CURRENT STATUS OF POLLAN *COREGONUS AUTUMNALIS POLLAN* IN LOUGH REE, IRELAND

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ABSTRACT

The Irish pollan *Coregonus autumnalis pollan* is a unique and threatened freshwater fish species endemic to the island of Ireland, with its current known distribution limited to five lakes; Lough Neagh, Lower Lough Erne, Lough Allen, Lough Ree and Lough Derg. The Lough Neagh pollan are still relatively abundant, contributing approximately 25% of the total fish abundance. However, populations in Lower Lough Erne and the three Shannon lakes contribute $< 1\%$ of total fish abundance. As a result, pollan are listed as 'Endangered' in the Irish Red Data Book and the IUCN Red List of Threatened Species. Empirical data on pollan population size in Irish lakes is lacking, with current estimates based mainly on expert opinion. The current work combines new hydroacoustic data with an extensive gill netting survey, suggesting an abundance estimate for pollan greater than 10cm in length in Lough Ree to be in excess of 6000 individuals. The age classes 1+ and 2+ were captured and the hydroacoustic data displayed a strong cohort of 0+ fish, indicating reproductive success in the previous three years. This new abundance data contributes significantly to the knowledge of the Lough Ree pollan stock. Future and ongoing monitoring of population size, along with the identification of spawning locations, will help to inform management decisions aimed at protecting this unique and endangered fish species.

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Cite as follows: Harrison, A.J., Connor, L., Morrissey, E. and Kelly, F.L. 2012 Current status of pollan *Coregonus autumnalis pollan* in Lough Ree, Ireland. *Biology and Environment: Proceedings of the Royal Irish Academy* 2012. DOI: 10.3318/BIOE.2012.09.

Received 30 June 2011. Accepted 25 October 2011. Published 30 April 2012.

INTRODUCTION

The pollan *Coregonus autumnalis pollan* (Pallas, 1776) is a unique and threatened freshwater fish species endemic to the island of Ireland. It is a land locked relict of post-glacial colonization of the anadromous 'Arctic Cisco' that still occur in North America and northern Eurasia where they inhabit low productivity river systems (Maitland and Campbell 1992; Harrod *et al.* 2001). The distribution of pollan is limited to five lakes in Ireland; Lough Neagh, Lower Lough Erne, Lough Derg, Lough Ree and Lough Allen (Harrison *et al.* 2010). Of these lakes, only Lough Neagh is known to support a large stock, contributing approximately 25% of the total fish community (Harrod *et al.* 2002). Populations in the remaining four lakes have undergone significant declines since 1970 (Rosell *et al.* 2004). Due to their restricted geographic range and decline in numbers, pollan are afforded a high conservation status; they are listed in Annex V ('Animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures') of the EU Habitats Directive (Council of the European Communities 1992) and are classified as 'Endangered' in the Irish Red Data Book (Whilde 1993) and the IUCN Red List of Threatened Species (Frehof and Kottelat 2008). Pollan are included in the Priority List of species in the UK for which Species Action Plans have been prepared under the UK Biodiversity Action Plan (Maddock 2007). This is reflected in the publication of the All Ireland Species Action Plan for pollan (EHS 2005; NPWS 2005).

It is somewhat surprising that, despite the high conservation status of pollan, there are very little empirical data on the size of each population. In a recent report on the status of habitats and species for which protection is required under the EU Habitats Directive, pollan are described as being at critically low levels, with 'only hundreds or very low thousands of fish remaining in each of the three Shannon lakes'. This is largely based on expert opinion, with the quality of data on habitat and population size regarded as 'poor'. The resulting overall status assessment is given as 'Bad' (NPWS 2008). It is imperative that reliable abundance estimates are attained for each of the extant pollan populations in order to inform management decisions on their future protection.

Lough Ree is a 10,500ha lake with a maximum depth of 36m and an average depth of 6.2m. It is the middle of the three large Shannon lakes, with Lough Allen to the north

and Lough Derg to the south (Fig. 1). Much of the northern end of the lake is relatively shallow, with only one deep basin reaching a maximum depth of 31m. The southern end of the lake has several deep basins, with depths exceeding 35m (Fig. 3). Pollan tend to inhabitat these cooler, deeper waters of large lakes and, as such, are particularly suited to detection by hydroacoustic surveys (Rosell 1997; Rosell *et al.* 2004; Harrison *et al.* 2010).

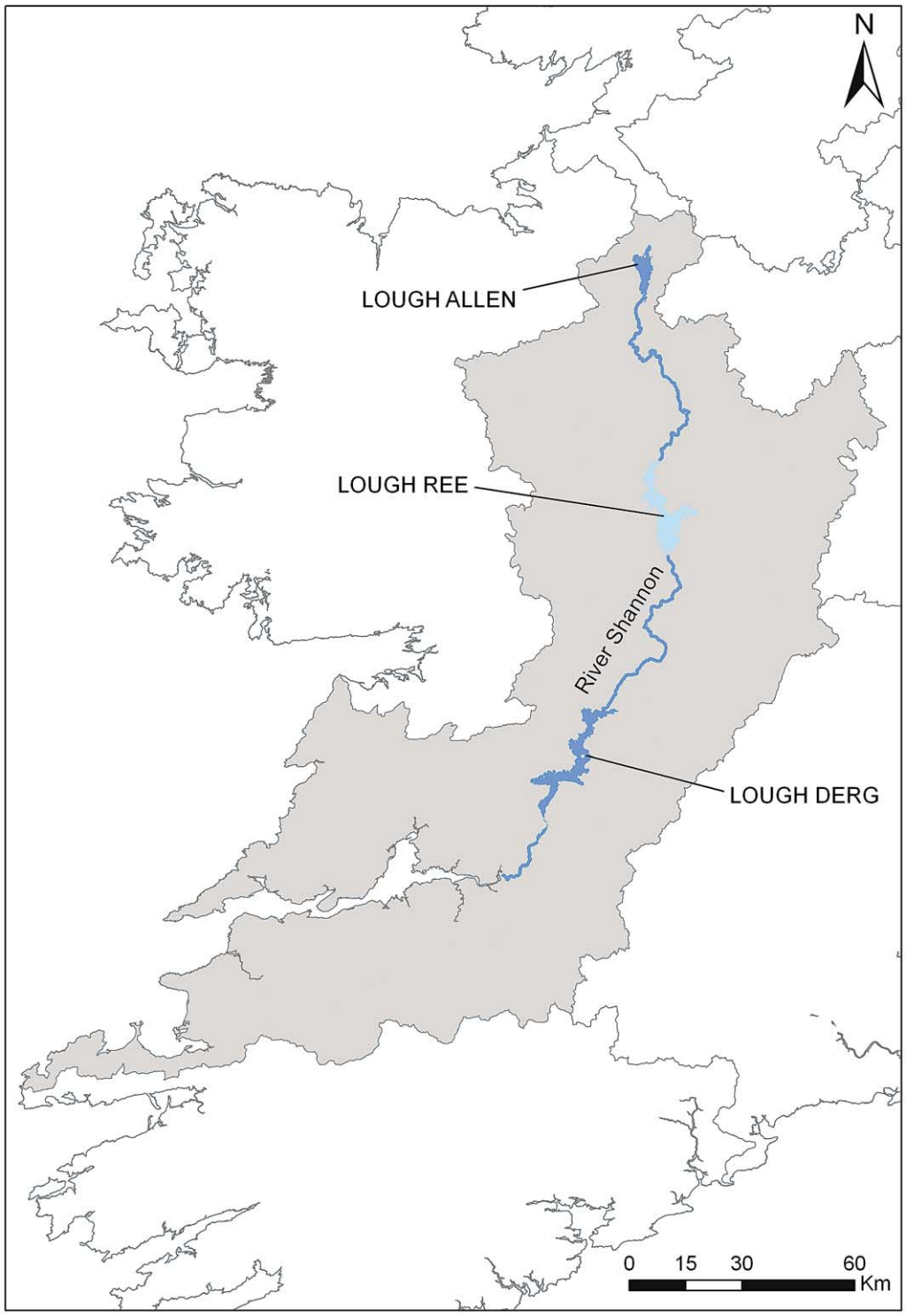

Fig. 1—Location of Lough Ree within the Shannon International River Basin District.

A systematic hydroacoustic survey was conducted by Inland Fisheries Ireland (IFI) during June 2010 in areas with depths in excess of 10m, along with a concurrent netting survey, in an attempt to assess the current status of the pollan population in Lough Ree.

MATERIALS AND METHODS

HYDROACOUSTIC SURVEY DESIGN, ECHOSOUNDER SETUP AND DATA PROCESSING

A hydroacoustic survey was conducted on Lough Ree during the daytime over a two-day period from 21 to 22 June 2010. Twenty-two latitudinal and nine longitudinal transects (total track length of approximately 64km) spaced 250m apart were identified (Fig. 2) and hydroacoustic data were recorded at a constant speed of 5km h^{-1}.

The sonar system consisted of a Simrad EY60 scientific echosounder with two vertical split-beam transducers (SIMRAD ES200-7C: 200KHz operating frequency, circular 3dB beam angle 6.5° and SIMRAD ES120-7C: 120KHz operating frequency, circular 3dB beam angle 6.5°) mounted using an adjustable bracket on the boat's starboard side at a depth of 0.5m. Sonar parameters were set as follows; transceiver power output: 90W, ping rate: 5 pings s^{-1}, pulse duration: 256μs, range: 70m, amplitude echogram threshold: −120dB.

Data were processed using Sonar5-Pro (Balk and Lindem 2004) post-processing software. Base threshold for data conversion was −120dB. Amplitude echograms were converted to TVG 40logR. Single Echo Detection (SED) criteria were defined as follows; minimum echo length: 0.7, maximum echo length: 1.6, maximum phase deviation: 0.6, maximum gain compensation: 3dB (one-way), multi peak suppression: medium. Minimum target strength (TS) for SED acceptance was set at −45dB, which is equivalent to vendace (a similar species of coregonid to pollan) of approximately 10cm in length (Mehner 2006).

Echo integration was used to obtain abundance estimates for transects of interest, with the TS distribution being obtained from the SED echogram. Using this method, the total back scattered echo energy from all fish targets within an analysed region is divided by the mean TS of single fish echoes to give an estimation of the total number of fish present, with the results being expressed as the number of fish per hectare. Files were manually checked to erase unwanted 'noise' before conducting the abundance analysis.

NETTING SURVEY

A concurrent netting survey was conducted from 15 to 25 June 2010 as part of IFI's fish monitoring programme for the Water Framework and Habitats Directives. This was used to 'ground-truth' species identification in the hydroacoustic data. A total of 48 benthic and eleven floating monofilament multimesh survey gill nets (30m × 1.5m, 12 panel, 5–55mm mesh size), nine benthic braided survey gill nets (27m × 2m, 62.5mm mesh size) and twelve sets of fyke nets (1 set = 3 × double fyke nets) were randomly set throughout the lake in accordance with a modified version of the CEN (2005) gill netting method, adapted by IFI for Water Framework Directive fish monitoring to reduce the netting effort by approximately half for Irish lakes (Kelly *et al.* 2008). This netting effort was supplemented by four pelagic monofilament multimesh survey gill nets (30m × 6m, 12 panel, 5–55mm mesh size) deployed in areas and depths where targets likely to be pollan were identified during the hydroacoustic survey.

Weather conditions during the 2-week survey period were sunny and calm, with the temperature profile in deep water showing a gradual decline from a surface temperature of 18.0°C to 12.2°C at 30m.

RESULTS

Eight fish species and one type of hybrid were recorded during the netting survey, with a total of 1499 fish being captured. The number and biomass of each species recorded, along with minimum and maximum lengths are shown in Table 1.

A total of fifteen pollan were recorded, distributed throughout eight nets (4 benthic, 2 floating and 2 deep pelagic) in the deeper sections of the lake (Fig. 3, Table 1). Although seven of these nets were situated in the southern end of the lake, the hydroacoustic data showed very sparse fish distributions in these areas and reliable abundance estimates were not possible. The highest density of fish targets recorded in the hydroacoustic data was found in one small basin in the northern end of the lake, covered by Transects 1 and 2 (Fig. 2). This area contained one large shoal of fish within the pelagic layer between 12m and 25m (Fig. 4), displaying typical pollan hydroacoustic echoes (relatively high acoustic TS with strong individual fish targets) and deep water shoaling behaviour. The pelagic gill net set in this area was lowered into the middle of the shoal for two hours and retrieved with a single pollan specimen and no other species present, indicating that the concentration of fish was most probably pollan. The mean abundance estimate of fish > 10cm within this shoal was 114.6 fish ha^{-1} (Transect

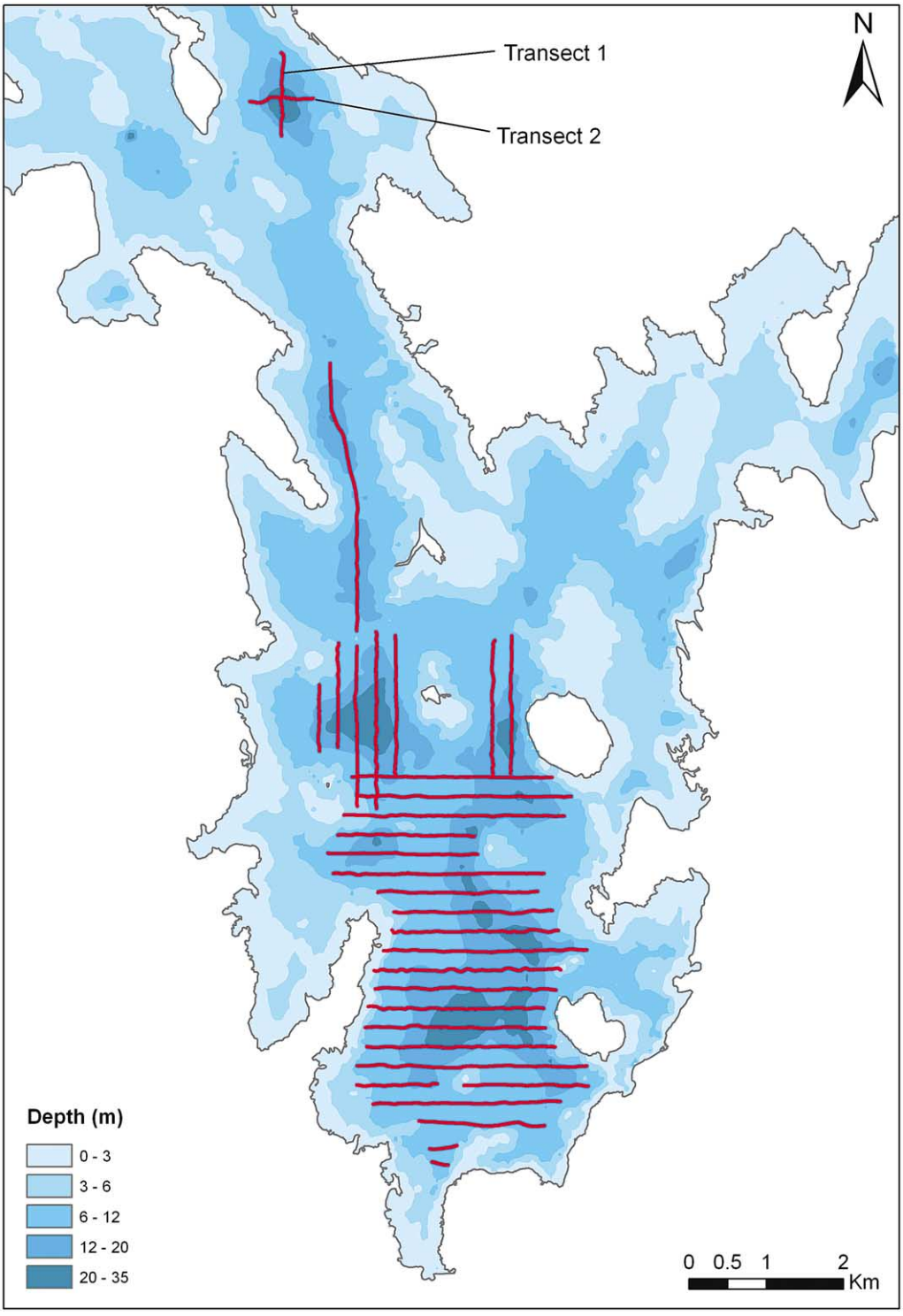

Fig. 2—Position of sailed transects during which data were recorded on Lough Ree, June 2010.

$1 = 91.4$ fish ha^{-1}, Transect $2 = 137.8$ fish ha^{-1}). The total area of the basin in excess of 12m in depth is approximately 49ha, giving an estimate of the number of fish >10cm within this shoal to be between 5000 and 6000 individuals.

Of the fifteen pollan captured, twelve specimens were aged $1+$ and three were aged $2+$. The mean lengths at age one and age two were 13.3cm and 20.4cm, respectively. Mean lengths at age for pollan in other Irish lakes are given in Table 2.

Table 1—Number, biomass, minimum and maximum length of all fish species captured during the netting survey.

Common name	*Scientific name*	*Number*	*Percentages of abundance*	*Biomass (kg)*	*Percentage of biomass*	*Minimum length (cm)*	*Maximum length (cm)*
Perch	*Perca fluviatilis*	995	66.4	71.1	24.2	3.2	31.0
Roach	*Rutilus rutilus*	211	14.1	84.9	28.9	5.2	35.1
Roach × Bream		150	10.0	98.8	33.6	20.8	41.9
Eel	*Anguilla anguilla*	111	7.4	20.6	7.0	34.5	59.5
Pollan	*Coregonus autumnalis pollan*	15	1.0	1.5	0.5	13.8	26.0
Brown trout	*Salmo trutta*	8	0.5	3.8	1.3	18.8	45.2
Pike	*Esox lucius*	7	0.4	10.4	3.5	29.5	73.3
Bream	*Abramis brama*	1	0.1	1.8	0.6	42.0	42.0
Tench	*Tinca tinca*	1	0.1	1.2	0.4	40.2	40.2

Although no 0+ fish were captured during the netting survey, reducing the hydroacoustic threshold to −55dB (equivalent to a fish of approximately 4cm in length) indicated the presence of a substantial cohort of 0+ fish within the shoal.

DISCUSSION

This current work has attempted to provide an estimate of the size of the pollan population in Lough Ree using new hydroacoustic data combined with an extensive netting survey. Estimates from this survey indicate that the size of the pollan population may be larger than previously assumed, with one large shoal alone containing 5000–6000 fish > 10cm in length. Pollan were also captured in seven other locations throughout the lake, within each of the deep basins, and although hydroacoustic data show that fish abundances in these areas were relatively low, these extra shoals of pollan would contribute further to the total pollan stock within the lake. Furthermore, this abundance estimate only includes fish > 10cm in length. Including smaller 0+ fish in the abundance analysis would substantially increase the total population size. From a conservation perspective, the size of the mature individual population is of critical importance. Pollan from both Lough Neagh and Lough Erne are sexually mature at 2+ (Rosell *et al.* 2004). Assuming a similar life history in the Lough Ree pollan stock, the hydroacoustic data indicates that the number of fish aged 2+ and older (mean L2 = 20.4cm) within the large single shoal was in the region of 2500 individuals.

It is recognized that the single pollan specimen captured in the 'ground truth' gill net within the large shoal can not be taken as definitive evidence that this shoal only contained pollan. However, the authors are confident, using expert opinion on the interpretation of the spatial distribution and density of hydroacoustic targets, that it is highly likely that this was a single-species shoal of pollan resting relatively immobile during the day before rising and dispersing throughout the surface waters during the night. Vendace, a similar coregonid species, are known to rest relatively inactive in deeper, cooler waters during the daytime before actively rising and dispersing throughout the water column at night (Mehner and Schulz 2002; Emmrich *et al.* 2010). A second pelagic gill net set in the middle of the shoal during the following day failed to capture any fish. Again, this is not entirely unexpected due to the relatively sedentary nature of coregonids inhabiting deep water during the daytime. Furthermore, perch, a much more abundant species that is more susceptible to capture by gill nets due to their comparatively greater activity levels than cyprinids or coregonids (Prchalova *et al.* 2008), were not recorded in either net. It is intended in future hydroacoustic pollan surveys to use a custom-designed pelagic trawl net to actively sample fish within the depth strata of interest. This active sampling method is more effective than gill nets for capturing deep water, pelagic fish and has been used successfully to sample other coregonid species (Emmrich *et al.* 2010), providing immediate and definitive confirmation of species identification. Furthermore, it is suggested that a randomized netting survey using passive fishing gear may not always accurately reflect the true distribution of pelagic fish species, such as is evident in the current survey, where most pollan specimens were captured by gill nets in southern areas of the lake that

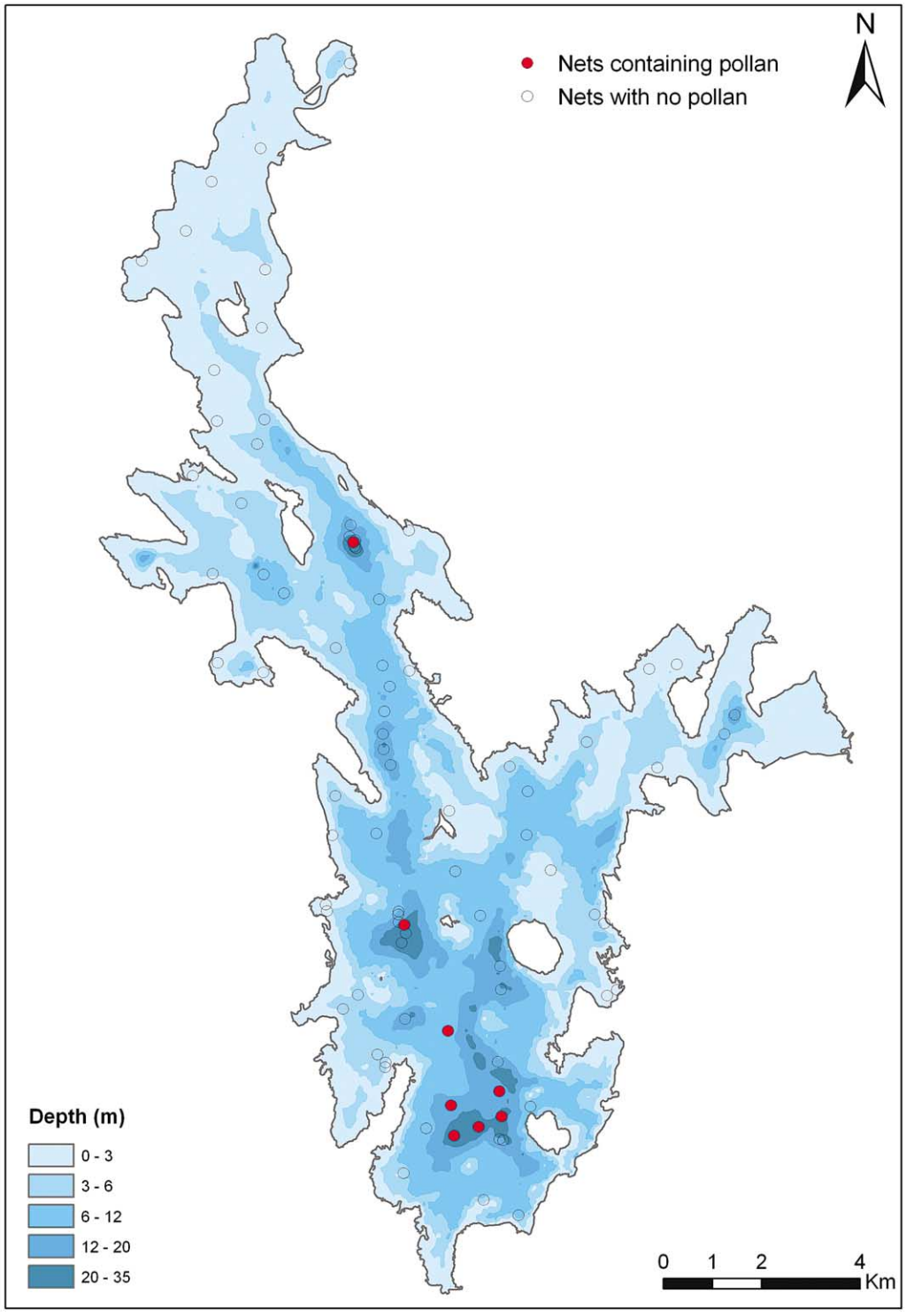

Fig. 3—Location of nets containing pollan (red circles) and nets with no pollan (clear circles) on Lough Ree, June 2010.

displayed relatively low fish densities in the hydroacoustic data. Active sampling methods, such as pelagic trawling, will aid in investigating the spatial distribution of these species.

Although it is encouraging that the pollan population in Lough Ree may be higher than previously assumed, there is still cause for concern with regards to the conservation status of this species. An abundance estimate of more than 6000 individuals > 10cm in length may at first seem significant, particularly when compared to the recently discovered population in Lough Allen

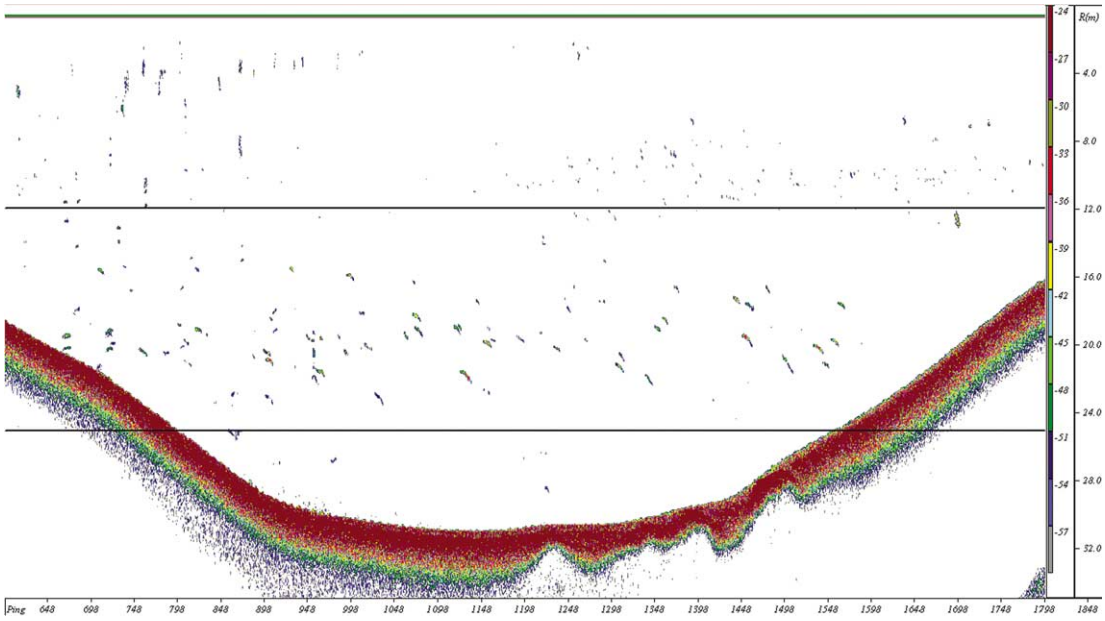

Fig. 4—Transect 2 echogram showing large shoal of pollan in northern basin of Lough Ree between 12m (upper black line) and 25m (lower black line), June 2010. Colour scale indicates acoustic target strength in dB.

in which the number of individuals > 10cm in length was estimated to be less than 1000 (Harrison *et al.* 2010). However, this value of 6000 individuals is relatively small when taken in the context of the size of Lough Ree and the amount of area available as potential pollan habitat. Pollan are known to prefer the cooler, deeper water of large lakes (Rosell 1997; Rosell *et al.* 2004; Harrison *et al.* 2010), with Lough Ree having approximately 850ha of its area greater than 12m in depth. Furthermore, the number of pollan captured during the netting survey was only 1% of the total fish numbers captured, with perch, roach and roach × bream hybrids making up 69%, 15% and 10% of the total catch, respectively (Table 1). In terms of biomass, pollan only contributed 0.5% of the total biomass of fish captured (Table 1). These figures are similar to those quoted by Rosell (1997) and Harrod *et al.* (2002) who state that pollan levels in Lower Lough Erne and the Shannon lakes are down to 1% or less of total fish biomass from former known levels of 5%–9%.

Table 2—Mean lengths at age of pollan captured in Irish lakes. Data for Loughs Neagh, Erne and Derg taken from Harrod *et al*. (2002).

Lake	*Mean L1 (cm)*	*Mean L2 (cm)*
Lough Erne 1992–1997	17.7	23.8
Lough Neagh 1997–1999	13.4	20.9
Lough Ree 2010	13.3	20.4
Lough Derg 1995	12.0	19.4
Lough Allen 2006	11.8	16.1

One of the main perceived threats to the survival of pollan is competition with non-native fish species, particularly roach, which compete directly with pollan for zooplankton food resources (Griffiths 1997; Harrod *et al.* 2001; Rosell *et al.* 2004). Roach were absent from all lakes containing pollan as recently as 1950 and their subsequent introduction has coincided with a decline in pollan abundance in the Shannon lakes and Lower Lough Erne (EHS 2005; NPWS 2005). During the current netting survey, roach and roach × bream hybrids contributed more than 60% of the total fish biomass, clearly providing significant competition for food resources with the pollan population in the lake. Furthermore, the extent of predation by abundant non-native piscivorous fish such as perch and pike on pollan fry is unkown.

The zebra mussel *Dreissena polymorpha*, an invasive bivalve species accidently introduced to the Shannon-Erne system relatively recently, circa 1992–1993 (McCarthy and Fitzgerald 1997), is also a major perceived threat to pollan populations, with a reduction in phytoplankton altering the abundance, community structure and composition of zooplankton communities (Harrod *et al.* 2001). Furthermore, pollan spawn in shallow littoral areas over a gravel substrate (Rosell *et al.* 2004), therefore the direct impact of zebra mussel settlement on potential pollan spawning habitat is also likely to have a detrimental effect on the reproductive success of the pollan population in the lake. Perhaps of even greater concern is the discovery in 2010 of the Asian clam

Corbicula fluminea, another highly invasive bivalve species, within the Shannon system (IFI 2010). This species exhibits similar life history traits to the zebra mussel and has the potential to expand its range rapidly, posing serious threats to native fish and invertebrate species (Caffrey *et al*. 2011).

Another very recent invasive species introduction to Lough Ree with the potential to negatively impact the pollan population is that of the bloody-red shrimp *Hemimysis anomala*, first recorded in 2008 (Minchin and Boelens 2010). Early investigations suggest that this highly voracious shrimp species has the potential to alter freshwater ecosystems through predation of other invertebrate species and competition for prey with the native opossum shrimp (*Mysis salemaai*), an important food source for pollan (Penk 2011). Future investigations on stomach contents of the Lough Ree pollan stock, along with monitoring of the mysis populations, will be necessary to elucidate any changes in the utilization of both shrimp species as a food source for pollan. Furthermore, the bloody-red shrimp has also been shown to prey directly on pollan eggs and larvae under experimental conditions (Gallagher *et al*. 2011), raising significant concerns about the potential negative impacts of the species on pollan populations in the Shannon lakes.

Water abstraction, such as that originally proposed in the Water Supply Project—Dublin Area (WSP-DR 2008a; 2008b), could also have negative impacts on pollan stocks through the lowering of water levels exposing spawning gravels. Pollan are a relatively short lived species, with populations generally consisting of two to three spawning year classes (Harrod and Griffiths 2004). A reduction in reproductive success in even two consecutive year classes, therefore, is likely to have a significant impact on population size. Two-year classes (1+ and 2+) were captured during the current survey and the hydroacoustic data also shows the presence of a substantial cohort of 0+ individuals, indicating reproductive success in the previous three years. Although this relatively strong 0+ year class might imply an upward trend in population size over the next few years at least, we do not know enough about the survival rate of pollan fry in Lough Ree to suggest whether or not this will be the case.

The pollan of Lough Ree have similar growth characteristics to those of other Irish lake populations, including the two Shannon lakes (Allen and Derg) and Lough Neagh. Lough Erne pollan exhibit much larger growth rates than those in other Irish lakes, partly attributed to the potential effects of a more suitable thermal regime in this lake (Rosell *et al*. 2004). Pollan in Lough Allen appear to exhibit slower growth rates than the other pollan populations; however, we must consider the relative paucity of data when drawing conclusions from these relatively small sample sizes.

Perhaps the biggest perceived threat to the survival of pollan is eutrophication, directly affecting mortality through a reduction in dissolved oxygen availability and indirectly suppressing pollan populations through the competitive advantage of roach which thrive in enriched waters (Rosell *et al*. 2004). Although pressures such as cultural eutrophication and the resultant effect on pollan populations can only be addressed with long-term solutions, it is imperative that conservation plans and protective measures are put in place to ensure the survival of the species in the short to medium term. In particular, spawning grounds must be identified and protected, along with ongoing regular monitoring of population size and structure. Investigations of pollan habitat utilization and prey selectivity will also help to increase our understanding of the impacts of invasive species on sensitive fish populations. Firmer biological data is also required on age class structure to corroborate hydroacoustic estimates of year class strength, reproductive success and juvenile survival. Early warning of recruitment failure or a significant further reduction in the already fragile population size in Lough Ree is essential in order to provide effective and scientifically sound management decisions, with a view to protecting this unique and threatened fish species.

ACKNOWLEDGEMENTS

The authors wish to gratefully acknowledge the help of all the IFI field staff from the Shannon International River Basin District, along with their colleagues in IFI Swords who conducted the netting survey. Bathymetric data for Lough Ree was provided by Mr Ken O'Neill (IFI, Limerick). Dr Jimmy King contributed useful comment and discussion in preparation of this manuscript. This survey was funded by the Department of Communications, Energy and Natural Resources as part of the Water Framework Directive and Habitats Directive fish monitoring programmes in Ireland.

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