Monitoring of Lamprey in the Solway SAC 2015

First published February 2022

Natural England Commissioned Report NECR409

www.gov.uk/natural england

Natural England Commissioned Report NECR409

Monitoring of Lamprey in the Solway SAC 2015

Tom Napier-Munn, Nicola O'Keeffe

Published February 2022

ISBN: 978-1-78354-914-6

Project details

This report should be cited as: Napier-Munn, T. O'Keeffe, N. (2022). Monitoring of Lamprey in the Solway SAC. APEM Scientific Report 413554. NECR409 Natural England.

Natural England Project manager

Fiona Neale

Contractor

APEM Ltd, Riverview, A17 Embankment Business Park Heaton Mersey, Stockport

Tel: 0161 442 8938

Author

Tom Napier-Munn, Nicola O'Keeffe

Keywords

Sea Lamprey, Solway Firth, SAC, Special Area of Conservation

Further information

This report can be downloaded from the Natural England Access to Evidence Catalogue: **http://publications.naturalengland.org.uk/** . For information on Natural England publications contact the Natural England Enquiry Service on 0300 060 3900 or e-mail **enquiries@naturalengland.org.uk**.

Monitoring of Lamprey in the Solway

SAC Natural England

413554

March 2015

Tom Napier-Munn, Nicola O'Keeffe

Client: **Natural England**

Address:

Project reference: **413554**

Date of issue: **March 2015**

Project Director: **Nicola Teague**

Project Manager: **Peter Dennis**

Other:

APEM Ltd
Riverview
A17 Embankment Business Park
Heaton Mersey
Stockport
SK4 3GN

Tel: 0161 442 8938
Fax: 0161 432 6083

Registered in England No. 2530851

Revision and Amendment Register

Version Number	Date	Section(s)	Page(s)	Summary of Changes	Approved by
1.0	23/12/14	7	46	First draft	NO
2.0	02/03/15	3,4,5,6	8,10,28-37	Final report	PD
3.0	31/03.15	6	27-28	Addition of statistics	PD

Contents

List of Figures

List of Tables

1. Introduction

The Solway Firth is a Special Area of Conservation (SAC) and the Upper Solway Flats and Marshes are a Special Protection Area (SPA) and Ramsar site. The Solway Firth is a large shallow complex estuary formed by a variety of historical physical influences including glaciation, river erosion, sea level change and geological barriers from hard rock outcrops.

River lamprey (*Lampetra fluviatilis*) are a designated feature of the Solway Firth SAC and the Upper Solway Flats and Marshes Site of Specific Scientific Interest (SSSI). The Solway Firth provides an important marine migration route for river lamprey to their spawning and nursery grounds in a number of rivers, including The Eden, Esk, Wampool and Waver rivers. There is limited information on the Solway Firth river lamprey population, both within the estuary and associated migratory routes to spawning sites in the River Eden and other river systems. Sea lamprey (*Petromyzon marinus*) are also a designated feature of the site, however, very little is known about the sea lamprey in the Solway Firth, except that the estuary forms an essential part of the species' migratory route. Both river lamprey and sea lamprey are also listed as designated features of the River Eden SAC and SSSI.

The aim of this study was to provide up-to-date data on ammocoete populations and habitat of the Solway Firth river lamprey populations within the associated riverine environments to inform the condition assessment of the species. It is envisaged that this study would focus on the freshwater part of the life-cycle through studies on the ammocoete populations and associated habitats and would cover the Eden, Esk, Waver and Wampool River systems, which all empty into the Solway Firth from England. Following Natural England specifications however, priority was given to the River Eden catchment, as it is considered to be the most important river for the Solway Firth lamprey population. .

This study aimed to assess the following attributes of the Solway Firth river lamprey population through surveys of ammocoete populations;

- Locate how far lamprey ammocoete populations penetrate upstream and reside downstream within the target river systems
- Provide GPS locations of important sites and maximum penetration for ammocoetes for the Solway Firth population
- Sample ammocoete populations to provide an indication of the success of the spawning population in 2014 notably in terms of ammocoete density, population age structure and distribution within the catchment
- Record appropriate habitat measures whilst on site to give an indication of condition.
- Compare the location of ammocoete populations located in the field with any known suitable habitat and historic ammocoete locations and, if possible, assess if there has been a contraction or expansion of the population.

2. Objectives

The primary objectives of the project are:

- To undertake ammocoete surveys for river and (if encountered) sea lamprey on the Rivers Eden, Esk, Waver and Wampool, prioritising the Eden.

- In light of the results obtained; to provide a preliminary assessment of the condition of river and sea lamprey, in accordance with Common Standards Guidance.

3. Methodology

3.1 Sample sites

Prior to initiation of field surveys APEM undertook a habitat inspection using high resolution aerial & satellite imagery to identify suitable locations for monitoring. This was supplemented by APEM's extensive walkover experience in each of the four catchments. This process enabled areas of suitable habitat to be identified which minimised time taken during the field survey and facilitated adequate site access to be arranged. In addition, the location of Eden sites 1 to 18 were provided by Natural England, as previously surveyed lamprey sites, which should be repeated in the current survey.

For any monitoring programme it is important that sufficient samples be collected. This is imperative from a statistical point of view. If too few samples are collected, spatial and temporal variability cannot be assessed and subsequently changes cannot be determined. The number of samples required can be calculated mathematically having first carefully considered the following points:

- Desired level of identifiable change within the population
- Degree of confidence that the estimates are correct
- The size of the study area (catchment / river / reach)
- The population distribution (spatial and temporal variance)

Harvey & Cowx (2003) recommend that approximately 40 sites should be surveyed in UK river catchments to provide an acceptable level of precision of ammocoete abundance. These locations are provided in Table 3.1. However, due to budget constraints the maximum number of 40 sites per catchment were not able to be surveyed. There were 40 sites surveyed in total, which were split between the Eden, Esk, Waver and Wampool catchments as follows. The Eden was prioritised with 22 sites, then the Esk with eight sites, the Waver with five sites and the Wampool with five sites. This distribution of sites gave an overview of the status of the populations within the estuary SAC site as a whole but may not be sufficient to detect changes in individual river catchment populations.

Sites were selected to provide good spatial variability and included the lower river and upper estuary (Figure 3–1). Tributaries outside the SAC boundary were included as they may be important in contributing to the overall sustainability of the population in the SAC.

Accessibility to survey sites was also considered, in particular with respect to health and safety, and as such may have affected the spatial distribution of the sites. At each identified site location, specific sample sites were selected on the basis of the habitat types present as identified from the habitat assessment with representative optimal and sub-optimal areas being identified.

Table 3.1 Site locations for each catchment

Catchment	Sub catchment	Site	Easting	Northing	NGR
Eden	Upper	Eden 1	373500	508500	NY7350008500
Eden	Upper	Eden 2	374900	510900	NY7490010900
Eden	Upper	Eden 3	377600	508900	NY7760008900
Eden	Upper	Eden 4	379700	514700	NY7970014700
Eden	Middle	Eden 5	333800	535000	NY3380035000
Eden	Middle	Eden 6	328800	537100	NY2880037100
Eden	Middle	Eden 7	330100	538900	NY3010038900
Eden	Middle	Eden 8	332300	539800	NY3230039800
Eden	Middle	Eden 9	361700	532700	NY6170032700
Eden	Middle	Eden 10	347100	524500	NY4710024500
Eden	Middle	Eden 11	352400	528700	NY5240028700
Eden	Middle	Eden 12	352400	528700	NY5240028700
Eden	Middle	Eden 13	360900	528100	NY6090028100
Eden	Upper	Eden 14	362600	516400	NY6260016400
Eden	Upper	Eden 15	370200	516600	NY7020016600
Eden	Upper	Eden 16	370900	514900	NY7090014900
Eden	Upper	Eden 17	373200	520800	NY7320020800
Eden	Upper	Eden 18	368300	520600	NY6830020600
Eden	Lower	Eden 19	338237	556525	NY3823756525
Eden	Lower	Eden 20	346764	557011	NY4676457011
Eden	Lower	Eden 21	351009	547268	NY5100947268
Eden	Lower	Eden 22	355031	540314	NY5503140314
Esk	-	Esk 1	335478	564912	NY3547864912
Esk	-	Esk 2	337953	569180	NY3795369180
Esk	-	Esk 3	339886	572462	NY3988672462
Esk	-	Esk 4	338676	578142	NY3867678142
Esk	-	Esk 5	336229	584858	NY3622984858
Esk	-	Esk 6	333854	588875	NY3385488875
Esk	-	Esk 7	331128	590332	NY3112890332
Esk	-	Esk 8	325392	590858	NY2539290858
Wampool	-	Wampool 1	324127	324127	NY2412755623
Wampool	-	Wampool 2	326712	326712	NY2671251426
Wampool	-	Wampool 3	330628	330628	NY3062849437
Wampool	-	Wampool 4	333838	333838	NY3383848578
Wampool	-	Wampool 5	332830	332830	NY3283045003
Waver	-	Waver 1	318394	551385	NY1839451385
Waver	-	Waver 2	322207	549118	NY2220749118
Waver	-	Waver 3	321780	547305	NY2178047305
Waver	-	Waver 4	324873	544559	NY2487344559
Waver	-	Waver 5	322873	543545	NY2287343545

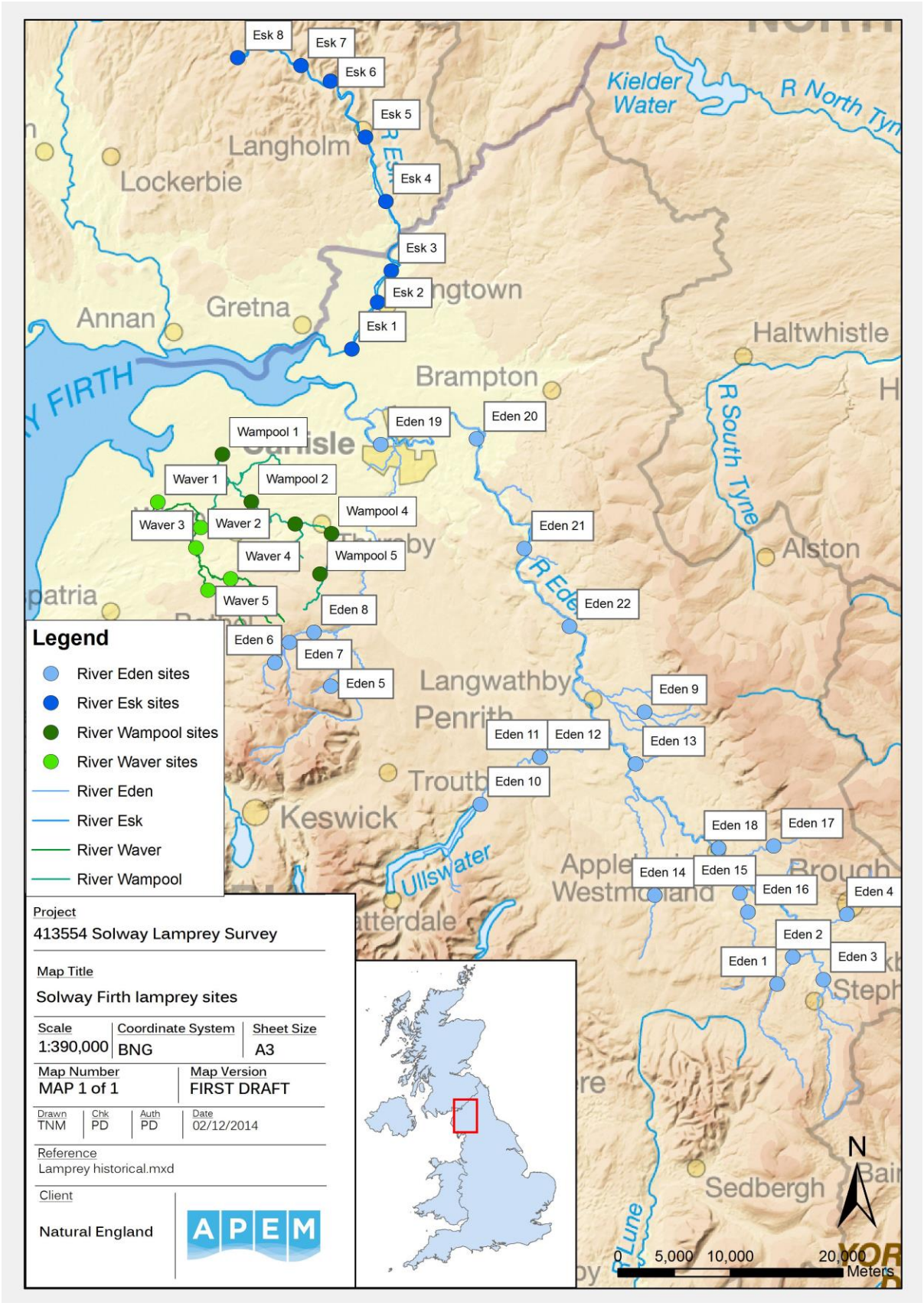

Figure 3–1 Site locations on the Solway Firth catchment

3.2 Lamprey sampling

At all times, standard electric fishing practice for operators and equipment were followed as developed by the European Standards Committee (CEN, 2001) and detailed in the Environment Agency Code of Practice and Electric Fishing Equipment Annex A and B, Issue II regulations (1998). Furthermore, prior to any fisheries assessment, appropriate permissions were sought from EA/NE with respect to the standard FR2 “Application to use fishing instruments (other than rod and line) and / or remove fish from inland waters” form. Sites were accessed via bridge crossings where possible; where public access was not possible, permission was obtained from the land owner.

As detailed in the LIFE protocol (Harvey & Cowx 2003), where possible surveys were carried out in both optimal and sub-optimal habitat at each site. At each site a thorough search was carried out of the river to locate optimal and sub-optimal lamprey habitat. Habitat was surveyed quantitatively using an enclosed area as a barrier to fish movement in optimal and sub-optimal locations. A 1 m^2 quadrat, enclosed with 2 mm fine mesh netting was positioned over the selected habitat at each survey site and then left to settle.

Electric fishing was undertaken within the quadrat in such a way as to draw individual lamprey out of the sediment rather than stunning and trapping them in the silt. This was achieved by energising the anode in short bursts of 20 seconds followed by 5 second gaps and was carried out over a two minute period. This procedure is classed as a single run, which in optimal habitats would be subsequently repeated at least twice within the same quadrat (with a five minute gap between runs). The reason for carrying out three or more electric fishing runs within the same quadrat is to enable an absolute population estimate to be made using the Carle and Strub (1978) depletion methodology. This centres around the premise that the number of ammocoetes caught in each of the runs reduces as the ammocoete population in the site area becomes depleted. For example, in the first run 15 ammocoetes may be caught, followed by seven in the second run and three in the final run. The Carle and Strub (1978) methodology then takes these figures and calculates an absolute estimate for the population present within the 1 m^2 habitat site based upon the depletion over the three runs. In some cases, however, the first run may have resulted in very few ammocoetes being caught in comparison to the second due to the ammocoetes taking longer to be drawn out of the silt. As is standard in such situations further runs were therefore carried out. The Carle and Strub calculation was then applied to the last three runs and the number of ammocoetes in the previous runs simply added on to this calculated estimate to provide an overall total population estimate.

In sub-optimal habitats a single run was carried out for each of the sites. The single run data was then converted to a total population estimate using a calculated efficiency or multiplication factor derived from the Carle and Strub (1978) estimates from the triple run carried out on the optimal habitat from the same site. This factor was determined by dividing the total population estimate of the optimal site by the number caught in the first run. This therefore gives the proportion of the total population estimate that is caught by the first electric fishing run. This proportion was then applied to the catch obtained from a single run within a different quadrat to give a population estimate. This assumed that both the optimal and sub-optimal sites deplete on an equal gradient and therefore the ratio between the numbers caught in the first run to the total catch was the same for both the sub-optimal and optimal site.

3.3 Site assessment

At each site (100 m stretch) a habitat assessment was undertaken to map the extent of optimal or sub-optimal habitat.

In accordance with current thinking (APEM, 2002) optimal habitat is defined as areas with:

- Several square metres of stable, fine sediment at least 150mm deep (Potter et al., 1986; Harvey and Cowx, 2003)
- Low water velocity (Thomas, 1962; Malmqvist 1980)
- Shallow water depth (Malmqvist, 1980)
- Organic detritus (Potter et al., 1986)
- Presence of shade (Potter et al., 1986)

Sub-optimal habitat was defined in accordance with APEM (2002) as patchy, shallow sediment interspersed among coarser substrate with comparatively high velocity flow, more typically described as salmonid fry and parr habitat.

At each site the full list of environmental variables cited in Box 1 of Harvey & Cowx (2003) was recorded as follows:

- Average width of wetted area (m)
- Average depth (m)
- Maximum depth (m)
- Water current class – slow, intermediate, rapids and estimated current speed (m s-1)
- Aquatic vegetation (absent, sparse, intermediate, species-rich)
- Dominating type of aquatic vegetation (submerged, floating, emergent)
- Classification of surrounding riparian zone (urban, grazing, arable, forestry)
- Shade
- Presence of woody debris
- Altitude
- Pollution sources
- Habitat degradation
- Stream gradient (slope per thousand)
- Photographic documentation
- Sample area (m2)
- Habitat classification (optimal, sub-optimal, none)
- Sediment type (silt, sand, mud, gravel)
- % contribution of each sediment type in sample area
- Depth of sediment (cm)
- % of organic material

3.4 Identification

All lamprey ammocoetes and transformers (macropthalmia) were measured to the nearest mm and identified in the field, distinguishing between *Lampetra spp*. (river or brook lamprey) and sea lamprey for ammocoetes and individual species for transformers, as described in Gardiner (2003). All lamprey were then returned to the exact area of substrate sampled.

In the field, sea lamprey can be distinguished from river/brook lamprey at both the ammocoete and transforming stage of their life cycle. Sea lamprey ammocoetes can be identified by the presence of pigmentation on the lower half of the oral hood and on the caudal fin. Ammocoetes without this pigmentation were categorised as Lampetra genus. A useful confirmation characteristic is that sea lamprey typically have between 67 and 74 trunk muscle blocks (myomeres) running along the body from the last gill opening to the anus, whilst Lampetra sp. ammocoetes generally have less than 67 (Potter & Osbourne, 1975). Although sea lamprey were not the target species for this study their incidental presence were recorded if encountered.

River and brook lamprey are indistinguishable during the ammocoete life stage and can only be differentiated once they transform. A characteristic that varies between river and brook lamprey transformers is the differing lengths that they grow to before they transform. Gardiner (2003) describes a number of studies that have investigated the lengths at which river and brook lamprey transform. From these studies it is generally considered that river lamprey transform at a length of less than 120mm (typically 90-120 mm), whilst brook lamprey typically metamorphose at a length of 120-150mm (Maitland, 2003). It should be noted however that river and brook lamprey have been found to transform outside of these length categories. Relatively large ammocoetes of up to 180 mm have been identified in previous APEM surveys (Hendry & Waterfall, 2005), which are above the lengths that are typically found in Gardiner's (2003) review.

In addition to using the length of the transformers as a guide to identification, other anatomical features of the lamprey can also be used. River lamprey generally become more silvered than brook lamprey after transformation and typically appear more slender. These features coupled with the length of the transformer were therefore used to distinguish between river and brook lamprey transformers.

3.5 Biosecurity

When working within the aquatic environment biosecurity is always essential, even if disease or invasive non-native species for example are not immediately apparent. As a precautionary measure, to minimise the risk of transmitting disease or spreading non-native species, strict movement controls and disinfection procedures were followed.

APEM has an operational responsibility to have a good biosecurity routine and have strict procedure for all field staff to follow. APEM's procedure includes codes of practise for disinfection which follow DEFRA, Scottish Government, CEFAS and Natural England guidelines.

It was noted during the planning stages that the spread of disease carried by the invasive signal crayfish to the native white-claw crayfish was of particular concern in the River Eden Catchment, as such The Eden catchment was surveyed before other catchments to eliminate the possibility of transmitting disease to known white-claw regions.

3.6 Condition assessment

There is a requirement under the Habitats Directive to monitor species to establish their status against a predetermined set of conservation objectives; a process known as 'condition assessment' in the UK. Condition assessment is carried out at individual sites and can

contribute to an assessment of conservation status of each species across its geographical range in the UK.

The condition assessment of the Solway Firth SAC should be able to provide information on the present status of the species and give at least a broad indication as to trends. The data collected should therefore be suitable to allow comparison between sites and years, particularly if it is to contribute to determining conservation status. The ability to compare different sites is important because sampling protocols and strategies may be used in SAC rivers with different habitat characteristics.

In addition to the survey data collected during this round of surveys other data would be used in the preliminary condition assessment to determine whether lamprey populations are in favourable condition in the Solway Firth SAC and if possible to highlight and discuss any decline in distribution. This would include lamprey surveys conducted on the Eden catchment by the Environment Agency in 2012.

As defined under Common Standards Monitoring Guidance (JNCC, 2005) the preliminary condition assessment was measured against the following lamprey population attribute targets (or performance indicators):

- Ammocoete density – divided into Lampetra species and Petromyzon.
- Distribution throughout the catchment.
- Age structure.
- Spawning activity (sea lamprey only).

The common standards monitoring guidance for freshwater fauna (JNCC 2005) set out by the JNCC lists favourable conditions for lamprey with respect to age structure, distribution and ammocoete density. These targets have been summarised in Table 3.2.

Table 3.2 Summary of favourable condition table for *Lampetra spp* (JNCC 1995)

Attribute	Targets
Distribution within catchment	Lamprey should be present at not less than 2/3 of sites surveyed. As a minimum, there should be no reduction in the distribution of ammocoetes within the catchment.
Ammocoete density	Lampetra spp: Optimal habitat: >10 m^{-2} Chalk streams >5 m^{-2} Overall catchment mean: >5m^{-2}
Age structure (*Lampetra spp* only)	For samples of 50 or less, at least two distinct size classes should normally be present. If more than 50 ammocoetes are collected, at least three size classes should be present.

3.7 Data analysis

The data collected from the surveys were collated and analysed in a way that benefits the determination of condition status of the lamprey in the Solway Estuary. Further details on this element of the work are provided later, however the data required to undertake this assessment include ammocoete density, distribution, and age structure.

Catch data is presented for each site in terms of density (individuals per m^2) of each species. The absolute density for each site was calculated using the Carle and Strub (1978) depletion methodology. A figure for ammocoete density within the entire catchment was also calculated for the purposes of the condition assessment.

The demographics of the various populations were thoroughly assessed through the production of length-frequency histograms. Such histograms are produced to show the presence of different age classes (cohorts) present within the population.

Lamprey inhabit sediment for up to six years and as such a patch of substrate may contain lamprey ammocoetes of differing ages. Since the ammocoetes grow each year, each age class has a differing range of lengths. The idea behind creating the length frequency histograms is to show the presence of these age classes. It is assumed that the number of individuals within each age class has a normal distribution and as such, the length frequency plots should show several peaks corresponding to the typical length of an individual from a specific age class. While, in theory, each age class should be able to be defined in this way, in practice the cohorts are often not distinct enough to distinguish exactly between each age class. It is usually possible however to distinguish 'by eye' between the 0+ age class (the first significant cohort seen in the length frequency plot) and the rest of the population. This is sufficient to determine the success of the Young Of the Years[1] (YOYs) recruitment and survival. The maximum length of 0+ ammocoetes can also be estimated from the plots, which is also guided by the general thinking that ammocoetes grow to around 50 mm in the first year (Maitland, 2003).

The production of length-frequency histograms would ideally be undertaken separately for each site, as ammocoetes present in different sections of river may have differing growth rates resulting from varying environmental conditions. If less than 20 ammocoetes were caught at a site however this does not provide a sufficient sample size to apply the histogram techniques described above. Length data from different sites was therefore grouped appropriately. It was not appropriate to group together the sites from the entire catchment due to the differing growth rates that may be present in the different parts of the catchment. A balance therefore has to be found between grouping enough sites to gain a large enough data set to create a meaningful histogram, while not over grouping the sites so that the cohorts become unclear. In the past APEM have found that the 'best' length frequency histograms were produced by grouping the sites into those located in the upper, mid and lower parts of the catchment. This technique was applied to the Eden catchment, while all the sites of the Esk, Wampool and Waver catchments were pooled within their respective catchments due to their smaller size.

[1] Young of the year refers to the 0+ population i.e. the fish that are less than a year old.

3.8 GIS Mapping

All data will be provided with the final report in ESRI ArcGIS format compatible with ArcGIS 9.3.1 and have attached metadata which would display the spatial patterns of lamprey densities at sampling sites throughout the Solway Firth SAC.

The GIS files were used to create maps of lamprey sampling sites indicating information such as presence/absence and historical comparison. An accompanying CD / DVD will be produced providing an interactive GIS product which can be interrogated by the user.

4. Results

The survey was conducted between the 13th and 20th September 2014, in order to ensure a range of size classes were caught (Harvey & Cowx, 2003) as well as to minimise the impact of the survey on salmonid spawning habitat.

In total, 161 lamprey (Figure 4–1) were caught during this survey, of which 75 were in the River Eden catchment, 18 were in the River Waver catchment, 27 in the River Wampool catchment and 41 in the River Esk catchment. The number of lamprey caught in sub-optimal habitat in each catchment was 11, 4, 9 and 9 respectively. There were four transformers caught in the River Eden, zero in the River Esk, two in the River Wampool and one in the River Waver, totaling seven in the entire catchment. No sea lamprey ammocoetes were caught in any of the four catchments surveyed however, a previous study noted a tendency for sea lamprey ammocoetes to occupy habitat deeper than those targeted in the current study (Teague et al, 2012). Therefore sea lamprey ammocoetes may be present in the Solway Firth and may have a tendency to occupy habitat that was not targeted.

Figure 4–1 River/brook lamprey

4.1 River Eden catchment

4.1.1 Habitat availability

Optimal habitats (Figure 4–2) were recorded at 63% (14/22) of sites in the Eden, while sub-optimal sites were recorded at 86% (19/22) of sites. No ammocoete habitat, optimal or sub-optimal, was recorded at three sites (sites 5, 6 and 17).

Figure 4–2 Example of optimal lamprey habitat

4.1.2 Geographic distribution

The *Lampetra spp* ammocoetes were caught throughout most of the extent surveyed of the River Eden catchment (Figure 4–3). Ammocoetes were caught at the very lower extent of the catchment surveyed and as high up the catchment as site 2. Ammocoetes were caught at 13 of the 22 sites (59% of sites). Many of the no catch sites were in the upper reaches of the catchment. All of the sites where no lamprey were caught were on tributaries to the main stem. Ammocoetes were only caught on four of the nine upper Eden sites (44%). Ammocoetes were caught on all of the lower Eden sites. No catch was recorded at the sites on the River Caldew (sites 5 to 8) however, ammocoetes were caught on all other middle Eden sites.

In optimal habitat, ammocoetes were caught in 93% (13/14) of sites, while in sub-optimal habitat ammocoetes were caught in 30% (6/20) of sites. There is an impassable barrier (Stenkrith Falls) to lamprey at Kirkby Stephen however, this is a natural barrier and no lamprey were caught at site 3, downstream of this barrier, indicating the natural extent of lamprey may be downstream of this barrier.

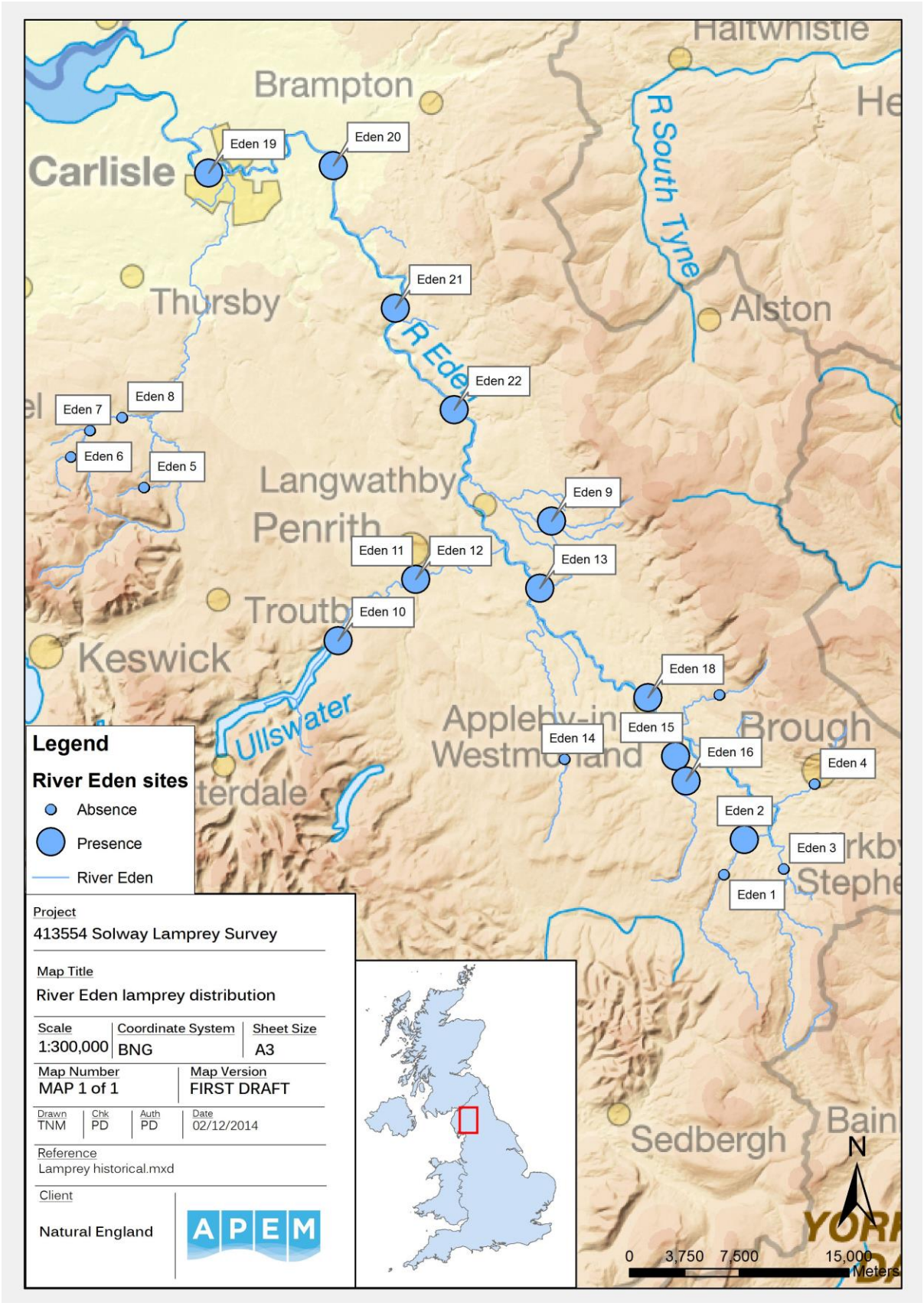

Figure 4–3 Location of *Lampetra spp* ammocoetes caught in the River Eden catchment

4.1.3 Densities

The mean density of *Lampetra spp* in the River Eden catchment was 5.4 m^{-2} in optimal habitat and 0.8 m^{-2} in sub-optimal habitat. When optimal and suboptimal habitats are considered together the mean density was 3.1 m^{-2}.

The absolute density of ammocoetes was similar at most sites where ammocoetes were present, with the exception of sites 11 and 19 where they were much higher than other sites (Figure 4–4). The concentration of ammocoetes was much higher in the middle to lower reaches of the River Eden and tributaries.

The absolute densities of ammocoetes in optimal habitat were generally much higher than in sub-optimal habitat. Site 20 was an exception to this with more than twice the density calculated to be in the sub-optimal habitat compared to the optimal habitat.

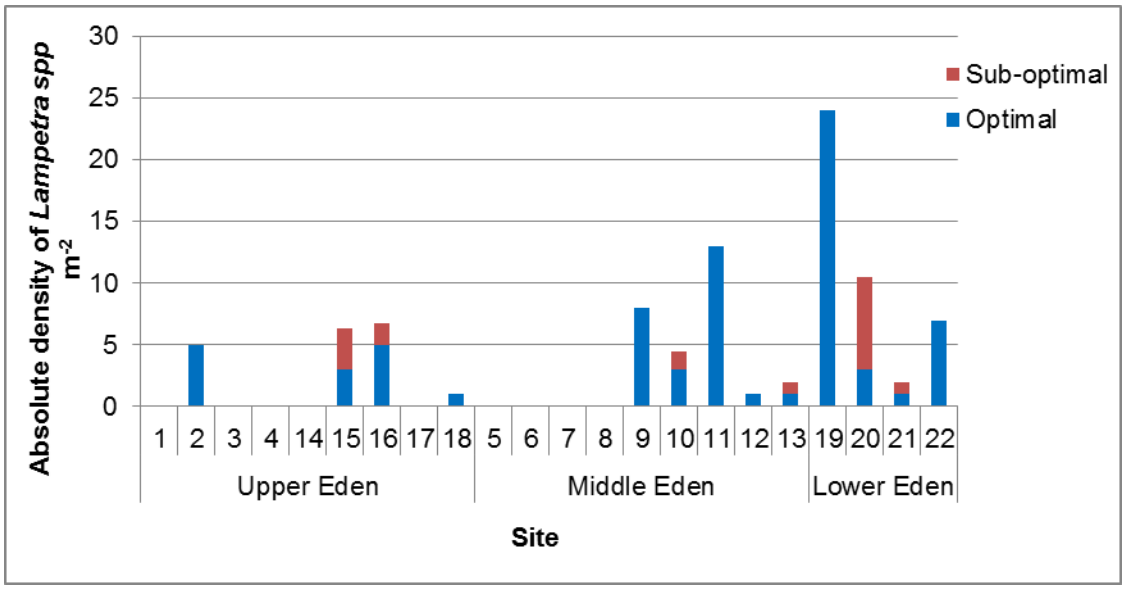

Figure 4–4 Absolute density of *Lampetra* spp. ammocoete at sites across the River Eden catchment

4.1.4 Population structure

For the purposes of analysis of the age structure the Eden catchment sites have been split into groups based on river location. The catch at each site was not sufficient to calculate the age structure for each site individually and due to the size of the catchment it would not be appropriate to group all sites together. Growth rates of ammocoetes depend on many factors which may be variable between large distances within the catchment.

The lower Eden length frequency histogram was calculated from data grouped from sites 19 to 22; the middle Eden from data grouped from sites 5 to 13 and the upper Eden from data grouped from sites 1 to 4 and 14 to 18.

A total of 35 *Lampetra spp* were caught in the lower Eden, of which none had reached transformer stage. The lengths ranged from 18 to 128 mm with a mean length of 58 mm. At

least two age cohorts were present at most sites within the River Eden catchment, where ammocoetes were caught (Table 4.1).

In the lower Eden, the 0+ cohort was likely to be made up of individuals up to around 50 mm in length (Figure 4–5). There appear to be three older cohorts on the lower Eden sites. The data indicates that the 0+ age cohort is the most numerous in this section of the River Eden and the number caught generally reduced as the age cohort got older. This trend would be expected in successful ammocoete spawning and survival.

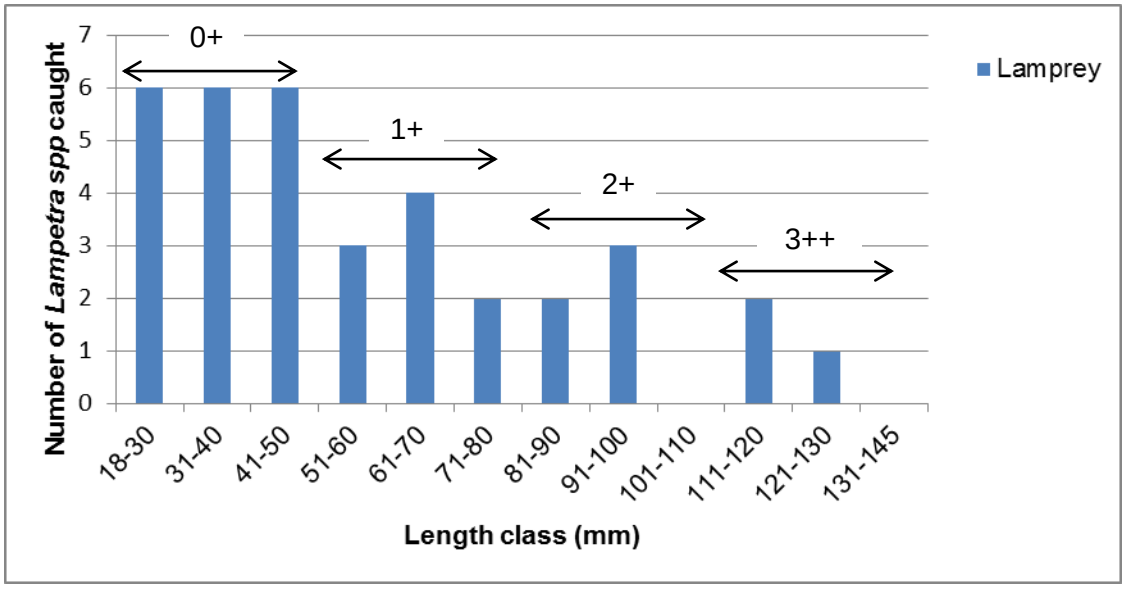

Figure 4–5 Frequency distribution of *Lampetra spp* ammocoete length classes on the lower Eden

A total of 25 *Lampetra spp* were caught in the middle Eden, of which two had reached transformer stage (at site 10). The Lengths ranged from 21 to 141 mm with a mean length of 90 mm.

In the middle Eden the 0+ cohort appears to be made up of individuals up to around 50 mm in length (Figure 4–6). The data indicate there were three older cohorts on the middle Eden sites. The data indicates that the 0+ age cohort is less numerous than older cohorts and that the older cohorts are similar in number to each other. This indicates a variation in the distribution of the age cohorts throughout the catchment.

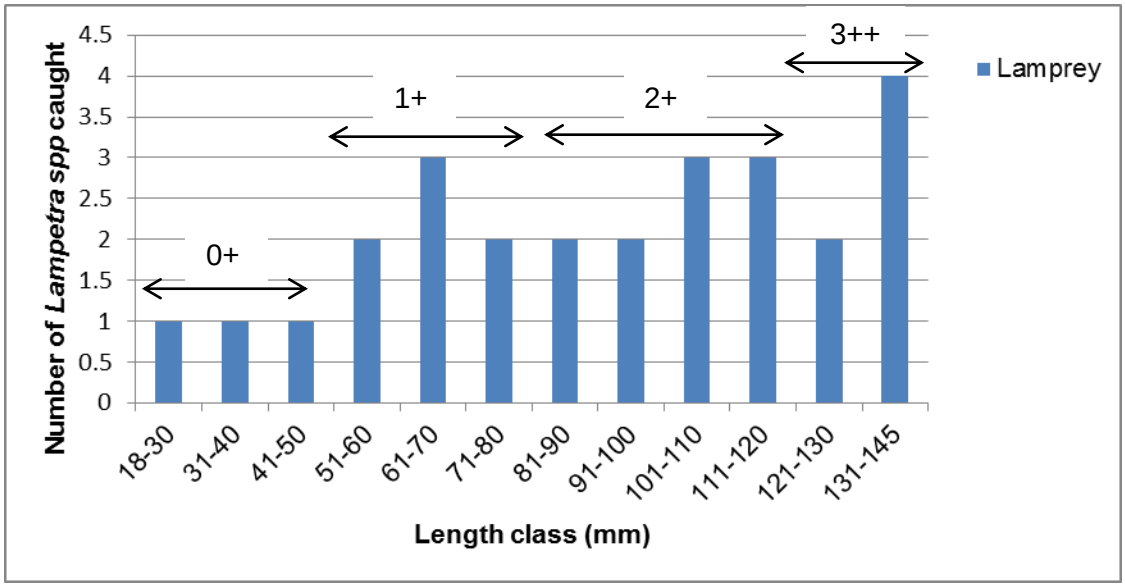

Figure 4–6 Frequency distribution of *Lampetra spp* ammocoete length classes on the middle Eden

A total of 15 *Lampetra spp* were caught in the upper Eden, of which two had reached transformer stage (sites 2 and 16). The lengths ranged from 38 to 144 mm with a mean length of 111 mm.

In the upper Eden the 0+ cohort appears to be made up of individuals up to around 40 mm in length (Figure 4–7). There was only one individual less than 90 mm in length caught in the upper Eden. The total number of lamprey caught was much lower than in the middle and lower parts of the catchment and those that were caught were of the older age cohorts. The data indicates the presence of three age cohorts in the upper Eden, although there is an obvious gap in individuals between 40 and 90 mm in length, indicating at least one missing age cohort.

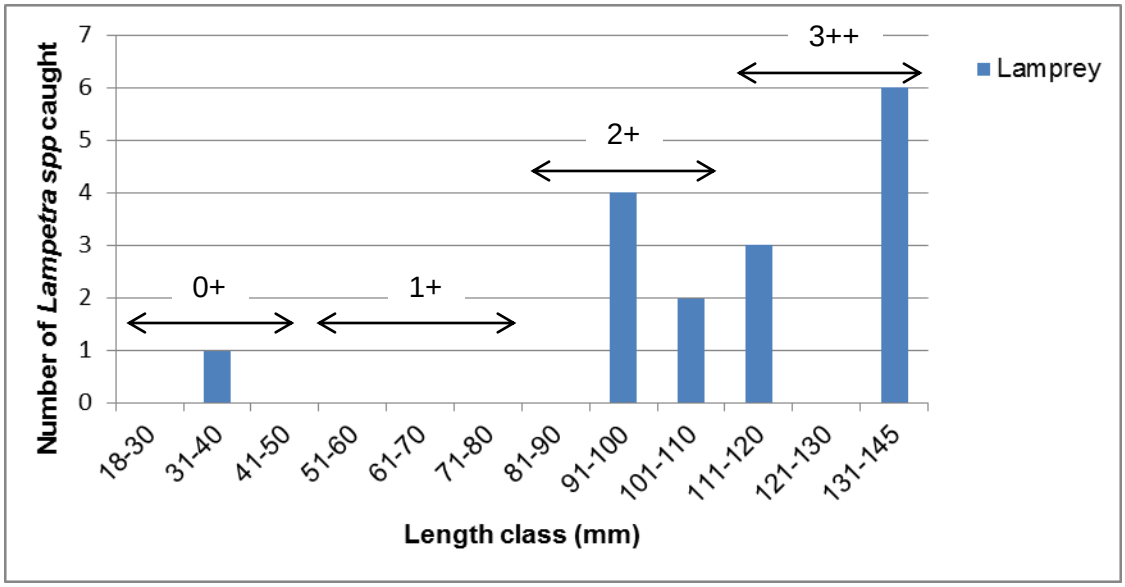

Figure 4–7 Frequency distribution of *Lampetra spp* ammocoete length classes on the upper Eden

Table 4.1 Total Lampetra spp catch and age cohorts present at each sampling site in the Eden

Site	Total catch	Age cohorts present
Eden 1	0	
Eden 2	4	III
Eden 3	0	
Eden 4	0	
Eden 5	0	
Eden 6	0	
Eden 7	0	
Eden 8	0	
Eden 9	7	0,I,II
Eden 10	3	II, III
Eden 11	12	0, I, II, III
Eden 12	2	0
Eden 13	2	II
Eden 14	0	
Eden 15	5	II, III
Eden 16	5	II, III
Eden 17	0	
Eden 18	1	0
Eden 19	20	0, I,
Eden 20	7	0, I, II
Eden 21	2	II, III
Eden 22	6	0, I, II, II

4.2 River Esk catchment

4.2.1 Habitat availability

Optimal habitats were recorded at 75% (6/8) of sites in the Esk, while sub-optimal sites were recorded at 88% (7/8) of sites. Either optimal or sub-optimal ammocoete habitat was recorded at all sites.

4.2.2 Geographic distribution

The *Lampetra spp* ammocoetes were caught throughout most of the extent surveyed of the River Esk catchment (Figure 4–8). Ammocoetes were caught at the very lower extent of the catchment surveyed and as high up as site 7. Ammocoetes were caught at six of the eight sites surveyed (75%). Both no catch sites were in the upper reaches of the River Esk.

In optimal habitat, ammocoetes were caught in 100% (6/6) of sites, while in sub-optimal habitat ammocoetes were caught in 25% (2/8) of sites.

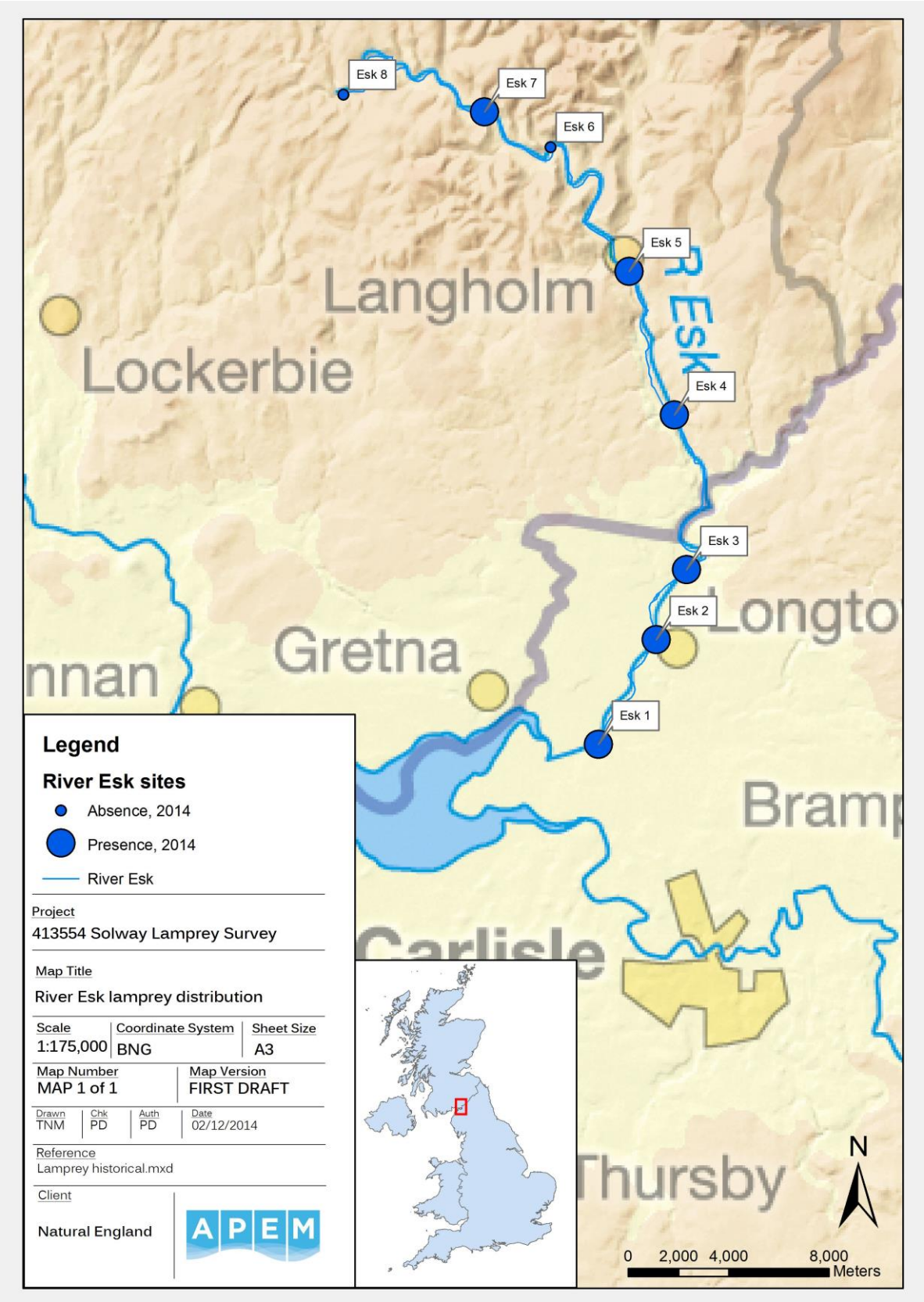

Figure 4–8 Location of *Lampetra spp* ammocoetes caught in the River Esk catchment

4.2.3 Densities

The mean density of *Lampetra spp* in the River Esk catchment was 6 m^{-2} in optimal habitat and 2.5 m^{-2} in sub-optimal habitat. When optimal and suboptimal habitats are considered together the mean density was 4.3 m^{-2}.

The absolute density of ammocoetes varied between sites (Figure 4–9). Only one individual was caught at sites 1 and 3 while 13 ammocoetes were calculated to be at site 7. Where ammocoetes were caught, there was a general pattern of increased density upstream with the exception of site 2.

Ammocoetes were only caught in sub-optimal habitat at two of the eight sites; however at site 7 the absolute density of ammocoetes was higher in sub-optimal habitat than in optimal habitat.

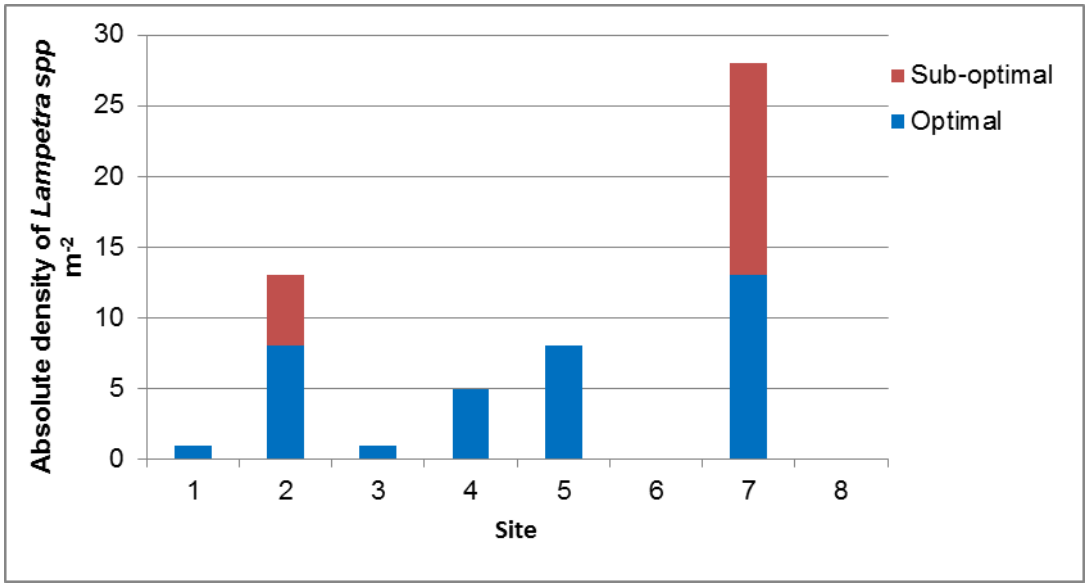

Figure 4–9 Absolute density of Lampetra spp ammocoetes at sites across the Esk catchment

4.2.4 Population structure

A total of 41 *Lampetra spp* were caught on the River Esk, of which none had reached transformer stage. The lengths ranged from 20 to 142 mm with a mean length of 68 mm. At least two age cohorts were present at most sites within the River Esk catchment, where ammocoetes were caught (Table 4.2).

In the River Esk the 0+ age cohort appears to be made up of individuals up to 50 mm in length (Figure 4–10). In addition, the data indicates the presence of three older age cohorts. The data indicates that the younger cohorts (up to approximately 110 to 120 mm in length) are more numerous than the older cohorts, which is an expected trend as age cohort populations are reduced over time due to pressures such as predation.

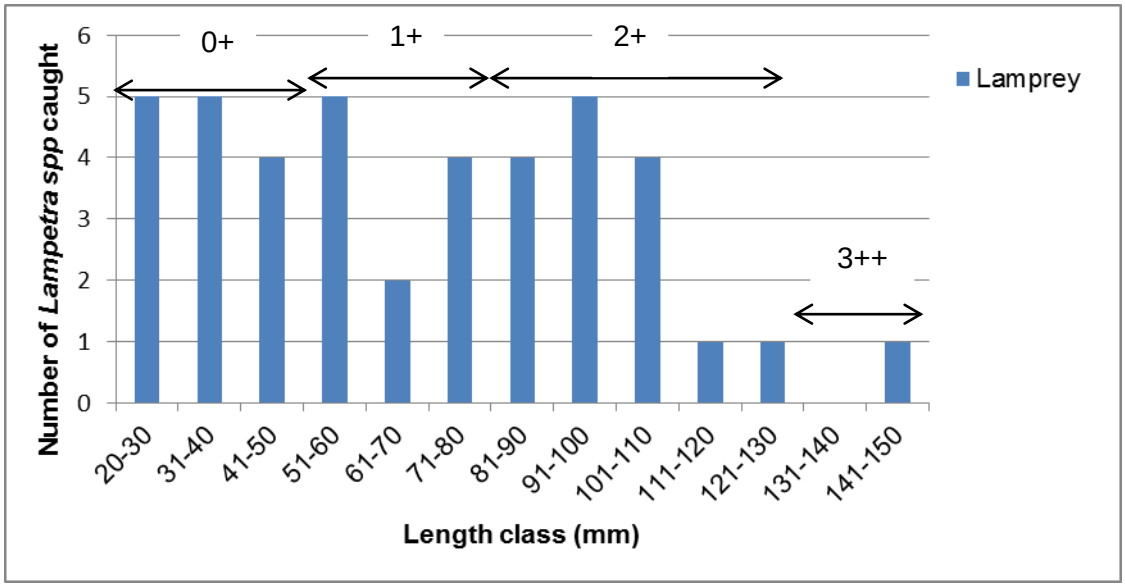

Figure 4–10 Frequency distribution of Lampetra spp ammocoete length classes on the River Esk

Table 4.2 Total *Lampetra spp.* catch and age cohorts present at each sampling site in the Esk

Site	Total catch	Age cohorts present
Esk 1	1	I
Esk 2	9	0, I
Esk 3	1	II
Esk 4	4	0, I, II
Esk 5	7	0, I, II, II
Esk 6	0	
Esk 7	19	0, I, II, III
Esk 8	0	

4.3 River Wampool catchment

4.3.1 Habitat availability

Optimal and sub-optimal habitats were recorded at 100% (5/5) of sites in the Wampool.

4.3.2 Geographic distribution

The *Lampetra spp* ammocoetes were caught at only two sites (sites 2 and 3) within the River Wampool catchment (40%); these sites were in the middle of the catchment (Figure 4–11). No ammocoetes were caught in the upper or lower reaches of the catchment.

In optimal habitat, ammocoetes were caught in 40% (2/5) of sites, while in sub-optimal habitat ammocoetes were caught in 20% (1/5) of sites.

Due to survey constraints mentioned in Section 3.1 , a number of the tributaries to the River Wampool were not surveyed and therefore the extent of *Lampetra spp* may extend into these tributaries.

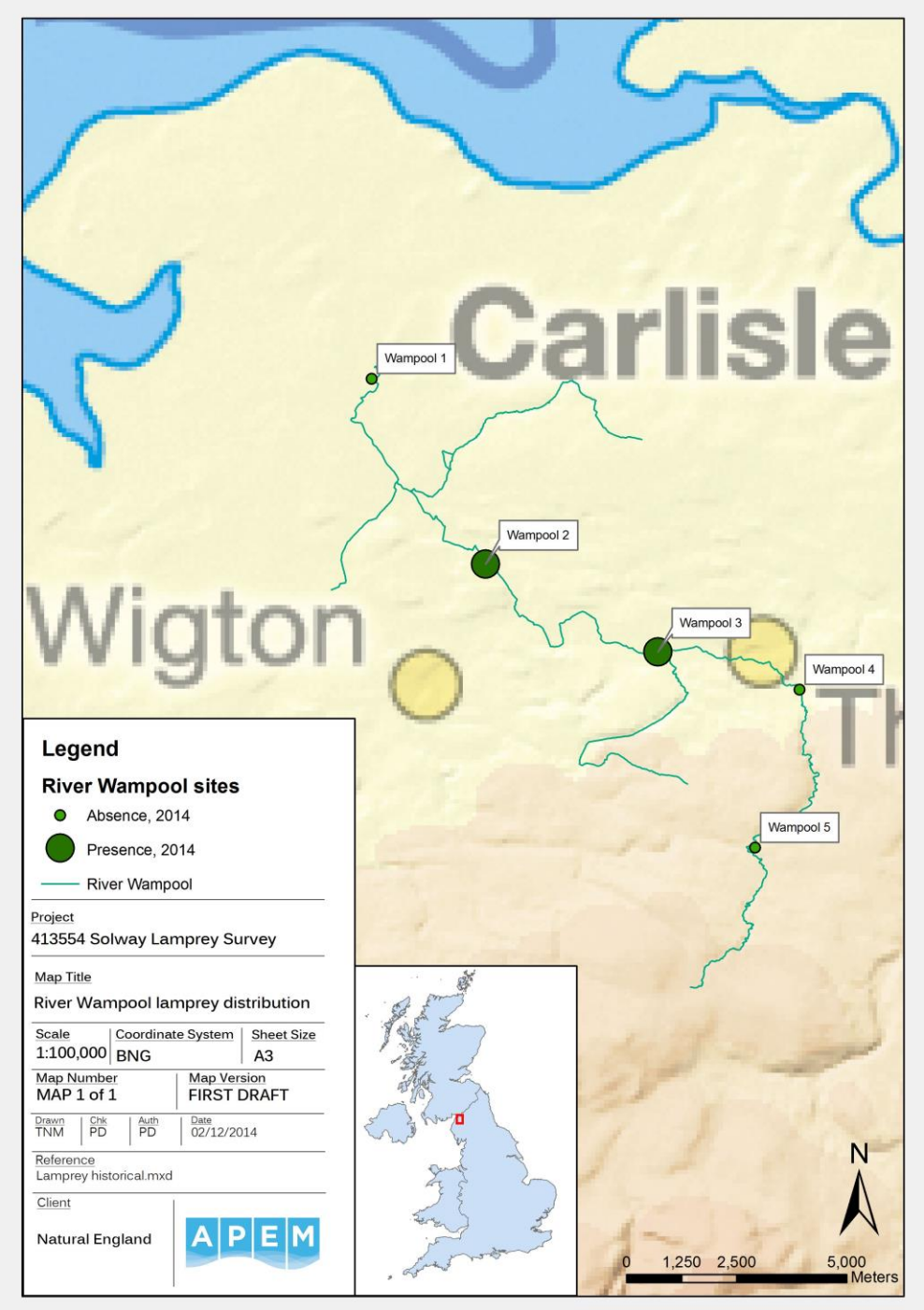

Figure 4–11 Location of *Lampetra spp* ammocoetes caught in the River Wampool catchment

4.3.3 Densities

The mean density of *Lampetra spp* in the River Wampool catchment was 4.2 m^{-2} in optimal habitat and 4.5 m^{-2} in sub-optimal habitat. When optimal and suboptimal habitats are considered together the mean density was 4.4 m^{-2}.

The absolute density of ammocoetes was concentrated very much in the middle of the catchment, at sites 2 and 3 (Figure 4–12). With the exception of one ammocoete caught at site 2, all were caught at site 3.

Site 3 was the only site where ammocoetes were caught at sub-optimal habitat, where the absolute density was calculated to be slightly higher in sub-optimal habitat than in optimal habitat. The ammocoete habitat at this site was of high quality compared to the rest of the catchment and as such, the sub-optimal habitat was also of high quality and supported many ammocoetes.

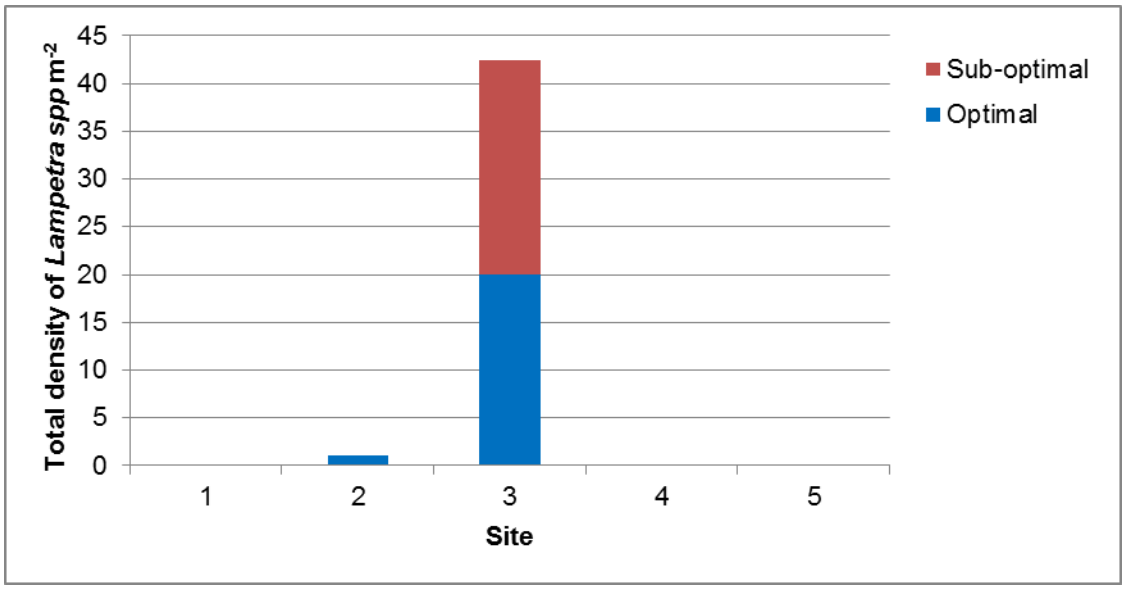

Figure 4–12 Absolute density of Lampetra spp ammocoetes at sites across the Wampool catchment

4.3.4 Population structure

A total of 27 *Lampetra spp* were caught on the river Wampool, of which two had reached transformer stage. These two were caught at sites 2 and 3. The lengths ranged from 35 to 163 mm, with a mean length of 90 mm. At least two age cohorts were present at one of the two sites within the River Wampool catchment, where ammocoetes were caught (Table 4.3).

In the River Wampool catchment, the 0+ cohort appears to be made up of one individual at 35 mm in length within the individuals caught during this sampling exercise. There may be up to two further cohorts, though the oldest is made up of one individual at 163 mm, which was a transformer caught at site 2. The lack of individuals in the 0+ age cohort suggests that spawning and / or the young of the year may not have been successful within this catchment however, due to the limited number of sites further investigation would be

required to substantiate this. The one or two age cohorts between 60 and 120 mm in length are present at site 3 in strong numbers.

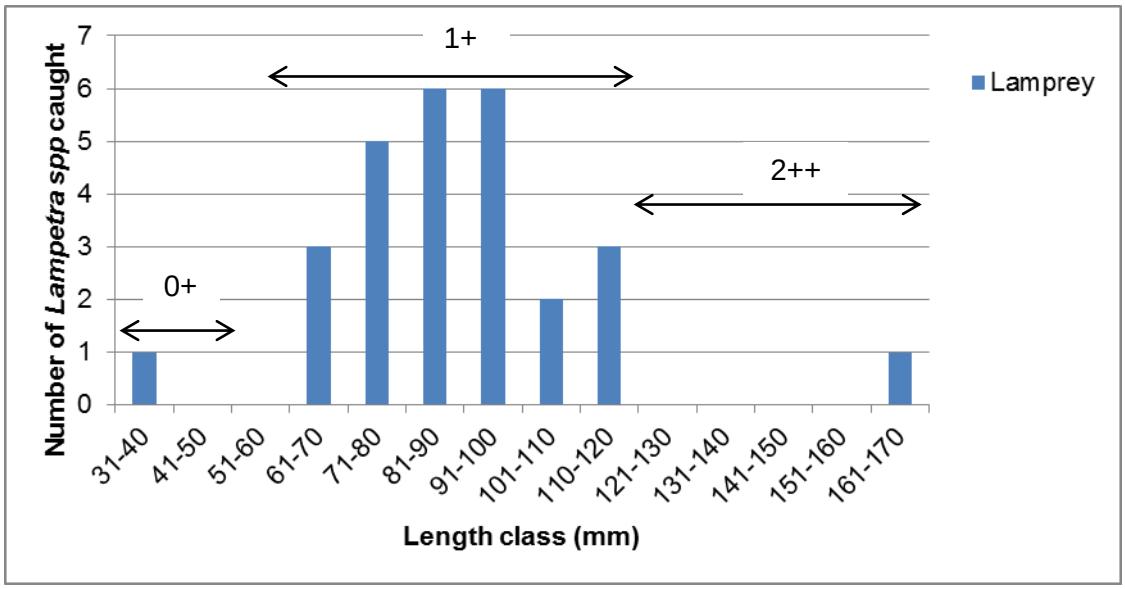

Figure 4–13 Frequency distribution of *Lampetra spp* ammocoete length classes on the River Wampool

Table 4.3 Total *Lampetra spp.* catch and age cohorts present at each sampling site in the Wampool

Site	Total catch	Age cohorts present
Wampool 1	0	
Wampool 2	1	II
Wampool 3	26	0, I, II
Wampool 4	0	
Wampool 5	0	

4.4 River Waver catchment

4.4.1 Habitat availability

Optimal habitats were recorded at 60% (3/5) of sites in the Waver, while sub-optimal sites were recorded at 100% (5/5) of sites. Either optimal or sub-optimal ammocoete habitat was recorded at all sites.

4.4.2 Geographic distribution

The *Lampetra spp* ammocoetes were caught at three of the five sites surveyed (60%) within the River Waver catchment (Figure 4–14). Ammocoetes were present at sites 2 and 3 in the

middle reaches and at site 5 on the tributary, Little Waver. No ammocoetes were caught at the upstream or downstream extent of the River Waver (sites 4 and 1 respectively).

In optimal habitat, ammocoetes were caught in 100% (3/3) of sites, while in sub-optimal habitat ammocoetes were caught in 20% (1/5) of sites.

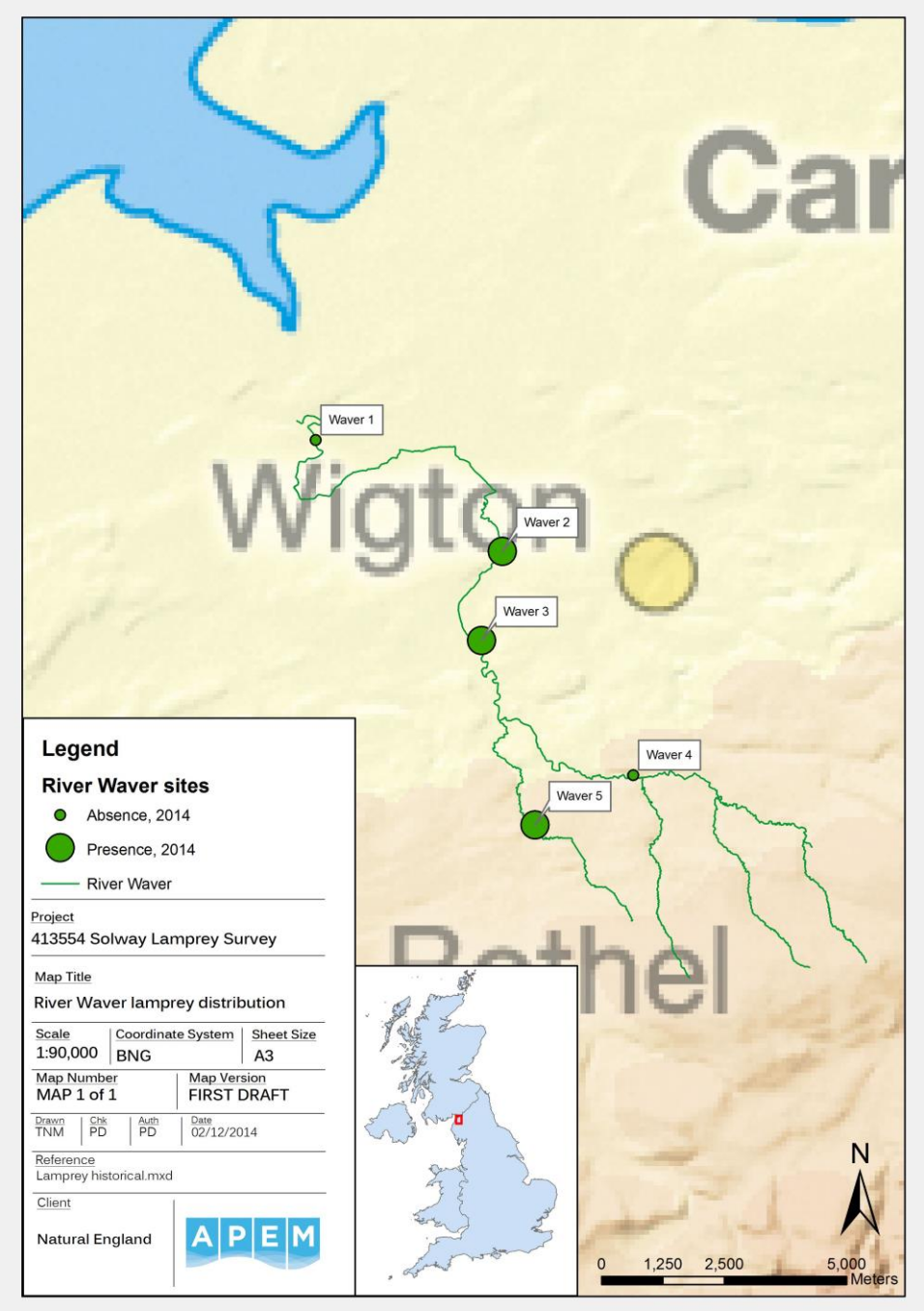

Figure 4–14 The location of *Lampetra spp* ammocoetes caught in the River Waver catchment

4.4.3 Densities

The mean density of *Lampetra spp* in the whole Waver catchment was 5.7 m^{-2} in optimal habitat and 1 m^{-2} in sub-optimal habitat. When optimal and suboptimal habitats are considered together the mean density was 3.3 m^{-2}. The absolute density of ammocoetes was similar at all sites where ammocoetes were present, ammocoetes were not present at sites 1 and 4 (Figure 4–15), where not optimal habitat was recorded.

Site 2 was the only site where ammocoetes were caught at sub-optimal habitat, where the absolute density was calculated to be the same in both optimal and sub-optimal habitat.

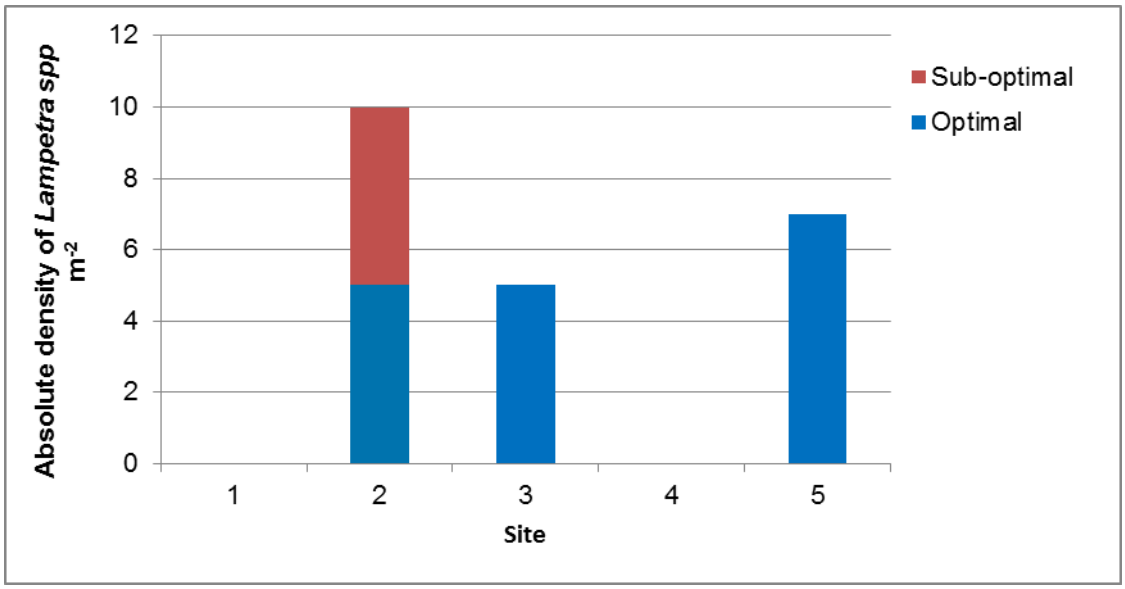

Figure 4–15 Absolute density of Lampetra spp ammocoetes at sites across the Waver catchment

4.4.4 Population structure

A total of 18 *Lampetra spp* were caught on the River Waver, of which one (at site 5) had reached transformer stage. The lengths ranged from 31 to 164 mm with a mean length of 112 mm. At least two age cohorts were present at most sites within the River Waver catchment, where ammocoetes were caught (Table 4.4).

In the River Waver catchment, the 0+ cohort was likely to be made up of individuals up to approximately 70 mm in length (Figure 4–16). There may be up to two older cohorts in the River Waver sites. The 0+ cohort is the least numerous compared to the older cohorts however, no cohort is obviously stronger in numbers than others. This coupled with the low catch numbers may indicate that the whole population is low but many of those that do survive their first year go on to survive further years. However, there appears to be at least one age cohort missing in the catch data, between 70 and 100 mm. This may be due to poor recruitment in recent years.

It should be noted that for more accurate data, more than five sites within this catchment should be surveyed.

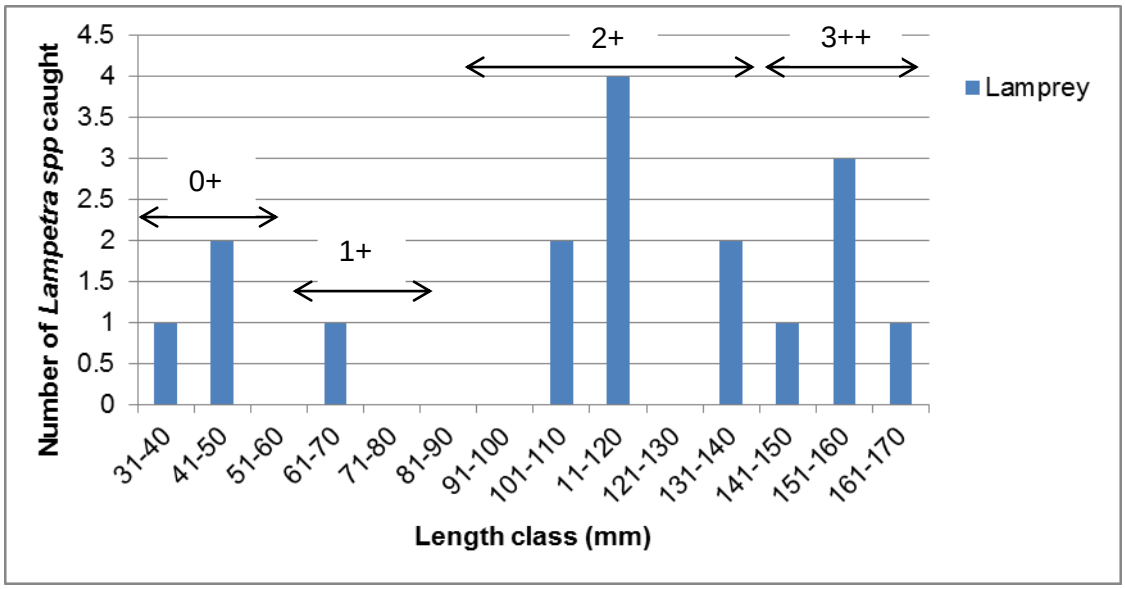

Figure 4–16 Frequency distribution of *Lampetra spp* ammocoete length classes on the River Waver

Table 4.4 Total *Lampetra spp.* catch and age cohorts present at each sampling site in the Waver

Site	Total catch	Age cohorts present
Wampool 1	0	
Wampool 2	8	I, II
Wampool 3	4	I
Wampool 4	0	
Wampool 5	6	0, III

6. Conclusion

6.1 Condition and historical comparison

6.1.1 The River Eden

The lower and middle sections of the Eden complied with the target of ammocoetes present in at least 2/3 (67%) of sites surveyed however; ammocoetes were only recorded at 44% of sites in the upper Eden. Ammocoetes were recorded at 59% of sites in the Eden taken as a whole, which is slightly lower than the JNCC target (Table 6.2). Barriers to migration did not appear to be limiting the distribution of ammocoetes. Only one impassable barrier is known on the River Eden, which was a natural barrier and upstream of a no catch site, indicating the natural extent of lamprey may be downstream of this barrier. However, as there was only one no catch site (site 3) downstream near the barrier, the absence of ammocoetes may be due to specific conditions at site 3.

With regard to the influence of flow regimes on ammocoete distribution, a negative relationship was shown by potter et al (1986) between ammocoetes and current velocity in autumn, indicating ammocoetes may be flushed out of nursery habitat by high flows and substrate remobilisation. These ammocoetes would be redistributed to habitats of fine sediment in low velocity areas of the river. The flow regime of the current study was low at the time of the survey; therefore redistribution of ammocoetes due to the flow regime is unlikely to have occurred recently. However, low flows may have impacted some lamprey habitat where they were susceptible to desiccation, such that mortality or ammocoete redistribution to deeper habitats may have occurred recently.

In order to determine whether lamprey ammocoete abundance and distribution had changed compared to previous sampling years, data collected in the 2014 sampling season was statistically compared with data collected by the Environment agency in 2002 (Harvey & Cowx, 2003). The data from the 2002 survey was chosen for comparison as the survey method adopted was the same targeted lamprey sampling method as the 2014 survey, and the sampling sites were the same in both years thus offering a direct comparison. The mean number of ammocoetes caught in the 2002 samples is greater than the mean number of ammocoetes in 2014, however the standard deviation from the mean was much higher in 2002 due to some large catches at certain sites compared to others. The difference in abundance between the two sampling years was not statistically significant (Mann-Whitney, $p=0.986$). In order to further investigate shifts in distribution and abundance between years, a more thorough sampling regime which includes increased sample replication/effort over each of the sites would be needed. Table 6.1 below shows the total number of ammocoetes caught at 18 sites in 2002 and 2014.

Table 6.1 Total ammocoete catch at 18 sampling sites in the Eden Catchment in 2002 and 2014.

Site	Watercourse	NGR	Total Catch per 1m^2 in 2002	Total Catch per 1m^2 in 2014
1	Scandal Beck	NY7350008500	0	0
2	Scandal Beck	NY7490010900	5	3
3	River Eden	NY7760008900	0	0
4	Swindale Beck	NY7970014700	0	0
5	Carrock Beck	NY3380035000	0	0
6	Park End Beck	NY2880037100	0	0
7	Park End Beck	NY3010038900	0	0
8	Park End Beck	NY3230039800	0	0
9	Skirwith Beck	NY6170032700	53	7
10	River Eamont	NY4710024500	0	1
11	River Eamont	NY5240028700	0	12
12	River Eamont	NY5240028700	1	1
13	Crowdundle Beck	NY6090028100	24	2
14	River Lyvennet	NY6260016400	0	0
15	Helm Beck	NY7020016600	48	5
16	Helm Beck	NY7090014900	23	4
17	Hilton Beck	NY7320020800	0	0
18	Eden	NY6830020600	3	1
		Mean	**8.7**	**2.0**
		St.Dev	**16.9**	**3.2**

The data from this survey was also compared to the most recent survey conducted by the Environment Agency in 2012 (Table 6.2). In 2012, the Eden catchment was surveyed for ammocoetes at several sites, some of which were located at or near to those surveyed in 2014 however, the methods used in 2012 did not specifically target lamprey. Ammocoetes were caught at eight out of 49 sites (16%) in 2012 compared to 12 out of 22 sites (52%) in 2014. This suggests that the distribution of ammocoetes has not reduced and in fact may have increased. As such, the Eden catchment met the target set by JNCC. It should be noted however, that the sites surveyed are spot sampling and that where no ammocoetes were recorded there may still have been ammocotes that were not caught due to a variety of reasons (e.g. access restrictions or limited resources).

The River Eden failed to reach the ammocoete mean density target of >10 m^{-2} in optimal habitat or >5 m^{-2} in the overall catchment.

In each of the lower, middle and upper Eden sections, where less than 50 individuals were caught, there were at least two age classes identified (up to four, four and three size classes present respectively). This complies with the target set out by the JNCC of at least two size classes present.

The Eden catchment met the targets set out by JNCC with respect to distribution relative to previous surveys and presence of age classes across the catchment. However, the Eden catchment failed to reach the target for geographic distribution among sites surveyed and density in optimal habitat and in the overall catchment.

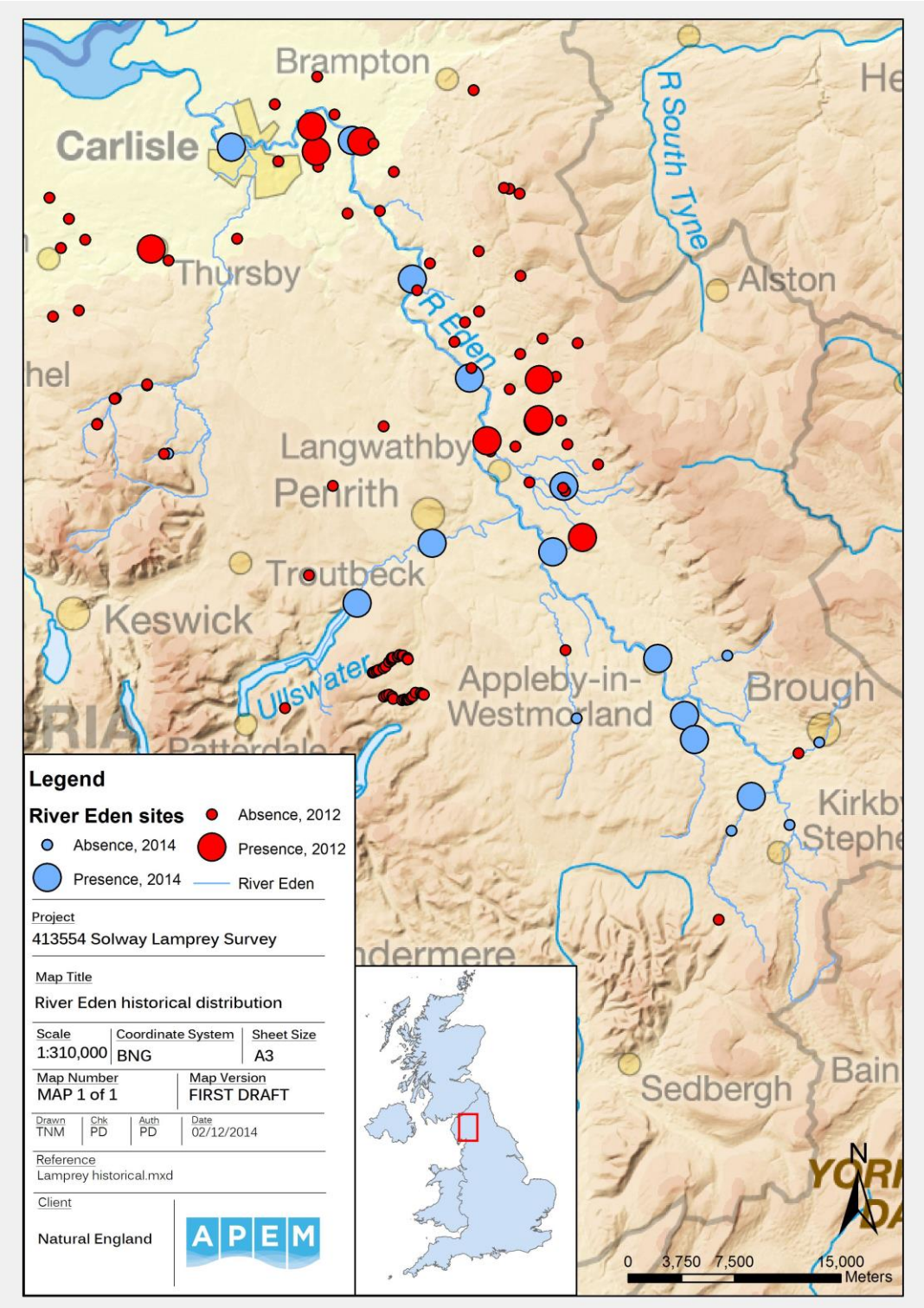

Figure 6–1 Distribution of ammocoetes in surveys in 2012 and 2014 in the Eden catchment

1.1.1 The River Esk

In the River Esk, ammocoetes were present at 75% of sites, which exceeds the JNCC target (Table 6.2).

The data from this survey was compared to the most recent survey conducted by the Environment Agency in 2012 (Figure 6–2). The Esk catchment was surveyed for lamprey at several sites, a few of which were located at or near those surveyed in 2014 however, the methods used in 2012 did not specifically target lamprey. In 2012 there were no ammocoetes found in the Esk catchment out of five sites surveyed, while ammocoetes were found at six out of eight sites, thereby exceeding the JNCC target. No impassable barriers are known within the reach surveyed on the River Esk, indicating migration may not be limited by barriers.

With regard to the influence of flow regimes on ammocoete distribution, a negative relationship was shown by potter et al (1986) between ammocoetes and current velocity in autumn, indicating ammocoetes may be flushed out of nursery habitat by high flows and substrate remobilisation. These ammocoetes would be redistributed to habitats of fine sediment in low velocity areas of the river. The flow regime of the current study was low at the time of the survey; therefore redistribution of ammocoetes due to the flow regime is unlikely to have occurred recently. However, low flows may have impacted some lamprey habitat where they were susceptible to desiccation, such that mortality or ammocoete redistribution to deeper habitats may have occurred recently.

Ammocoete density in the River Esk failed to reach the target mean of >10 m^{-2} in optimal habitat or >5 m^{-2} in the overall catchment.

In the River Esk, where less than 50 individuals were caught, there were at least two size classes identified (up to four size classes present), which exceeds the target set out by the JNCC.

The Esk catchment exceeded the targets set out by JNCC with respect to geographic distribution among sites surveyed, distribution relative to previous surveys and presence of age classes across the catchment. However, the Esk catchment failed to reach the target for density in optimal habitat and in the overall catchment.

.

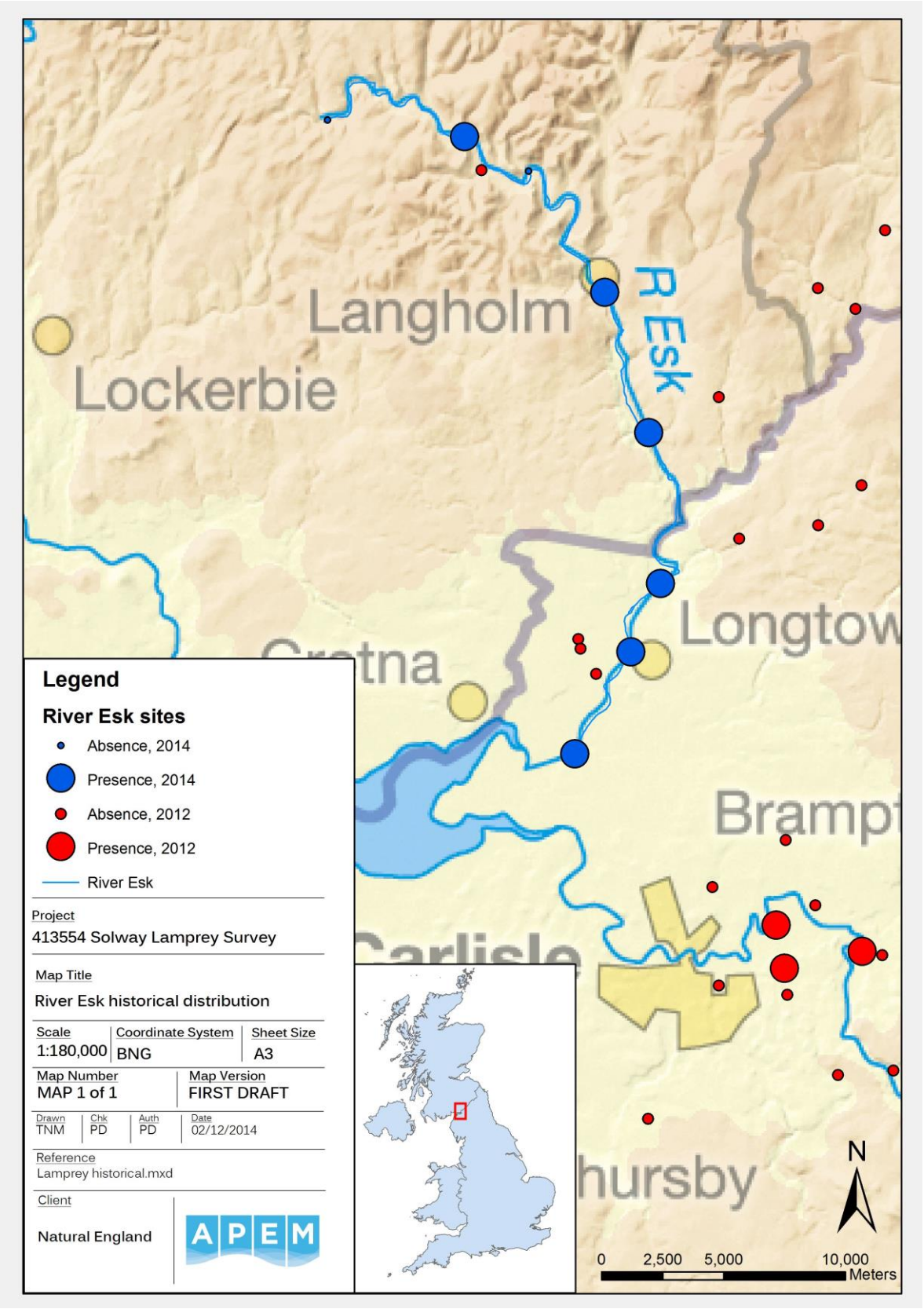

Figure 6–2 Distribution of ammocoetes in surveys in 2012 and 2014 in the Esk catchment

1.1.2 The River Wampool

In the River Wampool, ammocoetes were only recorded at 40% of sites surveyed, which is lower than the target of 67% (Table 6.2).

The data from this survey was compared to the most recent survey conducted by the Environment Agency in 2012 (Figure 6–3) however, the methods used in 2012 did not specifically target lamprey. In 2012, ammocoetes were only caught at one out of six sites (16%), while they were caught at two sites in 2014. Although ammocoetes were caught further upstream in 2012, the distribution of the population was considered to have increased because they were caught at more sites, thereby exceeding the JNCC target. No impassable barriers are known within the reach surveyed on the River Wampool, indicating migration may not be limited by barriers.

With regard to the influence of flow regimes on ammocoete distribution, a negative relationship was shown by potter et al (1986) between ammocoetes and current velocity in autumn, indicating ammocoetes may be flushed out of nursery habitat by high flows and substrate remobilisation. These ammocoetes would be redistributed to habitats of fine sediment in low velocity areas of the river. The flow regime of the current study was low at the time of the survey; therefore redistribution of ammocoetes due to the flow regime is unlikely to have occurred recently. However, low flows may have impacted some lamprey habitat where they were susceptible to desiccation, such that mortality or ammocoete redistribution to deeper habitats may have occurred recently.

Ammocoete density in the River Wampool failed to reach the target mean of >10 m^{-2} in optimal habitat however, the density was 4.4 m^{-2} in the overall catchment which falls only slightly short of the target of 5 m^{-2} set by JNCC.

In the River Wampool, where less than 50 individuals were caught, there were at least two size classes identified (up to four size classes present), which complies with the target set out by the JNCC.

The Wampool catchment exceeded the targets set out by JNCC with respect to distribution relative to previous surveys and presence of age classes across the catchment. However, the Wampool catchment failed to reach the target for geographic distribution among sites surveyed and density in optimal habitat and in the overall catchment.

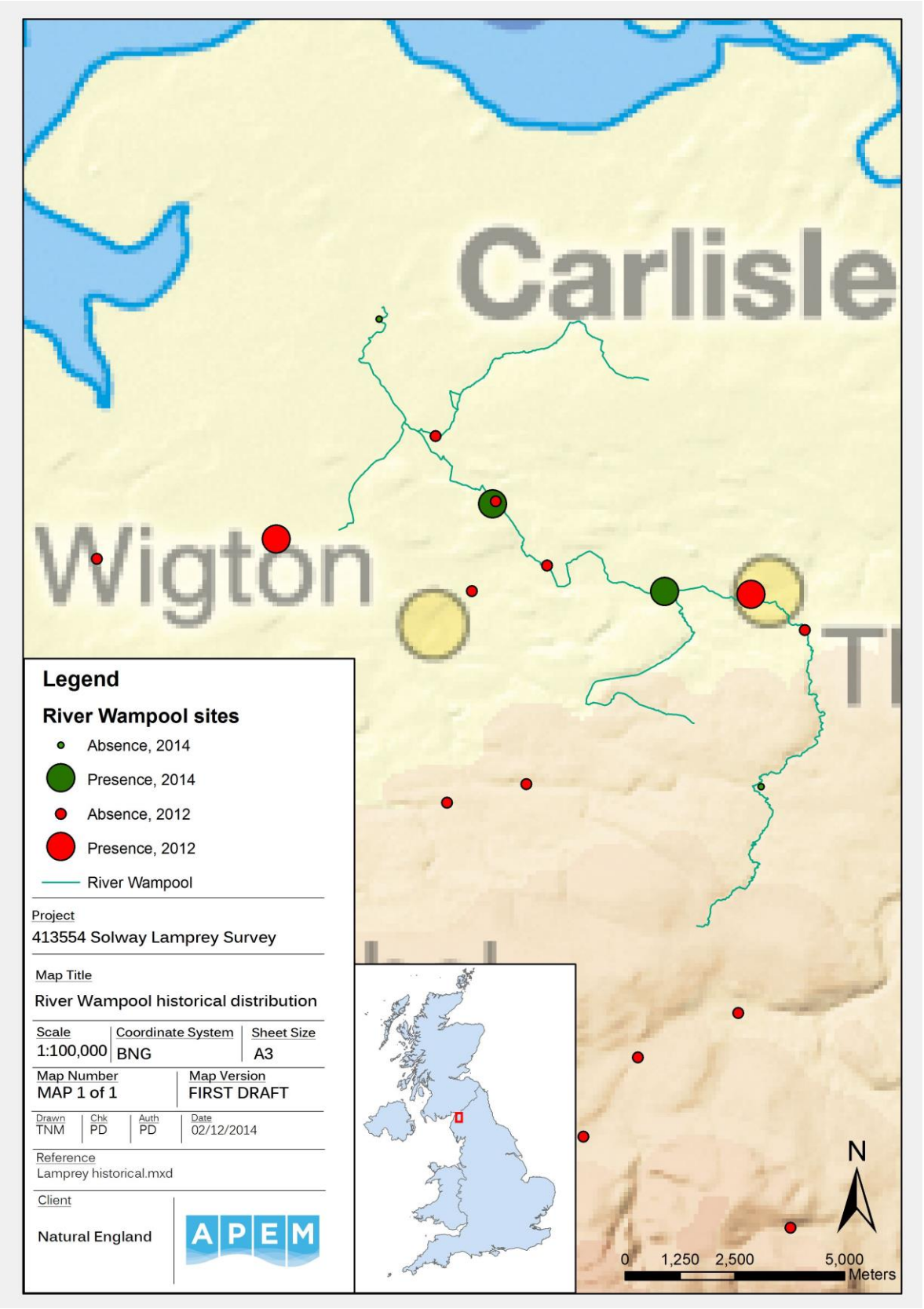

Figure 6–3 Distribution of ammocoetes in surveys in 2012 and 2014 in the Wampool catchment

1.1.3 The River Waver

In the River Waver, ammocoetes were only recorded at 60% of sites surveyed, which is slightly lower than the target of 67% (Table 6.2). The data from this survey was compared to the most recent survey conducted by the Environment Agency in 2012 however, the methods used in 2012 did not specifically target lamprey. In 2012, ammocoetes were caught at only one out of five sites (20%) in the Waver catchment, while they were caught at three sites in 2014 (Figure 6–4). The extent of ammocoetes was recorded further downstream in 2012 than in 2014 however they were recorded much further upstream and at more sites. The distribution of the population was therefore considered to have increased thereby exceeding the JNCC target. However, it should be noted that the confidence in the change in distribution of lamprey ammocoetes is limited due to the low catch in both surveys. Further surveys with additional sites would be recommended to confirm this expansion of the population. No impassable barriers are known within the reach surveyed on the River Waver, indicating migration may not be limited by barriers.

With regard to the influence of flow regimes on ammocoete distribution, a negative relationship was shown by potter et al (1986) between ammocoetes and current velocity in autumn, indicating ammocoetes may be flushed out of nursery habitat by high flows and substrate remobilisation. These ammocoetes would be redistributed to habitats of fine sediment in low velocity areas of the river. The flow regime of the current study was low at the time of the survey; therefore redistribution of ammocoetes due to the flow regime is unlikely to have occurred recently. However, low flows may have impacted some lamprey habitat where they were susceptible to desiccation, such that mortality or ammocoete redistribution to deeper habitats may have occurred recently.

Ammocoete density in the River Waver failed to reach the target mean of >10 m^{-2} in optimal habitat or >5 m^{-2} in the overall catchment.

In the River Waver, where less than 50 individuals were caught, there were at least two size classes identified (up to three size classes present), which complies with the target set out by the JNCC.

The Waver catchment exceeded the targets set out by JNCC with respect to distribution relative to previous surveys and presence of age classes across the catchment. However, the Waver catchment failed to reach the target for geographic distribution among sites surveyed and density in optimal habitat and in the overall catchment.

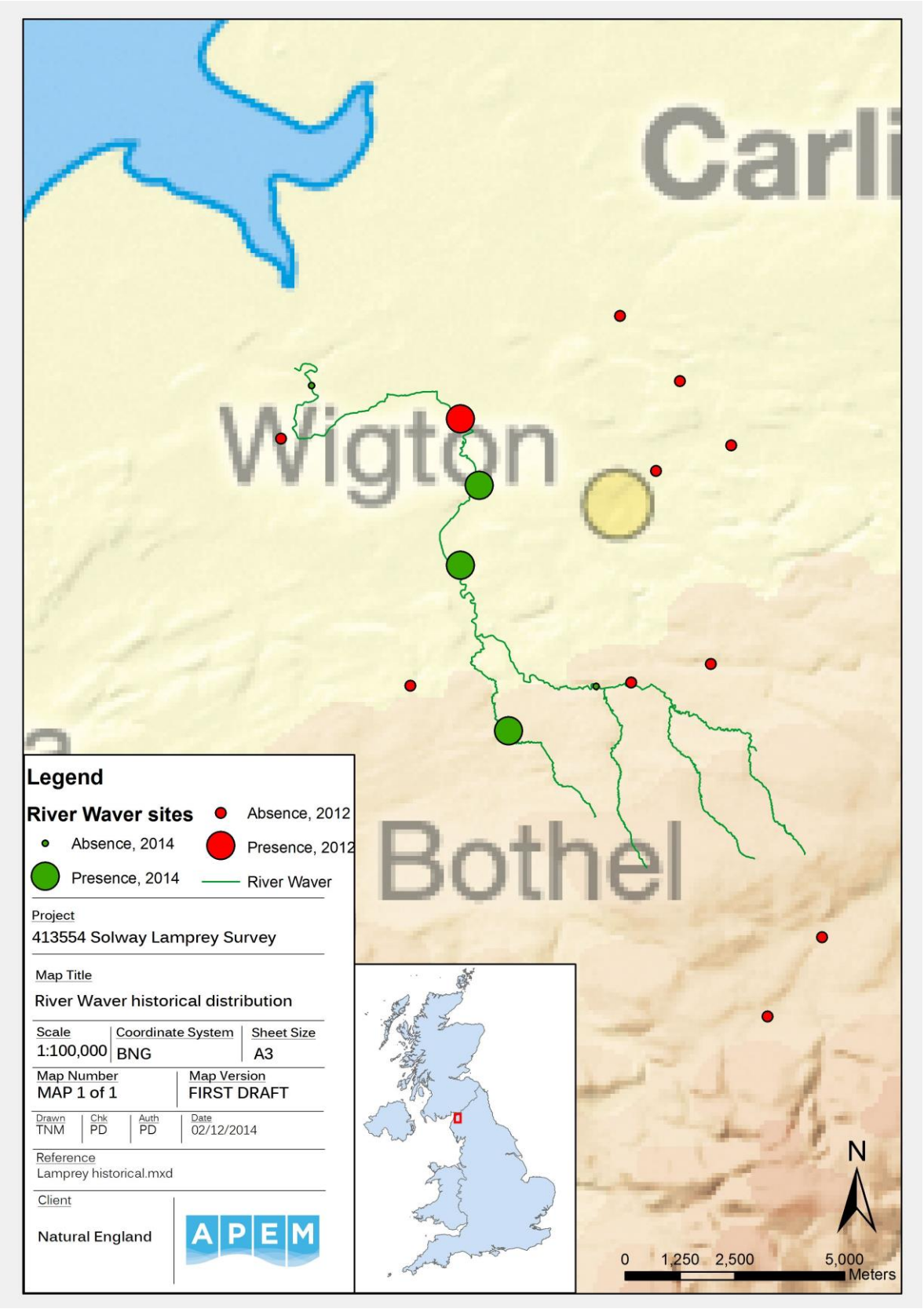

Figure 6–4 Distribution of ammocoetes in surveys in 2012 and 2014 in the Waver catchment

Table 6.2 Preliminary indication of condition of *Lampetra spp.* for catchments in the Solway Firth.

Favourable condition target	Lower Eden	Middle Eden	Upper Eden	Esk	Wampool	Waver
Distribution						
Present at not less than 2/3 of sites surveyed	No (59%)			Yes (75%)	No (40%)	No (60%)
No reduction in distribution	Yes			Yes	Yes	Yes
Ammocoete density						
Lampetra spp: Optimal habitat: >10 m^{-2}	No (5.4)			No (6)	No (4.2)	No (5.7)
Overall catchment mean: >5m^{-2}	No (3.1)			No (4.3)	No (4.4)	No (3.3)
Age Structure						
For samples of 50 or less, at least two distinct size classes	Yes	Yes	Yes	Yes	Yes	Yes
Overall	No	No	No	No	No	No

2. Summary and recommendations

2.1 Key points

2.1.1 Solway Firth

- 40 sites, across four river catchments, were surveyed for Lampetra spp and *P. marinus*.
- *Lampetra spp.* were recorded at 24 sites.
- No *P. marinus* were caught throughout all four catchments surveyed.
- All four catchments failed to comply with at least one JNCC target for habitat condition. This was generally due to low densities in optimal habitat and overall catchments.

2.1.2 River Eden catchment

- The Eden catchment was not in favourable condition status for *Lampetra spp*.
- *Lampetra spp* ammocoetes were distributed across the majority of the catchment and at more sites over a greater extent than in 2012.
- Impassable barriers may not be affecting distribution within the catchment however, further surveys near the barrier in Kirkby Stephen to establish higher resolution of the population extent would be recommended.
- Absolute density within the Eden was generally similar across sites, although lower than the JNCC target in each of the three sub-catchments.
- At least two age cohorts were identified in each section of the catchment.
- There was good recruitment in general in the River Eden, although there were very few 0+ ammocoetes in the upper reaches.

2.1.3 River Esk catchment

- The Esk catchment was not in favourable condition status for *Lampetra spp*.
- *Lampetra spp* ammocoetes were distributed across the majority of the catchment, while none were caught in the 2012 survey.
- Impassable barriers did not appear to be affecting distribution within the catchment.
- The density of ammocoetes generally increased upstream in the catchment, although was lower than the JNCC target in optimal habitat and the overall catchment.
- At least two age cohorts were identified in the catchment.
- There was good recruitment in general in the River Esk

2.1.4 River Wampool catchment

- The Wampool catchment was not in favourable condition status for *Lampetra spp*.
- *Lampetra spp* ammocoetes were only caught within the middle reaches of the catchment however the extent of the population had increased since 2012.
- Impassable barriers did not appear to be affecting distribution within the catchment.
- The vast majority of ammocoetes were caught at one site, which had among the highest density of all sites across the four catchments.
- The density in the overall catchment was above the JNCC target however, the density in optimal habitat was below the JNCC target.
- At least two age cohorts were identified in the catchment, although the youngest and the oldest cohorts consisted of one individual each.
- Recruitment appears to have failed in the most recent year, with only one individual from the 0+ cohort caught, though more sites should be surveyed to substantiate this.

2.1.5 River Waver catchment

- The Waver catchment was not in favourable condition status for *Lampetra spp*.
- *Lampetra spp* ammocoetes were caught at three of the five sites which was less than the JNCC target for distribution however, the distribution had increased since 2012. The limited catch in both 2012 and the current survey would necessitate further surveys with additional sites to confirm the expansion of the distribution.
- Impassable barriers did not appear to be affecting distribution within the catchment.

- Absolute density within the Eden was generally similar across sites where ammocoetes were present however, it was less than the JNCC target in both optimal habitat and the overall catchment.
- At least two age cohorts were identified in the catchment, although at least one cohort was missing from the 70-100 mm range.
- There may be limited recruitment in the catchment, with fewer 0+ ammocoetes caught than older cohorts, though more sites should be surveyed to substantiate this.

2.2 Recommendations

- Due to resource limitations, only 40 sites could be surveyed for the entire Solway Firth, which meant that the level of resolution within each catchment was reduced and some tributaries were not surveyed (e.g. The river Lyne in the Esk catchment).
- As Harvey & Cowx (2003) recommend 40 sites for each catchment, future surveys should include more sites within each catchment, if resources allow.
- Future surveys should repeat, at least, the current sites, in order to compare population traits over time.
- As long term trends need to be monitored, future condition assessment should be carried out at least every six years, in accordance with the six-year rolling cycle suggested in Harvey and Cowx (2003). As lamprey populations rely quite heavily on yearly recruitment however, a six-year time span will almost certainly be insufficient to pick up problems before they are advanced. If resources can be made available sampling should therefore, be undertaken on a yearly or at least a biyearly basis.

4. References

APEM (2002b). Sampling methodologies for condition assessment within SAC Rivers for adult sea, river and brook lamprey, bullhead and spined loach. Phase IIa Report. LIFE in UK Rivers Project, pp. 38.

Teague, N., Webb, H., Allen, V., Cesar, C. P., Thomas, Rh., and Hatton-Ellis, T. (2012) Lamprey monitoring on the River Dee Special Area of Conservation (SAC) 2011. CCW Contract Science Report No: 975.

Carle, F.L. & Strub, M.R. (1978) A new method for estimating population size from removal data. Biometrics, 34, 621-830.

CEN, (2001) Directive for Water Analysis – Sampling of Fish with Electricity. Work Item 230116, revision of PREN 14011, October 25, 2001

Cowx, I.G. & Harvey, J.P. (2003). Monitoring the bullhead, Cottus gobio. Conserving Natura 2000 Rivers Monitoring Series No. 4, English Nature, Peterborough, pp. 28.

Environment Agency Code of Practice and Electric Fishing Equipment Annex A and B, Issue II regulations (1998)

Gardiner (2003) Identifying Lamprey. A field key for Sea, River and Brook Lamprey. Conserving Natura 2000 Rivers Conservation Techniques Series No. 4. English Nature, Peterborough

Harvey J.P. & Cowx I.G. (2003) Monitoring the River, Brook and Sea Lamprey, Lampetra fluviatilis, L. planeri and Petromyzon marinus. Conserving Natura 2000 Rivers Monitoring Series No. 5, English Nature, Peterborough

Harvey J.P. & Cowx I.G. (2003) Standardised sampling strategies and methodologies for condition assessment for bullheads, sea river and brook lamprey in SAC rivers in the UK, Phase 2b: Testing and Refinement, LIFE in UK Rivers Project.

Hendry, K., and Waterfall, R. (2005). River Axe bullhead and lamprey investigation. APEM scientific report, EA 789.

Joint Nature Conservation Committee (2005), Common Standards Monitoring Guidance for Freshwater Fauna 2005

Maitland (2003) Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5, English Nature, Peterborough

Malmqvist (1980) Habitat selection of larval brook lampreys (*Lampetra planeri*, Bloch) in a South Sweden stream. Oecologia, 45: 35-38.

Potter & Osbourne, (1975) The systematics of British larval lampreys. Journal of Zoology, 176: 311-329.

Potter, I.C., Hilliard, R.W., Bradley, J.S & McKay., R.J. (1986). The influence of environmental variables on the density of larval lampreys in different seasons. Oecologia, 70: 433-440.Thomas, 1962

Natural England is here to secure a healthy natural environment for people to enjoy, where wildlife is protected and England's traditional landscapes are safeguarded for future generations.

Natural England publications are available as accessible pdfs from www.gov.uk/natural-england.

Should an alternative format of this publication be required, please contact our enquiries line for more information: 0300 060 3900 or email enquiries@naturalengland.org.uk.

ISBN: 978-1-78354-914-6

Catalogue code: NECR409

NATURAL ENGLAND