Definition of Favourable Conservation Status for European sturgeon, *Acipenser sturio* L. and Atlantic sturgeon, *Acipenser oxyrinchus* M.

Defining Favourable Conservation Status Project

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Executive summary

This document sets out Natural England's view on favourable conservation status for European sturgeon and Atlantic sturgeon in England.

Favourable conservation status is the minimum threshold at which we can be confident that the two species are thriving in England and are expected to continue to thrive sustainably in the future.

This definition has been produced following the Natural England approach to defining favourable conservation status described in the guidance document Defining Favourable Conservation Status in England.

Section 1 of this document describes the species covered by this definition and their ecosystem context.

Section 2 specifies the units used to describe the three favourable conservation status parameters. These are:

- Natural range and distribution (where the species occur).
- Population (how many there are of the species).
- The extent and quality of habitat supporting the species' populations.

Section 3 outlines the evidence considered when developing the definition. This definition is based on the best available evidence on the ecology of European sturgeon and Atlantic sturgeon. The evidence covers the current situation, historical changes and possible future changes.

Section 4 sets out the conclusions on the favourable values, that is the value for each of the three parameters when the species have achieved favourable conservation status.

This document does not include any action planning, or describe actions, to achieve or maintain favourable conservation status. These will be presented separately, for example within strategy documents.

Summary definition of favourable conservation status

This definition covers the two species of sturgeon that are found in English waters - namely European or common sturgeon, *Acipenser sturio* L. and Atlantic or Baltic sturgeon, *Acipenser oxyrinchus* M. These two species are closely related; for a time they were believed to be the same species and share many life history traits and niche requirements so are treated together here.

Sturgeon are large, long-lived fish with late maturation, low fertility and specific homing behaviour. They are migratory and utilise freshwater, estuarine and marine habitats at different stages throughout their life cycles. Adult fish return to freshwater rivers in the

summer months to spawn in good quality water with a rocky-gravel substrate. Six months after hatching the young fish migrate to the estuary where they may stay for up to two years before migrating to the marine environment. Juvenile and adult fish are found across the coastal shelf in relatively shallow waters (up to 50 m), foraging on polychaete worms and crustaceans found in soft, muddy or sandy substrates.

Historically, sturgeon occurred in all coastal waters and the main rivers of north-west Europe, including English waters. Both species became functionally extinct in Europe (the last recorded natural spawning of European sturgeon occurred in 1994) due to a combination of over-fishing and destruction of, and restricted access to, spawning grounds. Records in English waters declined as European populations declined.

Achievement of favourable conservation status will require a significant increase in sturgeon populations such that juvenile and adult fish are found where there is suitable habitat throughout English coastal waters and estuaries. There should be groups of adult fish frequenting all large rivers. An increase in populations will require restoration of freshwater riverine and estuarine habitat and reduced bycatch pressure in the marine environment in order to support the favourable population.

Table 1 Confidence levels for the favourable values

Favourable conservation status parameter	**Favourable value**	**Confidence in the favourable value**
Range and distribution	Juvenile and adult sturgeon present throughout English coastal waters and in all large estuaries and rivers where there is suitable habitat.	Moderate
Population	Groups of adult fish frequenting all large rivers.	Moderate
Supporting habitat	Maintenance of the current coastal habitat. Sufficient suitable estuarine and river habitat to support the favourable population.	Moderate

As at May 2023, based on a comparison of the favourable values with the current values, neither sturgeon species is in favourable conservation status. Note, this conclusion is based solely on the information contained within this document and not on a formal assessment of status nor on focussed and/or comprehensive monitoring of status.

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About the Defining Favourable Conservation Status project

Natural England's Defining Favourable Conservation Status (DFCS) project is defining the minimum threshold at which habitats and species in England can be considered to be thriving. Our Favourable Conservation Status (FCS) definitions are based on ecological evidence and the expertise of specialists.

Through setting our ambition and aspiration for species and habitats, our definitions will inform decision making and actions to achieve and sustain thriving wildlife.

Our FCS definitions will be embedded into delivery of the 25 Year Environment Plan, through the Nature Recovery Network, biodiversity net gain and environmental land management schemes (ELMS).

Conservation bodies will use them to inform their work, including management planning for the land they own. Businesses will have a clear understanding of how their work impacts nature recovery and how they can help contribute to achieving thriving nature.

By considering the evidence for FCS, decisions will be more confident and strategic, with an understanding of their contribution to, or impact on, the national ambition.

1. Species definition and ecosystem context

1.1 Species definition

Great Britain is within the native range of two sturgeon species:

- Atlantic or Baltic sturgeon, *Acipenser oxyrinchus M.*
- European or common sturgeon, *Acipenser sturio L.*

The two species of sturgeon included here are closely related, and for a time were believed to be the same species (Nikulina & Scmolcke 2016). Evidence for the genetic distinction between *A. oxyrinchus* and *A. sturio* was presented in 1997 (Birstein 1997) and then further developed in 2002 (Ludwig 2002). There is evidence that both species are present in some of the same geographic areas, with some hybridisation occurring (Chassaing and others 2012). It is important to note that new discoveries are still being made about these two species, and a great deal remains unknown.

Because they are closely related, and share many life history traits and niche requirements, both are included in this definition. Throughout this document, if a section refers to 'sturgeon' it is referring to both species. Where the species differ, this will be made clear in the text by identifying the species by their common names (Atlantic sturgeon and European sturgeon).

1.2 Species status

European sturgeon *(A. sturio)*

IUCN Red List status

- Global: Critically Endangered (Gessner and others 2022).
- European: Critically Endangered (Freyhof & Brooks 2011).
- GB: Not Assessed - listed as a vagrant or visitor.

Conservation status

- EU Habitats Directive (1992) - Appendix II and IV.
- Bern Convention (1979) (UK contracted 1982) Annex II.
- OSPAR. Annex V: Protection and conservation of the ecosystems and biological diversity of the maritime area. Reviewed 2021.
- CITES (1998) - Appendix I.
- CMS - Appendix I and II.
- Wildlife and Countryside Act 1981.

- Section 41 (England) of the Natural Environment and Rural Communities (NERC) Act 2006. Species of Principal Importance in England.
- Conservation of Habitats and Species Regulations 2010. Schedule 2 (European protected species of animals) lists those species of animals listed in Annex IV(a) to the Habitats Directive which have a natural range which includes any area in Great Britain.

Atlantic sturgeon (*A. oxyrinchus*)

IUCN Red List status

- Global: Vulnerable (Hilton and Fox 2022).
- European: This species was not included in the European Red List assessment, as it was determined to be no longer present in Europe. (Freyhof & Brooks 2011; Kottelat and Freyhof 2007).
- HELCOM (The Baltic Marine Environment Protection Commission): Regionally Extinct (HELCOM Red List Fish and Lamprey Species Expert Group 2013).
- GB: Not assessed.

Conservation status

- EU Habitats Directive Appendix II treated as *A. sturio.*
- Bern Convention (1979) - Not listed since the species was discriminated from *A. sturio* in 2002 only.
- Bonn Convention (1979) - Convention on Migratory Species (CMS) - Appendix I and II treated as *A. sturio.*
- Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) (1998) Appendix II.

1.3 Life cycle

Both European and Atlantic sturgeon are anadromous, meaning they require freshwater habitats to spawn (Friedrich and others 2018; Rosenthal and others n.d.; Gessner and others 2010).

The life history of the European sturgeon is still not fully described. The last known spawning population was in the Gironde, with no known natural spawning anywhere after 1994. As such, the life cycle phases of the European sturgeon and Atlantic sturgeon are based upon literature (Krananbarg and others 2018; Gessner and others 2010; Holcik and others 1989) and field observations in the Gironde estuary in France.

Sturgeon spawning takes place in the summer months (April-August), after mature sturgeon return to freshwater river habitats and begin their spawning migration upstream (Acolas and others 2011; Van Eenennaam and others 1996). Adults tend to travel in a loose congregation, often in pairs, until they reach suitable spawning habitat, described in Table 3. Eggs are released into the water column for males to fertilise before they drift

downstream a short distance and adhere to coarse substrates. The females lay 500,000 to 2,500,000 eggs, depending on their length and weight (Kranenbarg and others 2018; Gessner and others 2010; Holčik and others 1989). Spawning may take place in the main channel, side channels or tributaries. Once eggs are laid, adults return to the sea. Although the current rates of post-spawning mortality are unknown, the available evidence suggests rates are low due to the fact that mature adults can spawn multiple times in their lives, and studies undertaken on Atlantic sturgeon involved the capture of post-spawn adults (Balazik & Musick, 2015). Between 5 and10% of adult sturgeon stray from their natal river to exploit new habitats (Stabile and others 1996; Rochard and others 1997; Nikulina & Schmolcke 2016). They are not known to feed while undertaking spawning migrations and can survive for a number of months without food when necessary (World Fish Migration Day 2021).

Eggs take several days to hatch (dependent upon temperature). Once hatched, the yolk-sac larvae drift downstream and settle in crevices in the gravel close to the spawning site. There they spend up to a week hidden among the substrate, absorbing their yolk sacs. They then become free-swimming and begin to drift downstream with the current. The freshwater phase lasts approximately six months (Acolas and others 2011) towards the end of which the young reach the estuary where, during the first two years of the juvenile phase, most (at least in the Gironde) stay exclusively in the brackish waters of the estuary (Nikulina & Schmolcke 2016).

Some sturgeon migrate into the sea in their first year, but most do so later, when they are around 30 cm long (up to three years old). Juveniles between three- and eight-years old conduct seasonal migrations from the lower reaches of the estuary to the coastal shelf (Acolas and others 2011). This migration is not well understood, but observations in the Gironde suggest that it may be due to selective feeding, in addition to the fish beginning to adjust to wider salinity ranges (Acolas and others 2011).

Data regarding reproductive frequency are scarce. Scientists had previously considered that males might be able to spawn each year, while the females would spawn every two, three or even four years. More recently, tagging of wild brood fish has suggested that male European sturgeon spawn three times at two-year intervals. Observations of farmed European sturgeon suggest a two-year recurring cycle in females. Two-year cycles have also been observed in farmed stocks of the white sturgeon (*A. transmontanus*) and the Siberian sturgeon (*A. baerii*). Wild-originated European sturgeon males reared under controlled conditions displayed extreme variability in the frequency of maturity between individuals (Williott and others 2011).

Sturgeon grow at different rates, dependent on environmental factors such as temperature, and are believed to live up to 100 years. Life history information reported in the literature for both species of sturgeon varies. This is due to both species being poorly studied, as well as regional variation. The information cited here is taken from the sources cited by the IUCN red listing for both species (Gessner and others 2022; Hilton and Fox 2022) (besides European sturgeon maximum length, which was not included in the IUCN red listing).

Table 2 Sturgeon life history information as cited by the IUCN (Gessner and others 2022; Hilton and Fox 2022).

Species	Age (years) when first penetrates into the sea	Female age (years) at first reproduction	Male age (years) at first reproduction	Max length (m)	Max weight (kg)
European sturgeon	2-3 years (IUCN)	14-18 (IUCN)	10-12 (IUCN)	5 m (Williot and others 2011)	
Atlantic sturgeon	2-6 year (IUCN)	10-20 (ASMFC 1990)	6-10 (ASMFC 1990)	4.3 m (Vladykov & Greely 1963)	368 kg (Vladykov & Greely 1963)

Confidence: Moderate

1.4 Supporting habitat

Both sturgeon species are fully migratory across their European range. They utilise freshwater, estuarine and marine habitats at different stages throughout their life cycles, migrating between these different habitats for spawning, feeding and overwintering (Nikulina & Schmölcke 2016). This migration often covers long distances and may cross international boundaries.

Freshwater

Sturgeon spawning grounds comprise river habitat with rocky-gravel substrate (pebble >3 cm or rock 10-30 cm) with low sedimentation, high oxygenation, current velocity of 0.4-2 m/sec, a depth of 1-12 m and at a temperature of 17-22 ^{o}C. Such conditions would normally occur in the lower and middle freshwater reaches of a large river (Gessner and others 2011: Gessner & Bartel 2000).

Table 3 Spawning parameters for sturgeon based on the current European sturgeon population in France and on closely related Acipenseriformes (Capron 2021).

Environmental variable	Known parameters	Source
Flow velocity (m/s)	0.4-2.0	Gessner & Bartel 2000
Temperature (°C)	European sturgeon: 17-20 Atlantic sturgeon: 17-22	Gessner & Bartel 2000

Environmental variable	Known parameters	Source
Dissolved oxygen (mg/l)	≥ 7.5	Jenkins and others 1995 (*A. brevirostrum*); Delage and others 2014
Pool Depth (m)	1.0-12.0	Gessner & Bartel 2000
Substrate Size (cm)	3.0-30.0	Gessner & Bartel 2000
Salinity (ppt)	0.0-7.0	Jenkins and others 1995 (*A. brevirostrum*)
Turbidity (NTU)	0.0-5.0	Gessner & Bartel 2000

Estuaries

Adult and juvenile sturgeon both spend part of their lives in estuaries. For European sturgeon, the first two years of life is spent exclusively in the estuary (Nikulina & Schmolke 2016). For Atlantic sturgeon, the time spent in estuaries is shorter (Nikulina & Schmolke 2016). Juveniles of both species make seasonal migrations in and out of the estuary, as do adults, whether spawning or not.

In estuaries, the European sturgeon is known to feed primarily on polychaete worms and some crustaceans, rooting around in soft mud and sand in the subtidal and intertidal environment (Acolas and others 2011). During their juvenile phase (between three and eight years old), sturgeon migrate from the lower reaches of the estuary (at least in the Gironde) to the adjacent coastal shelf during the summer months, feeding in the intertidal and subtidal muddy substrates. In the autumn they return to similar habitats in the estuary (Acolas and others 2011).

Coastal waters

Movements of European sturgeon at sea are poorly described and, also, movements between estuaries and coastal areas have yet to be fully documented. Tagging work in the Gulf of Mexico has shown that adult Atlantic sturgeon make extensive seasonal migrations along the shallow coast shelf to and from overwintering grounds (Stabile and others 1996). Sturgeon are not known to utilise deep water environments exceeding 100-200 m and do not generally make extensive offshore migrations. Most European reports come from incidental captures by marine fishermen (Acolas and others 2011). The European IUCN Red List Assessment describes the European sturgeon as requiring subtidal, neritic habitats comprising sand, sandy mud and mud (Gessner 2010).

Sturgeon feed across the coastal shelf in relatively shallow waters (up to 50 m), foraging on polychaete worms and crustaceans found in soft, muddy or sandy substrates. The feeding habits of Atlantic sturgeon were studied in 2011 in the Bay of Fundy, Canada, where a large aggregation of fish appeared in the summer months (McLean and others 2013). The study demonstrated a clear preference for feeding on sandy tube-dwelling polychaetes, plus small crustacea. The composition of the diet appeared to bear no relationship to the length of the fish.

In another study involving juvenile European sturgeon in the Gironde estuary between 1998 and 2000, a similar preference for tube-dwelling polychaetes was observed with small crustaceans being the second most abundant group of prey (Brosse and others 2011).

1.5 Ecosystem context

Sturgeon (Acipenseridae) are one of the oldest fish families still living on Earth (Friedrich and others 2018). Sturgeon fossils were found in the Northern Hemisphere from the Triassic period, 208 to 245 million years ago (Friedrich and others 2018). Worldwide, 26 species are known, all of them endemic to the Northern Hemisphere. All, including the Atlantic sturgeon and the European sturgeon, share specific characteristics, such as late maturation, long life span, low specific fertility and specific homing behaviour (First Sturgeon Action Plan for the Lower Rhine 2020).

Historically, the European sturgeon occurred in all coastal waters and the main rivers of north-west Europe, including those in England. The Atlantic sturgeon is widely distributed along the east coast of North America from Florida to Labrador. In Europe, it was originally considered to be confined to the Baltic Sea and its tributaries; however, this is now being challenged. Archaeological work has demonstrated that Atlantic sturgeon have lived alongside European sturgeon on the Atlantic coast of Europe for the past 2,000 years at least (Nikulina & Schmolcke 2016). Whilst there is currently no known spawning population of either sturgeon species in English rivers, both species have been caught in English coastal waters both historically and in the modern era (Colclough 2021).

Figures 1 and 2 are adapted and taken (respectively) from the Pan-European Action Plan for Sturgeons (Friedrich and others 2018). They describe the past and present distribution of European and Atlantic sturgeon in Europe, respectively. At the turn of the 18th century, European sturgeon had a wide distribution in Western Europe, from the Mediterranean to Scandinavia (Lassalle, Beguer & Rochard 2011). Research into the historic distribution has demonstrated that the species does not display the classic core-periphery model of distribution, which shows a dense area where most of the population reside and progressively smaller numbers away from this core area. Rather, spawning basins were generally separated by significant distances. In the areas between the spawning basins, sturgeon might be absent (unexplored basins), or individuals might regularly enter some rivers for exploration, without leaving any evidence of spawning in situ (transitory basins) (Lasalle and others 2011).

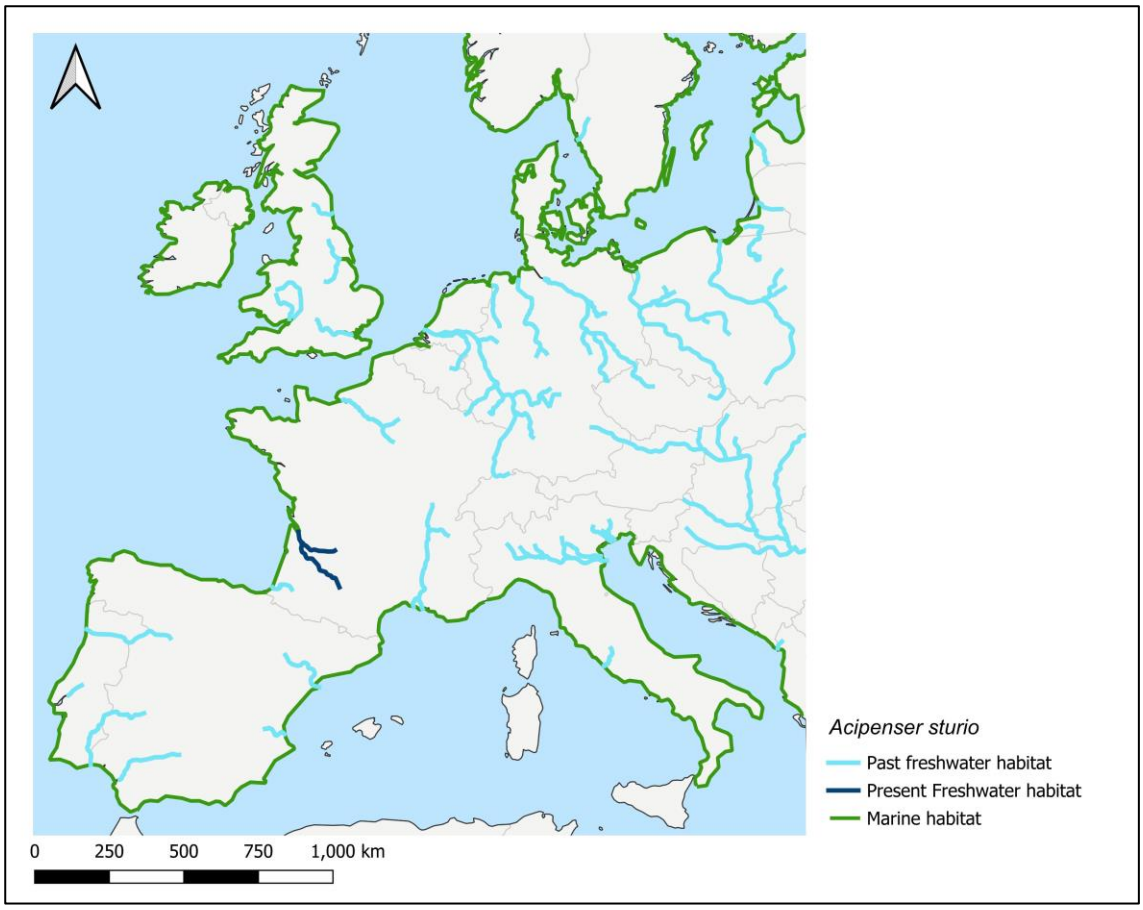

Figure 1 Past and present distribution map of European sturgeon. Adapted from the Pan-European Action Plan for Sturgeons (Friedrich and others 2018).

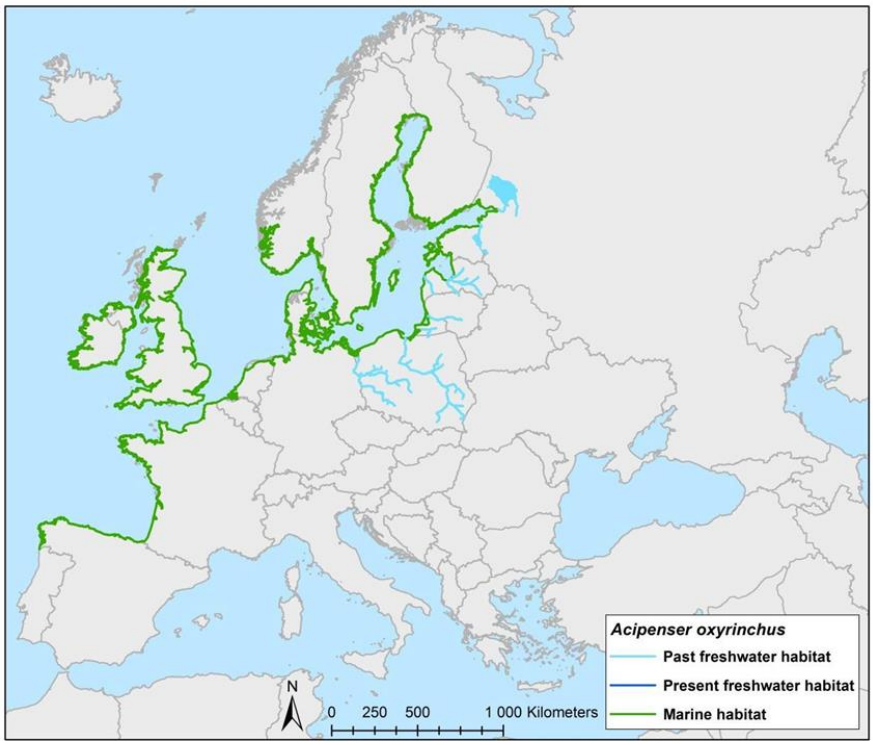

Figure 2 Past and present distribution map of Atlantic sturgeon. Adapted from the Pan-European Action Plan for Sturgeons (Friedrich and others 2018).

Both species are characteristic of natural ecosystem function across the land/sea interface. Closely related adult Gulf sturgeon (*A. oxyrinchus desotoi*) overwintering in marine habitats were found to translocate marine carbon (from, for example, benthic prey) back to their natal river, functionally connecting freshwater and marine environments. This has also been documented for specific clupeids and salmonids. Gulf sturgeon likely transport nutrients during the spring immigration, as individual fish deposit marine carbon into the freshwater environment via excretion, reproduction and death (Vick and others 2018). While this sort of analysis has not been conducted for European and Atlantic sturgeon, it is possible they play similar roles in the ecosystems they inhabit. This functioning reflects the importance of migratory species across the whole open aquatic landscape.

2. Units

2.1 Natural range and distribution

The units used to define the natural range and distribution will be:

Presence of both juvenile and adults within large rivers* and estuaries, and marine areas in the 10 km grid squares adjacent to these river mouths/estuaries.

2.2 Population

With little information about sturgeon spawning and historic population sizes, setting a metric for favourable conservation status for sturgeon in England is difficult. Therefore, the population metric will be the number of large rivers that groups of adult sturgeon frequent.

2.3 Habitat for the species

Marine and freshwater habitat for sturgeon will be measured using the following units:

- Length (km) of river and estuary providing suitable, naturally accessible and functional habitat for sturgeon species, including accessible spawning gravels.
- Area in hectares of suitable marine habitat (within 12 nm) adjacent to estuaries or rivers and on migration routes.

* River Habitat Survey river classes of: Flow category 9: 40 - 80 m^3 s^{-1} (large river) and Flow category 10: > 80 m^3 s^{-1} (large river)

3. Evidence

3.1 Current situation

Both species are migratory and are now considered vagrants/rare visitors to England and all other British waters. It is possible that both species in Europe share a complex of spawning, nursery and feeding grounds.

Data presented throughout this document come from a database which includes both modern and historical sturgeon capture and sighting records (Colclough 2021). They comprise records up to 2022 but, note, this database is being added to as further records are identified. The sources of these records include newspapers, direct communication with fishers, and sightings/photos. It should be noted that these records are likely to represent areas where fishing effort was higher, and they may not be comprehensive. These data, along with more information about their sources and further interpretation, are presented in an unpublished Evidence Report (Colclough 2021) and will be available to the public for download by April 2024.

The last known natural spawning of the wild stock of European sturgeon in its natural range was in the Gironde in 1994 (Rochard and others 1997). For this reason, and keeping in mind sturgeon's longevity, all sturgeon records in English waters from before and including 1994 are considered "historic", and sturgeon records after 1994 are considered "current."

Natural range and distribution

There have been 15 sightings of sturgeon in English waters since 1994. Most have been in coastal and marine waters, with one in the Swale estuary. It is important to stress that these records are unlikely to represent the full current distribution of sturgeon in English waters. Most are from commercial bycatches, which means the information gathered is based partly on fishing effort. It therefore remains unknown if sturgeon are present in more isolated areas, or areas that are not regularly fished.

These modern records are shown in Figure 3. The locations are indicative for most of the specimens, given the incomplete information on which each is based. The database of historic records contains numerous records from the south coast, so these modern records suggest these individuals are occupying some of the same marine feeding areas as their predecessors (Colclough 2021). The records included in this dataset are associated with a high confidence that the species identified was an Atlantic or European sturgeon. However, it is important to note that not everyone who reported these sightings was able to include a photo or video. The sightings that cannot be fully authenticated will have a confidence rating of less than 100%.

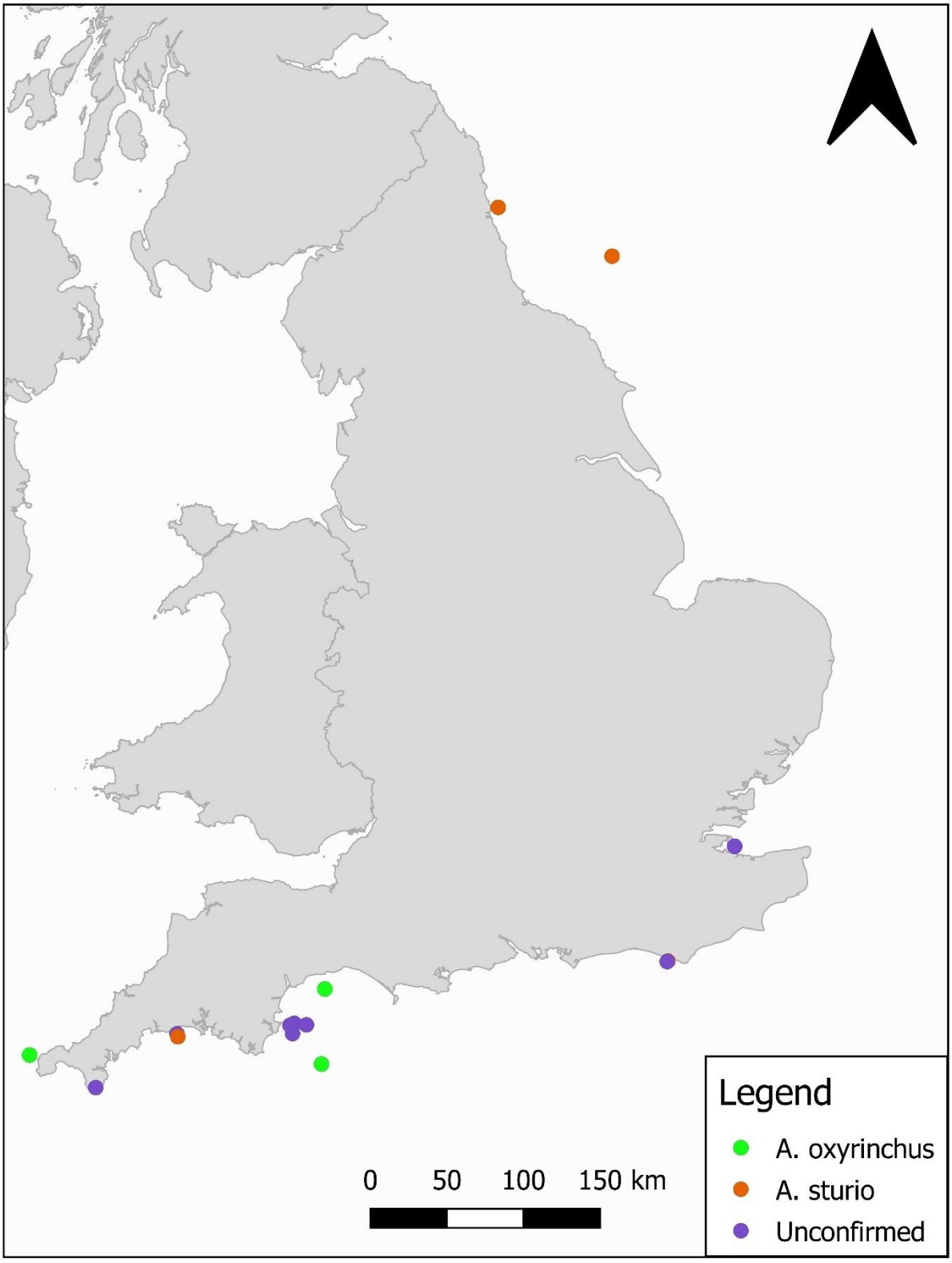

Figure 3 Sturgeon recorded in English waters since 1994. Data obtained from Colclough, 2021.

Confidence: Moderate

Population

The current population of both Atlantic and European sturgeon in England is small. There are currently no known breeding populations both in England, or in Europe, and there are no recent records from English rivers where sturgeon may spawn (indeed, only one individual has been reported in English rivers and estuaries since 1994). The lack of spawning is further evidenced by the lack of juvenile sturgeon reported in English waters.

Table 4 “Current” (post 1994) records of sturgeon in English waters (Breve and others 2022; Colclough 2021).

Year	Landing or catch location	Species	Size/weight
1999	2.5 miles south of Looe	Unknown	8 kg
1999	Looe	Unknown	Unknown
1999	Southeast of Newhaven	Unknown	Unknown
2001	Cadgwith	Unknown	2 m, 30 kg
2015	Queenborough, Swale estuary	Unknown	1.5 m
2016	Newlyn	Atlantic sturgeon	80 kg
2016	2 miles southeast of Newhaven	European sturgeon	14 kg
2017	25 miles SE of Brixham	Atlantic sturgeon	Unknown
2019	5 miles south of Beer Head	Atlantic sturgeon	0.9 m, 4.1 kg
2020	off Berry Head	European sturgeon	Unknown

Year	Landing or catch location	Species	Size/weight
2021	off Brixham	Unknown	Unknown
2021	off Looe	European sturgeon	Unknown
2022	off Looe	European sturgeon	1.3 m, 17.5 kg
2022	3 miles east of Newbiggin	European sturgeon	Unknown
2022	near Brixham	European sturgeon	1.5 m

Table 4 lists the post 1994 records of sturgeon in English waters. Before interpreting these records, it is important to first summarise the sturgeon restoration programmes that have taken place in Europe. This will help to clarify whether the sturgeon recorded in English waters are remnants of wild populations, or of reintroduced stock. In the 1990s, 53 specimens of the European sturgeon were collected in the Gironde and were used to create an ex-situ brood stock. This brood stock has been used to restock fry and fingerlings in the Gironde basin since 2007 (paused since 2015 to monitor fish returning) and the Elbe basin since 2009 (again paused since 2015). The last wild Atlantic sturgeon was caught in the Baltic in 1996 (200 kg). A brood stock has been developed from Canadian stock and fry and fingerlings have been restocked since 2005 (Breve and others 2022; Colclough 2021).

These are the first examples of Atlantic sturgeon in UK waters in modern times. They are also the first examples to be reported outside of the Baltic in modern times (E Rochard, pers comm), but all are likely to have originated from the Baltic restoration programme. However, a fish of 120 kg taken off Glamorgan in June 2004 and later identified as Atlantic sturgeon must have been a remnant of wild populations, its size indicating that it would be too big, and therefore too old, to come from the restoration programmes.

Assuming that all the other specimens reported from English waters since 1994 are European sturgeon, whether confirmed or not, it is highly probable that each derived from a restoration programme. The 8 kg fish taken off Looe in 1999 and the 30 kg fish taken off the Lizard in 2001 may have arisen from spawning in the wild in the Gironde, whilst the 14 kg fish taken off Newhaven in 2016 and the 17.5 kg fish taken off Looe in March 2022 may have arisen from the release of fingerlings in either the Gironde or Elbe in 2014 or 2015. Due to its location off the north-east coast the European sturgeon captured off Newbiggin

likely originated from the German reintroduction efforts in the Elbe. It is also the first sturgeon recorded off the north-east coast since the early 1900s.

Habitat for the species

The map in Figure 4 shows the current coastal and freshwater habitat that may be suitable for sturgeon.

The coastal foraging substrate types are those used by EUNIS (European Nature Information System) seabed habitat GIS layer (EUSeaMap, 2023). The types included are sand, mud, muddy sand, fine mud, and sandy mud. The EUNIS dataset does not show all potential sturgeon foraging habitat. For example, it is known that Morecambe Bay has substrate suitable for sturgeon foraging, however it is not shown as such on Figure 4. Despite its incompleteness, the area of suitable foraging habitat that is displayed by the EUNIS map covers much of the English coast, as much of the coastal shelf marine habitat offers suitable habitat.

There are no records of a sturgeon in an English river since 1994. It is thus unclear how much river habitat might be suitable for sturgeon, not least because upstream migration might be constrained by artificial barriers on otherwise suitable rivers. The rivers shown on the map in Figure 4 are thought to represent the historic river habitats for sturgeon in England, each with more than 12 historical sturgeon records. The map also indicates the rivers for which there is evidence of intent to spawn (see Section 3.2). The barriers on these rivers are also displayed. The barrier data are from the Environment Agency's River obstacle dataset (Environment Agency, 2021). All barriers on these main rivers have been included, unless it was obvious that they do not form a barrier to the main river channel (for example, a barrier on a smaller tributary or a wetland). Further investigation is needed to assess whether these barriers would in reality be a barrier to sturgeon migration and habitat assessments are necessary to identify suitable river and estuarine habitats for sturgeon in these rivers. Survey work undertaken on the Rivers Severn and Wye in summer 2021 identified that both rivers possess suitable spawning and nursery habitat (defined in Table 3) (Capron 2021). But whilst the Wye has no barriers to migration (most were removed before the 1700s), the Severn has a number of barriers preventing sturgeon reaching potential spawning grounds between Bridgnorth and Shrewsbury.

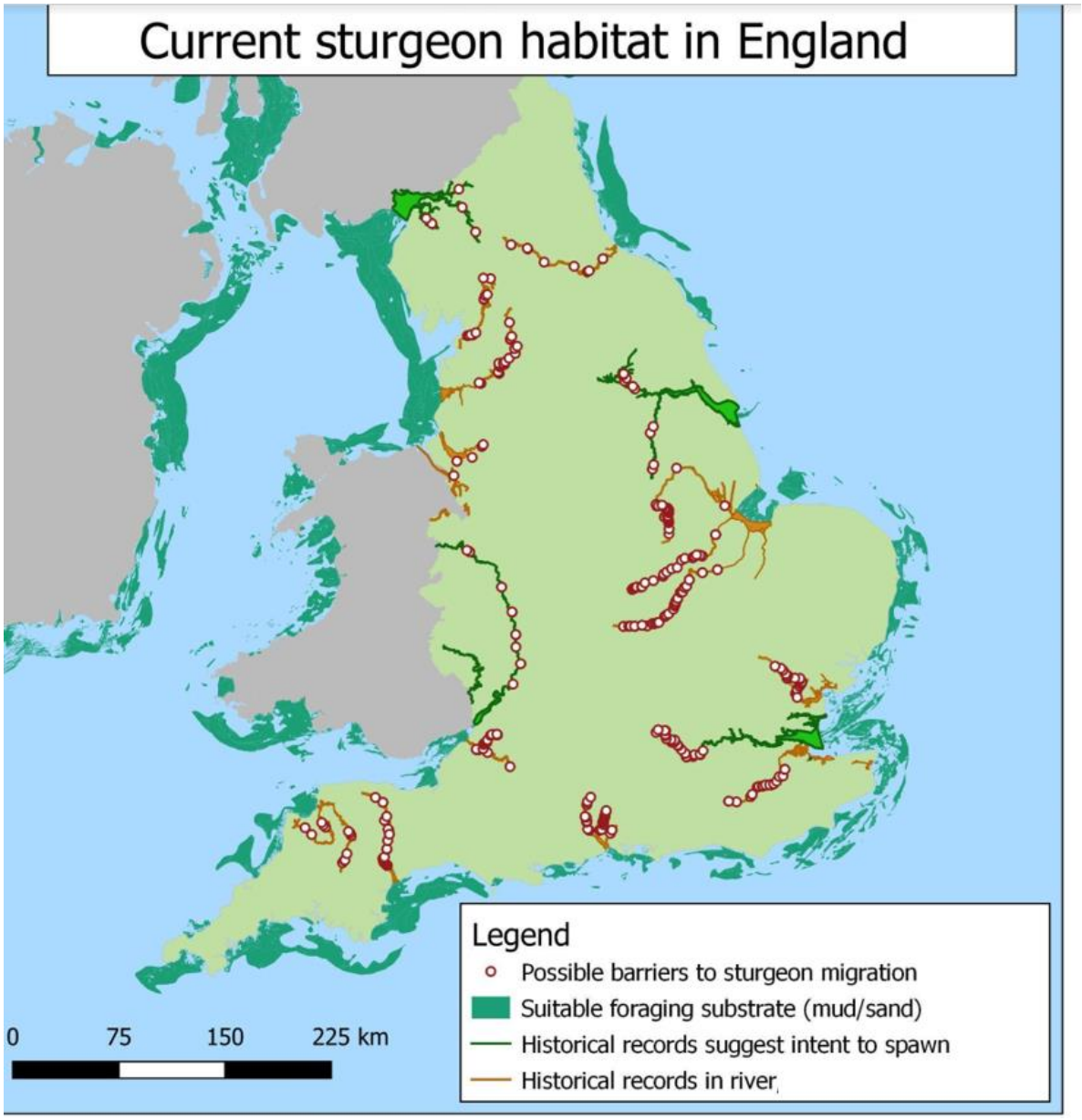

Figure 4 Map of current possible sturgeon habitat in English coastal and fresh waters. The mapped rivers are based on historic sturgeon distribution (see Section 3.2). Potential barriers to sturgeon migration are shown on these waterbodies.

Confidence: Moderate

3.2 Historical variation in the above parameters

Most sturgeon are long-lived, large-bodied, late-maturing fish that undertake long-distance anadromous migrations through marine, estuarine and riverine habitats (Bemis & Kynard 1997). Many factors have been degrading sturgeon habitats for centuries.

Much of their original riverine habitat has been modified or lost over the past few hundred years (Freidrich and others 2018) due to barriers such as weirs, dams, sluices and hydropower plants, amongst others (Rochard and others 1997; Birstein and others 1997; Puijenbroek and others 2019, Breve 2022). Water mills and grain mills appeared across

Europe from the ninth century whilst works to extend any limits to navigation began in the Middle Ages, with significant expansion after the 15th century (Colclough 2021), all frustrating access to potential and actual spawning sites. Other factors, such as increased sedimentation associated with changing agricultural management and urban drainage, maintenance dredging for navigation and aggregate extraction and channel modification for water conveyance and development would have degraded both spawning and early nursery habitats (Williott & Castelnaud 2011). Acute toxicity was a pressure common to all migratory species. Wastewater purification was rare in most of Europe up to the late 19th century (Schiemenz 1905).

Much estuarine habitat has also been lost or degraded. For example, 85% of British estuaries have suffered very significant land claim over the past 200 years and up to 80% of the intertidal habitat has been lost (Attrill and others 1999) removing much productive feeding habitat.

Anadromous fish species are vulnerable to overfishing in both rivers and coastal waters and this is considered to be a main contributing factor to the decline of the sturgeon in England, and across Europe. Sturgeon catches in Europe began to dwindle in the late nineteenth century, at a time when river engineering first strongly affected the sturgeon's reproductive habitats in the Lower Rhine and delta areas. From then onwards, North Sea fishery pressures increased, as trawlers switched from sail to steam-powered propulsion. These sea fisheries harvested all age-classes of sturgeon year-round, ultimately resulting in total population collapse (Breve and others 2022). Twenty-four spawning basins across Europe were identified for the period 1750-1850. This number decreased to 18 in 1950 and to a single example in the Gironde/Dordogne/Garonne system by 2000.

An example of the scale of decline is provided by the river Elbe. Sturgeon were formerly abundant in the river: early in the 19th century it was possible for a single fisherman to catch 1,000 fish between April and August. The fishery peaked around 1875 with an estimated catch of 10,000 fish. An added pressure from the late 19th century was the demand for caviar and catches declined significantly after 1888, despite increased fishing efforts and by 1890 catches had declined by 50%. Sturgeon became rare after 1930 even though steam trawlers were used to seek more individuals out into the Waddenzee. The last catch was made at the mouth of the Oste river in 1985 (Gessner and others 2011). This decline mirrored that in other European rivers, the last fish being taken from the Gironde in 1978 (Castelnaud 2011).

Kolman and others (2011) provide a history of sturgeon in the Baltic and Lake Ladoga, Russia where a significant fishery had been present from the Middle Ages onwards. Detailed genetic investigations have established that the genotype present in the Baltic closely resembles that of the Atlantic sturgeon (Desse-Berset 2009).

The peak in reports of sturgeon in English waters coincides with the peak in Europe's fisheries. With minimal, if any, spawning occurring in English waters, the numbers of fish using English rivers will have been directly linked to those populations in the Elbe, Rhine,

Baltic, Gironde and elsewhere. As these populations declined so did reports from English waters.

Natural range and distribution

The natural range and distribution of sturgeon in England can be deduced using the historic records database. Figure 5 shows the rivers and estuaries in which sturgeon records were most abundant (Colclough 2021). It is important to note that the map in Figure 5 does not show every single river in which a sturgeon has been reported in England but those with at least twelve historical records of sturgeon. The figure (12) is chosen arbitrarily to provide clear mapping information.

There is some indication that these two species had different distributions across England and UK waters, but more information would be needed to confirm this. The map also shows the English waterbodies that sturgeon may have used as spawning grounds. This assessment of possible spawning areas is based on evidence of intent to spawn that is explained in Table 5.

Figure 5 Historic sturgeon distribution based on the waterbodies with the highest numbers of historic records of sturgeon. This map also shows in which rivers the records have indicated potential spawning, and those in which spawning was less likely.

Population

There are 951 records of sturgeon observed or taken from British rivers and estuaries (Colclough 2021), though none provide hard evidence that sturgeon actually spawned in British rivers. However, several British rivers and coastal waters were used extensively by sturgeon in the distant and recent past as part of their normal habitat and there is ample evidence of an intent to spawn, with multiple historic descriptions of small groups of fish ascending specific rivers in the summer months, including fertile females (OSPAR 2020). The locations of where sturgeon have been more commonly recorded are described in Table 5.

Table 5 The locations of historic sturgeon sightings and catches in British rivers and estuaries between 1198 and 1990 and evidence of possible intent to spawn.

River	Number of sturgeon recorded 1198-1990 (as of May 2022)	Percentage of total sturgeon recorded 1198-1990 (as of May 2022)	Evidence of possible intent to spawn
Severn only	224	23.6%	Strong evidence of intent to spawn. 32% of the 224 fish recorded appeared to have been in small groups on spawning migrations when captured on 27 occasions between 1817 and 1937. Where available, length/weight data suggests that both sexes were present in most of these groups. One fish of 102 kg taken in 1864 at Tewkesbury was later dissected and found to contain some 19 kg of roe estimated to contain 1.88 m ova. The largest grouping was in 1875 when 10 fish ran up the estuary over a five-week period. The suggested reaches for suitable spawning habitat would have been above Bridgnorth, which would have been unavailable after the 1840's due to navigation 'improvements' and weir construction. Some of the earlier reports come from as far upstream as Shrewsbury. Most of the later reports come from the tidal limit at Tewkesbury and the inner estuary down to Purton. There are several records of juvenile fish, the smallest being 1.14 kg taken in 1901 at Berkeley. The weight would suggest an age of some 18 months. It is questionable whether this fish was then large enough to have come from the continent. There is no other evidence of reproduction *in situ*.

River	Number of sturgeon recorded 1198-1990 (as of May 2022)	Percentage of total sturgeon recorded 1198-1990 (as of May 2022)	Evidence of possible intent to spawn
Thames (Blackwater, Medway, Roach & Crouch)	115	12.1%	A weak “signal” of intent to spawn in all these waters. Only six single pairs of fish across all these rivers between 1758 and 1883. Several fish penetrated above the current tidal limit on the Thames at Teddington from 1736 to 1829. Construction of Teddington Lock started in 1810 preventing future migration upstream of this point. The relatively high numbers of fish after this period might have been feeding in the estuaries, but with no capability of undertaking spawning runs.
Yorkshire Ouse and tributaries	96	10.1%	Strongest “signal” of intent to spawn after the Severn. 17 examples of groups of fish moving upstream over a few weeks. The upstream-most report comes from York in 1896, though most reports come from the estuary between Goole and Selby, with several at the tidal limit at Naburn. A fish taken at Selby in 1829, described as a “sea monster”, was later dissected and contained “2 stone of roe, one grain containing 370 eggs”.
Trent	89	9.3%	A weak “signal,” but still evident. Thirteen examples of small groups of fish migrating upstream between 1813 and 1888. The best year was 1887 when 14 fish moved upstream over a six-week period. There are a

River	Number of sturgeon recorded 1198-1990 (as of May 2022)	Percentage of total sturgeon recorded 1198-1990 (as of May 2022)	Evidence of possible intent to spawn
			number of reports of multiple fish being seen in weir pools such as Averham near Newark. Prior to 1870, some reports extended as far upstream as Nottingham. After this period all of the reports came from the tidal river below Cromwell.
Solway	75	7.9%	A strong “signal”. Seventeen groups of fish in the Solway, penetrating into the Scottish rivers (Cree, Annan and Nith) as well as the Eden and Exe. Two fish taken at Skinburness in 1900 were identified as female by the recipient fishmonger. One of these weighed 222 kg and contained 30 kg of roe.
Welsh Dee	61	6.4%	Weak “signal”. Six groups of fish were noted over a brief period from 1887 to 1899. These fish were probably feeding in the estuary, with no prospect of negotiating the historic weir at Chester.
The Wash (Welland, Great Ouse, Nene and Witham)	48	5.1%	Unlikely. Only one example of a pair of fish moving upstream together in 1806. However, individual fish did penetrate far upstream and quite recently. In the Welland upstream to Spalding until 1890, in the Nene upstream to Peterborough as recently as 1955 and in the Great Ouse to Hemingford Grey in 1924. One female caught near Hemingford Grey in 1754

River	Number of sturgeon recorded 1198-1990 (as of May 2022)	Percentage of total sturgeon recorded 1198-1990 (as of May 2022)	Evidence of possible intent to spawn
			weighed 52 kg and contained over 19 kg of roe.
Wye, Usk and Parrett	46	4.8%	Likely not, more likely in the Severn.

There are a number of other rivers with data of some note, described here in descending numbers of reports in the historic database. Twenty-seven records exist from the Ribble with four pairs of fish moving upstream up to 1920. One pair from 1870 were dissected and found to be one female and one male. There are 22 reports from the Tweed between 1804 and 1909, but no groups are evident. Nineteen fish have been reported from the Lune with single pairs of fish apparent in four separate years up to 1924. There are 19 reports from the Exe, with only one pair evident in 1897. Fish have been reported from the Taw/Torridge system, with only one pair of fish apparent. Several juvenile fish have been reported from this estuary. There are 14 reports from the Tees, with two pairs evident. Eleven reports came from the Test, Itchen and Hamble, with no groupings. Eight records are available from the Frome and Stour/Avon combined, again with no groupings apparent. Other than those listed above, most other rivers and estuaries in England have had one or two reports dating back over the past three hundred years.

The majority of historic records come from the period 1800-1920, with numbers of records peaking in 1880. 86% of the fish were reported from the period April-August and 54% from June and July. This is the recognised spawning period. This ties in with the paper published in 2022 by Breve and others on historical spatiotemporal distribution of sturgeon in north-west Europe (over 5,000 records encompassing over 40,000 fish) which describes catches of riverine sturgeon increasing from March onwards, with a dominant peak in June, after which catches declined again until August.

Where dimensions are available, 93% were considered to be adults (greater than 165 cm) (Acolas and others 2017). The majority of the fish lie in the 1.8-2.7 m range. The largest fish recorded was 4.24 m. The heaviest fish recorded was 305 kg taken in the Dee estuary in 1875. The smallest fish reported was 1.14 kg (approximately 60 cm in length) from the Severn in 1901. Rochard and others (1997) suggest that 50 cm (1 year) is the smallest size that European sturgeon are able to negotiate a transfer through full strength seawater to a distant catchment. This is one of a very few small fish in the British record database and it may be the only evidence we have of some limited reproduction in the British Isles. With the large Severn database, there is some evidence that fish travelled in groups with

up to eight fish being reported from the same stretches of river over a two-month period. Some respondents reported “companion fish” observed but not captured. In some years, the smaller (probably male) fish ascended first. This is classic sturgeon spawning behaviour (Nikulina & Schmolcke 2016).

The coastal data for England show that 2,848 sturgeon have been captured at sea between 1800 and 1994. 447 fish have been taken from locations around the English coasts. 147 fish have been landed at Fleetwood, Newlyn, Plymouth, Brixham and Ramsgate where the location of capture is unknown. Marine reports began in 1800 and peaked around 1910. The majority of the fish were taken between October and March (44%), a seasonal trend mirrored in French records for the Gironde fishery (Castelnaud 2011). 18.5% of fish were less than 165 cm in length. The largest fish ever taken were two fish landed at Brixham in 1865 at 345 kg and 377 kg.

With the single capture reports there is some evidence of the existence of aggregation areas, which might indicate feeding areas over soft substrates. Specific examples include Start Bay - 43 fish taken between 1824 and 2020, Lyme Bay - 32 fish between 1823 and 2019, Sussex Bay - 28 fish between 1806 and 2016.

Habitat for the species

Lack of spatial data on coastal and marine habitat and substrate types make it difficult to identify how these habitats may have changed, but with sturgeon sightings in most rivers and all along the English coast, most English coastal and marine waters could well have provided habitat for sturgeon.

It must be noted that there have been significant changes in the benthic near-shore environment of England’s coastal waters since the 1800s including the loss of 95% of native oyster beds, 85% of saltmarsh and 50% fewer waterbodies with seagrass (Environment Agency 2021). However, Figure 4 demonstrates that despite these losses, there still exists significant feeding habitat for sturgeon in England’s coastal waters. In addition, some of the “aggregation areas” identified by capture records from Colclough (2021) may have been important feeding grounds at sea. Some of the past aggregation areas bear some correlation to areas of soft substrate which are recognised today as marine protected areas (MPAs) for example, Morecambe Bay, East of Start Point, Bristol Channel (Colclough 2021).

Confidence: High

3.3 The future for the species and its conservation

Appendix 1 summarises the main threats to sturgeon, and their potential severity. Their potential impacts on distribution, population, and habitat are described in the following sub-sections.

As targeted fishing was historically the leading cause of decline in Atlantic and European sturgeon populations, this threat remains relevant. The species are now protected under the Habitats Directive and Wildlife and Countryside Act and fishing is prohibited. Despite recent increases in compliance with fisheries prohibitions, bycatch in commercial benthic trawls and gillnet fisheries threatens reintroduction efforts and is considered to be the main threat to the remaining populations in Europe. To address this, the French have engaged upon a very successful public relations and education campaign for marine fishermen (Michelet 2011). As the numbers of sturgeon in UK waters increase, the rate of marine bycatch may also increase. Data from fisheries reporting and wider research concur that particular gear types have notable bycatch of other protected migratory fish species (in the order of tonnes) and have identified regional hotspots, but the data is not currently sufficient in either the scale or the spatial resolution to determine the impact that this may be having either on a species overall or the impact on particular protected areas. It is likely that the same lack of evidence may hinder achievement of favourable conservation status for sturgeon. Six of the recent marine captures described in Section 3.1 have been properly reported, identified and authenticated, and at least some of the fish have been returned to the water alive.

A further potential threat is the presence of non-native sturgeon species. In addition to the risks through the transmission of diseases and competition, there is the possibility of hybridisation with exotic sturgeon which is considered an important and increasing threat to re-establishment of Atlantic and European sturgeon (OSPAR 2020). The importation into England of all Acipenser and Huso species for the pet trade is permitted under general licence, and no licence is necessary to keep these species in ornamental ponds or in private residences. However, three species of sturgeon began to appear illegally in angling lakes by 2005 (Britton and others 2006). Some of those lakes lie in the floodplain, allowing the species in these lakes access to rivers during flood events (Colclough, pers comm). Siberian sturgeon (*A.baerii*), sterlet (*A. ruthenus*) and other exotics have now appeared in the Trent, Thames and elsewhere across the country.

While population sizes remain small, there is the potential for genetic bottlenecks. This remains a concern as reintroduction programmes use the only existing source population to restock sturgeon. However, there is potential for individuals from the last remaining wild populations to introduce genetic variation into these reintroduced populations. In addition, the tendency for 5% of populations to stray from their natal rivers may maintain gene flow between established populations.

There is the potential for climate change to have an impact on the distribution of sturgeon through changes in river flow and discharge, high temperatures, and false cues for spawning that impact reproduction. However, based on the sturgeon’s high range of temperature tolerance, this is not likely to be a major impact.

Water quality will impact sturgeon differently at each life stage. Sensitivity to environmental conditions is greatest in early life stages (eggs, embryos, larvae) and generally decreases with age and size (Flinders 2014). Given their sensitivity to poor water quality, standards suitable for salmonids, as sensitive indicators of poor water quality, could also suit

sturgeon. These are defined within Water Environment (Water Framework Directive) Regulations, Common Standards Monitoring (CSM) guidance for freshwater fauna (JNCC 2015) and Common Standards Monitoring Guidance for Rivers (JNCC 2016). Within these reports, it states that if standards for Good Ecological Status under the Water Framework Directive are more stringent than CSM targets then those GES standards should be used as targets for favourable conservation status. These standards can be found in Water Framework Directive implementation in England and Wales: new and updated standards to protect the water environment 2014 (Defra 2014).

Natural range and distribution

Given the current and historical records for sturgeon, all English coastal waters, large estuaries and rivers where there is, or should be, suitable spawning habitat (accessible or not) is within the natural range and distribution of sturgeon.

Population

The minimum number of individuals to achieve successful spawning is not known. In the British database, there are examples of small groups of fish ascending specific rivers during the main spawning period (May-August). In some instances, single large fish were later dissected and found to contain mature ova. In at least two instances, ova were discharged as the fish was removed from the river. These behaviours indicate some intent to spawn, but without success. That might have been related to poor habitat/environmental quality or possibly low numbers of spawners present (Colclough 2021). Recent findings of two juvenile specimens under 50 cm long in English museum collections, originating from UK freshwaters, provide new evidence of possible spawning (McCormick, pers. comm.)

Given these records relate to a population that had already been impacted by anthropogenic development from the Middle Ages, it is likely that they represent a population that was not in a favourable conservation status. Therefore, restoration of favourable populations for sturgeon will require an increase in populations compared to the historical record. Favourable status is proposed as groups of adult fish frequenting all large rivers.

Habitat for the species

The prime requirement for favourable sturgeon populations is the ability to move freely between good quality freshwater, estuarine and marine habitats. For sturgeon to thrive in English waters, it is necessary for our river, estuarine and coastal ecosystems to be as close to naturally functioning as possible. Such a system would include rich coastal foraging habitats abundant with invertebrates, estuaries with rich foraging grounds for all sturgeon life stages, and healthy rivers with accessible, clean, sediment free, gravels. Further research is needed to quantify the habitat extent necessary to sustain a local population of sturgeon. River restoration to achieve the environmental parameters listed in Table 3 would be necessary to ensure habitat is available for potential future spawning.

Ensuring free migratory access to potential spawning areas in rivers is necessary to achieve thriving populations of sturgeon.

It is imperative that estuarine habitat quality is maintained and more often enhanced, and this is particularly important in the estuaries adjoining the rivers known to be frequented by sturgeon.

Confidence: High

3.4 Constraints to expansion or restoration

There are few immovable ecological constraints to restoration of sturgeon populations.

Low flows arising from the impacts of climate change could limit the availability of spawning grounds in rivers and streams. In some rivers, this threat could be reduced through abstraction management.

Physical artificial barriers to sturgeon migration, which would prevent them accessing critical habitats, could be a limitation, as retention of barriers may be necessary to protect significant urban development. However, in many cases, action could be taken to open up rivers, allowing sturgeon to access these habitats.

Against the background of European restoration schemes, along with the inclusion of measures to protect sturgeon and prevent overexploitation, the main challenges to sturgeon population increase should have been removed. There is then a high feasibility of increase for these populations both throughout Europe, and in UK waters. The reintroduction programmes that are currently ongoing in Europe are cautiously optimistic. Due to the species' longevity, it is still too early to determine their success. However, the increased number of sturgeon encounters is an early indication of potential population increases. It is theoretically possible that natural colonisation in English waters could occur as a result of these restoration programmes. Several individuals have been observed in recent years, in Start Bay, Lyme Bay, Sussex Bay and the Medway estuary. All individuals were in good condition, suggesting plentiful food and habitat availability.

The potential impact of sturgeon on other native fish populations is believed to be minimal or non-existent, but evidence is needed.

Conversely, the removal of barriers to the spawning migration of such a large anadromous fish may benefit other fish species by opening up free migratory passage. Good water and sediment quality would also benefit other aquatic species with highly oxygenated flows and reduced pollutant inputs being requirements for sturgeon. Sturgeon could be considered a flagship species for healthy and resilient English waters.

Confidence: High

4. Conclusions

4.1 Favourable range and distribution

Juvenile and adult sturgeon present throughout English coastal waters and in all large estuaries and rivers where there is suitable habitat may be expected to occur under natural conditions.

4.2 Favourable population

Groups of adult fish frequenting all large rivers.

4.3 Favourable supporting habitat

Maintenance of the current coastal habitat. Sufficient suitable estuarine and river habitat to support the favourable population.

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Appendix 1 Threats to sturgeon

Threats table, describing the potential for each threat to impact different sturgeon life stages in England using a High, Moderate, Low, and Unknown system.

High: major impediment to the return of the species

Moderate: potential impediment to the return of the species

Low: no impediment to the return of the species

Unknown: there is insufficient knowledge to make an estimate

Main threats impacting various life stages of sturgeon in England	**Life stage**			**Status in England**	**Reference**
	Adult	**Juv.**	**Egg & larvae**		
Upstream migration	**High**	n/a	n/a	There are 36,804 records of artificial river obstacles including dams and weirs in UK rivers registered on the Catchment-based Approach Data Hub River Obstacles database. These are likely to create significant barriers to upstream migration for adult sturgeon to critical spawning grounds. **Future actions:** Restoring fish passage where it has been lost due to artificial barriers within rivers for all characteristic species to allow access to	River Obstacles | Catchment Based Approach

Main threats impacting various life stages of sturgeon in England	Life stage			Status in England	Reference
				habitat required for all life stages and strategies.	
Downstream migration	**Moderate**	**Moderate**	**Moderate**	There are currently no spawning populations of sturgeon. In theory, larval fish and juvenile fish could migrate downstream over certain types of barriers with the flow of water. Potential barriers to downstream migration include pumping stations for flood management, intake pipes for dams where mortalities could occur (Cooke and others 2020). Research into the impact of pumping stations on the European eel *Anguilla anguilla* and coarse fish show that altered pumping regimes can reduce the risk of entrainment.	Environment Agency 2017
River habitat quality	**Unknown**	**Unknown**	**Unknown**	River habitat quality to support sturgeon has not been assessed in England. **Future actions:** Conduct sturgeon habitat assessment	n/a

Main threats impacting various life stages of sturgeon in England	Life stage			Status in England	Reference
				on English catchments.	
Estuarine habitat quality	**Low**	**Low**	n/a	There is an indication that the extent of soft sand, sandy mud, and muddy habitats are sufficient for sturgeon as primary feeders. This is supported by estuaries hosting thriving populations of seals and other fish species such as smooth hounds who forage on similar prey.	Cox, T. and others 2020
Impingement and Entrainment	**Moderate**	**High**	**High**	Throughout their lifecycle Sturgeon are exposed to the risk of impingement and entrainment at water intake structures across fresh, estuarine and marine waters. However, the scale of the impact on current and future populations is unknown	Cook, S.J. and others 2020
Coastal habitat quality	**Low**	**Low**	n/a	Coastal infrastructure developments can have detrimental effects through loss of productive feeding habitats, migration obstruction, entrainment and impingement risks. Stability of bottom sediments and	Jaric & Gessner 2013. OSPAR Status Assessment European Sturgeon 2020.

Main threats impacting various life stages of sturgeon in England	Life stage			Status in England	Reference
				maintenance of hydrodynamic conditions providing ample opportunity for benthic invertebrates to thrive are essential prerequisites for a sufficient food base for these species. Dredging, hydro-constructions (groynes), and bottom touching fishing gear adversely affect these conditions and results in a reduction of carrying capacity. (OSPAR 2020)	Cooke and others 2020. Mussen and others 2014. Western Gateway 2023.
Water quality	**Unknown**	**Unknown**	**Unknown**	Not known for sturgeon.	
Sediment quality	**Unknown**	**Unknown**	**Unknown**	Historic pollution of English waterbodies has led to a legacy of contaminated sediments particularly in the estuarine environment. Persistent pollutants including PCBs enter the food chain through the primary feeders. As a large slow growing fish, bioaccumulation of persistent pollutants in body tissue affecting fish health	Jepson and others 2016

Main threats impacting various life stages of sturgeon in England	Life stage			Status in England	Reference
				and reproduction may be a threat. However, the impact on sturgeon is not yet documented in the literature.	
Introduction of non-native sturgeon species	**High**	**Moderate**	**Moderate**	Introduction of non-native sturgeon species has increasingly been observed. The potential impacts of the alien species comprise introduction of pathogens, hybridization, and competition for food.	Arndt and others 2002
Anthropogenically altered fish assemblages and non-native predators	**High**	**Moderate**	**Moderate**	The introduction and mismanagement of predators such as the Wels catfish (*Silurus glanis*) for angling purposes increases the risk of predation of sturgeon juveniles.	Kirschbaum and others 2011
Underwater noise	**Unknown**	**Unknown**	**Unknown**	The impact of underwater noise on migration patterns of sturgeon is not known.	n/a
Marine bycatch	**High**	**High**	**Low**	Bycatch is the main threat for the last remaining population. Poaching in the future potentially can have a detrimental impact upon population development (Jaric & Gessner 2013).	Jaric & Gessner 2013 MMO 2017

Main threats impacting various life stages of sturgeon in England	Life stage			Status in England	Reference
				Risk of mortality due to marine by-catch. Survival rate depends on awareness of fishermen and innovation of fishing gear. Sector is closely involved in raising awareness and conducting monitoring. The Marine Management Organisation provides advice for fishers.	
Climate change	**Moderate**	**Moderate**	**Moderate**	While not a current threat, there is the potential for climate change to adversely impact the species through changes in flow and discharge that impact reproduction, high temperatures, and false cues for spawning. **Future actions:** Temperature regimes and water discharges should be modelled for sturgeon in English rivers under climate change scenarios.	Delage and others 2014 Lassalle and others 2010

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Natural England is here to secure a healthy natural environment for people to enjoy, where wildlife is protected, and England's traditional landscapes are safeguarded for future generations.

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