TITLE: Estimation of glass eel recruitment River Wye to determine if a surplus for exploitation was present

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Navigation

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1.1 Introduction

The study was undertaken on spring tides over a period from March 26th to May 12th 2021. The site chosen was at the lowest point of the glass eel fishery on the River Wye at Brockweir, 10 kilometres inland from confluence of where the River Wye joins the Severn estuary.

Fig 1.1 Study site at Brockweir road crossing

2.1 Equipment

- Net Design: This is similar to a plankton trawl but without the flow limitations due to small mesh sizes. It is a specially fabricated net with mesh sizes to accommodate sediment loads and allow free flow of water.
- Net: Woven monofilament nylon.
- Main body of net: Meshes 5 per cm, monofilament diameter 330 microns.
- Cod end: Meshes 9 per cm, monofilament diameter 200 microns.

The anchor bridle was made of 1.5 stainless steel wire so not to obstruct the entrance of the net to the glass eels. The net was supported by a float so that it had a positive buoyancy of 0.5 kg.

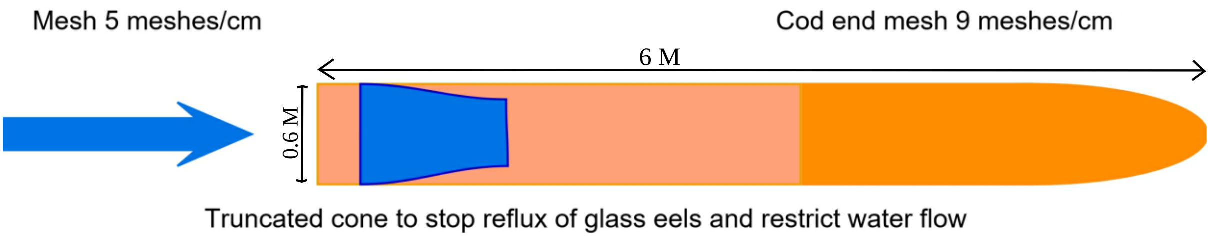


Fig 2.1 Trawl net for sampling glass eels

A mechanical logger (NASA) with paddle wheel mounted on a separate platform adjacent to the net to measure water velocity and distance of lateral movement of fished sector that was displaced by the tide. These data were to be used to estimate the volume of water filtered.

3.1 Method

Samples were collected over 23 evening spring tides that were greater than 7.0 metres (Sharpness datum) at Brockweir. The majority of the sampling was undertaken in twilight or after sunset. There was no fishing on the dawn or daylight tides. The samples were taken from the start of the flood tide until high water. The upstream lateral displacement of the tide was recorded as being between 90 and 120 minutes depending on the height of the tide.

The net was lowered upstream side of the bridge during the flood tide. It was anchored to the river bed. The horizontal spatial distribution of the net was restricted to the slower velocities in the river in order to avoid the flotsam and jetsam. The area of the river with the fastest velocities was heavily contaminated with debris and not fishable (fig 3.1).

Fig 3.1 Debris

The velocity of the flood tide determined the depth at which the net fished. At the highest water velocities (greater than 0.9 m/sec) the net fished on the river bed. At slack water the net came to the surface and at other velocities the net fished at intermediate depths of the water column.

The water column was contaminated with small detritus that the impellor of the logger frequently stalled. For this reason, an alternative method to measure the velocity was trialed using illuminated Pooh sticks (AA Milne) timed over a distance of 50 metres upstream of the bridge. However the mean velocity recorded did not accurately represent the faster velocities near to the bridge where the net was anchored.

The conventional approach would be to estimate the total abundance of glass eel by dividing the total number captured by the total volume sampled. Then for each tide, the total volume of water would be estimated by multiplying the total duration of the flood tide (s) x the average tidal speed (ms^{-1} x the mean cross-sectional area of the channel (m^2)).

In view of the problem of recording continuous flow data our approach was to estimate the total abundance of glass eels by sampling as much as the flood tide as possible. The immigrating population was calculated by dividing the cross-sectional area of the river by the cross-sectional area of the sample net and multiplying by the number of captured glass eels. The immigrating abundance is based on the numbers of glass eels caught over the number of active flood tides.

The total estimate was calculated as follows. There are some inherent assumptions.

- Eels are distributed evenly throughout the water column, both horizontally and vertically.
- Selective tidal transport only carried the glass eels up stream in the flood tide.
- Net efficiency was 100%

3.2 Schematic

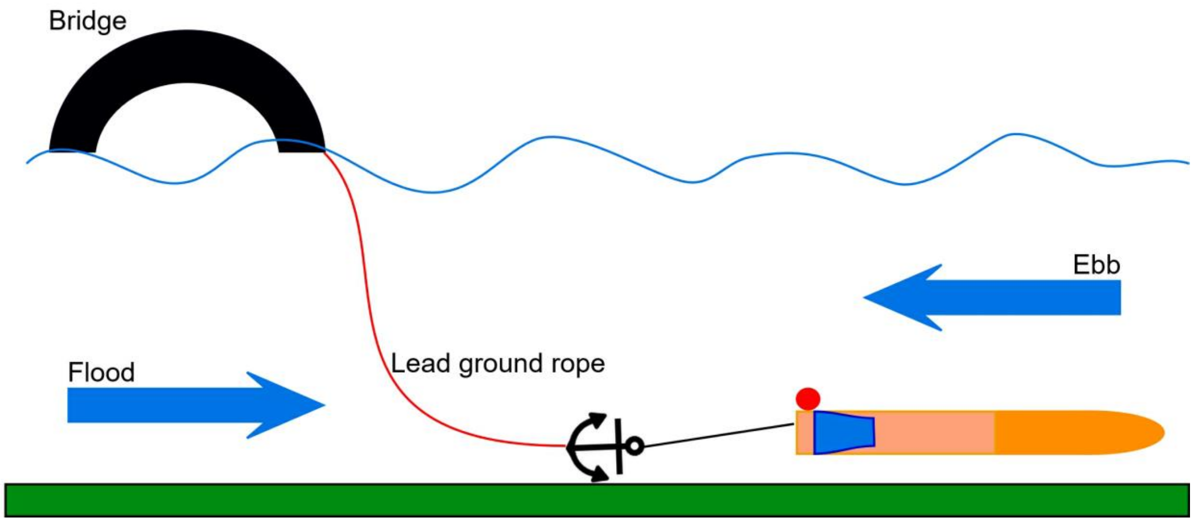


Fig 3.2 Representation of sampling method

Fig 3.3 Deployment of net

Fig 3.4 Net in water

4.1 Results

The duration if the flood tide was between 90 and 120 minutes. The mean sampling time was 70 minutes per tide. 26.5 hours of sampling was undertaken over 23 tides yielding a total of 2,929 glass eels. (Figure 4.1). Based on mean cross-sectional area of the river of 170.7 m^2 (width 48.77m; mean depth 3.5m (appendix 1) and the abundance of glass eels caught (2929 fish) on the flood tides fished in March/April was equivalent to 595 kgs of glass eels (Table 4.1). Assuming the duration of the flood tide at Brockweir was between 90 and 120 minutes the estimated total catch of glass eel would have been between 709.8 – 946.4 kg (Table 4.1).

No immigrating glass eels were detected after April 30th.

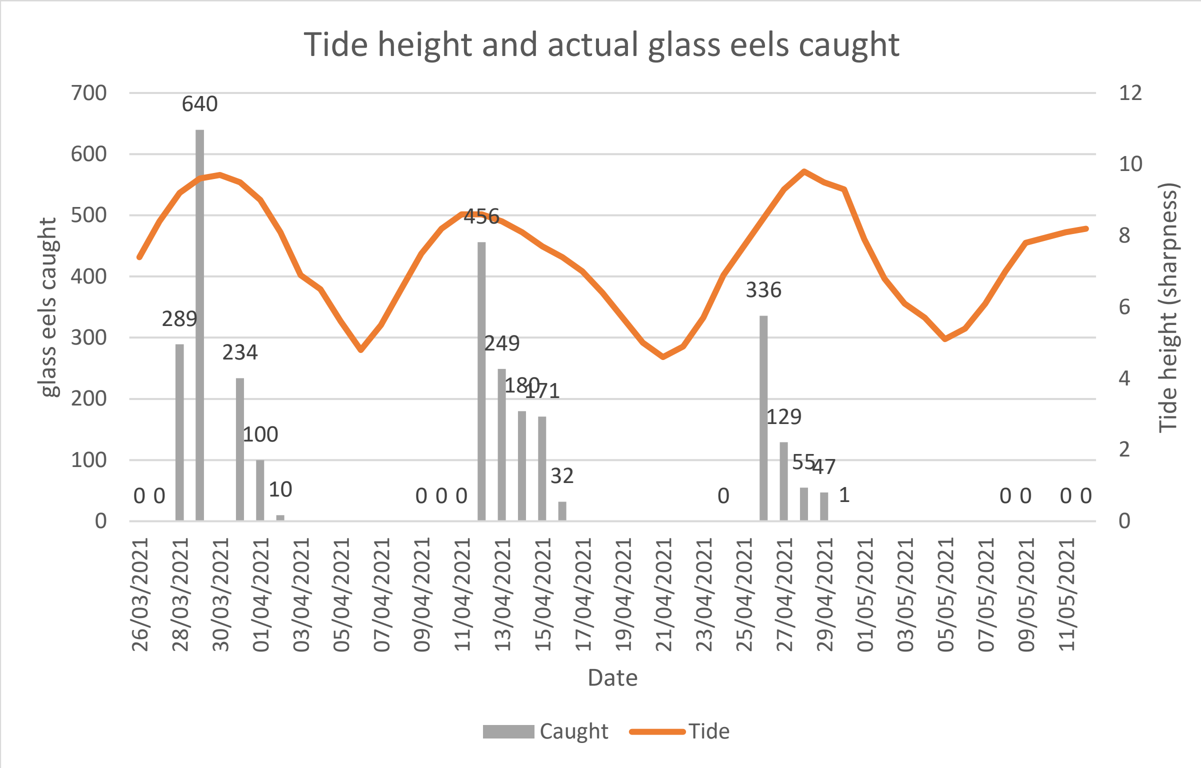


Fig 4.1 Actual number of glass eels caught during sampling process on each tide

Width of river (m)	*a*	*48.77*
Depth of river (m)	*b*	*3.5*
Area of net (m^2)	*c*	*0.28*
Nets per river cross section	*(a x b)/c = d*	*609.625*
Number of glass eels/ kg	*e*	*3000*

Table 4.1 Catch and estimated total quantity of glass eel at Brockweir during the sampling period

Date	Tide	Caught	Fish running	KG	Time net in water	kg/ hr	kg/1.5 hr	kg/2hr
		f	f x d = g	g/e = h				
26/03/2021	7.4	0			00:27	0	0	0
27/03/2021	8.4	0			01:30	0	0	0
28/03/2021	9.2	289	176182	59	01:24	42.1	63.15	84
29/03/2021	9.6	640	390160	130	01:40	78	117	156
31/03/2021	9.5	234	142652	48	01:55	25	37.5	50
01/04/2021	9.5	0			01:20	0	0	0
01/04/2021	9	100	60963	20	01:19	15.2	22.8	30
02/04/2021	8.7	0			01:10	0	0	0
02/04/2021	8.1	10	6096	2	01:03	1.9	2.85	4
							0	0
09/04/2021	7.5	0			01:07	0	0	0
10/04/2021	8.2	0			00:30	0	0	0

11/04/2021	8.6	0			00:56	0	0	0
12/04/2021	8.6	456	277989	93	01:10	79.7	119.55	159
13/04/2021	8.4	249	151797	51	01:13	41.9	62.85	84
14/04/2021	8.1	180	109733	37	01:05	34.2	51.3	68
15/04/2021	7.7	171	104246	35	01:10	30	45	60
16/04/2021	7.4	32	19508	7	01:00	7	10.5	14
							0	0
24/04/2021	8.5	0			01:12	0	0	0
26/04/2021	9.3	336	204834	68	01:05	62.8	94.2	126
27/04/2021	9.7	129	78642	26	00:45	34.7	52.05	69
28/04/2021	9.8	55	33529	11	01:00	11	16.5	22
29/04/2021	9.5	47	28652	10	01:02	9.7	14.55	19
30/04/2021	9.3	1	610	0	01:25	0	0	0
							0	0
08/05/2021	7.1	0			01:00	0	0	0
09/05/2021	7.8	0			01:35	0	0	0
11/05/2021	8.2	0			01:35	0	0	0
12/05/2021	8.2	0			00:30	0	0	0
Total kg of glass eels migrated up on the nights fished				595		473.2	709.8	946.4

In addition to the glass eels caught a very large number of gammarids were caught. On some occasions as much as 4.0 litres. This would have equated to hundreds of kilos on any one tide. No other species were detected.

Fig 4.2 Sample of gammarids caught

5.1 Discussion

It became apparent, very early in the program that the quantity of flotsam and jetsam (fig 3.1) on these flood tides was a significant hazard to the net and proved to be very challenging. Not only with the net becoming snagged by debris but also the impellor of the logger being stalled when in contact with detritus. Without continuous management tidal velocity data was intermittent, introducing another level of variability in the sampling process.

Our approach in the future will be to increase the sample time to cover all of the flood tide period. This will eliminate the errors associated with measuring water velocities and volumes.

Using an anchor to secure the net also had some advantages. The leaded recovery ground rope was submerged and not under any tension. The line could be set to one side to avoid debris. The static loads were directly on the anchor. There was no static load on the recovery rope and consequently no static load on the bridge. The static loads on the recovery rope if attached directly to the bridge at times at the high flow rates could be in excess of 50 kgs.

By anchoring the net to the bottom of the river as opposed to the bridge it was possible to fish the whole of the vertical profile including the deeper water.

We were able to eliminate a number of assumptions and concerns raised in the APEM assessment as follows:

- *Clogging of net.* A larger monofilament mesh was used. There were no problems with clogging with sediment.
- *Difficulty of sampling deeper water*. Using an anchor, it was possible to sample glass eels across the whole of the vertical column.
- *Double sampling*. Glass eel were are only sampled once as they are carried up stream in the flood tide. Some additional sampling was carried out in the first 30/45 minutes of the ebb tide. More than 30 minutes after high water the increasing velocity of the ebb flow made the recovery of the sample net difficult/impossible. During our trial no glass eels were caught on the ebb tide. It is possible that un-acclimatised glass eels confronted by low river temperatures and high freshwater flows might be carried downstream along the riverbed.

Matters still outstanding.

- All the sampling was carried out on the evening tides with reduced light levels or in the dark. We were not able to confirm that there were any correlations between glass eel density and light intensity for either surface samples alone, deep samples alone, or total combined samples.
- It was not possible to determine the fishing efficacy of the net. Different configurations of net design and mesh sizes would have to be trialled.
- The retrieval on the net proved to be challenging. Net retrieval was very difficult to impossible with water velocities over 2.5 knots. Manual net retrieval can only be achieved at low water velocities.

Static loads on the net increased exponentially with velocity. Static loads greater than 25 kgs made the net difficult to retrieve by hand. Retrieval loads were greater than static loads. Data would indicate larger nets could not retrieved by hand. See Appendix 2 static loads.

Tests on a larger net 1.2 diameter in water velocities of 3.5 knots compromised the integrity of the net. Retrieval of this net with a winch introduced additional loads that collapsed the net support ring where the bridle was attached.

6.1 Conclusion

The study would suggest that somewhere between 710 - 946 kg of glass eel migrated upstream during the sampling period. This can be taken as a minimum estimate of the total quantity immigrating into the Wye for the following reasons:

1. The estimate is based on a sample of 25 out of a possible 38 evening tides for March and April.

2. No consideration has been given to daytime immigration (Bardonnet et al 2005) or any immigration in February.
3. The net efficiency has been taken as 100% and is likely to be an overestimate as under high flows a pressure wave forms at the front of the net and will divert the glass eel around the net.
4. The glass eel are assumed to be evenly distributed both horizontally and vertically. However as mentioned in section 3.1 there were areas of high flow where the net could not be fished, and sampling was confined to the lower velocity areas and possibly fewer glass eel per unit time.

EA river modelling data indicates that the Wye requires 670 kg of glass eels to meet its silver eel carrying capacity (EA Elver River modelling data EA. 2018). The EA glass eel modelling data for the Wye shows an average catch of 42 kgs for years 2015-17   This study together with that carried out on the Severn (Aprahamian M. and Wood P. 2020) would suggest that there are enough glass eel entering the Wye and Severn to meet the carrying capacity requirement in terms of silver eel output of 11.98 kg/ha.

However, the fact that the current silver eel output for the River Wye is estimated at 0.29 kg/ha raises the very significant question as to "why is current output so low?"

This suggests that either:
1) The monitoring programme does not accurately assess silver eel production.
2) There is a very high mortality of glass eel from causes as yet unknown.

6.2 Comments

We should not lose sight of the fact that glass eel exploitation using the traditional hand net on the Wye is totally dependent on the active migration of the glass eels.

Glass eel immigration is a passive migration using selective tidal stream transport. It is a low energy strategy largely independent of local environmental conditions such as temperature. Our sample data indicates that there is significant immigration taking place early in the spring.

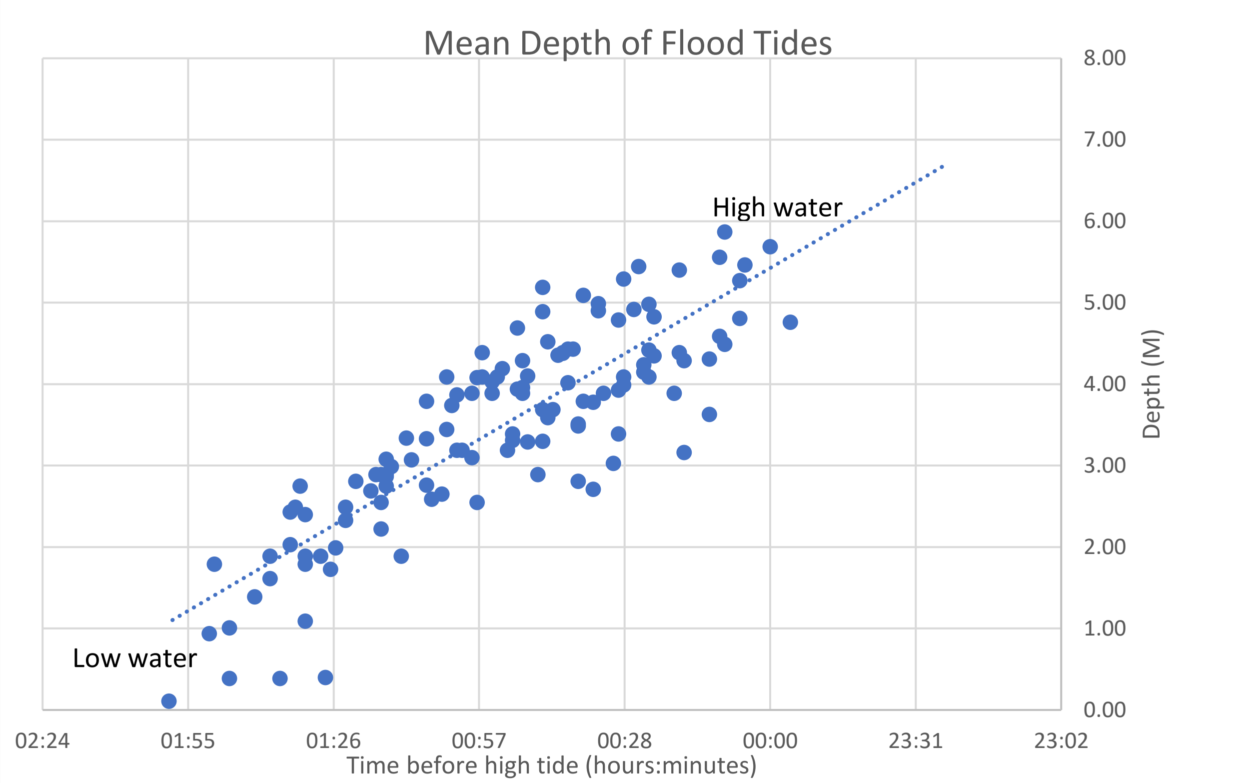
The hand net fishery relies wholly on the active migration of the glass eels which is highly sensitive to local conditions particularly temperature. The active migration is a short term (15-30 minutes) high energy strategy. Historical fishing data indicates that active migration does not take place on the river Wye until late spring.

Conditions for active and passive migration conditions do not occur concurrently in this river.

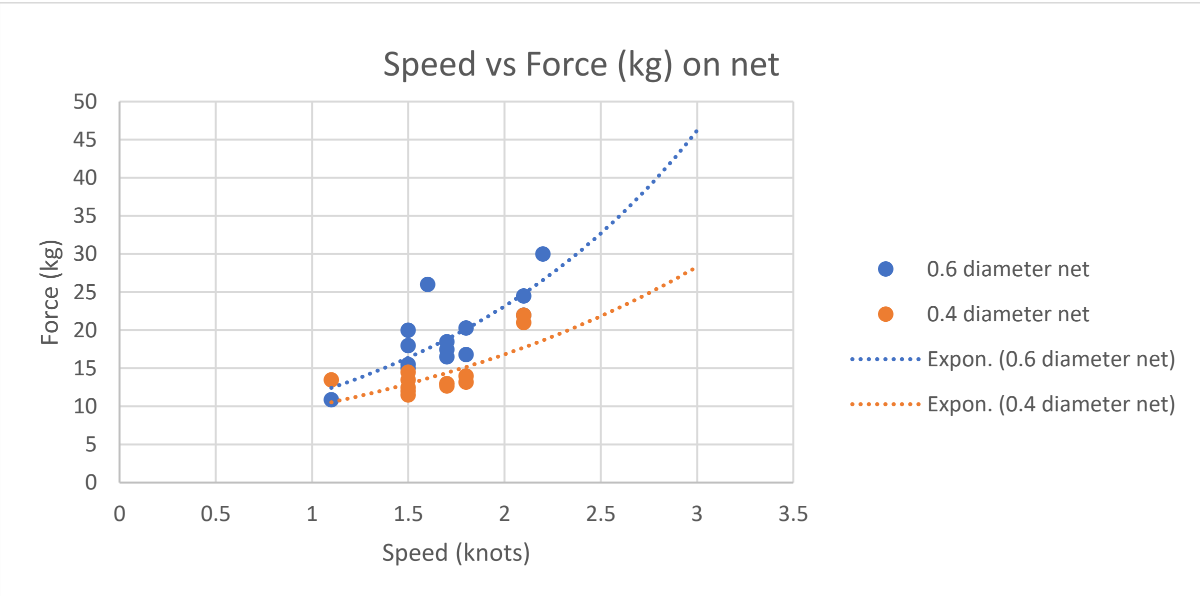
The measured lateral tidal movement at Brockweir is in the order of 7 kms per tide. The fishery is located on a 5.0 km stretch between Brockweir and Bigsweir. It is highly likely that with the selective tidal transport mechanism that the immigrating glass eel population will passively traverse the fishery in just one tide undetected and unfished with 100% escapement. This is because active migration on which the hand net fishing is so dependent is absent in the early part of the spring.

For this reason alone, catch returns on this river are not a reliable proxy for recruitment. They are only a proxy for stocks that have not taken advantage of the selective tidal transport mechanism.

Appendix 1



Appendix 2



Aprahamian M. and Wood P. 2020. Estimation of glass eel (*Anguilla anguilla*) exploitation in the Severn Estuary, England. Fisheries Management & Ecology 28, 65-75. https://doi.org/10.1111/fme.12455

A.Bardonnet, V. Bolliet, V. Belo Recruitment abundance estimation: Role of glass eel (Anguilla anguilla L.) response to light Journal of Experimental Marine Biology and Ecology 321 (2005) 181– 190.

