National Research Survey Programme

Lakes 2017

Lough Melvin

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Iascach Intíre Éireann
Inland Fisheries Ireland

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National Research Survey Programme

Fish Stock Survey of Lough Melvin, July 2017

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

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Cover photo: Netting survey on Lough Derravaragh © Inland Fisheries Ireland

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1.1 Introduction

Lough Melvin is situated in the north-west of Ireland and is bordered by Co. Leitrim and Co. Fermanagh (Plate 1.1, Fig. 1.1). The lake is 12 kilometres in length, with a maximum width of less than three kilometres and a surface area of 2,125ha. The lake is greater than 10m in depth over 28% of its area, with a shallower area around the islands in the Co. Fermanagh section and at the western end in Co. Leitrim. Approximately 46% of the lake is less than 5m in depth. A deep trench runs east-west from Rossinver Bay towards the Drowes river outflow and has a maximum depth of 45m (Ferguson, 1986; Girvan and Foy, 2003). The geology of the catchment is dominated by Carboniferous rocks, predominantly sandstones and shales. The lake is categorised as typology class 8 (as designated by the EPA for the Water Framework Directive), i.e. deep (>4m), greater than 50ha and moderate alkalinity (20-100mg/l $CaCO_3$). It has also been classed as 1a (i.e. at risk of failing to meet good status by 2015) in the WFD characterisation report (EPA, 2005). Lough Melvin has been designated as a Special Area of Conservation (SAC) based on the fact that it is an oligo-mesotrophic lake, a lake category listed on Annex I of the EU Habitats Directive (NPWS, 2005). The lake is also designated as an SAC due to the presence of Atlantic salmon and otter, both species listed on Annex II of the same Directive.

Lough Melvin is one of the most important salmon and trout fisheries in the north-west of Ireland. It is an excellent example of a natural, post-glacial salmonid lake. The lake holds a relict population of Arctic char, Atlantic salmon (both of which are listed in the Irish Red Data Book (King *et al.*, 2011) as vulnerable), perch and brown trout (NPWS, 2005). It is the brown trout that are of primary interest to most anglers. Three distinct varieties of brown trout (*Salmo trutta*) occur in this lake: sonaghan (*Salmo nigripinnis*), gillaroo (*Salmo stomachius*) and ferox (*Salmo ferox*). These have been found to be genetically distinct species and can be readily identified on the basis of their morphological and meristic features (Ferguson, 1986). The three types of trout exhibit distinct feeding patterns: sonaghan feed primarily on cladocerans (water fleas), chironomid pupae (non-biting midges) and *Chaoborus* (phantom midge larvae)*;* gillaroo feed almost exclusively on benthic animals, including snails, trichopteran (caddis fly) larvae and *Gammarus* spp. (freshwater shrimp) and ferox trout feed primarily on fish, including perch, Arctic char and brown trout (Ferguson, 1986).

The water quality of Lough Melvin has been surveyed intermittently since 1990 and the lake has consistently demonstrated mesotrophic characteristics (Champ, 1998; McGarrigle *et al.*, 2002; Girvan and Foy, 2003). The water in Lough Melvin is heavily peat stained, which is thought to be the principal

factor limiting primary production; the algal crop did not appear to change in diversity or abundance between 1990 and 2001/2002, but monitoring work on the lake has shown a substantial shift towards phosphorus enrichment with mean total phosphorus concentrations in the open water increasing from 19µg to 30µg P/l since 1990 (Girvan and Foy, 2003). There is evidence that blue green algal blooms are now more severe than previously. The health and status of the lake is particularly vulnerable to human activities, such as an increase in phosphorus loadings from housing, forestry and agriculture within the surrounding catchment (Campbell and Foy, 2008). As part of the EU Intereg IIIA programme, a Catchment Management Plan was developed for Lough Melvin to promote the attainment of good ecological status and address the threat of nutrient enrichment, particularly from agriculture, forestry and domestic waste water (Campbell and Foy, 2008).

The lake has been surveyed for fish previously, primarily to evaluate brown trout stocks, by Inland Fisheries Ireland (previously the Central Fisheries Board and the Northern Regional Fisheries Board) in 1986 and 2001 using the standard IFI netting method for assessing brown trout stocks in lakes (O'Grady, 1981; Delanty and O'Grady, 2001). More recently it was surveyed in 2005 as part of the NS Share "Fish in Lakes Project (Kelly *et al*., 2007) and in 2008, 2011 and 2014 as part of the Water Framework Directive surveillance monitoring programme (Kelly *et al*., 2009, 2012a, 2015a and 2015b). During the 2014 survey, perch was the most abundant fish species recorded. Arctic char, salmon, three types of brown trout (sonaghan, gillaroo and ferox), rudd, roach x rudd hybrids and eels were also recorded.

This report summarises the results of the 2017 fish stock survey carried out on the lake. In addition to the routine fish stock survey results the report includes a summary of a parallel hydroacoustic and pelagic gill netting survey. The latter survey aimed to incorporate hydroacoustic technology into the existing standard sampling protocols used to assign ecological and conservation status for the Water Framework and Habitats Directive for conservation and endangered fish species. The hydroacoustic survey concentrated on the deeper sections of the lake (depth >9m) and covered *circa* 31km of hydroacoustic transects.

Plate 1.1. Lough Melvin

Plate 1.2. An tSionainn, IFI's Research boat on Lough Melvin

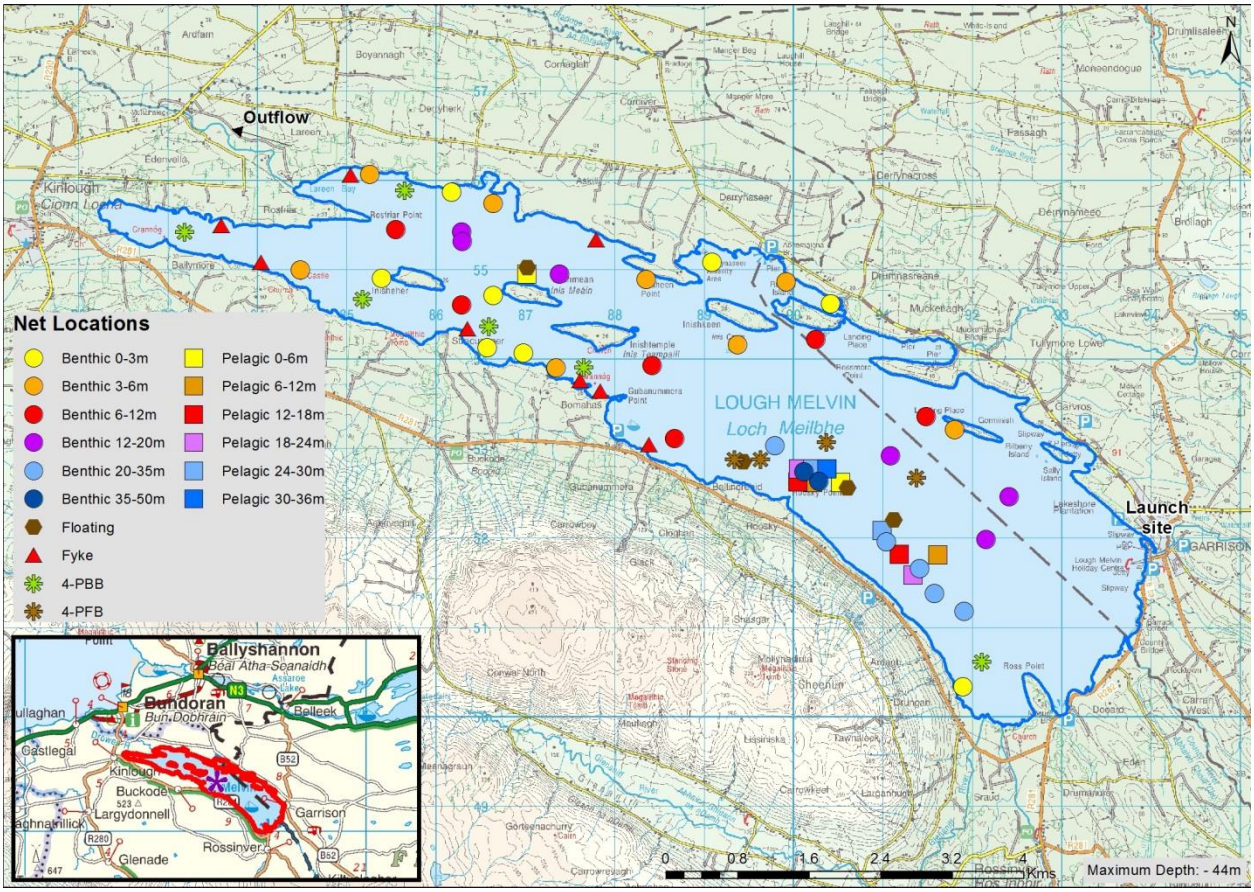

Fig. 1.1. Location map of Lough Melvin showing locations and depths of each net (outflow is indicated on map)

1.2 Methods

1.2.1 Netting methods

Lough Melvin was surveyed over three nights between the 17th and the 20th of July 2017. A total of eight sets of Dutch fyke nets (Fyke), 35 benthic monofilament multi-mesh (BM CEN) (12 panel, 5-55mm mesh size) CEN standard survey gill nets (8 @ 0-2.9m, 8 @ 3-5.9m, 6 @ 6-11.9m, 6 @ 12-19.9m, 5 @ 20-34.9m and 2 @ 35-49.9m) and four floating monofilament multi-mesh (FM CEN) (12 panel, 5-55mm mesh size) CEN standard survey gill nets were deployed in the lake (47 sites) (Fig. 1.1). The netting effort was supplemented using six four-panel benthic braided survey gill nets (4-PBB) and four four-panel floating braided survey gill nets (4-PFB). The 4-PBB nets are composed of four 27.5m long panels each a different mesh size (55mm, 60mm, 70mm and 90mm) tied together randomly. A further eleven pelagic multi-mesh (12 panel, 6.25-55mm mesh size) 30m x 6m CEN standard survey gill nets were also deployed (PM CEN) (Fig. 1.1).

Nets were deployed in the same locations as were randomly selected in the previous survey. 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 apart from perch were measured and weighed on site and scales were removed from all brown trout, salmon and rudd. 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.

1.2.1 Hydroacoustic survey of the pelagic zone

Arctic char are of high conservation importance; therefore it is desirable to monitor them using minimum impact techniques such as hydroacoustic technology. Hydroacoustic (echo-sounding) technology sends a beam of sound into the water column and sends back an echo from fish or other objects (e.g. air bubbles) that differ in density from water detected in the beam. The location of these objects is determined by the time it takes for the echo to return and the size of the object by how loud the returning echo is.

A hydroacoustic survey was conducted on Lough Melvin between the hours of 22:27 and 01:34 on the nights of the 17th and the 20th of July 2017. The survey in accordance with the European standard (CEN, 2015) followed a systematic parallel transect design, had a total track length of 31.2km and the degree of coverage had a co-efficient of variation (CV) of 0.09.

A SIMRAD EY60 scientific echosounder with two vertical split-beam circular transducers (120kHz and 200kHz) were deployed off the side of the boat at a depth of 0.5m. Both transducers were calibrated using the appropriate standard copper sphere and the nominal 3dB beam angle of the transducers was 7°. Ping rate was set at 5 pings s^{-1}, pulse duration was 0.256ms. A differential GPS connected to the echosounder recorded the location and reported an average sailing speed of 7km h^{-1} or 1.9m s^{-1}. Range sampled was 60m; transmitted power was 100 W for 120kHz and 90 W for 200kHz. Lake conditions were generally ideal with no wave action.

Sonar5 Pro post-processing software (Balk and Lindem, 2014) was later used to analyse the hydroacoustic recordings. Inspection of the echograms revealed that a large proportion of the recorded water volume contained gas bubbles that were ascending from the bottom sediments to the surface. The removal of these unwanted echoes from the echograms resulted in the removal of a significant proportion of the recorded water volume. Consequently it was not possible to obtain a reliable estimate of the Arctic char population and therefore no results are reported here.

1.2.2 Fish diet

Fish were frozen before being dissected for stomach content analysis in the IFI laboratory. Total stomach contents were inspected and individual items were counted and 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).

$$\%FO_i = (N_i / N) \times 100$$

Where:

$\%FO_i$ is the percentage frequency of prey item i,
N_i is the number of a particular species with prey i in their stomach,
N is total number of a particular species with stomach contents.

1.2.3 Biosecurity - disinfection and decontamination procedures

Procedures are required for disinfection of equipment in order 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.

1.3 Results

1.3.1 Species Richness

A total of five fish species and three types of brown trout (sonaghan, gillaroo and ferox) were recorded on Lough Melvin in July 2017, with 725 fish being captured. The number of each species captured by each gear type is shown in Table 1.1. Perch was the most common fish species recorded, followed by brown trout, rudd, Arctic char, eels and salmon. During the previous surveys in 2008, 2011 and 2014 the same species composition was recorded with the exception of three-spined stickleback which were only recorded in 2011 and roach x rudd hybrids which were not recorded in 2017 (Kelly *et al*., 2009, 2012a, 2015a and 2015b).

Table 1.1. Number of each fish species captured by each gear type during the survey on Lough Melvin, July 2017

Scientific name	Common name	Number of fish captured					
		BM CEN	FM CEN	4-Panel	Fyke	PM CEN	Total
Perca fluviatilis	Perch	507	0	1	8	0	516
Salmo nigripinnis	Sonaghan	2	18	11	0	17	48
Salmo trutta	Brown trout (*undetermined)	35	0	6	1	4	47
Salmo stomachius	Gillaroo	8	0	1	0	0	9
Salmo ferox	Ferox trout	7	0	2	0	0	9
Scardinius erythrophthalmus	Rudd	43	0	0	4	0	47
Salvelinus alpinus	Arctic char	7	0	0	0	8	15
Salmo salar	Salmon	2	0	5	0	0	6
Anguilla anguilla	Eel	2	0	0	26	0	28

*it was not possible to assign all trout to a variety without genetic analysis, these unassigned trout have been classified as undetermined

1.3.2 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. Mean CPUE and BPUE for all fish species captured in the 2017 survey are summarised in Table 1.2.

Perch was the dominant fish species in terms of abundance (CPUE) and biomass (BPUE) captured during the 2017 survey (Table 1.2).

The mean CPUE and BPUE (excluding data from the 55mm, 70mm and 90mm mesh panel of each 4-PBB) for all species captured in the 2008, 2011, 2014 and 2017 surveys are illustrated in Figures 1.2 and 1.3.

Although the mean brown trout (total trout) and perch CPUE and BPUE fluctuated slightly over the four sampling occasions, these differences were not statistically significant (Table 1.2; Fig 1.2 and 1.3). However, rudd CPUE and BPUE in 2011 was significantly lower than all other sampling years (Kruskal-Wallis $H=16.8$, $P<0.001$ and $H=17.09$, $P<0.001$).

Table 1.2. Mean (S.E.) CPUE and BPUE for all fish species captured on Lough Melvin, 2017

Scientific name	Common name	Mean CPUE (± S.E) **
Perca fluviatilis	Perch	0.251 (0.053)
Salmo trutta	Brown trout (all varieties)	0.040 (0.008)
Scardinius erythrophthalmus	Rudd	0.022 (0.010)
Salvelinus alpinus	Arctic char	0.004 (0.002)
Salmo salar	Salmon	0.002 (0.001)
Anguilla anguilla	European eel*	0.054 (0.019)*
		**Mean BPUE (± S.E) ** **
Perca fluviatilis	Perch	23.230 (5.337)
Salmo trutta	Brown trout (all varieties)	9.219 (2.512)
Scardinius erythrophthalmus	Rudd	2.756 (0.831)
Salvelinus alpinus	Arctic Char	0.982 (0.489)
Salmo salar	Salmon	2.935 (1.532)
Anguilla anguilla	European eel*	5.975 (2.238)

Note: On the rare occasion 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

**CPUE and BPUE data above for all fish species except eels are not comparable to earlier surveys as extra panels were added to the 1-PBB to provide additional information on large fish.

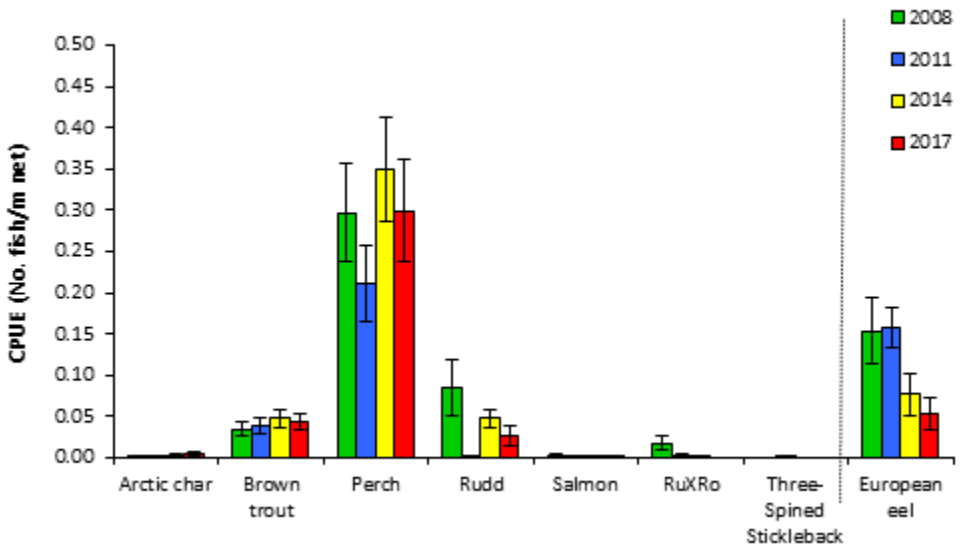

Fig. 1.2. Mean (±S.E.) CPUE for all fish species captured in Lough Melvin (Eel CPUE based on fyke nets only), 2008, 2011, 2014 and 2017.

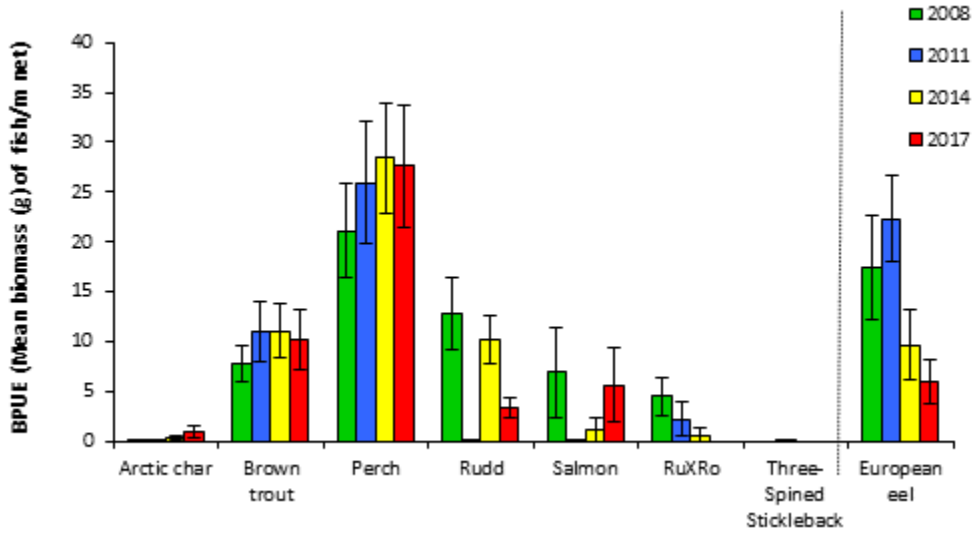

Fig. 1.3. Mean (±S.E.) BPUE for all fish species captured in Lough Melvin (Eel BPUE based on fyke nets only), 2008, 2011, 2014 and 2017

1.3.3 Length frequency distributions and growth

Brown trout (all varieties)

Brown trout captured during the 2017 survey ranged in length from 11.0cm to 62.1cm (mean = 22.9cm) (Fig. 1.4). Seven age classes were present, ranging from 1+ to 7+, with a mean L1 of 6.3cm (Table 1.3). The dominant age class was 2+ (Fig. 1.4). Mean brown trout L4 in 2017 was 25.5cm indicating a slow rate of growth for brown trout in this lake according to the classification scheme of Kennedy and Fitzmaurice (1971) (Table 1.3). Brown trout captured during the 2008, 2011 and 2014 surveys had similar length and age ranges, with larger fish recorded in 2011, 2014 and 2017 (Fig.1.4).

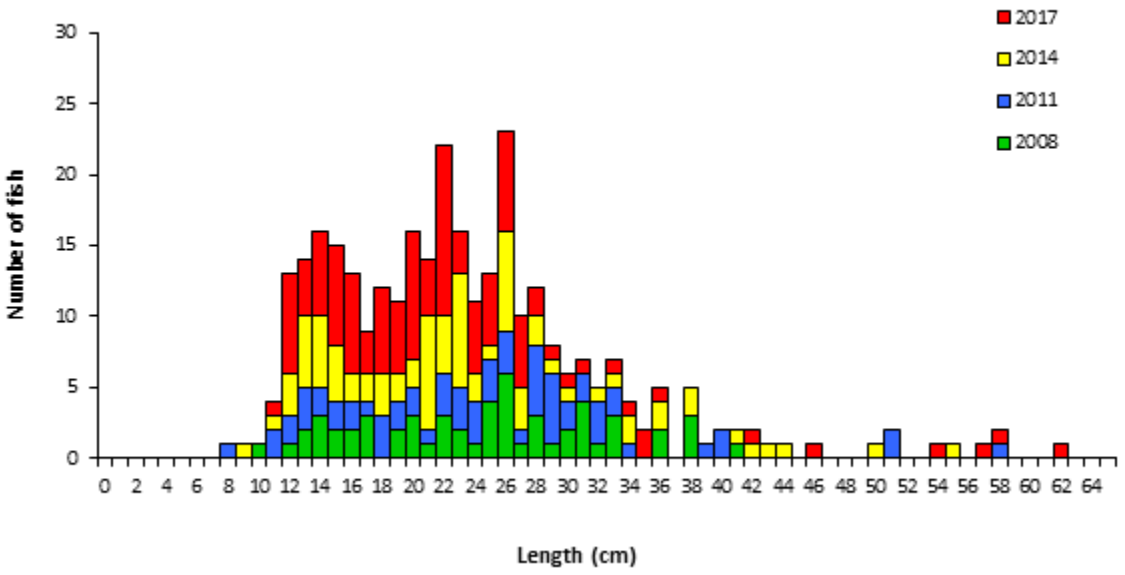

Fig. 1.4. Length frequency of brown trout (all varieties) captured on Lough Melvin, 2008, 2011, 2014 and 2017

Table 1.3. Mean (±S.E.) brown trout (all varieties) length (cm) at age for Lough Melvin, July 2017

	L_1	L_2	L_3	L_4	L_5	L_6	L_7	Growth Category
Mean (±S.E.)	6.3 (0.1)	13.6 (0.3)	19.7 (0.4)	25.6 (0.7)	32.4 (1.7)	41.0 (2.3)	48.8 (3.2)	Slow
N	85	73	43	26	11	5	4	
Range	4.0-9.9	7.9-20.3	12.3-25.8	20.0-34.2	24.4-42.2	35.4-46.7	40.7-54.2	

Perch

Perch captured during the 2017 survey ranged in length from 7.5cm to 34.1cm (mean = 17.7cm) (Fig.1.5) with nine age classes present, ranging from 1+ to 13+, with a mean L1 of 5.8cm. The dominant age class was 3+ (Fig. 1.5). Perch captured during the 2008, 2011 and 2014 surveys had a similar length and age range (Fig.1.5).

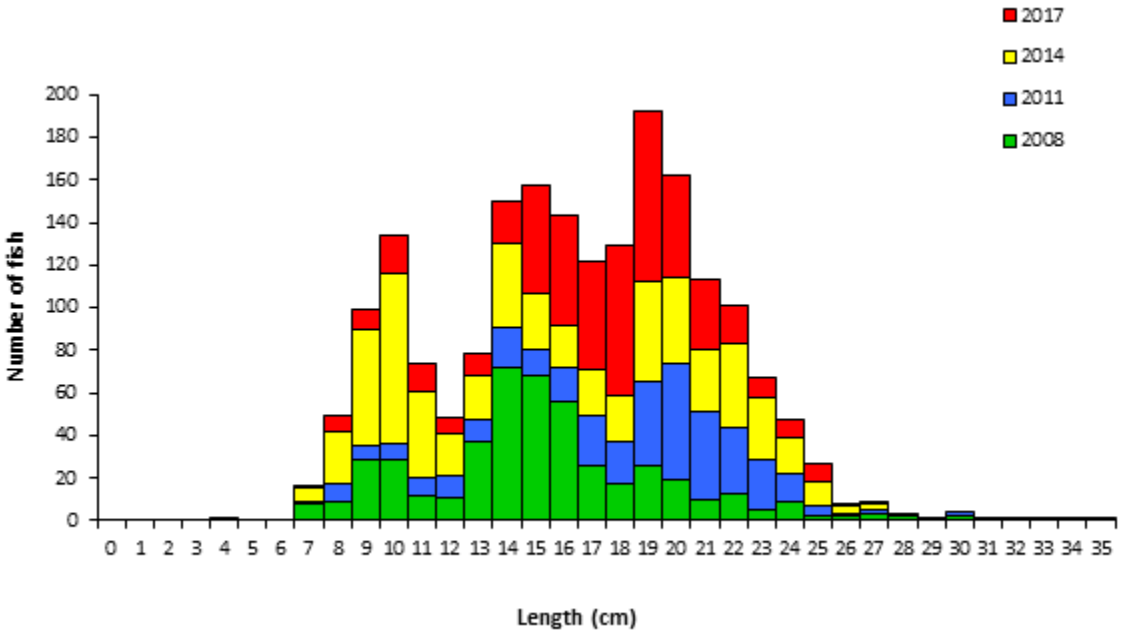

Fig. 1.5. Length frequency of perch captured on Lough Melvin, 2008, 2011, 2014 and 2017

Table 1.4. Mean (±S.E.) perch length (cm) at age for Lough Melvin, July 2017

	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 (±S.E.)	5.8 (0.1)	10.5 (0.3)	14.9 (0.3)	18.8 (0.3)	20.6 (0.5)	22.2 (0.5)	23.4 (0.7)	23.6 (1.1)	24.6 (1.1)	26.6 (1.1)	30.9	32.2	33.5
N	66	53	53	28	17	15	13	7	7	4	1	1	1
Range	4.1-7.7	6.7-15.1	9.2-19.7	12.6-22.0	14.0-23.5	16.1-24.9	17.9-27.4	18.7-26.8	18.9-27.5	24.8-29.5	30.9-30.9	32.2-32.2	33.5-33.5

Rudd

Rudd captured during the 2017 survey ranged in length from 12.1cm to 25.8cm (mean = 17.9cm) (Fig.1.6) with nine age classes present, ranging from 3+ to 11+, with a mean L1 of 2.7cm (Table 1.5). The

dominant age class was 4+ (Fig. 1.6). Rudd captured during the 2008 and 2014 survey had a similar length and age range with some larger fish recorded in both years. The smallest length range was recorded in the 2011 survey (Fig. 1.6).

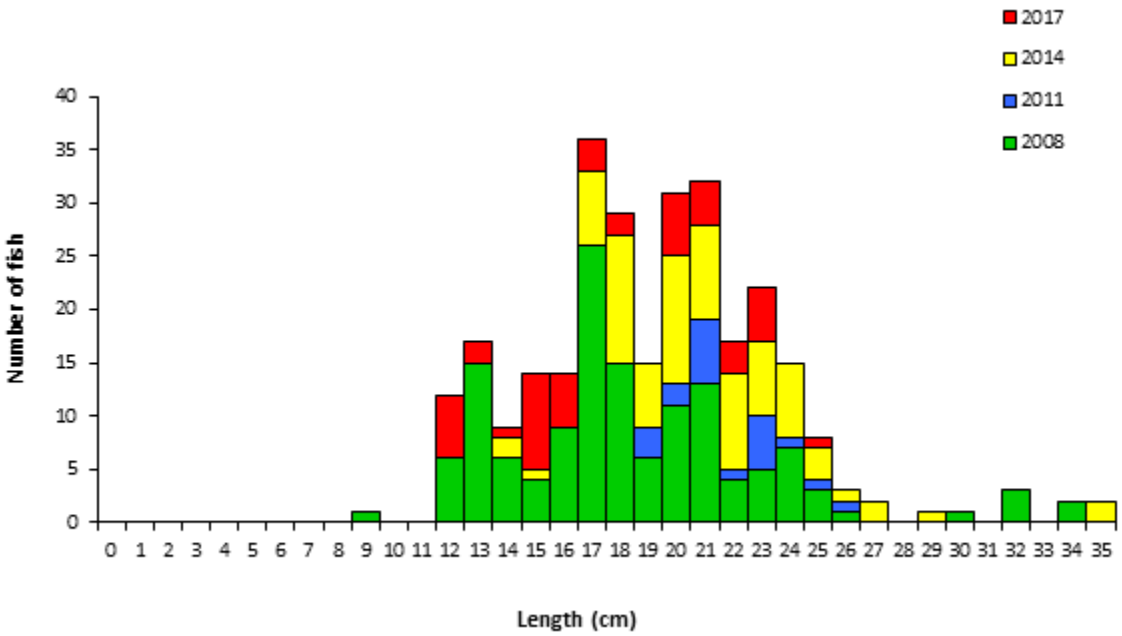

Fig. 1.6. Length frequency of rudd captured on Lough Melvin, 2008, 2011, 2014 and 2017

Table 1.5. Mean (±S.E.) rudd length (cm) at age for Lough Melvin, July 2017

	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}
Mean (±S.E.)	2.7 (0.1)	6.2 (0.2)	10.2 (0.3)	14.2 (0.4)	15.9 (0.5)	18.2 (0.5)	19.6 (0.4)	20.2 (0.4)	21.3 (0.7)	21.8 (0.8)	22.8
N	25	25	25	20	11	8	6	4	3	2	1
Range	2.0-3.5	4.5-8.2	7.7-13.3	10.5-17.0	13.1-18.4	15.9-20.9	18.7-20.6	19.2-21.3	19.9-22.2	21.0-22.7	22.8-22.8

Other fish species

Eels captured during the 2017 survey ranged in length from 22.0cm to 61.2cm. Salmon captured measured 13.4cm to 78.1cm and ages ranged from 1+ to 3.1+. Arctic char ranged in length from 13.5cm to 29.9cm and ages ranged from 1+ to 5+.

1.3.4 Stomach and diet analysis

Dietary analysis studies provide a good indication of the availability of food items and the angling methods that are likely to be successful. However, the value of stomach content analysis is limited unless undertaken over a long period as diet may change on a daily basis depending on the availability of food items. The stomach contents of a subsample of brown trout and perch captured during the survey were examined and are presented below.

Brown trout

Adult trout usually feed principally on crustaceans (*Asellus* sp. and *Gammarus* sp.), insects (principally chironomid larvae and pupae) and molluscs (snails) (Kennedy and Fitzmaurice, 1971, O'Grady, 1981). A total of 62 stomachs were examined. Of these 29 were found to contain no prey items. Of the 33 stomachs containing food, 55% contained unidentified digested material, 30% zooplankton and 15% invertebrates (Fig. 1.7).

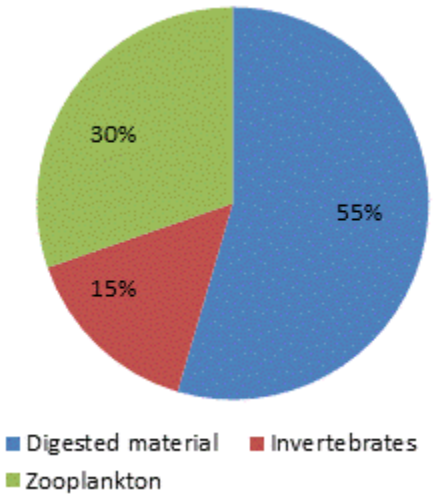

Fig 1.7. Diet of brown trout (n=33) captured on Lough Melvin, 2017 (% FO)

Perch

Perch initially start to feed on pelagic zooplankton. Once they reach an intermediate size they start feeding on benthic resources eventually moving on to feed on fish once they are large enough (Hjelm *et al.*, 2000). A total of 82 stomachs were examined. Of these 32 were found to contain no prey items. Of the remaining 50 stomachs containing food, 46% contained zooplankton, 38% unidentified digested material, 12% invertebrates and 4% fish (Fig. 1.8).

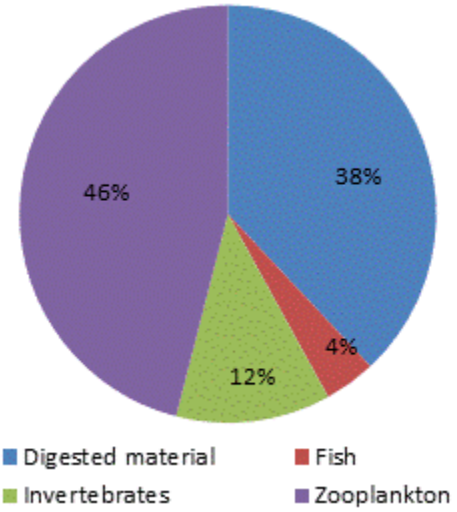

Fig 1.8. Diet of perch (n=50) captured on Lough Melvin, 2017 (% FO)

1.4 Summary and ecological status

A total of five fish species and three types of brown trout (sonaghan, gillaroo and ferox) were recorded on Lough Melvin in July 2017. Perch was the dominant species in terms of abundance (CPUE) and biomass (BPUE) captured in the survey gill nets during the 2017 survey.

Brown trout (all varieties) ranged in length from 11.0cm to 62.1cm with seven age classes present, ranging from 1+ to 7+, indicating reproductive success in seven of the previous eight years. The dominant age class was 2+. Length at age analyses revealed that brown trout in the lake exhibit a slow rate of growth according to the classification scheme of Kennedy and Fitzmaurice (1971). Brown trout captured during the 2008, 2011 and 2014 surveys had similar length and age ranges, with larger fish recorded in 2011, 2014 and 2017.

Perch ranged in length from 7.5cm to 34.1cm and ranged in age from 1+ to 13+, indicating reproductive success in nine of the previous fourteen years. The dominant age class was 3+. Perch captured during the 2008, 2011 and 2014 surveys had a similar length and age range.

Rudd ranged in length from 12.1cm to 25.8cm and ranged in age from 3+ to 11+, indicating reproductive success in nine of the previous twelve years. The dominant age class was 4+. Rudd captured during the 2008 and 2014 survey had a similar length and age range with some larger fish recorded in both years. The smallest length range was recorded in the 2011 survey.

Although the mean brown trout and perch CPUE and BPUE fluctuated slightly over the four sampling occasions, these differences were not statistically significant. However, rudd CPUE and BPUE in 2011 was significantly lower than all other sampling years.

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*., 2012b). Using the FIL2 classification tool, Lough Melvin has been assigned an ecological status of Good for 2017 based on the fish populations present. In previous years the lake was assigned a fish status of Moderate in 2008, High in 2011 and Good in 2014.

In the 2010 to 2015 surveillance monitoring reporting period, the EPA assigned Lough Melvin an overall ecological status of Moderate.

1.5 References

Amundsen, P.A., Gabler H.M., Staldvik F.J. (1996) A new approach to graphical analysis of feeding strategy from stomach contents data—modification of the Costello (1990) method. *Journal of Fish Biology,* **48,** 607–614.

Caffrey, J. (2010) *IFI Biosecurity Protocol for Field Survey Work*. Inland Fisheries Ireland.

Campbell, E. and Foy, B. (Eds.) (2008) *Executive Summary of Lough Melvin Catchment management Plan*. Northern Regional Fisheries Board.

Champ, W.S.T. (1998) Phosphorus/Chlorophyll relationships in Irish lakes: ecological consequences and suggested criteria for ecosystem management. In: Wilson, J. (Ed.) *Eutrophication in Irish Water*, 91-105. Royal Irish Academy, Dublin.

Connor, L., Matson R. and Kelly F.L. (2017) Length-weight relationships for common freshwater fish species in Irish lakes and rivers. *Biology and Environment: Proceedings of the Royal Irish Academy*. Vol. **117**, No. 2, 65-75.

Hjelm, J., Persson, L., and Christensen, B. (2000) Growth, morphological variation and ontogenetic niche shifts in perch (*Perca fluviatilis*) in relation to resource availability. *Oecologia*, **122, (2),** 190-199.

Delanty, K. and O' Grady, M. (2001) *Lough Melvin Fish Stock Report*. Central Fisheries Board. Internal report.

EPA (2005) *The Characterisation and Analysis of Ireland's River Basin Districts in accordance with section 7 (2&3) of the European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003).* National Summary Report (Ireland). 166pp.

Ferguson, A. (1986) Lough Melvin – A unique fish community. *Occasional papers in Irish Science and Technology*, No. 1, 17pp.

Girvan, J. and Foy, R. (2003) *Water Quality and Limnology of Lough Melvin (cSAC) – 1990 and 2001/02 (EHS CON 4/4/42)*. Report prepared for Environment and Heritage Service by Queens University Belfast and Department of Agriculture and Rural Development Northern Ireland.

Kelly, F., Connor, L. and Champ, T. (2007) *A Survey of the Fish Populations in 46 lakes in the Northern Regional Fisheries Board, June to September 2005 and 2006*. Central Fisheries Board. Internal report.

Kelly, F.L, Champ, W.S.T., Connor, L., Rosell, R., Harrison, A. and Girvan, J. (2007) Sampling procedures for fish in lakes (PART B). *Testing of various fish sampling gear types (fyke nets, monofilament multi-mesh gillnets, braided gill nets, seine nets and electrofishing) on selected lakes in the NS Share area*. Central Fisheries Board. NS Share project report.

Kelly, F.L., Harrison, A., Connor, L., Allen, M., Rosell, R. and Champ, T. (2008) *FISH IN LAKES Task 6.9: Classification tool for Fish in Lakes. FINAL REPORT*. Central Fisheries Board. NS Share project report.

Kelly, F.L., Connor, L., Wightman, G., Matson, R. Morrissey, E., O'Callaghan, R., Feeney, R., Hanna, G. and Rocks, K. (2009) *Sampling fish for the Water Framework Directive – Summary report 2008*. Central and Regional Fisheries Boards. Internal report.

Kelly, F.L., Connor, L., Morrissey, E., Wogerbauer, C., Matson, R., Feeney, R. and Rocks, K. (2012a) Water Framework Directive Fish Stock Survey of Lough Melvin, July 2011. Inland Fisheries Ireland.

Kelly, F.L., Harrison, A.J., Allen, M., Connor, L. and Rosell, R. (2012b) Development and application of an ecological classification tool for fish in lakes in Ireland. *Ecological Indicators*, **18**, 608-619.

Kelly, F.L., Connor, L., Morrissey, E., Coyne, J., Feeney, R., Matson, R. and Rocks, K. and Rocks, K. (2015a) *Sampling Fish for the Water Framework Directive – Summary Report 2014*. Inland Fisheries Ireland.

Kelly, F.L., Connor, L., Morrissey, E., Coyne, J., Feeney, R., Matson, R. and Rocks, K. (2015b) Water Framework Directive Fish Stock Survey of Lough Melvin, July 2017. Inland Fisheries Ireland.

Kennedy, M. and Fitzmaurice, P. (1971) Growth and food of brown trout *Salmo trutta* (L.) in Irish waters. *Proceedings of the Royal Irish Academy*, 71 (B) (18), 269-352**.**

King, J., Marnell, F., Kingston, N., Rosell, R., Boylan, P., Caffrey, J., Fitzpatrick, U., Gargan, P., Kelly, F., O' Grady, M., Poole, R., Roche, W. and Cassidy, D. (2011) *Ireland Red List No. 5: Amphibians, Reptiles and Freshwater Fish*. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

McGarrigle, M.C., Bowman, J.J., Clabby, K.J., Lucey, J., Cunningham, M., MacCárthaigh, M., Keegan, M., Cantrell, B., Lehane, M., Clenaghan, C. and Toner, P.F. (2002) Water Quality in Ireland 1998-2000, 128pp. Environmental Protection Agency, Wexford.

O' Grady, M.F. (1981) *A Study of Brown Trout (Salmo trutta L.) Populations in Selected Irish Lakes*. Ph.D. Thesis, National University of Ireland.

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