European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC)

Fourth Report by the United Kingdom under Article 17

on the implementation of the Directive
from January 2013 to December 2018

Supporting documentation for the
conservation status assessment for the species:

S1109 - Grayling (*Thymallus thymallus*)

ENGLAND

IMPORTANT NOTE - PLEASE READ

- The information in this document is a country-level contribution to the UK Report on the conservation status of this species, submitted to the European Commission as part of the 2019 UK Reporting under Article 17 of the EU Habitats Directive.
- The 2019 Article 17 UK Approach document provides details on how this supporting information was used to produce the UK Report.
- The UK Report on the conservation status of this species is provided in a separate document.
- The reporting fields and options used are aligned to those set out in the European Commission guidance.
- Explanatory notes (where provided) by the country are included at the end. These provide an audit trail of relevant supporting information.
- Some of the reporting fields have been left blank because either: (i) there was insufficient information to complete the field; (ii) completion of the field was not obligatory; (iii) the field was not relevant to this species (section 12 Natura 2000 coverage for Annex II species) and/or (iv) the field was only relevant at UK-level (sections 9 Future prospects and 10 Conclusions).
- For technical reasons, the country-level future trends for Range, Population and Habitat for the species are only available in a separate spreadsheet that contains all the country-level supporting information.
- The country-level reporting information for all habitats and species is also available in spreadsheet format.

Visit the JNCC website, https://jncc.gov.uk/article17, for further information on UK Article 17 reporting.

Report on the main results of the surveillance under Article 11 for Annex II, IV and V species (Annex B)

NATIONAL LEVEL

1. General information

1.1 Member State	**UK (England information only)**
1.2 Species code	**1109**
1.3 Species scientific name	**Thymallus thymallus**
1.4 Alternative species scientific name	
1.5 Common name (in national language)	Grayling

2. Maps

2.1 Sensitive species	No
2.2 Year or period	2013-2018
2.3 Distribution map	Yes
2.4 Distribution map Method used	Based mainly on extrapolation from a limited amount of data
2.5 Additional maps	No

3. Information related to Annex V Species (Art. 14)

3.1 Is the species taken in the wild/exploited?		Yes
3.2 Which of the measures in Art. 14 have been taken?	a) regulations regarding access to property	Yes
	b) temporary or local prohibition of the taking of specimens in the wild and exploitation	Yes
	c) regulation of the periods and/or methods of taking specimens	Yes
	d) application of hunting and fishing rules which take account of the conservation of such populations	Yes
	e) establishment of a system of licences for taking specimens or of quotas	Yes
	f) regulation of the purchase, sale, offering for sale, keeping for sale or transport for sale of specimens	Yes
	g) breeding in captivity of animal species as well as artificial propagation of plant species	Yes
	h) other measures	Yes

Grayling in all English rivers are subject to controls on angling activity. The primary legislation for the regulation of angling is the 'Salmon and Freshwater Fishery Act 1975'. Under this legislation the Environment Agency has powers to licence recreational angling. Fishery byelaws regulate when, where and how angling can take place. The licencing approach records the number of licenced individuals and regulates the gear and effort used. As part of this managed exploitation, pressure on the population can be controlled and data can be collected on grayling stocks. The taking of grayling from English waters is specifically cited within the regulations and there is a limit of 2 grayling (30cm to 38cm) imposed. In addition to the Salmon and Freshwater Fishery Act, the stocking of fish to freshwaters is regulated by 'The Keeping and Introduction of

Report on the main results of the surveillance under Article 11 for Annex II, IV and V species (Annex B)

Fish (England and River Esk Catchment Area) Regulations 2015'.

3.3 Hunting bag or quantity taken in the wild for Mammals and Acipenseridae (Fish)

a) Unit

b) Statistics/ quantity taken	Provide statistics/quantity per hunting season or per year (where season is not used) over the reporting period					
	Season/ year 1	Season/ year 2	Season/ year 3	Season/ year 4	Season/ year 5	Season/ year 6
Min. (raw, ie. not rounded)						
Max. (raw, ie. not rounded)						
Unknown	Yes	Yes	Yes	Yes	Yes	Yes

3.4. Hunting bag or quantity taken in the wild Method used

3.5. Additional information

BIOGEOGRAPHICAL LEVEL

4. Biogeographical and marine regions

4.1 Biogeographical or marine region where the species occurs

Atlantic (ATL)

4.2 Sources of information

Addy, S., Cooksley, S., Dodd, N., Waylen, K., Stockan, J., Byg, A. & Holstead, K. 2016. River restoration and biodiversity: Nature based solutions for restoring rivers in the UK and Republic of Ireland. CREW ref. CRW2014/10

5. Range

5.1 Surface area (km²)

5.2 Short-term trend Period

5.3 Short-term trend Direction

Stable (0)

5.4 Short-term trend Magnitude

a) Minimum

b) Maximum

5.5 Short-term trend Method used

5.6 Long-term trend Period

5.7 Long-term trend Direction

5.8 Long-term trend Magnitude

a) Minimum

b) Maximum

5.9 Long-term trend Method used

5.10 Favourable reference range

a) Area (km²)
b) Operator
c) Unknown
d) Method

Report on the main results of the surveillance under Article 11 for Annex II, IV and V species (Annex B)

5.11 Change and reason for change in surface area of range	No change The change is mainly due to:
5.12 Additional information	

6. Population

6.1 Year or period	2013-2018	
6.2 Population size (in reporting unit)	a) Unit	number of map 1x1 km grid cells (grids1x1)
	b) Minimum	
	c) Maximum	
	d) Best single value	195
6.3 Type of estimate	Minimum	
6.4 Additional population size (using population unit other than reporting unit)	a) Unit	
	b) Minimum	
	c) Maximum	
	d) Best single value	
6.5 Type of estimate		
6.6 Population size Method used	Based mainly on extrapolation from a limited amount of data	
6.7 Short-term trend Period	2007-2018	
6.8 Short-term trend Direction	Stable (0)	
6.9 Short-term trend Magnitude	a) Minimum	
	b) Maximum	
	c) Confidence interval	
6.10 Short-term trend Method used	Based mainly on expert opinion with very limited data	
6.11 Long-term trend Period	1994-2018	
6.12 Long-term trend Direction	Stable (0)	
6.13 Long-term trend Magnitude	a) Minimum	
	b) Maximum	
	c) Confidence interval	
6.14 Long-term trend Method used	Based mainly on expert opinion with very limited data	
6.15 Favourable reference population (using the unit in 6.2 or 6.4)	a) Population size	
	b) Operator	
	c) Unknown	
	d) Method	
6.16 Change and reason for change in population size	No change The change is mainly due to:	
6.17 Additional information		

Report on the main results of the surveillance under Article 11 for Annex II, IV and V species (Annex B)

7. Habitat for the species

7.1 Sufficiency of area and quality of occupied habitat	a) Are area and quality of occupied habitat sufficient (to maintain the species at FCS)?	Unknown
	b) Is there a sufficiently large area of occupied AND unoccupied habitat of suitable quality (to maintain the species at FCS)?	Unknown
7.2 Sufficiency of area and quality of occupied habitat Method used	Insufficient or no data available	
7.3 Short-term trend Period	2007-2018	
7.4 Short-term trend Direction	Stable (0)	
7.5 Short-term trend Method used	Based mainly on extrapolation from a limited amount of data	
7.6 Long-term trend Period		
7.7 Long-term trend Direction		
7.8 Long-term trend Method used		
7.9 Additional information		

8. Main pressures and threats

8.1 Characterisation of pressures/threats

Pressure	Ranking
Physical alteration of water bodies (K05)	H
Modification of hydrological flow (K04)	M
Mixed source pollution to surface and ground waters (limnic and terrestrial) (J01)	H
Invasive alien species of Union concern (I01)	M
Management of fishing stocks and game (G08)	M
Hydropower (dams, weirs, run-off-the-river), including infrastructure (D02)	M

Threat	Ranking
Physical alteration of water bodies (K05)	H
Modification of hydrological flow (K04)	H
Mixed source pollution to surface and ground waters (limnic and terrestrial) (J01)	H
Other climate related changes in abiotic conditions (N09)	M
Invasive alien species of Union concern (I01)	H
Management of fishing stocks and game (G08)	M
Hydropower (dams, weirs, run-off-the-river), including infrastructure (D02)	H
Problematic native species (I04)	M

8.2 Sources of information

8.3 Additional information

Report on the main results of the surveillance under Article 11 for Annex II, IV and V species (Annex B)

9. Conservation measures

9.1 Status of measures	a) Are measures needed?	No
	b) Indicate the status of measures	
9.2 Main purpose of the measures taken		
9.3 Location of the measures taken		
9.4 Response to the measures		
9.5 List of main conservation measures		
9.6 Additional information		

10. Future prospects

10.1 Future prospects of parameters	a) Range b) Population c) Habitat of the species
10.2 Additional information	

11. Conclusions

11.1. Range	
11.2. Population	
11.3. Habitat for the species	
11.4. Future prospects	
11.5 Overall assessment of Conservation Status	
11.6 Overall trend in Conservation Status	
11.7 Change and reasons for change in conservation status and conservation status trend	a) Overall assessment of conservation status No change The change is mainly due to: b) Overall trend in conservation status No change The change is mainly due to:
11.8 Additional information	

12. Natura 2000 (pSCIs, SCIs and SACs) coverage for Annex II species

Report on the main results of the surveillance under Article 11 for Annex II, IV and V species (Annex B)

12.1 Population size inside the pSCIs, SCIs and SACs network (on the biogeographical/marine level including all sites where the species is present)	a) Unit b) Minimum c) Maximum d) Best single value
12.2 Type of estimate	
12.3 Population size inside the network Method used	
12.4 Short-term trend of population size within the network Direction	
12.5 Short-term trend of population size within the network Method used	
12.6 Additional information	

13. Complementary information

13.1 Justification of % thresholds for trends
13.2 Trans-boundary assessment
13.3 Other relevant Information

Distribution Map

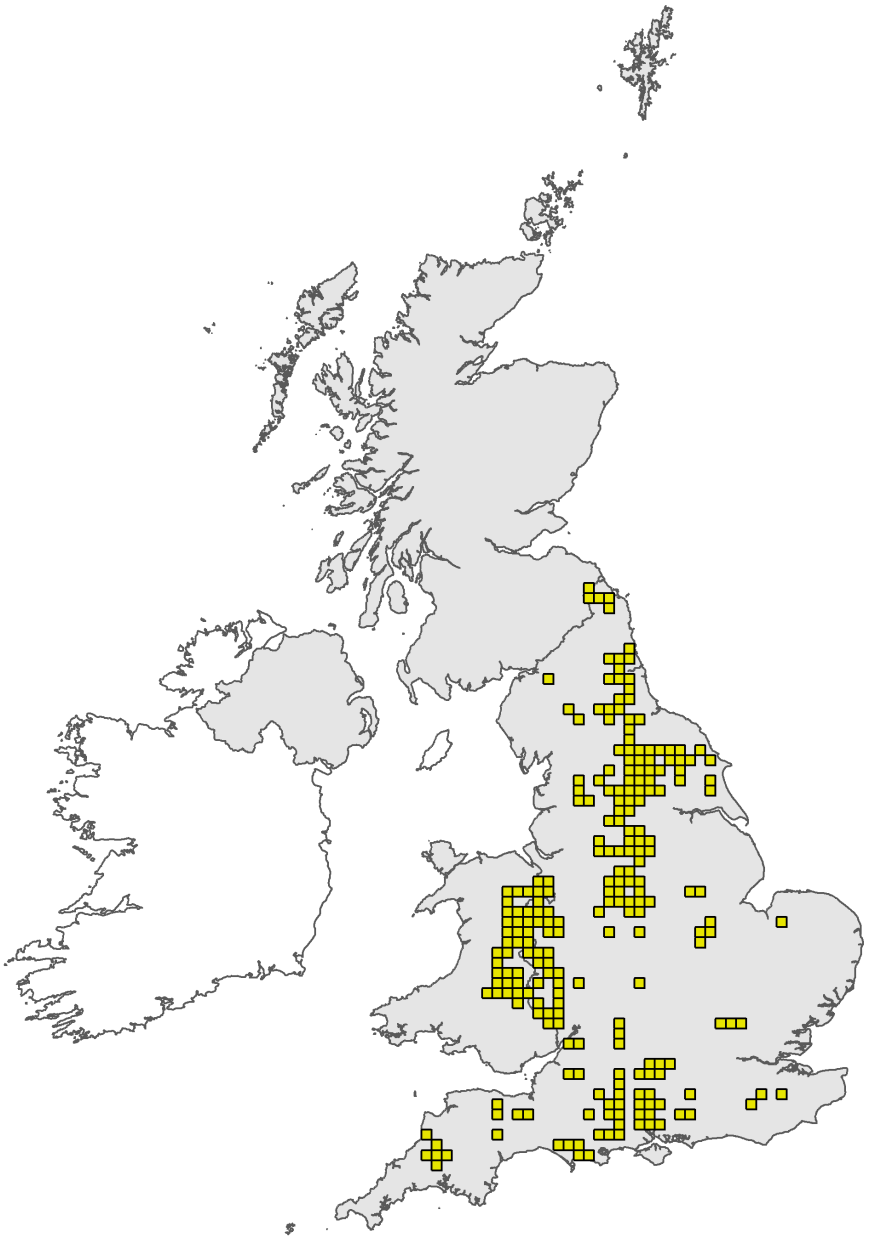

Figure 1: UK distribution map for S1109 - Grayling (*Thymallus thymallus*). Coastline boundary derived from the Oil and Gas Authority's OGA and Lloyd's Register SNS Regional Geological Maps (Open Source). Open Government Licence v3 (OGL). Contains data © 2017 Oil and Gas Authority.

The 10km grid square distribution map is based on available species records within the current reporting period. For further details see the 2019 Article 17 UK Approach document.

Range Map

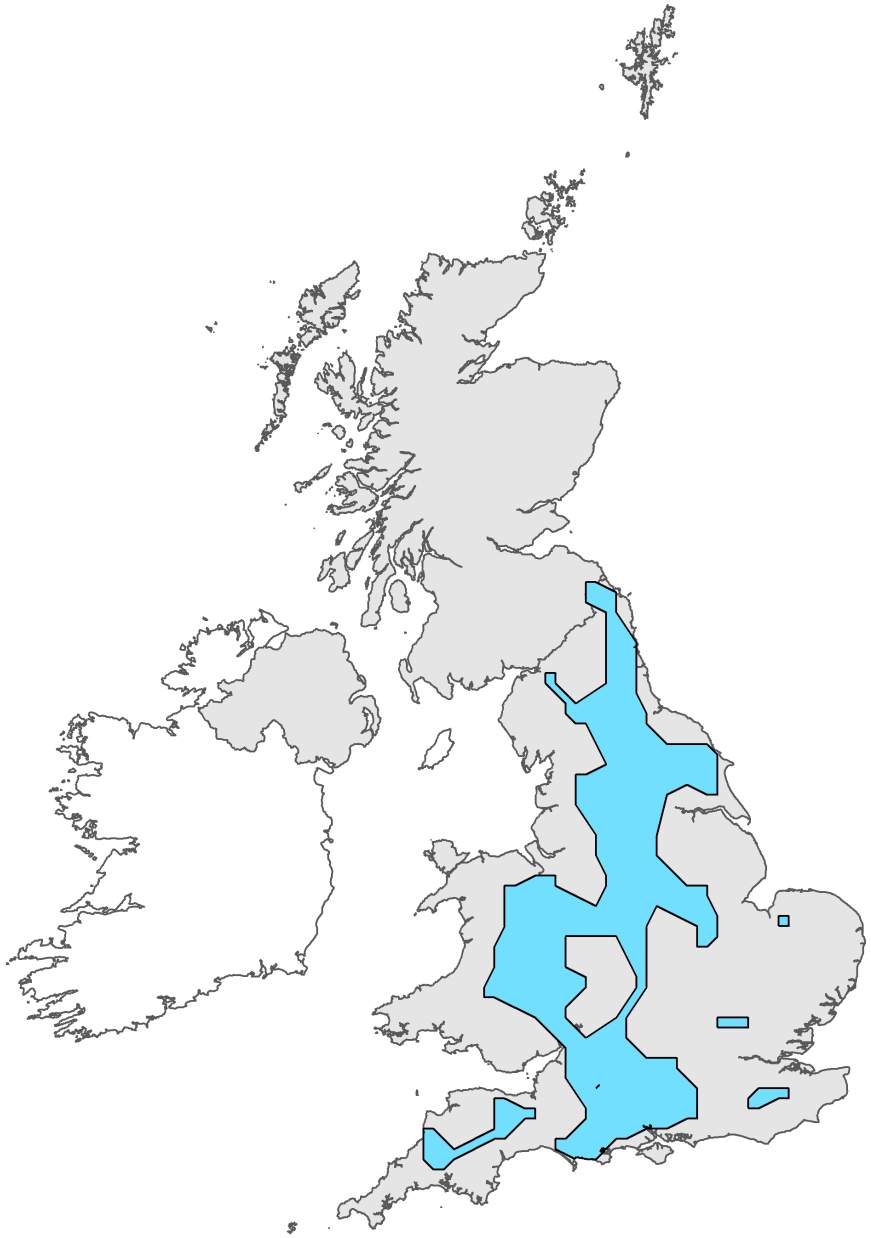

Figure 2: UK range map for S1109 - Grayling (*Thymallus thymallus*). Coastline boundary derived from the Oil and Gas Authority's OGA and Lloyd's Register SNS Regional Geological Maps (Open Source). Open Government Licence v3 (OGL). Contains data © 2017 Oil and Gas Authority.

The range map has been produced by applying a bespoke range mapping tool for Article 17 reporting (produced by JNCC) to the 10km grid square distribution map presented in Figure 1. The alpha value for this species was 25km. For further details see the 2019 Article 17 UK Approach document.

Explanatory Notes

Species name: Thymallus thymallus (1109)

Field label	Note
2.4 Distribution map; Method used	Data contained within the Environment Agency Fish Population Database has been used to produce distribution maps for grayling. Adult and juvenile grayling are captured during routine electric fishing surveys, therefore, recording effort across England is relatively high. The grayling has a tendency to be more active during daylight hours and to rest in deeper water during darkness, therefore, capture efficiency may be increased compared with some other fish species. However, they may be under recorded due to the difficulty of surveying grayling habitats with electric fishing gear caused by strong flows and abundant submerged macrophytes. In addition, grayling are a relatively sensitive fish and high mortality rates can occur if electric fishing is carried out during spawning periods or fish are held in the electric field or close to the anode for too long. Therefore, there may be a tendency to avoid targeting grayling to avoid injury to the fish. The grayling is a widespread species in England. It is thought that the species reached Britain via the North Sea River, prior to isolation from continental Europe after the last glacial period. Native grayling populations are thought to be restricted to the Rivers Ouse, Trent, Hampshire Avon and possibly the rivers Severn, Wye, Thames, Ribble and Welsh Dee and their tributaries. However, graying range has been artificially increased due to stocking for recreational angling purposes for approximately 200 years. Enhancement stocking has also been undertaken wihin their native range as a perceived conservation measure to boost dwindling natural stocks. The effect of such extensive stocking has made the natural distribution of grayling unclear. Recent genetic studies of grayling indicate further differentiation of grayling populations can be made within England as there appear to be distinct genetic differences between rivers / physically isolated populations. These differences have led to calls for individual river stocks to be managed as discrete management units to avoid a loss of gentic specificity within the management unit. Due the lack of clarity on the historic distribution grayling and the large period of time over which introductions have been made, records related to artificial expansions of range due to stocking have been included in the distribution map.
3.1 Is the species take in the wild/ exploited	Grayling are highly valued as a quarry species for many recreational anglers. A small minority of trout and salmon anglers regard them as a nuisance species, resulting in their removal from some waters. However, this attitude is rapidly becoming rare with grayling being recognised as an important member of the wider fish community and an indicator of good habitat and water quality. Grayling may be subject to catch and release or taken as a food species in England. If catch and release methods are used, angler capture and handling of this relatively sensitive species may lead to mortality for a small number of individuals and a reduction in fitness or spawning success for others. Grayling in all English rivers are subject to controls on angling activity. The primary legislation for the regulation of angling is the 'Salmon and Freshwater Fishery Act 1975'. Under this legislation the Environment Agency has powers to licence recreational angling. Fishery byelaws regulate when, where and how angling can take place. The licencing approach records the number of licenced individuals and regulates the gear and effort used. As part of this managed exploitation, pressure on the population can be controlled and data can be collected on grayling stocks. The taking of grayling from English waters is specifically cited within the regulations and there is a limit of 2 grayling (30cm to 38cm) imposed. In addition to the Salmon and Freshwater Fishery Act, the stocking of fish to freshwaters is regulated by 'The Keeping and Introduction of Fish (England and River Esk Catchment Area) Regulations 2015'.

3.3 Hunting bag or quantity taken in the wild for Mammals and Acipenseridae (Fish)	No recording unit available due to a combination of catch and release and fish taken with no national requirement for catch returns to be submitted.
3.4 Hunting bag or quantity take in the wild; Method used	Grayling are subject to a combination of catch and release and fish taken in England. There is no national requirement for catch returns to be submitted
3.5 Additional information	Grayling are highly valued as a quarry species for many recreational anglers. A small minority of trout and salmon anglers regard them as a nuisance species, resulting in their removal from some waters. However, this attitude is rapidly becoming rare with grayling being recognised as an important member of the wider fish community and an indicator of good habitat and water quality. Grayling may be subject to catch and release or taken as a food species in England. If catch and release methods are used, angler capture and handling of this relatively sensitive species may lead to mortality for a small number of individuals and a reduction in fitness or spawning success for others. Grayling in all English rivers are subject to controls on angling activity. The primary legislation for the regulation of angling is the 'Salmon and Freshwater Fishery Act 1975'. Under this legislation the Environment Agency has powers to licence recreational angling. Fishery byelaws regulate when, where and how angling can take place. The licencing approach records the number of licenced individuals and regulates the gear and effort used. As part of this managed exploitation, pressure on the population can be controlled and data can be collected on grayling stocks. The taking of grayling from English waters is specifically cited within the regulations and there is a limit of 2 grayling (30cm to 38cm) imposed. In addition to the Salmon and Freshwater Fishery Act, the stocking of fish to freshwaters is regulated by 'The Keeping and Introduction of Fish (England and River Esk Catchment Area) Regulations 2015'. No recording unit available due to a combination of catch and release and fish taken with no national requirement for catch returns to be submitted.

Species name: Thymallus thymallus (1109) Region code: ATL

Field label	Note

5.11 Change and reason for change in surface area of range	Data contained within the Environment Agency Fish Population Database has been used to produce distribution maps for grayling. Adult and juvenile grayling are captured during routine electric fishing surveys, therefore, recording effort across England is relatively high. The grayling has a tendency to be more active during daylight hours and to rest in deeper water during darkness, therefore, capture efficiency may be increased compared with some other fish species. However, they may be under recorded due to the difficulty of surveying grayling habitats with electric fishing gear caused by strong flows and abundant submerged macrophytes. In addition, grayling are a relatively sensitive fish and high mortality rates can occur if electric fishing is carried out during spawning periods or fish are held in the electric field or close to the anode for too long. Therefore, there may be a tendency to avoid targeting grayling to avoid injury to the fish. The grayling is a widespread species in England. It is thought that the species reached Britain via the North Sea River, prior to isolation from continental Europe after the last glacial period. Native grayling populations are thought to be restricted to the Rivers Ouse, Trent, Hampshire Avon and possibly the rivers Severn, Wye, Thames, Ribble and Welsh Dee and their tributaries. However, graying range has been artificially increased due to stocking for recreational angling purposes for approximately 200 years. Enhancement stocking has also been undertaken wihin their native range as a perceived conservation measure to boost dwindling natural stocks. The effect of such extensive stocking has made the natural distribution of grayling unclear. Recent genetic studies of grayling indicate further differentiation of grayling populations can be made within England as there appear to be distinct genetic differences between rivers / physically isolated populations. These differences have led to calls for individual river stocks to be managed as discrete management units to avoid a loss of gentic specificity within the management unit. Due the lack of clarity on the historic distribution grayling and the large period of time over which introductions have been made, records related to artificial expansions of range due to stocking have been included in the distribution map.
5.12 Additional information	Data contained within the Environment Agency Fish Population Database has been used to produce distribution maps for grayling. Adult and juvenile grayling are captured during routine electric fishing surveys, therefore, recording effort across England is relatively high. The grayling has a tendency to be more active during daylight hours and to rest in deeper water during darkness, therefore, capture efficiency may be increased compared with some other fish species. However, they may be under recorded due to the difficulty of surveying grayling habitats with electric fishing gear caused by strong flows and abundant submerged macrophytes. In addition, grayling are a relatively sensitive fish and high mortality rates can occur if electric fishing is carried out during spawning periods or fish are held in the electric field or close to the anode for too long. Therefore, there may be a tendency to avoid targeting grayling to avoid injury to the fish.
6.6 Population size; Method used	A detailed methodology used for population assessment at the 1 km2 resolution and the associated interpolation approach can be found in the Interagency Freshwater Group paper, 'Procedure for estimating population using 1km square resolution records data' (Hatton-Ellis 2018).
6.8 Short term trend; Direction	Records for grayling are common throughout the short term trend period, however, survey effort is not consistent across the species range. In addition, specific surveys may underestimate grayling numbers due to the difficulties of carrying out detailed surveys within typical grayling habitat. It is therefore impossible to accurately assess a trend direction. The species is regularly recorded across what is thought to be its natural range and water quality of many English rivers has improved in recent years improving the probability of both adult and juvenile survival. It is therefore likely that the population is at least stable.

6.12 Long term trend; Direction	Due to varying levels of survey effort throughout the English grayling range it is not possible to accurately assess population trends for this period. However, as the species has been consistantly recorded across its natural range the species is considered to be at least stable. Water quality in many English rivers has improved markedly over the period which may in turn benefit adult and juvenile survival. This may have led to an increasing trend in the population over this period, however, this may have been counteracted by the rapid expansion of the invasive, non-native signal crayfish population which has the potential to impact on rheophilous fish species. In addition, fine sediments resulting from poor agricultural practices have continued to be deposited on spawning gravels in many typical grayling rivers reducing successful recruitment.
6.16 Change and reason for change in population size	A detailed methodology used for population assessment at the 1 km2 resolution and the associated interpolation approach can be found in the Interagency Freshwater Group paper, Procedure for estimating population using 1km square resolution records data.
7.1 Sufficiency of area and quality of occupied habitat	Access restrictions to historical river habitat due to poor water quality is thought to have been responsible for the exclusion of grayling from some areas of English rivers within their natural range. The extent to which poor water quality has effected grayling populations and continues to do so is uncertain, however, the excessive deposition of fine sediments on gravels used for egg deposition may reduce recruitment success. In addition, macrophytes may be lost from water courses due to pollution. A lack of submerged macrophytes will reduce cover for adults during daylight foraging. Grayling are associated with rivers of moderate to high gradient, and diverse flow types. This type of environment has been greatly altered by man made channel modifications, often for flood risk management and agricultural purposes. Channel reprofiling and riparian management has resulted in a degraded grayling habitat due to removal of features such as gravel shoals and overhanging vegetation. These habitats may be used for refuge and/or feeding and their loss may reduce the probability of a grayling successfully completing its lifecycle. Habitat connectivity is important for grayling. Where suitable optimal habitat exists, grayling may remain within a very small home range. However, where suitable spawning habitat is not present in a section of river grayling may undergo large scale movements within a river system to find suitable spawning gravels. Upstream movements by grayling may be blocked by man-made barriers such as weirs. It has been demonstrated that grayling can often successfully pass moderatley sized obstructions. Larger barriers may have fish passes added to improve their passibility by some fish species, however, while grayling have been recoreded as successfully navigating technical fish passes intended for trout and salmon, the passage efficiency for grayling is reduced and movements within the river will be impeded when compared with a natural river channel. In addition, the large expenditure on technical pass construction may delay the ultimate removal of the barrier from the channel. Additional stocking of other rheophylic species such as trout at high biomasses for recreational angling purposes may increase interspecific competition. In addition, the supplimentary stocking of grayling to boost stocks in a riverine environment is unlikly to be effective due to stocked fish rapidly moving to new areas or being outcompeted by native fish. Genetic studies have also highlighted the risks associated with stocking fish into a genetically distinct population and the possibility of weakening the vigour of the population as a whole. Invasive non-native crayfish species such as signal crayfish Pacifastacus leniusculus also have the potential to increase predation pressure on grayling eggs. Invasive non-native crayfish may be more aggressive and achieve greater biomasses than the indigenous white clawed crayfish Austropotamobious pallipes which may have co-existed with grayling in rivers across England. The invasion of habitats by INNS crayfish and the displacement of indigenous crayfish species may therefore have led to an increase in interspecific competition with between crayfish and grayling.

7.4 Short term trend; Direction	Sporadic survey effort and the widespread distribution of grayling within England, make a detailed assessment of habitat quality trends impossible at the present time. However, progress has been made with reducing nutrient and organic pollution levels in many rivers across England within the short-term trend period, which may have a beneficial effect on the quality of spawning substrates. Water quality improvements in a number of rivers are also likely to facilitate passage to spawning grounds. However, issues of siltation of spawning gravels, physical barriers to movement and physical habitat degradation are still significant stressors for grayling populations within England. In addition, the increased focus on run of river hydropower schemes may result in man-made barriers to grayling movements being perpetuated for the foreseeable future as technical fish passage solutions may still represent a significant obstacle to grayling passage. When taking into account the marked improvement in water quality in many English rivers which may in turn benefit adult and juvenile grayling survival, it would be reasonable to expect an increasing trend in the available habitat and habitat quality within the native range of grayling over this period. However, this may be off-set by the continued expansion of INNS crayfish range and new hydropower infrastructure.

8.1 Characterisation of pressures/ threats	Pressures: K05 - Physical modification of river channels may remove habitat heterogeneity and the mosaic of habitats utilised by grayling. Although grayling will occupy a small home range if optimal habitats are present, if suitable spawning gravels are not present they will undertake large scale movements to source them. Upstream migrations by grayling may be blocked by man-made in-stream barriers such as weirs. These barriers may also act synergistically with water quality problems such as increased sediment and nutrient load. Impoundments behind structures may lead to increased deposition of fine sediment on gravel substrates and dissolved oxygen sags due to a lack of turbulent flow. In some areas fish passes have been added to barrier structures. While grayling are often capable of navigating the turbulent flows intended for the passage of trout and salmon, these passes are often inefficient for passage of grayling. K04 - Grayling require a habitat mosaic of gravels, macrophytes, riparian cover and flow types for refuge, foraging and egg deposition. Changes to the hydrological regime may increase deposition rates of fine sediment on gravels, increase the resistance of structures to passage by grayling and lead to stranding of fish or desiccation of eggs during low flows. In addition river engineering works may increase spate flow velocities within the catchment which may result in juvenile grayling being washed out of areas of favourable habitat within the river system. If low flows are maintained over long periods of time, elevated water temperatures, deoxygenation, siltation and bed armouring may become evident. Conversely very high flows may scour gravel substrates used for egg deposition. J01 - Grayling are intolerant of poor water quality and often succumb to pollution events before most other English fish species. Diffuse agricultural pollution has increased the input of fine sediment, phosphate and nitrate to rivers leading to eutrophication issues such as increased algal production and changes in the macrophyte community. Urbanization and industrialization have resulted in discharges of both raw and treated sewage effluent, industrial effluents and diffuse urban pollution. These discharges may prove acutely toxic to grayling or produce lethal effects due to deoxygenation. A wide variety of other chemicals, including pesticides and endocrine disrupters, have been released into the aquatic environment. Pollutants may result in obvious lethal effects, however, a wide variety of sub-lethal effects, such as reduced fertility may affect the overall fitness of grayling. Due to the diverse array of sources and impacts, the severity and contribution of each individual stressor on the population as a whole is unknown. N09 - Increases in temperature may produce synergistic effects with other environmental stresses such as increased toxicity of pollutants and more rapid deoxygenation. Low flows may reduce the ability of grayling to pass barriers and reach new habitat. High spate flows may lead to juvenile fish and eggs being washed out of areas of suitable habitat. I01 - Invasive non-native crayfish species such as signal crayfish Pacifastacus leniusculus have the potential to increase predation pressure on grayling eggs. Invasive non-native crayfish may be more aggressive and achieve greater biomasses than the indigenous white clawed crayfish Austropotamobious pallipes which may have co-existed with grayling in many areas across its English range. The invasion of habitats by INNS crayfish and the displacement of indigenous crayfish species may therefore have led to an increase in interspecific competition with between crayfish and grayling. G06/G08 - Grayling have been both translocated and artificially reared for release into the wild within and outside of their presumed native range within England. The reasons for these releases include conservation, augmentation, compensation, re-establishment and increased angler catch. This may increase competition between released and wild fish, leading to a displacement of wild fish. Hatchery reared fish demonstrate poorer survival rates but may have a substantial impact if released in large numbers. If releases are based on local populations, the genetic impacts relate to inbreeding and domestication in the artificially propagated stock. If releases are based on non-native fish, in addition to loss of variability in the hatchery, local adaptations may be lost and erosion of the genetic structure of the species may result. Conversely, in some waters fished for trout and salmon, grayling have been actively removed from the area due to a perceived risk of

competition with the target trout or salmon quarry. In recent years, this behaviour has become much less acceptable to many anglers and grayling have increased in prominence as a quarry species in their own right. Grayling may be subject to both catch and release and taken as a food fish in England. When catch and release angling is implemented, capture by rod and line methods will still impart stress on the fish and may result in mortality or reduced spawning success. This pressure is more acute in grayling populations when compared with many other freshwater fish species as they are relatively intolerant of capture stress and handling damage. D02 - Hydro-electric schemes may form major obstructions as grayling populations are denied passage over spillways, through turbines and impoundments. Impounding structures may disrupt sediment movement down river, deepen and stabilise water levels, reduce hydraulic scour and increase siltation behind the structure. They may restrict the free movement of grayling up and down the river. Designs may require the abstraction of water out of the channel through an off-line turbine, leaving a depleted reach. Other designs divert water within the channel through the turbine which may create current velocities that attract grayling. Bank reinforcements affect riparian habitats, whilst turbine arrangements without suitable screening can entrain grayling, generating injuries and mortalities. Turbine offtakes may attract grayling resulting in delays to spawning migration and increased predation. I04 - Piscivorous birds such as cormorant and goosander are a natural part of the freshwater environment, however, large numbers of such birds on a small stretch of river may influence grayling behaviour, leading to migratory movements away from the stretch. This may result in grayling being moved from optimal to sub-optimal habitat. If the large numbers of birds are as a result of birds being moved on from adjacent waters used for recreational angling these practices may impact on the success of wild grayling populations. Threats: K05 - Continued channel modification may remove refuges such as gravel substrates and riparian vegetation. This may also remove the diversity of flow types, such as riffles, pools and low energy margins, utilised by grayling. Although new barriers are unlikely to be built within river systems used by grayling, the modification of existing structures by the addition of fish passes which are inefficient for grayling, may hinder the removal / decommissioning of these structures. This will allow their impacts on geomorphological process and associated impacts on grayling to be perpetuated K04 - increased pressure on water supplies for drinking water and agricultural irrigation may lead to increased abstraction and lower flows within the channel. Increased reliance on large scale water transfer schemes may increase genetic mixing of previously isolated grayling stocks. Increased channel engineering and flow modification for flood risk management may continue to degrade the complex habitat mosaic required for grayling to complete their lifecycle. J01 - while great improvements have been made in water quality across England, particularly relating to point source inputs of gross organic pollution, diffuse rural sources of nutrients and sediment emanating from agricultural land use are likely to continue to be a stress on the aquatic environment. N09 - The potential for climate change to impact on future grayling populations is poorly understood. However, future climate change scenarios indicate a shift to a pattern of increasingly extreme events such as more prolonged low flows and higher, more energetic spate flows. This is likely to add further stress on grayling populations. However, grayling are relatively tolerant of higher water temperatures and may allow both the colonisation of new areas and a competitive advantage with other salmonid species which currently occupy similar niches in the freshwater environment. I01 - Signal crayfish, together with other INNS crayfish species, continue to increase their range and populations in many English river catchments. There are no effective control measures for INNS crayfish and their range is expected to continue to expand in river networks for the foreseeable future. G06/G08 - Competitive pressure from fish species stocked above their natural carrying capacity is likely to remain at current levels due to pressure from recreational angling interests for high stock densities. However, as the genetic impacts of enhancement stocking become better understood, there is a

	developing resistance to stocking for conservation purposes. Together with a growth in interest in angling for 'wild' fish, with a wide variety of literature made available to anglers by NGO's such as the Wild Trout Trust, there may be a decline in grayling stocking in future years. In addition, the removal of grayling from river reaches due to their perceived competitive pressure on trout and salmon exploited for recreational angling purposes is becoming increasingly unpopular with many anglers, river owners, NGO's and statutory agencies. This practice is expected to continue to decline. D02 - the potential for an expansion of hydropower development across England may lead to a continuation of barriers to grayling movements within a river system. While fish passage must be considered by these developments, pass designs may continue to be targeted at trout and salmon and inefficient for grayling. I04 - Piscivorous birds such as cormorant and goosander are most efficient at feeding in waterbodies with poor habitat structure, often due to river engineering. As the river restoration process continues across the freshwater network, the foraging efficiency of piscivorous birds will be reduced and their impact on both fish numbers and fish behaviour will reduce in parallel. This may be set against increased bird scaring activities from an increased number of commercial fisheries which seek to move birds away from their heavily stocked artificial water bodies containing little or no habitat structure to impede fish predation.
10.2 Additional information	As improvements continue to be made regarding water quality and the re-establishment of natural riverine processes in England the area of freshwater habitat suitable for grayling may be expected to increase. The recent increased understanding of genetic differentiation between grayling stocks has led to changes in stocking policy and more enlightened angling practices have reduced direct pressure on grayling populations. Set in opposition to this generally positive outlook are the unknowns of climate change effects which may lead to more extreme flow variations, the potential for continued diffuse agricultural pollution resulting in inputs of nutrients and fine sediment, the increase and expansion of non-native crayfish populations and the possibility of increases in energy production infrastructure associated with run of river hydropower.