Arch. Hydrobiol. Spec. Issues Advanc. Limnol. 57, p. 627–638, July 2002
Biology and Management of Coregonid Fishes – 1999

Current status of the pollan (*Coregonus autumnalis* Pallas 1776) in Ireland

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with 2 figures and 4 tables

Abstract: Only four populations of *Coregonus autumnalis* have been described in Western Europe. All occur in large, shallow, productive lakes in Ireland. The ecology of the Irish populations contrasts markedly with that of the species in the remainder of its distribution. Recent surveys of Lower Lough Erne, Lough Derg and Lough Ree have indicated that these populations are threatened, with pollan contributing less than 1% to each fish community. The Lough Neagh population is still numerically strong, comprising 25% of the fish community, but has recently shown indications of population stress, with fluctuations in size structure. Although fluctuations are a noted feature of many coregonid stocks, recent changes have been associated with habitat degradation and the introduction of the roach (*Rutilus rutilus*) in all four lakes. Although at risk, there is evidence of recent spawning in each population. Threats to the future survival of the Irish populations from introduced species, eutrophication, fishing and parasites, are considered.

Introduction

Irish populations of *Coregonus autumnalis* are disjunct and found at the southern extreme of the species distribution (McPhail 1966, Ferguson et al. 1978). They contrast markedly in their biology with non-Irish *C. autumnalis* in regard to their life-histories, population dynamics and their habitats: Irish *C. autumnalis* (known locally as pollan) are lacustrine, non-anadromous, short-lived, display early maturation and rapid growth rates and are found in a temperate oceanic climate. Although Ireland has more than 4,000 lakes larger than 5 ha in size (Reynolds 1998) only four, Loughs Neagh, Erne, Derg & Ree, support populations of pollan (Fig. 1).

Much of our knowledge of pollan biology stems from work on the diet, behaviour of larvae and fry, growth and population dynamics of the L. Neagh stock during the 1970s by Dabrowski, Wilson, and co-workers (see Wilson 1993 for review). Winfield et al. (1993) estimated pollan abundance during the late 1980s, whilst Winfield & Wood (1990) summarised the

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0071-1128/02/0057-627 $ 3.00

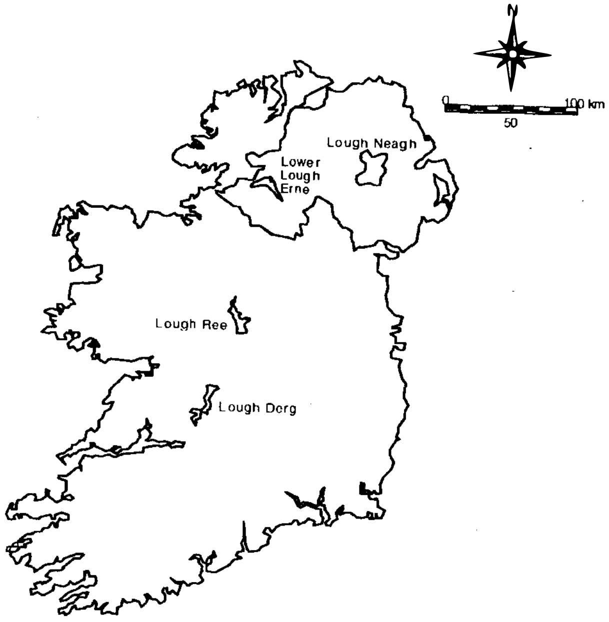

Fig. 1. Irish loughs supporting populations of *Coregonus autumnalis*.

conservation status. KIRKWOOD (1996) described diets and dietary-overlap between pollan, roach (*Rutilus rutilus*) and perch (*Perca fluviatilis*).

Information on the remaining pollan stocks, although extremely limited, indicates a similar ecology. ROSELL (1994) compared the results of large-scale gill netting surveys carried out on Lower L. Erne in 1972–3 and 1991–2 and highlighted the decline in pollan numbers. During the earlier study, pollan formed 5% of the food of pike *Esox lucius* (DANI 1973) but during the 1991–2 survey no pollan were caught and they were absent from pike stomachs. Consequently, ROSELL (1997) conducted extensive, sonar-directed, gillnetting surveys between 1992–5 but obtained only 21 specimens. WENT (1946) described the pollan of the Shannon system (Loughs Derg & Ree) as occurring in large numbers prior to a Nineteenth-century decline. Little has been written about Shannon pollan, but an early description of the fish community of L. Derg from a substantial gillnetting study conducted between 1918–23 provides useful baseline data prior to eutrophication and the introduction of roach, both of which have been implicated elsewhere in pollan decline (WINFIELD & WOOD 1990, ROSELL 1997). Studies have described Shannon pollan diet (SOUTHERN & GARDINER 1926, FITZMAURICE 1977) and parasites (FAHERTY 1996).

The pollan still supports part of what is and has historically been the largest freshwater fishery in the British Isles (L. Neagh) (WOOD 1989). The fishery currently provides employment to *ca.* 400 individuals in an area of considerable rural deprivation and therefore has substantial socio-economic value (WOOD op. cit.).

The Irish freshwater fish fauna is notably depauperate with 25 species (of which only 14 are indigenous), in comparison with Britain (47 spp.) and continental Europe (194 spp.) (GRIFFITHS 1997). The pollan is the only Irish vertebrate not to occur elsewhere in Europe (WHILDE 1993), making it an important component of Ireland's limited biodiversity. Previous conservation studies have considered single populations (WINFIELD & WOOD 1990, ROSELL 1994, 1997) or have relied on outdated or anecdotal evidence regarding pollan status, but indicate that *C. autumnalis* is endangered in Europe (MAITLAND & LYLE 1991, WHILDE 1993, UK Steering Group on Biodiversity 1995, QUIGLEY & FLANNERY 1996). This paper details the current status of, and threats to, the pollan in Ireland.

Materials and methods

The location and limnological characteristics of each lough are given in Fig. 1 and Table 1. The loughs are located at low altitude, are large, relatively shallow, increasingly eutrophic, and have recently undergone large shifts in community structure after introductions/invasions of exotic species (WOOD & SMITH 1993, MCCARTHY et al. 1997, BOWMAN 1998, REYNOLDS 1998, GIBSON 1998).

Pollan have been regularly caught in the north-west of L. Neagh since 1991 during routine (approximately monthly) monitoring of the fish community. During the early 1990's a benthic trawl was used but after its use was stopped by the fishery in early 1994, vertical monofilament gillnets covering the entire water column have been employed (6, 10, 16 mm bar mesh). Since 1997 regular monthly surveys have included bottom and surface-set multipanel survey nets (45 x 1.5 m with 14 panels ranging from 6.3–75 mm bar mesh). Nets were positioned at a range of depths (1–20 m) and typically set at dusk and lifted at dawn.

Table 1. Some limnological characteristics of pollan loughs. (L. Neagh, WOOD & SMITH 1993 & GRIFFITHS unpubl.; Lower L. Erne, GIBSON 1998 and L. Derg & Ree, BOWMAN 1998).

Lake	Position	Altitude (m)	Surface area (km^2)	Max. depth (m)	Mean depth (m)	Annual mean total P (mg/m^3)	Annual mean Chl.*a* (mg/m^3)	Max. Chl.*a* (mg/m^3)
Neagh	54° 35'N 6° 25' W	15	383	34	8.9	173	47	93
Erne	54° 30' N 7° 50' W	46	109	62	11.9	59	5	-
Ree	53° 30' N 7° 58' W	38	105	35	6.2	47	15	42
Derg	52° 55' N 8° 15' W	33	117	36	7.5	43	17	72

In large–scale gillnetting surveys of Lower L. Erne in 1991–2 no pollan were caught (Rosell 1994). Subsequently gillnetting effort was directed to areas that returned echosounder (Simrad EY-200) targets thought to be pollan and in 1992 two pollan were caught. In summer surveys in 1994, 1995 and 1997 nets were set for 24 hours aimed at targets within 3–5 m of the bottom, at depths below the summer thermocline (i.e. usually 20 m or more). Gillnets used were 45 x 1.5 m, with six panels with mesh sizes from 12 to 45 mm (bar). This mesh range appears to catch all but 0+ group fish. Within each year's netting, half the nets were bottom set and half were floated to fish with the leadline 2 m off the bottom.

The fish communities of L. Derg and L. Ree were sampled during the late summer/early autumn of 1995 using 91 x 2.1 m gillnets of 50 and 100 mm bar mesh, set for 24 hours. Pollan were also collected from L. Derg as by-catch from eel-nets set to catch migrating eels (*Anguilla anguilla*).

Results

Population structure

The size structure of each pollan population is shown in Fig. 2. Catches of Erne pollan were consistently low with only 32 fish captured from a total of 79 individual sonar-directed nettings over three summers. Rosell (1997) noted that the catch included pollan larger and older than those previously described from Irish populations. Over this period, fish ≥ 300 mm fork length have contributed ~40% of the total catch, the largest individual being a 7+ female fish of 370 mm fork length and 781 g mass. One 340 mm, 4+ female caught in 1994 weighed 858 g. Regan (1911) recognised Erne pollan as a separate species, mainly due to their large individual size.

Although pollan numbers are low in the Shannon lakes, many smaller fish (0–2+) were caught in L. Derg, indicating successful spawning in recent years. The scarcity of larger pollan in the catch may reflect gill-net selectivity. The L. Neagh pollan sample shown was taken in multipanel gillnets in July 1999. Pollan hatched prior to 1995 were rare, and fish of the slow-growing 1996 year-class dominated the population, with a modal fork length of 240 mm. Recruitment was poor in 1997, and 1998 but fish of the 1999 cohort have been well represented in catches during summer 1999, suggesting the rise of a particularly strong year-class.

Community structure & relative abundance of pollan

All the loughs currently show fish communities dominated by roach (Table 2). Although the gears used during the 1918–23 Lough Derg survey (gillnets of mesh sizes ranging from 25–63.5 mm bar) differed from those used in the recent work, comparison with the 1995 data suggests that major changes have occurred in the fish community. In the earlier study, perch (a species probably introduced to Ireland during the 17th Century; Kennedy & Vickers 1993) dominated the system but are now uncommon after a dramatic decline as a consequence of disease. A further indicator of change is the apparent loss of the rudd (*Scardinius erythrophthalmus*), which in 1918–23 contributed 5% to the catch. This species has disappeared from

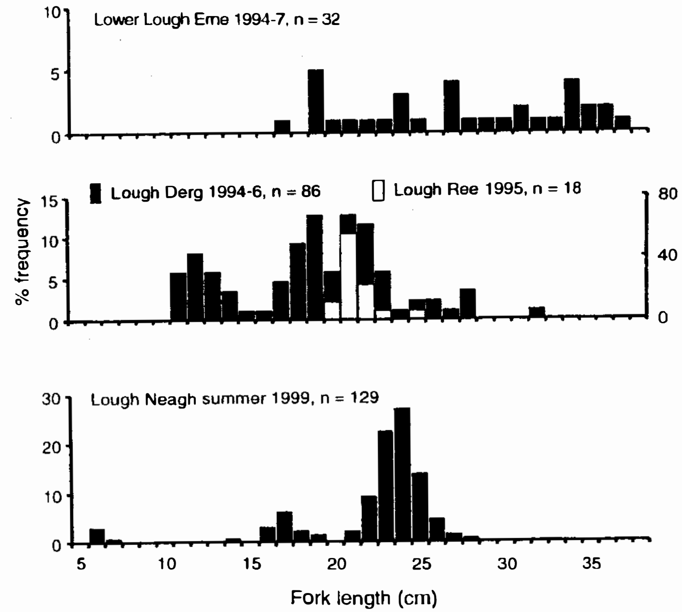

Fig. 2. Pollan length frequency distributions. N.B. samples were collected using a range of gillnet sizes. The right-hand vertical axis of the middle figure corresponds to the L. Ree sample. Note the use of different scales on vertical axes.

many other Irish waters since the introduction of roach, including L. Neagh & L. Erne (Fitzmaurice 1981, Kennedy & Vickers 1993). In the summer, roach dominate inshore but perch are more common offshore (L. Erne Table 2; L. Neagh Winfield et al. 1993). During the early 1990s, the fish community of Lough Neagh was dominated by perch (Winfield et al. 1993, Griffiths unpublished): the reason for the subsequent decline is unknown. Roach numbers have recovered from a crash in the late 1980's due to mass infection by the cestode *Ligula intestinalis* (Winfield et al. 1993).

Pollan are currently relatively abundant in Lough Neagh, making up ~25% of catches (Table 2). By contrast, even with a considerable, actively targeted, sampling effort (1896 net hours), Erne pollan catches were negligible (n = 32). For a similar level of sampling effort in L. Neagh during 1998, where netting was not sonar-directed, > 1,100 pollan were captured (Harrod & Griffiths unpubl.). Pollan were absent from shallow areas in L. Erne, and scarce in the deep-water community. They occupy all habitats in L. Neagh. Pollan in the Shannon lakes currently make a very small contribution to the catch and appear to have decreased since 1918–23.

Table 2. Fish community structure of Irish pollan loughs. The figures give percentage contribution in gillnet catches. Lough Neagh data are from 10 surveys in the north-west and south-east of the lough between August 1998-July 1999. L. Erne results are given for surveys carried out in shallow and deep-water areas during 1991–4. Data from a 1918–1923 survey of L. Derg (ANON. 1924) are included to permit comparisons with the situation prior to the effects of cultural eutrophication and the introduction of roach. N.B. + indicates that the species is found in the lake but was not taken during this study. Other fish species also occur in the loughs.

Species	L. Neagh	L. Erne < 5 m	L. Erne > 5 m	L. Ree	L. Derg	L. Derg 1918–23
Pollan	25.61	–	1.60	0.57	0.31	8.87
Roach	57.88	62.42	26.28	72.26	78.90	–
Perch	2.54	31.14	65.37	7.78	5.97	75.99
Bream *Abramis brama*	2.01	2.10	8.02	1.30	2.01	0.68
Bream x Roach hybrid	0.57	2.65	0.37	12.52	9.83	–
Rudd *Scardinius erythrophthalmus*	–	–	–	0.19	–	5.13
Gudgeon *Gobio gobio*	9.32	+	+	+	+	+
Tench *Tinca tinca*	–	–	–	0.03	–	0.04
Brown trout *Salmo trutta*	2.08	0.55	3.56	2.41	1.88	2.03
Pike *Esox lucius*	+	1.14	0.89	2.84	0.99	1.56
Total catch =	2 640	2 470	898	3 691	2 929	16 559
Netting effort (No. nets set)	110	72	67	25	27	–

Recent population changes

Marked changes in population structure and shifts in spawning date in L. Neagh pollan took place between 1991 and 1996. The maximum-recorded size of pollan taken on each sampling occasion between May 1991 and October 1996 declined (r_s = –0.621, P = < 0.001, n = 51): fortunately this trend has subsequently reversed. Since different gears were utilised during this time, with fish being collected by trawls before 1994 and gillnets after, these data should be treated with caution. However, comparison of the length-frequency distributions of spawners from sites on the north shore of Lough Neagh in 1977 (DABROWSKI 1981) and 1996 supports a decline in pollan size during the 1990s (Mann-Whitney test of fork lengths: 1977 n = 106, median = 260 mm, range 235–305 mm; 1996 n = 63, median = 220 mm, range 196–239 mm, P < 0.001). These data are directly comparable since the nets used were of similar mesh size.

Such a decline in average size has ecological implications. WILSON & PITCHER (1984a) noted that pollan matured at 2+: they take May as the birthdate which, since fish grow little over the winter, implies that fish matured at about 240 mm. In 1977 98% of fish at the spawning site were larger than 240 mm, whereas in 1996 only 3% of spawners were larger than this. The median size of spawners in 1996 and 1977 (see above) corresponds to fecundities of approximately 3,000 and 8,000 eggs respectively (from information in WILSON & PITCHER 1984b). In addition, very few of the males examined in 1996 were sexually mature i.e. releasing milt. Few 0+ pollan were caught during 1997 and 1998, suggesting that recruitment was limited by small adult size.

Previous studies have recorded pollan spawning between late-November and mid-December (WILSON 1979, DABROWSKI 1981, WINFIELD & WOOD 1988). However, in 1996 pollan did not arrive on the spawning grounds until the first week of December and females with eggs were collected into mid-January 1997. This shift was not related to water temperature since end-of-year temperatures in 1996 were similar to those in 1977. Spawning date has been related to fish size/age in coregonids (NÜMANN 1972) so the change in spawning time is consistent with the hypothesised decrease in size.

The shifts in pollan size during the 1990s were probably due to the loss of larger fish from the population. Pollan growth rates have decreased slightly in the intervening two decades (HARROD unpubl.), but not sufficiently to account for the decrease in average spawner size.

These changes may simply be a function of natural population fluctuations, a feature characteristic of many coregonid stocks (e.g. CARANHAC & GERDEAUX 1998) including that of Lough Neagh. Pollan stocks have decreased to levels that interrupted commercial fishing in the 1800s, 1915–1925, early 1930s, and late 1970s (MENZIES 1924, WILSON 1979).

During his work on pollan genetics during the 1980s, Ferguson (pers. com.) found pollan without undue effort in L. Erne and pollan numbers were sufficient to support a small-scale commercial gillnet and purse-seine fishery in the past (REGAN 1911, ROSELL 1997). The Department of Agriculture for Northern Ireland recently suspended the issue of commercial licenses for Erne pollan due to the decline in numbers. ROSELL (1997) tentatively suggested that there had been an improvement in the state of the population between 1991 and 1995. The increased contribution of pollan of fork length 170–250 mm, fish in their first 2 years of life, in the 1997 sample indicates recruitment in 1995–6. Lack of data precludes discussion regarding recent changes in the Shannon pollan populations.

Inter-population comparisons

Although the scarcity of the species in three of the four loughs prevents anything but the most cursory comparisons between pollan stocks, some differences are apparent. L. Derg and especially L. Erne pollan are heavier for a given length than L. Neagh fish (Table 3). Similarly, pollan in L. Erne grow bigger than in the other loughs (Table 4).

Although Irish *C. autumnalis* experience similar climatic conditions (the populations are less than 200 km apart), there are considerable differences in abundance. The lakes do vary in their ecological and limnological states. The extremely productive L. Neagh, with mean chlorophyll *a* concentrations far higher than those typically encountered by coregonids, surprisingly supports the most abundant pollan population. Just why pollan are still abundant in L. Neagh, when they have declined in other loughs, is unclear.

Reasons for decline/ Perceived threats

Interspecific competition & invasive species

ROSELL (1997) suggested that competition with the now dominant roach presented the most likely reason for the recent decline in L. Erne. Roach are strong competitors and have been

Table 3. Length-weight (log-log) regressions for Irish *C. autumnalis* populations using data from fish collected throughout the year (Neagh & Derg) and summer (Erne).

Lough	a	b (± S.E.)	r^2	n	Length range (mm)	Mass range (g)
Neagh	–5.439	3.202 (± 0.080)	0.989	1901	53–325	1–478
Erne	–5.553	3.291 (± 0.156)	0.931	34	165–370	55–858
Derg	–6.140	3.512 (± 0.070)	0.967	86	105–316	7–480

shown to depress populations of other species (e.g. perch) in lake systems (Persson 1991). There is considerable dietary overlap between pollan and roach for both planktonic and benthic food in Lough Neagh (Kirkwood 1996), and laboratory studies are underway to investigate potential competitive asymmetries between 0+ pollan and roach for zooplankton prey.

The success of various species in invading Irish ecosystems is well documented (Dick 1996) and may further threaten the survival of pollan stocks. For example the colonisation of potential pollan spawning areas by large numbers of zebra mussels in L. Erne and L. Derg has been reported recently (McCarthy et al. 1997, Rosell et al. 1998).

Habitat degradation

The changes in Irish pollan populations have occurred against a background of considerable hydrochemical change. All pollan loughs have undergone recent cultural eutrophication, but L. Neagh is possibly the most studied. During the 1980–90's the enrichment of L. Neagh began to fall after the introduction of phosphate stripping in local sewage treatment works. However, the recent increase in lough productivity, with chlorophyll *a* concentrations now as high as those recorded in the 1970's, is due to saturation of agricultural land with phosphate fertilisers (Foy et al. 1995). This may affect fish community dynamics by influencing competitive interactions within the fish community, e.g. by intensifying competitive asymmetries between roach and perch. Although extremely eutrophic, Lough Neagh is shallow with a large fetch ensuring that it is generally wind-stirred with high dissolved oxygen concentrations (Gibson & Stewart 1993); Wood et al. (in press) concluded that it normally behaves as a cold oligotrophic lake. However, for short periods during the summer oxygen saturation levels drop to 80% or less (DANI unpublished data for 1994–97). Furthermore during (rare) periods of calm weather during summer, thermal gradients form and the water column can rapidly become deoxygenated. These conditions will intensify with increasing eutrophication. As a cold-adapted, typically arctic animal, pollan suffer temperature stress at elevated summer temperatures (Dabrowski 1985); above 18 °C respiratory demands account for much of the energy consumed from food. Wilson (1979) noted large numbers of dead pollan during the hot summer of 1976, when water temperatures reached 20 °C, and he reported that during the following autumn pollan were scarce and failed to recruit in 1977. Any metabolic stress due to temperature or reduced concentrations of O_2 will probably act selectively on larger fish (Coutant 1985). Temperature rises associated with global warming could fatally increase the stress on pollan stocks.

Table 4. Pollan fork lengths (mm) at age (years) and the von Bertalanffy growth curve parameters L_∞ and K.

Lough	Period	1	2	3	4	5	6	7	L_∞	K
Neagh	1997–99	134	209	233	251	271	290	–	297	0.49
Derg	1995	120	194	235	–	277			298	0.52
Erne	1992–97	177	238	293	340	350	–	359	379	0.46

Commercial exploitation

Lough Neagh pollan have been exploited for centuries by commercial fisherman (Thompson 1856). Recently demand for pollan has fallen, with only ~£0.5/kg being paid, and fisherman largely exploit eels, using long-lines and purse seines (~£4.00/kg). This contrasts with the situation at the turn of the century, when over 455 tonnes of pollan, equivalent to a yield of 12 kg/ha, were exported to Britain in a single season (Anon. 1901). However, pollan of all ages are still taken as by-catch during purse seining for eels (~50 fish day^{-1} $boat^{-1}$, Harrod pers. obs.) and adult pollan are still exploited for local consumption. Although identified as a risk to pollan conservation by Menzies (1924), fisherman still catch 0+ pollan to bait long-lines for eels. Each fishing boat takes approximately 1500 pollan/day for bait over a two-month period (M. Quinn pers. com.) suggesting that each summer over a million pollan could be removed by only 20 boats.

Parasites

Work since 1997 has shown that Lough Neagh pollan are heavily infected with metacercariae of the strigeid trematode *Ichthyocotylurus erraticus* (95% prevalence, n = 1645 fish). The worms are found encysted on the surface of the heart or aggregated in the surrounding pericardial cavity. In a sample of 350 infected fish individual burdens ranged from single cysts found in 0+ fish to 2890 cysts in one 4+ female, whilst mean parasite burden (± 1 S.E.) was 348 (± 18.1). Adult females suffered higher cyst burdens than males (Mann Whitney test: females n = 134, median = 364; males n = 172, median = 246, P = < 0.0001). Vickers (1951) noted that Lough Neagh pollan were regularly infected by what she tentatively identified as *Tetracotyle variegatus* (probably *I. erraticus*) but no detailed work has examined the effects of parasite infection on pollan biology. Mass mortalities of smelt (*Osmerus eperlanus*) and ruffe (*Gymnocephalus cernua*) have been linked to the pathological effects of infection by *I. erraticus* (Swennen et al. 1979). Petrushevski & Shulman (1961) record that infection of > 200 cysts/fish had a negative effect on host condition factor in Siberian coregonids. Work is ongoing to investigate the relationship between pollan and *I. erraticus*, and to elucidate any possible pathological effects of infestation.

Faherty (1996) found very few parasites in pollan from the Shannon system. Interestingly she recorded metacercariae of a unidentified *Tetracotyle* species (i.e. *Ichthyocotylurus* sp.) as the most prevalent parasite of pollan, but at a maximum individual burden of 10 cysts/host.

Conclusion

Pollan are extremely threatened in three of their four European habitats, contributing less than 1% to the fish communities of Loughs Derg, Ree and L. Erne. Even in Lough Neagh, where they are abundant, there have been changes suggesting population stress. Still, there is evidence suggesting recent spawning in all loughs. Eutrophication is a feature of all the pollan loughs and seems likely to impact the species both by reducing summer oxygen concentrations and by favouring cyprinid competitors such as roach. However it is unlikely that eutrophication can be controlled in a predominantly rural economy or that roach populations can be reduced. Management of the only extant pollan fishery, on L. Neagh, is minimal: stocks are not routinely monitored and there are few fishing regulations other than mesh size limits and closure of the fishery during the spawning season. Regular monitoring of size structure and juvenile abundance would give early warning of adult mortality and year-class failures while enforcement of the ban on using juvenile pollan for eel bait would reduce one potential threat to pollan in Lough Neagh. Given the limited ways in which threats to pollan can be ameliorated in the short term, there is a need for the establishment of back-up populations to safeguard the future survival of *C. autumnalis* in Europe. In the long term a pan-Irish action plan at the catchment scale is essential.

Acknowledgements

Thanks to Chris Goldspink & Calum MacNeil for comments. CH & DG would like to thank Matt Quinn, Ewan Bigsby & all other Traad folk for help in the field and laboratory. CH's attendance at the symposium was supported by a Fisheries Society of the British Isles travel grant and the work funded by a Dept. of Education for Northern Ireland postgraduate studentship. CH would also like to thank EO & CB. TKM was funded by the Electricity Supply Board, Dublin.

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