



**Scientific Advisory Group of the
International Atlantic Salmon Research Board**

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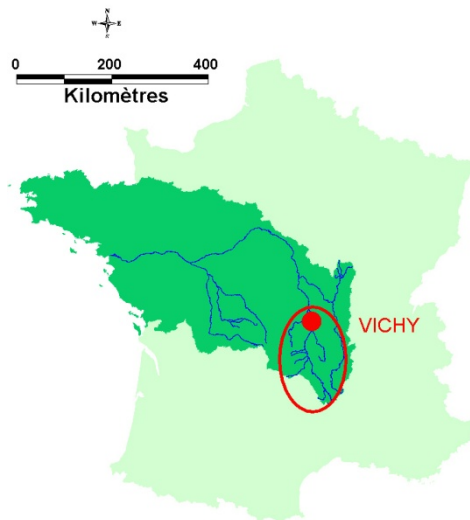
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Research on migration timing of salmon in the Loire/Allier, France

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Genetic analyses have shown that the salmon population of the Loire Allier axis is probably the most ancient in Europe and is an important biological heritage worthy of conservation (Dr Eric Verspoor pers. comm). Unfortunately it has declined markedly in abundance since the early 20th century and, despite a range of conservation measures, the adult population currently comprises only approximately 500 individuals each year with spawning restricted to the upper basin.

The rarity of this population relates to the extensive nature of its freshwater migrations. Indeed, the spawning grounds are located between 850 km and 1,000 km from the estuary, making the migrations of the Allier salmon the longest in Europe. (Fig. 1)



Salmon in the Loire/Allier have adapted to this extensive migration. While historical data (1890) shows that adult salmon entered the estuary all year round, except in August and September, the current window at the Vichy counting station (located 650 km from the estuary) is limited to about three months of the year from mid-March to mid-May.(Fig. 2)

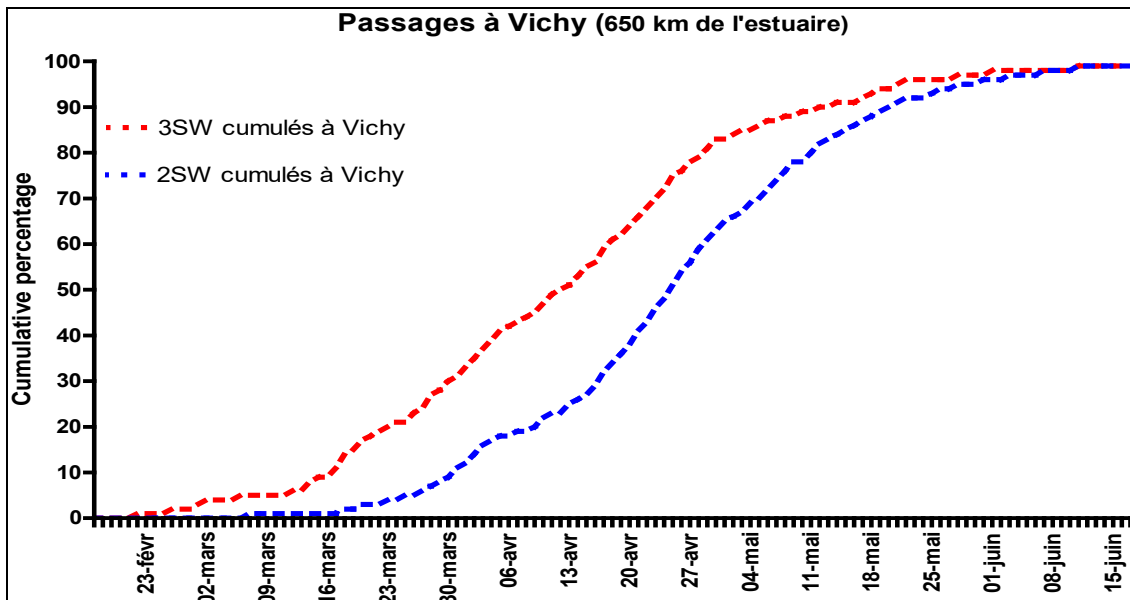


Figure 2

Outside this period, the water temperature is too high (above 26°C in the downstream part of the basin) (Fig. 3) to permit access to the spawning areas. The population reaching the upper basin is almost exclusively MSW (3SW and 2SW) salmon (>99%) which used to arrive in the estuary almost 14 months before their spawning.

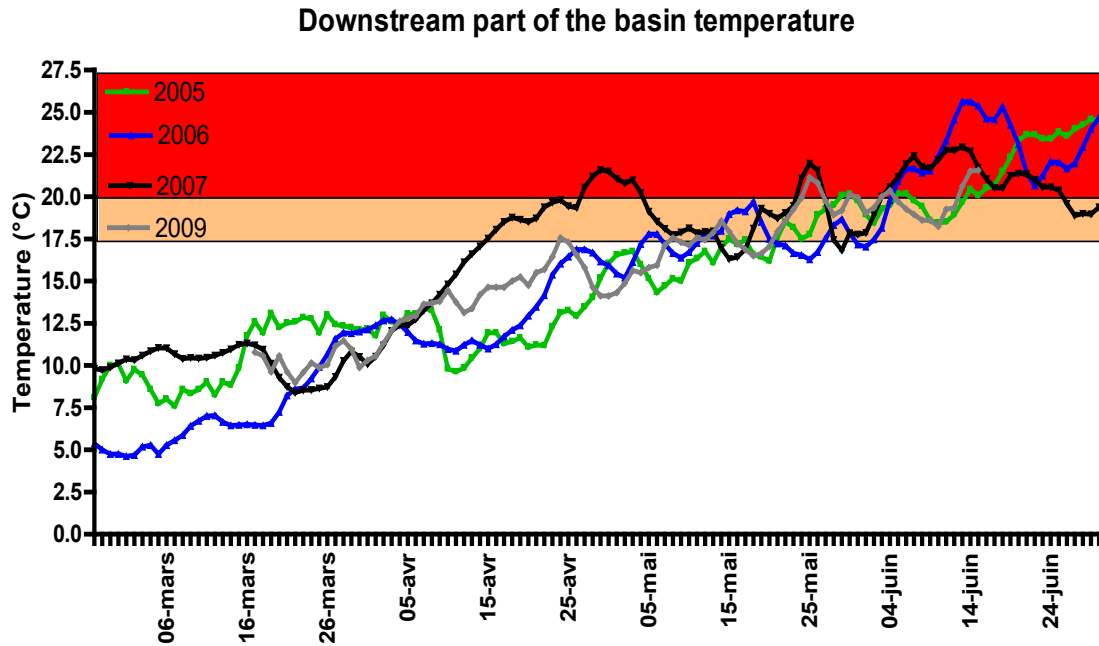


Figure 3

Analysis of data on the date of arrival of salmon at the spawning grounds indicates that the migration of fish has been delayed by about 1.5 days each year since the early 20th century. (Fig. 4)

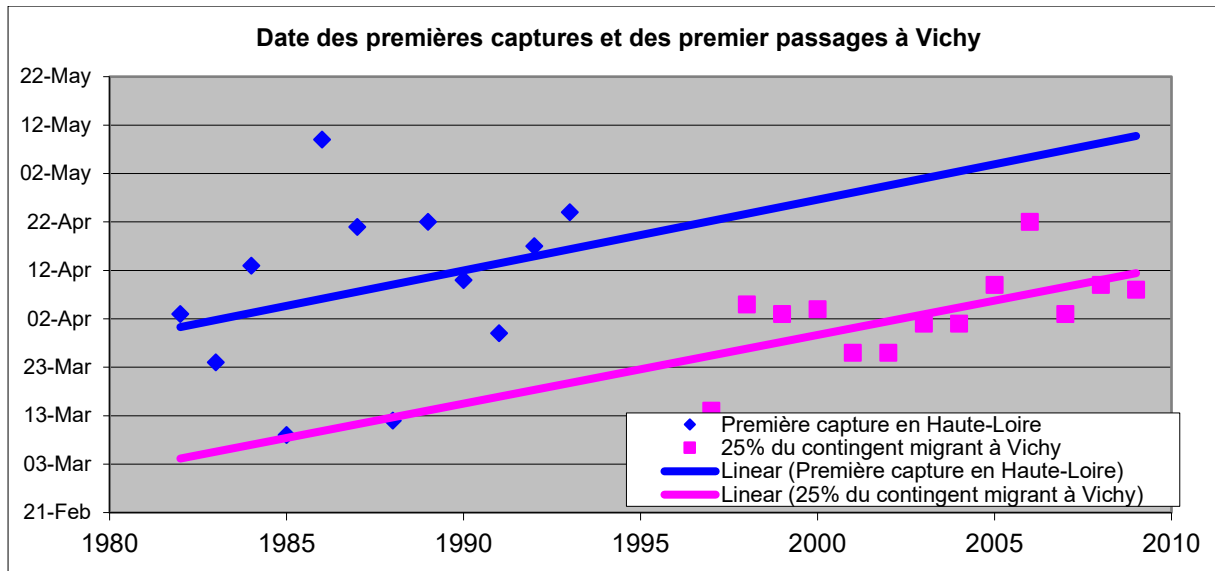


Figure 4

This delay could have adverse consequences for the population in the short-run because in parallel, the mean annual water temperature of the river has increased by 1.85°C in 24 years (Gosse *et al.* 2009)

The Allier River, located in the southern part of the distribution area of salmon, is subject to a marked continental climate. The problem of increasing water temperatures also impacts the downstream migration of smolts because the window of opportunity for migration to the estuary is very limited and decreasing. A late outmigration can cause mass mortality resulting from a loss of ability to adapt to sea water (physiological window) and arrival in the estuary at a time of unfavourable environmental conditions ("ecological window " e.g. unfavourable temperatures, oxygen levels and concentration of pollutants).

Individuals initiating their migration earliest in the year have a higher chance of reaching the ocean.

The CNSS has initiated a research program on the timing of the downstream migration of smolts to better characterize the populations of the Allier. Our data highlight the importance of water temperature for the initiation and modulation of downstream migratory behaviour. The sensitivity threshold temperature to initiate and regulate downstream migration is probably an adaptive response to environmental conditions and during migration; this temperature sensitivity will remain a key factor. So we determined for our smolts a thermal profile of activity with

an optimum temperature (TO) and sensitivity (TS) (fig. 5) and we try to analyse individual difference for possible subpopulations in our river. The development and use of this profile for each population, should allow restocking programme managers to select populations and habitat best-suited to the encountered conditions. We advocate taking into consideration the thermal stress associated with downstream migration in the development of predictive models of changing habitat with climate change.

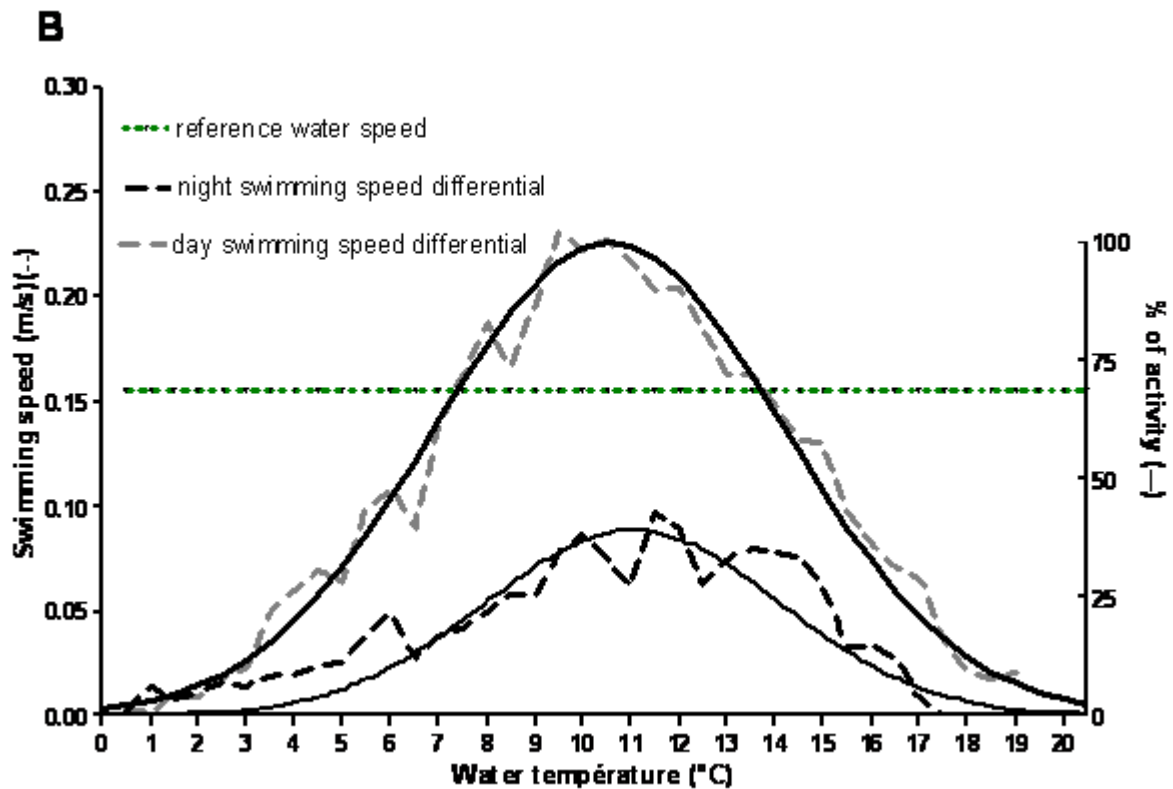


Figure 5

The migratory behaviour in the ocean, from the feeding grounds to the Atlantic coast, is a crucial factor in determining the time of arrival of adult salmon in the estuary and hence their ability to access the most favourable reproduction areas. The physiological, genetic and environmental factors that determine both the initiation and the rate of the return migration of adult salmon is beyond the research capability of the CNSS. Nonetheless, CNSS is keen to initiate a dialogue with other researchers working on the topic of migration timing of both smolts and adult salmon, particularly in large river systems.

- Feedback on the value of a research program on the theme of factors influencing the timing of migration of salmon (smolts and adults);

- identifying other laboratories or research organizations that are involved in the topic of migration timing of smolt and adult salmon that may wish to collaborate with CNSS in analysing data obtained from the Allier.