The status of the European eel (*Anguilla anguilla*) in watercourses of the Cairngorms National Park.

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CONTENTS

Page

SUMMARY

A short report on the status of eels (*Anguilla anguilla*) in four major river systems (Dee, North Esk, South Esk and Spey) in the Cairngorms National Park (CNP) was prepared for the park authority (CNPA). This comprised a short literature review of the trophic ecology of eels in freshwater ecosystems and preliminary analyses of historical eel data recorded opportunistically during electro-fishing surveys for juvenile salmonids. In terms of overall biomass and distribution, *A. anguilla* is probably an ecologically important species. Eels are widely distributed in the CNP, occurring in a number of major catchments. Significant changes in the status of eels at different sites may have occurred during a 20 yr period. At present, however, very little is known and, in consideration of the recent catastrophic decline in the numbers of elvers returning to European rivers, it is very important that targeted scientific research is carried out on the status and ecology of eels in the Cairngorms National Park as soon as possible. Any change in the status of eel populations in the freshwaters of the Cairngorms is likely to impact local salmonid stocks in some way and studies should focus on this relationship. In addition, the impacts on other species that utilise eels as part of their diet should also be examined further.

INTRODUCTION

The European eel (*Anguilla anguilla*) is an important but often under-valued fish species in freshwater ecosystems. Eels spend most of their adult life in freshwater before migrating downstream to the Sargasso Sea to breed. A mass-spawning event produces vast numbers of leptocephalus larvae that drift with ocean currents back across the Atlantic, gradually metamorphosing into tiny glass eels. On reaching the coasts of Europe, the glass eels develop pigmentation, metamorphose into elvers, enter rivers and migrate upstream during spring. Adult eels typically spend 2–20 years in freshwater before returning to the sea to spawn.

During the past 20 years, a catastrophic decline in the number of eels arriving at European rivers has occurred. Overall, numbers have declined to an extent that they are now 1% of those recorded in the mid-1980s (Decker, 2003). It is unclear if this decline is part of a natural cycle or whether it reflects an overall decline in the eel population. A number of factors have been suggested, including over-fishing, parasitic epidemics, large-scale degradation of riverine habitats, PCB pollution and changes in the North Atlantic Oscillation. There is little information available on the impact of this decline on the freshwater phase of *A. anguilla*, but anecdotal evidence indicates that it may have resulted in a decline in adult eels in Scottish rivers.

Eels are very important in freshwater ecosystems, both as predators of small fish and as the favoured prey of otters and certain piscivorous birds (e.g. herons). There is concern that a collapse in eel numbers will upset the balance between fish and predators in Scottish rivers and consequently have a negative impact on local salmonid stocks. Eels are a major component of otter diet in the Cairngorms (Kruuk, 1995) and otters may have to switch prey in order to survive. Quantitative data on eel numbers in Scottish rivers are limited, but there are sources of data, recorded opportunistically by district salmon fishery boards, that have never been properly collated and analysed.

In this short report, we briefly review available literature on the ecological importance of eels in freshwater ecosystems and conduct preliminary analyses of available information on eel numbers and distribution in some of the major watercourses of the Cairngorms National Park. A brief discussion on the implications of eel decline is also provided.

OBJECTIVES

1. Prepare a brief review of available literature on the importance of eels in freshwater ecosystems.
2. Determine the historic status of eels in selected river catchments in the Cairngorms National Park.
3. Make recommendations for future monitoring and investigations of eels in the Cairngorms National Park.

THE ECOLOGICAL IMPORTANCE OF EELS IN FRESHWATER ECOSYSTEMS

Eels as predators

Eels are voracious predators of aquatic invertebrates. In a study of the closely related American eel, *Anguilla rostrata* in North America, the insect orders Ephemeroptera, Plecoptera and Acronueria were found in most eel stomachs examined (Denoncourt & Stauffer, 1993). European eels in the English Lake District were also found to prey on Ephemmeroptera, Trichoptera, Coleoptera, chiromonid larvae and freshwater mollusc species (Frost, 1946), These groups are also preyed on by juvenile salmonids (Frost, 1950; Carlisle & Hawkins, 1998; Duffield & Nelson, 1998; Korjenic, 2003), hence there may be significant competition between eels and salmonids, particularly in nutrient-poor river systems. Large eels prey on fish (Lookabaugh & Angermeier, 1992; Radke & Eckmann, R., 1996), including juvenile salmonids (Frost, 1946; Mann & Blackburn, 1991) and are significant predators of fish eggs in some systems (Schulze *et al*., 2004).

Eels as prey

Several studies have indicated the significance of *A. anguilla* in the diets of various bird and mammal predators. A number of common piscivorous bird species, including cormorants (*Phalarocorax carbo*), herons (*Ardea cinerea*), goosanders (*Mergus merganser*), black-throated divers (*Gavia arctica*), and red-breasted mergansers (*Mergus serrator*) are known to prey on significant numbers of eels (Carrs & Marquiss, 1997; Carss & Ekins, 2002; Jackson, 2003; Marquiss & Leitch, 1990; Marquiss *et al*., 1998). Carss & Ekins (2002) reported that eels accounted for overall proportions as high as 25% by number and 47% by mass in the summer diets of cormorant nestlings at a reservoir in southern England. However, there appears to be considerable spatial and temporal variation in the relative numbers of eels consumed (Carrs & Ekins, 2002).

A large-scale study of bird diets on salmon rivers in Scotland by Marquiss *et al*. (1998) indicated the importance of eels in the diets of three important species that prey on salmonids (goosander, red-breasted merganser and cormorant). The proportions of eels in the diet of goosander averaged 3.5% by number and 17.1% by weight, the proportions in the diet of red-breasted merganser averaged 0.7% by

number and 1.6% by weight, and the proportions in the diet of cormorant averaged 2.5% by number and 4.0% by weight. The relative proportions of eels in the diets of these three species, compared to those of salmonids, are shown in Figure1.

According to Jackson (2003), eels and salmonids are important diet components that determine the reproductive success of black-throated divers (Gavia arctica) in breeding lakes in Scotland. In a study of nestling bitterns (*Botaurus stellaris*) in England, eels were found to make up the greatest proportion of the diet of nestling birds (Gilbert *et al*., 2003). With limited prey choice available to female birds feeding young, eels are considered to be crucial to the breeding success of bitterns in Britain.

Eels are often an important component in the diet of otters (*Lutra lutra*) (Kruuk, 1995; Bonesi *et al*., 2004). In a recent study, eel remains were recovered in 60% of otter spraints collected around Loch Lomond (McCafferty, 2005). Analysis of stomach contents of otters recovered from south west England indicated that eel was the dominant prey item, followed by bullhead, *Cottus gobio* and brown trout, *Salmon trutta* (Britton *et al*., 2006). Eels also feature prominently in the food of otters in the west of Ireland and Northern Ireland (Breathnach & Fairley, 1993; Preston *et al*., 2006). Other, generalist mammalian predators, including polecat (*Mustela putorius*) and mink (*Mustela vison*) also feed on eels, occasionally (Bonesi *et al*., 2004).

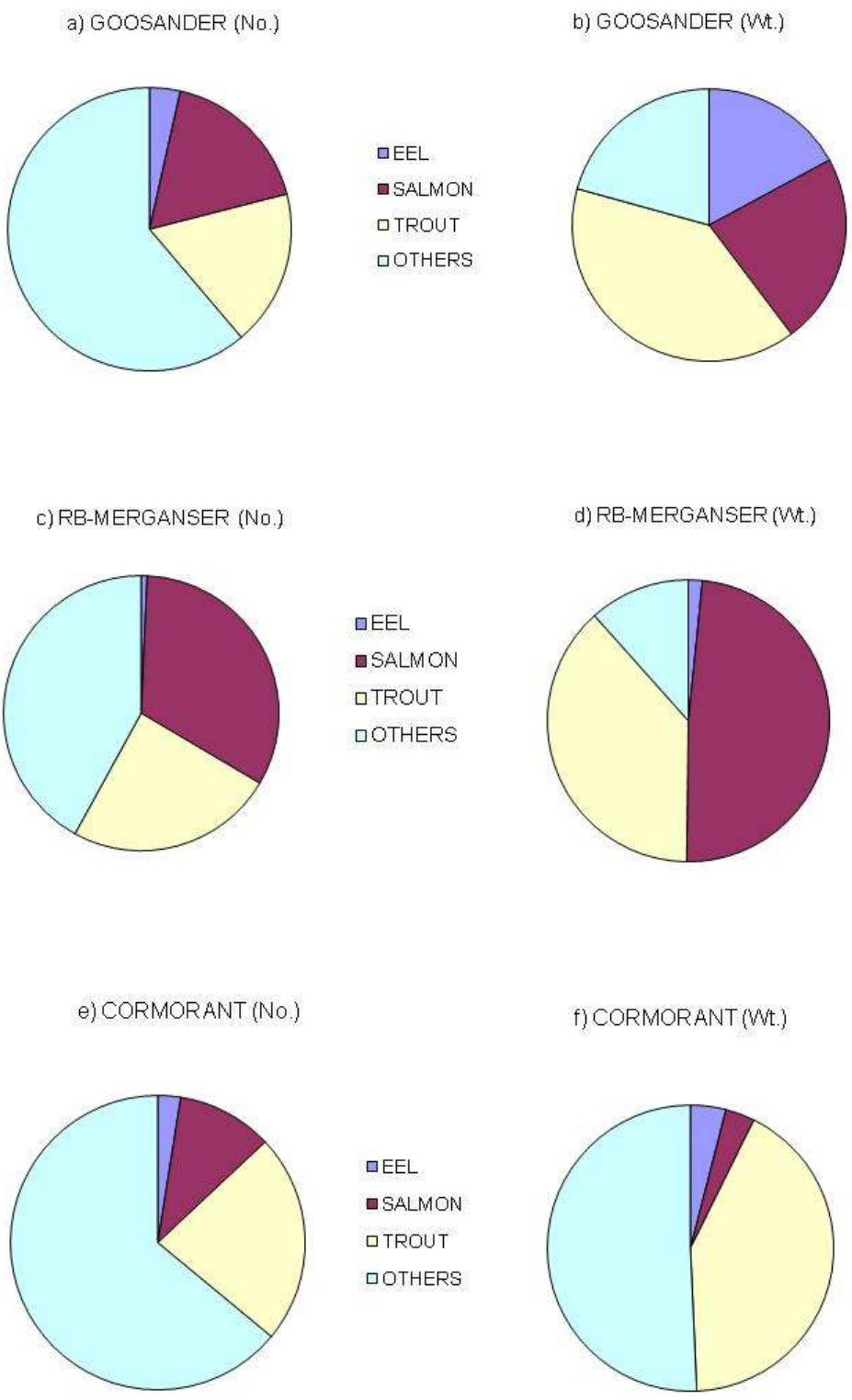


Figure 1. Pie charts showing proportions of main fish types in diets of goosander, red-brested merganser and cormorant (from Marquiss *et al.,* 1998).

HISTORICAL DATASETS

Eel data were obtained opportunistically during electrofishing surveys for juvenile salmonids carried out by the River Dee Trust (1992–2006), the Esk District Salmon Fishery Board (1995–2004), and the Spey Research Trust (1990–2006). Positive/negative records of eels at each electro-fishing site were available for four major watercourses (Rivers Dee, North Esk, South Esk and Spey) and additional mean eel density estimates were available for the River Dee sites.

River Dee catchment

Eels were recorded at 670 sites throughout the River Dee catchment (Fig. 2). Mean density estimates ranged from 0.0 to 4.7 eels.100m^{-2}. There appeared to be considerable temporal and spatial variability – in some tributaries (eg. catchments 4, 10, 27), there were marked declines in eel numbers between 1992 and 2006; whereas in others (eg. catchments (9, 30), eel numbers appeared to increase over the same period (Fig. 3). Overall, greater numbers of eels have been observed in the River Dee catchment in recent years (Fig. 4).

River North Esk catchment

Four sites, all located on the Water of Mark were electro-fished in 1995–1997, and in 1998–2004, the number of sites was increased to 12. The additional sites were spread throughout the catchment. Eels were generally absent at most sites on the River North Esk (Fig. 5a). The overall trend in prevalence (positive records) of eels in the River North Esk between 1995 and 2004 appeared to be upward, although no significant relationship between year and prevalence was observed, possibly due to small sample size (n = 12 sites).

River South Esk catchment

Five sites were electro-fished in 1995–1997 and in 1998–2004 the number of sites was increased to eight. Eels were recorded at most sites on the River South Esk , but not consistently (Fig. 5b). The overall trend in prevalence (positive records) in the River South Esk between 1995 and 2004 appeared to be downward, although no significant relationship between year and prevalence was observed, possibly due to small sample size (n = 8 sites).

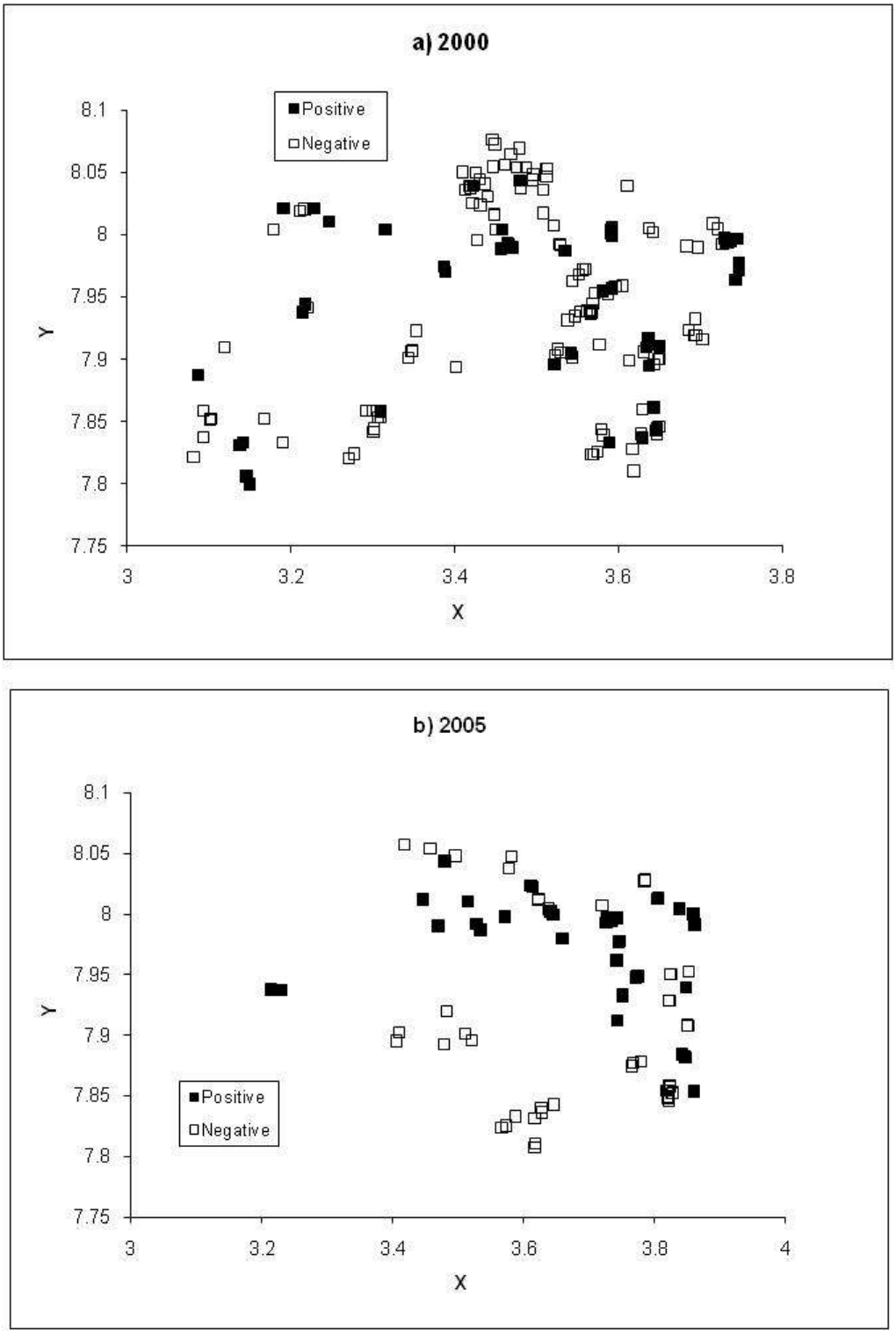


Figure 2. Electro-fishing sites in River Dee catchment, showing distributions of eel records in: a) 2000 and b) 2005. X and Y values refer to NGR eastings and northings, respectively.

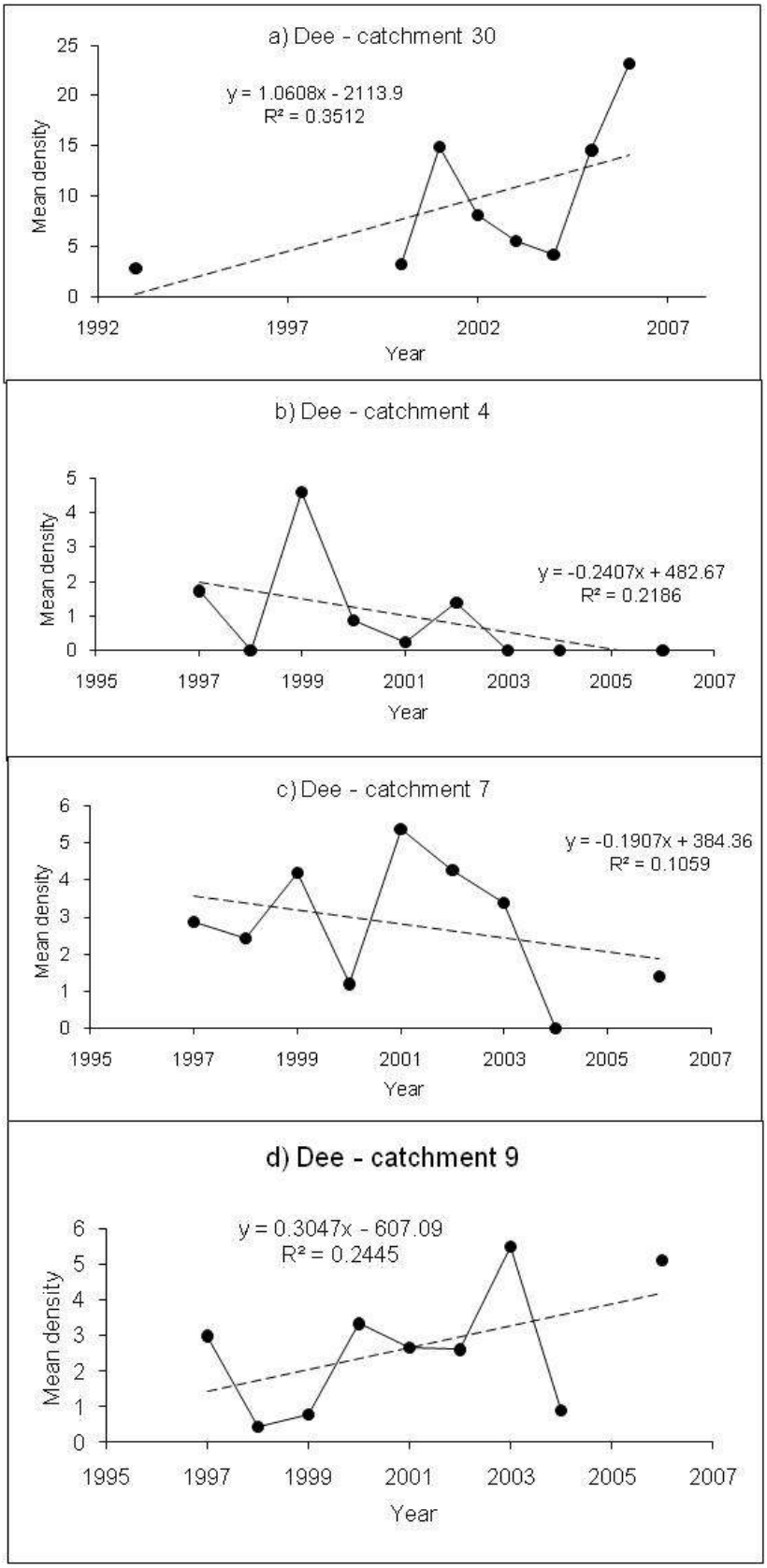


Figure 3. Estimates of eel density, based on electro-fishing surveys of seven River Dee tributary catchments.

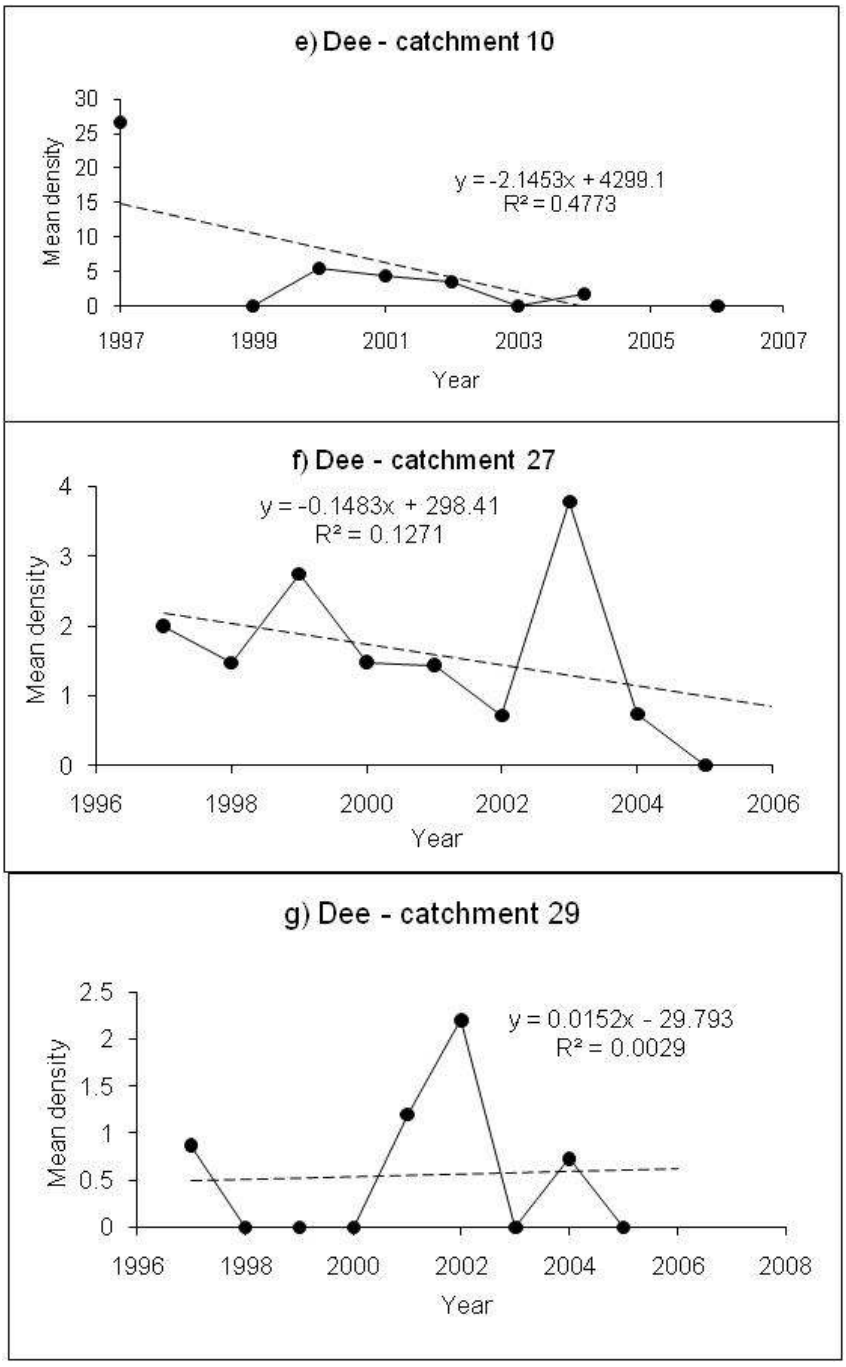


Figure 3. (continued)

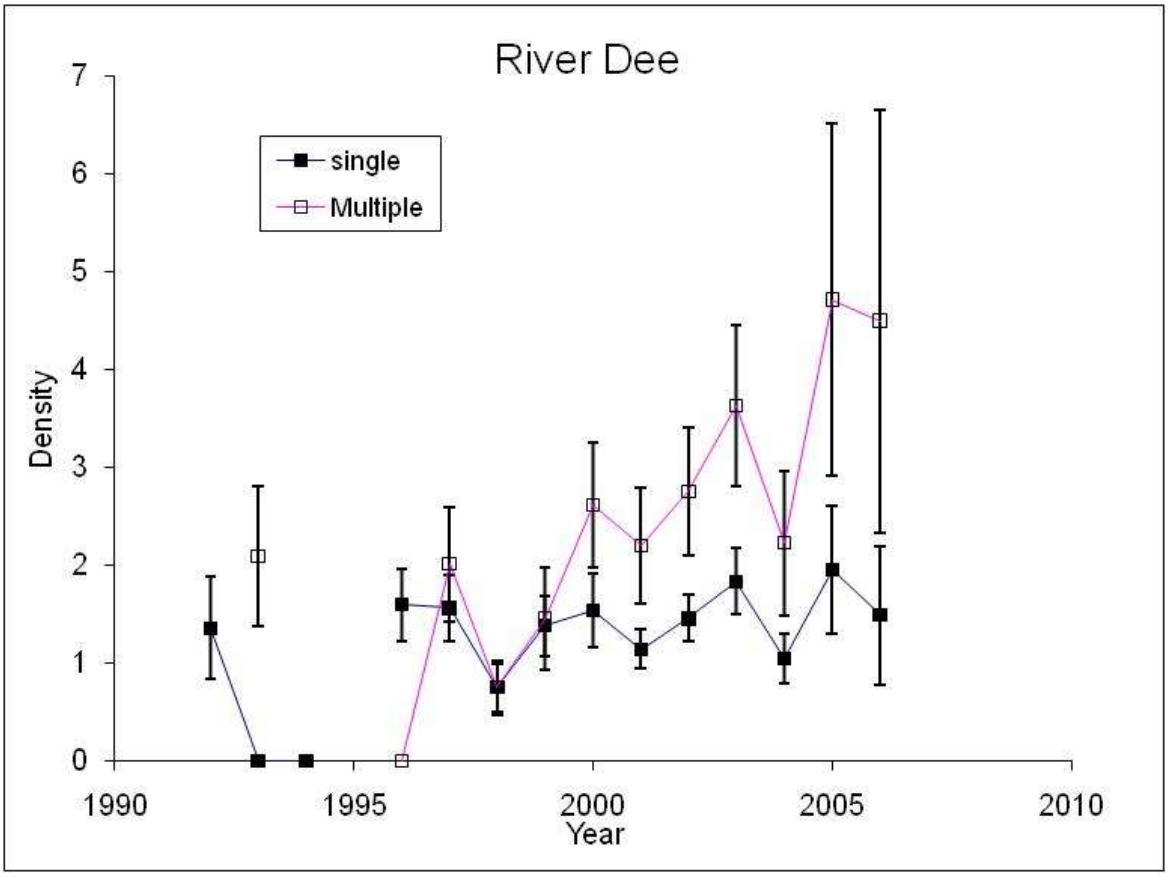
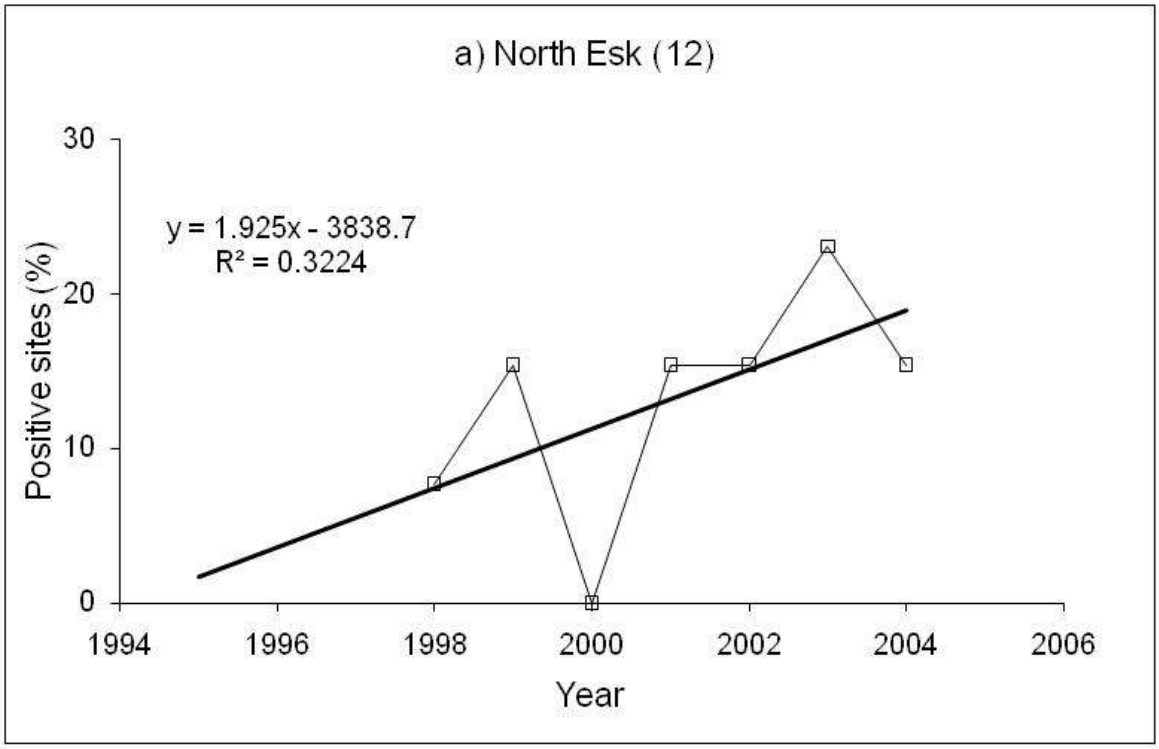


Figure 4. Mean of eel density estimates (overall) for River Dee catchment, based on electro-fishing surveys (single and multiple sweeps). SD bars shown.



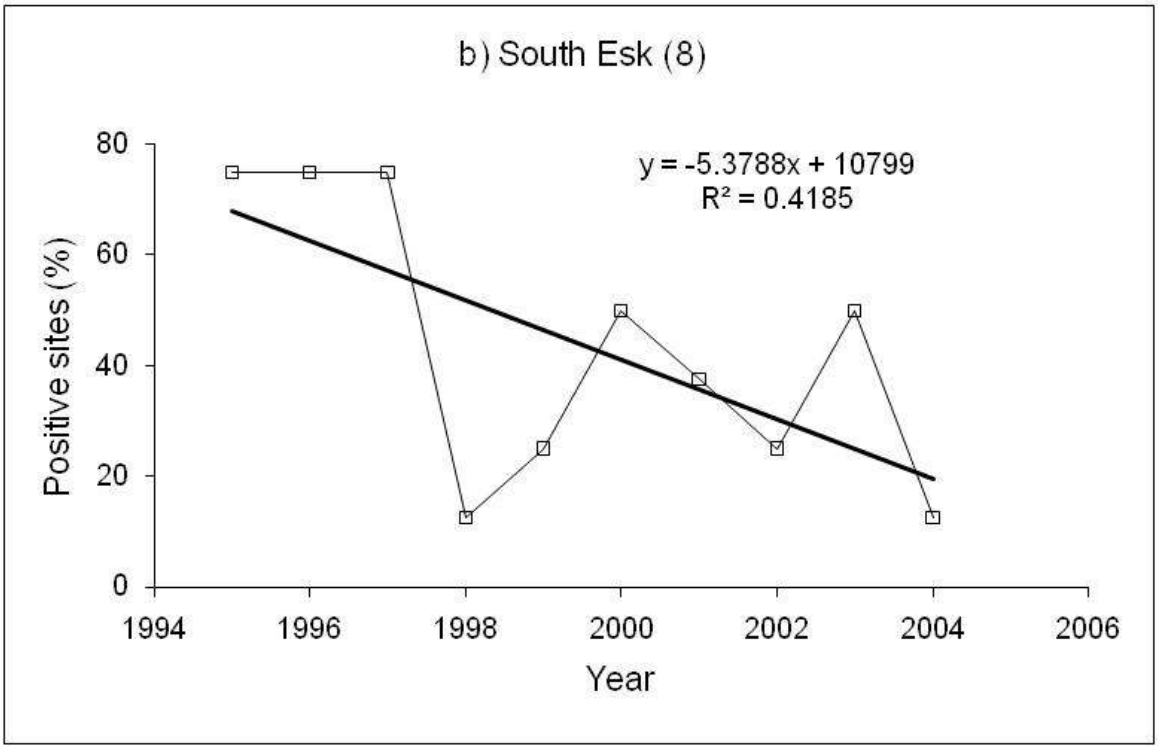


Figure 5. Proportion of electrofishing sites on a) River North Esk and b) River South Esk, where eels were recorded (1995-2004). Numbers of sites checked in parentheses. Fitted regresion lines displayed.

River Spey catchment

Eels were also recorded at 252 sites throughout the River Spey catchment (Fig. 6). Again, there appeared to be considerable temporal and spatial variability. The overall trend in prevalence (positive records) of eels in the Spey catchment between 1990 and 2006 appeared to be downward, although no significant relationship between year and prevalence was observed (Fig. 7)

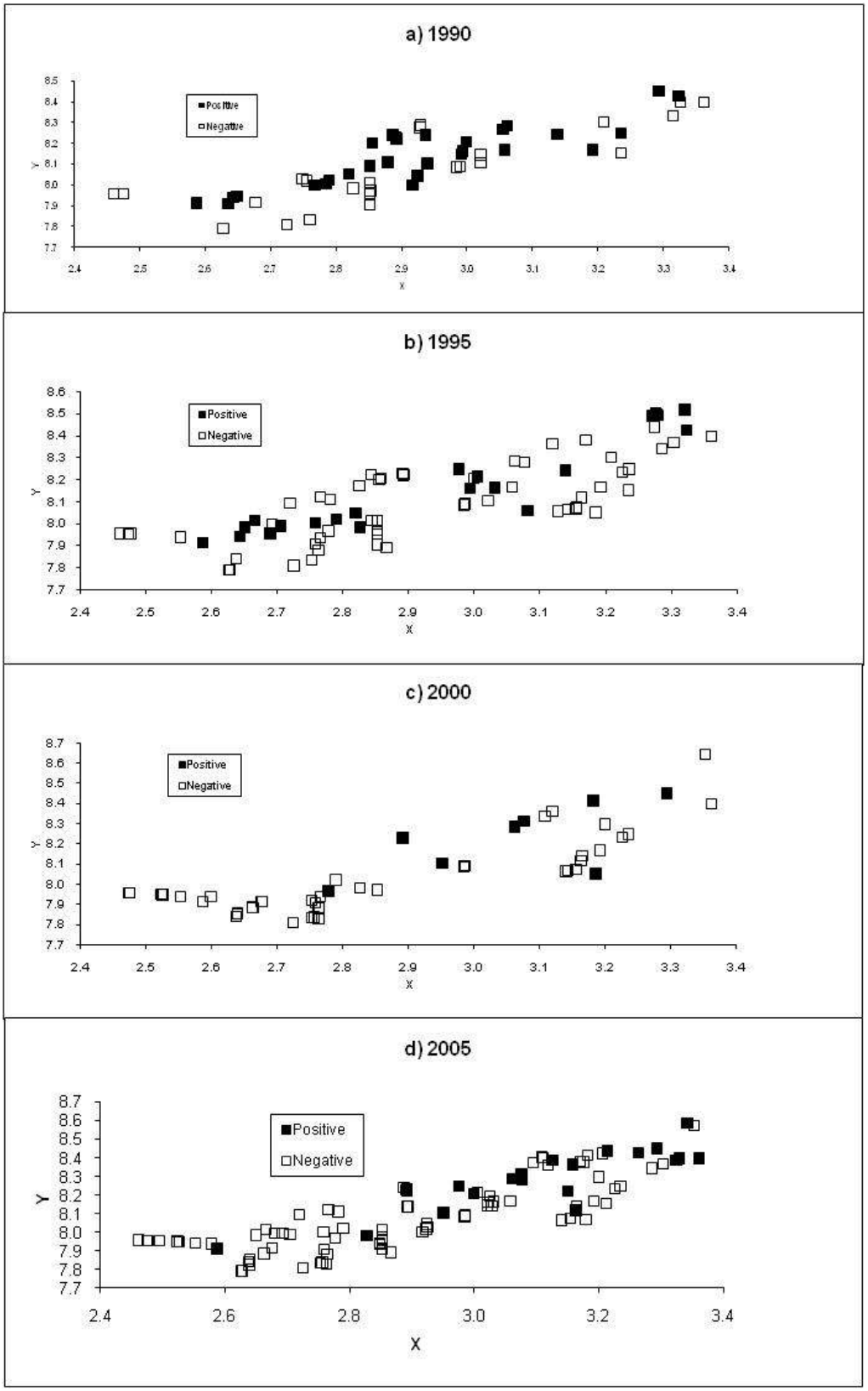


Figure 6. Electro-fishing sites in River Spey catchment, showing distributions of eel records in: a) 1990, b) 1995, c) 2000 and d) 2005. X and Y values refer to NGR eastings and northings, respectively.

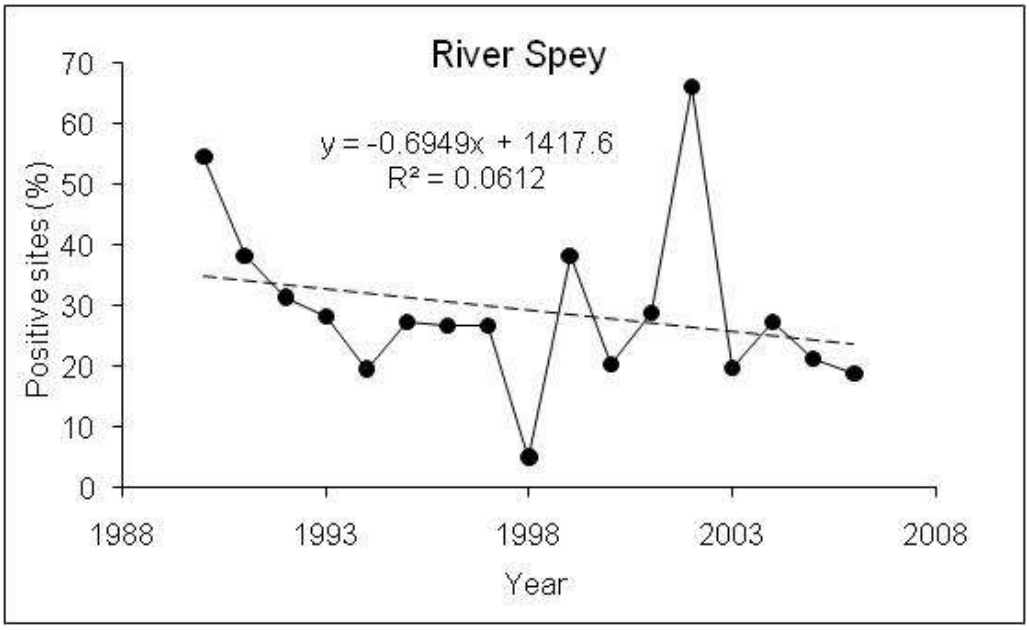


Figure 7. Proportion of electro-fishing sites in River Spey catchment (overall) where eels were recorded (1990-2005). X and Y values refer to NGR eastings and northings, respectively.

CONCLUSIONS AND RECOMMENDATIONS

In terms of overall biomass and distribution, the European eel is probably an ecologically important species in the watercourses of the Cairngorms National Park. Based on their potential importance, both as predators, competitors and as an alternative prey item in the freshwater ecosystem, it is likely that the expected decline of eels from the Rivers Dee, North Esk, South Esk and Spey may have some important repercussions for the conservation status of the salmonid populations in these river systems.

It is apparent that eels are widely distributed in the Cairngorms National Park, occurring in a number of major tributaries of the Rivers Dee, North Esk, South Esk and Spey. The eel (distribution) data analysed here are opportunistic and only a short time-series (<20 yr) was available for each river. Nevertheless, it is apparent that significant changes in the status of eels at different sites may have occurred during this period. There appeared to be considerable temporal and spatial variability in each river – at some River Dee sites, there were apparent declines in eel abundance; whereas in others, eel numbers appeared to increase over the same period. In the other rivers, no densities were available, but differences in the distribution patterns indicated that eels may also be declining at some sites.

The main conclusion from this short study is that the European eel could be a very important component in the freshwater ecosystems of the Cairngorms National Park. At present, however, very little is known and, in consideration of the recent catastrophic decline in the numbers of elvers returning to Scottish and other European rivers (Dekker, 2003), it is very important that targeted scientific research is carried out on the status and ecology of eels in the Cairngorms National Park as soon as possible. Any change in the status of eel populations in the freshwaters of the Cairngorms is likely to impact local salmonid stocks in some way and studies should focus on this relationship. In addition, the impacts on other species that utilise eels as part of their diet should also be examined further.

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