in black color. If the threshold is exceeded the dots are represented in red. The represented whiskers show the 25th percentile on each median value, and 75th percentile of all the data, for the input condition of increment. There are no significant points which fall within 50% of the limits of whiskers.
The statistical analysis of normalized data for C10-C14 cross-section point out a better fit of extrapolation results after dredging process (2021 survey campaign).

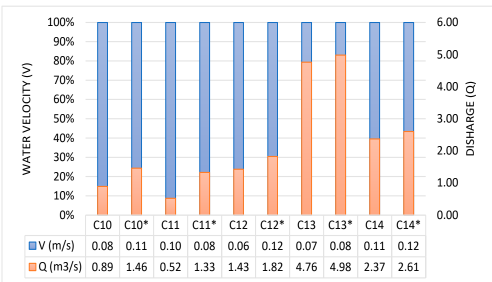


Figure 15. The discharge (Q) and water velocity increase comparison between two survey campaigns

The discharge (Q) for C13 is higher than 4.5 $m^3 \times s^{-1}$. These high values depend on fluctuation of water level in Danube River and Cordon Litoral channel junction with nearest channels. When the water flows in C14 profile direction the discharge value decrease to 2.37 in 2020 year and 2.61 in 2021. This is due of so-called effects "reverse-flow" of Danube River. These effects lead to the decrease of water velocity because the higher water level of Danube River push the water back to the channel. C14 cross-section has an accentuated sedimentation rate, versus C13 profile. The 0.125 – 0.225 $m \times s^{-1}$ water velocity value for C13 profile is proportionally distributed for more than 60% of entire length of these, contrary to C14 profile where the higher water velocity a concentrated only on left side of the cross-section. Thus, these run to sedimentation in right part of profile.

CONCLUSIONS

The ecological restoration by dredging processes of Ivancea channel and Cordon Litoral channel led to a positive effect on water flow parameter. After the ecological restoration process the average discharge for all 5 cross-sections increase with 34.82%. The water velocity also has increased its value with 25.75%, especially for C12 cross-section where the velocity increase with 66.66%, from first to second survey.

At the same moment the ecological restoration changes the entire morphology of the channel. During the first survey campaign in 2020 year, close to C11 cross-section the water depth was critically low with an average of 0.96 m, referred to BS level Datum. After the channel reconstruction the average depth at this profile climbed up to 2.04m. An important positive effect of restoration was identified for C12 cross-section, where the depth increases with more than 59.62%.

The restauration of these channel has an important role not only on hidromorphological parameters of channels, but also on the whole habitats and water ecosystems. By increases the depths, discharge and water flow velocity we facilitate the fish migrating. At the same time, by the dredging process we contribute to self-cleaning deltas water ecosystems.

The next step derived from this survey campaign is to asses from scientific point of view how we can predict the maximum discharge water flow on these channels, based on historically maximum water levels height.

ACKNOWLEDGEMENTS

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