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Against all odds: silver eel mortality in the River Meuse in a population perspective

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Abstract

European eel *Anguilla anguilla* is in strong decline. Among many factors, hydropower and fisheries mortality during the downstream migration of silver eels in rivers plays an important role. To determine the impact of hydropower and fisheries on silver eel in the River Meuse, radio-telemetry experiments were performed during 2002-2006. For this study, 18 fixed detection stations (Nedap Trail-System®) covering the entire river width at different sections in the River Meuse, and 2 stations were used covering the entrance of each of the the two hydropower plants. This allowed to distinguish individuals entering the turbine from individuals passing over the adjacent weir. Recaptures in fisheries were used to assess fisheries mortality. In - total 300 silver eels were surgically implanted with Nedap-transponders. Per stretch between stations mortality rates were assessed and attributed to the different factors. To determine the overall effect on the escapement of silver eels from the River Meuse, insight in the distribution of starting silver eel along the catchment of the River Meuse is required. Here, data for yellow eel distribution, and total fluxes of silver eel at two locations are used to illustrate distribution patterns. Consequences on the population level of the Meuse catchment and management are discussed.

Introduction

The European eel population shows a sharp decrease over the last decennia (Dekker 2004). Here, we focus on the hazards they face during their downstream silver eel stages. As a previous study has shown, in the Dutch section of the River Meuse, hydropower and fisheries are the major causes for extra mortality during the downstream migrations of silver eel (Winter, Jansen & Bruijs 2006). By means of radio telemetry, during 2002-2006, and using an array of fixed stations, it was assessed what the mortality rates for downstream migrating silver eel were and to which cause these could be attributed for each of the eight river stretches that were separated by detection stations. In European Community policies, silver eel escapement plays an important role. Based on the mortality rates, the consequences for escapement rates of the total silver eel population migrating from the River Meuse Catchment will be discussed.

Objectives:

- What was the silver eel mortality per river stretch in the Dutch Meuse

- To which factors can this be attributed? e.g. fisheries and hydropower
- In what way might the overall effect on the total Meuse population be determined

Material and methods

Study area
The downstream section of the River Meuse in the Netherlands (315 km in length) has seven weirs and two hydropower stations: one 254 km from the North Sea and one 116 km from the sea (HPS2, Fig. 1, Winter, Jansen & Bruijs 2006). Fisheries in the River Meuse in the downstream sections of the Rivers Meuse and Rhine (Fig. 1), are usually using large fykenets. In the upstream Dutch section of the River Meuse, fishing takes place with electrofishing, more extensive fykenet-fishing and anchored stow nets at two locations, directly downstream from HPS 1 and HPS 2 (Fig. 1).

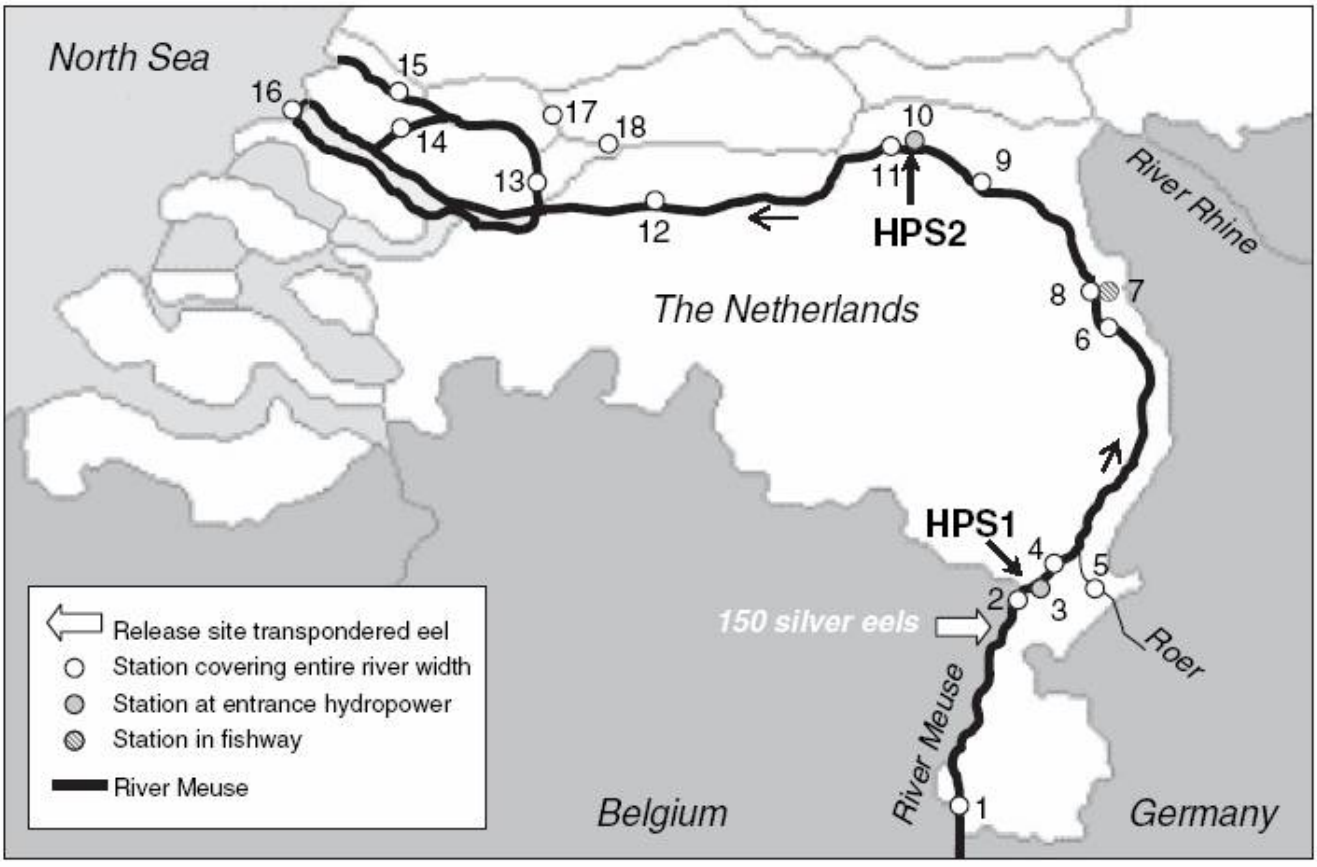

Figure 1: map of the study area showing the 18 different detection stations, the two hydropower plants (HPS1 and HPS2), the site of release of 150 silver eels in 2002 and 150 in 2004. Small arrows along the river indicate flow direction.

Telemetry experiments
In the River Meuse, 18 fixed stations based on a new telemetric method, the Nedap Trail™ System, were used (Winter, Jansen & Bruijs 2006). Silver eels were caught with fykenets by a professional fisherman during September 2002 and September 2004 in the River Meuse at Ohé en Laak, The Netherlands (Fig. 1). In September 2002 and 2004 in

total 300 silver eels were surgically implanted with transponders and released at Ohe en Laak according to the protocol as described in Winter, Jansen & Bruijs 2006. The eels ranged from 64 to 93 cm in total length Males do not grow that large before migrating (Dekker 2000), thus all fish were females. Each transponder had an instruction label and would easily be discovered while preparing the caught eels for consumption. A clearly readable reward of 30€ was offered for every tag recovered to estimate fisheries mortality.

The effects of implanting these transponders on the mortality and behaviour of silver eel were tested in a tank-experiment prior to this study (Winter et al. 2005). There was no effect on mortality and timing of activity. There was no tag loss, nor any signs of expulsion or encapsulation by tissue. The eels with implanted transponders, however, showed a significantly lower activity level than the control.

Data analysis

Passage data were stored in a data-logger at each station and automatically retrieved daily by a telephone line connection (Winter, Jansen & Bruijs 2006). Proportional hazard models (Genstat) were used to estimate survival rates per stretch and attributing to the following factors when fate was known: fisheries recapture; direct HPS mortality. Population estimates based on Mark-Recapture experiments: At three locations eels with transponders could be recaptured within a registered total number of eels: in the turbine fyke catches at Linne (KEMA), in the stationary trawl (anchored stow net) in the main stream directly downstream of the weir and hydropower station of Linne and in the three stationary trawls in the tailrace of the hydropower station at Lith-Alphen. At the fykenet fisheries at Reuver-Belfeld total number of eels caught were not known, because only four fykenets were registered, whereas a variable total number of nets was used depending on catches. Based on the unbiased modified Lincoln-Petersen method which assumes that the ratio of the marked individuals (M) to the population (N) is equal to the ratio of recaptured fish (R) to the catch taken for census (C) (Ricker, 1975; Pollock et al., 1990), an estimate of the total population passing during the period when transpondered individuals have a chance to be caught, i.e. after the release date, could be calculated:

$$N = (M+1).\ (C+1)\ .\ (R+1)-1$$

To calculate SD, R was treated as a binomial variable when low numbers of eels (< 25) were recaptured and the variance V (with SD= $\sqrt{}$ (v)) was estimated according to Seber (1970):

$$V = ((M+1).(C+1).(M-R).(C-R)) / ((R+1)2.(R+2))$$

Results and discussion

Highest mortality rates were observed in the river stetches downstream HPS2 (between stations 9-11) and the downstream stretch (between stations 12 and 15-16) as given in Figure 2. In stretches 2 and 6, hydropower mortality was considerable. Fisheries

mortality was highest in stretch 6 and 8 (Figure 2). As could be expected for silver eels, recreational fisheries recaptured only very few silver eels.

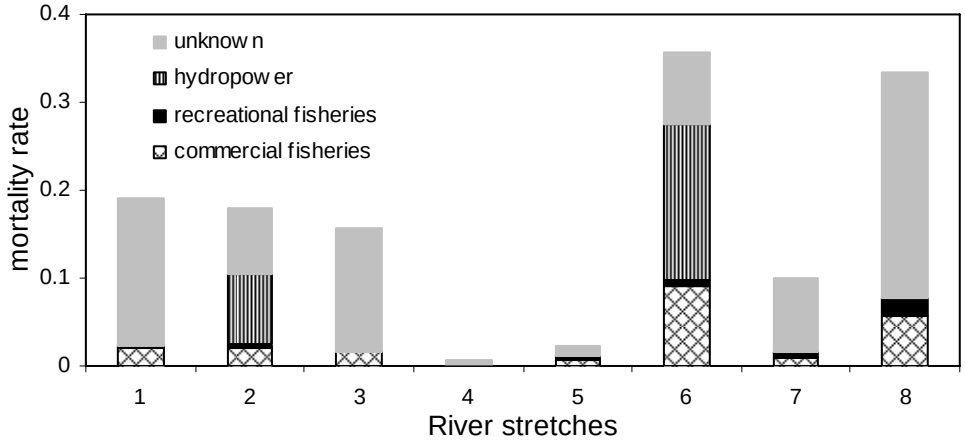

Figure 2. Mortality rates for the upstream river stretch 1 (between stations 1and 2) to the downstream stretch covered by the seaward detection stations.

From the mark-recapture experiments it was estimated that the number of silver eels passing at the downstream stations at Lith were more than a factor 2 higher than at the upstream location at Linne (Table 1). These results confirm that in the course of the river, despite extra mortality, more silver eels start their migration.

Table 1: estimated silver eel population size based on mark-recapture data at three catch locations: two directly downstream HPS1 (Linne) and one directly downstream HPS2 (Lith).

Location	M	C	R	Period	Estimated population size ± S.D.	Extrapolation over total period (assuming R=5)
HPS turbine fyke Linne	104	1,104	3	8 Sept – 16 Feb	29,006 ± 12,699	
Stationary trawl Linne	104	1,922	3	8 Sept – 16 Feb	50,479 ± 22,118	94,000 (62,000)
Stationary trawl Lith (HPS)	36	6,708	3	21 Oct – 16 Feb	62,058 ± 26,202	182,000 (121,000)
Stationary trawl Lith (total)	62	6,708	3	21 Oct – 16 Feb	105,667 ± 45,717	225,000 (150,000)

Thus, to estimate the mortality rates on total silver eel escapement from the River Meuse catchment area, ideally the distribution of all starting silver eels must be known. Silver eels starting their migration in downstream sections suffer less mortality than silver eels starting in the upper parts of the river that are subjected to the cumulative mortality rates in each of the river stretches they subsequently pass. Because female silver eels disperse deeper into river systems than male silver eels and in addition the longer female silver eels suffer higher mortality rates in hydropower turbines, the escapement of female silver eels is estimated to be less than male silver eels. It is believed that particularly protecting female silver eels is vital for the rehabilitation of European eels (Dekker 2000, Dekker 2004).

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