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:

S1095 - Sea lamprey (*Petromyzon marinus*)

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	**1095**
1.3 Species scientific name	**Petromyzon marinus**
1.4 Alternative species scientific name	
1.5 Common name (in national language)	Sea lamprey

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?	No	
3.2 Which of the measures in Art. 14 have been taken?	a) regulations regarding access to property	No
	b) temporary or local prohibition of the taking of specimens in the wild and exploitation	No
	c) regulation of the periods and/or methods of taking specimens	No
	d) application of hunting and fishing rules which take account of the conservation of such populations	No
	e) establishment of a system of licences for taking specimens or of quotas	No
	f) regulation of the purchase, sale, offering for sale, keeping for sale or transport for sale of specimens	No
	g) breeding in captivity of animal species as well as artificial propagation of plant species	No
	h) other measures	No

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	No	No	No	No	No	No

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

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Guan, R-Z. & Wiles, P.R. 1996. Ecological Impact of Introduced Crayfish on Benthic Fishes in a British Lowland River. Conservation Biology, 11
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Wheeldon, J. 2012. River Restoration Planning and implementation on River Sites of Special Scientific Interest in England. Internal Natural England paper.

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	
5.11 Change and reason for change in surface area of range	No change The change is mainly due to:	
5.12 Additional information	Data contained within the Environment Agency Fish Population Database has been used to produce distribution maps for river lamprey. This data has been collated from both routine and ad-hoc Environment Agency fish surveys. Sea lamprey distribution is likely to be under-represented in England. Routine fish survey techniques have a low probability of capturing sea lamprey individuals due to their preference for habitat not readily assessed by electric fishing. In addition, lamprey ammocoetes are unlikely to be speciated due to difficulties with identification. These factors lead to a patchy recording of distribution across English rivers.	

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	9
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	Records for sea lamprey are sporadic throughout the short term trend period and survey effort is not consistant across the species range. It is therefore impossible to accurately assess a trend direction. The species is still being recorded across what is thought to be its natural range and there has been no significant increase in pressures, which suggests that the population is at least stable. The likelihood of an improving trend seems low because many of the artificial physical barriers to upstream migration that have blocked passage to historical spawning grounds are still in place. Where fish passes have been added, thery are generally unsuitable for sea lamprey. However, the water quality of a number of English estuaries and rivers has improved in recent years, and this may have removed chemical barriers for migrating adults and improved ammocoete survival. Due to varying levels of survey effort throughout the sea lamprey range, compunded by evidence of large between year fluctuations in the numbers of migrating sea lamprey, it is not possible to accurately assess population trends for this period. However, as the species has been consistantly recorded across much of its natural range and many of the barriers to sea lamprey migration have not changed significantly, the species is considered to be at least stable. In addition, both esturine and river water quality have improved markedly over the period in many areas which may benefit both adult and ammocoete survival.

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)?	No
	b) Is there a sufficiently large area of occupied AND unoccupied habitat of suitable quality (to maintain the species at FCS)?	No
7.2 Sufficiency of area and quality of occupied habitat Method used	Based mainly on expert opinion with very limited data	
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 expert opinion with very limited data	
7.6 Long-term trend Period		
7.7 Long-term trend Direction		
7.8 Long-term trend Method used		
7.9 Additional information	Sea lamprey populations are reduced across England when compared with their natural/unimpacted reference condition. This decline is generally attributed to a reduction in habitat quality due to poor water quality which are still on-going and the historical introduction of physical barriers which stop sea lamprey	

reaching their spawning grounds and which are only now starting to be addressed.
Access restrictions (due to physical barriers) to historical river habitat combined with poor water quality is thought to have been responsible for the low numbers of sea lamprey within English rivers. It is likely that there would be an interaction between polluting inputs to the river/estuary and the presence of barriers, such as weirs, which may have compounded the impacts of individual stressors on the species. An example of this would be impoundments behind in-channel structures leading to increased deposition of fine sediment. This reduces the mosaic of habitats which characterise a naturally functioning riverine environment and provide the range of microhabitats utilised by lamprey at different stages of their lifecycle. The extent to which poor water quality has effected sea lamprey populations is uncertain, however, excessive fine sediment may smother spawning gravels and nutrient enrichment may stimulate increased algal growth in these areas. Sea lamprey bury their eggs in redds within the gravel, therefore, the eggs are suceptable to deoygenation effects related to gravel clogging. It is likely that the effects of water quality and physical habitat degredation are highly variable across the range of sea lamprey. The current barriers to migration are likely to limit access to some areas of habitat which would be of suitable quality to maintain a viable lamprey population, however, without further improvements in both water quality and habitat quality, there is unlikley to be a sufficient area of currently unoccupied high quality habitat to maintain the species at FCS.

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)	H
Mixed source pollution to surface and ground waters (limnic and terrestrial) (J01)	H
Mixed source marine water pollution (marine and coastal) (J02)	M
Invasive alien species of Union concern (I01)	M
Hydropower (dams, weirs, run-off-the-river), including infrastructure (D02)	M
Abstraction of surface and ground water for energy production (excluding hydropower) (D13)	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
Mixed source marine water pollution (marine and coastal) (J02)	M
Invasive alien species of Union concern (I01)	M
Other climate related changes in abiotic conditions (N09)	M

Hydropower (dams, weirs, run-off-the-river), including infrastructure (D02)	H
Abstraction of surface and ground water for energy production (excluding hydropower) (D13)	M
Wind, wave and tidal power, including infrastructure (D01)	H

8.2 Sources of information

8.3 Additional information

K05 - Physical barriers which prevent sea lamprey reaching their spawning grounds have been a pressure on many populations throughout their range. 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 gravels and dissolved oxygen sags due to a lack of turbulent flow. In some areas fish passes have been added to barrier structures, however, these tend to be focused on increasing turbulent flows for the passage of salmonid species and are not suited to the passage of sea lamprey which generally require lower flow velocities.
K05 - Although new barriers are unlikely to be built within river systems used by sea lamprey, the modification of existing structures by the addition of fish passes to facilitate the passage of fish (typically highly unsuitable for lamprey species), may hinder the removal / decommissioning of these structures. Such investment will allow the impact of these structures to be perpetuated
K04 - Sea lamprey require clean, well oxygenated gravels for spawning and silt substrates for ammocoetes. Changes to the hydrological regime may increase deposition rates of fine sediment on gravels, increase the resistance of structures to passage by sea lamprey and lead to stranding of ammocoetes during low flows. In addition river engineering works may increase spate flows within the catchment which may result in both adult and juvenile sea lamprey 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 spawning beds and deposited eggs or silt substrates for ammocoetes.
K04 - increased pressure on water supplies for drinking water and agricultural irrigation may lead to increased abstraction and lower flows within the channel. Increased channel engineering and flow modification for flood risk management may continue to degrade the complex habitat mosaic required for sea lamprey to complete their lifecycle.
J01/J02 - Diffuse agricultural pollution has increased the input of fine sediment, phosphate and nitrate to rivers leading to eutrophication issues such as increased algal production in spawning areas and smothering of spawning gravels. Urbanization and industrialization have resulted in discharges of both raw and treated sewage, industrial effluents and diffuse urban pollution. These discharges may prove acutely toxic to sea lamprey or produce lethal effects due to deoxygenation of the water column. A wide variety of other chemicals, including pesticides and endocrine disrupters, have been released into the aquatic environment. These may result in obvious lethal effects, however, a wide variety of sub-lethal effects, such as reduced fertility may affect the overall fitness of sea lamprey. 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. Although little is known about the marine phase of the sea lamprey lifecycle they may spend an

extended period in estuarine areas prior to commencing their spawning migration. They are therefore susceptible to water quality problems such as low dissolved oxygen in estuaries. Evidence has indicated that the regular dissolved oxygen sag in the Humber estuary may influence the timing of sea lamprey migration into rivers within the catchment. If the DO sag persists for an extended period, migration may be delayed and subsequent spawning success reduced.
See cell above
I01 - Invasive non-native crayfish species such as signal crayfish Pacifastacus leniusculus have the potential to increase predation pressure on both lamprey and their eggs. Invasive non-native crayfish may be more aggressive, more tolerant of poor water quality, better adapted to silty substrates and achieve greater biomasses than the indigenous white clawed crayfish Austropotamobious pallipes which may have co-existed with lamprey 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 lamprey.
I01 - Signal crayfish, together with other INNS crayfish species, continue to increase their range and populations in many English river and lake catchments. There are no effective control measures for INNS crayfish and their range is expected to continue to expand in river and lake networks for the foreseeable future.
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 sea lamprey to pass barriers and high spate flows may lead to adults, ammocoetes and eggs being washed out of areas of suitable habitat.
N09 - The potential for climate change to impact on future sea lamprey 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 to sea lamprey populations by making migratory barriers harder to pass and the ability to utilise high quality in-river habitats more difficult.
D02 - Hydro-electric schemes may form major obstructions as sea lamprey 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 sea lamprey 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 migrating lamprey. Bank reinforcements affect riparian habitats, whilst turbine arrangements without suitable screening can entrain lamprey, generating injuries and mortalities. Turbine offtakes may attract migrating lamprey resulting in delays to migration and increased predation.
D02 - the potential for an expansion of hydropower development across England may lead to a continuation of barriers to sea lamprey migration. While fish passage must be considered by these developments, pass designs may continue to be targeted at salmonid species and unsuitable for sea lamprey.
D13 - Sea lamprey migrate through a number of English estuaries, such as the

Humber, and will pass a variety of power station abstraction points while migrating to their riverine spawning grounds. Effects on sea lamprey at these sites may include direct entrainment in cooling water abstractions or dissolved oxygen fluctuations due to the discharge of artificially warm water from the site.
D13 - Plans have been made for the development of new power stations in England, such as Hinkley Point. This has the potential to modify coastal sea lamprey habitat and entrain fish in cooling water intakes.
D01 - N/A there are no tidal barrages in place affecting English sea lamprey populations at the present time.
D01 - Plans are being developed for a potential tidal barrage / lagoons within the Severn Estuary. This has the potential to affect sea lamprey populations in the estuary and associated river catchments.

9. Conservation measures

9.1 Status of measures	a) Are measures needed?	Yes
	b) Indicate the status of measures	Measures identified and taken
9.2 Main purpose of the measures taken	Expand the current range of the species (related to 'Range')	
9.3 Location of the measures taken	Both inside and outside Natura 2000	
9.4 Response to the measures	Medium-term results (within the next two reporting periods, 2019-2030)	

9.5 List of main conservation measures

Reduce impact of mixed source pollution (CJ01)
Reduce impact of multi-purpose hydrological changes (CJ02)
Restore habitats impacted by multi-purpose hydrological changes (CJ03)
Management of professional/commercial fishing (including shellfish and seaweed harvesting) (CG01)
Management of hunting, recreational fishing and recreational or commercial harvesting or collection of plants (CG02)
Adopt climate change mitigation measures (CN01)
Reduce impact of hydropower operation and infrastructure (CC04)
Adapt/manage renewable energy installation, facilities and operation (CC03)
Adapt/manage exploitation of energy resources (CC02)

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	Assumes no major development of estuarine barrages or lagoons in the foreseeable future As improvements continue to be made regarding water quality and re-establishment of natural riverine processes in England and plans are developed

and implemented to improve fish passage for sea lamprey in estuaries and rivers around England, the area of freshwater habitat suitable for lamprey spawning and ammocoete development may be expected to increase. 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 and the possibility of increases in energy production infrastructure associated with run of river hydropower, tidal barrages, lagoons and nuclear power. It is perhaps this final threat that, if implemented, may present the most serious long-term threat to the continuation of sea lamprey populations in English coastal, estuarine and freshwater habitats.

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

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	number of map 1x1 km grid cells (grids1x1)
	b) Minimum	
	c) Maximum	
	d) Best single value	0
12.2 Type of estimate	Minimum	
12.3 Population size inside the network Method used	Based mainly on expert opinion with very limited data	
12.4 Short-term trend of population size within the network Direction	Stable (0)	
12.5 Short-term trend of population size within the network Method used	Based mainly on expert opinion with very limited data	

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

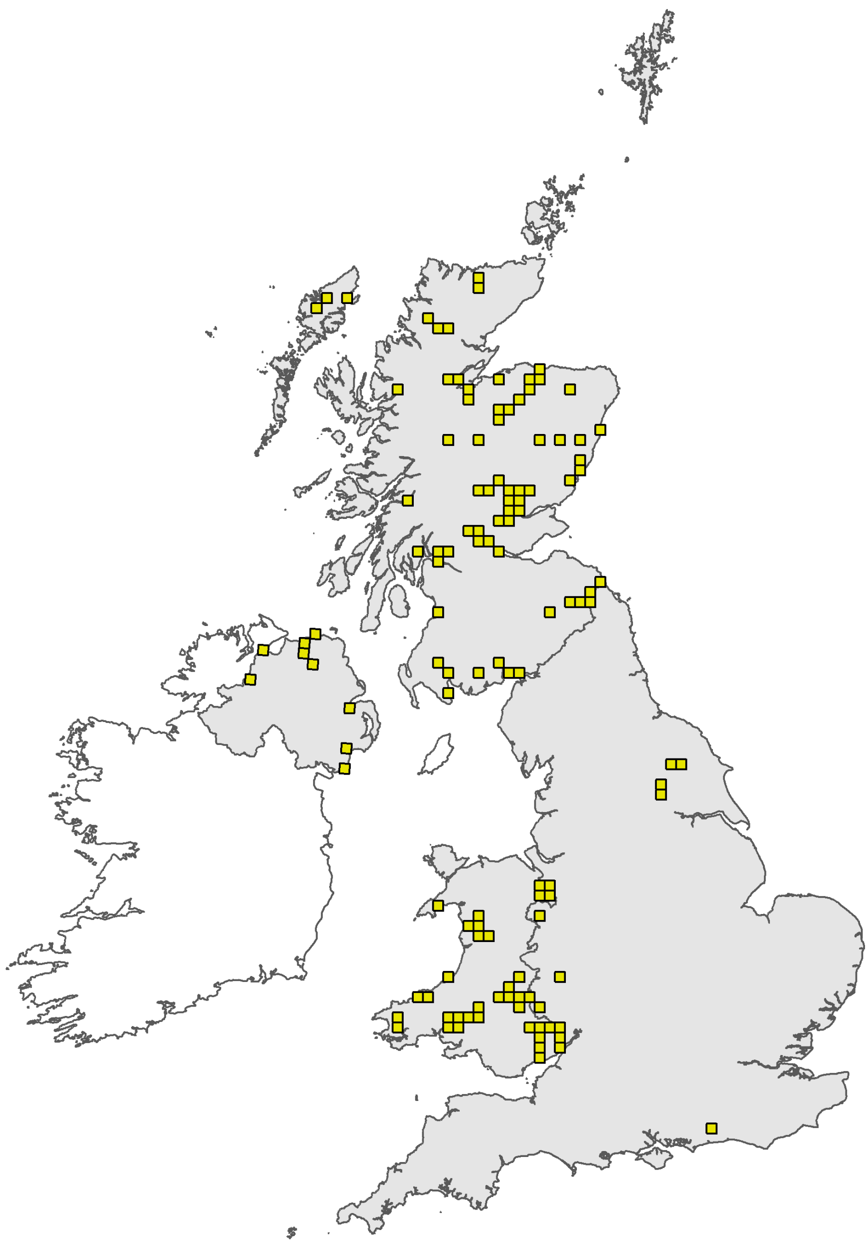

Figure 1: UK distribution map for S1095 - Sea lamprey (*Petromyzon marinus*). Coastline boundary derived from the Oil and Gas Authority's OGA and Lloyd's Register SNS Regional Geological Maps (Open Source). Open Government Licence v3 (OGL). Contains data © 2017 Oil and Gas Authority.

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

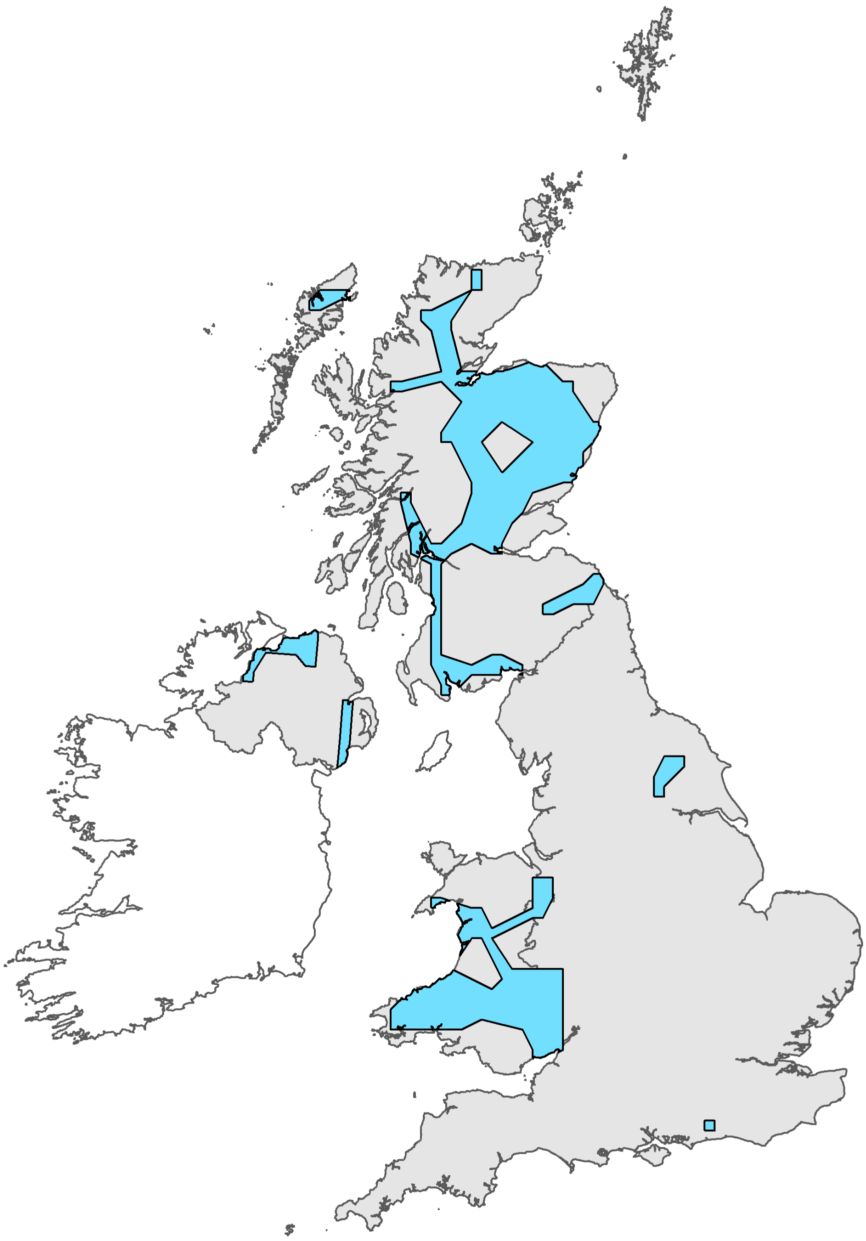

Figure 2: UK range map for S1095 - Sea lamprey (*Petromyzon marinus*). Coastline boundary derived from the Oil and Gas Authority's OGA and Lloyd's Register SNS Regional Geological Maps (Open Source). Open Government Licence v3 (OGL). Contains data © 2017 Oil and Gas Authority.

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: Petromyzon marinus (1095)

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 sea lamprey. This data has been collated from both routine and ad-hoc Environment Agency fish surveys. Sea lamprey distribution is likely to be under-represented in England as lamprey ammocoetes are often not speciated due to difficulties with identification. Only P. marinus records have been used in the distribution map provided as they are assumed to be associated with correctly identified adult individuals.

Species name: Petromyzon marinus (1095) 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 river lamprey. This data has been collated from both routine and ad-hoc Environment Agency fish surveys. Sea lamprey distribution is likely to be under-represented in England. Routine fish survey techniques have a low probability of capturing sea lamprey individuals due to their preference for habitat not readily assessed by electric fishing. In addition, lamprey ammocoetes are unlikely to be speciated due to difficulties with identification. These factors lead to a patchy recording of distribution across English rivers.
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.
6.8 Short term trend; Direction	Records for sea lamprey are sporadic throughout the short term trend period and survey effort is not consistant across the species range. It is therefore impossible to accurately assess a trend direction. The species is still being recorded across what is thought to be its natural range and there has been no significant increase in pressures, which suggests that the population is at least stable. The likelihood of an improving trend seems low because many of the artificial physical barriers to upstream migration that have blocked passage to historical spawning grounds are still in place. Where fish passes have been added, thery are generally unsuitable for sea lamprey. However, the water quality of a number of English estuaries and rivers has improved in recent years, and this may have removed chemical barriers for migrating adults and improved ammocoete survival.
6.12 Long term trend; Direction	Due to varying levels of survey effort throughout the sea lamprey range, compunded by evidence of large between year fluctuations in the numbers of migrating sea lamprey, it is not possible to accurately assess population trends for this period. However, as the species has been consistantly recorded across much of its natural range and many of the barriers to sea lamprey migration have not changed significantly, the species is considered to be at least stable. In addition, both esturine and river water quality have improved markedly over the period in many areas which may benefit both adult and ammocoete survival.
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	Sea lamprey populations are reduced across England when compared with their natural/unimpacted reference condition. This decline is generally attributed to a reduction in habitat quality due to poor water quality which are still on-going and the historical introduction of physical barriers which stop sea lamprey reaching their spawning grounds and which are only now starting to be addressed. Access restrictions (due to physical barriers) to historical river habitat combined with poor water quality is thought to have been responsible for the low numbers of sea lamprey within English rivers. It is likely that there would be an interaction between polluting inputs to the river/estuary and the presence of barriers, such as weirs, which may have compounded the impacts of individual stressors on the species. An example of this would be impoundments behind in-channel structures leading to increased deposition of fine sediment. This reduces the mosaic of habitats which characterise a naturally functioning riverine environment and provide the range of microhabitats utilised by lamprey at different stages of their lifecycle. The extent to which poor water quality has effected sea lamprey populations is uncertain, however, excessive fine sediment may smother spawning gravels and nutrient enrichment may stimulate increased algal growth in these areas. Sea lamprey bury their eggs in redds within the gravel, therefore, the eggs are suceptable to deoygenation effects related to gravel clogging. It is likely that the effects of water quality and physical habitat degredation are highly variable across the range of sea lamprey. The current barriers to migration are likely to limit access to some areas of habitat which would be of suitable quality to maintain a viable lamprey population, however, without further improvements in both water quality and habitat quality, there is unlikley to be a sufficient area of currently unoccupied high quality habitat to maintain the species at FCS.
7.4 Short term trend; Direction	Sea lamprey have complex habitat requirements as their eggs are laid in well oxygenated gravels, the ammocoetes require soft sediments and migratory passage, with relatively low flow velocities and turbulence, must be maintained for adults. In addition, the habitat required during the marine phase of their lifecycle is poorly understood. These factors, combined with sporadic survey effort and the widespread distribution of sea lamprey 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 and ammocoete substrates. Water quality improvements in a number of rivers and estuaries are also likely to facilitate passage to spawning grounds. However, issues of siltation of spawning gravels, physical barriers to migration and physical habitat degradation are still significant stressors for sea lamprey populations within England. In addition, the increased focus on run of river hydropower schemes may result in man-made barriers to lamprey migration being perpetuated for the foreseeable future as technical fish passage solutions are often biased towards salmonid species and may still represent a total barrier to lamprey passage.

8.1 Characterisation of pressures/ threats	Pressures: K05 - Physical barriers which prevent sea lamprey reaching their spawning grounds have been a pressure on many populations throughout their range. 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 gravels and dissolved oxygen sags due to a lack of turbulent flow. In some areas fish passes have been added to barrier structures, however, these tend to be focused on increasing turbulent flows for the passage of salmonid species and are not suited to the passage of sea lamprey which generally require lower flow velocities. K04 - Sea lamprey require clean, well oxygenated gravels for spawning and silt substrates for ammocoetes. Changes to the hydrological regime may increase deposition rates of fine sediment on gravels, increase the resistance of structures to passage by sea lamprey and lead to stranding of ammocoetes during low flows. In addition river engineering works may increase spate flows within the catchment which may result in both adult and juvenile sea lamprey 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 spawning beds and deposited eggs or silt substrates for ammocoetes. J01/J02 - Diffuse agricultural pollution has increased the input of fine sediment, phosphate and nitrate to rivers leading to eutrophication issues such as increased algal production in spawning areas and smothering of spawning gravels. Urbanization and industrialization have resulted in discharges of both raw and treated sewage, industrial effluents and diffuse urban pollution. These discharges may prove acutely toxic to sea lamprey or produce lethal effects due to deoxygenation of the water column. A wide variety of other chemicals, including pesticides and endocrine disrupters, have been released into the aquatic environment. These may result in obvious lethal effects, however, a wide variety of sub-lethal effects, such as reduced fertility may affect the overall fitness of sea lamprey. 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. Although little is known about the marine phase of the sea lamprey lifecycle they may spend an extended period in estuarine areas prior to commencing their spawning migration. They are therefore susceptible to water quality problems such as low dissolved oxygen in estuaries. Evidence has indicated that the regular dissolved oxygen sag in the Humber estuary may influence the timing of sea lamprey migration into rivers within the catchment. If the DO sag persists for an extended period, migration may be delayed and subsequent spawning success reduced. I01 - Invasive non-native crayfish species such as signal crayfish Pacifastacus leniusculus have the potential to increase predation pressure on both lamprey and their eggs. Invasive non-native crayfish may be more aggressive, more tolerant of poor water quality, better adapted to silty substrates and achieve greater biomasses than the indigenous white clawed crayfish Austropotamobious pallipes which may have co-existed with lamprey 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 lamprey. 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 sea lamprey to pass barriers and high spate flows may lead to adults, ammocoetes and eggs being washed out of areas of suitable habitat. D02 - Hydro-electric schemes may form major obstructions as sea lamprey 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 sea lamprey 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 migrating lamprey. Bank reinforcements affect riparian habitats, whilst turbine arrangements without suitable screening can entrain lamprey, generating injuries and mortalities. Turbine offtakes may attract migrating lamprey resulting in delays to migration and increased predation. D13 - Sea lamprey migrate through a number of English estuaries, such as the Humber, and will pass a variety of power station abstraction points while migrating to their riverine spawning grounds. Effects on sea lamprey at these sites may include direct entrainment in cooling water abstractions or dissolved oxygen fluctuations due to the discharge of artificially warm water from the site. D01 - N/A there are no tidal barrages in place affecting English sea lamprey populations at the present time. Threats: K05 - Although new barriers are unlikely to be built within river systems used by sea lamprey, the modification of existing structures by the addition of fish passes to facilitate the passage of fish (typically highly unsuitable for lamprey species), may hinder the removal / decommissioning of these structures. Such investment will allow the impact of these structures 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 channel engineering and flow modification for flood risk management may continue to degrade the complex habitat mosaic required for sea lamprey to complete their lifecycle. J01/J02 - 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. I01 - Signal crayfish, together with other INNS crayfish species, continue to increase their range and populations in many English river and lake catchments. There are no effective control measures for INNS crayfish and their range is expected to continue to expand in river and lake networks for the foreseeable future. N09 - The potential for climate change to impact on future sea lamprey 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 to sea lamprey populations by making migratory barriers harder to pass and the ability to utilise high quality in-river habitats more difficult. D02 - the potential for an expansion of hydropower development across England may lead to a continuation of barriers to sea lamprey migration. While fish passage must be considered by these developments, pass designs may continue to be targeted at salmonid species and unsuitable for sea lamprey. D13 - Plans have been made for the development of new power stations in England, such as Hinkley Point. This has the potential to modify coastal sea lamprey habitat and entrain fish in cooling water intakes. D01 - Plans are being developed for a potential tidal barrage / lagoons within the Severn Estuary. This has the potential to affect sea lamprey populations in the estuary and associated river catchments.

9.5 List of main conservation measures	CJ01 - Work has continued to reduce discharges to both the Natura and wider river network. Major infrastructure projects to improve sewerage, such as removal or upgrade of combined sewer overflows and improved phosphorus removal from treated sewage effluent, has been funded via the water industry's programme of strategic improvements such as AMP and PR rounds. However, further investigations are needed into the application of new best available technology for phosphorus removal and the increased availability of mains sewerage for rural populations. The England Catchment Sensitive Farming Initiative is continuing to promote a range of best agricultural practices to reduce pollution loads to priority aquatic sites. A combination of Natura 2000, SSSI and Water Framework objectives continues to drive improvements in water quality with diffuse water pollution prevention plans developed for many sites. CJ02/CJ03 - Abstraction management - Improvements have been achieved with limiting abstraction volumes and improving flow regimes by altering compensation flows from water company assets via AMP and PR rounds. However, further improvements are required to naturalise flows at many sites. As part of the on-going abstraction reform process, abstraction licences will become environmental permits and a greater emphasis will be given to environmental considerations. By 2022 all previously exempt abstractions will be permitted. CJ02/CJ03 - Physical habitat restoration - A major programme of physical restoration has been implemented on the designated river network, involving the development of a long-term strategic plan for each river and its programmed implementation. These plans address key issues such as dams and weirs, floodplain reconnection, channel modifications, lack of riparian habitat, lack of riparian trees and lack of woody debris in the channel. Outside of the designated site network, river restoration schemes have focused on addressing channel modifications and the many weirs and dams on the river network in England. A further driver for river restoration has been the increased prominence of natural flood management. If properly implemented, NFM has the potential to enable widespread improvements in many previously degraded riverine habitats. Specifically regarding sea lamprey, the 'Unlocking the Severn' project aims to significantly improve access to the R. Severn and tributaries by improving fish passage for non-salmonid species at a number of navigation weirs. CGO1/CG02 - Fisheries in all rivers are subject to exploitation controls. Sea lamprey are listed in Annexes II of the EC Habitats Directive. Annex II requires that Special Areas of Conservation are designated for sea lamprey and that Member States should ensure the appropriate management of these and other sites where they are known to occur so that the favourable conservation status of the species can be secured. Additional fishery specific issues are addressed by the 'Salmon and freshwater fisheries act 1975' and the Marine and Coastal Access Act. CC04 - In recent years the rapid increase in the installation of run-of-river hydropower schemes has led to concerns over their impacts on migratory fish such as sea lamprey. Research has been undertaken on the safety of various turbine designs but this has mainly focused on fish strike by turbine blades and their associated screening requirements. The effects of these installations on fish behaviour and the associated delays to migration, energy costs to fish and increased predation rates are less well understood. Many of the studies have assessed individual installations. While each individual installation may have a relatively low impact on fish, where multiple schemes have been planned on a river, their in-combination effects on sea lamprey have not been fully taken into account. In addition, fish passage mitigations at these installations take no account of the loss of geomorphological processes within the river and often lead to the barrier and its associated impoundment being perpetuated when opportunities for its complete removal and restoration of river processes may have been possible. In the case of strong swimming fish species such as salmon, the requirement for fish passage enhancements associated with these installations has led to increased connectivity between marine feeding grounds and riverine spawning habitat at some sites, however, sea lamprey may be excluded from passes with turbulent flows. It is therefore important to install fish passes which can be utilised by all species which would be

	considered representative of a location, including sea lamprey. CN01 - The rationale behind restoring river habitat in England is the restoration of natural riverine processes, which creates characteristic habitats and provides for individual species to an extent dependent on the natural character of the river. This rationale is also the main adaptation response for combatting climate change. Some aspects of restoring natural function are also seen as climate change mitigation measures, such as the re-establishment of natural tree cover and riparian vegetation which is being implemented as part of many river restoration schemes and agri-environment schemes. These interventions may result in moderated extremes of flow, reductions in water temperature and increased water quality. CC02/CC03 - Detailed assessments must be made of the potential risks to sea lamprey due to abstractions, discharges and potential barrier effects from new energy infrastructure. Any developments must be fully assessed and mitigation measures developed pre-construction phase. Continuous post construction monitoring must be undertaken and operational procedures modified if required. Tidal lagoon / barrage developments are in their infancy and detailed plans to protect sea lamprey will be required as part of the feasibility and development phase.
10.1 Future prospects of parameters	Assumes no major development of estuarine barrages or lagoons in the foreseeable future
10.2 Additional information	As improvements continue to be made regarding water quality and re-establishment of natural riverine processes in England and plans are developed and implemented to improve fish passage for sea lamprey in estuaries and rivers around England, the area of freshwater habitat suitable for lamprey spawning and ammocoete development may be expected to increase. 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 and the possibility of increases in energy production infrastructure associated with run of river hydropower, tidal barrages, lagoons and nuclear power. It is perhaps this final threat that, if implemented, may present the most serious long-term threat to the continuation of sea lamprey populations in English coastal, estuarine and freshwater habitats.