A Review of Changes in the Fish Stocks of Loughs' Conn and Cullin over time (1978 – 2001)

and

Recommendations in Relation to the Long-Term Management of these Lakes and the River Moy as Salmonid Fisheries.

Loughs Conn and Cullin have previously been regarded as two of Ireland's premier wild brown trout angling fisheries for over a century. In a European context quality wild lake brown trout fisheries are now a rarity. There are only twelve such waters in western Europe, eleven of which are in Ireland. As the reader of this report will discover, Lough Cullin, as of 2001, can no longer be included in this list. Any further deterioration in the quality of trout stocks in Lough Conn, as of 2001, will also mean the loss of this water as a trout angling fishery. L. Conn can no longer be regarded as a premier trout angling water.

This report outlines the status of fish stocks in both lakes, at intervals, from 1978 to date. Angling catch data, over a longer period for the (1920's and from 1957 to date) is also used to illustrate changes in the trout population. Recommendations are provided which, if implemented, should help to restore these waters to their previous status as premier wild brown trout fisheries.

2. METHODOLOGIES

In the late 1970's a gill-netting survey technique designed to assess the status of Irish lake brown trout stocks was developed (O'Grady, 1981 and 1983). Gangs of special survey gill nets are fished over-night at randomly selected locations. They are capable of catching a cross-section of the trout population, in proportion to their presence, for all trout ≥ 19.8cms in length. They can also catch a cross-section of all other fish species present. Over a period of years repeated surveys allow one to determine changes in fish stocks either in terms of the relative numbers present, stock structure, growth rates etc. The relative numbers of fish of any species present in a lough at the time of a survey are compared, over time, by looking at variation in the Catch per Unit of Effort (C.P.U.E.) – i.e. if in a survey 60 trout were caught having netted 60 sites then a C.P.U.E. value of 1.0 would be assigned. If in a subsequent survey in later years 120 trout were captured after netting 60 sites then a C.P.U.E. value of 2.0 would be assigned – the inference being that, at the time of the second survey, there were twice as many trout in the fishery as when it had been surveyed on the first occasion. This technique has been used as a stock-monitoring tool on all of Ireland's quality brown trout loughs, at intervals, since the late 1970's. It has proved to be a very effective management tool in illustrating the fluctuations in fish stocks over time.

Central Fisheries Board personnel have trained the staff of S.N.H. (Scottish Natural Heritage) in using this technique to monitor fish populations in Britains only quality wild brown trout fishery – Loch Leven.

Over the period 1978 to date a total of six fish stocks surveys have been carried out on Lough Conn (1978, 1984, 1990, 1994, 1998 and 2001) and three on Lough Cullin (1994, 1998 and 2001).

3. RESULTS

Data are provided here in relation to the changes evident in fish stocks in both Loughs Conn and Cullin over time. Subsequently the relative importance of the Castlebar River as a trout spawning and nursery stream for L. Cullin is highlighted and the demise of trout stocks in this river in recent years is illustrated (Appendix II).

3.1. The Lough Conn Charr Population

Charr (*Salvelinus alpinus* L.) have been recorded from L. Conn as early as 1867 (Went, 1957). Pike dietary studies in relation to fish being removed from L. Conn in the 1930's, as part of a predator control operation, noted that charr were a significant component of the pike's diet at that time (Went, 1971). The fish stock surveys of Lough Conn in 1978 and 1984 indicated the continued presence of a substantial charr in the lake in both years (Fig. 1) with C.P.U.E. values of 0.8 and 0.88 respectively. In the subsequent 1990 survey and thereafter, in the 1994, 1998 and 2001 surveys, no charr were recorded (Fig. 1). Following the apparent collapse of the charr population in 1990 the North western Regional Fisheries Board set nets in charr spawning areas where fish, if present, would be congregating to spawn. These nets were set during the charr spawning seasons of 1991, '92, '93 and '94. Three charr were captured in the 1991 sampling, one fish in 1992 and none thereafter in 1993 or 1994. An examination of pike stomachs from fish captured in various parts of Lough Conn, throughout the 1990's, found no charr (Igoe, *et al*., 2000). It is reasonable to assume therefore that charr had become extinct in Lough Conn by the mid-1990's.

The Anglers Guide to the Irish Free State (Anon, 1930) states that charr were present in L. Cullin. There are no other known historical or recent records of charr ever having been recorded in L. Cullin.

3.2. Changes in the Lough Conn and Cullin Brown Trout Populations over Time (1978-2001)

3.2.1. Lough Conn

Both of these waters were regarded as being among the best of Ireland's brown trout angling fisheries for over a century. Angling catch data for both waters from the late 1950's to 1983 illustrate the presence of very large populations of relatively small trout ($\leq$ 0.5 kgs) in both lakes (Inland Fisheries Trust Annual Reports 1957 to 1979/80).

Fish stock netting surveys, as described in Section 2 of this report, were carried out on L. Conn in 1978, 1984, 1990, 1994, 1998 and 2001 and, on L. Cullin in 1994, 1998 and 2001.

The findings of the initial two surveys on L. Conn in 1978 and 1984 reflect the angling catch data compiled over two decades (1957-1983) – i.e. a very substantial population of relatively small trout (Fig. 2). A very similar trout stock structure and relative density (C.P.U.E.) was noted in both the 1979 and 1984 netting surveys (Fig. 3). However, from 1990 onwards, two major changes were evident in the Lough Conn trout population relative to previous surveys – by 1990 the average size of adult trout had increased very significantly. This trend became even more exacerbated in the 2001 survey when individual fish up to 65.0cm in length were encountered (Fig. 2). The very significant increase in the average size of trout was coupled with a dramatic decline in the relative density of the trout population, particularly from 1994 onwards – C.P.U.E. values for trout in the 1978, ’84, ’90, ’94, ‘98 and 2001 surveys were 5.6, 6.8, 6.4, 4.3, 1.15 and 2.6 respectively (Fig. 3). These data for both the changes in stock structure and relative density reflect major instability in an Irish lake trout population and indicate substantial changes in the ecology of the catchment.

The growth pattern of trout samples from L. Conn in 1978, ’84, ’94, ‘98 and ’01 are presented in Figure 4 (with inset table). The data indicate an increase in the growth pattern of the 1994 sample, from three years of age on, compared to the 1978 and 1984 samples. A further increase in the growth of trout is evident in the 2001 sample compared to the 1994 data set – the mean (x) length of four and five year-old trout were 32.5 cm and 38.3 cm in 1978 and 37.6 cm and 43.3 cm respectively in 2001. These increases in mean length for L_3 and L_4 values are very significant and constitute a major increase in the growth pattern over this period. This change is also illustrated over time by the angling catch data – a majority of the trout caught by anglers are 3+ and 4+ year-old individuals. The fact that changes in the growth pattern of trout are only evident for 3+ year-old and older fish have a particular significance – electro-fishing studies in the L. Conn sub-catchments has indicated that most trout in these rivers and streams are $\leq$2+ years of age. In other words most of these fish migrate downstream to L. Conn before their third birthday. <u>This means that the increased growth pattern of trout in L. Conn in recent years reflects significant ecological change in the lake itself</u>.

Brown trout angling catch data for L. Conn was reviewed from a number of sources – Foster (1980) provides catch data from 1929/1930 and an angling guide published by the Ministry of Fisheries in Dublin (Anon, 1930) describe the type of trout stocks in Lough Conn at that time. Thereafter no angling catch data is available up to 1957. Subsequently, detailed catch information is available from three sources – Inland Fisheries Trust Annual Reports (1957 – 1979/80), North-western Regional Fisheries Board catch statistics (1982-2001) and records of catches from the Lough Conn and Cullin Anglers Association in relation to catches at their Whit weekend competition (1987-2000). The latter three databases are appended (Appendix I). The following is a summary of these data.

In the late 1920's Foster (1980) noted a mean (x) weight for trout caught on Lough Conn of 0.34 kgs. Anon (1930) reports an average weight of *circa* 0.45 kgs in the late 1920's. The catch data from 1957 to 1993 shows a very steady trend in terms of the mean (x) weight of fish caught annually (Fig. 5). During this period annual mean (x) weight values for angler caught fish fluctuated within a range from 0.34 kg to 0.57 kg. However, from 1994 to 2001 this value increased significantly to a record high of 0.84 kgs in 2001 (Fig. 5).

Angling catch data in terms of Catch per Unit of Effort Values (i.e. numbers of trout caught per rod day) illustrate very high returns through the late 1950's, 60's and early 1970's with annual mean (x) CPUE values being as high as 9.2 fish per rod day (Fig. 6a). Thereafter, significantly lower annual mean (x) CPUE values in the range of 2 to 3 fish per rod day were recorded up to 1979. The major change in annual mean (x) CPUE values on Lough Conn pre- and post-1974 (Figs. 6a and 6b) suggests a significant reduction in the trout carrying capacity of the lough at that time. This is most likely due to the fact that the summer lake level on L. Conn was lowered by 1.83 m (6 feet) in the autumn of 1966 as part of the Moy Arterial Drainage Scheme. This is likely to have reduced the extent of the euphotic zone in L. Conn – O'Grady (1981) has shown that the trout carrying capacity of Irish loughs is closely linked to the extent of the available euphotic zone in any one water. The lowest annual mean (x) weight figures for angling caught trout for L. Conn were also recorded in the ten-year period (1967 to 1977) following the lowering of the lake level (Fig. 6a) during that period fisheries staff noted that trout in L. Conn were generally in poor condition. This is most likely related to the ecological instability caused by the lowering of the lake level.

The annual mean (x) C.P.U.E. for catches per rod day stabilised in the late 1970's at *circa* 2 fish per rod day (Fig. 6a). No data is available on the annual CPUE for the catch per rod day on Lough Conn after 1979. However, catch returns from the Lough Conn and Cullin Anglers Associations major Whit weekend competitions are available from 1987 to 2000 (Appendix I). This competition is a valuable source of data because it is held annually during the peak angling period and participant numbers are high – between 224 and 309 rod days in any one year. Mean (x) CPUE values for the catches per rod day in this competition would probably be somewhat higher than annual mean (x) values, if such were available, because of the timing of the competition and the fact that participants would generally be competent anglers. These data indicate that the CPUE values for 1987 to 1992 lie in the same range as the annual values for the late 1970's (Figs. 6a and 6b). This suggests a stability in terms of the trout stock densities in Lough Conn over this period (1975 to 1992). Thereafter, there is a declining trend in the CPUE values from 1993 to 2000 (Fig. 6b). The downward trend is also reflected in the fish stock survey data series which illustrate a stability in terms of trout stock densities over the period 1978 to 1990 and a subsequent decline thereafter to date (2001) (Fig. 2).

Both data sets (fish stock surveys and angling catch data) illustrate that there has been a significant decline in the stock density of trout in Lough Conn in recent years. This change could be due either to:-

A - A reduced recruitment rate of trout from the stream catchments to the lake.

B - A reduced survival of young trout following their recruitment to the lake.

Extensive electro-fishing surveys of juvenile trout stocks in the L. Conn sub-catchments have been ongoing since 1996 to monitor the effectiveness of fishery enhancement programmes carried out in these channels by the Nw.R.F.B. (O'Grady and Delanty, unpublished C.F.B. data). These data indicate an increase in juvenile trout production following the work programmes which were completed in these sub-catchments in 1997. Consequently the decline in adult trout numbers in L. Conn in recent years is due to a failure of young trout to survive having migrated to the lake.

The two significant changes in the trout population in L. Conn, since 1994 (a reduced stock density and increased growth rate) both point to major ecological changes in the lake itself.

3.2.2. The Lough Cullin Trout Population

Historically, in angling terms, L. Cullin was noted for supporting a large population of relatively small (< 0.5 kg) trout. Three fish stock surveys were carried out on this water – in 1994, 1998 and 2001. The 1994 data confirm the presence of a very substantial population of relatively small trout (Fig. 7). Subsequent stock surveys in 1998 and 2001 indicate a dramatic decline in the trout stock density with declining C.P.U.E. values from 11.9 in 1994 to 0.9 and 1.5 in 1998 and 2001 respectively. This level of reduction in trout C.P.U.E. values constitutes a virtual "population crash".

The total number of trout captured in the 2001 survey on L. Cullin was fifteen fish. Essentially this is too small a sample to illustrate a stock structure.

3.2.1.1. Trout Recruitment to L. Cullin

Cultural eutrophication problems have been evident in Lough Cullin in recent years (McCarthy *et al*, 2001). While the enrichment of Lough Cullin may have contributed to the demise of the trout population there is another very obvious reason for the collapse of this stock. A baseline fishery survey of the Moy Catchment (O'Grady, 1994) illustrated that three particular sub-catchments were likely to be of significance as spawning and nursery areas for the Lough Cullin trout population – the Castlebar, Manulla and Clydagh River systems. Further investigation of fish stock in these sub-catchments indicated that, of the three systems involved, the Castlebar River was, by far, potentially, the most important spawning and nursery area for the L. Cullin trout population. Recognising this fact the Nw.R.F.B. expended significant monies in enhancing the capacity of the Castlebar River to optimise trout production. This programme failed because of declining water quality problems in the river to-date (2001) (Appendix II). Currently (2001) the river supports a very poor trout stock – several substantial fish kills have also been noted in this river in recent years (Nw.R.F.B., pers comm). **A failure of trout to recruit, in significant numbers, from the Castlebar River to Lough Cullin is undoubtedly a major factor in the demise of the lake trout population** – a small number of trout were tagged in the Castlebar River in 2000 while carrying out fish population estimates. It is noteworthy of the total catch of 15 trout in the 2001 L. Cullin survey three fish were individuals which had been tagged in the Castlebar River the previous year.

The demise of the trout population in Lough Cullin therefore is due to a different set of circumstances than the problems in Lough Conn where, in the latter case, changing ecological conditions in the lake itself would appear to be primarily responsible for the problem.

3.3. Cyprinid Populations in Loughs Conn and Cullin

Historically a small population of rudd (*Scardinius erythropotalamus* L.) are known to have been in Lough Cullin at least since the 1960's. There is no such historical record of rudd in Lough Conn.

Roach (*Rutilus rutilus* L.) were first recorded in the Moy catchment in Derryhick Lake in July, 1996 (Walsh, 1996). This water is a sub-catchment of Lough Cullin. A gill-netting survey at that time (July 1996) captured 40 roach in Derryhick Lake. Age analysis of this sample indicated the presence of roach up to 7+ years of age suggesting that roach were probably first introduced to Derryhick Lough by anglers illegally fishing for pike with live bait (roach) sometime in the mid-1980's. While the 1996 Derryhick survey was in progress large stocks of roach fry were observed in the outflowing channel from Derryhick Lough to L. Cullin (Walsh, 1996).

3.3.1. Changes in Cyprinid Stock Densities Over Time

3.3.1.1. L. Conn

Very dramatic increases are evident in the stock densities of cyprinids in both Lough Conn and Cullin in recent years (Figs. 8a,b,c&d).

In Lough Conn no rudd were recorded in the 1978, '84 and '90 fish stock surveys. Three rudd were captured during the 1994 survey. To the author's knowledge this is the first record of this fish species from L. Conn. Over the period 1994 to 2001 there has been an exponential expansion of the rudd population with CPUE values of 0.08, 0.4 and 16.33 being recorded in the '94, '98 and '01 surveys respectively (Appendix III).

The reader should note that the survey gill nets in use are not capable of capturing either rudd or roach in significant numbers until the fish are ≥16 cms in length – i.e. a substantial population of small (<16 cms) rudd or roach would not be detected with these

survey nets. This explains the "sudden appearance" of a substantial cyprinid stock in both Conn and Cullin (Figs. 8a, b, c & d).

No roach were recorded in the fish stock surveys on L. Conn in 1978, '84, '90, '94 and '98. By 2001 a large population, of young fish, had become established. The CPUE value for roach in the L. Conn 2001 survey (24.36) was higher than the equivalent rudd value (16.33) (Appendix III).

3.3.1.2. L. Cullin

A similar trend is evident on L. Cullin with a very dramatic increase in rudd stock densities from 1994 to 1998 (Fig. 8d). The establishment of the roach stock is even more dramatic with CPUE values for the 1994, '98 and '01 surveys being 0, 0.2 and 91.2 respectively. The 2001 CPUE value for roach in L. Cullin is the second highest such value ever recorded in an Irish lake.

3.3.2. Stock Structure and Age Composition of Cyprinids

Rudd and roach, unlike trout, tend to be relatively long lived fish. Kennedy and Fitzmaurice (1974) report the presence of rudd in Irish waters up to 17+ years of age. Roche (1999) indicates that roach populations in the British Isles can contain individual fish up to 12 years of age. Fish of this age (12+) were recorded in a stable, long established population of roach in the Cork Blackwater (Anon, 1976).

3.3.2.1.Lough Conn

Currently (2001) the rudd population in Lough Conn is dominated by three year-classes of relatively young fast growing fish (5+, 6+ and 7+ year-old) (Fig. 9c). Older fish are absent simply because of the recent proliferation of this population in L. Conn. King and O'Grady (1994) have shown the nets used in these surveys can catch rudd in significant numbers which are ≥16 cms in length. The small numbers of rudd between 16 cm and 20 cms captured in the 2001 L. Conn survey suggest the presence of a poor year-class of four year-old fish (Fig. 9c). The incapacity of the survey nets to catch smaller fish (<16 cms in length) means that one cannot comment on the relative strength of younger year-classes.

The current (2001) roach population in L. Conn is dominated by three year-classes of young fast growing fish (3+, 4+ and 5+ year-old) (Fig. 9a).

These data indicate that the cyprinid "invasion" of L. Conn was a two-phased process with the first large year-class of rudd becoming established two years before the roach started to proliferate.

3.3.2.2. Lough Cullin

The L. Cullin rudd population in 2001 is very similar in structure to the comparable population in L. Conn. It differs slightly in so far as there appears to be a slightly better representation of 3+ year-old fish in the L. Cullin population (Fig. 9d).

The roach population in L. Cullin in 2001 is very similar in terms of both the age and stock structure of the comparable population in L. Conn - the stock is dominated by a small number of young year-classes (3+ and 4+ year-old) (Fig. 9b).

3.3.3. Cyprinid Growth Patterns

The growth patterns of rudd and roach for both Loughs Conn and Cullin are illustrated. Comparative data for other Irish stocks of these species are also provided in order to put the Conn/Cullin growth patterns in perspective (Fig. 10a &b). Data indicate that both the rudd and roach population in both Loughs Conn and Cullin are the fastest growing stocks of these species ever noted in Irish waters. This is not surprising – Roche (1999) notes that introduced roach stocks, while still expanding, are particularly fast-growing.

Fish stock monitoring exercises on Irish trout loughs have been ongoing for 27 years. Over that period the presence of small stable rudd populations has been noted in most Irish trout lakes. This is the first time ever that "an invasion" and subsequent exponential expansion of a fast-growing population of rudd has been observed in large Irish trout loughs.

3.4. Pike Populations

The available pike C.P.U.E. data for the fish stock surveys in both lakes are presented (Appendix III). They indicate that the Nw.R.F.B. pike control policy in both lakes has, and continues to be, successful – the C.P.U.E values reflect the presence of a small well controlled population of this predator.

An examination of the dietary habits of pike captured in the 2001 surveys of both lakes illustrates the extremes to which pike will go to target trout as a dietary item (Table 4). Despite an abundance of cyprinids in both lakes pike continued to actively seek trout as a preferred dietary item – 22% of the pike with fish in their stomachs had eaten trout. This is not surprising – the same trend has been observed in pike dietary habits in Loughs Corrib, Sheelin and Derravaragh.

3.5. Perch Populations

A substantial number of perch (*Perca fluviatilus* L.) were captured in every fish stock survey on L. Conn since 1978. CPUE data for perch numbers captured in surveys are not available for the 1978 and 1984 surveys. The available data, in this form, is presented for both Loughs Conn and Cullin (Fig. 11a&b & Appendix III). Data indicate the presence of a substantial stock of this species in both lakes over the relevant survey period. The relative fluctuations in perch C.P.U.E. values recorded in these surveys are quite typical of Irish stocks – i.e. considerable variation in the recruitment of individual year-classes is a common feature of Irish perch populations.

The population structure of the perch samples from Loughs Conn and Cullin in 2001 are presented (Fig. 12a&b). These populations are similar to those found in many of Ireland's larger lakes.

4. DISCUSSION

The dramatic changes in both the fish stocks of Loughs Conn and Cullin over recent years are very disturbing from a fisheries management point of view. In trying to understand "cause and effect" it is important that each lake be examined as a separate case study even though the two waters are linked by an open channel. It is also critical that the various changes be viewed in chronological order – i.e. if we were to look at all of the changed ecological circumstances in L. Conn today (2001), without reference to the order in which they occurred, it would be much more difficult to assign cause and effect.

4.1. Lough Conn

In the Lough Conn situation the status of stocks was stable up to 1984 at which point fish populations in the lake were dominated by large numbers of relatively small trout, charr, perch and a managed pike population. Despite having free access to L. Conn the rudd population in L. Cullin did not expand into L. Conn in any significant numbers over the period 1978 to 1998. Indeed significant number of this species were not recorded in L. Conn until 2001.

Chronologically, the first major change, in fish stock terms, was the demise of the charr stock in 1990 followed by the apparent extinction of this species by the mid-1990's. At that time (1990) staff of the Nw.R.F.B. were unable to fish gill-nets – nets set overnight became completely coated with filamentous algae as did the survey nets fished in August of that year. This was the first time such an event was ever noted by fisheries staff on Lough Conn where these type of operations had been in progress since the 1960's. McGarrigle *et al* (1993) note that the total phosphorus load to Lough Conn had doubled from 1980 to 1990. The aforementioned algal growths are likely to be a consequence of this enrichment. Charr are known to be highly sensitive to cultural eutrophication problems and therefore their demise in L. Conn is likely to be linked to this enrichment problem.

The second major change in fish stocks, in chronological order, relates to the trout population. By 1990 very significant changes were evident in the population structure with significantly larger fish present in the stock. These fish were not living any longer than previous stocks. They were simply growing at a faster rate after they had migrated to the lake. From 1994 onwards and, particularly in 2001, further increases in the average size of trout in the population were evident. The increasing growth rate was coupled with a marked

decline in either the numbers of young trout recruiting to the lake or, the relative survival of young fish in the lake itself after they had left the streams.

Over the period 1996 to 1998 very extensive fishery enhancement programmes were carried out on all of L. Conn's sub-catchments. A monitoring of the effectiveness of these programmes has shown that the capacity of these rivers and streams to produce trout were significantly increased by these exercises – i.e. recruitment of young trout to the L. Conn population has greatly increased from 1998 to date (2001).

One can conclude therefore that the numerical decline in trout numbers in Lough Conn in 2001 is due to a failure of young trout, despite their increasing numbers in L. Conns sub-catchments, to survive in the lake itself. Similarly the increased growth rate of trout can be linked to changes in the lake.

The fish stock survey data indicates that the Nw.R.F.B. pike management programme has been and, still is (2001), successful. The paucity of trout in the lake cannot therefore, in this instance, be linked to increased predation rates by pike.

Young trout in Irish loughs tend to be largely pelagic for at least a year after migrating to the lough feeding principally on zooplankton (Kennedy and Fitzmaurice 1974). It seems most likely therefore that the cultural eutrophication problems in L. Conn have depressed the production of key food items required by young trout thereby limiting their survival.

A similar trend was observed by the author (O'Grady) in relation to the trout stock in Lough Sheelin when cultural eutrophication problems were evident in this lake in the early 1980's – i.e. the survival of juvenile trout recruiting to the lake declined markedly. It is very important to note that the decline in the survival of young trout recruiting to both Lough Conn in the mid-1990's and to Lough Sheelin in the early 1980's took place before large cyprinid populations became established in either fishery.

The most recent major change, chronologically, in the Lough Conn fish stock relates to the establishment of a very large cyprinid population since 1998 – in 2001 substantial populations of rudd and roach were present. Scale analysis indicates that the rudd population is the older of the two cyprinid stocks and had colonised the lake successfully two years

before the roach had become established. As previously stated a rudd population has been in Lough Cullin at least since the 1960's. The exponential expansion of a rudd population in L. Conn in a short time span (5 years) points to major ecological change in the lake over this period. McGarrigle (pers. Comm.) has noted a further increase in the phosphorus loading to L. Conn since 1997. It is most likely that the impact of this increased enrichment has triggered the explosion in the rudd population – both rudd and roach can thrive in culturally eutrophication conditions.

The rapid expansion of a roach population in Lough Conn, once introduced, is not surprising. The exponential increase in roach numbers following their introduction to the Erne and Shannon systems in the 1970's is well documented (Anon, 1977). Similar rapid expansion of roach numbers, following their introduction are also evident in Lough Corrib. Available data on roach populations in Irish fisheries suggests that over a period of years they are likely to become the dominant cyprinid species in both Loughs Conn and Cullin and may actually displace the rudd population (Anon, 1977).

The extinction of the charr population, marked changes in the trout population, the establishment of large cyprinid stocks and increasing enrichment problems in L. Conn have markedly changed the ecology of this water. While trout stocks had declined numerically prior to the establishment of the cyprinid stocks the presence now of rudd and roach may cause additional problems for the trout in two ways:-

A - There may be competition for food between cyprinids and trout either at the zooplankton and/or macroinvertebrate levels.

B - The presence of large numbers of young cyprinids will provide a food supply for trout ≥ 30 cms in length all year round. Should a significant proportion of the trout population become largely piscivorous then they will be less available (harder to catch) using traditional fly fishing methods. This trend is already evident – 12.2% of the large trout captured in the 2001 L. Conn and Cullin surveys had been feeding on cyprinid fry.

4.2. Lough Cullin

The fish stock survey data available from L. Cullin indicated the presence of a very large population of relatively small trout as recently as 1994. As already stated C.P.U.E. value for

trout in the Lough Cullin 1994 survey was relatively high by national standards. The 1994 L. Cullin trout stock density and population structure reflect the type of stock which was known to be present in the lake for many years – i.e. since the 1960's anglers have been catching large numbers of relatively small (25 cm – 30 cm) trout on this water. The recent (2001) fish stock survey on L. Cullin indicates a virtual collapse of this trout population – the trout C.P.U.E. values for the 1994 and 2001 surveys were 11.9 and 1.5 respectively, an 87.4% decline in the relative density of trout in 2001 compared to 1994.

A baseline fishery survey of the Moy Catchment carried out in 1993 (O'Grady, 1994) illustrated that of the three major rivers discharging to L. Cullin (Manulla, Clydagh and Castlebar) the Castlebar River was, by far, potentially the most important in terms of functioning as a trout spawning and nursery stream for the L. Cullin trout population. A monitoring of trout stocks in the Castlebar R. through the 1990's has illustrated a marked decline in trout stocks over time. By 1999 some channel sections, which previously supported a trout stock were virtually fishless and there were declining stocks even in the lower reaches of this river (Appendix II). In 2000, two fish kills took place in the Castlebar River. The continuing organic pollution problems generated by a failure to treat all of the sewage from Castlebar are clearly responsible for the demise of trout stocks. Therefore, the collapse of the L. Cullin trout stock can be directly linked to the continuing water quality problems in the Castlebar River.

Apart from the obvious trout recruitment problem there have been other significant changes in the ecology of L.Cullin over the last decade. Substantial beds of filamentous algae were in evidence over a substantial area of the lake bed at intervals (McCarthy *et al*., 2001). The nature and size of the cyprinid population changed markedly from 1994 to 2001. Rudd were present in significant numbers in 1994 and 1998. Roach were not recorded in the 1994 survey with a C.P.U.E. of 0.2 being recorded for this species in the 1998 survey. This C.P.U.E. value increased to 91.2 in the 2001 survey. Scale analysis of the 2001 roach sample indicate that it is a young rapidly expanding population.

5. SUMMARY AND CONCLUSIONS

The current fishery problems on Loughs Conn and Cullin are quite different in origin.

5.1. Lough Conn

Three major changes have taken place in relation to the fish stocks in Lough Conn in the last decade –

i - A large charr population has become extinct. Charr are known to be sensitive to cultural eutrophication problems.

ii - A marked decline in the survival of young trout recruiting to the lake is evident despite a significant increase in the production of such fish in many of its sub-catchments since 1997. The reduction in the lakes trout stock density is coupled with a very significant increase in the growth pattern of the fish. The author (O'Grady) noted similar changes in the trout population in Lough Sheelin in the early 1980's with the onset of cultural eutrophication problems. In L. Sheelin, like L. Conn the trout stock was in decline before a roach population became established. Declining trout populations have also been noted in Loughs Ennell and Leane following the onset of cultural eutrophication problems, and, at a time, when cyprinid populations in the latter two waters were insignificant.

iii - A very large rudd population has become established in Lough Conn since the mid-1990's. There are no records of rudd being present in Lough Conn prior to 1998 although small numbers of this species are known to have been in Lough Cullin at least since the 1960's. The rapid colonisation of Lough Conn by a very fast growing rudd population is alarming – adult rudd in Irish waters feed principally on algae or macrophytes. Studies have shown no significant increase in the extent of macrophyte beds in L. Conn from 1984 to 1994 (McCarthy, 2001) and there is no evidence to suggest significant change thereafter from 1994 to date (2001). Consequently the present rudd population is probably being sustained by some form/s of algal production.

These major changes in fish populations clearly illustrate a significant change in the ecology of Lough Conn. Charr and trout are known to be sensitive to cultural eutrophication problems. The establishment and maintenance of the large rudd population is most likely due to increased epiphytic algal production.

The key element controlling enrichment processes (cultural eutrophication) in lakes is phosphorus. McGarrigle *et al* (1993) reported a doubling of the phosphorus load to L. Conn from 1980 to 1990. Phosphorus loads to the lake declined somewhat in the early 1990's (McGarrigle, pers comm.). However, from 1995 to 1999 they have increased again and are similar to the high input levels recorded in the late 1980's (Donnelly, 2001).

The standard O.E.C.D. methodology to monitor changes in the trophic status of lakes involves measuring the chlorophyll 'a' content of the water column regularly at a mid-lake location. Should the production of phytoplankton increase then this would be reflected in increasing chlorophyll 'a' concentration. This type of monitoring programme has been ongoing on Lough Conn since 1975. It does not illustrate significant change in chlorophyll 'a' concentrations over time (T. Champ, pers comm.). In the case of Lough Conn the increased phosphorus load must be generating additional algal production on the lake bed, which is not measurable in a mid-lake sample – the current large fast-growing rudd population could not be sustained otherwise.

Apart from increased input of phosphorus to Lough Conn no other major changes are evident in the lake, or its catchment, which might have lead to the dramatic alterations observed in fish stocks in the last decade.

Lough Conn can no longer be regarded as a high quality lake brown trout fishery. The elimination of its charr population also constitutes a serious down-grading of this resource in conservation terms. **Until such time as the phosphorus load to the lough can be reduced substantially (to pre-1980 levels) there is no likelihood that this valuable BROWN TROUT fishery can be restored**.

5.2. Lough Cullin

Lough Cullin can no longer be regarded as a trout fishery. Data show that the trout fishery in Lough Cullin was heavily dependant on the recruitment of trout from the spawning

and nursery areas in the Castlebar river. The decline in trout stocks in the Castlebar River from 1995 to date (2000/2001) (Appendix II), despite the physical enhancement of extensive channel reaches, is primarily responsible for the collapse of this fishery. The inadequate treatment of sewage from Castlebar is responsible for this phenomenon. Unfortunately, virtually all of the potentially productive salmonid reaches in the Castlebar River are located downstream of the existing sewage outfall from Castlebar (O'Grady, 1994).

The proposed upgrading of the sewage plant and re-siting of the effluent discharge point into the lower reaches of the Castlebar River should resolve this problem- all of the quality spawning and nursery areas for trout are located upstream of the newly proposed discharge site in the Castlebar River.

5.3. The Lower Moy Salmon Fishery

Over the last five years anglers have occasionally reported difficulty in angling for salmon from Foxford downstream to Ballina – angling became impossible because of the extensive growths of epiphytic algae on the bed of the river which entangled the anglers bait, fly or worm. Such conditions were only evident downstream of the outfall from Lough Cullin to the Moy. Clearly the phosphorus load from the combined Conn/Cullin sub-catchments are responsible for this phenomenon. To-date (2001) this has only been an occasional problem. However, should the phosphorus load to the lower Moy increase further this could become a more persistent problem during periods of low summer flow and endanger what is currently one of the most productive Atlantic salmon fisheries in the world. **It is critical that the phosphorus load to the Moy be reduced to prevent such a problem.**

5.4. Roach in the Moy Catchment

Regrettably roach were introduced illegally to the Moy Catchment sometime in the mid-1980's – probably by pike anglers using live roach as bait. Their subsequent rapid expansion, first in Lough Cullin and subsequently in Lough Conn, is not surprising – once introduced into Irish catchments they have generally thrived. Since 1998 they have already become, by far, the more dominant of the two cyprinid species (rudd and roach) in Lough Cullin. This is not surprising - Anon (1977) noted a similar trend following their introduction into the Erne system. Over the next five years it is likely that roach will out-compete rudd and become the dominant cyprinid in both lakes.

The introduction of roach to these fisheries constitutes another significant ecological change which is entirely independent of the pollution problems. Roach, once introduced, can thrive in most Irish fisheries irrespective of their pollution status. Unlike rudd, adult roach are much more flexible in terms of their dietary requirements – they can feed on phytoplankton, zooplankton, epiphytic algae, rooted plant material and macro-invertebrates (Anon, 1977).

The long-term impact of a large roach population on trout stocks in these two lakes are difficult to ascertain. However, available data from two other large trout lakes, where there are no indications of cultural eutrophication problems, suggest that the presence of roach may not necessarily have a negative impact on trout stocks. Currently there is a large roach population throughout the Lough Corrib basin. Despite their presence there is presently (2001) a very large stable trout population in L. Corrib.

A recent (2001) fish stock survey of Lough Melvin, an unpolluted water, illustrates the presence of a large stable trout population in this water despite the presence of a substantial mixed (roach / rudd) cyprinid population (C.F.B. unpublished data).

6. RECOMMENDATIONS

1. The extinction of the charr population, decline in trout stocks and establishment of a large rudd population are all likely to be consequences of the increased phosphorus load to Lough Conn. It is critical that every effort be made to restore the phosphorus load to the lake to pre-1980 levels. **The recovery of Lough Conn as a trout fishery depends entirely on the implementation of this measure**.

2. Charr should be re-introduced to this fishery once ecological stability has been restored. The Lough Mask charr population would be a suitable donor stock.

3. The Nw.R.F.B. should continue to manage the pike populations in Loughs Conn and Cullin. Despite the abundance of cyprinids presently in both lakes research has shown that pike will specifically target trout as a prey item in such circumstances.

4. Once the treated sewage outfall from Castlebar has been re-routed to the lower reaches of the Castlebar River the Nw.R.F.B. should consider expending additional funds to further enhance the trout spawning and nursery potential of this channel. This would help to accelerate the recovery of Lough Cullin as a trout fishery.

5. Fish stock surveys of Loughs Conn and Cullin should continue periodically to monitor changes over time.

6. Now that large rudd and roach populations have become established in Loughs Conn and Cullin resources should be sought to study the dietary interactions of cyprinid species, perch and trout. The quantification of phytoplanktonic and zooplanktonic organisms would be an integral part of this exercise – i.e. this is critical in order to establish the selectivity of the different fish species, at juvenile stages, to available dietary items. Ideally such a study would be a part of a broader national programme involving parallel studies of this kind on a number of salmonid lakes which all now support mixed trout and cyprinid stocks.

7. REFERENCES

Anon, 1930. An Anglers Guide to the Irish Free State. Ministry of Fisheries, Dublin, 245pp.

Anon, 1957 to 1979/80. Annual Reports of the Inland Fisheries Trust Dublin - for each year listed.

Anon, 1976. Inland Fisheries Trust Annual Report, Dublin.

Anon, 1977. Inland Fisheries Trust Annual Report, Dublin.

Donnelly, 2001. The Response of Lough Conn and Lough Mask, two Irish Western Lakes, to Total Phosphorus Loading, 1995-1999. Unpublished Ph.D. Thesis, N.U.I., Dublin.

Foster, M. 1980. Muriel Fosters Fishing Diary. Viking Press, New York.

Igoe, F., O'Grady, M., Byrne, C., Gargan, P., Roche, W. and O'Neill, J. 2001. Evidence for the extinctions of two Arctic charr *Salvelinus alpinus* (L.) populations in the West of Ireland. *Aquatic Conserv. Mar. Freshw. Ecosys. 1*, 77-92.

Kennedy, M. and Fitzmaurice, P. 1971. Growth and food of brown trout (*Salmo trutta* (L.)) in Irish waters. *Proc. R. Ir. Acad., 71*, (B), (18) p269-352.

Kennedy, M. and Fitzmaurice, P. 1974. Biology of the Rudd *Scardinus erythrophatalamus* (L.) in Irish waters. *Proc. R. Ir. Acad., 74*, (B), (18) p245-303.

King, J.J. and O'Grady, M.F. 1994. Aspects of the limnology of Lough Gur, Co. Limerick. *Ir. Fish. Invest.* Series A (Freshwater), No. 37, 11pp.

McCarthy, T.K., Barbiero, R., Doherty, D. and Cullen, P., Ashe, P., O'Connell, M., Guiry, M., Sheehy-Skeffington, M., King, J. and O'Connor, B. 2001. Investigation of Eutrophication Processes in the littoral zones of Western Irish lakes. Environmental Protection Agency, Wexford. *R & D Report Series No. 13*.

McGarrigle, M.L., Champ, W.S., Norton, R., Larkin, P. and Moore, M. 1993. The trophic status of Lough Conn: an investigation into the causes of recent accelerated eutrophication. *Report prepared for the Lough Conn Committee*. Mayo County Council, Castlebar.

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

O'Grady, M.F. 1983. A technique for estimating brown trout (*Salmo trutta* L.) populations in Irish lakes : From *Advances in Fish Biology in Ireland, Ir. Fish. Invest.*, Series A, No. 23, pp43-46.

O'Grady, M.F. 1994. A Fishery Survey of the Moy Catchment and a Draft Development Plan for this Resource. Central Fisheries Board Report 43pp.

Roche, W. 1999. Fish Studies in Pollaphouca Reservoir, Co. Wicklow. Ph.D. Thesis, National University of Ireland.

Walsh, T. 1996. Roach in the Moy Catchment. Central Fisheries Board Report. 8pp.

Went, A.E.J. 1957. The pike in Ireland. *Ir. Nat. J. 12* : 177-181.

Went, A.E.J. 1971. The Distribution of Irish Charr (*Salvelinus alpinus*). *Ir. Fish. Invest*., A6, 5-11.

Facts *vis.* The Castlebar River, Cullin, Conn and the Lower Moy River

Castlebar River

1. Fishery research has shown that the adult trout stock in L. Cullin is very heavily dependant on the production of juvenile trout from the Castlebar River recruiting to the lake.
2. Over the last five years a monitoring of fish stocks in the Castlebar River has illustrated the presence of very poor trout numbers. Some reaches downstream of the town were virtually fishless as recently as September, 2000. Some sections in the lower reaches of the Castlebar river as recently as September, 2001, were supporting only 22% of the trout numbers one would expect to find in unpolluted conditions. [+ Siobhan's Fish Kill Data]

Lough Cullin

The trout population in Lough Cullin in 2001 is, numerically, only 12.6% of the stock which was present in 1994. This level of reduction constitutes a virtual population collapse. The ongoing pollution problems in the Castlebar River have, undoubtedly, played a primary role in the collapse of the L. Cullin trout population. Currently this water can no longer be regarded as a trout fishery.

Until the pollution problems in the Castlebar River are resolved Lough Cullin cannot be restored to its previous status as a quality brown trout fishery.

Lough Conn

Fish stock survey data for Lough Conn over the period 1978 to 2001 illustrate very dramatic changes in fish populations in this water over time. In chronological order the following sequence of events took place.

1. 1978 to 1984 – Lough Conn supported a large healthy stock of trout and charr. It was rightly regarded, at that time, as one of Europe's top quality brown trout fisheries. Angling catch data for L. Conn from the 1930's to 1984 reflect the presence of a large stable trout population over that time span.
2. 1990 to 2001 the large charr population become extinct – charr are known to be very sensitive to pollution problems. The EPA reported a doubling of the

phosphorus load to Lough Conn from 1980 to 1990 (principally from agricultural sources).

A very marked declines in the trout population took place – by 2001 the trout stock density in Lough Conn was only 36.5% of population recorded in 1984. The average size of trout had increased greatly. These changes in the trout stock are reflected in the angling catch data. Today (2001) Lough Conn can no longer be regarded as a quality brown trout fishery.

In the last decade a very large fast-growing rudd population has become established in Lough Conn. No rudd had been recorded in fish stock surveys of Lough Conn prior to 1994 although rudd are known to have been present in L. Cullin, in small numbers, since at least the 1960's. Adult rudd feed principally on algae and other plant material.

The decline in trout stocks and the explosion in rudd numbers are further clear indicators of pollution problems in Lough Conn.

Until the phosphorus load to Lough Conn is significantly reduced one cannot expect any improvement in this water as a trout fishery.

Moy River (Foxford to Estuarine Reaches)

Over the last decade anglers have occasionally complained about their inability to angle for salmon (in the river) and sea trout (in the estuary) because of extensive algal growths on the bed of the river. These growths are a consequence of the phosphorus load being discharged to the Moy from Loughs Conn and Cullin. Should phosphorus loads to the Moy increase further one can expect an increasing problem in this area and a decline in the quality of what is Europe's best Atlantic salmon fishery.

Martin O'Grady Ph.D.
Central Fisheries Board
16th November, 2001

APPENDIX I

Angling Catch Statistics for Lough Conn

Derived from three sources:-

i - Inland Fisheries Trust Annual Reports (1957-1979/80)

ii - North-western Regional Fisheries Board Catch Statistics (1982-2001)

iii - Lough Conn and Cullin Anglers Association (1987-2000)

APPENDIX 2

Fluctuations in Trout Stock Densities in specific reaches of the Castlebar and Manulla Rivers (1995 to 2001)

Both the Castlebar and Manulla Rivers were drained in the 1960's as part of the Moy Catchment Drainage Scheme. In 1996/1997 selected reaches of these two rivers were physically enhanced by the Nw.R.F.B. as part of the Moy Fisheries Enhancement Programme – a Tourism Angling Measure Programme. Trout stocks were quantified in four reaches of the Castlebar River and one reach of the Manulla River prior to, and at intervals after, the development programme in order to monitor the effectiveness of the physical enhancement exercise (Table 1).

In the developed reach of the Manulla River only ten trout (≥1+ year-old fish) were present in a reach at the pre-developmental stage. Two, three and four years after completion of the development programme a total of 174, 124 and 135 trout respectively were recorded in the same reach (Table 1).

The physical development programme implemented in the Castlebar and Manulla Rivers were very similar in type – i.e. one would expect to see similar increases in trout populations in both rivers post-works. This was not the case. Trout numbers in both developed and undeveloped reaches of the Castlebar River declined markedly following the completion of the enhancement programme (Table 1). In the authors opinion this decline is due to the polluted status of the Castlebar River from 1996 to-date.

Table 1. Electro-fishing data in relation to numbers of 1+ year-old and older trout in discrete sections of the Castlebar and Manulla Rivers at intervals from 1994 to 1999.

Castlebar River

Site Location	Date	River Bed area fished (m^2)	Nos. of 1+ year-old and older trout recorded	Development Status
U/s of "N5 Tyre Depot"	May, 1995	2166	127	
	May, 1996	1018	9	
	June, 1999	1378	53	Undeveloped
	September, 2000	1300	1	
At Turlough	May, 1995	1030	126	
	May, 1996	900	135	
	June, 1999	956	82	Developed in 1996
	September, 2000	1085	72	
Lower reaches u/s main Castlebar to Swinford Road Bridge	May, 1995	4780	127	
	May, 1996	4238	109	
	June, 1999	4590	131	
	September, 2000	4683	65	Undeveloped
	June, 2001	3870	69	
Lower reaches d/s main Castlebar to Swinford Road Bridge	May, 1995	3570	223	
	May, 1996	3743	275	
	June, 1999	3416	197	Developed in 1996
	September, 2000	3741	126	
	June, 2001	3424	183	

Manulla River

Site Location	Date	River Bed Area Fished ($m^{2)}$	Nos. of 1+ year-old and older trout recorded	Development Status
Lower reaches d/s of the last road bridge	June, 1994	1899	10	
	June, 1999	1891	174	Developed in 1997
	June, 2000	1963	124	
	June, 2001	1724	135	

APPENDIX III

Catch Per Unit of Effort Values (C.P.U.E.) records for all fish species in all fish stock surveys of Loughs Conn and Cullin

CPUE for L. Conn 1978 - 1984 - 1990 - 1994 - 1998 - 2001

	1978	1984	1990	1994	1998	2001
Trout	5.56	6.84	6.4	4.3	1.15	2.5
Salmon	na	na	0.2	0.2	0.1	0.17
Char	0.8	0.88	0	0	0	0
Pike	0.21	0.35	1.18	1.8	0.7	2.1
Perch	na	3.89	17.88	15.67	9.48	23.9
Rudd	0	0	0	0.08	0.4	16.33
Roach	0	0	0	0	0	24.36

Figure 2: Length Frequency Distribution of Trout Samples from L. Conn Surveys 1978 - 2001