Eel behaviour at navigation locks : finding the true path in acoustic telemetry data

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Introduction

Man-made hydraulic structures are major barriers for fish migration worldwide. Some of the most strongly affected species are European eel (*Anguilla anguilla*) and Atlantic salmon (*Salmo salar*). These species are representative for fish (respectively catadromous and anadromous) with a downstream migrating phase (van Ginneken and Maes 2005), during which they must pass navigation locks, pumping stations and hydropower plants.

In Flanders (Belgium), the Albert Canal connecting the river Meuse to the Port of Antwerp and the river Scheldt, is an important migration route for eel and salmon (Stevens et al. 2011). In the years to come, six pumping installations are to be constructed. These Archimedes screws can work as hydropower turbines in high flow periods and thus contribute to green power production. A first installation is already present at the lock complex of Kwaadmechelen (Ham). However, the presence of pumping stations and turbines can cause significant migration problems to the eel (Buysse et al. 2014). Resolving these problems is challenging due to a lack of insight into fish behaviour near the hydraulic structures. Therefore, fundamental knowledge on the relationship between hydrodynamic conditions and fish behaviour is essential. This research aims to investigate fish behaviour by use of acoustic telemetry and to link this behaviour to hydrodynamics quantified by Computational Fluid Dynamics (CFD) modelling. This paper presents the current stage of the research and some challenges to overcome. The swimming tracks of 28 eels were analysed to see whether they passed the sluice complex and which route they followed to pass. Future research will include Atlantic salmon as investigation species and will focus on the relationship between swimming behaviour and the hydrodynamics around the sluice complexes.

Materials and methods

The study site is located in Kwaadmechelen (Ham, Belgium) and consists of 3 adjacent navigation locks and a side channel towards the hydropower station. In November 2016, 28 eels were captured at the navigation lock of Genk, 36 km upstream of the study site, and tagged with a V13 acoustic transmitter of the Vemco VR2W Positioning System. For 10 eels, a depth sensor was included in the VPS-transmitter (V13P) to account for 3D-behaviour. The release location, 13 km upstream of the study site, differed from the capture location to avoid that the eels got stuck in other navigation locks before reaching the study site. A receiver array consisting of 12 receivers, 10 synchronization tags and 3 reference tags was installed at the navigation lock complex, in a configuration that allowed positioning in all areas upstream of the complex (Figure 1).

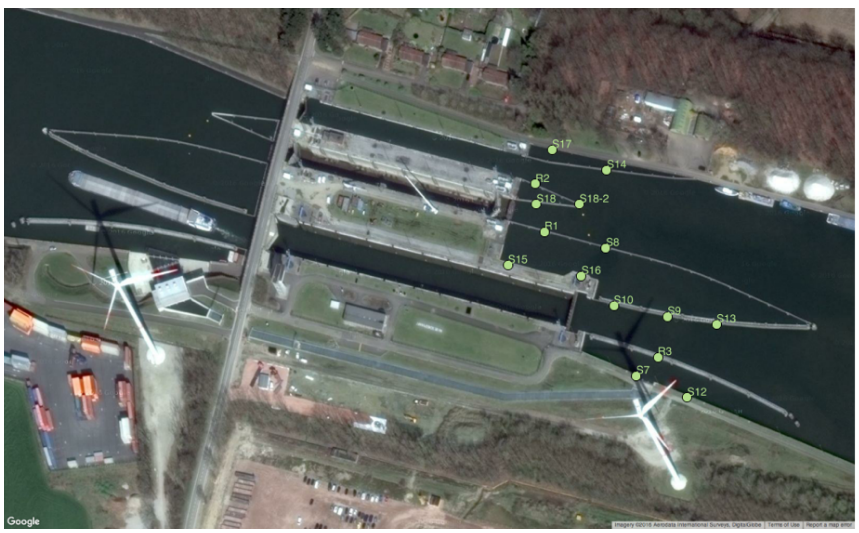

Figure 1. Study site with receiver stations (S…) and reference tags (R…).
All receiver stations also contain a synchronization tag, except S18-2 and S9.

Results

Of the 28 tagged eels, 11 eels passed the navigation lock complex via the left-bank lock, 1 via the middle-bank and 4 via the right-bank lock. 4 eels were never in the vicinity of the complex, 8 eels came close but didn’t find a passage. None of the eels passed via the hydropower station. The delay at the complex varied from 30 minutes to 46 days.

Hyperbolic positioning, used by Vemco to calculate positions, implies different types of errors. One of those is the error related to triangulation: depending on the geometry, some triangles lead to calculated positions with a larger error sensitivity than others. The error sensitivity is expressed in the Horizontal Positioning Error (HPE), given by Vemco. Another type of error is related to the specific research site situated in a canal with regular ship passage. The presence of concrete walls and passage of ship can cause reflections of the acoustic signal, leading to erroneous positions.

One way to detect erroneous positons is to identify reflected signals. Due to the presence of walls inside the receiver array, each receiver has a zone where transmitters cannot be in direct line of sight with the receiver. If a receiver is used to calculate a position in this zone, the detection on the receiver originates from a reflected signal. This is the case for 54% of the stationary tag positions (reference and synchronization tags) and 18% of the fish positions.

Another way to detect erroneous positons is to calculate apparent swimming velocities (the distance covered during the time between successive positions). If a fish covered more distance than possible since its previous positions, the current position is likely to be wrong (possibly originating from a reflected signal). According to Van Ginneken (2005), eels have a characteristic speed of 2 body lengths per second. A speed limit of 2 m/s (the maximum length of the tagged eels was about 1 m) identifies 21 % of the fish positions as erroneous positions.

Further analysis of the relationship between HPE and known error of the stationary tags will determine an appropriate threshold of acceptable HPE (error sensitivity).

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