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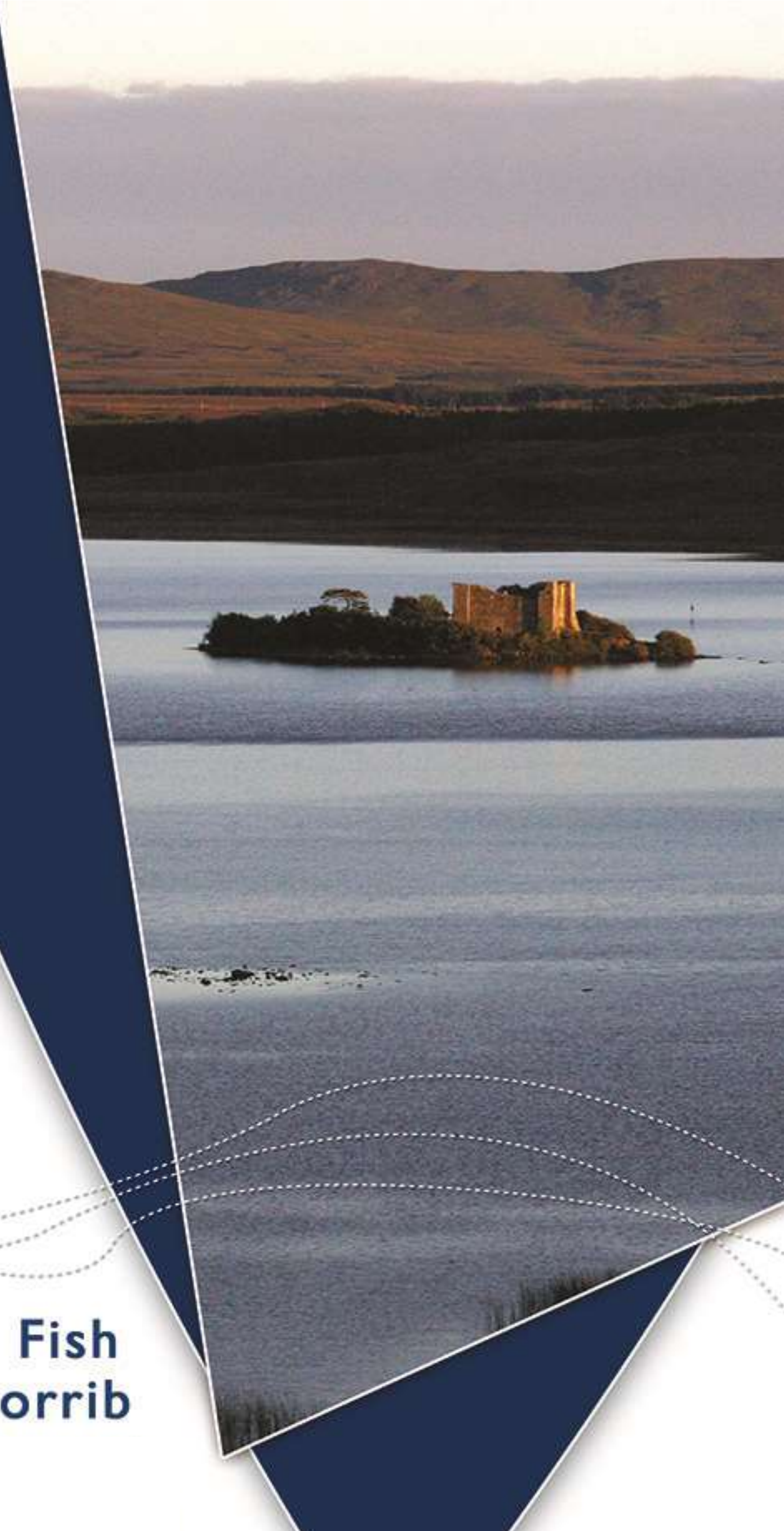

A Survey of Adult Fish Stocks in Lough Corrib

Iascach Intíre Éireann
Inland Fisheries Ireland

Preface

This report was written and researched by Martin O'Grady PhD and Karen Delanty PhD. A large number of personnel from Inland Fisheries Ireland (IFI) with assistance from a number of 3rd level students from Sligo IT, GMIT and UCD were involved in carrying out the survey and processing the data. Subsequent genetic analysis of the trout data was completed by Professor Paulo Prodohl and his team in Queens University Belfast. This was very much a team exercise with staff contributing in so many different ways to ensure the success of the project. A complete list of all the personnel involved is provided in the acknowledgements. A review of the methodology section will indicate to the reader why so many personnel with varying expertise were required to complete this operation safely, successfully and without impacting on the ecology of the lake.

This report outlines the findings of the L. Corrib fish stock assessment (2012) in relation to all fish species recorded though paying particular attention to the brown trout population. The report will also make comment and comparison to the previous L. Corrib fish stock assessment of 1996.

Summary comment is also provided in relation to the findings of the various trout genetic studies which have been carried out to date and some which are still ongoing.

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L. Corrib Fish Stock Survey Summary Findings

- Some significant changes in the fish stocks of L. Corrib since the 1996 survey are evident.
- A slight decline in the trout population is noted, however the trout population present was sufficient to provide quality brown trout angling that season (2012)
- Trout densities lower in upper Corrib and greater in lower Corrib
- A significant decrease in the pike population is noted.
- Significant increases in both the perch and roach x bream hybrid populations are evident.
- The Roach x bream hybrid stock is dominated by one old year class
- No major change to the roach population is evident in 2012 compared to 1996.
- Small numbers of bream were recorded in 2012.
- Two major ecological changes to the lake are evident in recent years, the introduction of zebra mussel and *Lagarosiphon* (curly-leaved water-weed)
- Balanced stable and healthy populations of most fish species are present in the lake.
- L. Corrib supports a relatively healthy, balanced and stable fish community
- Trout genetic studies to date illustrate a number of important findings
    1. 78% of the 2012 adult trout sample were produced by 5 sub-catchments – Abbert (23%), Grange (21%), Bealnabrack and Cornamona combined (19%), and the Oughterard (15%).
    2. Most trout migrating to the lake appear to stay in areas near the outfall of their natal river in springtime.
    3. The poor contribution of the Cross and Black rivers (a combined figure of 8%) may be responsible for the decline in trout numbers in the north eastern part of the lake noted since the 1996 survey.
    4. There is no evidence of brown trout fry released from the Oughterard hatchery making any contribution to fish stocks in the tributaries on the western or eastern side of the lake, where they are stocked out.

A Survey of Adult Fish Stocks in Lough Corrib , 2012.

1. Introduction

Lough Corrib is Ireland's largest and most valuable lake brown trout (*Salmo trutta*) fishery in socio-economic terms. In 2011 angling catches on the lake declined, relative to recent years, and there appeared to be conflicting evidence in relation to the relative size of the spawning runs of trout in tributary sub catchments. The Board of IFI decided that a fish stock assessment of the lake should be undertaken, in 2012, to establish the status quo of all adult fish stocks with particular reference to the brown trout population - only one such survey had taken place previously on L. Corrib (O'Grady *et al*., 1996). Extensive survey data for other trout lakes in Ireland over the last 35 years is available which would help to put the findings of the Corrib 2012 survey into perspective. It was intended that this survey would both allow one to review the current status of all fish stocks and to reflect on the relevance of current fishery management practice on the fishery and the necessity, if any, to change future management protocols in this area.

L. Corrib the second largest lake in Ireland (after Lough Neagh), is situated in Co. Galway in the River Corrib catchment. The main rivers draining into L. Corrib include the Bealnabrack, Black, Clare, Cregg, Owenriff rivers and the Cong canal which joins L. Corrib to Lough Mask. The lake can be divided into two parts; Lower L. Corrib - a relatively shallow basin underlain by carboniferous limestone in the south (Figure 1.1), and Upper L. Corrib - a larger, deeper basin underlain by more acidic granite, schists, shales and sandstones to the north (Figure 1.2) (NPWS, 2004). The lake has a surface area of 16,562 ha (5,042 ha Lower Lough and 11,520 ha Upper Lough), and has a maximum depth of 42m. The Lower lake falls into typology class 10 (as designated by the EPA for the Water Framework Directive), i.e. shallow (mean depth < 4m), greater than 50 ha and high alkalinity (> 100mg/l $CaCO_3$) and the Upper lake fits into typology class 12, i.e. deep (mean depth > 4m), greater than 50 ha and high alkalinity (> 100mg/l $CaCO_3$) (Kelly *et al*, 2009). The lake is currently classified as mesotrophic (Tierney *et al*., 2011).

The lake is known to hold brown trout, ferox trout (*Salmo ferox*), salmon (*Salmo salar*), pike (*Esox lucius*), perch (*Perca fluviatilis*), roach (*Rutilus rutilus*), bream (*Abramis brama*), roach x bream hybrids (*Rutilus rutilus x Abramis brama*), eels (*Anguilla Anguilla*) and three-spined stickleback (*Gasterosteus aculeatus*). Roach a non-native invasive fish species was first identified in Lower L. Corrib in 1982 and subsequently spread right throughout the lake (O' Grady *et al.*, 1996). Large numbers of roach were observed in routine netting operations on the lake from the late 1980s until 1992 when a decline in the stock was observed (O' Grady *et al.*, 1996). The zebra mussel (*Dreissena polymorpha*), another invasive species in Ireland was first recorded in L. Corrib during 2007, though it is thought they were introduced to the lake in 2000/2001. The most recent recorded invasive species to L. Corrib has been the highly invasive plant species *Lagarosiphon major* (also known as "curly-leaved waterweed") which was first identified in the lake in 2005 (Caffrey and Acevedo, 2007). This rapidly colonizing plant has already excluded native plant species from bays in which it has become established.

Plate 1. A – Zebra mussel, B – *Lagarosiphon major* (photos courtesy of IFI)

The lake was previously surveyed to assess its fish stocks by Inland Fisheries Ireland (formerly the Central Fisheries Board and the Western Regional Fisheries Board) in 1986 and 1996 (O' Grady, 1986; O' Grady *et al.*, 1996). The lake was also surveyed in 2008 and 2011 as part of the Water Framework Directive surveillance monitoring programme (Kelly *et al*., 2009 and 2012).

2. Methodologies

Following a number of meetings between the IFI Galway fisheries management senior personnel and research staff from IFI Swords the following survey strategy was adopted.

2.1. Survey Technique

It was decided to replicate the 1996 survey methods in the course of the 2012 survey in order to maximise the comparability of the two datasets. This involved carrying out the survey between late February and mid-March, 2012. The same sampling locations were used on both occasions, 1996 and 2012 (Figure 2.1).

2.2. Sampling Methodology

The field-work element of the L. Corrib fish stock survey commenced on February 27th and concluded on March 15th, 2012. The survey sampling involved the use of gill nets following a standard technique designed to monitor fish stocks in managed Irish trout lake fisheries. The survey nets used have been standardised since this type of survey commenced (O'Grady, 1981 and 1983). Each gang of nets contains equal lengths of panel every ½ inch mesh size from 2 inches to 5 inches inclusively (stretched mesh measurements). The total length of a survey net is 210m. The individual panels, within each survey net, are arranged randomly.

The survey nets in question are capable of catching all trout ≥ 19.8cm in length in proportion to their presence (O'Grady, 1981 and 1983). Experience has shown that these nets can capture samples of all perch ≥ 14cm, roach ≥ 16cm, roach x bream hybrids ≥ 12cm and bream ≥12cm. The smallest mesh panel in these survey nets (2") is physically capable of capturing small pike (≥ 25cm). However, pike ≤ 35cm are rarely captured in such surveys. This is most likely due to the fact that the smaller pike (≤ 35cm) live down in the "body" of the charophyte beds, below the level at which the gill nets are fishing. Charophyte beds are extensive areas of Stoneworts which are macroscopic green algae which commonly occur in limestone lakes where they become encrusted with a lime scale covering making them quite brittle to touch (Plate 2).

Plate 2. Underwater image of charophyte beds (photo courtesy of IFI)

The number of trout, or indeed any fish species, captured for a particular netting effort (catch per unit effort or CPUE) reflects the relative density of that fish present in the lake. CPUE values for each fish species are calculated by dividing the total number of that fish species caught by the total number of nets set. This type of fish stock assessment has been employed, by IFI, on numerous lake surveys nationally providing an extensive database of CPUE values for many fish species across a wide range of lake types. The availability of such data will benefit this report allowing direct comparisons to be made with similar type lake fisheries and provide useful comment on the current fish stock status of L. Corrib.

A total of 250 sampling locations were surveyed (Figure 2.1). These locations were originally chosen for the 1996 survey, whereby the lake was divided into a numbered grid system of squares each 250m x 250m and then using a random number generator 250 locations were selected. The number of sites sampled was based on lake area. Garmin GPS units pre-loaded with the netting site co-ordinates were used to locate the sampling sites.

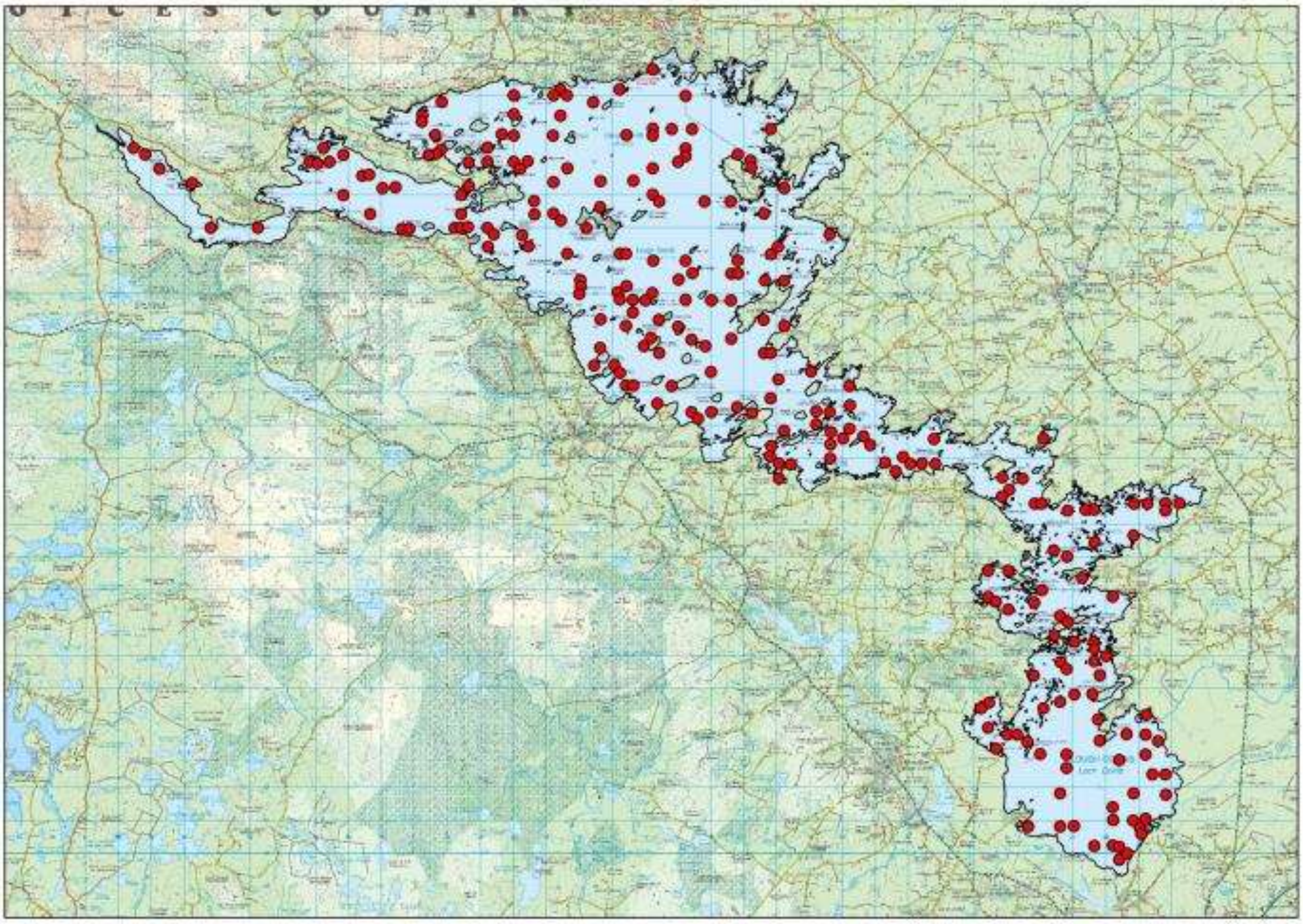


Figure 2.1. The sampling locations for both the 1996 and 2012 L. Corrib surveys.

A total of 5 boats with a 2 man crew on board were required to undertake the survey. The lake was divided into 5 sampling zones (Figure 2.2) each with a total of 50 netting locations, and each crew were allocated a sampling zone for the entire survey period. Boat crews were based all around the lake using the four IFI L. Corrib stores (Figure 2.2).

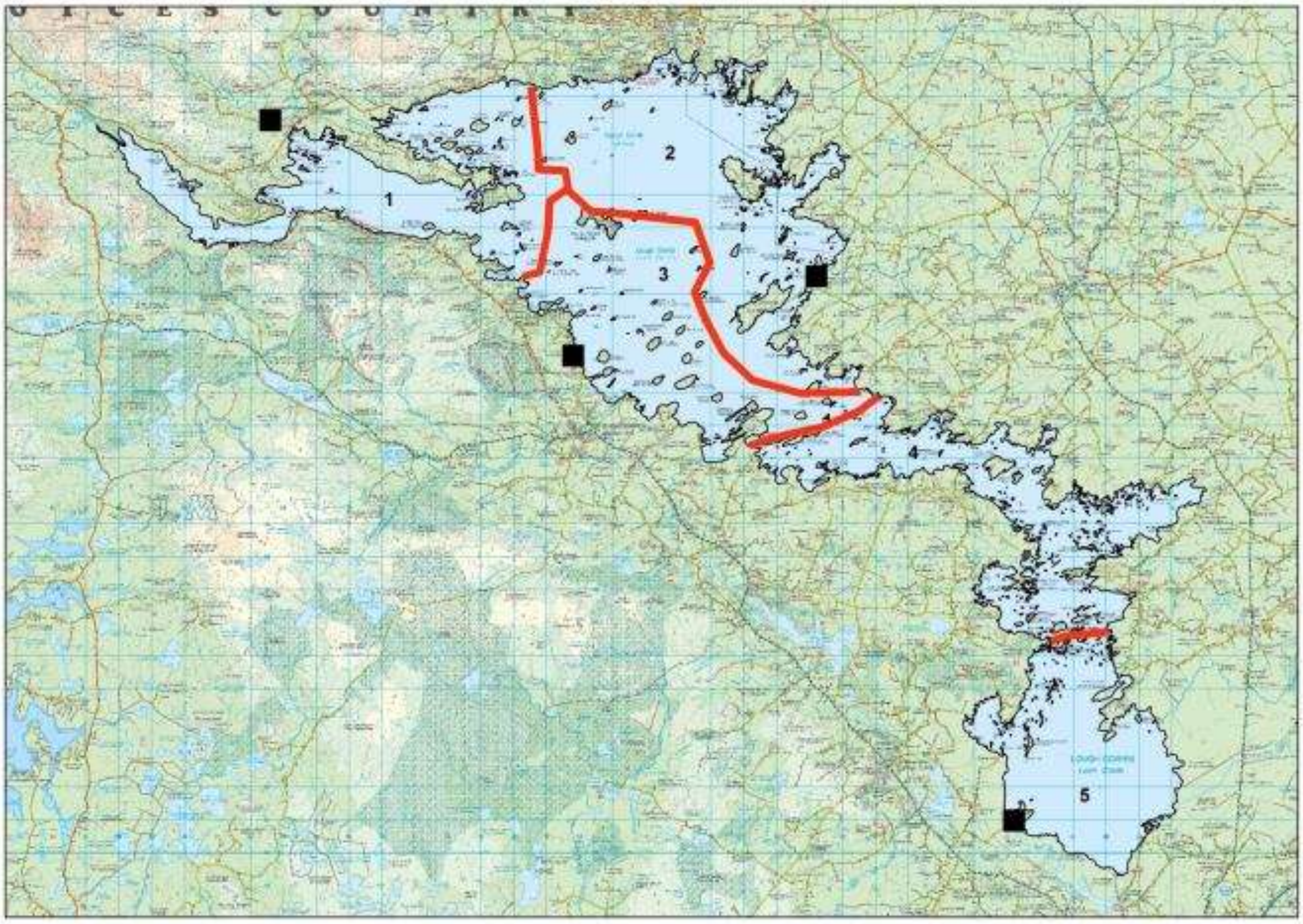


Figure 2.2. L. Corrib sampling zones (1 to 5) and IFI lake stores/offices.

All sets of survey nets were fished over-night; in general nets were set at each site in the morning and lifted the following morning. On all occasions when trout captured in the nets were found to be alive they were released in circumstances where the netting crew felt the fish were in good condition and had a good chance of survival. The lengths of all trout released along with a scale sample from each individual fish and their capture location were recorded on individual scale envelopes. Large pike (≥ 85cm) were treated in the same way. After that all other fish were retained in labelled bags for laboratory analysis. This involved the following;

- Initial processing of the catch was carried out at the IFI base at Cornamona. This involved weighing and measuring individual fish captured, retaining scale samples (and opercula in the case of perch) for subsequent age analysis.
- The stomach contents of all trout and many pike and perch were noted. Particular attention was paid to noting the presence of possibly new invasive macroinvertebrate species in fish stomachs - none were observed.
- Individual fish were examined in relation to their ecto- and endo-parasitic load - very heavy parasitic loads of freshwater lice (*Argulus spp.*) had been observed on both pike and trout in the previous survey of L. Corrib in 1996 (O'Grady *et al.*, 1996). None were evident in the 2012 survey.
- Gonadial material from some female pike were retained for further analysis by D. Pedreschi, a student currently undertaking a PhD study on Irish pike stocks.
- Two sets of scale samples were retained for all trout sampled - this was to allow both the growth/ageing analysis and a genetic analysis to proceed in tandem.
- Subsequent analysis of survey data continued thereafter at IFI, Swords with the assistance of two graduate students from UCD (Stephen Mc Carthy and John O'Connor) and an undergraduate student on a work study programme from GMIT (Cian Derbyshire).
- Trout scale samples collected for genetic purposes were sent to Queens University Belfast (Prof. P. Prodhol) for detailed analysis. This was followed in 2013 by additional genetic analysis of some older scale samples (1996) taken from trout in the Grange River.

2.3. Biosecurity Measures

Invasive species are an ever present threat in our aquatic and riparian systems and it is imperative that none of our field operations exacerbate the risks to the environment and to the economy that are posed by these species. Fish parasites, pathogens and diseases also represent a significant threat to the health status of our watercourses. The introduction or transfer of such pathogens or diseases has the potential to wipe out large populations of fish in affected waters or catchments. Vigilance is required if we are to stop the spread of invasive species and fish diseases, and it is imperative that we in IFI lead by example in the on-going struggle against these significant threats to our fishery watercourses.

IFI has a bio-security policy (IFI, 2010) which was adhered to as part of the survey. An addition to the current biosecurity strategy was designed and adopted (IFI, 2012) to ensure that;

1. The survey programme would not be responsible for the introduction of non-native plant or macroinvertebrate species to the lake.
2. Survey nets used would not be responsible for spreading *Lagarosiphon* beyond its current base in the lake or indeed its re-introduction into controlled bays.

Figure 2.3. Distribution of *Lagarosiphon* within L. Corrib, 2005 - 2012. (Source of data – CAISIE LIFE Project 2013)

2.4. Safety Measures

The safety measures and protocols identified and listed in the IFI Employee Safety Handbook (IFI, 2012) were fully employed at all times during the survey. In addition to those discussed in the safety manual a number of other safety measures were adopted during the course of the survey operations (IFI, 2012). The procedures implemented ensured the safety of all staff involved and helped to ensure that the survey ran smoothly and without incident.

3. Results

The 2012 fish stock assessment of L. Corrib is only the second one of this type to be carried out, the first one being in 1996. The lake has been subject to two WFD surveys in the intervening years (2008 & 2011). However those surveys were not as intensive nor as extensive as the 1996 and 2012 IFI surveys. The data collected is presented in this section.

3.1. A General Comparison with the 1996 Survey

The total numbers of fish of every species captured in both surveys (1996 and 2012) are outlined in Table 3.1. While CPUE values from both surveys are presented in Table 3.2.

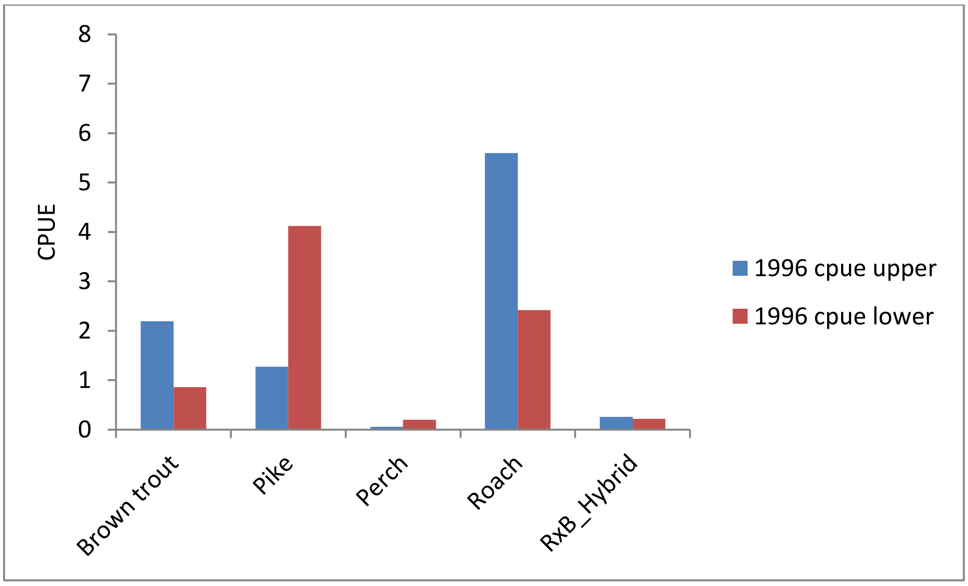
Table 3.1. Total fish numbers captured in the 1996 and 2012 surveys.

	1996		2012	
	Retained	Released	Retained	Released
Trout	130	358	132	253
Pike	461		223	13
Perch	21		699	
Roach	1240		1437	
Bream	0		33	
Rudd	5		0	
Roach/Bream Hybrid	63		631	
Salmon	5		5	

Table 3.2. CPUE values for all fish species recorded during the L. Corrib surveys, 1996 and 2012.

	1996	2012
Trout	1.95	1.54
Pike	1.84	0.94
Perch	0.08	2.80
Roach	4.96	5.75
Bream	0	0.13
Rudd	0.02	0
Roach/Bream Hybrid	0.25	2.52
Salmon	0.02	0.02

The data presented within this report generally refers to the whole of L. Corrib, however on occasion it is useful to separate out the data to show upper and lower Corrib independently (Figures 3.1 A&B). The differing characteristics of upper and lower Corrib (see Section 1) may impact on the fish populations and lake productivity between these two areas.



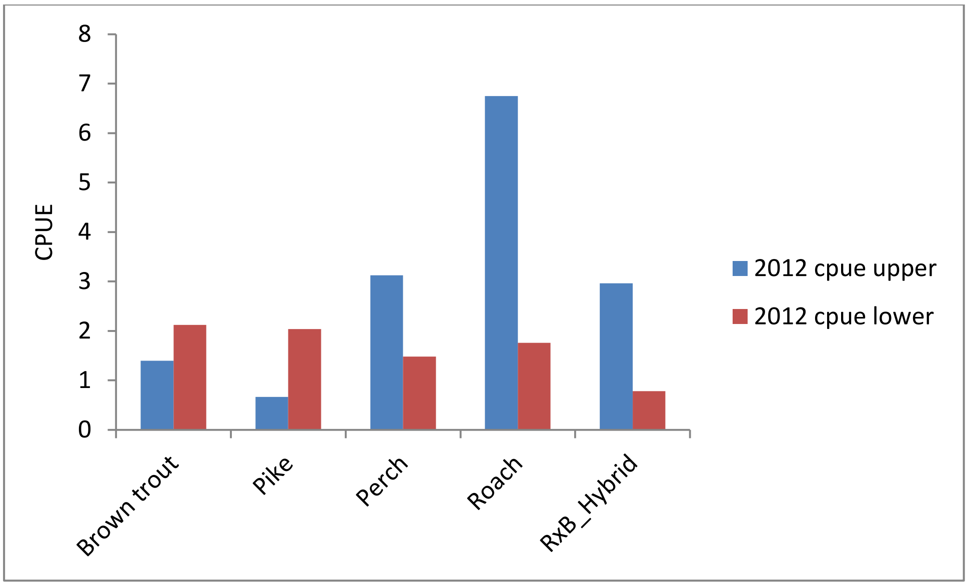


Figure 3.1 A & B. CPUE values for each fish species recorded from upper and lower L. Corrib, 1996 (A) and 2012 (B).

The 1996 survey data suggests that at that time roach dominated upper L. Corrib followed by trout. While numbers of pike and then roach were greater in the lower lake. The 2012 survey data follows a different trend with roach along with perch and roach x bream hybrids completely dominating the upper lake. Lower Corrib showed signs that the levels of trout, pike, roach and even perch were similar.

Of the total number of trout captured in the current survey (2012) 66% were released alive back into the lake. This figure was 73% in the 1996 survey.

Data from the current study (2012) indicates a number of significant changes in the relative abundance of different fish species compared to 1996 (Table 1). The most obvious changes can be summarised as follows;

1. There was a decrease in the numbers of trout captured - from 488 fish in 1996 to 385 individuals in 2012.
2. A very significant reduction in the adult pike population is evident - from 461 fish in 1996 to 248 individuals in 2012.
3. A major recovery in perch stocks has taken place with the catch increasing from 21 individuals in the 1996 survey to 699 fish in 2012. Prior to 1986 L. Corrib was known to have large stocks of perch.

4. The adult roach population recorded in both years is similar - 1240 fish in 1996 and 1437 individuals in 2012.
5. There has been a noted change in the bream stock. No bream were captured in the 1996 survey while 33 were noted in the 2012 exercise. WFD fish surveys of L. Corrib, in 2008 and 2011 (Kelly *et al*, 2009 & 2012) also recorded similar densities of bream as in the 2012 survey.
6. A very substantial increase in the roach x bream hybrid population is evident in 2012, 631 fish in 2012 compared to 63 such fish in the 1996 survey.
7. Regrettably no char were captured in either the 1996 or 2012 surveys suggesting that this species, in L. Corrib, is extinct and has been for some time (Igoe *et al*, 2001).
8. The recovery in the perch population in 2012, compared to 1996, in addition to the increase in roach x bream hybrid and bream numbers and the maintenance of a moderate roach and trout stocks in 2012 means that the standing crop or biomass of fishes feeding on plankton and macro-invertebrates was substantially higher in 2012 compared to 1996.
9. A comparison of Upper and Lower Corrib, in terms of fish CPUE values, indicates some differences in stock structure between the two lake sub-basins and compared to the 1996 survey (Figure 3.1 A & B).

3.2. Brown Trout.

Since the previous fish stock assessment of L. Corrib in 1996 zebra mussel have become established within the lake along with the invasive plant curly-leaved pond weed (*Lagarosiphon major*). The ecological impact of these to the trout population was not fully known. The data collected as part of the current survey has provided information in relation to this as well as the angling potential of the lake.

3.2.1. CPUE Values

The CPUE value for trout was lower in the 2012 survey (1.54) compared to the 1996 value (1.95). The 2012 L. Corrib CPUE value for trout is found to be in the mid-range when compared with data from a number of other Spring sampled Irish lakes (Figure 3.2). Angling returns from L. Corrib in the 2012 season were considered good, indicating that the current (2012) CPUE value for trout in the lake is sufficient to provided quality angling when weather conditions are favourable.

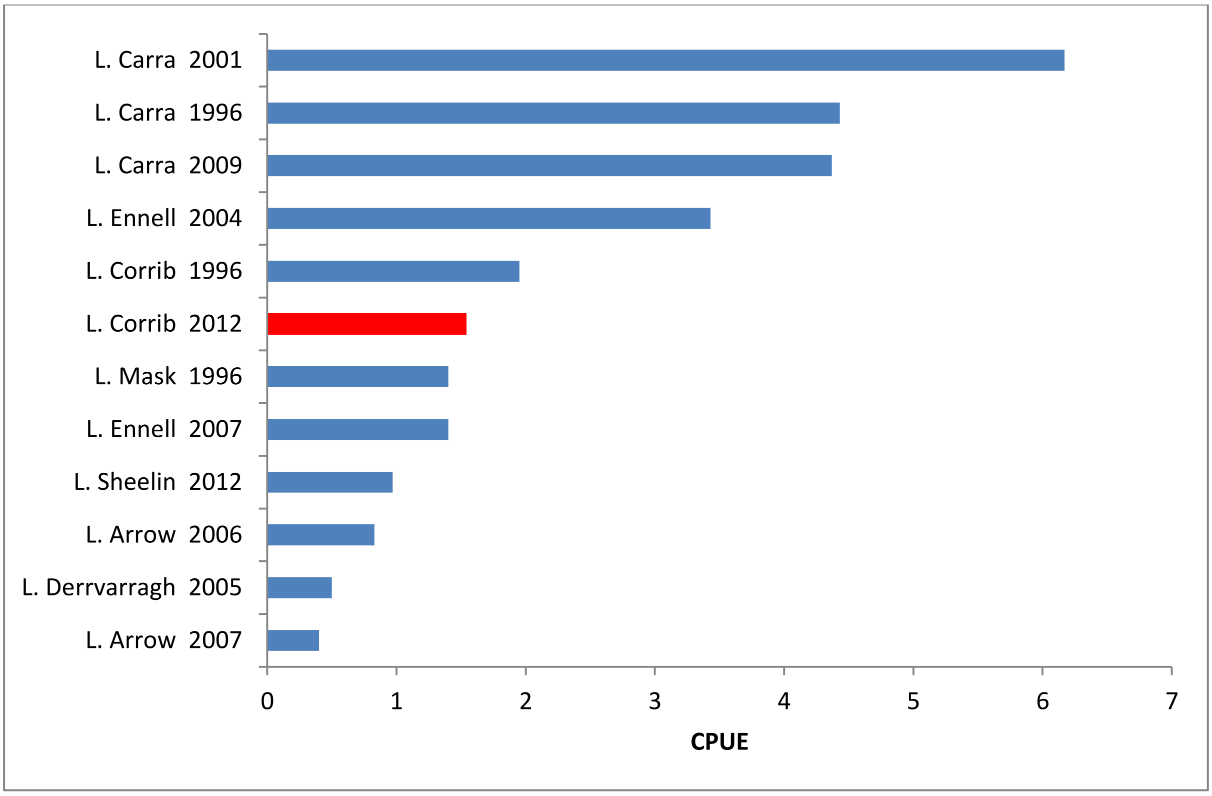


Figure 3.2. Brown trout CPUE values across a number of large Irish brown trout lakes.

3.2.2. Population Structure

The population structure of the brown trout stock in L. Corrib in 2012 is quite different to that observed in 1996 (Figure 3.3).

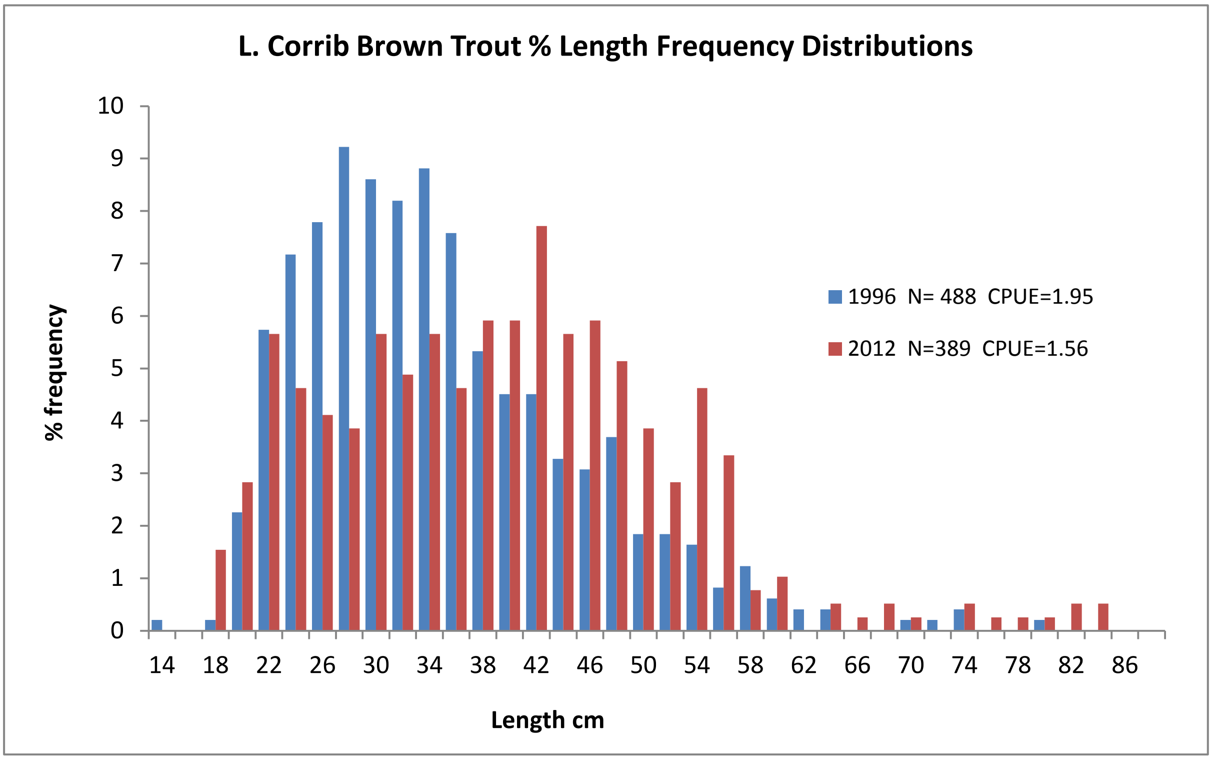


Figure 3.3. Percentage length frequency distribution and N values for brown trout in the 1996 and 2012 surveys.

The stock structure of the trout population was quite different in both surveys. In the 1996 survey the younger adult fish were more dominant than the older age groups. The reverse was true in 2012 with larger older fish being more dominant in the stock (Figure 3.3). However, the reader should note that younger year classes are still well represented in the 2012 dataset. The trout stock structure in 2012 reflects a healthy population with a significant recruitment level in successive year classes over the last 5 years and no indications of a very marked decline in the recruitment of young fish in any one or more years.

3.2.3. Growth Patterns

Backcalculated growth patterns for trout in the 1996 and 2012 Corrib surveys are virtually identical (Figure 3.4). This is a reflection of a significant level of stability within the trout population with little change noted over the past 16 years. The calculated L. Corrib trout growth rates are faster than those observed from other Irish lake surveys for fish greater than 5 years (Figure 3.4). This is most likely due to the presence of ferox trout in the population and therefore in the scale sample analysed from L. Corrib in both 1996 and 2012.

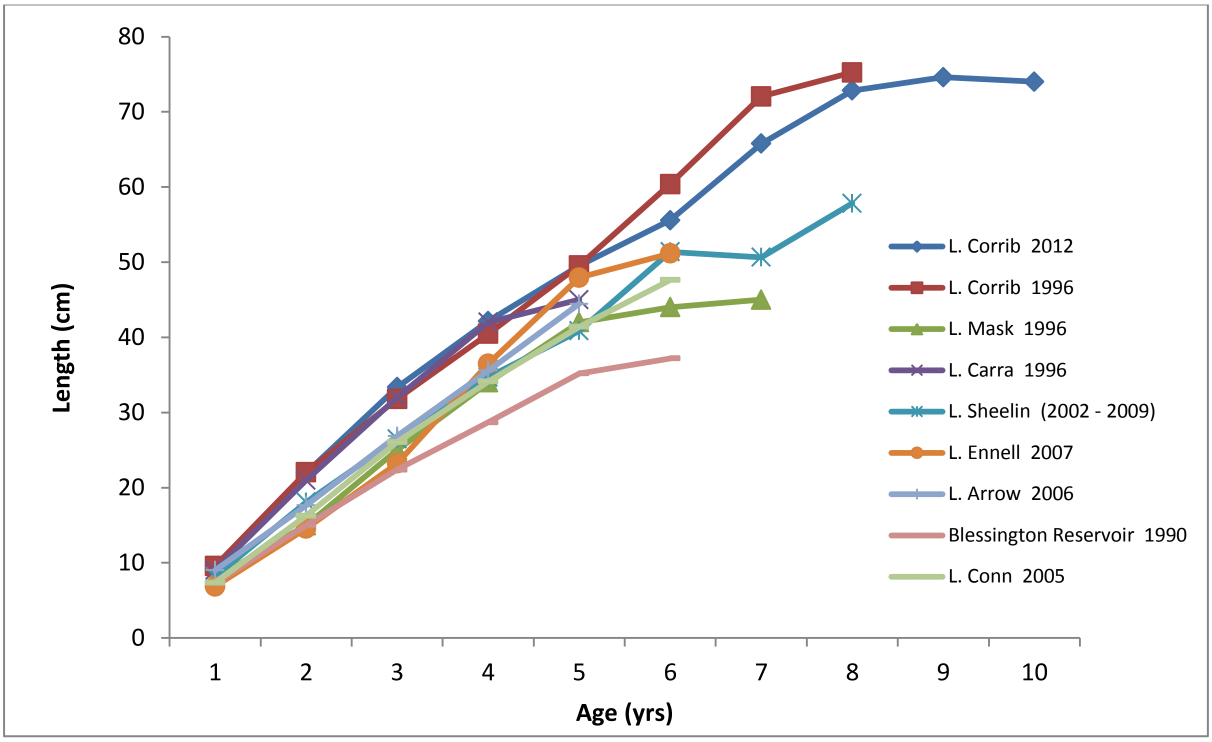


Figure 3.4. Brown trout growth patterns for L. Corrib 2012 and a number of other Irish lakes.

Major changes in Irish lake brown trout stocks have been observed in a number of waters over the last 35 years - most notably in Lough's Conn and Sheelin (Figure 3.5 A & B) (O'Grady & Delanty, 2001 and 2000). The absence of this trend in Corrib trout stocks from 1996 and 2012 is an important reflection of the current stability in the trout population.

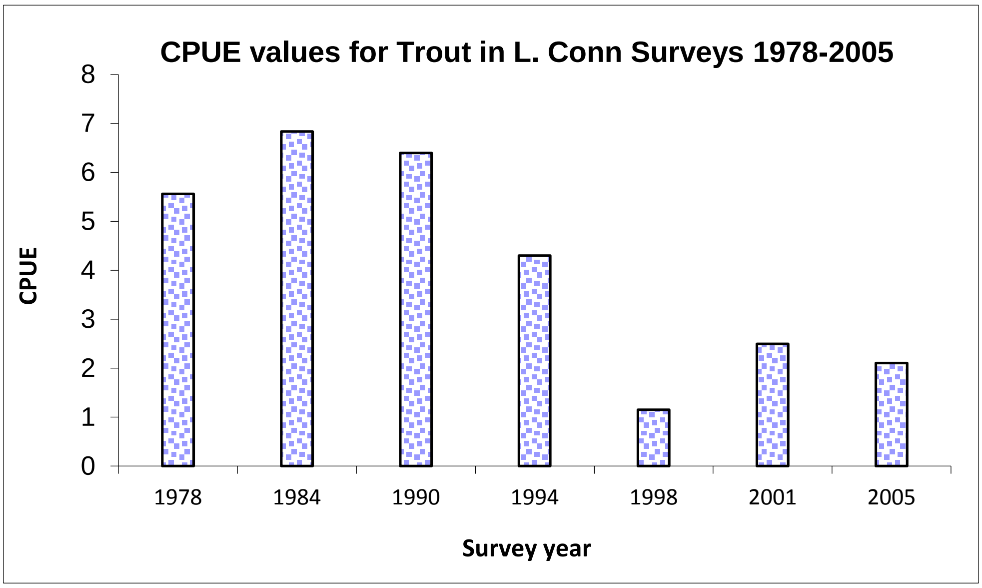


Figure 3.5 A . Brown trout CPUE values for L. Conn between 1978 and 2005.

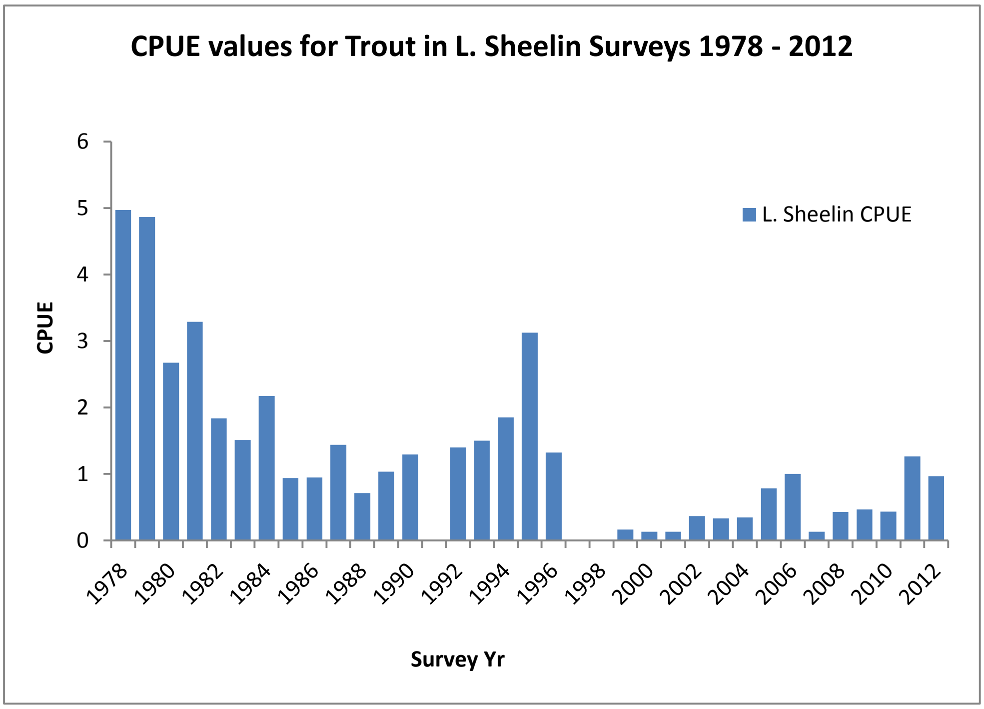


Figure 3.5 B. Brown trout CPUE values for L. Sheelin between 1978 and 2012.

3.2.4. Trout Age data

Trout age structure of the two survey periods (1996 and 2012) are very similar, again an indication of a relatively stable population (Figure 3.6).

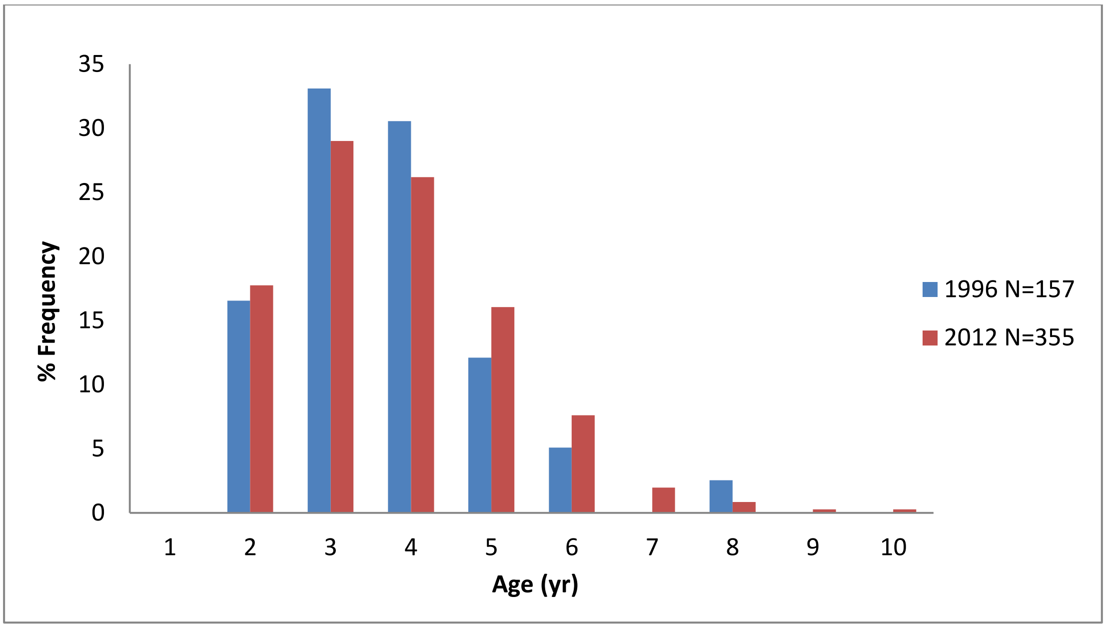


Figure 3.6. Trout age structure L. Corrib 1996 and 2012

3.2.5. Trout Dietary Patterns

An extensive database on the dietary habits of trout in Irish lakes in springtime is available over the last 50 years. In these waters, during this specific period, adult trout usually feed principally on crustaceans (*Asellus* and *Gammarus*), insects (principally chironomid larvae and pupae) and molluscs (snails) (Kennedy and Fitzmaurice, 1971, O'Grady, 1981). The Corrib trout dietary information for the 2012 survey reflects the norm in this regard. The comparable 1996 data in this area are very similar to the 2012 data set (Figure 3.7). This is another important feature which illustrates relative stability in the ecology of the macro-invertebrate fauna of L. Corrib.

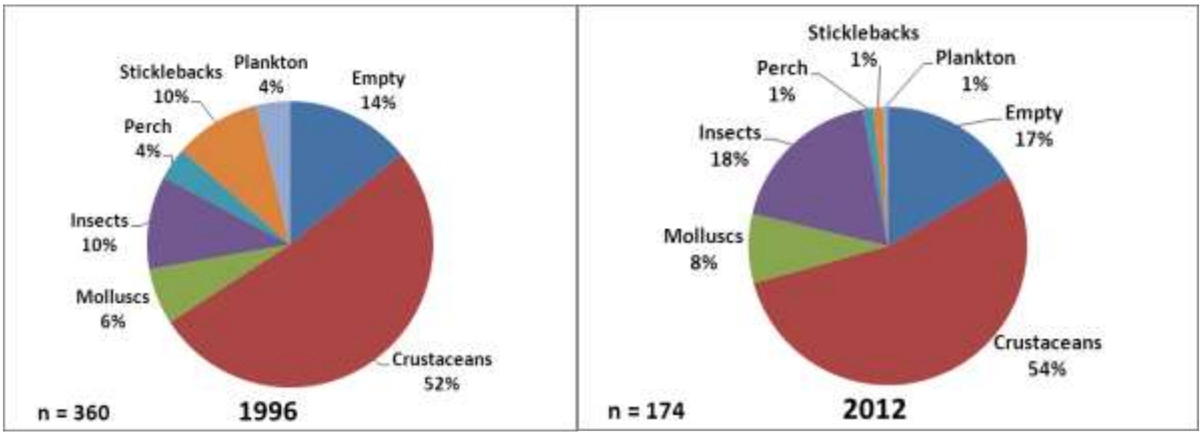


Figure 3.7. The dietary habits of trout samples from the 1996 and 2012 Corrib surveys.

3.2.6. Trout Sex Ratios

The sex ratio of fish within Irish trout populations is normally 50% females and 50% males (O'Grady, 1981a). Table 3.3 shows the sex ratio of the trout samples from both the 2012 and 1996 surveys. These sex ratios do not differ appreciably from the 50:50 ratio.

Table 3.3. Trout sex ratios.

	%		
	Male	**Female**	**N**
L. Corrib 1996	51	49	124
L. Corrib 2012	60	40	134

3.2.7. Trout Length / Weight Relationship

The relationship between length and weight of trout are expressed in terms of regression co-efficient and Fulton's condition factor (*K*) (Table 3.4). The regression of weight on length showed that the relationship for trout from both surveys (1996 and 2012) was very similar. A regression co-efficient (b) of 3 indicates isometric growth, that is growth with unchanging body proportions and specific gravity (Bagenal and Tesch, 1978).

Condition factor is a means of expressing and comparing the plumpness of fish in a quantifiable manner. This is based on the premise that heavier fish for a given length are in better condition (Bagenal and Tesch, 1978). Fulton's condition factor (*K*) was calculated for each fish using the formula;

$$K = W*100/L^3$$

where W = weight of fish(g) and L = length of fish (cm)

Fish in poor condition will have a condition factor of less than unity, while those in good condition will have *K* values greater than unity (Frost and Brown, 1967). The current L. Corrib survey condition factor and that for the 1996 survey (Table 3.3) suggest that trout are and were, in general, good condition and are in slightly better condition currently.

Table 3.4. Length: Weight Relationships.

	N	Log (a)	b	R^2	Condition Factor (K)
L. Corrib 1996	126	-4.81	2.94	0.88	1.10
L. Corrib 2012	128	-4.64	2.88	0.93	1.19

Average weight of trout over the legal minimum catchable size limit (of 13" or 33cm in 2012) was 1.02kg in 2012 and 0.76kg in 1996 (the original 1996 figures have been adjusted as the minimum catchable size limit has changed since 1996). There does appear to be an increase in the number of heavier 'catchable' trout since the 1996 survey.

The average weight for a 'catchable' trout recorded in Upper L. Corrib in 2012 was 1.034kg and 0.957kg for Lower L. Corrib (using fish of minimum catchable size of 13" or 33cm). When trout weights from upper and lower Corrib are compared currently and between the two survey periods, 1996 and 2102, there does appear to be some differences (Table 3.6). In general average weight of trout from lower Corrib has remained relatively stable. However the same is not true of trout from upper Corrib. These trout are currently heavier than those from lower Corrib and also heavier than those from the 1996 survey (Table 3.5).

Table 3.5. Total number trout recorded in L. Corrib.

	Lower Corrib	Upper Corrib
1996	43	445
2012	106	279

Table 3.6. Total number of catchable fish and their average weight

	N (Total number of retained trout)	Average over-all weight kg (all fish)	N (total number of catchable trout)	Legal Minimum catchable size kg (>13")
L. Corrib 1996	127	0.548	75	0.756
L. Corrib 2012	128	0.708	79	1.015
Upper Corrib 1996	120	0.528	68	0.742
Lower Corrib 1996	7	0.89	7	0.89
Upper Corrib 2012	98	0.715	60	1.034
Lower Corrib 2012	28	0.723	19	0.957

3.2.8. Upper and Lower L. Corrib

When the 2012 dataset is separated out to show upper and lower Corrib one can see that the older trout are found in upper Corrib (Figure3.8).

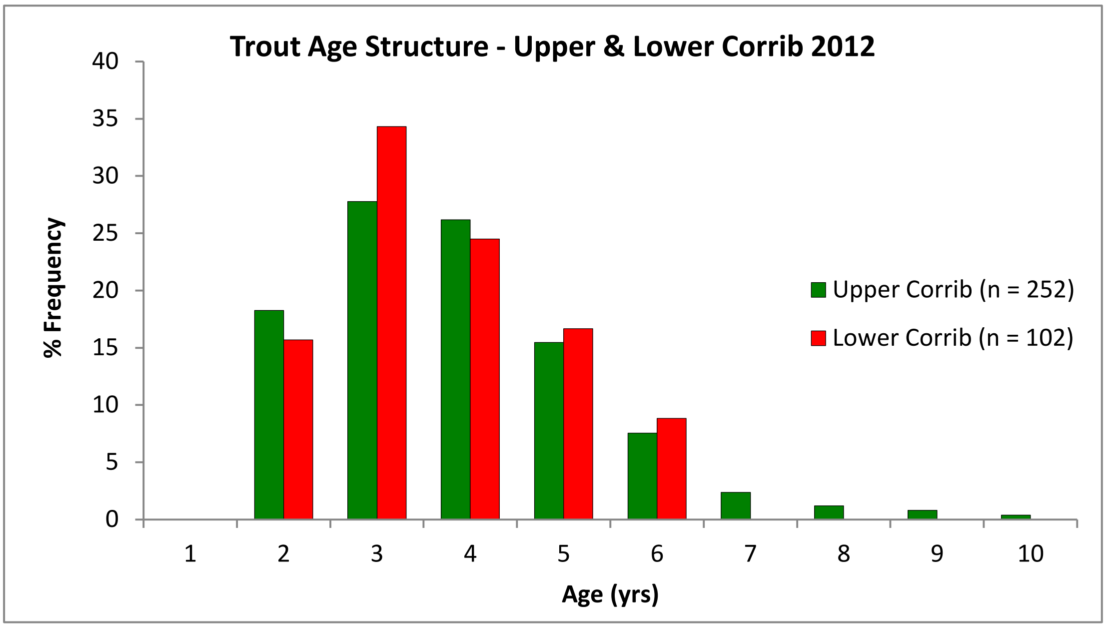


Figure 3.8. Trout age frequency distribution from upper and lower Corrib, 2012.

Data on trout length between upper and lower Corrib suggests that upper Corrib has a greater proportion of smaller and much larger fish (possibly ferox trout). While lower Corrib is more dominated by trout in the mid-range size of 36 to 56cm (Figure 3.9).

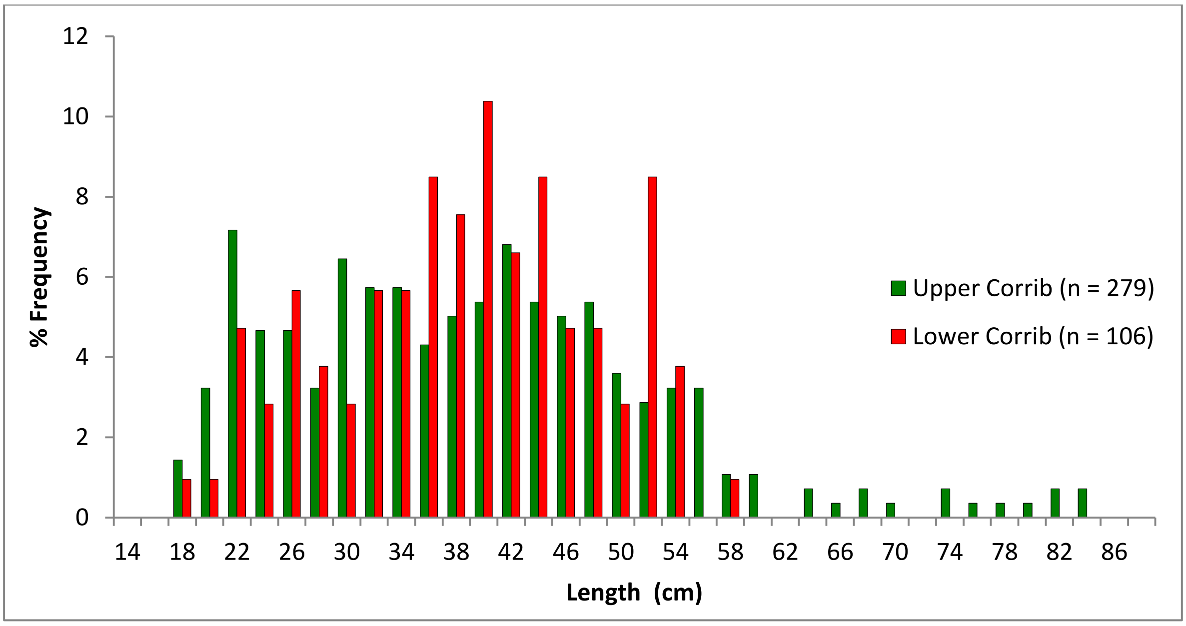


Figure 3.9. Trout length frequency distribution, upper and lower Corrib 2012.

No difference was observed for trout length at age data, both upper and lower Corrib were very similar (Figure 3.10).

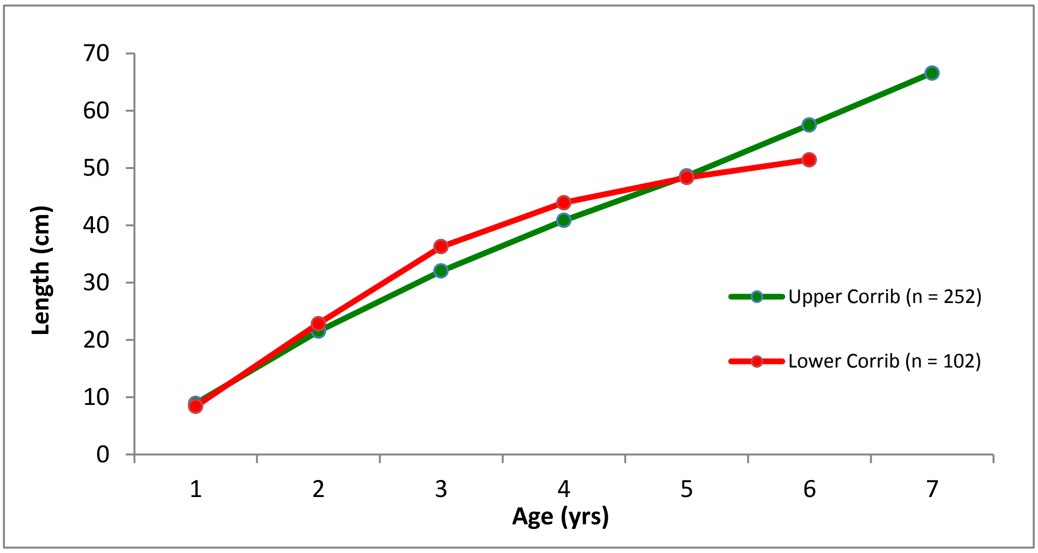


Figure 3.10. Trout length at age from upper and lower Corrib, 2012.

3.2.9. The Lake Wide Distribution of Trout in the 1996 and 2012 Surveys.

In general terms the highest concentrations of trout, in both the 1996 and 2012 surveys were generally associated with lake areas supporting charophyte beds. Some differences were evident in the distribution of trout across the 250 sampling sites in both surveys (Figure 3.11). The most notable of these would be many sites in upper Corrib recorded no trout in 2012, especially sites out in the deeper areas of the lake compared to 1996. While much higher densities were recorded in lower Corrib compared to the 1996 survey.

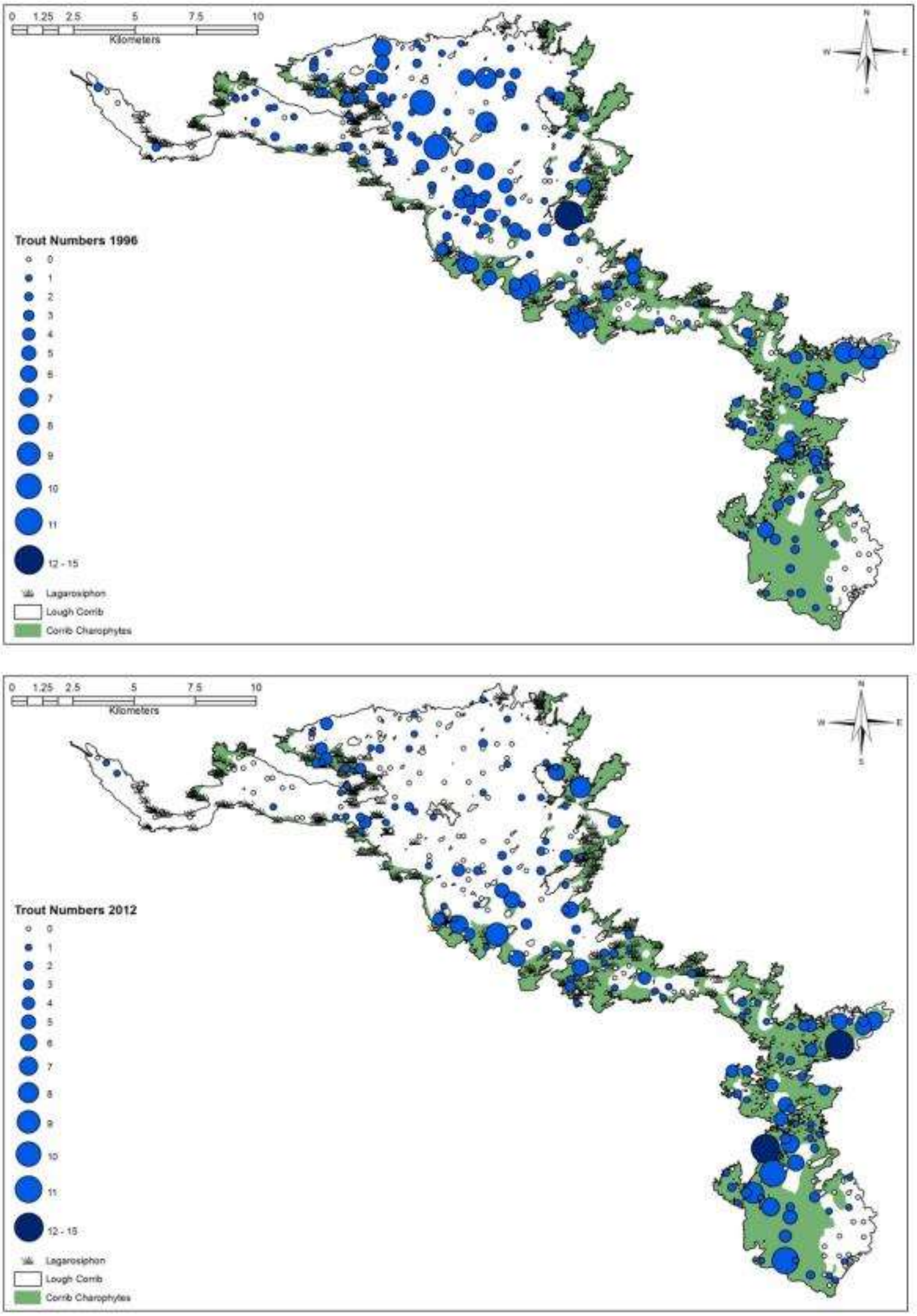


Figure 3.11. L. Corrib trout distribution map from the 1996 and 2012 surveys, with *Lagarosiphon* and *Chara* distributions also shown.

3.2.10. Trout Summary Findings

- 2012 trout CPUE value is less than the 1996 survey value. However it should be noted that any fish stock assessment is a reflection of stocks at that time. The 2012 trout CPUE figure is still a relatively moderate value when compared with other large lakes.
- 1996 and 2012 population structure differ, less smaller fish recorded in 2012
- More trout in lower Corrib than in 1996 survey
- Less trout in upper Corrib than in 1996 survey
- Average weight of trout for lower Corrib remains similar (for catchable size fish)
- Average weight of trout from upper Corrib is less than in 1996 (for catchable size fish)
- Upper Corrib may be showing signs of a less stable environment than it was in 1996
- Lower Corrib appears more stable and shows signs of an improved trout population.

3.3. Pike Stocks

The following sections present the results of this survey for pike and makes comparisons with the 1996 survey.

3.3.1. CPUE Values

The pike CPUE value has fallen from 1.84 in the 1996 survey to 0.95 in the 2012. This represents a fall in pike numbers by almost 50%.

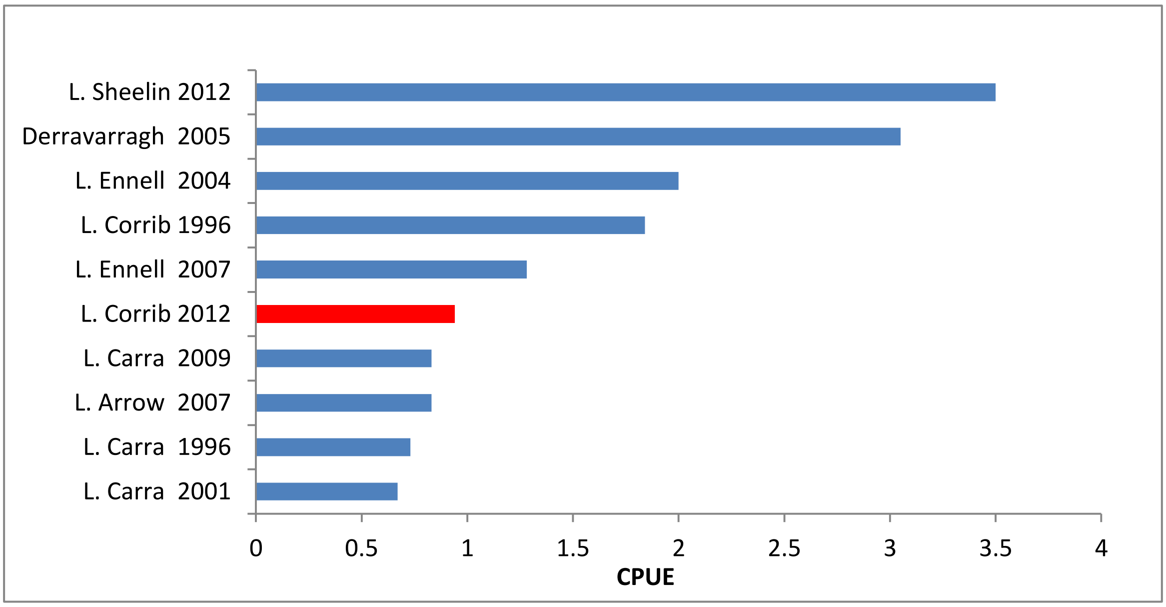


Figure 3.12. CPUE values for pike from L. Corrib and a number of other Irish lakes, spring sampled.

A comparison of pike CPUE data from L. Corrib with other spring sampled lakes shows that currently the pike CPUE value is within the moderate to slightly lower range of values recorded (Figure 3.12).

3.3.2. Population Structure

Very significant differences are evident in both the stock density and population structure of the pike population in L. Corrib in 1996 and 2012 (Figure 3.13 a & b). This survey has shown a greatly reduced pike population present in the lake. Also worthy of note is the reduction in smaller pike caught on this occasion, a reflection most likely of the pike management programme operated by IFI Galway.

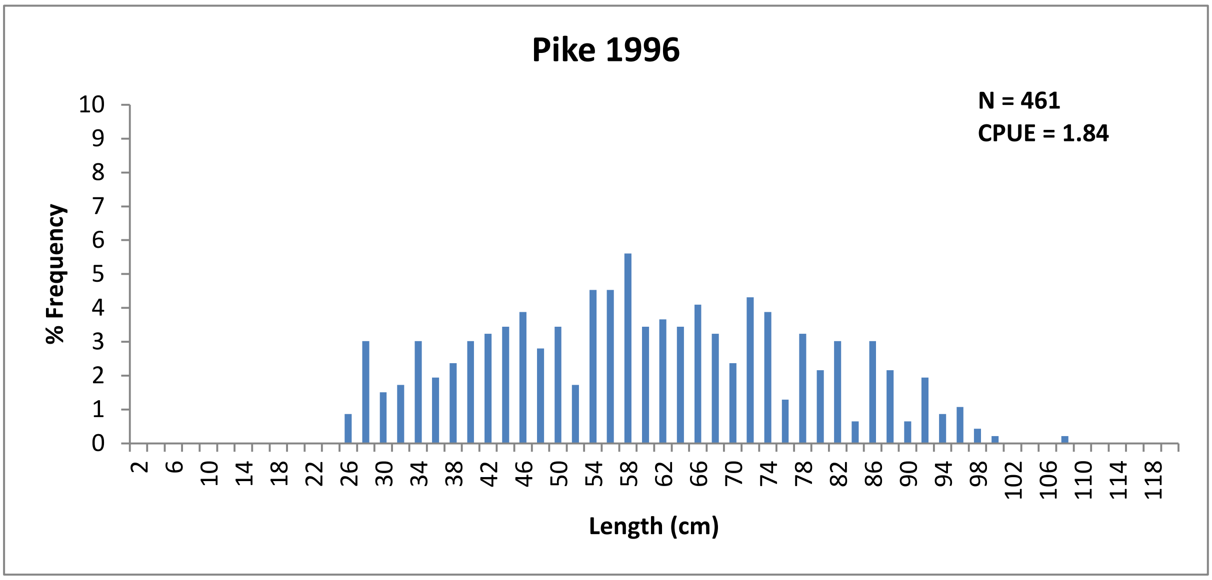


Figure 3.13a. The percentage length frequency distribution of pike and CPUE value for the 1996 survey.

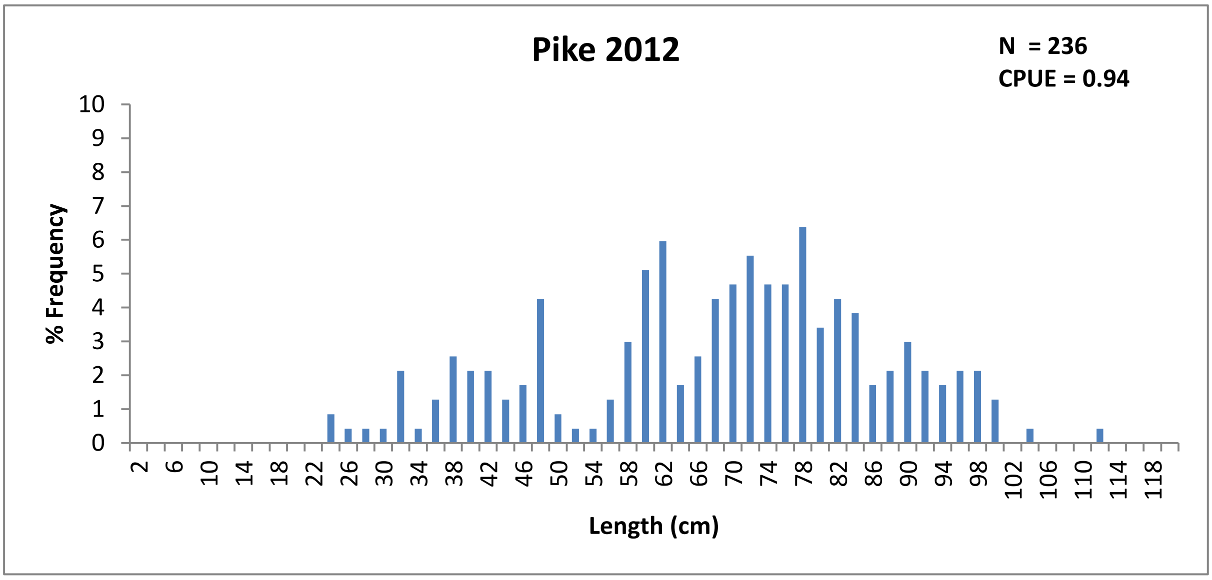


Figure 3.13b. The percentage length frequency distribution of pike and CPUE value for the 2012 survey.

The 1996 pike sample reflected the presence of a very large and relatively balanced adult pike population in the fishery at that time (O'Grady *et al.*, 1996) (Figure 3.13a). This is not surprising given that the management of pike stocks was relatively limited in the years prior to this survey.

3.3.3. Growth Patterns.

The growth patterns of pike in L. Corrib from 1996 and 2012 are shown in Figure 3.14. The data presented below shows pike growth rate was slightly greater in 1996 than it is currently.

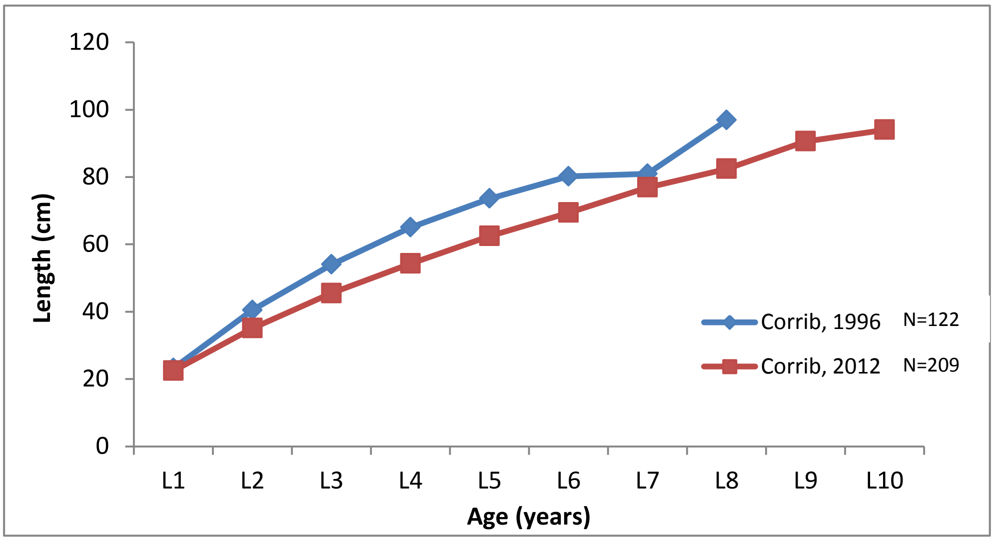


Figure 3.14 . L. Corrib Pike growth rates from 1996 and 2012.

When pike growth rates are compared with pike from across a number of other Irish lakes, spring sampled, (Figure 3.15) we can see that the L. Corrib 2012 pike data is well within the normal range for pike.

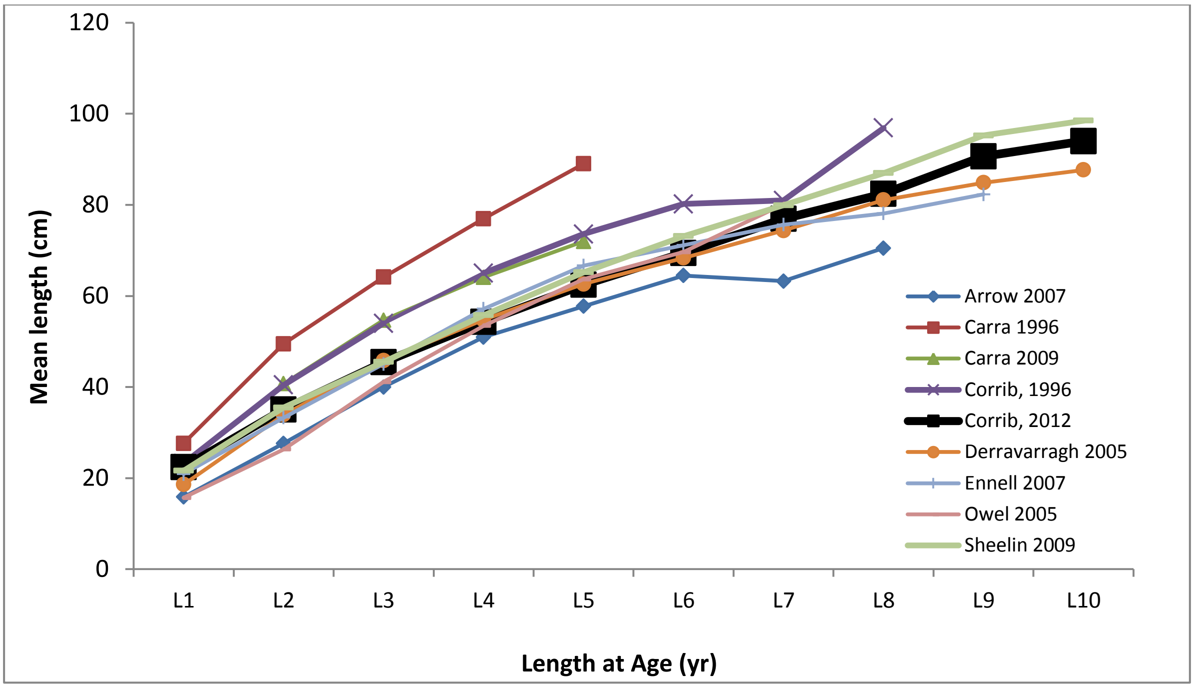


Figure 3.15. Comparative growth patterns for the pike across a number of Irish lakes, spring sampled.

3.3.4. Age Structure

The 2012 survey data highlights the fact that the recruitment of 3, 4 and 5 year old pike into the current stock has been very poor (Figure 3.16). These data indicate that the stock of adult pike is going to fall significantly in L. Corrib over the next four years - 6, 7, 8 and 9 year old fish would make up the majority of the adult pike stock in L. Corrib at any one time.

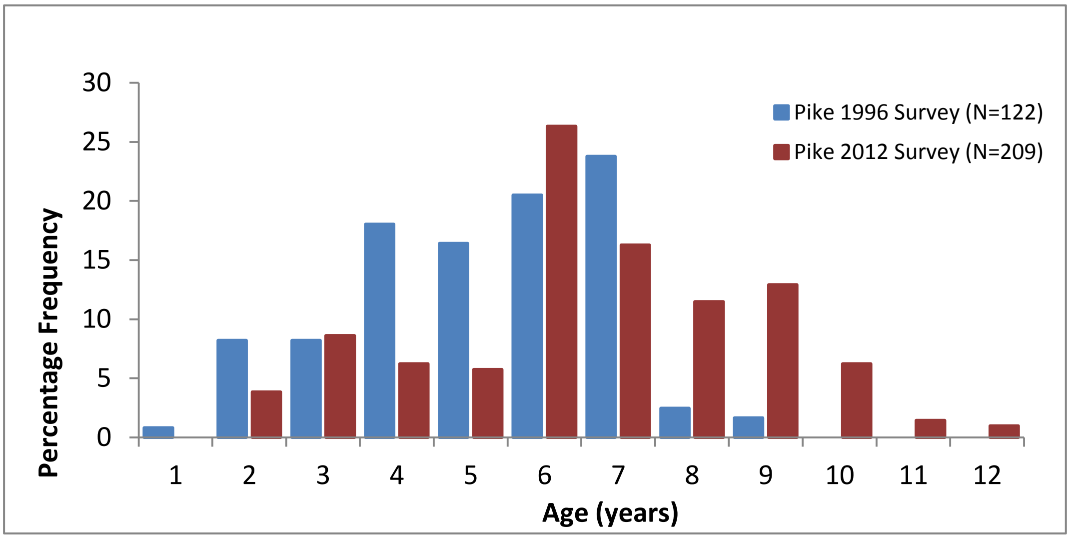


Figure 3.16. Pike age classes in the 1996 and 2012 surveys.

3.3.5. Dietary Habits of Pike

Data in relation to the dietary habits of pike examined in the 2012 survey sample are provided (Figure 3.17).

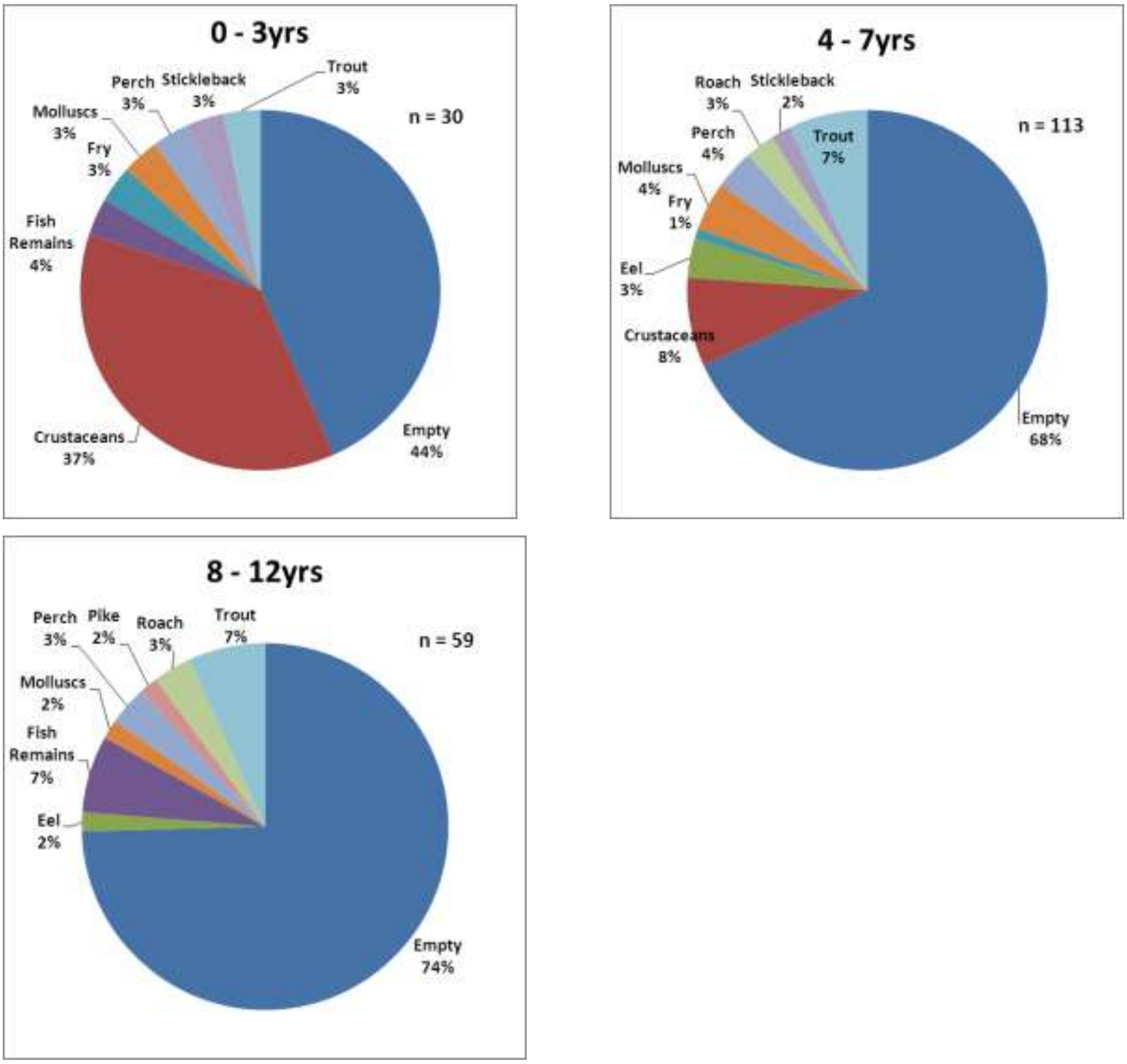


Figure 3.17. The dietary patterns for young (0+ - 3yrs), young adult (4 – 7yrs) and older adult pike in the 2012 Corrib survey.

These data reflect the historical database available for pike dietary patterns for these age groups in Irish lakes with the younger fish (0+ - 3yrs) feeding principally on macro-invertebrates and fish increasing in importance as a dietary item in larger older individuals. The selection of trout, by pike, as their favoured fish food item, despite bigger numbers of roach and perch being available, is entirely consistent with the large database of information available on this topic from Irish trout lakes. Very similar results were evident in the 1996 Corrib survey (O'Grady *et al.*, 1996). The stability in the dietary habits of pike in different age groups, when compared to historical data, is another important indicator of ecological stability in the Corrib basin.

The bias of the larger pike in preferentially selecting trout as a dietary item is probably a reflection of the distribution of the different prey fishes and the hunting practices of pike - most trout ≥ 30cm will be feeding in shallow weedy areas, the pikes preferred hunting area. In contrast many roach and perch may be feeding either pelagically or in benthic areas with a muddy/sandy bed, zones which are not the favoured hunting areas of pike.

Many of the larger pike examined had no food in their stomachs (Figure 3.17). This is a common feature of pike caught in gill nets. Many of these fish tend to regurgitate their stomach contents when caught in a net.

3.3.6. Pike Sex Ratios

In a large balanced pike stock, female individuals tend to be more dominant numerically than males because most of the larger older individuals are female. This trend was evident in the L. Corrib stock in 1996 (Figure 3.18). In the 2012 sample there was an even greater proportion of females in the stock. This is understandable given the paucity of younger age groups in the 2012 stock.

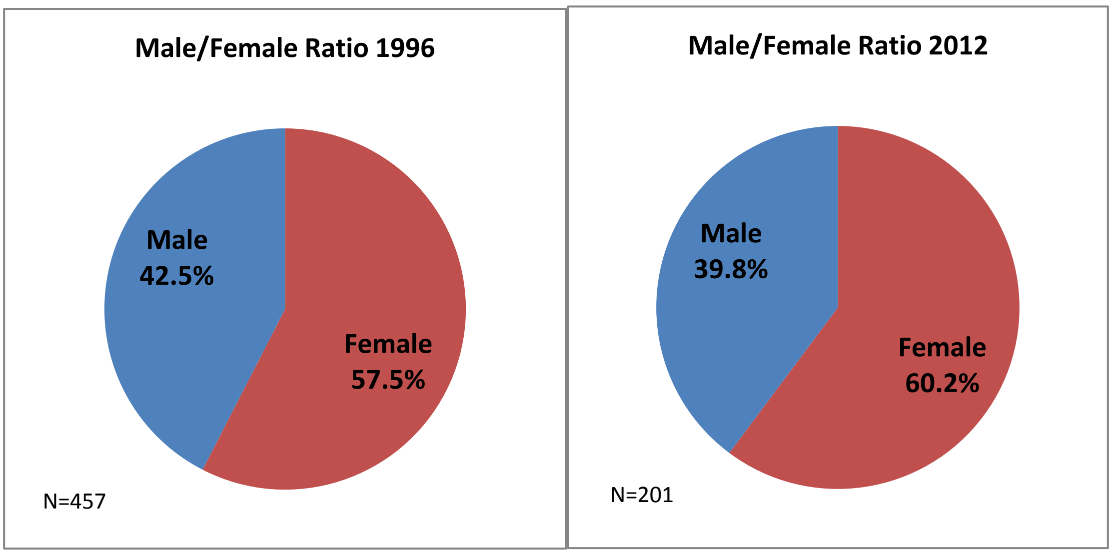


Figure 3.18. Sex ratios of pike in the 1996 and 2012 Corrib samples.

3.3.7. Length Weight Relationships - Condition Factor

As with the trout, the relationship between length and weight of pike was calculated and fish condition factor also determined (Table 3.7). As can be seen from the table below the regression coefficients and condition factor for pike from both surveys are almost identical.

Table 3.7. Pike length/weight relationship for L. Corrib 1996 and 2012.

	N	Log (a)	b	R^2	Condition Factor (*K*)
L. Corrib 1996	456	-6.19	3.41	0.97	0.88
L. Corrib 2012	204	-5.77	3.25	0.94	0.90

3.3.8. Upper and Lower Corrib Comparisons

No difference was noted in pike growth between fish in upper and lower Corrib, 2012 (Figure 3.19)

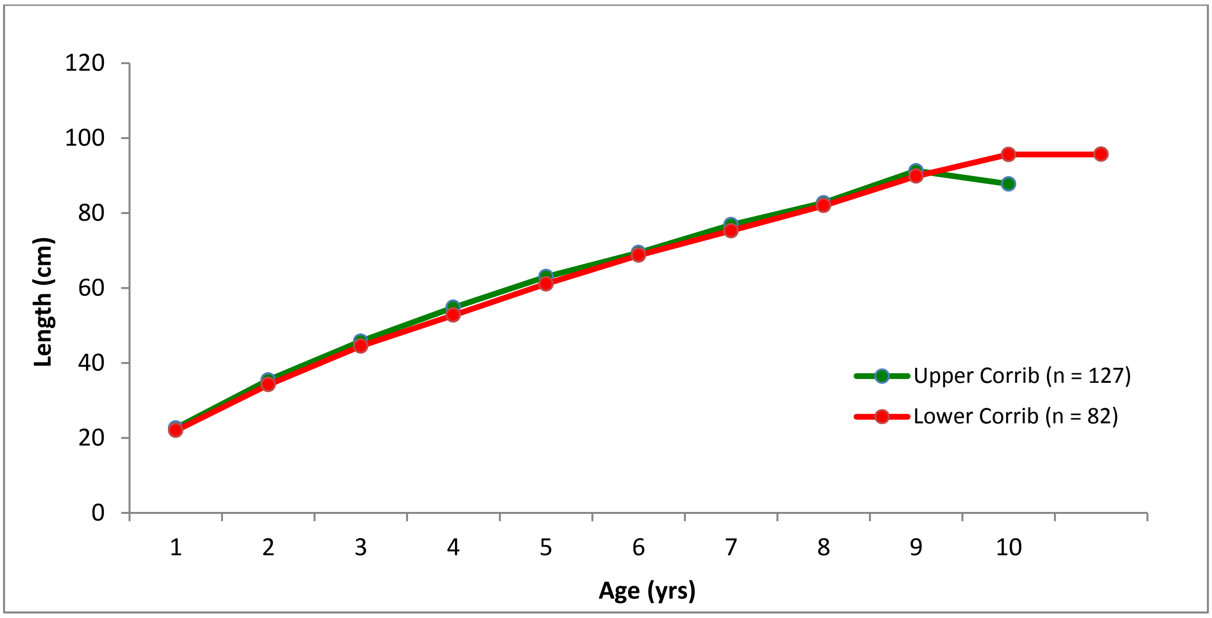


Figure 3.19 . Pike length at age data, Upper & Lower L. Corrib 2012.

Pike length frequency data for upper and lower Corrib, 2012, is not greatly different. Lower Corrib does appear to have more fish in the 40 to 52cm length range while upper Corrib recorded smaller fish and a greater percentage of fish in the 64 to 82cm length range (Figure 3.20).

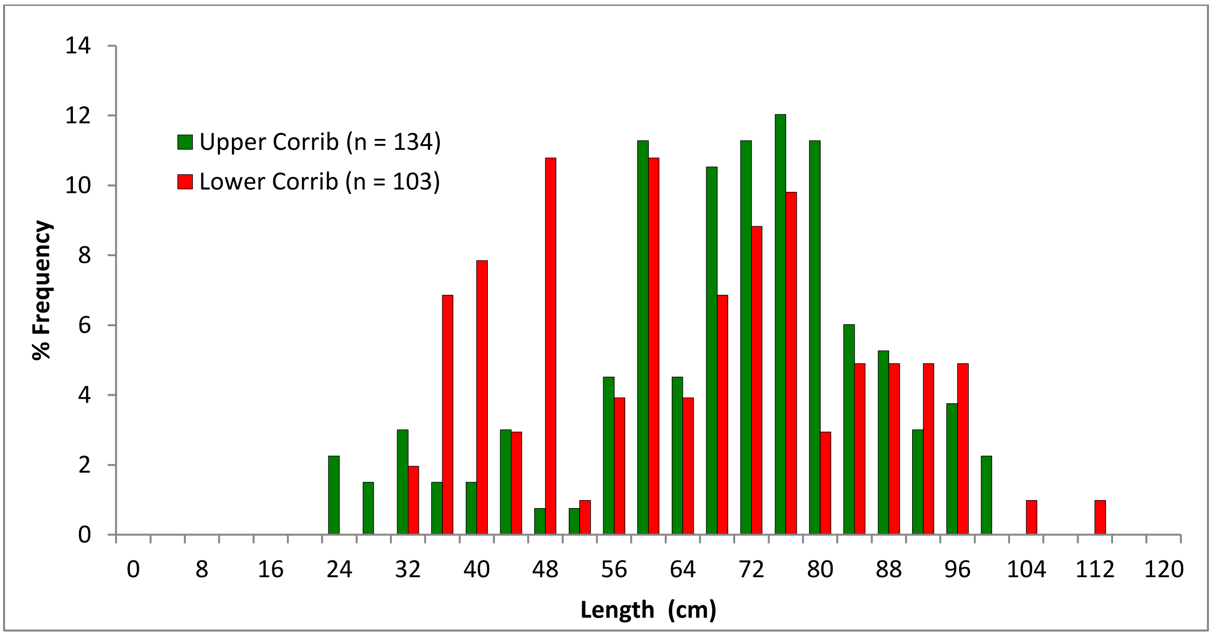


Figure 3.20. Pike length frequency distribution L. Corrib upper and lower, 2012.

Pike age frequency data for upper and lower Corrib, 2012, are very similar (Figure 3.21).

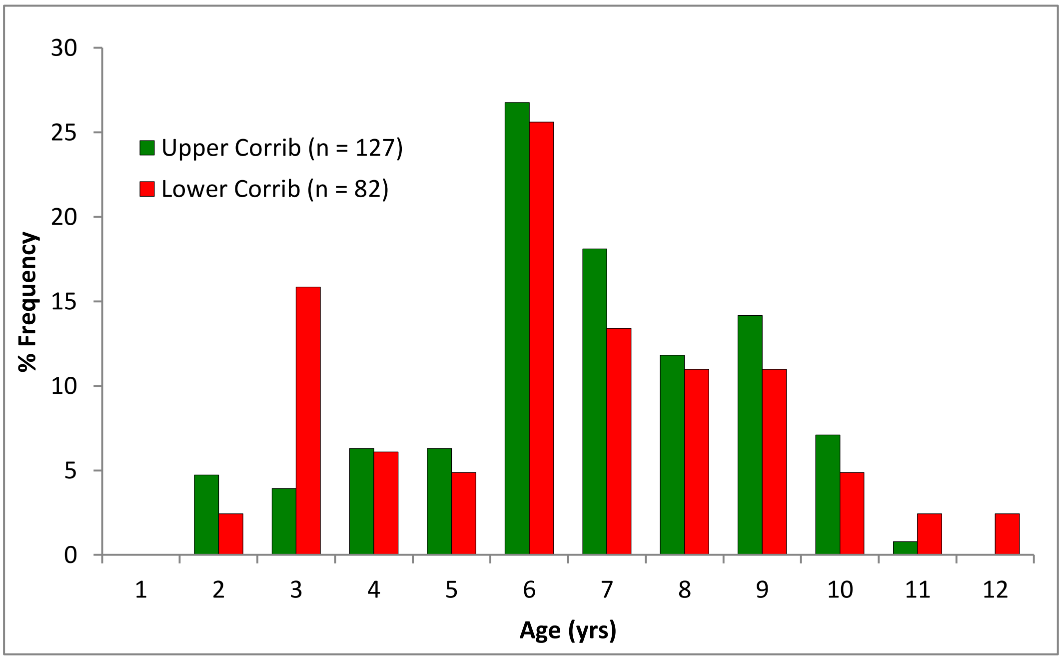
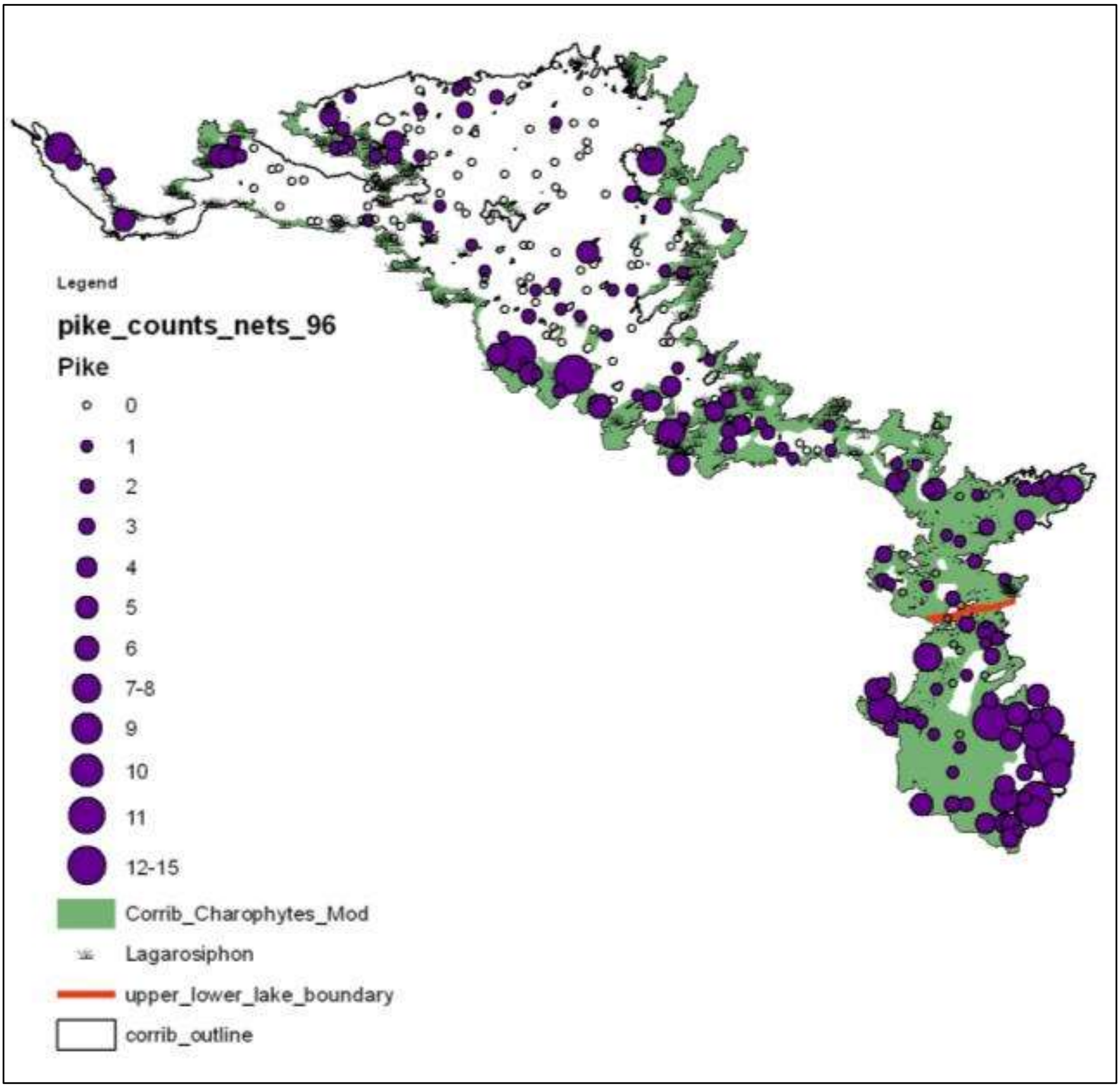


Figure 3.21 . Pike age frequency data, Upper and Lower L. Corrib 2012.

3.3.9. Lake wide distribution of Pike

The distribution of pike noted in both L. Corrib surveys (1996 and 2012) are illustrated (Figure 3.22). Pike distribution patterns from both the 1996 and the 2012 surveys show a lot of similarity. Pike are still most commonly found in around the Charophyte bed areas, as was the case in the 1996 survey. Very few pike were recorded in the open deeper areas of the lake during either surveys. However, while pike locations remain similar the numbers of pike recorded during each survey has changed. Less fish were noted at the same netting sites in most cases.



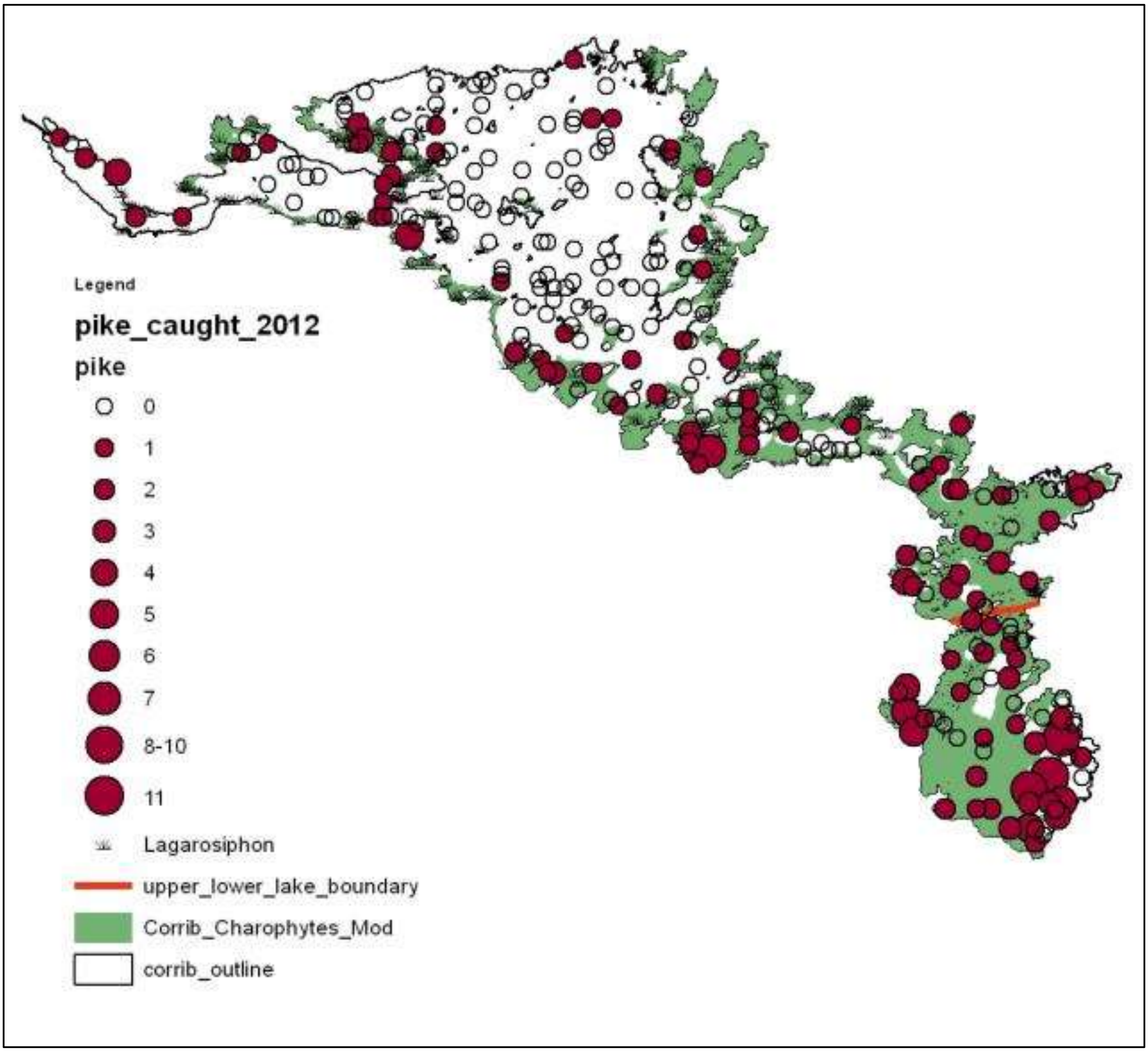


Figure 3.22. L. Corrib pike distribution maps from the 1996 and 2012 surveys.

3.3.10. Reasons for the Demise of Pike Stocks.

The poor recruitment rate of young adult pike into the Corrib stock in successive years prior to 2012 is very unusual. It might have been caused by a number of factors;

- **Availability of Quality Spawning Areas -** Pike spawn in the charophyte beds with the young fish living principally in these plant colonies for the first two years of their lives where they feed largely on crustaceans, some insect larvae and fish fry (Gargan, 1986, O'Grady *et al.,* 1996). A marked decline in the extent of charophyte beds in L. Corrib, prior to 2012, might have reduced pike spawning opportunities and/or significantly reduced the food supply of juvenile pike. Data indicates that the extent of charophyte beds has not declined significantly in recent years despite the establishment of *Lagarosiphon* colonies (Figure 3.23), thereby eliminating this factor as a possible explanation for the decline in pike stocks.

- **Availability of Fodder Fish for Young Adult Pike** - A major decline in the availability of fodder fish for young adult pike would also explain the marked reduction in pike numbers in 2012. On only one other occasion has a collapse of pike stocks been noted in an Irish lake brown trout fishery over a 35 year period - in Lough Sheelin in the mid 00's. At this point in time (2005/2006) the stocks of all fodder fish for adult pike in Sheelin had fallen to extremely low levels thereby limiting pike food supplies (Figure 3.24). In contrast the available fish fodder supply for pike in L. Corrib presently (2012) is significantly larger than it was in 1996 because of the continued presence of large roach and trout stocks, the major recovery of the perch population and the establishment of a large roach x bream hybrid stock since 2000 (see Table 3.1). In these circumstances the demise of pike stocks in L. Corrib in 2012 cannot be associated with food shortages for this species.

Figure 3.23. Distribution of *Lagarosiphon major* and *Chara* within L. Corrib.

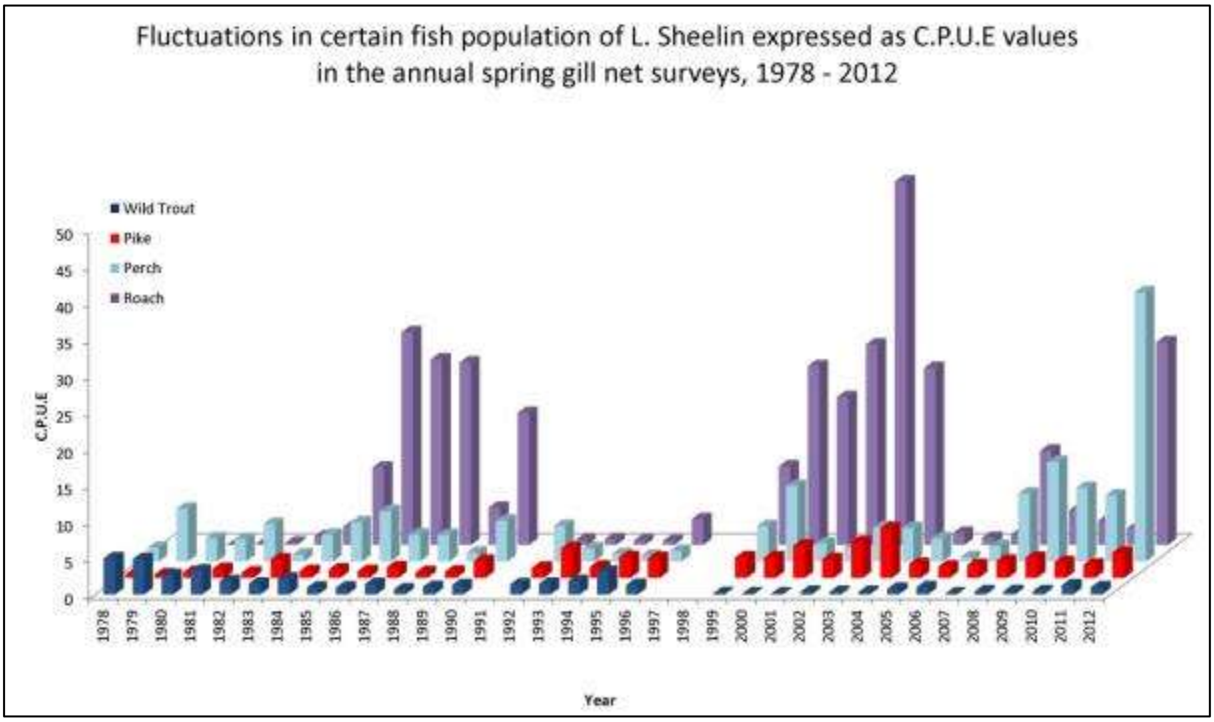


Figure 3.24. L. Sheelin CPUE data for pike and its main fodder fish species, 1978 - 2012.

- **Disease Problems -** In recent years no reports have been received in relation to the presence of diseased or sick pike in L. Corrib. All pike captured or released during the course of the 2012 survey on Corrib were healthy fish in good condition. It is reasonable therefore to conclude that the reduction in pike numbers recorded during the current survey in L. Corrib is not a disease related issue.

- **Pike Management Measures -** Since 2008 IFI personnel have used an additional pike management technique which entails electrofishing in shallow (≤ 4.5m) sheltered areas of L. Corrib which are heavily colonised with charophytes. In the autumn periods this has proved successful in capturing large numbers of 0+ and 1 + year old pike which are living in the charophyte beds. This procedure has also proved effective, at times, in capturing larger pike in relatively shallow (≥ 2.5m) weedy areas. Data in relation to the capture rates of juvenile pike using both this methodology and netting programmes are presented (Table 3). IFI staff have noted that the electrofishing technique used has proved most successful by rotating the locations fished annually (L. Gavin, *pers. com.,* 2012). In the authors' opinion the successful application of this electrofishing technique, in combination with on-going netting programmes, is most likely to be responsible for the dearth of young adult pike in L. Corrib presently (2012). Data in relation to the capture rate of pike in L. Corrib using both methodologies, since 2008, is presented (Table 3.8).

Table 3.8. Gill net and electrofishing catches of pike from the L. Corrib management programme (2008 - 2012).

	Gill Netting Data			Electrofishing Data				
Year	Total Pike Numbers	Total Weight (kg)	Average weight of pike	Total Pike 0+	Other Pike	Weight (kg)	Average weight 0+ pike	**Total Number Pike Removed**
2008	2269	1753	0.773	533	391	285	0.535	**3193**
2009	1555	2026	1.303	119	223	137	1.151	**1897**
2010	1583	1731	1.093	1206	567	364	0.302	**3356**
2011	918	1904	2.074	457	329	152	0.333	**1704**
2012	942	1103	1.171	1710	377	241	0.141	**3029**

The numbers of large (≥ 85cm) pike released, per annum, in the course of pike management operations on L. Corrib are also documented (Table 3.9).

Table 3.9. The numbers of large pike (≥ 85cm) released following their capture in L. Corrib (2008 - 2012).

Year	Pike (≥ 85cm) Released
2008	10
2009	20
2010	8
2011	9
2012	3

3.3.11. Management Implications of Releasing Large Pike

For the last decade IFI personnel have been releasing all large (≥ 85 cm) pike captured in gill nets. The numbers of such fish is not great (Table 3.8) suggesting that the numbers of pike ≥ 85cm is not substantial. The release of a small number of large pike does not appear to have led to an increased recruitment rate of pike into this fishery, it is more likely due to the efficiency of the juvenile pike control programme and the removal of significant numbers of young adults in nets (Table 3.7).

3.4. Perch

The following sections present the results of this survey for perch and makes comparisons with the 1996 survey.

3.4.1. CPUE Values

The perch stock in L. Corrib in 1996 was very small - a total of only 21 perch were captured in the entire 1996 survey (CPUE - 0.084). However it should be noted that during 1996 (and even earlier possibly) the perch population was significantly affected by disease and most likely contributed to the low perch numbers recorded during the survey. In contrast in the 2012 survey a total of 687 perch (CPUE - 2.75) were encountered. This illustrates that there has been a major recovery in the perch stock in the intervening years. The current size of the perch stock in L. Corrib in 2012 is still relatively moderate by Irish standards - CPUE values of ≤ 36 have been recorded for perch stocks in L. Sheelin in 2012 (O'Grady, 2012) (Figure 3.25). Though perch numbers can fluctuate greatly within a lake over a number of years as has been observed through repeat sampling in a number of IFI lake surveys.

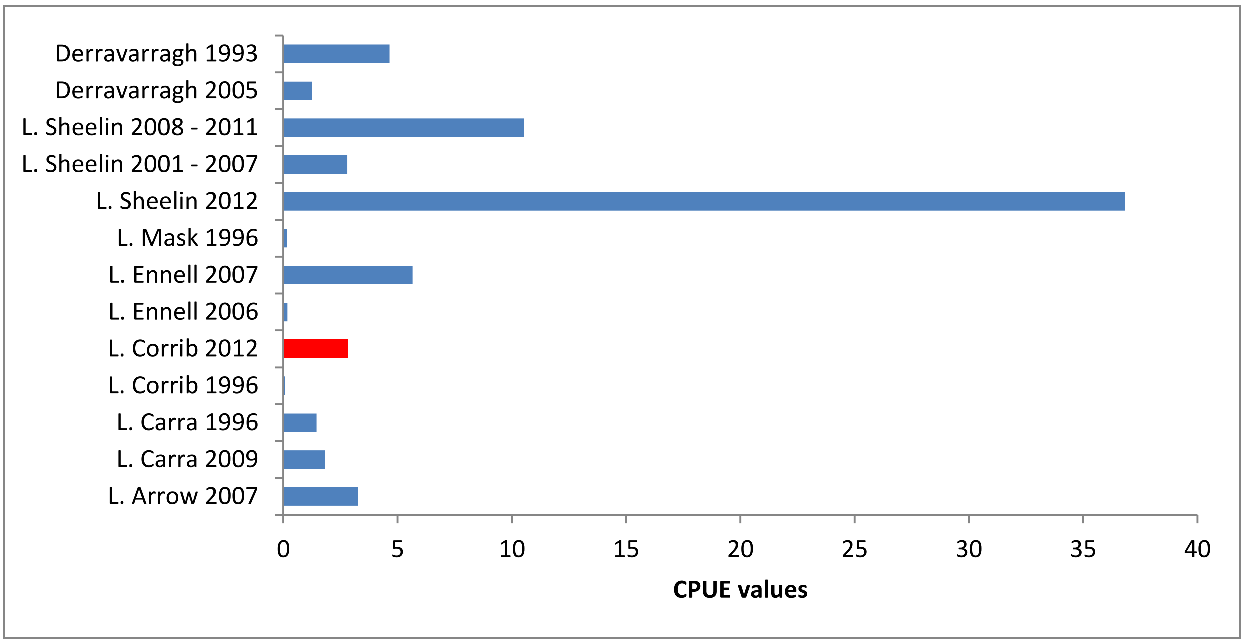


Figure 3.25 . Perch CPUE values across a range of Spring sampled Irish lakes.

3.4.2. Population Structure

Perch length frequency distribution for both the 1996 and 2012 surveys are presented (Figure 3.26). Only 21 perch were taken in the 1996 survey while 699 individuals were recorded in 2012. The 2012 population represents a much more balanced perch community. This 2012 population is dominated by fish in the length range of 17 to 27 cm which represents fish between 2 and 5 years old.

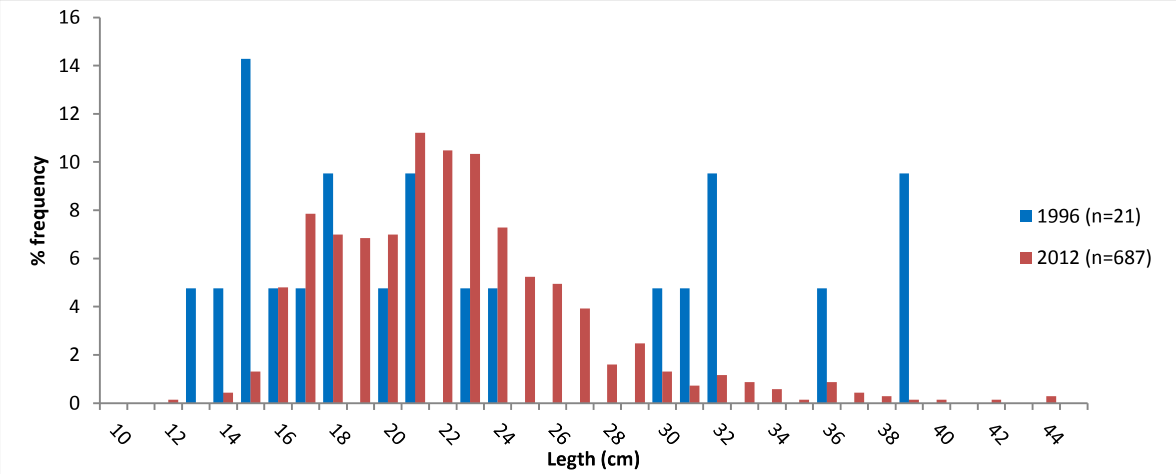


Figure 3.26. Perch length frequency distribution for L. Corrib 1996 & 2012.

3.4.3. Perch Growth Patterns

Perch growth patterns for L. Corrib in 2012 along with a number of other Irish lakes are provided in Figure 3.27. Data indicates that the current (2012) perch population in L. Corrib are in the slightly fast growth rate group. It is worth noting that the Corrib perch population do not live to a very old age, oldest fish were 7 years.

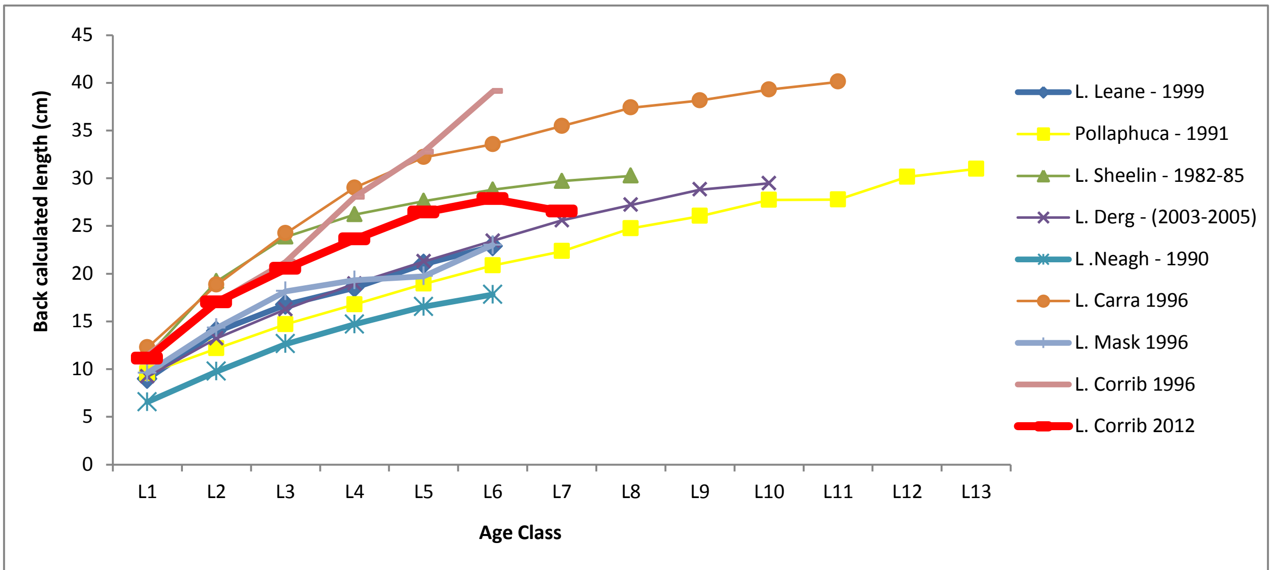


Figure 3.27. Growth patterns for perch in L. Corrib in 2012 compared with other Irish lakes.

3.4.4. Age Structure

The virtual collapse of the perch stock in L. Corrib in 1996 and its recovery since is difficult to explain. Currently (2012) the perch stock recruitment rate is relatively stable with significant numbers of 2, 3, 4 and 5 year old fish in the population (Figure 3.28). This type of stock structure is typical of Irish perch populations with the adult stock being dominated by 3, 4 and 5 year old fish.

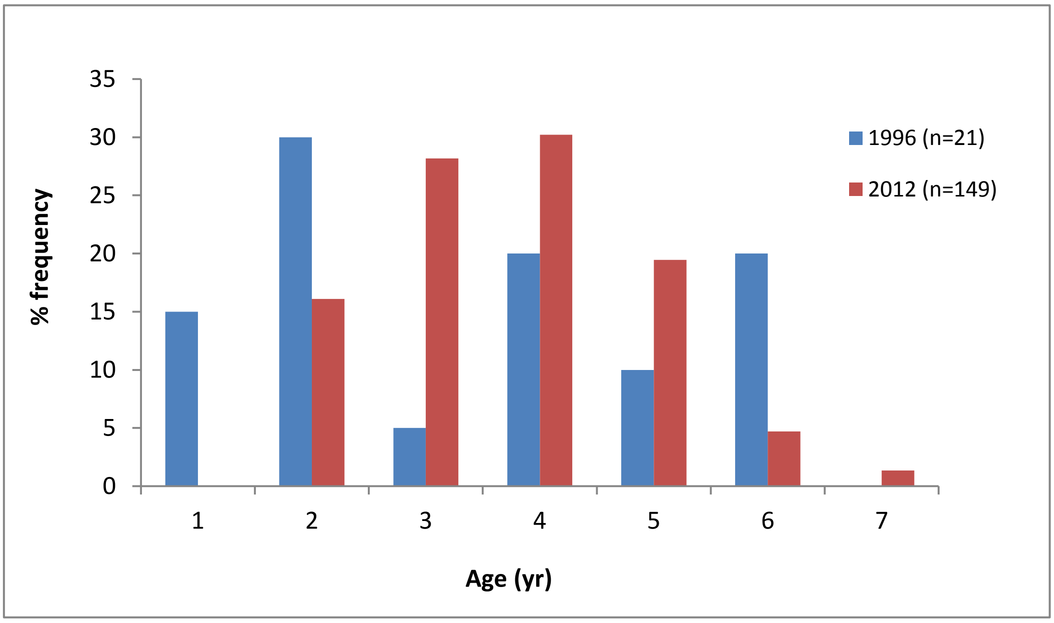


Figure 3.28. Year class strength in the perch sample from the 2012 Corrib survey.

3.4.5. Perch Dietary Habits

Fifty adult perch stomachs were examined in the first week of the survey. No food was found in these stomachs - these fish were approaching maturation. It is common for such fish to stop feeding prior to spawning. No further examination of perch stomachs took place over the course of this survey following the aforementioned initial observations.

3.4.6. Perch Sex Ratios

Only a small number of the perch sample was sexed in 2012 and no fish were sexed from the 1996 survey. The percentage frequency of males to females is presented in figure 3.29 for the perch from L. Corrib 2012. The dominance of females in the perch stock is not unusual - the larger, older fish in Irish perch stocks are predominately females.

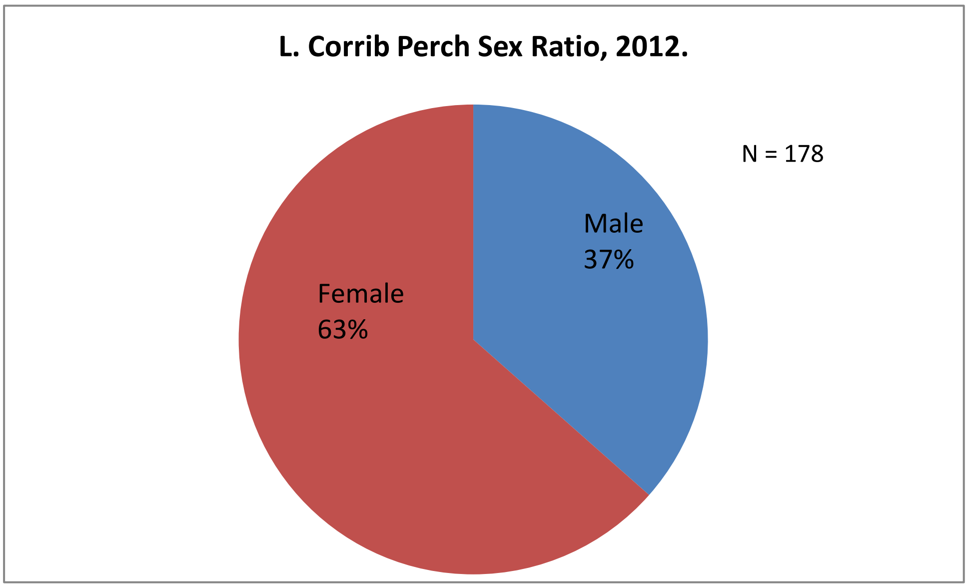


Figure 3.29. Perch sex ratio, L. Corrib 2012.

3.4.7. Length Weight Relationship & Condition Factor

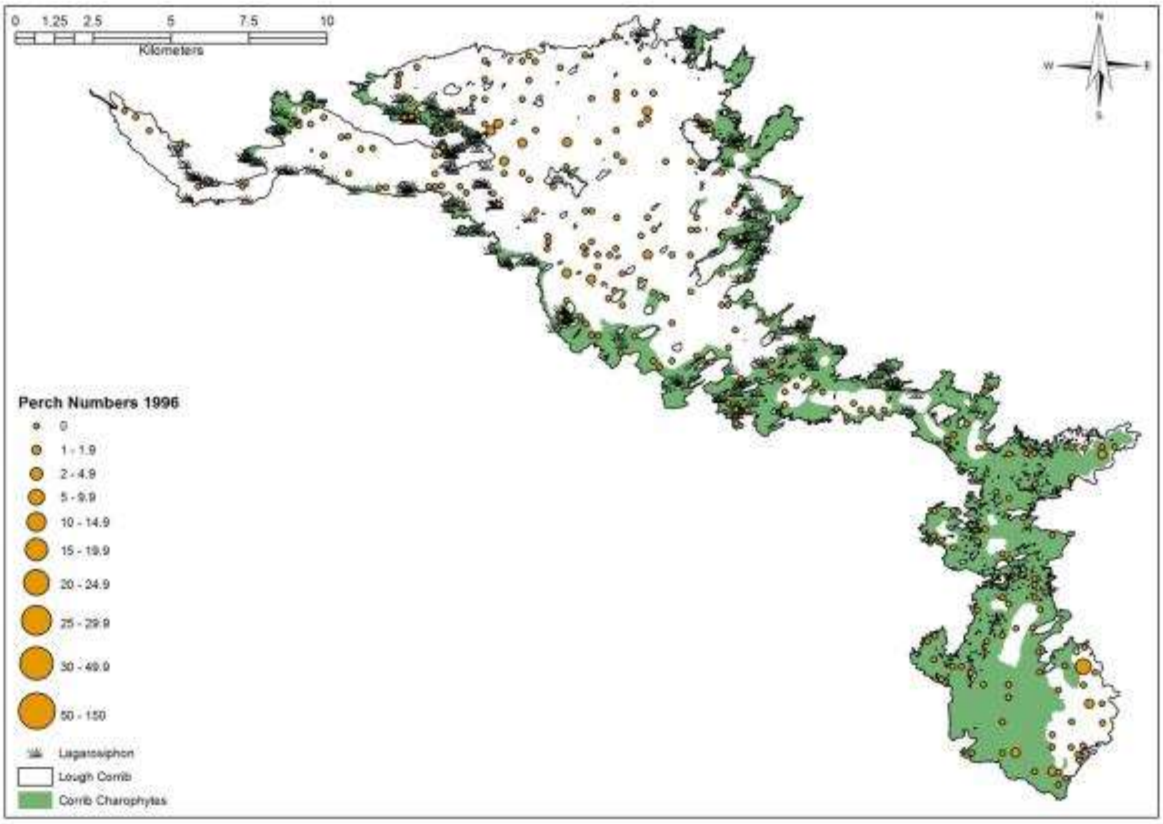
The relationship between length and weight of perch was calculated along with fish condition factor for L. Corrib 2012 and compared with the L. Corrib 1996 results (Table 3.10). Condition factor for perch populations of 1996 and 2012 are very similar.

Table 3.10. Perch Length / weight relationship & Condition Factor, L. Corrib.

Survey Year	N	Log (a)	b	R^2	Condition Factor (K)
L. Corrib 1996	21	-4.86	3.03	0.96	1.66
L. Corrib 2012	191	-5.57	3.31	0.86	1.56

3.4.8. Perch Distribution patterns

The perch sample captured in the 2012 survey was widely distributed throughout the Corrib basin. The largest concentrations of this fish were in the central area of the northern basin (Figure 3.30). Unlike most of the other fish species, of L. Corrib, perch were commonly recorded out in the deeper areas of the lake. The 1996 distribution pattern is less extensive as that for 2012, this reflects the smaller perch population present in the lake at that time.



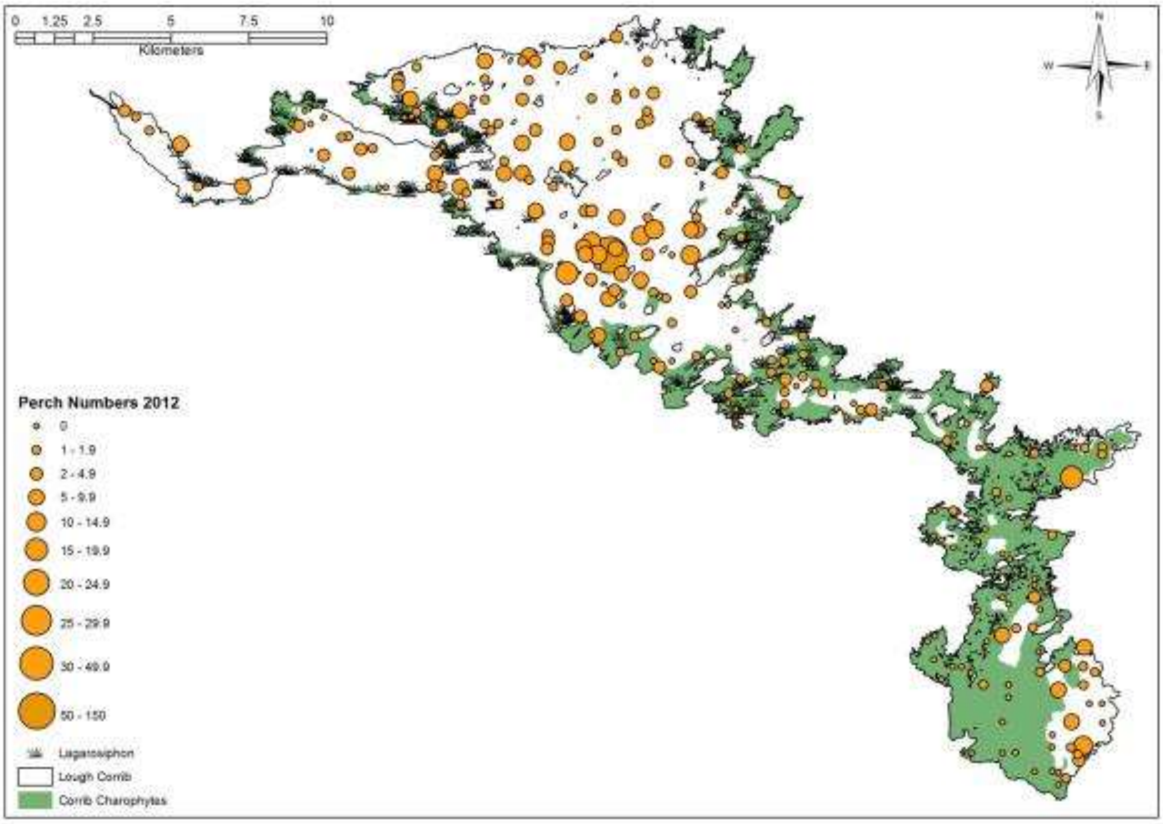


Figure 3.30. The distribution of perch from the 1996 and 2012 L. Corrib surveys.

3.5. Roach Stocks

The following sections present the results of this survey for roach and makes comparisons with the 1996 survey.

3.5.1. CPUE Values

In 1996 L. Corrib recorded a roach CPUE value of 4.96 and in 2012 this value was 5.96. These CPUE values are very similar to those recorded in many other Irish lakes with the exception of eutrophic lakes, such as L. Sheelin (Figure 3.31). In L. Sheelin in the ‘80’s and ‘00’s roach CPUE values > 20.0 were recorded regularly (Figure 3.32) (O’Grady & Delanty, 2000). The lower roach CPUE values recorded in L. Corrib are a reflection of the fact that cultural eutrophication problems in this water are at a significantly lower level. The introduction of zebra mussels to L. Corrib in 2007 may also be “capping” roach standing crops, by reducing plankton production.

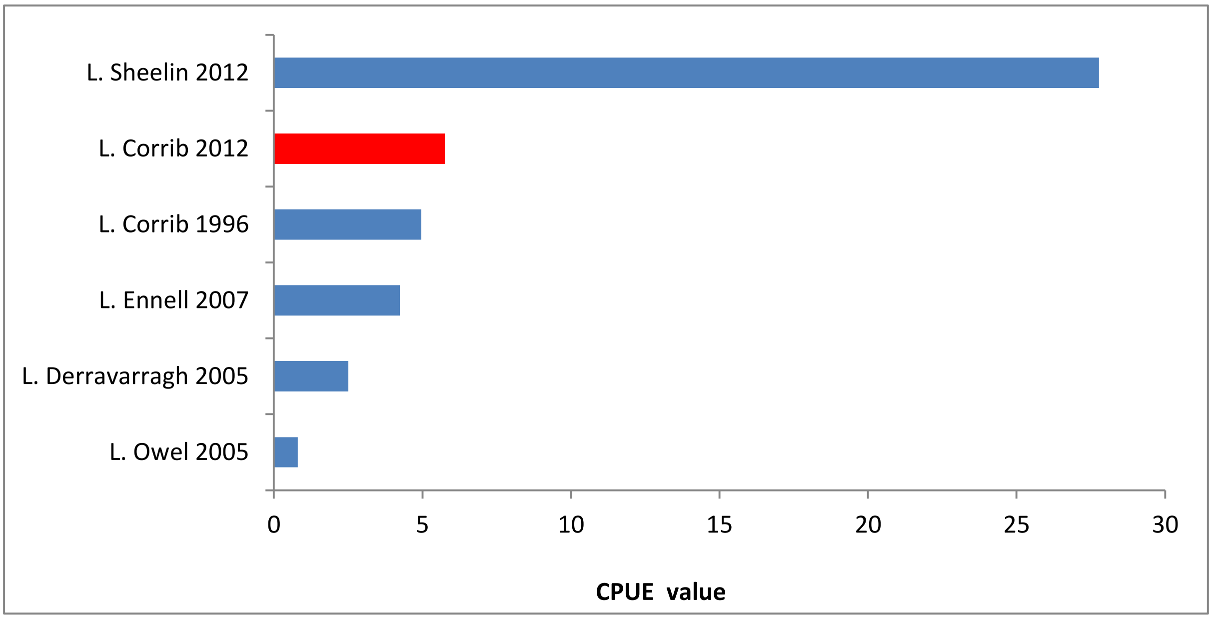


Figure 3.31. Roach CPUE values for L. Corrib and a number of other Irish lakes.

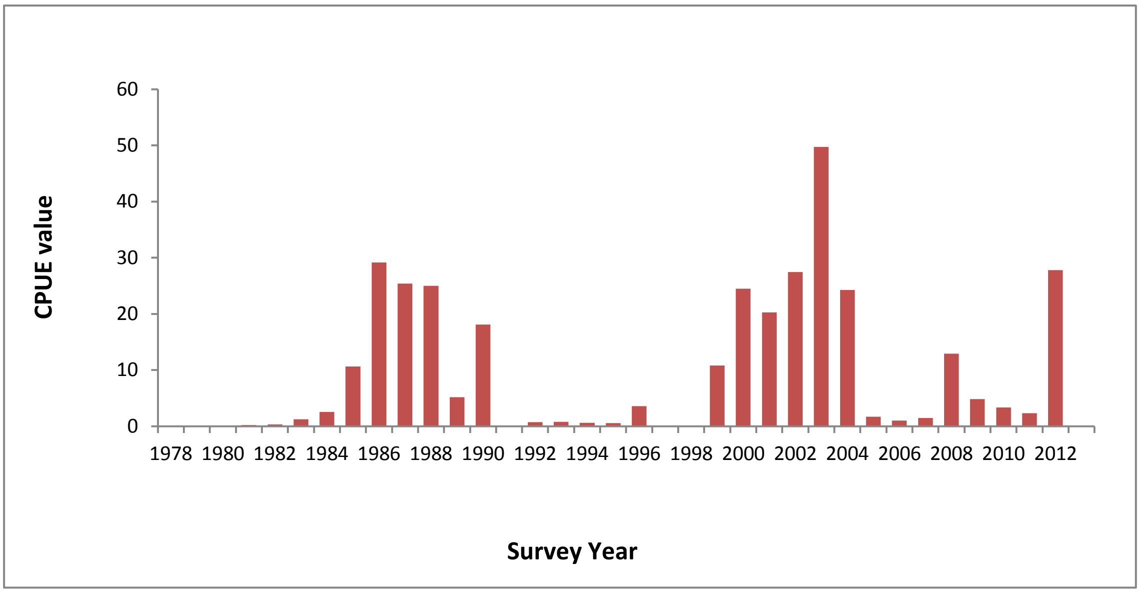


Figure 3.32. L. Sheelin Roach CPUE values over the period 1978 to 2012.

3.5.2. Population Structure

Comparison of the length frequency data over the two survey periods shows a greater number of younger fish present in the lake currently (2012) than in 1996 (Figure 3.33). This would suggest that roach recruitment is better now then it was back in the mid to late 90's. The roach data of 2012 seems to represent a more balanced population structure.

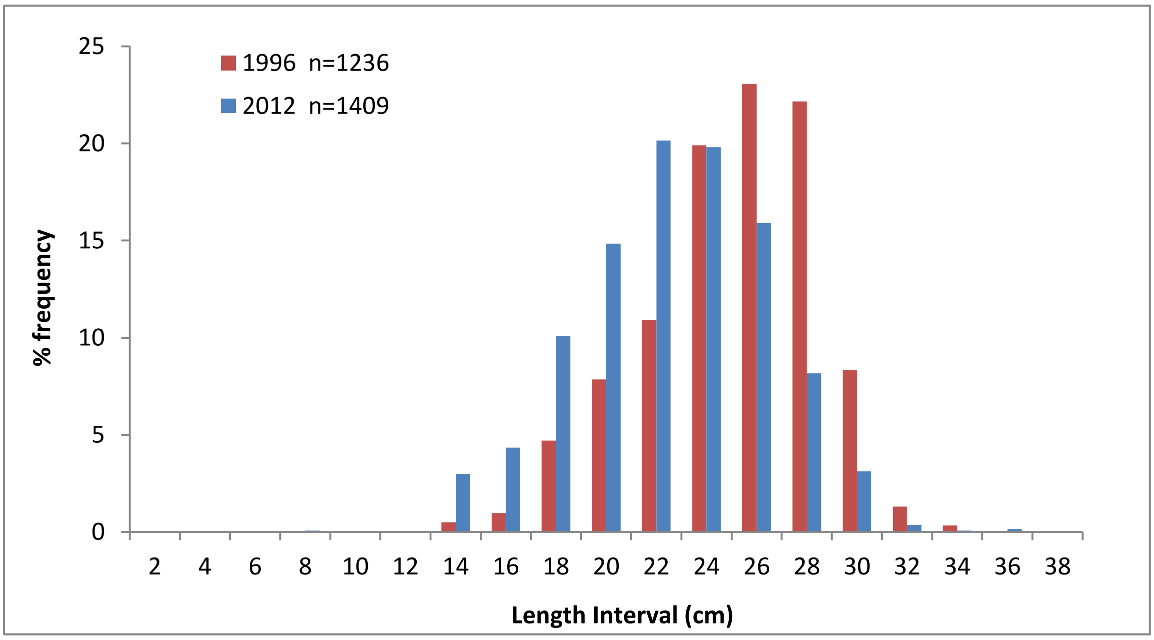


Figure 3.33. Roach length frequency distribution for L. Corrib, 1996 and 2012.

3.5.3. Roach Growth Patterns

Growth patterns for roach in L. Corrib in 1996 and 2012 along with data from a number of other Irish lakes are illustrated in Figure 3.34.

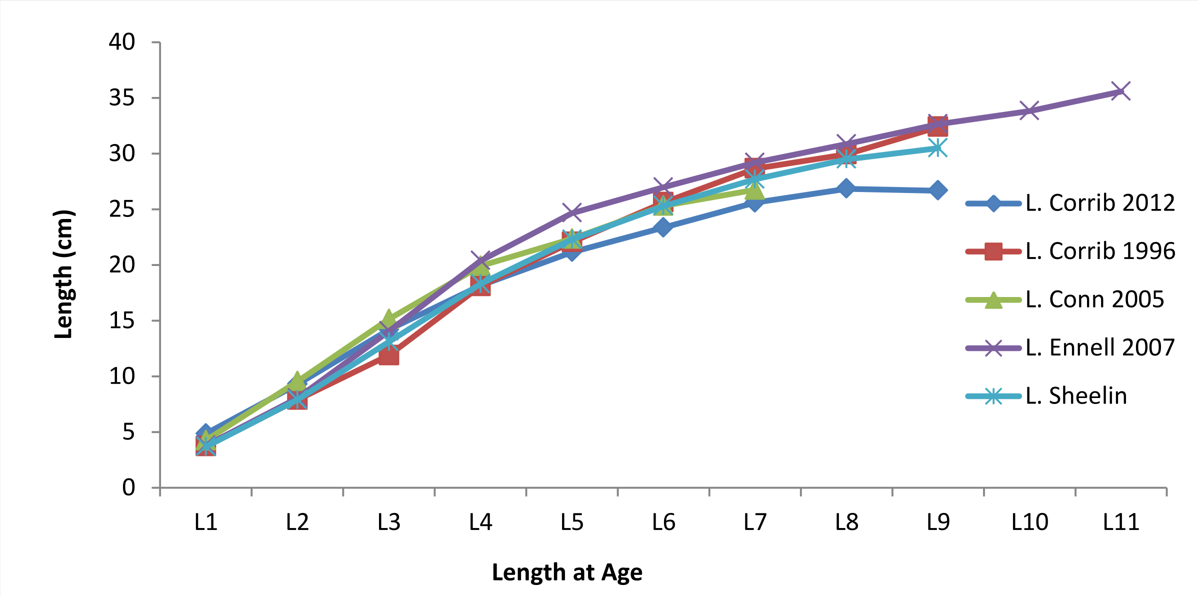


Figure 3.34. Growth patterns for roach in L. Corrib in 1996, 2012 and selected other waters.

Growth patterns for this species in the Corrib 1996 and 2012 samples are very similar not only to each other but with the other lakes presented.

3.5.4. Age Structure

A review of relative roach year class strengths in the 1996 and 2012 surveys illustrate quite erratic recruitment rates of young adult roach from year to year, particularly in the 1996 data (Figure 3.35). The 1996 L. Corrib roach stock was dominated by older year classes whereas the 2012 roach stock is again showing signs of a more stable and balanced age structure.

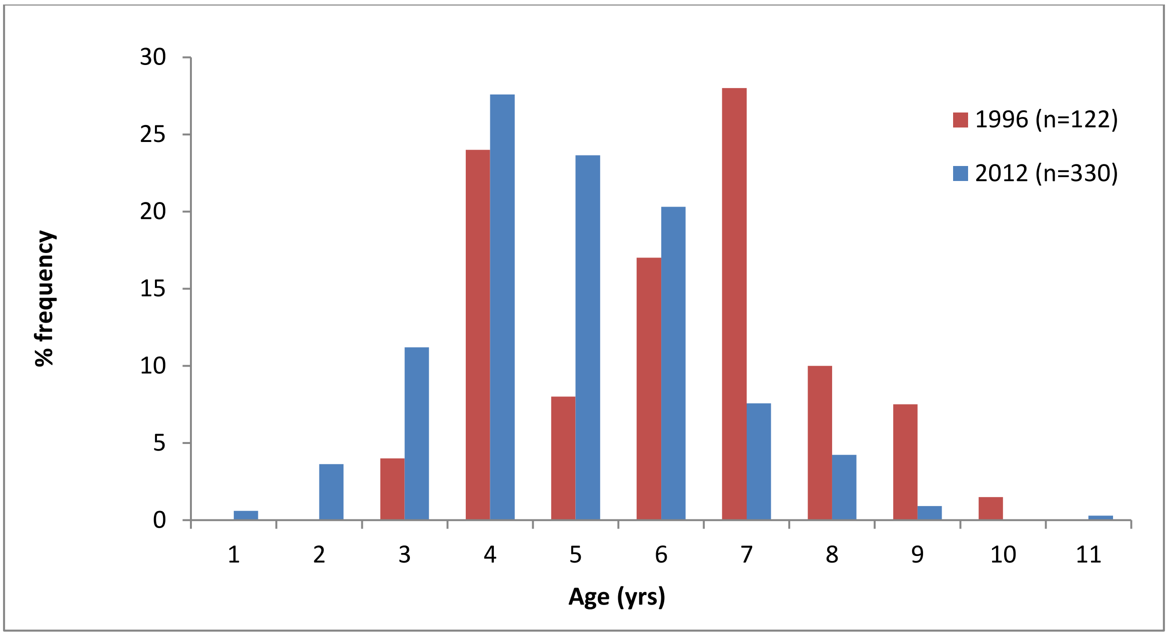


Figure 3.35. The relative year class strengths of roach in the L. Corrib 1996 and 2012 survey samples.

3.5.5. Roach Sex Ratios

Roach, like other cyprinids, perch and pike populations, tend to be dominated by larger, older female fish. The sex ratio in the 2012 roach sample from Corrib reflect this trend and is very similar to a long term data set on this feature of roach populations in L. Sheelin (Figure 3.36).

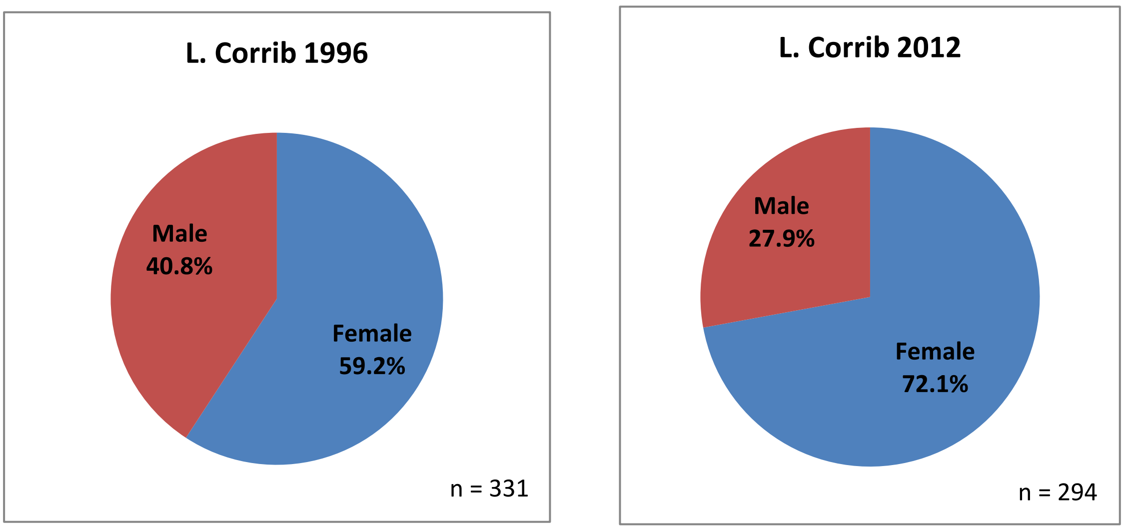


Figure 3.36. The sex ratio of roach examined from L. Corrib in 1996 and 2012.

3.5.6. Length / Weight Regressions

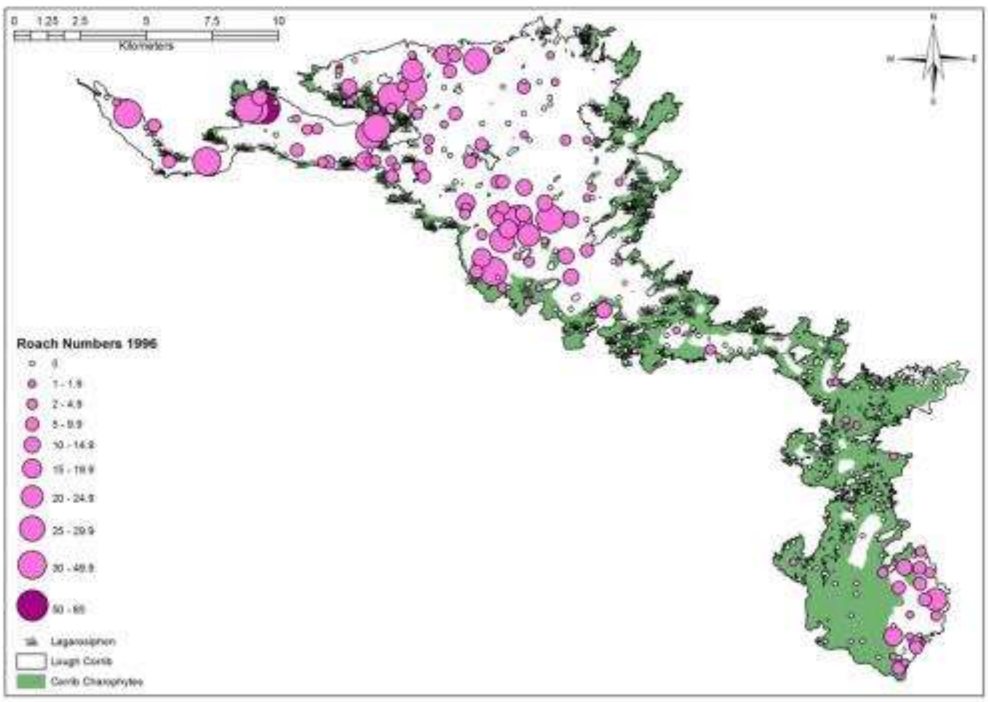
The relationship between length and weight of roach was calculated and fish condition factor also determined (Table 3.11p). As can be seen from the table below the regression coefficients and condition factor for roach from both surveys are almost identical.

Table 3.11. Roach length/weight relationship, L. Corrib 1996 and 2012.

Roach					
	N	**Log (a)**	**b**	**R^2**	**Condition Factor (K)**
L. Corrib 1996	345	-4.88	3.06	0.91	1.87
L. Corrib 2012	327	-5.32	3.25	0.94	1.86

3.5.7. The Distribution of Roach in L. Corrib.

Roach distribution patterns were very similar for the 1996 and 2012 surveys. On both sampling occasions roach were dominate in the ‘non charophyte areas’ of the lake. A similar distribution has been observed in L. Sheelin over many years (IFI unpublished data).



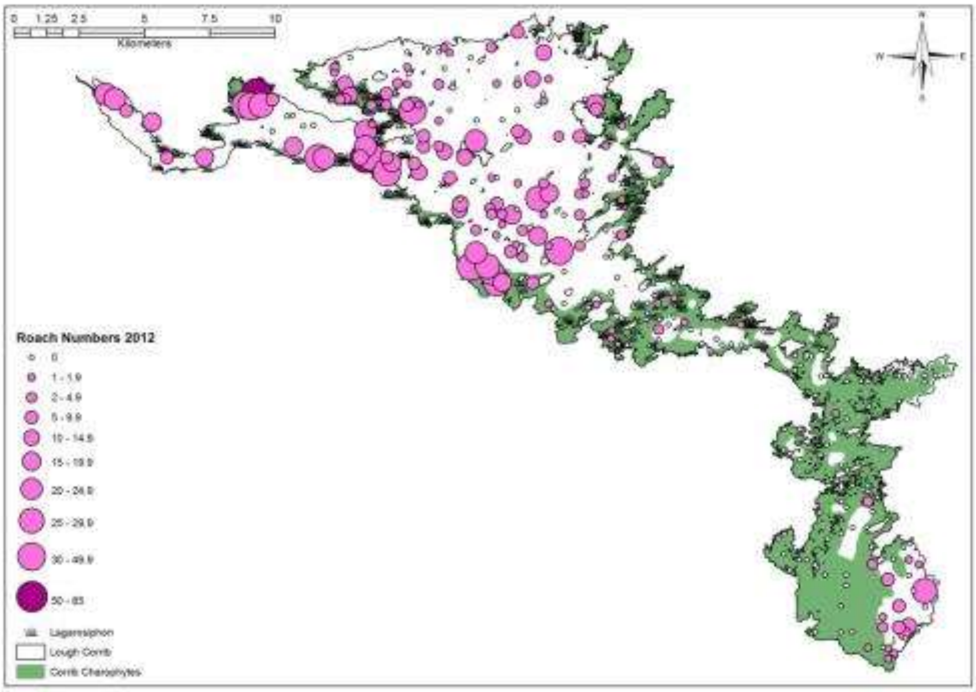


Figure 3.37. Roach distribution patterns, 1996 & 2012.

3.6. Roach x Bream Hybrids

Cyprinid hybrids, like roach x bream, roach x rudd (*Rutilus rutilus* x *Scardinius erythrophthalmus*) or rudd x bream (*Scardinius erythrophthalmus* x *Abramis brama*) are a feature of cyprinid fish stocks in Europe generally. However, the level of cyprinid hybrids in Irish waters, particularly roach x bream, is regarded as being very high by European standards (Hayden *et al.*, 2010).

The only cyprinid hybrids recorded in L. Corrib, from either the 1996 and 2012 surveys, were roach x bream hybrids. Although the 2011 WFD survey of L. Corrib did record one roach x rudd hybrid. The findings of the current survey has shown that there has been a very dramatic change in the population of roach x bream hybrids in L. Corrib in 2012 compared to 1996 (Figure 3.38).

3.6.1. CPUE Values

During the 1996 survey a total of 63 roach x bream hybrids (CPUE of 0.25) were recorded. The 2012 survey recorded a catch of 631 hybrids (CPUE of 2.52). During the intervening years two WFD surveys have been carried out in L. Corrib (Kelly *et al*, 2008 & 2011), both of these studies indicated that the roach x bream populations had begun to increase since the 1996 survey.

3.6.2. Population Structure

The stock of these fish has increased substantially in 2012 compared to 1996. However the current population structure is not a stable well balanced one with a skewed length frequency distribution pattern noted (Figure 3.38). The majority of the hybrids caught were bigger older fish with little recruitment of younger fish to the population evident.

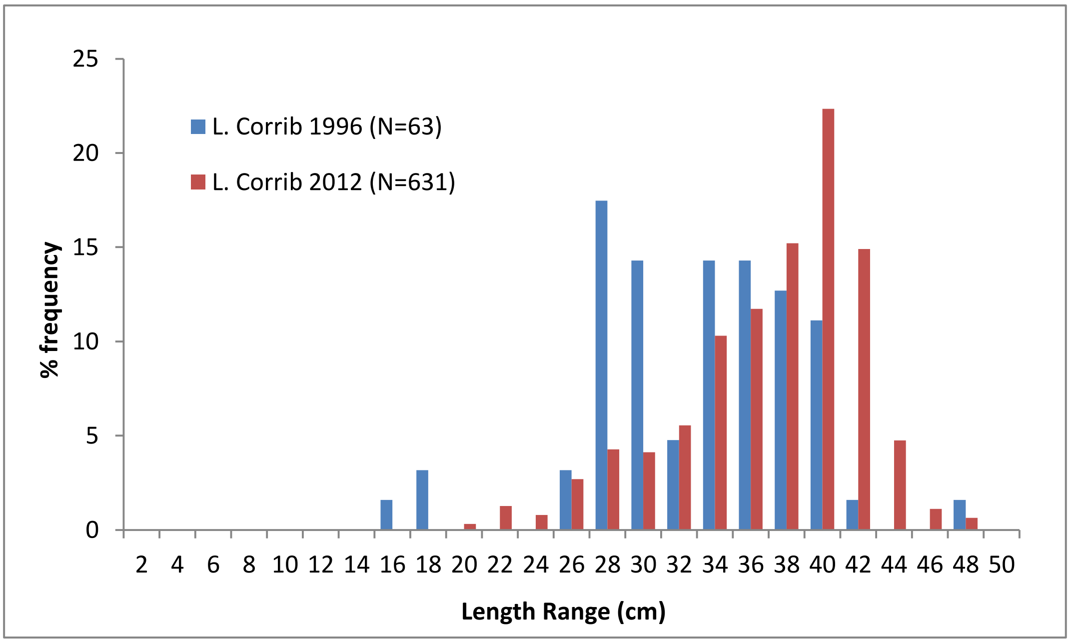


Figure 3.38. The percentage length frequency distribution for roach x bream hybrid samples in the 1996 and 2012 surveys.

3.6.3. Growth Patterns

A scale sample of the roach x bream hybrids were collected for ageing analysis. This also allowed for length at age information (or back-calculations) to be determined. The growth patterns for the L. Corrib 2012 hybrid sample are presented below (Figure 3.38) along with those for other Irish lakes and reservoirs. The L. Corrib hybrids exhibit very fast growth rates similar to those recorded for Inniscarra Reservoir (Caffrey, 2008 unpublished data). No data is available for the L. Corrib 1996 hybrid sample.

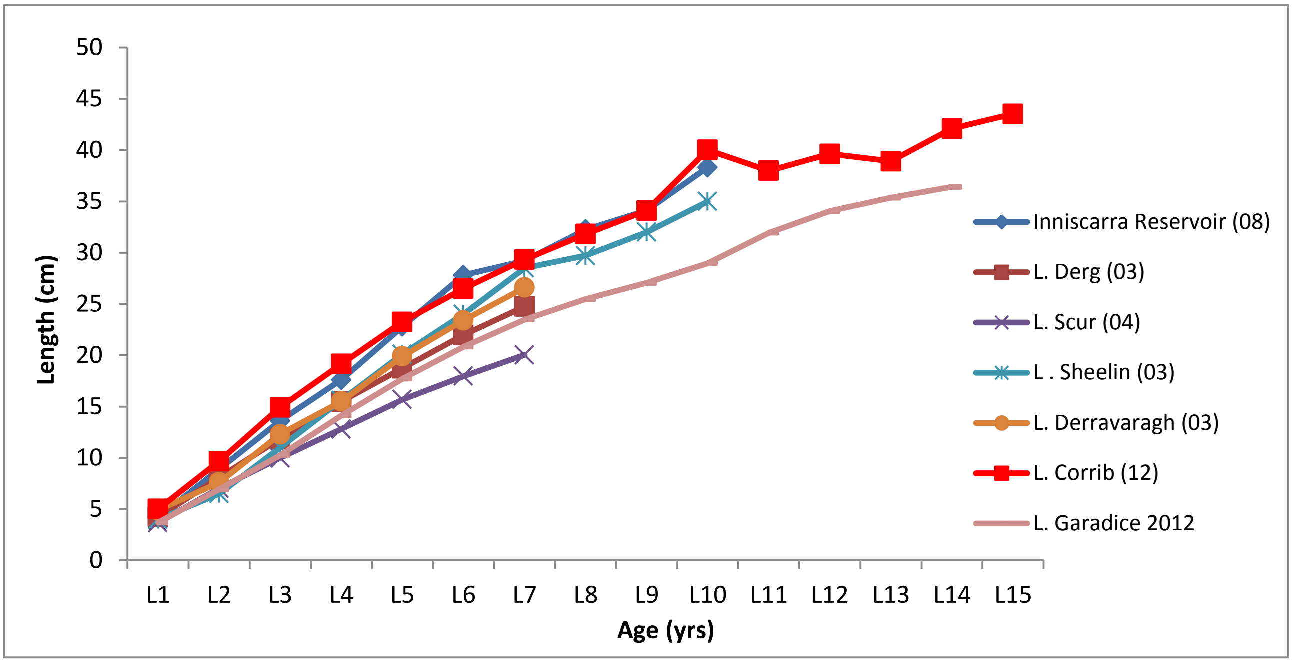


Figure 3.39 . Roach x Bream growth patterns for L. Corrib and a number of other Irish waters. (Data from Caffrey & Acevedo, 2008)

3.6.4. Age Structure

A review of the year class strengths of roach x bream hybrids in L. Corrib in the 2012 survey illustrates a very unusual situation with a very high proportion of the population being 12 year old individuals (Figure 3.40). This very unusual population structure is not common, having only been somewhat observed within roach populations from a small number of fish stock surveys on L. Ennell (O'Grady, 2005) and to a lesser degree in the L. Sheelin surveys.

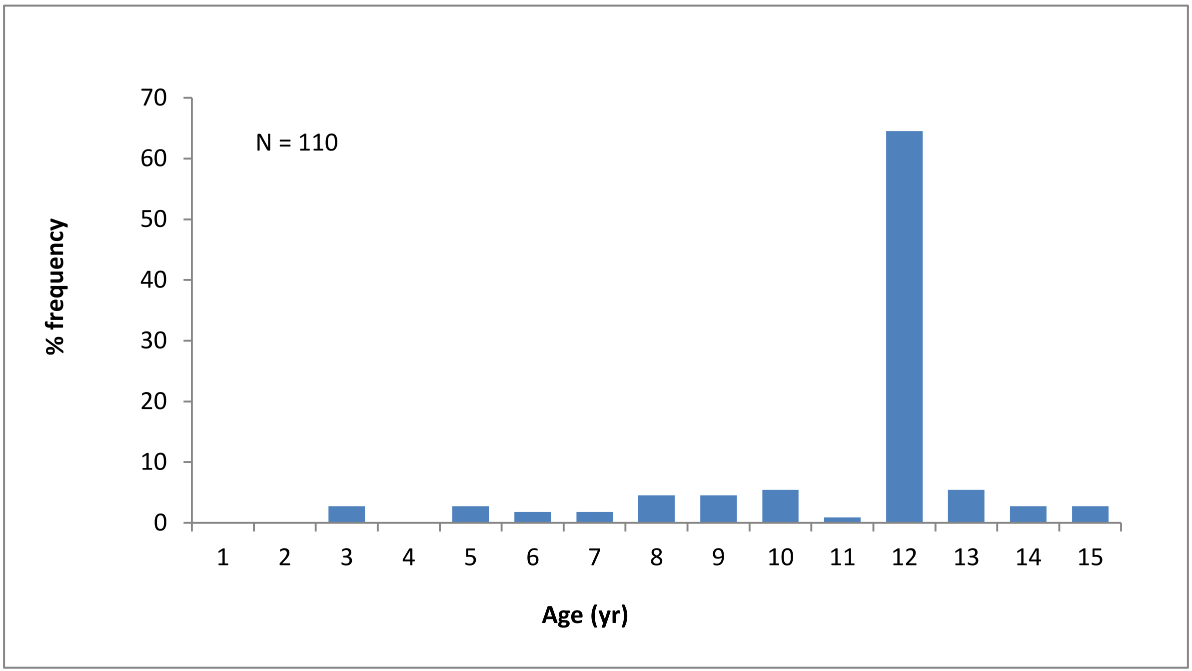


Figure 3.40. Year class strength among the roach x bream hybrid sample captured in the 2012 Corrib survey.

3.6.5. Roach x Bream Genetics

In 2010 Hayden *et al.* published a detailed morphometric/DNA study on roach x bream hybrids in four Irish waters including L. Corrib and Ross Lake, a part of the Corrib system. Some of their findings provide additional useful information in relation to these hybrid fishes in L. Corrib;

- Virtually all roach x bream hybrids examined from both Corrib and Ross lakes were F^1 hybrids.
- Mitochondrial DNA analysis indicated that virtually all of these fish were ♂ roach X ♀ bream.
- They found little evidence of F^2 roach x bream hybrids in L. Corrib.
- Very few roach X roach x bream hybrids were encountered in their L. Corrib sample.

The almost complete dominance of one year class has been noted in L. Sheelin and L. Ennell, in relation to roach stocks. However in both cases it was not as marked as the roach x bream hybrids of L. Corrib in 2012. A review of air temperature data from the meteorological station in Claremorris (Tank *et al*, 2002) in the year this hybrid year class were born (2000), suggests that an extremely low temperature regime in April of that year may have delayed the roach spawning period resulting in a major overlap in the roach and bream reproduction periods and leading to the creation of this abnormally large hybrid year class (Figure 3.41). Clearly other factors, following this cyprinid spawning season, would have had to favour the exceptional survival of this year particular year class.

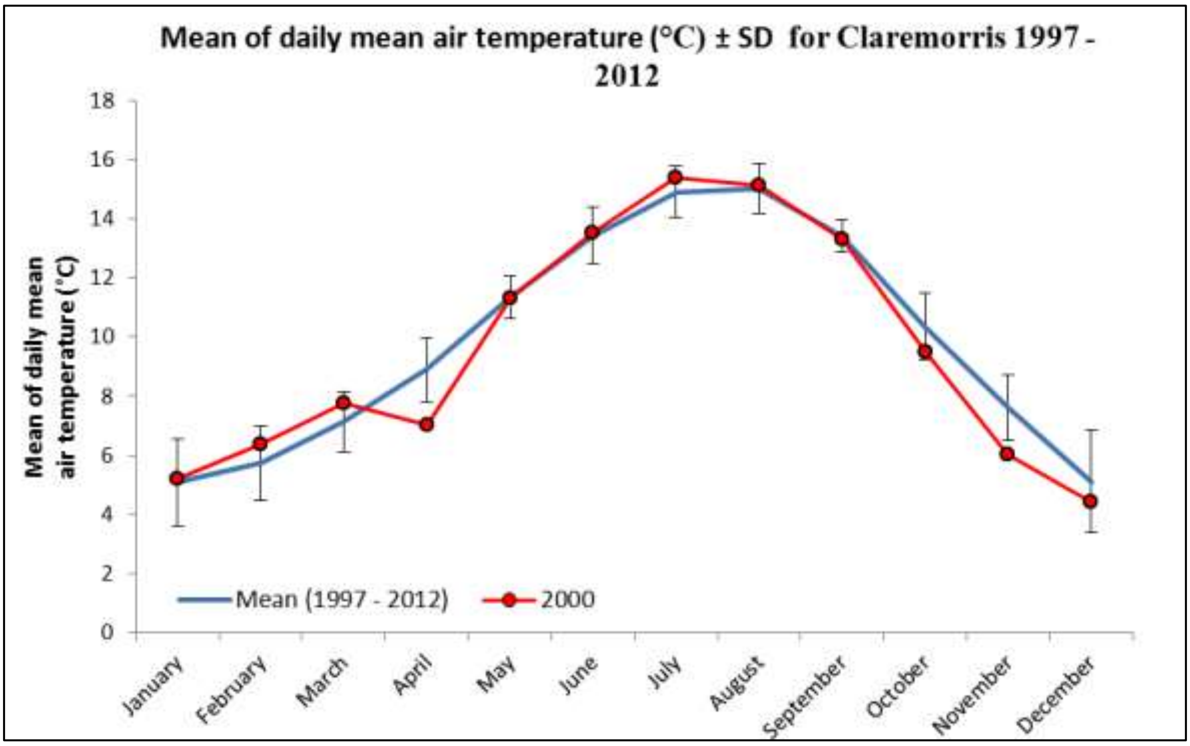
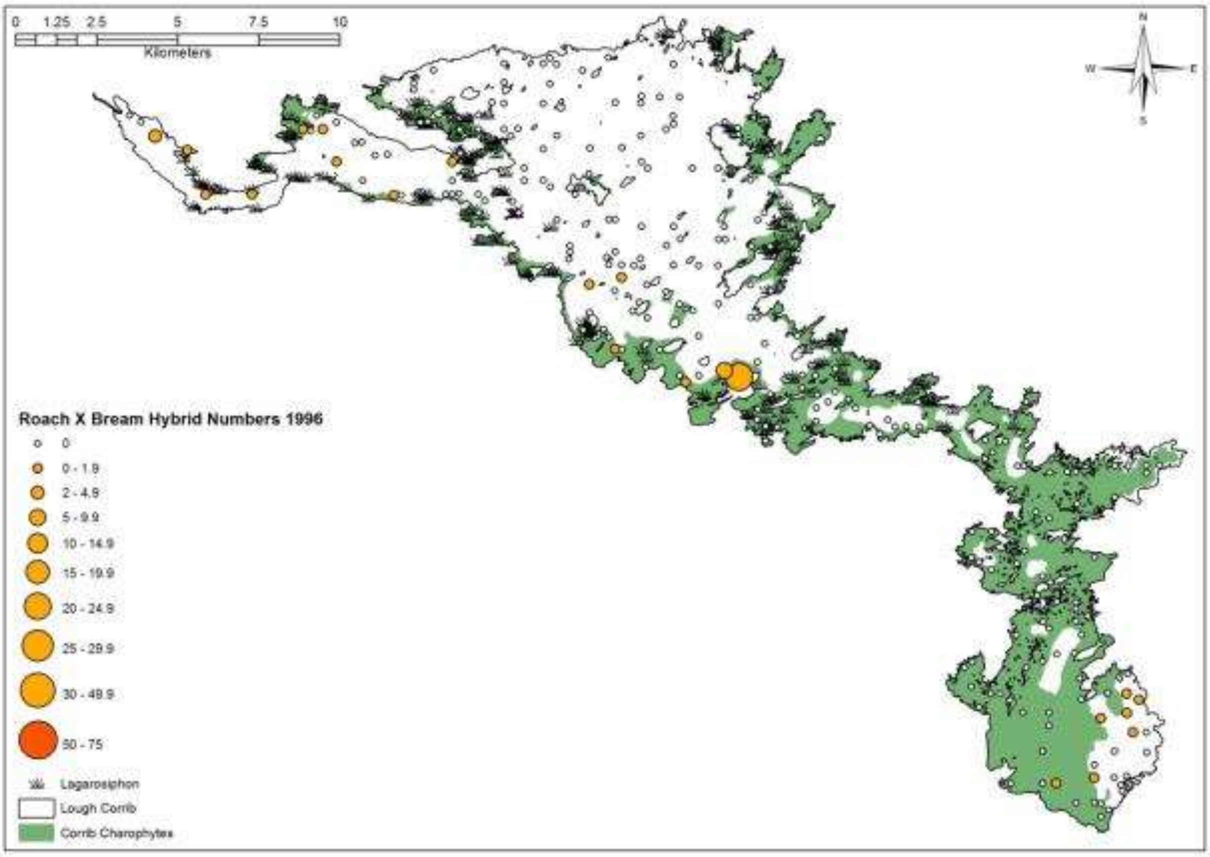


Figure 3.41. Air temperature data from Claremorris illustrating the exceptionally cold conditions which prevailed in April of 2000 (taken from Tank *et al*, 2002).

3.6.6. The Distribution of Roach x Bream hybrids in L. Corrib.

Roach x Bream hybrids were very limited in their distribution throughout the lake in 1996, which would be typical of a small population present. However the increase in the populations (as recorded in the 2012 survey) has seen this species extend the reach beyond that previously noted. Hybrids are now present all along the northwest and west shore of L. Corrib, with smaller numbers present in Lower Corrib (Figure 3.42). Like the roach, many roach x bream hybrids were located outside the weed bed areas.



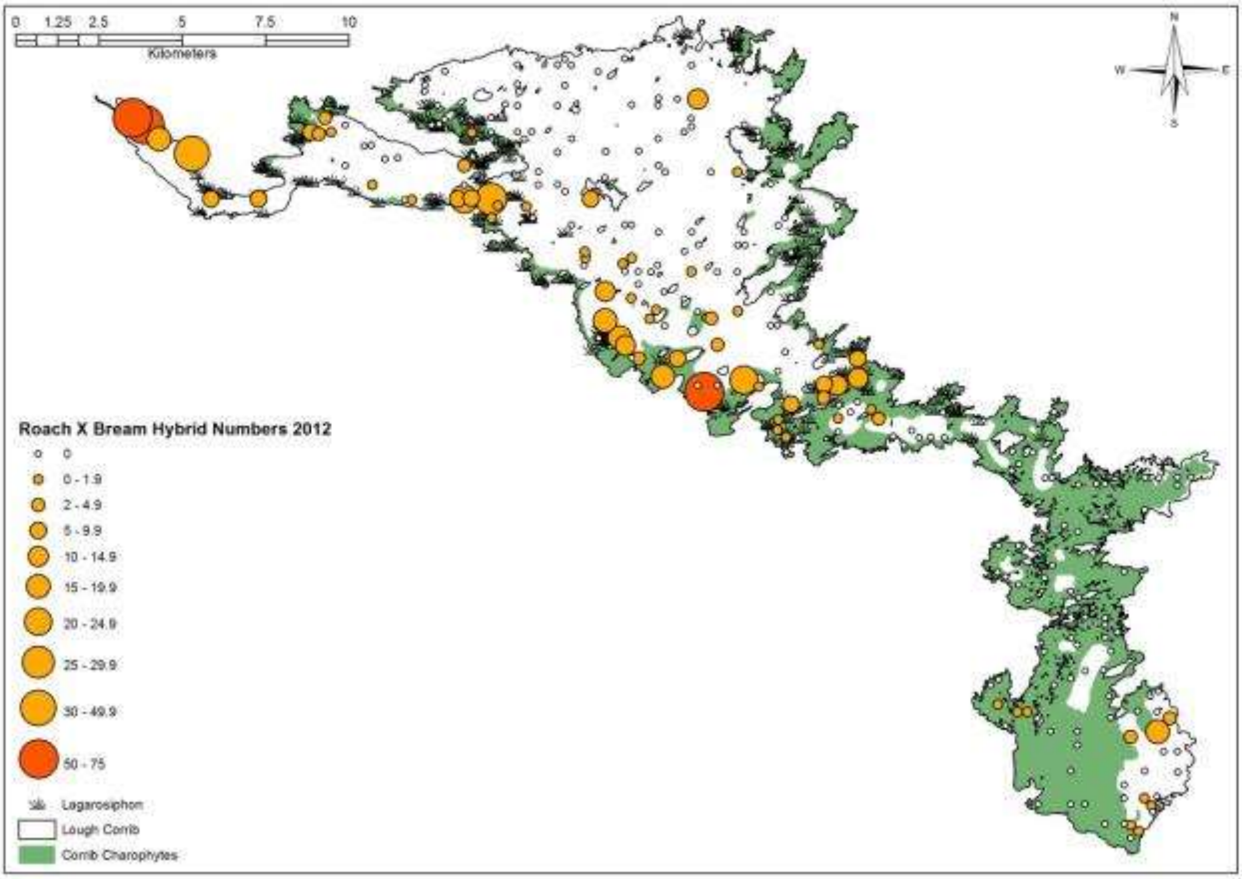


Figure 3.42. Roach x Bream hybrid distribution patterns from L. Corrib 1996 and 2012.

3.6.7. Recent Observations in Relation to the Roach x Bream Stock in L. Corrib.

- Last autumn, towards the end of the angling season anglers were observing occasional large dead cyprinid hybrids along the northern shore of L. Corrib (M. Butler, *pers com*).
- In the December/January period of 2012/2013, Inspector Martin Butler (IFI) noted sea gulls feeding along the north-western shore of L. Corrib. On investigation he noted that the birds were feeding on dead adult roach x bream hybrids which had been washed ashore. He also found the remains of a large roach x bream hybrid some two fields away from the lake shore which had been partially consumed.
- All of this information suggests that this most unusual large old year class of this species in the lake are reaching the end of their natural lifespan.

3.7. Bream Populations

No bream were captured in the 1996 Corrib though the presence of this species has been noted by staff in this fishery as far back as the 1970's. The population of bream in the Corrib has increased in recent years, with similar numbers of bream recorded in the two previous WFD surveys of 2008 and 2011 (Kelly *et al*, 2009 & 2012). A total of 33 bream were encountered in the 2012 survey (Table 1).

3.7.1. CPUE Values

A total of 33 bream were recorded during the 2012 L. Corrib survey, none were found in the 1996 survey. Bream CPUE values are compared with those for a small number of other Irish lakes were bream have been recorded during IFI surveys (Figure 3.43). The data suggests that the Corrib bream population is quite low. However it also shows that between years there can be great variation in CPUE values within the same lake. Movement of bream within a lake is very temperature dependant with very little movement in colder water temperatures. At the time of the survey water temperature of the lake ranged from 9 to 11 ^{o}C.

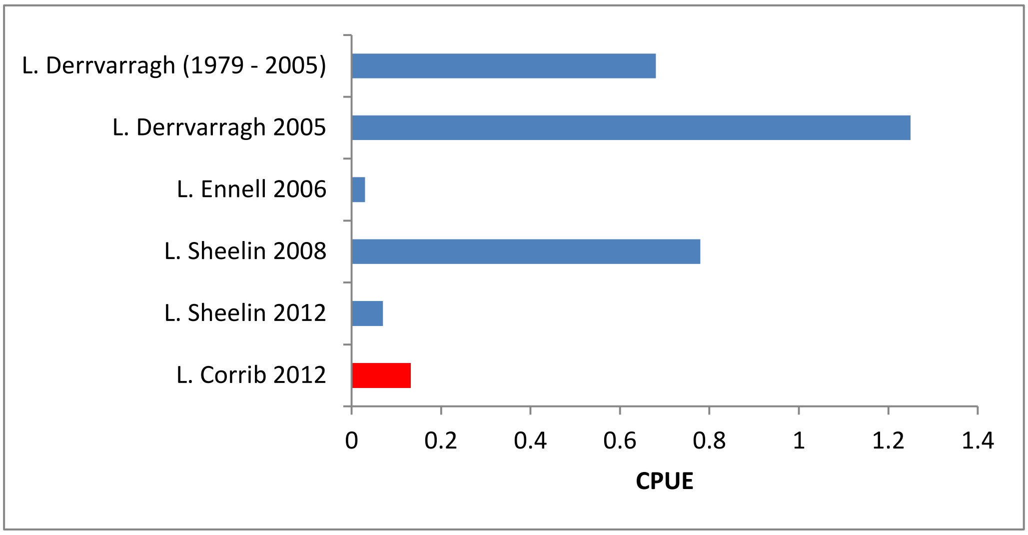


Figure 3.43 . L. Corrib Bream CPUE values compared with those from a number of other Irish lakes, Spring sampled.

3.7.2. Population Structure

The small size of the bream sample limits the comment one can make on the nature of this stock. The population represents a collection of individuals ranging in age from 7 to 15 years of age (Figure 3.44). No bream were recorded during the 1996 survey.

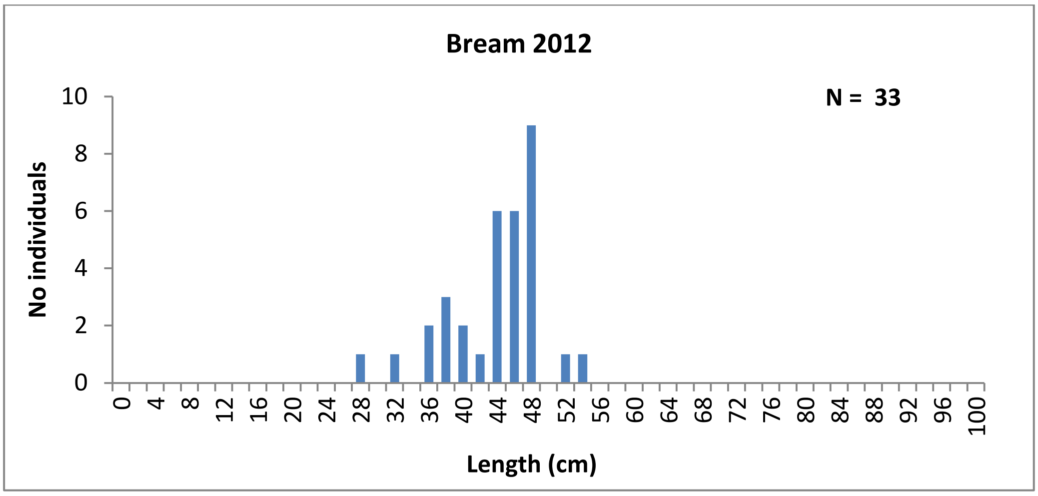


Figure 3.44. The percentage length frequency distribution of bream in the Corrib 2012 survey sample.

3.7.3. Growth Pattern

Bream growth patterns show that the bream of L. Corrib 2012 exhibited growth rates very similar to those of other Irish waters even being slightly faster growing in the early years (Figure 3.45).

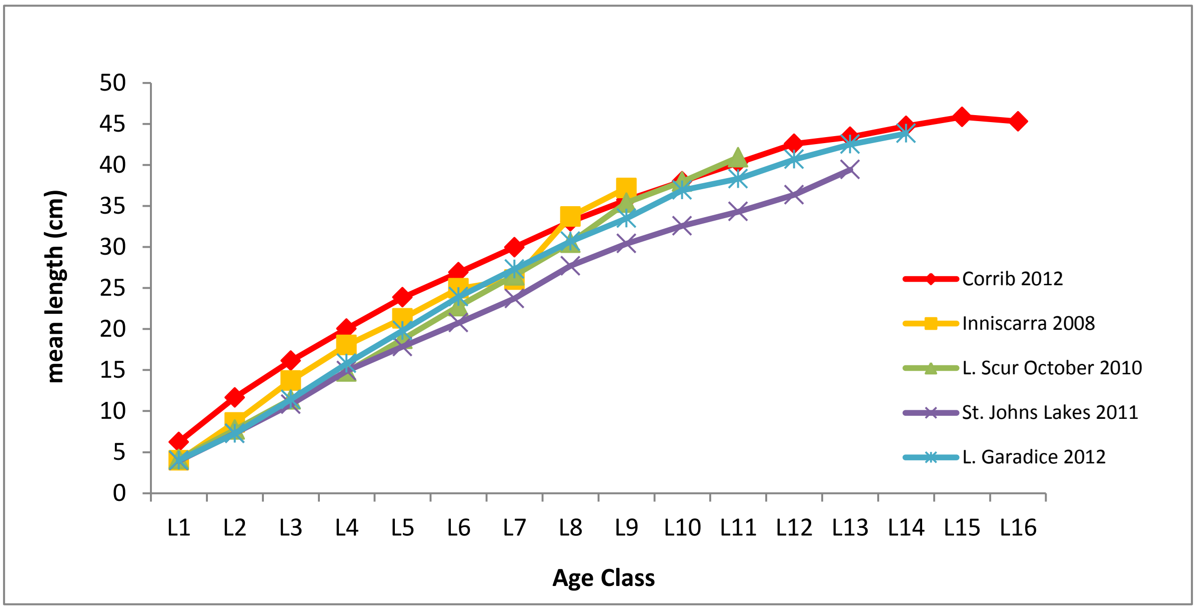


Figure 3.45. Growth pattern of the bream sample in the Corrib 2012 survey relative to other Irish stocks. (Comparison data provided by Caffrey *et al*, unpublished data)

3.7.4. Distribution of Bream in L. Corrib

The bream distribution pattern seen below (Figure 3.46) is typical of a species present in low numbers, their distribution is limited only occurring in pockets around the lake. Like the other cyprinid species (roach and roach x bream hybrids) in the lake they were found principally outside the weeded areas.

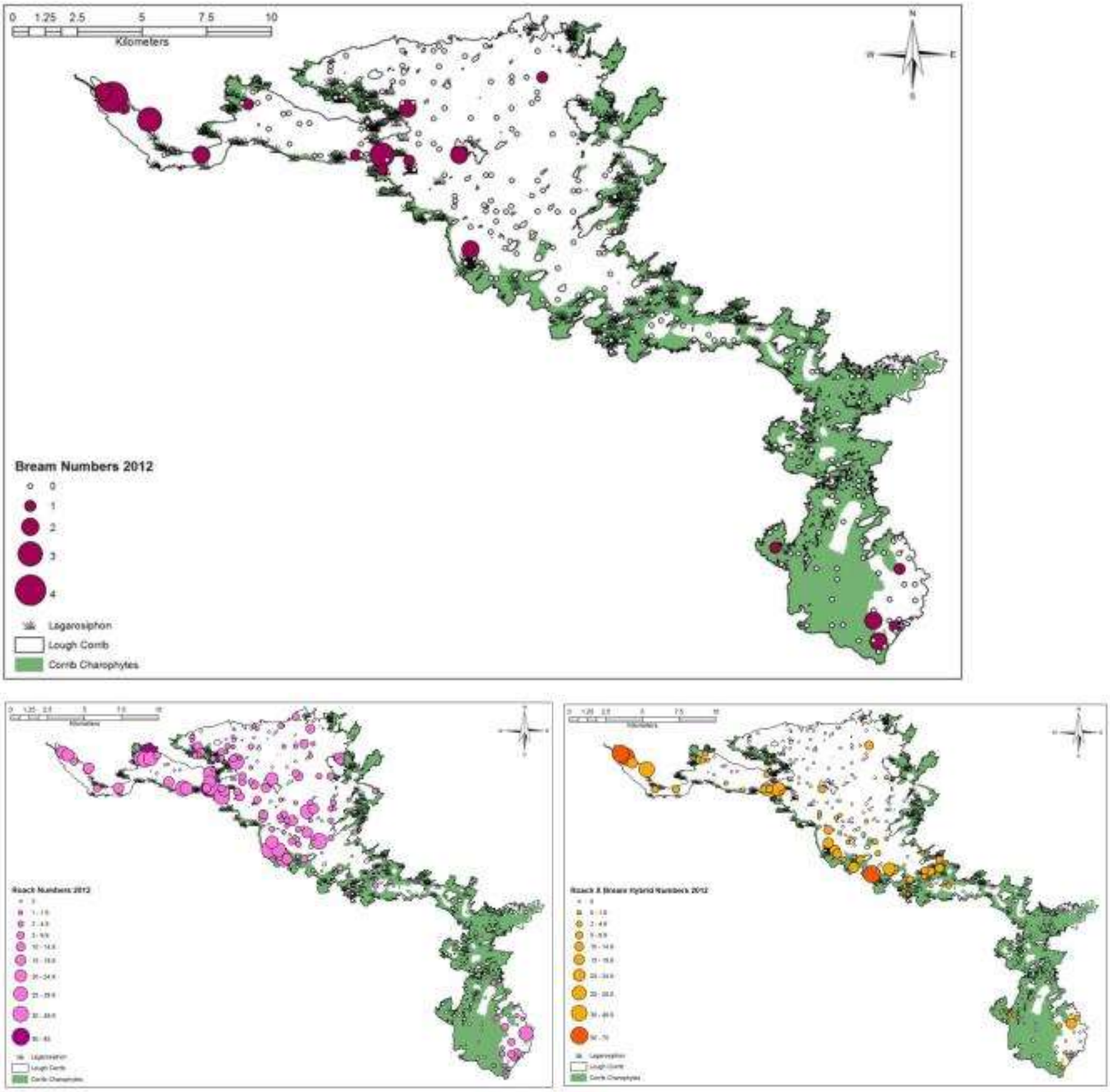


Figure 3.46. L. Corrib Bream population distribution for 2012. Also shown are the roach and roach x bream hybrid distribution patterns.

3.8. Other Fish Species

A total of four other fishes were recorded in the 1996 and/or 2012 surveys in L. Corrib - salmon, rudd (*Scardinius erythrophthalmus*), sea lamprey (*Petromyzon marinus*) and a rudd x bream hybrid. None were present in significant numbers (Table 3.1).

Water Framework Directive surveys carried out on Corrib in the summers of 2008 and 2011 recorded the presence of an additional three species and one hybrid to those listed above - three-spined sticklebacks, eels, tench (Tinca tinca) and one roach x rudd hybrid (Kelly *et al.*, 2009 and 2012).

The small numbers of adult salmon captured in both the 1996 and 2012 surveys is not surprising. At this time of year (late February/March) the kelts have either died or gone back to sea and there are few “fresh fish” in the lake. Eels are rarely caught in gill nets, hence their absence from the 1996 and 2012 surveys. No fyke nets were used during either of the two L. Corrib surveys of 1996 and 2012. Tench hibernate in Irish waters until late April and are therefore rarely captured in netting surveys in springtime. Three-spined sticklebacks are too small to be captured in the survey nets used in the 1996 and 2012 surveys.

4. Genetic Studies of trout stocks in L. Corrib and their implications in relation to the management of this resource.

4. 1. Introduction.

Two major studies have been carried out in relation to brown trout genetics in the L. Corrib catchment since 2008. The first study was carried out by University College Dublin (UCD) as part of a PhD study, on I.F.I.'s behalf, (Massa-Gallucci, 2009, Massa-Galluci *et al*., 2010) and the second study was a collaborative project between IFI and Queens University Belfast (QUB) (Bradley *et al.,* inpress). Both studies involved sampling juvenile trout from all of the major L. Corrib sub catchments. In the first study a sample of adult trout from the lake, caught by anglers, were examined. In the second study the adult trout sample from the lake were the fish captured as part of the 2012 IFI fish stock survey. This is the first Irish study where the exact location of every trout sampled in the lake is known and where each individual fish can be traced back to its natal stream – i.e. the distribution of trout in the lake from any one sub-catchment can now be illustrated.

As part of the current L. Corrib genetics study QUB, through Professor Prödohl and his team, additional work has been carried out in relation to genetically typing a set of historical scale samples from the Abbert and Grange River fish which had been collected in the mid 1990's and have also genetically typed a sample of fry from the Oughterard hatchery.

A third major genetic study of the trout stocks of the L. Mask catchment was carried out in 2010 (Mariani and Massa – Gallucci, 2010).The reader should note the relevance of the Mask study to the Corrib report with regard to the "ferox trout" population in both lakes (Section 4.6)

The genetic data compiled through these studies, are of particular importance in fishery management terms, and are summarised here and comment is provided in relation to their implications for the management of the resource.

4. 2. Identification of individual sub- populations in genetic terms.

Both major studies (Massa – Gallucci *et al.*, 2010 and Bradley *et al.*, in press) from the Corrib illustrate that trout from the individual sub-catchments can be identified as discrete genetic sub-populations. In broad terms there appears to be a "broad split" with the tributary populations in rivers on the eastern side of the lake (from the Cross going south) being closely aligned genetically while the stocks in rivers on the western side are distinctly different as eastern group (Bradley *et al.*, in press and Fig.1).

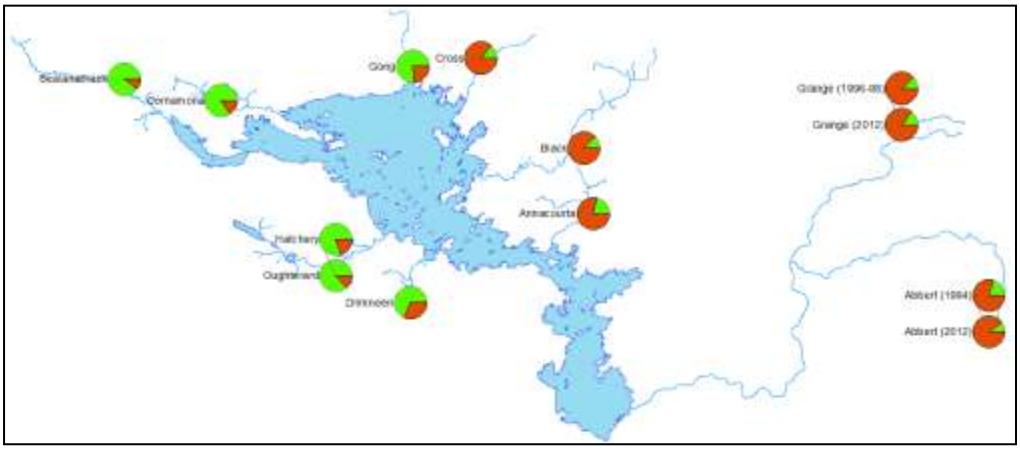


Figure 1. An illustration of the two main genetic groups in Corrib trout stocks (from Bradley *et al*, in press).

Bradley *et al.,* (in press) is clear that while these two groups of rivers are related they are distinct groups in their own right. This study (Bradley *et al.*, in press) also illustrate the interrelationships of these groups in a phylogenetic tree (Fig. 2)

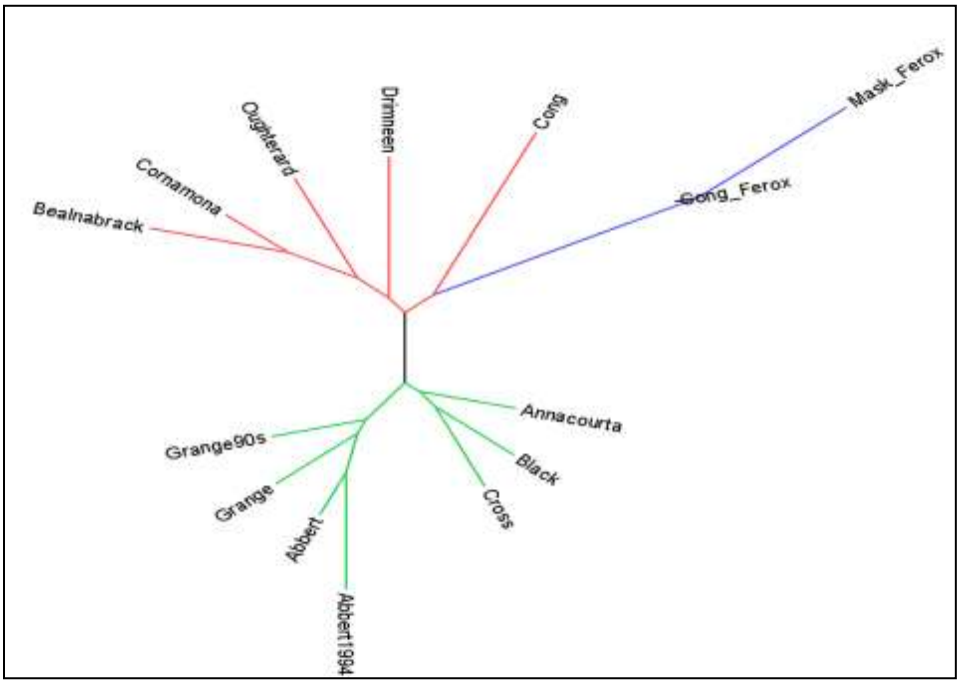


Figure 2. Unrooted NJ phylogenetic tree based on Nei's DA (1983) genetic distance illustrating relationship among Lough Corrib samples. Different colours represent major genetic groups as coded in previous STRUCTURE analysis. (Fig.6 in Bradley *et al.*, in press)

4. 3.The contribution of the various sub-populations to the adult stock in the lake.

The genetic stock identification of lake trout from the 2012 survey is illustrated in Figure 3 (from Bradley *et al.,* in press). In this particular study the contribution of trout from the Bealnabrack and Cornamona Rivers are presented as a single group as are fish from the Cross and Black Rivers.

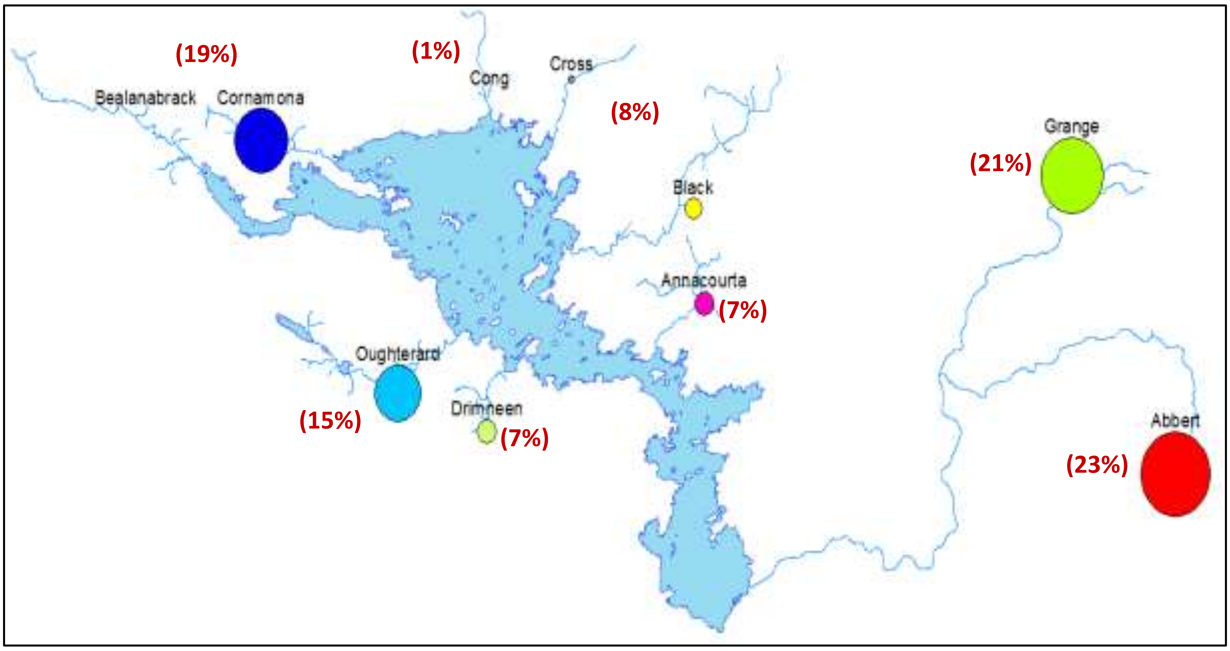


Figure 3. The genetic stock identification of trout (from Bradley *et al*, in press)

These data indicate that 78% of the adult fish in L. Corrib in March 2012 were from one of five sub-catchments – Abbert (23%), Grange (21%), Bealnabrack and Cornamona (19%) and the Oughterard River (15%).

These results differ significantly from the first major study of Massa- Gallucci *et al.,* (2010) in one respect - Bradley *et al.*, (in press) suggest that the Grange River fish make a significant contribution to the L. Corrib adult stock. Massa – Gallucci *et al.,* (2010) on the other hand had concluded that Grange trout were entirely sedentary spending their entire life cycle in the Grange River. In order to resolve this issue Professor Prodohl's group undertook an analysis of scales from IFI's "scale library" which had been collected from trout in the river over the period 1996 to 1998. An analysis of these samples indicated that Grange trout from the 1990's were very similar genetically to the 2012 sample and very different to Massa – Gallucci's sample collected in 2008. Bradley *et al.,* (in press) conclude that Massa- Gallucci's trout sample from the Grange were possibly salmon. This explains why she could not identify Grange trout in the adult sample from the lake. Unfortunately the Massa – Gallucci Grange samples were not retained thus preventing a re-analysis of this material.

4.4. The distribution of fish of different sub-catchment origins in the lake.

The availability of GPS (global positioning system) records for every trout captured in the 2012 survey in combination with the genetic analysis allows one to plot the distribution of trout from the different tributaries in the lake itself. The distributions of fish from the different L. Corrib sub catchments varied significantly (Bradley *et al.*, in press) (Figs. 4a, b, c and d).

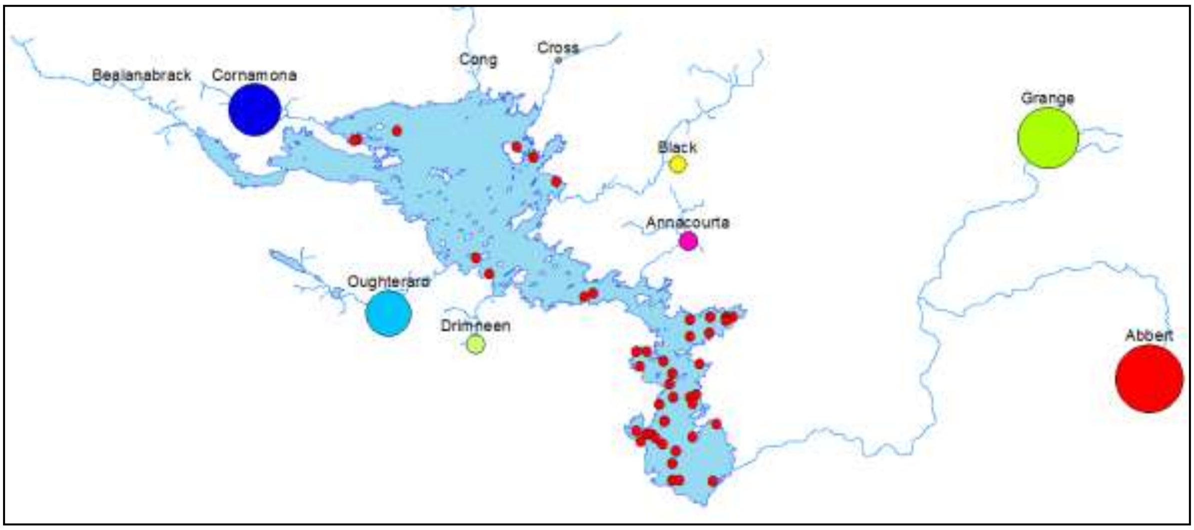


Figure 4 a. The distribution of trout of Abbert origin in the 2012 lake survey sample.

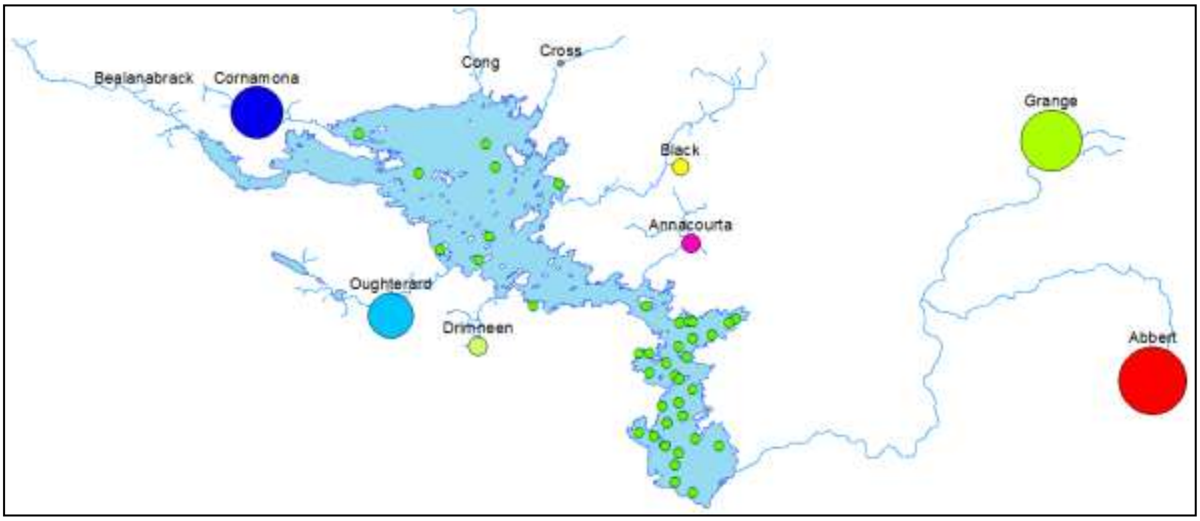


Figure 4 b. The distribution of trout of Grange origin in the 2012 lake survey sample.

In the case of both the Grange and Abbert stocks most adult trout from these rivers were found in the lower Corrib basin (Fig's 4a and b).

Trout from the Oughterard River were a little more widely distributed. However a majority of these fish were located in the southern half of the upper basin not far from the outfall of the Oughterard River to the lake (Fig. 4c).

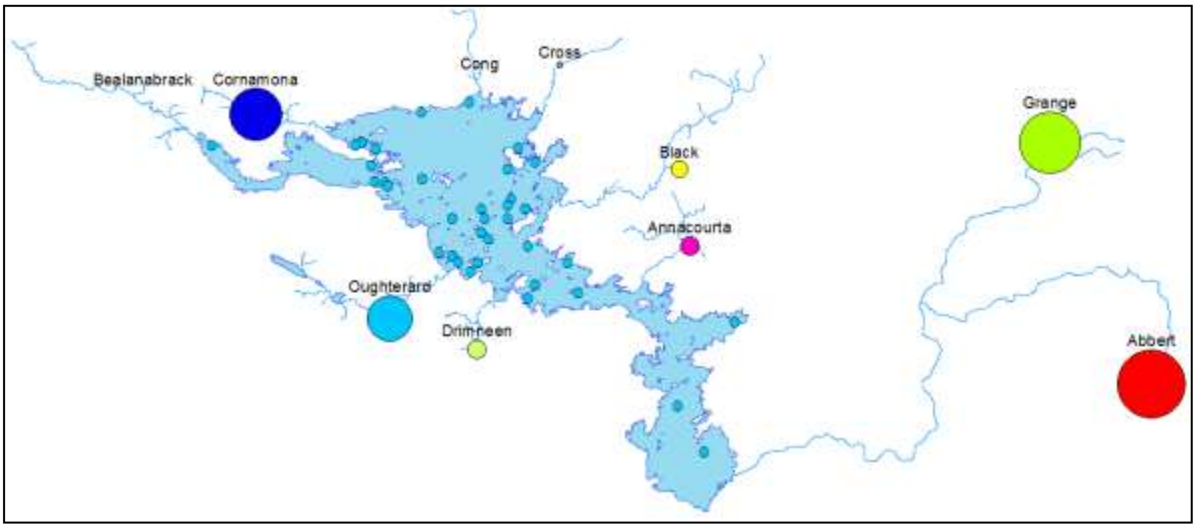


Figure 4 c. The distribution of trout of Oughterard River origin in the 2012 lake survey sample.

Trout originating from the Bealnabrack and Cornamona Rivers had a very different distribution to the aforementioned tributaries. Many of these fish had migrated south and were living in the central area of L. Corrib (Fig. 4d).

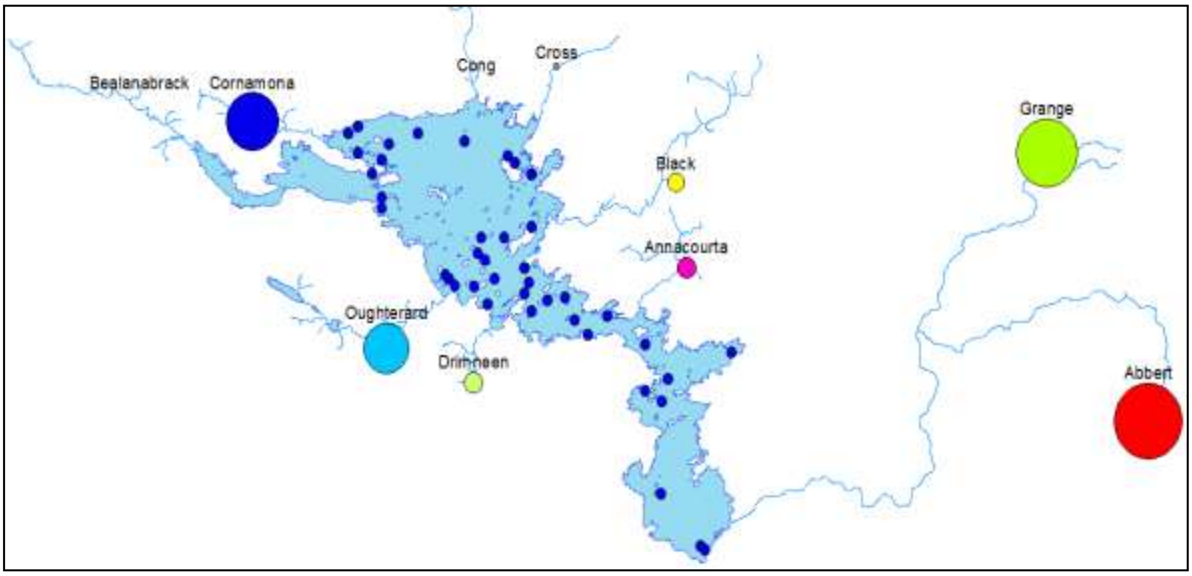


Figure 4d. The distribution of trout of Bealnabrack and Cornamona River origin in the 2012 lake survey sample.

The differences observed in relation to the distribution of fish in the lake relative to the location of their natal stream is most likely related to the availability of food in different parts of the lake. The lower basin of L. Corrib is heavily colonised by Charophytes, a very high quality habitat for trout. It is not surprising therefore that most trout migrating to the lake from the Grange or Abbert Rivers remain in the lower lake basin. Similarly trout migrating to the lake from the Oughterard River enter another shallow productive area in the lower half of the upper basin. In contrast the Bealnabrack and Cornamona Rivers discharge into the deepest and least productive part of the Corrib Basin. It is not surprising therefore that many trout from these rivers migrate south once entering the lake to the richer feeding grounds in the central area of the lake.

The sample size of trout from other tributaries captured in the 2012 survey is too small to warrant comment in relation to their distribution in the lake.

4.5. The contribution of the Oughterard Hatchery fish to the L. Corrib trout stock.

Both major genetic studies of Corrib trout stocks (Massa – Gallucci *et al.,* 2010 and Bradley *et al.,* in press) point out that the Oughterard hatchery makes no significant contribution to the L. Corrib fishery. As already illustrated the "genetic nature" of trout stocks in rivers on the eastern side of Corrib is distinctly different to those in the western side of the catchment. No trace of Oughterard type fish could be found in any of the eastern sub catchments indicating that releases of Oughterard hatchery fish in these rivers have not contributed to stocks in these rivers. Bradley *et al*., (in press) established a genetic profile for the Oughterard hatchery fish and found them, not surprisingly, to be genetically similar to the wild Oughterard fish stock.

Massa- Gallucci *et al*., (2010) also point to evidence of "gene flow" into, rather than out from, the Oughterard stock. The implication here is that evidence of gene flow from the Oughterard River to other sub catchments would reflect a high survival of Oughterard hatchery fish being released into other rivers. No such evidence exists.

In conclusion both genetic studies suggest that the stocking of fry from the Oughterard hatchery has had no impact, either positive or negative, on the overall Corrib trout population.

Both genetic studies warn of the dangers of mixing these unique genetic stocks. To quote Bradley *et al*., (in press) – "Movement of fish between rivers should be avoided to prevent a loss of irreplaceable genetic diversity."

In the authors' opinion, if the precautionary principle were to be applied here, the hatchery should close.

4. 6. Ferox Trout Stocks

Ferox trout are a group of trout considered endemic to a small number of lake catchments in Ireland and Scotland (Ferguson, 2004). The presence of ferox trout in both Loughs' Corrib and Mask has long been recognised. When Professor Mariani's group were carrying out the first Corrib genetic survey and a subsequent study on Lough Mask trout stocks a parallel radio tagging study in relation to the distribution of ferox trout in rivers during the spawning season was in progress. Dr. P. Gargan (IFI) who designed and ran the radio tracking programme kindly supplied fin clip samples of all adult ferox trout which were radio tagged and released in both Loughs' Corrib and Mask to Professor Mariani's group for genetic analysis. Subsequent analysis of these data in combination with all of the other genetic information is presented in Massa – Gallucci *et al.,* (2010) and Mariani and Massa – Gallucci (2010). Information of particular importance in fishery management terms can be summarised as follows;-

1. Juvenile ferox trout in the Corrib sub catchments could only be found in the Cong Canal/ Cong River channel.
2. No juvenile ferox trout were found in any of the inflowing rivers to L. Mask.
3. The Corrib and Mask adult ferox fish were genetically identical but distinctly different from all other trout groups in both Corrib and Mask.
4. Data in 1. to 3. above suggest that ferox trout from Corrib possibly colonised L. Mask when the artificial manmade surface channel was built in the 1840's – prior to this the natural discharge channels from L. Mask to Cong Village were all subterranean channels (Fig 5).
5. Genetic analysis of ferox fish indicates that the population of these fish in both lakes is probably no more than a few hundred fish. Obviously these unique fish require special attention in conservation terms.
6. The findings of the radio tracking programme corroborate the genetic findings (P. Gargan, *pers com*.). Ferox trout, at spawning time, were almost exclusively located in the Cong Canal/ Cong River channel. Two Ferox trout tagged and released in L. Mask were located at a spawning site in the Cong River only a few 100 meters from its outfall to L. Corrib.

Figure 5. An outline of subterranean passages from L. Mask to L.Corrib and the location of the man-made canal. (Map taken from www.GSI.ie)

5. Summary and Recommendations

This fish stock survey, when compared with both the previous 1996 survey for the Corrib and the long-term survey data base for other Irish lake trout fisheries, allows one to put the current status of this fishery in perspective.

5.1. Ecological Stability

Clearly the introduction and establishment of *Lagarosiphon major* (Ridley) beds in L. Corrib in recent years is a major cause for concern in relation to the long-term ecological stability of this fishery (Caffrey *et al.*, 2011). However, to date, the available fish stock survey data indicate a relative degree of stability on this water compared to other Irish lake fisheries.

Fish stock surveys in Irish trout lakes over a 30 year period have illustrated major instability in the status of fish stocks following the onset of cultural eutrophication problems in combination with the introduction of non-native species, most notably, zebra mussels and roach. This ecological instability has been particularly evident in Lough's Conn, Cullin, Sheelin and Derravaragh. The 1996 and 2012 fish stock surveys indicate no such gross instability in L. Corrib despite the establishment of a zebra mussel population and *Lagarosiphon* (curly water-weed) at this point in time.

Fish Stock Information.

- Trout and roach populations in L. Corrib in both 1996 and 2012 are similar both in terms of their CPUE values and stock structure (Section 3.1). The changes noted in the perch populations indicate that the population has recovered from the disease outbreak it suffered in 1996. The alterations in pike stocks appear to reflect changes in stock control policy rather than any major ecological change in the lake.
- The growth patterns of trout, pike and perch have not altered significantly in 2012 compared to 1996, another reflection of stability (Sections 3.2.3, 3.3.3 and 3.4.3).
- The dietary habits of trout and pike recorded in both Corrib surveys are very similar - further evidence of stability.
- No excessive parasite load or "sick fish" of any species were noted in the course of these surveys.

Clearly the fact that eutrophication problems on the Corrib are limited, compared to other waters, has helped to "buffer" the impact of invasive species. While successful control measures implemented in the case of *Lagarosiphon* has greatly reduced the spread of this plant species around the lake.

The authors recognise that the most imminent threat to the viability of L. Corrib as a trout fishery is the establishment of *Lagarosiphon* colonies. The necessity of controlling this plant from a fishery perspective, on an on-going basis, is well documented (Caffrey *et al.,* 2011).

5.1.2. The Current Status of Lough Corrib as a Trout Fishery.

The excellent trout angling returns recorded on L. Corrib in the 2012 season confirm that the trout CPUE value recorded for the lake in the 2012 survey (1.56) reflects the presence of sufficient trout to provide quality angling given favourable angling conditions (M. Butler, *pers com*) - clearly the persistent and unseasonable windy wet weather which provided good angling conditions for most of the 2012 season helped to increase trout catches. It is likely that in any particular year the weather conditions will play a crucial role in dictating the quality of angling catches even when the standing crop of trout in the fishery is good.

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APPENDIX I

List of all Staff involved in the L. Corrib Fish Stock Survey 2012

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