

The establishment of Scotland's rarest freshwater fish, the vendace (*Coregonus albula*), in conservation refuge sites

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ABSTRACT

In recent decades conservation measures for the rarest freshwater fish in the U.K., the vendace (*Coregonus albula*), have included attempts to form conservation refuge populations in Scotland. Here we report that at two of these refuge sites where the status of the introduced vendace was previously unknown (Loch Earn and Daer Reservoir) surveys have established that vendace are reproducing successfully *in situ*, albeit that these populations appear to be relatively numerically small. At a third site, Loch Valley, there was no evidence of vendace in the survey, but it is possible that a small, but as yet undetectable population is in the process of establishing.

INTRODUCTION

The vendace is the rarest freshwater fish in the U.K., having only ever been recorded in historical times from four locations. Two of these are in the English Lake District: Bassenthwaite Lake and Derwent Water; and two in southern Scotland: Castle Loch and Mill Loch, adjacent to the town of Lochmaben in Dumfriesshire (Maitland, 2007) (Fig. 1). Of these, the Bassenthwaite Lake population was thought to have been lost in 2008 (Winfield *et al.*, 2012), as a result of eutrophication of the lake, sedimentation of the vendace spawning grounds and the introduction of non-native fish species, although there is now evidence of their re-establishment there, most likely by re-colonisation by vendace from Derwent Water which has a direct river connection into Bassenthwaite Lake (Winfield & Gowans, 2014; Winfield *et al.*, 2017). In Scotland, both native vendace populations have been lost. The Castle Loch population in the early 20th century, mostly likely as the result of eutrophication from a new sewage works; the Mill Loch population sometime between 1966 and around 1975, also mostly likely as the result of eutrophication but in this case from diffuse pollution (Maitland & Lyle, 2013). The rarity of vendace in the U.K. and the loss of three of the four known historical populations, including both Scottish populations, prompted the then Nature Conservancy Council in 1986 to initiate conservation management actions which included efforts to establish new vendace populations in selected sites, to which they were not native, to act as conservation refuge or "Ark" sites. Since 1996, Scottish Natural Heritage and the

Environment Agency (England) have promoted, through the U.K. Biodiversity Action Plan Steering Group (Vendace), a continuation of the vendace conservation programme and there are now five water bodies where attempts to create refuge populations have been made: Loch Earn, Daer Reservoir, Loch Valley and Loch Skeen in Scotland, plus Sprinkling Tarn in Cumbria (Fig. 1).

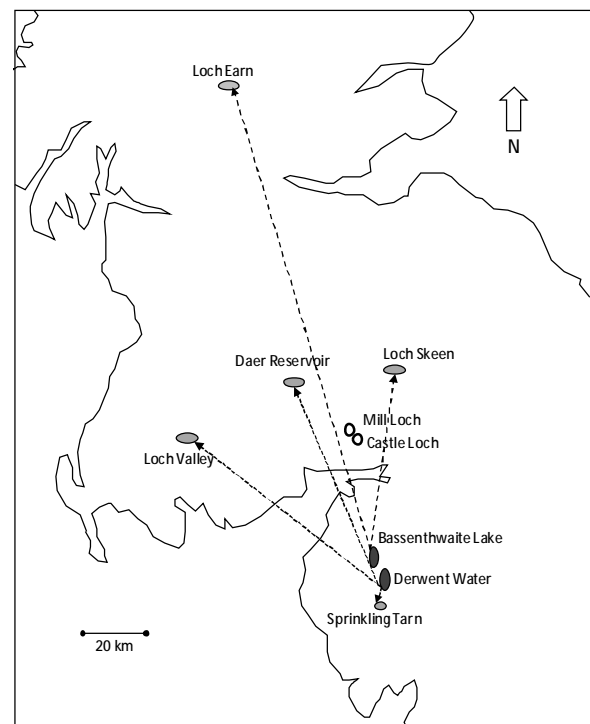


Fig. 1. A map showing the locations of the vendace (*Coregonus albula*) source population sites: Bassenthwaite Lake and Derwent Water in the English Lake District, Cumbria; and the conservation refuge sites: Loch Earn, Daer Reservoir, Loch Valley and Loch Skeen in Scotland, plus Sprinkling Tarn in Cumbria. The locations of the now extinct Castle Loch and Mill Loch vendace populations in Scotland are also shown.

The translocation of 17,550 fry and 47,500 eyed eggs to Loch Skeen between 1997 and 1999 has resulted in an established, self-sustaining population of vendace there

and is fully reported elsewhere (Maitland & Lyle, 2013; Adams *et al.*, 2014). The success of the vendace introduction to Sprinkling Tarn remains unknown. Here we report on recent surveys at the other three conservation refuge sites to investigate the status of vendace there.

METHODS

Previous attempts to assess whether fish translocations have been successful in Scotland have relied on the use of gillnetting and hydroacoustic approaches (Maitland *et al.*, 2003, 2007). This was based on the understanding that fish are more active and susceptible to capture in gill nets during summer periods, and that vendace occupy the pelagic zone of standing waters at night and are easy to detect and count using hydroacoustic techniques.

The approach taken for Loch Earn and Daer Reservoir differed from this in that surveys were undertaken during the known spawning periods for vendace in the U.K., and sampling effort was targeted towards habitats that matched the spawning substrates considered to be similar to those used elsewhere (Coyle & Adams, 2011). The survey at Loch Valley, however, was conducted in summer since winter access to this more remote upland loch could be uncertain.

Loch Earn (NN644237)

Loch Earn, in Perthshire, is one of the larger Scottish lochs. It has a surface area of 1,013 ha, a maximum depth of 87.5 m and a mean depth of 42.0 m (Murray & Pullar, 1910). It has a length of 10.4 km and an average width of about 1 km and lies at an altitude of 97 m aod (Fig. 2).

Loch Earn was surveyed between 27th and 29th November 2016 during the vendace spawning period. Single mesh monofilament benthic gill nets (30 m x 1.5 m and 30 m x 3.0 m) of mesh sizes likely to capture adult vendace (i.e. 18.5, 22 and 25 mm mesh, knot-to-knot) were used and set overnight - six nets on 27th/28th and four nets on 28th/29th. These nets were set onto the loch bed in littoral and sub-littoral zones of the loch (2-12 m depth) in areas which appeared to be suitable vendace spawning sites (comprising well washed gravel to cobble sized substrate) (Fig. 2).

Daer Reservoir (NS980086)

Daer Reservoir lies in the Lowther Hills in Lanarkshire within the River Clyde catchment. It is a public water supply controlled by Scottish Water. The reservoir measures 202 ha in surface area, with a maximum depth of 37.1 m and lies at an altitude of 342 m aod (Fig. 3). Daer Reservoir was surveyed on 5th/6th December 2017 during the spawning period for vendace. A combination of benthic Norden survey gill nets (Appelberg *et al.*, 1995) (see below) and single mesh size nets (30 m x 1.5 m and 18.5, 22 and 25 mm mesh sizes) were used. Five nets (two Norden nets and one each of the three single mesh size nets) were deployed at sites that appeared suitable for vendace spawning (well washed gravel to cobble sized substrate) in water depths of

4-19 m on the 5th December, left overnight and retrieved the following morning (Fig. 3).

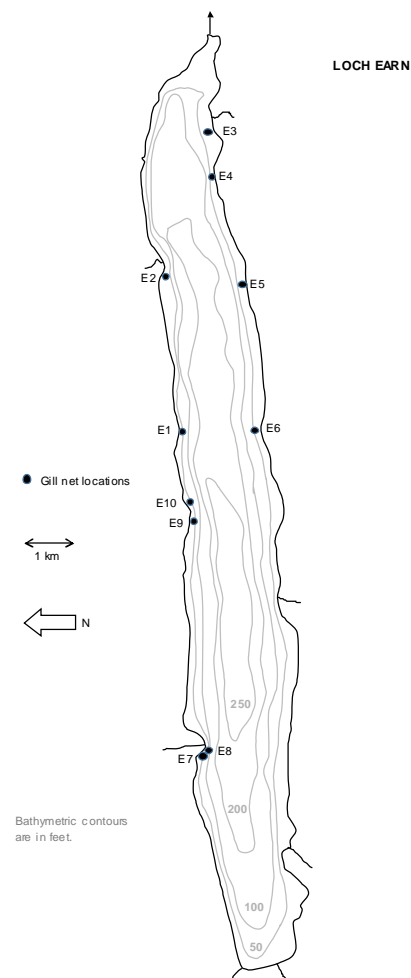


Fig. 2. Loch Earn, Scotland showing the 10 benthic gill net locations (E1-E10) used in the survey. Depth contours are in feet (derived from Murray & Pullar, 1910).

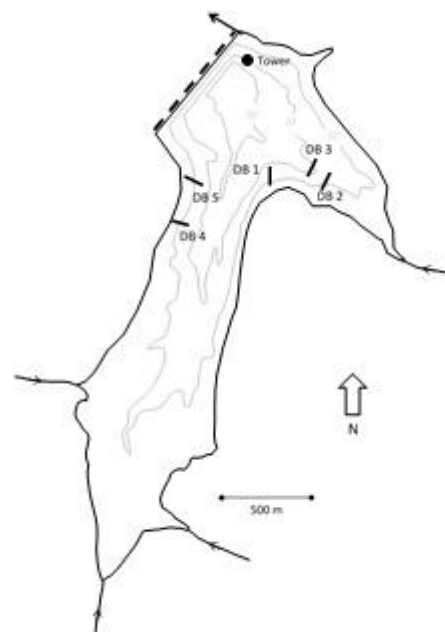


Fig. 3. Daer Reservoir, Scotland showing the locations of the five benthic survey nets. Bathymetric contours are in metres.

Loch Valley (NX444817)

Loch Valley is located in the Galloway Forest Park in southwest Scotland. The loch is 35.8 ha in area with a maximum depth of 17.2 m and lies at an altitude of 322 m aod (Fig. 4).

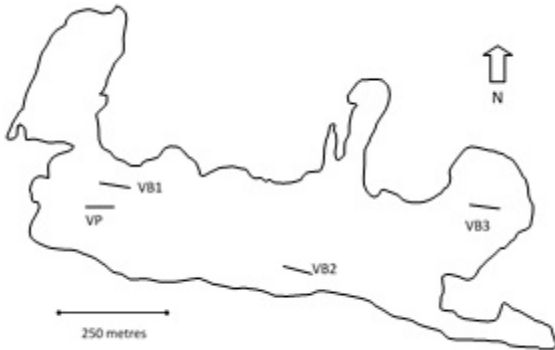


Fig. 4. Loch Valley, Scotland showing the locations of the four survey net sites (VP= pelagic, VB= benthic).

Loch Valley was surveyed during the summer feeding period for vendace. The survey was conducted overnight on 3rd/4th July 2017 using three Norden benthic survey gill nets (30 m x 1.5 m) set onto the loch bed, and one Norden pelagic net (27.5 m x 6 m) set at the water surface. Norden net types comprise 12 (benthic) and 11 (pelagic) panels with mesh sizes 8-55 mm knot-to-knot

(Appelberg *et al.*, 1995). The survey here was deliberately of low intensity to avoid any undue impact on a potentially newly establishing fish population (Fig. 4).

Full details of these surveys are given in the official reports to Scottish Natural Heritage: Adams & Lyle (2017) for Daer Reservoir and Loch Valley, and Lyle & Adams (2016) for Loch Earn.

RESULTS

Loch Earn

Gill netting surveys at Loch Earn captured brown trout (*Salmo trutta*) (N=186), Arctic charr (*Salvelinus alpinus*) (N=21), and a single vendace. The vendace was 209 mm fork length and a 5+ years old male which was exuding sperm indicating that it was in spawning condition at that time.

Daer Reservoir

Gill netting surveys at Daer Reservoir recorded brown trout (N=37) and a single vendace (Fig. 5) which was collected in the 25 mm single mesh size net. The vendace was 211 mm in length and weighed 105 g and was a female that had recently spawned.

Loch Valley

Surveying at Loch Valley recorded brown trout (N=25) but no vendace were found.



Fig. 5. The first vendace (*Coreginus albula*) recorded at the Daer Reservoir, Scotland conservation refuge site in 2017.

DISCUSSION

Background - conservation translocations at the refuge sites

The methodology of refuge site selection and practical translocations of vendace for conservation management in Scotland have been reported more fully elsewhere (Maitland & Lyle, 1990, 2013; Adams *et al.*, 2014), but a brief summary of relevant elements for the three sites examined in this study is given here.

Loch Earn In 1989, 8,400 vendace fry from the Bassenthwaite Lake population were introduced into Loch Earn (Maitland & Lyle, 1990). There were no subsequent reports of vendace having established there from (unconnected) netting surveys by others, or by anglers, until a single specimen was caught by an angler in 2005. Consequently, a dedicated gill netting and hydroacoustic survey was carried out in 2007 (Maitland *et al.*, 2007) but vendace were not detected. A second vendace was reported caught by an angler in 2012 and in 2016 the survey for vendace reported here was commissioned by Scottish Natural Heritage.

Daer Reservoir Translocations of vendace from the Derwent Water population were made to Daer Reservoir in 1998, 2005 and 2008. In total 25 adults, 12,800 unfed fry and 32,300 eggs were transferred. Extensive gill netting surveys in 2003 (Maitland *et al.*, 2003) and again in 2009 (Lyle *et al.*, 2009) both failed to detect any vendace and the status of the conservation translocation population remained uncertain. In 2017 Scottish Natural Heritage commissioned a further survey, the results of which are given above.

Loch Valley An introduction of vendace to this site was carried out in 1968 but it failed to establish probably due to acidification (Maitland *et al.*, 2013). Water quality monitoring by Marine Scotland Science has shown that water quality (pH) has shown a consistent recovery from acidification and is now able to support salmonid fish (Harriman *et al.*, 2003).

In 2011, 70,000 eyed eggs collected from spawning vendace from Derwent Water were translocated to Loch Valley (Lyle & Dodd, 2011). Prior to the survey reported above, there had been no attempt to assess the status of this translocation.

Conclusions from this survey

Loch Earn

Although only a single vendace was collected from Loch Earn, this result shows that a population of vendace has established and that it has survived for over 27 years, equivalent to at least nine generations since translocation to this location in 1989. Although this survey does not provide for a robust analysis of vendace population size, the very low catch rate compared with that of brown trout and Arctic charr and the absence of any vendace in the 2007 survey (Maitland *et al.*, 2007) suggest that only a very small population of vendace has established in Loch Earn.

Daer Reservoir

Although three separate introductions of vendace were made to Daer Reservoir over a ten-year period (1998-2008) and by different means of material transfer (adults, fry and eggs) it cannot be concluded which of those transfers or methods was successful. However, since vendace live for five to six years (Maitland & Campbell, 1992), the capture of even a single specimen indicates that there has been successful reproduction for at least three generations of vendace in Daer Reservoir since the last translocation in 2008. The indications from this survey are that the population is currently relatively small and if it was one of the later translocations that was first successful it is possible that the population is only now in the process of fully establishing itself.

Loch Valley

The lack of a record of vendace at Loch Valley does not necessarily lead to the conclusion that vendace have not established there. It is exceedingly difficult to establish presence or absence of any animal that is possibly at low abundance with any low intensity survey technique. The earlier, very extensive and intensive surveying of Loch Earn indicates how easy it is to miss detection of a numerically small fish population. It remains possible that the vendace introduction to Loch Valley, which was made only six years (*ca.* two generations) before the survey reported here, has established a small but as yet undetected population.

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