National Research Survey Programme

Lakes 2022

Lough Eske

IFI/2023/1-4659

Iascach Intíre Éireann
Inland Fisheries Ireland

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National Research Survey Programme

Fish Stock Survey of Lough Eske, September 2022

Iascach Intíre Éireann
Inland Fisheries Ireland

Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24.

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1. Introduction

Lough Eske is a large lowland oligotrophic lake. It lies approximately 5 km north-east of Donegal town (Plate 1.1, Figure 1.1). The lake has a surface area of approximately 364ha and a maximum depth of 30.1m. The lake is categorised as typology class 4 (as designated by the EPA for the purposes of the Water Framework Directive (i.e., deep (>4m), greater than 50ha and high alkalinity (<20mg/l CaCO3).

Lough Eske forms part of the Lough Eske and Ardnamona Wood Special Area of Conservation (SAC). The site also includes the River Eske and short stretches of the Lowerymore, Clogher and Drummenny Rivers, as well as a number of smaller tributaries (NPWS 2015). The site is selected as a SAC for containing Atlantic salmon (*Salmo salar*) and freshwater pearl mussel (*Margaritifera margaritifera*), both species listed on Annex II of the E.U. Habitats Directive. Ardnamona Wood, an old oak woodland is also found within the SAC. It displays a habitat range from dry areas dominated by Pedunculate Oak (*Quercus robur*) to wet woodland with Alder (*Alnus glutinosa*). The SAC also contains some petrifying springs, a priority Annex I habitat under the E.U. Habitats Directive (NPWS 2015).

Lough Eske is one of the largest lakes in Donegal an supports an important salmonid fishery. All species including char may be captured. Brown trout are small with occasional fish to 4.5lb (2kg) caught (Angling Ireland, 2024). Sea-trout average 0.75lb (0.34kg) and some much bigger fish to 5lb(2.27kg) possible. Eske remains a good salmon fishery and all angling is by boat (O'Reilly, 2007).

Lough Eske was previously surveyed in 2006 and 2012 by Inland Fisheries Ireland. Brown trout (*Salmo trutta*), Arctic char (*Salvelinus alpinus*), sea trout (*Salmo trutta*), Atlantic salmon (*Salmo salar*), three-spined stickleback (*Gasterosteus aculeatus*) and European eel (*Anguilla anguilla*) were recorded across the surveys (Rooney *et al*., 2013 and IFI unpublished data).

This report summarises the results of the 2022 fish stock survey carried out on the lake using Inland Fisheries Ireland's fish in lakes monitoring protocol. The protocol is WFD compliant and provides insight into fish stock status in the lake.

Plate 1.1. Lough Eske (launch site), September 2022

Plate 1.2. Arctic char from Lough Eske, September 2022.

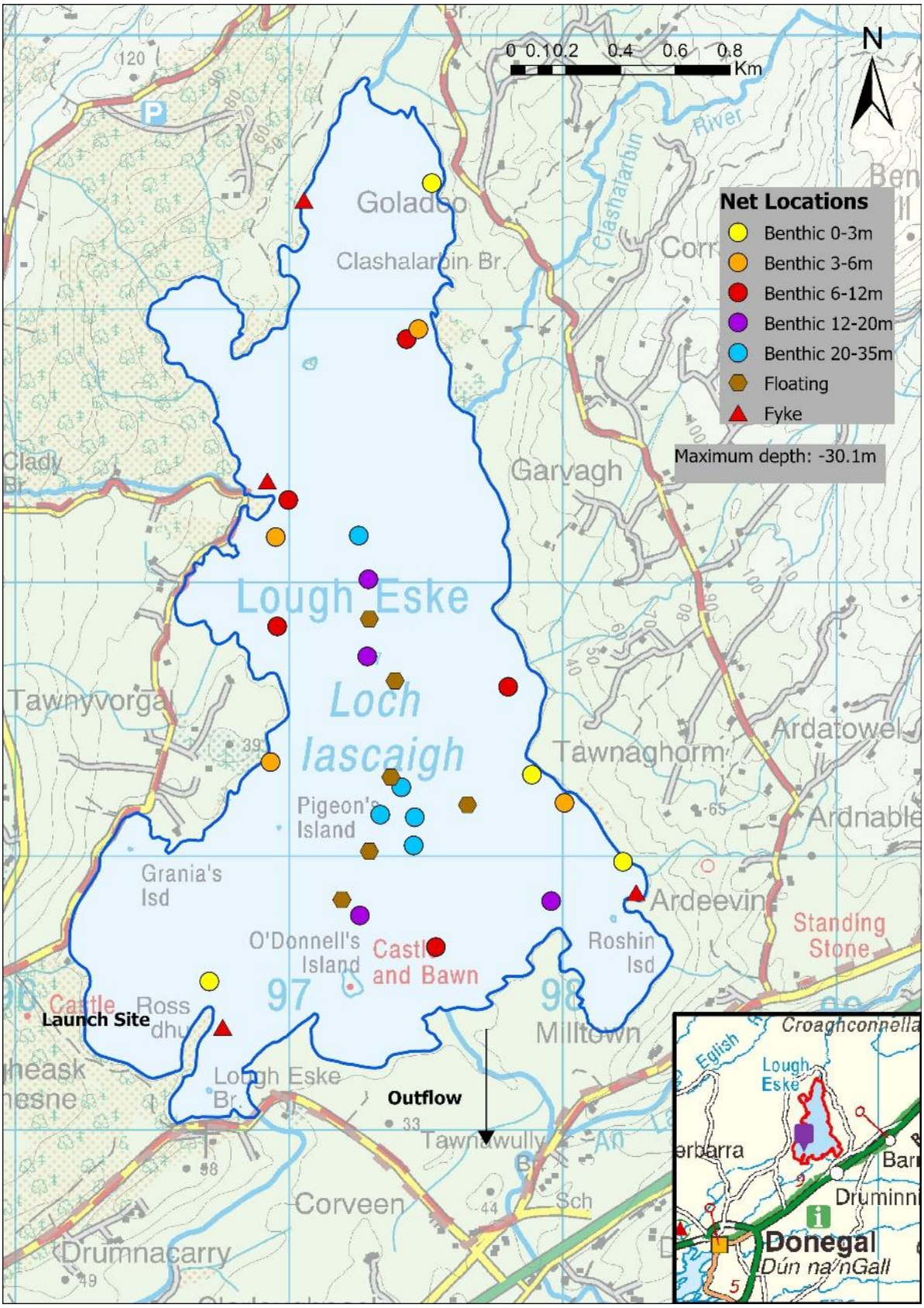

Figure 1.1. Location map of Lough Eske showing net locations and depths of each net (outflow is indicated on map).

2. Methods

2.1. Netting methods

Lough Eske was surveyed over two nights from the 5th to the 7th of September 2022. A total of four sets of Dutch fyke nets, 23 benthic monofilament multi-mesh (12 panel, 5-55mm mesh size) CEN standard survey gill nets (BM CEN) (4 @ 0-2.9m, 5 @ 3-5.9m, 5 @ 6-11.9m, 4 @ 12-19.9m and 5 @ 20-34.9m) and six floating monofilament multi-mesh (FM CEN) (12 panel, 5-55mm mesh size) CEN standard survey gill net were deployed in the same locations as were randomly selected in previous surveys (33 sites).

A handheld GPS was used to mark the precise location of each net. The angle of each gill net in relation to the shoreline was randomised.

All fish were measured and weighed on site and scales were removed from a sub-sample of other species except eels. Live fish were returned to the water whenever possible (i.e., when the likelihood of their survival was considered to be good). Samples of fish were retained for further analysis. Fish were frozen immediately after the survey and transported back to the IFI laboratory for later dissection.

2.2. Fish diet

Total stomach contents were inspected, and individual items were identified to the lowest taxonomic level possible. The percentage frequency occurrence (%FO) of prey items were then calculated to identify key prey items (Amundsen *et al.*, 1996).

$$\mathbf{FO}_i = \left(\frac{\boldsymbol{N_i}}{\boldsymbol{N}}\right) * \mathbf{100}$$

Where:
$\mathbf{FO}_i$ is the percentage frequency of prey item i,
$\boldsymbol{N_i}$ is the number of fish with prey i in their stomach,
$\boldsymbol{N}$ is total number of fish with stomach contents.

2.3. Biosecurity - disinfection and decontamination procedures

Procedures are required for disinfection of equipment to prevent dispersal of alien species and other organisms to uninfected waters. A standard operating procedure was compiled by Inland Fisheries Ireland for this purpose (Caffrey, 2010) and is followed by staff in IFI when moving between water bodies.

3. Results

3.1. Species Richness

Six fish species (sea trout are included as a separate 'variety' of trout) were recorded in Lough Eske in September 2022. A total of 254 fish were captured (Table 3.1). Brown trout was the most numerous fish species recorded, followed by Arctic char. Eels, three-spined stickleback, sea trout and salmon were also captured. The same species composition was present in 2006, while sea trout and salmon were not recorded in 2012 (IFI unpublished).

Table 3.1. Number of each fish species captured by each gear type during the survey on Lough Eske, September 2023.

Scientific name	Common name	Number of fish captured			
		BM CEN	FM CEN	Fyke	Total
Salmo trutta	Brown trout	140	5	12	157
Salvelinus alpinus	Arctic char	82	0	1	83
Gasterosteus aculeatus	Three-spined stickleback	5	0	0	5
Salmo trutta	Sea trout	1	0	0	1
Salmo salar	Salmon	1	0	0	1
Anguilla anguilla	European eel	1	6	0	7

3.2. Fish abundance

Fish abundance (mean CPUE) and biomass (mean BPUE) were calculated as the mean number/weight of fish caught per metre of net. For all fish species except eel, CPUE/BPUE is based on all nets, whereas eel CPUE/BPUE is based on fyke nets only. Brown trout and char were the dominant species captured in terms of both abundance (CPUE) and biomass (BPUE) (Table 3.2).

For comparison purposes box plots of CPUE and BPUE for each species captured in all surveys per net type between 2009 and 2021 are presented in Figures 3.1 and 3.2 respectively and illustrates fish community change over time. Overall, brown trout populations have remained relatively stable across all sampling occasions, although there was an apparent decline in the number and biomass of fish captured in surface floating gill nets (Figure 3.1 and 3.2).

The median CPUE and BPUE of Arctic char was lower in 2022 than previous surveys in both the benthic and floating survey gill nets. CPUE and BPUE of eel in fyke nets were also lower in 2022 compared to the earlier surveys (Figure 3.1 and 3.2).

Table 3.2. Mean (S.E.) CPUE and BPUE for all fish species captured on Lough Eske, September 2023.

Scientific name	Common name	Mean CPUE (± S.E)	Mean BPUE (± S.E)
Salmo trutta	Brown trout	0.156 (0.031)	23.123 (4.746)
Salvelinus alpinus	Arctic char	0.084 (0.024)	8.644 (3.136)
Gasterosteus aculeatus	Three-spined stickleback	0.005 (0.004)	0.008 (0.007)
Salmo trutta	Sea trout	0.001 (0.001)	0.202 (0.202)
Salmo salar	Salmon	0.001 (0.001)	0.023 (0.023)
Anguilla anguilla	European eel	0.025 (0.008)*	2.335 (0.723)*

Note: Where biomass data was unavailable for an individual fish, this was determined from a length/weight regression for that species (Connor et al., 2017). *Eel CPUE and BPUE based on fyke nets only.

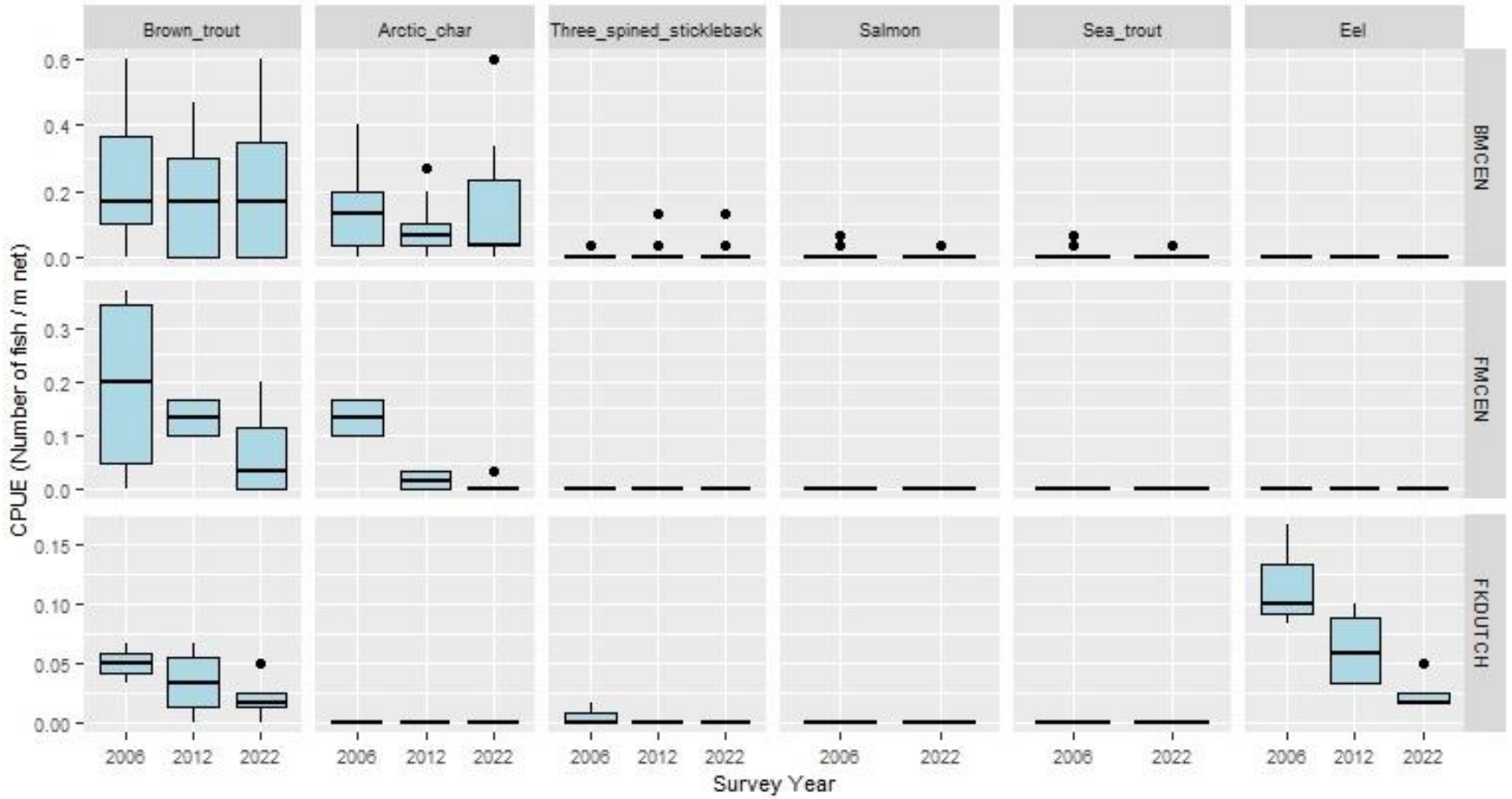

Figure 3.1. CPUE of all fish species captured in each net type during surveys of Lough Eske between 2006 and 2022. Figures are expressed as numbers of fish captured per linear meter of net deployed. The horizontal bars represent the median value of the sample, while the 75th and 25th percentiles are marked by the upper and lower boundary of each box. The vertical 'whiskers' show the data range. Outliers are marked by dots. The y axis (CPUE) is unique for each net type.

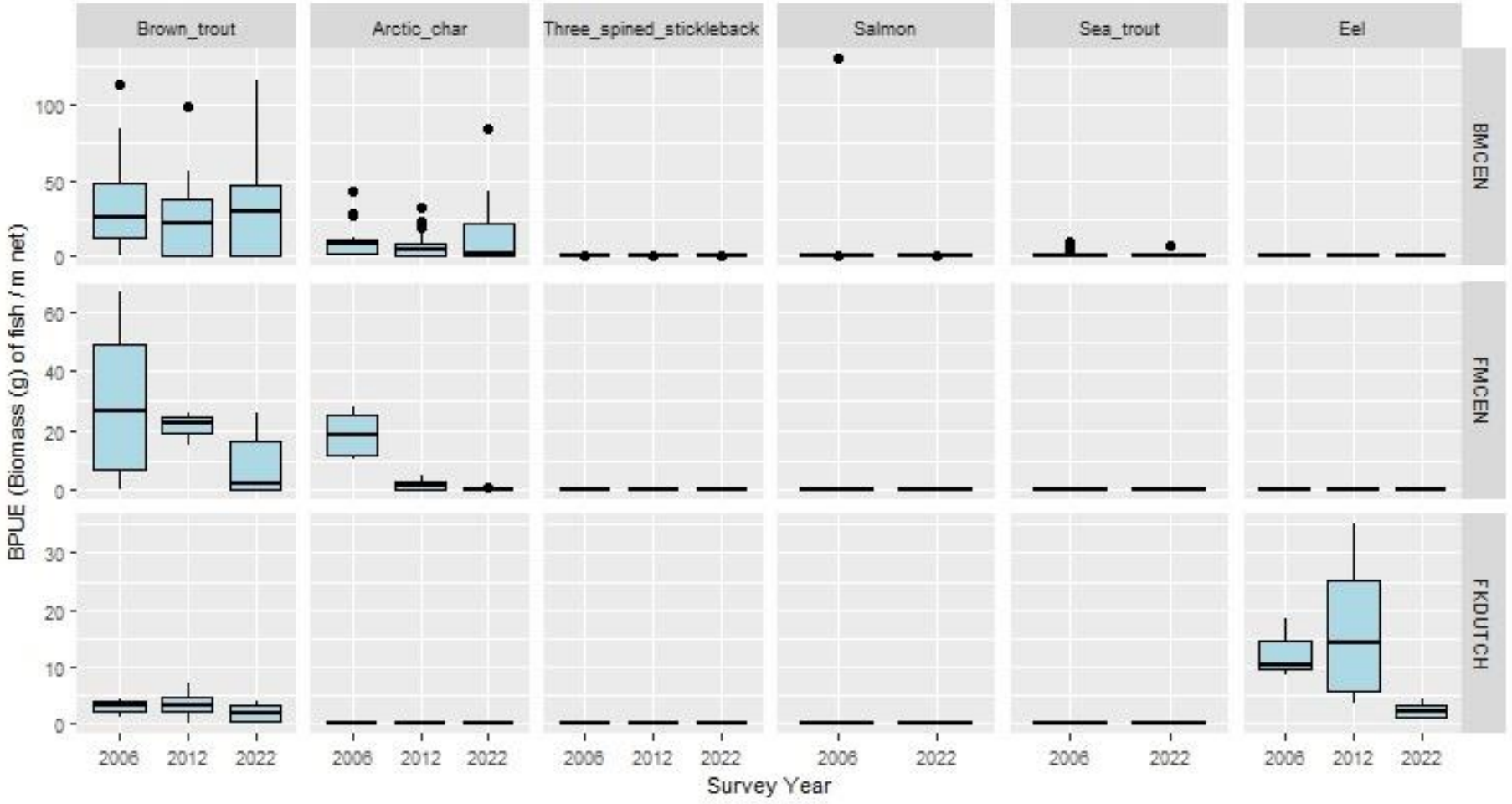

Figure 3.2. BPUE of all fish species captured in each net type during surveys of Lough Eske between 2006 and 2022. Figures are expressed as biomass (g) of fish captured per linear meter of net deployed. The horizontal bars represent the median value of the sample, while the 75th and 25th percentiles are marked by the upper and lower boundary of each box. The vertical 'whiskers' show the data range. Outliers are marked by dots. The y axis (BPUE) is unique for each net type.

3.3. Length frequency distributions and growth

Brown trout

Brown trout captured during the 2022 survey ranged in length from 10.0cm to 47.6cm (mean 21.9cm) Length range and distribution remained relatively stable across all surveys (Figure 3.3). Trout in the sample were aged between 1+ and 5+. Two year old fish were the most abundant age cohort. Mean L1 (i.e. length at the end of the first year was 7.1cm (Table 3.3).

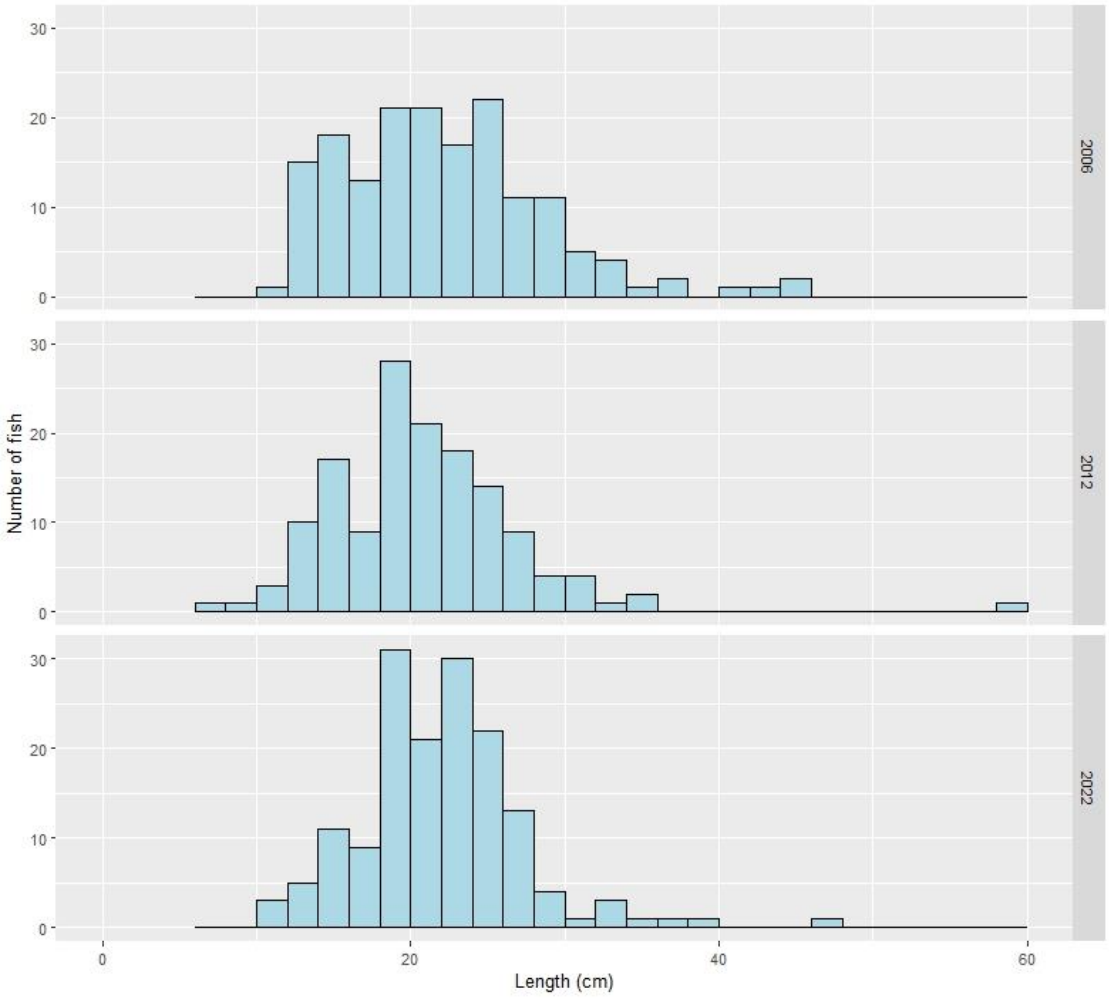

Figure 3.3. Length frequency of brown trout captured on Lough Eske, 2006, 2012 and 2022.

Table 3.3. Mean (±S.E.) brown trout length (cm) at age for Lough Eske, September 2022.

Length (cm)	L_1	L_2	L_3
Mean (±S.E.)	7.1 (0.1)	16.0 (0.2)	23.2 (0.0)
N	13	16	1
Range	5.8 - 8.3	14.4 - 17.0	23.2

Arctic char

Arctic char captured during the 2022 survey ranged in length from 8.0cm to 24.8cm (mean 19.3cm) (Figure 3.4).

Fish greater than 25cm in length were more prominent in 2006 than in latter surveys. Arctic char length frequencies from 2012 and 2022 are similar, although a larger cohort of fish in the 22-23 cm length class is present in 2022 compared to 2012. In both 2012 and 2022, Arctic char numbers-at-length decreased rapidly after a peak in abundance above 20 cm, with no fish above 25 cm captured (Figure 3.4).

In 2022, Arctic char in Lough Eske ranged in age from 1+ to 5+. The population was dominated by the 3+ and 4+ age cohorts.

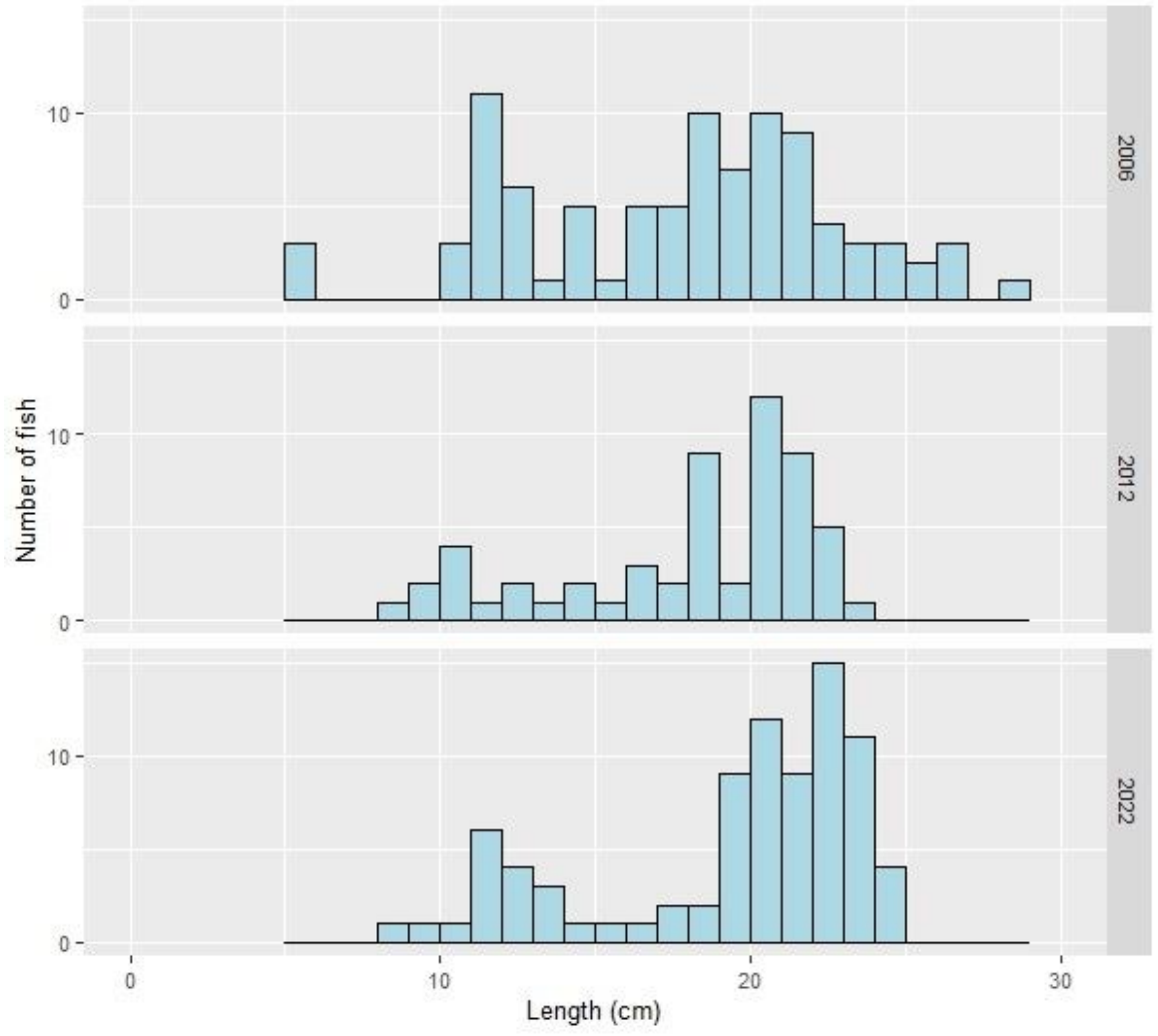

Figure 3.4. Length frequency of Arctic char captured on Lough Eske, 2006, 2012 and 2022.

Table 3.4. Summary age data from Arctic char captured on Lough Eske, September 2022. Number of fish (N) and length ranges of all fish aged in the sample is presented.

Length (cm)	Age Class					
	0+	1+	2+	3+	4+	5+
N	-	8	5	26	22	4
Mean L (cm)	-	12.2	17.1	20.4	22.8	24
Min L (cm)	-	9.9	14.9	19.0	21.0	23.4
Max L (cm)	-	15.3	18.9	22.3	24.6	24.8

An analysis of the current status of the Arctic char population in Lough Eske, with respect to the extent of any anthropogenic impacts is presented in section 3.4

Other species

Seven eels measuring 33.5cm and 46.9cm (mean 40.5cm) were captured and released during the 2022 survey. One sea trout was captured measuring 27.4cm in length. One salmon measuring 12.5cm was also recorded. Five three-spined stickleback (mean length 3.6cm) were also captured.

3.4 Using Arctic char life history characteristics to estimate vulnerability to overfishing or other anthropogenic disturbances

Length Based Spawning Potential Ratio Models

In marine fisheries, and where fisheries data is limited, length based stock assessment models (e.g. Length Based Spawning Potential Ratio LB-SPR**)** are important tools to assess the potential impact of excess fishing mortality on fished stocks or populations. In freshwater environments, the potential of LB-SPR to assess the possible impact on freshwater species has been demonstrated using data collected during IFIs fish stock assessments on four Irish Lakes (Hommik *et al*., 2015).

Using known growth, maturity, and fecundity data LB-SPR compares the reproductive capacity of fish in an exploited or impacted population to that in an unfished population, or a population that is not impacted by anthropogenic factors (Hordyk *et al*., 2015, 2016). It estimates how the capacity of a species to reproduce has been reduced by fishing or other factors and provides a measure of excess mortality, above that which might be expected naturally. Compared to marine environments, freshwaters can be subject to greater anthropogenic influences (e.g. habitat degradation, water

quality or invasive species colonisation) . LB SPR can therefore also be used to infer the impact that these factors are exerting on a population compared to pristine or unimpacted populations (Cousido-Rocha *et al*., 2022; Pons *et al*., 2019; Rudd and Thorson, 2018).

In healthy or pristine populations SPRs higher than 30-40% are expected (Brooks *et al*., 2009; Clark, 2002).

Fish stock assessment data collected in the three surveys (2006, 2012 and 2022) of Lough Eske were used to estimate LB SPR (and therefore population health) for Arctic char. Length and maturity data from all three surveys and age data from 2022 were used. Von Bertalanffy growth rates (Figure 3.5) and maturity indices (Figure 3.6) were estimated and natural mortality was derived using established growth based methods (Pauly NLS-T, Then *et al*., 2015). Summary parameters used in the model are presented in Table 3.5.

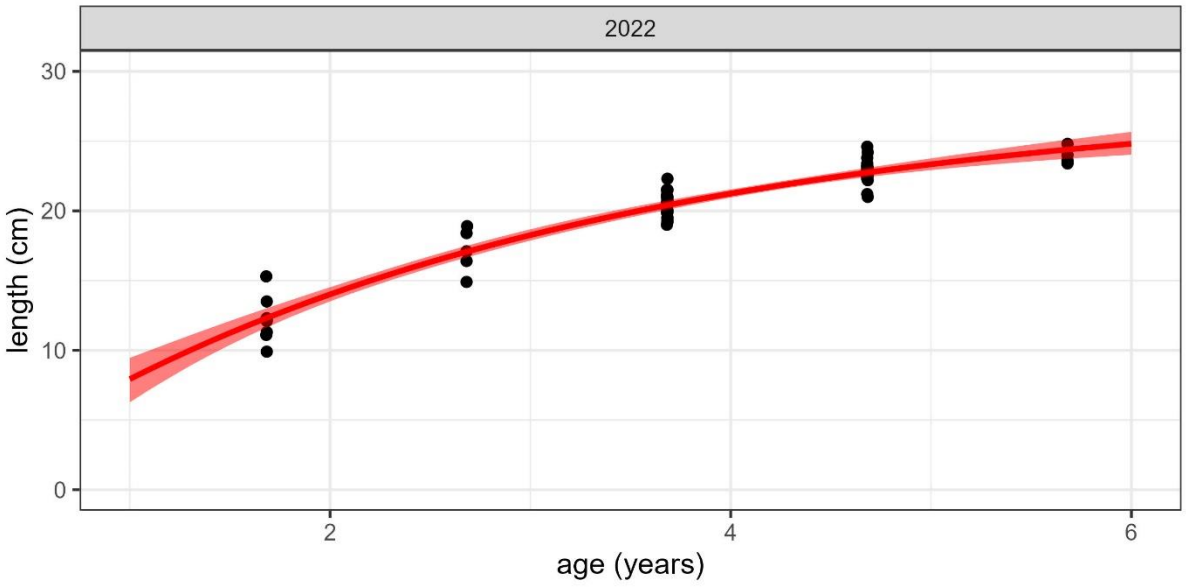

Figure 3.5. Von Bertalanffy growth fit (red) with confidence intervals (shaded red) for the mean length-at-age of Arctic char in Lough Eske based solely on 2022 otolith age determination.

LB-SPR assumes that recruitment remains constant; that natural mortality is constant across lengths/ages and that growth rate of males and females, as well as growth rate across time and across cohorts remains constant (Pons *et al*., 2020).

Estimations of excess mortality for Arctic char in each survey year are presented in Figure 3.7.

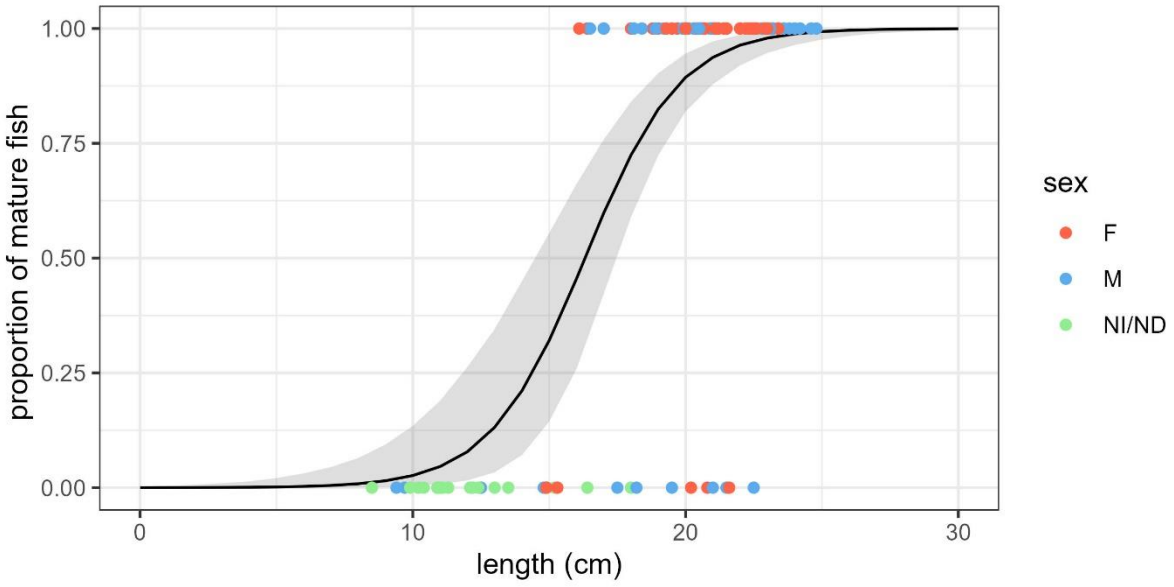

Figure 3.6. Maturity-at-length model fit (mean and confidence intervals indicated by black line and shaded grey region) to maturity data collected in the 2012 and 2022 Lough Eske fish stock surveys. Fish captured noted to have "no gonads" and fish recorded at maturity stage "I" were assigned maturity status 0.

LB-SPR SPR estimates, including uncertainty for each survey year, and with typical target and limit SPRs (i.e. target reference point=40% and limit reference point=30%) which would correspond to healthy / unimpacted stocks (Brooks *et al*., 2009; Clark, 2002) are presented in Figure 3.8. This illustrates that the SPR was significantly above the target reference point in 2006 and decreased to below 40% SPR in 2012. In 2022 the SPR was above 40%. However there is a high degree of uncertainty in predicted SPRs for the 2012 and 2022 surveys.

While there are some differences in population length (i.e. less fish greater than 25cm in 2012 and 2022 compared to 2006), and in estimated mortality and SPRs between the 2006 and latter surveys, there is currently too much uncertainty in the LB-SPR estimates to suggest definitively that the Arctic char population in Lough Eske has been impacted by anthropogenic activities.

Continued monitoring of this important, but vulnerable char population will be required.

Table 3.5. Life history parameter estimates for Lough Eske Arctic char. Growth parameters are based on otolith-derived age data obtained from a sub-sample of char captured during the Lough Eske 2022 fish stock survey. Empirical natural mortality estimators derive from the VBG parameter estimates.

Parameter	Source	Estimate
Asymptotic length L_∞	Sub-sample of Lough Eske 2022 survey catch (aged using otolith structures)	28.6 cm
Growth rate k		0.36 yr-1
CV L_∞	LB-SPR default (Hordyk et al., 2016)	0.1
Natural mortality M	$M_{PaulyNLS-T} = 4.118K^{0.73}L_\infty^{-0.33}$ $M_{2K} = 0.098 + 1.55K$ (Then et al., 2015)	0.65 yr-1 0.66 yr-1
Length-at-50% maturity L50	Eske fish stock survey data (2012, 2022)	16.3 cm
Length-at-95% maturity L95	Eske fish stock survey data (2012, 2022)	21. 4 cm
Mass-length coefficient α	Eske fish stock survey data (2006, 2012, 2022)	$1.296\times10^{(-5)}$
Mass-length exponent β	Eske fish stock survey data (2006, 2012, 2022)	2.969
Fecundity-length exponent	LB-SPR default (Hordyk et al., 2016)	3
Fishery selectivity shape	LB-SPR default (Hordyk et al., 2016)	Asymptotic (logistic)

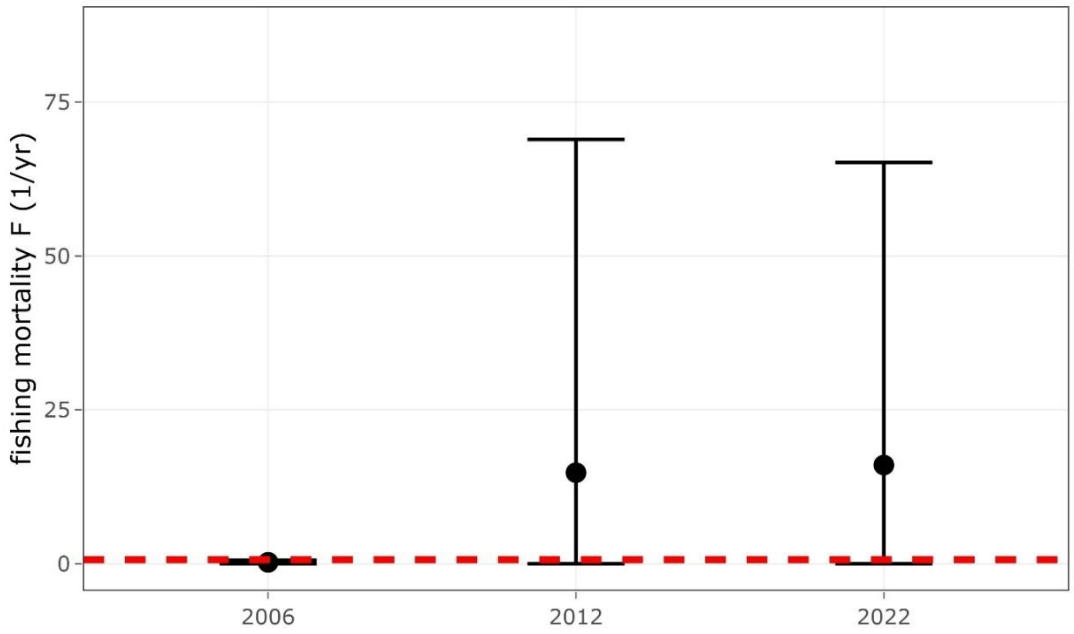

Figure 3.7. LB-SPR estimated excess mortality (i.e. measure of excess mortality, above that which might be expected naturally) F at full selectivity for 2006, 2012, 2022 survey length compositions excluding fish below 15 cm.

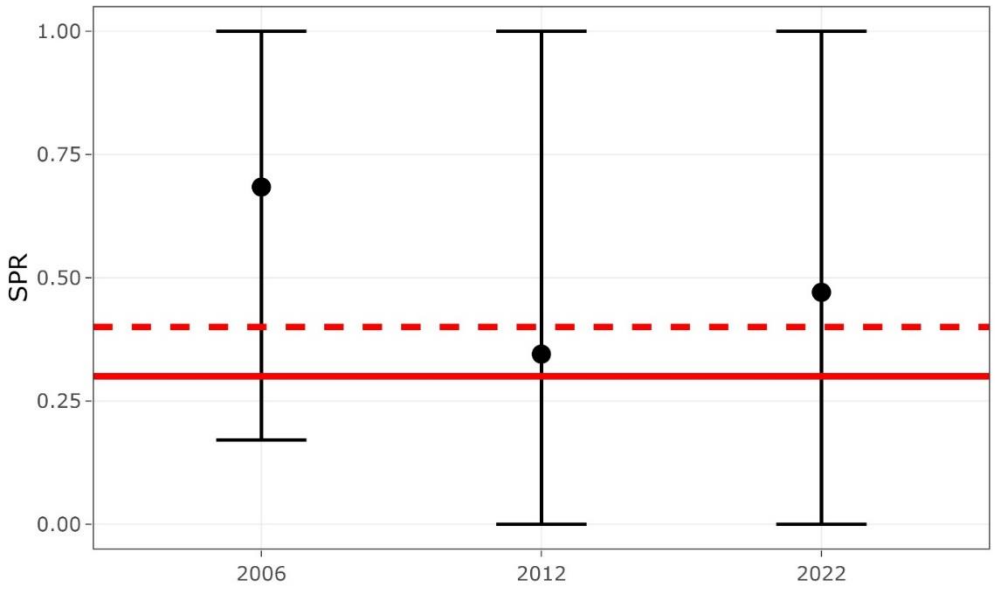

Figure 3.8: Spawning potential ratio (SPR) estimates from the LB-SPR model based on survey length compositions (Figure 3.4 and estimated life history parameters (Table 3.5). The dashed red line denotes a typical target reference point of SPR = 0.4 (40%) and the solid red lines denotes the limit reference point of SPR = 0.3 (30%).

3.5. Stomach and diet analysis

The dietary analysis conducted provides insight to the prey of examined fish immediately prior to capture. Longer term and seasonal studies provide a more robust assessment of fish diet. The stomach contents of a subsample of brown trout and Arctic char captured during the survey were examined and are presented below.

Brown trout

A total of 61 brown trout stomachs were examined. Nineteen (31.2%) were empty. Of the remaining 42 stomachs containing prey, 17 (41%) contained zooplankton. Invertebrates were the sole prey type recorded in 10 (24%) stomachs and were found together with zooplankton in nine (21%) stomachs. Fish was the sole prey type recorded in one (2%) stomach and was found with invertebrates in one other brown trout. Four stomachs contained unidentified digested material (Figure 3.9).

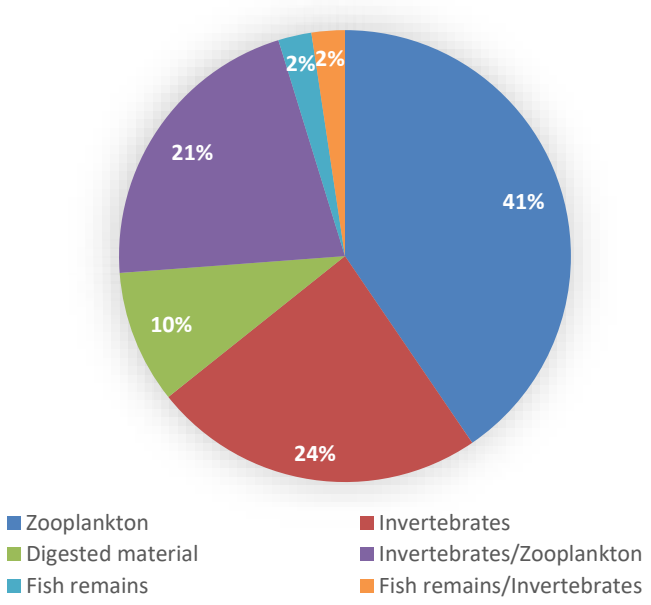

Figure 3.9. Diet of brown trout (N = 42) captured on Lough Eske 2022 (% FO).

Arctic char

A total of 71 Arctic char stomachs were examined. Fifty-three (74.7%) were empty. Of the remaining 18 stomachs containing prey, 16 (89%) contained zooplankton. Invertebrates and unidentified digested material were each recorded in one stomach (Figure 3.10).

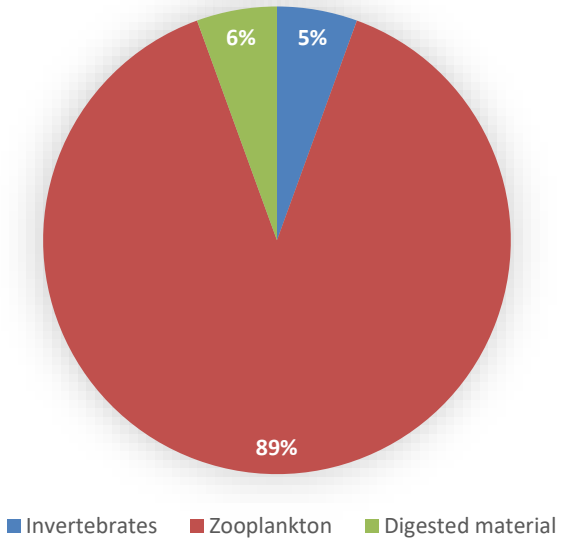

Figure 3.10. Diet of Arctic char (N = 18) captured on Lough Eske 2022 (% FO).

4. Summary

Six fish species (sea trout are included as a separate 'variety' of trout) were recorded in Lough Eske in September 2022.

Brown trout were the most abundant species recorded in Lough Eske and the population has remained relatively stable across all three recent surveys.

CPUE and BPUE of eel in fyke nets were also lower in 2022 compared to the earlier surveys

Lough Eske retains a significant population of Arctic char. Between 2006 and 2022 there was an apparent decline in the median CPUE and BPUE of Arctic char captured in benthic and surface floating survey gill nets. There was also a change in the length frequency of Arctic char. While the proportion of larger and older fish was higher in 2022 compared to earlier surveys, fish longer than 25cm, which were present in 2006 were not captured in 2022. LB-SPR analysis of the Eske char population indicates that excess, anthropogenic mortality was higher in both 2012 and 2022 compared to 2006. However, there is a degree of uncertainty around these estimates, and it is therefore difficult to ascribe these changes to anthropogenic effects. Continued monitoring of this vulnerable population will be necessary.

Classification and assigning lakes with an ecological status is a critical part of the WFD monitoring programme. It allows River Basin District managers to identify and prioritise lakes that currently fall short of the minimum "Good Ecological Status" that is required if Ireland is not to incur penalties. A multimetric fish ecological classification tool (Fish in Lakes – 'FIL') was developed for the island of Ireland (Ecoregion 17) using IFI and Agri-Food and Biosciences Institute Northern Ireland (AFBINI) data generated during the NSSHARE Fish in Lakes project (Kelly *et al.*, 2008). This tool was further developed during 2010 (FIL2) in order to make it fully WFD compliant, including producing EQR values for each lake and associated confidence in classification (Kelly *et al*., 2012).

Using the FIL2 classification tool, Lough Eske has been assigned an ecological status of High for 2022 based on the fish populations present. This is an improvement in status from 2006 and 2012, when the lake was assigned Good status (Figure 4.1).

In the 2016 to 2021 surveillance monitoring reporting period, the EPA assigned Lough Eske an overall ecological status of Good, based on all monitored physico-chemical and biological elements, excluding fish (EPA 2021).

Figure 4.1. Fish ecological status, Lough Eske, 2006 2012 and 2022 (dashed line indicates EQR status boundaries).

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