Common Standards Monitoring Guidance

for

Freshwater fauna

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Common Standards Monitoring Guidance for Freshwater Fauna (2015)

1. Introduction

This chapter deals with Common Standards Monitoring (CSM) for freshwater pearl mussel, white-clawed crayfish and all freshwater fish species on SSSIs, ASSIs and Special Areas of Conservation (SACs). It provides guidance on the identification of attributes, targets and methods of assessment for these species where these are notified or qualifying interest features. Amphibians are included in the Reptiles and Amphibians guidance, the otter is covered by the Terrestrial Mammals guidance and other freshwater invertebrates are dealt with by the Invertebrates guidance.

2. Interest features

The following freshwater faunal species, included on Annex II of the Habitats Directive, are qualifying features on SACs in the UK:

Austropotamobius pallipes (white-clawed (or Atlantic stream) crayfish)
Margaritifera margaritifera (freshwater pearl mussel)
Petromyzon marinus (sea lamprey)
Lampetra planeri (brook lamprey)
Lampetra fluviatilis (river lamprey)
Alosa alosa (allis shad)
Alosa fallax (twaite shad)
Salmo salar (Atlantic salmon)
Cobitis taenia (spined loach)
Cottus gobio (bullhead)

Details of their distribution and ecology can be found on the National Biodiversity Network Gateway (https://data.nbn.org.uk/), on the JNCC website (Jackson and McLeod, 2002; McLeod *et al*., 2002 – www.jncc.gov.uk) and in the publications from the Life in UK Rivers project (www.english-nature.org.uk/lifeinukrivers/index.html).

The following additional fish species may also be qualifying features on SSSIs:
Coregonus lavaretus (powan, schelly, gwyniad)
Coregonus albula (vendace)
Salvelinus alpinus (Arctic charr)

This guidance encompasses all the species listed above.

3. Explanation of terms

The following terms are used in this guidance:

- ASSI – Area of Special Scientific Interest (applies in Northern Ireland only)
- SSSI – Site of Special Scientific Interest
- SAC – Special Area of Conservation
- WFD – Water Framework Directive
- GES – Good Ecological Status (as reported in WFD monitoring)
- HES – High Ecological Status (as reported in WFD monitoring)
- EQI – Ecological Quality Index
- EQR – Ecological Quality Ratio

'Designated site' – the whole of an SSSI / ASSI / SAC.

'Survey site' – an area of freshwater habitat within which ecological data are collected.

'Assessment unit' – an area of a designated site for which an assessment of condition is made. See the CSM guidance for rivers and lakes for further details.

Conservation agencies – Natural England (NE), Natural Resources Wales (NRW), Northern Ireland Environment Agency (NIEA) and Scottish Natural Heritage (SNH).

Environment agencies – Environment Agency (EA), Natural Resources Wales (NRW), Northern Ireland Environment Agency (NIEA) and Scottish Environment Protection Agency (SEPA).

4. Attributes and targets

Guidance on setting conservation objectives for monitoring each of the freshwater faunal interest features listed in Section 2 is summarised in a set of generic Favourable Condition Tables (FCTs). Where appropriate, the guidance for several similar species has been combined in a single table (lampreys – sea lamprey, brook lamprey, river lamprey; whitefish – powan/schelly/gwyniad, vendace; shads – allis shad, twaite shad). These tables list the attributes (mandatory and discretionary) that should be assessed for each species and give guidance on target setting.

A combination of direct (population) and indirect (habitat) attributes have been selected for each species to enable a sound assessment of condition to be made. Sustainability of the species is an important consideration when selecting attributes and setting targets. This is an integral part of the concept of favourable conservation status (FCS). For species, the key components used for assessing conservation status include population dynamics, species range and habitat extent and quality, and the attributes used can be related to these elements.

For **population dynamics** the chosen attributes and targets vary between species to reflect ecological differences and current knowledge. Advice is given on target setting for appropriate measure(s) of population density, reproductive activity, age structure and distribution within the designated site. In some cases, target thresholds can be set whereas for others presence or absence may be the only practicable option at present.

The **habitat attributes** chosen (physical, hydrological, chemical) are generally those used for freshwater habitat features (rivers, lakes, ditches or canals). The targets used for each habitat feature are recommended for individual species in most instances, since these are intended to maintain a naturally functioning ecosystem with low levels of human impact within which all species can thrive to a degree characteristic of the habitat. Links to standards supporting WFD ecological status objectives are made where appropriate. In some instances, additional guidance is given on targets over and above those set for habitats to reflect particular species requirements where known.

It should be noted that local modifications to habitat targets are permitted where compliance with a generic target can be demonstrated to be technically infeasible, even in the long term. In such cases, a target value should be set to approach the generic target as closely as possible.

Within each FCT various other attributes that relate to environmental disturbance have been included. These activities (e.g. fish stocking, exploitation and vegetation management) have been included to help set the context for condition assessment.

5. Methods of assessment

Standard methods of assessment for each of the freshwater faunal interest features are provided in the following CSM protocols (1-9). Each protocol includes details on sampling methods, site selection, timing and frequency of survey, data processing, licensing, access and biosecurity. Each protocol is followed by the FCT for the relevant species.

The final assessment of condition rests with the statutory conservation agencies. However, it is important to stress that the field survey required for monitoring the condition of the 13 species listed above is not always undertaken by conservation agency staff. Most of the methods require specialist expertise that is normally available only through external contracts, although in some cases it would be feasible for appropriately trained staff in the conservation agencies to carry out field work themselves. Some data are held by various statutory and non-statutory bodies so the method for assessing condition has been designed with these data sources in mind.

6. Assessing feature condition

The guidance given in the generic species FCTs recognises that the long-term sustainability of freshwater populations depends on a range of biological, physical and chemical attributes. The habitat attributes in the FCT are critical in providing the necessary supporting conditions for the species. The general rule is that all mandatory attributes must meet their targets for the species feature to be in favourable condition. This means that any one attribute failing to meet its target will result in a judgement of unfavourable condition for the assessment unit. The discretionary attributes may be useful for informing the assessment but should not be used individually to 'fail' the feature.

If condition assessment is required for the whole site then all assessment units must be in favourable condition to report the whole site as favourable. However, expert judgement can be used to decide whether the failure of individual assessment units in a larger SAC/SSSI is sufficient to warrant the whole site being classed as unfavourable.

Where a site is not designated for its underlying habitat but is only designated for one or more species, formal assessment of one or more mandatory habitat attributes can be waived if the populations of notified species are meeting condition targets and there are no significant environmental pressures on the population. This judgement must take into account any significant impacts on habitat integrity that may not be manifested in the population assessment, either due to the resolution of the population assessment, the variability of population data, or time lags between environmental impact and population effects. Where formal assessment of habitat attributes is undertaken, expert judgement may be used to assess the significance of minor non-compliances in instances where population attributes are favourable.

Equally, where a site is designated for its underlying habitat but has additional species features, then detailed population monitoring can be waived if the habitat attributes applied to the site are providing an adequate indication of site condition. In such instances, the minimum requirement is to check for the continued presence of the species features.

7. Selection of survey sites for species monitoring

Data are collected and analysed at the level of individual assessment units and survey sites need to be selected with this in mind. If the site is designated as an SSSI or SAC for freshwater habitat, the task of defining assessment units forms part of Common Standards procedures for monitoring the designated habitat. Guidance on how to divide sites into assessment units is given in the separate CSM Guidance documents for Rivers, Lakes, Canals and Ditches (see: http://jncc.defra.gov.uk/page-2232). If the site is not designated for its habitat, it is recommended that the same process of site division is employed before survey sites are selected.

Selection of survey sites must consider the need to assess the geographical distribution of the species within the designated site and the abundance of the species/life stage at 'representative' survey sites.

The number and distribution of survey sites should be chosen based on the best understanding of the distribution of the species within the designated site under near-natural conditions. Where the present distribution exceeds the historical distribution (and is not influenced by human impact), the present distribution should be used. Survey sites should be located to gain a representative picture of population status across the designated site.

8. References and further reading

References that apply to individual species can be found within the CSM protocol for each species. The following references relate to the general monitoring approach for all the species considered within this chapter.

Jackson DL and McLeod CR (eds) (2002) *Handbook on the UK Status of EC Habitats Directive Interest Features: provisional data on the UK distribution and extent of Annex I habitats and the UK distribution and population size of Annex II species.* Version 2. JNCC Report, No. 312. http://jncc.defra.gov.uk/page-2447

JNCC (2005) *Common Standards Monitoring Guidance for Canals,* ISSN 1743-8160 (Online) http://jncc.defra.gov.uk/page-2232

JNCC (2005) *Common Standards Monitoring Guidance for Ditches,* ISSN 1743-8160 (Online) http://jncc.defra.gov.uk/page-2232

JNCC (2014) *Common Standards Monitoring Guidance for Rivers,* ISSN 1743-8160 (Online) http://jncc.defra.gov.uk/page-2232

JNCC (2015) *Common Standards Monitoring Guidance for Freshwater Lakes,* ISSN 1743-8160 (Online) http://jncc.defra.gov.uk/page-2232

Life in UK Rivers (2003) *Conserving Natura 2000 Rivers, Ecology Series.* English Nature, Peterborough. www.english-nature.org.uk/lifeinukrivers/index.html.

Life in UK Rivers (2003) *Conserving Natura 2000 Rivers, Monitoring Series.* English Nature, Peterborough. www.english-nature.org.uk/lifeinukrivers/index.html.

McLeod CR, Yeo M, Brown AE, Burn AJ, Hopkins JJ and Way SF (eds) (2002) *The Habitats Directive: Selection of Special Areas of Conservation in the UK.* 2nd edition. Joint Nature Conservation Committee, Peterborough. http://jncc.defra.gov.uk/SACselection

CSM Monitoring Protocol 1
Common Standards protocol for population monitoring of freshwater pearl mussel (*Margaritifera margaritifera*)

Prepared by: Iain Sime (2015)

Acknowledgements
This protocol is based on the methods originally drafted by Mark Young, Lee Hastie and Susan Cooksley as part of the LIFE in UK Rivers project (Young *et al*., 2003). It has been further informed by work to prepare a draft guidance standard on monitoring freshwater pearl mussel populations and their environment, led by Phil Boon for the European Committee for Standardization.

1. Introduction

This protocol gives information on how and when to monitor freshwater pearl mussel in sites designated as Sites of Special Scientific Interest (SSSI), Areas of Special Scientific Interest (ASSI) or Special Areas of Conservation (SACs) for the species. Details of population attributes and targets are given in the associated generic Favourable Condition Table (FCT) for freshwater pearl mussel.

2. Sampling method

This protocol provides guidance on how to collect the information needed to assess the population targets in the FCT for freshwater pearl mussels. Methods for most of the supporting habitat attributes follow other protocols (especially the CSM Guidance for Rivers), or standard methods (e.g. using data from environment agency monitoring).

The following sub-sections describe the methods for sampling pearl mussels, their hosts and specific habitat components. It should be noted that information that may prove useful for subsequent assessment of condition should also be gathered, including evidence of point source pollution, recent management of channel vegetation, and any signs of obvious changes since the previous visit. Points where specific observations are made should be marked on the site map, as well as being noted on the recording form. Observations can be made by the surveyor or gathered by others (e.g. conservation agency staff, environment agency staff) and may be interpreted using expert judgement and the results applied to the condition assessment. These observations may also trigger further detailed investigations or remedial action.

2.1. Sampling freshwater pearl mussel

For very small populations or those considered very vulnerable to disturbance there are important caveats to this method – outlined later in this section and in Section 3.

When commencing a survey for freshwater pearl mussel, enter the river at particularly suitable sites and search for mussels in an upstream direction using a viewing bucket in good searching conditions. Concentrate on ideal substrate and favoured locations, including under/near the bank and beneath overhanging trees. If no mussels are found, repeat the generalised searches in each likely area in each potentially suitable unit. Do not accept a negative result at any location until after 2 hours of search. If dead mussel shells are found, continue as if live mussels had been found. If mussels are present, carry out a 50 m transect survey.

Mussels are highly clumped in their distribution, even in a river with a thriving population, and random placement of sampling stations runs a real risk that few or no mussels will be included in the samples. Consequently, a selective approach is recommended.

For all potential assessment units, a survey of five 50 m transects should be carried out where mussels are present or environmental conditions appear suitable. As a guide, this is where clean, coarse sand is present in pockets sheltered by cobbles or boulders. If possible, these should be spread equally along the unit. If fewer than five generally suitable locations are available, but a location can accommodate more than one transect, then the transects can be grouped. However, target notes are required to indicate this.

The location of the start and end points of the 50m transect must be recorded using a 10 figure National Grid Reference and on a sketch map including local features made on the reverse of the recording form. The position of all samples must be marked clearly on the sketch map or base map, coded to allow ease of transfer to a database, and with target notes referring to obvious landmarks. A photograph should be taken, in an upstream direction, showing the start and end points of the survey transect. The position and direction from which the photograph is taken should also be marked. Additional photographs should be taken of any notable features.

The 50m transect should be surveyed in an upstream direction. Using a viewing bucket all mussels that are visible on the river bed should be counted in an area that is 1m wide and 50m long. These are recorded as 'visible' mussels. The starting point should be in an area that clearly never dries out. A $1m^2$ quadrat is searched more thoroughly at 10m, 20m, 30m, 40m and 50m intervals. In these quadrats all 'visible' mussels are counted and carefully removed to a bucket of river water. Mussels should be kept for as brief a period as necessary, typically 10-15 minutes. All loose stones and other obstructions should also be removed. The underlying sand is then gently disturbed and all 'buried' mussels now revealed should be counted and removed, with special care taken to include small mussels. All of the mussels removed from the quadrats should be measured along their longest dimension and the length recorded (mm).

If it becomes clear that more than 250 mussels are present in a transect, then the transect strip count should be abandoned and instead five $1m^2$ quadrats surveyed at 10m intervals. The number of mussels present in these is multiplied up to provide a 50m estimate.

After the mussels have been measured, replace all stones in the quadrat as close to the original arrangement as possible. Then return all juveniles, placing them under stones as found. Adults should then be placed carefully back into areas of coarse sand/fine gravel in available spaces within the quadrat, from where they will re-establish themselves. It is important to note that it may not be necessary to undertake quadrat searches during each CSM cycle as this may expose mussels at survey locations to excessive disturbance. In such instances it is more appropriate to conduct quadrat searches every 12 years (i.e. every other monitoring cycle) and undertake counts of visible mussels on a more frequent basis. However, if a baseline record of abundance is needed against which to compare future surveys, all five quadrats should be completed.

A count should be made of all dead mussel shells in each transect, with target notes indicating whenever possible whether they seem to have died of natural causes (often seen as paired shells with only a small gape), or have been torn open by pearl fishermen (often left in piles of widely open shells on the river bank). A search should also be made of the river bank within 100m of the transect and all dead shells recorded. These should be removed to avoid advertising the presence of mussels, and a decision made by the relevant statutory agency of where they should be kept for future study.

At least 150 mussels, chosen randomly, should be measured to provide a population profile. If the population is too low, a population profile cannot be obtained. At least 150 mussels, but generally not more than 250, should be measured carefully along their longest axis to the nearest 1mm. These must be chosen without any size bias, usually including all that have been found in the quadrats, but not those present in the general transects. If fewer than 150 are present in the five quadrats then extra quadrats should be searched carefully, to ensure that cryptic, juvenile mussels are included in the selection, rather than visible mussels only. It is essential to record the numbers of juvenile mussels (conventionally taken as ≤ 65mm) and recently recruited mussels (≤ 30mm) in each quadrat.

In small streams, or for small mussel beds, quadrat sampling may disturb a significant proportion of the population. This risk may be so serious that a decision is taken not to use invasive sampling, but merely to record visible mussels. However, this will not permit the detection of juvenile mussels, most or all of which will be buried. In these cases the observation of any visible juvenile mussels is taken as an indication of population viability but with a much lower level of confidence.

All mussels that have been disturbed should be replaced carefully. If many are present in an area of generally suitable substrate then it is sufficient to replace them gently onto the surface of the substrate, from where they will rebury themselves in a suitable position. If only a small number are being counted and/or there is a strong current or little suitable substrate, then it may be better to lodge the mussels in a partly buried position in a suitable patch of substrate. In practice, where few mussels are involved, they can be quickly measured and gently replaced exactly where they were found. Remember to place them the correct way up, and in their original orientation to the current.

Mussel numbers must be recorded and reported in a standardised way, using the correct terminology. On the standard recording form (Appendix I), the total numbers are recorded directly, as are the numbers of juveniles (≤ 65mm long) found; the numbers of dead shells; and the numbers of both visible and total mussels recorded in the quadrats. Date and time of survey, weather conditions, surveyor's name and location details should also be recorded.

SNH uses letter codes to refer to abundance categories for live mussels in each transect and therefore numbers in each 1m^2 (Table 1). These should be used in Scotland to refer to abundance for freshwater pearl mussel surveys. It is recommended that the following codes also be used in England, Wales and Northern Ireland to assist with standardisation and reporting.

Table 1: Freshwater pearl mussel abundance categories

Numbers of live mussels per 50 x 1 m transect	**Equivalent numbers of live mussels per m^2**	**Abundance level (letter code)**
0	0	E
1 – 49	1	D
50 – 499	2 – 10	C
500 – 999	11 – 20	B
≥ 1000	> 21	A

2.2 Sampling host fish and glochidial development

Salmonid fish native to each catchment are essential hosts for freshwater pearl mussel. Glochidia released from the female mussel are viable for a short period, needing to find a host fish within approximately 1 or 2 days. Glochidia snap shut when they encounter the gills of their fish host.

Glochidia will attach to a range of fish species, but are quickly lost from species other than those of their suitable hosts. Suitable hosts in Europe are native salmonid fish, such as Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*). Studies have shown that in general survival of glochidia to become juvenile mussels is often restricted either to trout or to salmon, or they may use both species, depending on the mussel population. It is important to determine the host fish species in each river system.

Densities of fish should be those that are typical for the natural trophic status of each individual river and the target for UK pearl mussel rivers is >0.1 fish per m^2. Fish need to be in close proximity to mussels (for encystment) and mussel habitat (for juvenile drop-off). It is unlikely that host fish move large distances and return to the mussel beds. However, the movement of encysted fish may help to expand the distribution of mussels.

It is important to determine the species and density of host fish that a mussel population needs, and whether encystment is occurring. Electrofishing should be carried out twice using standard methods, once in early autumn to establish the presence and density of suitable fish hosts as a proportion of the fish population just downstream of mussel beds, and again in late spring to establish the presence of yearling fish in the vicinity of permanent mussel habitat. The fish in the second survey should be checked for encystment of glochidia on the gills, which are visible on the live fish (Figure 1). More detailed studies of fish numbers and glochidial encystment (e.g. number of glochidia per fish) can be undertaken but the objectives above should be considered as a minimum requirement.

Figure 1: Glochidia on the gills of a young salmonid (© Natural Resources Wales)

Fish species composition and densities should be derived from electrofishing (catch per unit effort or efficiency) in sites where glochidial attachment is likely (i.e. downstream of the sites with pearl mussels) (Table 2). Depending on the size of the river, the current velocity, and the technical feasibility, stream sections at least 50 m long should be investigated. These should be located in areas where glochidial encystment is likely to occur. Where blocking with nets and multiple electrofishing runs are not possible, values of minimum densities should be reported. If a valid correction factor for catch efficiency can be applied from other quantitative sites, this should also be reported (Bacon and Youngson, 2007).

Table 2: Checklist of recommended monitoring for fish hosts in rivers with *Margaritifera*

Aspect	Method	Output (units)	Notes
Numbers of 0+ fish in autumn	Electrofishing	Numbers per 100 m^2	Baseline in all rivers, with fish density surveyed every 3-6 years. Electrofished site should be downstream of large beds of mussels.

Numbers of yearling fish in spring	Electrofishing	Numbers per 100 m^2	
Numbers of encysted fish in spring	Electrofishing and visual check of gills	% of fish encysted. Estimated density of glochidia per fish (and by fish species)	

2.2. Redox surveys

The infiltration of high loads of fine sediment (often linked with eutrophication) typically results in low oxygen supply to the interstices of the substrate. Redox measurements provide a way of determining the reduction of available oxygen within the substrate compared with the open water, and the removal of oxygen from oxidized nitrogen molecules. As the technique measures the continued reduction in the sediment, it is more useful than direct oxygen measurement. This is a method that allows a large amount of data to be gathered comparatively quickly. It can be used to measure improvement or deterioration in river-bed quality over time. Surveys should be undertaken during low-flow periods during the summer months to capture the most adverse conditions.

The principle is to measure a millivolt difference between a platinum electrode (that can be directly inserted into the substrate) and a reference Ag/AgCl2 electrode held within the water column. Separate readings should be obtained for substrate depths typically ranging from 2 cm to 10 cm. At conditions of very low conductivity a salt bridge should be used. It may take several minutes after inserting the electrode in the sediment for the reading to stabilise. In such circumstances, it is the initial drop in redox potential that is recorded as the gradual influx of water from the surface may be the reason for gradual changes in potential.

Large differences in redox potential (temperature-corrected values) between the open water and the substrate indicate habitat of poor quality for juvenile *Margaritifera*. Redox potential should indicate oxic conditions at all times, with temperature-corrected values <300mV typically indicating anoxic conditions (Geist and Auerswald, 2007).

2.3. Filamentous algae

Excessive algal and macrophyte growth can indicate nutrient enrichment or problems of low flow. Filamentous algal monitoring should be undertaken in conjunction with phosphorus monitoring, and excessive algal growth should trigger further investigative monitoring. Visual assessments should be made of *Margaritifera* habitat during the algal growing season (typically April to September) and estimates made of the percentage of filamentous algal cover. A standard area of a mussel bed that is considered to be vulnerable to algal growth (i.e. an unshaded, shallow area) and is easily accessible (e.g. visible from a bridge or stopping point) should be chosen and used for regularly assessing algal growth. Filamentous algal cover should also be recorded as a standard part of any pearl mussel survey. Fixed point photography can be very useful for monitoring any changes over time.

3. Site selection

Procedure to be used if the mussel population is too low for standard sampling

In very small rivers, or rivers with small or very localised mussel occurrence, the standard sampling protocol may disturb the few mussels present to an unacceptable degree. This possibility should be considered river by river and action agreed with the appropriate conservation agency. In such cases it may be appropriate to undertake an exhaustive generalised search, to map individual mussels or mussel colonies as closely as possible and attempt to count them. Use of historical data and a focus on suitable substrate will assist such a search. If very few mussels are present it may also be inappropriate to search a quadrat to provide mussels for an age profile. A report should be prepared to describe the methods used, areas covered and results obtained.

Procedure to be used for the standardised survey methodology
Five 50m survey transects should generally be surveyed in each assessment unit that is considered to support suitable habitat. These should be targeted at areas where freshwater pearl mussels are found. Existing knowledge of mussels in the river should be used to identify the location for the placement of monitoring transects.

Electrofishing and redox surveys
These should both be conducted in close proximity to the locations of known pearl mussel populations.

4. Timing and frequency of survey

It is advisable to conduct surveys of freshwater pearl mussel during periods of low flows and good visibility. Typically this will be **between April and September** when water temperatures will also generally provide more favourable conditions for searching quadrats for juveniles.

Surveys of freshwater pearl mussels should be conducted every 6 years, but it is advised that invasive searches within quadrats are conducted only every 12 years to minimise disturbance to this more sensitive life stage.

Electrofishing surveys of host salmonids should ideally be conducted more frequently (e.g. every 3 years), due to the natural annual variation in population densities, and during the **autumn** (to measure densities) and during the **spring** (to identify the host species and establish glochidia densities – see Section 2.2).

Redox surveys can be carried out at the same time as pearl mussel surveys. They should ideally be carried out during the **summer months** when algal growth is likely to be at its greatest and at a greater frequency than pearl mussel surveys to build up a picture of inter-annual variation.

5. Data processing

Data on the number of pearl mussel population parameters should be aggregated between survey sites within each assessment unit. Total or mean estimates should be produced for each assessment unit and compared with the favourable condition targets (population density, age structure, recruitment and dead shells).

Data on individual mussel lengths should be recorded and maintained.

6. Licensing

Freshwater pearl mussel is protected under Schedule 5 of the Wildlife & Countryside Act 1981 (as amended) and by the Conservation (Natural Habitat etc.) (Amended) Regulations (Northern Ireland) 2007. Therefore surveyors will need a licence from the relevant conservation agency. Surveyors will also need the relevant permissions to conduct electrofishing surveys.

7. Access

It is the responsibility of the contractor to ensure that all access permissions have been obtained prior to any survey taking place. Risk assessments should be carried out before commencing any of the activities outlined in the monitoring protocol.

8. Biosecurity

It is essential that contractors take every step necessary to prevent the introduction of non-native species and diseases to new locations. Before gaining access to any water body, it is essential that all personal and survey equipment has been properly checked and, if necessary, disinfected before any work takes place. All contractors must comply with the Check, Clean, Dry guidelines as a minimum requirement (http://www.nonnativespecies.org/checkcleandry/).

9. Data

All output data should be stored in national databases where appropriate and uploaded onto the National Biodiversity Network (at the agreed resolution to protect site anonymity).

10. References and further reading

Bacon PJ and Youngson AF (2007) *The application of electro-fishing to produce census estimates of juvenile salmonid populations within defined areas: taking stock of the options.* Scottish Fisheries Research Report No. 67. Scottish Government.

Bauer G (1988) Threats to the freshwater pearl mussel *Margaritifera margaritifera* L. in central Europe. *Biological Conservation,* **45**: 239-253.

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APPENDIX I – Freshwater Pearl Mussel Survey

Sheet 1 of 2 – 50 m transect data

1. Catchment……..…………… 2. Watercourse……………….…………………………………

3. Location of site (description)……………………………………………………………………………..

…….

4. Bank (Left / Right looking downstream)……………. 5. Distance from bank (m) Start…………End………

6. Grid reference (DS)………………..……………………..7. Grid reference (US)…………………………….....

8. Date of survey…………………………… 9. Weather conditions and water level………………………….

…………………………………………….. 10. Survey team (names)……………………..…………………

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11. Were pearl mussels found? YES / NO If "NO" then go to Q15

12. Number of visible mussels in 50m transect……………………………………….

13. Number of mussels ≤65mm in quads……. 14. No. of mussels ≤30mm in quads…...

15 Number of dead shells found……………………………………………………..

16. Number and lengths of mussels in transect and $1m^2$ quadrates (visible and full search totals for quadrats)

Not in quad.	QUADRATS				
	Dist.	Vis.	Total	Juvs	Lengths (mm) – continue on another sheet if required
	10				
	20				
	30				
	40				
	50				

Lengths (mussels from any additional quadrats not listed above. Continue on another sheet if required):

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17. Photo number/reference…………………………………………………………….

18. Average river width and depth (m): W: D: 17. Host fish seen (none / few / many)

19. Substrate type in quadrats. Express as % of area covered

SI	Fine SA <0.5mm	Coarse SA 0.5–2 mm	GR 2-4 mm	PE 4-64 mm	CO 64-256 mm	BO >256 mm	BE solid	Other (specify)	% algal cover

20. Main adjacent land use types………………………………………………………..

21. Nature of bankside vegetation………………………………………………………

22. Any evidence of threats e.g. pearl fishing?……………………….…………………

23. Max. and min. redox measurements (full records on separate sheet)………… ……………

24. Further comments, including *pers. comms.*

Freshwater Pearl Mussel Survey

Sheet 2 of 2 – 50 m transect data

Draw a sketch map of the location and include target notes:

Favourable Condition Table 1 – Freshwater Pearl Mussel (*Margaritifera margaritifera*)

Details of the standard methodology can be found in the monitoring protocol for freshwater pearl mussel.

Attribute (* = discretionary)	Target	Method of Assessment	Comments
POPULATION			
a. Spatial extent	Should reflect distribution under near-natural conditions.	Visual survey of riverbed	Population distribution should be close to that expected under near-natural conditions throughout the site, taking into account natural habitat conditions and allowing for natural fluctuations. The target is to secure a sustainable population of mussels that is able to utilise all naturally suitable habitat within the river.
b. Population density	≥ 5 mussels per m^2 within sample transects.	Visual survey of river bed.	The density data from all transects within each monitoring unit should be aggregated and the resulting figure assessed against the target. In smaller rivers where 50m transects have not been surveyed, density data from all quadrats should be aggregated and assessed against the target. (Note: Young *et al.* (2003) recommended a favourable condition target of 10 mussels per m^2 in UK rivers. This has been revised to 5, but locally agreed higher targets may be appropriate.)
c. Age structure	i. At least 20% of population ≤65mm ii. At least one mussel ≤30mm.	Length measurement of mussels recorded in quadrats within 50m transects.	Population profiles should not be attempted where mussel beds are vulnerable to damage. In this case, the target is to find at least one pearl mussel ≤65mm. This results in a lower degree of confidence that the population is reproductively viable but should protect it from potential adverse disturbance during survey. The target for mussels ≤30mm may be 5% at some sites (e.g. Northern Ireland) but, generally, is applied as a threshold of at least one mussel in order to confirm recent recruitment and minimise disturbance of a population during survey.
d. Dead shells	<1% of population per year and scattered distribution.	Counting within 50m transects.	1% (based on a 100 year life span) considered to be indicative of natural losses for survey sites and for the entire river population per year. Where >1% dead shells are found, an investigation into the cause should be carried out to assess whether it may be an exceptional natural event or an indication of an unnatural kill. The dead shells should be examined for freshness (by checking the colour of the nacre) to help assess the likelihood of a problem.

Attribute (* = discretionary)	Target	Method of Assessment	Comments
WATER QUALITY For freshwater pearl mussel, organic pollution, reactive phosphorus, acidification, and other nutrients are particularly important.	See sub-attributes below. Generally, targets included in the CSM Guidance for Rivers should be used. These targets are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. All chemical targets, and also biological targets relating to macroinvertebrates (WHPT, PSI and AWICS) and diatoms, are applicable. However, depending on circumstance, UKTAG standards for HES under the WFD may be applicable. In addition to habitat-based targets, some more stringent targets for pearl mussel are listed below.	Standard monitoring protocols in CSM Guidance for Rivers. (Data from environment agencies).	Generally, water quality should not be injurious to any life stage. All classified reaches within the designated site that contain, or should contain, freshwater pearl mussel should comply with the targets given. Data from the last 3 years should be used. All water quality data should be available on request from the environment agencies.
a. Phosphorus	In locations where annual mean soluble reactive phosphorus (SRP) levels are <5 µg L^{-1}, the target should be 5 µg L^{-1}. For rivers that exceed this target a suggested target is the more stringent value of either: high status values for SRP under the WFD, or the SRP target for CSM river habitat.	Standard monitoring protocols in CSM Guidance for Rivers. (Data from environment agencies).	The SRP target value should not be set for a river without first checking the baseline P levels and any historical data available for that river. Undetectable levels of SRP are not necessarily a guarantee of good health, particularly if the local analysis equipment is unable to perform at low concentrations. If all the available phosphorus is being transferred into filamentous algae then it will not be detectable as SRP in open water. A combination of very low SRP with the absence of filamentous algae is considered to indicate nutrient levels conducive to *Margaritifera* populations in favourable condition.

Attribute (* = discretionary)	Target	Method of Assessment	Comments
b. Nitrogen - Nitrate	Annual median value of <0.125 mg L^{-1} N	Standard monitoring protocols in CSM Guidance for Rivers. (Data from environment agencies).	Various thresholds of nitrate have been proposed in the literature with respect to Margaritifera: 0.5 mg L^{-1} N in central Europe (Bauer, 1988), 1 mg L^{-1} N for the UK (Oliver, 2000), 0.125 mg L^{-1} N for Ireland (Moorkens, 2006). Note, that one UK population with some recent recruitment has a median value of 0.338 mg L^{-1} N (Moorkens and Killeen, unpublished data). Like phosphorus, nitrate levels are a measure of the naturalness of the surrounding catchment, and limits should be set at those natural for that catchment. Where nutrient levels are too high to sustain pearl mussel populations, levels of all nutrients should be reduced until sustainability is achieved.
c. BOD	Mean BOD <1.0 mg L^{-1}	Standard monitoring protocols in CSM Guidance for Rivers. (Data from environment agencies).	Rivers with reproducing populations in the UK, Ireland and Spain have BOD levels consistently < 1.0 mg L^{-1} (Moorkens and Killeen, unpublished data). Elevated BOD (>1.4 mg L^{-1}) has been linked with poor juvenile survival in Central Europe (Bauer, 1988).
FLOW	Ideally, flow targets included in the CSM Guidance for Rivers should be used, as these are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. As a minimum, UKTAG standards for GES under the WFD should be met.	Gauging stations. (Data from environment agencies).	River flow affects a range of habitat factors of critical importance to freshwater pearl mussel, including current velocity, water depth, wetted area, substrate quality, dissolved oxygen levels and water temperature. The maintenance of both flushing flows and base flows, based on natural hydrological processes, is vital. Detailed investigations of habitat–flow relationships may indicate that a more or less stringent threshold may be appropriate for a specified reach; however, a precautionary approach would need to be taken to the use of less stringent values. Naturalised flow is defined as the flow in the absence of abstractions and discharges. The availability and reliability of data is patchy – long-term gauged data can be used until adequate naturalised data become available, although the impact of abstractions on historical flow records should be considered.
HABITAT STRUCTURE In-channel structures and morphology	The targets in the CSM Guidance for Rivers should be used. These are intended to provide a natural, dynamic biotope mosaic with high connectivity that caters for the whole biological community and individual species to a degree characteristic of the river. The comments column provides details of the importance of individual biotopes to freshwater pearl mussel.	Assess using CSM methods for river habitat or species-specific methods if available and appropriate.	The river's natural form and function should support all of the habitat features necessary for pearl mussels to thrive, in characteristic proportions. Widening or deepening of channels, and extensive artificial reinforcement of banks, are indicators of unfavourable condition. Further information on the importance of physical habitat to pearl mussels is available in draft CEN guidance. Information on in-channel structures is available in the CSM Guidance for Rivers.

Attribute (* = discretionary)	**Target**	**Method of Assessment**	**Comments**
OTHER ATTRIBUTES			
a. Fine sediment (redox)	There should be no pronounced difference in redox potential (typically <20%) between open water and interstitial water at 5 cm depth.*	Redox measurements collected in open water and river bed, at or around population transect locations.	Excessive delivery of fine sediment, from the catchment or artificially enhanced bank erosion, may lead to a range of problems relating to surface siltation, the compaction or concretion of river beds and to the in-filling of substrate interstices. This affects oxygen supply and exchange within the substrate as well as the ability of juvenile mussels to burrow. Infiltration by fine sediments is one of the main causes of decline in juvenile recruitment for pearl mussel populations. * The infiltration of high loads of fine sediment typically results in low oxygen supply to the interstices of the substrate. Redox measurements provide a reliable estimate as a surrogate for the oxygen level within the interstices of the substrate compared with the open water.
b. Fine sediment (siltation)	The PSI targets in the CSM Guidance for Rivers should be used.	Macroinvertebrate data collected and analysed by environment agencies.	PSI (Proportion of Sediment-sensitive Invertebrates) is an index developed to measure the impact of fine sediment on river-bed invertebrates (Extence *et al.,* 2013). It complements the methods suggested in the siltation section, although it is recommended as a more cost-effective, accurate and easily measurable target.
c. Filamentous algae	<5% cover across assessment units.	Visual assessment during mussel survey and relevant metrics collected during LEAFPACS survey by environment agencies.	Filamentous algal cover should be measured during the pearl mussel survey. In oligotrophic conditions nutrient levels should never be high enough to allow dense mats of filamentous algae to grow. The persistence of filamentous algae is an indication that nutrient levels may be too high for sustainable *Margaritifera* populations, but may also indicate low flow problems. Using the LEAFPACS method, with 3-5 sections per assessment unit surveyed depending on its size. More variable assessment units may require more surveys.
d. Fish host populations: native juvenile salmonid densities (0+ and 1+ year classes)	1. Should be abundant: > 0.1 native juvenile host salmonids per m^2. 2. Should be able to find fish infected with glochidia between September and May.	Standard electrofishing protocols. Visual inspection of gills, particularly later in the glochidia incubation period.	An abundant supply of native juvenile salmonids is vital to the survival of the larval stage. The relative importance of salmon and migratory and non-migratory brown trout populations to pearl mussels will vary between rivers. Physical and chemical conditions need to be suitable for the well-being of all life stages of salmonids, including free access up the river and conditions in the estuary and lower river where the juveniles of migratory salmonids are present. It is important to determine the species of host fish that a mussel population needs in a particular river as local pearl mussel populations can use salmon, trout or both species. Electrofishing should be carried out twice using standard methods, once in early autumn to establish the presence and density of suitable fish hosts as a proportion of the fish population just downstream of mussel beds, and again in late spring to establish the presence of 1+ fish in the vicinity of permanent mussel habitat. This does not adversely affect pearl mussels. The fish in the second survey should be checked for encystment of glochidia on the gills, which are visible on the live fish. More detailed studies of fish numbers and glochidial encystment (e.g. number of glochidia per fish) can be undertaken but the above should be considered as a minimum requirement.

Attribute (* = discretionary)	Target	Method of Assessment	Comments
e. Alien/locally non-native species	No non-native species likely to cause impairment of freshwater pearl mussel populations.	Survey data collected and analysed by the environment agencies.	Non-native species constitute a major threat to many river systems. Impacts may be on the river habitat itself (e.g. damage to banks and consequent siltation) or directly on characteristic biota (through predation, competition and disease), or a combination of these. Assessment of non-native species is based on the principles used in assessing high ecological status under the WFD, and applies to species on the banks and in the riparian zone as well as species of the channel and the margins. There is evidence that American signal crayfish may disturb freshwater pearl mussel, particularly juveniles (Gladman, 2012). Otherwise, refer to the WFD list of alien/locally absent species* (but not to be used exclusively). * http://www.wfduk.org/tagged/alien-species#. Note: This document includes a separate list of alien species for Ecoregion 17 (in which Northern Ireland lies); this list contains only high-impact species.
* f. Stocking transfers of other species	No inappropriate stocking/translocation of fish species.	Fishery stocking consents. Impact assessments of stocking consents on a catchment scale may be required to determine an acceptable level.	Rainbow trout and brook trout are resistant to glochidial infection and are not, therefore, suitable host species. Stocking of these species will create competition with native salmonids and is likely to reduce host opportunities for glochidia. Any stocking of native salmonids must take account of the genetic diversity of resident salmonids. The host fish/mussel relationship seems likely to have a genetic component, which could be affected by inappropriate stocking.
* g. Introduction/ transfers of freshwater pearl mussel	No introduction/transfers of freshwater pearl mussel unless agreed to be in the best interests of the population.	Knowledge of site management.	Translocation is not generally recommended as a conservation tool. It is a technique that has been little used, and must still be considered experimental. Translocation (if feasible) should therefore be seen as a last resort. In GB and Northern Ireland, genetically distinct freshwater pearl mussel populations have been found to exist in separate catchments (Cauwelier, 2009). Evolutionary Significant Units (ESUs) exist in GB between Scotland/northern England and NE Wales; and southern England and the remainder of Wales. It would be inappropriate to undertake translocations between these ESUs. Any translocations or transfers of freshwater pearl mussels must follow IUCN and other local guidelines (e.g. Scotland Code for Conservation Translocations).
* h. Pearl fishing	No evidence of pearl fishing.	Standard survey protocol.	Pearl mussel fishing is prohibited throughout the UK.
* i. In-stream activities	No evidence of damage of existing mussel beds.	Environment agencies monitoring/ consenting programmes and standard survey protocol.	Engineering works that disturb river beds can be disastrous for mussel populations, so every effort needs to be made to leave them undisturbed. Other relevant activities include fishing (wading in the river) and canoeing (at access points to the river) particularly for vulnerable populations. As a minimum, existing areas should be safeguarded, whilst habitat lost through engineering works should be reinstated.

CSM Monitoring Protocol 2
Common Standards Protocol for population monitoring of white-clawed crayfish

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1. Introduction

This protocol gives information on how and when to monitor white-clawed crayfish (WCC) at Sites of Special Scientific Interest (SSSIs), Areas of Special Scientific Interest (ASSIs) and Special Areas of Conservation (SACs) for the species. For details of population attributes and targets, please see the associated generic Favourable Condition Table (FCT) for white-clawed crayfish.

This protocol follows on from a report produced as part of the LIFE in UK Rivers Project (Peay and Hirst, 2003), and also draws upon results from the Environment Agency trial catchment-wide survey (Pugh *et al.*, 2005), together with results of WCC monitoring at designated sites through to 2014. The protocol has been updated to incorporate all changes made to the survey and assessment methods since 2003.

Biosecurity is essential when undertaking any work with white-clawed crayfish. If biosecurity requirements cannot be met the survey should not be undertaken. Further details are provided in Section 8. CIEEM has produced competency guidelines for WCC survey (Bradley and Peay, 2013) and surveyors should meet these.

2. Sampling method

The standard CSM method involves manual searching which should be applied at all sites with suitable searchable substrate. Baited trapping may be carried out where manual searching is not possible. Refuge traps may be used at sites where neither manual search nor trapping are appropriate, for example due to the presence of water voles at trapping sites, and where there are few in-stream refuges (e.g. in chalk streams).

2.1 Manual search

Manual search survey sites should have, on the day of survey, water depth within the range 5-40cm, water flow of <20 cm s^{-1}, a relatively smooth water surface, and a clarity of water that enables a clear view of the bed substrate in areas with potentially searchable physical habitat for WCC. If searchable physical habitat is present, but water conditions are unsuitable on the day, the survey must be abandoned and re-scheduled.

Manual searching involves facing upstream (at flowing water sites), gently lifting, sliding/turning and returning potential refuges, and looking for WCC. Within each survey site 100 refuges should be searched initially. If five or more WCC are found, this is sufficient; if not, searching should continue until 250 refuges have been searched. A refuge may be a single stone (or another item of physical refuge), but if stones are overlapping then multiple stones may need to be lifted until the gravel substrate (or finer substrate) is reached. This still counts as one refuge. The number of refuges searched should always be recorded so that catch per unit effort (CPUE) can be calculated. An attempt should be made to capture any WCC that are observed. Captured crayfish should be kept cool in water until the end of the search. A small hand net can help catch small crayfish. Advice for surveyors on finding and capturing WCC can be found in Peay and Hirst (2003).

An example survey form for the manual search method is provided in Appendix I. As a general rule, two surveyors are unlikely to need more than one hour to survey a site but the time required is highly dependent on environmental conditions. Sites with a silty substrate and those with abundant aquatic macrophytes will take the longest time to survey. Recording habitat information for the site overall may help in interpreting the results. This would include the type and extent of potentially suitable habitat in any submerged banks, margins and mid-channel/deeper water within the site, together with an appraisal of the accessibility of searchable refuges for manual survey, as well as details of any adverse factors seen at the time.

2.2 Trapping

At sites that are not amenable to the manual search method, baited trapping may be used (Reynolds *et al.,* 2010). A sufficient number of traps should be used to generate a reasonable understanding of abundance. The exact number and position of the traps will be dependent on the presence of suitable habitat within a site. As a guideline a minimum of 10 traps should be used per 500m stretch of river or standing water shoreline. Traps should be set for one night in the first instance, but if this is not successful further trapping nights should be carried out. This is because trapping may be unsuccessful due to hydrological conditions or moulting. Trapping should not be carried out if rain is forecast or if a watercourse is still under moderate or high flow after rainfall. A trapping session is not valid for recording crayfish abundance if there is any increase in flow between trap setting and 4 hours after sunset. The number of traps used should always be recorded so CPUE can be calculated. If additional nights' trapping are carried out, catches should be recorded separately. If trapping has been part of long-term monitoring it is inadvisable to change trap type, but for new surveys it is advised that the mesh size on traps should not exceed 15mm. Trapping carries a range of additional risks, including mortality of non-target species, such as European otter, water vole and eel and these should be minimised. Care must also be taken to minimise the risk of unlicensed interference with unattended traps - by minimising public visibility of trapping surveys, both in the setting and the daily checking of traps. Catches from manual surveys and from trapping must not be aggregated to a total abundance as each sampling method has significantly different bias.

2.3 Crayfish attributes

The crayfish captured from manual searching and trapping should be carefully processed, recording the species, sex and carapace length (CL) of each animal (measurement to 1mm accuracy is sufficient). Crayfish that measure <10mm CL may be attributed as unsexed juveniles and may also be difficult to identify to species level. Also record: (i) the number of animals showing gross signs of thelohaniasis (porcelain disease); (ii) any animals that have been found dead or moribund; and, (iii) (although unlikely) any animals that are freshly injured as a result of the survey.

Crayfish plague is very difficult to identify in the field. If more than 10 dead animals or more than five moribund animals are found, consider retaining specimens for laboratory analysis. It is essential to telephone the laboratory in advance. Contact the Fish Health Inspectorate and follow instructions for overnight delivery to Weymouth (tel: 01305 206 700 or email: fhi@cefas.co.uk). There is no charge for this service. A sample of 10 animals should ideally comprise both moribund and apparently healthy animals, kept damp in a cool box with non-absorbent packing material (e.g. bubble wrap) and very little water. If only freshly dead specimens are available they may be sent in minimum 70% ethanol.

White-clawed crayfish populations may occur at very low density. Although a monitoring survey can conclusively determine WCC presence at a site, a survey (via manual search or trapping) that finds no crayfish at a site might not safely conclude that WCC are absent. More advanced survey methods may be necessary to detect a population that is at low density or very patchily distributed. Attributes that might lead to a conclusion of WCC absence might include: (i) pH (<6.4) or total Ca (<2.5 mg L^{-1}); (ii) evidence that the site dries completely; (iii) the presence of a high-density population of invasive non-native crayfish; (iv) evidence of unsuitable water quality; or (v) a previously confirmed outbreak of crayfish plague at the site with no surviving physically isolated remnants of the former population.

3. Site selection

Hand searching and trapping locations should be chosen that would be expected to support the species if the site was unimpaired (i.e. the natural species range). This should include sites where human pressures are likely to lead to a reduction in densities and affect recruitment dynamics, so that the data can reflect impacts on the site. For manual searching, sites (stretches of watercourse or lake margin) should be chosen that have plentiful moveable refuges, e.g. cobbles, small boulders, woody debris.

3.1 Flowing water sites

A survey site may be up to 200m stretch of a watercourse, but it will depend on the abundance of refuges and how accessible they are for manual survey. A sufficient number of survey sites at least 400m apart should be selected to generate both a reasonable understanding of abundance within each assessment unit and sufficient information on spatial distribution. As a general guide, between eight and 15 sites per assessment unit is likely to be appropriate. 500m river lengths within an assessment unit can be selected at random and then survey sites selected within them. It is recommended that half the survey sites in an assessment unit remain constant over monitoring cycles whilst the other half are selected at random in each cycle so that changes over time are detected while increasing the knowledge of the distribution across the assessment unit. A similar approach should be used when setting traps at multiple sites throughout the assessment unit.

3.2 Standing water sites

Shoreline stretches 100-200m long should be selected for hand searching where possible. In small water bodies shorter shoreline stretches may be required. The number of shoreline stretches to be surveyed will depend on the size of the water body and the shoreline morphology. Standing waters naturally have exposed and sheltered shores; the latter are naturally silty and vegetated and cannot be surveyed effectively using the manual search method. When trapping, approximately 10 traps should be employed per 500m of shoreline, subject to the availability of potentially suitable habitat. It is also advisable to locate additional traps at inlets and outlets to encompass the full range of conditions across a water body.

4. Timing and frequency of survey

The optimum time for surveying is after WCC have released their young, and before the start of the next breeding season. The timing of release varies from the end of June in southern England to mid-July in northern England. The optimal period for surveys is typically from the second half of July through to late September. In northern England WCC trap catches may decline from mid-September as water temperature falls. In flowing waters, a survey should be abandoned and re-scheduled if mean flow exceeds 20 cm s^{-1}. In wet summers, flow conditions may be unsuitable for most of the survey season.

The standard survey method described in this protocol should be undertaken in good daylight. Night-time application of the method would be equally successful, using high-powered diving torches, but is likely to be more expensive, and involve additional constraints.

Local extinctions of WCC occur rapidly, and reconnaissance level monitoring (to confirm continued WCC presence) should be undertaken every year. For CSM condition monitoring, a frequency of three years may be appropriate.

5. Data processing

5.1 Spatial extent - For each assessment unit, data should be used to identify any significant absence of white-clawed crayfish in locations where they would be expected under near-natural conditions.

5.2 Abundance - Record the mean number of crayfish (including those not caught) per 100 refuges searched to calculate CPUE. If bait trapping, record the mean number of crayfish caught per trap per night. When interpreting results, it should be noted that data derived from trapping can vary widely with trap design, bait used, frequency of trap checking and re-baiting, trap density, trap location, number of nights trapped, weather conditions and timing within season.

5.3 Age structure - The percentage of the population less than 25mm in carapace length should be calculated. This provides a good indication of both the efficiency of the survey, and that the survey was carried out in suitable conditions. Using the standard method, the proportion of juveniles (<25mm CL) from a healthy population is likely to be about 40%. If less than 20% of the population is juvenile this may be due to lower efficiency of survey, or may indicate a problem with recruitment.

5.4 Population health - The frequency of thelohaniasis in the population should be calculated, and compared with the favourable condition target. Any results of crayfish plague analysis by Cefas should also be recorded.

5.5 Non-native crayfish - The presence of non-native crayfish should be recorded. Any data on non-native crayfish in the catchment can be used in the assessment and the risk of non-native crayfish reaching the WCC population should be assessed.

5.6 Environmental data - Factors such as siltation or channel modification that lead to a reduction in good refuges should be recorded during any crayfish survey. In degraded conditions manual survey is likely to show an overall reduction in recorded catch if the survey is done properly, ranging through potentially suitable habitats throughout a site, although it may still be possible to find crayfish in patches that are less affected and the time required for 100 or 250 refuges is likely to be greater. Timed searches without a record of refuges searched are variable both between surveyors and sites, so that comparisons between surveys are not possible. Consequently, the method of searching favourable patches is advocated, but it is particularly important to consider both habitat and population attributes when undertaking the condition assessment for this species. The environmental attributes in the CSM Guidance for river and lake habitats are used for condition assessments but a form for recording the environmental characteristics of the site is available in Appendix I to provide context for the surveys.

6. Licensing

A licence to handle WCC is required from the relevant conservation agency. Trapping in England and Wales also requires approval from the relevant environment agency because traps constitute 'fixed engines' under the terms of the Salmon and Freshwater Fisheries Act 1975. See the guidelines on Permission to trap crayfish, eels, elvers, salmon and sea trout. Any form of handling of WCC in rivers in Northern Ireland requires a permit from DCAL under the

Fisheries Act (Northern Ireland) 1966 and a licence under the Wildlife (Northern Ireland) Order 1985.

7. Access

It is the responsibility of the surveyor to ensure that all access permissions have been obtained before any survey takes place. Risk assessments should be carried out before commencing any of the activities outlined in the monitoring protocol.

8. Biosecurity

It is essential that surveyors take every step necessary to prevent the introduction of non-native species and diseases to new locations. To avoid spreading plague start surveying sites furthest upstream first. Survey off-stream sites before visiting on-stream sites. Consider disinfection if there is a physical barrier between sites that may be a temporary or permanent barrier to non-native crayfish or the spread of crayfish plague. Before gaining access to any water body, it is essential that all personal and survey equipment has been properly checked, is clean and if necessary disinfected before any work takes place. As a minimum, all surveyors must comply with the Check, Clean, Dry Guidelines (http://www.nonnativespecies.org/checkcleandry/).

9. Data

All output data should be uploaded onto the National Biodiversity Network. This can be done via a form on the Biological Records Centre website (http://www.brc.ac.uk/crayfish).

10. References and further reading

Bradley P and Peay S (2013) *Competencies for species survey: white-clawed crayfish*. Technical Guidance Series. Chartered Institute of Ecology and Environmental Management. http://www.cieem.net/data/files/Resource_Library/Technical_Guidance_Series/CSS/CSS_-_WHITE-CLAWED_CRAYFISH_April_2013.pdf

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APPENDIX I. White-clawed crayfish manual survey form

Crayfish Record – Manual Survey

Site name:	**Watercourse:**	Catchment:	N.G.R.:
Date:	Time(s):	Refuges:	Area searched (approx):
Temp:	pH:	Conductivity:	Agency contacts:
Surveyors:	Contact no.:	Licence no.:	Water colour:
Mean flow (max 20 cm s^{-1}):	Max depth in survey (max 40cm):	Turbidity:	% <25mm C.L.:
No. not caught/juvs:	Crayfish/100 refuges:	% Thelohania:	

	Species	M	F	C.L.	<25mm C.L.	Thelohania	F+young or eggs	Injured	Mori/dead	Notes
		√	√		√	√	√	√	√	
1										
2										
3										
4										
5										
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Habitat record card

Refuges **tick all present ring main type(s) searched**		**Main substrate beneath**		**Refuges in bank**	
cobble (6.5-15cm)		bedrock		none	
cobble (15-25.6cm)		cobble (6.5-15cm)		cobble/boulder	
boulder (25.6-40cm)		pebble (<6.5cm)		tree roots, large	
boulder (>40cm)		gravel (<1.6cm)		vertical or undercut bank	
rubble (give size)		sand (<2mm)		dry stone wall	
woody debris		clay		other reinforced	
other urban debris		silt		crayfish burrows	
tree roots, fine		**Shading above (>30%)**		**Evaluation crayfish habitat for whole site** **(0 none, 1 pres., 2 freq., 3 abund.)**	
moss					
filamentous algae				in margins	
other submerged veg.				in mid channel	
emergents				in banks	
Siltation		**Description of the site and any additional comments including problems**			
none					
low					
moderate					
high					
Problems: 1 - pollution 2 - erosion; E if >33% affected 3 - non-native crayfish					

Key:

Evaluation of searchable crayfish habitat for whole site:

0 not evident, or only minimal potential for refuges
1 present, but localised or sparse, in less than a third of site
2 frequent, covering more than a third of site in total,
3 abundant, potential refuge habitat continuous, or semi-continuous, along more than two thirds site.
? Can use/include query if not sure of evaluation, (e.g. cannot see well)

Siltation:

0 none: organic material if present is coarse leaf litter, no accumulation of silt on surfaces
1 low: a little silt trapped in moss/algae on stones; refuges clear, e.g. only some leaf litter, or clearing before crayfish can wander off.
2 moderate: usually abundant algae on stones or bed, with silt or other fines clouding water when moved, but clearing slowly. May be a little silt below stones. Need to wait longer to view under refuge, but can still see crayfish if present.
3 high: silt cover on all surfaces and some in refuges. May be a soft suspended layer just above bed, very slow to clear and may not settle sufficiently for effective survey (crayfish wander off). If dense suspended silt is present, it may be unsuitable for crayfish.

Favourable Condition Table 2 - White-clawed crayfish (*Austropotamobius pallipes*)

Details of the standard method for population assessment can be found in the monitoring protocol for white-clawed crayfish.

The Lakes CSM targets used in this FCT relate to the habitat requirements of white-clawed crayfish in a range of standing waters including water bodies which are large and small and of natural or artificial origin.

Attribute *=discretionary	**Target**	**Method of assessment**	**Comments**
POPULATION			
a. Spatial extent	Should reflect distribution under near-natural conditions.	Hand searching and trapping	
b. Population abundance	Shallow water: A mean of at least 5 out of 100 refuges containing white-clawed crayfish within a unit of assessment, but see comments. Deep water: At least 1 individual caught per trap on average	Hand searching Trapping	Crayfish densities may be lower than these generic targets for some assessment units (rivers and lakes) due to natural factors and it would be wrong to assume that such lower densities necessarily constitute unfavourable condition. Determination of unfavourable condition should only be made where low densities are known to be related to an impact of some kind, or where historical survey data suggest that higher densities should be present. Where higher densities have been found and this is not due to unnatural causes, (e.g. organic inputs and artificial habitat such as gabions), a higher target may be set to prevent deterioration.
c. Population structure	At least 20% of population should be <25 mm carapace length (CL), as evidence of recruitment. Approximately equal numbers of sexes in the adult population.	Hand searching	Using the standard method, the proportion of juveniles (<25mm CL) from a healthy population is likely to be about 40%. If less than 20% of the population is juvenile this may be due to lower efficiency of survey, or may indicate a problem with recruitment. Size and sex ratio can only be established through the hand search method as the use of traps can favour the capture of the more aggressive, dominant males. Expert judgement should be used to determine whether or not any imbalance in the ratio between males and females is significant and leads to a conclusion of unfavourable condition.

Attribute *=discretionary	Target	Method of assessment	Comments
WATER QUALITY	Ideally, targets included in the CSM guidance for river or lake habitat should be used. These targets are intended to support a healthy, naturally functioning ecosystem which protects the whole biological community and individual species to a degree characteristic of the water body. As a minimum, UKTAG standards for GES under the WFD should be met.	See CSM guidance for river or lake habitat as appropriate. If appropriate, use environment agencies' data on compliance with relevant GES standards.	Generally, water quality should not be injurious to any life stage.
<u>Rivers:</u> Organic pollution, phosphorus, other pollutants.	All CSM chemical targets, and also CSM biological targets relating to macroinvertebrates (WHPT, PSI and AWICS), are applicable.		All classified reaches within the designated site that contain, or should contain, white-clawed crayfish should comply with the targets given. Data from the last 3 years should be used. All water quality data should be available on request from the environmental agencies.
<u>Standing waters:</u> Total phosphorus, dissolved oxygen, other pollutants.	All lake CSM chemical targets are applicable.		Annual means should be used from at least quarterly and preferably monthly sampling.
HYDROLOGY	Ideally, targets included in CSM guidance for river or lake habitat should be used, as these are intended to support a healthy, naturally functioning ecosystem which protects the whole biological community and individual species to a degree characteristic of the water body.	See CSM guidance for river or lake habitat as appropriate.	River flow affects a range of habitat factors of critical importance to white-clawed crayfish, including current velocity, water depth, wetted area, substrate quality, dissolved oxygen levels and water temperature. The maintenance of both flushing flows and baseflows, based on natural hydrological processes, is vital. Detailed investigations of habitat–flow relationships may indicate that a more or less stringent threshold may be appropriate for a specified reach; however, a precautionary approach would need to be taken to the use of less stringent values.
<u>Rivers</u>	CSM flow targets are applicable. As a minimum, UKTAG flow standards for GES under the WFD should be met.		
<u>Standing waters</u>	Lake CSM hydrology and surface area targets are applicable.		

Attribute *=discretionary	Target	Method of assessment	Comments
HABITAT STRUCTURE			
Rivers:	The targets in CSM guidance for river habitat should be used. These are intended to provide a natural, dynamic biotope mosaic with high connectivity that caters for the whole biological community and individual species to a degree characteristic of the river. The comments column provides details of the importance of individual biotopes to white-clawed crayfish.	Assess using the CSM Guidance for Rivers.	Natural channel morphology provides a diversity of refuge and feeding opportunities. The proximity of different refuges facilitates foraging and the movement of individuals to different habitats with age. Operations that widen, deepen and/or straighten the channel reduce variations in habitat. New operations that would have this impact are not acceptable within an SAC, whilst restoration may be needed in some reaches. Extent of cobbles/ boulders: where they occur naturally, cobbles and boulders are used extensively by crayfish as a refuge. Engineering works can result in the loss of large material – any works should at least replace the pre-works availability of such refuges. Extent of large woody debris: where they are present, fallen branches and trunks are used extensively by crayfish as refuge. Woody debris is typically removed during maintenance operations, but it is important to retain as much as possible, particularly where other forms of refuge are in short supply. Density of bankside refuges: these provide important refuges and are often lost during engineering operations. Any works should at least replace the pre-works availability of refuges. Extent of submerged and marginal vegetation: submerged higher plants provide cover away from the banks, and also represent a valuable food source. Marginal emergents also provide important cover and feeding opportunities Extent of bankside tree cover: overhanging trees provide valuable shade and food sources and, in addition, supply woody debris to the river. Submerged tree-root systems provide important cover and refuges from flood flows.
Standing waters:	The targets for lake substrate, shoreline and connectivity in CSM guidance for lake habitat should be used. These are intended to provide a natural habitat and connectivity that caters for the whole biological community and individual species to a degree characteristic of the water body.	Assess using the CSM Guidance for Freshwater Lakes.	Extent and diversity of shoreline refuges such as submerged tree roots, bank crevices and marginal vegetation are important for provision of necessary shade and refugia, as well as proving a detrital food supply.

Attribute *=discretionary	**Target**	**Method of assessment**	**Comments**
OTHER ATTRIBUTES			
a. Fine sediment	No unnaturally high levels of siltation. Siltation targets included in CSM guidance for river habitat are appropriate	Assess using the CSM Guidance for Rivers.	Some life-cycle stages are potentially susceptible to damage from siltation, the source of which may lie elsewhere in the catchment outside the site boundary. Sources of fines include run-off from arable land, land (especially banks) trampled by livestock, sewage and industrial discharges
b. Non-native species	No non-native species likely to cause impairment of white-clawed crayfish populations	Routine assessments and ad hoc investigations	Once non-native crayfish species are established in a water body, native populations are usually eliminated quite rapidly, if not by competition and predation then by crayfish plague. If already present in an SAC and it is not feasible to carry out an eradication treatment while the non-native crayfish are still in a small water body, then the potential of natural and artificial barriers to resist invasion of crayfish should be assessed, and where feasible improved. Biosecurity measures should be put in place to reduce the risk of further introductions of non-native crayfish or crayfish plague.
c. Health	Absence of individuals infected with crayfish plague	Routine assessments and ad hoc investigations	Crayfish plague can be introduced by the entry of non-native crayfish species into a site, but also by a variety of other routes, including contaminated equipment (nets, boots, etc.) and stocked fish from infected waters. Outbreaks of crayfish plague typically result in 100% mortalities, unless there are isolated headwaters with crayfish in the catchment. This target requires that the utmost care be taken in fish stocking and general surveying/monitoring to ensure that plague vectors are not introduced. Disinfection or thorough drying of equipment (or perhaps dedicated equipment for use only in native crayfish rivers) and stocking fish from uninfected waters are vital elements.
	Thelohaniasis (porcelain disease) should not affect >10% population.	Population monitoring methods: hand searching or trapping	This disease may be present in a population at low levels without apparent harm. However this can be an indication of environmental stress and increases in occurrence over time have been linked to declines in CPUE and therefore are a cause for concern.
* d. Stocking/ transfers of other species	No stocking/transfers of fish species at excessively high densities or of fish which may be a vector of plague.	Fishery stocking consents. See CSM river or lake habitat guidance as appropriate.	Fish stocking and transfers are a potential vector of crayfish plague. Fish should only be stocked from fish farms or other sources that are free of non-native crayfish or crayfish plague, or fish farms where suitable quarantine arrangements are in place. Excessively high densities of other fish species may cause unacceptably high predation pressure and competitive interactions. Care needs to be taken to ensure that stocking exercises do not keep the densities of such species at unnaturally high levels.
* e. Stocking/ transfers of white-clawed crayfish*	No stocking/transfers of white-clawed crayfish unless agreed to be in the best interests of the population.	Knowledge of site management	White-clawed crayfish should not be added to extant populations. In addition to the risk of transferring plague this may cause genetic damage to the population or otherwise reduce population fitness. May also obscure underlying problems with site condition and devalue monitoring of population attributes. Transfers may be undertaken under licence to secure populations or establish ark sites.

Attribute *=discretionary	Target	Method of assessment	Comments
* f. Vegetation management			
Rivers:	Vegetation management should be limited to no more than 50% of the channel width (submerged plants) and 50% of bank length (marginal fringe). Extent of overhanging riparian vegetation: this should cover at least 10% of bank length throughout the year, distributed in patches along the margins, and considerably more where other forms of refuge are in short supply.	Various sources including during population surveys, other condition surveys, ad hoc observations, etc.	
Standing waters:	Riparian vegetation should be maintained. Submerged vegetation should not be managed.		Management of riparian vegetation may be required to maintain a habitat mosaic of open and shaded areas that would supply shade, detrital food sources and refuges whilst allowing macrophytes to grow.

CSM Monitoring Protocol 3/4
Common Standards protocol for population monitoring of Arctic charr, whitefish and vendace

Prepared by: Colin Bean, Ruth Hall and Rhian Thomas (2015)

1. Introduction

This protocol provides information on how and when to monitor Arctic charr, whitefish and vendace populations in sites designated as SSSIs for this species. It is based on the previous Common Standards Monitoring (CSM) method (Bean 2003a, b) which has been updated to incorporate all changes made to the survey and assessment method since 2003. For details of population attributes and targets, see the associated Favourable Condition Tables (FCTs) for Arctic charr (FCT 3) and whitefish and vendace (FCT 4). Note that for any given site, population density targets may be substituted with site-specific targets where suitable data exist.

2. Sampling method

Biological monitoring for whitefish and vendace (hereafter referred to as 'coregonids') and Arctic charr is based on two techniques: gill netting and quantitative hydroacoustics.

2.1 Gill netting

Gill netting is the most used employed technique for sampling Arctic charr and coregonids and has been widely used as a means to collect samples of this species in numerous studies. The standardised CEN 'NORDIC' multi-mesh gill nets are routinely used when sampling lacustrine fish populations, including Arctic charr and coregonids (BSI, 2015). The NORDIC gill net consists of 12 different mesh sizes ranging from 5 to 55 mm (bar mesh size from knot to knot) when stretched. The mesh sizes are arranged in a geometric series (Table 1).

Table 1. Mesh-size distribution (knot to knot) and thread diameter in the NORIDC multi-mesh gillnets (after Appelberg, 2000).

Mesh Number	Mesh size (mm)
1	43
2	19.5
3	6.25
4	10
5	55
6	8
7	12.5
8	24
9	15.5
10	5
11	35
12	29

Each benthic gill net is constructed from homogeneous, uncoloured nylon. Each gill net measures 30 m and 1.5 m in height. Each mesh panel is 2.5 m long and the hanging ratio is 0.5 for all mesh sizes. Pelagic gill nets are deeper than their benthic counterparts and extend to a depth of 6 m. The use of low intensity NORDIC style multi-mesh gillnetting, in conjunction with hydroacoustics, is the standard method for sampling coregonids.

Although targeted NORDIC style multi-mesh gill netting is the recommended method for validating hydroacoustic data and for obtaining samples of coregonids and Arctic charr for additional analyses (e.g. for scale ageing and condition), the use of this technique may not be possible at some designated sites. Some licensing bodies and fishery owners may be reluctant to provide permission for their use. This is due to the perceived destructiveness of this technique and its potential to affect fish populations which may already be in danger. If permission cannot be granted then the hydroacoustics survey should still be undertaken, but there will be lower confidence in the results as the proportion of the fish population that comprises coregonids or Arctic charr will be unknown.

2.2 Hydroacoustics

The use of hydroacoustic methods for the assessment and monitoring of lake fish populations has increased markedly throughout Europe and North America over the last two decades. This is primarily due to advances in the hardware and software components of systems. When used in conjunction with technical improvements and affordability in Global Positioning Systems, hydroacoustic methodologies now offer a cost-effective and non-destructive means of rapidly obtaining information on lake fish abundance, demographics and geographical distribution (Winfield *et al.,* 2009, 2012, 2013).

Although it is possible to use sonar to examine species composition, primarily through separating echoes on the basis of fish size or distribution, it is not currently possible to do so with a high degree of confidence. Similarly, hydroacoustic studies alone will not allow an assessor to determine the sex, age or condition of individual fish. To overcome these problems, this method is commonly used alongside complementary fish sampling techniques, such as gill netting.

Hydroacoustic surveys should be carried out using a split-beam system which has been properly calibrated for use in freshwater and compliant with CEN standards (BSI, 2014). Coregonid and Arctic charr numbers obtained by hydroacoustic survey are generally higher during nocturnal periods suggesting that fish are either more active during this period or display a habitat shift to pelagic areas at night. As a minimum, hydroacoustic surveys and any associated gill netting must therefore be carried out during this period (see Section 4). The ratio of hydroacoustic survey coverage (length of surveys:square root of the research area) should be at least 3:1.

3. Site selection

The position of each gill net in each water body is determined by the need to ensure that the catch should constitute an unbiased sample of the catchable part of the fish assemblage in that location. This means that nets should be set in areas of suitable habitat that are accessible to the species of interest: coregonids or Arctic charr.

In order to maximise the accuracy of the survey thorough planning should precede all fish sampling. If a bathymetric map is already available, this should be used to determine the location of gill net deployments across appropriate depth strata and hydroacoustic transects. If bathymetric data for the water body is lacking, sampling will be preceded by preliminary sounding to establish depth distributions within the site.

As habitat use varies both between fish species and size classes, it is important that that all key habitats are sampled. This means that littoral, benthic and pelagic habitats must be included in the sampling effort. Hydroacoustic survey, however, is restricted to depths >5 m.

Before undertaking the hydroacoustic component of the survey, the contractor should conduct a map-based appraisal of the survey site and select a transect series that avoids areas unsuitable for hydroacoustic sampling. While the preferred sampling survey design is the discrete systematic parallel type, the random distribution of non-suitable habitat types within each lake suggests that most surveys will follow a discrete random parallel design.

The start and finishing points of each transect should be mapped accurately. The use of handheld or integrated GPS must be used to provide accurate grid references. This will allow accurate mapping using GIS and ease replicability in future years. In addition to mapping the location of transects, it is recommended that the time taken to complete each transect is also recorded. As well as providing a temporal reference for each sampling event, the data will allow the contractor to assess whether transect speeds exceed that required to carry out an effective survey.

4. Timing and frequency of survey

Arctic charr populations should be sampled between July and August, when fish distribution is not polarised into shoals, shallow in-lake habitats or (in some cases) spawning streams. Coregonid populations should be assessed between July and September, when fish have attained a body size suitable for field sampling and hydroacoustic discrimination. Late summer temperatures mean that fish will still be actively foraging during this period and this may increase the likelihood of capture within pelagic areas. By surveying at a time when underyearling coregonids and Arctic charr have had the opportunity to attain a full summer growth, the likelihood of being able to discriminate successfully between this species and other components of the pelagic zone will be substantially increased.

Gill netting and hydroacoustic surveys should be carried out over a 24-hour period at each site. Sampling activity should be carried out during daylight and then repeated again during the hours of darkness. Ideally, surveying should be undertaken every year as populations may fluctuate considerably between years. However, monitoring budgets are unlikely to support this intensity of survey and a 3-yearly sampling frequency is likely to be the maximum that can be used. A 6-yearly programme can lead to difficulties in interpreting apparent changes in population attributes.

5. Data processing

Target strength and echo density data produced by the hydroacoustic system should be analysed using an appropriate post-processing software package. Data from previous CSM surveys have been analysed using the fish tracking function of Echoview Version 3.25.55.00 and earlier (Myriax, Hobart, Australia, www.echoview.com), Sonar5-Pro Version 5.9.8 (Lindem Data Acquisition, Oslo, Norway, www.fys.uio.no/~hbalk/sonar4_5) and EchoScape (Hyroacoustic Technology Inc. Seattle, USA, www.htisonar.com/echoscape.htm).

Hydroacoustic data should be converted to fish lengths using the target-strength-fish length relationship described by Love (1971), where: TS = (19.1 log L) – (0.9 log F) – 62.0 (TS is the recorded target strength (-dB), L is total fish length (mm) and F is frequency (kHz)).

As a guide fish targets can be classified into either small (-52 to -45dB, ~40 to 99 mm), medium (-44 to -37dB, ~100-249 mm) or large (>-37dB, ~250 mm or greater) length classes. Recent software advances now mean that smaller targets (-70 dB, < 4cm) can also be counted effectively. The total number of fish within the lake are best derived by summing the data obtained for each fish size category within each transect and calculating an overall geometric mean for each size class. Fish densities should be reported as the number of individuals (of each size class) per hectare. These data will be provided in the form of geometric means with 95% confidence limits.

Although abundance may be used as an indicator of population status, the differing ecological status of each locality means that reference values must be calculated that are unique for each water body. Only once this task has been completed can numerical density targets be set. A review of previous Arctic charr survey densities can be found in Winfield *et al.* (2009).

In the FCTs for Arctic charr and coregonids the population parameters require (as a minimum) that species presence be confirmed and that the population is spawning successfully. Additional criteria that may prove useful in assessing the population status of Arctic charr and coregonids include sex ratios, a measurement of fecundity and age class structure. By using a combination of quantitative hydroacoustics and gill netting methods, the sampling strategy as described should allow:

i) An accurate assessment of target species density and distribution within lakes.

ii) An assessment of the numbers of target species by size class.

iii) An assessment of population structure, growth rate, and condition.

iv) If a population is known to spawn in a particular area of a lake, or inflowing or outflowing streams in the case of Arctic charr, the assessment is expected to identify any issues that may limit access to known spawning sites.

In addition to fish sampling, the monitoring of coregonid and Arctic charr populations will also include an assessment of a range of habitat attributes. These attributes include water quality (dissolved oxygen, pH and nutrient status), hydrology, and habitat composition. The methodology for each of these attributes is contained in the CSM Guidance for Freshwater Lakes and targets are contained in the accompanying FCTs.

6. Licensing

Whitefish and vendace are listed under Schedule 5 of the Wildlife and Countryside Act and a species-specific licence is required to survey for this species. Licences can be obtained from the relevant country conservation agencies. Arctic charr is not listed under the Wildlife and Countryside Act and therefore no licence is required to survey this species. However, a licence to sample any fish using gill nets is required. Licences are issued by Marine Scotland Science (Scotland), Environment Agency (England) and Natural Resource Wales. In addition, under Section 28, consent may be required from the appropriate country agency (Scottish Natural Heritage, Natural England or Natural Resources Wales) to undertake fishing activities on a designated site (SSSI or SAC).

7. Access

It is the responsibility of the contractor to ensure that all access permissions have been obtained before any survey takes place. Risk assessments should be carried out before commencing any of the activities outlined in the monitoring protocol.

8. Biosecurity

It is essential that contractors take every step necessary to prevent the introduction of non-native species and diseases to new locations. Before gaining access to any water body, it is essential that all personal and survey equipment has been properly checked and, if necessary, disinfected before any work takes place. All contractors must comply with the Check, Clean, Dry guidelines as a minimum requirement (http://www.nonnativespecies.org/checkcleandry/).

9. Data

All survey data should be stored in national databases where appropriate and uploaded onto the National Biodiversity Network.

10. References and further reading

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Favourable Condition Table 3 - Arctic charr *(Salvelinus alpinus)*

Details of the standard method for population assessment can be found in the monitoring protocol for Arctic charr, whitefish and vendace.

Attribute * = discretionary	**Target**	**Method of assessment**	**Comments**
POPULATION			
a. Population density	Minimum requirement should be the confirmation that Arctic charr are present and spawning successfully.	Gill netting with NORDIC design nets in conjunction with quantitative hydroacoustics.	Gill netting may not be a survey option in some sites. In such cases, recruitment may be inferred from hydroacoustic data.
b. Age structure	i. Juvenile (0+ and 1+) fish should comprise 70% of the total number of individuals within the Arctic charr population. ii. No loss of age classes (usually dominated by 3+ and 4+ individuals) in gill net catches. Older fish should also be well represented and a pattern of consistent recruitment should be visible.	Gill netting with NORDIC design nets in conjunction with quantitative hydroacoustics.	Up to 10 age-classes may be present; however, more commonly only four or five may be evident. A pattern of consistent recruitment should be visible. Gill netting may not be a survey option in some sites. In such cases, recruitment may be inferred from hydroacoustic data.
c. Population size	Productivity varies widely between sites. The target population size should be one which lies within 50% of an established baseline for each site.	Gill netting with NORDIC design nets in conjunction with quantitative hydroacoustics.	The baseline will be agreed and based on previous surveys from each site, or based on expert judgement where data are limited.

Attribute * = discretionary	Target	Method of assessment	Comments
WATER QUALITY Lakes: Rivers:	Ideally, targets included in the CSM guidance for lake (and, where applicable, river) habitats should be used. These targets are intended to support a healthy, naturally functioning ecosystem which protects the whole biological community and individual species to a degree characteristic of the site. As a minimum, UKTAG standards for GES under the WFD should be met. All water quality targets in the CSM Guidance for Freshwater Lakes are appropriate. For rivers, all chemical targets, and also biological targets relating to macroinvertebrates (WHPT, PSI and AWICS), are applicable.	See CSM guidance for lake and river habitats.	Arctic charr are largely restricted to oligotrophic and mesotrophic lakes. The targets used in this assessment reflect those required to maintain biological communities in lakes with this trophic status. Some populations may use inflowing rivers during spawning time. This may occur during the autumn or spring, depending on the population being studied. Riverine targets relate to nursery and spawning grounds. Water quality should also be sufficient to permit the passage of Arctic charr to riverine spawning areas at all times. Generally, water quality should not be injurious to any life stage of Arctic charr. A wide range of water quality parameters can affect the status of interest features, but standard biological monitoring techniques provide a reasonably integrated picture in relation to many parameters. All classified reaches within the site that contain, or should contain, Arctic charr under near-natural conditions should comply with appropriate CSM rivers and UKTAG targets.
HYDROLOGY	In lakes, there should be no deterioration in hydrological regime compared with baseline In rivers, flow targets included in the CSM Guidance for Rivers should be used, as these are intended to support a healthy, naturally functioning riverine ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. As a minimum, UKTAG standards for GES under the WFD should be met.	See CSM guidance for lake and river habitats. Gauging stations (data available from environment agencies)	Baseline may be defined as being the situation at the time of designation, or may refer to natural conditions, depending on the objectives for the individual lake. River flow affects a range of habitat factors of critical importance to designated interest features, including current velocity, water depth, wetted area, substrate quality, dissolved oxygen levels and water temperature. The maintenance of both flushing flows and baseflows, based on natural hydrological processes, is vital. Detailed investigations of habitat–flow relationships may indicate that a more or less stringent threshold may be appropriate for a specified reach; however, a precautionary approach would need to be taken to the use of less stringent values. Naturalised flow is defined as the flow in the absence of abstractions and discharges. The availability and reliability of data is patchy – long-term gauged data can be used until adequate naturalised data become available, although the impact of abstractions on historical flow records should be considered.
CONNECTIVITY	No loss of connectivity within, or between, lacustrine and riverine habitats used by Arctic charr.	See CSM Guidance for Freshwater Lakes.	Access to all habitats used by Arctic charr to complete its life cycle must be maintained. This applies to movement within lakes and to movements between lakes and riverine spawning habitat.

Attribute * = discretionary	Target	Method of assessment	Comments
HABITAT STRUCTURE	The targets for lake substrate, sediment load and shoreline in CSM guidance for lake habitat should be used. These are intended to provide a natural habitat and connectivity that caters for the whole biological community and individual species to a degree characteristic of the water body.	See CSM guidance for lake habitats.	Near-shore areas are principally used for spawning and, in some instances, feeding. No clear information is available relating to the in-lake spawning requirements of Arctic charr. Known spawning grounds should, as far as possible, comply with targets for salmonids. No loss of spawning substrate should be recorded between sampling events.
OTHER ATTRIBUTES			
* a. Non-native/locally absent species	No non-native species likely to cause impairment of Arctic charr populations, e.g. pike.	See CSM guidance for lake habitat.	Refer to the WFD list of alien/locally non-native species (but not to be used exclusively).
* b. Stocking/transfers of other species	No stocking/transfers of fish species at excessively high densities	Fishery stocking consents. Impact assessments of stocking consents at a catchment scale may be required to determine an acceptable level.	Excessively high densities of other fish species may cause unacceptably high predation pressure and competitive interactions. Care needs to be taken to ensure that stocking exercises do not keep the densities of such species at unnaturally high levels.
* c. Stocking/transfers of Arctic charr	No stocking/transfers of Arctic charr unless agreed to be in the best interests of the population.	Knowledge of site management	May cause genetic damage to the population or otherwise reduce population fitness. May also obscure underlying problems with site condition and devalue monitoring of population attributes.
* d. Abstraction intakes and discharges	Effective screening on all intakes and discharges.	Environment agencies monitoring/ consenting programmes.	Entrainment of Arctic charr in intakes and discharges can occur. Escapes from fish farms are a form of uncontrolled introduction and should be prevented.
* e. Water temperature	Maintenance of temperatures appropriate for Arctic charr survival at all life history stages.	Liaison with fisheries officers, developers and regulators.	High temperatures (>7^{o}C) must be avoided during Arctic charr incubation periods. High temperatures during other times of the year can have an impact on dissolved oxygen availability, either directly or through the contributory development of algal blooms.

Favourable Condition Table 4 – Coregonids: *Coregonus lavaretus* (powan, schelly, gwyniad) and *Coregonus albula* (vendace)

Details of the standard method for population assessment can be found in the monitoring protocol for whitefish, vendace and Arctic charr.

Attribute * = discretionary	**Target**	**Method of assessment**	**Comments**
POPULATION			
a. Spatial extent	Should reflect distribution under near-natural conditions.	Spatially targeted and short-duration gill netting using NORDIC design nets in conjunction with quantitative hydroacoustics.	Coregonids should be present in all areas of the lake to which they require access. This may include access to areas above and below a thermocline. Gill netting may not be an option in some sites.
b. Population density	Minimum requirement should be the confirmation that coregonids are present and spawning successfully.	Gill netting with NORDIC design nets in conjunction with quantitative hydroacoustics.	Gill netting may not be possible in some sites. In such cases, recruitment of juvenile fish may be inferred from hydroacoustic data.
c. Age structure	Juvenile (0+ and 1+) fish should comprise 70% of the total number of individuals within the coregonid population. No loss of age classes (usually dominated by 3+ and 4+ individuals) in gill net catches. Older fish should also be well represented and a pattern of consistent recruitment should be visible.	Gill netting with NORDIC design nets	Gill netting may not be possible in some sites. In such cases, recruitment of juvenile fish may be inferred from hydroacoustic data. Discernible age classes up to at least 9+ years but may be present. On occasion fish age may extend up to 13+. Gill netting may not be possible in some sites. In such cases, recruitment may be inferred from hydroacoustic data.
d. Population size	Productivity varies widely between sites. The target population size should be one that lies within 50% of an established baseline for each site.	Gill netting with NORDIC design nets in conjunction with quantitative hydroacoustics.	The baseline will be agreed and based on previous surveys from the site, or based on expert judgement where data are limited.

Attribute * = discretionary	Target	Method of assessment	Comments
WATER QUALITY	Ideally targets in the CSM guidance for lake habitats should be used as these are intended to support a healthy, naturally functioning lacustrine ecosystem which protects the whole biological community and individual species characteristic of the lake. As a minimum, UKTAG standards for GES under the WFD should be met. All lake CSM water quality targets are applicable.	See the CSM Guidance for Freshwater Lakes. If appropriate use environment agencies' data on compliance with relevant GES standards.	Coregonids are largely restricted to oligotrophic and mesotrophic lakes. The targets used in this assessment reflect those required to maintain biological communities in lakes with this trophic status.
HYDROLOGY	Targets for hydrology and surface area in the CSM Guidance for Freshwater Lakes should be used as these are intended to support a healthy, naturally functioning lacustrine ecosystem which protects the whole biological community and individual species characteristic of the lake.	See the CSM Guidance for Freshwater Lakes	Drawdown associated with water abstraction can lead to spawning grounds being; a) inaccessible to fish, or b) exposed resulting in the desiccation of eggs. It is important that spawning areas are protected from drawdown during spawning and incubation times.
CONNECTIVITY	No loss of connectivity within, or between, habitats used by coregonids.	See the CSM Guidance for Freshwater Lakes	Access to all habitats used by coregonids to complete their life cycle must be maintained.
***HABITAT STRUCTURE:**	The targets for lake substrate, sediment load and shoreline in CSM guidance for lake habitats should be used. These targets are intended to provide a natural habitat and connectivity that caters for the whole biological community and individual species to a degree characteristic of the water body.	See the CSM Guidance for Freshwater Lakes	Near-shore areas are principally used for spawning and, in some instances, feeding. Visual assessment by mini-ROVs (if possible) should be used to assess habitat quality. Coregonid spawning areas are sensitive to siltation. These areas, which comprise gravel and cobble, typically lie within areas of <5 m depth. The presence of introduced macrophytes (such as New Zealand pygmyweed) have caused problems at some sites by reducing the quality of littoral spawning substrates.

Attribute * = discretionary	Target	Method of assessment	Comments
OTHER ATTRIBUTES			
* a. Non-native/locally non-native species	No non-native species likely to cause impairment of coregonid populations; for example, pike, ruffe and New Zealand pygmyweed.	See the CSM Guidance for Freshwater Lakes	Refer to the WFD list of alien/locally non-native species (but not to be used exclusively).
* b. Stocking/transfers of other species	No stocking/transfers of fish species at excessively high densities.	Fishery stocking consents. Impact assessments of stocking consents at a catchment scale may be required to determine an acceptable level.	Excessively high densities of other fish species may cause unacceptably high predation pressure and competitive interactions. Care needs to be taken to ensure that stocking exercises do not keep the densities of such species at unnaturally high levels.
* c. Stocking/transfers of coregonids	No stocking/transfers of coregonids unless agreed to be in the best interests of the population.	Knowledge of site management.	May cause genetic damage to the population or otherwise reduce population fitness. May also obscure underlying problems with site condition and devalue monitoring of population attributes.
* d. Abstraction intakes and discharges	Effective screening on all intakes and discharges.	Environment agencies' monitoring/ consenting programmes.	Entrainment of coregonids in intakes and discharges can occur. Escapes from fish farms are a form of uncontrolled introduction and should be prevented.

CSM Monitoring Protocol 5
Common Standards protocol for population monitoring of Atlantic salmon (*Salmo salar*)

Prepared by: Colin Bean, Chris Mainstone and Rhian Thomas (2015)

1. Introduction

This protocol gives information on how and when to monitor Atlantic salmon in sites designated as Sites of Special Scientific Interest (SSSIs), Areas of Special Scientific Interest (ASSIs) or Special Areas of Conservation (SACs) for the species. For details of population attributes and targets, see the associated generic Favourable Condition Table (FCT) for Atlantic salmon.

The protocol reflects established practices used for monitoring and assessing salmon in different parts of the UK. There are significant differences in the methods used and this protocol is designed to reflect these, yet this protocol and the FCT incorporate a common standard in the attributes/targets used to assess favourable condition across the UK.

2. Sampling method

Biological monitoring for Atlantic salmon considers two separate life history stages, namely juveniles and adults. Assessment of both is important because they tell us different things: the adult run tells us something about the overall health of the catchment's population, but juvenile assessment is needed to tell us about the condition of the species in different parts of the catchment. The general approach in this protocol is broadly similar to that described by Cowx and Fraser (2003).

2.1 Juvenile monitoring

Juvenile Atlantic salmon are surveyed by electrofishing. In Scotland, electrofishing is carried out according to the methodology developed by the Scottish Fisheries Coordination Centre (SFCC, 2007). In contrast to the situation in Scotland, where sampling is normally carried out by contractors, electrofishing data in England, Wales and Northern Ireland are collected by the relevant agencies. English and Welsh surveys adhere to the BSI standard for electrofishing (BSI, 2003), and those carried out in Northern Ireland use the survey methodology described in Crozier and Kennedy (1995).

Three survey methods can be applied:

(i) *Quantitative sampling* – where two or more repeat fishings are carried out in a fixed area using stop nets. Data are used to obtain estimates of absolute abundance using catch-depletion techniques. Depletion methods are considered to be self-calibrating because the catch data are used to derive the probability of capture (Wyatt and Lacey, 1994). Typically the overall estimate of fish abundance (provided as fry and parr) is made using the maximum likelihood estimator described by Zippin (1956) and the weighted maximum likelihood estimator described by Carle and Strub (1978). As a general rule the Zippin model is most reliable when the proportion of the population removed remains relatively high and constant with each successive sampling run. The Carle and Strub approach is a development of the Zippin method and has the advantage of being able to produce population estimates and confidence limits under situations where Zippin fails, e.g. when the probability of catch varies from run to run, or when the population size is small. A minimum of two electrofishing runs is required for these methods to be applied.

(ii) *Semi-quantitative sampling* – involves single run electrofishing in open (non stop-netted) sites. This survey approach allows population estimates with a low level of precision to be made. The simplest form of a semi-quantitative survey is a single-run electrofishing survey. This uses the number of fish captured to derive a 'minimum estimate' of the fish population. This method does not involve the use of statistical models and simply provides data relating to the minimum density of fish caught at that site. It provides only a 'relative index' related to the number of fish or to the population density, but where the exact relationship is unknown or is not calibrated (Wyatt and Lacey, 1994). If similar effort is used to carry out the survey, then the single run electrofishing survey can be deemed to be identical to the first run of a multiple-run, fully quantitative survey. It is therefore possible to increase confidence in these data by calibrating the results of the single run against the multiple-run surveys which have been carried out in the same area (assuming site characteristics are similar).

(iii) *Timed electrofishing* - this is used to provide an index of fry abundance. Timed methods allow a larger number of sites to be sampled per day. Fishing should be carried out in an upstream direction for a minimum of five minutes, using one anode with backpack or bankside equipment depending on conductivity and local conditions. In Northern Ireland the sampling direction is downstream, in accordance with the protocol of Crozier and Kennedy (1995). If the catchment is known to have low fish densities the standard time may need to be increased to maximise the chance of catching a representative sample. This method is the only juvenile salmon survey method used in Northern Ireland.

All data relating to the catch (numbers, fish measurements) and site characteristics (sampling site dimensions, conductivity, sampling type, etc.) are recorded at the time of survey. This should include total survey length at each sampling site, and average widths for the wetted bed and bank. Cowx and Fraser (2003) list the range of environmental variables and catch data that should be recorded at each sampling site, regardless of the survey method employed.

2.2 Adult assessment

Data relating to adult Atlantic salmon numbers are not collected in a consistent way throughout the UK.

2.2.1 Scotland

In Scotland, rod catches are the primary source of adult abundance data and an analysis of catch trends have, historically, dominated the way in which population trends have been reported. Despite the lack of information on fishing effort, these data still allow the analysis of catches since 1952 and, to date, this remains the best available method for the assessment of adult abundance in Scottish Atlantic salmon SACs. Previous condition assessments for the adult component of the population were derived by comparing the average rod catch in the year that the site was put forward as an SAC. More recently, and as part of the Scottish Government's reporting obligations to the North Atlantic Salmon Conservation Organisation (NASCO) a new rod-catch assessment tool has been used. This assessment identifies whether conservation measures or local investigations are required for any of the spring, summer or autumn seasonal catch components based on catch records for each seasonal component over the last 20 years. Further details of the NASCO rod-catch assessment tool can be obtained from: http://www.nasco.int/pdf/far_fisheries/FisheriesFAR_Scotland.pdf.

Conservation Limits (CLs) for SAC rivers (possibly supported by a counter network), are currently being developed for use in Scotland by Marine Scotland Science. Once available these will form the basis of future adult Atlantic salmon assessments in Scotland.

2.2.2 England and Wales

In England and Wales 'Returning Stock Estimates' (RSEs) for adult salmon are obtained on some SAC rivers through the operation of automatic (usually resistivity) fish counters or partial traps. For example, on the Welsh Dee run estimates are derived using trapping and mark–recapture methods. RSEs for counted rivers in England and Wales are published in annual assessments of salmon stock and fishery status (Cefas, Environment Agency and Natural Resources Wales, 2014).

RSEs provide the most reliable estimates available on adult returns, and on index rivers are combined with biological information (e.g. on the age and size composition of stocks) and other details (e.g. estimates of smolt output) to explore changes in the structure and dynamics of populations over the whole life cycle. RSEs are also used to assess spawning escapement and egg deposition levels for comparison with river-specific CLs.

The CLs set in England and Wales reflect the modelled smolt production capacity of individual catchments and indicate the minimum desirable spawning stock level below which further reductions in spawner numbers are likely to result in significant reductions in the number of juvenile fish produced in the next generation. The CL should be calculated using estimates of spawning/juvenile habitat under near-natural conditions, and it is important to check that this has been the basis of its calculation at a site level. A Management Objective (previously called a Management Target) is then set for each catchment to comply with the CL in 4 years out of 5 on average, based on numbers of returning adults, and this Management Objective forms the numerical adult population target for favourable condition in SSSI/SAC rivers. CLs (and associated Management Objectives) have been derived for all principal salmon rivers in England and Wales in line with national and international (ICES and NASCO) requirements, and have been used to assess stocks annually since 1996. Where RSEs are not available (the great majority of rivers), reliance is placed on rod catch-based estimates of spawning escapement for CL compliance assessment. Further information on the derivation and application of CLs in England and Wales can be found in Cefas, Environment Agency and Natural Resources Wales (2014).

2.2.3 Northern Ireland

The Loughs Agency and Agri-Food and Biosciences Institute (AFBI) has responsibility for monitoring and managing Atlantic salmon in Northern Ireland. The Agency uses a real-time management regime to monitor Atlantic salmon within ASSI/SACs and to control exploitation. These use the concept of CLs and Management Targets (MT) as described above to provide a number of key targets around which various closures can be made to protect Atlantic salmon in ASSI/SACs.

3. Site selection (for juvenile assessment only)

Survey sites should be chosen to provide a representative picture of juvenile population densities across the ASSI/SSSI/SAC and within each assessment unit. For existing ASSI/SSSI/SACs, monitoring sites have already been selected and can only be changed if there is a clear case for doing so.

The position of each electrofishing site in each ASSI/SSSI/SAC is determined by the need to ensure that the catch constitutes an unbiased sample of the juvenile Atlantic salmon populations in key habitat types. Since habitat use varies between size classes (fry and parr), it is important that the proportion of all representative habitats is recorded within each sampling site. These are fully described in Hendry and Cragg-Hine (2003) and, for juvenile Atlantic salmon, include riffles, glides and pools. Surveyors should be aware of the need to sample effectively at all times, and the limitations of electrofishing in fast-flowing and deep-water habitats.

Electrofishing sites should be capable of reflecting impacts on site condition, for instance relating to water quality, physical habitat degradation, artificial barriers to access, or artificial flow modifications. They should also be able to reflect impacts on the population from stocking, either with salmon or trout. However, they should not be positioned where there is uncertainty over natural accessibility to salmon. In addition, due to the difficulties in interpreting the effects of salmon stocking (possible increases in population size but with long-term declines in natural recruitment), any areas that are stocked with salmon should be avoided.

4. Timing and frequency of survey

To ensure early detection of any decline in the population status, surveys should ideally be carried out annually to detect fluctuations in population trends. However, a 3-yearly sampling frequency is acceptable. A 6-yearly sampling programme will give rise to difficulties in interpreting apparent changes in population attributes. In most parts of the UK, the survey data used will be those generated by the respective environment agencies, so survey frequency is governed by those monitoring regimes. In Scotland bespoke surveys may be augmented by additional temporal data for some sites from the local Fishery and Rivers Trust or District Salmon Fishery Board.

All juvenile surveys must take place between the months of June to September. All fully quantitative and timed sites should be visited once during this period.

Adult data are collected over the course of the calendar year (for counters) and during the angling season (for rod-catch). The closed season for Atlantic salmon fisheries may vary between river systems (particularly in Scotland) but generally these cover the months of November to February. Data are collated by the relevant agencies. Typically, these data are made publically available 6-12 months in arrears.

5. Data processing

5.1 Juvenile data – Scotland, England and Wales

The National Fisheries Classification Scheme (FCS2) is used in England and Wales to evaluate fish population status. In this scheme population densities are graded from A to F based on the frequency distribution of juvenile density values in a national database of fish survey data. Monitoring sites can be assessed using either true population estimates or minimum density data. A similar system has been developed in Scotland, with class thresholds set at higher values due to the generally higher juvenile densities in Scotland.

Both the FCS2 and the Scottish scheme allow for an instant comparison of fishery performance against a nationally based reference system. Data are presented separately for 0+ fish and older juveniles (0++) at each sampling site and a separate grade is derived for each age class. In Scotland, class boundary values are provided at both a national and a regional level in Godfrey (2005) and several Fishery Trusts and District Salmon Fishery Boards have further refined these for individual SACs by including additional survey data. FCS2 has no regional evaluation.

It is not possible to be prescriptive about how the results of applying these classifications should be used to assess compliance with the FCT target for juvenile density. Expert judgement will be needed to consider natural stream productivity and the carrying capacity of each individual monitoring site and assessment unit to allow data interpretation and assessment. Different parts of the UK have local schemes for judging the status of juvenile salmon densities, based on a more detailed understanding of local conditions. These may be more suitable for condition assessment than national classification schemes. Equally, the predictive model HABSCORE may be useful in some parts of the UK (in areas where the model was developed).

5.2 Juvenile data – Northern Ireland

Juvenile Atlantic salmon assessments in Northern Ireland are based solely on timed electrofishing of salmon fry. Data are assessed against the criteria presented in Table 1.

Table 1: The fry abundance classification scheme used in Northern Ireland.

Grade	Criteria (Number of 0+ Atlantic salmon per 5-minute fishing)
Excellent	>25
Good	15-24
Fair	5-14
Poor	1-4
Bad	0

5.3 Adult data - Scotland

In Scotland, adult data are obtained from Marine Scotland Science and divided into temporal components that broadly reflect life-history stock components. January-June represents the spring Multi-Sea-Winter (MSW) fish component, July-August tends to be numerically dominated by grilse (1 SW) fish and the autumn (September-December) comprises both grilse and MSW fish.

Rod catch data for each stock component in the year of designation form the baseline for each site. However, because rod catch data (with no measure of effort) can be highly variable from year to year, catch data in the year of assessment are also compared with those collected over the long term (1952-present) and short term (the period elapsed since designation. The performance of each stock component against the previous CSM assessment is also assessed. In addition to these assessments, data for the last 20 years (which includes the most recent catch data available for the SAC) are then put through the NASCO Rod-catch Assessment Tool. This identifies whether conservation measures or local investigations are required for any of the spring, summer or autumn seasonal catch components.

This analysis helps to support the case for conservation action if: a) the most recent annual catch data are the lowest in the series; b) two of the lowest catches occur within the last 3 years; or c) if four of the lowest catches have occurred within the last 6 years.

It is a legal requirement for District Salmon Fishery Boards to provide adult catch data to the Scottish Government at the end of each fishing season. Adult data are collected and collated by Marine Scotland Science and published at a Fishery District level annually. Details of catches can be obtained from the Scottish Government website at:
http://www.scotland.gov.uk/Topics/marine/science/Publications/stats/SalmonSeaTroutCatches.

5.4 Adult data - England, Wales and Northern Ireland

England, Wales and Northern Ireland use a combination of rod catch and catch-independent methods (such as counters) to determine whether the CLs for Atlantic salmon of each SAC have been reached. The data necessary to make an assessment for each ASSI/SSSI/SAC are available in the annual reports on catch statistics for salmon and sea trout generated for England and Wales, and also for Northern Ireland (by the Loughs Agency).

The judgement on adult run size should be reached using the annual statistics report to determine if the Management Objective has been met at the time of the condition assessment, i.e. the CL has been exceeded in 4 of the preceding 5 years. The composition of the adult run should be assessed by expert judgement, considering whether the MSW component and seasonal components of the run have declined significantly relative to historical records, and whether this is likely to be due to human impacts.

6. Licensing

Electrofishing in inland waters is a licensable activity. Permission to use this technique for survey purposes must be obtained from Marine Scotland Science (as well as the local District Salmon Fishery Board if in Scotland), the Environment Agency (England) or Natural Resources Wales. In Northern Ireland permission should be sought from the Loughs Agency for waters within the Foyle and Carlingford area or the Department of Culture, Arts and Leisure (DCAL) for the remainder.

Atlantic salmon are not protected under Schedule 5 of the Wildlife & Countryside Act 1981 (as amended) or Schedule 5 of the Wildlife and Natural Environment Act (Northern Ireland) 2011. However, consent may be required from the appropriate Country Agency (Scottish Natural Heritage, Natural England, Natural Resources Wales or the Northern Ireland Environment Agency) to undertake electric fishing on a designated site.

7. Access

It is the responsibility of the contractor to ensure that all access permissions have been obtained before any survey takes place. Risk assessments should be carried out before commencing any of the activities outlined in the monitoring protocol.

8. Biosecurity

It is essential that contractors take every step necessary to prevent the introduction of non-native species to new locations. Before gaining access to any water body, it is essential that all personal and survey equipment has been properly checked and, if necessary, disinfected before any work takes place. All contractors must comply with the Check, Clean, Dry guidelines as a minimum requirement (http://www.nonnativespecies.org/checkcleandry/).

9. Data

All survey data should be stored in national databases where appropriate and uploaded onto the National Biodiversity Network.

10. References and further reading

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Hendry K and Cragg-Hine D (2003) *Ecology of the Atlantic Salmon*. Conserving Natura 2000 Rivers Ecology Series No. 7. English Nature, Peterborough.

JNCC (2014) *Common Standards Monitoring Guidance for Rivers,* ISSN 1743-8160 (Online)
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Favourable Condition Table 5 – Atlantic salmon (*Salmo salar*)

Details of the standard method for population assessment can be found in the monitoring protocol for Atlantic salmon.

Attribute *=discretionary	**Target**	**Method of Assessment**	**Comments**
POPULATION			
a. Spatial extent	Should reflect distribution under near-natural conditions.	Electrofishing	Juvenile Atlantic salmon should be present in all areas of the catchment to which they have natural access. This does not include areas above naturally impassable barriers, but areas where access has been limited by man-made obstructions should be identified. See the associated monitoring protocol for further details.
b. Population density: juveniles	These should not differ significantly from those expected for the river type/reach under conditions of high physical and chemical quality.	Quantitative, semi-quantitative and timed electrofishing	Juvenile densities vary naturally between rivers and between survey sites on rivers, depending on the productivity and natural habitat character of the system. Observed densities therefore need to be assessed in relation to the expectation for each river and each river reach. See the associated monitoring protocol for further details.
c. Population density: adult run size	Total run size at least matching an agreed reference level, including a seasonal pattern of migration characteristic of the river and maintenance of the multi-sea-winter component.	Fish counters where available Rod catch data	The numbers of returning salmon should be sufficient to ensure that all naturally available spawning and nursery habitat is utilised. Different rivers have different seasonal patterns of adult migration associated with the environmental characteristics of the catchment and river system. Multi-sea winter fish are an important component of a natural salmon run and have declined considerably in recent years. The data available to assess this attribute vary widely across the UK. See the associated monitoring protocol for further details.
WATER QUALITY Organic pollution, reactive phosphorus, acidification, other pollutants	Targets included in the CSM Guidance for Rivers should be used. These targets are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. All chemical targets, and also biological targets relating to macroinvertebrates (WHPT, PSI and AWICS), are applicable.	Standard monitoring protocols in the CSM Guidance for Rivers. (Data from environment agencies.)	Atlantic salmon are susceptible to a range of water quality impacts, particularly in juvenile life stages (egg, fry, parr and smolt). Generally, water quality should not be injurious to any life stage. All reaches within the designated site that contain, or should contain, Atlantic salmon should comply with the targets given. Data from the last 3 years should be used.

Attribute *=discretionary	Target	Method of Assessment	Comments
FLOW	Ideally, flow targets included in the CSM Guidance for Rivers should be used, as these are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. As a minimum, UKTAG flow standards for protecting salmonids at GES under the WFD should be met.	Gauging station data. (Data from environment agencies.)	River flow affects a range of habitat factors of critical importance to designated interest features, including current velocity, water depth, wetted area, substrate quality, dissolved oxygen levels and water temperature. The maintenance of both flushing flows and baseflows, based on natural hydrological processes, is vital. Detailed investigations of habitat–flow relationships may indicate that a more or less stringent threshold may be appropriate for a specified reach; however, a precautionary approach would need to be taken to the use of less stringent values. Naturalised flow is defined as the flow in the absence of abstractions and discharges. The availability and reliability of data is patchy – long-term gauged data can be used until adequate naturalised data become available, although the impact of abstractions on historical flow records should be considered. Headwater sections are particularly vulnerable to abstraction, and this may affect the survival of juvenile fish and prevent the upstream migration of adult fish to key habitats.
HABITAT STRUCTURE In-channel structures Other aspects	The targets in the CSM Guidance for Rivers should be used. These are intended to provide a natural, dynamic biotope mosaic with high connectivity that caters for the whole biological community and individual species to a degree characteristic of the river. The comments column provides details of the importance of individual biotopes to Atlantic salmon.	Assess using the CSM Guidance for Rivers or species-specific methods if available and appropriate. Species-specific examples include HABSCORE (Northern England and Wales only); SFCC Habitat Survey methodology (Scotland) or the AFBI in-stream habitat scoring system.	The characteristic channel morphology provides the diversity of water depths, current velocities and substrate types necessary to fulfil the spawning, juvenile and migratory requirements of Atlantic salmon. The close proximity of different habitats facilitates movement to new preferred habitats with age. Operations that widen, deepen and/or straighten the channel reduce variations in habitat. New operations that would have this effect are not acceptable within an SAC, while restoration may be needed in some reaches. There should be no artificial barriers preventing unimpeded migration to natural spawning areas. Where barriers exist they should be removed wherever possible, or at least made passable. Spawning habitat: defined as stable coarse substrate without an armoured layer, in the pebble to cobble size range (16-256 mm) but with the majority being <150 mm. Water depth during the spawning and incubation periods should be 15-75 cm. Coarse woody debris should not be removed from rivers as it plays a significant role in the formation of new gravel beds, except where infrastructure, human life or property is under threat. Fry habitat: indicated by water of <20 cm deep and a gravel/pebble/cobble substrate. Parr habitat is indicated by water 20-40 cm deep and similar substrate. Holding areas: defined as pools of at least 1.5 m depth, with cover from features such as undercut banks, vegetation, submerged objects and surface turbulence. Bankside tree cover: overhanging trees provide valuable shade and food sources, while tree root systems provide important cover and flow refuge for juveniles.

Attribute *=discretionary	Target	Method of Assessment	Comments
OTHER ATTRIBUTES			
a. Fine sediment	No unnaturally high levels of siltation. Siltation targets included in the CSM Guidance for Rivers may be appropriate.	See the CSM Guidance for Rivers.	Elevated levels of suspended solids can clog the respiratory structures of Atlantic salmon. Siltation can also prevent the flow of dissolved oxygen to eggs and prevent the movement of waste products from redds.
* b. Alien/locally non-native species	No non-native species likely to cause impairment of Atlantic salmon populations	Various sources, including ad hoc observations, specific site investigations and data collected by the environment agencies.	Refer to the WFD list of alien/locally absent species (but not to be used exclusively).
* c. Stocking/ transfers of Atlantic salmon	No stocking/transfers of Atlantic salmon unless agreed to be in the best interests of the population	Knowledge of site management	Stocking represents a loss of naturalness and, if successful, obscures the underlying causes of poor performance (potentially allowing these risks to perpetuate). It carries various ecological risks, including the loss of natural spawning from broodstock, competition between stocked and naturally produced individuals, disease introduction and genetic alterations to the population. There is a large body of evidence indicating that rearing locally sourced juveniles for release has a long-term impact on salmon populations by removing natural selection mechanisms in the juvenile phase of life, The management objective for sites notified for Atlantic salmon is to attain naturally self-sustaining populations. Stocking of Atlantic salmon should not be routinely used as a management measure. The nature conservation aim is to provide conditions in the river that support a healthy and natural population, achieved through habitat protection or restoration and the control of exploitation as necessary.
* d. Stocking/ transfers of other species	No stocking/transfers of fish species at excessively high densities	Fishery stocking consents. Impact assessments of stocking consents at a catchment scale may be required to determine an acceptable level.	Excessively high densities of other fish species may cause unacceptably high predation pressure and competitive interactions. Care needs to be taken to ensure that stocking exercises do not keep the densities of such species at unnaturally high levels.
* e. Abstraction intakes and discharges	Effective screening on all intakes and discharges.	Environment agencies' monitoring/ consenting programmes.	The entrainment of juvenile and adult fish into hydropower intakes or even fish farms can lead to a loss of fish. This can be avoided through the use of screening at appropriate locations. Guidance on screening is available through regulatory bodies such as the EA, NRW and SEPA. It is important that screens are also used to prevent the escape of fish from fish farms and fisheries connected to rivers. Escapes from fish farms are a form of uncontrolled introduction and should be prevented.

Attribute *=discretionary	Target	Method of Assessment	Comments
f. Exploitation	All exploitation should be undertaken sustainably without compromising any components of the population.	Environment agency data on licences and catch statistics	Exploitation controls should be applied to all areas where Atlantic salmon migrate to designated sites, within territorial waters. This should include estuarine and coastal net fisheries, as well as exploitation within the ASSI/SSSI/SAC from rod fisheries.
g. Weed-cutting	Should not interfere with the provision of juvenile habitat in river types naturally supporting submerged vascular plants.	Evaluation of conditions on land drainage consents and knowledge of adherence to them.	Areas of submerged and marginal plants: juvenile salmon in chalk rivers use submerged and marginal vegetation as cover. Cutting operations should aim to leave at least 50% of the vegetation uncut.

CSM Monitoring Protocol 6
Common Standards protocol for population monitoring of allis shad (*Alosa alosa*) and twaite shad (*Alosa fallax*)

Prepared by: Rhian Thomas and Heather Garrett (2015)

Acknowledgements
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1. Introduction

This protocol gives information on how and when to monitor allis and twaite shad at Sites of Special Scientific Interest (SSSIs) and Special Areas of Conservation (SACs) for the species. For details of population attributes and targets, see the associated generic Favourable Condition Table (FCT) for these species.

The protocol follows on from a report produced as part of the LIFE in UK Rivers Project (Hillman *et al*., 2003). This protocol has been updated to incorporate all changes made to the survey and assessment methods since 2003.

Different monitoring protocols and strategies have been recommended for different life stages of shad, specifically eggs, juveniles and adults (Hillman *et al*., 2003). However, the success rate of the methods for each life stage has varied in practice, with issues in particular with the adult and juvenile methods. Further testing and refinement of these methods is required. If thought to be appropriate for a site, trials are recommended. It is important to note that it is not possible to differentiate between allis and twaite shad using these methods without destructive sampling or the use of genetic analysis.

2. Sampling method

2.1 Shad egg surveys – kick sampling

Sampling should start at the downstream end of the survey site to prevent the re-recording of eggs dislodged in previous kicks. A standard macroinvertebrate hand net (250 μm mesh) should be used to collect material dislodged by kicking upstream of the net for 15 seconds. The net should be checked after each kicking interval and any detritus or channel substrate removed before kicking is resumed.

A minimum of 10 kick samples should be taken at each site, with the number of eggs found in each kick recorded. If a total of 10 or more shad eggs are recorded after 10 kicks, the survey should be terminated at that site. However, if fewer than 10 shad eggs are recorded, kick sampling should continue either until 10 eggs are found or, if no eggs are found, the survey should be terminated after 25 kicks (Thomas and Dyson, 2012). If 0-9 eggs are found at the site then the site should be resurveyed again within the spawning season.

The identification of shad eggs is crucial to this method of monitoring. Eggs are clear, non-adhesive, semi-buoyant and between 1.5 and 5.0 mm in diameter (typically 2.5 mm). It is not possible to differentiate between the eggs of allis and twaite shad. It is recommended that a proportion of the eggs are genetically tested to prove that they are shad eggs and if possible to distinguish between allis and twaite shad. Results from a Welsh study highlights the importance of genetic testing along with the field methodology as some eggs were found not to be shad (Hardouin *et al*., 2013). It should be noted that 20 eggs per site may be required for genetic testing. The laboratory will advise on the sampling methodology for any genetic testing and should provide the equipment required.

Any other observations of relevance should be noted during the field survey and contribute to the condition assessment as appropriate. For example, whether any developing larvae can be seen in the eggs gives an indication of the viability of the eggs and when spawning took place. Angler records, bailiff observations and other reliable records can be used to augment survey data to inform the assessment of spatial extent. Spent carcasses can also be a useful resource as the gill rakers can be examined to determine the species. Genetic samples can be obtained as well as length and age data (from scales).

A flow chart for sampling is given in Appendix 1. If collecting eggs for genetic analysis the laboratory method for fixing the eggs should be followed. This is likely to involve immersing the eggs in a suitable chemical (e.g. 70% ethanol) in the field.

2.2 Adult shad abundance

Fish counters of various forms can be used where available and appropriate to count adult shad as they migrate upstream. However, when testing this method in designated rivers several issues were encountered, e.g. on the River Wye shad were deterred by the lower frequencies used to monitor salmonids. The beam had to be switched to a higher frequency for shad to move upstream. Hence further research into using fish counters to detect and monitor adult shad is required, e.g. using DIDSON or similar technology (Davies *et al.,* 2011). Work carried out with DIDSON on the River Tywi has indicated that the method has the potential for monitoring shad species. If the method is thought to be appropriate for a site, initial trials are recommended. If DIDSON is used then the beam should have full river coverage and cameras should be used to confirm shad identification.

2.3 Netting juvenile shad

The principal method for quantitative assessment of shad stocks is micromesh seine netting of juvenile shad in the lower river (including the saline transition zone). Assessment against this target should relate specifically to the condition of the population within the river SSSI/SAC only and this should be reflected in the location of sampling sites. Sampling sites may be included around the estuary head but particular care is needed where the upper estuary is linked to a number of contributing rivers, including rivers that are notified as SSSI/SAC for the species and rivers that are not.

Initial indications show that the effectiveness of juvenile survey is very site-specific with very few individuals caught at some sites (Noble *et al.*, 2007). Hence, due to the issues with the effective timing of netting, survey costs and high variability of success, further testing and refinement of the method is required. If thought to be appropriate for the site, testing is recommended.

The sampling method is as follows:

- Seine netting should be undertaken by (at least) three people.
- A minimum of three sampling sites should be surveyed.
- Three sweeps of the net should be taken at each site.
- Netting should be carried out on the ebb flow of neap tides, on a similar sized tide each month.
- Netting should be carried out from the river bank or estuary foreshore, using a small inflatable boat to set the net.
- Water and air temperature should be measured during each survey, while flow data can be obtained from Environment Agency or Natural Resources Wales gauging stations.
- If the weather or flow conditions are unfavourable, netting should be abandoned in the interest of safety.

The following equipment is required:

- A 6 mm hexagonal stretched mesh seine net, 30 m in length and 2.8 m in depth, with barrel leads approximately 37 cm apart and floats 32 cm apart.
- A small inflatable boat. This should be rowed when setting the net and the net should be set from the back of the boat.
- Containers of ethanol in which to preserve samples of juvenile shad.
- Thermometer.

3. Site selection

3.1 Shad egg surveys

Kick sampling should be undertaken over an area judged to be naturally suitable spawning habitat throughout the site, including areas upstream of known barriers to confirm continued absence from naturally suitable habitat. Historical spawning sites are listed in Aprahamian *et al*. (1998). If 10 or fewer sites are located on each river in the comprehensive survey, all sites should be surveyed in subsequent years. If more than 10 spawning sites are recorded on a river during the initial survey, 50% of sites should be randomly selected for survey, provided this equates to 10 or more survey sites.

3.2 Adult shad abundance

Where assessed, a suitable fixed location for monitoring in the lower river (with full river coverage) should be selected by the Environment Agency or Natural Resources Wales.

3.3 Netting juvenile shad

If this method is used:

- At least six potential survey sites should be identified, from which three should be chosen based on the results of a preliminary survey.
- Potential sites should be located either in the lower river, or where appropriate in the upper estuary.
- Surveys undertaken later in the year should concentrate on the upper estuary as juvenile shad will have probably dispersed downstream by this time.
- Sampling should take place at the edge of the main channel, rather than in the peripheral areas.
- In the late summer period priority should be given to sites that yield relatively large numbers of juvenile shad, furthest upstream, where river flow is not as great.

4. Timing and frequency of survey

4.1 Shad egg surveys

The extent of spawning should be monitored during May and June. Kick sampling should only take place when river and weather conditions permit. The exact timing of sampling will depend upon the prevailing environmental conditions each year. Observations of shad migration may be available from fish traps, anglers, bailiffs or other monitoring (e.g. DIDSON cameras, temperature changes), which may help to inform suitable timing for sampling.

To ensure early detection of any decline in the population status, surveys should ideally be carried out annually to detect fluctuations in population trends. However, a 3-yearly sampling frequency is acceptable. A 6-yearly sampling programme will give rise to difficulties in interpreting apparent changes in population attributes.

4.2 Adult shad abundance

The adult spawning migration is usually April until June, with peak migration typically occurring in May (Aprahamian *et al.*, 2002). Where assessed the timing of recording shad shoals needs to remain flexible each year, because the onset of adult migration will be delayed by high flows or low water temperatures. Alternatively higher temperatures may trigger earlier migration.

4.3 Netting juvenile shad

If seine netting is carried out it should be done systematically over the migration period so that sampling effort is equally spaced throughout the period with a frequency dependent on the level of precision required. Sampling should be carried out monthly from July to October, with a preference for earlier sampling before juveniles have dispersed into the upper estuary. The timing of surveys each year should be the same, albeit allowing for adjustment of dates to utilise the appropriate tides.

5. Data processing

5.1 Shad egg surveys

For each relevant assessment unit, data should be used to evaluate any significant absence of shad spawning in locations where they would be expected under near-natural conditions, including upstream of artificial barriers to migration. If budgets allow then genetic analysis should be used to validate the field identification of eggs at a sub-set of sites or where identification in the field is uncertain.

5.2 Adult shad abundance

Appropriate detailed records should be collected that include the date and numbers of shad where possible. Specific data collected will depend upon the method used. For example, with DIDSON surveys, criteria such as size and behaviour should be used to identify shad, their number and the direction of movement (i.e. upstream or downstream). Suitable software can be used to identify shad, but manual identification should occur for quality assurance. Work carried out with the DIDSON on the River Tywi showed that the behaviour of shad through the monitored area makes them readily distinguishable from sea trout. The set-up at the trial location did not allow for full river coverage so it was not clear whether fish that moved out of the DIDSON beam passed back downstream before re-entering. Therefore a reliable estimate of numbers could not be obtained. Further trials are required with full river coverage before DIDSON can be considered as a suitable method.

5.3 Netting juvenile shad

Since shad are susceptible to handling, every care must be taken when recording biological data, such as body length. It is recommended that a minimum of 30 individuals are measured (fork length to nearest mm) in the field for length–frequency analysis. As it is impossible to distinguish juvenile twaite shad from allis shad in the field, a sample of juveniles should be retained and preserved in 90% ethanol for later laboratory analysis. No more than 40 juvenile shad per year should be retained from each SAC river. Considering natural mortality, this figure is unlikely to have a significant impact upon the population. Care must be taken to select a representative sample. Preference should be given to retaining juvenile shad that are damaged during the netting and as such are unlikely to survive.

Identification of juvenile samples should be carried out, as in the case of adults, by counting the number of gill rakers on the first gill arch. A microscope (e.g. x 10 magnification) should be used to count gill rakers. See Cowx and Harvey (2003) for further information on how to identify species of shad using gill rakers.

Population targets should be set based upon the average catch per unit effort (CPUE) detected during the first 6-year monitoring period. For each year of survey:

- Calculate density and catch variance per river using data collected annually.
- Retain samples for measurement of body length and calculate the proportion of 0+ and 1+ group fish in the population.
- Examine the gill rakers to assess the proportion of twaite and allis shad in each population.
- Produce a yearly CPUE per SAC river (or associated estuary).
- Compare annual CPUE to the targets/limits set using data from the first 6-year monitoring period.

6. Licensing

Allis and twaite shad are protected under Schedule 5 of the Wildlife & Countryside Act 1981 (as amended). Also under section 9 it is an offence to 'intentionally kill, injure or take' (allis shad only) and/or to 'intentionally or recklessly damage or destroy or obstruct access to, any structure or place which a shad uses for shelter or protection' (allis and twaite shad). Under Section 28 consent is required from the appropriate conservation agency (Natural England or Natural Resources Wales) to undertake sampling of shad at any life stage on an SSSI or SAC. Consent will also be required for seine netting by the Environment Agency or Natural Resources Wales.

7. Access

It is the responsibility of the contractor to ensure that all access permissions have been obtained before any survey takes place. Risk assessments should be carried out before commencing any of the activities outlined in the monitoring protocol.

8. Biosecurity

It is essential that contractors take every step necessary to prevent the introduction of non-native species to new locations. Before gaining access to any water body, it is essential that all personal and survey equipment has been properly checked and, if necessary, disinfected before any work takes place. All contractors must comply with the Check, Clean, Dry guidelines as a minimum requirement (http://www.nonnativespecies.org/checkcleandry/).

9. Data

All survey data should be stored in national databases where appropriate and uploaded onto the National Biodiversity Network.

10. References and further reading

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Hillman RJ, Cowx IG and Harvey JP (2003) *Monitoring the Allis and Twaite Shad.* Conserving Natura 2000 Rivers Monitoring Series No. 3. English Nature, Peterborough.

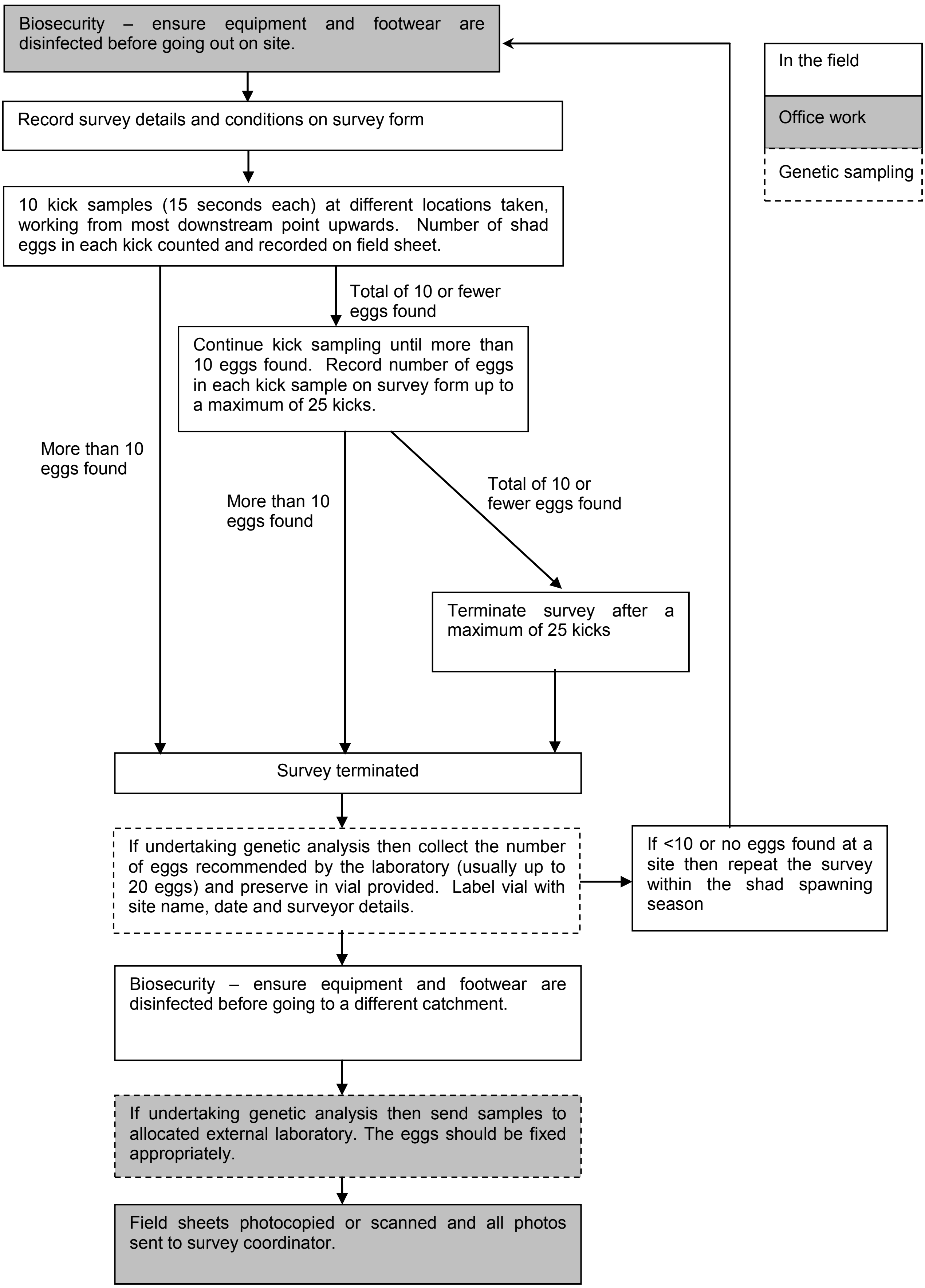
JNCC (2014) *Common Standards Monitoring Guidance for Rivers,* ISSN 1743-8160 (Online) http://jncc.defra.gov.uk/page-2232

Noble RAA, Nunn AD, Harvey JP and Cowx IG (2007) *Shad monitoring and assessment of conservation condition in the Wye, Usk and Tywi SACs.* CCW Environmental Monitoring Report No. 40. Countryside Council for Wales, Bangor.

Thomas R and Dyson, C (2012) *River Usk Shad Egg Survey 2011.* CCW Staff Science Report No. 11/8/3. Countryside Council for Wales, Bangor.

Appendix 1 - Shad egg survey protocol

Note: this assumes that the relevant risk assessment for the sites have been undertaken before commencement of survey.



Favourable Condition Table 6 - Allis shad (*Alosa alosa*) and twaite shad (*Alosa fallax*)

Details of the standard method for population assessment can be found in the monitoring protocol for allis and twaite shad.
Note: this FCT and associated protocol are intended to assess the condition of river SSSIs/SACs notified for these species. They are not suitable for assessing the condition of designated estuaries which include these species as features in relation to migratory passage.

Attribute	Target	Method of Assessment	Comments
POPULATION			
a. Spatial extent	Should be present in naturally suitable habitat throughout the designated site. Distribution indicated by presence of shad eggs should reflect near-natural conditions.	Kick sampling for shad eggs	This should be the monitoring method of choice at all sites. Historic records should be used to determine the likely extent of spawning in catchments and to set monitoring sites accordingly. Genetic sampling of a sub-set of sites is recommended to quality assure that the eggs collected are shad and also to distinguish between allis shad and twaite shad where possible. Monthly mean and minimum flow data from in-river gauges should be assessed for May to June (and possibly into July if evidence of late spawning) from the Environment Agency or Natural Resources Wales. An assessment should be made as to whether the flow conditions could affect the spawning distribution due to the impassability of barriers. Where discharges are made from reservoirs to the rivers between April-July, and are considered to cause potential issues for migration (e.g. due to lower river temperatures) an assessment should be conducted including records of the discharge amounts and frequency.
* b. Population density: adult run size	Annual run size should reflect natural conditions.	Fish counters, hydroacoustic counters and video equipment.	Data should be used from counters where available. Note: available technology only allows number of shoals, not number of individuals, to be counted at present. Consequently this target refers to number of shoals at present, but in future adult run size should comply with an agreed target for each river. Other counters can be used to determine run duration. Their use for estimating run size is currently being investigated and tested (e.g. DIDSON and ARIS). Further development of the method is required.
* c. Population density: presence of adult spawning shad	Evidence of spawning activity	Visual observation from reliable sources and analysis of spent carcasses.	Angler records, bailiff observations and other reliable records can be used to augment records collected by methods above. Spent carcasses can also be a useful resource as the gill rakers can be examined to determine species. Genetic samples can be obtained as well as length and age data (from scales).
* d. Population density: juveniles	These should not differ significantly from those expected under near-natural conditions.	Seine netting in lower river between July and October.	Assessment against this target should relate specifically to the condition of the population within the river SSSI/SAC only and this should be reflected in the location of sampling sites in the lower river. Initial indications show that the effectiveness of juvenile survey is very site-specific. Further testing and refinement of the method is required. If thought to be appropriate for a site, testing is recommended.

Attribute	Target	Method of Assessment	Comments
WATER QUALITY Organic pollution, reactive phosphorus, acidification, other pollutants	Ideally, targets included in the CSM Guidance for Rivers should be used. These targets are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. All chemical targets, and also biological targets relating to macroinvertebrates (WHPT, PSI and AWICS), are applicable. As a minimum, UKTAG standards for GES under the WFD should be met.	See the CSM Guidance for Rivers. (Data from environment agencies.)	Generally, water quality should not be injurious to any life stage. All classified reaches within the designated site that contain, or should contain, allis or twaite shad should comply with the targets given. Data from the last 3 years should be used.
FLOW	Ideally, flow targets included in CSM guidance for river habitat should be used, as these are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. As a minimum, UKTAG standards for GES under the WFD should be met.	Gauging stations. (Data from environment agencies)	River flow affects a range of habitat factors of critical importance to shad, including current velocity, water depth, wetted area, substrate quality, dissolved oxygen levels and water temperature. The maintenance of both flushing flows and baseflows, based on natural hydrological processes, is vital. Detailed investigations of habitat–flow relationships may indicate that a more or less stringent threshold may be appropriate for a specified reach; however, a precautionary approach would need to be taken to the use of less stringent values. Naturalised flow is defined as the flow in the absence of abstractions and discharges. The availability and reliability of data is patchy – long-term gauged data can be used until adequate naturalised data become available, although the impact of abstractions on historical flow records should be considered.
HABITAT STRUCTURE	The targets in the CSM Guidance for Rivers should be used. These are intended to provide a natural, dynamic biotope mosaic with high connectivity that caters for the whole biological community and individual species to a degree characteristic of the river. The comments column provides details of the importance of individual biotopes to allis or twaite shad.	Assess using CSM Guidance for Rivers or species-specific methods if available and appropriate.	Artificial barriers are probably the single most important factor in the decline of shad in Europe. Impassable obstacles between suitable spawning areas and the sea can eliminate breeding populations of shad. Both species (but particularly allis shad) can make migrations of hundreds of kilometres from the estuary to spawning grounds in the absence of artificial barriers. Existing passes are often not effective for shad, and any new provisions need to take their requirements into account. Even bridge footings form barriers to shad migrations. Artificial in-channel structures such as weirs, dams, sluices, fords, groynes, inappropriate bridge footings and culverts may constitute barriers to the free movement of water, sediment and aquatic organisms, and may affect river-bed structure and hydrology downstream. Although attention is often focused on whether artificial structures allow the passage of migratory fish, the wider environmental impacts also need to be considered in the assessment of site condition.

Attribute	Target	Method of Assessment	Comments
OTHER ATTRIBUTES			
a. Fine sediment	No unnaturally high levels of siltation.	Assess using the CSM Guidance for Rivers or species-specific methods if available and appropriate.	
* b. Alien/locally non-native species	No non-native species likely to cause impairment of allis and twaite shad.	Various sources, including ad hoc observations, specific site investigations and data collected by the environment agencies.	Refer to the WFD list of alien/locally absent species (but not to be used exclusively).
* c. Stocking/ transfers of other species	No stocking/transfers of fish species at excessively high densities.	Fishery stocking consents. Impact assessments of stocking consents at a catchment scale may be required to determine an acceptable level.	Excessively high densities of other fish species may cause unacceptably high predation pressure and competitive interactions. Care needs to be taken to ensure that stocking exercises do not keep the densities of such species at unnaturally high levels.
* d. Abstraction intakes and discharges	Effective screening on all intakes and discharges.	Environment agencies' monitoring/ consenting programmes.	Entrainment of allis shad or twaite shad in intakes and discharges can occur.

CSM Monitoring Protocol 7
Common Standards protocol for population monitoring of brook lamprey (*Lampetra planeri*), river lamprey (*Lampetra fluviatilis*) and sea lamprey (*Petromyzon marinus*)

Prepared by: Angus Tree, Rhian Thomas and Chris Mainstone (2015)

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1. Introduction

This protocol gives information on how and when to monitor brook, river and sea lamprey in rivers designated as Sites of Special Scientific Interest (SSSIs) or Special Areas of Conservation (SACs) for the species. Note that this protocol and the associated Favourable Condition Table (FCT) are intended to guide the assessment of the species in river SSSIs and SACs. They should not be used in the assessment of estuaries designated to protect the migratory passage of anadromous lamprey. For details of population attributes and targets, see the associated FCT for brook, river and sea lamprey.

This protocol is based on a report produced as part of the LIFE in UK Rivers Project (Harvey and Cowx, 2002). It is an updated version to incorporate developments in the methodologies since 2002. Questions about the effectiveness of the sampling methods used and the reliability of the results generated by them during two cycles of reporting using the Common Standards Monitoring (CSM) Guidance have led to this revision. Research into the use of other survey techniques is under way. These include air lift sampling, drift netting, and the use of settlement tiles. Until these techniques have been thoroughly field tested and the associated methods finalised, electrofishing should remain the mainstay of surveying for larval lamprey.

The description of the habitat used by larval lamprey has been expanded in response to the results of monitoring which suggest that they use a greater variety of habitat than was previously thought. Optimal and Sub-optimal habitat descriptions are no longer thought to be appropriate as, for example, surveyors often find that densities are higher in the latter than the former.

Attempts to refine the nomenclature applied to the various life history stages of lamprey have been made recently and it is recommended that the terms given in Docker *et al.* (2015) are used. These include: ‘larval lamprey’ to describe lamprey during the period before they begin their transformation into adults; ‘transformer’ to describe lamprey undergoing the metamorphosis from larva to adult; and ‘macropthalmia’ to describe the immediate post metamorphosis stage when the eyes are conspicuous when compared with the blind larvae.

2. Sampling method

2.1 Larval lamprey

Numbers of larval lamprey are likely to exhibit considerable inter-annual variation and monitoring should therefore ideally be undertaken as a rolling programme of annual surveys across the site. However, in some countries, it is unlikely that monitoring budgets will support such intensity and surveying once every 3 years is considered to be an acceptable compromise. The frequency of monitoring will affect the larval lamprey sampling methods used. The differences in the approaches are outlined below.

The focus of biological monitoring for all three species of lamprey is on the larval phase. Suitable habitat includes a wider variety than previously described. Larval lamprey are negatively phototactic (i.e. they move away from light) and positively thigmotactic (i.e. they seek contact with other objects) and as a result they commonly burrow into soft sediment in the margins of streams and rivers. They may also be found in detritus overlying coarse substrate, among submerged tree roots, emergent vegetation rooted in silt, shallow patches of fine sediment among coarser substratum, or submerged branches or twigs that have trapped fine sediment.

There is a growing body of evidence that *Petromyzon* larvae may prefer similar habitat but in areas of deeper water. Electrofishing these areas is problematical and research into the use of alternative sampling methods, e.g. air lift sampling, is continuing.

Conventional handheld electrofishing apparatus should be used, but the technique is different from that commonly used to catch fish swimming in the water column. A pulsed direct current is used. Care should be taken to ensure that this is sufficiently high to attract larvae to the anode. The anode should be held approximately 10–15 cm above the habitat and, to avoid immobilising the larvae in it, energised for 20 seconds and then turned off for five. This on-off cycle draws larval lamprey from their habitat into the water column where they may be netted. Surveyors should be familiar with the CEN standard for sampling fish with electricity when surveying water bodies in England and Wales (BSI, 2003).

A sampling site should comprise a 100 m length of watercourse in which four spatially discrete patches of potentially suitable habitat, each ≥ 1 m^2, may be electrofished.

2.1.1 One in three year monitoring programme

The amount of different types of suitable habitat electrofished in a sample site should be in proportion to their availability within it. No firm categorisation is given of different types of suitable habitat, but some example descriptions are given above and also in Box 1. In practice the amount of potentially suitable habitat available may preclude sampling the minimum area; in such instances the strategy should be modified accordingly. Both banks of a watercourse should be considered. The size of each habitat patch electrofished should be recorded to allow the number of larvae per m^2 to be calculated.

Recent developments in the understanding of larval lamprey habitat preferences suggest that trying to isolate some patches using a quadrat may prove impossible due to their physical character, e.g. patches of large wood that have trapped fine sediment. The standard sampling method, therefore, does not use quadrats but comprises, single-pass, semi-quantitative electrofishing that allows the calculation of minimum density estimates. These estimates should be converted to true population estimates using calibration sites where quadrats and standard catch depletion methods are used to derive conversion factors. However, where it is considered more cost-effective to use quadrats and catch depletion in all habitat patches, true population estimates can be derived directly and there is no need for a calibration exercise.

For the standard method, the calibration exercise requires a sampling efficiency to be derived for each type of habitat electrofished in an assessment unit. This is because sampling efficiency varies between different types of habitat. Values of sampling efficiency are used as correction factors and are applied to the minimum density estimates for the habitat patches that are electrofished to derive true population estimates. Where necessary, separate correction factors should be derived for each assessment unit.

The habitat patches used to derive calibration data should be isolated using a 1 m^2 quadrat. The isolated area should be electrofished according to established depletion sampling techniques. Where it is not possible to isolate habitat patches in this way, it will not be possible to derive correction factors and only minimum density estimates may be established.

2.1.2 Annual monitoring programme

If an annual monitoring programme is followed it should result in fewer sites being surveyed per assessment unit each year, but an improved dataset and understanding of the lamprey population over the 6-year cycle. Consequently, quantitative electrofishing calibration using a 1 m^2 quadrat at the sampling site level is recommended rather than per habitat type for the assessment unit. The correction factor derived should be applied to the results for that site.

2.2 Adult lamprey

River and sea lamprey are anadromous: after metamorphosis river lamprey migrate to estuaries and sea lamprey to sea where they feed parasitically on fish. Both species remain in the marine environment for at least a year before returning to rivers to spawn. The difficulties associated with differentiating between larval brook and river lamprey in the field, and the often low numbers of larval sea lamprey that are caught during electrofishing surveys, mean that additional information about river and sea lamprey is needed for reliable assessments of their populations to be made. This information may be gathered by trapping adults using fyke nets or bespoke traps (e.g. Morris and Maitland, 1987), through the direct observation of adults at spawning sites, or by detecting adults using dual frequency identification sonar (DIDSON). Traps or DIDSON apparatus should be deployed in the lower reaches of a river to ensure that as many returning adults as possible are recorded.

Unlike other species of anadromous fish, river and sea lamprey do not exhibit complete fidelity to their natal river (Genner *et al.*, 2012; Bracken *et al.*, 2015). Inter-annual variations in run size may therefore be the result of more than changes in predation, for example. Assessments should take account of this lack of fidelity. Monitoring over several years is likely to be necessary to establish the degree of variation in annual run size.

3. Site selection

The larval lamprey sampling sites selected must represent the distribution of each species under near-natural conditions. Information from previous studies may enable the upper and lower geographical limits of the different species to be identified and so guide sampling site selection. Note that barriers to the migration of adult river and sea lamprey will restrict their distribution, and thus the conservation status of these species. A method for assessing obstacles to fish migration (SNIFFER, 2010) has been developed and may help to establish the true effects of perceived barriers. Where an artificial barrier is known to exclude river or sea lamprey from an area there is no need to survey upstream of it, but the isolated area should be included in the assessment. If there is uncertainty about whether a barrier is passable, an upstream survey should be undertaken.

A walkover survey of each assessment unit should be carried out to record the range of habitat types and to identify suitable sampling sites before electrofishing begins. See JNCC (2014) for information on deriving assessment units.

Harvey and Cowx (2002) state that 'as [a] rule of thumb, approximately 40 [sampling] sites should be surveyed in UK river catchments to provide an acceptable level of precision'. A recent analysis of UK larval lamprey data (Bull and Law, 2015) supports this but also states that, where the total number of sampling sites available is < 200, adequate precision may be achieved by sampling only 30. The distribution of sampling sites both between and within assessment units should be proportionate to the availability of habitat.

If annual monitoring is undertaken it is recommended that surveys are spread across assessment units according to a rolling programme with a proportion of sites being monitored each year.

4. Timing and frequency of survey

4.1 Larval lamprey

Larval lamprey should be surveyed between August and October. This period should allow the capture of a range of larval size classes, and of larvae as they transform into adults. This metamorphosis usually occurs between July and September, and the immediate post-metamorphosis stage is termed ‘macrophthalmia’ because, when compared with the blind larvae, the eyes are conspicuous. It is possible to differentiate between brook and river lamprey macropthalmia in the field (Gardiner, 2003), and plans for larval lamprey surveys should take account of the opportunity to do so. Surveys may be conducted later in the year but are more likely to be hampered by poor weather and high flow conditions.

Surveying every 6 years may result in erroneous condition assessments due to considerable year-to-year variability in cohort strength. Ideally, annual surveys should be undertaken to properly characterise between-year variation. In this case survey sites should be spread across assessment units on a rolling programme with a proportion of sites being monitored each year. However, it is unlikely that monitoring budgets will support such a high temporal frequency of survey, and surveying once every 3 years is considered to be an acceptable compromise.

4.2 Adult lamprey

The period during which the majority of lamprey enter a river to spawn is likely to vary across the United Kingdom. To establish the best period in the year for an adult survey, it is recommended that the upstream migration of adult river and sea lamprey is initially monitored to ascertain the peak migration period. The timing of, shorter, subsequent surveys should then accord with the period of peak migration that is identified during this intensive sampling period. It is hoped that the increasing use of fish counters will aid the identification of peak migration periods and will enable reliable assessments of the inter-annual variation in the numbers of migrating adults.

5. Data processing

5.1 Larval lamprey

The larvae caught at each sampling site should be anaesthetised (if required), counted, and measured (total length). As it is not possible to distinguish between the larvae of brook and river lamprey before metamorphosis using external characteristics in the field, their populations are reported as *Lampetra*. It is possible to distinguish between *Lampetra* and *Petromyzon* larvae in the field and the two should be recorded separately.

The larval density of a sampling site is the mean of the results derived for each patch of habitat expressed as larvae per m^2. The larval density of an assessment unit is the mean of the sampling site results expressed as larvae per m^2. A worked example is given in Box 1. When comparing values against the targets in the FCT, expert judgement will need to be applied where only minimum estimate data are available. The total length data should plotted as length-frequency histograms using 2 mm length categories.

Box 1. Calculating sampling site and assessment unit population density estimates

The following patches of example habitat are fished in a sampling site:

a) 1.00 m^2 sediment amongst submerged large wood
b) 1.20 m^2 fine sediment at margin of river
c) 1.50 m^2 cobble and fine sediment patchwork
d) 0.75 m^2 fine sediment under steep bank

When sampling once every 3 or 6 years, the density estimate for each patch of habitat is derived by applying a habitat-specific correction factor determined during the assessment unit calibration exercise. When sampling annually the density estimate for each patch of habitat is derived by applying a sampling site-specific correction factor.

patch	m^2	no. larvae	Habitat-specific catch efficiency	correction factor	density estimate (larvae per m^2)
a	1.00	24	0.7	1.43	34.32
b	1.20	52	0.9	1.11	48.10
c	1.50	29	0.8	1.25	24.16
d	0.75	15	0.7	1.43	28.60

The population density estimate for the sample site is the mean of these values and in this instance 33.78 larvae per m^2.

The population density estimate for the assessment unit will be the mean of the sampling site density estimates.

5.2 Adult lamprey

The target for both *Lampetra fluviatilis* and *Petromyzon marinus* is: 'Annual run size should reflect that expected under natural conditions'. Establishing what this should be is likely to be difficult as the current run size of each may be affected by both natural and artificial phenomena, e.g. predation, exploitation, or barriers to migration that reduce the amount of spawning habitat available. Assessments of compliance with this target will not be possible until several years' worth of adult-specific monitoring has been undertaken and should take account of the activities that are likely to suppress the number of migrating adults. A future version of this protocol will include guidance on how to analyse adult lamprey data.

6. Licensing

Trapping and electrofishing in inland waters is a licensable activity and permission to use these techniques for survey purposes in Scotland must be obtained from both Marine Scotland Science and from the local District Salmon Fishery Board, in England from the Environment Agency, and in Wales from Natural Resources Wales. In Northern Ireland permission should be sought from the Loughs Agency for waters within the Foyle and Carlingford area or from the Department of Culture, Arts and Leisure for elsewhere.

Brook, river and sea lamprey are not protected under Schedule 5 of the Wildlife and Countryside Act (1981) (as amended) but, under Section 28 consent may be required from the country conservation agencies (Scottish Natural Heritage, Natural England or Natural Resources Wales) to trap or electrofish in an SSSI or SAC. In Northern Ireland undertaking these activities will require a consent under Article 32 (Duties of owners and occupiers of land included in ASSI) and/or Article 39 (Public bodies: duties in relation to operations) of The Environment (Northern Ireland) Order 2002.

7. Access

It is the responsibility of the contractor to ensure that access permission has been given before a survey is undertaken. Risk assessments should be conducted before beginning any of the activities outlined in this monitoring protocol.

8. Biosecurity

It is essential that contractors take every step necessary to prevent the introduction of non-native species to new locations. Before gaining access to any water body, it is essential that all personal and survey equipment has been properly checked and, if necessary, disinfected before any work takes place. All contractors must comply with the Check, Clean, Dry guidelines as a minimum requirement (http://www.nonnativespecies.org/checkcleandry/).

9. Data

All survey data should be stored on the appropriate national databases and added to the National Biodiversity Network.

10. References and further reading

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http://www.sniffer.org.uk/files/7113/4183/8010/WFD111_Phase_2a_Fish_obstacles_manual.pdf

Favourable Condition Table 7 - Brook lamprey *(Lampetra planeri)*, river lamprey *(Lampetra fluviatilis)* and sea lamprey *(Petromyzon marinus)*

Details of the standard monitoring protocol can be found in the monitoring protocol for brook, river and sea lamprey. Note that this FCT and the associated protocol are intended to guide the assessment of river SSSIs and SACs. They should not be used in the assessment of estuaries designated to protect the migratory passage of anadromous lamprey.

Attribute * = discretionary	**Targets**	**Method of assessment**	**Comments**
POPULATION			
a. Spatial extent	*Petromyzon*: i. Should reflect distribution under near-natural conditions. *Lampetra*: i. Should reflect distribution under near-natural conditions ii. As a minimum, *Lampetra* should be present in not less than 50% of all sampling sites surveyed with suitable habitat present within the natural range. iii. Where *Lampetra* have been found in the past they should be present in 90% of sampling sites if suitable habitat remains.	Electrofishing	Larval lamprey are sampled by electrofishing. Other techniques (e.g. air lift sampling, settlement tiles, drift netting) are under development. Sampling should focus on habitat that is suitable for larval lamprey. Any accessible suitable habitat should be expected to contain the larvae of *Lampetra* spp. although in practice some may be naturally unoccupied (e.g. due to washout). A description of suitable larval habitat is given in the *habitat structure* section below. No numerical target is given for *Petromyzon* larvae because of uncertainty about their habitat preferences. They have been found in greater densities in habitat in deeper water but sampling this requires the use of methods that are still under development. The natural range of *Petromyzon* in a catchment should be established through historical records, maps and field surveys to determine natural barriers to migration. Electrofishing surveys undertaken after larvae have metamorphosed will benefit from the relative ease with which the macropthalmia (newly metamorphosed lamprey, often referred to as transformers, or macropthalmia because of their large eyes) of *Lampetra* and *Petromyzon* may be identified.
b. Annual run size	*Petromyzon* and *L. fluviatilis*: Annual run size should reflect that expected under near-natural conditions.	DIDSON Direct observation of spawning sites. Trapping using fyke nets or specially designed traps. CPUE data from catch returns.	Unlike other species of anadromous fish, river and sea lamprey do not exhibit complete fidelity to their natal river. Inter-annual variations in run size may therefore be the result of more than changes in predation, for example. Assessments should take account of this lack of fidelity. Monitoring over several years is likely to be necessary to establish the degree of variation in annual run size. Assessments of compliance will not be possible until several years' worth of adult specific monitoring has been undertaken. Assessments should take account of the activities that are likely to suppress the number of migrating adults, e.g. predation, exploitation and artificial barriers to spawning habitat. DIDSON – dual frequency identification sonar Assessments using CPUE (catch per unit effort) data will only be possible for the few rivers that continue to support a lamprey fishery.

Attribute * = discretionary	**Targets**	**Method of assessment**	**Comments**
c. Age structure (*Lampetra* spp. only)	There should be evidence of recent recruitment in each assessment unit. For individual sites where 20–50 larvae are caught, at least two distinct size classes should be present. If more than 50 larvae are caught, at least three distinct size classes should be present.	Length frequency analysis using 2 mm length categories.	Larval lamprey grow at a steady rate. Distinct size classes are usually apparent in larval lamprey size distributions and these typically relate to age classes. Larvae typically range from 10–150 mm in length, corresponding to up to six year classes. The largest larvae are usually brook lamprey, as river lamprey metamorphose when approximately 100–120 mm long, while the smallest individuals are likely to be young-of-year sea lamprey since this species spawns later in the year than *Lampetra* spp. If macropthalmia are caught during surveys, record their presence. The full range of size classes of larvae, from 0+ to metamorphosis, should be present at the catchment scale. However, sampling error may make these difficult to discern unless large samples are taken. For individual sites where fewer than 20 larvae are caught, compliance with this target should not be assessed.
d. Larval lamprey density (*Lampetra* spp. only)	Overall assessment unit: mean in suitable habitat >5 m^{-2}.	Electrofishing	As their larvae are generally found in low numbers in habitat in water of wadeable depth, this target does not apply to *Petromyzon*.
WATER QUALITY **Rivers**: Organic pollution, reactive phosphorus, acidification, other pollutants	Ideally targets included in the CSM Guidance for Rivers should be used. These targets are intended to support a healthy, naturally functioning riverine ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. All chemical targets, and also biological targets relating to macroinvertebrates (WHPT, PSI and AWICS), are applicable. As a minimum, UKTAG standards for GES under the WFD should be met.	See the CSM Guidance for Rivers. If appropriate, use environment agencies' data on compliance with relevant GES standards.	Generally, water quality should not be injurious to any life stage. All classified reaches within the designated site that contain, or should contain, lamprey should comply with the targets given. Data from the last 3 years should be used. All water quality data should be available on request from the environment agencies.

Attribute * = discretionary	Targets	Method of assessment	Comments
FLOW	Ideally flow targets included in CSM Guidance for Rivers should be used, as these are intended to support a healthy, naturally functioning riverine ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. As a minimum, UKTAG standards for GES under the WFD should be met.	Gauging station data from environment agencies. See CSM Guidance for Rivers.	River flow affects a range of habitat factors of critical importance to lamprey, including current velocity, water depth, wetted area, substrate quality, dissolved oxygen levels and water temperature. The maintenance of both flushing flows and base flows, based on natural hydrological processes, is vital. Detailed investigations of habitat–flow relationships may indicate that a more or less stringent threshold may be appropriate for a reach, but a precautionary approach should be taken to the use of less stringent values. Naturalised flow is defined as the flow in the absence of abstractions and discharges. The availability and reliability of data is patchy. Long-term gauged data can be used until adequate naturalised data become available, although the impact of abstractions on historical flow records should be taken into account.

Attribute * = discretionary	**Targets**	**Method of assessment**	**Comments**
HABITAT STRUCTURE: In-channel structures/ barriers	The targets in the CSM Guidance for Rivers should be used. These are intended to provide a natural, dynamic biotope with high connectivity that caters for the whole biological community and individual species that are characteristic of the river. The comments column provides details of the importance of individual biotopes to lamprey.	Assess using river habitat CSM methods or species-specific methods if available and appropriate. Analysis of historical and current distribution.	The characteristic channel morphology provides the diversity of water depth, current velocity and substrate necessary for spawning, and the juvenile and migratory requirements of the species. Lamprey species need coarse substrate for spawning and areas comprising predominantly sand/silt for larval development. The close proximity of these habitats facilitates movement to new preferred habitats with age. Operations that widen, deepen or straighten the channel reduce habitat variability. Operations that may have this effect are not acceptable within the SAC, whilst restoration may be needed in some reaches. Spawning habitat comprises well-oxygenated gravel/pebble (1.5–11.0 cm diameter) dominated substrate of at least 10 cm depth and overlain by a range of water depths (0.2–1.5 m). River and sea lamprey typically spawn in deeper water than brook lamprey, but in larger reaches brook lamprey will also spawn in deep water. Elevated levels of fines (< 0.83 mm diameter) can interfere with egg survival. Larval habitat commonly comprises fine sediment in which organic detritus may or may not be present. Other suitable habitats include organic detritus overlying coarse substrate, submerged tree roots, submerged silt banks and emergent vegetation rooted in silt. Small patches of shallow fine sediment among coarse substrate, submerged cattle drinks and submerged branches/twigs trapping fine sediment may also contain larval lamprey. Larvae are often found in the relatively slack areas of rivers and streams where fine material readily accumulates, e.g. in channel margins, backwaters, behind weirs. The larval habitat requirements of the three species are similar and so they are often found in the same nursery beds. However, greater numbers of sea lamprey may be found in deeper water. Lampreys can pass some potential barriers by attaching themselves to structures or river banks by their suctoral discs and creeping up by strong bursts of swimming. The passability of barriers by different species and sizes of lamprey should be assessed on a site-specific basis. Brook lamprey will be the only species present above natural or artificial barriers. Pre-electrofishing walkover surveys to identify suitable habitat may be used to record the presence and passability of natural features and artificial structures. The use of SNIFFER (2010) may provide some insight into the passability of artificial barriers, but note that its use for assessing barriers to lamprey has not yet been validated.

Attribute * = discretionary	Targets	Method of assessment	Comments
OTHER ATTRIBUTES			
a. Fine sediment	No unnaturally high levels of siltation. Targets included in the CSM guidance for river habitat should be used.	See CSM Guidance for Rivers.	Siltation prevents the flow of dissolved oxygen to eggs and the flushing of waste products from redds.
* b. Alien/locally non-native species	No non-native species likely to cause impairment of lamprey populations.	See CSM Guidance for Rivers.	Larval lamprey are mostly sedentary animals and may be at risk of predation by non-native crayfish.
* c. Abstraction intakes and discharges	Effective screening on all intakes and discharges	Environment agencies' monitoring / consenting programmes.	Entrainment of lamprey in intakes and discharges can occur.
* d. Exploitation	All exploitation should be undertaken sustainably without compromising any components of the stock.	Liaison and agreement with fisheries officers.	A few commercial fisheries for lamprey remain.

CSM Monitoring Protocol 8
Common Standards protocol for population monitoring of bullhead (*Cottus gobio*)

Prepared by: Heather Garrett and Rhian Thomas (2015)

Acknowledgements
This protocol is based on methods given in the references and additional advice from specialists in Natural Resources Wales (Chris Dyson, Sophie Gott, Chris Lawrence, Neil Smith and Leila Thornton).

1. Introduction

This protocol gives information on how and when to monitor bullhead in sites designated as Sites of Special Scientific Interest (SSSIs) or Special Areas of Conservation (SACs) for the species. For details of population attributes and targets, see the associated generic Favourable Condition Table (FCT) for bullhead.

The protocol is set out in two parts: Section 2 outlines how to undertake monitoring surveys where bullhead is the target species (based on Cowx and Harvey, 2003) and Section 3 advises how to use records from fish surveys where bullhead is not the targeted species. Bullhead can occupy smaller streams than salmon and trout and aspects of its biology and ecology means that sampling specifically for bullhead is a different technique from that needed for juvenile salmonid surveys. However, there is some scope for surveying both juvenile salmonids and bullhead at the same time and an alternative revised protocol which tries to facilitate this approach is outlined in Section 3.

2. Monitoring protocol for targeted bullhead surveys

2.1 Sampling method

Electrofishing is the preferred field survey method and single pass electrofishing (without stop nets) over at least 100m^2 of wetted area is recommended (Yeomans *et al.*, 2008; Cowx and Harvey, 2003). The survey area may be smaller depending on the level of historical densities in the tributary. See Cowx and Harvey (2003) for further guidance. Juvenile bullheads are very small; e.g. a 3-year old fish will be less than 1 cm in length (Maitland and Campbell, 1992), so it is recommended that small aquarium nets (approximately 10 cm wide) are used to catch juvenile and adult bullhead found between boulders.

The survey should have a number of sites where all bullheads, including juveniles, are measured and a sub-set of sites where the presence of juveniles is recorded but not measured. This approach should give sufficient data for an assessment and, if required, provide economies on field survey time.

2.2 Site selection

The survey data will provide evidence to undertake an assessment of the attributes for the population within the SAC river boundary. Using one or more of the three criteria listed below, the site locations should be selected for their capability to:

- Reflect on impacts from anthropogenic stresses that are likely to lead to a reduction in densities and affect recruitment dynamics.
- Include habitat coverage that encompasses all the life stages of bullheads and consider the distribution of sub-populations.
- Support the species under near-natural conditions.

A statistical method for selecting a suitable number of sites is detailed in Cowx and Harvey (2003) but as a rule of thumb a minimum of one single-pass survey is required per assessment unit. Research has shown that bullhead catches do not level off with repeated depletion sampling and as a species they suffer from differential catchability due to their ecology and physiological response to electrofishing (Cowx and Harvey, 2003; Yeomans *et al*, 2008). Yeomans *et al* (2008) demonstrated that single-pass sampling generates sufficiently reliable data for a condition assessment.

2.3 Timing and frequency of survey

To ensure early detection of any decline in the population status, surveys should ideally be carried out annually to detect fluctuations in population trends. However, a 3-yearly sampling frequency is acceptable. A 6-yearly sampling programme will give rise to difficulties in interpreting apparent changes in population attributes.

Bullhead spawn between February and June and surveys should be conducted in late summer to reduce the problem of saturation of catches with 0+ individuals and the possible damage to juvenile development. It is recommended that bullhead monitoring surveys are carried out at the earliest in mid to late August, and preferably in September or October.

2.4 Data collection and processing

All bullhead should be counted and measured at the majority of sites with the exception of a smaller number of sites where only the presence or absence of juveniles is recorded. Minimum population estimates are calculated by dividing the bullhead abundance by the area of river fished.

Understanding the size structure of fish populations is important as size is fundamental to understanding the population dynamics. Body length may be summarised by length–frequency distributions which will confirm the size structure of the underlying population, recruitment and juvenile mean length. It should be recognised that difficulties associated with catching juvenile bullheads may slightly skew the plot.

For information on licensing, access, biosecurity and data storage see relevant headings in sections 4 to 7.

3. Monitoring protocol for bullhead condition assessments using data from juvenile salmonid monitoring surveys

3.1 Introduction

Bullheads are often captured as by-catch in surveys which target other species. Standard monitoring programmes often generate a number of bullhead by-catch records e.g. invertebrate kick sampling and juvenile salmonid electrofishing surveys. The invertebrate kick sampling records can only be used to confirm presence but the juvenile salmonid data offer the opportunity for assessing population distribution, structure and density.

Using the bullhead records extracted from juvenile salmonid monitoring surveys negates the need for separate bullhead surveys. However, aspects of bullhead biology and ecology mean that sampling specifically for bullhead is a different method from that needed for salmonids. Consequently, the results from a condition assessment using these data will have a lower confidence.

3.2 Sampling method

This sampling method relies entirely on bullhead by-catch records from the juvenile salmonid survey which are undertaken in the same physical habitat generally occupied by salmon, trout and bullhead.

Juvenile salmonid electrofishing surveys are usually conducted between June and September and three survey methods are used: quantitative (Q), semi-quantitative (SQ) and timed electrofishing (5-minute fishing - 5MF). Densities cannot be calculated using the 5MF data as the area is not measured. Bullhead do not respond to the electric current as well as salmonids and so the catch total may be lower than the habitat conditions suggest.

3.3 Site selection

Sample sites currently used for juvenile salmonid monitoring should be assessed for their suitability for also monitoring bullhead populations (although the same sites should not be sampled more than once per year). The use of existing monitoring sites has a number of advantages, namely:

- Habitat requirements of bullhead and juvenile salmonids are similar.
- Existing sites are usually well distributed throughout each SSSI/SAC.

3.4 Timing and frequency of survey

The optimal survey period for juvenile salmonid survey is June and July whereas bullhead should ideally be surveyed between mid-August and October. Surveys before the August period are more likely to pick up juvenile bullheads and there is the potential for damage to juvenile development. Agencies frequently survey for salmonids beyond the end of July so timing may not be an issue.

To ensure early detection of any decline in the population status, surveys should ideally be carried out annually to detect fluctuations in population trends. However, a 3-yearly sampling frequency is acceptable. A 6-yearly sampling programme will give rise to difficulties in interpreting apparent changes in population attributes. Juvenile salmonid surveys are conducted annually and bullhead records from between 3 and 5 years of survey data should be used for a population condition assessment.

3.5 Data collection and processing

All bullhead should be counted and the presence of juveniles noted at every sample site. The calculation of population densities is a simple division of the bullhead abundance recorded by the area of river fished. This is commonly used for semi-quantitative surveys. For quantitative surveys the population densities are usually calculated by staff of the Environment Agency or Natural Resources Wales.

4. Licensing

Bullhead are not scheduled under the Wildlife & Countryside Act 1981 (as amended). However under Section 28, consent may be required from the appropriate conservation agency (Natural England or Natural Resources Wales) to undertake electrofishing on an SSSI or SAC.

Electrofishing in inland waters is a licensable activity and permission to use this technique for survey purposes must be obtained from the Environment Agency (England) or Natural Resources Wales.

5. Access

It is the responsibility of the contractor to ensure that all access permissions have been obtained before any survey takes place. Risk assessments should be carried out before commencing any of the activities outlined in the monitoring protocol.

6. Biosecurity

It is essential that contractors take every step necessary to prevent the introduction of non-native species to new locations. Before gaining access to any water body, it is essential that all personal and survey equipment has been properly checked and, if necessary, disinfected before any work takes place. All contractors must comply with the Check, Clean, Dry guidelines as a minimum requirement (http://www.nonnativespecies.org/checkcleandry/).

7. Data

All survey data should be stored in national databases where appropriate and uploaded onto the National Biodiversity Network.

8. References and further reading

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Favourable Condition Table 8 – Bullhead (*Cottus gobio*)

Details of the standard method for population assessment can be found in the monitoring protocol for bullhead.

Attribute * = discretionary	**Target**	**Method of assessment**	**Comments**
POPULATION			
a. Spatial extent	Should be present in naturally suitable habitat throughout the designated site	Various methods/data sources: e.g. electrofishing surveys, kick-sampling, hand searches. Incidental records should be obtained from other standard monitoring surveys, e.g. EA / NRW fisheries surveys and biological kick sampling for water quality monitoring samples.	Bullheads can occur in very small channels (less than 1 m wide) where they may be the only fish species present.
b. Population density	There should be no reduction in densities from existing levels, and in any case no less than 0.2 m^{-2} in upland rivers (source altitude >100m) and 0.5 m^{-2} in lowland rivers (source altitude ≤100m).	Densities estimated at an assessment unit scale.	
c. Recruitment	There is evidence of recent recruitment in each assessment unit.	Length–frequency analysis of selected samples; recording juvenile bullheads during electrofishing surveys.	Juvenile fish should be easily identifiable using length–frequency analysis. In September 1-year old fish are typically between 30-50 mm, although they can vary in length. The field methodology makes it extremely difficult to capture smaller (young) fish so it is sufficient to confirm population recruitment by establishing their presence or absence in an assessment unit.

Attribute * = discretionary	Target	Method of assessment	Comments
WATER QUALITY Organic pollution, reactive phosphorus, acidification, other pollutants	Ideally, targets included in the CSM Guidance for Rivers should be used. These are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. All chemical targets, and also biological targets relating to macroinvertebrates (WHPT, PSI and AWICS), are applicable. As a minimum, UKTAG standards for GES under the WFD should be met.	See CSM Guidance for Rivers. (Data from environment agencies.)	Generally, water quality should not be injurious to any life stage. All classified reaches within the designated site that contain, or should contain, bullhead should comply with the targets given. Data from the last 3 years should be used.
FLOW	Ideally, flow targets included in the CSM Guidance for Rivers should be used, as these are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. As a minimum, UKTAG standards for GES under the WFD should be met.	Gauging station data. (Data from environment agencies.)	River flow affects a range of habitat factors of critical importance to bullhead, including current velocity, water depth, wetted area, substrate quality, dissolved oxygen levels and water temperature. There should be >5 cm water depth over riffles in summer. The maintenance of both flushing flows and baseflows, based on natural hydrological processes, is vital. Detailed investigations of habitat–flow relationships may indicate that a more or less stringent threshold may be appropriate for a specified reach. However, a precautionary approach would need to be taken to the use of less stringent values. Naturalised flow is defined as the flow in the absence of abstractions and discharges. The availability and reliability of data is patchy – long-term gauged data can be used until adequate naturalised data become available, although the impact of abstractions on historical flow records should be considered.
HABITAT STRUCTURE	The targets in the CSM Guidance for Rivers should be used. These are intended to provide a natural, dynamic biotope mosaic with high connectivity that caters for the whole biological community and individual species to a degree characteristic of the river. The comments column provides details of the importance of individual biotopes to bullhead.	Assess using CSM Guidance for Rivers or species-specific methods if available and appropriate	The characteristic channel morphology provides the diversity of water depths, current velocities and substrate types necessary to fulfil the spawning, juvenile and dispersal requirements of the species. The close proximity of different habitats facilitates movement to new preferred habitats with age. Operations that widen, deepen or straighten the channel reduce variations in habitat. New operations that would cause these effects are not acceptable within the SAC, while restoration may be needed in some reaches. Points to consider include the following: <u>In-channel structures</u>: vertical drops greater than 18-20 cm are sufficient to prevent upstream movement of adult bullheads. They will therefore prevent recolonisation of upper reaches affected by lethal pollution episodes, and will also lead to constraints on genetic interactions that may have adverse consequences. New instream structures should be avoided, while the impact of existing structures needs to be evaluated

Attribute * = discretionary	**Target**	**Method of assessment**	**Comments**
			<u>Slack-water refuges</u>: these provide important refuges against high-flow conditions. Suitable refuges include pools, submerged tree root systems and marginal vegetation with >5 cm water depth. <u>Woody debris</u>: bullhead are particularly associated with woody debris in lowland reaches, where it is likely that it provides an alternative source of cover from predators and floods. It may also be used as an alternative spawning substrate. <u>Tree cover</u>: the relative importance of shade compared with the provision of woody debris is unclear, but the maintenance of intermittent tree cover in conjunction with retention of woody debris ensures that habitat conditions are suitable. In lowland reaches without any riparian trees, it may be desirable to introduce a limited amount of cover.
OTHER ATTRIBUTES			
a. Fine sediment	No unnaturally high levels of siltation and use the targets for siltation in the CSM Guidance for Rivers.	See the CSM Guidance for Rivers	Bullhead require un-silted coarse-dominated substrate (gravel/pebble/cobble). Males guard sticky eggs on the underside of stones. Larger stones on a hard substrate providing clear spaces between the stream bed and the underside of pebbles/cobbles are therefore important. Elevated levels of fines can interfere with egg and fry survival. Sources of fines include run-off from arable land, land (especially banks) trampled by livestock, sewage and industrial discharges.
* b. Alien/locally non-native species	No non-native species likely to cause impairment of bullhead populations through predation and competition for shelter and food, e.g. the introduced North American signal crayfish (*Pacifastacus leniusculus*).	Crayfish surveys in catchments thought to be at risk.	Refer to the WFD list of alien/locally absent species (but not to be used exclusively). Bullhead densities have been found to be negatively correlated with densities of non-native crayfish in the River Great Ouse, suggesting competitive or predator-prey interactions.
* c. Introduction/ transfer of bullhead	No stocking/transfer of bullhead unless agreed to be in the best interests of the population.	Knowledge of site management.	This may cause genetic damage to the population or otherwise reduce population fitness. May also obscure underlying problems with site condition and devalue monitoring of population attributes. Since bullhead are of no angling interest, deliberate transfers between sites are unlikely to have been undertaken in the past, such that the genetic integrity of populations is likely to be intact.
* d. Stocking/ transfers of other fish species	No stocking / transfers of other fish species at excessively high densities.	Fish stocking consents.	Excessively high densities of other fish species may cause unacceptably high predation pressure and competitive interactions. Care needs to be taken to ensure that stocking exercises do not keep the densities of such species at unnaturally high levels. Impact assessments of stocking consents at a catchment scale may be required to determine an acceptable level.
* e. Abstraction intakes and discharges	Effective screening on all intakes and discharges	Environment agencies monitoring/consenting programmes.	Escapes from fish farms are a form of uncontrolled introduction and should be prevented.

CSM Monitoring Protocol 9
Common Standards protocol for population monitoring of spined loach (*Cobitis taenia*)

Prepared by: Chris Mainstone (2015)

Acknowledgements

This protocol is based on methods in the references below and additional advice from the following experienced spined loach field surveyors: Adrian Williams (APEM), Andy Nunn (HIFI) and Ian Cowx (HIFI). The UK conservation agencies are indebted to these contributors.

1. Introduction

This protocol gives information on how and when to monitor spined loach in sites designated as Sites of Special Scientific Interest (SSSIs) or Special Areas of Conservation (SACs) for the species. For details of population attributes and targets, see the associated generic Favourable Condition Table (FCT) for spined loach.

The protocol is based on the previous CSM method by Williams and Hendry (2006). This document is an updated version to accommodate changes made to the CSM freshwater guidance and recent experiences of spined loach surveying.

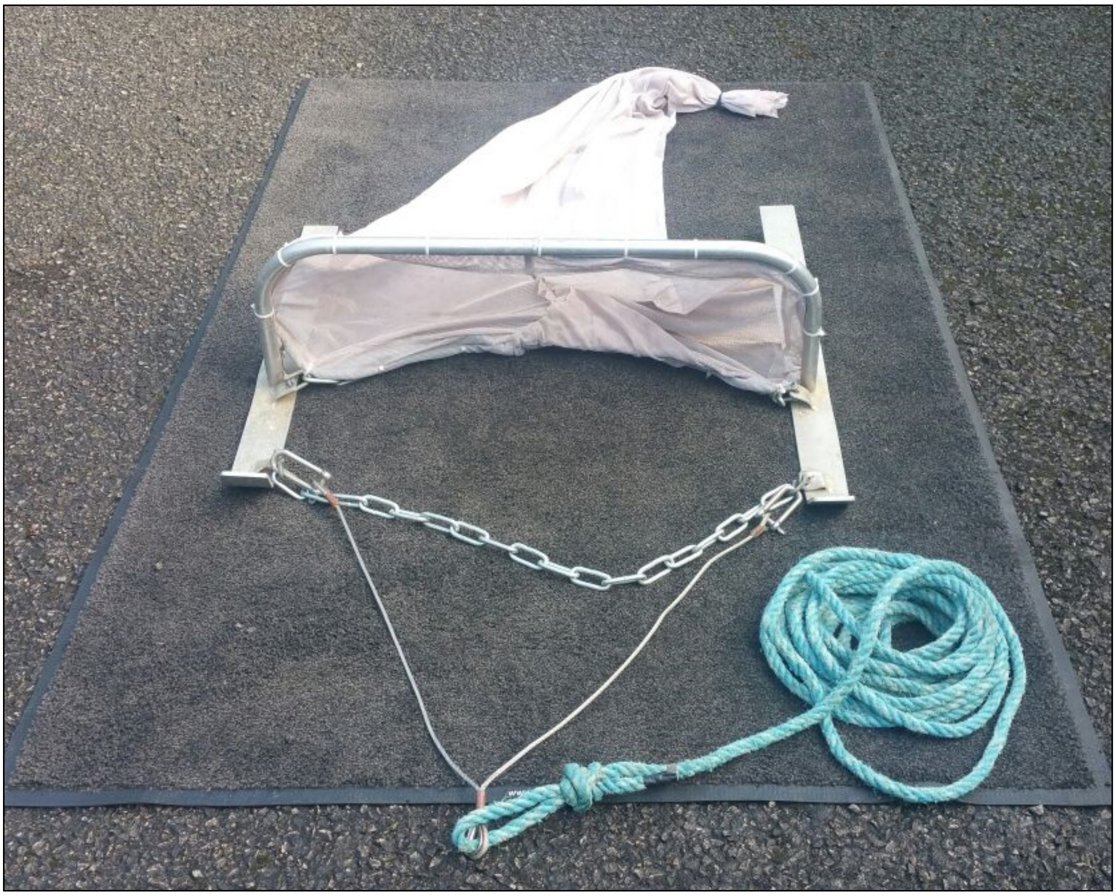
2. Sampling method

Surveying for spined loach in recent years has indicated that hand-trawls are more effective and economical than standard quantitative electrofishing techniques in both drains and rivers where spined loach occurs. Hand-trawling is therefore the sole technique recommended for assessing the condition of spined loach populations. This also improves the consistency of results when compared with population targets.

Trawling should be conducted using an epibenthic sledge (Figure 1). This would ideally be of standard design but minor variation in dimensions is acceptable since survey data are converted to density estimates. Suitable dimensions are approximately 1 m in width and 20 cm in height with a 0.5 mm cod-end (Nitex cloth) and a steel rod offset 2-4 cm above the bottom of the skids. This arrangement allows the sledge to glide over the substratum, minimising the retention of sediment while effectively capturing fish disturbed by a tickle chain.

The trawl should be pulled across the sediment surface for a standard length of 6 m at a speed of approximately 0.25 m per second. Trawls should aim to provide a representative picture of population densities at the sampling site, but there are no fixed rules concerning how this should be achieved; e.g. trawling across the channel or parallel to the bank. The trawl disturbs the substrate so cannot be repeated at exactly the same location on the same sampling occasion.

Figure 1: Example of an epibenthic sledge. (© Adrian Williams, APEM)



3. Site selection

For the purposes of condition assessment all SSSIs are divided into assessment units and population assessments are required for each unit. A sufficient number of sites should be selected to generate both a reasonable population estimate within each unit and sufficient information on spatial distribution. Hand-trawling is a rapid technique so a relatively large number of sites can be accommodated (40 or 50 trawls per day for a two-person team).

The density of sites would ideally be estimated from a site-specific understanding of spatial variability in population density. However, general recommendations are given below. Differences in recommendations for drains and rivers are based on practical considerations associated with ease of access rather than differences in natural population variability.

- In drains, a minimum of 40 trawls per 5 km of drain is recommended, distributed evenly around the drain network and individual assessment units within it.
- In rivers, a minimum of 40 trawls per 10 km of assessment unit is recommended. To address practical access difficulties, hand-trawls can be grouped together around suitable access points as long as this does not bias site selection unduly. Site locations should be chosen that would be expected to support the species under near-natural or reference conditions. This should include sites where human pressures are likely to lead to a reduction in densities and affect recruitment dynamics, so that the data can fully reflect any impacts on the site.

4. Timing and frequency of survey

Surveys should be conducted in September or October, i.e. after spawning and after the initial period of highest young-of-year mortality. This provides more stable estimates of density and less processing of very small individuals.

Ideally, surveying should be undertaken every year as populations may fluctuate considerably between years. However, monitoring budgets are unlikely to support this intensity of survey and a 3-yearly sampling frequency is likely to be the maximum that can be used. A 6-yearly programme will lead to difficulties in interpreting apparent changes in population attributes.

5. Data processing

- **Spatial extent** – for each assessment unit, data should be used to evaluate any significant absence of spined loach in locations where they would normally be expected.

- **Age structure** – at each survey site, the length of all individuals (including young-of-year) should be recorded. A length–frequency distribution should be generated for each assessment unit and compared with the favourable condition target.

- **Adult population densities** – adults are defined as >0+ individuals, which can either be derived from the length–frequency analysis or be based on a 40mm size cut-off. Data on adult numbers and surveyed area should be pooled across sites at each survey location to generate mean adult population density estimates. A mean density estimate should be produced for each assessment unit and compared with the favourable condition target.

- **Recruitment** – at each survey site, the total number of young-of-year should be expressed as a percentage of the total number of spined loach present. A mean percentage value should be produced for the assessment unit and compared with the favourable condition target.

6. Licensing

Spined loach is not listed under the Wildlife & Countryside Act and therefore no species-specific licence is required to survey this species.

7. Access

It is the responsibility of the contractor to ensure that all access permissions have been obtained before any survey takes place. Risk assessments should be carried out before commencing any of the activities outlined in the monitoring protocol.

8. Biosecurity

It is essential that contractors take every step necessary to prevent the introduction of non-native species to new locations. Before gaining access to any water body, it is essential that all personal and survey equipment has been properly checked and, if necessary, disinfected before any work takes place. All contractors must comply with the Check, Clean, Dry guidelines as a minimum requirement (http://www.nonnativespecies.org/checkcleandry/).

9. Data storage and accessibility

All survey data should be stored in national databases where appropriate and uploaded onto the National Biodiversity Network.

10. References and further reading

APEM (2001) *Standardised sampling strategies and methodologies for condition assessment within SAC rivers for sea, river and brook lamprey, bullhead and spined loach.* English Nature report, 636. English Nature, Peterborough.

APEM (2002) *Sampling methodologies for condition assessment within SAC rivers for sea, river and brook lamprey, bullhead and spined loach.* Report for LIFE in UK rivers project.

APEM (2010) *River Mease SSSI and SAC Fish Survey*. APEM Scientific Report 410902. Natural England, Peterborough.

JNCC (2014) *Common Standards Monitoring Guidance for Rivers,* ISSN 1743-8160 (Online) http://jncc.defra.gov.uk/page-2232

JNCC (2005) *Common Standards Monitoring Guidance for Ditches,* ISSN 1743-8160 (Online) http://jncc.defra.gov.uk/page-2232

Nunn AD, Tewson LH, Bolland JD, Harvey JP and Cowx IG (2014) Temporal and spatial variations in the abundance and population structure of the spined loach (*Cobitis taenia*), a scarce fish species: implications for condition assessment and conservation. *Aquatic Conservation: Marine and Freshwater Ecosystems*, **24**, 818-830.

Williams AE and Hendry K (2006) *Investigation of Ecological Requirements of Spined Loach*. APEM Scientific Report EA 660. English Nature and Environment Agency.

CSM Favourable Condition Table 9 – Spined loach (*Cobitis taenia*)

Details of the standard method for population assessment can be found in the monitoring protocol for spined loach.

Attribute * = discretionary	**Target**	**Method of assessment**	**Comments**
POPULATION			
a. Spatial extent	Should be present in naturally suitable habitat throughout the site	Hand-trawl	Routine Environment Agency monitoring is not capable of providing suitable data. See the associated monitoring protocol for further details.
b. Adult population densities	There should be no reduction in densities from baseline levels (if a suitable baseline exists), and in any case no less than 0.1 m^{-2}.	Hand-trawl	Routine Environment Agency monitoring is not capable of providing suitable data. See the associated monitoring protocol, which can be used at suitable local reference (near-natural) sites to derive a local target as well as monitoring against that target. Adults are defined as >0+ year group. This can be derived from length–frequency graphs or taken to be equivalent to >40 mm in length.
c. Age structure	At least three year-classes should be present at significant densities.	Hand-trawl and length–frequency analysis	Spined loach are difficult to age so length–frequency distribution should be used as a surrogate. Routine Environment Agency monitoring is not capable of providing suitable data. See the associated monitoring protocol for further details.
d. Recruitment	30-60% of the population should consist of 0+ fish.	Hand-trawl	Timing of survey is critical to appropriate treatment of the 0+ cohort. Results will have to be interpreted with expert judgement to ensure that problems are not highlighted spuriously. The 0+ year group can be derived from length–frequency graphs or taken to be equivalent to <40 mm in length.

Attribute * = discretionary	Target	Method of assessment	Comments
WATER QUALITY			
Rivers: Organic pollution, reactive phosphorus, other pollutants	Ideally, targets included in CSM Guidance for Rivers would be used, as these are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. All chemical targets, and also biological targets relating to macroinvertebrates are applicable. As a minimum, relevant UKTAG standards for GES under the WFD should be met.	See CSM Guidance for Rivers. (Data from environment agencies.)	The spined loach is susceptible to both episodic and chronic organic pollution. Episodic pollution causes direct mortalities while chronic pollution affects substrate condition through the build up of sediment oxygen demand and excessive microbial populations. If the organic content of the substrate becomes too high, reduced oxygen availability near the sediment/water interface may lead to enhanced egg and juvenile mortality. Nutrient enrichment can lead to loss of substrate condition for spined loach due to benthic algal growth and associated enhanced siltation and sediment anoxia. It also increases the risk of impacts on the submerged plant community, which the spined loach uses for cover. All classified reaches within the designated site that should contain spined loach under near-natural conditions should comply with the targets set.
Drains/ditches: Total phosphorus	Ideally, values used for general protection of SSSI ditches would be used. As a minimum, no more than 0.1 mg L^{-1} TP annual mean.	See CSM Guidance for Ditches.	In ditches, spined loach can be abundant in enriched conditions with high levels of filamentous algal cover – however, this is not considered to be 'favourable' habitat conditions for the species, and is not consistent with the conservation of the wider biological assemblages of ditches. Nutrient concentrations should allow a submerged vascular plant community to be maintained.
FLOW			
Rivers:	Ideally, flow targets included in the CSM Guidance for Rivers would be used, as these are intended to support a healthy, naturally functioning river ecosystem which protects the whole biological community and individual species to a degree characteristic of the river. As a minimum, UKTAG flow standards for GES under the WFD should be met.	See CSM Guidance for Rivers	River flow affects a range of habitat factors of critical importance to spined loach, including current velocity, water depth, wetted area, substrate quality, dissolved oxygen levels and water temperature. The maintenance of all components of the flow regime, based on natural hydrological processes, provides the dynamic mosaic of biotopes that spined loach uses in rivers. Detailed investigations of habitat–flow relationships may indicate that a more or less stringent threshold may be appropriate for a specified reach; however, a precautionary approach would need to be taken to the use of less stringent values.
Drains/ditches:	Should be sufficient to avoid risk of stagnation.	Visual inspection during population or other survey	Although spined loach is adapted to cope with moderately low oxygen levels, it is susceptible to significant deoxygenation that may occur due to inadequate flows through the drain system.

Attribute * = discretionary	Target	Method of assessment	Comments
HABITAT STRUCTURE (Rivers) In-channel structures, barriers.	The targets in CSM Guidance for Rivers should be used. These are intended to provide a natural, dynamic biotope mosaic with high connectivity that caters for the whole biological community and individual species to a degree characteristic of the river. The comments column provides details of the importance of individual biotopes to spined loach.	Assess using the CSM Guidance for Rivers or species-specific methods if available and appropriate.	Habitat conditions for spined loach vary naturally in rivers. Some sections may provide optimal habitat while others may be largely unsuitable. A natural river morphology provides the diversity of breeding/nursery habitat, cover from predators, refuge against high flows, and feeding opportunities that best meet the full life-cycle requirements of the species. The close proximity of riffles and pools is particularly important for this sedentary animal. A characteristically diverse biotope mosaic and natural levels of connectivity allow spined loach and other species to move within the river channel to locate optimal habitat conditions in the face of a fluctuating flow regime. Although the species can tolerate silt and mud, it has a preference for sandy substrates. High sediment cohesiveness is likely to affect feeding. A mosaic of bare substrate and submerged beds of higher plants provides optimal conditions for feeding, cover from predators and spawning (which occurs on submerged plants). Marginal emergents also provide important cover and feeding opportunities. Free movement within the channel is necessary to ensure maintenance of genetic diversity (and therefore population viability) and to provide the potential for recolonisation of upstream reaches that have become artificially denuded of spined loach (e.g. through pollution incidents or extreme low flows). New in-stream structures should be avoided, while the impact of existing structures needs to be evaluated. (Note: this has links to the population target on spatial extent.)
OTHER ATTRIBUTES			
a. Fine sediment **(Rivers)**	No unnaturally high levels of siltation. Siltation targets included in the CSM Guidance for Rivers may be appropriate. However, spined loach has a preference for relatively fine substrates so some assessment of the nature of any siltation may be required to assess the likelihood of adverse effects.	See CSM Guidance for Rivers.	Although the species can tolerate silt and mud, it has a preference for sandy substrates, and these substrates should be maintained or restored in watercourses where sufficient hydraulic energy can be generated. If the organic content becomes too high, reduced oxygen availability near the sediment/water interface may lead to enhanced mortality of eggs and juveniles. High sediment cohesiveness is likely to affect feeding.
b. Alien/locally non-native species	No non-native species likely to cause impairment of spined loach populations.	Various sources, including ad hoc observations, specific site investigations and data collected by the environment agencies.	The WFD UKTAG lists alien and locally non-native species that should be considered (although other species may also be relevant). In particular, non-native crayfish may create unacceptably high levels of competitive and predatory pressure on spined loach.

Attribute * = discretionary	Target	Method of assessment	Comments
* c. Introduction/ transfers of spined loach	No introduction/transfers of spined loach unless agreed to be in the best interests of the population.	Knowledge of site management.	Genetic differences have been found in spined loach populations in Europe, and there is no reason why they should not exist in England. Considering the wide range of environmental conditions in which the spined loach is found (from swiftly flowing streams to drainage ditches), such differences may well have adaptive significance. Since the species is of no angling interest, deliberate transfers between sites are unlikely to have been made in the past, such that the genetic integrity of populations is likely to be intact.
* d. Stocking/ transfers of other species	No stocking/transfers of fish species at excessively high densities	Fishery stocking consents. Impact assessments of stocking consents on a catchment scale may be required to determine an acceptable level.	Excessively high densities of predatory and benthivorous fish species can cause unacceptably high predation pressure and alter sediment characteristics and sedimentary food supply in ways that are highly detrimental to spined loach. Care needs to be taken to ensure that stocking does not keep the densities of such species at unnaturally high levels.
* e. Weed-cutting	**For riverine sites**, see targets in the CSM Guidance for Rivers. **For drains**, cutting operations should leave at least 50% of open water area (and bank length within each assessment unit in any one season) cut in patches.	Evaluation of conditions on land drainage consents and knowledge of adherence to them.	A mosaic of bare substrate and submerged beds of vascular plants provides optimal conditions for feeding, cover from predators and spawning (which occurs on submerged plants). Marginal emergents also provide important cover and feeding opportunities. Site-specific weed-cutting targets can be set where sufficient local information exists.
* f. Abstraction intakes and discharges	Effective screening on all intakes and discharges.	Environment Agency's monitoring/consenting programmes.	Entrainment of spined loach in intakes and discharges can occur.