

Executive Summary of the ecological crime scene investigation report

Fish kill in the Neretva River in September 2025: Identifying water releases from the Ulog Hydropower Plant as likely cause

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In September 2025, a major fish kill occurred in the upper Neretva River, immediately downstream of the newly constructed Ulog Hydropower Plant (HPP). Local fishermen reported hundreds of dead fish, including the critically endangered softmouth trout, as well as white-clawed crayfish. The fish die-off was observed directly following three abrupt rises in river discharge recorded at the Kašići gauging station and consistent with sudden reservoir releases ("hydropеaking").

The Ministry of Spatial Planning, Construction and Ecology of Republika Srpska publicly claimed there was no evidence linking the fish kill to Ulog HPP. Here, we present the results of an ad hoc investigation that refute this claim and identify Ulog HPP as a textbook case for ecologically destructive hydropower operation.



In early September, a fish kill occurred downstream of the Ulog Hydropower Plant, also claiming endangered softmouth trout and other endangered species. © Hrabren Kapić, Organizacija Sportskih Ribolovaca "Konjic"

Key Findings

1. Strong reservoir stratification caused oxygen depletion in deep water layers.

Depth profiles of **temperature** (red) and **oxygen concentration** (blue) in the reservoir near the dam (**Figure 1**), measured on 28 Sept 2025, indicate a clearly stratified water column. Temperature measurements reveal a warm, oxygenated surface layer, a sharp thermocline at 4–5 m depth (marked by horizontal red dotted lines), and a deep hypolimnetic layer isolated from atmospheric exchange. Oxygen concentrations show a pronounced minimum at the thermocline (as low as 0.68 mg L^{-1}) and remain **below critical survival thresholds for trout** throughout depths below 5 m—including the depth windows where water is drawn into the penstocks (dark grey bar at 9.6–13.5 m). While the shallow oxygen minimum reflects respiration of sinking algae from summer algal blooms, the low-oxygen conditions at greater depths are typical for newly flooded reservoirs with large amounts of decomposing organic matter from formerly forested land. The **penstocks** likely drew water from low-oxygen layers during the releases of early September, but if reservoir levels dropped—as confirmed by satellite data—extremely hypoxic water ($<1 \text{ mg L}^{-1}$) may have reached the penstocks.

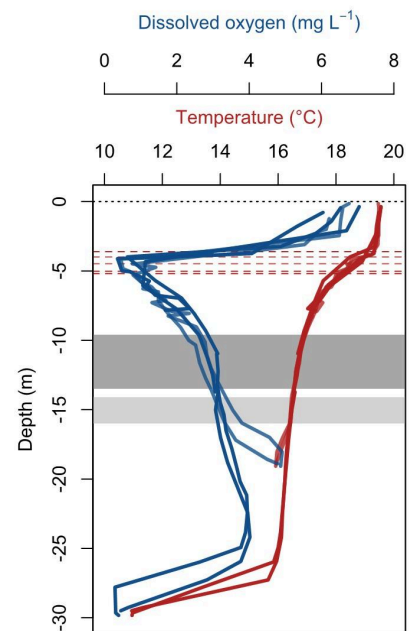


Figure 1: Depth profiles of temperature and oxygen in Ulog HPP reservoir.

- ### 2. Analysis of public hydrograph data shows multiple sudden flow increases that cannot be explained by rainfall alone. At the time of the fish-kill incident (**Figure 2**), two distinct hydropeaks raised the local discharge at the powerhouse by a factor of 15, thus creating sizeable and sudden flood events. These two hydropeaks were followed by a mixed discharge event, which could be decomposed into a rainfall-driven component and **a longer than average hydropeak** attributable to reservoir releases. The shape of the mixed event, in particular its rising and falling limbs, is inconsistent with natural flow patterns and strongly indicative of a substantial hydropeak that required ~ 34 hours of continuous reservoir release.

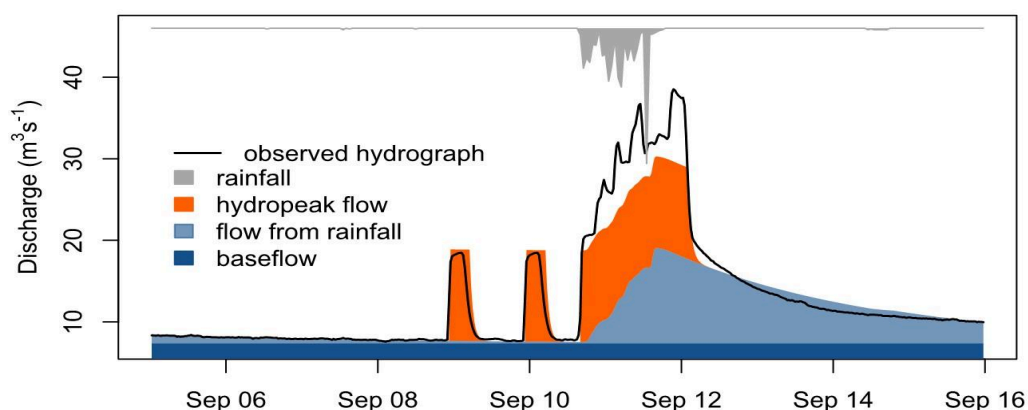


Figure 2: Results of hydrograph partitioning for flow during the fish kill incident.

3. **Remote sensing and reservoir volume changes:** Sentinel-2 imagery shows that the reservoir surface area decreased from 535,877 m² on 5 September to 404,498 m² on 12 September, corresponding to a water level drop of ~2.5 m and a net volume loss of 1.18 million m³. Even without accounting for simultaneously occurring inflow into the reservoir, this net volume loss can only be explained when the third long hydropeak is included in the computation of cumulative flow observed downstream. Remote sensing data thus confirms substantial operational releases coinciding with the fish kill incident.

4. **Downstream oxygen dynamics:**

Re-oxygenation modelling indicates that oxygen-depleted water released from the reservoir would not gain oxygen quickly enough in the fast-flowing and deep Neretva River downstream of the powerhouse. Spatial modelling at the end of a modelled 6-hour hydropeak (**Figure 3**) identifies a low-oxygen (red) river section unsuited for trout survival, that extends from the powerhouse to at least the confluence with the Ljuta River entering from the north. The length of this 'death zone' matches the observed spatial extent of the fish kill, yet critical oxygen levels (yellow, ~6 mg/L) extend even further downstream. Notably, the river section with critical oxygen concentrations changes its length dynamically as a consequence of the hydropeaking flow regime, and thus likely acts as an ecological trap for trout moving in during the long periods with non-critical oxygen conditions. In contrast, the short section immediately downstream of the dam remains persistently hypoxic and is never suitable for trout survival.

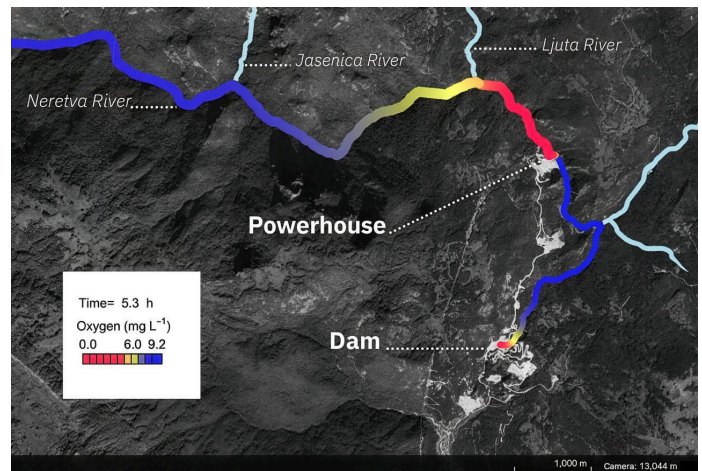
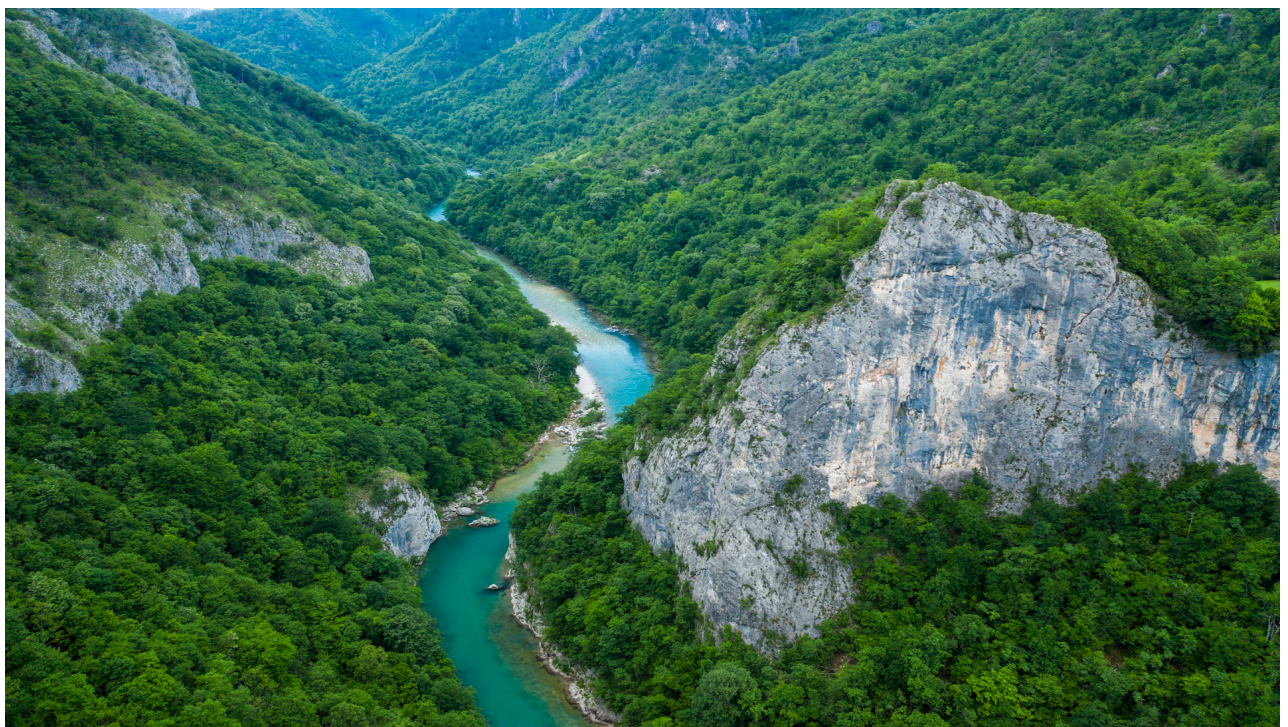


Figure 3: Patterns of oxygen concentration in the Neretva River downstream of the dam at the end of a hydropeak.



The Neretva downstream of the Ulog Hydropower plant. © Bruno D'Amicis

Conclusion

The fish-kill incident observed in the Neretva River in September 2025 was **highly likely caused by the operation of the Ulog Hydropower Plant**. All available evidence—from reservoir stratification, hydrograph partitioning, remote sensing, and re-oxygenation modelling—strongly supports the conclusion that **Ulog HPP operated in a hydropeaking mode**, releasing deep, oxygen-depleted, chemically altered water in sudden flow pulses, which suffocated fish and crayfish. **This mode of operation is in violation of Ulog HPP's environmental permit.**

We recommend:

- Stop hydropeaking and enforce the operation of the Ulog HPP in accordance with its environmental permit in run-of-the-river mode.
- Install a monitoring system in the reservoir and downstream of the dam, that transparently reports oxygen concentration, water temperature and discharge. Such data may also be used to guide HPP operations.
- Keep the remaining sections of the Neretva River network free-flowing to safeguard its unique biodiversity.