



Guidelines for the Selection of Biological SSSIs

Part 2: Detailed Guidelines for Habitats and Species Groups

Chapter 19 Freshwater Fish

Authors

Bean, C.W., Mainstone, C.P., Hall, R.A., Hatton-Ellis, T.W., Lee, A.S.L. and Boon, P.J.

To view other Part 2 chapters and Part 1 of the SSSI Selection Guidelines visit:

<http://jncc.defra.gov.uk/page-2303>

Cite as: Bean, C.W., Mainstone, C.P., Hall, R.A., Hatton-Ellis, T.W., Lee, A.S.L. and Boon, P.J. 2018. *Guidelines for the Selection of Biological SSSIs. Part 2: Detailed Guidelines for Habitats and Species Groups. Chapter 19 Freshwater Fish*. Joint Nature Conservation Committee, Peterborough.

Cover Note

This chapter updates and replaces the previous Freshwater Fish SSSI Selection Guidelines chapter (Nature Conservancy Council 1989). It was prepared by Colin Bean, Phil Boon and Alison Lee (Scottish Natural Heritage), Chris Mainstone and Ruth Hall (Natural England) and Tristan Hatton-Ellis (Natural Resources Wales), and provides detailed guidance for use in selecting freshwater fish sites throughout Great Britain to recommend for notification as SSSIs. It should be used in conjunction with Part 1 of the SSSI Selection Guidelines, as published in 2013 (Bainbridge *et al* 2013), which detail the overarching rationale, operational approach and criteria for selection of SSSIs.

The main changes from the previous version of the chapter are that it:

- reflects our greater understanding of fish diversity within the British Isles, and within-species diversity in particular. All of the data sources have been updated to reflect this;
- provides better alignment between the identification of valuable freshwater fish populations and fish assemblages and the protection of the habitats which support them. Linkages are made between this chapter and SSSI Selection Guidelines for Freshwater habitats where appropriate;
- provides a better context for the geographical selection of sites for the protection of native freshwater fish or fish communities of conservation value. It also provides more detailed guidance relating to the identification of site boundaries; and
- separates freshwater fish from those normally associated solely with estuaries; and
- includes a glossary to provide clarity in relation to the technical terms used within the chapter.

This chapter has been subjected to appropriate levels of evidence quality assurance. It is compliant with the JNCC Evidence Quality Assurance Policy (2014, and has been subjected to external peer review by Professor Peter Maitland.

1 Introduction

- 1.1. This guidance covers selection for any eligible native fish species in Great Britain that inhabit freshwater systems for all or part of their life cycle (Table 1), including migratory species that spend part of their life cycle at sea (i.e. diadromous species). Those species that use rivers, estuaries and marine environments must have free movement between them if they are to complete their life cycles. Linked and contiguous notifications for river and estuarine habitat, including the river's saline transition zone, are therefore the best means of protecting the full range of characteristic fish assemblages. This guidance covers the same habitats as SSSI Selection Guidelines for Freshwater habitats and aligns with the guidance in that chapter.
- 1.2. Fish assemblages in the fresh waters of Great Britain vary naturally owing to a combination of environmental tolerances, competitive interactions and barriers to colonisation. The last glaciation and the associated post-glacial period were highly influential in shaping British fish communities (Davies *et al* 2004). This has resulted in the establishment of a north/west–south/east gradient in the number of native fish species present in British freshwater habitats.
- 1.3. Fresh waters to the south east of Great Britain that were directly connected to the European mainland contain a greater variety of species than are present in the north or west of the country. These communities contain a variety of species (particularly cyprinids and percids) which are naturally absent from elsewhere on these islands. To the north and west (including islands), fish colonised fresh water from the sea, and species that have marine affinities (such as the salmonids) dominate. Even in southern Great Britain, however, many European fish species are missing from natural assemblages and some European species (such as spined loach, barbel and grayling) are only naturally present in certain southern and eastern catchments. In northern and western Great Britain, natural gaps in the fish community allow other species such as trout and Arctic charr to exploit vacant niches, so creating unique freshwater communities. The absence of cyprinid fish, in particular, allows certain freshwater plant and invertebrate communities to develop, particularly in standing waters.
- 1.4. Freshwater fish communities, probably more than any other biological group, are heavily influenced by human introductions. A wide range of fish species have been introduced to rivers and lakes outside their native range. These may be fish which are native to other parts of Great Britain, or have been introduced from other parts of the world. Although such introductions are now regulated, many took place before legislation existed, and accurate records are often not available. Therefore, great care should be taken when designating any non-migratory fish species as a specific SSSI feature or part of an assemblage. This is discussed further below.
- 1.5. Some debate surrounds the status of crucian carp (*Carassius carassius* L.) as a native species in Great Britain. This species was until recently thought to be native to southeastern England and under threat (Sayer *et al* 2011). However, recent genetic evidence suggests that it was introduced to England as recently as the 15th century (Jeffries *et al* 2015). For this reason, there is currently no basis for including Crucian carp in the list of native freshwater species (Table 1).

Table 1. Native fish recorded in freshwater habitats in Great Britain (adapted from Maitland 2004).

Order	Family	Common name	Scientific name		
Petromyzoniformes	Petromyzontidae	River lamprey ³	<i>Lampetra fluviatilis</i> (L.)		
		Brook lamprey	<i>Lampetra planeri</i> (Bloch)		
		Sea lamprey ³	<i>Petromyzon marinus</i> L.		
Acipenseriformes	Acipenseridae	Common sturgeon ^{1,3}	<i>Acipenser sturio</i> L.		
Anguilliformes	Anguillidae	European eel ^{1, 3}	<i>Anguilla anguilla</i> (L.)		
Clupeiformes	Clupeidae	Allis shad ³	<i>Alosa alosa</i> (L.)		
		Twait shad ³	<i>Alosa fallax</i> (Lacépède)		
Cypriniformes	Cyprinidae	Silver or white bream	<i>Blicca bjoerkna</i> (L.)		
		Common bream	<i>Abramis brama</i> (L.)		
		Bleak	<i>Alburnus alburnus</i> (L.)		
		Barbel	<i>Barbus barbus</i> (L.)		
		Gudgeon	<i>Gobio gobio</i> (L.)		
		Chub	<i>Leuciscus cephalus</i> (L.)		
		Dace	<i>Leuciscus leuciscus</i> (L.)		
		Eurasian minnow	<i>Phoxinus phoxinus</i> (L.)		
		Roach	<i>Rutilus rutilus</i> (L.)		
		Rudd	<i>Scardinius erythrophthalmus</i> (L.)		
		Tench	<i>Tinca tinca</i> (L.)		
			Cobitidae	Spined loach	<i>Cobitis taenia</i> L.
			Balitoridae	Stone loach	<i>Barbatula barbatula</i> (L.)
		Esociformes	Esocidae	Pike	<i>Esox lucius</i> L.
		Osmeriformes	Osmeridae	Smelt ³	<i>Osmerus eperlanus</i> (L.)
Salmoniformes	Coregonidae	Vendace	<i>Coregonus albula</i> (L.)		
		Pollan	<i>Coregonus autumnalis</i> (Pallas)		
		Whitefish (Powan, Gwyniad or Schelly)	<i>Coregonus lavaretus</i> (L.)		
		Houting ^{1,2,3}	<i>Coregonus oxyrinchus</i> (L.)		
			Salmonidae	Atlantic salmon ³	<i>Salmo salar</i> L.
				Trout (incl. sea trout ³)	<i>Salmo trutta</i> L.
				Arctic charr	<i>Salvelinus alpinus</i> (L.)
			Thymallidae	European grayling	<i>Thymallus thymallus</i> (L.)
		Gadiformes	Gadidae	Burbot ²	<i>Lota lota</i> (L.)
		Gasterosteiformes	Gasterosteidae	3-spined stickleback	<i>Gasterosteus aculeatus</i> (L.)
9 or 10-spined stickleback	<i>Pungitius pungitius</i> (L.)				
Scorpaeniformes	Cottidae	Bullhead	<i>Cottus gobio</i> L.		
Perciformes	Percidae	Ruffe	<i>Gymnocephalus cernuus</i> (L.)		
		Perch	<i>Perca fluviatilis</i> L.		
		Sea bass ⁴	<i>Dicentrarchus labrax</i> (L.)		
		Thick-lipped grey mullet ⁴	<i>Chelon labrosus</i> (Risso)		
		Thin-lipped grey mullet ⁴	<i>Liza ramada</i> (Risso)		
		Golden grey mullet ⁴	<i>Liza aurata</i> (Risso)		
			Gobiidae	Common goby ⁴	<i>Pomatoschistus microps</i> (Kroyer)
		Pleuronectiformes	Pleuronectidae	Flounder ⁴	<i>Platichthys flesus</i> (L.)

Key: 1 = Species that spawn in freshwater but for which no spawning record exists for Great Britain.

2 = Species that are extinct in the wild in Great Britain.

3 = Diadromous species.

4 = Predominantly estuarine species. (In this context 'estuarine' means species that spend most of their life cycle in the estuary but periodically use the tidally influenced lower reaches of the river.

2 International and national importance

- 2.1. Great Britain supports a sub-set of the European fish fauna, within which many of the species present occupy more prominent positions than they occupy on the continent. This has led to the development, in some cases, of unique fish communities. Several species which may be relatively common in a European context may be rare in Great Britain, where they are at the limit of their European range.
- 2.2. A range of British fish species appear on UK and international lists of conservation importance (Table 2). Presence on these lists is considered in the notification advice below.
- 2.3. Houting (*C. oxyrinchus*) is considered to be a 'vagrant' and known in the British Isles only from specimens formerly caught off the coast of southwest England, where it no longer occurs (Maitland 2004). Despite being listed as 'Extinct' on the Global IUCN Red List, recent studies have confirmed the species to be extant in the River Vidaa, Denmark only (Jensen *et al* 2015). For these reasons, Houting is not included in Table 2
- 2.4. Burbot (*L. lota*) is also known to be extinct in the wild in Great Britain and is therefore also excluded from Table 2. Atlantic sturgeon (*A. sturio*) is retained because although there is no evidence of sturgeon spawning activity in British rivers, adult fish are still occasionally captured in coastal waters.

3 Selection requirements

- 3.1. Fish inhabiting fresh waters (either wholly or partially) may qualify as features for notification in freshwater habitats under three different categories:
 - rare and threatened species;
 - within-species diversity;
 - natural fish assemblages.
- 3.2. A set geographical region of search is not appropriate for notifications of fish features because the nature of some of the freshwater habitats which support them may, in the case of rivers, extend over significant areas, or in the case of smaller water bodies, be tightly clustered within a relatively small geographical area. This means that the distribution of fish within Great Britain does not, in most cases, fit well with the standard 'Area of Search' approach. Selection of sites will depend on the location of species notified under the three categories above.
- 3.3. In notifying sites for fish species and assemblages, care is needed to avoid SSSI notifications that are unlikely to be sustainable in the face of climate change. Therefore, predicted shifts in the climate space of species should be considered.
- 3.4. In all cases, the SSSI series for freshwater habitats should be the starting point when considering fish-related notifications (see SSSI Selection Guidelines for Freshwater habitats). The Freshwater habitats chapter and this chapter provide the basis for conserving fish species in naturally functioning habitat as part of the broader characteristic biological assemblage, and allowing for shifts in community composition as a result of climate change. Freshwater habitat sites are useful in providing a basis for notifications for fish. Sites considered for notification beyond the freshwater habitat series should also be assessed against the guidelines in SSSI Selection Guidelines for Freshwater habitats. Where there is a choice between sites of otherwise similar merit,

the one functioning most naturally, and with a greater number of justifications for selection according to the above categories, should be selected.

- 3.5. Wherever sites designated for their freshwater habitat are also used as sites for notified rare or threatened fish species, those notified species features should be presented as specific components within the broader habitat notification. This does not suggest a hierarchy of importance in notified features, but rather a means of ensuring that the species features are accommodated as part of the characteristic assemblage of a healthy functioning ecosystem as far as possible.
- 3.6. Similarly, characteristic fish assemblages associated with notified freshwater habitats should not generally be notified features in their own right, but should instead form part of the description of the habitat notification.

4 Rare and threatened species

- 4.1. Owing to the widespread British distribution of many of the fish species listed under Annex II of the Habitats Directive, the presence of these species alone is not an automatic criterion for site selection. In rivers, the SSSI notification requirements of widespread species (European eel, brook lamprey, river lamprey, sea lamprey, bullhead, and Atlantic salmon) should be met through their representation within sites notified for river habitat (Section 6).
- 4.2. The fish species listed below are considered sufficiently rare within Great Britain to require specific consideration in the context of the SSSI series to ensure their protection. Sites of critical importance for these species should be considered for notification, based on synergies with notification for freshwater habitat, relative ease of conservation, population size, local or country-level distribution and resilience to climate change. The appropriate Statutory Nature Conservation Body (SNCB) specialist should be consulted to determine whether notification is justified.
- 4.3. If present or re-established within their native range, the locations of the following self-sustaining breeding populations may qualify for selection:
 - vendace
 - whitefish
 - smelt
 - Arctic charr
 - allis shad
 - twaite shad
 - sturgeon
 - houting
 - burbot
- 4.4. Where it is necessary to introduce one of these species to a site in which it has never been naturally present to ensure the survival of the species, it may be appropriate to notify the site if a self-sustaining population is established there.
- 4.5. Spined loach has a restricted geographical distribution in Great Britain but within its natural range is relatively widespread both in rivers and drains. Within rivers notifications for river habitat should be sufficient for its protection; however, drains that support populations of spined loach may be selected where suitable river sites are absent.

Table 2. Rare and threatened fish species using freshwater habitats in Great Britain.

Scientific name	W&C Act	UK BAP	HD Annex	Cons Regs Schedule	Bern Conv Appendix	Bonn Conv Appendix	CITES	IUCN 2015
<i>Lampetra fluviatilis</i> L.		Y	II, V	3	III			LC
<i>Lampetra planeri</i> Bloch			II		III			LC
<i>Petromyzon marinus</i> L.		Y	II		III			LC
<i>Acipenser sturio</i> L.	Sch. 5	Y	II, IV	2	III	I, II	I	CR
<i>Anguilla anguilla</i> L.		Y				II	II	CR
<i>Alosa alosa</i> L.	Sch. 5	Y	II, V	3	III			LC
<i>Alosa fallax</i> Lacepede	Sch. 5	Y	II, V	3	III			LC
<i>Barbus barbus</i> L.			V	3				LC
<i>Cobitis taenia</i> L.		Y	II		III			LC
<i>Osmerus eperlanus</i> L.		Y						LC
<i>Coregonus albula</i> L.	Sch. 5	Y	V	3	III			LC
<i>Coregonus lavaretus</i> L.	Sch. 5	Y	V	3	III			VU
<i>Salmo salar</i> L.		Y	II, V	3	III			LC
<i>Salmo trutta</i> L.		Y						LC
<i>Salvelinus alpinus</i> L.		Y						LC
<i>Thymallus thymallus</i> L.			V	3	III			LC
<i>Cottus gobio</i> L.			II					LC

Notes on Table 2

Legislation	Relevant schedules and appendices as listed in Table 2
Wildlife and Countryside Act 1981 (as amended)	<i>Schedule 5</i> – animals other than birds) that are protected
UK BAP	<i>UK BAP priority fish species list</i>
EC Habitats Directive	<i>Annex II</i> - designation as qualifying feature within SACs for the species listed. <i>Annex IV</i> – special protection for the species listed. <i>Annex V</i> – exploitation may be subject to management.
The Conservation Natural Habitats etc. Regulations 1994	<i>Schedule 2</i> – European Protected Species in Great Britain <i>Schedule 3</i> – animals that may not be taken in certain ways
Bern Convention (Convention on the Conservation of European Wildlife and Natural Habitats)	<i>Appendix III</i> – regulation of the exploitation of species listed.
Bonn Convention (The Convention on Migratory Species)	<i>Appendix I</i> - migratory species that are endangered. <i>Appendix II</i> - migratory species that require international agreements for their conservation and management.
CITES (Convention on International Trade in Endangered Species)	<i>Appendix I</i> - trade only in exceptional circumstances. <i>Appendix II</i> - trade subject to licensing.
Global IUCN Red List	CR - Critically endangered, VU - Vulnerable, LC - Least Concern, EX - Extinct.

5 Within-species diversity

5.1. It may not be possible to capture the full phenotypic or genetic diversity of all species through SSSI notification; for instance, each population of Atlantic salmon is considered to be genetically unique at various levels. To a large degree this diversity

should be accounted for by representative notifications for freshwater habitat across Great Britain (see SSSI Selection Guidelines for Freshwater habitats). Notification of other sites may be justified where there are sufficiently important elements of phenotypic or genetic diversity in the fish community. In these instances, a set geographic region of search is not appropriate.

- 5.2. Some species, such as Arctic charr, three-spined stickleback and brown trout can display an unusually high degree of variance in phenotype, or 'phenotypic plasticity'. Phenotypic variation also occurs between and within whitefish populations in Great Britain, but may be less obvious than that displayed by other species. This variation can manifest over a wide range of characteristics including: morphological, meristic, colouration, behavioural and in life history. Geographic isolation of populations, including the land-locking of migratory species, generates conditions for a genetic basis to phenotypic variation.
- 5.3. The conservation of organisms requires the development of identifiable taxonomic units on which management can be based. There continues to be a lack of consensus over what defines a species, e.g. Coyne and Orr (2004). In a recent review of the taxonomy of the freshwater fishes in Europe (Kottelat and Freyhof 2007), the previously accepted total of 317 European fish species (Maitland 2000) was increased to 546. To achieve this, Kottelat and Freyhof (2007) used the 'Evolutionary Species Concept' (ESC) to resurrect species names and afforded species status to descriptions that had latterly been regarded as sub-species, races, or infra-specific variants of a more widely defined species. They recognise that the use of the ESC as a taxonomic tool could result in the recognition of many thousands of distinct species.
- 5.4. Whilst the taxonomy put forward by Kottelat and Freyhof (2007) has been accepted by the IUCN and incorporated into the Global Red List, it has not received universal acceptance from the international scientific community. A recent, successful challenge to their revised taxonomy of *C. lavaretus* within the UK splitting this species into *C. clupeoides*, *C. stigmaticus* and *C. pennantii* (Etheridge *et al* 2012) has led to the view that only two coregonid species are present within UK fresh waters – *C. lavaretus* (powan, schelly and gwyniad) and *C. albulula* (vendace). Another coregonid species, *C. autumnalis*, is restricted to Ireland only.
- 5.5. Arctic charr is a particularly well-studied example of phenotypic variation and evolutionary divergence. Phenotypically discrete morphs occupying the same system have now been widely recorded for this species from across its distributional range. Sympatric polymorphisms of up to three morphs in a single lake have been recorded in Scotland but more commonly sympatric polymorphisms comprise two forms. Examples of sympatric polymorphism in Arctic charr can be found throughout its British range and these provide an excellent example of evolutionary divergence in action. Multiple polymorphisms may be present due to successive colonisations of populations that have previously diverged genetically (allopatry). Kottelat and Freyhof (2007) suggested that up to 20 'new' species of charr are present within Great Britain and Ireland, with many more undescribed. These 'new species' of charr, the names of which have largely been resurrected from historical accounts, have been incorporated into the IUCN Red List.
- 5.6. In a comparison of intraspecific variation within the ten most variable fish species, Kelemetsen (2013) identified Arctic charr as being the 'most variable (wild) vertebrate on earth'. Whilst there is some evidence that evolutionary processes have caused significant divergence within and between some populations of Arctic charr within the UK and elsewhere, the case for affording these 'species' status has not yet been widely accepted within the scientific community. Consequently, for the purposes of these guidelines, all 'Charr' in Great Britain are considered a single species, *S. alpinus*.

5.7. Important examples of within-species diversity that may qualify for notification include:

- i) naturally isolated sites creating distinct genetic sub-groups of a species associated with long-term reproductive isolation, such as in brown trout, e.g. ferox and ancestral forms), Arctic charr, whitefish, and 'land-locked' migratory fish such as 'dwarf' river lamprey in Loch Lomond);
- ii) high levels of polymorphism within a species, e.g. trout, Arctic charr, three-spined stickleback), either in geographically separated or sympatric populations.

5.8. In all cases, proposals should be supported by clear scientific evidence. Where there is good reason to suspect the presence of important evolutionary selection pressure, scientific evidence should be gathered to allow a judgement of importance. Critical considerations in assessing individual sites for notification are given below:

- if the range of phenotypic/genetic diversity is already adequately captured in the existing SSSI series, the site should not normally be notified;
- the population should be pristine, i.e. no evidence of artificial genetic mixing, introductions or stocking;
- sites that are highly vulnerable to artificial (accidental or deliberate) introduction of fish that would interfere with the interest should not normally be notified;
- unique phenotypes and genotypes should be given high priority for notification;
- populations that are geographically isolated should generally be given higher priority, since this would sustain and drive phenotypic and genetic differentiation;
- multiple phenotypes or genotypes (sympatric or allopatric polymorphisms) at a site should be given higher priority for notification;
- a population that is a good exemplar of a particular form, genetic group, or ecological type (an ecotype) should be given higher priority;
- sites where the protection of the population and its supporting habitat would also protect an evolutionary process should be given higher priority.

6 Natural fish assemblages

6.1. In view of the strong influence of colonization history and human impact on fish faunas in Great Britain, there is great uncertainty regarding the natural status of fish communities in many rivers and lakes. This has hindered the identification of patterns of variation in natural assemblages, except in very general terms. Consequently, the selection of SSSIs relating to natural fish assemblages outside of the freshwater habitat SSSI series should not be carried out unless supported by strong evidence identifying specific sites with natural fish assemblages that are of high importance by virtue of their unusualness (see below).

6.2. Fish are a key component of freshwater ecosystems and the natural characteristic fish assemblage forms an integral component of notifications for freshwater habitat. This should ensure that representative examples of characteristic assemblages are afforded SSSI protection. A description of the natural fish community should be included in the description of any freshwater habitat designation.

- 6.3. Details of how freshwater habitat SSSIs should be selected, including consideration of their fish assemblage, are provided in the SSSI Selection Guidelines for Freshwater habitats. The aim is to select sites with natural fish assemblages that are free of non-native fish species, and also free of British native fish species that would not naturally occur in that locality (WFD Alien Species Group 2012). In reality, these requirements have to be considered alongside other aspects of naturalness in the site selection process, but the subsequent management of the site is based on conserving the fish assemblage in the most natural state possible.
- 6.4. Unusual natural fish assemblages, with rare and important species associations, are of conservation value and should be considered for notification. These species associations may also be captured by notifications for freshwater habitat. Rare or unusual species combinations that typically occur in upland areas, where natural connectivity constraints generally have a greater bearing on assemblages, may be worthy of selection. Those of greatest conservation importance are the examples of association between Arctic charr and whitefish, and between Arctic charr and ferox trout. These sites may also warrant notification based on other criteria in this chapter.

7 Defining site boundaries

- 7.1. The boundary of the site should be defined by reference to the guidance in the SSSI Selection Guidelines for Freshwater habitats. The following points should be considered:
- the life-cycle requirements of the species (breeding, juvenile development and adult growth) should be catered for within the site boundary. For instance, streams (both inflowing and outflowing) which lake fish populations use for spawning (e.g. Arctic charr, ferox trout) should also be included within the site boundary;
 - flood zones needed to satisfy the life-cycle requirements of coarse fish (i.e. such as the use of floodplain habitat for spawning and juvenile development by pike) should also be included within the boundary;
 - in instances where the movement of notified species is constrained by artificial barriers the site boundary should include the full natural distribution of the species that would be expected in the absence of those barriers;
 - notifications of diadromous fish populations should be based on a whole-river habitat notification which includes the full migratory route.

8 Glossary

Allopatry – population divergence that occurs when biological populations of the same species become isolated from each other to an extent that prevents or interferes with genetic exchange.

Anadromous – having a life history that involves a migration to sea and a return migration to fresh water to spawn.

Catadromous – having a life history that involves a migration to fresh water and a return migration to the sea to spawn.

Diadromous – fish species that divide their life cycle between freshwater habitats and the sea, either spawning in freshwater and migrating to sea for adult development anadromous, (e.g. Atlantic salmon) or spawning at sea and migrating to fresh water for adult development catadromous (e.g. European eel).

Ecotype – a group or race within a species having unique physical characteristics genetically adapted to particular environmental conditions.

Evolutionary Species Concept - a species is a single lineage of ancestor-descendant populations which maintain its identity from other such lineages and which has its own evolutionary tendencies and historical fate.

Ferox trout – long-lived, late-maturing, piscivorous brown trout which in Great Britain are often present in large, deep glacier-formed lakes containing Arctic charr or whitefish species.

Genotype – the hereditary or genetic constitution of an organism defined by its particular combination of allelic variants possessed at one or more loci.

Locally non-native fish species – species that are native to Great Britain but are naturally absent from suitable habitat in some geographical areas because of natural colonisation barriers. Their presence in sites where they do not naturally occur generates a loss of naturalness in the species assemblage and can cause significant ecological damage to locally native assemblages. For instance, ruffe introduced into Cumbrian lakes and Loch Lomond has caused considerable damage to whitefish populations.

Meristic – relates to the counting of quantitative features of fish, such as the number of fins or scales; or measurement of physical characteristics, such as size.

Phenotype – the appearance of an organism resulting from the interaction of a genotype and the environment.

Phenotypic plasticity – variation in the phenotype of individuals with the same genotype due to their experiencing different environments. (See also Polymorphism.)

Polymorphism – two or more different forms (morphs) in the same species, which may be genetically determined, partially under genetic influence or the result of phenotypic plasticity.

Saline transition zone – the natural brackish water zone at the downstream end of a river, immediately upstream of the estuary (taken as the mean low water mark). This zone is very important to many fish species for migration to and from fresh water and (for some species) spawning, feeding and shelter.

SNCB – Statutory Nature Conservation Body.

Sympatric – populations occupying the same site or geographical area.

9 References and related reading

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). 1973.

Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). 1979.

Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention). 1979.

Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (The Habitats Directive). 1992.

- COYNE, J.A. AND ORR, H.A. 2004. *Speciation*. Sinauer Associates Publishers, Sunderland, Massachusetts.
- DAVIES, D., SHELLEY, J., HARDING, P., MCLEAN, I., GARDINER, R. AND PEIRSON, G. 2004. *Freshwater Fishes in Great Britain – The Species and Their Distribution*. Harley Books, Colchester.
- ETHERIDGE, E.C., ADAMS, C.E., BEAN, C.W., DURIE, N.C., GOWANS, A.R., HARROD, C., LYLE, A.A., MAITLAND, P.S. AND WINFIELD, I.J. 2012 Are phenotypic traits useful for differentiating among a priori *Coregonus* taxa? *Journal of Fish Biology*, **80**, 387-407.
- European Commission (2007) Council Regulation (EC) No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel.
- IUCN. 2016. *The IUCN Red List of Threatened Species. Version 2016-2*. Downloaded [date].
- JEFFRIES, D.L., COPP, G.H., HANDLEY, L.J.L., SAYER, C.D. AND HÄNFLING, B. 2015. Genetic evidence challenges the native status of a threatened freshwater fish (*Carassius carassius*) in England. *bioRxiv*, 026088.
<http://www.biorxiv.org/content/biorxiv/early/2015/09/03/026088.full.pdf>
- JENSEN, L.F., THOMSEN, D.S., MADSEN, S.S., EJBYE-ERNST, M., POULSEN, S.B. AND SVENDSEN, J.C. 2015. Development of salinity tolerance in the endangered anadromous North Sea houting *Coregonus oxyrinchus*: implications for conservation measures. *Endangered Species Research*, **28**, 175-186.
- JNCC. 2007. UK Biodiversity Action Plan: priority fish species list.
- KOTTELAT, M. AND FREYHOF, J. 2007. *Handbook of European Freshwater Fishes*. Publications Kottelat Cornol, Switzerland.
- MAITLAND, P. 2000. *Guide to Freshwater Fish of Great Britain and Europe*. Hamlyn, London.
- MAITLAND, P. 2004. *Keys to the freshwater fish of Great Britain and Ireland with notes on their distribution and ecology*. Freshwater Biological Association, Scientific Publication No.62.
- SAYER, C.D., COPP, G.H., EMSON, D., GODARD, M.J., ZIEBA, G. AND WESLEY, K.J. 2011. Towards the conservation of crucian carp *Carassius carassius*: understanding the extent and causes of decline within part of its native English range. *Journal of Fish Biology*, **79**, 1608-1624.
- The Conservation (Natural Habitats, &c.) Regulations. 1994.
- WFD Alien Species Group. 2012. *Aquatic alien species and the WFD: proposed list of 'locally absent' species and guidance on its interpretation*.
- WFD Alien Species Group. 2015. *Revised classification of aquatic alien species according to their level of impact*.
- Wildlife and Countryside Act. 1981. (as amended).