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1 **The cultural importance and international recognition of the Arctic charr *Salvelinus alpinus***
2 **populations of Windermere, UK**

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12

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14

15 **Abstract**

16

17 The Arctic charr *Salvelinus alpinus* populations of Windermere, England's largest natural lake in the
18 Lake District of north-west England, have been studied since the 1940s. However, the species'
19 cultural importance has a much longer history and these populations have been fished since 1223.
20 As early as 1660, Arctic charr were exploited in a high-profile commercial net fishery and greatly
21 enjoyed by locals and in a 'potted' form by wealthier members of UK society. However, overfishing
22 led to substantially decreased catches and commercial netting was stopped in 1921. Local fishing for

23 Arctic charr persists to the present as a small recreational plumb-line fishery using artificial lures.
24 These fishing activities and resulting catches have long held great cultural interest for the local
25 community and visiting national and international tourists. The cultural importance of the Arctic
26 charr populations of Windermere has recently been the subject of national media interest that
27 culminated in a 2017 documentary film highlighting environmental issues facing the Arctic charr and
28 also celebrating the role of this iconic species in the cultural life of Windermere. In addition,
29 international recognition of the Arctic charr populations of Windermere also contributed to the Lake
30 District becoming a UNESCO World Heritage Site in 2017.

31

32 **Key words**

33

34 conservation; ecosystem services; environmental management; fisheries; overfishing; public profile

35

36 **Acknowledgements**

37

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39 and laboratory over recent decades within numerous scientific projects which have advanced our
40 understanding, management and appreciation of the Arctic charr populations of Windermere.

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42 made substantial contributions through their operation of the Windermere Arctic Charr Anglers' Log
43 Book Scheme and we thank them for allowing us to use their data. Liz Davey of the Environment
44 Agency kindly provided useful information in relation to Windermere Reflections. We are also
45 grateful to the Freshwater Biological Association for their joint stewardship of the Windermere long-
46 term data sets and to Carol Davies, Rachel Roberts and Brian Fell of Kendal Museum, Museum of

47 Lakeland Life & Industry and Brian Fell Sculpture & Metalwork, respectively, for helping us into the
48 world of cultural importance and recognition. Finally, we thank Steven Barber for his kind
49 permission to use his photograph of the magnificent Arctic charr sculpture at Ambleside.
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51 Environment Agency, Lake District National Park Authority, Natural England, Natural Environment
52 Research Council, United Utilities and Wildsmith Hotels.

53

54 **Introduction**

55

56 The Arctic charr *Salvelinus alpinus* (Linnaeus, 1758) is one of the most widely researched fish species
57 in the world (Klemetsen, this volume), with much of this long and detailed study being driven
58 ultimately by the cultural importance of this highly edible salmonid for the many human
59 communities with which it shares extensive circumpolar northern habitats. These communities
60 include some in the UK, where the Arctic charr is relatively widespread in Scotland but extremely
61 restricted in distribution in England, Northern Ireland and Wales. In England, all native populations
62 are restricted to the Lake District where they persist in just eight lakes including Windermere
63 (Maitland et al., 2007; Ferguson et al., in press). Given this relatively limited national distribution
64 and a range of environmental threats facing the species, the Arctic charr is listed as a UK Biodiversity
65 Action Plan Priority Species which affords its populations some degree of protection from direct and
66 indirect impacts. Nevertheless, the Arctic charr is also fished recreationally with a low intensity in a
67 small number of UK water bodies (Winfield, 2016).

68

69 The lake of Windermere in the Lake District National Park of north-west England (Fig. 1) provides a
70 range of ecosystem services to approximately 17,500 individuals resident in its local communities

71 and to many of the approximately 16M national and international tourists that visit this National
72 Park each year (Clarke & Anteric, 2014). Nevertheless, like many temperate lakes around the world,
73 Windermere also faces significant pressures from eutrophication, climate change, sedimentation,
74 and species introductions (Maberly & Elliott, 2012). Harnessing such cultural importance to deliver
75 improved environmental management was recently a major driving philosophy behind Windermere
76 Reflections, a GBP1.7M Landscape Partnership Scheme funded by the UK Heritage Lottery Fund
77 running from 2010 to 2014. This ambitious project sought to conserve and enhance the
78 Windermere catchment by both direct, practical, short-term interventions, and by promoting longer-
79 term attitudinal and behavioural changes in residents, businesses and visitors, encouraging
80 engagement and a sense of responsibility through interpretation, education and training (Clarke &
81 Anteric, 2014). The Arctic charr played an important role throughout this innovative project by
82 offering an excellent and highly relatable example of the ways in which environmental threats can
83 impact lake ecosystems. Consequently, 'Albert the Arctic charr' played a visible role in promotional
84 literature and other activities used during the lifetime of Windermere Reflections that still persists in
85 the form of two cameo appearances illustrating effects of eutrophication and sedimentation within
86 the entertaining and educational 'Windermere Song' (www.youtube.com/watch?v=X_VAMHJQJU,
87 accessed 11 June 2018).

88

89 From a global perspective, the fundamental and applied scientific literature on members of the
90 *Salvelinus* genus is immense in terms of both historical duration and volume as considered by
91 Klemetsen (this volume). However, specific considerations of the interactions of such fishes with
92 human societies are remarkably rare. It is now over 30 years since Johnson (1984) provided a novel
93 philosophical perspective on such interactions, but the vast majority of subsequent *Salvelinus*
94 studies have remained firmly focussed on either fundamental biology and ecology or fisheries
95 management. The persistence of this approach is despite an increasing need for scientists to

96 communicate their findings to wider society and to demonstrate their tangible benefits (Winfield,
97 2010; Kuehne & Olden, 2015). In contrast, many of the recent activities at Windermere described
98 above have embraced a more society-orientated approach and here we present an overview of the
99 cultural importance of the Arctic charr populations of this iconic lake and the ways in which they
100 have recently contributed to its management and international recognition. Before these wider
101 issues are covered, however, it is appropriate first to review briefly the considerable scientific
102 studies of the Arctic charr populations of this lake.

103

104 **Scientific studies**

105

106 Windermere has been subjected to over 75 years of continuous scientific study, with much of the
107 ecosystem aspects of this work up to 2012 being described by Maberly & Elliott (2012). In terms of
108 the lake's fish populations, work on Arctic charr by Winifred E. Frost undertaken from the 1950s to
109 the 1980s has been widely and repeatedly recognised as ground-breaking by authors from around
110 the world (e.g. Klemetsen, 2010). The present review purposefully does not cover all of Frost's work
111 because it has already been reviewed in detail by Baroudy (1995). However, it is appropriate to
112 emphasise here that Frost's work on Arctic charr spawning grounds, spring- and autumn-spawning
113 biology, and the existence of races or sub-populations as exemplified by Frost (1965) has both
114 advanced fundamental biological understanding and simultaneously informed local conservation
115 management of this iconic species.

116

117 Since Frost's prolific studies, research has continued on the fundamental biology and ecology of
118 Arctic charr in Windermere, exemplified by Mills (1989), Mills & Hurley (1990), and Elliott & Baroudy
119 (1995). However, partly in response to the local cultural importance of Arctic charr, numerous more

120 applied studies have also been undertaken in response to the observed eutrophication of
121 Windermere, which has been evident in both of its north and south basins but more marked in the
122 latter. Le Cren et al. (1972) reported an early examination of the effects of exploitation and
123 eutrophication on the salmonid community of the lake, while Mills et al. (1990) developed this
124 theme with specific reference to its Arctic charr populations. Subsequently, Jones et al. (2008) used
125 detailed long-term dissolved oxygen and hydroacoustic survey data to examine eutrophication
126 impacts on habitat availability for Arctic charr, while Winfield et al. (2008) expanded their treatment
127 of environmental threats to this species to include climate change and fish species introductions.
128 More recently, Winfield et al. (2015) returned to one of the original topics of Frost (1965) and used a
129 novel hydroacoustics system to quantify and assess the condition of Arctic charr spawning grounds
130 in the lake's two basins.

131

132 Finally, in terms of advances in applied science that have been made from research at Windermere,
133 an exhaustive and semi-popular account of the restoration of Windermere provided by Pickering
134 (2001) included specific sections on Arctic charr in the initial description of the lake's ecology and
135 within chapters on historic deterioration of water quality and its restoration. Such incidences attest
136 to both this species' value as an indicator species and to its local cultural importance.

137

138 **Fisheries**

139

140 The island nature of the UK has given this geographical area a long history of commercial marine
141 fisheries. In contrast, its abundant fresh waters support very few commercial fisheries, although
142 they do provide extensive recreational opportunities (Winfield, 2016). Windermere is a notable
143 exception to this scant history of freshwater commercial fisheries, possibly as a result of the

144 combination of this lake's large size and its once relative geographical isolation from major sea
145 fishing ports.

146

147 Kipling (1973) described 113 commercial netting sites used historically on Windermere, but the
148 lake's commercial fisheries were most extensively documented by Kipling (1972). The latter noted
149 that in addition to Arctic charr, fisheries also existed for brown trout *Salmo trutta* Linnaeus, 1758,
150 European eel *Anguilla Anguilla* (Linnaeus, 1758), perch *Perca fluviatilis* Linnaeus, 1758, pike *Esox*
151 *lucius* Linnaeus, 1758 and migratory Atlantic salmon *Salmo salar* Linnaeus, 1758. The first written
152 mention of the fisheries of Windermere was in a court case of 1223 between William de Lancaster
153 4th Baron of Kendal and the Abbot of Furness as reported in Curia Regis Rolls (1955). Historically,
154 the main fishing technique for Arctic charr was seine nets operating within commercial fisheries.
155 Apparently, little or no historical recreational fishing targeted Arctic charr on Windermere, although
156 the famous angler Izaak Walton wondered about the species' sporting potential in his classic
157 recreational fishing book *The Compleat Angler* first published in 1653 (Walton & Cotton, 2008). A
158 full historical record of commercial catches is unavailable, but Kipling (1972) indicated that the
159 amount of Arctic charr caught became unsustainable in the middle of the 19th century, with
160 temporarily disastrous results. This precipitous decline came at a time when trade in this species
161 was flourishing and both the local population and the tourist trade were increasing. Restrictions on
162 the most efficient fishing methods were swiftly imposed by the lake's proprietors. Soon afterwards,
163 and as the result of a Royal Commission addressing concerns over national fisheries issues, Boards of
164 Conservators were established for fishery districts in 1865, and at Windermere the policy from 1880
165 onwards was to rent all net fisheries with a view to closing them down. Watson (1899) cited
166 Nicholson & Burn (1777), who noted the existence and importance of the Arctic charr fishery on
167 Windermere and even commented that the lake contains three sorts of 'chars'. Watson (1899) also
168 cited a Mr Berrington's Report on Salmon and Freshwater Fisheries in 1890, which stated that recent

169 protective measures for Arctic charr in Windermere had borne excellent results. By 1915, the Board
170 of Conservators responsible for Windermere had amassed complete control over netting activities
171 and the last commercial netting took place in 1921.

172

173 As the above commercial netting story was unfolding, in 1840 a Mr Spencer from Manchester first
174 introduced to Windermere a way of fishing for Arctic charr from a row boat using a plumb-line
175 technique involving a small number of artificial lures deployed by a purpose-built rod, or more
176 usually by a pair of rods (Day, 1887). This technique persists today virtually unchanged as the sole
177 means by which Arctic charr are fished in Windermere, where this practice is undertaken by a few
178 tens of anglers as a recreational fishery (Fig. 2). The fishery is now regulated by the Environment
179 Agency with a fishing season running from 15 March to 30 September and a minimum takeable size
180 of 200 mm, with no other restrictions on the catch or effort of this very small-scale fishery
181 (Environment Agency, 2009). Further details of this unusual fishery may be found online
182 (www.fishingmuseum.org.uk, accessed 11 June 2018).

183

184 Variations in catch-per-unit-effort (CPUE) recorded by two Windermere Arctic charr anglers over the
185 period 1966 to 1991 were found by Elliott & Baroudy (1992) to agree with corresponding variations
186 in CPUE of non-destructive gill nets operated on a north basin spawning ground over the same or
187 similar periods as far as data availability permitted. Subsequently, Winfield et al. (2008) showed that
188 these agreements persisted from 1990 to 2005 with an angler catch dataset that had been expanded
189 from 2004 onwards to include catches of additional anglers recorded under the Environment
190 Agency's Windermere Arctic Charr Anglers' Log Book Scheme, which persists to the present as the
191 best monitoring metric for Arctic charr populations of the lake's north and south basins (Fig. 3).
192 Unfortunately, this metric also reveals a declining trend of CPUE in both basins, with the decline in
193 the more-eutrophicated south basin being particularly severe.

194

195 **Cultural importance and international recognition**

196

197 The historical cultural importance of the Arctic charr populations of Windermere has already been
198 alluded to above in their context of historically supporting commercial fisheries for this valued
199 species, i.e. in providing an important provisioning ecosystem service. In addition, mention of this
200 species in Izaak Walton's original 1653 edition of his classic recreational fishing book *The Compleat*
201 *Angler* suggests that the sporting value of Arctic charr may also have been appreciated as long ago
202 as several hundred years (Walton & Cotton, 2008). Similarly, in his account of his extensive travels
203 through Great Britain, the literary writer Daniel Defoe noted that the Arctic charr of Windermere
204 had a reputation not simply as a basic food fish, but as a dainty (or delicacy) that was traded near
205 and far as a gift (Defoe, 1727). Writing somewhat later, Watson (1899) also noted the high regard in
206 which the Arctic charr was held by the local community, which was such that for a short period a
207 small private hatchery was operated for this species on the banks of Windermere and as many as
208 180,000 fry were introduced to the lake each year.

209

210 In more recent decades, the Arctic charr populations of Windermere have enjoyed a consistently
211 high profile in a range of popular or semi-popular books or articles on the lake or its surrounding
212 areas such as those by Palmer (1945) and Frost (1989). Part of this persistent attraction stems from
213 the species' high culinary value, with a notable recent resurgence in the context of so-called 'slow
214 food' that is produced or prepared following local culinary traditions and usually uses high-quality,
215 locally sourced ingredients. For example, the Arctic charr is featured on the website of 'Slow Food in
216 the UK' (www.slowfood.org.uk, accessed 11 June 2018). The species also continues to feature in
217 exhibits of the local Kendal Museum and the Museum of Lakeland Life & Industry in the contexts of

218 natural history (with the species' renowned morphological plasticity amongst an angler's catches
219 evident and recognised as long ago as 1914) and fisheries, respectively. In addition, a small
220 exhibition of Arctic charr fishing tackle is planned for the Windermere Jetty Museum of Boats, Steam
221 and Stories (www.windermerejetty.org, accessed 11 June 2018), which will open soon on the lake's
222 shore (Rachel Roberts, Museum of Lakeland Life & Industry, *pers. comm.*).

223

224 The contemporary cultural importance of the Arctic charr populations of Windermere was also
225 prominent in a recent exploration and documentation of the current condition of the lake in an
226 historical context within the Clear Waters Project conducted by the Freshwater Biological
227 Association (Davy-Bowker, 2015). This volunteer-based oral history project focussed on
228 Windermere with the help of volunteers and research materials provided by the Centre for Ecology
229 & Hydrology, Kendal Oral History Group, University of Cumbria, and Wordsworth Trust. Specifically,
230 38 interviewees recalled socio-economic, climatic, and ecological changes that they had observed at
231 the lake over recent decades. The project reported on 21 May 2014, with transcripts of its
232 interviews subsequently archived and available on registration at the website of the Ambleside Oral
233 History Archive (www.aohg.org.uk, accessed 11 June 2018). The acknowledged cultural importance
234 of this work was such that a well-attended mobile exhibition then visited a number of venues
235 including the Aquarium of the Lakes, Cumbria County Council, Lakeland Arts Trust, and Lancaster
236 Maritime Museum. Similarly, a range of evening talks and other publicity was disseminated through
237 the Freshwater Biological Association, Lakeland Arts Trust, Newsletters, South Cumbria Rivers Trust,
238 and Windermere Reflections.

239

240 In the present context, 19 interviewees (50%) of the Clear Waters Project specifically referred to
241 Arctic charr, or char as the species is frequently also known locally. Moreover, interviewees
242 demonstrated a familiarity with basic features of Arctic charr ecology, such as individuals

243 frequenting deeper areas of the lake and moving deeper when the weather is hot and sunny,
244 together with an appreciation of observable differences between Arctic charr from the lake's north
245 and south basins. Interviewees were also well aware of the history of the local Arctic charr fishery,
246 including that its high-value product was usually sold locally in butchers rather than fishmongers and
247 that its lucrative potting operations facilitated transport further afield to London and elsewhere.
248 Many interviewees were also well aware of the fishery's demise from a peak in Victorian times and
249 the relative rarity of contemporary fishing activities for this remarkable species.

250

251 In addition to the above demonstrable local cultural importance of the Arctic charr populations of
252 Windermere, these fish recently also received international recognition when the Lake District was
253 listed as a UNESCO World Heritage Site on 9 July 2017 (Lake District National Park Partnership,
254 2016). This listing was made in the category of Cultural Landscape, reflecting the area's identity as a
255 dramatic farmed landscape, the inspiration that it has given to art, literature and love of place, and
256 its pivotal early role in the nature conservation movement of the UK. The nomination case also
257 made specific reference to the area's populations of Arctic charr, and incidentally also to two other
258 rare fish species, vendace *Coregonus albula* (Linnaeus, 1758) and European whitefish *Coregonus*
259 *lavaretus* (Linnaeus, 1758), known locally as schelly.

260

261 This listing of the Lake District as a UNESCO World Heritage Site will undoubtedly elevate the area's
262 international recognition, potentially boosting tourism and thus delivering benefits to local
263 communities and businesses as a direct result. An associated programme of celebration with the
264 Social Media hashtag #WeAreTheLakes has been developed and contains two components directly
265 related to the Arctic charr populations of Windermere. Firstly, as part of the Lakes Ignite Festival a
266 large metal sculpture of a group of larger-than-life Arctic charr (Fig. 4) was installed in a high profile
267 location in the town of Ambleside at the north end of Windermere, which will be seen by many of

268 the approximately 16M national and international tourists that visit the lake and its surrounding
269 areas each year. Secondly, and again precipitated in large part by the Lake District's successful bid to
270 become a UNESCO World Heritage Site, the 12-minute film 'Brass, Three Down' centred on the
271 Arctic charr fishery of Windermere was made by two of the present authors. This film brings
272 together environmental issues described earlier and also celebrates the role that the Arctic charr has
273 played and continues to play in the cultural life of Windermere. This film premiered at the Kendal
274 Mountain Festival in November 2017, where it attracted both regional and national media interest,
275 and has subsequently been shown to a number of local natural history and other groups and is also
276 accessible online (<https://vimeo.com/241788130>, accessed 11 June 2018). Although taking the
277 fishery as its main theme, this film also considers wider environmental issues and documents an
278 evident shift of Arctic charr from historically providing a purely provisioning ecosystem service to
279 now providing a multi-faceted cultural ecosystem service.

280

281 **Closing remarks**

282

283 The Arctic charr populations of Windermere have been researched continuously for approximately
284 78 years, during which time major contributions have been made to fundamental scientific
285 understanding. At the same time, well-documented changes have been observed in Arctic charr
286 habitat and population abundance in response to a range of pressures including eutrophication,
287 climate change, and species introductions. All of these pressures are currently being addressed
288 through management informed by the improved scientific understanding. Although a poorly
289 managed commercial fishery historically had a significant adverse impact on the Arctic charr
290 populations, this was eventually and far-sightedly closed and fishing activities persist today only as a
291 negligible-impact recreational activity.

292

293 The cultural importance of the Arctic charr populations of Windermere to its local communities has
294 been evident since the 1200s through frequent and substantial references in the non-scientific
295 literature, museum collections, and oral histories. This local importance is now recognised
296 internationally through a specific mention of Arctic charr in the recent listing of the Lake District as a
297 UNESCO World Heritage Site in 2017. This intervening period of over 800 years has also
298 documented the shift of the Arctic charr populations of Windermere from historically providing a
299 purely provisioning ecosystem service in the form of food for local and distant human populations,
300 to now providing a range of cultural ecosystem services encompassing cultural, spiritual, historical,
301 recreational, and educational dimensions. Given the extensive geographical distribution of Arctic
302 charr and closely related species, the specific case history presented here provided by the
303 Windermere populations is likely to have relevance and application to the management and societal
304 importance of these remarkable fishes in many other locations around the globe.

305

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416

417 **Figure legends**

418

419 **Fig. 1** The north basin of Windermere, a large multi-use lake within the Lake District UNESCO World
420 Heritage Site which provides a range of ecosystem services to local communities and visiting national
421 and international tourists. Photograph copyright Ian J. Winfield

422

423 **Fig. 2** A recreational angler fishing for Arctic charr on Windermere using a traditional plumb-line
424 technique. Photograph copyright Henry Iddon

425

426 **Fig. 3** Catch-per-unit effort (CPUE, expressed as number of fish angler⁻¹ h⁻¹) of the Arctic charr
427 fisheries of the north (closed symbols, solid line) and south (open symbols, broken line) basins from
428 1966 to 2016. No data are available for the south basin in 2002 and 2003, while data points for 2004
429 and onwards are presented as means \pm 95% confidence limits.

430

431 **Fig. 4** Sculptors Brian (right) and George (left) Fell with their metal sculpture of Arctic charr installed
432 as part of the Lakes Ignite Festival in a high profile public space in Ambleside at the north end of
433 Windermere. Photograph copyright Steven Barber.

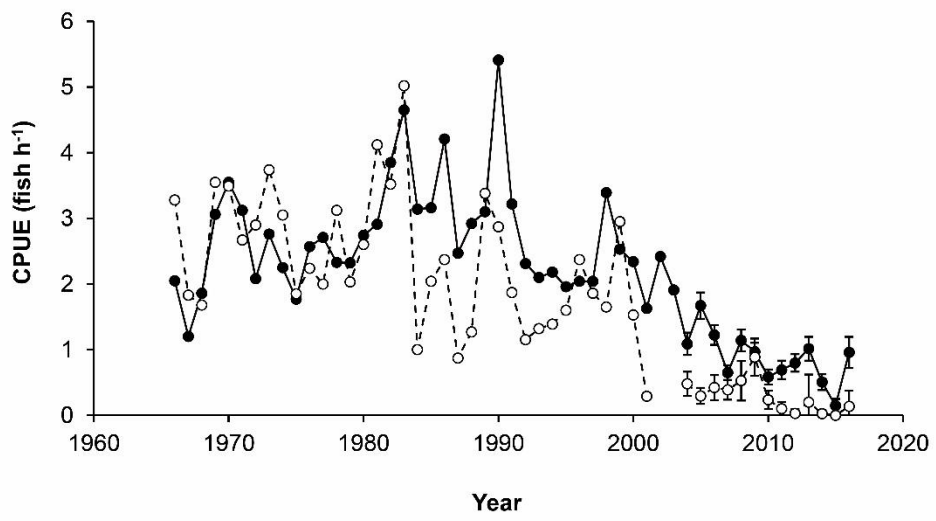
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