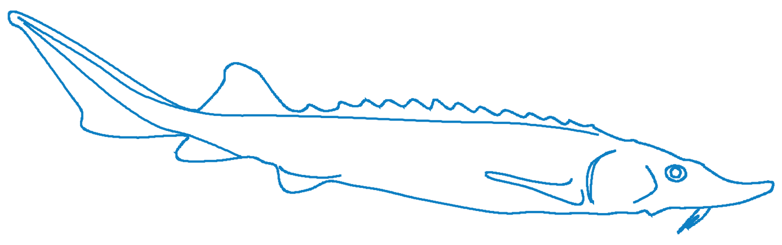
Hypoxia tolerance in *Acipenser sturio* juveniles



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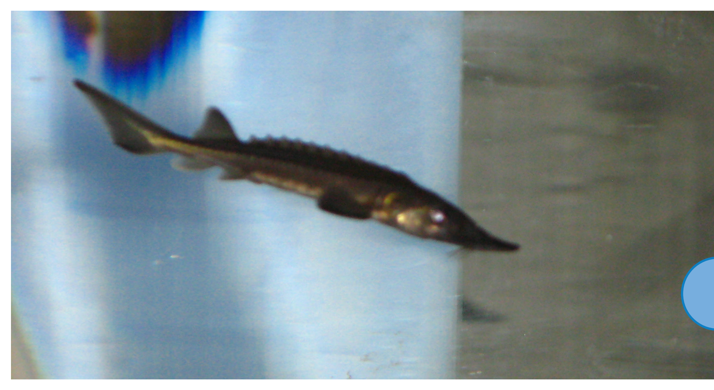
Formerly present in European coastal waters from Black Sea to North Sea, European sturgeon *(Acipenser sturio)* populations have drastically declined due to anthropogenic pressure (*Lepage et al. 2000; Williot et al. 2002*).

The last population, which colonized the Gironde-Garonne-Dordogne basin for reproduction, is greatly threatened of extinction. An ambitious restoration program was defined in the framework of the Berne Convention (*Rosenthal et al. 2010*) with concrete action plan developed in France and Germany (*Anonyme 2011; Gessner et al. 2010*). As part of the restoration program, stocking operations were managed (*Acolas 2012*) and from 2007, more than 1 million larvae or juveniles were stocked in the Gironde-Garonne-Dordogne basin.

During their migration to reach the estuary, stocked fish have to cross a mud plug located in the upper part of the estuary, which presents severe hypoxic events during summer (*Abril et al. 1999*).

The goal of this study was to assess the hypoxic tolerance of European sturgeon juveniles.



MATERIAL AND METHODS

Experimental approach

based on Critical Thermal Limit (la ref biblio) and U-Crit (les ref biblio) determining

Fish

Age : 3 months
Length: 12±0.1 cm mean±SE
Weight: 7.3±0.3 g mean±SE
Number of fish per tank: 3

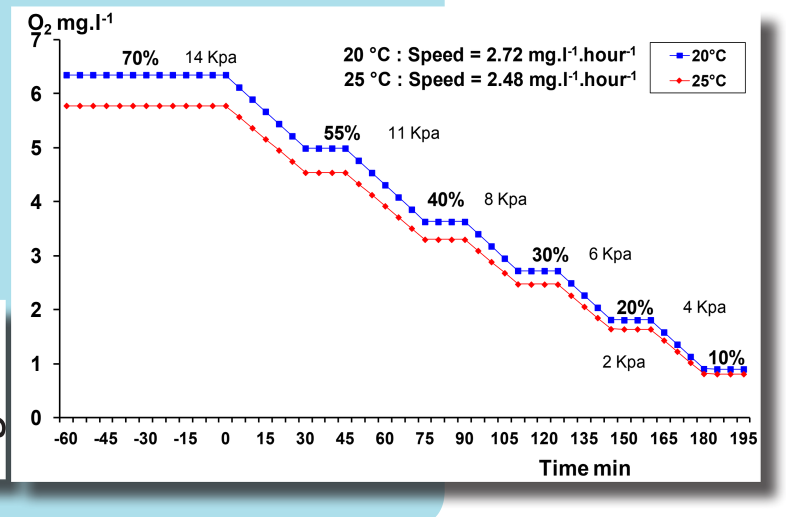
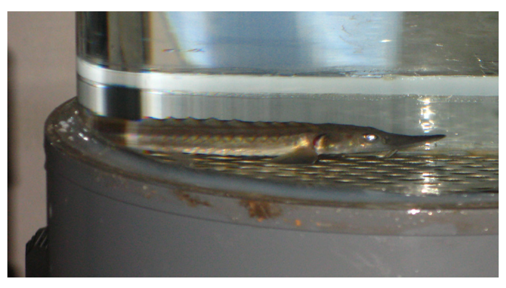


Figure 1

Experimental method

Programmed deoxygenating procedure (Fig 1)
3 behavioral indicators (altered swimming, loss of equilibrium, death)
Opercula beats (video recording)

Four 14 liters experimental tanks (3 replicates + 1control) (Fig 2)
3 experiments per temperature



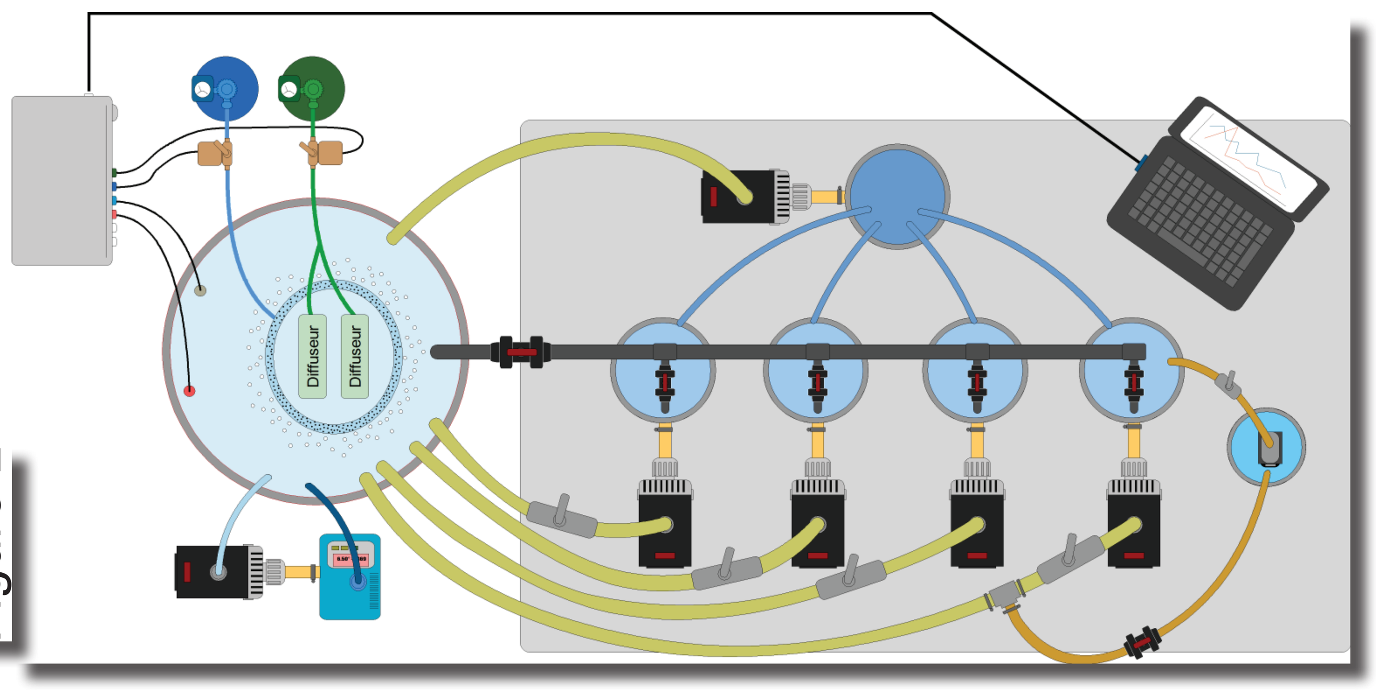


Figure 2

RESULTS

Behaviour (Figure 3)

At 20°C, altered swimming was observed at 3.13 ± 0.10 mg.l^{-1} mean±SE compared to 3.59 ± 0.07 mg.l^{-1} mean±SE at 25°C (Mann Whitney, p=0).
On the other hand, no significant difference was recorded between the 2 temperatures for the other behavioural indicators.

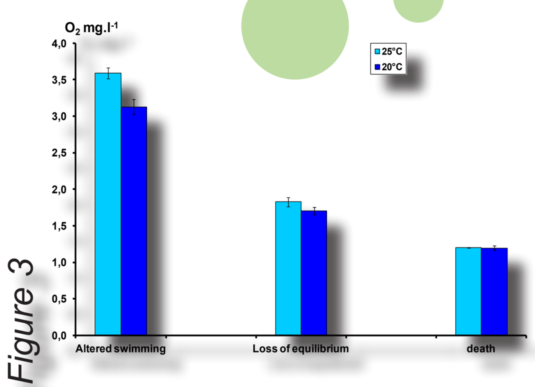


Figure 3

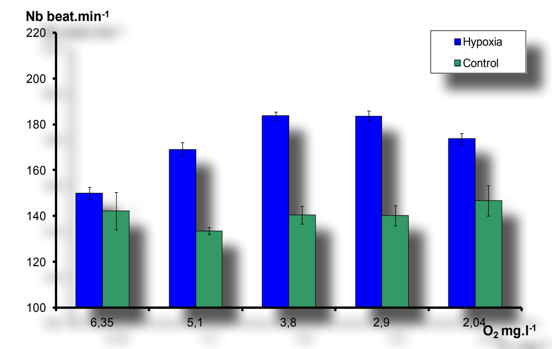


Figure 4

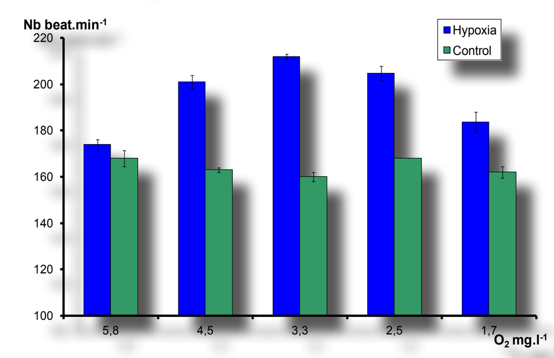


Figure 5

Loss of equilibrium appeared at 1.71± 0.05 mg.l^{-1} mean±SE and 1.83 ± 0.06 mg.l^{-1} mean±SE at 20 and 25°C respectively, and was significantly different from altered swimming and death (Mann Whitney, p=0). Whatever the temperature, fish in the control tank did not exhibit any modification of their behavior.

Opercular Beat Frequency (OBF) (Figures 4 and 5)

Whatever the temperature, OBF exhibited a similar pattern, with an increase with decreasing O_2 level until 3.8 and 3.3 mg.l^{-1} for 20 and 25°C respectively, and a decrease afterwards. At both temperature, OBF in fish exposed to hypoxia were significantly different from control fish (Kruskall-Wallis, p=0).

At 25°C OBF were increased in both experimental and control groups compared to 20°C (Mann-Whitney, p=0)

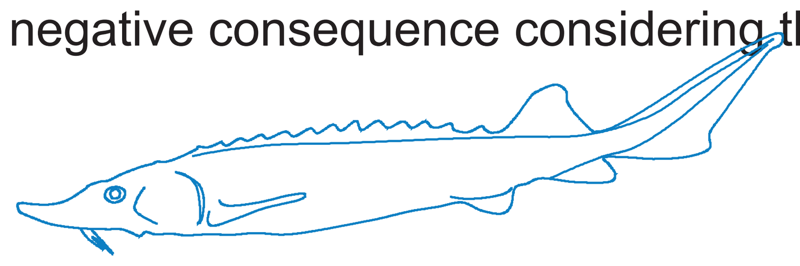
DISCUSSION

Temperature did not seem to have a great influence on the appearance of behavioural indicators (loss of equilibrium – death). Conversely, OBF clearly increased with temperature.

The rise of OBF with decreasing O_2 level is probably a compensatory mechanism to maintain oxygen consumption and so metabolism. The decrease of OBF could correspond to the critic O_2 pressure (PO_2 crit) after which metabolism is depleted. This result led to hypothesized that the European sturgeon is probably an oxyregulator as other sturgeon species (*Nonnotte et al. 1993; Randall et al. 1992; Ruer et al. 1987*).

Loss of equilibrium is an expression of functional and metabolic disturbances, preventing fish to escape from danger (*Beitinger et al. 2000*), would determine the lower limit of O_2 level to preserve the likelihood of fish survival.

These oxygen levels were already, but rarely, recorded during severe summer hypoxic events, in the upper part of the Gironde estuary, near Bordeaux. The crossing of the mud plug by 3 month old European sturgeon juveniles during their downstream migration is probably without negative consequence considering the oxygen parameter.



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