

INVESTIGATING CURRENTS, FLOW VELOCITIES, AND RIVERBED MORPHOLOGY - AN ADCP-CENTRIC APPROACH TO UNDERSTANDING HYDRODYNAMICS AND EROSION PATTERNS

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Abstract

The sediment movement on a river plays a crucial role in safe navigation and economic activities on navigable channels. Environmental changes over time are given by the morphological characteristics of the riverbed during seasonal water variation on the Danube River. This study presents a comprehensive assessment of the Danube River's velocity and current characteristics based on Acoustic Doppler Current Profiler measurements. The correlation between flow velocities and depths helps to understand the factors that influence sediment patterns and provides insights into the sustainable management of the river system. The study was conducted along a 71-kilometer length of the Sulina Branch from the Danube River, where ADCP measurements were collected at multiple locations and over periods. The data collected included water depth, flow velocity, and current direction. By clustering the column depth cell velocities, it revealed significant spatial and temporal variations in the velocity and current patterns, influenced by factors such as river morphology, discharge, and seasonal changes.

Keywords: ADCP, multibeam bathymetry, sediment deposition, water velocity, Sulina branch, river discharge.

INTRODUCTION

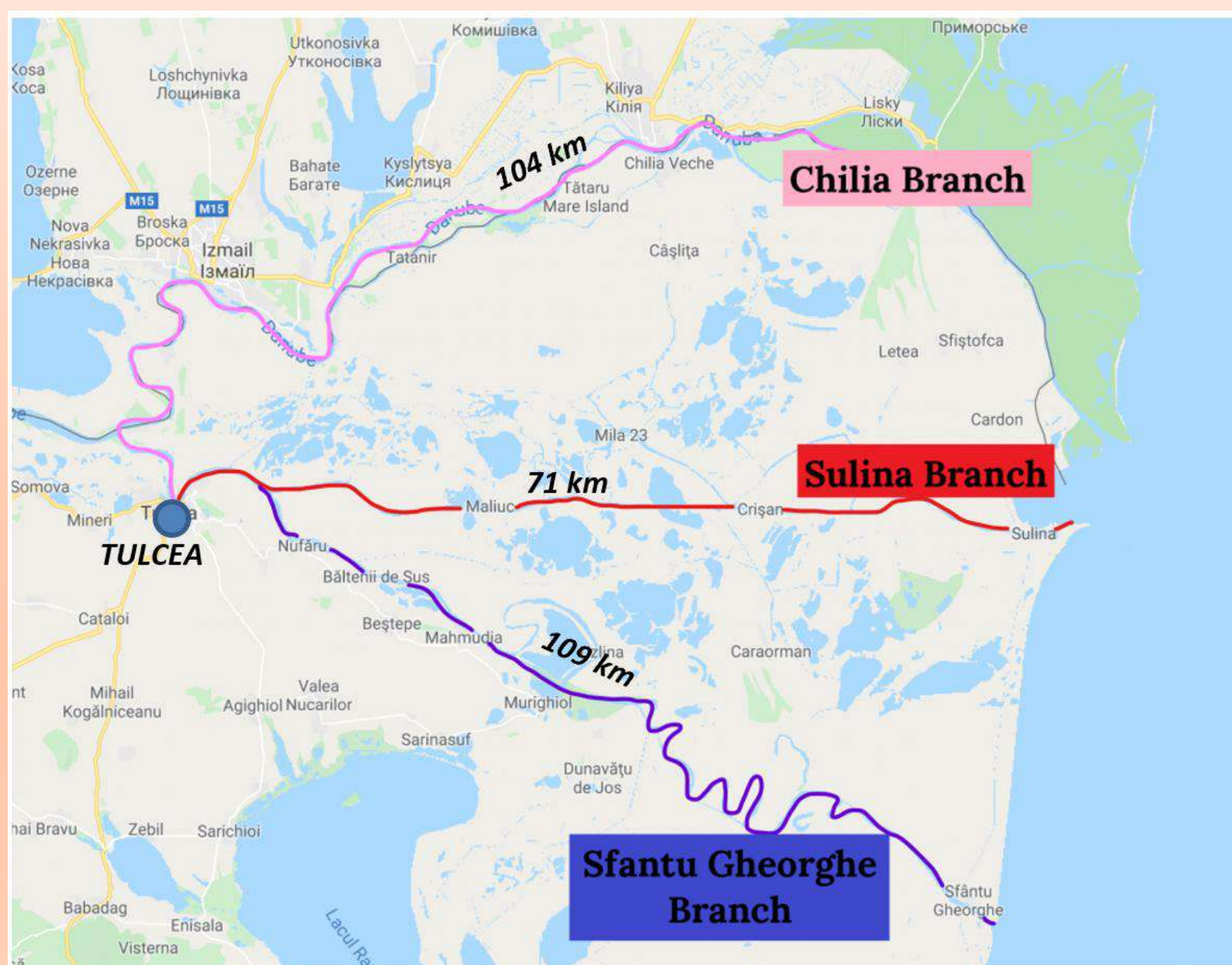


Figure 1. The main branches of the Danube River

The present study aims to investigate the relationship between hydro-morphological parameters surveyed on the Sulina branch from the Danube River. The physical characteristics and dynamic parameters help to understand the patterns of erosion, underwater forms, and turbulence in the study area.

The Sulina branch is the main waterway of Romania, for the ships with a maximum 7.01m ±10-15cm draught, from the Black Sea up to Braila city. (Cociasu et al., 1996; Giosan et al., 2006). The Sulina branch carries a significant amount of sediment, particularly during flood events, which can lead to the deposition and accumulation of sediments Danube Delta.

MATERIALS AND METHODS

The study area is focused on the Sulina branch on 6 points of observation located downstream of Partizani, Maliuc, Gorgova, Crisan, and Sulina villages (Figure 2), and one at an intermediate point between T4 and T6. To obtain a detailed picture of the hydro-morphological parameters on the Sulina branch, several measurement campaigns were carried out. ADCP (Acoustic Doppler Current Profiler) technology was used (Figure 3). Energy flow - equation 1 (Guseva et al., 2021) and the total suspended sediment concentration (SSC) on each vertical profile from each cross-section was calculated – equation 2 (Boldt, 2015).

$$E = \frac{1}{2} \cdot \rho \cdot Q \cdot v^2 \quad (1); \quad \log_{10} SSC = \log_{10}(a \cdot 10^{b \cdot DB}) \quad (2)$$

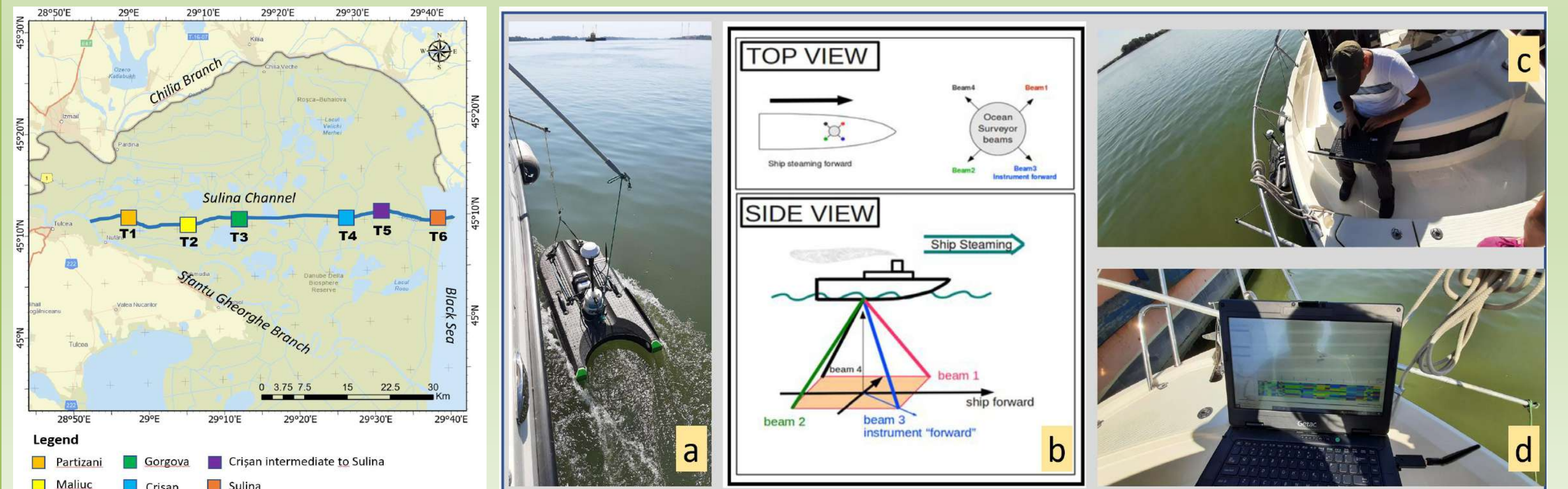


Figure 2. Study area

Figure 3. Study area map located on the Sulina navigable channel from the Danube Delta area

RESULTS AND DISCUSSIONS

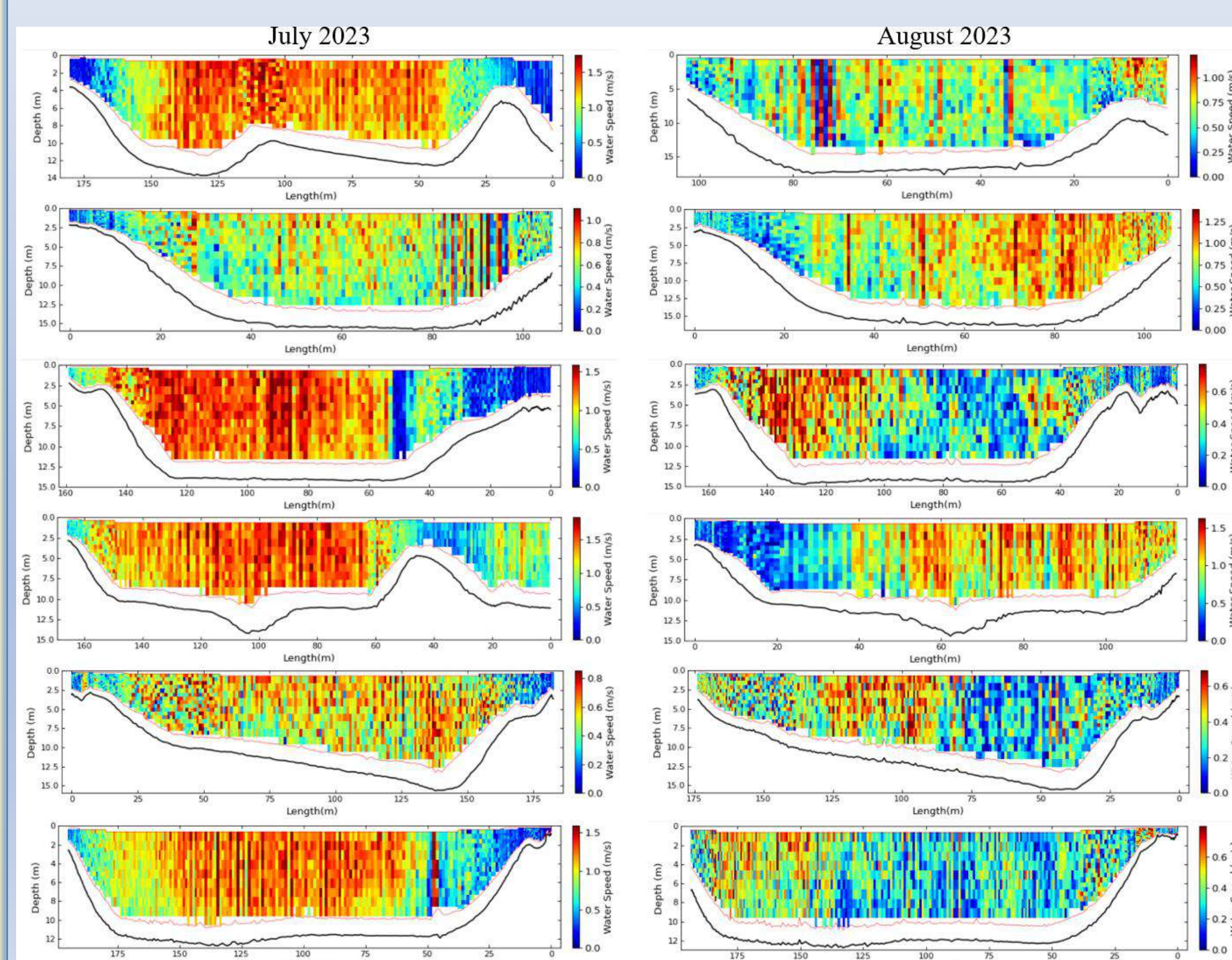


Figure 4. The ADCP velocity representation on the T1 to T6 cross-section

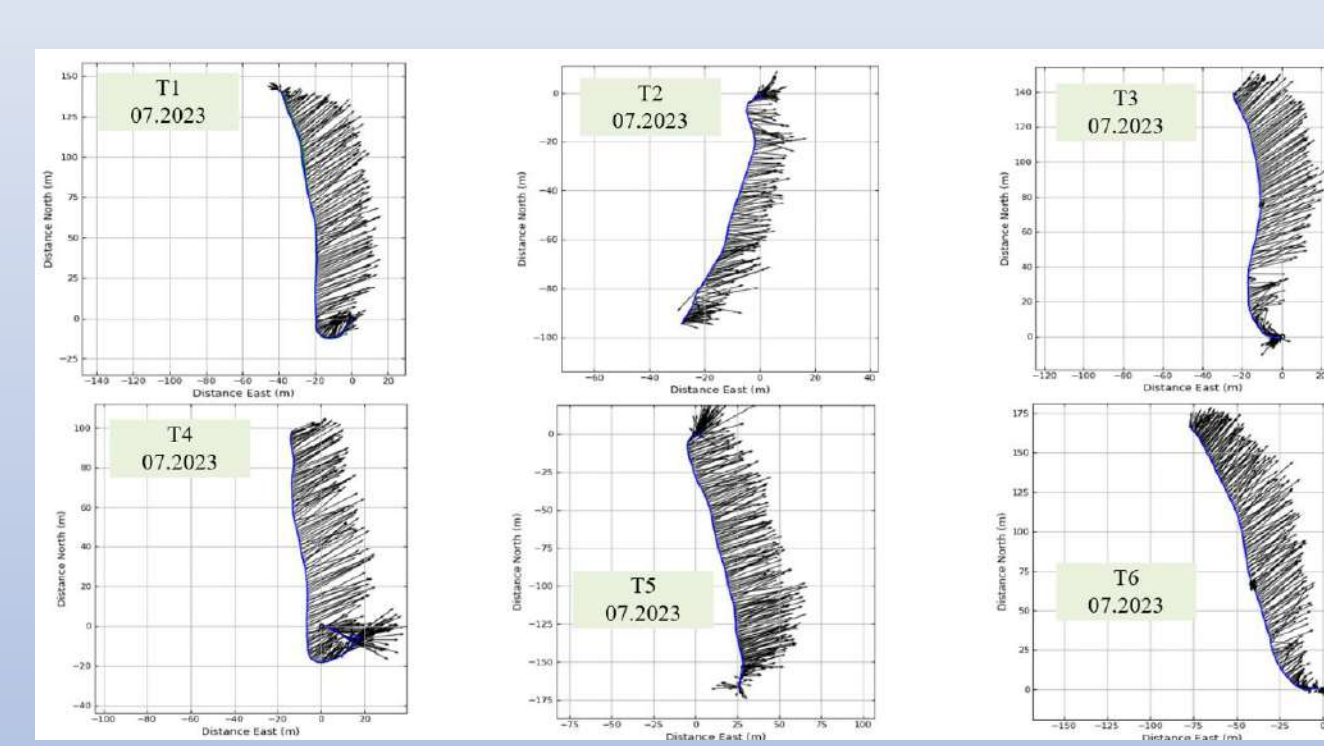


Figure 5. Directions, and intensities of currents for the July survey

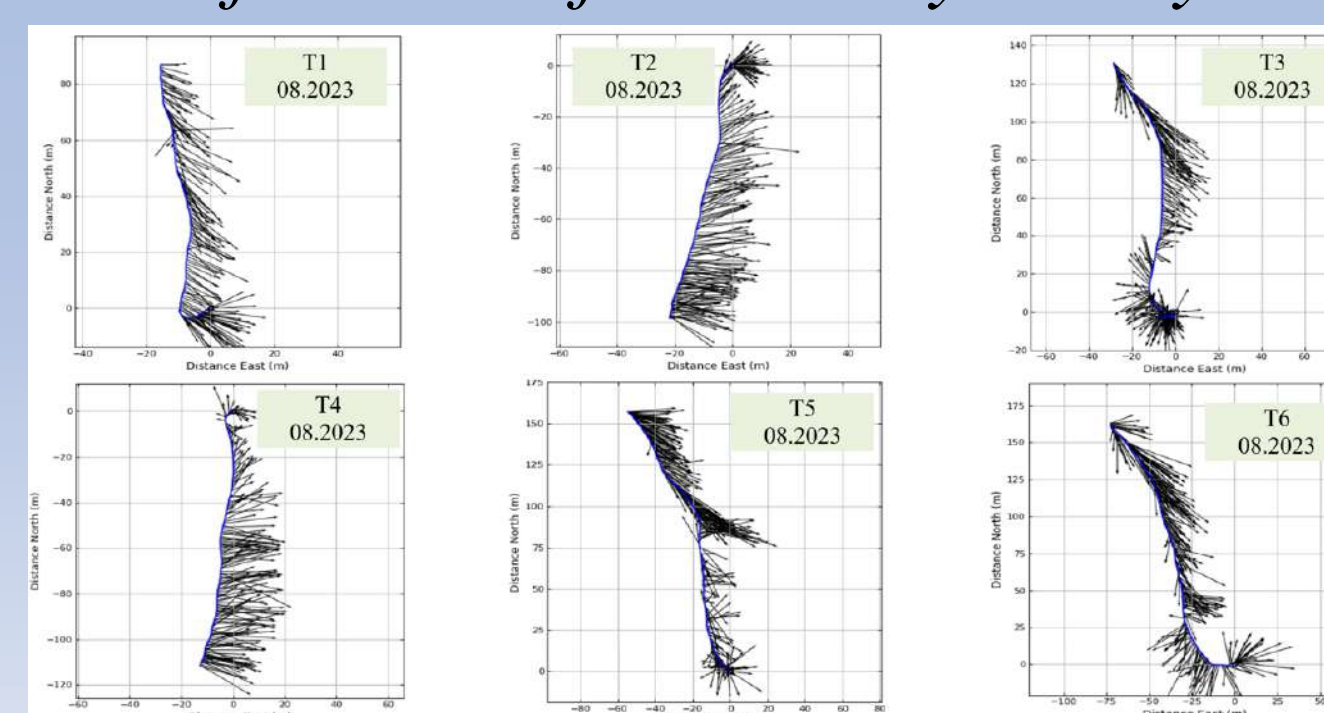


Figure 6. Directions, and intensities of currents for the August survey

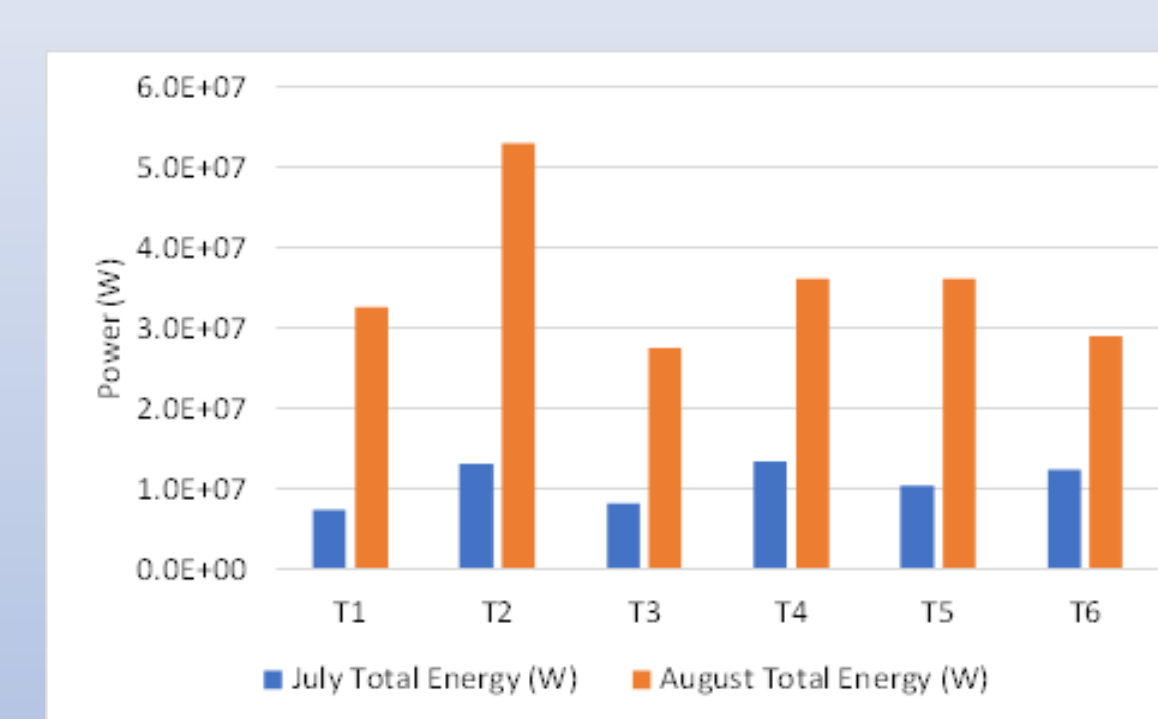


Figure 7. The total energy power

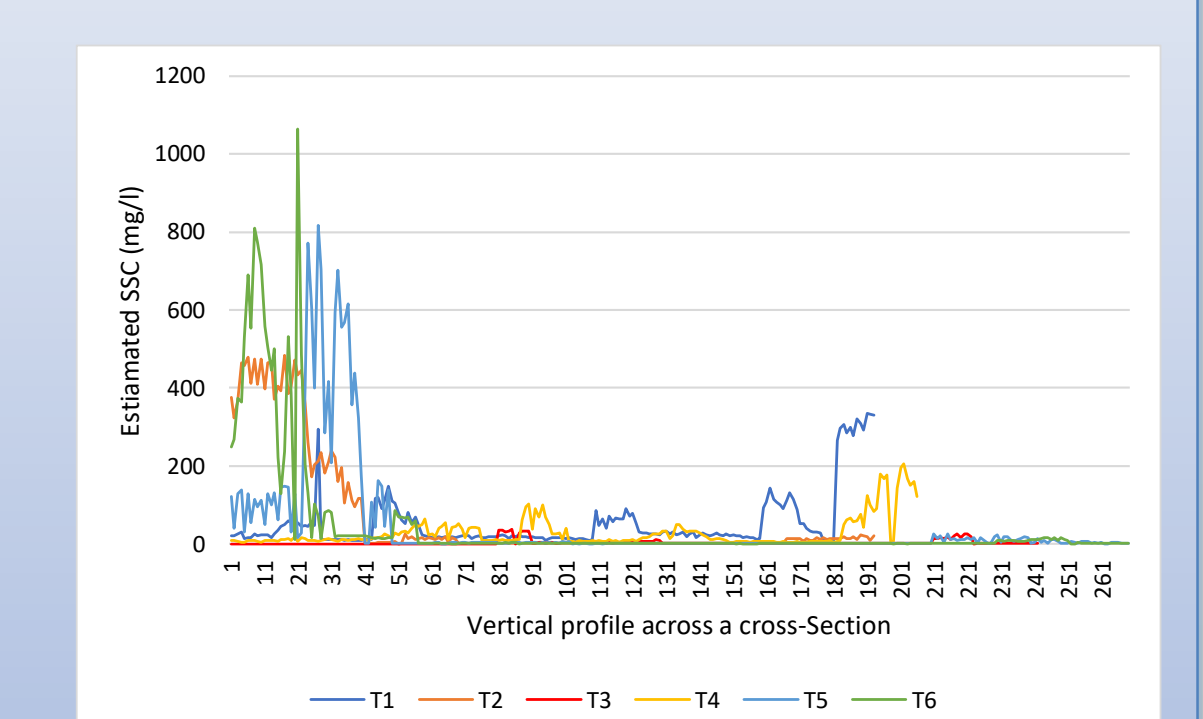


Figure 8. SSC – ADCP estimation on the July 2023 survey

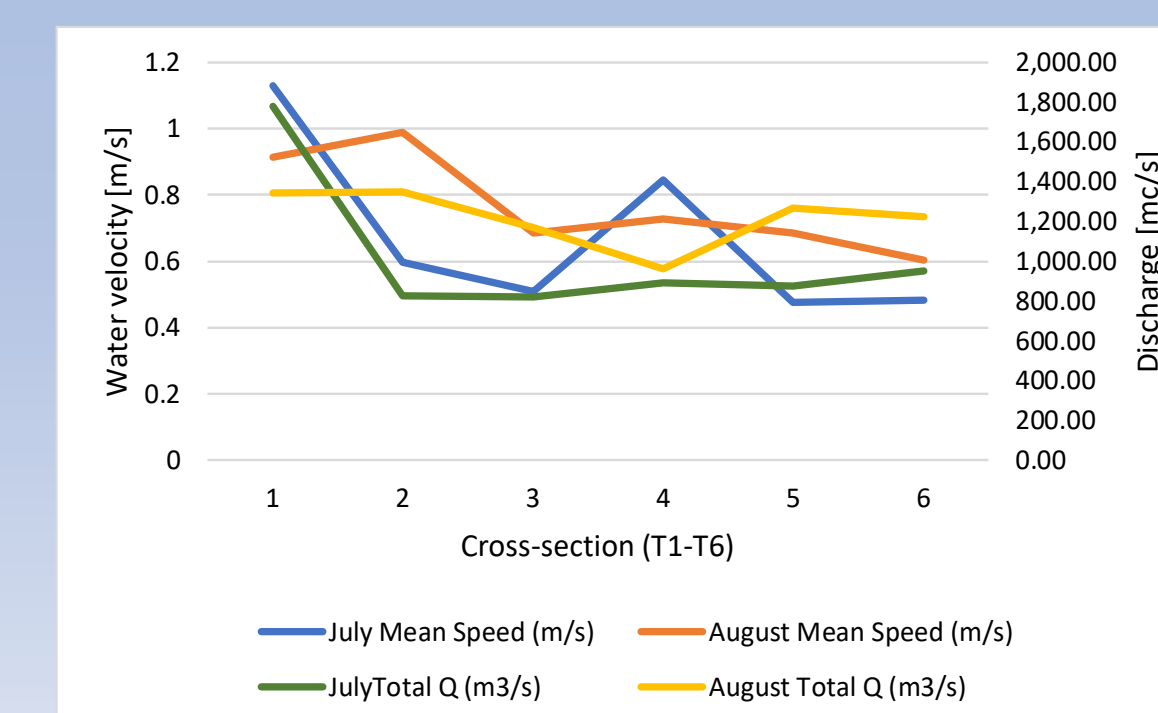


Figure 9. The water V and Q average values

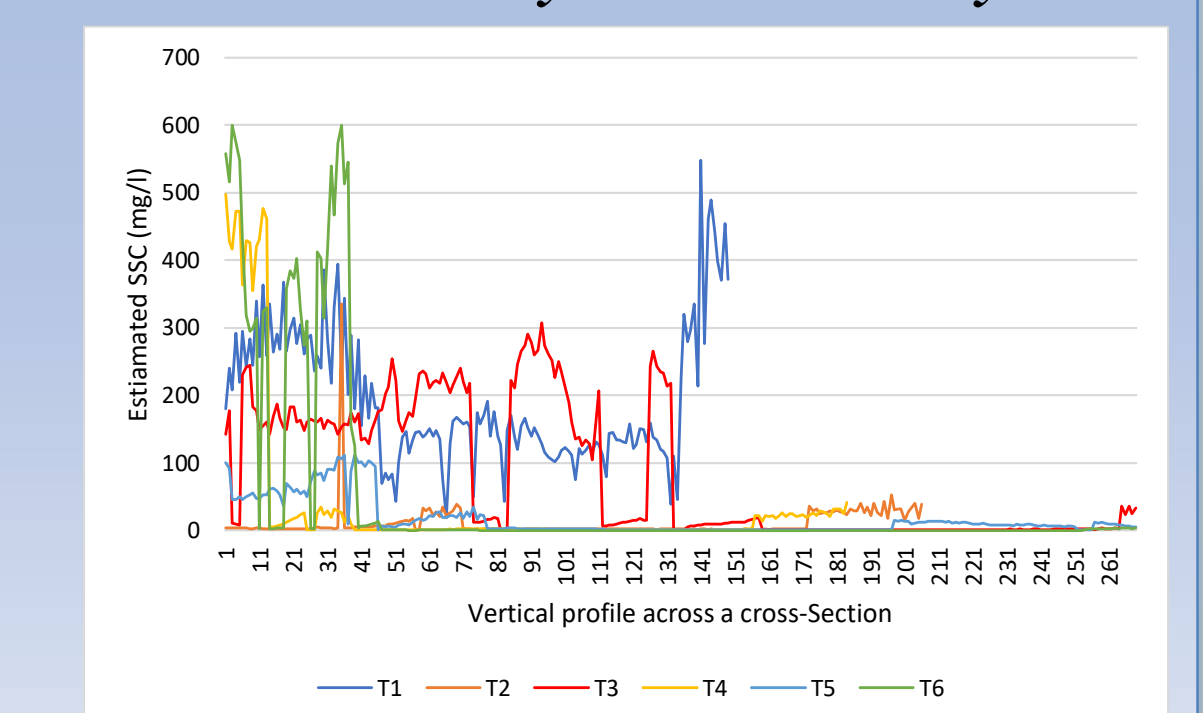


Figure 10. SSC – ADCP estimation - July 2023 survey

CONCLUSIONS

The research study carried out for the monitoring of flow currents by the ADCP method helps to determine the phenomenon of sediment transport in fluvial environments. The high values of the SSC concentration in July 2023 (1064.5 mg/l) and August 2023 (941.4 mg/l) in section T6 show the presence of sediment transport processes towards the confluence with the Black Sea, and their deposition in the „Bara Sulina” area. The hydrodynamic parameter E (energy), increased in value especially in August 2023, in the upstream sections T1 (3.3×10^7 W) and T2 (5.3×10^7 W), and decreased in value in the T6 section in both months, indicates the erosion trend from upstream to downstream. Applying the method of estimating the SSC from the backscattering of the ADCP signal, we concluded that the largest amounts of sediments are in the downstream area of the Sulina channel. The effect of sediment transport from upstream to downstream only increases the clogging of the Sulina channel at the confluence with the Black Sea. Thus, continuous monitoring and investigation of currents and flow velocities by the ADCP method is mandatory.

ACKNOWLEDGEMENTS

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