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using Multiple Mesh Size Gillnets**

**A Comparative Study 2023 v 2004**

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**August 2023**

Cover: The outlet of Loch Insh into River Spey, August 17, 2023.  
Photo: Johan Hammar (© 2023)

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## Introduction

The native fish fauna of Scottish freshwaters is largely comprised of 12 boreo-Arctic species including Arctic charr (*Salvelinus alpinus* sp. complex), Brown trout (*Salmo trutta*), Atlantic salmon (*Salmo salar*), European eel (*Anguilla anguilla*), Three-spined stickleback (*Gasterosteus aculeatus*), and lampreys (*Lampetra planeri*, *L. fluviatilis*, *Petromyzon marinus*), i.e. mainly northern euryhaline and/or stenothermal species that tolerate a combination of low temperature and high salinity, and thus could colonise the Highland ice sheet melt streams from coastal ice age refugia. Powan (*Coregonus lavaretus* sp. complex) remain in only two lochs (Lomond and Eck). The now extinct Vendace (*Coregonus albula*) was never reported in the Highlands. The Flounder (*Platichthys flesus*) and Ten-spined stickleback (*Pungitius pungitius*) occur north of the Highland Boundary Fault but are only locally common. Maitland (1977, 1994) extensively summarised distribution data. Since then, several new records for Arctic charr have been reported (e.g., Greer 1995, Natural Resources Scotland 1997, Alexander & Adams 2000).

Anthropogenic introductions, both deliberate and accidental, have, however, occurred in numerous water systems in Scotland and elsewhere in the British Isles. These largely comprise introductions of fish species from the nearby Eurasian continent, but do also include some species from North America. Just as significantly, they also include transfers of fish within the British Isles to areas outside of their original, internal British biogeographical occurrence. Globally, such introductions have been recorded as causing serious ecological and genetic changes to original salmonid and other native fish communities, because of competition, predation, hybridization and introgression. Among the non-native species so far recorded in Scotland are Eastern Brook charr (*Salvelinus fontinalis*), American Rainbow trout (*Oncorhynchus mykiss*), Northern pike (*Esox lucius*), Perch (*Perca fluviatilis*), Ruffe (*Acerina cernua*), Roach (*Rutilus rutilus*), Rudd (*Scardinius erythrophthalmus*), Dace (*Leuciscus leuciscus*), Chub (*Leuciscus cephalus*) and Barbel (*Barbus barbus*) (Maitland 1994). Pike introductions are widely considered by game fishing interests and biologists to be inimical to salmonid populations. Numerous attempts to control and exterminate introduced pike populations in Europe and North America have been tried but have mainly failed (Svärdson 1964).

With the extensive interest and significance of angling in Scotland (Radford *et al.* 2004), the lack of knowledge of the original distribution of freshwater fish species, other than Atlantic salmon and Brown trout, within the country must be considered as astonishing. Recent, increased interest in angling for pike, with associated live bait use, and for other coarse fish species, with associated fresh introductions of a variety of non-native cyprinids and percids (in e.g., Landward 2004, BBC Scotland), represent a potential threat of major, still unknown changes occurring in the ecology of Scottish freshwaters. Such changes would place the integrity of Scotland's native freshwater biodiversity and fish resources at high risk. This is of special significance in the light of global climate change favouring some of the southern species, and thus rendering the post-establishment expansion of non-native fish populations and ecological impact on charr, trout and salmon, as well as some lake-dwelling bird species more likely.

In 2004 the Spey Fishery Board, in agreement with the Scottish Natural Heritage (SNH) and the Royal Society for the Protection of Birds (RSPB) contacted the authors to

initiate a fish survey in the River Spey catchment, employing Swedish standard methods of using multiple mesh size gillnets, a then first of its kind survey in the system, if not in Scotland (Greer & Hammar 2004). This follow-up study and report, by the same researchers and authors, in cooperation with the Spey Fishery Board and supported by the Cairngorms National Park Authority, gives new details on a subsequent study in two of the lochs surveyed in 2004 (Lochs Insh and Alvie) during August 2023. The impetus behind this follow-up study was reports of anglers catching Perch (*Perca fluviatilis*) in Loch Alvie in 2017, and the results of eDNA analyses of water samples from Loch Insh by the Scottish Environmental Protection Agency (SEPA) suggesting the presence of Perch there. In both situations no specimens of this species were caught in the 2004 study, and their establishment since then would represent a dramatic change in the species composition of the fish assemblages in the lochs concerned, with profound ecological implications for much of the River Spey watershed including compromising existing conservation designations such as its classification as a Special Area of Conservation. (SAC).

## Material and methods

Lochs Insh and Alvie in the Aviemore region of upper River Spey were re-surveyed during August 14<sup>th</sup> to 17<sup>th</sup> 2023 with the same multiple mesh size gillnets used during the 2004 survey, following the established standardized European method for a stratified random sampling procedure (Appelberg 2000). The method basically recommends the distribution of gillnet efforts to tail the areal proportions of depth zones in each lake, illustrated by a gradual decline of efforts with increasing depth. The manual offers two quantitatively different methods, one being the extensive standard sampling procedure allowing the detection of 50% changes between sampling occasions, and the other a simplified inventory sampling method using lesser number of efforts. The latter method is strongly recommended in natural, unexploited and unknown fish communities, and was thus the one again applied in the new survey. Major benefits of this latter method include; its applicability to the abiotic and biotic nature of Highland lochs, its low labour intensity and its likely effectiveness in catching a wide range of species across the spectrum of the spatial subdivisions within the loch, ranging from shallow littoral-benthic and profundal-benthic areas to the pelagic zone (e.g. Hammar & Filipsson 1985).

The gillnets are made from monofilament nylon and composed of different mesh sizes following a geometric series with a ratio between mesh-sizes of about 1.25. The benthic sets of gillnets are 30 m long and 1.5 m deep and are composed of 12 different mesh size panels ranging from 5 to 55 mm knot to knot, each panel being 2.5 m wide (Table 1). The design of the pelagic gillnet is similar, although this gear lacks the 5 mm panel because of manufacturing difficulties, and thus only include 11 mesh sizes. The pelagic gillnet is 27.5 m long, and 6 m deep, and thus has a surface area being 3.7 larger than the benthic design. The pelagic gillnet is also divided in half allowing it to be treated as two efforts, sampling 0-3 and 3-6 m, respectively.

Both benthic and pelagic gillnets were used in Loch Insh, as per the 2004 study, but because a technical deficiency of a powerful outboard engine only benthic nets were used in Loch Alvie in 2023 (Table 2).

## Repeat Non-Native Fish species Survey – River Spey 2023 v 2004

Table 1. Mesh-size distribution and monofilament diameter of multiple mesh size gillnets of the Nordic type.

Mesh no	Mesh size, knot to knot (mm)	Thread diameter, mm
1	43	0.20
2	19.5	0.15
3	6.25	0.10
4	10	0.13
5	<b>55</b>	0.23
6	8	0.10
7	12.5	0.13
8	24	0.16
9	15.5	0.15
10	<b>5</b>	0.10
11	35	0.20
12	29	0.16

Table 2. The physical characteristics of the two lochs in River Spey surveyed, dates of gillnetting and numbers of gillnet efforts used in 2023. Background information on area, maximum and mean depths are from Natural Resources Scotland's Bathymetrical Survey. The maximum depths given within brackets were those recorded during the survey. The numbers of efforts given within brackets are those recommended for an inventory and a standard sampling program, respectively.

Loch	Area	Max depth	Mean Depth	Date	Number of Efforts	
	ha	m	m		Benthic	Pelagic
Alvie	57	(18.5) 21	8	08.16-17	8 <sup>(8,24)</sup>	
Insh	114	(25.8) 30	11	08.14-15	8 <sup>(8,40)</sup>	4 <sup>(0,8)</sup>
Total					16 <sup>(16,64)</sup>	4 <sup>(0,8)</sup>

Whereas all benthic gillnets were set individually at the bottom and clearly marked with floats in both ends, the two pelagic gillnets were linked together and set at the surface over a deeper part of the lake. In Loch Insh the pelagic gillnets were set over 21-22-26 m of water. The large pelagic gear requires special handling in order to properly sample the specified surface depth zones (see Hammar & Filipsson 1985), and was clearly marked with a series of larger buoys. The depth distribution of the individual gillnets is shown in Table 3.

Table 3. Depth distribution of benthic and pelagic gillnet set over night in the two lochs surveyed in River Spey in 2023.

Loch	Number of efforts						
	Benthic depths, m					Pelagic depths, m	
	0-2.9	3.0-5.9	6-11.9	12.0-19.9	20.0-34.9	0-3	3-6
Alvie	2	2	2	2			
Insh	2	2	2	1	1	2	2
Total	4	4	4	3	1	2	2

All fish caught from Loch Insh were frozen before sampled two days later together with the fish from Loch Alvie. The fish were then individually weighed and measured for

fork- and/or total length to the nearest gram and mm, respectively. For each fish its sex and maturity stage identified and, depending on species, otoliths (charr, trout, perch) and scales (trout) were removed for future age analyses. For systematic comparisons, all charr were sampled for a set of morphological and meristic parameters. All stomachs of Arctic charr, Brown trout and subsamples from Perch from both lakes were preserved in alcohol for future diet and parasite analyses. The stomachs of pike were examined, and their contents identified during sampling.

## Results

### *Diversity, and presence of non-native species*

In total 305 individuals belonging to six species were caught, with pike and three cyprinid species – minnow, roach and perch - being considered non-native.



Two non-native fish species, Roach (left) and Perch (right) caught in the littoral zone of Loch Alvie on August 17, 2023. Photos Johan Hammar (© 2023)

For comparison of the changes, the new fish species recorded, and the total numbers and weight of individuals caught and sampled in both 2004 and 2023 are presented in Tables 4 and 5.

Table 4. Species and total numbers of fish recorded, caught and sampled in two River Spey lochs with benthic and pelagic Nordic survey nets in June-July 2004 and August 2023.

Loch	Arctic charr	Brown trout	Salmon	Pike	Eel	Minnow	Perch	Roach	Total
Alvie 2004		14		5	1				20
Alvie 2023		1		8	x		222	8	239
Insh 2004	56	13	1	4	x				74
Insh 2023	16	1		2	x	1	46		66
Total	72	29	1	19	1	1	268	8	398

## Repeat Non-Native Fish species Survey – River Spey 2023 v 2004

Table 5. Species and total weight in grams of fish recorded, caught and sampled in two River Spey lochs with benthic and pelagic Nordic survey nets in June-July 2004 and August 2023.

Loch	Arctic charr	Brown trout	Salmon	Pike	Eel	Minnow	Perch	Roach	Total
Alvie 2004		4,526		901	106				5,533
Alvie 2023		1,396		5,145	x		13,699	643	20,883
Insh 2004	13,344	9,176	1,207	690	x				24,417
Insh 2023	1,378	96		393	x	3	2,455		4,325
Total	14,722	15,194	1,207	7,129	106	3	16,154	643	55,158

Although eels were only caught in Loch Alvie in 2004, the presence of eel were again noted in both Loch Alvie and Insh in 2023 by slime rings left on the gillnets, and the remains of perch being eaten and digested by eel after being caught by the gillnets. While the lakes were inhabited and visited by red-throated diver, goldeneye, teal, common mallard, barnacle goose, mute swan, grey heron and osprey during the survey no by-catch of birds or mammals occurred.

### *Water temperature*

The water temperature measured at the surface of Loch Insh on August 14<sup>th</sup> 2023 was 18.5 °C and in Loch Alvie on August 16<sup>th</sup> 2023 20.0°C. The water temperature in the lochs surveyed in June-July 2004 varied within 13.2 -15.0° C. In the deeper lochs a week thermocline was noted between 10 and 15 m, with temperatures around 8-9°C being recorded at the bottoms in 2004 (Fig. 1).

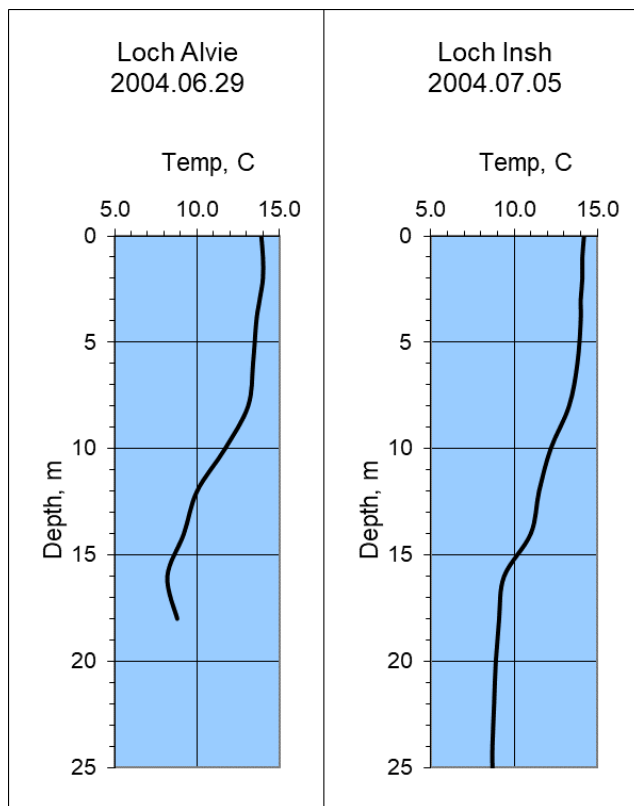


Figure 1. Water temperature profiles to the bottom in Lochs Alvie and Insh surveyed in 2004.





Lochs Alvie (above) and Insh (below) in mid-August 2023. Photos Johan Hammar (© 2023)

**Catch statistics and Depth distribution.**

In the 2023 sampling, the total abundance and biomass of fish in Loch Alvie was 29.9 individuals and 2,610.4 gram per gillnet and night at the bottom, with the relative abundance and biomass thus being roughly 16 and 8 times higher, respectively, of those recorded in 2004. In Loch Insh the total abundance and biomass of fish was 7,8 individuals and 525,6 gram per gillnet and night at the bottom in 2023 with the relative abundance thus being 1.7 times higher and the biomass less than half of those recorded in 2004 (Fig. 2).

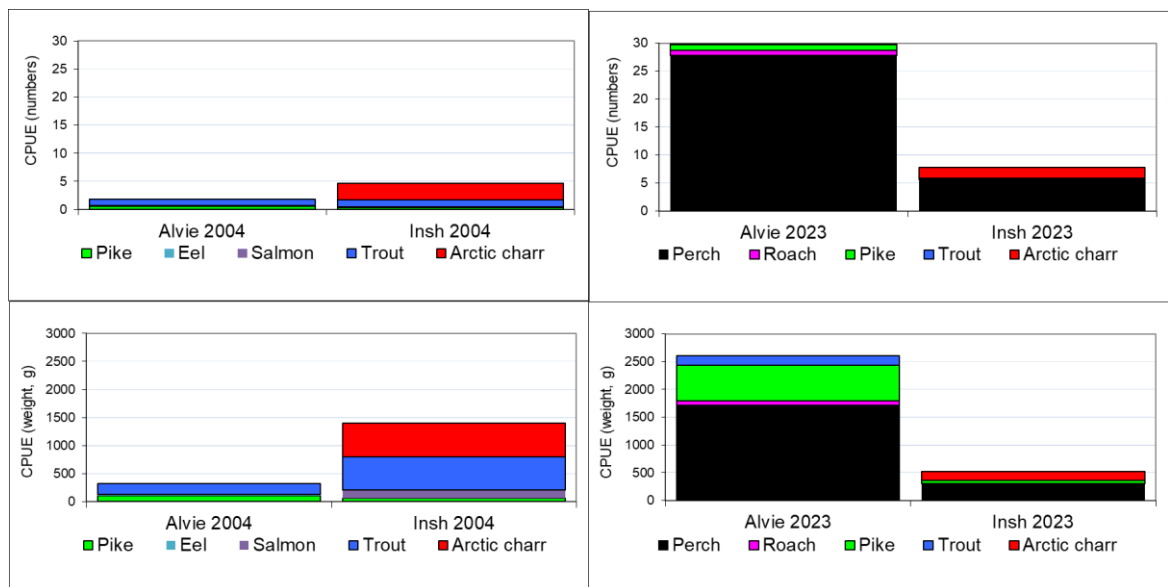


Figure 2. Comparative relative abundance and biomass of fish in Lochs Alvie and Insh measured as catch per unit effort (CPUE) with Nordic multiple mesh size gillnets set at the bottom in June-July 2004 and August 2023.

While the total abundance and biomass of fish in the pelagic catch in Loch Insh in 2023 was only 1.0 individual and 30.0 gram per gillnet and night, the comparative pelagic catch in 2004 was more than 9 times in numbers and more than 110 times in weight higher than in 2023 (Fig. 3).

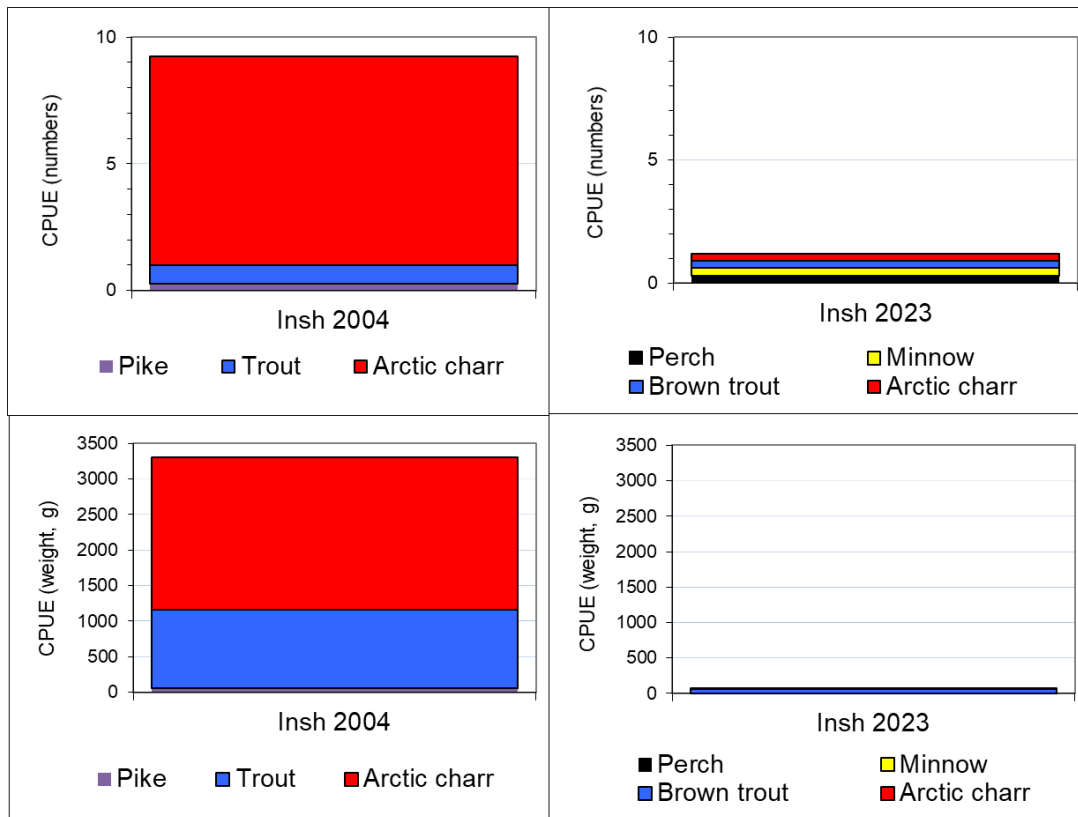


Figure 3. Comparative relative abundance and biomass of fish in Loch Insh measured as catch per unit effort (CPUE) with Nordic multiple mesh size gillnets set in the upper pelagic zone in June-July 2004 and August 2023. Note that the pelagic gillnet surface is 3.7 times larger than the benthic one.

Brown trout dominated the catches in Loch Alvie in 2004, but in the 2023 survey Perch has replaced them as the dominant species in the lake. Likewise, a combination of Arctic charr and Brown trout dominated the 2004 catch in Loch Insh, but Perch now comprise a new, prominent and indeed dominating feature in the catches.

In Loch Insh, there has thus been a remarkable reduction in the numbers and proportion of Brown trout in the 2023 catches compared to 2004, and Arctic charr were now smaller and absent in the benthic net catches shallower than 12 metres with only one specimen being caught in the pelagic nets. In the 2023 survey in Loch Insh no fish were caught in the 6–12-meter depth zone. Details of the relative abundance and biomass of fish at different depths are presented in Table 6, Figures 4 and 5 for benthic gillnets, and in Table 7, Figures 6 and 7 for pelagic gillnets.

Repeat Non-Native Fish species Survey – River Spey 2023 v 2004

Table 6. A comparison of the abundance of different species of fish shown as catch per unit effort (CPUE) in numbers and weight per gillnet set at different depths overnight at the bottom of Lochs Alvie and Insh in 2004 and 2023.

Depth, m	Efforts	CPUE, numbers						CPUE, weight (g)					
		0-3	3-6	6-12	12-20	20-35	Total	0-3	3-6	6-12	12-20	20-35	Total
<b>Loch Alvie 2004</b>													
Trout	8	2.5	0.0	1.0	0.7		1.1	351	0.0	325	83		759
Eel	8	0.0	0.0	0.0	0.3		0.1	0	0	0	35		13
Pike	8	2.0	1.0	0.0	0.0		0.6	433	35	0	0		113
Total	8	4.5	1.0	1.0	1.0		1.9	784	35	325	119		326
<b>Loch Alvie 2023</b>													
Trout	8	0.0	0.5	0.0	0.0		0.1	0	698	0	0		175
Pike	8	2.0	0.5	1.5	0.0		1.0	1369	144	1060	0		643
Perch	8	44.0	44.5	22.0	0.5		27.8	2574	2825	1390	61		1712
Roach	8	4.0	0.0	0.0	0.0		1.0	322	0	0	0		80
Total	8	50.0	45.5	23.5	0.5		29.9	4265	3667	2449	61		2610
<b>Loch Insh 2004</b>													
A. charr	8	0.5	0.5	6.0	8.0	1.0	2.9	199	150	1211	1622	50	599
Trout	8	3.0	2.0	0.0	0.0	0.0	1.3	1899	474	0	0	0	593
Salmon	8	0.5	0.0	0.0	0.0	0.0	0.1	604	0	0	0	0	151
Pike	8	1.0	0.5	0.0	0.0	0.0	0.4	110	118	0	0	0	57
Total	8	5.0	3.0	6.0	8.0	1.0	4.6	2812	741	1211	1622	50	1400
<b>Loch Insh 2023</b>													
A. charr	8	0.0	0.0	0.0	5.0	10.0	1.9	0	0	0	810	551	170
Pike	8	0.5	0.5	0.0	0.0	0.0	1.3	96	101	0	0	0	49
Perch	8	18.5	4.0	0.0	0.0	0.0	5.6	996	230	0	0	0	306
Total	8	19.0	4.5	0.0	5.0	10.0	7.8	1091	331	0	810	551	526

Table 7. The change in abundance of different species of fish shown as catch per unit effort (CPUE) in numbers and weight per gillnet set at different depths overnight in the pelagic zone of Loch Insh 2004 and 2023.

Depth, m	Effort number	CPUE, numbers			CPUE, weight (g)		
		0-3	3-6	Total	0-3	3-6	Total
<b>Loch Insh 2004</b>							
Arctic charr	4	9.5	7.0	8.3	2229	2048	2139
Trout	4	1.0	0.5	0.8	1763	452	1107
Pike	4	0.0	0.5	0.3	0	118	59
Total	4	10.5	8.0	9.3	3992	2617	3305
<b>Loch Insh 2023</b>							
Arctic charr	4	0.0	0.5	0.3	0.0	8.5	4.3
Trout	4	0.0	0.5	0.3	0.0	48	24
Minnow	4	0.5	0.0	0.3	1.5	0.0	0.8
Perch	4	0.5	0.0	0.3	2.0	0.0	1.0
Total	4	1.0	1.0	1.0	3.5	56.5	30

Repeat Non-Native Fish species Survey – River Spey 2023 v 2004

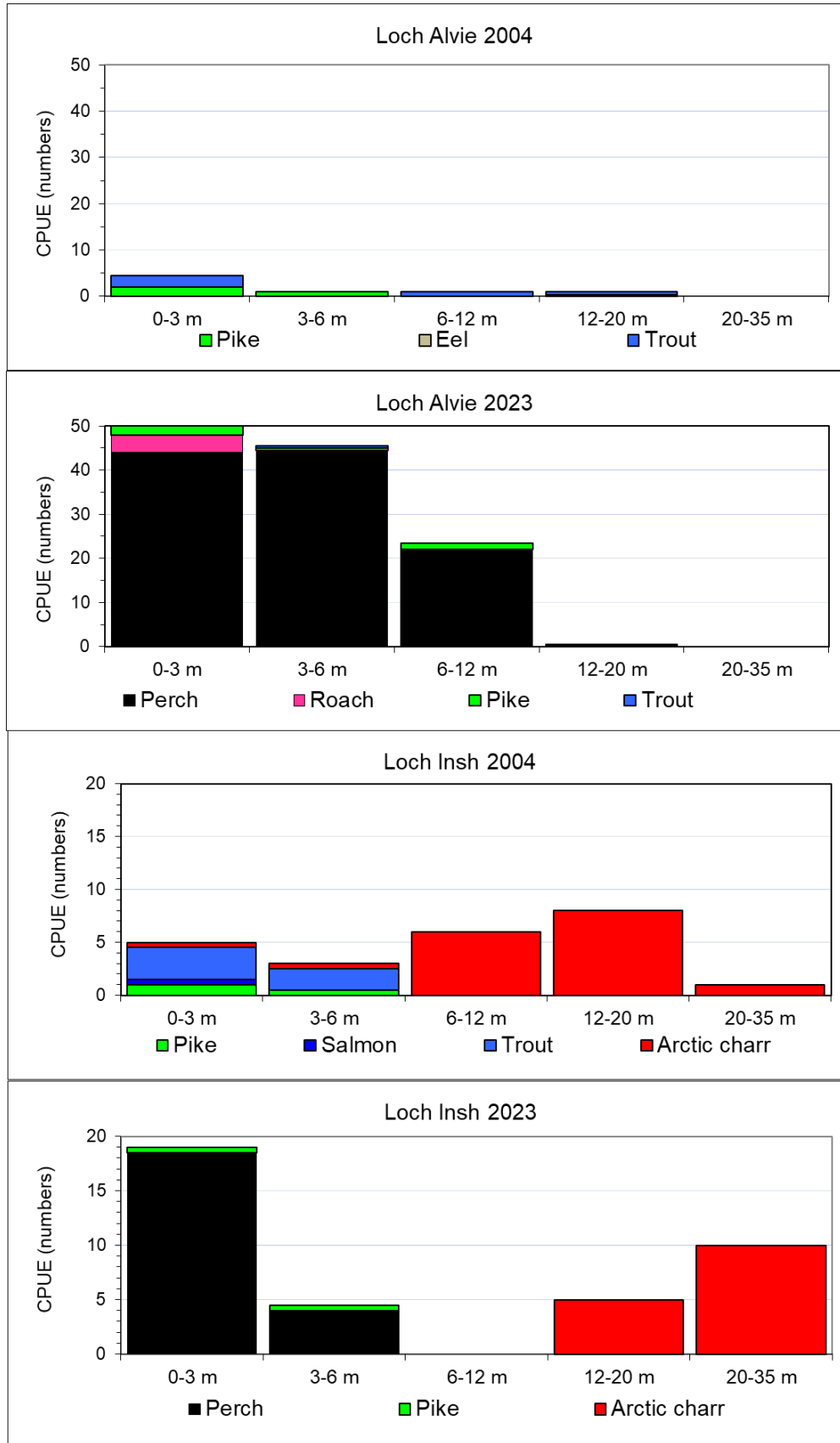


Figure 4. The change in diversity and the relative abundance of different species of fish shown as catch per unit effort (CPUE) in numbers per gillnet set at different depths overnight at the bottom in Lochs Alvie and Insh in 2004 and 2023.

Repeat Non-Native Fish species Survey – River Spey 2023 v 2004

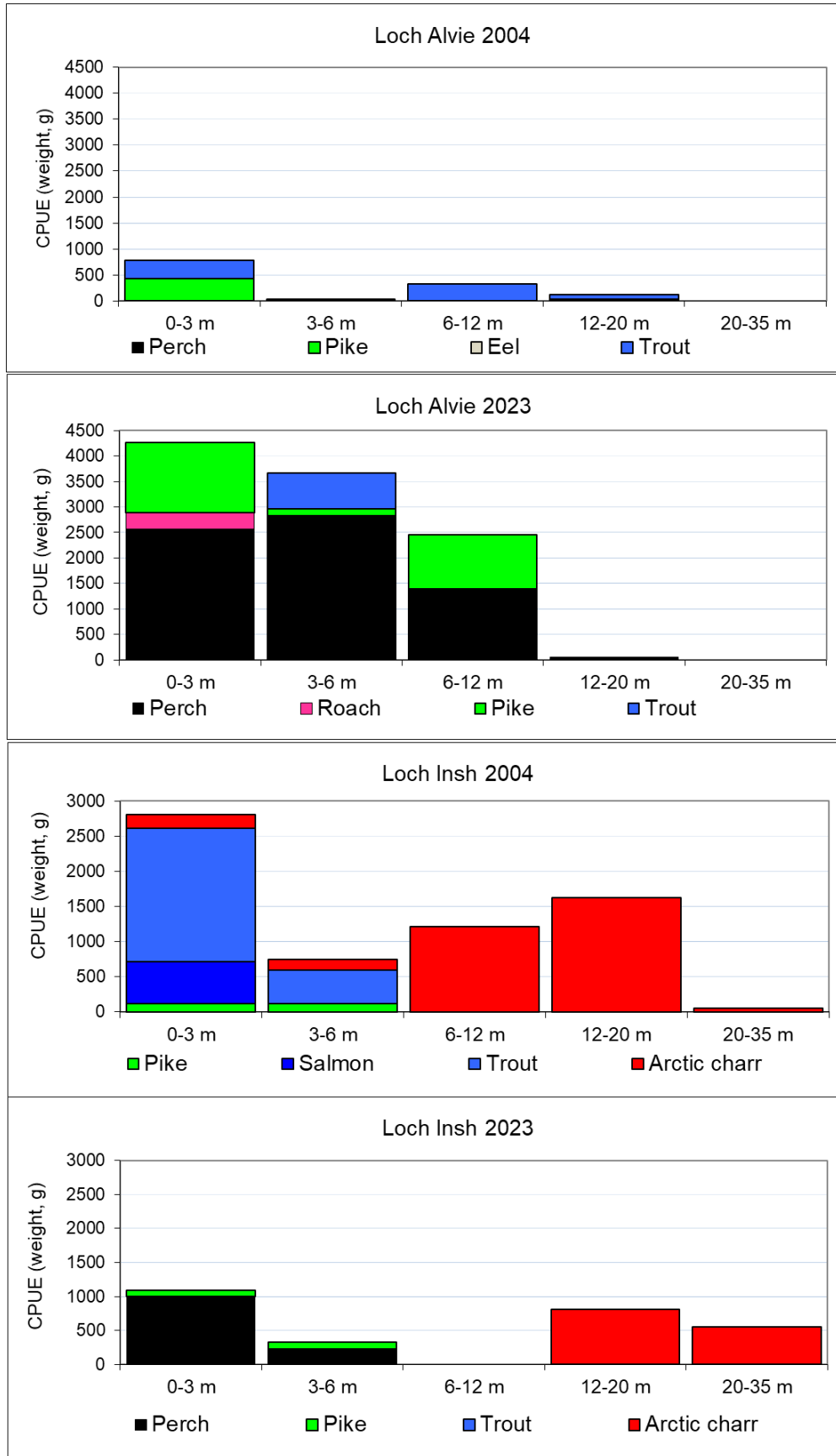


Figure 5. The change in diversity and the relative biomass of different species of fish shown as catch per unit effort (CPUE) in weight per gillnet set at different depths overnight at the bottom in Lochs Alvie and Insh in 2004 and 2023.

## Repeat Non-Native Fish species Survey – River Spey 2023 v 2004

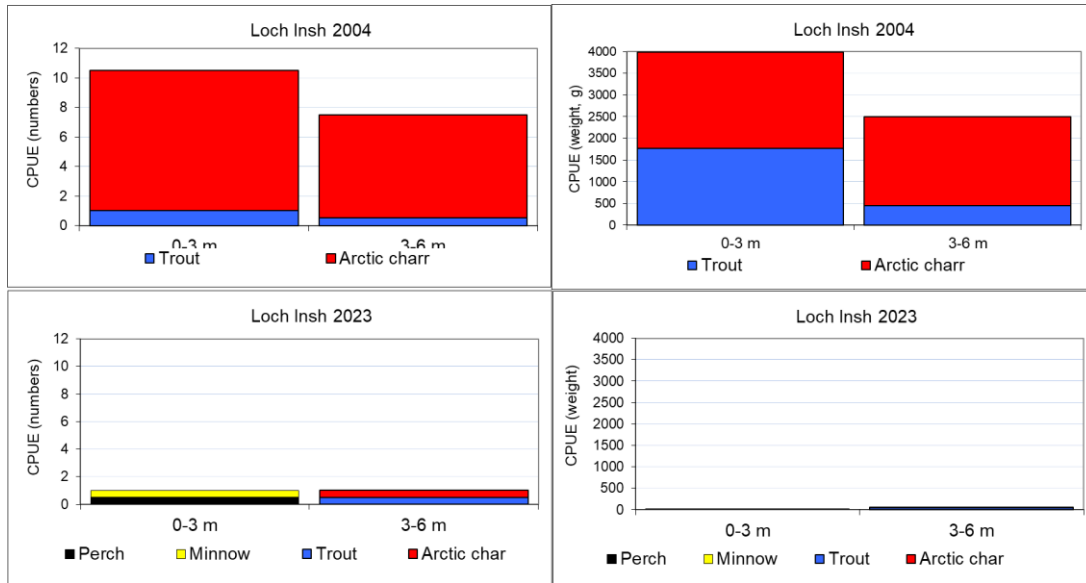


Figure 6. The change in relative abundance and abundance of different species of fish shown as catch per unit effort (CPUE) in numbers and weight per gillnet set at 0-6 m overnight in the pelagic in Loch Insh 2004 and 2023.

### Size distribution

With the use of similar gillnets with multiple mesh size, the size distribution of fish in the catch from the two lochs surveyed in 2023 becomes comparable (Table 8, Figures 7 and 8).

Table 8. Change in mean lengths (mm) and weights (g) of the various fish species caught with Nordic gillnets of multiple mesh size in Lochs Alvie and Insh 2004 and 2023. Variation is given as standard deviation (SD). Note that the total length was recorded for Arctic charr, Brown trout, Eel, Pike, Perch and the cyprinids.

Species		L. Alvie 2004			L. Alvie 2023			L. Insh 2004			L. Insh 2023		
Length, mm													
		Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Arctic charr	TL							291	61	56	192	68	16
Brown trout	TL	290	99	14	451		1	394	131	13	217		1
Salmon	FL							485		1			
Eel	TL	393		1									
Pike	TL	285	102	5	473	71	8	299	61	4	347	11	2
Perch	TL				170	36	222				156	24	46
Roach	TL				185	47	8						
Minnow	TL										62		1
Weight, g													
		Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Arctic charr	W							238	132	56	86	102	16
Brown trout	W	323	312	14	1396		1	706	566	13	96		1
Salmon	W							1207		1			
Eel	W	106		1									
Pike	W	180	180	5	643	278	8	181	90	4	197	8	2
Perch	W				62	45	222				53	15	46
Roach	W				80	69	8						
Minnow	W										3		1

The presence of smaller and larger individuals of Perch in Loch Alvie in addition to two dominating size groups around 120-160 and 200-220 mm indicate multiple

recruitment events. Also in Loch Insh juvenile Perch were recorded, although the dominating size group of Perch here measured 140-180 mm thus being slightly larger than the comparable cohort in Loch Alvie. Analyses of the age of Perch, however, is needed to confirm whether recruitment and year-classes coincide in the two lakes. The larger size group in Loch Insh may, however, suggest better growth for the Perch. Further indication of better feeding conditions for Perch in Loch Insh was the presence of considerable amounts of visceral fat in these fish.

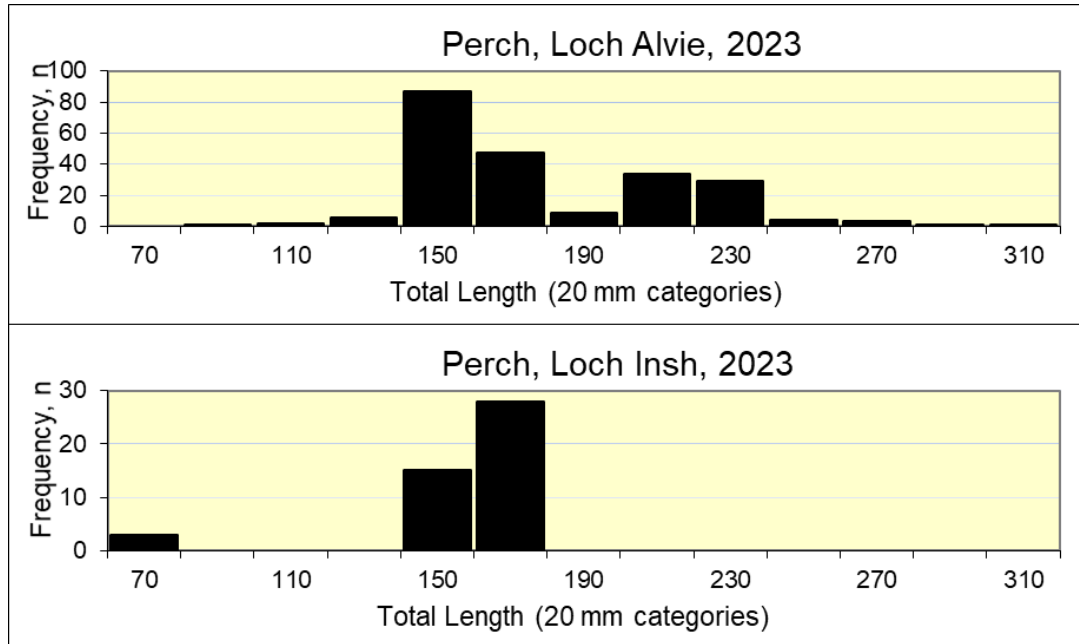


Figure 7. The length frequency distribution of Perch caught with Nordic gillnets of multiple mesh size in Lochs Alvie and Insh in 2023. For each size category of 20 mm, the mean is given on the x-axis.

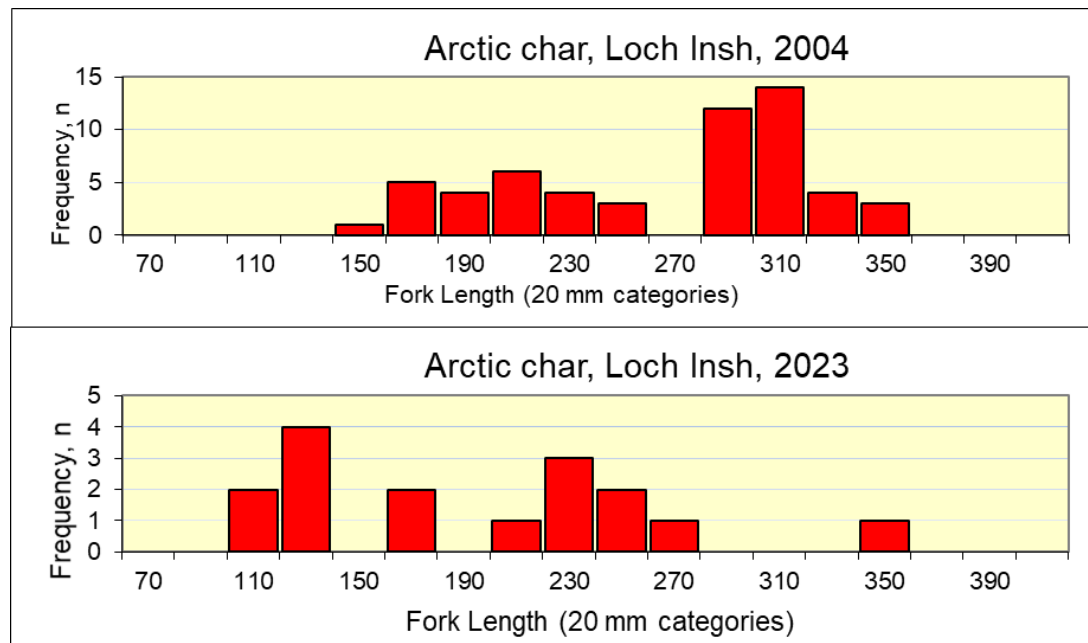


Figure 8. The change in length frequency distribution of Arctic charr caught with Nordic gillnets of multiple mesh size in Loch Insh in 2004 and 2023. For each size category of 20 mm, the mean is given on the x-axis.

## Discussion, Conclusions and Recommendations

The present study did indeed validate the anecdotal reports from anglers on social media that Perch were present in Loch Alvie, and the eDNA analyses by the Scottish Environmental Protection Agency suggesting the presence of Perch in Loch Insh. However, the scale of the changes in the fish species present in the two lochs since the 2004 study, in overall abundance of numbers, absolute/relative biomass and distribution within the basin morphometry of both lochs, was startling and indeed, from the point of view of the original native fish biodiversity, ominous, not only for this, but also for the high conservation status placed upon the watershed that supports them.

In the 2004 study there was no evidence that there had been a large-scale recent establishment of exotic species in the four lochs sampled and indeed, despite anecdotal information to the contrary, the species composition encountered was, by and large, one that may have been expected in the 18<sup>th</sup> century. The exception to this was the occurrence of both Roach and Rudd in Loch Beag. However, the occurrence, indeed the pronounced, remarkable prevalence, of Perch in the 2023 samples radically changes that perception, with the threat that was described in 2004 as being ‘latent and potential rather than immediate’ now being a direct and manifest one, representing a profound challenge to the perceived unspoiled nordicity of the Cairngorm National Park, its various conservation designations (e.g. The SAC for the River Spey) and its unique biota. We are dealing with a situation roughly analogous to the famous native pinewoods of the Cairngorm National Park (Abernethy, Rothiemurchus) being invaded by Japanese/Himalayan Knotweed and *Rhododendron ponticum*, only with the aquatic situation presenting a more intractable problem.

The nature of that threat to native fish populations is likely to be manifested in competition for habitat-volume and food, and the predation on juveniles. The numbers of Arctic charr and Brown trout caught in Lochs Alvie and Insh were much smaller in 2023 than in 2004. Predation pressure from Perch is likely to impact on all native salmonid species in both riverine and lacustrine habitats of the Spey system, and is one that the native salmonids have not co-evolved with in this watershed. The threat to the Charr of Loch Insh will be especially acute from all three aspects as this species is generally considered the most vulnerable salmonid, especially to rapid environmental alterations, including both abiotic and biotic changes (Hammar 2014). In southern Sweden, 74 % of the marginal populations of Arctic charr have been lost in just over a century, with many populations being lost because of introductions of competitive and predatory species of fish (Hammar 2012). The threat to the Charr of Loch Insh will potentially be even worse if the Roach, proven to be established in Loch Alvie, subsequently colonizes Loch Insh. Analyses of stomachs of the Arctic charr and Brown trout from Loch Insh reveal prime prey such as *Gammarus lacustris*, large cladoceran species, *Pisidium* sp. and a variety of insect larvae to dominate their diet (J. Hammar unpublished data), likely to be the main prey also of Perch – to begin with. All this should be viewed against the long-term thermal enhancement of the River Spey catchment reported by the James Hutton Institute (2016), with climate change negatively impacting on the cold stenothermal species of the native salmonid community and favouring species, such as those caught in the recent survey, that are more tolerant of warmer water.



The situation regarding the status and long-term well-being of the Arctic charr of Loch Insh is, especially concerning as Perch are probably just in the early stages of colonization, with Roach also likely to make their way there in the not too distant future. A translocation to a suitable loch within the Cairngorms National Park which does not already contain Charr and has no direct connection with other Charr lochs above or below it would appear to be the best option for saving them. Loch Muick stands out in this respect.

The point source of the newly discovered Roach in Loch Alvie is very likely to have been from the connected Loch Beag, where they featured in the 2004 catch. However, no Perch were caught here or in Loch Alvie in 2004, with their subsequent occurrence and spread probably being attributable to an independent, deliberate and clandestine introduction by an unknown individual or group. The impacts will be ongoing, long-term and are likely to include an increased potential for eutrophication brought about by the feeding ecology of the newly established species changing trophic pathways within the loch environment. There are no practicable, effective and safe management protocols available to reverse these dramatic changes and the ecology of the Spey watershed has been irrevocably changed

Though specific fish ecology interests may have dominated the impetus behind the two netting studies, especially in relation to Arctic charr, a species every bit as characteristic of the Boreo-Arctic affinities of the Cairngorm National Park as the northern avian or mammalian fauna, wider concerns of the effects of the establishment of exotic fish species on other taxa should be engaged with. Among these, in a negative sense, will, through the extensive episodic flooding events in the floodplain of the Insh Marshes allowing Perch access to lochans, ponds and ditches, will raise the likelihood of predation threats to native amphibians and invertebrates such as dragonfly and damselfly species. However, the much greater fish biomass figures in the 2023 catches (mainly comprising Perch) compared to 2004 may represent an improved situation for various iconic piscivorous bird species such as Grey Heron, Osprey, White-Tailed Eagle and Diver species. Regarding the latter, the authors subjectively noted a greater presence of Red-Throated Divers at Loch Alvie compared to 2004.

The recent increase in the appreciation and value of coarse fishing in Scotland is a welcome change to the negative and atavistic attitudes that prevailed in the recent past. This is a valuable resource that offers increased future potential and should be harnessed appropriately especially regarding recreational fishing at Loch Insh, as a possible way of adapting to the reality of the new fish species biodiversity. The culture and practice of coarse fishing in Scotland is, however, largely a derivation from that pertaining in the industrial regions of England and one which originated in a very different biological environment. Transposing the norms of this angling culture to another environment, such as the Highlands, may have latent threats to the wellbeing of native biodiversity. The most obvious manifestations would be the introduction of new species and further spread of existing ones. A tight watching brief would be highly advisable so that neither further introductions of locally established exotic species or new species occur.

To better evaluate the current status of native stocks and establish any likely threats from non-native fish stocks, a larger scale inventory sampling programme needs to be carried out. Notwithstanding recent ill-informed and vitriolic correspondence in the local press and social media regarding the impacts of gill netting, the inventory

sampling method employed, proved useful in obtaining moderate sized, but scientifically valid samples of fish stocks without harm to mammals or birds. It should comprise a main part of a multi-method approach of stock assessment of lochs in the wider Spey drainage basin in the future, key examples being Lochs Einich and Pityoulish. The authors would be happy to participate in any such future sampling program.

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