Chapter (non-refereed)

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Fish introductions and translocations – their impact in the British Isles

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1 Introduction

The dispersion of fish species across land masses has always been a matter of some debate and controversy. Many people believe in the ability of fish to cross watersheds via inter-catchment connections, migrating waterfowl and other natural means. Others doubt such phenomena and assume that humans are the main factor in moving fish overland. The truth probably lies somewhere between these 2 views, but there seems little doubt that, whatever their involvement in prehistoric times, humans are now a major factor in transporting fish in many countries of the world. The ecological repercussions from many of these introductions have been colossal. The main objective of this paper is to discuss the philosophy of introductions and translocations in the context of experience in the British Isles and elsewhere.

The closing stages of the last ice age (about 10 000 years ago) can be considered as the starting point in any assessment of the distribution of freshwater fish in the British Isles. At its maximum extent, the last major ice cap covered all of the British Isles except parts of southern Ireland and the Midlands and south of England (Figure 1). There were no fish present in any of the areas further north, and indeed it is probable that there were few species in most of the northern unglaciated areas, whose climate must still have been very cold and the glacial rivers unsuitable for aquatic life. The land mass of the British Isles was very different in extent at this time, for Ireland was still connected to Great Britain which, in turn, was still joined to the main continental land mass. As the ice gradually retreated northwards, so did the British Isles assume their present form, the link between Ireland and Great Britain breaking to form the Irish Sea and that between England and the continent to form the English Channel. Before the final separation from the continent, it is likely that all species of purely freshwater fish at present regarded as indigenous to the British Isles had established themselves, at least in the south-east of England. From this area they dispersed themselves at varying rates to other parts of the country.

A broad outline of the fish fauna and the conservation of freshwater fish in the British Isles has been given by Maitland (1974). There, the status and distribution of all species of fish and their value as a resource is reviewed. The value of freshwater fish to the community is far greater than is normally appreciated and includes human consumption, sport, fisheries, amenity, educational and scientific aspects, as well as a valuable store of genetic material. The main pressures on existing fish stocks are related to the effects of fisheries, pollution and land use. The principal trends in the British Isles are away from natural and stable stocks comprising a mixture of native species towards artificially maintained, unstable stocks of a few species of sporting or commercial value. In particular, the rarer, more sensitive, fish species with poor powers of distribution are being eliminated and replaced by commoner, more robust, species with greater powers of dispersal. Many of these sensitive species appear unable to compete with, or cope with predation from, the more successful southern species (Plate 11).

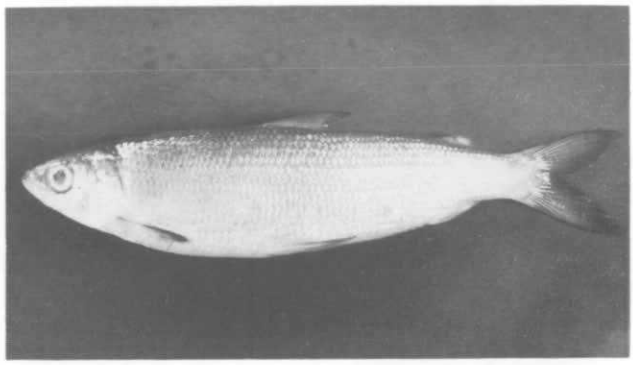

Plate 11. The vendace, one of Britain's rarest species. The introduction of any new species to water containing this fish should be avoided (Photograph P S Maitland)

A second paper (Maitland 1979) considers the rarer species and genetic strains of freshwater fish in the British Isles in some detail. Their present status is reviewed and conservation measures proposed in relation to the priorities involved. Several populations of major importance have already been lost and others are likely to disappear if action is not taken soon. The recent Wildlife and Countryside Act 1981 has drawn attention to the scientific evaluation of conservation sites. In order to produce credible schemes for such assessments, it is necessary to establish national criteria against which the characteristics of any particular site can be evaluated. Maitland (1985) has proposed such criteria for freshwater fish.

2 The British fish fauna

Of the 55 species of freshwater fish found in the British Isles (Table 1), none is endemic, 3 occur only as vagrants, and 12 species have been introduced by humans. Many of the remaining 40 indigenous species are common and widespread, but several are declining in numbers or restricted in distribution. Fish occur in

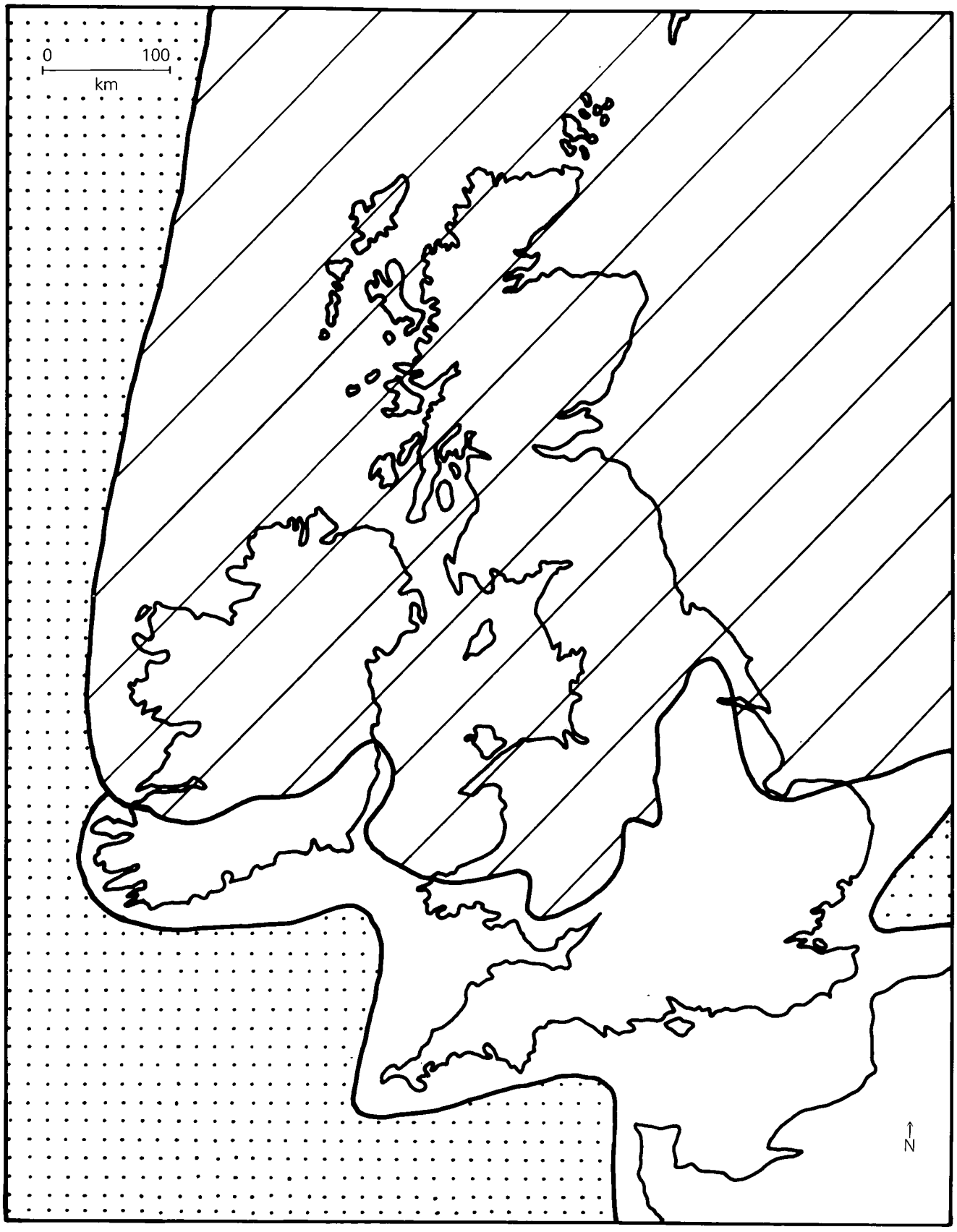

Figure 1. The probable maximum extent of the ice sheet (hatched) covering the British Isles during the last ice age. The approximate boundaries of the sea (stippled) and the land at that time are also indicated

almost all types of open water, except extremely acidic peat pools, grossly polluted waters, high-altitude waters, and those that dry out periodically. Although the general distribution of most freshwater species in the British Isles is now quite well known (Maitland 1969), information is still needed from a number of important sites which it has not yet been possible to examine in detail.

The indigenous fish species of the British Isles may be categorized as follows:

i. those with a marine propensity, ie migratory, including now landlocked migratory species;
ii. those that appear to have mechanisms of dispersal and have moved extensively beyond their original catchments;
iii. those with poor powers of dispersal which are still largely confined to their original catchments.

In general, the number of fish species decreases from south to north in Great Britain: many species are confined to the south and east of the country, and only a few to the north and west. Thus, the maximum number of species which could be expected to occur decreases as one moves north. Some species are well distributed over a large part of the country and found in both running and standing waters, eg salmon (*Salmo salar*), trout (*Salmo trutta* and *Salmo gairdneri*), pike

Table 1. Freshwater fish species established in the British Isles. Closed circles (●) indicate that the species is: A. indigenous, B. of marine origin, C. rare, D. local, E. threatened. Open circles (0) mean the opposite

Common name	Scientific name	A	B	C	D	E
Sea lamprey	*Petromyzon marinus*	●	●	0	0	0
River lamprey	*Lampetra fluviatilis*	●	●	0	0	0
Brook lamprey	*Lampetra planeri*	●	0	0	0	0
Sturgeon	*Acipenser sturio*	●	●	●	●	●
Allis shad	*Alosa alosa*	●	●	●	●	●
Twaite shad	*Alosa fallax*	●	●	●	●	●
Atlantic salmon	*Salmo salar*	●	●	0	0	0
Brown trout	*Salmo trutta*	●	●	0	0	0
Rainbow trout	*Salmo gairdneri*	0	0	0	0	0
Humpback salmon	*Oncorhynchus gorbuscha*	0	0	●	0	0
Arctic charr	*Salvelinus alpinus*	●	●	●	●	●
Brook charr	*Salvelinus fontinalis*	0	0	0	●	0
Whitefish	*Coregonus lavaretus*	●	●	●	●	●
Pollan	*Coregonus autumnalis*	●	●	●	●	●
Vendace	*Coregonus albula*	●	●	●	●	●
Houting	*Coregonus oxyrinchus*	●	●	●	●	●
Grayling	*Thymallus thymallus*	●	0	0	0	0
Smelt	*Osmerus eperlanus*	●	●	●	●	●
Pike	*Esox lucius*	●	0	0	0	0
Carp	*Cyprinus carpio*	0	0	0	0	0
Crucian carp	*Carassius carassius*	0	0	0	0	0
Goldfish	*Carassius auratus*	0	0	0	0	0
Barbel	*Barbus barbus*	●	0	0	0	0
Gudgeon	*Gobio gobio*	●	0	0	0	0
Tench	*Tinca tinca*	●	0	0	0	0
Silver bream	*Blicca bjoerkna*	●	0	0	●	0
Bream	*Abramis brama*	●	0	0	0	0
Bleak	*Alburnus alburnus*	●	0	0	0	0
Minnow	*Phoxinus phoxinus*	●	0	0	0	0
Bitterling	*Rhodeus sericeus*	0	0	0	●	0
Rudd	*Scardinius erythrophthalmus*	●	0	0	0	0
Roach	*Rutilus rutilus*	●	0	0	0	0
Chub	*Leuciscus cephalus*	●	0	0	0	0
Orfe	*Leuciscus idus*	●	0	0	●	0
Dace	*Leuciscus leuciscus*	●	0	0	0	0
Spined loach	*Cobitis taenia*	●	0	0	●	0
Stone loach	*Noemacheilus barbatulus*	●	0	0	0	0
Wels	*Silurus glanis*	0	0	●	●	0
Eel	*Anguilla anguilla*	●	●	0	0	0
Three-spined stickleback	*Gasterosteus aculeatus*	●	●	0	0	0
Ten-spined stickleback	*Pungitius pungitius*	●	●	0	0	0
Burbot	*Lota lota*	●	0	●	●	●
Sea bass	*Dicentrarchus labrax*	●	●	0	0	0
Largemouth bass	*Micropterus salmoides*	0	0	●	●	0
Pumpkinseed	*Lepomis gibbosus*	0	0	●	●	0
Rock bass	*Ambloplites rupestris*	0	0	●	●	0
Perch	*Perca fluviatilis*	●	0	0	0	0
Ruffe	*Gymnocephalus cernua*	●	0	0	0	0
Pikeperch	*Stizostedion lucioperca*	0	0	0	●	0
Common goby	*Pomatoschistus microps*	●	●	0	0	0
Thicklipped mullet	*Crenimugil labrosus*	●	●	0	0	0
Thinlipped mullet	*Chelon ramada*	●	●	0	0	0
Golden mullet	*Chelon auratus*	●	●	0	0	0
Bullhead	*Cottus gobio*	●	●	0	0	0
Flounder	*Platichthys flesus*	●	●	0	0	0

(*Esox lucius*), minnow (*Phoxinus phoxinus*), roach (*Rutilus rutilus*), eel (*Anguilla anguilla*), 3-spined stickleback (*Gasterosteus aculeatus*), 10-spined stickleback (*Pungitius pungitius*) and perch (*Perca fluviatilis*). In a somewhat similar category are those that are common in many sites in the southern half of the country (possibly a few elsewhere), but mostly restricted to standing or very slow-flowing waters (crucian carp (*Carassius carassius*), tench (*Tinca tinca*), bream (*Abramis brama*), silver bream (*Blicca bjoerkna*), rudd (*Scardinius erythrophthalmus*) and chub (*Leuciscus cephalus*)), or to running waters (sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*), brook lamprey (*Lampetra planeri*), grayling (*Thymallus thymallus*), gudgeon (*Gobio gobio*), bleak (*Alburnus alburnus*), dace (*Leuciscus leuciscus*), stone loach (*Noemacheilus barbatulus*), ruffe (*Gymnocephalus cernua*), bullhead (*Cottus gobio*) and flounder (*Platichthys flesus*)).

3 Introduced species

An account of the species of freshwater fish introduced to the British Isles has been given by Wheeler and Maitland (1973). The study describes the natural distribution of such fish, the history of their introductions, their success in acclimatization, and their distribution in the British Isles. More than 20 different species are known to have been introduced at various times, but of these only 12 seem to have been successful and have viable populations at present.

The introduction of exotic species of plants and animals to the British Isles was discussed by a working group set up by the Nature Conservancy Council (1979). Unless the reasons are very compelling ones (eg for pest control or food production), the introduction of foreign species is regarded as undesirable, and usually detrimental to nature conservation interests. Thus, it would seem logical to disregard introduced species of fish in nature conservation assessments.

The extensive published information available for Scotland has been reviewed by Maitland (1977), and from this review it is possible to produce some idea of rates of movement of fish into this country (Figure 2). The starting point for Scotland may be taken as the last ice age, say a minimum of 5000 years ago; prior to about 10 000 years ago, the country had been completely covered by ice. The only fish able to colonize as the ice disappeared were those with marine affinities, capable of existing in the ice lakes and glacial rivers which prevailed at the time. Thus, some time later (say 1000 years), there were probably only about 12 species present.

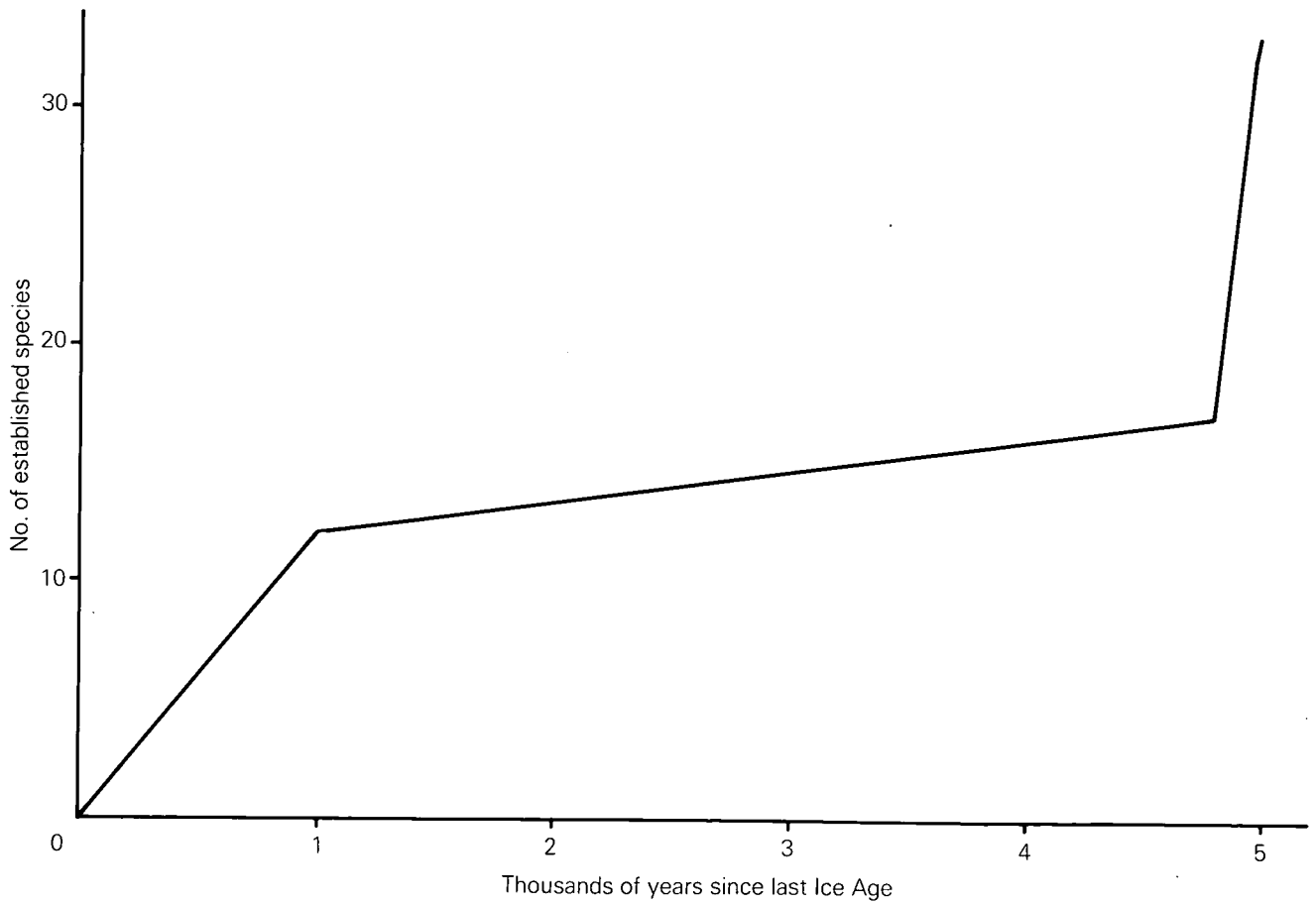

Figure 2. The probable numbers of established species of freshwater fish in Scotland since the disappearance of the last ice sheet, some 5000 years ago. It is assumed that all the present anadromous and catadromous species became established during the first 1000 years

Several thousand years later, by about 1790, only another 5 species had been added to the Scottish fauna: pike, minnow, roach, stone loach and perch. The reasons for the successful movement north of these species are uncertain, but 3 of them (pike, minnow and perch) must have effective powers for dispersal for, apart from species with marine affinities, these are probably the most widely distributed and abundant of British freshwater fish today. The dispersal of fish eggs on the feet of waterfowl is often mentioned as a means of distribution and, while it is true that these 5 species all have adhesive eggs or egg ribbons, there is little real evidence of their dispersal in this or in any other specific way during this period. The role of humans is uncertain, but Campbell (1971) and others believe that they have been responsible for much of the movement of fish in this country.

Some 90 years later (1880), another 5 species were known to occur in Scotland: brook charr (*Salvelinus fontinalis*), grayling, tench, bream (Plate 12) and chub. The main agent of dispersal during this period (and subsequently) was probably human, and there are numerous records of introductions of these and many other species (several of them foreign to the British Isles) around this time. This was a most intensive period of introduction and movement of fish, and many landowners introduced new fish to waters on their estates.

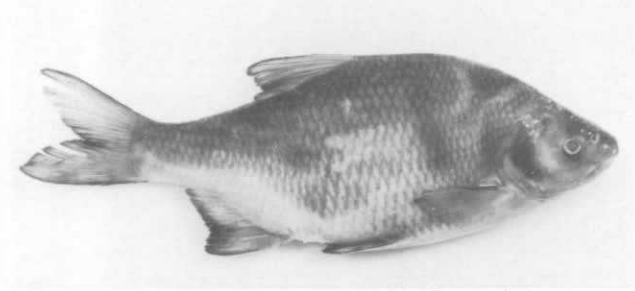

Plate 12. A roach × bream hybrid. One of the many undesirable effects of introducing new species of fish to a water is that they may hybridize with species already present (Photograph P S Maitland)

By 1970, another 8 fish species were known to have established definite populations in Scotland, and for virtually all of them humans seem to have been responsible for the introductions. Many of them are likely to have taken place before 1900; for example, carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*) are mentioned by Scott (1901) as occurring in certain waters in the Glasgow area at that time. Since 1970, another 2 species have been confirmed for Scotland – both probably introduced. Crucian carp actually appear to have been present for some considerable time, whereas ruffe are relatively recent (Maitland *et al.* 1983). It should be noted that many other species were introduced unsuccessfully during these periods.

4 Translocations

For many years there has been an increasing demand from game fishermen, not only for improved fishing for native species such as salmon and trout, but also for introduced species like rainbow trout (*Salmo gairdneri*). A greater interest is also being encouraged in charr, and both the native arctic charr (*Salvelinus alpinus*) and the American brook charr are likely to increase in popularity with anglers. There is also some demand for other North American salmonids which it has not yet been possible to establish in this country.

Especially in Scotland and Ireland (where there is no close season for coarse fish), coarse fishing is increasing rapidly at present due to a combination of increased leisure time, advertizing by tourist agencies and the realization that many of the waters in these countries hold large numbers of specimen fish of various species. This greater interest has brought with it an increasing tendency to move coarse species about (eg Burkel 1971), and more introductions of non-game species are probably taking place now than at any other time this century (Plate 13). The discovery in 1982 (Maitland *et al.* 1983) that ruffe were present and established in Loch Lomond 100 km north of their previous most northerly site was a surprise. Equally surprising has been the apparent enormous increase in their numbers in Loch Lomond since then (Table 2).

Table 2. Numbers of ruffe collected from the trash screens of a water supply system at Loch Lomond

Year	1982	1983	1984	1985
Total numbers	17	47	406	2021
Percentage fish catch	8	19	56	76

5 Stocking

A regular policy of stocking was once considered by many (and is still thought by some) to be the main management tool to be used in fisheries. The large number of derelict fish hatcheries and ponds in many parts of the country provides evidence of the faith of past generations in this procedure. There is no doubt that stocking is a valuable part of the management policy of some fisheries, but it is only necessary where spawning or nursery areas are inadequate to provide recruitment for the angling or commercial fishing pressure involved. The numbers of waters where this is true are in the minority and are likely to remain so, except where 'put and take' fisheries are being developed.

6 Legislation

There have been a number of changes in legislation in recent years, following various attempts to introduce alien fish species to different parts of the United Kingdom. Fortunately, it is now much more difficult to bring foreign temperate fish species into this country and to move them from one part of the country to another. Control is possible through sections included in a number of Acts, the more important of which are listed in Table 3.

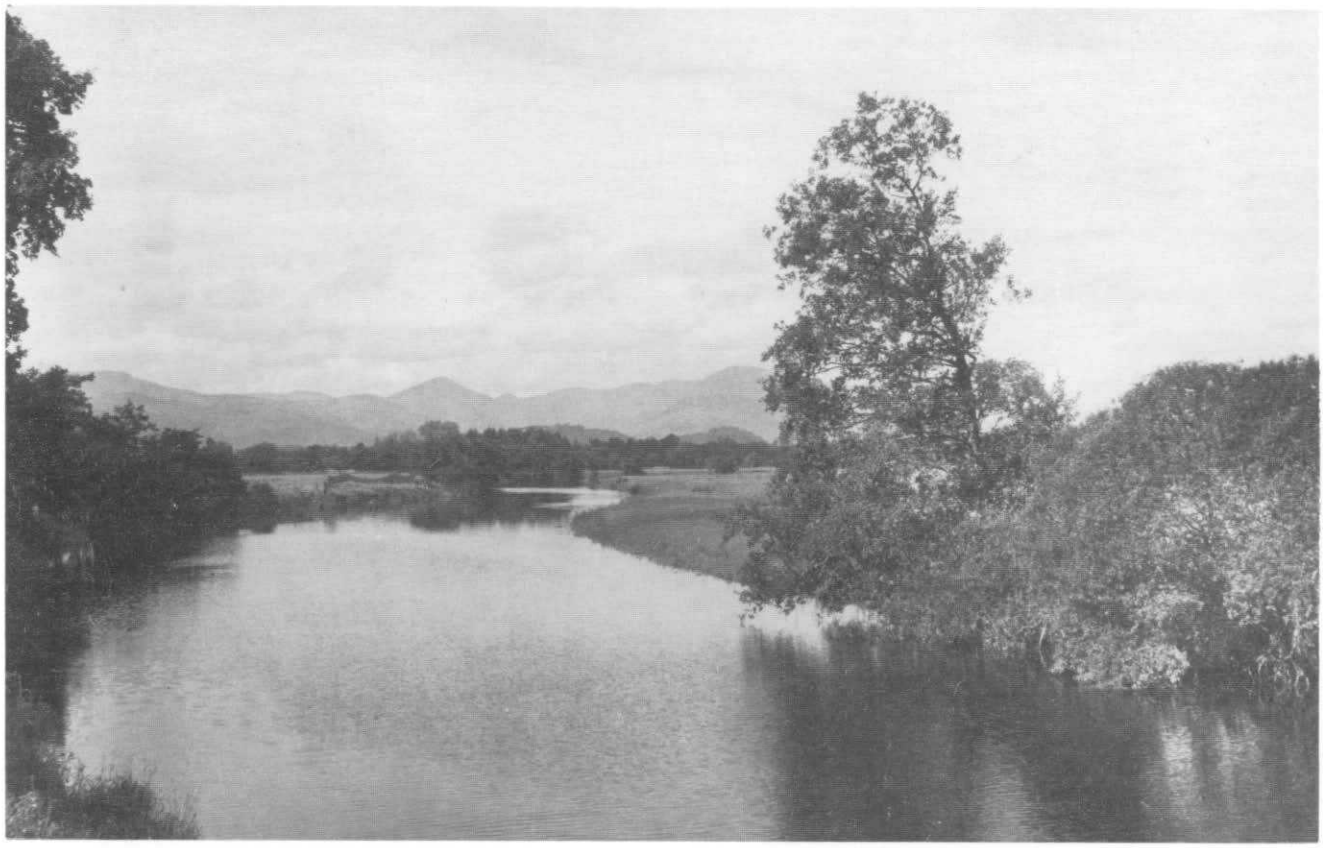

Plate 13. The River Endrick near its junction with Loch Lomond. Absent 10 years ago, gudgeon and ruffe introduced here are now among the commonest species (Photograph P S Maitland)

Table 3. The principal pieces of legislation related to the introduction and translocation of freshwater fish in the United Kingdom

Diseases of Fish Act 1937
Salmon and Freshwater Fisheries Act 1975
Import of Live Fish (Scotland) Act 1978
Import of Live Fish (England and Wales) Act 1980
Wildlife and Countryside Act 1981
Diseases of Fish Act 1983

These Acts have a number of strengths and together mean that, as far as the United Kingdom is concerned, it is:

i. illegal to import any live salmon or freshwater fish, or the live eggs of those fishes into Great Britain without a licence under the Diseases of Fish Act 1937;
ii. not an offence to move fish into Scotland from England without a licence, with the exception of Coho salmon (*Oncorhynchus kisutch*, for which an order has been made under the 1978 Act);
iii. unlawful to introduce fish into an inland water in England and Wales (say from Scotland or another Water Authority area) without the written consent of the relevant Water Authority.

Part of the Wildlife and Countryside Act 1981 makes it an offence to introduce any species of fish not at present established in Great Britain to waters in Great Britain. It is also an offence under this Act to introduce the following species: bitterling (*Rhodeus sericeus*), wels (*Silurus glanis*), largemouth bass (*Micropterus salmoides*), pumpkinseed (*Lepomis gibbosus*), rock bass (*Ambloplites rupestris*), and pikeperch (*Stizostedion lucioperca).*

The controls offered by the Diseases of Fish Act might seem to be comprehensive and cover more than the 2 Import of Live Fish Acts do. However, import could only be prevented under the Diseases of Fish Act if the fish to be imported did not meet the Government's current disease criteria; it would be an improper use of the Act to refuse a licence on other grounds. It can be seen, therefore, that the Act does not provide for control of imports *per se*. The Import Acts allow the Secretary of State to make orders in respect of any species whose importation it is considered needs to be prevented or controlled because of environmental or conservation effects.

7 Discussion

It seems likely that there are few aquatic ecosystems into which new species of fish could be introduced and established without some major alteration within the system. Thus, all proposed introductions and translocations of new species, and indeed most stockings of indigenous species, to a water system within the British Isles should be given careful consideration before any action is taken.

Many native species appear to be still gradually distributing themselves throughout the British Isles by natural means (eg pike and perch), but their invasion of new waters may still have dramatic consequences. Several cases are known of pike gaining access to

waters containing populations of brown trout and completely eliminating them (Munro 1957). Many species, too, have been dispersed by humans with harmful results. The introduction of roach and dace to the Blackwater system in Ireland, and their influence on other fish there, has been described by Healey (1956), while recently the barbel (*Barbus barbus*) has been moved north in England, well beyond its former area of occurrence. Another controversial translocation in England in recent years has been the pikeperch which has been successfully moved, for angling purposes, outside its previous range. Many hundreds of lesser introductions take place annually, but mostly within the existing distribution boundaries of the species involved.

Undoubtedly, there are some circumstances where the translocation of native species may be justifiable. Obvious cases include introductions to clean waters whose former fish populations have been destroyed by pollution of some kind, and the establishment of suitable species in newly created waters such as reservoirs (Plate 14). Some natural waters contain no fish, and, while it is scientifically desirable that some of these remain without them, a case could be made for the introduction of certain suitable fish into others. It is especially undesirable, on the other hand, that any new species are introduced into waters containing rare native species. Rare native fish may well be moved to other waters as a conservation measure (Maitland 1972).

Where any fish species has become extinct from an area, the original sites from which it has disappeared should always be given first consideration, if reintroduction is contemplated. Extinctions are among the few examples where introductions are fully justified (Nature Conservancy Council 1979), but in a number of cases the conditions at the sites concerned have deteriorated so much that, in the short term at least, alternative sites must be sought to establish new viable populations. Ideally, certain criteria should be followed when selecting such new sites. First, they must offer the full range of habitats necessary for all life stages of the species concerned. Second, the geography of any new sites should be as near as possible to that of the original, and strong preference should be given to those within the same watershed. Finally, the stock chosen for the introduction attempt should normally be from the nearest available site, and certainly from within the British Isles. Precautions should be taken to maximize the genetic diversity of

Plate 14. Loch Awe (left) and Cruachan reservoir (right). One of Britain's rarer fish, the arctic charr, has been accidentally pumped up to the artificial Cruachan reservoir where it now thrives: an example of a useful, if unintentional, introduction (Photograph P S Maitland)

the stock being introduced (Maitland 1979), and introductions from abroad should be considered only as a last resort.

Where fish species new to the British Isles are being considered, several factors should be taken into account before any decision is taken to introduce.

i. There should be a real purpose behind the introduction.
ii. It is normally highly undesirable to introduce species that are likely to have a major influence on the ecosystem.
iii. Consideration should be given as to whether or not the species could be controlled readily.

The rainbow trout is an introduced species which has a very high sporting value and which, though it usually grows faster and may compete with the native brown trout, is never likely to oust it or any other native species because it rarely breeds naturally in this country, and so its numbers can be readily controlled. A similar situation seems likely to hold with the grass carp (*Ctenopharyngodon idella*), which has been introduced to a number of waters (Cross 1969) and is the subject of world-wide interest as a means of controlling aquatic vegetation (Shireman & Smith 1983).

Fish culture, especially of salmonids, has increased enormously in importance in recent years in the British Isles. As well as the evidence of pollution and eutrophication from fish farms which has been detected in some systems, there seems little doubt that caution should also be exercised in relation to damage to wild stocks of fish, particularly that resulting from genetic mixing and change. In developing certain strains of previously wild species of fish to make them more suitable for domestic purposes, they are almost certainly made less suitable for the wild. One of the primary aims of the management of such stocks should be to keep wild and farmed strains separate: this separation is not being done at present. It seems that many of the large farming units for Atlantic salmon in Scotland have many hundreds of thousands of young fish available for sale each year. Many of these fish appear to be sold to private fisheries for stocking in the wild. There are also many escapes to the wild from farm units.

In spite of recent changes in legislation, there is still room for improvement in various areas. The most obvious loophole relates to the aquarium trade, through which it is possible to import, quite legally, a large number of foreign species which could undoubtedly become established in the British Isles. A solution to this problem might be to produce a 'blacklist' of potentially dangerous temperate species which are not allowed into the country without special permits. Another problem, peculiar to Scotland, is the fact that here there is no legislation comparable to that for England and Wales, which aims to prevent fish being moved from one major catchment to another. The introduction of the ruffe to Loch Lomond, described above, is a blatant example of this kind of introduction and parallels, on a lesser scale, the infamous story of the Nile perch (*Lates niloticus*) to Lake Victoria and other African waters (Barel *et al.* 1985). There is no legislation to prevent movement from England into Scotland of species which are held to be indigenous to Great Britain even though they may not be indigenous to Scotland (ie it is not just a matter of lack of control within Scotland).

At the time of writing (April 1986), the Salmon Bill which is being discussed in Parliament has been amended by the Ministry of Agriculture, Fisheries and Food so as to remove control by Water Authorities in England and Wales over introductions into fish farms in their areas. This amendment would have the effect of reducing the extent of Water Authority control over introductions and seems, like several other alterations to or omissions from the Bill, a retrograde step. Welcomme (1986) recently proposed international measures to control introductions.

Finally, in addition to developing adequate legislation, it is extremely important that a social conscience in this area is developed in the public mind – especially among anglers, aquarists, naturalists and others. Only if this education is successful, can we hope to generate the advantages of fish introductions and translocations without receiving many of the potential disadvantages. These codes of conduct among angling and aquarium organizations, in particular, setting out the dangers of moving fish around indiscriminately would be a constructive step towards stabilizing the future of our existing fish fauna.

8 Summary

The nature of fish communities and the fish fauna of fresh waters in the British Isles was originally determined largely by the last glaciation and the separation of southern Britain from the continental land mass. With the retreat of the glaciers, many species with marine affinities invaded most previously glaciated fresh waters, especially barren waters in the north of the country. Thereafter, the dispersion of species was probably a rather slow, chance, process, involving the gradual movement north of many species originally confined to south-eastern England by the glaciers. In recent centuries, humans have had an increasingly important role in the translocation of fish within the country and in the introduction of new species from abroad, and now must be the dominant factor in determining the changing nature of our fish fauna. The fauna is made up at present of 55 established species, 12 of which have been introduced from abroad. At least 12 other species have been introduced unsuccessfully. Many native species have been (and are being) moved successfully into new waters. The latest dramatic example is the ruffe into Loch Lomond, where it may now be the commonest species. Present legislation to control such introductions and translocations, and knowledge of their impact on indigenous

stocks are inadequate, and should be reviewed and improved. Equally important is the education of a social conscience in those groups mainly involved in the movement of fish anglers, fishery managers and aquarists and recognized codes of conduct to control the situation should be produced by appropriate governing bodies.

9 Acknowledgements

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