CENTRAL FISHERIES BOARD

THE ECOLOGY, BIOLOGY AND MANAGEMENT OF PIKE IN IRISH WATERS WITH PARTICULAR REFERENCE TO WILD BROWN TROUT LAKE FISHERIES

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PREFACE

In Ireland, the management of any freshwater fish of angling importance is based on a foundation of the best available science in relation to the ecology and biology of the species in question. Many important studies on the ecology and biology of Ireland's freshwater fish were carried out from the 1950's to the 1970's. In relation to wild brown trout lake fisheries a very detailed database is available – for example the status of fish stocks has been monitored in most important lakes and, particularly in ecologically unstable waters, at intervals, since the late 1970's. These studies are very broad based, including many different disciplines – water chemistry, phytoplanktonic studies, aquatic plant ecology, macroinvertebrate studies and fish stock investigations. In lake catchments where arterial drainage programmes were carried out the design and implementation of stream enhancement programmes was also an essential part of the lake trout management exercise. The co-ordination of all of these studies and the cross referring of available databases allows one to interpret trends. This involves considerable level of collaboration between experts in different fields.

From time to time anglers often request technical information in one or more of the aforementioned areas. This often leads to confusion and misunderstandings in that looking at one of these data sets in isolation can, at worst, be misleading and, in many cases, simply be uninformative. The comment in this report is designed to avoid such pitfalls by ensuring that all available data, across all disciplines are reviewed and integrated as far as is possible. The reader should note that databases can only be summarised in a document of this nature. To provide all of the raw data would require a document running to several thousand pages and simply confuse a non-scientist.

Three examples are provided here to illustrate the complexities involved and the background information required to ensure that the information is being correctly interpreted. Mean (x) annual chlorophyll values for Lough Sheelin in 1988 and 2007 were similar (17.1 ug/l and 24.8 ug/l respectively). One might expect that these relatively high values, indicating significantly high levels of algal blooms would have a similar impact on the fishery. An examination of these data, compiled from monthly samples, indicates that this is not the case (Figure 1a). In the case of the 1988 data relatively high chlorophyll values (algal blooms) were evident in April, May, July and August (Figure 1a). These were high enough to limit the sunlight reaching the bed of the lake thereby depressing weed growth and leading to a loss of trout habitat. They were also sufficient through the summer months, to supply enough food to sustain a very large roach population. In contrast the 2007 monthly chlorophyll values were more varied with a very high spring peak followed by a succession of low summer values. In this case the low summer values meant that there was insufficient food to sustain a large roach population over the course of the year (Figure 6). These low

summer values also accommodated the growth of rooted aquatic plants because there was sufficient incident light reaching the lake bed during the plant growing season.

The large algal bloom in Lough Sheelin, in March, 2007 (Figure 6) was the first major phytoplankton bloom in this lake since 2003 when the zebra mussel population became established. This might have been caused by a collapse of the zebra mussel population over the winter period of 2006/2007. A survey was carried out in March 2007 to examine the status of zebra mussel. No decline was evident in the zebra mussel population in March 2007 compared to 2006. The dominant algal species in this bloom was a large diatomaceous species (Mellosira) which the mussels either could not, or did not wish to eat.

Similarly, the decline in wild trout stock in Lough Sheelin, from the mid 1990's, to date might be attributed to, either unsuitable ecological conditions for this species in the lake or, a collapse in the production of juvenile trout in the lakes sub-catchments. Surveys of the stream sub-catchments indicated the presence of substantial juvenile trout confirming that conditions in the lake, not trout recruitment rates, were causing the problem.

1. INTRODUCTION AND BACKGROUND INFORMATION

The pike (*Esox lucius* L.) in Ireland is regarded as an introduced species (Went, 1957). The Gaelic name for this fish is "Gall Eisc", meaning foreign fish (Farran, 1946). Interestingly in the Gaelic dialect spoken in west Mayo there is no word in the language for pike – not surprisingly because, to our knowledge, pike have not yet been introduced to any waters west of Crossmolina!

The management of all fish stocks, including pike, is an area which has evolved since the 1950's when the management and promotion of inland fisheries in Ireland was first actively pursued. Since 1980 this State function has been vested in the Central and Regional Fisheries Boards.

Throughout this period (1950's to date) scientists employed in the Fishery Service and others based in Universities have been studying various aspects of the biology and ecology of freshwater fishes in Ireland and, over time, providing advise in relation to the management of species. All relevant peer reviewed scientific publications on Irish lakes are included in the reference list (Section 9) of this document. Not all of these documents are specifically referenced in this paper. This list is provided to give the reader a perspective of the depth of limnilogical studies in Ireland of the last 60 years. Clearly additional studies on many fish species have been ongoing since then. The lake fish stock monitoring programme, being carried out by the Central Fisheries Board, which have been ongoing since the late 1970's and continues today has proved crucial to an understanding of the dynamics of lake fish stock populations. To the authors knowledge the annual fish stock monitoring programme, which has been ongoing on Lough Sheelin for 30 years, is the most longterm comprehensive study of the dynamics of fish populations in any lake in Western Europe.

The objectives of this position paper are:-

- to update the last position paper written in 1995.
- to provide the known ecological and biological facts on pike stocks in Ireland – information of interest to all anglers.
- to review the rationale and necessity of pike management exercises on a small number of managed wild brown trout lake fisheries.
- to inform all resource users in relation to the status of fish stocks in many of our lake trout fisheries, past and present, and provide the rational for current management practice.
- to forewarn our marketing personnel that the large pike populations evident in many culturally eutrophic lakes in the 1990's may not be

sustained in future years if and when zebra mussel populations become established in such fisheries.

2. A SUMMARY OF ECOLOGICAL AND BIOLOGICAL FACTS ON IRISH PIKE POPULATIONS

2.1 Distribution

Like many introduced fish species the distribution of pike stocks is erratic nationally. To our knowledge, currently, there are no pike in the lakes in Wicklow, west Cork or in any watershed in Co. Kerry. Pike are also absent from the waters of west Galway, west Mayo and north Donegal.

In recent times the distribution of pike has been expanding through unauthorised human intervention. Over the last 20 years pike have been introduced to at least 5 lakes in south Donegal (Loughs Avehy, Golagh, Lee, Shinnagh and Vearty). Prior to their introduction these waters supported mixed trout and perch populations. Recent surveys of these lakes suggest that the trout populations in all of these lakes are now extinct (F. Kelly, pers. com.). There are now only two large trout lakes in Ireland, of significant importance to native salmonid species, where pike are still absent (Loughs Leane and Melvin).

2.2 Relative Densities – In Rivers

Pike have failed to establish large populations in many of our larger shallow relatively fast flowing river systems despite the presence of substantial quantities of fodder fish (trout and salmon parr). Extensive electrofishing surveys and information from anglers indicate that there are very limited pike populations in river systems like the Boyne, Slaney, Nore, Suir, Cork Blackwater and Moy. This is probably because the pike in these systems have very few quality spawning and nursery areas – shallow marshy drains and backeddies.

In contrast, slow flowing rivers, where the aforementioned features are common, support substantial pike populations. Typical examples of riverine habitat where this introduced species has thrived would include the Barrow, Suck and Shannon.

2.3 Relative Densities – In Lakes

Gill netting surveys and, more recently, lake electrofishing operations indicate that the relative density of pike in our lakes is controlled primarily by the extent of charaphyte and other weed beds in individual waters – in other words the more extensive the weeded area in an individual water the greater its capacity will be to produce pike. The distribution of pike in annual surveys carried out in March in Lough Sheelin, each year over 30 years, clearly indicates a correlation between high pike numbers at spawning time in, or adjacent to charaphyte beds (Figure 1). Other factors will subsequently control the capacity of a water to support a large adult pike stock – particularly the extent to which fodder fish are available.

2.4 Spawning and Early Life Cycle

Like most freshwater fish in Ireland pike spawning activity in individual populations can extend over quite a period. Data indicate that most pike will spawn at some point between early February and mid-April when water temperatures rise to 9/10^{0}C (Fitzmaurice, 1983). Fecundity is high with female pike producing circa 30,000 eggs per kg. of body weight. Incubation of the eggs takes from 8 to 14 days. The larva, on hatching, measure 8.0-9.0mm. At 13/14 mm in length the larva start feeding before the yolk sac is completely absorbed (Kennedy, 1969).

2.5 Maturation Age and Subsequent Spawning Frequency (Lake Populations)

In lake populations most male fish mature for the first time as two year old individuals. Occasional mature year old male pike have been observed. Most females mature for the first time as three year old individuals. Occasional two year old mature females have also been observed.

In all Irish lake pike populations both the male and female fish, once mature, spawn each year thereafter – this is in marked contrast to lake brown trout populations where many individual fish only spawn every other year.

Occasional barren older pike (mostly females) have been encountered. These fish were usually ≥ 7kgs in weight.

Male adult individuals are usually smaller than their female counterparts – few male pike ever exceed 4kgs in weight. A few notable exceptions to this generalisation have been noted – the largest male pike encountered in an Irish lake survey was a fish weighing 29lbs (13.2kgs). This individual had a non functional gonad.

2.6 Differential Growth Patterns and Life Span

Male and female pike in Irish lakes have distinctly different growth rates with the female fish growing faster and living longer than their male counterparts. Growth patterns for overall pike populations in five Irish lakes and one English water (Windermere) are provided in (Figure 2a). The differential growth pattern for males and females in Lough Sheelin are illustrated (Figure 2b).

Pike in Irish lakes are relatively fast growing short lived fish. Few individuals in a stock exceed six years of age. It is very unusual to find any fish in a stock exceeding ten years of age (Figure 6).

2.7 Pike Stock Structure (Lake Populations)

The population structure of an undisturbed lake pike population (for fish > 24cm) is illustrated (Figure 3). Undisturbed, in this context, means a population largely unaffected by angling and subject to no management – i.e. fluctuations in the stock are entirely related to changes in recruitment levels, natural mortality, predation and the availability of food.

The percentage length frequency for pike in Figure 3 was that established in a netting survey of lower Lough Corrib in 1996 following a six year period when stock management was significantly reduced due to a lack of resources. These data illustrate two important points.

- Even in large productive water bodies, like lower Lough Corrib, the pike stock does not include large numbers of fish >10kgs. in weight. There is a misconception among anglers that there are "endless numbers" of 20 to 30 lb fish in such waters. This is simply not the case – <u>few fish live long enough to reach that weight</u>.

- The population structure will contain a substantial number of young adult fish (50cm-80cm in length) with a very sharp tapering off in numbers above 80cm in length. <u>This represents the norm for an undisturbed Irish lake pike population</u>.

2.8 The Dietary Habits of Pike (In Lakes)

On hatching the first food of pike in Irish lakes consists of Cladocera and Copepoda (Kennedy, 1969). In their first year they graduate to feeding on available macroinvertebrates.

Extensive investigations have been carried out in relation to the dietary habits of older pike in Irish lakes. The data provided in Figures 4a and 4b illustrate a typical dietary pattern for pike of varying sizes in a productive Irish lake – these are Lough Sheelin data compiled from samples captured in annual surveys on this lake over 30 years. A number of points are noteworthy.

- Small pike (<39.9cm) live principally on invertebrates (Asellus and Gammarus) and fish fry (Figure 4a).

- Medium sized pike (40cm to 59.9cm) still have a decided preference for crustaceans and, to a lesser extent, consume fish (Figure 4b).

- Larger pike have a decided preference for fish as a dietary item (Figure 5a). They also show a very marked bias for feeding on trout even when far greater numbers of roach (compared to trout) are available (Table 1).

- An additional study of the dietary habitats of 1,690 pike examined seasonally over two years from L. Sheelin as part of a Ph.D. study indicated similar trends – the incidence of trout as a prey item for pike increased with pike size and trout were the single most important prey item for pike >60cm in length despite the presence of substantial roach numbers at that time (Gargan et. al., In Prep.).

These findings are not unusual in relation to Irish waters. Healy (1956) noted the dominance of trout in the diet of pike in Lough Glore despite the presence of a large perch stock.

Toner (1959) in his research into the food of pike in Lough Corrib states that "1,710 pike weighing nearly 5.5 tonnes, were calculated to have eaten over 46 tonnes of trout and 11 tonnes of coarse fish".

3. AN UNSTABLE ECOSYSTEM

Stocks of pike and other fish species in Irish lakes have fluctuated widely since the late 1970's as a consequence of ecological instability – the question of pike management and its impact on stocks is regarded here as a separate issue and will be dealt with separately in Section 4. The fluctuations in stocks illustrated here are a direct consequence of ecological changes in our lakes.

3.1 Critical Changes and the Rationale for Monitoring Exercises

A number of factors are involved, the most critical being:-

a) The onset of serious cultural eutrophication problems from the late 1970's in many lakes
b) The introduction of roach to many catchments at some point since the early 1980's
c) The introduction and establishment of large zebra mussel populations

A number of other introductions (of fish, invertebrates and plants) in more recent times may lead to further instability and major changes in future years. Recent introductions of note include a freshwater shrimp (*Gammarus tigrinis*) to Lough Conn in the 1990's, an American amphipod (*Crannogonix pseudogracilis*) which is now widespread across Ireland (J. Caffrey, pers. comm.), a number of exotic aquatic plants, particularly Lagarosiphon, and a European fish species called Chub (*Leuciscus cephalus*). The difficulty with all such introductions is that, in their "new environment" (Irish waters) we have no guarantee that they will "fill a certain niche" as they do in Britain, mainland Europe or elsewhere. Ireland's freshwater ecology is quite unique. For example indigenous Chub populations in southern Britain or France do not have the option of living in shallow, productive limestone lakes like Loughs Ree or Corrib. We have therefore no published literature to aid us in trying to assess their longterm impacts on the existing flora and fauna of Irish waters. In these circumstances the importance of longterm monitoring in managing and understanding the dynamic of our lakes cannot be overstated.

3.1.1. Observations in Relation to Changes in Lough Sheelin

The status of fish stocks in Lough Sheelin has been monitored annually (except for 3 years) since 1978. Over the period 1978 to 1993 adult pike numbers were controlled with a netting programme so comment in relation to natural fluctuations in pike stocks is irrelevant. However, in relation to brown trout, roach and perch, major fluctuations in stock densities are evident. These changes can be related to fluctuations in cultural eutrophication levels (as measured here in chlorophyll 'a' values) (Figure 6). As the lake became more

eutrophic trout stocks declined very significantly. A partial recovery in the trout population in the mid 1990's was evident following a temporary abatement of the pollution problem. In complete contrast perch stocks, over the same period, tended to expand when the lake was badly polluted and fell when cleaner conditions were evident (Figure 6). Roach were only recorded as being present in Lough Sheelin for the first time in 1980. However, in the polluted conditions they thrived. By 1986 the numbers and biomass of roach exceeded, by far, the numbers and biomass of all other species in the lake (Figure 6). Following an improvement in water quality in the lake in the early 1990's the roach populations completely collapsed (Figure 6).

From 1999 to date (2007) pike control had largely ceased on Lough Sheelin. Consequently fluctuations in pike populations over this period can be regarded as part of the natural dynamic. The roach population continued to expand from 1999 onwards reaching an all time high in 2003. Substantial perch numbers were also present over this period (Figure 6). The chlorophyll a values in Lough Sheelin fell significantly in 2004 and have stayed at very low levels since – research has shown that this is due to the now established zebra mussel population and not to any significant reduction in phosphorous input to the lake (Kerins et al, 2007). Following the elimination of algal blooms in the lake the huge roach population crashed, perch numbers declined markedly and no significant increase in trout numbers was evident. Pike stocks declined markedly and understandably – clearly the very large roach stock and substantial perch population was providing sufficient fodder to maintain a large pike population (Figure 6). In the absence of a major supply of fodder fish, of any species, the large pike population, present in 2004, could not survive. A significant decline in pike stocks was evident in '05, '06 and '07 (Figure 6).

3.1.2 The Crucial Importance of the Sheelin Data and Information from other Fisheries

From a pike management perspective these Sheelin data are very important for two very different reasons:-

I. The changing ecological status of Lough Sheelin since the late 1970's, because of cultural eutrophication, the introduction of roach and, subsequently zebra mussels, is probably a microcosm of what has been happening to fish stocks, particularly pike and roach, in the Shannon lakes generally since the 1990's. These data suggest that, as zebra mussel infestations in these lakes eliminate major algal blooms, the extraordinary large roach stocks generated by the pollution problems subsequently collapsed. Where this happens pike populations will inevitably decline significantly in waters, like Sheelin, where the recruitment of pike is not limited by the availability of quality pike spawning and nursery water, but by the absence of fodder fish, including trout.

The evidence now available suggests that it is unlikely that the artificially high level of pike stock in the Shannon main stem and large lakes will ever recover to the “pre zebra mussel era” unless mussel populations collapse and major algal blooms become a regular feature of this waters ecology.

II. Annual survey data from Lough Derravaragh, at intervals from 1979 to 2005, reflect the pattern observed in Lough Sheelin in relation to persistent algal blooms allowing an introduced roach stock to expand to extraordinarily high levels and then subsequently crash once an established zebra mussel population (early 1990’s) has eliminated algal blooms (Figure 7). In contrast to Lough Sheelin it is noteworthy that pike stocks remained at a relatively low level. Pike netting has not been a feature of the fishery management programme on Lough Derravaragh since the mid 1980’s. Yet, they (pike) did not increase or decrease appreciably as roach stocks fluctuated (Figure 7). There is an inference here that, in Lough Derravaragh, unlike Sheelin, the lakes capacity to produce pike, rather than the availability of fodder fish is capping pike production.

Trends evident in Lough Ennell reflect the pattern seen in Lough Derravaragh – i.e. standing crops of pike, over time, have not increased significantly when increased fodder fish became available. In the case of Lough Ennell the increased fodder base for pike was in the form of trout, roach and some perch (Figure 8).

4. THE NECESSITY FOR, AND EFFECTIVENESS OF, PIKE MANAGEMENT ON LAKE BROWN TROUT FISHERIES

4.1 The Effectiveness of this Measure

A number of data sets are available to illustrate the effectiveness of adult pike control in lake trout fisheries.

4.1.1. The Lough Sheelin Management Programme

In the autumn/spring periods of two successive years (1977/78 and 1978/79) the standing crops of adult pike in Lough Sheelin were estimated (O'Grady, 1983) – the estimates for the two periods in question were 1198 and 882 fish respectively. The length frequency range of individuals involved was from 45.7cm to 57.2cm in length. The reader should note that in the early 1970's up to 15,917 pike were removed from this lough per annum (O'Grady, 1983). This means, in essence, that the standing crop of adult pike in the 1977 to 1979 period was less than 6% of the standing crop present in 1971. This clearly shows just how effective this operation can be.

4.1.2 Reviewing Data Sets following the Cessation of Pike Control Measures

The rapid expansion of pike populations, following the cessation of control measures, has been noted on two other waters, lower Lough Corrib and Lough Carra. The temporary cessation of pike control measures on both of these waters was due to a temporary lack of resources – not to any change in management strategy.

The pike stock structure in lower Lough Corrib, at five intervals between 1968 and 1996, are illustrated (for 1968, 1975, 1981, 1986 and 1996) (Figure 9). Substantial management of pike numbers from the late 1950's through to 1968 are reflected in the stock structure present in 1968 i.e. – a population with limited numbers of adult fish (Figure 9). Declining control levels in the early 1970's lead to an expansion in the proportionality of larger pike in the stock by 1975 (Figure 9). More rigid control of pike numbers through the latter half of the 1970's lead to a diminution of large pike in the stock by 1980 (Figure 9). Following a complete cessation of netting in 1982 a major recovery in the proportionality of adult pike in the population was evident by 1986. Through the 1990's up to 1996 pike netting in lower Lough Corrib had ceased. This is clearly reflected in the stock structure in the 1996 survey (Figure 9).

A similar trend was evident in relation to fluctuations in pike standing crops in Lough Carra. Adult pike stocks were controlled in Lough Carra through the

1970's and up to 1981. Due to lack of resources pike control was very limited thereafter from 1981 to 1986. Annual fish stock surveys were carried out on Lough Carra in 1978, 1979, 1980, 1981 and 1986. The major reduction in pike control operations from 1981 onwards are reflected in these survey data – i.e. a five fold increase in adult pike numbers was evident in Lough Carra five years after a major reduction of netting exercise (Figure 10).

In summary these data for Loughs Carra and lower Lough Corrib again illustrate how effective adult pike control programmes can be and also illustrate the resilience of a pike population to recover once netting programmes cease.

4.2 The Necessity for Control

The necessity for controlling adult pike populations in managed lake trout fisheries is a straightforward issue for a number of reasons:-

I. Adult pike in trout lakes show a clear preference for consuming adult trout even in circumstances where other fish species are much more abundant than trout (roach and/or perch) (Table 1).

II. Pike, like all predatory fishes, have relatively poor maintenance and food conversion rates – Fitzmaurice (1983) estimated that pike in Irish lakes had maintenance and food conversion rates of circa 5:1 and 7:1 respectively. In circumstances where pike are feeding principally on trout a relatively small adult pike population could consume a very substantial number of adult trout. For example a single pike which increased in weight from 2.3kgs to 3.6kgs in a year could have consumed 9.1kgs of trout (circa eighteen 3+ year-old fish). One can see that a substantial adult pike population can "cap" an adult trout stock. This is the kernel of the issue. The quality of trout angling on many managed lake trout fisheries will decline markedly where adult pike stocks are not managed.

4.3 Where is Control Currently Required?

Essentially a combination of factors determine the necessity for pike control on managed lake trout fisheries. Three of the most important factors are:

I. The extent and quality of pike nursery areas in individual waters – i.e. with an increasing availability of fodder can an adult pike populations expand to exploit a greater food supply? This will be dictated by the extent of weeded area in a water relative to its overall surface area.

II. Trout recruitment rates to individual managed lake trout fisheries are very variable. In waters with very small trout recruitment rates because

of very limited stream production areas (productive wetted area) the presence of pike can actually lead to the extinction of native trout stocks (see page 4). This is rather unusual in Ireland. The norm is more likely to be a severe reduction in the trout population to a point where the quality of trout angling is significantly impaired.

III. The extent to which a trout population feed pelagically can also influence pike predation rates. Pike cannot hunt pelagically feeding fishes. They target fish feeding in sublittoral areas within, or close to, weed bed areas.

Taking particular cognisance of i to iii (above) and reviewing all of the available lake trout survey data compiled over the last 30 years the author would make the following specific recommendations for the necessity, or not, for pike control in managed lake trout waters.

4.3.1 Specific Recommendations for Individual Waters

4.3.1.1 Lough Sheelin

The rapid expansion of the pike population in this water when fodder levels increased in the early years of this century show that pike stocks in this water can expand rapidly when additional food supplies are available – this population of pike subsequently declined markedly when this large food supply (mostly roach and some perch) was no longer available (Figure 6). Over the next five to ten years in Lough Sheelin one would expect to see a gradual recovery of the wild trout population and a further expansion of weed bed areas – no significant expansion of the current small roach population is likely in the continued absence of persistant algal blooms.

In these circumstances one can expect to see the pike population expand in tandem with any increase in wild trout standing crops. The very large population of trout, evident in the lake in the 1970's will not be regenerated unless pike stocks are controlled – heavy pike predation will depress trout stocks to a point where quality angling will not be available.

4.3.1.2 Loughs Ennell, Owel and Derravaragh

A significant fish stock survey database is now available for these three waters (Figures 7, 8 and 11). There has been no pike control programme in operation on these waters for 5 years on Lough Ennell and a much longer period (15 years or more) on Owel and Derravaragh. This is the first time that a survey data set is available for these waters with lengthy periods with, and without, pike control operations in place.

Roach were first recorded in a Lough Derravaragh survey in 1979. Subsequently this population expanded to extraordinary levels (the highest ever recorded in an Irish lake survey) (Figure 7). With the introduction of zebra mussels and the elimination of persistent algal blooms early in this century the large roach population had collapsed by 2005 (Figure 7). It is noteworthy that, while roach stocks were at very high levels from 1983 to at least 1993, the type of major increase in pike populations which were evident in Lough Sheelin in similar circumstances never took place in Lough Derravaragh. There was no pike control programme in place on Lough Derravaragh from the mid 1980's onwards. A failure of the pike population to expand in this period (mid 80's to mid 90's), despite there being up to a 12 fold increase in the availability of fodder fish, indicates that pike production in this water, unlike Sheelin, is currently governed by limited quality juvenile pike nursery area.

Similar trends are evident on both Loughs Ennell and Owel, where despite increases in the availability of pike fodder fish (roach, wild trout and perch on Ennell and perch and rudd on Lough Owel) and the absence of a pike netting programme in recent years no significant increase in adult pike numbers is evident (Figures 8 and 11). Clearly ecological conditions (limited quality pike nursery areas) are governing adult pike production in both waters.

In the light of these findings the author can see no reason to reintroduce pike control programmes on these three lakes in the immediate future on the basis that:-

I. their capacity to produce pike is relatively limited

II. the current largely "undisturbed" pike population, particularly in Lough Ennell, did not prohibit a significant increase in the adult wild trout population in this lake following the Shannon Regional Fisheries Boards successful stream enhancement programme in this fishery. Lake survey C.P.U.E. values for wild trout in Lough Ennell surveys from 2002 and 2006 ranged from 3.4 to 4.0 (Figure 8). The highest wild trout C.P.U.E. value ever recorded in a midland trout lake was 5.0 in Lough Sheelin in 1978 (Figure 6). Given that Lough Ennell has a significantly smaller euphotic zone than Lough Sheelin it is likely that a C.P.U.E. value for wild trout in Lough Ennell of 4.0 reflects this waters optimum trout carrying capacity.

4.3.1.3 Lough Inchiquin

This water was surveyed on three occasions in the late 1970's. 2002 survey data compiled in relation to trout and pike C.P.U.E. values for these surveys are presented in Figure 12. A pike control programme was in place on this water in the 1970's. However, there has been no pike control programme on this water for over 20 years.

Data indicate similar C.P.U.E. values for trout in the 1970's and 2002 surveys. The pike population therefore would appear to be having no major impact on the trout population. A combination of two factors are probably involved here:-

I. Lough Inchiquin is a deep lake with limited weeded areas. This probably "caps" the production of pike at a relatively low level.

II. This water is naturally eutrophic and generates very large zooplankton populations. Survey data suggest that a majority of the trout in this water have a pelagic existence for lengthy periods of the year feeding on zooplankton. All survey data for Irish lakes indicates clearly that pike will not /cannot prey on pelagic fishes. This factor may significantly reduce the vulnerability of trout in Lough Inchiquin to predation by pike.

Currently the author would see no significant advantage, in trout management terms, to reintroducing a pike control programme on this water.

4.3.1.4 Loughs Corrib and Mask

O'Grady et al (1996) estimated that the pike population in Lough Corrib, in 1995 alone, had probably consumed 255,000 trout, a maintenance ration for pike of circa 116 tonnes of trout per annum. While there are established roach populations in both Corrib and Mask the numbers present are very small – the culturally eutrophic conditions which caused the "explosion" of roach stocks in waters like Sheelin and Derravaragh have not developed in these western lakes. Consequently trout will be the dominant food item in the pikes diet. The existing pike stock in Corrib in 1996 had probably consumed a total of circa 736,463 trout to reach their recorded standing crop figure in 1996 (O'Grady *et. al*, 1996).

Lough Corrib, like Lough Sheelin, has very extensive weeded areas. Recent electro-fishing surveys have indicated that these zones are very high quality pike nursery areas. It is likely therefore that, like the Lough Sheelin population, the pike population can expand to exploit any increases in available fodder fish (mostly trout (80%) in this case). An uncontrolled pike population in Lough Corrib has the capacity to consume circa 50% of the trout standing crop thereby seriously depressing the quality of this fishery as a trout angling venue.

The survey data compiled for Lough Corrib in 1996 followed a lengthy period when no pike control programme had been in place. A review of the pike stock structure on lower Lough Corrib, at intervals, from 1968 to 1996 shows just how effective adult pike control programmes can be when in place (Figure 9).

Given the capacity of pike in Lough Corrib and Mask to consume very large numbers of trout and the ability of these populations (of pike) to expand, should additional fodder fish (more trout) become available, it is imperative that pike

control operations continue on these large lakes to ensure a continuity of quality trout angling in future years.

4.3.1.4.1 Effectiveness of the Current Pike Control Programme on Loughs Corrib, Mask and Carra

A pike control programme on an Irish trout lake will only prove effective, in terms of significantly reducing predation rates on trout, if one can remove a substantial proportion of the pike in the stock which are ≥ 50cm in length – fish >2.5kgs in weight (Section 2.8).

Data are provided here in relation to the mean weight of pike which have been removed in the control programme on Loughs Corrib, Mask and Carra annually from 2003 to 2007 inclusive (Table 2). These data show that the population of pike in all three lakes is currently dominated by young fish. This means that the major threat of predation by large pike on trout is currently being effectively controlled.

4.3.1.5 Lough Carra and Arrow

These two lakes have been managed as trout fisheries since the late 1950's. Pike management programmes have been, and still are, a part of the management programme on both waters.

The productive trout nursery stream area (m^2) for individual trout lake subcatchments are compared to the surface area (km^2) of the particular lake they are servicing (Figure 13). These data show that the two managed trout lakes with least potential for trout recruitment, are Loughs Carra and Arrow. This fact has long been recognised – the stream sub-catchments to both lakes were specially targeted during the TA.M. programme for enhancement to try to optimise trout production.

Given the severe natural "cap" on trout recruitment to both lakes it is absolutely crucial that pike management programmes continue on both lakes. Even limited predations by pike on trout could significantly reduce the adult trout population to a level where these lakes would no longer function as viable trout fisheries.

O'Grady et al (1996) calculated that the standing crop of pike in Lough Carra in 1996 had probably eaten a total of 4,705 trout in 1995 alone. This figure (4,705) could be as high as 50% of the entire population of trout in Lough Carra (O'Grady, 1996).

4.3.1.6 Loughs Conn and Cullin

The ecology of these two waters has become very unstable over the last decade (O'Grady and Delanty, 2001). The following major changes took place:-

I. a large char population present in Lough Conn up to the mid 1980's became extinct by the 1990's.

II. the onset of major cultural eutrophication problems were evident in the 1990's.

III. the large population of relatively small trout present in both lakes up to 1990 declined markedly thereafter and was replaced by a much smaller population of faster growing large trout. Angling catches of trout, per rod day, declined markedly. A major increase in the populations of rudd became evident in both lakes at the start of this century.

IV. roach, a species introduced to both waters in the mid-1990's, became prolific by 2001 – a similar trend to that observed in earlier decades in Loughs Sheelin and Derravaragh (Figure 14).

V. There has been a significant increase in stock density of pike in Lough Conn, at intervals, from 1978 to 2001 (Table 3) despite an ongoing pike control programme. The expansion of the pike population is most likely related to the large increase in the availability of fodder fish (roach and rudd) in this lake since 1990 – the huge expansion of cyprinid populations despite a concurrent reduction in trout numbers means that a far greater abundance of fodder fish was available to pike.

   This trend is also reflected in pike cropping rates for Lough Conn. A comparison of the numbers of pike cropped annually prior to the onset of major eutrophication problems and the introduction of roach (1969 to 1979) with figures from recent years also reflect the increase in the pike population (Table 3 and Figure 14). The mean (x) weight of pike being cropped in Lough Conn in recent years (2002-2006) remains at a relatively low level indicating that this control operation, like those in operation on Loughs Corrib, Mask and Carra is being efficient.

VI. Zebra mussels were found in Lough Conn in 2006 and have since become widely distributed throughout this lake.

To date the series and sequence of major ecological changes evident in Loughs Conn and Cullin mirror those evident in Loughs Sheelin in 1980's and 90's. More recent survey data from these lakes (2005-2007) (not yet fully processed) indicates that the ecological instability described above continued at least up to 2007.

If the trends evident to-date in Lough Sheelin are mirrored in Conn and Cullin over the next 5 years then one might expect to see a collapse of cyprinid populations and possibly a recovery of the trout population. The increase in pike

stocks in these two lakes, since 1990, indicate the necessity for a continued pike control programme – an expanding trout stock and declining cyprinid stock would simply result in the pike targeting the increasing trout population.

Though there is no guarantee that the trends evident to date in Lough Sheelin will be mirrored in Lough Conn over time. Should a lot of the algal production in Lough Conn be epiphytic (as opposed to phytoplanktonic) this material will not be consumed by zebra mussels. In these circumstances the large cyprinid populations will persist until such time as the background pollution problems are resolved. These circumstances would obviously encourage continued high predation levels of pike. This pike population will selectively prey on trout even if cyprinid stocks remain numerically dominant (see Section 2.8).

4.3.1.6 Smaller Trout Lakes

Numerous smaller lakes in various parts of Ireland are stocked with hatchery trout to provide angling. Many of these waters have extensive weeded areas and therefore a significant capacity to produce pike where they are present. Hatchery trout stocked in lakes, initially, have no fear of predators and will be consumed in large numbers by pike and cormorants (O'Grady, 1981). Consequently when stocking trout in small lakes which support a pike population one should be aware that:-

I. A resident pike stock will probably consume a majority of the hatchery fish unless:-

   a) Many trout are cropped by anglers shortly after their release

   b) Stocked trout are ≥1.0kg in weight on release – only the very large pike will consume very big trout

   c) The larger pike (>50cms in length) are controlled thereby limiting predation levels.

4.4 The Future

The Fisheries Boards in Ireland were well aware of the necessity of monitoring the ecological status of our lakes long before the adoption of the Water Framework Directive – monitoring operations have been in progress since the late 1970's. Data compiled has been used to generate scientifically based management programmes, not just in trout lakes, but in relation to all major aquatic resources in Ireland. The available data base on both riverine and lake fish stocks far exceeds that available in most European countries and provides a rational basis for all our fishery management programmes.

The alarming ecological changes which have taken place in many of our trout lakes since the 1970's, regrettably may continue in future years – particularly in relation to the introductions of additional exotic plants, invertebrates and fish species. It is therefore absolutely essential that monitoring programmes continue to assess change over time and, where necessary, alter management programmes to accommodate new circumstances.

Currently additional practical research programmes, funded and/or supported by the national research fund of the Fisheries Boards are underway. Stable isotope analysis of fish flesh samples are ongoing to provide us with a greater understanding of the position and interaction of different fish species (trout and cyprinids) in our lake ecosystems.

A detailed study of ecology and biology of zebra mussels in Lough Sheelin will be completed later this year.

Genetic studies, using micro satellite D.N.A. markers, are also in progress in relation to trout and cyprinid fishes to see if these procedures can be of practical value in fishery management terms.

A study of the ferox trout populations in Lough Corrib is also in progress. Radio tagged fish are being tracked to establish the spawning areas of these unique trout.

5. REVIEWS OF CURRENT FISHERY MANAGEMENT PRACTICES AND POSSIBLE FUTURE STRATEGIES IN IRELAND

In recent years the Central Fisheries Board, in collaboration with the Regional Fisheries Boards, and, following wide public consultation with "user groups", have produced a number of documents in this area. The two documents of most relevance to pike management are those reviewing policy and strategy in relation to pike (Anon, 2003) and wild brown trout (Anon, 2006).

The pike document (Anon, 2003) acknowledges the necessity for controlling pike stocks or managed trout lake fisheries based on scientific advice (Anon, 2003, page 9, Section 2.1.4). The Wild Brown Trout Review Forum concurs (Anon, 2006, page 8, Section 5.1.3). This document advances this process in updating the scientific advise following a review of 12 additional years of survey data (1995 to 2007).

The fact that the Fisheries Boards have prioritised the preparation of reviews on both pike and trout illustrates their serious intent in relation to the management of both of these resources.

6. THE EXTENT OF QUALITY LAKE ANGLING IN IRELAND FOR PIKE AND BROWN TROUT

Recently the location and extent of quality pike angling venues in Ireland ("Centres of Excellence") have been updated (http://www.cfb.ie/fishing_in_ireland/pike/where_to_fish.htm) and regional maps are also available. These data show a breath and depth of quality pike angling venues in Ireland which far exceed the few quality lake trout angling venues left. From a marketing perspective this pike angling database may need to be reviewed as zebra mussel populations colonise new waters. The Lough Sheelin monitoring programme indicates that in many culturally eutrophic lakes, which currently supports large roach stocks, one may see a significant reduction in pike populations once zebra mussels become established.

The small number of quality lake brown trout fisheries in Ireland are absolutely unique in terms of their species diversity and ecology – there are no other trout fisheries like those anywhere else in the world. The control of pike, an introduced fish species, in these waters, given the size of the pike angling resource elsewhere in Ireland, does not impede the Irish or tourist pike angler from enjoying excellent sport throughout most parts of Ireland.

7. THE FUTURE MANAGEMENT OF PIKE ANGLING FISHERIES

Current and likely future management policy for pike angling fisheries is clearly stated in the document entitled "Report on the Review of the Current Policy and Strategy for the Management of Pike and Pike Angling in Ireland" (Anon, 2003). This document was produced following extensive public debate with stakeholders.

The fact that pike was one of the first species to be considered in relation to strategic reviews of inland fisheries management practices illustrates the Fisheries Boards' clear intent to manage this species in the interest of stakeholders.

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Appendix 1 – Tables

Table 1. Total numbers of fish captured in survey nets and total number of trout and roach in pike stomachs, from the March gill netting surveys of L. Sheelin, 1980 – 2007

Table 1.	Survey date	1980	1981	1983	1986	2000	2001	2002	2003	2004	2005	2006	2007
	Fish species												
Total No.of fish captured in survey nets	Wild Trout	162	220	90	67	4	4	11	10	7	22	28	4
	Roach	3	18	97	2361	735	611	824	1492	485	47	28	44

	Survey date	1980	1981	1983	1986	2000	2001	2002	2003	2004	2005	2006	2007
	Fish species												
Total No.of fish in pike stomachs	Wild Trout	6	25	5	4	2	2	2	1	0	2	1	1
	Roach	0	0	2	9	11	14	7	5	7	4	5	6

Table 2. The numbers, total weight and mean weight of pike removed from Lough Carra, Mask and Corrib in pike control operations (2003 – 2007)

Lough Carra					
Year	2003	2004	2005	2006	2007
No. Pike	218	297	314	241	302
Wt (kg)	272.5	318.6	278.2	250.6	361.2
Ave Wt (kg)	1.25	1.07	0.89	1.04	1.20
Lough Corrib					
Year	2003	2004	2005	2006	2007
No. Pike	1016	1522	1080	1497	1563
Wt (kg)	1503.3	2153.9	1691.0	1934.2	1311.4
Ave Wt (kg)	1.48	1.42	1.57	1.29	0.84
Lough Mask					
Year	2003	2004	2005	2006	2007
No. Pike	180	840	901	291	746
Wt (kg)	382.4	1998.6	2320.2	459.3	1374.7
Ave Wt (kg)	2.12	2.38	2.58	1.58	1.84

Table 3. Pike C.P.U.E values for fish stock surveys on Lough Conn at intervals from 1978 to 2001

Year	1978	1984	1990	1994	1998	2001
Pike C.P.U.E	0.21	0.35	1.18	1.8	0.7	2.1

Table 4. Pike removal figures and weights from Lough Conn by the Inland Fisheries Trust (IFT) 1969 to 1979 and the North Western Regional Fisheries Board (NWRFB) 2002 – 2006

Pike Removal from L. Conn (from IFT annual reports and NWRFB data)			
Year	Total Nos.	Total Wt (Kg)	Ave Wt (kg)
1969	147	249.0	1.69
1970	190	413.2	2.17
1971	281	627.3	2.23
1972	304	475.8	1.57
1973	156	330.7	2.12
1974	401	856.4	2.14
1975	229	465.8	2.03
1976	269	584.2	2.17
1977	267	529.3	1.98
1978	362	871.4	2.41
1979	278	704.0	2.53
2002	1048	2210.8	2.11
2003	1136	2249.8	1.98
2004	1025	2475.7	2.42
2005	1079	2253.4	2.09
2006	381	692.2	1.82

Appendix 2 – Figures

Figure 1. Relative density of pike caught during the March gill netting surveys of Lough Sheelin (1978 – 2007) in relation to Charophyte beds

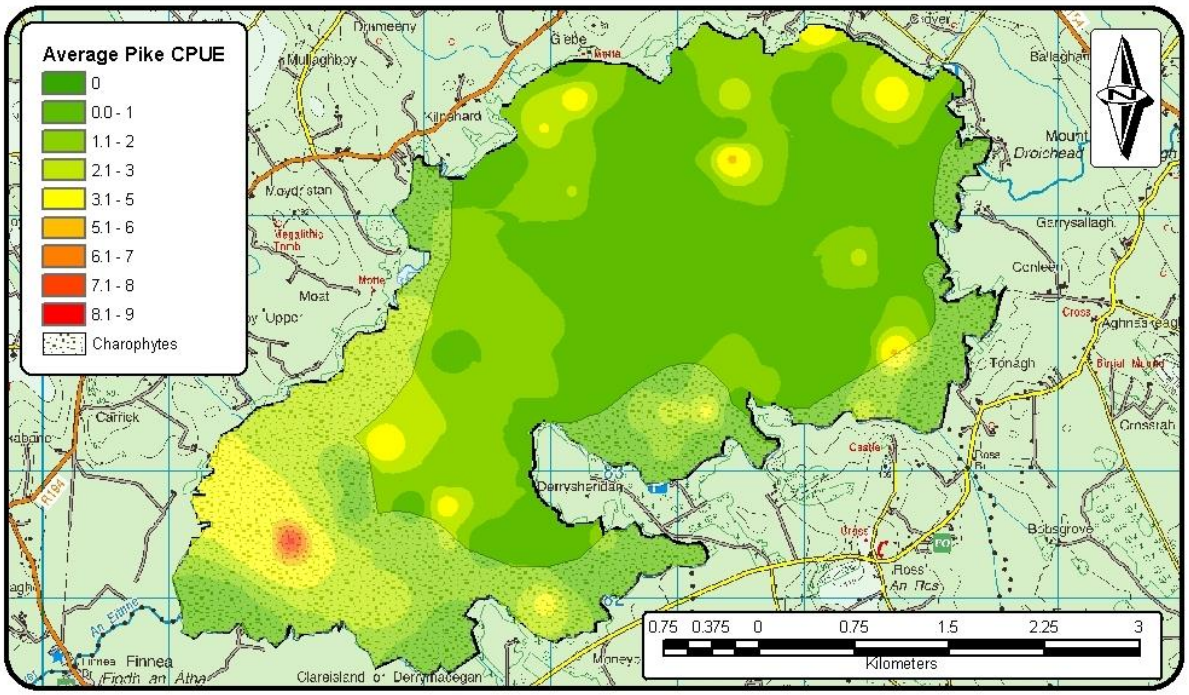


Figure 1a. Lough Sheelin Chlorophyll levels (µg/l) in 1988 and 2007

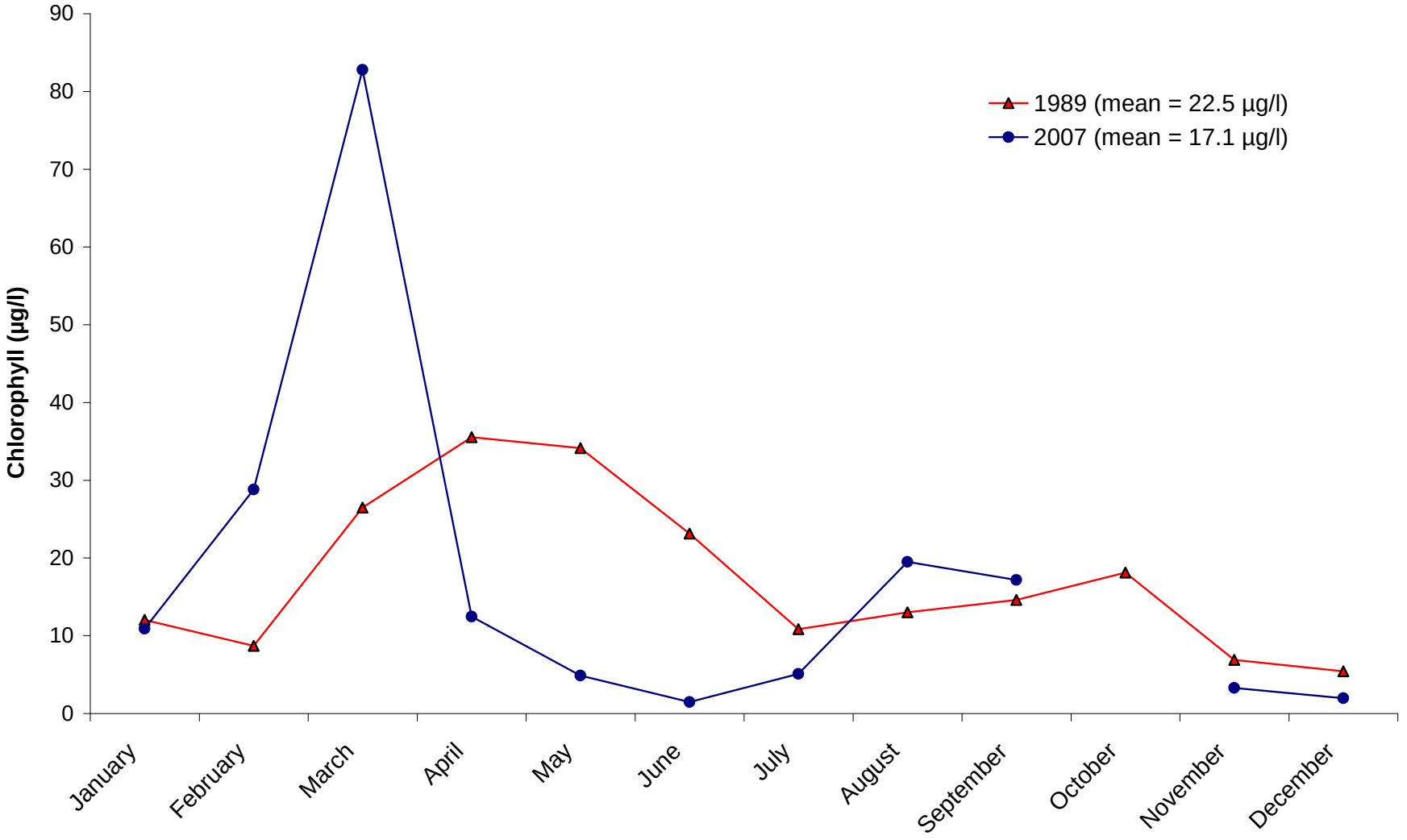
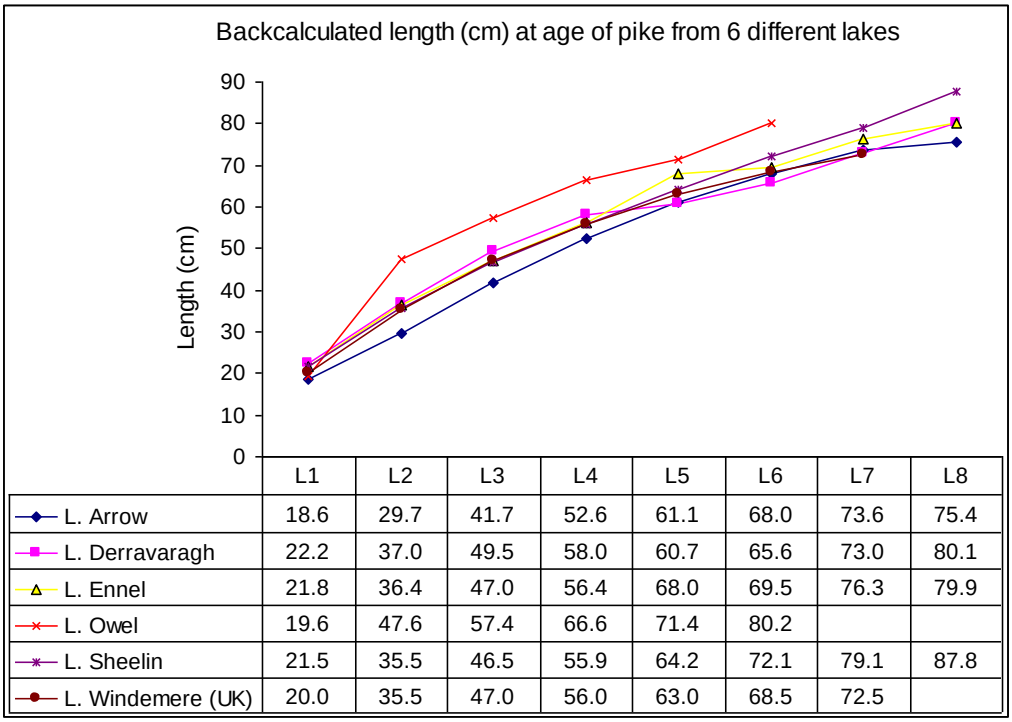
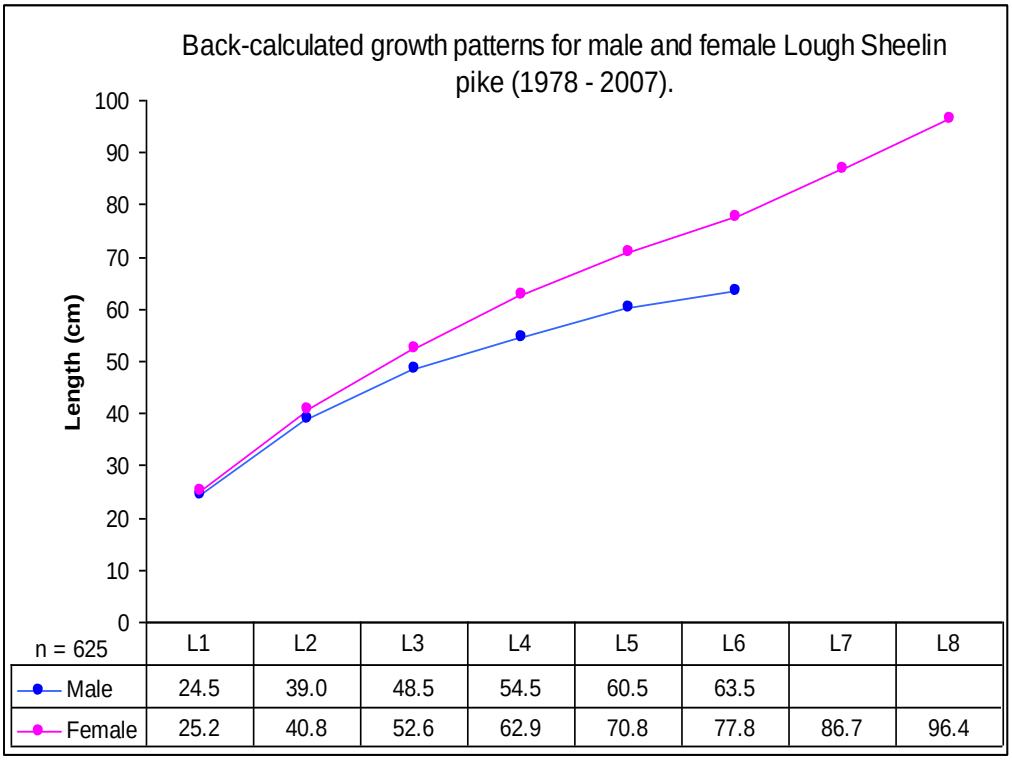


Figure 2a. Pike growth patterns for stocks in five Irish Loughs and from Lake Windermere in England



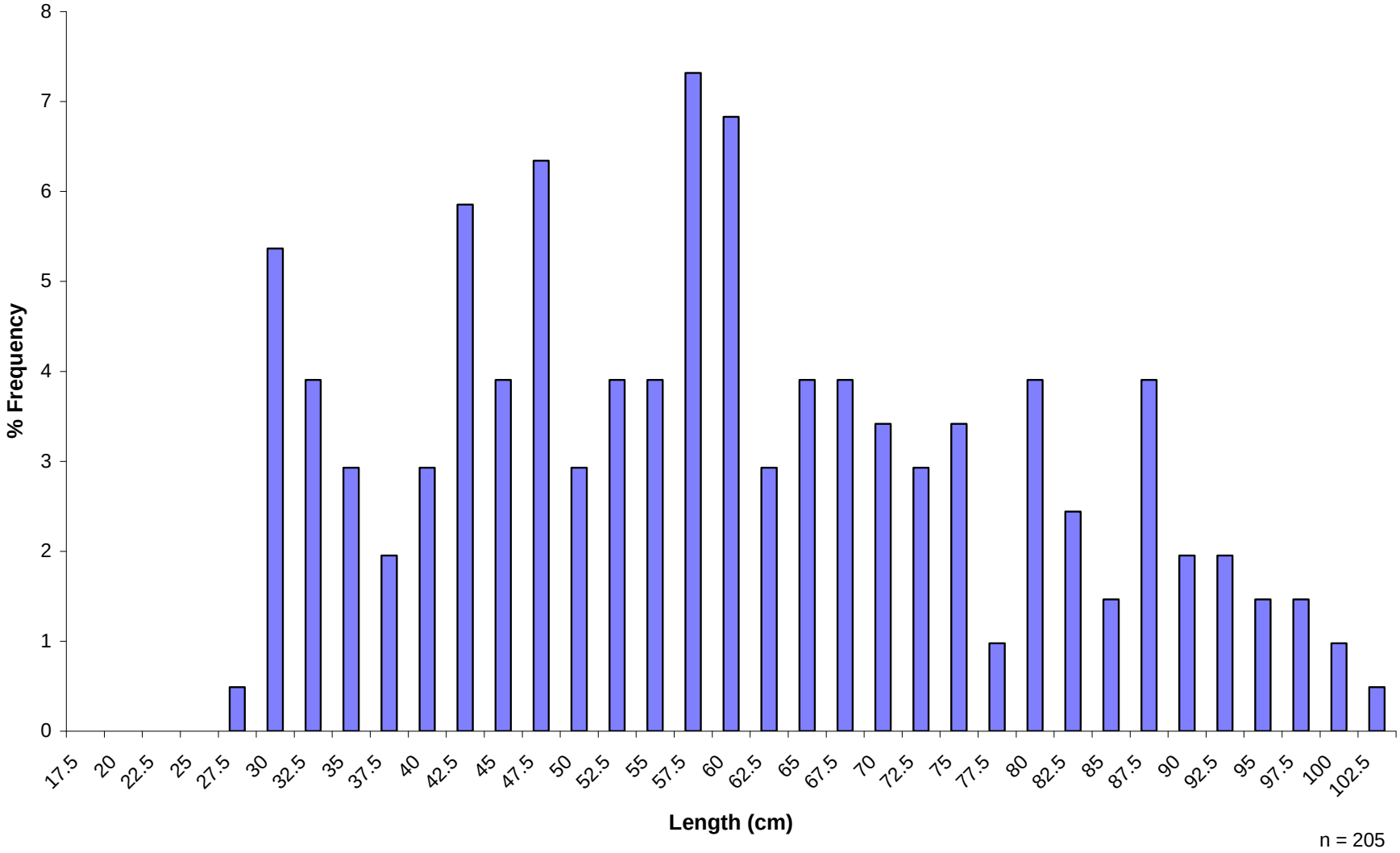
	L1	L2	L3	L4	L5	L6	L7	L8
L. Arrow	18.6	29.7	41.7	52.6	61.1	68.0	73.6	75.4
L. Derravaragh	22.2	37.0	49.5	58.0	60.7	65.6	73.0	80.1
L. Ennel	21.8	36.4	47.0	56.4	68.0	69.5	76.3	79.9
L. Owel	19.6	47.6	57.4	66.6	71.4	80.2		
L. Sheelin	21.5	35.5	46.5	55.9	64.2	72.1	79.1	87.8
L. Windemere (UK)	20.0	35.5	47.0	56.0	63.0	68.5	72.5	

Figure 2b. Separate backcalculated growth patterns for male and female pike from Lough Sheelin over the period 1978 – 2007



n = 625	L1	L2	L3	L4	L5	L6	L7	L8
Male	24.5	39.0	48.5	54.5	60.5	63.5		
Female	25.2	40.8	52.6	62.9	70.8	77.8	86.7	96.4

Figure 3. Percentage length frequency distribution of pike captured in a survey of lower Lough Corrib in 1996



Footnote – Small pike (<30 cm) are rarely captured in significant numbers in this type of survey

Figure 4a

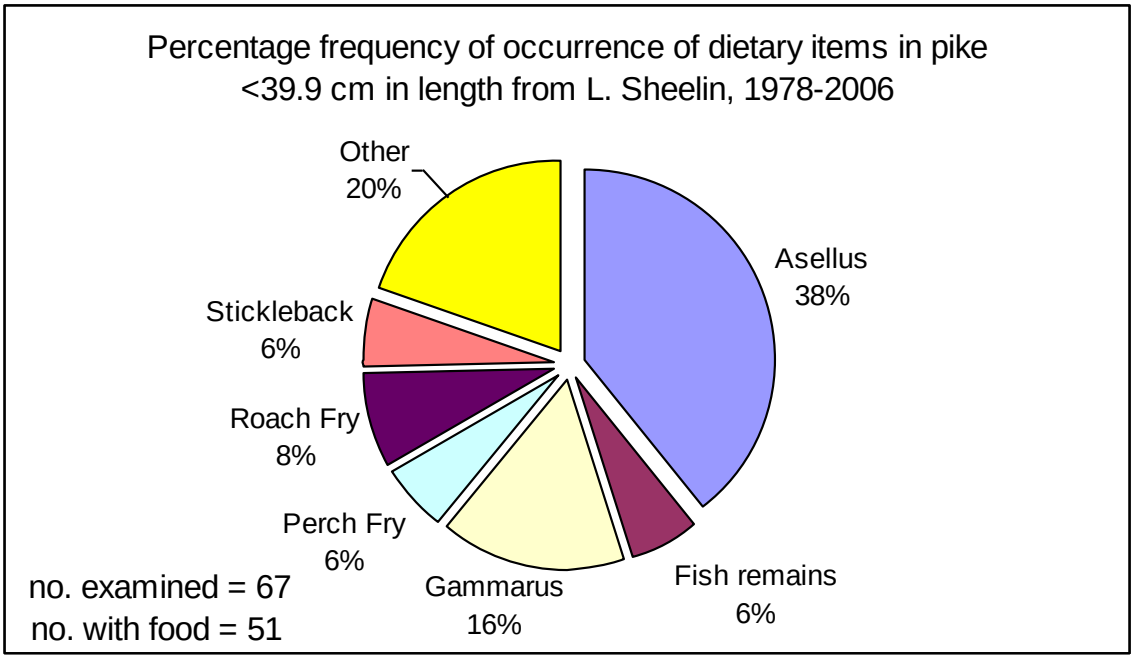


Figure 4b

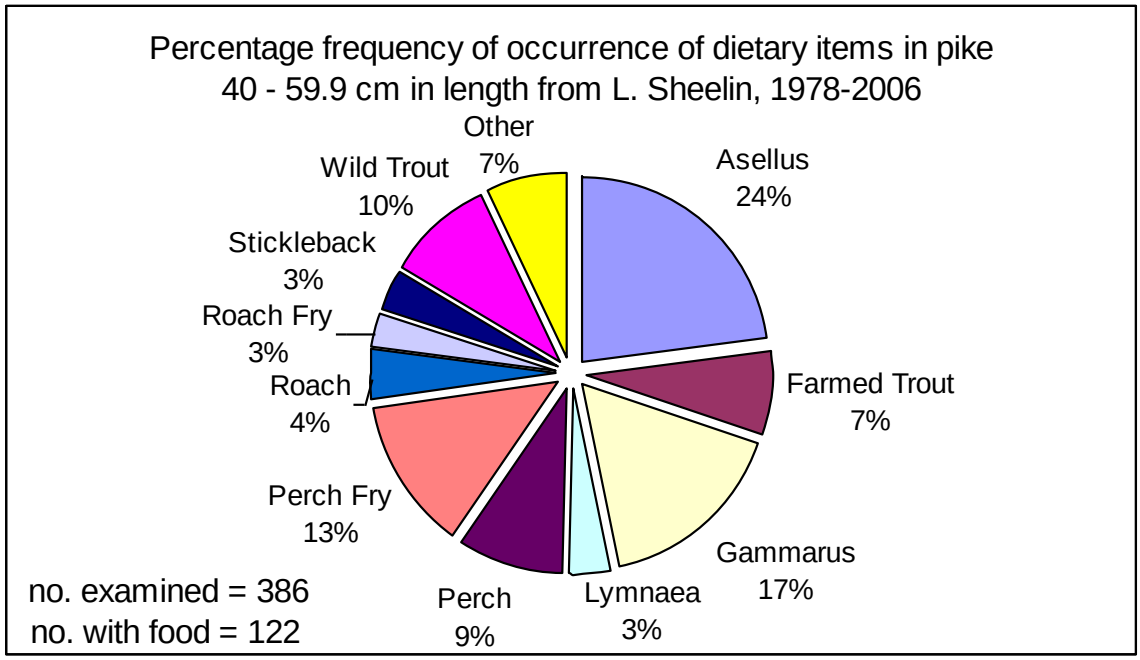


Figure 5a

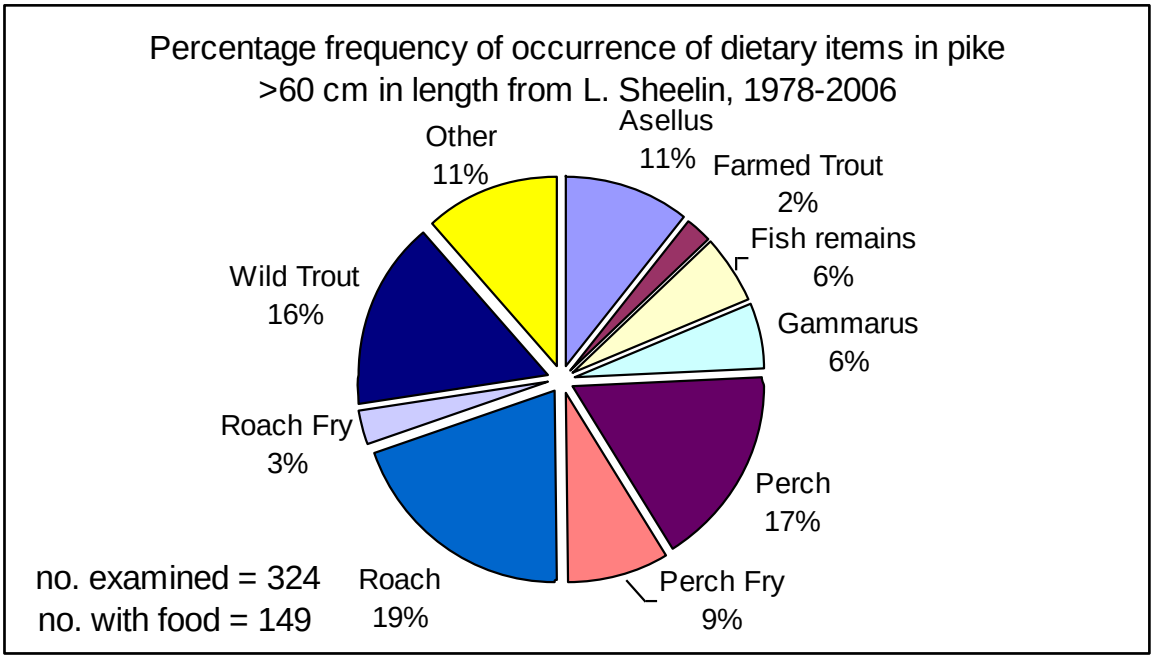


Figure 5b

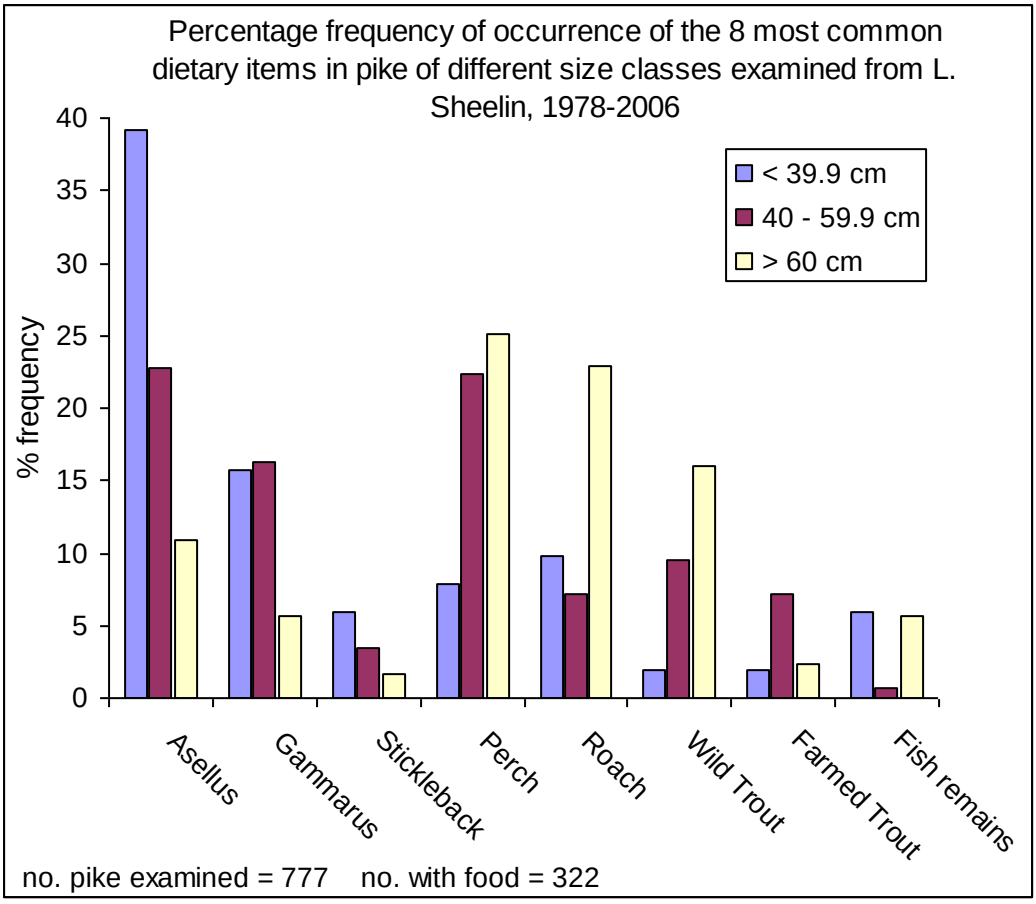
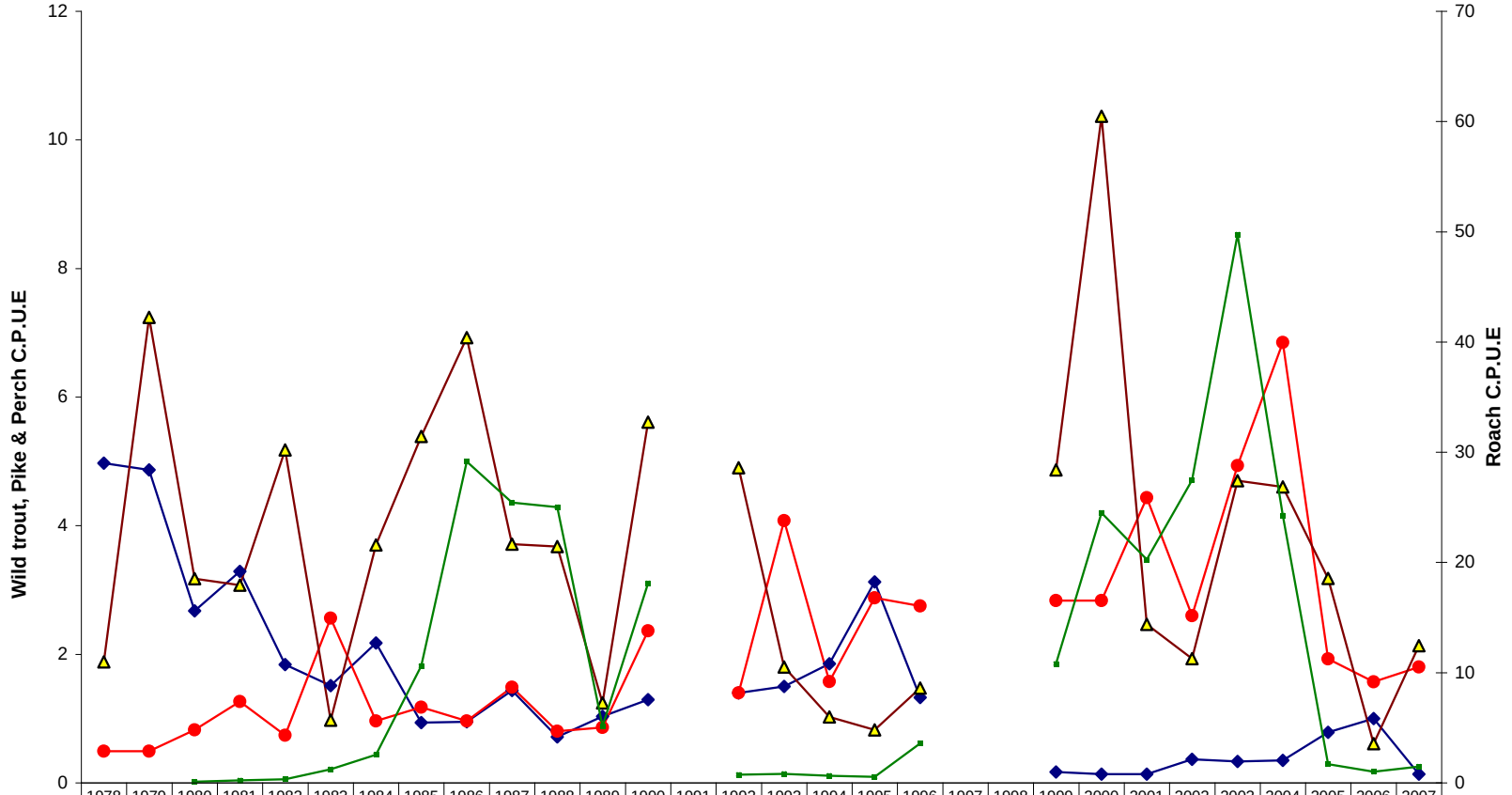


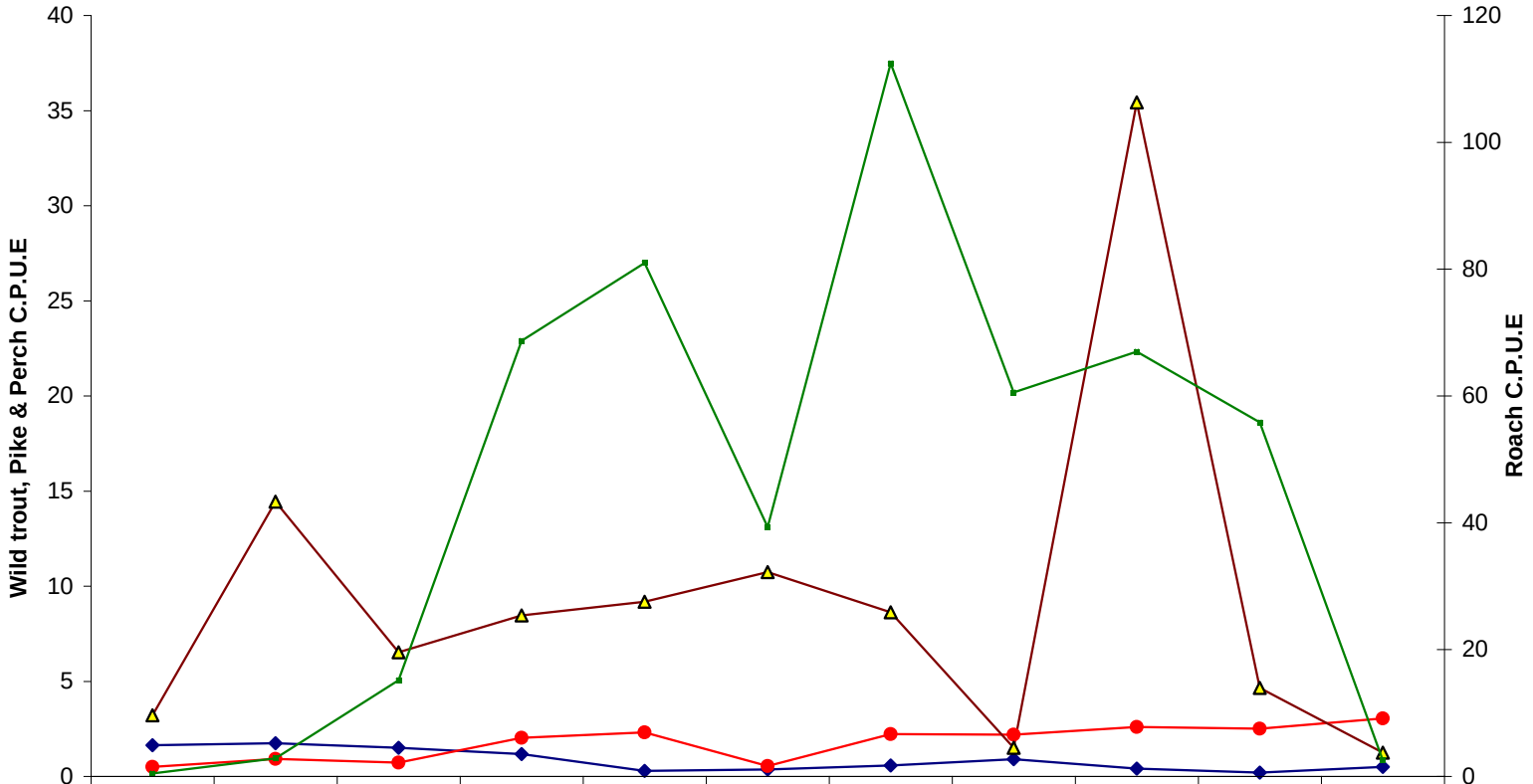
Figure 6. Lough Sheelin C.P.U.E and Chlorophyll data 1978 - 2007



	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Wild Trout	5.0	4.9	2.7	3.3	1.8	1.5	2.2	0.9	1.0	1.4	0.7	1.0	1.3		1.4	1.5	1.9	3.1	1.3			0.2	0.1	0.1	0.4	0.3	0.4	0.8	1.0	0.1
Pike	0.5	0.5	0.8	1.3	0.7	2.6	1.0	1.2	1.0	1.5	0.8	0.9	2.4		1.4	4.1	1.6	2.9	2.8			2.8	2.8	4.4	2.6	4.9	6.9	1.9	1.6	1.8
Perch	1.9	7.2	3.2	3.1	5.2	1.0	3.7	5.4	6.9	3.7	3.7	1.2	5.6		4.9	1.8	1.0	0.8	1.5			4.9	10.4	2.5	1.9	4.7	4.6	3.2	0.6	2.1
Roach*			0.1	0.2	0.3	1.2	2.5	10.6	29.1	25.4	25.0	5.1	18.1		0.7	0.8	0.6	0.6	3.6			10.8	24.5	20.3	27.5	49.7	24.3	1.7	1.0	1.5
Chlorophyll mg/m3	17.4	29.2	28.0	39.6	61.1	20.9	14.9	18.1	31.2	40.1	23.3	22.5	9.5	8.8	8.6	15.0	24.5	20.7	14.2	19.1	32.2	23.6	23.8	19.3	24.3	20.4	11.1	5.7	5.8	17.1

* Roach C.P.U.E values on right hand axis

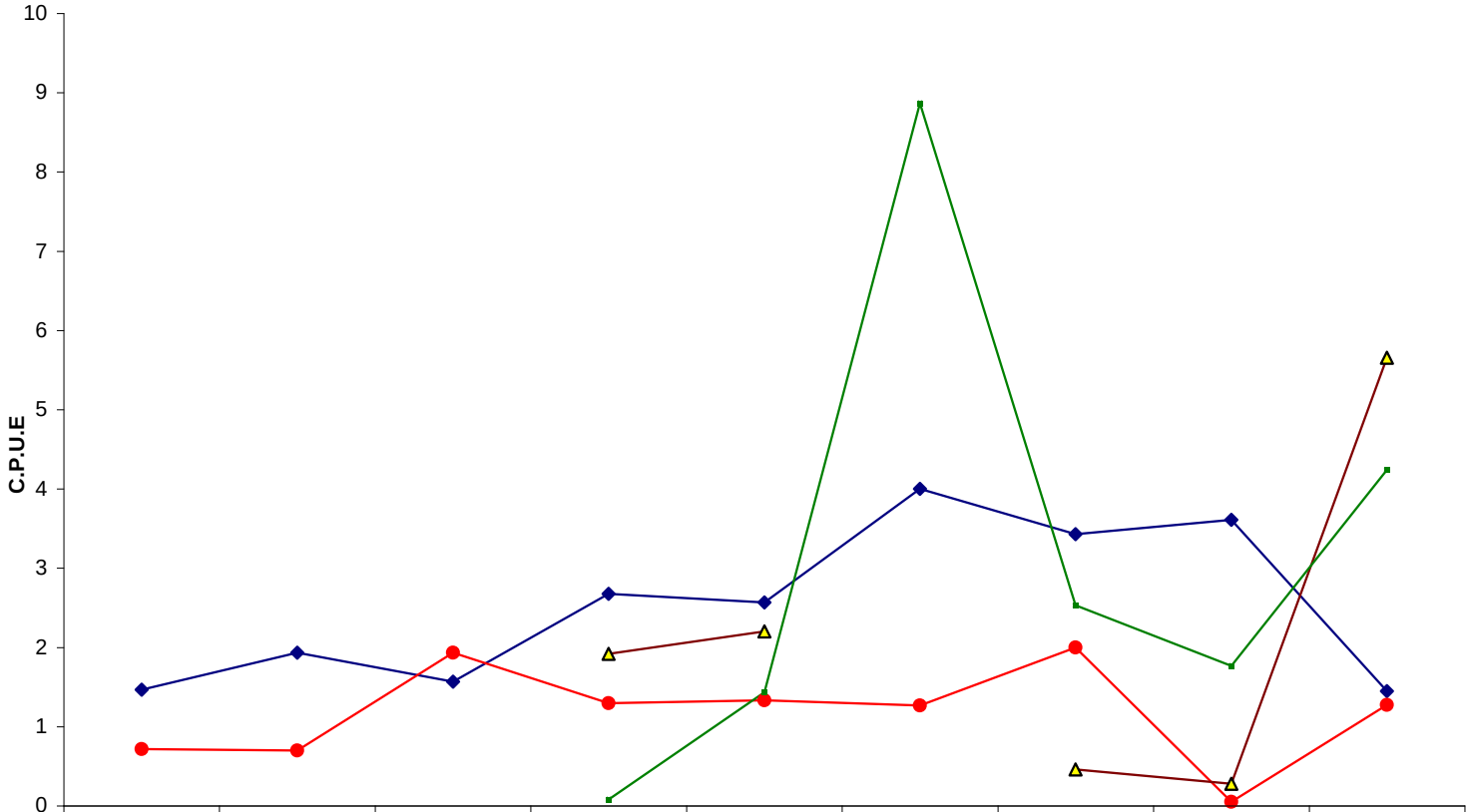
Figure 7. Lough Derravaragh C.P.U.E and Chlorophyll data 1979 – 2005



	1979	1980	1982	1983	1984	1985	1986	1987	1990	1993	2005
Wild Trout	1.6	1.7	1.5	1.2	0.3	0.4	0.6	0.9	0.4	0.2	0.5
Pike	0.5	0.9	0.7	2.0	2.3	0.5	2.2	2.2	2.6	2.5	3.1
Perch	3.2	14.4	6.5	8.5	9.2	10.7	8.6	1.5	35.4	4.7	1.3
Roach*	0.5	2.8	15.2	68.7	80.9	39.3	112.4	60.5	67.0	55.8	2.5
Chlorophyll (µg/l)	9.5	7.9	22.7	15.9	12.0	6.1	13.3	12.4	7.0	7.2	

* Roach C.P.U.E values on right hand axis

Figure 8. Lough Ennel C.P.U.E and Chlorophyll data 1983 – 2007



	1983	1984	1985	1992	1999	2002	2004	2006	2007
Wild trout	1.5	1.9	1.6	2.7	2.6	4.0	3.4	3.6	1.4
Pike	0.7	0.7	1.9	1.3	1.3	1.3	2.0	0.1	1.3
Perch				1.9	2.2		0.5	0.3	5.7
Roach				0.1	1.4	8.9	2.5	1.8	4.2
Chlorophyll (ug/L)	17.0	9.6	14.4	5.1		19.0	2.0	5.5	7.4

Figure 9. The Pike stock structure from lower Lough Corrib calculated at intervals from 1968 to 1996

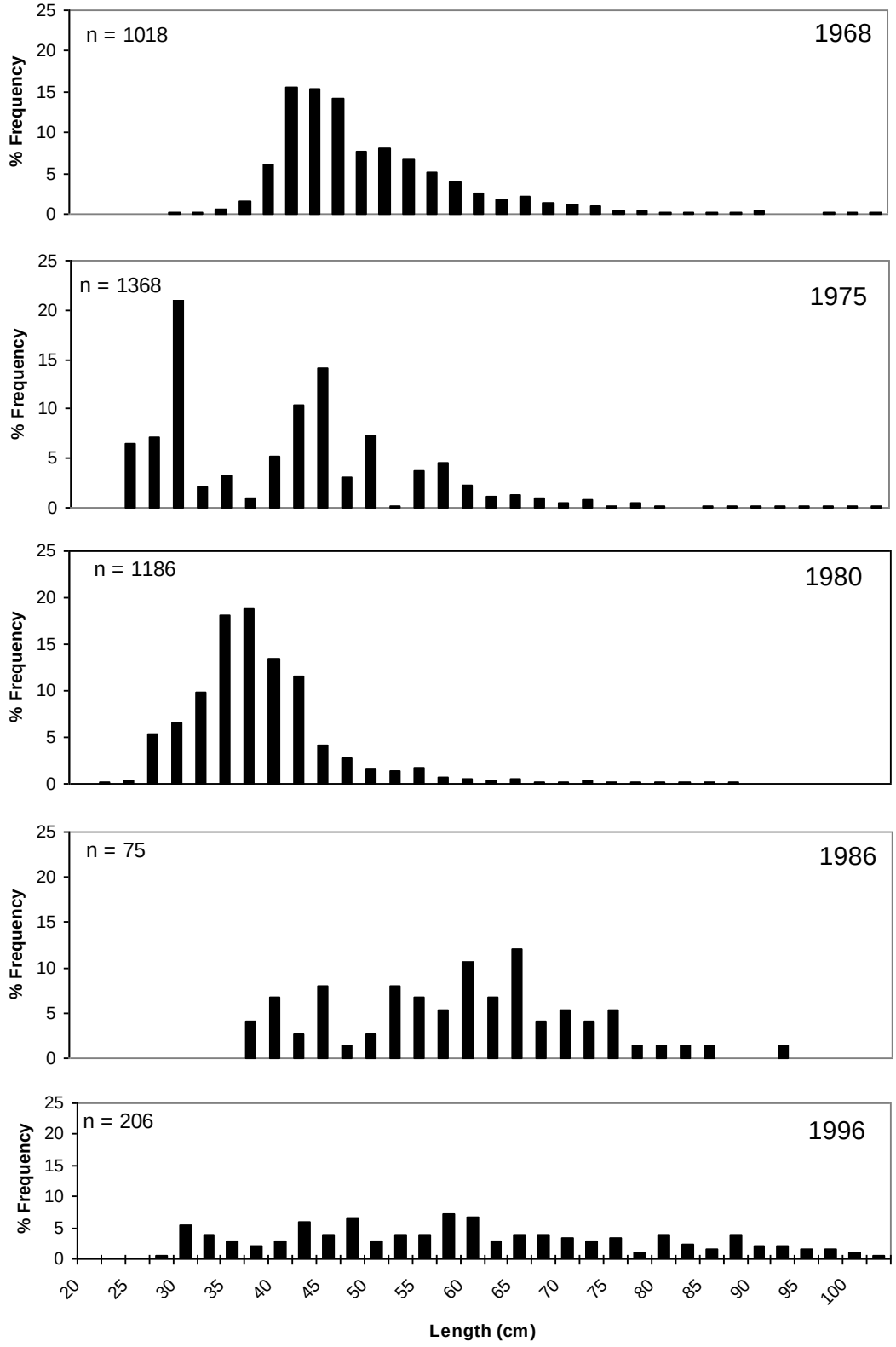


Figure 10. C.P.U.E values of pike in stock surveys on Lough Carra (1978 – 1986)

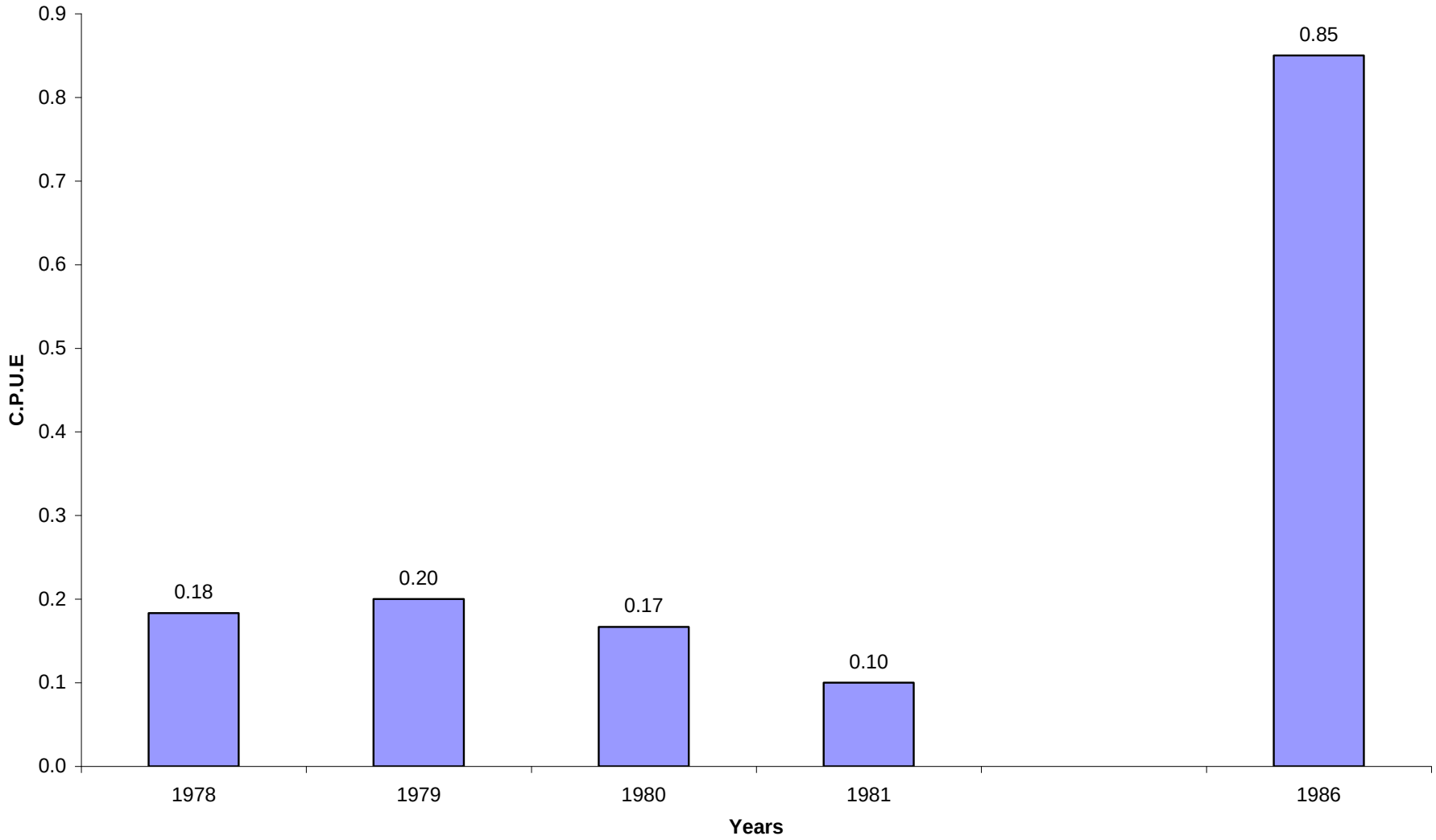
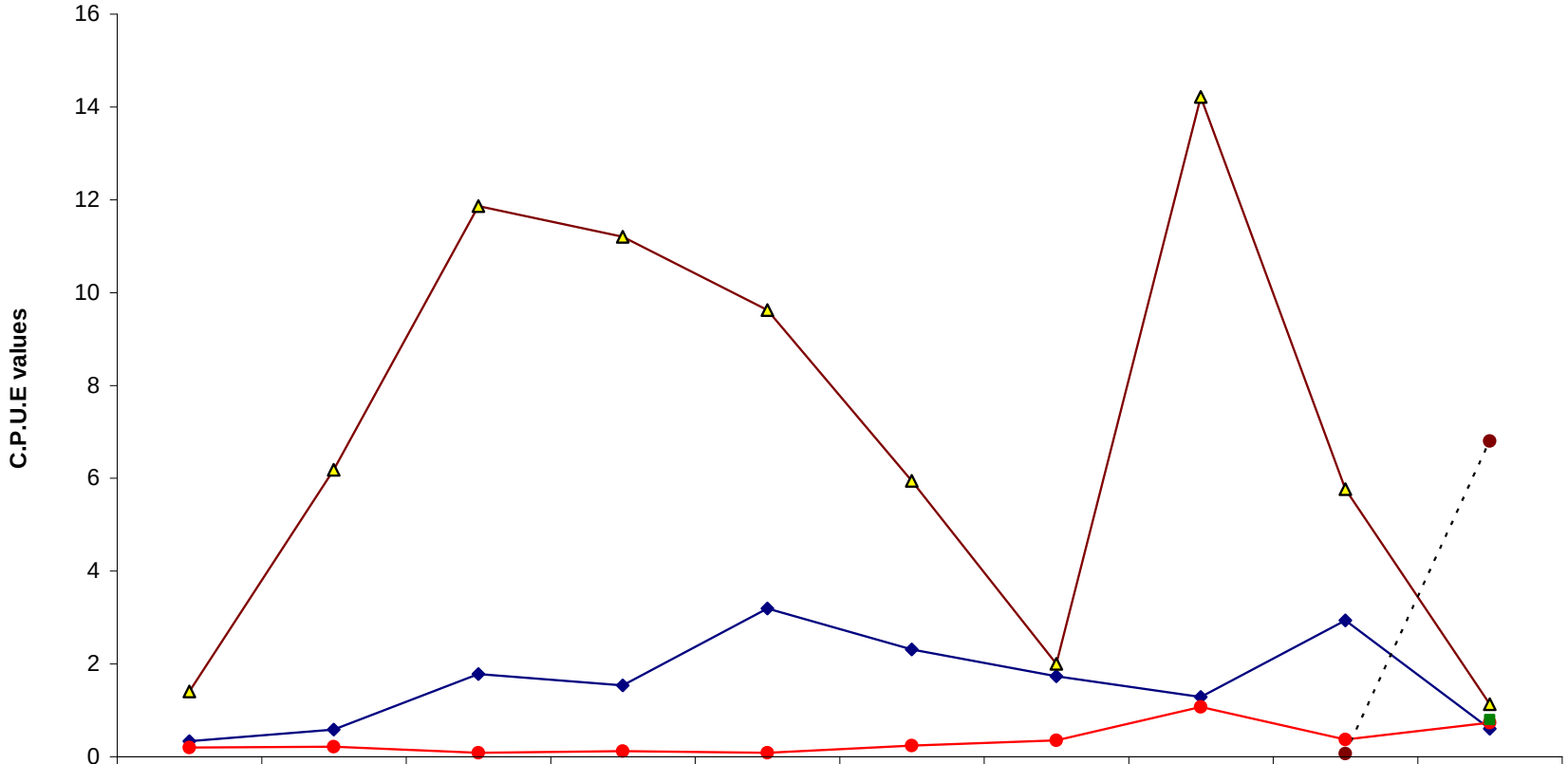
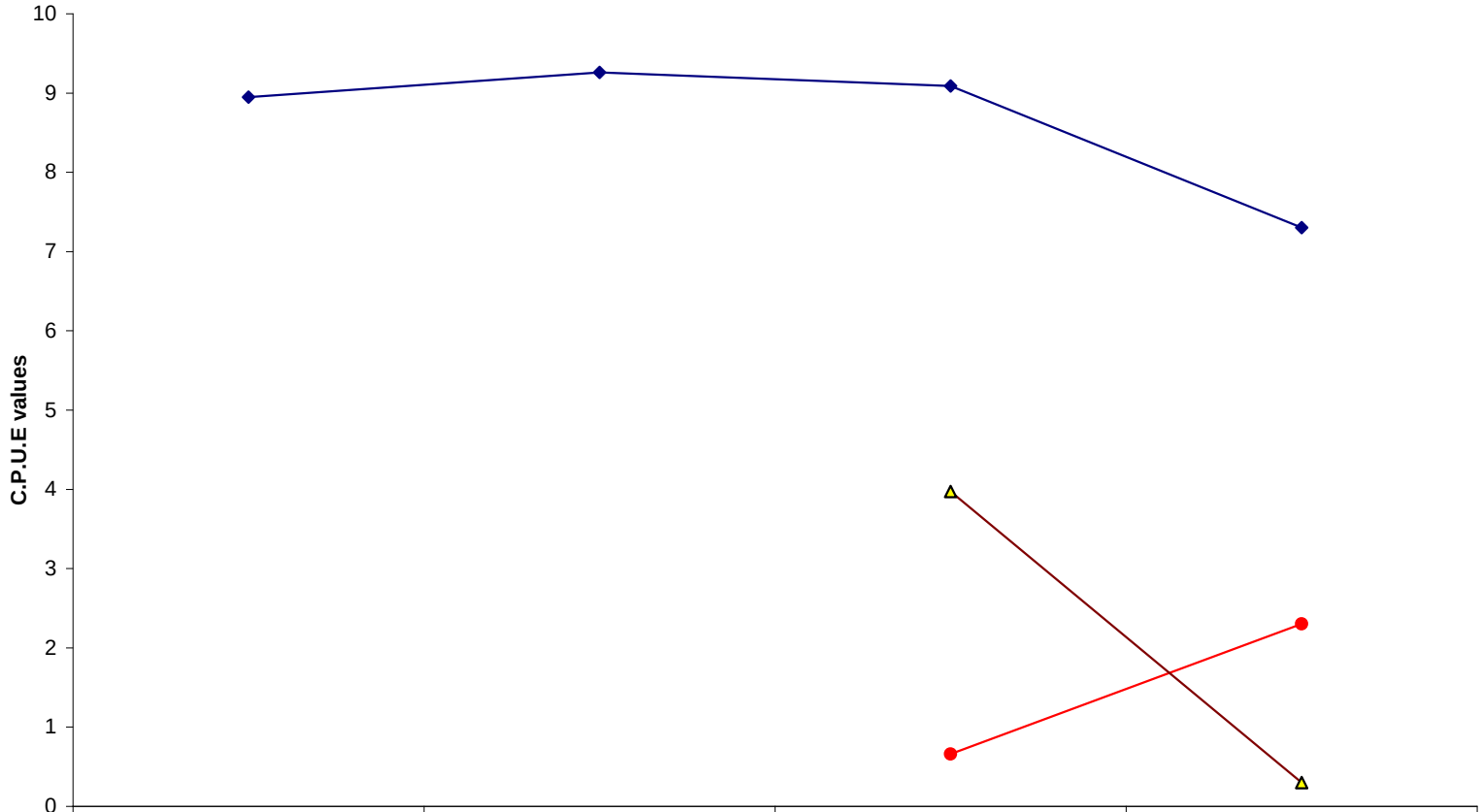


Figure 11. Lough Owel C.P.U.E values 1979 – 2005



	1979	1980	1981	1982	1983	1984	1985	1986	1987	2005
Wild Trout	0.3	0.6	1.8	1.5	3.2	2.3	1.7	1.3	2.9	0.6
Pike	0.2	0.2	0.1	0.1	0.1	0.2	0.4	1.1	0.4	0.7
Perch	1.4	6.2	11.9	11.2	9.6	5.9	2.0	14.2	5.8	1.1
Rudd									0.1	6.8
Roach										0.8

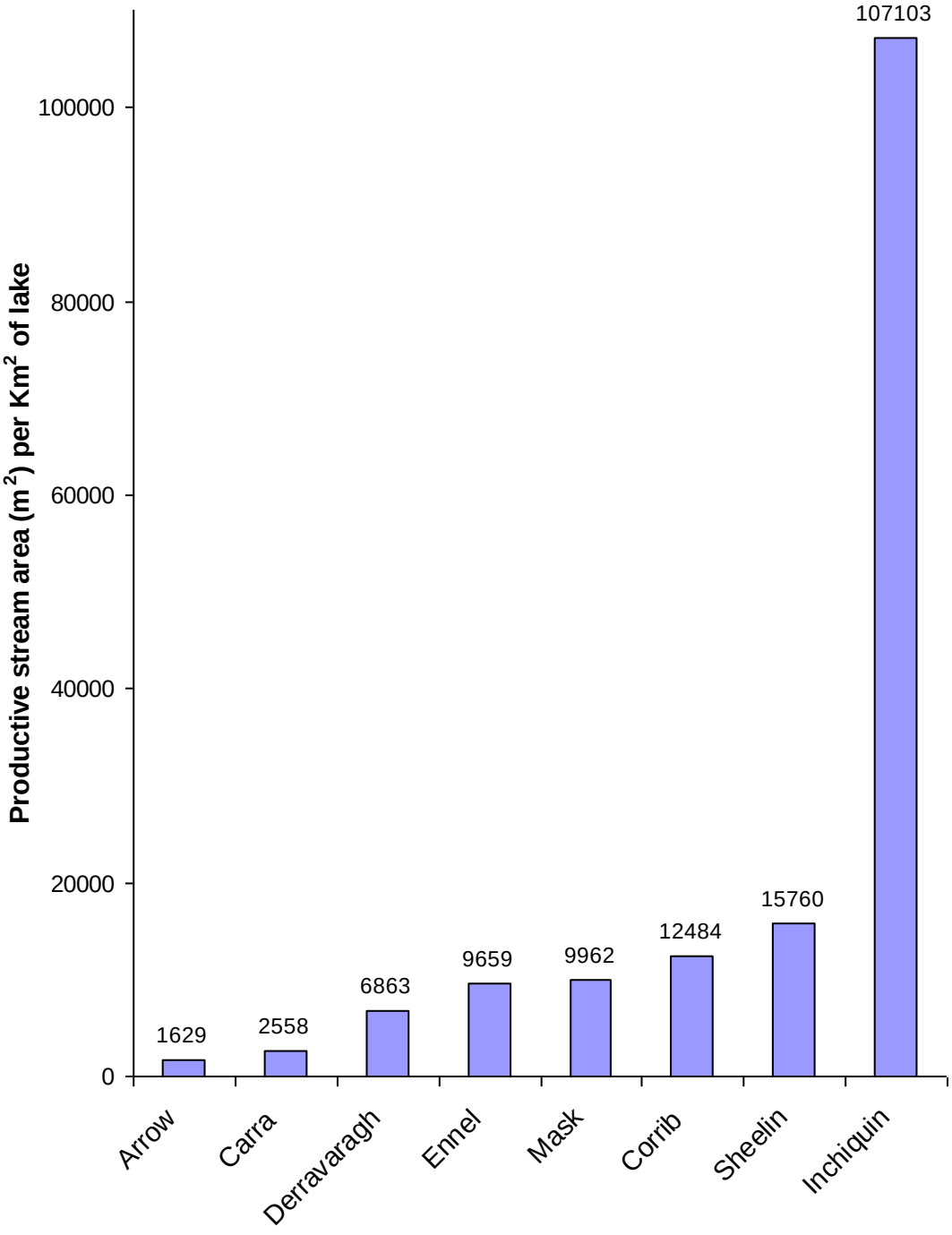
Figure 12. Inchiquin C.P.U.E values 1976 -2002



	1976	1977	1978	2002
Wild Trout	8.95	9.26	9.09	7.30
Pike	N/D*	N/D*	0.66	2.30
Perch	N/D*	N/D*	3.97	0.30

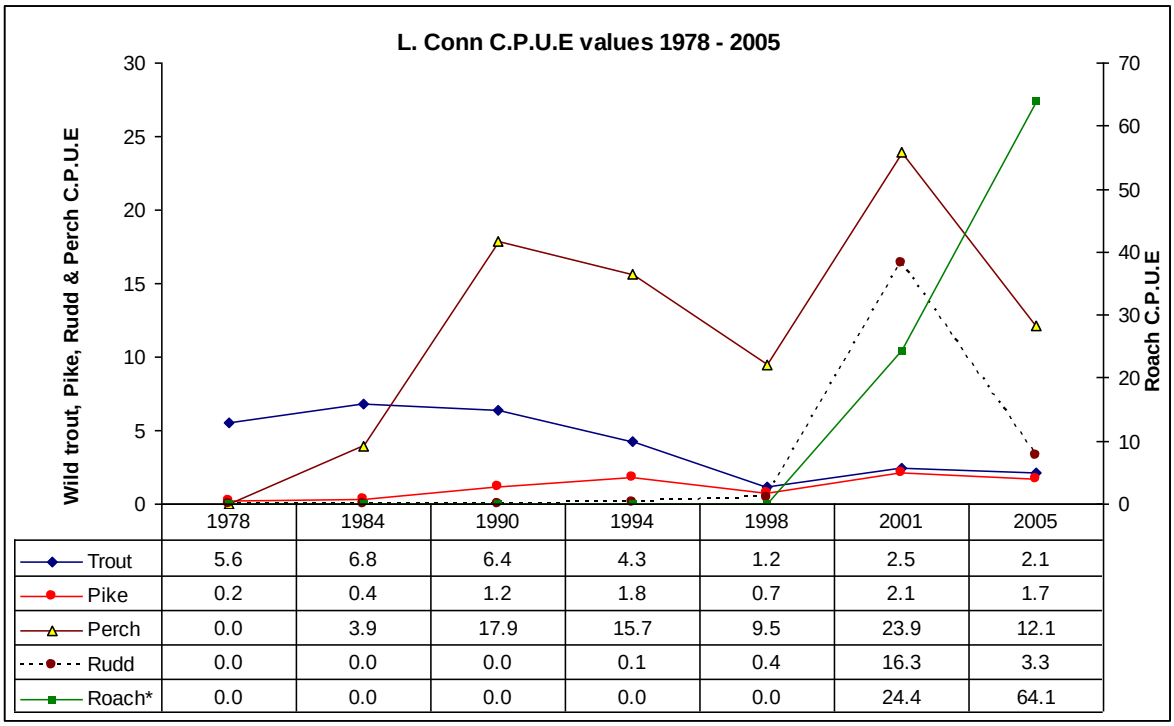
N/D* No data

Figure 13. The relationship between productive area (m^2) of trout stream in all subcatchments per km^2 of lake area which they service

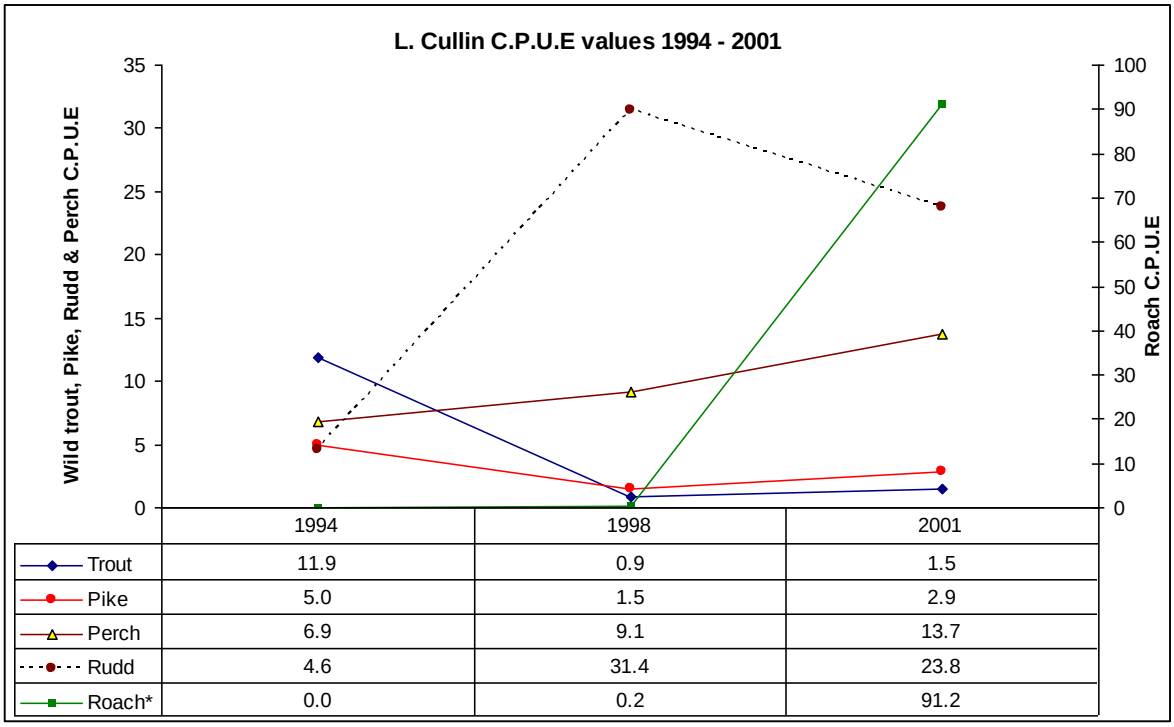


Footnote – Calculations in relation to Loughs Conn and Cullin have been excluded because the extent to which the wider Moy catchment contributes to adult trout stocks in these lakes is unknown

Figure 14. Lough Conn and Cullin C.P.U.E values



	1978	1984	1990	1994	1998	2001	2005
Trout	5.6	6.8	6.4	4.3	1.2	2.5	2.1
Pike	0.2	0.4	1.2	1.8	0.7	2.1	1.7
Perch	0.0	3.9	17.9	15.7	9.5	23.9	12.1
Rudd	0.0	0.0	0.0	0.1	0.4	16.3	3.3
Roach*	0.0	0.0	0.0	0.0	0.0	24.4	64.1



	1994	1998	2001
Trout	11.9	0.9	1.5
Pike	5.0	1.5	2.9
Perch	6.9	9.1	13.7
Rudd	4.6	31.4	23.8
Roach*	0.0	0.2	91.2

*Roach C.P.U.E values on right hand axis

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