TRANSLOCATION OF VENDACE FROM DERWENTWATER TO SAFE REFUGE LOCATIONS (2005/6)
FINAL REPORT

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SUMMARY

The vendace *Coregonus albula* is a silvery, medium sized, lake dwelling fish that is currently the rarest indigenous freshwater fish species in Great Britain. Of four populations that existed here at the start of the 20th Century, Derwentwater in Cumbria is believed to be the last remaining lake which continues to support a vendace population in acceptable condition. The vendace is protected in Great Britain by the Wildlife and Countryside Act (1981).

Several conservation projects for vendace have been undertaken in the last decade on behalf of the Environment Agency, English Nature and Scottish Natural Heritage. These include vendace introductions to two new sites in Scotland. The objective of this project is to create new, safeguard stocks in Sprinkling Tarn, Cumbria and in Daer Reservoir, Lanarkshire. Both these sites were surveyed earlier to assess their suitability for this purpose.

The approach taken was first, to attempt to collect live adult vendace in October 2005 using surface nets to capture them during their dusk migration up from deep water. Fish were then to be transported either by helicopter to Sprinkling Tarn, or by road to Daer Reservoir. Second, depending on the success of the above, in December 2005 pre-spawning vendace would be caught in nets to supply eggs for transplanting in the new sites. If possible, the eggs would be held in special boxes in the lake at a secure location during their incubation period prior to transfer. Also, some would be held at a local hatchery. This work was carried out with considerable staff and equipment contributions from the Environment Agency.

The adult transfer approach in October was not successful. In sixty hours of netting, only 11 adult vendace were caught and their survival in holding tanks was poor. Consequently, maximum effort was focused on egg collection in December. Intensive netting on and around recognised vendace spawning locations over a three week period produced a catch of 146 vendace. From these, eggs were obtained from 82 females and were fertilized with milt from 38 males. An estimated total of over 200,000 fertilized eggs were collected. Low lake levels prevented the use of the special incubation boxes and eggs were transferred on the day of their collection. Some 40,000 eggs were taken to the hatchery, over 130,000 to Sprinkling Tarn and almost 30,000 to Daer Reservoir. In addition, 25 adult vendace were taken to Daer Reservoir and released there. The hatchery proved to be unsuitable and surviving eggs were returned to Derwentwater in January 2006, except for *ca.* 100 eggs given to the Aquarium of the Lakes under appropriate licences.

Overall the project achieved its aims but whether it is ultimately successful in producing new, self sustaining vendace populations will not be known for several years. The most disappointing aspect was the failure of the adult collection programme. An advance in non-destructive collection methods (e.g. trapping) is required, particularly for fragile populations as at Derwentwater. The physical, biological and legislative difficulties in finding suitable new introduction sites are a major problem for future exercises of this type.

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Introduction and Background

The vendace *Coregonus albula* (Plate 1) is currently the rarest freshwater fish in Great Britain (Maitland & Lyle, 1991). It is a medium sized lake-dwelling fish, generally 200 – 250 mm in length, with a silver, herring-like appearance. Vendace are found in lakes throughout north-west Europe (Svardson, 1956) and in some, are caught on a commercial basis. Although vendace inhabit a range of sizes of lakes throughout its European distribution, certain physical characteristics are regarded as important. A water depth of several metres is necessary to provide refuge from heat stress in summer and from predators (e.g. pike *Esox lucius*). Shallower areas of clean gravels and stones are required for spawning. Vendace are a pelagic species, occupying the deeper open water areas in daylight, ascending to feed at dusk (Maitland, 1967). They are almost exclusively plankton feeders, rarely taken by anglers. In British waters their reproduction takes place during late November to late December when eggs are laid over gravel/stone areas in near shore locations. Females may carry up to 5000 eggs depending on fish size.

Plate 1. Female vendace from Derwentwater in spawning condition. P. Maitland.

The eggs are 1.5 to 1.8 mm in diameter and are orange in colour. Incubation time varies with temperature but is relatively lengthy compared to most fish. Huet (1972) suggests between

300 to 360 degree days from European studies, but hatchery results for British vendace were substantially longer at 520 to 800 degree days (Lyle *et al.*, 1998, 1999). On hatching the fry are about 10mm long and are free swimming. Vendace reach maturity after two years and their normal life span is six years.

Because of its rarity, vulnerability and decreasing distribution, the vendace in Great Britain is given protection under various legislative powers. It is included in Schedule 5 of the Wildlife and Countryside Act 1981 where it is illegal to capture, kill or keep in captivity vendace without licence. It is also included in Appendix III of the Bern Convention and in Annex V of the EC Habitats and Species Directive. In an appraisal of the conservation needs of British freshwater fish, Maitland & Lyle (1992) gave vendace the highest priority category.

The status of vendace in Great Britain is now of serious concern and of the four populations that existed at the start of the 20th Century probably only one remains in acceptable condition. Two Scottish populations in Dumfriesshire became extinct during the last century, one at the Castle Loch in the 1920s (probably due to the input of sewage effluent) and another at the Mill Loch in the 1970s (due to extreme eutrophication and the introduction of other fish species). The original two Cumbrian populations in Bassenthwaite Lake and Derwentwater have been under stress for several years but most damagingly at the former site where the vendace population has declined below detectable levels as a result of adverse environmental conditions (e.g. enrichment, sedimentation and non-native fish introductions (Winfield *et al.*, 2004)). At Derwentwater (Plate 2) the principal threat to vendace is the arrival and increase of other fish species which may compete for food (e.g. roach *Rutilis rutilis* and dace *Leuciscus leuciscus*) and prey on eggs (ruffe *Gymnocephalus cernus*). Winfield *et al.* (2004) noted that concern for the Derwentwater stock will increase if the recent decline in population abundance (which was then within the normal variation shown by this species) did not reverse soon. Although the results of the monitoring programme in 2005 have yet to be fully analysed and interpreted, preliminary analyses indicate that no further decline has occurred and a range of year classes persist in the vendace population of this lake (CEH Lancaster, unpublished data). It may be concluded that a healthy population of vendace inhabited the deep areas of Derwentwater immediately prior to the present programme.

Plate 2. Derwentwater from Lodore Pier. P. Maitland

A review of the characteristics of spawning habitat for vendace in Derwentwater and Bassenthwaite Lake was carried out by Maitland (1996). The study identified a number of factors controlling the success or otherwise of spawning, egg incubation and the recruitment of young vendace in the wild. Some of these factors are completely natural (e.g. weather) and little can be done to modify their impact. Others are the result of human activities and thus possibly open to modification. One important point to note is that high variability in year-class success is a characteristic of many populations of vendace.

The present conservation project for vendace was commissioned by the Environment Agency to be carried out in the winter of 2005/2006 and its purpose was to translocate vendace from Derwentwater in Cumbria to refuge locations at Daer Reservoir (Lanarkshire) and Sprinkling Tarn (Cumbria) to establish safeguard populations.

Previous introductions of vendace were carried out at Daer Reservoir (12,800 unfed fry) in 1998 and to Loch Skene (65,000 unfed fry and eyed eggs) in 1997 and 1999 (Lyle *et al.* 1998, 1999). This work was funded by Scottish Natural Heritage as part of its Species Recovery Programme. Subsequently, small scale surveys of these waters in 2003 funded by English Nature (Maitland *et al.* 2003) showed that vendace had become established in Loch Skene but no vendace were found at Daer Reservoir. At the latter site it is uncertain if a

small stock of vendace may have survived but below a level that is readily detectable. The earlier introductions of vendace fry to Daer Reservoir were relatively low in number and it is appropriate that further introductions are carried out to improve the likelihood of establishing a self sustaining population and also to enhance genetic diversity.

In 2004/2005 a similar project to translocate vendace commissioned by English Nature (Lyle *et al*., 2005) failed to find spawning vendace at Derwentwater. A significant factor was encroachment onto the known spawning areas of dense macrophyte growth, in particular the recently arrived *Crassula helmsii*. This highly invasive plant may have intruded and changed the shoreline habitat to the extent that it has altered vendace spawning behaviour. Also, the density and extensive coverage of the lake bed by *Crassula* seriously reduced the effectiveness of vendace capture by netting. However, preliminary results of a survey of macrophyte cover on likely vendace spawning grounds undertaken by the Centre for Ecology and Hydrology in 2005 for the Environment Agency under a separate contract (Winfield *et al.*, 2006) suggested that the previously dense growths in these areas had been substantially reduced, probably by storms and severe flooding earlier in the year.

Site Descriptions

Daer Reservoir

This site was surveyed in November 1995 for Scottish Natural Heritage to asses its potential for vendace introduction (see Lyle *et al.* 1996). Daer Reservoir (Plate 3) (NGR NS 980085) is 202 ha in area at an altitude of 342 m. Its maximum depth is 37.1 m and bathymetry is shown in Figure 1. In 1994 and 1995 pH was 7.07 and 6.8 respectively. This is a public water supply under the control of Scottish Water. There are extensive areas of suitable spawning substrate and water levels are consistently high during the winter months (i.e. the vendace spawning and egg incubation period). The lowest water supply take-off depth is 20m and even if this drawdown was ever reached a loch of some 46ha and 17m in depth would remain. Brown trout *Salmo trutta* and minnow *Phoxinus phoxinus* were the only fish species recorded. There has been no recent fish stocking and angling is controlled. The site is relatively remote. Any fish entrained during abstraction are caught in the filtration works although it may be possible for fish to escape in compensation water or reservoir overflow. However there are no standing waters below this point.

Plate 3. Daer Reservoir, Lanarkshire. P. Maitland

Plate 4. Sprinkling Tarn, Cumbria. A. Gowans

Sprinkling Tarn

Conveniently, Sprinkling Tarn (Plate 4) (NGR NY 228091) lies within the Derwentwater drainage area. The tarn was surveyed for fish, water chemistry, plankton and shoreline substrates by Environment Agency staff in August 2005. This small water is 2.34ha in area with a maximum depth of 9m and lies at an altitude of 598m. The bathymetry is shown in Figure 2. There is adequate gravel/stone substrate for vendace spawning. The tarn is remote

with no road access and is owned by the National Trust. At the time of the survey pH was 7.7. Fish species recorded were brown trout and minnow *Phoxinus phoxinus*. Subsequently this site was selected for vendace introduction.

Objectives

1. Establish a new (or enhance existing) vendace population in Daer Reservoir, Lanarkshire by translocating a target number of 75,000 eggs, or a number of adult fish capable of providing that number of eggs.

2. Establish a new vendace population in Sprinkling Tarn, Cumbria by translocating a target number of 25,000 eggs, or a number of adult fish capable of providing that number of eggs.

Subsequently, the Environment Agency, in consultation with English Nature, requested that target numbers for any adult transfers be up to 200 fish per site.

Methods

For the field work at Derwentwater a shore base was established at Lodore pier on the south shore of the lake. This included limited indoor facilities. A powered boat and additional field staff were supplied by the Environment Agency. Permissions for access and all necessary licences for the netting, capture, handling and transfer of vendace at Derwentwater were obtained by the Environment Agency, who also obtained permission to introduce vendace into Sprinkling Tarn. The necessary permissions and licences for Daer Reservoir were obtained from Scottish Water and Scottish Natural Heritage respectively.

Collection of live adults from Derwentwater to transfer to Sprinkling Tarn and Daer Reservoir

Following the experiences of attempted egg collection in 2004 (Lyle *et al.* 2005) when extended efforts to locate spawning vendace failed, the authors recommended trying to capture and transfer adult vendace. This would be best carried out well before their spawning period when the fish are in prime condition but not until water temperatures had cooled to improve survival chances during holding and transfer handling. This had not been attempted

before in Great Britain with large numbers of this delicate species but has been done in Scandinavia (Jurvelius *et al*,. 1995) albeit on a larger scale with much larger populations. A detailed plan was constructed with a central static netting location to take advantage of the vendace diurnal migration to surface waters at night. Success with this method could have resulted in the entire field effort being devoted to adult transfer rather than to including egg collection later in the year.

Collections of adult fish were carried out on 17 – 19 October 2005. This was the earliest date available after the placement of the contract. Surface gill nets were set around the existing marker buoy for the central deep area (*ca.* 22m) (Figure 3). Mooring buoys were set out by Environment Agency staff some 40m to the east, west and north of the marker buoy with connecting lines to the latter, and nets were suspended along these lines. (Special pelagic nets (30m long, 3m deep and 16.5, 18.5, 22.0 or 25.0mm mesh) were ordered specifically for this purpose but did not arrive in time). The nets used were mostly monofilament gill nets, 1.8m deep. Three of the nets were 25m long and of single mesh (19, 22 and 25mm). Another was 60m long with 12 panels each 5m of meshes 16, 19, 21 and 25mm. A multifilament net 25m long, 3m deep and 28mm mesh was also used. Different combinations of nets were deployed over the three nights of netting (Table 1).

Nets were set in the afternoon to be in place to catch vendace when they rose to surface waters at dusk. They were checked every two hours and nightly set times varied between four and eight hours. Over the three nights a total of 60 net hours was fished.

To minimise damage and stress to vendace caught in the nets, fish were immediately placed in a tank of water in the boat and the net carefully cut from them. Numbers of other species of fish caught were noted. On return to the shore base vendace were placed into large holding tanks supplied with oxygen.

As a further check on the possible location of adult vendace, a 60m multimesh monofilament gill was set off the east shore (Figure 3) on 19 October in water approximately 3–10m deep. Numbers and species of fish caught in this net were recorded.

The transfer of adult vendace to the introduction sites was to be by a helicopter supplied by the Royal Air Force to Sprinkling Tarn, and by road in a suitable fish transport container to

Daer Reservoir. Before their release into the introduction sites each adult fish would be checked for external parasites, notably *Argulus*, which would be removed.

Progress meeting.

Following the first adult transfer phase, progress and the allocation of the remaining field time to adult or egg transfer was discussed at a meeting with the Environment Agency called by the authors on 20 October. Minutes from this meeting are given in Appendix 1. It was agreed to focus on egg collecting with additional adult transfers if the opportunities arose.

Collection of vendace eggs at Derwentwater

The vendace spawning period may occur between late November and late December (Winfield *et al*., 1998) and the first netting and trapping visit was undertaken in w/c 28 November to establish the spawning condition of vendace at that time. Subsequent netting and trapping was carried out each week for the following two weeks (this included a one week extension to the contract).

Plate 5. Setting nets at Derwentwater (at Site D on Figure 3). D. McCartan

Netting and trapping at Derwentwater were carried out in near shore locations previously identified as being vendace spawning grounds (Lyle *et al*. 1998; Winfield *et. al*. 1998) using several monofilament single-mesh nets (Table 2) specifically designed for vendace work, set onto the lake bed. The special nets ordered for the live adult collection (see above) were now available and these were also used. Five large fyke nets (1m opening) (two double nets and one single) and a large box funnel trap approximately 1.5m square were also set onto prospective spawning areas. The locations of the net and trapping stations are shown in Figure 3. Nets were set during mid to late afternoon (Plate 5) and lifted the next morning. Nets were set singly, or in a joined line of two or three (see Appendix 2). Any vendace caught were cut from the nets and held in a tank of water on the boat until they were transferred into large, oxygenated tanks at the shore station. The numbers of other species caught were recorded.

Female vendace that were ripe were stripped of eggs (Plate 6) which were fertilised with milt taken from a selection of two to four males, if possible. Milt was collected from these males using capillary tubes held against the vent (Plate 7). Several tubes were collected from each male so that mixtures of milt from several males could be used for different eggs batches.

Plate 6. Stripping eggs from a female vendace. D. McCartan

The milt was blown then washed through the capillary tubes onto the eggs. Once fertilised and washed, the volume of eggs was measured to allow an estimate of numbers from the number/volume ratio given by Lyle *et al.* (1998), i.e. 164 eggs ml^{-1}. (Although a single female may hold up to 5000 eggs, it is unlikely that such a number of good quality eggs can be obtained from a single fish by their collection from the wild. The average from egg collection at Derwentwater in 1997 was *c.*2800 eggs per stripped female (Lyle *et al.*, 1998)).

Plate 7. Taken milt from a male vendace using a capillary tube. D. McCartan

The eggs were then placed in vacuum flasks and immediately transported to Sprinkling Tarn (partly by road then walking) by Environment Agency staff, or by vehicle to Daer Reservoir. On the final day of the field programme (15 December) surviving adults were transported to Daer Reservoir in an oxygenated tank after the final netting session.

The adult fish that were used for egg collection and fertilization were measured for fork length. This was not done for adults being held for transfer to reduce stress on them. Throughout, any dead adult vendace were frozen and stored for possible future analysis.

It was originally intended that fertilised eggs would be placed into incubation boxes (Plate 8) which were prepared, based on a model successfully used in the introduction of schelly *Coregonus lavaretus* from Haweswater to Small Water in 1997 by Winfield *et al.* (1997). Each box was constructed from a plastic plant propagator measuring *c.* 350mm long, 250mm wide and 170mm high and lined with a layer of synthetic grass (Model RA1) made by

Nordon Enterprises Limited (Metcalf Drive, Altham Business Park, Accrington, Lancashire BB5 5TU, U.K.). Twelve such boxes were assembled into two rows of 6 boxes in a metal frame measuring 1.85m long and 1.02m wide, resting on legs which held the synthetic grass

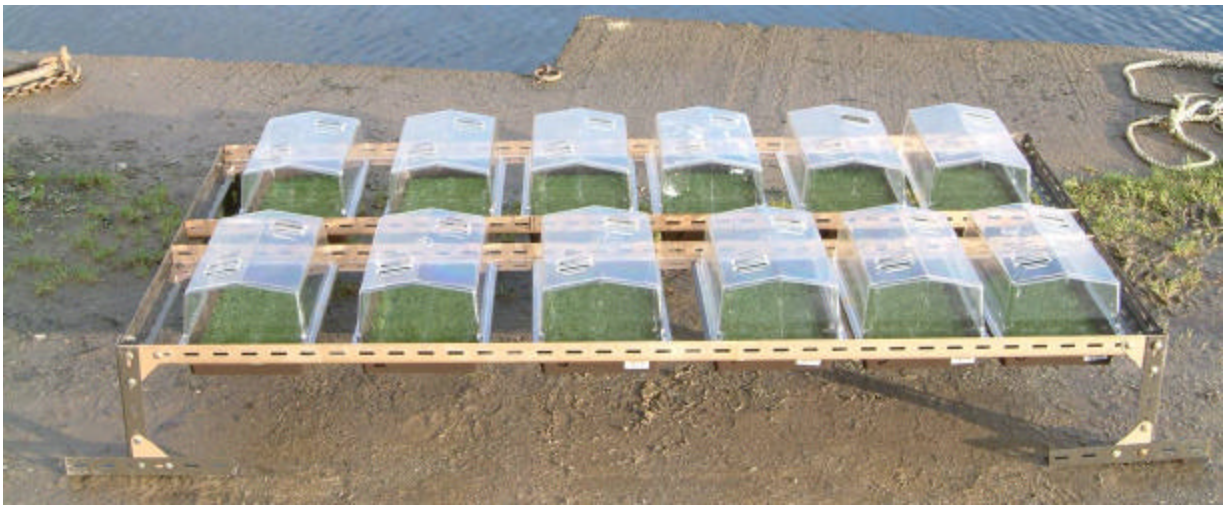

Plate 8. Egg incubation boxes which were to be submerged in Derwentwater. I. Winfield

0.23m above the substrate. A suitable location for the frame in Derwentwater was difficult to find since it required accessibility to the trays over the egg collection period to place eggs into them via a tube system and access thereafter for egg inspection. A site was selected at the Lodore pier but low water levels prevented that location being used and in the event eggs were either transported directly to the introduction sites where they were distributed over suitable substrates after temperature equalisation, or held in incubation boxes set in hatching troughs in the nearby Keswick Anglers Association hatchery. The hatchery is attended daily and is supplied with high quality spring water. However, there is no control on water temperature which at the time was higher than ideal at 8.5^{o}C. The development of the embryos was to be monitored and when sufficiently advanced (and temperatures in the recipient waters had risen to stimulate food production) the eggs would be transported in vacuum flasks to the introduction sites.

As part of an arrangement, at no extra cost to the project, it was agreed to give a small quantity of the eggs from the hatchery to a conservation grouping led by Jen Nightingale of Bristol Zoo Gardens. Holding appropriate licences, Ms Nightingale has agreed to act as a primary contact for a number of aquaria and zoological gardens keen to develop captive populations of vendace for conservation and education purposes.

Again during this phase, the transportation of any live adult vendace available (plus eggs) up to Sprinkling Tarn by helicopter was offered by the Royal Air Force. Unfortunately the availability of both the helicopter and captured adults could not be matched. However, efforts to do so did have some influence on the structure and timing of the netting programme.

Results

Collection of live adults from Derwentwater to transfer to Sprinkling Tarn and Daer Reservoir

The surface netting for adult vendace was not successful in terms of the numbers of adults caught or their condition. In the 60 net hours used over three nights only 11 vendace were caught (predominantly in 22mm mesh nets) (Table 2). Of these, 10 failed to survive more than 24 hours in the shore holding tanks, although they had been in the nets for only short periods and were apparently healthy and undamaged at the time of capture. The weather conditions during this exercise were good (i.e. calm), the water temperature was 12^{o}C at this time and all technical and practical aspects were carried out satisfactorily. Previously, the capture of vendace over deep water by similar methods (Maitland, 1966) had collected fish at a much higher rate and the results here gave rise to some concern over the current numbers in the vendace population at Derwentwater.

Adult transfers to the introduction sites had been the preferred method of translocation but the poor results stimulated a reconsideration of the allocation of field time between adult capture and egg collection – hence the discussion meeting reported in Appendix 1.

Egg collection at Derwentwater

The netting programme for spawning adult vendace which was carried out between 28 November and 15 December 2005 consisted of 11 overnight sessions, setting a total of 92 nets (for periods of approximately 20 hours) and three short-term nets (for two to three hours) at the five different netting areas shown in Figure 3. Full details of the nets used, their locations, periods of netting and catches are given in Table 3 and Appendix 2.

A summary of the results of the vendace catch, egg collection and transfers is given below:

TOTAL VENDACE CATCH	146
NUMBER OF FEMALES STRIPPED FOR EGGS	82
NUMBER OF MALES STRIPPED FOR MILT	38
TOTAL VOLUME OF EGGS COLLECTED	1247ml
ESTIMATED NUMBER OF EGGS COLLECTED	204,508
EST. NUMBER OF EGGS TO SPRINKLING TARN	134,480
EST. NUMBER OF EGGS TO DAER RSVR.	28,700
EST. NUMBER OF EGGS TO HATCHERY	41,328
NUMBER OF LIVE ADULTS TO SPRINKLING TARN	0
NUMBER OF LIVE ADULTS TO DAER RSVR.	25

The trapping programme lasted up to 11 days and the fyke nets and box trap were checked up to five times during that period at irregular intervals as best fitted into the netting programme. No vendace were caught. Two perch and over 200 roach were trapped but all these fish were juveniles. Details are given in Appendix 3.

The fork length was measured for 122 vendace, 81 females and 41 males. The female length range was 162 – 215mm, the male length range was 164 – 207mm. The percentage frequency distribution of females and males is shown in Figure 4.

Water temperature varied between 4.5^{o}C and 6.0^{o}C over the netting period and information from Centre for Ecology and Hydrology staff on 1st December showed the temperature profile in the deep area to be 4.7^{o}C throughout. Lake water level rose 0.39m from 28 November to 5 December then fell 0.26m to 15 December.

The eggs transferred to Keswick Anglers hatchery initially seemed satisfactory. However, in January 2006 serious fungal infection was reported and attempts to treat the fungus were not successful. Consequently, most of these eggs were placed back into Derwentwater to give any fungal free eggs some chance of survival and approximately 100 were transferred to the Aquarium of the Lakes at Windermere (contact Scott Davidson) as part of the arrangement with Ms Nightingale (above). Hatching was underway at the time of writing.

Conclusions

Overall the project was successful in that a large number of vendace eggs were translocated to Sprinkling Tarn and eggs and adult fish were transferred to Daer Reservoir. Attempts to capture live adult vendace both by surface netting in October and by trapping were disappointing and further consideration should be given to different and improved methods to collect, hold and transport these delicate fish.

Discussion

One of the major problems for fish translocation exercises such as this one is finding suitable introduction sites. An earlier survey for the Environment Agency (Lyle & Winfield, 1999) considered 87 waters in Cumbria for vendace introduction and concluded that none were immediately suitable for the purpose of providing a secure location for a permanent population of that species. Under the criteria applied then, Sprinkling Tarn was not considered because of its small size and it is an indication of the urgent need for sites that it is now. That Sprinkling Tarn lies within the Derwentwater catchment is an advantage but it would be difficult to consider a small vendace population there as a satisfactory solution to the prospect of perhaps losing the two main British vendace populations in Cumbria - Derwentwater and Bassenthwaite Lake – and indeed, the latter may already have gone. In the presently unlikely event of any large, acceptable waters becoming available in the near future, refuge sites need to be sought elsewhere. In this regard Daer Reservoir is currently highly appropriate, albeit an artificial water body and water supply reservoir. Even if the present project is successful (i.e. populations of vendace are established in Sprinkling Tarn and Daer Reservoir) the position will still not be satisfactory as far as securing a future secure status for this species in Great Britain is concerned. Ideally, several more permanent safeguard populations should be created if this is to be the case. Although there have been difficulties in finding appropriate sites in both Cumbria and southwest Scotland, the reduction in acid deposition in recent years has meant that one or more of the previously acidified lochs in Galloway may now, or soon, be appropriate as safeguard sites for vendace. For example, one of these, Loch Valley, seems eminently suitable – it is relatively large, deep and at high altitude. In addition, though smaller sites are less desirable, a recent offer by the Forestry Commission of several other lochs in southwest Scotland should be given

serious consideration in due course. The source of stock for any new populations is a matter for discussion for, assuming that the vendace in Bassenthwaite Lake is now extinct, or nearly so, it would be desirable that at least one or two of any new populations would be from Bassenthwaite stock – i.e. from Loch Skene. However, transfers from that site would have several logistical difficulties, mainly due to access and climate. In addition, given the very uncertain status of the population in Bassenthwaite Lake a new population in Cumbria is seen as a high priority.

The attempts in October to catch adult vendace by surface netting at night were unsatisfactory. After some consideration, discussion and consultation with others experienced in vendace behaviour, our opinion is that the most likely reason for low catches was that this operation was just too late in the year and the vendace had begun to change their behaviour in preparation for spawning and were not visiting the surface waters at night in the numbers expected throughout most of the year. Also, almost all the fish taken had distended swim bladders which prevented their survival in the holding tanks. These fish were taken from less than 2m below the surface. This is much shallower than the vendace caught in December in water up to 10m deep - but these fish did not display similar swim bladder problems. It is quite possible that the earlier problem was caused by the vendace being caught as they rose from deep water to the surface, or soon after, and their swim bladders were not yet fully adjusted or stabilised to the new depth. Whereas in December, the vendace caught would have become acclimatised to the shallower water. In this respect a better method of collection would be some sort of surface trap which could be deployed to capture and hold fish overnight.

The high number of eggs (134,480) transferred to Sprinkling Tarn greatly exceeded the objective target of 25,000, whilst those taken to Daer Reservoir (28,700) fell well below the target of 75,000 (although the 25 pre-spawning adults released there may have made up some of that shortfall). The reasons for these discrepancies were a combination of logistical, practical and circumstantial factors. Sprinkling Tarn was declared the priority site but the original intention of holding all the eggs until a later stage of incubation and subsequent proportional distribution was eventually abandoned due to low water levels at Derwentwater and concerns over the hatchery water temperatures. This meant that eggs had to be transferred immediately after fertilization. Of course it was not known how many vendace would be caught or eggs collected each day and there was some endeavour to be ready to use

the offer of helicopter transport for Sprinkling Tarn if possible, which tended to take precedence over preparing road transport to take eggs to Daer. Consequently, this resulted in Environment Agency staff standing by to carry eggs to Sprinkling Tarn until the final day of netting when the eggs collected that day were taken to Daer Reservoir.

Although good numbers of vendace were eventually taken by netting in December, they were not caught over the specific habitat areas previously recognised as their spawning grounds. Experience from earlier work at Derwentwater and Bassenthwaite Lake showed that spawning vendace could be caught in shallow water of 1 to 2m depth within a few metres of the shore. On this occasion nets on these areas caught no or very few vendace. Most were taken some 20 to 60m offshore in water depths of up to 10m. These areas would not be regarded as good spawning grounds but perhaps gathering areas prior to spawning runs, which could explain the numbers caught there but it is perhaps concerning that netting on the spawning grounds was so unproductive.

The general description of vendace given earlier describes them as being 200 – 250mm in length. However, the Derwentwater vendace measured are conspicuously smaller than that (and of the Bassenthwaite Lake stock). For the fish measured, the mean female length was 195mm whereas the average male length was 187mm. This concurs with observations of results from earlier studies e.g. Lyle *et al.* (1998, 1999).

The encroachment of *Crassula* onto the netting areas appeared to be less extensive than in December 2004 (Lyle *et al.*, 2005) when its presence severely disrupted the efficiency of netting and may have altered vendace spawning behaviour. As stated earlier, the decrease may have been due to storms and floods during 2005 and so may only be a temporary respite from further dense encroachments which would limit the effectiveness of similar netting programmes should they be required in future, and necessitate the application of different capture methods for fish which inhabit shoreline areas.

Although significant effort was put into trapping vendace at Derwentwater this was completely unsuccessful. Non destructive capture methods become more important (and difficult) in sites where the target species is scarce. Investment to advance capture techniques and equipment is perhaps necessary for safer and more efficient operations in future.

The early results of the netting programmes at Derwentwater initially gave rise to concerns over the current size of the vendace population there since catches were small and sporadic. However, later in the programme (but in some areas only) vendace were readily caught and indicated that a viable population probably still exists there, although this is not a reliable measure of the stock. Continued monitoring is required at Derwentwater and in addition surveys at Sprinkling Tarn and Daer Reservoir are recommended in three to five years time. Monitoring populations of vendace is often difficult and expensive, especially so in remote sites like Sprinkling Tarn and Loch Skene. However, the fact that anglers, surprisingly, catch vendace at the latter site regularly affords an opportunity to accumulate a time series of catch data for this population. It would be extremely useful, if they were willing, for the National Trust for Scotland to maintain a log book at their base at the Grey Mare's Tail in which anglers could record any catches of vendace in Loch Skene.

Acknowledgements

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TABLES

Table 1. Descriptions of the surface gill nets used on 17-19 October 2005 set over deep water to capture adult vendace.

Net Code	Length m	Depth m	Mesh mm
P1 (monofilament)	25	1.8	19
P2 (monofilament)	25	1.8	22
P3 (monofilament)	25	1.8	25
P4 (monofilament, mixed mesh)	60	2	16,19,22,25.
P5(multifilament)	25	3	28

Table 2. Descriptions of the monofilament benthic gill nets used to capture ripe adult vendace for egg collection between, 28 November and 15 December 2005.

Net Code	Number of nets	Length m	Depth m	Mesh mm
B1	2	30	1.8	18.5
B2	2	30	1.8	22
B3	1	30	1.8	25
B4	2	30	3.0	18.5
B5	2	30	3.0	22
B6	1	30	3.0	25
B7	1	25	1.8	19
B8	1	25	1.8	22
B9	1	25	1.8	25

Table 3. The numbers of adult vendace caught in the surface nets set over deep water on 17-19 October 2005.

Net Code	17 October Netting times		18 October Netting times				19 October Netting times	
	17.45 -19.45	19.45 -21.45	14.45 -16.45	16.45 -18.45	18.45 -20.45	20.45 -22.45	17.00 -19.00	19.00 -20.00
P1	-	-	-	-	-	-	0	**1**
P2	**1**	**2**	0	0	**3**	0	**1**	**1**
P3	0	0	0	0	0	0	-	-
P4	0	0	0	0	**1**	0	0	**1**
P5	-	-	0	0	0	0	0	0

FIGURES

Figure 1. Daer Reservoir in Lanarkshire. Bathymetric contours are in metres. The locations of adult vendace and egg introductions are shown.

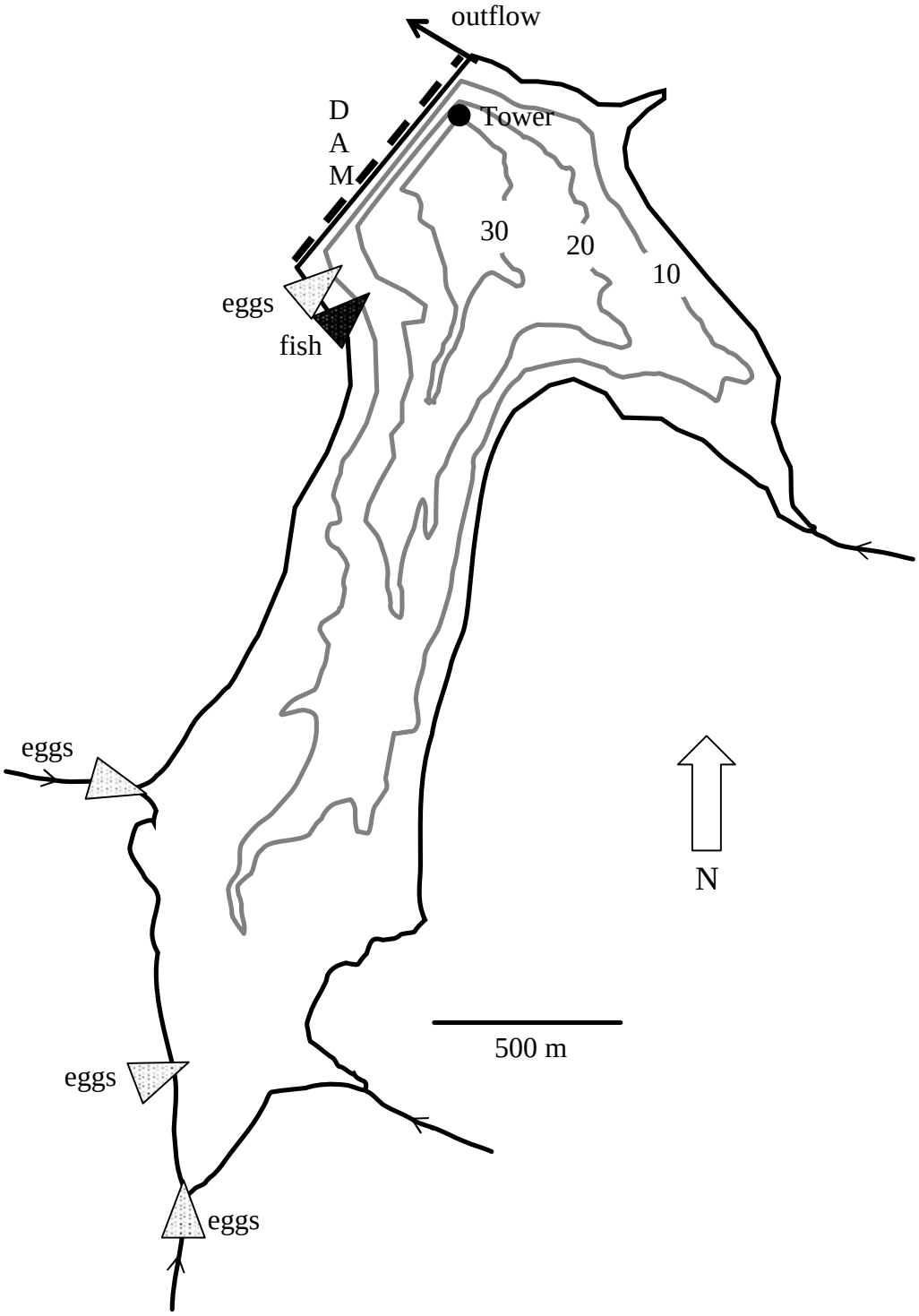


Figure 2. Sprinkling Tarn in Cumbria. Bathymetric contours are in metres. The locations of vendace egg introductions are shown.

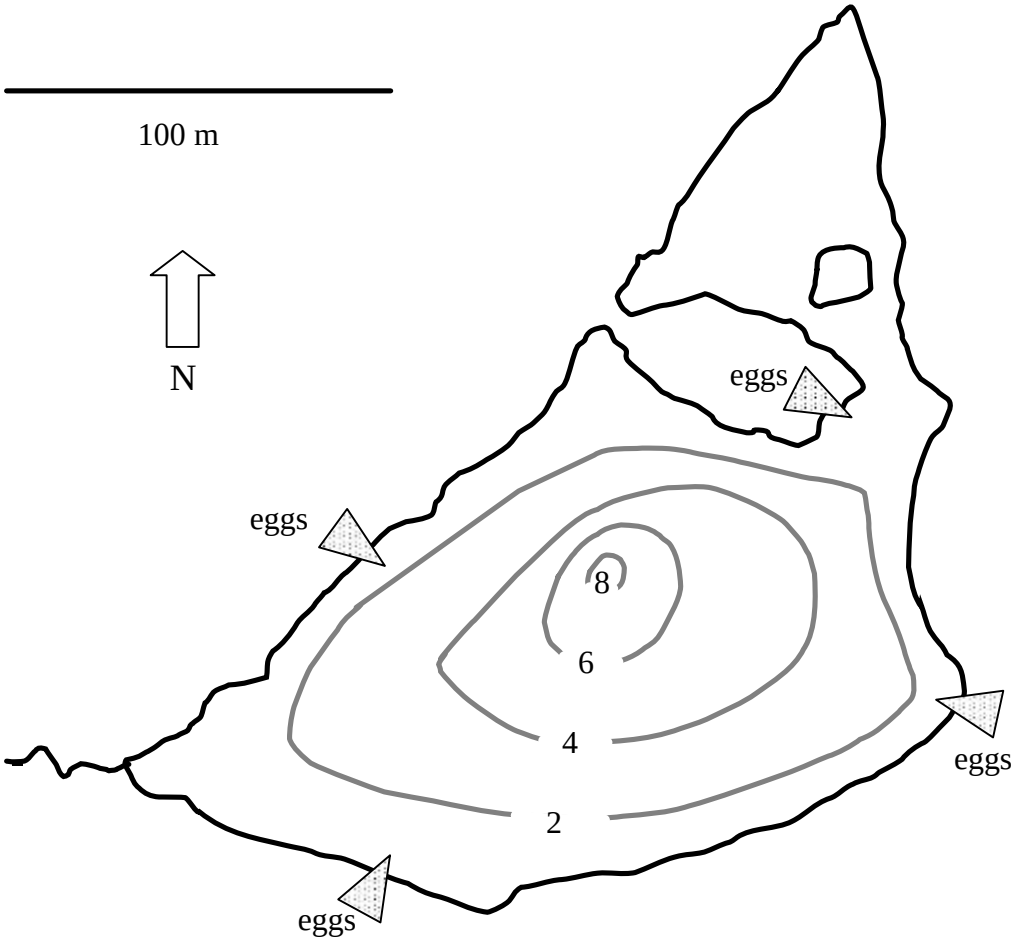


Figure 3. Derwentwater in Cumbria. Bathymetric contours are in metres. The locations of the netting sites on 17-19 October 2005, and the Lodore shore station are shown. Also, shown are the netting and trapping stations (A-E) used from 28 November to 15 December 2005.

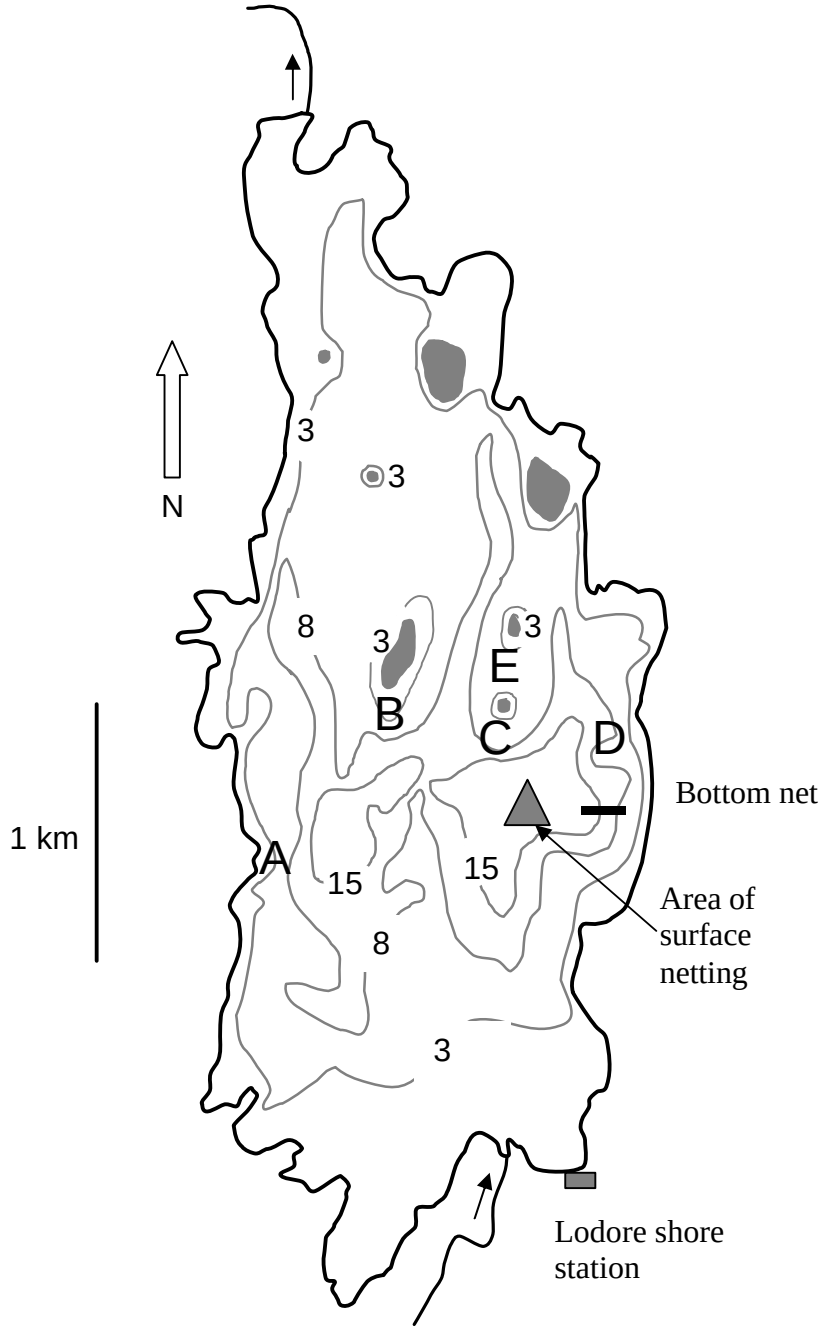
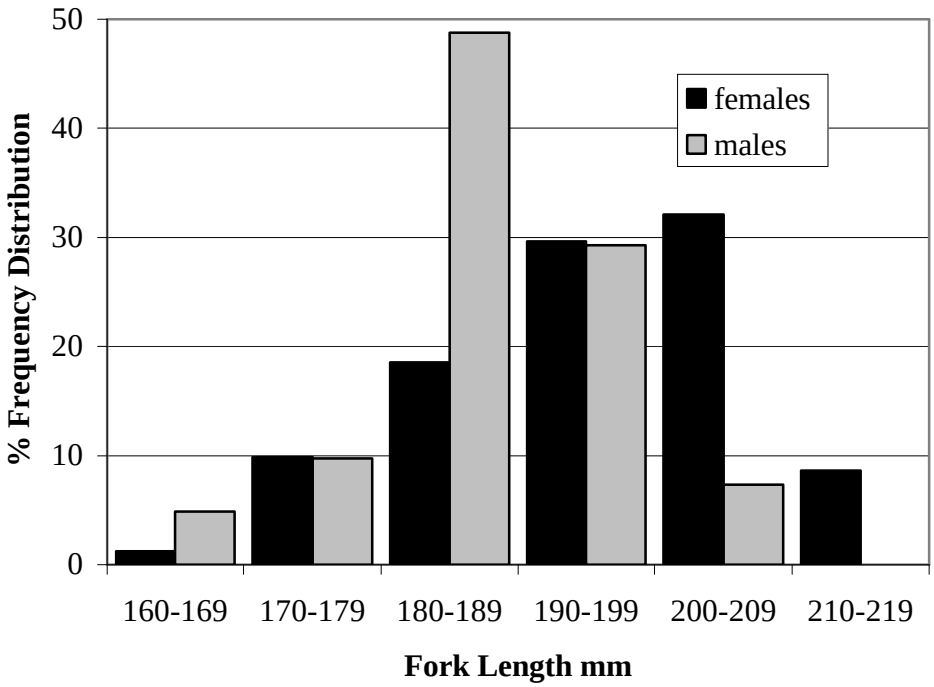


Figure 4. The percentage frequency distribution of fork length for 81 female and 41 vendace caught for egg collections at Derwentwater in November/December 2005.



APPENDICES.

Appendix 1.

DERWENTWATER VENDACE TRANSLOCATION 2005.
Notes from a meeting held at the Lodores Falls Hotel 20 October 2005.
Present: from the EA - Keith Kendal, Dennis McCartan, Vic Semple.
Contractors. Alex Lyle, Peter Maitland, Ian Winfield.

The meeting was requested by AL & PM following three days (17 – 19 October) of work with EA staff to collect adult vendace from Derwentwater.

Points raised.

1) Contract terms in relation to adult and/or eggs transfers. This was raised by the contractors for clarification between apparent fixed terms in written communications, and a more flexible approach understood from earlier discussions. The EA confirmed that flexibility of methods was acceptable in order to find the best way to achieve the project objectives. It was emphasised that the final contract cost should not deviate significantly from the agreed price. Effectively, there are three weeks of fieldwork, one of which has been carried out attempting adult vendace collections. Further discussion focused on the best way ahead for the remaining two weeks.

2) Adult transfer – Report on the first weeks work. The special pelagic nets ordered from Sweden did not arrive in time for this work despite repeated requests for urgent delivery. Surface netting over deep water was achieved by improvising with a selection of other nets with appropriate meshes set between buoys laid out earlier by EA staff. In all practical aspects this worked well and weather conditions were ideal. Netting had continued from late afternoon to up to 23.00 hrs for three days. Nets were checked every two hours. There are two main points of concern over the results,
    a) *Catches have been very low.* In a total of 60 net hours only 11 vendace were caught (plus 4 roach). Possible reasons include; (i) the project started too late and the adult vendace are now altering their behaviour as their spawning season approaches, (ii) the vendace are occupying another area of the lake, (iii) light from a full moon at the time may have discouraged them from coming close to the surface, (iv) there are very few vendace in the lake.
    b) *The survival rate of the vendace caught is very low.* Of the 11 vendace caught only one survived in good condition although none seemed damaged by the netting. The sole survivor was the only fish which did not seem 'inflated' in the holding tanks. This is most likely a swim bladder problem and was unexpected since the fish were taken from near the surface. Again, altered behaviour approaching spawning may be the reason. The fish are perhaps only making brief visits to upper levels and their swim bladders are not fully adjusted. PM and IW will investigate literature etc. Water temperature at the time was 12^{o}C and not thought to be responsible. This problem overrides capture methodology since no method is useful if the fish do not survive.

   With regard to the possibility that the vendace were occupying other areas of the lake then that most likely seemed to be intermediate depths between the deep area and the shore zone. In this respect a mixed mesh net was set in 4 – 10 metres depth off the east shore. In two hours the catch was 21 perch, 25 ruffe and 35 roach. No vendace.

This high number of other species in such a short time is concerning for the practicalities, effort and net damage for any egg collecting work in December.

3) <u>Options for the remaining two weeks fieldwork</u>.

1) Continue surface gill netting with new nets. – Because of the low catches, low survival and the urgency and limits of the situation, this option was discounted. Plus, if vendace behavioural changes are the main reason for the above then netting closer to spawning time will be even less effective.
2) Trawling. The possible availability of a trawl net was offered by the EA. Following discussion it was agreed that to use one of the two remaining weeks conducting a new type of operation much of which would be experimental with considerable effort required to identify and mark trawl lines was risky at this stage. There were also unknown aspects of likely catch success, net handling, larger boat required, and the survival of vendace in a trawl net. Consequently this option was rejected.
3) Egg collection. The option of egg collecting, incubation and transfers was discussed and the problems experienced last year were restated. The difficulties in netting because of macrophyte encroachment of the vendace spawning grounds last winter may have been reduced because of a reported clearing out of plants during a storm earlier this year. IW will be conducting a survey of spawning grounds under another contract in November which could provide valuable guidance in net positioning. Along with benthic nets on the spawning grounds, the new pelagic nets could also be used, set as screens offshore. The potentially serious problems of high catches of coarse fish were noted. The use of fyke nets was discussed and it was agreed that, if these were able to catch Vendace, they would have advantages over gill nets in not damaging Vendace and saving the time consuming and frustrating job of extracting large numbers of coarse fish from gill nets. If possible, large fyke nets could be used in conjunction with the gill nets from the outset to enable early comparisons of catches (PM to check contacts for information, DMcC to check if any large fyke nets are available through the EA). Past experiences have shown that vendace caught at this time often survive even gill netting in good condition. With careful attention paid to this aspect then an adult transfer programme could be carried out at the same time, particularly for fish that are pre-spawners. Simultaneous deployment of benthic, pelagic and fyke nets would require considerable staff effort. KK emphasised that given the urgency of the situation the EA was prepared to contribute as much staff time as possible.

A dual operation of this type (3) was agreed by all as the best way forward. The first week of netting will be carried out on w/c 28 November and a decision made for the second week will be based on results. A further advantage is that this approach conforms to the 'fixed terms' stated in the contract. Additional points to note:

a) the shore base will be at the Lodore landing (DMcC to arrange)
b) egg boxes may be placed under the Lodore pier (IW to confirm if suitable)
c) egg boxes may be held at Keswick Anglers Ass. hatchery (DMcC to check)
d) new benthic nets are needed (cost already in contract, PM to follow up).

Meeting ends.

Alex Lyle

Appendix 2. Details of the netting programme and catches. For net codes see Table 2.

		NET SETTING		NET RETRIEVAL			FISH CAUGHT	
SITE	NET CODE	DATE	TIME IN	DATE	TIME OUT	HOURS SET	VENDACE	OTHER SPECIES
A	B5	28-Nov	16.00	28-Nov	18.00	2.00	0	0
B	B1	28-Nov	16.15	29-Nov	10.00	17.45	0	0
D	B2	28-Nov	16.30	29-Nov	10.10	17.40	0	0
D	B1,B2	29-Nov	14.30	30-Nov	10.20	19.50	0	1trout,1perch,1roach
D	B4,B5	29-Nov	14.40	29-Nov	17.20	2.40	**1**	2perch,2roach
C	B4	29-Nov	14.50	29-Nov	17.30	2.40	0	2perch,2roach
C	B7,B8	29-Nov	15.00	30-Nov	10.15	19.15	0	1roach
B	B1,B2	29-Nov	15.30	30-Nov	10.00	18.30	0	3trout,2roach
A	B5	29-Nov	15.40	30-Nov	9.50	18.10	0	1 trout
D	B4,B5	30-Nov	14.00	01-Dec	9.45	19.45	0	3perch,7roach
D	B3,B7,B8	30-Nov	14.15	01-Dec	9.50	19.35	0	3trout,1perch,2roach
C	B5	30-Nov	14.20	01-Dec	10.10	19.50	0	1roach
C	B1,B2	30-Nov	14.30	01-Dec	10.00	19.30	0	0
B	B1	30-Nov	14.40	01-Dec	10.30	19.50	0	3ruffe
B	B2	30-Nov	14.50	01-Dec	10.25	19.35	**2**	0
A	B4	30-Nov	14.55	01-Dec	10.35	19.40	0	1ruffe
B	B4	01-Dec	14.00	02-Dec	9.40	19.40	net badly torn	
B	B1,B2,B3	01-Dec	15.15	02-Dec	9.55	18.40	**1**	0
B	B5	01-Dec	15.20	02-Dec	9.45	18.25	0	0
E	B1,B2	01-Dec	15.30	02-Dec	10.10	18.40	0	1perch,2roach
D	B7,B8,B9	01-Dec	15.40	02-Dec	10.20	18.40	0	0
D	B5,B6	01-Dec	15.50	02-Dec	10.25	18.35	0	3trout,1roach
B	B1,B2,B3	05-Dec	13.30	06-Dec	9.50	20.20	0	7trout,1perch,5roach
B	B5	05-Dec	13.40	06-Dec	10.05	20.25	0	1dace,1roach
B	B6	05-Dec	13.45	06-Dec	10.00	20.15	0	1trout
E	B1,B2	05-Dec	13.50	06-Dec	10.10	20.20	0	1trout,6roach
D	B7,B8,B9	05-Dec	13.55	06-Dec	10.20	20.25	0	1pike,1perch,11roach
D	B6	05-Dec	14.00	06-Dec	10.25	20.25	0	1trout,1pike,13roach
D	B4	05-Dec	14.10	06-Dec	10.30	20.20	**11**	1trout,3pike,4perch.9roach,3ruffe
D	B4	06-Dec	14.00	07-Dec	10.00	20.00	**1**	1dace,1trout,1perch,13roach
D	B5	06-Dec	14.05	07-Dec	9.45	19.50	0	1trout,1perch,12roach,2ruffe
D	B5	06-Dec	14.10	07-Dec	9.55	20.05	**3**	1trout,2perch,14roach
D	B6	06-Dec	14.20	07-Dec	9.50	20.10	**1**	10roach
D	B1,B2,B3	07-Dec	13.00	08-Dec	10.20	21.20	0	0
D	B4	07-Dec	13.10	08-Dec	9.55	20.45	**2**	2trout,2perch,4roach,1ruffe
D	B5	07-Dec	13.15	08-Dec	10.00	20.45	**3**	1trout,3perch,1roach
D	B6	07-Dec	13.20	08-Dec	10.05	20.45	**1**	1trout,1perch,2roach
D	B5	07-Dec	13.25	08-Dec	10.10	20.45	0	1pike,3perch,1roach
B	B1,B2	08-Dec	13.50	09-Dec	9.40	19.50	**8**	2salmon,2trout,12roach,5ruffe
D	B1,B2,B3	08-Dec	14.00	09-Dec	10.00	20.00	**25**	1trout,1pike,15perch,32roach
D	B5	08-Dec	14.10	09-Dec	10.25	20.15	0	1trout,1pike,1perch,3roach
D	B5	08-Dec	14.15	09-Dec	10.30	20.15	0	1pike,1perch,3roach
D	B6	08-Dec	14.20	09-Dec	10.20	20.00	0	1trout,2roach
D	B4	08-Dec	14.25	09-Dec	10.15	19.50	**2**	2trout,4roach
B	B1,B2	12-Dec	12.50	13-Dec	9.30	20.40	**11**	1trout,2perch,14roach,1ruffe
D	B7,B8,B9	12-Dec	12.55	13-Dec	9.45	20.50	**5**	1pike,7perch,67roach
D	B6	12-Dec	13.00	13-Dec	9.55	20.55	**3**	1perch,19roach
D	B5	12-Dec	13.05	13-Dec	10.00	20.55	**8**	1trout,1pike,3perch,35roach
D	B4	12-Dec	13.10	13-Dec	10.10	21.00	**8**	37roach
D	B5	12-Dec	13.15	13-Dec	10.15	21.00	**6**	51roach
B	B1,B2	13-Dec	14.00	14-Dec	9.30	19.30	**1**	1dace,1perch,11roach

D	B7,B8,B9	13-Dec	14.05	14-Dec	9.40	19.35	**5**	1pike,2perch,23roach
D	B6	13-Dec	14.10	14-Dec	9.50	19.40	**2**	6roach
D	B5	13-Dec	14.15	14-Dec	9.55	19.40	**8**	25roach
D	B4	13-Dec	14.20	14-Dec	10.05	19.45	0	1trout,1perch,5roach
D	B5	13-Dec	14.25	14-Dec	10.10	19.45	0	2dace,18roach
A	B4	14-Dec	13.30	15-Dec	9.30	20.00	0	2trout,1pike,7roach
B	B1,B2	14-Dec	13.35	15-Dec	9.40	20.05	**9**	2perch,62roach,2ruffe
D	B1,B2,B3	14-Dec	13.40	15-Dec	9.45	20.05	**10**	1trout,2perch,10roach
D	B6	14-Dec	13.45	15-Dec	9.55	20.10	0	1trout,16roach
D	B5	14-Dec	13.50	15-Dec	10.00	20.10	**8**	1trout,4perch,23roach
D	B5	14-Dec	13.55	15-Dec	10.05	20.10	**1**	1salmon,23roach

Appendix 3. Details of the trapping programme and catches. FN – fyke nets. Box – box trap (approx 1.5m square).

	SET		CHECKED		
SITE	Date/time	Type	Date/time	Catch	
	28-Nov				
A	16.00	FNx2			
B	16.15	FN			
D	16.30	FNx2			
D	16.40	Box			
			29-Nov		
A		FNx2	11.00	0	
B		FN	10.45	0	
D		FNx2	10.15	1perch,3roach	
D		Box	10.30	174roach	
			30-Nov		
A		FNx2	15.45	0	
B		FN	15.30	0	
D		FNx2	15.20	0	
D		Box	15.15	*ca.*20roach	
			02-Dec		
A		FNx2	12.10	0	
B		FN	12.25	0	
D		FNx2	12.30	0	
D		Box	12.35	*ca.*30roach	removed
			05-Dec		
A		FNx2	14.50	0	removed
B		FN	14.20	0	
D		FNx2	14.15	0	
B (from A)	14.55	FNx2			
			08-Dec		
B		FN	14.35	0	removed
D		FNx2	14.30	1perch	removed
B		FNx2	14.4	0	removed