Environment Agency

Monitoring elver and eel populations

The Eel Manual – GEHO0211BTMY-E-E

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Horizon house, Deanery Road
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Tel: 0117 934 4000
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E: enquiries@environment-agency.gov.uk.

***Sound Metrics Corporation,** 15029 Bothell Way NE, Suite 100, Lake Forest Park, WA 98155

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1 Introduction

EU Council Regulation (EC) No. 1100/2007 Article 9 requires member states to evaluate the effectiveness of Eel Management Plans (EMPs) and report to the European Commission initially every third year, starting 30 June 2012.

For each member state the reports shall provide the best available estimates of:

- the proportion of the silver eel biomass that escapes to the sea to spawn, or
- the proportion of the silver eel biomass leaving the territory of that Member State as part of a seaward migration to spawn, relative to the target level of escapement.

The target level of escapement is at least 40 percent of the silver eel biomass relative to the best estimate of historic escapement that would have existed if no anthropogenic influences had impacted the stock.

The 11 EMPs for England and Wales highlight a paucity of monitoring data on eel and describe actions to gather more and better-targeted information on eel populations. The following chapters set out the sampling methodologies that can be used to assess the status of eel populations and evaluate management measures taken to aid recovery of the eel.

This guidance document should be read in conjunction with the Environment Agency Operational Instruction (OI) 'Sampling Eel Populations in Rivers' and includes text taken from the OI.

It should be noted that Natural England or Countryside Council for Wales permission must be sought prior to carrying out monitoring operations in designated rivers (SSSI/SAC).

This document was produced by Liz Baldwin, Ros Wright, Sally Chadwick, Andy Don, Kevin Nash, Jim Lyons, Matt Hart, Jon Hateley, Sophie Arbuthnot, Ben Bayliss and Pete Sibley.

2 Glass eel/elver monitoring

2.1 Site selection

The best places to monitor glass eels and elvers are weirs or barriers with elver passes. Choose sites where you have good access and can set traps safely. Avoid areas where there is commercial elver fishing.

Where possible, select sites where most of the elvers and glass eels will use the pass and therefore be captured in the trap.

Some sites will be suitable for remote monitoring using cameras.

2.2 Trap design

Always choose a trap that is the right design for the site. Some general pointers include:

- The trap must be large enough to hold all the elvers and eels that could be caught between inspections. Check what works in practice. It may be difficult to predict just how many animals will get caught and when there will be peaks of activity.
- The trap should provide safe refuge for the glass eels/elvers to prevent them from continuously trying to escape and exhausting themselves. This is particularly important when there are long gaps between inspections or when large numbers of eels are migrating.

Don’t use sacking bags or brightly lit boxes without refuges. The animals will constantly try to escape from these.

- The design should make it easy to remove and transfer the trapped animals safely – without endangering either the animals or the trap operator.
- Direct sunshine could raise the temperatures in the trap to excessive levels. Avoid this: either place the trap in natural shade or provide shading.

References

Solomon, D. J. & Beach, M. H. (2004) Manual for provision of upstream migration facilities for Eel and Elver. Science Report SC020075/SR2 Environment Agency, Bristol

2.3 Data requirements

You will need to record:

- date and time of trapping;

- length of fishing period;
- water temperature;
- the numbers of glass eels/elvers caught;
- where possible, an estimate of the proportion of the migrating population that has been captured.

Estimating numbers caught

If you catch very large numbers of eels and elvers, it is acceptable to estimate the numbers caught from the weight of the catch. First you must count and weigh a representative subsample. Then you must weigh the rest of the catch. The equation to use is:

N = (([Weight of rest of catch/weight of subsample] x count of subsample) + count of subsample)

If you use this technique, record both the total (estimated) number of eels/elvers caught and the total weight of the catch.

2.4 Examples of traps for glass eel and elver

Figure 2.1 Elver trap at Judas Gap, River Stour, Anglian
Picture: Ros Wright

Figure 2.2 Simple elver trap under bridge, River Lydd, Kent
Picture: Sally Chadwick

Figure 2.3 Trial trap at Mocketts Pumping station, Southern region
Picture: Sally Chadwick

Figure 2.4 Siphon-fed trap being fitted on anchor-tilting weirs, Sussex Ouse Picture: Sally Chadwick

2.5 Remote monitoring

At some locations, you can use cameras to monitor glass eels and elvers using passes. Although your final set up will depend on the site, there are some general considerations. These include:

- the security of cameras;
- how to record images;
- how to process images – this can be time-consuming;
- when to monitor;
- the other data that you need collect – such as flow, rainfall, temperature.

We have used remote monitoring successfully at Oath lock on the River Parrett and at the Greylake sluices on King's Sedgemoor Drain in Somerset. Cameras allowed us to monitor the effectiveness of the passes and to observe elver and glass eel behaviour.

At these sites we found that:

- most activity takes place between midnight and 03:00 – regardless of the weather or other environmental conditions;

- true elvers and larger eels use the passes;
- there are pulses of activity;
- there are signs of queuing– if the pass goes off-line, numbers spike on re-start;
- size of eels using the pass is related to bristle density
- elvers show resting behaviour while using the bristle pass
- the eels can use the passes even when water flow is low;
- the migration season is long, from March to November.

Figure 2.5 Image from camera at Oath Lock, Somerset
Picture: Andy Don

For further information on eel passes please refer to 'Elver and eel passes: A guide to the design and implementation of passage solutions at weirs, tidal gates and sluices', one of the four guidance manuals within The Eel Manual.

3 Yellow eel monitoring

3.1 Introduction

There are two methods for monitoring yellow eels in rivers: electric fishing and fyke netting.

Use electric fishing as far down the catchment as is feasible. This method can produce fully quantitative estimates of density.

In some places electric fishing will not be possible – for example due to depth. In such cases it's best to use fyke netting.

On large lowland rivers this may mean that you use electric fishing to survey the tributaries of a catchment and fyke netting in the main stem. However, if you use this approach, identify the position of any significant barriers to upstream migration.

Ideally you should survey ten sites with electric fishing, and carry out additional fyke netting to get representative coverage of the catchment.

Establishing a range of sites which reflect spatial variation across a catchment can be difficult . It may not be possible to find enough sampling sites which are suitable for electric fishing or fyke netting.

Wherever possible you should choose electric fishing rather than fyke netting. We need to improve our understanding of the quality of the data we get from fyke netting. For example:

1. We can't always be sure of the area of river bed that a fyke net samples. This area may be equivalent to the eels' home range, and this will depend on the size of the eel.

2. We don't know enough about how environmental factors may affect eel behaviour.

It is possible to allow for the effect of environmental factors by standardising the Catch Per Unit Effort (CPUE) over time – using key variables such as water temperature and turbidity. Use a General Linear Model to remove variations due to recordable and significant environmental factors. This will improve the value of your analysis of CPUE over a given time period.

3.2 Site selection

3.2.1 Factors affecting site selection

When you choose a site, consider:

- safety and access;
- catchment representation and barriers to migration.
- survey method.

Safety and access

As you develop your monitoring programme, make sure you assess the health and safety risks at each site.

Catchment representation and obstructions to migration

Physical barriers like weirs make it difficult or impossible for elver and eel to travel upstream.

If possible, place some of your survey sites downstream of these significant obstructions. This will avoid an underestimation of eel and elver numbers.

However, on most large rivers, all the potential sites for electric fishing are upstream of these barriers. If this is the case, use fyke netting downstream of the obstructions and electric fishing upstream.

If you place your sites carefully in relation to known barriers, your surveys may provide you with excellent information on how those barriers affect eel distribution.

Use your monitoring data to create **eel density v estuary distance** graphs. These will help you to:

- interpret data;
- identity where eel passages are most needed;
- refine your monitoring programme.

Survey method

If possible, survey yellow eel surveys by using wading electric fishing. This is the most efficient method for sampling smaller eel. However large eels in deep water will be under-represented in the catch.

Where wading is not practical, you can electric fish from a boat. However the catch will then be biased towards larger eels.

Electric fishing from a boom boat is **not suitable** for eel surveys.

If you can't use electric fishing at a particular site, see if you can move your survey somewhere else.

If you can't move to a site where electric fishing is possible, use fyke netting. This method is biased towards larger eels. Use a mark, release and recapture (MRR) method to estimate population size.

Use the decision tree in Figure 3.1 to select the best sites for your monitoring.

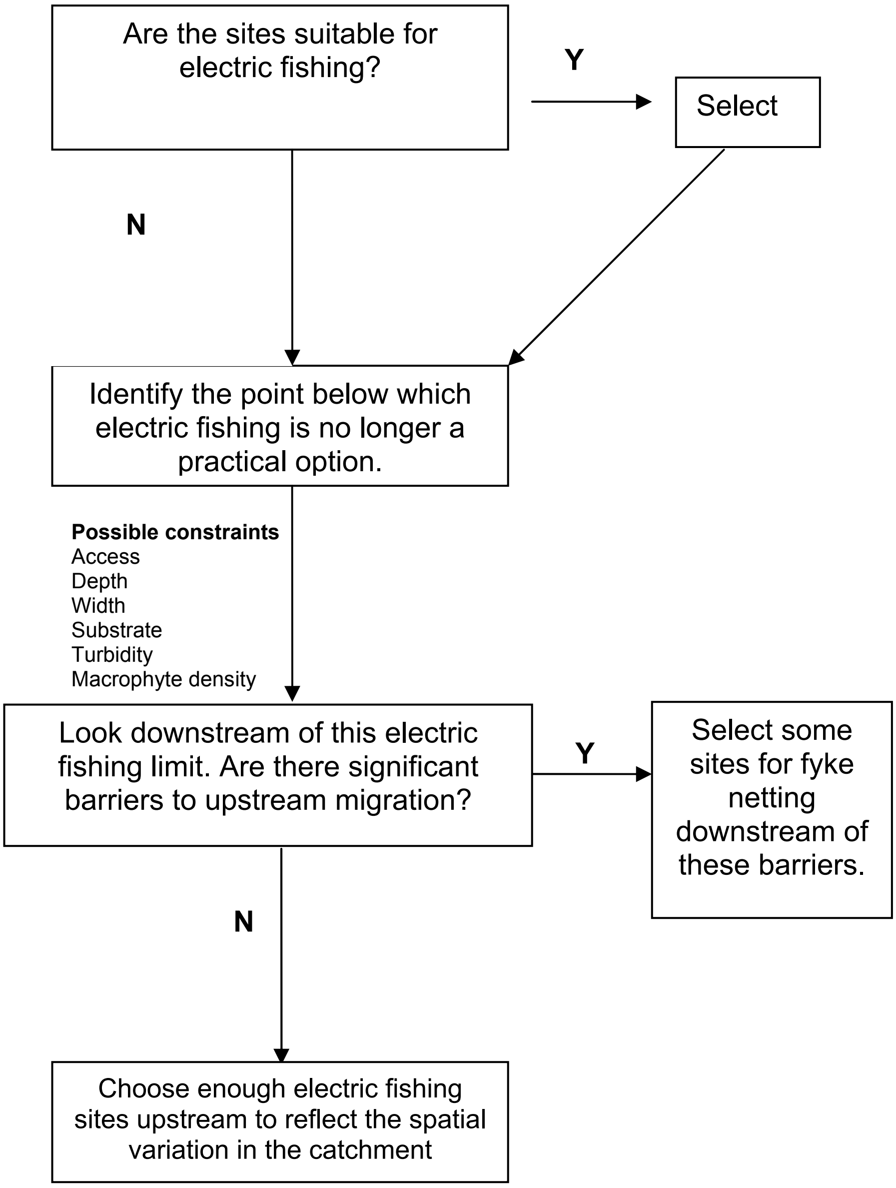


Figure 3.1 Decision tree for selecting survey sites for yellow eels

3.3 Electric fishing

Timing

Survey eels using electric fishing from the beginning of June to the end of October

River depth

- Electric fishing by wading is suitable in rivers with a mean depth of less than 0.8 metres.

- Where the substratum is soft and easily disturbed, wading may be inappropriate. Cloudy water (turbidity) will significantly reduce your catch rate.
- Electric fishing by boat, using hand-held equipment, is suitable for rivers with a mean depth that is more than 0.8 metres but not more than 1.5 metres. Note: this survey method is biased towards larger eels.

Visibility

Only undertake an eel survey when the water is particularly clear. Eel tend to be stunned on the river bed, and are more difficult to see than other species of fish.

Team members must concentrate hard when looking for eel and work slowly and methodically in an upstream direction.

Quantitative surveys

Your quantitative surveys must use the standard catch depletion method.

To satisfy the conditions of the population estimation method, you must isolate the site being fished. Use stop nets and/or natural barriers. You must fish the full width of the river. **It is essential that you put the same effort into fishing throughout all fishing runs.**

You must fish a site at least three times and may need to do up to six runs if catches are still relatively large. There is no advantage in doing more than six runs. If your catch efficiency is low you will not get an accurate population estimate. Your data will still give you a minimum population estimate and age/size structure of the population.

Electrical output

Best practice guidance on electric fishing recommends the use of 30-40 Hz and a 10% duty cycle for eel.

The following table gives guidance on the recommended voltages. These are depend on ambient conductivity at the site.

Ambient Conductivity	Voltage
150-500 µs/cm	200-300 volts
500-800 µs/cm	150-200 volts
800-1000 µs/cm	120-180 volts
>1000 µs/cm	100-150 volts

You may need to reduce the voltage to avoid harming sensitive species. However this is likely to reduce your catch rate.

Important – conductivity varies with temperature. If your conductivity meter corrects for temperature it will give you ambient conductivity. Many conductivity meters are calibrated to 25ºC. This means the reading is the value that the conductivity would be at 25ºC. If your conductivity meters is calibrated to 25ºC you must convert the measured conductivity to ambient using the following formula or the table in Appendix 1

$KA = Ks/ 1.023(25-t)$

Where KA = ambient conductivity

Ks = specific conductivity at 25ºC

t = water temperature

Nets

Stop nets

We recommend that you use stop nets when electric fishing for eel.

The recommended mesh sizes are:

- 3 mm micromesh for lower reaches – that is up to 30 km upstream of the tidal limit;
- 5 mm mesh for sites further upstream.

Hand nets

We recommend that you use 'D' shaped hand nets with 3 mm micromesh to capture fish.

Processing captured eel

Keep eel in a separate container from other fish. Stressed eel produce lots of mucus. This can increase the viscosity of the water in the container to the point where other fish are unable to breathe satisfactorily. If holding eel for a short period they can be placed in a dry container. However for longer periods the holding container should have a large volume of water.

Eel can climb. You must hold eel in containers that are tall enough to make escape unlikely. Ideally the containers should have lids. If this is not possible then a net should be placed over the container.

Record the length of yellow eel to the nearest 5 mm.

If very large numbers of eel are captured, measure a representative sample of all sizes.

Record the number, if any, of glass eel/elver captured.

3.4 Fyke netting

Timing

Use fyke nets to survey eels from the start of June to the end of December.

Net specification

Fyke nets (with leaders or wings) are conical nets with inscales and a circular or D-shaped opening held open by metal rings. There is a series of interconnecting nets with a one-way entry to trap fish.

There should not be more than two leaders (or wings acting as leaders) on each fyke net. Each wing or leader should not exceed 10 m in length.

The net, excluding wings or leaders, should not exceed 5 m in length or 1 m at its widest point. The height of any wing or leader should not exceed the width of the net opening at its widest point. No part of any net, wing or leader should be made of a mesh greater than 36 mm (when fully stretched).

The cod ends of fyke nets for eel should have 10 mm mesh.

Licensing fyke nets and using otter guards

All fyke nets must be licensed by the Environment Agency (EA) Fisheries Permitting Team and must be tagged.

Tell your local EA Fisheries, Recreation and Biodiversity and Environmental Crime teams where and when you will be fyke netting.

All fyke nets must be fitted with otter guards. These will be issued with your licence.

River depth

Fyke netting is suitable for rivers with a mean depth of between 1.5 and 15 metres.

Catch per unit effort surveys

You can use catch per unit effort (CPUE) fyke sampling to produce a basic assessment of eel populations. The table below sets out how.

1	**Use single or double-ended fyke nets. Use a minimum of 10 cod ends. Number each cod end (trap).**
2	Fish for at least 24 hours.
3	Recover the fyke nets.
4	Record the number of cod-ends (traps), and the time spent fishing (in hours and minutes).
5	You will need to record the number of the cod end (trap) each eel was caught in. So keep catches separate until they have been measured.
6	Process all the captured eel as for electric fishing surveys.

Mark release and recapture surveys

1	Use the fyke nets as for CPUE surveys.
2	Recover the fyke nets after a minimum of 24 hours fishing. Record the time spent fishing.
3	Process all the captured eel as for electric fishing surveys.
4	Mark all the eels that have been measured individually on their ventral side, between the pectoral fins. Use alcian blue in a Panjet or hypodermic needle. You may decide to use anaesthetic, see using anaesthetic for guidance.
5	Return the marked eels to the site. Leave them for at least 24 hours so that they can disperse through the site.
6	Redeploy the fyke nets.
7	Recover the fyke nets after fishing for at least 24 hours. Record the time spent fishing.
8	You will need to record the number of the cod end (trap) each eel was caught in. You must therefore keep catches separate until they have been measured.
9	Process all captured eel as for electric fishing surveys.

MRR fishing without stop nets

It is impractical to use stop nets in rivers for the long periods however eels have a small home range. MRR fishing without stop nets therefore produces the best achievable estimates of population. We consider this to be an acceptable quantitative method for eel surveys.

4 Silver eel monitoring

4.1 Fyke netting

Fyke netting can be used to assess silver eel escapement and to validate other methods such as Didson or resistivity counters.

For more information on fyke netting methods, see section 3.5.

4.2 DIDSON

DIDSON™ stands for Dual-frequency Identification Sonar. It is a high resolution, imaging sonar which is being used increasingly for fisheries monitoring .

Set up

- Ensure DIDSON is safe from theft and vandalism.
- Ensure DIDSON has a reliable power supply:
  Options include:
  - 240V / 110V AC from mains or generator;
  - 24V / 12 V DC from batteries or a methanol fuel-cell via universal power supply or invertor.
  - Consider using a low-power logging computer – such as an ITX – and a USB-powered external drive.
- Ensure beam fits the river's profile. Avoid acoustic dead zones and structures which obscure images of eels.
- Look for a site where the river is more less than 15 m wide. Operate the DIDSON at high frequency (1.8 MHz).
- Aim for a minimum frame-rate of ~5 fps (frames per second).
- Ensure there is no unwanted movement in front of the beam – for example from weed, milling fish, debris. Cut weed periodically if required.
- Use a single, secure, protected mounting.
- Ensure beam is perpendicular to eel movement (~30° max offset).
- Deploy DIDSON well before you expect there to be eel movement.
- Species ID. Make sure the camera isn't picking up other species such as lamprey. If necessary, validate your results with trapping.

Operation

- Log 24 hours a day, every day. If issues such as data storage or power make this impossible, carry out night logging and do spot checks in the daytime.

- Do you know how deep the eels are? If you don't, try to sample all of the water column. Consider doing hourly samples at different depths.

- If you're just sampling at a fixed depth, map the beam to estimate the proportion of water that is being sampled and use the count as an index of eel run.

Data processing

- Use DIDSON software for most studies.

- Try CSOT file-shrinkage and batch processing:

    - To keep the down the size of your files, experiment with different settings for thresholds, cluster sizes and persistence.

- Play in image mode at an elevated frame rate (~ 15-30 fps).

- Use the 'Mark Fish' tool for lengths, timings and direction.

- Use the 'Tallywhack' tool for simple numbers and direction.

- To convert your results to silver eel biomass, use appropriate length / weight regressions from local data or published length/wieght relationships.

- Other software is available for more difficult applications: SONAR5-Pro may be able to tell you the depth of the eels from shadows. It also has a more versatile eel-measuring tool.

- Auto-counting is still a long way off.

References

Hateley, J., Gregory, J. & Ingleby, A. (2006). Enumerating Silver Eel Escapement at Welford Mill Trap. Extract from: Evaluation of a multi-beam imaging sonar system (DIDSON) as a Fisheries Monitoring Tool. Project Record, October 2006.

Hunt, K. & Clark, P.F. (2009). Report on use of Dual Frequency Identification Sonar (DIDSON) to monitor entrainment of *Anguilla anguilla (*Linnaeus, 1758) in a water intake at Walton on Thames, Surrey. 'Environment Agency Report.

Bilotta, G.S., Sibley, P., Hateley, J. and Don, A. (2011). The decline of the European eel *Anguilla* anguilla: quantifying and managingl escapement to support conservation. Journal of Fish Biology **78**, 23-38

For further information on the use of DIDSON contact Jon Hateley, Environment Agency.

4.3 Eel racks and traps

You can use eel racks to assess silver eel migration. The ideal option is to arrange for an operator of a commercial eel rack to help with data collection.

If there is no commercial operator, and you will be operating the eel rack, you need to consider how the rack may affect the water level.

Inform or consult other Environment Agency teams

1. Flood and Coastal Risk Management (FCRM) team:
    - Obtain consent from the FCRM team. Agree thresholds – for example for the upstream water level. These thresholds may be defined in the structure's operating manual.
    - Tell the FCRM team when you will be operating the trap: increased water levels may trigger a FCRM incident response.
2. Hydrometry and Telemetry (H&T) team:
    - Tell the H&T team when you will be operating the trap. Changes in water levels may affect flow calculations.
3. National Customer Contact Centre (NCCC):
    - Produce a standard paragraph. Use or adapt the example below in green. The NCCC will issue this to members of the public who report a small change in water level near the trap.

In the event of any calls relating to water levels at [INSERT LOCATION] on [INSERT DATE], please issue the following statement:

What are we doing?

Environment Agency staff are operating an eel trap at [INSERT LOCATION] between [INSERT START/FINISH TIME]. This is to monitor the adult eel population. This may result in a slight change in water level.

Why?

Eel numbers have fallen to an all-time low across Europe. Scientists estimate that the number of eels that are surviving the glass eel (juvenile) stage is now less than 5% of what it used to be. To save the eels, we need a clearer picture of what is happening. One key figure that we need to establish is the number of adult eels which are returning to sea to spawn.

Further information

Please contact [INSERT NAME OF LEAD OFFICER] or visit

http://www.environment-agency.gov.uk/

Inform local residents/angling clubs

Tell local residents, angling clubs and any other affected parties what is happening. Give them the dates and times when the trap will be operated. This will reduce the number of calls received by the NCCC.

Health and safety

Always assess the risks before you start monitoring. Consider the general risks, the risks for that site, and the dangers associated with that particular task.

Data recording

Record:

- the date;
- the length (to the nearest 5 mm) and weight of silver eel;
- the silvering;
- the temperature and flow (at the nearest gauging station);
- the fishing start and finish time;
- the duration of the fishing period;
- the lunar phase.

There is a draft silver eel recording sheet in Appendix 2.

4.4 Resistivity counters

The use of resistivity counters is not an established method for monitoring migrating silver eels. The reliability and accuracy of counts will depend on the site. Trials of use of resistivity counters for silver eel are being carried out on the Rivers Leven (North West) and Fowey (South West).

River Leven

Data from this counter has been used to evaluate silver eel migration for several years. The nature of the river at this point means that most eels are detected. We can be fairly confident from the timing of the migration (Figure 4.1) and the patterns detected (Figure 4.2) that the counts are for silver eel movements. Video cameras are being installed in 2010 to verify the counter data.

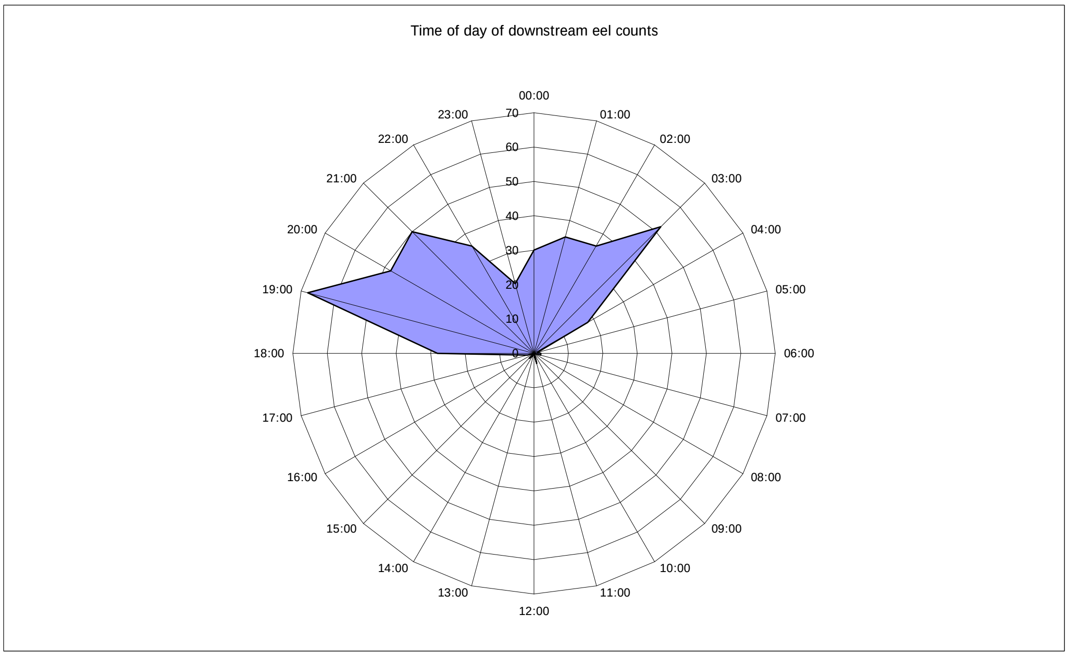


Figure 4.1 Time of day of downstream silver eel counts

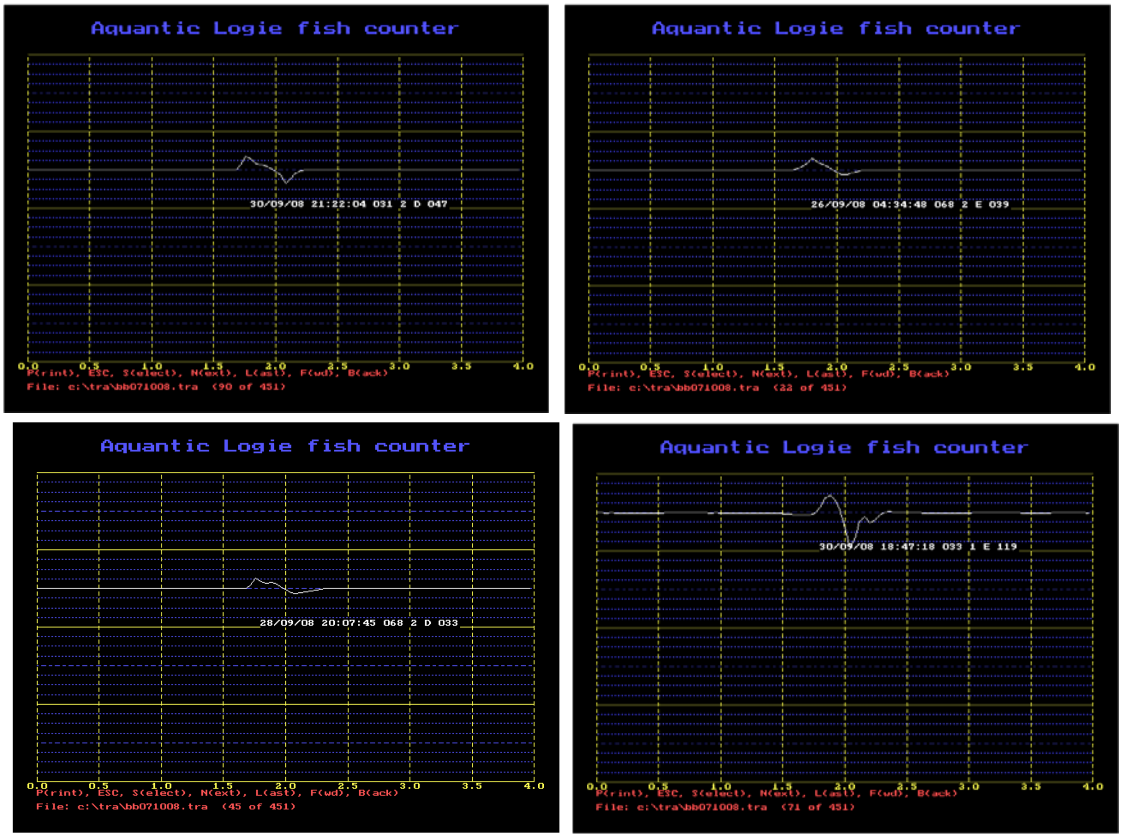


Figure 4.2 Examples of silver eel traces

River Fowey

A trial using the resistivity counter with video verification on the Fowey to monitor silver eel migration was carried out using 2008 and 2009 data.

Of the 211 identifiable downstream counts, only 27 were eels. Many of the other counts were otters.

The following method was used to estimate the silver eel escapement:

- a sub-sample of those counts for which video was available was analysed to establish the proportion of eels to fish/otters.
- this proportion was applied to the downstream counts on the day of that sub-sample. This gave an estimate of eel counts for that day.
- Where no video footage was available an average count was calculated for the days before and after this period. This gave an estimation of the proportion of eels to fish/otters to apply to the downstream counts for the days with no video verification.

The lengths of eels were measured on the screen and converted to their actual length. This length data can be used to calculate biomass (using established length to weight relationships).

Sources of error include:

- eels not being detected by the counter;
- eels not being visible during high turbidity.

Further analysis of the data will include:

- the average of eel lengths;
- the time of day when migration takes place (using the eel video and count data from 2008 and 2009);
- the moon phase, moon rise time, and the date of eel migration;
- eel counts at times of high turbidity;
- the deflection size of eels compared with that of other species.

Our initial analysis of deflection size found that the maximum deflection generated by eels (85) is generally smaller than that for fish and otters. This finding may allow the data to be filtered in future, reducing the number of counts which need to be verified on video.

The potential to discriminate eel from other fish by the shape of traces was also investigated. Eel tend to create a 'spikier' trace than other fish species do but the relationship is not clear enough to reliably identify eel and non-eel traces.

5 Eel measuring and use of anaesthetics

5.1 Measuring eel

For each run or netting, measure all eel caught to the nearest 5 mm and record the length. Avoid the use of anaesthetic when measuring and marking eels. If you need to use anaesthetic, follow the using anaesthetic guidance. Environment Agency staff must follow the guidance in the Operational Instructions Fish handling, storage and processing and Benzocaine supply and use (available on Easinet).

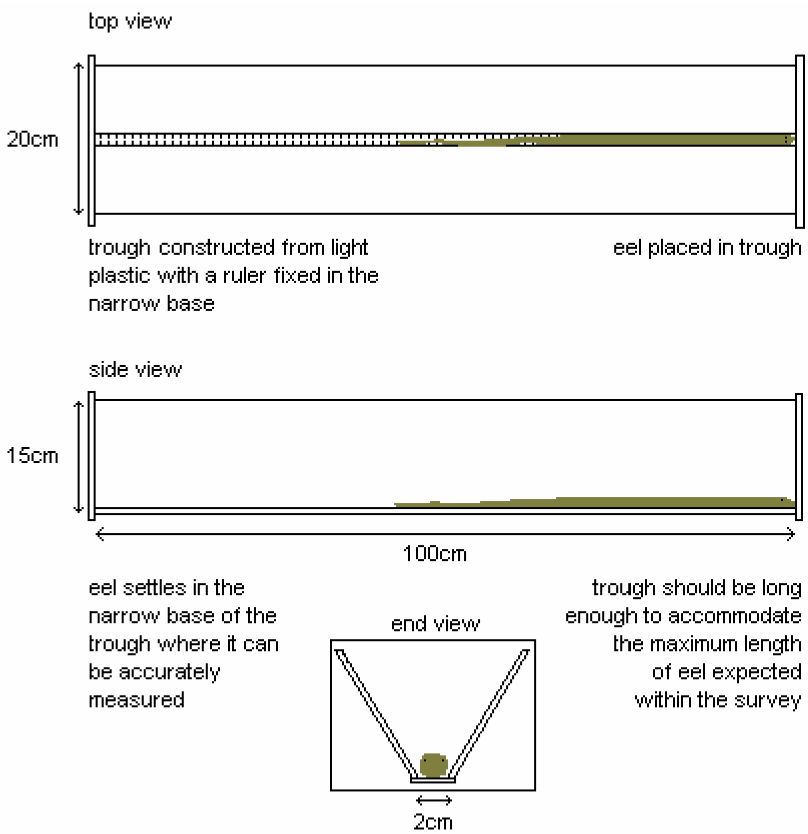
There are specific devices for measuring eels. We recommend you use them.

You can estimate eel biomass from lengths of eel by using established length to weight relationships.

5.2 Eel measuring equipment

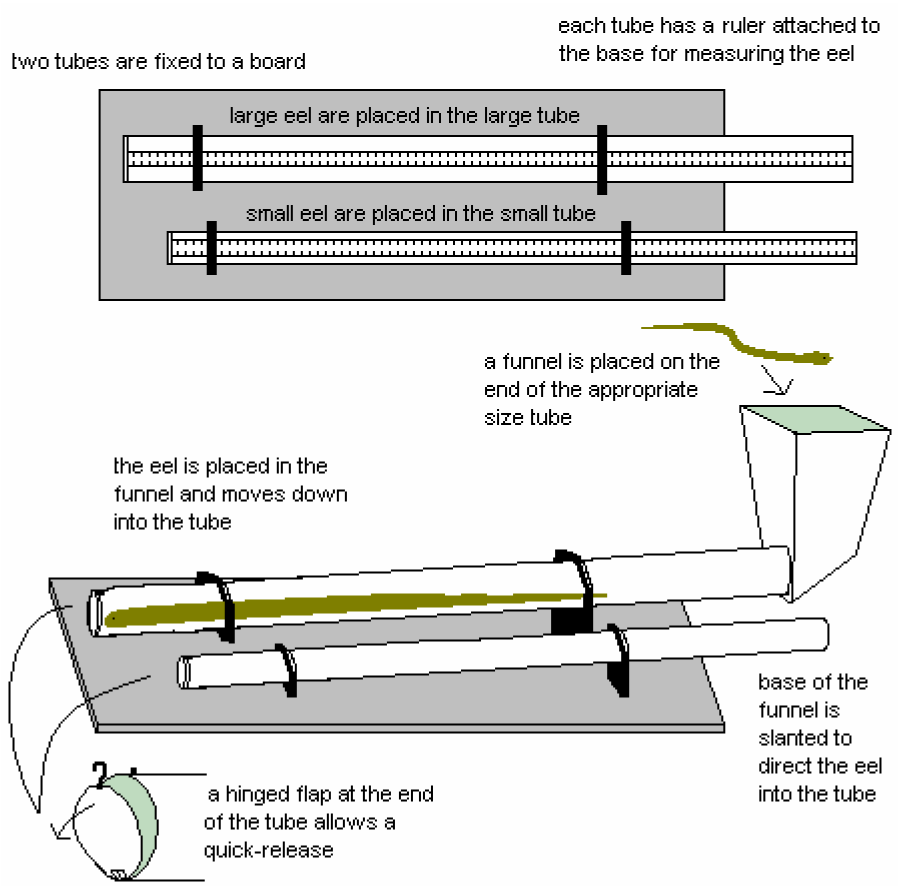
5.2.1 Eel measuring trough

This trough is suitable for measuring adult eels.
A smaller version would be suitable for smaller eels and elvers.
Avoid over-handling eels when putting them into the trough as this makes them more active. It is then more difficult to measure them accurately.
You should wait for the eel to settle in the trough before measuring them.



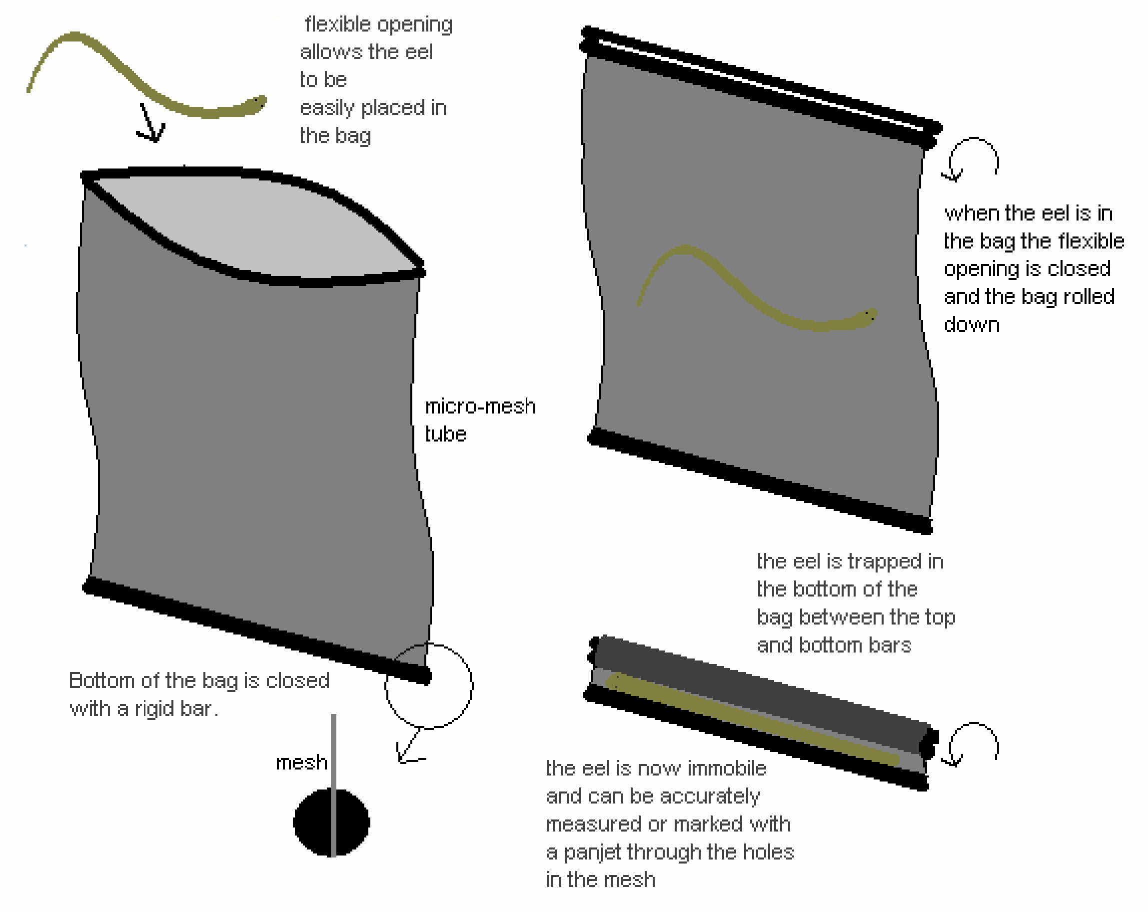
5.2.2 Eel measuring tube

This equipment has two tubes of different diameters. This is to accommodate different eel sizes. As with the trough, avoid over-handling eels and allow them to settle before measuring.



5.2.3 Eel measuring bag

The eel measuring bag can be used for a range of eel sizes.
It is also useful for immobilizing eels when marking them with Panjet inoculators.



You could also use a suitably sized plastic bag with a measuring scale marked on the outside.

5.3 Using anaesthetic

Where possible, avoid using anaesthetics. However, anaesthetic can reduce stress levels and may be appropriate in certain situations – for example when measuring highly active eels or when marking eels. The use of an anaesthetic should only be undertaken by an experienced person.

Because eels may enter the food chain, the only anaesthetic you are allowed to use is benzocaine (Ethyl p-aminobenzoate).

Benzocaine provides a wide margin of safety but still has good anaesthetic properties. Also, benzocaine does not trigger the initial excitement that other anaesthetics do.

Reference

Laird, L. M., & Oswald, R. L. (1975). A note on the use of benzocaine (ethyl-p aminobenzoate) as a fish anaesthetic. Journal of the Institute of Fisheries Management 6:92-94.

5.3.1 Levels of consciousness (LC) in fish

For animal husbandry and general handling, such as measuring, it is normally sufficient for the eels to be at a level of consciousness that causes partial loss of equilibrium.

Level 1 – Loss of reaction to external stimuli

Level 2 – Partial loss of equilibrium

Level 3 – Total loss of equilibrium

Level 4 – Loss of reflex

Level 5 – Medullary collapse

1. Sedation (LC = 1-2)

At low concentrations of the anaesthetic (0.3-0.5 ml/L active ingredient), the animal reaches a steady sedated state. Here the metabolic clearance rate of the anaesthetic equals the animal's rate of uptake. The animal will remain sedated and never become fully anaesthetised.

Steady state sedation: **Anaesthetic uptake = Metabolic clearance**

This steady state is ideal when you need to keep the eel for several hours – for example if you are transporting the animal.

2. Handleable (LC = 2-3)

Where the rate of uptake of the anaesthetic is equal to or greater than the rate of metabolic clearance (1.0 ml/L active ingredient), it is safe to handle the eel. At these concentrations, the animal loses equilibrium and may slowly progress deeper into anaesthesia.

Progression to anaesthesia: **Anaesthetic uptake ≥ Metabolic clearance**

3. Deep anaesthesia (LC = 4)

Above a certain concentration of the anaesthetic (2.0 ml/L), there is a steady progression: from loss of reaction to external stimuli, through to loss of equilibrium. This is followed by loss of reflex and eventually total medullary collapse. At higher concentrations, such as 4.0 ml/L, the animal moves more quickly into a deeply anaesthetised state. **Avoid these higher concentrations for general husbandry and handling.**

For general measuring, do not anaesthetise fish beyond partial loss of equilibrium (level of unconsciousness = 2)

5.3.2 Application of benzocaine

Benzocaine acts as a hypoxic agent. You must aerate or oxygenate the holding tanks.

It is good practice to reduce stress levels on eels when administering an anaesthetic. Where possible, place the animals in the shade or in a darkened area. If you can, partially cover the container. This will provide the eel with a quiet refuge area, but you will still be able to observe the fish for external signs of anaesthesia.

Observe opercular activity. This is a good measure of respiration. It also a very useful external indicator of the state of unconsciousness. In general, opercular movement moves through a series of stages. These are:

1. a slow deep movement;
2. a rapid deep movement;
3. a rapid shallow movement;
4. a slow shallow movement.

The response is not always ‘textbook’. However, unless you are carrying out invasive surgery, the rapid shallow phase is sufficient. This usually coincides with an initial loss of equilibrium (see notes below on levels of consciousness).

Some eels can move very quickly from slow shallow to no movement, the point at which the eel is in danger of dying. In general, the faster a fish responds to the anaesthetic the faster the recovery will be.

Although the use of anaesthetics is based on good scientific principles, it takes experience and skill to recognise the subtle responses of fish. Fish can move quite quickly, even with benzocaine, through the latter stages of anaesthesia. Recognising the signs will improve fish husbandry and reduce stress levels. Given this variation in response you should limit the number of fish anaesthetised in a single batch. Always have a recovery tub containing fresh aerated water – in case some individuals ‘turn over’ faster than required and need to be removed from the anaesthetic solution.

Make sure all anaesthetised eel have recovered from the effects of the anaesthetic before returning them to the river.

6 Additional sources of data

Wherever possible, use data from other sources to support your survey data. There will be areas where you have no survey data. Other sources will then be the only option for assessing the status of your eel populations. The quality of data may be variable but this should not prevent its use – provided of course that you are aware of its limitations.

Additional sources of data include:

- recording eel from non eel-specific surveys;
- Water Framework Directive TraC monitoring;
- ecological monitoring for impact assessment of incidents;
- angling catch records, Anguilla club;
- county records offices;
- opportunities to add monitoring to existing or new structures (such as weirs, hydropower, flap gates, passes);
- external organisations – such as the Zoological Society of London, RSPB, Rivers Trusts, Wildlife & Wetlands Trust, Wildlife trusts, and the Centre for Environment, Fisheries & Aquaculture Science (Cefas);
- commercial data from fishermen, records from silver eel racks;
- power station intakes;
- reservoir draw downs;
- canal fish removals;
- fish kills;
- consultancy reports;
- research papers;
- lake monitoring;
- stocking records.

7 Using eel monitoring data

7.1.1 Utilise all available data

Use internal (EA) and external (non-EA) data, past and present.

Where possible, standardise data so that you can make direct comparisons.

Support your interpretation of the eel data with information on water quality, flow, other ecological factors, morphology and habitat. Explain your findings.

7.1.2 Assess the quality of your data

Ensure data is fit for purpose. Check that the quantity and quality of data meet the aims of the investigation. For example, you may not need a detailed statistical analysis of data to produce spatial distribution maps of presence/absence.

If you spot an error within data sets such as National Grid References, notify the system administrator so that corrections can be made.

Identifying errors and correcting them benefits your work and improves future use of the data.

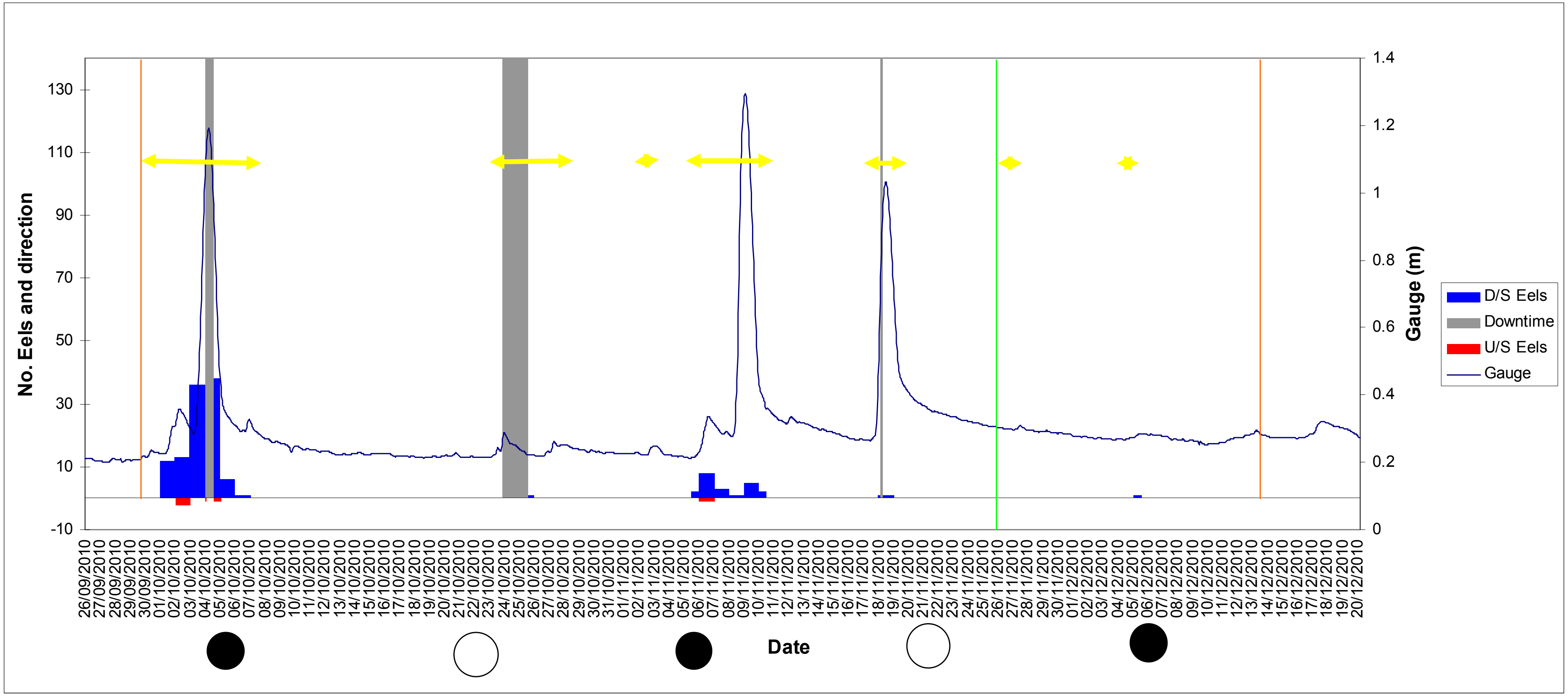
7.1.3 Effective presentation of data

Where possible, present data in a graphical form. This makes it easier for others to understand your findings.

Think about your audience: what message do you want to get across? how much do they understand?

Keep it simple.

See example below: River Leadon silver eel study.



River flow and eel movements over a 3 month time period, September 2010 to December 2010.

DIDSON was deployed in the period between the two vertical red lines. The yellow arrows indicate processed data (eel numbers were extrapolated for the unsampled periods), the green line indicates an alteration in the DIDSON tilt angle to sample surface waters.

139 eels were counted and measured, the majority (115; 83%) running during the first high flow event in October.

7.1.4 Examples of use of eel data

A Review of the Yellow Eel Populations in the Thames River Basin District (RBD)

Review carried out by Matt Hart, Environment Agency.

Project aims

- To review eel survey data (from NFPD) for Thames RBD, updating previous reports – such as those by Naismith (1998) and Knights (2005).
- To identify spatial and temporal eel population trends within Thames RBD and sub-catchments.
- To provide baseline monitoring for the Thames Eel Management Plan (EMP) and contribute to the next EMP reporting round in 2012.

Methodology

- Knights (2005) report drew on data from NFPD and historical survey records (some of which dated back to the 1970s). For this study all eel data for the Thames RBD from 2005 to 2008 (inclusive). was obtained from NFPD There were 3,360 individual records.
- mean density, biomass and length were calculated for each site for 2005, 2006, 2007 and 2008.
- 2005-2008 data was combined with historical survey information. Graphs were produced comparing changes over time and space – by plotting mean density, biomass and length against the distance from the tidal limit.
- comparisons were made at a sub-catchment level before grouping catchments into rivers that enter the River Thames below the tidal limit (Tidal Catchments) and rivers that enter above (River Catchments).

Additional notes

- The analysis was initially limited to graphical comparisons. This was due to a lack of repeat surveys and a paucity of robust data.
- The analysis showed some general patterns as well as localised detail. Examples of general patterns included mean biomass, density and length trends. Localised detail included eel stockings in the River Lee catchment in early 1990s and possible barriers to migration (for example at Rickmansworth on the River Colne).

- The quality of data from non-specific fisheries surveys for analysing eel populations is not ideal. However, as all Environment Agency staff use standard methods, the data is comparable.

- The next stage of the project is to go through the data from the catch per unit effort survey. This will include other data – for example the Thames elver data from the Zoological Society of London.

North Wessex Eel Project:

The status and management of eel populations in the North Wessex area

This project set out to:

- assess the current status of eel populations in the north Wessex area;

- determine whether population numbers have changed over time;

- investigate potential causes of these changes.

Possible effects of the local fisheries for glass eel and of barriers to migration were examined.

The area studied included the Somerset rivers of the Somerset Levels and Moors and the Bristol Avon.

The findings will be to inform management and monitor of eel populations in the future.

Most of the data analysed came from routine EA electric fishing and fyke net surveys.

Somerset Levels Eel Assessment – Fyke Net & Trap Eel Survey 2008

This project investigated the distribution and relative abundance of eels at a series of locations across the Somerset Levels and Moors. Standard commercial fyke nets and fine net basket traps were used at 25 different locations.

The survey began on the 8th August 2008 and ran for 14 consecutive nights – to the 22

August. Each site was netted for either three or four nights. The survey design and Grouping of sites was aimed at gathering information on how migration is affected by potential barriers such as pumping stations and sluice gates.

All fish captured in the fyke nets were identified, measured and recorded. At each site bulk weight of eels was recorded. Eels were in 0.5 cm increments, and other fish to the nearest 0.1 cm. Eels were recorded at 18 of the 25 sites surveyed. The highest catch rates per fyke end per night occurred downstream of Pibsbury Weir on the River Yeo.

Usk eel monitoring site assessment

Sophie Arbuthnot, Environment Agency.

Introduction and methods

The aims of the assessment were to

- identify ten Index survey sites for eel on River Usk
- trial the use of marginal surveys for assessment of eel.

Local knowledge of the catchment was used to select 15 survey on tributaries of the Usk. The aim was to represent the spatial variation of habitat within the catchment.

Electric fishing surveys were carried out using a fully quantitative catch depletion technique between stop nets. A minimun of three runs were completed at each site and anodes were continuously energised during each run.

Marginal surveys were carried out as Catch Per Unit Effort (CPUE) surveys. The surveys covered approximately 100 m along each bank, out to a width of no more than 2 m. As with the quantitative surveys, the team worked slowly and methodically in an upstream direction. Long periods near likely eel haunts such as roots and overhangs were used to draw eel out. No stop nets were used for these surveys.

Data recorded

For all surveys – both quantitative and marginal – the following data was collected as a minimum requirement.

- the species of fish captured;
- the length of all eels captured, to the nearest 10 mm;
- the fork length of all salmonids and coarse fish captured, to nearest mm;
- the total length of any marine or estuarine fish caught, to the nearest mm;
- the estimated number for each minor species captured – such as bullhead, stone loach and stickleback;
- the variables specific to the site and survey– including site length, width, the 10-digit National Grid Reference, water conductivity and temperature.

For the marginal surveys, the survey area and the time taken to survey each bank were recorded.

For all the quantitative surveys, the Carle and Strub method was used to calculate population and density estimates with confidence limits.

Weights were calculated using standard length to weight relationships for eel.

Results

Eels in varying numbers at all the survey sites in the Usk catchment. A number of other species were also present, including salmon, brown trout, gudgeon, chub and lamprey.

Density and biomass calculations indicate that for the majority of surveys, eel populations were either excellent (A) or good (B) based on the Fisheries Classification Scheme (FCS). Confidence limits were very variable as catch depletions were poor at some sites. Low confidence limits mean that some density and biomass estimate are not accurate.

The marginal surveys on the Usk confirmed that good eel populations are present in the main river.

The quantitative surveys and the marginal surveys found that populations further up the catchment were dominated by larger, heavier eels. Smaller eels dominate the populations in the lower catchment. These findings are consistent with the migratory pattern of the eel.

Conclusions

Ten Index sites were selected, mostly for their location within the catchment. However other factors, including site access and the success of the 2009 survey were also considered.

The size of the river Usk makes it impossible to carry out quantitative surveying at the places where the majority of eels are thought to reside. The marginal eel surveys provided a useful insight into the eel populations in this stretch of the river. They also helped to put into context the density and biomass calculations derived from the quantitative surveys on the tributaries.

APPENDIX 1 Conductivity look up table

Use this table to correct for temperature when measuring conductivity with a meter calibrated to 25ºC.

		Temperature				
		5	10	15	20	25
Specific conductivity	50	32	36	40	45	50
	100	63	71	80	89	100
	150	95	107	119	134	150
	200	127	142	159	179	200
	250	159	178	199	223	250
	300	190	213	239	268	300
	350	222	249	279	312	350
	400	254	284	319	357	400
	450	286	320	358	402	450
	500	317	355	398	446	500
	550	349	391	438	491	550
	600	381	427	478	536	600
	650	412	462	518	580	650
	700	444	498	558	625	700
	750	476	533	597	669	750
	800	508	569	637	714	800
	850	539	604	677	759	850
	900	571	640	717	803	900
	950	603	675	757	848	950
	1000	635	711	797	893	1000
	1050	666	747	836	937	1050
	1100	698	782	876	982	1100
	1150	730	818	916	1026	1150
	1200	761	853	956	1071	1200
	1250	793	889	996	1116	1250
	1300	825	924	1036	1160	1300
	1350	857	960	1075	1205	1350
	1400	888	995	1115	1250	1400
	1450	920	1031	1155	1294	1450
	1500	952	1066	1195	1339	1500
	1550	984	1102	1235	1383	1550
	1600	1015	1138	1275	1428	1600

APPENDIX 2 Silver Eel Record Sheet

Length (mm)	Weight (g)	Characteristic		Yellow	Silver	Intermediate
		Pigmentation1 (Y/N)	Lateral line2 (Y/N)			

Key:
1. Contrasted pigmentation between dorsal (usually dark) and ventral (usually white-silver) sides.
2. Complete and clearly defined lateral line.

Eels can be considered to be silver if both of these characteristics are observed. Eels showing one of these characteristics are intermediate. Eels showing neither of these characteristics are classified as yellow.

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