

Electronic Supplementary Material

Historical changes in the ecological connectivity of the Seine River for fish: a focus on physical and chemical barriers since the mid-19th century

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Online resource 1

Table S1. On-site and online historical and current sources used to document the studied periods.

Sources type	1900	1970	2018
National Archives	Serie F ¹⁴ , maps :1899 (Paris-Rouen) –		
Public Works ministry	1880/1893 (estuary)		
Departmental Archives	Inland navigation 1800-1940 (sub series 3S)		
(Seine maritime, Yvelines)	Ponts et Chaussées service / navigation service of the Seine River		French Navigation Rivers service
Public works and transport	/ autonomous port service		
GPMR Archives (Rouen harbour)	1966 ----- >		
Fluvial navigation guides (Ministry of public works)	1891	1921	1957
National circulars, decrees, laws, engineers reports	<i>Fishing Act 1865, salmon fishing circular 1889, fish ladder decree 1904</i>	<i>Fish passage decree 1974</i>	<i>Water law 2006, Action plan for ecological continuity 2010</i>
Online documents	Bibliothèque nationale -- > https://gallica.bnf.fr/ ArchiSeine website -- > http://archiseine.sisyphe.jussieu.fr/site/		
	Topographic maps, aerial photos since 1940 (IGN) ---- > https://remonterletemps.ign.fr		Topographic maps, aerial photos GoogleEarth, IGN Geoportail.fr

Table S2. Fish ladders built on the Seine River at the end of the nineteenth century. Specific ladders for eel passage are indicated in italic.

Navigation weir (see Figure 3)	Type	Date	Supposed destruction	Length (m)	Width (m)	Depth (m)	Slope	Fall (m)
Martot	Cameré type, overflowing ladder	1867	1938	12.5	1.8	0.35	0.161	
Poses	Cameré type, overflowing ladder	1895	1967	20.45	0.69	0.35	0.29	4.18
Port Mort	Cameré type, overflowing ladder	1903	1962	2.65				
<i>Port-Villez</i>	<i>Mobile frame ladder with special inner shelves for eels</i>	<i>1885</i>	<i>1965 (weir removal)</i>	<i>6.65</i>	<i>0.45</i>	<i>0.19</i>	<i>0.2</i>	<i>2.33</i>
<i>Méricourt</i>	<i>Mobile frame ladder with special inner shelves for eels</i>	<i>1889</i>	<i>1964 (weir renovation)</i>	<i>7</i>	<i>0.45</i>	<i>0.2</i>	<i>0.2</i>	<i>4.5</i>
Andrézy	Incline plan ladder with open baffle walls	1890	1953 (weir renovation)	35.9	1.02-1.2	0.38	0.02-0.192	2.84
<i>Andrézy</i>	<i>Mobile frame ladder with special inner shelves for eels</i>	<i>1890</i>	<i>1953 (weir renovation)</i>	<i>7</i>	<i>0.76</i>	<i>0.4</i>	<i>0.38</i>	<i>2.84</i>
Marly	Incline plan ladder with open baffle walls	1866	1888	19.7	1.5-1.8		0.14	3.2
Marly	Incline plan ladder with open baffle walls	1892	1968 (weir renovation)	17	1.2	0.4	0.14	3

Online resource 2

Resistance values assignment: All resistance values were chosen according to the longitudinal thickness of the barriers. A high resistance value was chosen for impassable physical barriers: gate dams, hydroelectric plants, and lateral fish ladders connected upstream to fisheries (80,000), and locks (8,000), for which passing cost would be equivalent to barrier-free migration of 800 km (resistance value * longitudinal thickness (m)). This maximum value was chosen to be close to the order of magnitude of known migration capacities of Atlantic salmon in large rivers (up to almost 1000 hydrographic km [62]) and potential distance to reach headwaters in the Seine River basin (700–870 km). Needle and rolling curtain weirs were considered to be twofold more passable for Atlantic salmon and allis shad, but just 1.5 times more for sea lamprey, according to their structure and potential opening time. Resistance values for fish ladder, vertical slot, and secondary channel passes were affected according to expert choice relative to the maximum value of the impassable barrier. For chemical barriers, a maximum resistance value of 100, 20 and 10 was chosen for the 1-km-long reaches where DO was below the threshold preference for the Atlantic salmon, alis shad and sea lamprey respectively. For oxygen classes above the threshold values for the three species (Table 1), resistance values were neutral ($R=1$). As mean DO values in the 2010s for all species/migration periods were above 6 mg.l^{-1} , the resistances in reaches for this period are always neutral ($R=1$).

Online resource 3

Figure S1. Longitudinal changes in the contribution of the scenario with physical barriers on the overall functional distances calculated for Atlantic salmon in the 1900s according to the migration periods.

