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Management plan to save the eel Optimising the design and management of installations

The Eels & Installations R&D programme is the result of a partnership between Onema, Ademe and five hydroelectric companies. Over the past three years, the programme launched 18 research projects to optimise the design and management of installations to protect migrating eels. On 28 and 29 November 2011, the feedback symposium brought together 160 persons, including researchers, water managers, associations and hydroelectric companies, in the conference room of the Porte Dorée aquarium in Paris. This key event in the French eel-management plan sketched a panorama of the results achieved in a series of presentations addressing the operational aspects of issues. The presented solutions and tools pave the way for a collaborative response by the economic participants to the challenge of restoring the species.

The European eel is an emblematic species in European rivers. Over the past 30 years, it has suffered a severe drop in numbers due to a series of anthropogenic pressures including water and sediment pollution, habitat degradation, overfishing and poaching, hydropower turbines and obstacles to its colonisation of rivers and to its downstream migration.

A silver eel.

The R&D programme is a regulatory necessity for an ecological crisis

Eels are considered endangered by the International union for the conservation of nature (IUCN) and in 2007 the European Union voted a regulation (EC 1100/2007) requiring the Member States to adopt restocking measures targeting (article 2.4) a return to the quantity of adult-eel biomass that existed prior to 1980. In France, this pro-active policy resulted in the decision to launch a management plan to reduce catches by 60% by 2015 and other causes of mortality (including those caused by installations blocking rivers) by 75% by 2018. This goal led the Ecology ministry to prepare an R&D programme on installations blocking rivers, comprising a coherent set of 18 research projects carried out from 2009 to 2011 in the framework of a partnership between Onema, Ademe and five hydroelectric companies, namely Compagnie nationale du Rhône, EDF, France Hydroélectricité, GDF Suez and Société hydroélectrique du Midi.

A mysterious life cycle between the Sargasso Sea and inland waters

The Sargasso Sea, in the North-western Atlantic, is the only known spawning zone for the species. Eels begin as transparent larvae, 5 to 10 mm long, called leptocephali, that become glass eels (75 mm) one to three years later, depending on the hypothesis considered, when they reach the European continental shelf toward the end of the summer. They enter estuaries and migrate to inland water bodies. In the process of growing, they become yellow eels and settle in highly diverse environments (rivers, marshes, isolated ponds, etc.). Sexual differentiation occurs when the fish are about 20 cm long, with the males primarily in coastal zones and the females upstream. Once they have finished growing, the yellow eels become silver eels and can exceed one metre in length. Following a heavy rainfall, often in the fall, the silver eels race down the rivers to the sea and migrate 5 000 km across the ocean to the spawning grounds in the Sargasso Sea.
This life cycle still harbours many mysteries, notably the factors determining the zones colonised, sexual differentiation and reproduction.

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François Travade, EDF R&D

Make use of the initial feedback

«This R&D programme was necessary given our insufficient knowledge worldwide on how eels can overcome obstacles. The programme enabled us to make progress in diagnosing impacts and concerning possible solutions. Of course, these solutions must be adapted to each hydropower plant. Such a «tailored» approach, very common in the empirical science of fishway engineering, must absolutely take into account the feedback from initial projects. It is critically important to evaluate the functionality of the initial systems created and to apply the knowledge gained to subsequent projects.»

Antennas installed at each installation informed on the time of passage and, above all, the paths followed by the eels given the configuration of each installation, in conjunction with a number of other parameters acquired on each site (hydrology, conductivity, temperature, etc.). A majority of the fish passed via the spillways (68% on average), with significant discrepancies depending on the general configuration of the spillway and the spaces between the bars of the water intakes. Tools were proposed to estimate escapement rates as a function of hydrological conditions, flow rates at the water intakes and the configuration of installations.

A similar approach based on the NEDAP technology using RFID (radio-frequency identification) was implemented on the French side of the Rhine to see how eels overcame a series of six obstacles equipped with detection systems (long underwater antennas) (E. de Oliveira, EDF-LNHE). During the first two years, the experiments suffered from numerous technical problems that have since been solved. Though expensive and difficult to implement, this technique should inform on the paths followed by the fish in overcoming the obstacles and, using the mortality equations for each type of turbine, make it possible to estimate not only the number of eels travelling downstream and succeeding in overcoming the installations along the French section of the Rhine, but also the time taken by each individual, which can vary considerably. For this project, the plan is to equip and release over 300 eels each year over the next four or five years.

Understanding the effects of installations and series of installations

This new knowledge on downstream-migration rhythms and on the behaviour of the fish in and around installations has made it possible to evaluate the cumulative losses caused by a series of installations along a river. This type of evaluation is a necessary step toward integrated management of entire river basins (P. Gomes, M. Larinier, Ph. Baran, Onema). Using the results and models produced for the Gave de Pau river, a downstream-migration model was created for a series of characteristic flow rates, i.e. during the migratory period, the eels are divided equally among the flow rates considered characteristic (Q75, Q90, Q95, Q97.5 and Q99). This model was enhanced with statistical models on flow rates at turbine intakes and with the mortality equations for each type of turbine (see figure 1). This new method, the only one validated to date, provides for a given period a percentage of escaping eels for each installation and an overall percentage of eels surviving all the installations. When applied to a river in south-west France comprising 26 installations, the model indicated an overall percentage of escaping eels between 33% and 66%, with an average of 49%.

Turbine management to reduce mortality rates

In addition to these efforts to diagnose the situation, the R&D programme looked a different means to reduce mortality rates caused by the turbines. One obvious solution is to halt generation during peak migration periods, but this is very expensive in terms of energy production. To time the stops in production as best possible, managers must be in a position to anticipate, for a given river, the time periods when the largest numbers of fish are underway. The MIGROMAT® biomonitor, designed specifically for this purpose, analyses the movements of silver eels equipped with transponders and held captive in basins supplied with river water. The eels react to changes in water characteristics, thus signalling by their enhanced activity that downstream migration is likely. This system, marketed

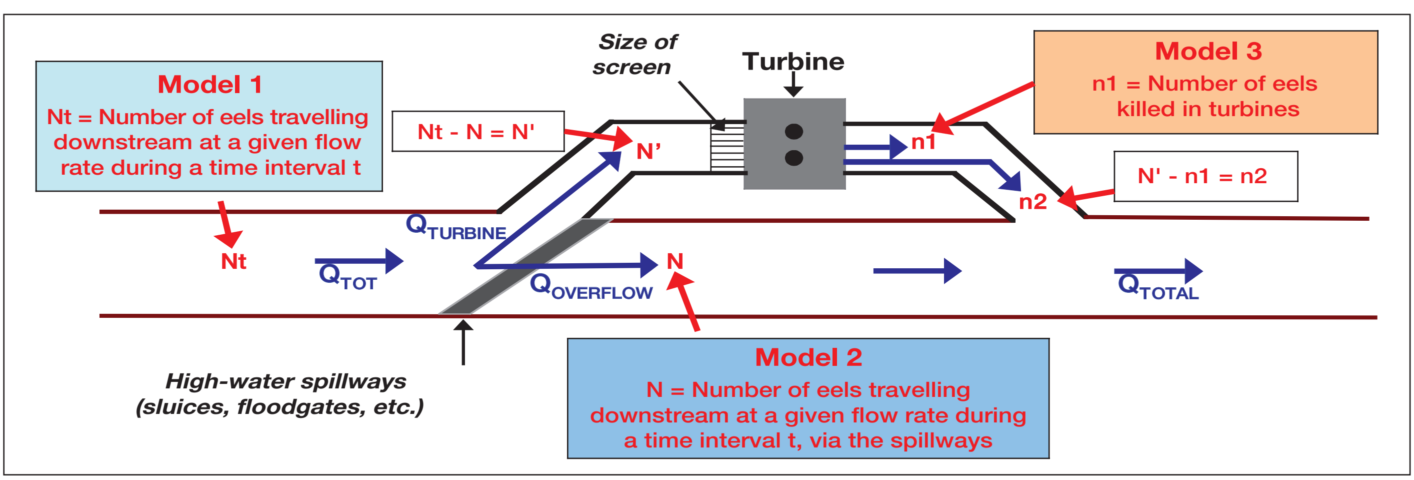

Figure 1. Cumulative losses for a series of installations by combining predictive models for one installation.