

Redbreast Sunfish (*Lepomis auritus*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, November 2022
Revised, November 2022
Web Version, 3/5/2025

Organism Type: Fish
Overall Risk Assessment Category: High



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<https://www.flickr.com/photos/briangratwicke/6790476900> (November 2022).

1 Native Range and Status in the United States

Native Range

From Fuller and Cannister (2022):

“Atlantic and Gulf Slope drainages, from New Brunswick [Canada] to central Florida, and west to the Apalachicola and Choctawhatchee drainages, Georgia and Florida (Page and Burr 1991).”

From COSEWIC (2008):

“In Canada, the redbreast sunfish has been reported from only southwestern New Brunswick where it has been documented from eight lakes and seven rivers or streams, all within the Saint John River drainage.”

Status in the United States

From NatureServe (2022):

“Native range encompasses the Atlantic Slope [...] south to central Florida, and west on the Gulf Slope to Apalachicola and Choctawhatchee drainages, Florida and Georgia. This species has been introduced in Gulf drainages as far west as the Rio Grande and in the Mississippi River basin as far north as Kentucky and Arkansas (Page and Burr 1991).”

From Fuller and Cannister (2022):

“Established in most locations.”

Fuller and Cannister (2022) report nonindigenous occurrences of *Lepomis auritus* from the following U.S. States and territories: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Missouri, New York, North Carolina, Oklahoma, Pennsylvania, Puerto Rico, South Carolina, South Dakota, Tennessee, Texas, Vermont (status unknown), Virginia, and West Virginia.

There is evidence of *Lepomis auritus* being sold through private fish farms with the intention of producing stock for recreational and aquacultural purposes. For example, the following record was found from a retailer based in Hawkinsville, Georgia.

From Owen and Williams (2022):

“The redbreast sunfish (*Lepomis auritus*) [...] A panfish popular with anglers, the redbreast sunfish is also kept as an aquarium fish by hobbyists.”

“1-2 inches \$0.30”

Regulations

Lepomis auritus is regulated in New Hampshire (NHGF 2022). It is regulated at the family level, Centrarchidae, in Arizona (Arizona Game and Fish Commission 2022) and New Mexico (NMDEF 2010). Please refer back to state agency regulatory documents for details on the regulations, including restrictions on activities involving this species. While effort was made to find all applicable regulations, this list may not be comprehensive. Notably, it does not include regulations that do not explicitly name this species or its genus or family, for example, when omitted from a list of authorized species with blanket regulation for all unnamed species.

From Morris et al. (2005):

“[...] sunfish may be classified as game fish, and the ability to sell them may be limited. In addition, some states, (e.g., Wisconsin), have regulations against the stocking of hybrid sunfish in waters classified as public.”

Means of Introductions within the United States

From Texas Invasive Species Institute (2014):

“[...] intentionally introduced in to [sic] other states for sport fishing, especially in Texas, Alabama and Louisiana.”

From Genard (2014):

“*L. auritus* was introduced into the upper portions of TRD [Tennessee River drainage] in the early 1940s by intentional stocking.”

From Rodríguez-Barreras et al. (2020):

“[...] the dominance of aquarium species in our list [includes *Lepomis auritus*] and the lack of an established aquaculture industry in Puerto Rico indicate that the pet trade has been critical in the introduction of exotic freshwater fish.”

Remarks

Lepomis auritus has been intentionally stocked outside its native range within the United States by State fishery managers to achieve fishery management objectives. State fish and wildlife management agencies are responsible for balancing multiple fish and wildlife management objectives. The potential for a species to become invasive is now one important consideration when balancing multiple management objectives and advancing sound, science-based management of fish and wildlife and their habitat in the public interest.

From Fuller and Cannister (2022):

“In North Carolina, Menhinick (1991) lists this species as introduced into the New and Tennessee drainages. There are no records of Redbreast Sunfish from Mississippi (Scott and Crossman 1973; Lee et al. 1980 et seq.). It is also not mentioned in the manuscript on Mississippi fishes by Ross and Brenneman (1991). This species is not mentioned as occurring in Kentucky by Clay (1975). In their book on Alabama fishes, Mettee et al. (1996) presented some conflicting information regarding native versus introduced ranges. These researchers stated that *Lepomis auritus* is introduced to the Tennessee, Black Warrior, and Choctawhatchee drainages, but they listed the species as "native" in their summary table.”

“Will form natural hybrids with warmouth, green, bluegill, and pumpkinseed sunfish (Scribner et al. 2001).”

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2022):

Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Actinopterygii
Class Teleostei
Superorder Acanthopterygii
Order Perciformes
Suborder Percoidei
Family Centrarchidae
Genus *Lepomis*
Species *Lepomis auritus* (Linnaeus, 1758)

According to Fricke et al. (2022), *Lepomis auritus* is the current valid name for this species.

The following synonym of *Lepomis auritus* was used to search for additional information for this report: *Labrus auratus*.

Size, Weight, and Age Range

From Froese and Pauly (2022):

“Max length: 30.5 cm TL [total length] male/unsexed; [IGFA 2001]; common length : 10.8 cm TL male/unsexed; [Hugg 1996]; max. published weight: 790.00 g [International Game Fish Association 1991]”

From Woods (2014):

“They reach maturity at about two years of age, and have been recorded as large are 900 grams (Etnier and Starnes 1993).”

From South Carolina Department of Natural Resources (2015):

“Average Length: 2-9 inches

Average Size: 3-8 ounces

South Carolina State Record: 2 pounds (1975)

Life Expectancy: Approximately 8 years”

Environment

From Froese and Pauly (2022):

“Freshwater; demersal; pH range: 7.0 - 7.5; dH [depth] range: 15 - ?.”

From Alsip (2022):

“*Lepomis auratus* [sic] is a warmwater species typical of temperate systems where water temperatures range 4-22°C, but is reported to prefer temperatures of 27-29°C (Froese & Casal 2017; Beauchene et al. 2014; Aho & Terrell 1986). This species has been observed in thermally impacted reservoirs where temperatures were as high as 33-35°C (Siler 1975).”

Climate

From Froese and Pauly (2022):

“Temperate”

From Soes et al. (2010):

“*L. auritus* rarely encounters in its native range winter air temperatures below 2°C.”

Distribution Outside the United States

Native

Part of the native range for this species is within the United States, see Section 1 for a complete description of the native range.

From COSEWIC (2008):

“In Canada, the redbreast sunfish has been reported from only southwestern New Brunswick where it has been documented from eight lakes and seven rivers or streams, all within the Saint John River drainage.”

Introduced

From COSEWIC (2008):

“It has been introduced west to Mexico, and abroad to Italy [...].”

From Soes et al. (2010):

“A recent review of the exotic fishes in Italy does not list *L. auritus* (Gherardi et al., 2008) and Fenoglio et al. (2010) actually suggest that Besana [1908] misidentified the ‘sunfish’ [*Lepomis auritus*] and that he actually introduced *L. gibbosus*.”

“For *L. auritus* and *L. cyanellus* there is no conclusive evidence for established populations in Europe and clearly no established populations are present in Germany nowadays [Kottelat and Freyhof 2007].”

“*L. auritus* is not currently listed as present in Europe.”

Lusk et al. (2010) list *Lepomis auritus* as introduced to the Czech Republic around 1913 but it did not result in an established population.

Means of Introduction Outside the United States

According to Soes et al. (2010), *Lepomis auritus* was deliberately imported into Europe in the late 1800s and early 1900s.

Short Description

From Warren (2009):

“**Characteristics:** [...] Body deep, compressed, depth 0.38 to 0.48 of SL [standard length]. Mouth moderate, terminal, oblique, supramaxilla small (>3 times and ≤ 4 times into length of maxilla), upper jaw extending to (or almost to) anterior margin of eye. Wavy blue lines apparent on preorbital area, cheek, and usually opercle. Opercular flap long, narrow, flexible, oriented horizontally or pointing upward, black to posterior margin, usually bordered above and below with blue line. Soft dorsal fin acute. Pectoral fin short and rounded, tip usually not reaching past eye when bent forward. Short thick gill rakers, 9 to 12, longest about twice the greatest width in adults. Lateral line complete. Lateral scales, (39)41 to 50(54); rows above lateral line, 7 to 9; rows below lateral line, 14 to 16(17); caudal peduncle scale rows, (21)22 to 23(25); cheek scale rows, 6 to 9; pectoral rays, (13)14(16). Pharyngeal arches narrow with short, pointed teeth. Teeth on palatine bone. No teeth on endopterygoid, ectopterygoid, or glossohyal (tongue) bones (Scott and Crossman 1973; Barlow 1980; Etnier and Starnes 1993; Mabey 1993; Boschung and Mayden 2004).”

“**Coloration:** Narrow, elongate black ear flap, dark to posterior margin, bordered above and below with blue lines. Wavy, often narrow, blue lines radiate from mouth across sides of snout onto cheek and opercle, broken and often less distinct on opercle. Dark olive above and on sides with yellow flecks and rows of red-brown to orange spots on upper sides, orange spots scattered on lower side. White to orange below. Clear to dusky yellow to orange fins. Breeding male with bright orange breast and belly, orange fins, light powder blue sides with orange spots (Page and Burr 1991; Jenkins and Burkhead 1994; Marcy et al. 2005).”

Biology

From South Carolina DNR (2015):

“The redbreast sunfish can be found areas with slow-moving or sluggish water such as pools and backwaters of streams and rivers and upstream reaches of reservoirs. They can be found in areas with woody debris, stumps, undercut banks, shoreline riprap and rocky points. They prefer areas with a sandy bottom and generally avoid areas that are stagnant or heavily vegetated.”

From Froese and Pauly (2022):

“Adults feed on terrestrial insects and both immature and adult aquatic insects, particularly larger varieties such as mayflies and dragonflies. Juveniles consume benthic organisms such as dipteran larvae [Etnier and Starnes 1993].”

“The female lays around 1000 eggs in the depression created by the male who later takes care of eggs and young alone [Balon 1975].”

From NatureServe (2022):

“In streams with rapids, this fish occurs in deeper slower areas over rock and gravel, often near cover or obstructions. It aggregates in deeper holes when water temperature fall below about 5 C. Eggs are laid in nests made by male on bottom; nests may be close together in ponds and lakes, usually on the downstream side of a rock in a stream.”

“Spawns in spring and summer; male guards[sic] nest, fans eggs, and may briefly guard hatchlings; sexually mature when 2-3 years old; nests may be close together (Scott and Crossman 1973, Manooch 1984).”

From Soes et al. (2010):

“Nest building and spawning begin as water temperature increases from about 17 to 20°C and continues to 31°C. Spawning is protracted (April-early June to August or even October), depending in part on latitude (Bass & Hitt, 1974; Lukas & Orth, 1993). Nesting activity decreases over the summer and is related strongly to the number of degree-days accumulated after water temperatures reach 20°C, although declines may also be related to re-nesting by unsuccessful males or declining numbers of spawning ready females (Sandow et al., 1975; Lukas & Orth, 1993).”

From Alsip (2022):

“In northern latitudes, *Lepomis auratus* [sic] tend to be smaller due in part to shorter growing seasons, making them more vulnerable to predation (Gautreau & Curry 2012).”

Human Uses

From Woods (2014):

“The Redbreast Sunfish, *Lepomis auritus* (Linnaeus 1758), is a popular game fish in eastern United States (Etnier and Starnes 1993).”

From COSEWIC (2008):

“[In Canada,] Sunfishes are not generally regarded by anglers as a sport or food fish, and the redbreast sunfish, because of its small size, is probably one of the least important of the family.

However, they are known to take live bait and, on light tackle may be attractive to young anglers in particular. They do well in captivity and are good test animals in the laboratory.”

Diseases

No information was found associating *Lepomis auritus* with any diseases listed by the World Organisation for Animal Health (2022).

From Texas Invasive Species Institute (2014):

“[...] the redbreast sunfish has been found to carry 2 trematodes, 1 nematode, acanthocephala and leech.”

From Johnson (2019):

“From *L. auritus* [S. Concho River, West Central Texas], the most common and abundant helminth was metacercariae of *Posthodiplostomum minimum*, which were found to infect 100% of all fish. Metacercariae of *Clinostomum marginatum* (prevalence = 11%) were encysted in various tissues. The gills were infected with *Cleidodiscus* sp. with a prevalence of 66%. Swim bladders were infected with the eggs of *Huffmanella* sp. (prevalence = 53%). Adults of *Leptorhynchoides thecatus* (prevalence = 53%), *Bothriocephalus* sp. (prevalence = 7%), and *Camallanus oxycephalus* (prevalence = 19%) were found in the intestine. Juveniles of *Capillaria contonata* (prevalence = 96%) and *Contracaecum* sp. (prevalence = 15%) were encysted in tissue of the gastrointestinal tract.”

Anderson et al. (2015) list the following additional parasites as collected from *Lepomis auritus*: *Diplostomulum* sp., *Pisciamphistoma stunkardi*, *Clinostomum complanatum*, *Crepidostomum cooperi*, *Proteocephalus* sp., *Philometra intraoculis*, *Philometra* sp., *Spinitectus carolini*, and *Neochinorhynchus cylindricus*.

Poelen (2014) lists the following additional parasites and pathogens for *Lepomis auritus*: *Acanthocephalus dirus*, *Actinocleidus bennetti*, *Actinocleidus georgiensis*, *Actinocleidus longus*, *Actinocleidus reversus*, *Aeromonas salmonicida*, *Arhythmorhynchus brevis*, *Bothriocephalus claviceps*, *Camallanus* sp., *Cleidodiscus globus*, *Cleidodiscus similis*, *Contracaecum brachyurus*, *Dactylogyrus centrarchidi*, *Diplostomum cuticola*, *Epistylus colisarum*, *Fessisentis tichiganensis*, *Haplocleidus dispar*, *Huffmanella huffmanii*, Largemouth Bass virus, *Leptorhynchoides apoglyphicus*, *Leptorhynchoides atlanteus*, *Leptorhynchoides macrorchis*, *Leptorhynchoides seminolus*, *Lyrodiscus lanceolatus*, *Neascus wardi*, *Neoechinorhynchus salmonis*, *Onchocleidus* sp., *Onchocleidus ferox*, *Pilum pilum*, *Pomphorhynchus lucyi*, *Proterometra macrostoma*, *Pterocleidus* sp., *Spinitectus micracanthus*, *Spiroxys contorta*, *Urocleidus dispar*, and *Urocleidus principalis*.

Threat to Humans

From Lotti et al. (2022):

“From a human health perspective, 11% of the adult sunfish [includes *Lepomis auritus*] analyzed in this study [in Rhode Island] had Hg [mercury] concentrations exceeding the U.S. EPA

threshold level of 1.36 ppm dry weight. Therefore, only very frequent consumption of sunfish from the study area (> 1 meal/week) are anticipated to pose a risk to human health regarding mercury.”

From Froese and Pauly (2022):

“Potential pest”

3 Impacts of Introductions

From Fuller and Cannister (2022):

“There is circumstantial evidence to indicate that Redbreast Sunfish are displacing native longear sunfish (*L. megalotis*) in eastern Tennessee through direct competition (Etnier and Starnes 1993). Will form natural hybrids with warmouth, green, bluegill, and pumpkinseed sunfish (Scribner et al. 2001).”

From Genard (2014):

“Results indicate that *L. megalotis* abundance declined in reservoirs [Tennessee River drainage] where *L. auritus* was found in high or increasing abundances. Also, *L. auritus* surpassed *L. megalotis* in mean percent abundance in Nickajack-Chickamauga River section and has consequently shifted *Lepomis* species composition. Although it is difficult to isolate causal variables, the interaction of both biotic (i.e., *L. auritus* competition) and abiotic (i.e., geographic variables, land use, and water quality) factors likely explain the changes in *L. megalotis* abundance and variability within river sections.”

From Texas Invasive Species Institute (2014):

“This sunfish has been recorded in Texas since the 1960s and already has placed several fish on the endangered species list. This sunfish competes with the native longear sunfish directly, causing the balance of the ecosystems to be thrown off.”

“In Texas, *Lepomis auratus* [sic] is amongst several non-native species which have become established within the range of the Devils River minnow (*Dionda diaboli*) and has caused the minnow to be species listed as threatened by the Texas Parks and Wildlife Department, the Texas Organization for Endangered Species and the Endangered Species Committee of the American Fisheries Society. It has been recommended since 2001 to no longer introduce *Lepomis auratus* [sic] because of its negative impact on native sunfishes and other fishes.”

Lepomis auritus is regulated in the following States (see section 1): Arizona (Arizona Game and Fish Commission 2022), New Hampshire (NHFG 2022), and New Mexico (NMDGF 2010).

4 History of Invasiveness

Lepomis auritus has been introduced beyond its native range, primarily in the eastern United States and Puerto Rico to create sport fisheries. Many introductions have resulted in established

populations. Although regulated in some States, *L. auritus* appears to be available from retail vendors in the United States. There were no records found quantifying the number of individuals in trade. Several sources report that introductions of *L. auritus* harm native species via competition. The History of Invasiveness category for *L. auritus* is therefore High.

5 Global Distribution

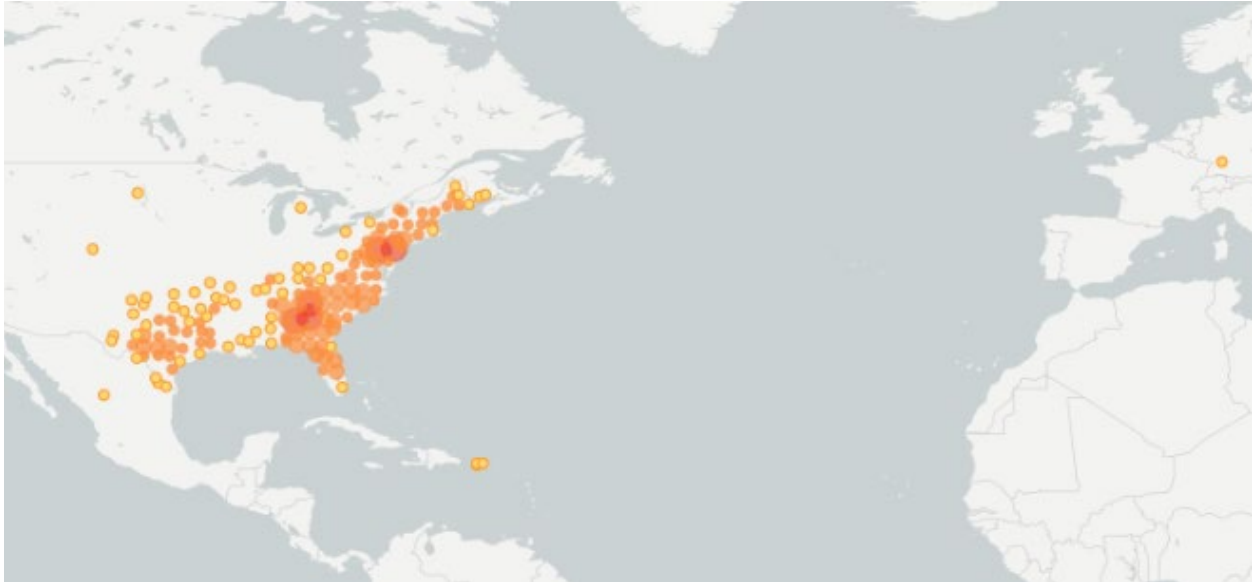


Figure 1. Reported global distribution of *Lepomis auritus*. Map from GBIF Secretariat (2022). Reported observations from Michigan, South Dakota, Colorado, northwestern Mexico, western Pennsylvania, central New York along Lake Ontario, and Germany were excluded from the climate matching analysis as they could not be confirmed to represent established populations of *L. auritus*.

6 Distribution Within the United States



Figure 2. Reported nonindigenous observations of *Lepomis auritus* in the United States. Orange diamonds indicate nonindigenous observations while the orange shading indicates the native range of the species. Map from Fuller and Cannister (2022). The observations from South Dakota were not confirmed to represent established populations and were not used as source points in the climate matching analysis. The observation in western Pennsylvania is outside the known range of the species in the State, could not be confirmed to be an established population (Lorantas and Frick 2018), and was not used as a source point for the climate matching analysis.

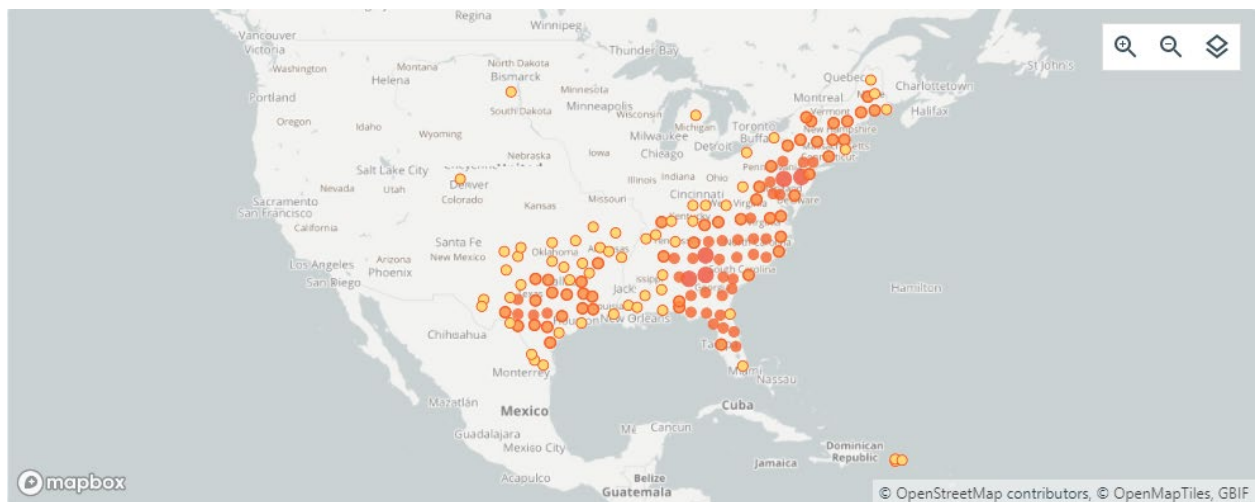


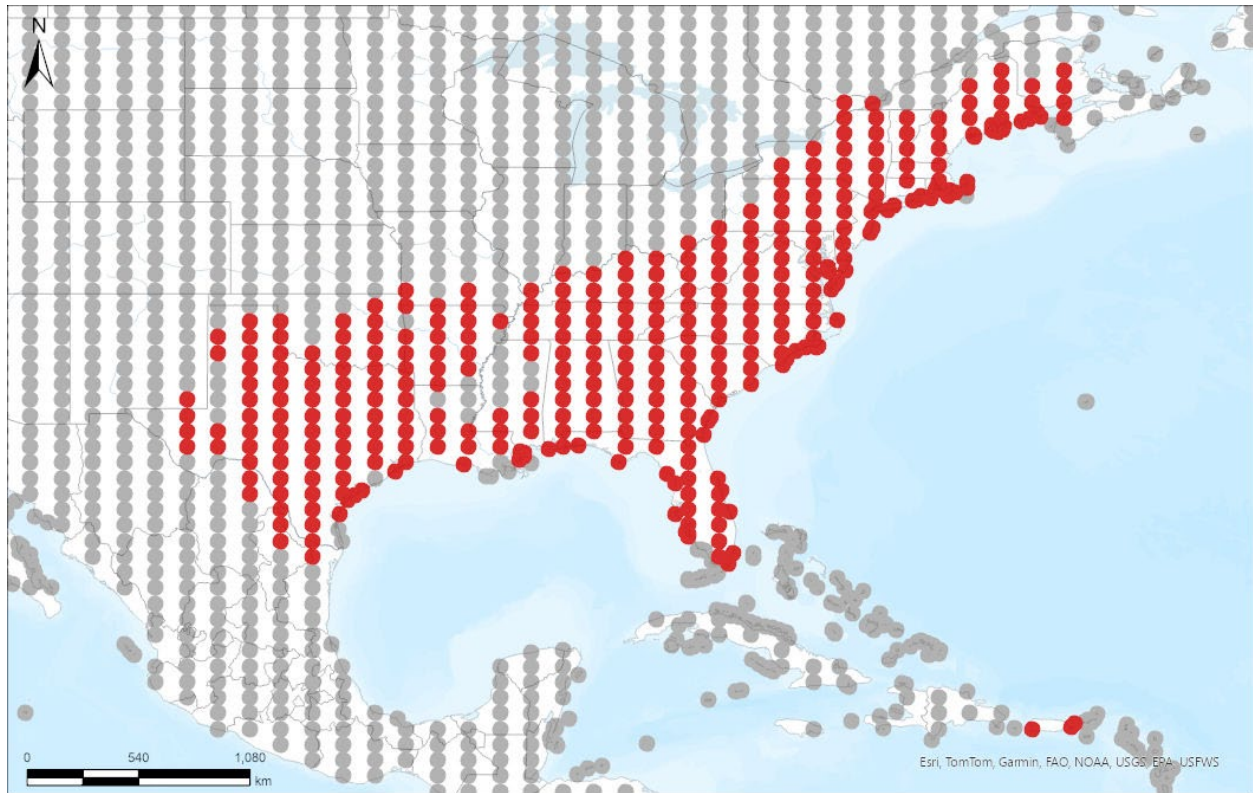
Figure 3. Reported distribution of *Lepomis auritus* in the United States. Map from GBIF-US (2022). Reported observations from Michigan, South Dakota, Colorado, and western Pennsylvania were excluded from the climate matching analysis as they were not found to represent established populations of *L. auritus*. The observation in central New York is outside the known range of the species in the State, could not be confirmed to be an established population (Carlson et al. 2016) and was excluded from the climate matching analysis.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Lepomis auritus* in the contiguous United States was generally high east of the Continental Divide, where *L. auritus* is native. Isolated areas of high match were also found in the Southwest and Rocky Mountains. Medium matches were found generally west of the Continental Divide and in the Upper Midwest. Low matches were restricted to the coastal Pacific Northwest, Cascade Mountains, and Sierra Nevada. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.756, indicating that Yes, there is establishment concern for this species outside its native range. The Climate 6 score is calculated as: (count of target points with scores ≥ 6)/(count of all target points). Establishment concern is warranted for Climate 6 scores greater than or equal to 0.002 based on an analysis of the establishment success of 356 nonnative aquatic species introduced to the United States (USFWS 2024).

Projected climate matches in the contiguous United States under future climate scenarios are available for *Lepomis auritus* (see Appendix). These projected climate matches are provided as additional context for the reader; future climate scenarios are not factored into the Overall Risk Assessment Category.



Species: *Lepomis auritus*

Selected Climate Stations ●



RAMP

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Figure 4. RAMP (Sanders et al. 2023) source map showing weather stations in eastern North America selected as source locations (red; United States, Canada, Mexico) and non-source locations (gray) for *Lepomis auritus* climate matching. Source locations from GBIF Secretariat (2022). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

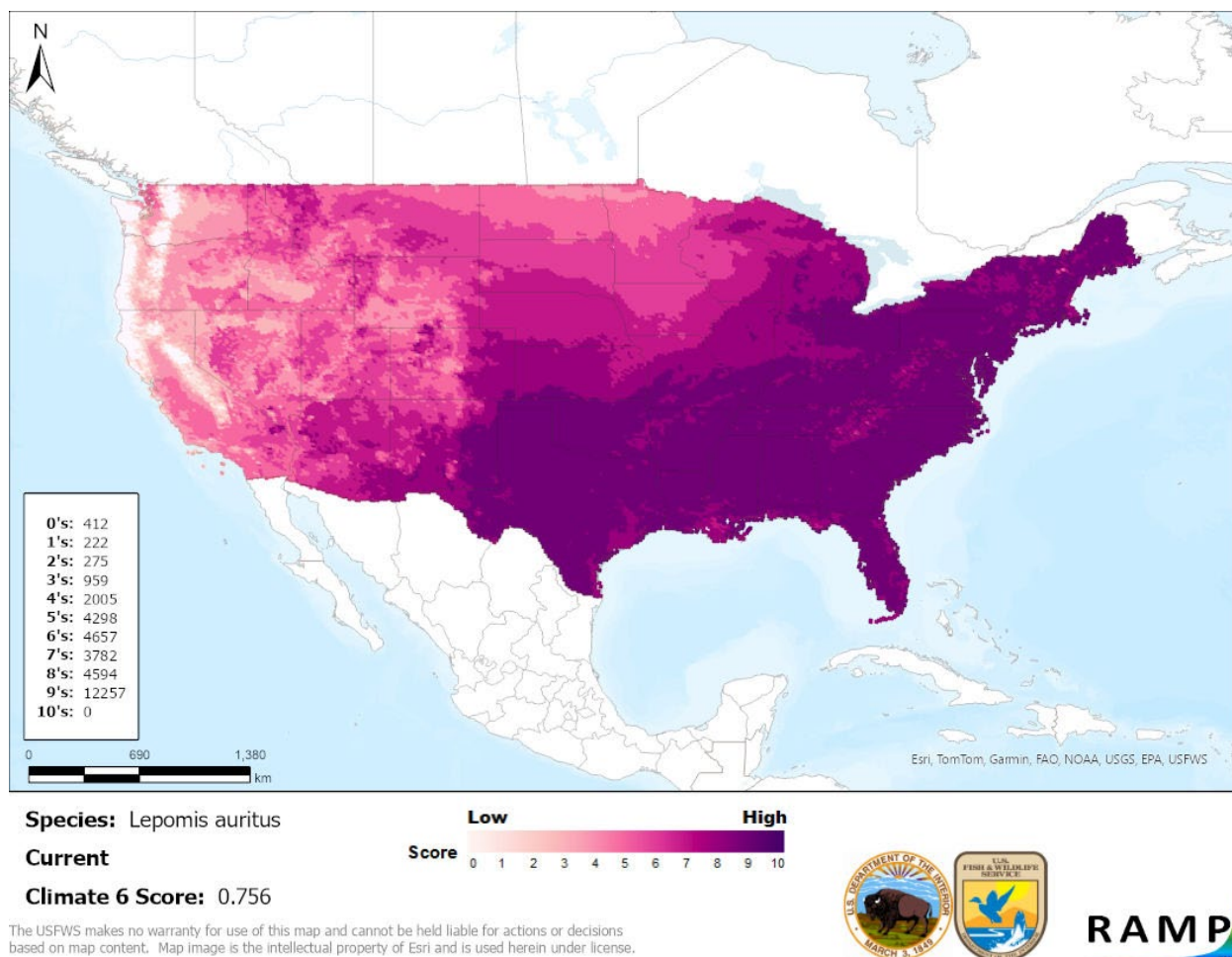


Figure 5. Map of RAMP (Sanders et al. 2023) climate matches for *Lepomis auritus* in the contiguous United States based on source locations reported by GBIF Secretariat (2022). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The certainty of assessment for *Lepomis auritus* is classified as Medium. There is a reasonable amount of information regarding its distribution, ecology, and introductions. However, there is limited peer-reviewed evidence documenting the impacts of established populations of this species, and in some cases, impacts of *L. auritus* may be difficult to distinguish from impacts of other introduced species.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Lepomis auritus, Redbreast Sunfish, is a fish native to the Atlantic and Gulf Slope drainages of eastern North America where it is found in slow-moving freshwater pools, rivers, and lakes with rocky and sandy substrate, and low to medium vegetation. *L. auritus* is a popular gamefish in the United States and has been intentionally stocked beyond its native range. Several introductions

of *L. auritus* have led to established populations, particularly in the southeastern United States, Texas, and Puerto Rico. The History of Invasiveness for *L. auritus* is classified as High. Sources state that introductions of *L. auritus* may harm native species such as *L. megalotis* (Longear Sunfish) and *Dionda diaboli* (Devils River Minnow) via competition and hybridization with congeners. Limited information was found on trade history associated with *L. auritus*. This species is regulated in at least three States. The climate matching analysis for this contiguous United States indicates establishment concern for this species outside its native range. Areas with high match were generally found east of the Continental Divide. Low matches were restricted to the coastal Pacific Northwest, Cascade Mountains, and Sierra Nevada. The Certainty of Assessment is classified as Medium due to limited peer-reviewed information regarding the impacts of established populations. The Overall Risk Assessment Category for *L. auritus* in the contiguous United States is High.

Assessment Elements

- **History of Invasiveness (see section 4): High**
- **Establishment Concern (see section 7): Yes**
- **Certainty of Assessment (see section 8): Medium**
- **Remarks, Important additional information: None**
- **Overall Risk Assessment Category: High**

10 Literature Cited

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in section 11.

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Appendix

Summary of Future Climate Matching Analysis

Future climate projections represent two Shared Socioeconomic Pathways (SSP) developed by the Intergovernmental Panel on Climate Change (IPCC 2021): SSP5, in which emissions triple by the end of the century; and SSP3, in which emissions double by the end of the century. Future climate matches were based on source locations reported by GBIF Secretariat (2022).

Under the future climate scenarios (figure A1), on average, high climate match for *Lepomis auritus* was projected to occur in the Appalachian Range, Great Lakes, Gulf Coast, Mid-Atlantic, Northeast, Southeast, Southern Atlantic Coast, Southern Florida, and Southern Plains regions of the contiguous United States. This area includes the native range of the species. Areas of low climate match was projected to occur in the Northern Pacific Coast region and along the Sierra Nevada. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.788 (model: MPI-ESM1-2-HR, SSP5, 2085) to a high of 0.850 (model: UKESM1-0-LL, SSP3, 2055). All future scenario Climate 6 scores were above the Establishment Concern threshold, indicating that Yes, there is establishment concern for this species outside its native range under future scenarios. The Climate 6 score for the current climate match (0.756, figure 5) falls below the range of scores for future projections. The time step and climate scenario with the most change relative to current conditions was SSP5, 2085, the most extreme climate change scenario. Under one or more time step and climate scenarios, areas within the Northern Plains saw a large increase in the climate match relative to current conditions. Additionally, areas within the Colorado Plateau, Great Basin, Great Lakes, Southern Plains, and Western Mountains saw a moderate increase in the climate match relative to current conditions. Under one or more time step and climate scenarios, areas within the Appalachian Range, Gulf Coast, Mid-Atlantic, Northeast, Southeast, Southern Atlantic Coast, Southern Florida, Southern Plains, and Southwest saw a moderate decrease in the climate match relative to current conditions. No large decreases were observed regardless of time step and climate scenarios, although additional, very small areas of large or moderate change may be visible on the maps (figure A3). The degree of change increased with time.

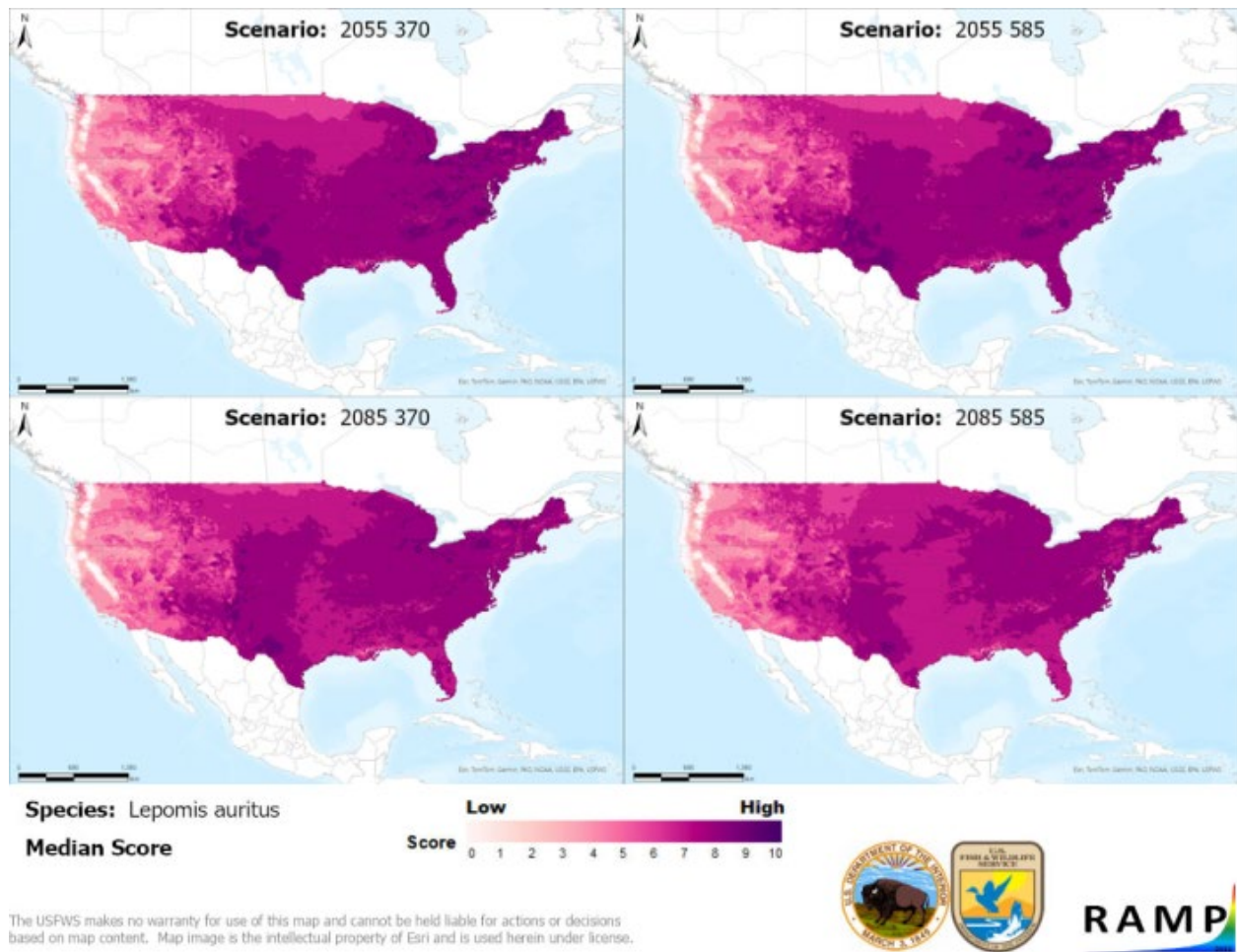


Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Lepomis auritus* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2022). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

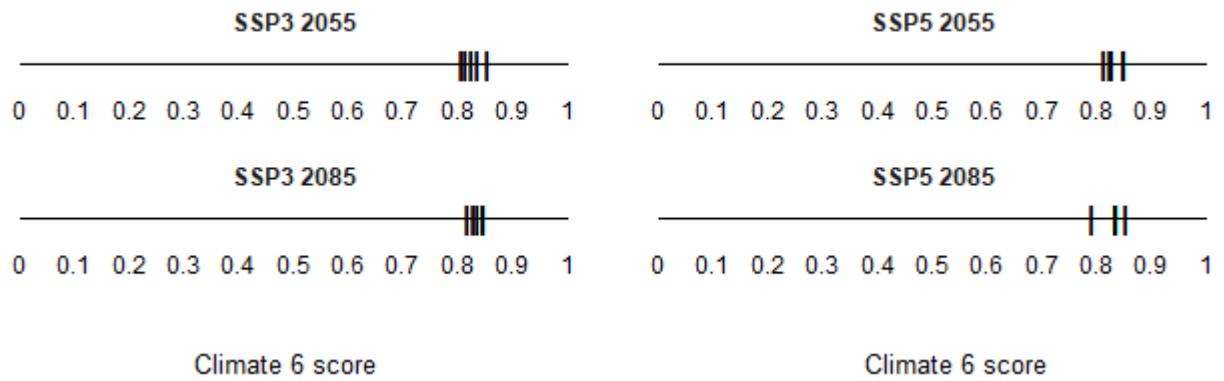


Figure A2. Comparison of projected future Climate 6 scores for *Lepomis auritus* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0.

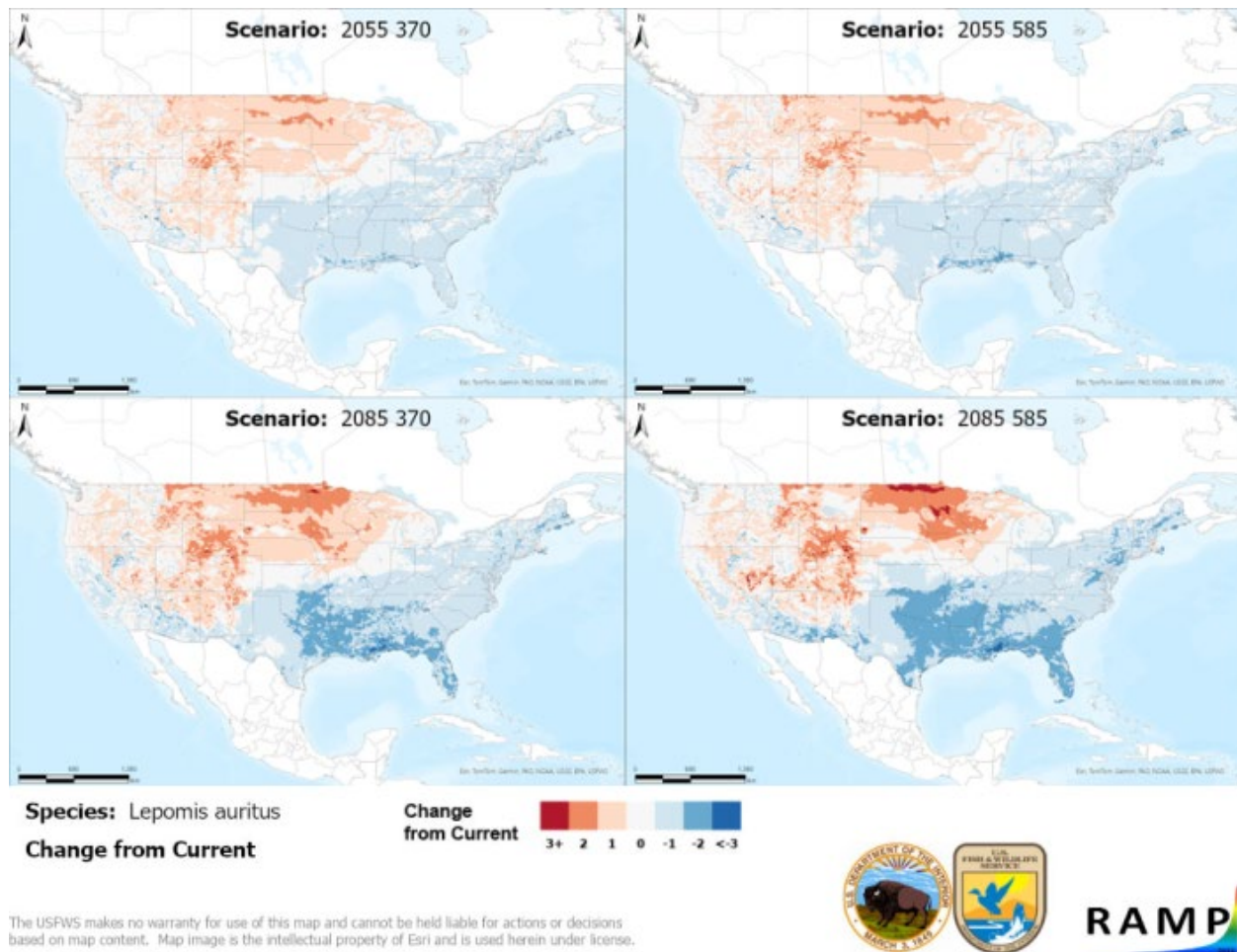


Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 5) and the median target point score for future climate scenarios (figure A1) for *Lepomis auritus* based on source locations reported by GBIF Secretariat (2022). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. Shades of blue indicate a lower target point score under future scenarios than under current conditions. Shades of red indicate a higher target point score under future scenarios than under current conditions. Darker shades indicate greater change.

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