

National Research Survey Programme

Lakes 2022

Lough Carra

IFI/2023/1-4656



Iascach Intíre Éireann
Inland Fisheries Ireland

Fish Stock Survey of Lough Carra, July 2022



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Inland Fisheries Ireland**

National Research Survey Programme

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1. Introduction

Lough Carra is situated in County Mayo and forms the most northerly part of the Great Western Lakes system of Loughs Corrib, Mask and Carra (Plate 1.1, Figure 1.1). The lake is located approximately 5km north of Ballinrobe, Co. Mayo.

Lough Carra is the largest marl lake in Ireland, with a surface area of approximately 1600ha (NPWS, 2015; Irvine *et al.*, 2003). It is a hard water lake which acquires most of its water via the feeder streams that flow in at various points around its perimeter (Huxley and Huxley, 2009). Much of the lake is shallow with a mean depth of approximately 1.8m; however, there are sections of the lake where depths reach over 19m (Huxley and Huxley, 2009). Lough Carra is well known for its green/blue colour which is due to the formation of calcareous encrustations (NPWS, 2015). The lake contains well developed stonewort communities with *Chara curta*, *C. desmacantha*, *C. rudis* and *C. contraria* also recorded (NPWS, 2015).

The lake is categorised as typology class 10 (as designated by the EPA for the purposes of the Water Framework Directive (WFD)), i.e., shallow (<4m), greater than 50ha and highly alkaline (>100mg/l CaCO₃).

The average size of the brown trout (*Salmo trutta*) taken from Lough Carra is greater than any of the other western lakes and the lake has previously produced a specimen of 8.2kg (O' Reilly, 2007). Lough Carra is believed to be one of the few remaining wild brown trout calcareous lakes within the EU (Irvine *et al.*, 2003). During the 1990s fishery rehabilitation and enhancement works were undertaken in Lough Carra's spawning streams by Inland Fisheries Ireland (IFI) (previously the Central and Regional Fisheries Boards) and this led to increased recruitment of juvenile brown trout to the lake (O' Grady, 2009).

The lake was surveyed eight times from 1978 to 2009 as part of IFI's brown trout research programme using seven-panel benthic braided survey gill nets. Brown trout, perch (*Perca fluviatilis*) and pike (*Esox lucius*) were recorded on all of those sampling occasions. The most recent results (March 2009) using that survey method suggested that the lake supported an excellent and healthy stock of brown trout (IFI, 2009). The lake has also been surveyed on four occasions since 2009, (2009, 2012, 2015 and 2019) (Kelly *et al.*, 2010, 2013, 2016 and Corcoran *et al.*, 2020).

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 also provides insight into fish stock status in the lake.

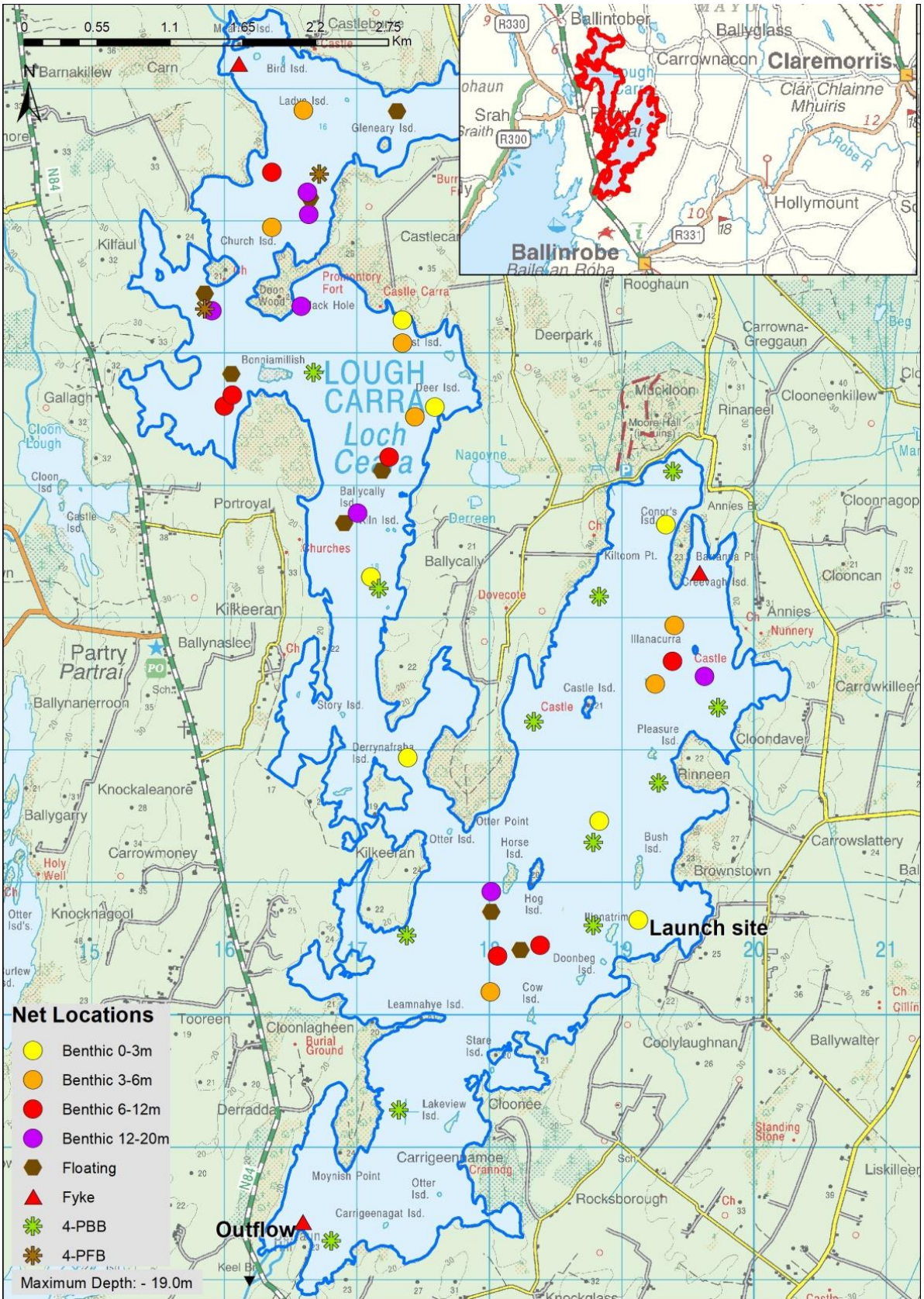


Figure 1.1. Location map of Lough Carra showing net locations and depths of each net (outflow is indicated on map)

2. Methods

2.1. Netting methods

Lough Carra was surveyed over three nights from the 18th to the 21st of July 2022. A total of three sets of Dutch fyke nets, 28 benthic monofilament multi-mesh (12 panel, 5-55mm mesh size) CEN standard survey gill nets (7 @ 0-2.9m, 7 @ 3-5.9m, 7 @ 6-11.9m and 7 @ 12-19.9m) and eight surface floating monofilament multi-mesh (12 panel, 5-55mm mesh size) CEN standard survey gill nets were deployed in the lake at the same locations as previous surveys (39 sites).

The netting effort was supplemented using four-panel benthic braided survey gill nets (4-PBB) and four-panel floating braided survey gill nets (4-PFB) at 14 additional sites. The 4-PBB and 4-PFB survey gill nets are composed of four 27.5m long panels each a different mesh size (55mm, 60mm, 70mm and 90mm knot to knot). These survey nets were deployed in random locations throughout the lake.

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

All fish apart from perch 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 (Amundsen *et al.*, 1996).

$$FO_i = \left(\frac{N_i}{N} \right) * 100$$

Where:

FO_i is the percentage frequency of prey item i ,

N_i is the number of fish with prey i in their stomach,

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.



Plate 1.1. Lough Carra, July 2022

3. Results

3.1. Species Richness

Five fish species were recorded in Lough Carra in July 2022 (Table 3.1). A total of 784 fish were captured. Perch was the most common fish species recorded, representing 94% of all fish captured in the survey. Brown trout, pike, eels and roach were also captured. During previous surveys conducted since 2009 a similar species composition was recorded, with the exception of three-spined stickleback which were not recorded in survey nets in the 2022 survey (Kelly *et al.*, 2010, 2013, 2016 and Corcoran *et al.*, 2020).

Table 3.1. Number of each fish species captured by each gear type during the survey on Lough Carra, July 2022.

Scientific name	Common name	Number of fish captured					
		BM CEN	FM CEN	4-PBB	4-PFB	Fyke	Total
<i>Perca fluviatilis</i>	Perch	718	10	12	0	0	740
<i>Salmo trutta</i>	Brown trout	13	1	9	0	0	23
<i>Esox lucius</i>	Pike	12	0	1	0	0	13
<i>Rutilus rutilus</i>	Roach	1	0	0	0	0	1
<i>Anguilla anguilla</i>	European eel	0	0	0	0	7	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. The CPUE and BPUE for each species captured in the 2022 survey is summarised in Table 3.2. Perch was the dominant species in terms of abundance (CPUE) and biomass (BPUE) recorded in the 2022 survey (Table 3.2).

Table 3.2. Mean (S.E.) CPUE and BPUE for all fish species captured on Lough Carra.

Scientific name	Common name	Mean CPUE (\pm S.E)	Mean BPUE (\pm S.E)
<i>Perca fluviatilis</i>	Perch	0.461 (0.126)	25.510 (5.882)
<i>Salmo trutta</i>	Brown trout	0.010 (0.003)	8.805 (2.581)
<i>Rutilus rutilus</i>	Roach	0.001 (0.001)	0.032 (0.032)
<i>Esox lucius</i>	Pike	0.006 (0.126)	1.824 (1.178)
<i>Anguilla anguilla</i>	European eel	0.039 (0.020)	12.947 (10.301)

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.

For comparison purposes box plots of CPUE and BPUE for each species captured in all surveys per net type between 2009 and 2022 are presented in Figures 3.1 and 3.2 respectively and illustrates fish community change over time. The median CPUE and BPUE of perch showed an increasing trend across all surveys conducted since 2009, while the median eel CPUE and BPUE were highest in the 2009 survey.

Other species were caught in lesser numbers across all net types (Figures 3.2a and 3.2b). Catches of these species have fluctuated across surveys and no clear trends were apparent. Brown trout population trends are described below (Figures 3.3a and b).

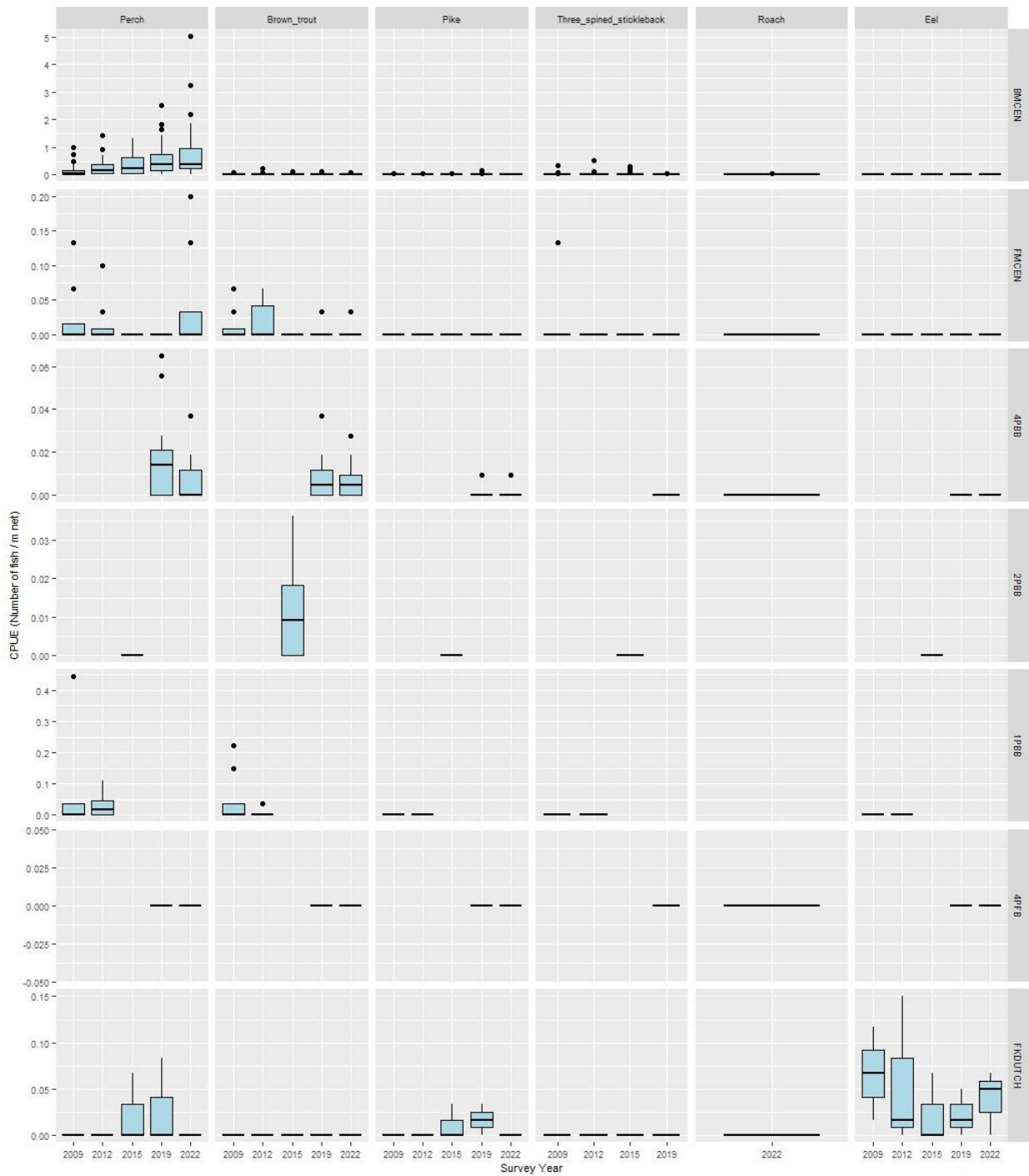


Figure 3.1. CPUE of all fish species captured in each net type during surveys of Lough Carra between 2009 and 2022. Figures are expressed as numbers of fish captured per linear meter of net deployed. The horizontal bars represent the median value of the sample, while the 75th and 25th percentiles are 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.

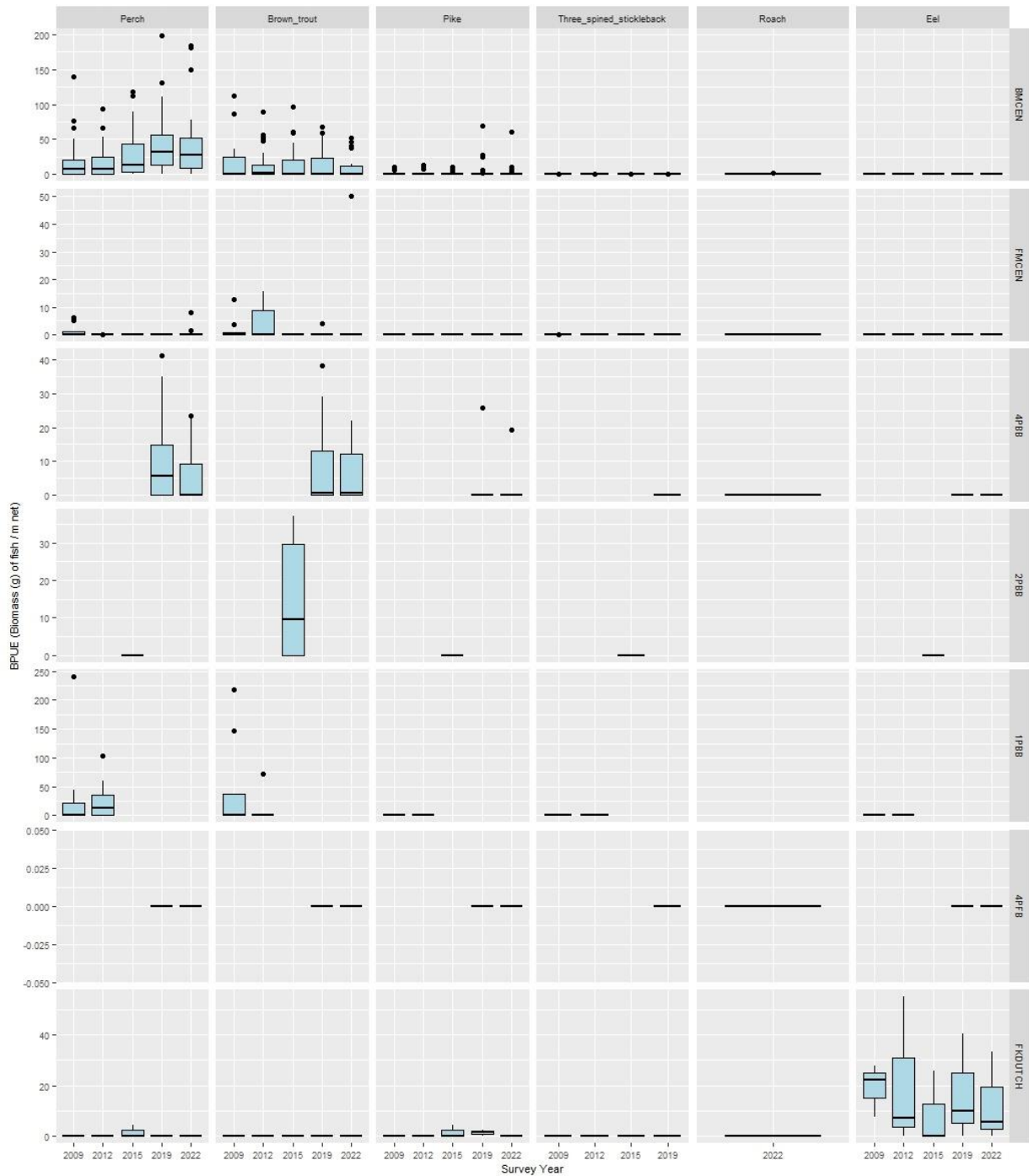


Figure 3.2. BPUE of all fish species captured in each net type during surveys of Lough Carra between 2009 and 2022. Figures are expressed as biomass (g) of fish captured per linear meter of net deployed. The horizontal bars represent the median value of the sample, while the 75th and 25th percentiles 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

Brown trout CPUE in Lough Carra

Survey catch data is inherently subject to considerable variation. Larger bodied species (e.g. brown trout), which may be naturally less abundant than smaller species such as perch are often captured in relatively low numbers and in a small proportion of the survey nets deployed. Changes in netting methodologies have occurred since 2009 where the number and mesh size of supplementary braided survey gillnets has varied. This is apparent in the graphs above (Figures 3.1 to 3.2) which can make visual interpretation of fish catches difficult.

For brown trout, fish catches and CPUEs from floating and benthic CEN nets have been pooled to reduce some of this variation. This has been achieved by aggregating catches within each depth zone for BM CEN nets on each sampling occasion. In this way, all the nets deployed within each depth zone were treated as one sampling unit for that survey occasion. Sampling effort, and netting locations across surveys were essentially identical. Braided survey nets which were set in varying quantities and with varying mesh sizes, and fyke nets (which captured no brown trout in any survey) have been excluded. Aggregate CPUEs and BPUEs for Lough Carra are presented in Figure 3.3a and 3.3b. Stocks of brown trout appeared to fluctuate in the lake. There is some indication that the trend in median CPUE of brown trout captured in monofilament survey gill nets is declining compared to earlier years. However, no decline in BPUE was evident (Figure 3.3a and 3.3b).

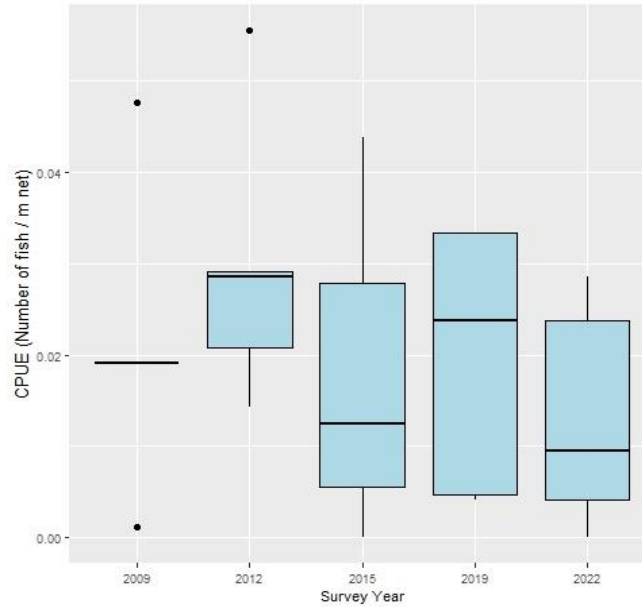


Figure 3.ab. CPUE (number of fish captured per linear meter of net deployed) of brown trout captured in benthic and floating CEN nets during surveys of Lough Carra between 2009 and 2022. Data has been pooled within each depth zone. The horizontal bars represent the median value of the sample, while the 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.

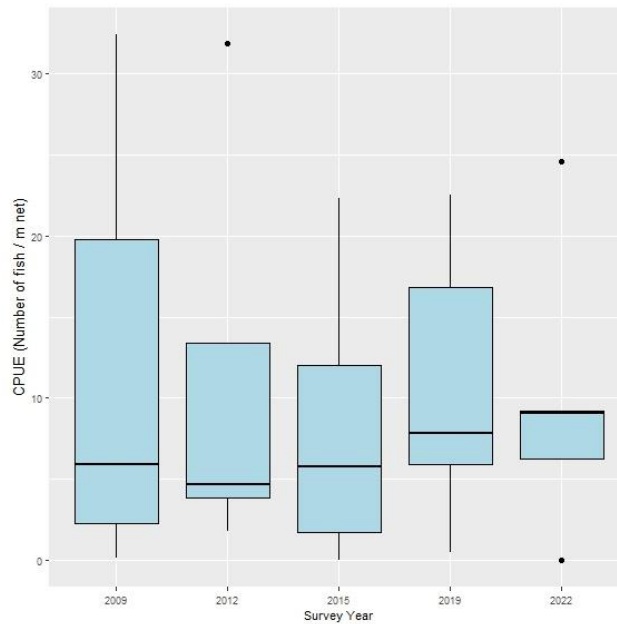


Figure 3.3b. BPUE (biomass of fish captured per linear meter of net deployed) of brown trout captured in benthic and floating CEN nets during surveys of Lough Carra between 2009 and 2022. Data has been pooled within each depth zone. The horizontal bars represent the median value of the sample, while 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.

3.3. Length frequency distributions and growth

Perch

Perch captured during the 2022 survey ranged in length from 3.0cm to 41.5cm (mean 12.7cm) (Figure 3.4). Perch captured in 2022 had a similar length range compared to earlier surveys, although the proportion of different size (and age) classes varied. In 2022 perch were aged from 0+ to 13+ (Table 3.3) and all age groups between 0+ and 8+ were present in the sample aged. The most abundant age group in the sample aged was 4+. However, there was considerable variation in the length of these individuals (c. 13cm -29cm). A strong modal peak, at 8-13cm, indicates that the population was dominated by fish aged between 1+ and 3+ (Figure 3.4). Mean L1 (i.e. length at the end of the first year) was 6.6cm (Table 3.3).

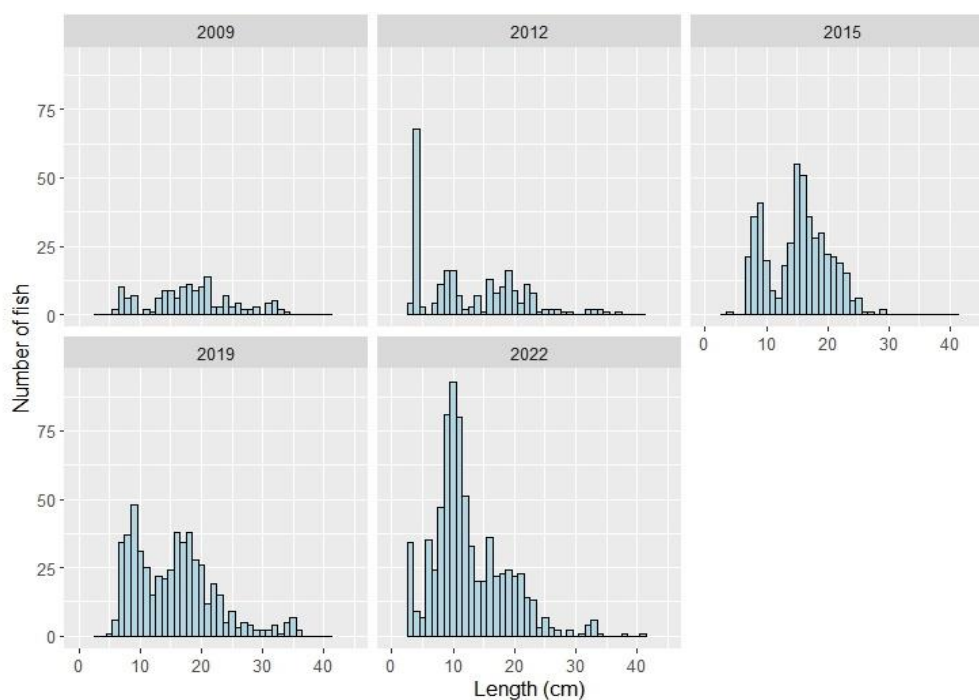


Figure 3.4. Length frequency of perch captured Lough Carra, 2009, 2012, 2015, 2019 and 2022.

Table 3.3. Mean (\pm S.E.) perch length (cm) at age for Lough Carra, July 2022

Length (cm)	L ₁	L ₂	L ₃	L ₄	L ₅	L ₆	L ₇	L ₈	L ₉	L ₁₀	L ₁₁	L ₁₂	L ₁₃
Mean (\pm S.E.)	6.6 (0.1)	10.5 (0.4)	14.5 (0.5)	17.5 (0.5)	18.8 (0.9)	20.8 (1.4)	25.3 (2.2)	23.5 (3.0)	25.5 (4.9)	26.8 (6.3)	28.6 (6.3)	29.4 (7.2)	-
N	104	90	78	63	31	13	6	3	2	2	2	2	1
Range	2.5 - 10.2	3.3 - 16.8	4.0 - 21.3	4.4 - 27.2	5.1 - 30.4	12.7- 28.8	17.8- 31.3	17.8- 28.2	20.5 - 30.4	20.5 - 33.0	22.2 - 34.9	22.2 - 36.6	-

Brown trout

Brown trout captured during the 2022 survey ranged in length from 17.2cm to 50.0cm (mean 37.5cm) (Figure 3.5). While the length range captured was generally similar across all surveys, proportionately fewer small brown trout were recorded in 2022 compared to earlier surveys (Figure 3.5). Brown trout were aged between 1+ and 6+ (Table 3.4). While all intervening age classes were present, 5+ fish were the most abundant age class in the sample (c. 43-50cm) (Figure 3.4). Smaller numbers of 3+ and 4+ fish recorded in 2022 corresponds with the absence of fish between c.27cm-42cm (Figure 3.5). Mean brown trout L4 (i.e. age at the end of the 4th year) in 2022 was 33.2cm indicating a fast rate of growth for brown trout in this lake according to the classification scheme of Kennedy and Fitzmaurice (1971) (Table 3.4).

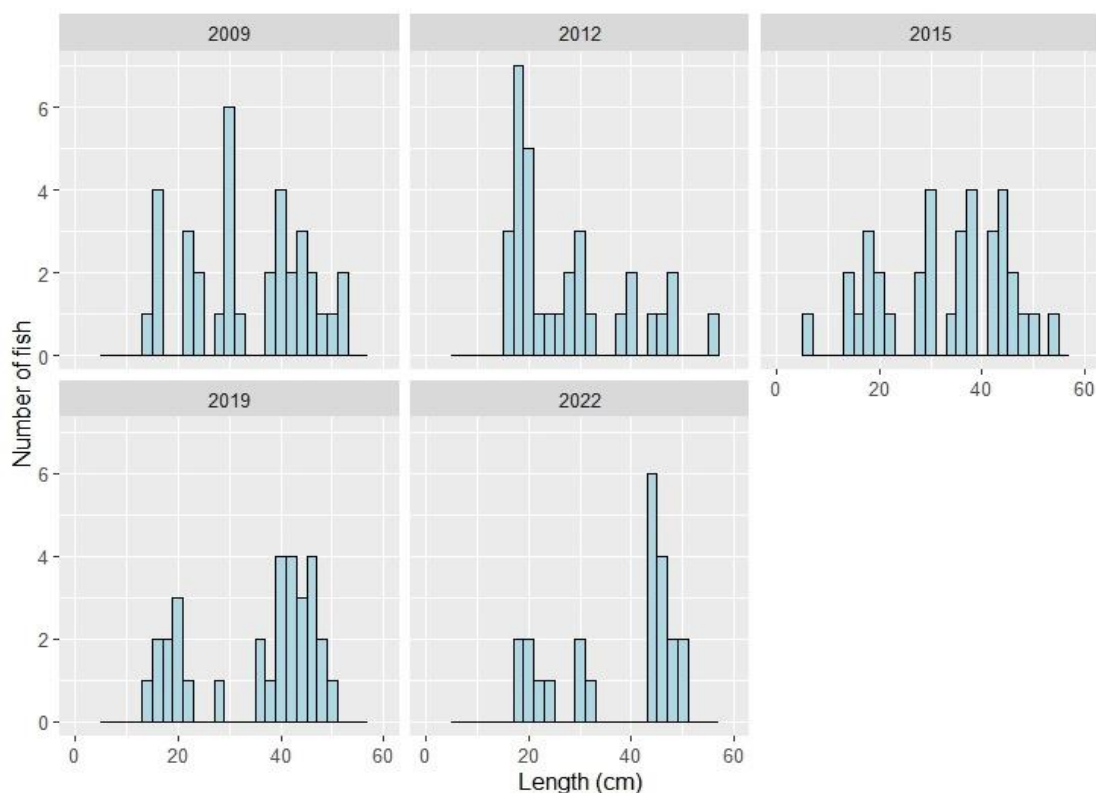


Figure 3.5. Length frequency of brown trout captured on Lough Carra, 2009, 2012, 2015, 2019 and 2022.

Table 3.4. Mean (\pm S.E.) brown trout length (cm) at age for Lough Carra, July 2022

Length (cm)	L ₁	L ₂	L ₃	L ₄	L ₅	L ₆	Growth Category
Mean (\pm S.E.)	7.1 (0.2)	14.7 (0.4)	22.4 (0.5)	30.9 (0.9)	39.5 (0.8)	45.0 (0.6)	Fast
N	18	16	12	10	10	2	
Range	5.5 - 8.5	12.3 - 17.7	20.2 - 25.4	28.1 - 38.7	36.7 - 45.3	44.4 - 45.6	

Other fish species

Pike (N = 13) ranged in length from 8.5cm to 65.0cm (mean = 28.5) and were aged between 0+ and 5+. Seven eels ranging from 36.0cm to 78.5cm were captured in the survey. One roach measuring 14.4cm and aged at 3+ was also recorded.

3.4. 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 perch, brown trout and pike captured during the survey were examined and are presented below.

Perch

A total of 123 perch stomachs were examined. Of these 101 (82%) were found to contain no prey items. Of the 22 remaining stomachs 13 (59%) contained invertebrates. Fish remains were recorded in one stomach (4.5%). Eight stomachs (36%) contained unidentified digested material (Figure 3.5).

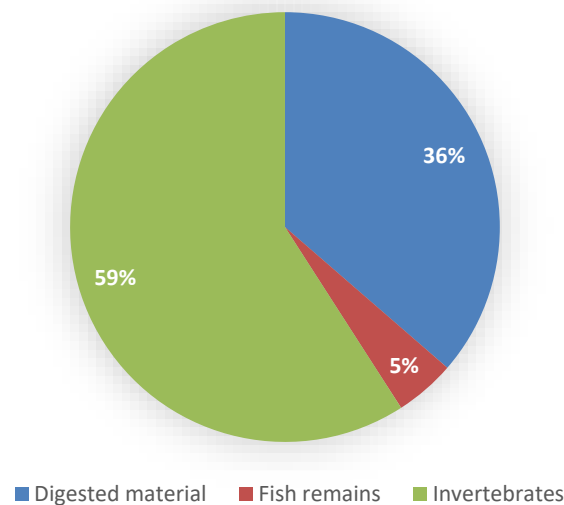


Figure 3.5. Diet of perch (N = 22) captured on Lough Carra, 2022 (% FO)

Brown trout

A total of 13 brown trout stomachs were examined; of these 11 were found to contain no prey items. Of the remaining two stomachs containing food, 100% contained invertebrates.

Pike

A total of 11 pike stomachs were available for analysis. Nine stomachs contained food. Fish were the sole prey found in five stomachs (22%) and were found together with invertebrates in one stomach (11%). Invertebrates were the sole prey item found in one pike stomach. Unidentified digested material was recorded in two stomachs (22%) (Figure 3. 6). Pike which had consumed fish (N = 6) ranged in length from 10.5cm to 65cm. Perch and three-spined stickleback were recorded in two stomachs while, pike and brown trout were each recorded in one pike.

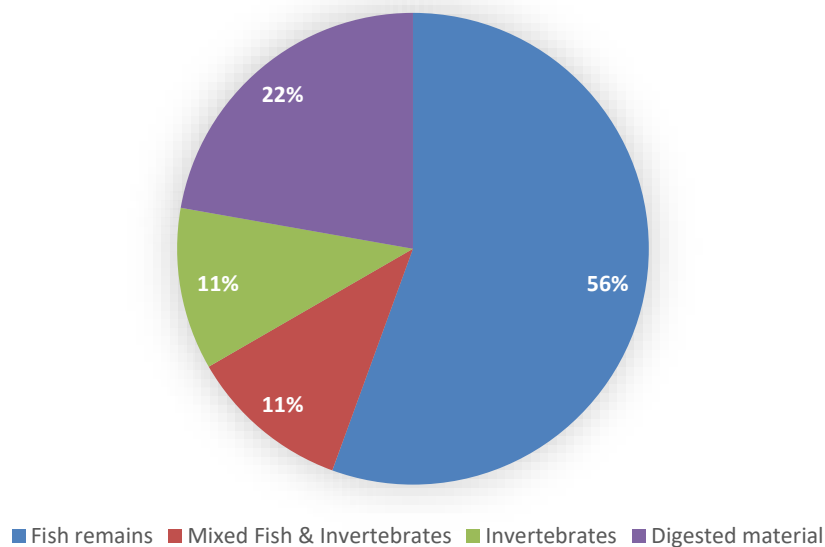


Figure 3.6. Diet of pike (N = 9) captured on Lough Carra, 2022 (% FO).

4. Summary

A total of five fish species were recorded survey in Lough Carra in July 2022. A sixth species (three-spined stickleback) were noted as prey in pike stomachs but were not captured in the survey itself.

Perch was the dominant fish species in terms of abundance (CPUE) and biomass (BPUE) captured during the 2022 survey. Both metrics show gradually increasing trends across all surveys conducted since 2009. Perch were aged between 0+ and 13+. All year classes between 0+ and 8+ were recorded indicating regular and strong recruitment in the lake. While the population was dominated by younger individuals, there was considerable persistence of larger and older individuals.

Lough Carra is a renowned brown trout fishery which is probably now unique in Europe (Irvine *et al.*, 2003). However, while stocks of perch (the most abundant species in the lake) appear to be increasing no such increase in brown trout stocks is apparent. The median CPUE of brown trout recorded in monofilament survey gill nets was lower in 2022 than previous years. While subject to considerable variation between surveys, there is some indication to suggest a weak declining trend in overall abundance recorded. However, biomass of brown trout has remained relatively stable, with the population captured in 2022 being dominated by a greater proportion of older (and corresponding reduction in smaller and younger cohorts) compared to earlier surveys. Further surveys may help define any trends in brown trout population status.

One individual roach (aged 3+) was captured in 2022. This is the second record for roach in the lake, following a previous single record in the 2015 intercalibration survey.

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) 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 Carra has been assigned an ecological status of Good for 2022 based on the fish populations present. Previously Lough Carra had been assigned a status of High in 2012 and 2015 and Good in 2019 and 2009 (Figure 4.1).

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

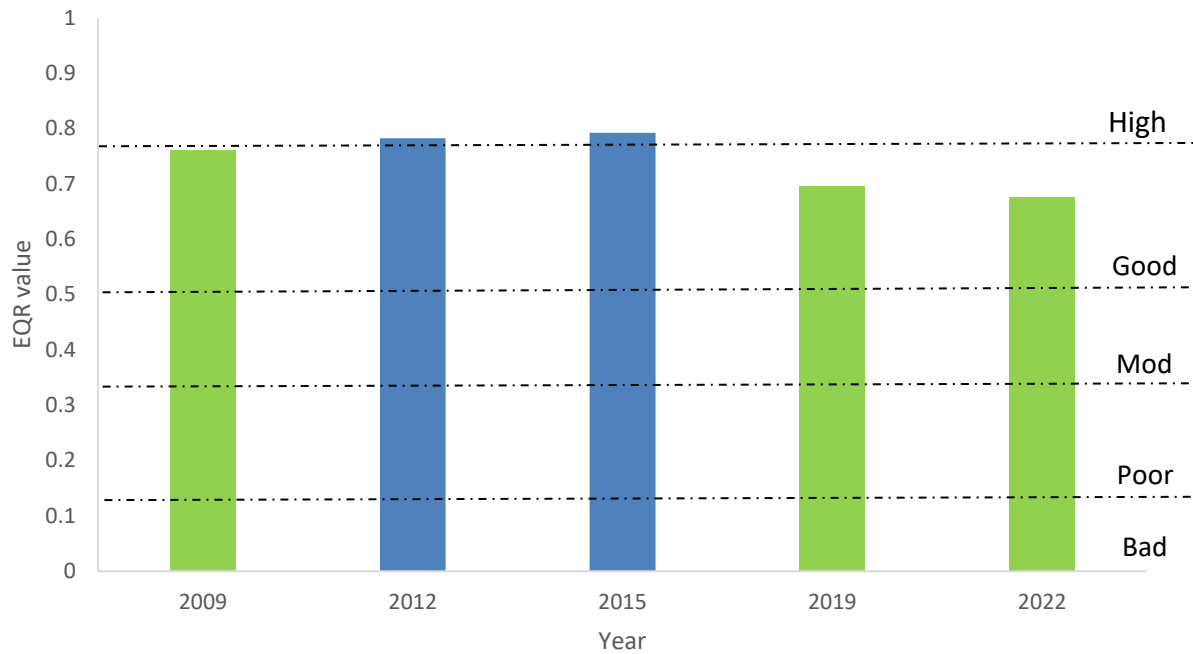


Figure. 4.1. Fish ecological status, Lough Carra, 2008, 2012, 2015, 2019 and 2022 (dashed line indicates EQR status boundaries).

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