An experimental study of the swimming velocity of glass eels

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A quantitative assessment of maximum swimming velocities of late season pigmented glass eels was undertaken to investigate the probability of glass eels being able to undertake upstream migrations through flap/door type flood defence mechanism.
The theoretical water velocities experienced on submerged faces of these mechanisms are likely to exceed the maximum swimming velocity where head differences are greater than two centimetres.

The European eel population, especially glass eel recruitment has declined since the late 1970's. A number of factors as climate change, pollution, diseases, parasites, fisheries, loss of habitat and migratory pathways will have a negative impact on the eel population.

Fig 1:Typical flood defence doors/flaps.

The Severn estuary has a well developed flood defence system. The majority of fresh water discharges entering the estuary/river between Avonmouth and Tewkesbury are fitted with mechanisms to prevent the reflux of water from the main river into these feeder streams. In recent decades new engineering techniques, modern materials and different attitudes to flood risk management have made these structures formidable obstructions to migratory fish including glass eels.

This study was undertaken to determine the swimming velocities at different water temperatures and the swimming endurance of glass eels. The theoretical water velocities that might be experienced between the door/flap and the sealing face of the discharge exit. was calculated. The experiment is based on pristine conditions.

Materials and methods

A river sample of late season pigmented glass eels, approximate mean weight of 0.3 gms was used. The physical status of the eels appeared to be normal.

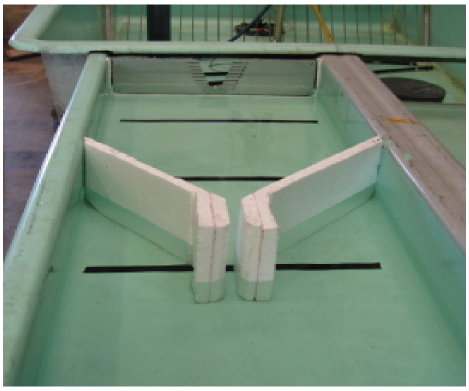


Fig 2: Swimming Channel

Water was re-circulated from a reservoir along a channel which was restricted by an aperture 80 mm long and 20 mm wide. The temperature was stabilised using an in line refrigeration system. Water flows were calculated using a calibrated V Notch Sharp Crested Weir.

Procedures

Once the flow rate was stabilised a batch of 300 individuals was released into the chamber below the restriction. The number of escapees that managed to migrate through the channel in the first minute was counted. The procedure was repeated at different flow rates using fresh batches of individuals.

The experiment was also repeated in an open channel to test the swimming endurance of the glass eels.

Results

Table 1: Endurance. Swimming performance in constant velocity open channel.

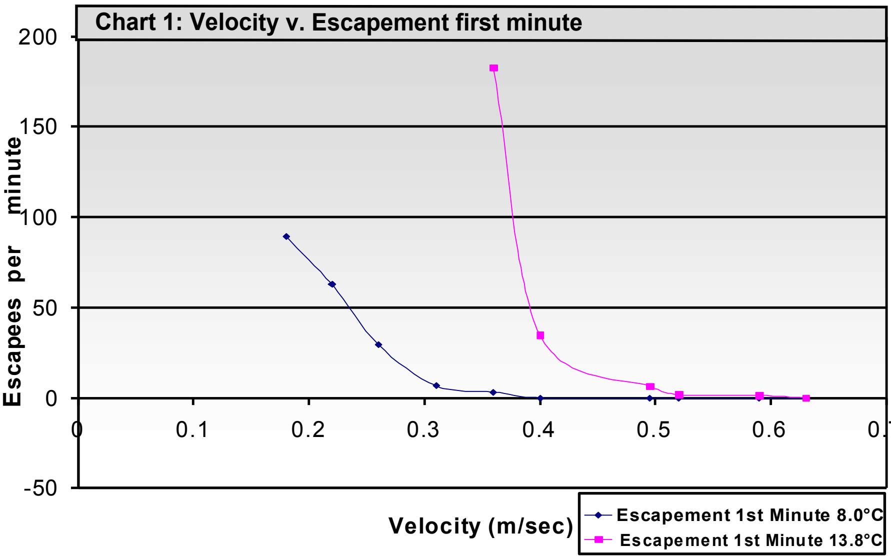
Temp 13.8C		
Length M	Velocity M/sec	Maximum Swimming distance Meters
2.44	0.64	0.90
2.44	0.44	2.10

At temperatures of 13.8 °C the swimming endurance was limited to 0.9 meters at water velocity of 0.64 M/sec and 2.1 meters at water velocity of 0.44 M/sec before being carried back into the reservoir by the water flow.

Table 2: Velocity v. escapement. first minute			
Escapement 1st Minute 8.0°C	Velocity M/Sec	Escapement 1st Minute 13.8°C	Velocity M/Sec
0.00	0.63	0.00	0.63
0.00	0.59	1.30	0.59
0.00	0.52	1.70	0.52
0.00	0.50	6.30	0.50
0.00	0.40	34.70	0.40
3.00	0.36	182.70	0.31
6.67	0.31		
29.33	0.26		
62.67	0.22		
89.33	0.18		

At temperatures of 13.8°C the maximum swimming velocity is 0.55M/sec.

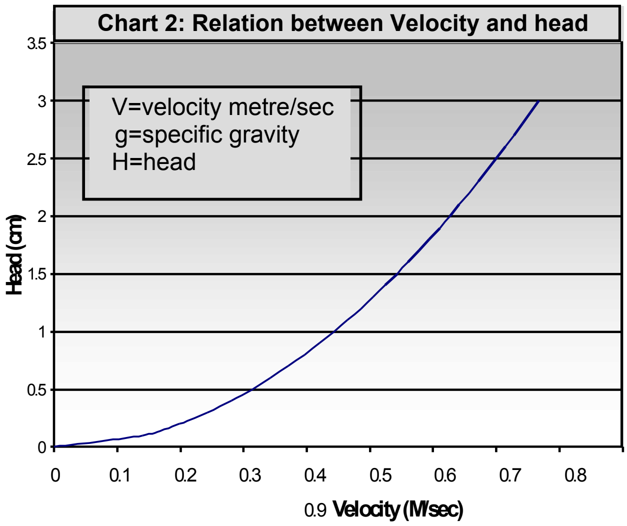
At temperatures of 8.0°C the maximum swimming velocity is 0.35M/sec.



Discussion

At water velocities of greater than 0.6M/sec glass eels are unlikely to be able to negotiate a channel that is 80 mm long and 20 mm wide such as might be identified on the sealing rim of a discharge with a flood protection door/flap. Swimming velocity increases with temperature. The endurance of glass eels is limited and high levels of activity can only be maintained for periods of less than a minute. There is a relationship between velocity and head which can be defined as V=SQRT(2gH). Chart 2 .

While it is understood by the authors that the discharge velocity across the seal faces of a door/flap does not confirm strictly to the formula V-SQRT(2gH) at the air/water interface. It is however a good approximation for majority of the flap/door seal faces. Where the difference in head is greater than 2.0 cms between the inner and outerface



of submerged door/flap the exit water velocity will exceed the maximum swimming ve locity of a glass eel.

The experimental work would indicate that tidal flap mechanisms in pristine conditions are likely to prevent the migration of glass eels because of high water velocities. The approximate velocities experienced can be determined by examining the head differential of the exiting water and referring to the above chart.

The default setting for this type of flood control mechanism should be set open rather than closed. Design changes should be adopted that make the flap mechanism deliver a zero head differential under low flow conditions.

Figure 3: Head must not exceed 1.5cms

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