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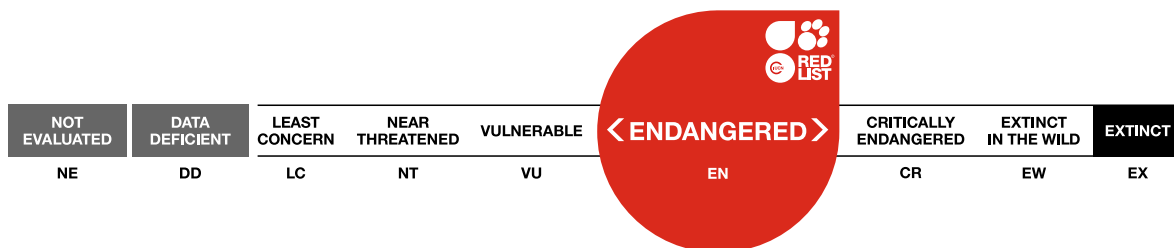
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HAL Authorization

Salmo salar Allier subpopulation

Assessment by: Evanno, G., Legrand, M., Nevoux, M., Prévost, E. & Phillips, K.



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Taxonomy

Kingdom	Phylum	Class	Order	Family
Animalia	Chordata	Actinopterygii	Salmoniformes	Salmonidae

Scientific Name: *Salmo salar* Allier subpopulation

Parent Species: See [Salmo salar](#)

Assessment Information

Red List Category & Criteria: Endangered A3bd; C1+2a(ii) [ver 3.1](#)

Year Published: 2023

Date Assessed: January 23, 2023

Justification:

The *Salmo salar* Allier subpopulation occurs in France where it is restricted to the Allier river upstream from the city of Vichy and its tributary the Alagnon river. The Allier is a tributary of Loire and it holds the only wild subpopulation left in the broader Loire river network.

Application of the Red List Categories and Criteria:

Criterion A: Projections of the number of potential breeders (i.e. moving upstream from Vichy) show clearly that, under a regime of environmental perturbations identical to the past (i.e. since the 1990s), the Allier subpopulation size is in decline. The conditions relative to the causes of the decrease for considering the fulfilment of criteria A3 are met. These causes are not fully understood. Among those identified, the constraint imposed by dams on fish migrations (both upstream and downstream) is one of, if not the major one and has not ceased, despite some slow improvement over the last two or three decades. The reduction in the number of breeding adults over three generations (i.e. 15 years) is estimated at 78%. The reduction is assessed relative to the average number of adults observed at the Vichy counting facility over the last decade (2011-2020: 658). The estimated decrease does not quite meet CR A3 (i.e. slightly lower than the 80% threshold), but it does meet **EN A3bd**.

Criterion B: The extent of occurrence (EOO) is 13,588 km² and the area of occupancy (AOO) is 552 km² meeting VU B1 and VU B2, respectively. The additional subcriteria are not investigated further given the species qualifies in a higher category based on other criteria.

Criterion C: **EN C1+C2a(ii)** is fulfilled with a reproductive population size of 658, in continuing decline at a rate of 72% over two generations (i.e. 10 years), and with all mature individuals in a single subpopulation.

Criterion D: The average reproductive population size over the last decade is 658 meeting VU D1.

Criterion E: A quantitative analysis of the probability of extinction in the wild is not considered and so

criterion E cannot be used.

Given all the elements reported herein, the Allier subpopulation of Atlantic Salmon is assessed as **Endangered A3bd; C1+C2a(ii)**. It should be noted that the subpopulation is close to meeting CR A3bd.

Geographic Range

Range Description:

Gilbey *et al.* (2018) place this subpopulation within the France/Spain subpopulation of *Salmo salar* based on the 18 most genetically distinct stocks (all of which are assigned >80% accuracy) in the European component of the species' range (see final column in Table 2; Figure 4C). However, here it is considered a distinct subpopulation. Atlantic Salmon is known for its homing behaviour, i.e. salmon adults have a very marked propensity to return to spawn in the river they were born. In France, the 34 salmon rivers holding wild populations are structured into five genetic clusters: Upper Normandy, Lower Normandy, Brittany, Allier, and Adour (Perrier *et al.* 2011). The Allier subpopulation forms a distinct cluster that is the most differentiated from all other subpopulations in France (Perrier *et al.* 2011, 2013). The local adaptation of the Allier subpopulation has been demonstrated through distinct reaction norms of embryos to hypoxic and thermal stress (Côte *et al.* 2012, 2016). The salmon adults of the Allier spend longer time at sea: they are almost exclusively made of so-called Multi-Sea-Winter fish (MSW), i.e. having spent more than one winter at sea (two to three). This unique feature in France and Europe is most likely linked to another unique feature: in the Allier, salmon adults need to accomplish an extremely long upstream migration to reach their spawning grounds, located 750 to 950 km from the river mouth. Combined with a distance of more than 100 kilometres between the Loire river mouth and that of the closest neighbouring salmon rivers (in Brittany), it makes extremely unlikely that propagules originating from other subpopulations can demographically rescue the Allier subpopulation. Accordingly, in the different genetic analyses performed in the Allier subpopulation, no immigrant from another subpopulation was identified, whereas such individuals are observed in the other populations and genetic clusters in France (Perrier *et al.* 2011, 2013).

The Allier subpopulation is located in the Allier River that is a tributary of the Loire river, the longest river in France which flows into the Bay of Biscay. The spawning grounds and the nursery habitats for juveniles are located from 750 to 950 km from the estuary. After spending one or two years in freshwater, the individuals undertake a wide range migration in the North Atlantic Ocean, up to the west coast of Greenland. See Figure 1 in the Supplementary Information for a detailed figure of the Allier River and its tributaries.

The extent of occurrence (EOO) is 13,588 km² and the area of occupancy (AOO) is 552 km² meeting VU B1 and VU B2, respectively. Note, however, that the area of fluvial habitat actually supporting the Allier subpopulation has been mapped and it amounts to only 3.6 km².

For further information about this species, see [Supplementary Material](#).

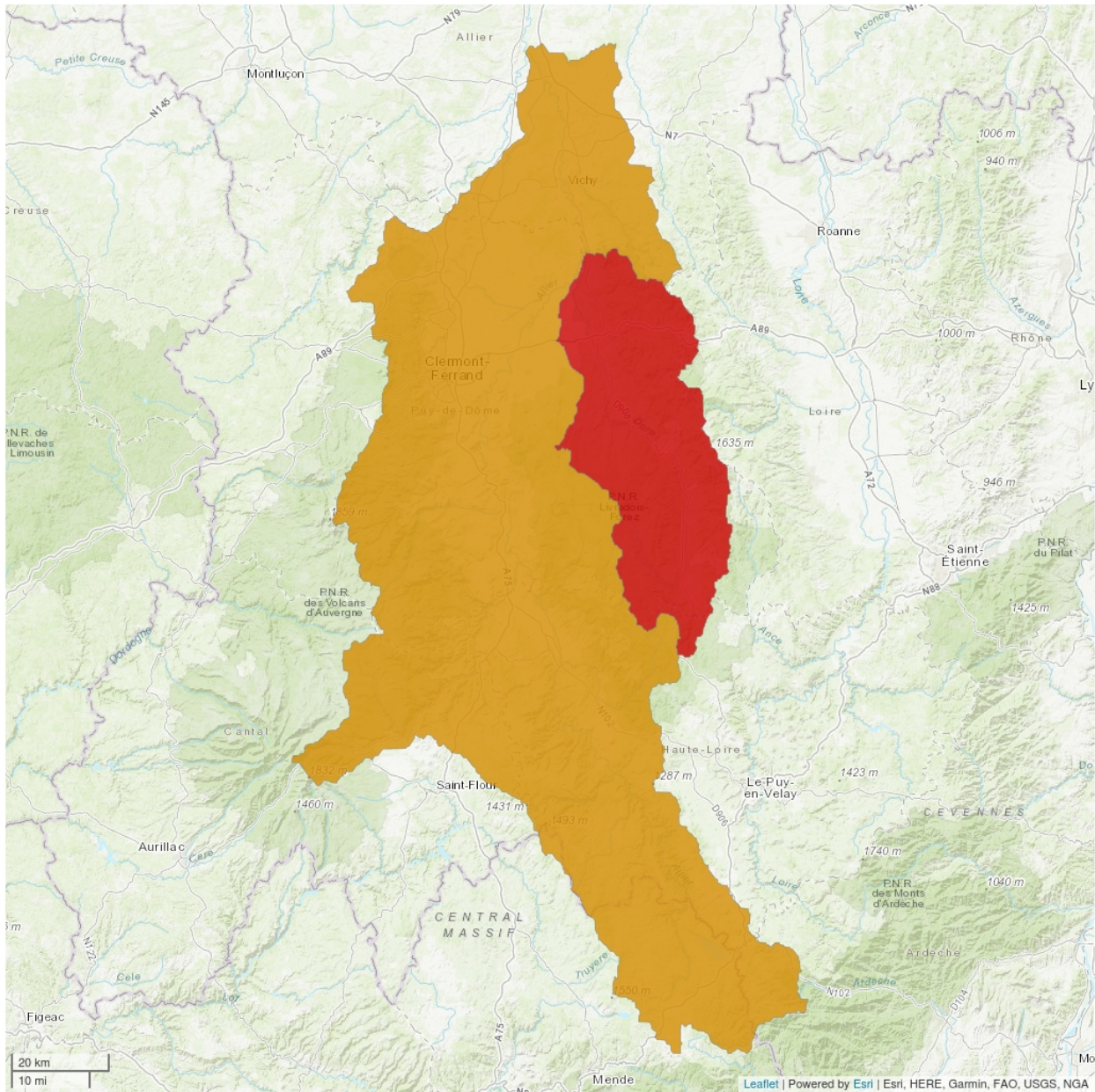
Country Occurrence:

Native, Extant (resident): France (France (mainland))

FAO Marine Fishing Areas:

Native: Atlantic - northeast

Distribution Map



Legend

- EXTANT (RESIDENT)
- EXTINCT

Compiled by:

IUCN (International Union for Conservation of Nature) 2023



The boundaries and names shown and the designations used on this map do not imply any official endorsement, acceptance or opinion by IUCN.

Population

Salmon fishing is prohibited in the entire Loire network since 1994. With the aim of helping the maintenance of the population, juveniles produced in hatchery from broodstock originating from the Allier are released in the river since the 1970s. This supplementation policy has notably intensified from the 1990s. See Figure 2 in the Supplementary Information for adult returns at Vichy and 20 years projection without supplementation from releases of hatchery produced juveniles.

The Allier subpopulation has been monitored since at least the 1980s. The quality, quantity, and spatial coverage of the data gathered has increased over time. Historically, only the catches (both commercial and recreational) were recorded. Currently, the number of adults returning at Vichy (with complementary counts made upstream at Langeac and Poutes), the number of spawning redds, and the densities of riverine juveniles are monitored. The habitat suitable for spawning and juvenile rearing has been mapped too. More details about the monitoring programme can be found at the LOGRAMI website (<https://www.logrami.fr/actions/>; <https://www.migrateurs-loire.fr/les-indicateurs/saumon/>).

An Integrated Population Model (Schaub and Kéry 2022) representing the salmon demographics in the Allier was set by Dauphin and Prévost (2013) (Dauphin *et al.* 2013, 2017). It is inspired by the life cycle modelling approach presented by Rivot *et al.* (2004). This model is updated and improved yearly (Legrand and Prévost 2015, 2016, 2017). Its Bayesian treatment synthesizes the diverse assemblage of data sets available (Rivot and Parent 2013). It allows to quantify retrospectively since the 1980s and to forecast the abundance of the population at the adult and juvenile (young of the year) stages. The contribution of the hatchery reared fish is separated from the component issuing from wild reproduction (Dauphin *et al.* 2017).

The number of adults is fully counted at the Vichy's dam facility (<https://www.logrami.fr/actions/stations-comptage/vichy/>). It is a proxy that overestimates the number of breeders actually contributing to reproduction, because riverine mortalities of potential breeders have been documented between the time they reach Vichy and the spawning season (in late November to December; Baisez *et al.* 2011). This number fluctuates significantly between years but, since the beginning of the counting in 1997, it is almost always greater than 250 (227 in 2010 and 246 in 2022), the lowest threshold used by IUCN for the CR C, but always lower than the 2,500 threshold used for EN C. The average over the last decade (2011-2020) is 658.

Population trends are assessed by means of the projection made using the latest version of the Bayesian Life Cycle model developed for the Allier subpopulation (Dauphin and Prévost 2013; Legrand and Prévost 2015, 2016, 2017). These projections reflect the current demographics under the hypothesis that the past regime of environmental perturbations would remain stationary in the future. A projective analysis has been preferred to a retrospective analysis, because the adult returns observed in the Allier are made of a mixture of wild origin and of hatchery origin. These two components cannot be easily separated out at the adult stage, but the model does allow to derive wild reproduction only projections for adults. Note also that, even though projections in the future are used, they are based on the environmental perturbation regime that prevailed in the past, hence they represent sort of a mixture of retrospective and prospective trends. Thanks to the Bayesian approach used, probabilistic statements of fulfilment of the IUCN criteria can be produced. The numbers of breeding adults in the future is estimated by the median of the distributions of the corresponding projections.

Projections of the number of potential breeders (i.e. moving upstream from Vichy) show clearly that, under a regime of environmental perturbations identical to the past (i.e. since the 1990s), the Allier subpopulation size is in decline. The conditions relative to the causes of the decrease for considering the fulfilment of criteria A3 are met. These causes are not fully understood. Among those identified, the constraint imposed by dams on fish migrations (both upstream and downstream) is one of, if not the major one and has not ceased, despite some slow improvement over the last two or three decades. The reduction in the number of breeding adults over three generations (i.e. 15 years) is estimated at 78%. The reduction is assessed relative to the average number of adults observed at the Vichy counting facility over the last decade (2011-2020: 658). The estimated decrease does not quite meet CR A3 (i.e. slightly lower than the 80% threshold), but it does meet EN A3b. The reduction in the number of breeding adults over two generations (i.e. 10 years) is estimated at 78%. Given the small population size and the subpopulation structure, the subpopulation also meets EN C1+2a(ii).

For further information about this species, see [Supplementary Material](#).

Current Population Trend: Decreasing

Habitat and Ecology (see Appendix for additional information)

The ecology of the Atlantic Salmon is described in detail by Mills (1989) and Aas *et al.* (2010) and is summarised below. It should be noted that these are general characteristics and may not always apply to individual subpopulations.

Habitat

Atlantic Salmon is found in rivers where water temperature rises above 10°C for at least three months per year and does not exceed 20-25°C for more than a few weeks in summer. Juveniles and resident stream populations inhabit riffles of fast-flowing, moderately cold streams and rivers. In northern Europe, juveniles may live in cold lakes. Salmon spawn mostly in natal streams, in rivers and streams with swift flowing water and a succession of riffles and pools. Lacustrine populations migrate to tributaries. They usually spawn in depressions made by the female fish in the gravel. It has a pelagic lifestyle at sea or in large lakes, mostly foraging in surface layers, but also performs frequent dives to several hundred meters in depth (Hedger *et al.* 2017). In the ocean, the Atlantic Salmon can dive to 900 m depth, but is usually present at depths of 0-10 m (Strøm *et al.* 2017).

The salmon rivers of France are a mix of slow flowing streams with limited elevation change and relatively high precipitation passing through broad fertile well vegetated plains, with rivers rising in the mountains, which are snow-capped into the early summer, and have ample rainfall. Many of the rivers are heavily impacted by human activities and dams.

Biology

Atlantic Salmon includes both anadromous and landlocked subpopulations. Evidence suggests that spawning in 'couples' occurs the minority of times, with most spawnings involving multiple males. Spawning occurs mostly from mid-November to mid-December in France, although spawning time can also vary among subpopulations. They generally spawn in streams, usually in gravel-bottomed riffles

above or below a pool. Females select the spawning sites and create shallow spawning sites (redds; areas of disturbed gravel) which may contain one or more nests, each nest being the result of a separate spawning event. Males guard and defend females against other males. An individual female may dig up to fourteen nests (average of around six) depending on their size, and both sexes may mate with several partners. The female spawns into the nest depression and eggs are covered with gravel by the female. On completion of spawning, females drop downstream, while males may remain to spawn with further females. All males essentially die after reproduction, while some females (kelts; post-spawning adult) may survive spawning and migrate back to sea in autumn or overwinter in rivers and migrate again in spring (Belding 1934).

Eggs are covered with 10-30 cm of gravel and hatch in 45-160 days, or 110 days on average, and normal egg development requires water temperatures less than 10°C (optimum 6°C) (Drummond Sedgwick 1982). Successful development of eggs and alevins (fry with egg sack attached) requires a water permeability through gravel above one meter per hour. Alevins are negatively phototactic and move deep into gravel. Fry are positively phototactic and inhabit very shallow riffles, usually downstream of spawning site. Fry usually emerge from gravel between February and March when the temperature rises above 8°C. Young over one year old (parr) are territorial, feeding on drifting and benthic invertebrates. Some males may spawn for the first time when they are still parr and are then able to fertilise more than 20% of eggs by sneaking into redds of anadromous couples (Saunders *et al.* 1982). In some cases fertilization rates for these precocious parr may be even higher (e.g. Grimardias *et al.* 2010). Mature parr are also able to successfully fertilize eggs in the absence of anadromous males. Mature male parr usually migrate to sea but have a lower probability of returning to breed as adults than males that did not mature as parr. Some parr may remain in freshwater. Ripe female parr are very rare. A few landlocked stream populations maturing as parr are known from Norway, in streams where waterfalls prevent access to anadromous salmons. Parr feed for 1-7 (usually 2-3) years in freshwater depending on temperature and feeding conditions. Usually at 100-150 mm salmon parr change into an intermediary life stage adapted for life in salt water which is known as a smolt; smoltification is triggered by increasing day length in winter. Neither sex feeds in freshwater during the spawning and post-spawning migrations. Usually, 0.3-6.0% of females reproduce a second time. They may spawn in the year following the first reproduction or may remain at sea for 18 months before returning once more to the river.

Smolts start to migrate downstream in April-May when temperature increases above 8-10°C from low winter levels. Migration peaks when rising water levels coincide with increased turbidity during spring floods or heavy rain. A small number may migrate to sea in autumn. Smolts are gregarious and migration is nocturnal with peaks at dusk and dawn. Learning the route during downstream migration seems to be the main factor determining successful homing. Smolts may spend some time in brackish estuaries or they may immediately move to the sea. At sea, the species is pelagic and feeds on small fish and large crustaceans such as amphipods and euphausiids. After spending between one and three winters at sea, individuals migrate to their natal river. As returning adults, neither males nor females feed in fresh water, and the migration and spawning process results in an approximate 40% loss in body weight (Belding 1934).

Patterns of upstream migration depend on the particular river and age of the fish. Individuals may enter rivers in any month of the year, with some fish entering more than a year before spawning. Individuals that have spent more than one winter at sea usually seem to enter rivers in spring while those that spent a single winter at sea dominate the autumn run. A number of individuals enter their non-natal

river and either stay (and may breed successfully) or leave and enter another river (either natal or non-natal). During upriver migration, the silvery colour of the marine phase is replaced by a dark breeding colour; the skull of males enlarges and they develop a kype on the lower jaw.

The generation length of the species ranges, largely depending upon latitude, between two year (if you include mature precocious male parr) to 10 years (Hutchings and Jones 1998, Erkinaro *et al.* 2019), with an average of between four and five years. Juveniles spend one or two years in the river before migrating to sea. Their marine migration last two or three years before returning as mature adults in the Allier. They spend almost a full year in the riverine environment between their entry in the river mouth and their reproduction. Almost all fish have a single reproductive event before dying. Hence, the average generation time for the Allier subpopulation is considered to be five years.

Systems: Freshwater (=Inland waters), Marine

Use and Trade

In general, the species is an important food and sport angling fish. For this subpopulation, recreational and commercial fisheries are closed since 1994.

Threats (see Appendix for additional information)

In the Allier subpopulation, the specific threats identified include:

- reduced access to spawning and nursery habitats due to weirs and dams;
- deterioration of spawning and juvenile habitats;
- insufficient reserved flow levels in some stretches of water;
- a lack of appropriate spawning gravel due to dams blocking river transport;
- an increase in sedimentation linked to dam management and changing farming practices;
- deteriorating conditions for migration in the lower stretches of large river, notably linked to reduced low-water levels (abstractions and climate change), and;
- downstream mortalities around hydro-electric developments.
- increased mortality (juveniles, adults) in river due to climate change and increasing temperature and decreasing precipitation and river flow, especially since freshwater migration is extremely long in this river from the estuary to spawning grounds.
- repeated organic pollution from farming activities (ex: manure spill over).
- predation from the invasive Wels Catfish (*Silurus glanis*).
- climate change with increased intensity and occurrence of extreme events (low and high flows in particular), together with increased water temperature in summer (above 20°C).

Conservation Actions (see Appendix for additional information)

The regional management plan (PLAGEPOMI) 2022-2027 for diadromous fish, including salmon, is the fifth since 1996 in the Loire basin. Developed in consultation with the main water stakeholders of the Loire basin, the PLAGEPOMI issues guidelines and recommendations which ultimate objective is to ensure environmental management and human activities are compatible with the safeguarding of diadromous species.

The recommendations focus mainly on the following themes:

- Restore ecological continuity between the sea and the riverine habitat: the objective is to limit fish being killed or held up in the lower and mid sections of their upstream migration routes or delayed during their downstream journey. Ecological continuity is even more important in this large system given the huge migration distance to and from the spawning grounds (up to 950 km). The obstacles to fish migration are identified and mapped and an action plan has been developed for their removal where possible. However, this objective may be undermined by recent legislative incitation to develop micro-hydraulic activities, in order to increase the production of renewable energy in France. Nevertheless, a list of 162 priority dams has been drawn up. These are dams on which actions to ensure compliance with upstream and downstream migration must be particularly monitored and encouraged.
- Identify, preserve and restore the most productive habitats for reproduction and juvenile rearing of Atlantic salmon: the objective is to improve the identification and characterization of habitats of major importance for the reproduction and growth of juveniles and to reinforce the preservation of these habitats.
- Take into account the needs of salmon in the quantitative management of water resources at the basin scale: the objective is to define a minimum biological flow compatible with the requirements of Atlantic salmon for the completion of its life cycle of salmon in the Allier
- Improve knowledge and monitoring of the Allier subpopulation in a context of global change. The Allier subpopulation has been monitored since at least the 1980s. The quality, quantity, and spatial coverage of the data gathered has increased over time. Historically, only the catches (both commercial and recreational) were recorded. Currently, the number of adults returning at Vichy (with complementary counts made upstream at Langeac and Poutes; see Figure 1 in the Supplementary Information), the number of spawning redds, and the densities of riverine juveniles are monitored. The habitat suitable for spawning and juvenile rearing has been mapped too. More details about the monitoring programme can be found at the LOGRAMI website (<https://www.logrami.fr/actions/>; <https://www.migrateurs-loire.fr/les-indicateurs/saumon/>). The objective is to maintain the current monitoring on salmon and to increase knowledge on the less monitored sub-catchments or on the downstream areas of the basin (i.e. estuary).
- Facilitate the recovery of productive and accessible habitats through temporary stocking program. With the aim of helping the maintenance of the population, juveniles produced in hatchery from broodstock of foreign origin (Iceland, Scotland) in the 1970s, then from broodstock originating from the Allier since the 1980s are released in the river. This supplementation policy has notably intensified since the 1990s. The objective of the stocking program is to sustain the wild population until it reaches a level of viability.
- Maintain the recreational and commercial fishing ban on this subpopulation.

For further information about this species, see [Supplementary Material](#).

Credits

Assessor(s):	Evanno, G., Legrand, M., Nevoux, M., Prévost, E. & Phillips, K.
Reviewer(s):	Rand, P.S. & Thorstad, E.B.
Facilitator(s) and Compiler(s):	Sayer, C.

Authority/Authorities: IUCN SSC Salmonid Specialist Group

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Citation

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External Resources

For [Supplementary Material](#), and for [Images and External Links to Additional Information](#), please see the Red List website.

Appendix

Habitats

(<http://www.iucnredlist.org/technical-documents/classification-schemes>)

Habitat	Season	Suitability	Major Importance?
5. Wetlands (inland) -> 5.1. Wetlands (inland) - Permanent Rivers/Streams/Creeks (includes waterfalls)	Breeding season	Suitable	Yes
9. Marine Neritic -> 9.1. Marine Neritic - Pelagic	Non-breeding season	Suitable	Yes
10. Marine Oceanic -> 10.1. Marine Oceanic - Epipelagic (0-200m)	Non-breeding season	Suitable	Yes
13. Marine Coastal/Supratidal -> 13.4. Marine Coastal/Supratidal - Coastal Brackish/Saline Lagoons/Marine Lakes	Passage	Suitable	No
13. Marine Coastal/Supratidal -> 13.5. Marine Coastal/Supratidal - Coastal Freshwater Lakes	Passage	Suitable	No

Use and Trade

(<http://www.iucnredlist.org/technical-documents/classification-schemes>)

End Use	Local	National	International
1. Food - human	No	Yes	Yes
14. Research	No	Yes	Yes
15. Sport hunting/specimen collecting	No	Yes	Yes

Threats

(<http://www.iucnredlist.org/technical-documents/classification-schemes>)

Threat	Timing	Scope	Severity
7. Natural system modifications -> 7.2. Dams & water management/use -> 7.2.9. Small dams	Ongoing	Majority (50-90%)	Slow, significant declines
7. Natural system modifications -> 7.2. Dams & water management/use -> 7.2.10. Large dams	Ongoing	Majority (50-90%)	Rapid declines
8. Invasive and other problematic species, genes & diseases -> 8.1. Invasive non-native/alien species/diseases -> 8.1.2. Named species (Silurus glanis)	Ongoing	Majority (50-90%)	Slow, significant declines
9. Pollution -> 9.3. Agricultural & forestry effluents -> 9.3.2. Soil erosion, sedimentation	Ongoing	Majority (50-90%)	Unknown

11. Climate change & severe weather -> 11.3. Temperature extremes	Ongoing	Whole (>90%)	Slow, significant declines
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Conservation Actions in Place

(<http://www.iucnredlist.org/technical-documents/classification-schemes>)

Conservation Action in Place
In-place research and monitoring
Action Recovery Plan: Yes
Systematic monitoring scheme: Yes
In-place land/water protection
Conservation sites identified: No
Occurs in at least one protected area: Yes
In-place species management
Harvest management plan: No
Successfully reintroduced or introduced benignly: No

Conservation Actions Needed

(<http://www.iucnredlist.org/technical-documents/classification-schemes>)

Conservation Action Needed	Notes
1. Land/water protection -> 1.1. Site/area protection	-
2. Land/water management -> 2.3. Habitat & natural process restoration	-
3. Species management -> 3.1. Species management -> 3.1.1. Harvest management	-
3. Species management -> 3.2. Species recovery	-

Research Needed

(<http://www.iucnredlist.org/technical-documents/classification-schemes>)

Research Needed	Notes
1. Research -> 1.2. Population size, distribution & trends	-
1. Research -> 1.4. Harvest, use & livelihoods	-
1. Research -> 1.5. Threats	-
2. Conservation Planning -> 2.2. Area-based Management Plan	-
3. Monitoring -> 3.1. Population trends	-

Additional Data Fields

Distribution
Estimated area of occupancy (AOO) (km ²): 552
Continuing decline in area of occupancy (AOO): Unknown
Extreme fluctuations in area of occupancy (AOO): No
Estimated extent of occurrence (EOO) (km ²): 13588
Continuing decline in extent of occurrence (EOO): Unknown
Population
Number of mature individuals: 658
Continuing decline of mature individuals: Yes
Extreme fluctuations: No
Population severely fragmented: No
No. of individuals in largest subpopulation: 658
Habitats and Ecology
Continuing decline in area, extent and/or quality of habitat: Yes
Generation Length (years): 2-10,5
Movement patterns: Full Migrant
Congregatory: Congregatory (and dispersive)

The IUCN Red List Partnership



The IUCN Red List of Threatened Species™ is produced and managed by the [IUCN Global Species Programme](#), the [IUCN Species Survival Commission \(SSC\)](#) and [The IUCN Red List Partnership](#).

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