MONITORING THE EFFICIENCY OF POOL-TYPE FISHWAY: TWO YEARS RESULTS FROM THE COIMBRA BRIDGE-WEIR

Pedro Raposo de ALMEIDA[1,2], Catarina Sofia MATEUS[2], Carlos Manuel ALEXANDRE[1,2], Ana Filipa FERREIRA[2], Gabriela CARDOSO[2], Esmeralda PEREIRA[2], João FERREIRA[3], Ana TELHADO[3], Felisbina QUADRADO[3], Bernardo Ruivo QUINTELLA[2,4]

[1]Departamento de Biologia, Escola de Ciências e Tecnologia, Universidade de Évora; [2] Centro de Oceanografia, Faculdade de Ciências, Universidade de Lisboa ; [3]Agência Portuguesa do Ambiente, I.P.; [4]Departamento de Biologia Animal, Faculdade de Ciências, Universidade de Lisboa

Introduction

Dams and weirs are known to have major impacts on migratory fish as they serve as barriers, but these deleterious effects can be mitigated by the construction of efficient fishways where suitable habitats exists beyond the barrier (Roscoe & Hinch 2010).

In 2011, a pool-type fishway was installed by the Portuguese Environment Agency in Coimbra Weir to unblock the upstream stretches that were historically used by diadromous fish. Since then, a field study is being conducted in River Mondego using an integrative approach with the aim to determine the effectiveness and efficiency of this fishway for diadromous and potamodromous species.

Methodology and Results

SURVEY COMMERCIAL FISHERIES

The professional fishermen of the River Mondego that capture sea lamprey (*Petromyzon marinus* L.) allis shad (*Alosa alosa* L.) or twaite shad (*Alosa fallax*, Lacépède 1800) were asked to participate in a daily catch survey.

The number of fishermen that agreed to participate in the study was low. Figures 1 and 2 represent the number of sea lampreys and the kilograms of allis shad captured by the inquired fishermen. There is no data for the twaite shad since it is not captured by fishermen due to its low economic value.

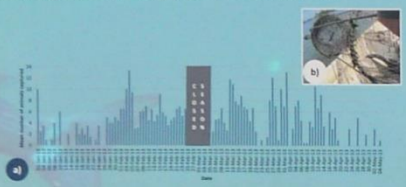

Fig. 1 – a) Mean number of sea lampreys captured per day by a sample of professional fishermen (n=21) in the River Mondego during the fishing season of 2013. The closed (no fishing allowed) season is also represented; b) Fyke nets used by professional fishermen to capture sea lampreys.

Fig. 2 - Mean kilograms of allis shads captured per day by a sample of professional fishermen (n=7) in the River Mondego during the fishing season of 2013. The closed (no fishing allowed) season is also represented.

VISUAL COUNTS

The existence of a monitoring building in Coimbra fishway, with a viewing window, allowed to count all the fish that used the device in 2013 (Tab. 1). Also, the recording of a number of abiotic parameters, allowed to relate the number of individuals that use the fishway with environmental predictors.

Table 1 - Total number of fishes that used the fishway in 2013 to migrate upstream.

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
P.m.	10	78	725	6657	846	5	1	4	0	0	0	7	8333
A.a./A.f.	0	10	6	3267	3731	373	106	10	0	0	0	0	7503
L.b.	51	18	232	7964	5210	2716	1014	733	1007	530	342	504	20321
P.p.	4976	1213	7851	17197	2602	2011	183	170	51	24	228	15945	52451
L.r.	44	0	0	16912	38892	70012	490557	170096	80075	13544	70	3	880205
A.a.	0	0	19	45	16	244	204	16	3	5	1	0	553
S.t.	1	3	0	5	16	159	39	4	4	0	5	7	243
E.S.	0	0	0	2	3	13	1	6	44	25	22	0	116
NI	411	77	1025	906	188	272	67	165	111	34	24	234	3514
Total/m	5493	1399	9858	52955	51504	75805	492172	171204	81295	14162	692	16700	**973239**

Species: *P.m.* - sea lamprey, *A.a./A.f.* - *Alosa spp.*, *L.b.* - Iberian barbel (*Luciobarbus bocagei*, Steindachner, 1864), *P.p.* - nase (*Pseudochondrostoma polylepis*, Steindachner, 1864), *S.t.* - brown trout (*Salmo trutta*), *A.a.* – eel, *L.r.* – grey mullet (*Liza ramada*, Risso, 1827) and exotic species.

Fishway utilization by diadromous and potamodromous species was mainly related with flow, temperature , turbidity and specific conductivity (Fig. 5).

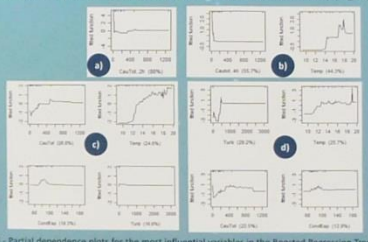

Fig.5 - Partial dependence plots for the most influential variables in the Boosted Regression Tree models applied to identify the predictors that influence the behavior of the following species: a) sea lamprey, b) *Alosa spp.*, c) Iberian barbel and d) nase. Variables: CauTot – weir discharges; Temp – Water temperature; CondEsp – Specific conductivity and Turb – Turbidity.

EMG TELEMETRY

Four sea lampreys were tagged with CEMG transmitters (Fig. 8), that record the level of muscle activity, and released in the Coimbra fishway to study their fine-scale behavior and assess the physical effort when swimming through this fish passage.

Fig. 8 – Sea lamprey cEMG tagging procedure : a) insertion of the transmitter in peritoneal cavity; b)-c) placement of the gold-tipped electrodes in the red axial muscle; d)-e) closure and disinfection of the wound.

Lampreys took 3 hours to negotiate the fishway and considering the average resting values exhibited by each lamprey, a high muscular effort was occasionally registered during fishway transposition, particularly during the passage, or passage attempts, of the vertical slots that connect pools (Fig. 9).

Fig. 9 - Behavior (recorded as cEMG values – i.e., muscle activity level) of one of the tagged lampreys during the complete fishway ascent. Average resting cEMG value for each lamprey is shown in the Y-axis.

ELECTROFISHING SAMPLING

Pre (2011) and post (2012-2013) operational (fishway) surveys (electrofishing sampling) were conducted in River Mondego (upstream and downstream of the fishway) and in two of its main tributaries, rivers Alva and Ceira (Fig. 3), to assess the evolution of the abundance of sea lamprey larvae (ammocoetes) and eels (*Anguilla anguilla* L.) (Fig. 4).

Fig. 3 – Electrofishing stations in River Mondego: M- downstream to the fishway and M-Montante to the fishway; A- stations in River Alva; S-stations in River Ceira.

Fig. 4 - Abundance of (a) lamprey ammocoetes and (b) eels captured during the years 2011, 2012 and 2013 during the electrofishing surveys. In grey and blue are represented, respectively, the captures that occurred on sampling stations located downstream and upstream of the fishway.

CONVENTIONAL RADIO TELEMETRY

In 2012 and 2013, a total of 28 sea lampreys were externally tagged with conventional radio-transmitters to study its migratory behavior through Coimbra fishway and through several upstream weirs (Fig. 6). After recovery, animals were released in previously selected sites within River Mondego and their location was tracked at a weekly basis.

Fig. 6 – a) Tagging and b) tracking of the tagged lampreys.

From the 28 lampreys released, 9 (~32%) reached the river stretch upstream Coimbra's fishway (Fig. 7). From these, four (~44%) entered in the first major tributary of the study area, the River Ceira. The other five migrated upstream through River Mondego, from which three managed to surpass the first weir, Palheiros (Fig. 7), while the next weir, Louredo, proved to be impassable for this species.

Fig. 7. Final record of the migratory movement of the sea lampreys tagged with radio-transmitters in 2012 and 2013, releasing sites and last position recorded.

PIT-tag

In order to evaluate the efficiency of the fishway for sea lamprey, Iberian barbel and thinliped grey mullet, a passive integrated transponder (PIT) antenna was installed in the upstream pool.

During the spawning migrations peak, a total of 223 sea lampreys (fyke net) and 251 Iberian barbels (electrofishing) were captured in the stretch downstream of the Coimbra Bridge-Weir, and PIT tags were implanted in the peritoneal cavity (Fig. 10).

After recovery, sea lampreys and Iberian barbels were released near the capturing sites. Passage efficiency was calculated as the proportion of successful passage events compared with the number of tagged fish.

Fig. 10 – a) PIT-tag detection antenna mounted in the upstream pool of Coimbra fishway; b) PIT tagging of sea lamprey; c) PIT tagging of Iberian barbel; d) Manual PIT tag reader.

A total of 67 sea lampreys were detected by the PIT antenna, resulting in a passage efficiency of 30%. Collection and analysis of data from barbel passages are still in progress and the capture and tagging of grey mullets is planned to be performed during this summer.

Conclusions

With this approach we demonstrate that Coimbra fishway is used by multiple species and that certain conditions of flow, temperature and turbidity affect the efficiency for different species.

Data from biotelemetry (radio, PIT Tags) corroborate that the efficiency of the fishway for sea lamprey is approximately 30% . These results are supported by the notorious increase in abundance of sea lamprey larvae particularly upstream of the fishway during 2013 sampling.

ACKNOWLEDGEMENTS: We thank to all the colleagues and students for the assistance in fieldwork and all the professional fishermen that agreed in participate.

REFERENCES:
- Roscoe, D.W. & Hinch, S.G., 2010. Effectiveness monitoring of fish passage facilities: historical trends, geographic patterns and future directions. *Fish and Fisheries*, 11(1), pp.12–33.

CENTRO DE OCEANOGRAFIA · UNIVERSIDADE DE ÉVORA · AGÊNCIA PORTUGUESA DO AMBIENTE · Passagem para Peixes