

Flathead Chub (*Platygobio gracilis*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, August 2023

Revised, September 2023

Web Version, 3/26/2024

Organism Type: Fish

Overall Risk Assessment Category: Uncertain



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<https://nas.er.usgs.gov/XIMAGESERVERX/2019/20191202152941.jpg> (August 2023).

1 Native Range and Status in the United States

Native Range

From Steffensen et al. (2014):

“Flathead Chubs [*Platygobio gracilis*] are found throughout the central United States and Canada (Lee et al. 1980). It ranges longitudinally from the Gulf Coast through the middle and lower Mississippi River (below the confluence of the Missouri River) and northwest throughout the Missouri River basin and the Northwest Territories and eastern Yukon of Canada (Olund and Cross 1961, Lee et al. 1980). A disjunct population is also found in the Rio Grande River in New

Mexico. In Nebraska, Flathead Chubs were historically collected throughout all large rivers and their main tributaries except the Blue River system (Johnson 1942, Jones 1963). Wanner et al. (2011) reports capturing 702 specimens from the Niobrara River in 2009; however, interior stream assessments by NDEQ [Nebraska Department of Environment and Energy] did not capture any Flathead Chubs from 2004 to 2008 (Bazata 2011).”

Status in the United States

From Steffensen et al. (2014):

“Flathead Chubs [*Platygobio gracilis*] are found throughout the central United States and Canada (Lee et al. 1980). It ranges longitudinally from the Gulf Coast through the middle and lower Mississippi River (below the confluence of the Missouri River) and northwest throughout the Missouri River basin [...]. A disjunct population is also found in the Rio Grande River in New Mexico. In Nebraska, Flathead Chubs were historically collected throughout all large rivers and their main tributaries except the Blue River system (Johnson 1942, Jones 1963). Wanner et al. (2011) reports capturing 702 specimens from the Niobrara River in 2009; however, interior stream assessments by NDEQ did not capture any Flathead Chubs from 2004 to 2008 (Bazata 2011).”

From Nico (2023):

“[...] Missouri-Mississippi River basin from [...] Montana to Louisiana; upper Rio Grande (including Pecos) drainage, New Mexico. Restricted to Mississippi River proper in Missouri, Illinois, and south; localized in Arkansas River drainage in Oklahoma, Texas, and New Mexico (Page and Burr 1991).”

“Recorded as having been established, at least temporarily, in part of the Gila drainage of New Mexico (Koster 1957); in contrast, Sublette et al. (1990) reported that the species did not become established there. In Colorado, the species apparently persisted for 15 years in the San Luis Closed Basin, but it is no longer considered extant in that region (Zuckerman and Behnke 1986).”

“The only New Mexico site where this species was mentioned as being introduced is Taylor Creek (Sublette et al. 1990). Koster (1957) did not mention the specific locality where this species occurred within the Gila River drainage of New Mexico. [...] Crossman and McAllister (1986) listed this species as possibly present in the U.S. section of the Red River drainage but gave no indication it was introduced there. Lee et al. (1980 et seq.) did not depict the species in that region.”

According to Nico (2023), nonindigenous occurrences of *Platygobio gracilis* have been reported in the following States. Range of observation years, watersheds, and population status (one or more watersheds) where reported in parentheses.

- Colorado (1986; San Luis; extirpated)
- Minnesota (1997-2001; Red; established)
- Montana (1999; Lower Yellowstone-Sunday, Middle Kootenai; eradicated or failed)

- Nebraska (2007; Upper Little Blue; unknown)
- New Mexico (1957; Upper Gila-Mangas; failed)
- North Dakota (1996; Red; collected)
- Wyoming (2010; Central Bear; established)

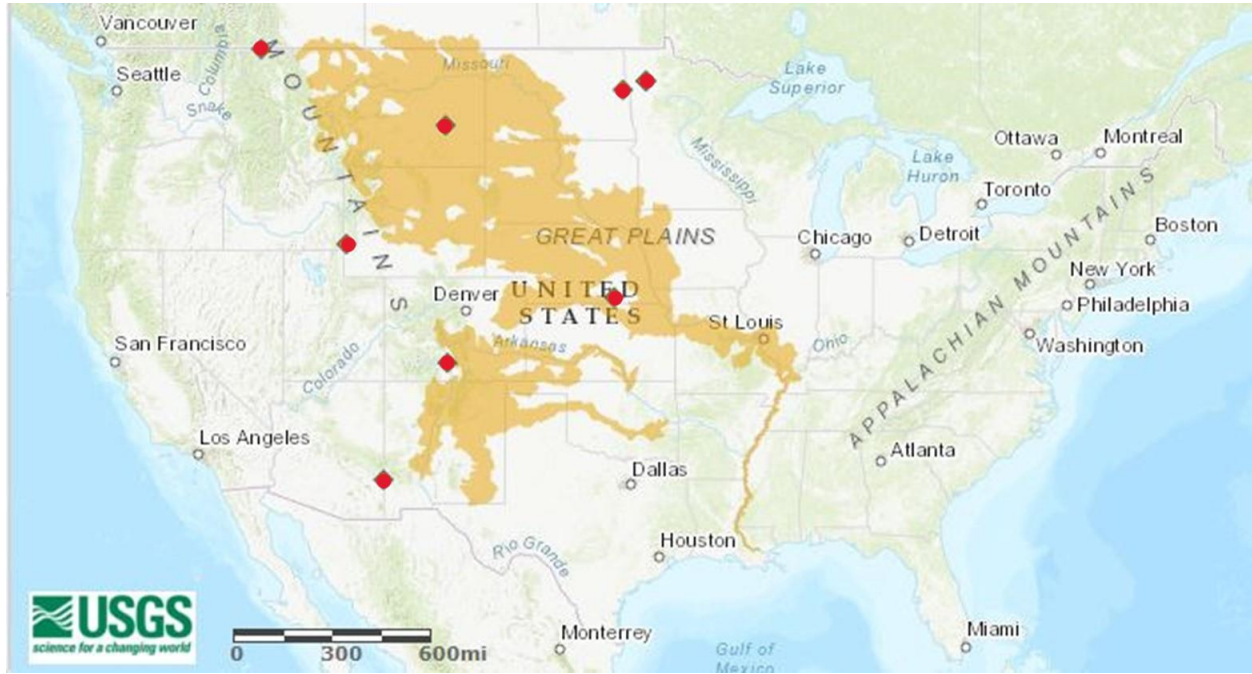


Figure 1. Map of the reported native (orange shading) and introduced (red dots) range for *Platygobio gracilis* in the United States. Map adapted from Nico (2023).

No records of *Platygobio gracilis* in trade in the United States were found.

Regulations

No species-specific regulations on possession or trade were found within the United States.

Means of Introductions within the United States

From Nico (2023):

“Introduced in the Gila River drainage of New Mexico via bait-bucket release (Koster 1957; Sublette et al. 1990). This species was privately stocked as prey for a trout hatchery in the Russell Lakes area of Colorado; the fish came from the Arkansas River drainage (Zuckerman and Behnke 1986). Probably bait-bucket release in Minnesota.”

Remarks

No additional remarks.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2023):

Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Actinopterygii
Class Teleostei
Superorder Ostariophysi
Order Cypriniformes
Superfamily Cyprinoidea
Family Cyprinidae
Genus *Platygobio*
Species *Platygobio gracilis* (Richardson, 1836)

According to Fricke et al. (2023), *Platygobio gracilis* is the current valid name for this species.

From NatureServe (2023):

“Removed from the genus *Hybopsis* and returned to the monotypic genus *Platygobio* by Mayden (1989) and by Coburn and Cavender (1992). This treatment was followed by Sublette et al. (1990) and in the 1991 AFS checklist (Robins et al. 1991).”

The following synonym of *Platygobio gracilis* from ITIS (2023) were used to search for information for this report: *Hybopsis gracilis*.

Size, Weight, and Age Range

From Nico (2023):

“**Size:** 32 cm.”

From Steffensen et al. (2014):

“Maximum reported size is 317 mm (Lee et al. 1980) but adults are typically less than 190 mm (9.5 in) in the Missouri River (Pflieger 1997).”

“The longitudinal range of Flathead Chubs greatly influences the species life span; however in states proximal to Nebraska, maximum age has been estimated at three to four years (Martyn and Schmulbach 1978, Pflieger 1997).”

Environment

From NatureServe (2023):

“Habitat Type: Freshwater

Riverine Habitats: Moderate gradient, MEDIUM RIVER, BIG RIVER, Low gradient”

“Turbid flowing (moderate to strong current) waters in main channels of small to large rivers; in shallow to fairly deep water over mud, rock, or sand. In Kansas, usually in shallow pools but also in strong current over clean sand bottoms (Collins et al. 1995).”

Climate

From Froese and Pauly (2024):

“Temperate; 70°N - 30°N”

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 Nico (2023):

“Mackenzie, Saskatchewan, and Lake Winnipeg drainages in Yukon, Northwest Territories, Manitoba, Saskatchewan, Alberta, and British Columbia [...]”

Introduced

According to Nico (2023), *Platygobio gracilis* was introduced to Lake Koocanusa, which spans the border between British Columbia, Canada, and Montana. Nico (2023) lists this introduction as failed.

Means of Introduction Outside the United States

No information was found regarding means of introduction of *Platygobio gracilis* in the wild outside the United States.

Short Description

From Steffensen et al. (2014):

“The Flathead Chubs [*Platygobio gracilis*] coloration features a light brown back, silvery sides and belly with no other distinct marking on the body [...]. Its mouth is subterminal below a flattened, wedge shaped [sic] head with maxillary barbels (Pflieger 1997).”

Biology

From NatureServe (2023):

“Relies on flood flows to spawn successfully (Collins et al. 1995). Spawns after rivers have subsided after peak flow, when the temperature is warmer and the bottom is more stable, July-August in Montana, Kansas, and Iowa, when temperature reaches about 23-25 C in Montana. Pflieger (1975) stated that spawning may occur in early spring because chubs less than one inch long were collected in Missouri in late May. Sexually mature at age 2 in Iowa, 4 in Canada (Gould 1985).”

“May move into smaller streams to spawn (Scott and Crossman 1973).”

From Steffensen et al. (2014):

“Flathead Chubs use these barbels and external taste buds to locate food as their eyes are small and of little value in turbid waters (Pflieger 1997). Their omnivorous diet primarily consists of terrestrial insects and small invertebrates and to a lesser extent plant material (Olund and Cross 1961).”

Human Uses

According to Nico (2023), *Platygobio gracilis* may have been used as bait.

From Froese and Pauly (2024):

“Fisheries: minor commercial”

“Rarely caught as a game fish [Coker et al. 2001]. Occasionally used as a food fish [Scott and Crossman 1973].”

“Preferred bait fish for blue catfish in Iowa [Scott and Crossman 1973].”

Diseases

No information was found associating *Platygobio gracilis* with any diseases listed by the World Organisation of Animal Health (2023).

Poelen et al. (2014) lists *Dactylogyrus albertensis*, *D. pseudobanghami*, *Rhabdochona canadensis*, *Ligula* sp., *Pomphorhynchus* sp., and *Bothriocephalus acheilognathi* as parasites of *Platygobio gracilis*.

Threat to Humans

From Froese and Pauly (2024):

“Harmless”

3 Impacts of Introductions

Records of introductions and resulting established populations were found. However, no information on impacts from those introductions was found. No State-specific regulations were found for *Platygobio gracilis*.

4 History of Invasiveness

The History of Invasiveness for *Platygobio gracilis* is classified as Data Deficient. *P. gracilis* has become established outside of its native range, however no evidence of negative impacts, or lack of impacts, of introduction were found. *P. gracilis* has been introduced in the United States by bait bucket release, indicating its possible use in trade, however no further information was found regarding its presence in trade.

5 Global Distribution

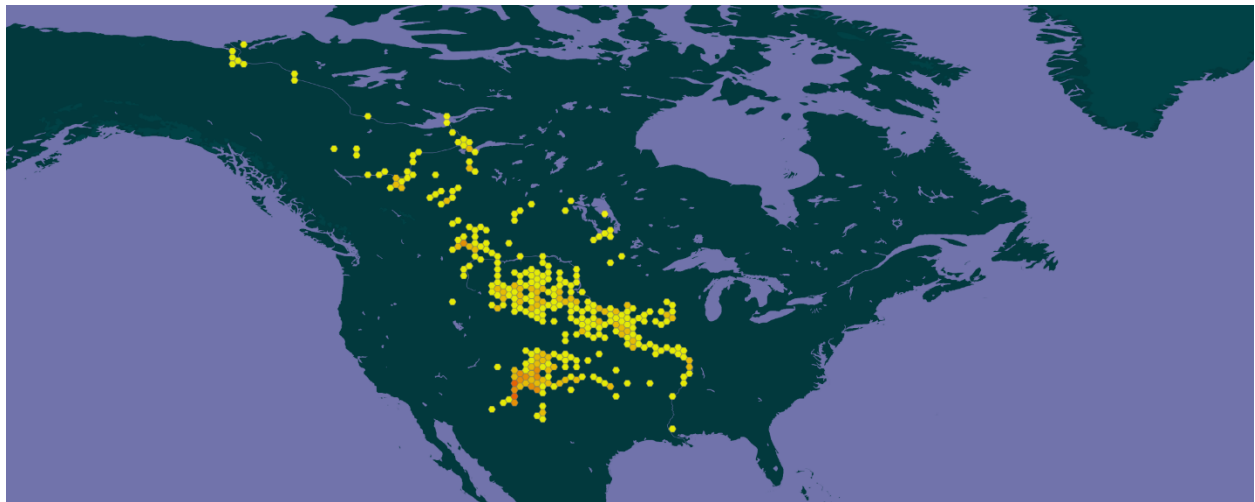


Figure 2. Reported global distribution of *Platygobio gracilis*. Map from GBIF Secretariat (2023). Observations are reported from the United States and Canada.

6 Distribution Within the United States



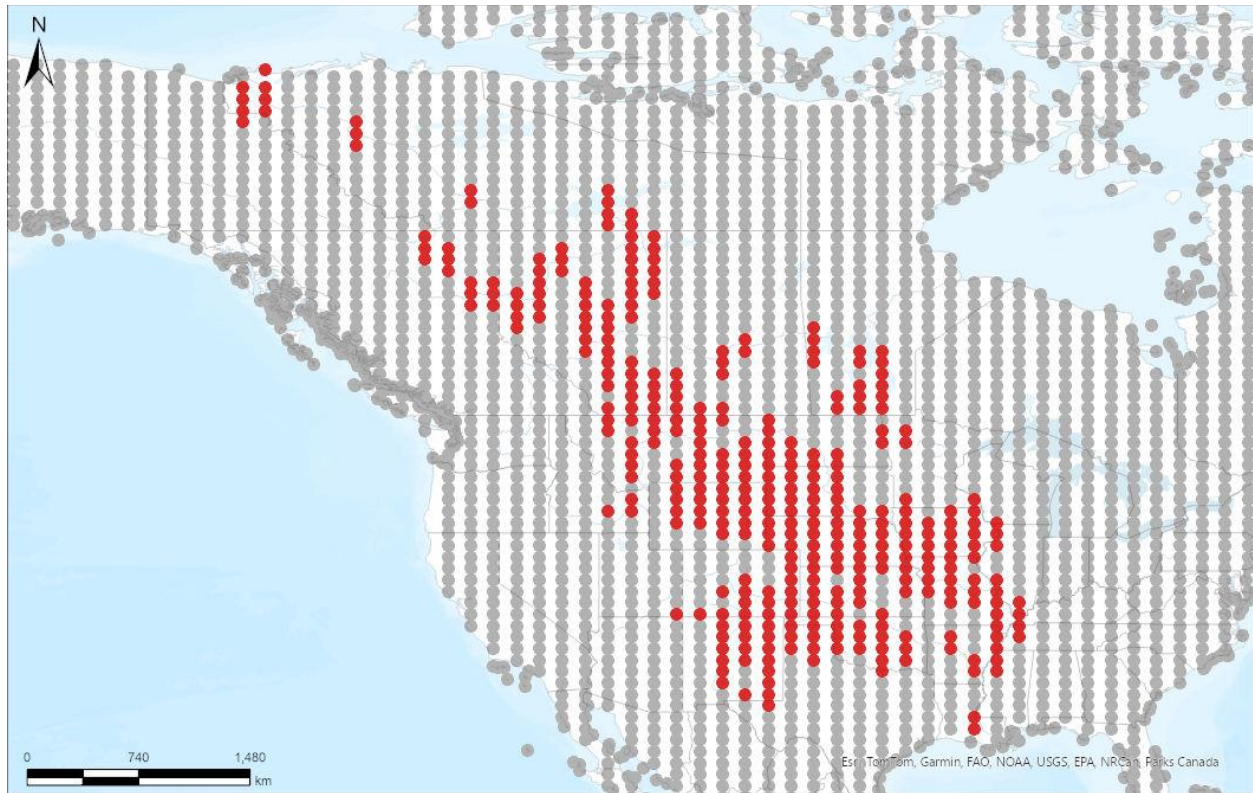
Figure 3. Reported distribution of *Platygobio gracilis* in the United States. Map from GBIF-US (2023). Observations are reported from the central United States stretching from Louisiana to Montana. The observation on the border of New Mexico and Arizona was not used to select source points for the climate match. Available information indicates that introduction failed to establish a population.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Platygobio gracilis* was generally high for the contiguous United States. Few areas of low and medium match were found. The areas of highest match were generally found in the central portion of the United States, in and around the native range. This area ranged from eastern New Mexico to the Gulf Coast, and northward to the Canadian border. Areas of low match were found along the Pacific Coast and in the Sierra Nevada and Cascade Mountains. The Overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.896, indicating that Yes, there is establishment concern for this species outside its native range. The Climate 6 score is calculated as: $(\text{count of target points with scores} \geq 6) / (\text{count of all target points})$. 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 *Platygobio gracilis* (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: *Platygobio gracilis*

Selected Climate Stations ●



RAMP

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

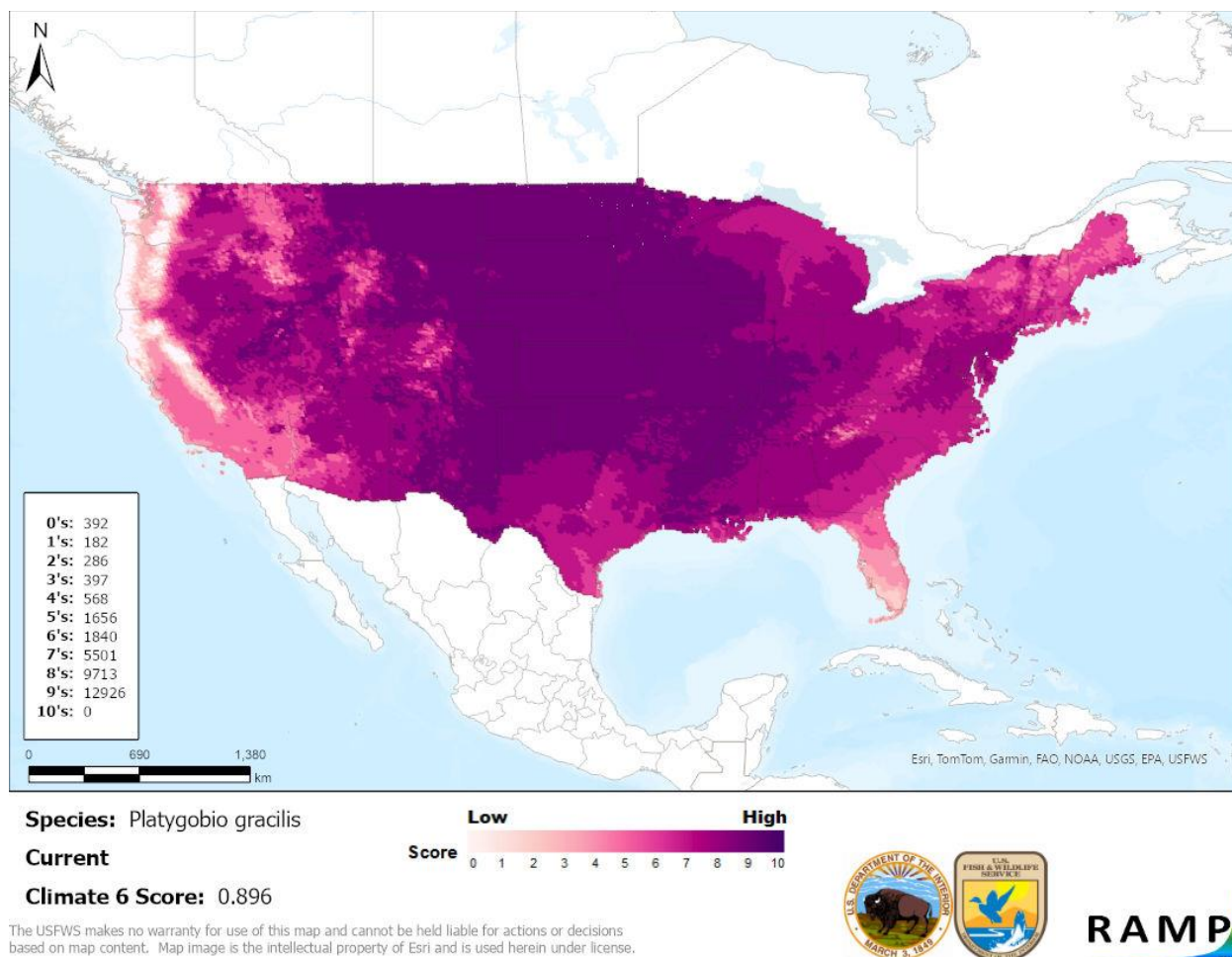


Figure 5. Map of RAMP (Sanders et al. 2023) climate matches for *Platygobio gracilis* in the contiguous United States based on source locations reported by GBIF Secretariat (2023). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *Platygobio gracilis* is classified as Low. While there is quality information regarding the ecology and biology of this species, no information was found regarding impacts where introduced.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Platygobio gracilis, the Flathead Chub, is a fish native to central and western drainages in the United States and Canada. An opportunistic invertivore, *P. gracilis* has been found to eat aquatic and terrestrial insects and algae. *P. gracilis* is found in turbid flowing waters in main channels of small to large rivers. Although it has been introduced via bait bucket releases, there is no further information on *P. gracilis* use in trade. The History of Invasiveness for *P. gracilis* is classified as Data Deficient due to a lack of information regarding negative impacts of its introduction. The

climate matching analysis for the contiguous United States indicates establishment concern for this species outside its native range. The areas of highest match were generally found in the central United States where this species is native. The Certainty of Assessment is classified as Low due to a lack of information on impacts of *P. gracilis* where it has been introduced. The Overall Risk Assessment Category for *P. gracilis* in the contiguous United States is Uncertain.

Assessment Elements

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

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.

GBIF Secretariat. 2023. GBIF backbone taxonomy: *Platygobio gracilis* (Richardson, 1836). Copenhagen: Global Biodiversity Information Facility. Available: <https://www.gbif.org/species/2362460> (August 2023).

GBIF-US. 2023. Species occurrences: *Platygobio gracilis* (Richardson, 1836). Available: <https://doi.org/10.15468/dl.wqvcgz> (August 2023).

Fricke R, Eschmeyer WN, van der Laan R, editors. 2023. Eschmeyer's catalog of fishes: genera, species, references. California Academy of Science. Available: <http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp> (September 2023).

Froese R, Pauly D, editors. 2024. *Platygobio gracilis* (Richardson, 1836). FishBase. Available: <https://fishbase.mnhn.fr/summary/Platygobio-gracilis.html> (March 2024).

[ITIS] Integrated Taxonomic Information System. 2023. *Platygobio gracilis* (Richardson, 1836). Reston, Virginia: Integrated Taxonomic Information System. Available: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=163882#null (August 2023).

NatureServe. 2023. NatureServe Explorer: an online encyclopedia of life. Arlington, Virginia: NatureServe. Available: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.105832/Platygobio_gracilis (August 2023).

Nico L. 2023. *Platygobio gracilis* (Richardson, 1836). Gainesville, Florida: U.S. Geological Survey, Nonindigenous Aquatic Species Database. Available: <https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=625> (August 2023).

Poelen JH, Simons JD, Mungall CJ. 2014. Global Biotic Interactions: an open infrastructure to share and analyze species-interaction datasets. *Ecological Informatics* 24:148–159.

Sanders S, Castiglione C, Hoff M. 2023. Risk Assessment Mapping Program: RAMP. Version 5.0. U.S. Fish and Wildlife Service.

Steffensen KD, Shuman DA, Stukel S. 2014. The status of fishes in the Missouri River, Nebraska: shoal chub (*Macrhybopsis hyostoma*), sturgeon chub (*M. gelida*), sicklefin chub (*M. meeki*), silver chub (*M. storeriana*), flathead chub (*Platygobio gracilis*), plains minnow (*Hybognathus placitus*), western silvery minnow (*H. argyritis*), and brassy minnow (*H. hankinsoni*). *Transactions of the Nebraska Academy of Sciences and Affiliated Societies* 34:49–67.

[USFWS] U.S. Fish and Wildlife Service. 2024. Standard operating procedure: how to prepare an “Ecological Risk Screening Summary.” Version 3.

World Organisation for Animal Health. 2023. Animal diseases. Paris: World Organisation for Animal Health. Available: <https://www.woah.org/en/what-we-do/animal-health-and-welfare/animal-diseases/> (August 2023).

11 Literature Cited in Quoted Material

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

Bazata K. 2011. Nebraska stream biological monitoring program 2004-2008. Lincoln: Nebraska Department of Environmental Quality.

Coburn MM, Cavender TM. 1992. Interrelationships of North American cyprinid fishes. Pages 328–373 in Mayden RL, editor. *Systematics, historical ecology, and North American freshwater fishes*. Stanford, California: Stanford University Press.

Collins JT, Collins SL, Horak LJ, Mulhern D, Busby W, Freeman CC, Wallace G. 1995. An illustrated guide to endangered or threatened species in Kansas. Wichita: University Press of Kansas.

Coker GA, Portt CB, Minns CK. 2001. Morphological and ecological characteristics of Canadian freshwater fishes. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2554.

Crossman and McAllister. 1986. [Source material did not provide full citation for this reference.]

Gould W. 1985. Aspects of the biology of the flathead chub (*Hybopsis gracilis*) in Montana. *Great Basin Naturalist* 45:332–336.

- Johnson RE. 1942. The distributions of Nebraska fishes. Master's thesis. Ann Arbor, Michigan: University of Michigan.
- Jones DJ. 1963. A history of Nebraska's fisheries resources. Lincoln: Nebraska Game and Parks Commission.
- Koster WJ. 1957. Guide to the fishes of New Mexico. Albuquerque: University of New Mexico Press.
- Lee DS, Gilbert CR, Hocutt CH, Jenknins RE, AcAllister DE, Stauffer JR. 1980. Atlas of North American freshwater fishes. Raleigh: North Carolina State Museum of Natural History.
- Martyn HA, Schmulbach JC. 1978. Bionomics of the flathead chub. Proceedings of the Iowa Academy of Sciences 85:62–65.
- Mayden RL. 1989. Phylogenetic studies of North American minnows, with emphasis on the genus *Cyprinella* (Teleostei: Cypriniformes). University of Kansas Museum of Natural History. Miscellaneous Publication 80.
- Olund LJ, Cross FB. 1961. Geographic variation in the North American cyprinid fish *Hybopsis gracilis*. University of Kansas Museum of Natural History Publications 13(7):323–348.
- Page LM, Burr BM. 2011. A field guide to freshwater fishes of North America north of Mexico. Boston: Houghton Mifflin Harcourt.
- Pflieger WL. 1975. The fishes of Missouri. Columbia: Missouri Department of Conservation.
- Pflieger WL. 1997. The fishes of Missouri. Jefferson City: Missouri Department of Conservation.
- Robins CR, Bailey RM, Bond CE, Brooker JR, Lachner EA, Lea RN, Scott WB. 1991. Common and *Platygobio gracilis* of fishes from the United States and Canada. Bethesda, Maryland: American Fisheries Society. Special Publication 20.
- Scott WB, Crossman EJ. 1973. Freshwater fishes of Canada. Bulletin of the Fisheries Research Board of Canada 184.
- Sublette JE, Hatch MD, Sublette M. 1990. The fishes of New Mexico. Albuquerque: University New Mexico Press.
- Wanner GA, Pegg MA, Schainost S, Klumb RA, Shuman DA. 2011. River geomorphology and fish barriers affect on spatial and temporal patterns of fish assemblages in the Niobrara, River, Nebraska. Pierre, South Dakota: U.S. Fish and Wildlife Service-Great Plains Fish and Wildlife Conservation Office.

Zuckerman LD, Behnke RJ. 1986. Introduced fishes in the San Luis Valley, Colorado. Pages 435-453 in Stroud RH, editor. Fish culture in fisheries management. Proceedings of a symposium on the role of fish culture in fisheries management at Ozark, MO. Bethesda, Maryland: American Fisheries Society.

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 (2023).

Under the future climate scenarios (figure A1), on average, high climate match for *Platygobio gracilis* was projected to occur in the Appalachian Range, Colorado Plateau, Great Basin, Great Lakes, Mid-Atlantic, Northeast, Northern Plains, Southeast, and Southern Plains regions of the contiguous United States. Areas of low climate match were projected to occur along the Northern Pacific Coast, in the Sierra-Nevada Range, and in Southern Florida. Areas of high match decreased in extent with time and from SSP3 to SSP5. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.779 (model: UKESM1-0-LL, SSP5, 2085) to a high of 0.894 (model: GFDL-ESM4, SSP3, 2055). All future scenario Climate 6 scores were above the Establishment Concern threshold, indicating that Yes, there is establishment concern for this species under future scenarios. The Climate 6 score for the current climate match (0.896, figure 5) falls above 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 (figure A3). Under multiple time step and climate scenarios, areas within the Northeast saw a moderate increase in the climate match relative to current conditions, including a few scattered locations with a large increase in the climate match. Under SSP5 in 2085, areas within the Great Basin, Gulf Coast, Southeast, and Southwest saw a large decrease in the climate match relative to current conditions. Additionally, areas within California, the Colorado Plateau, Mid-Atlantic, Northern Plains, Southern Plains, and Western Mountains saw a moderate decrease in the climate match relative to current conditions. The degree of change increased with time and between SSP3 and SSP5.

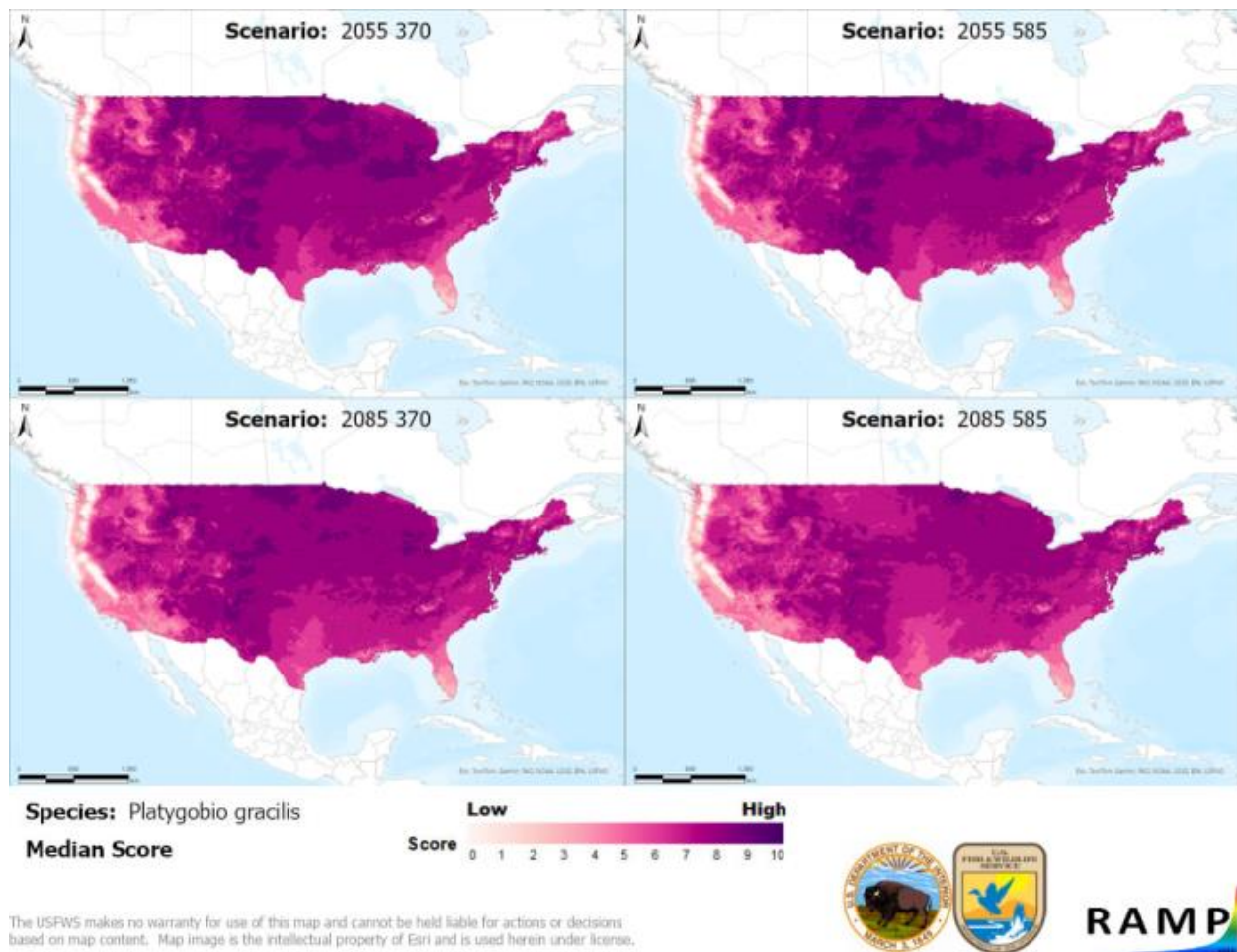


Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Platygobio gracilis* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2023). Shared 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.

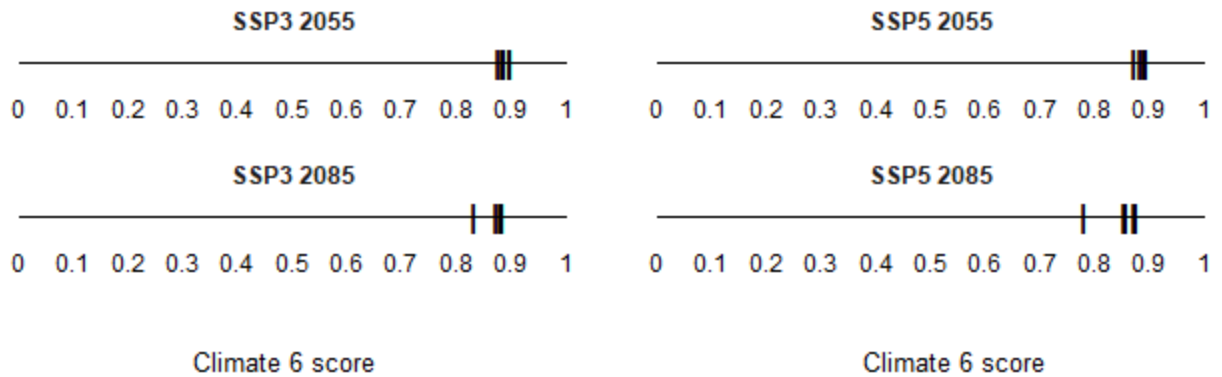


Figure A2. Comparison of projected future Climate 6 scores for *Platygobio gracilis* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; 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.

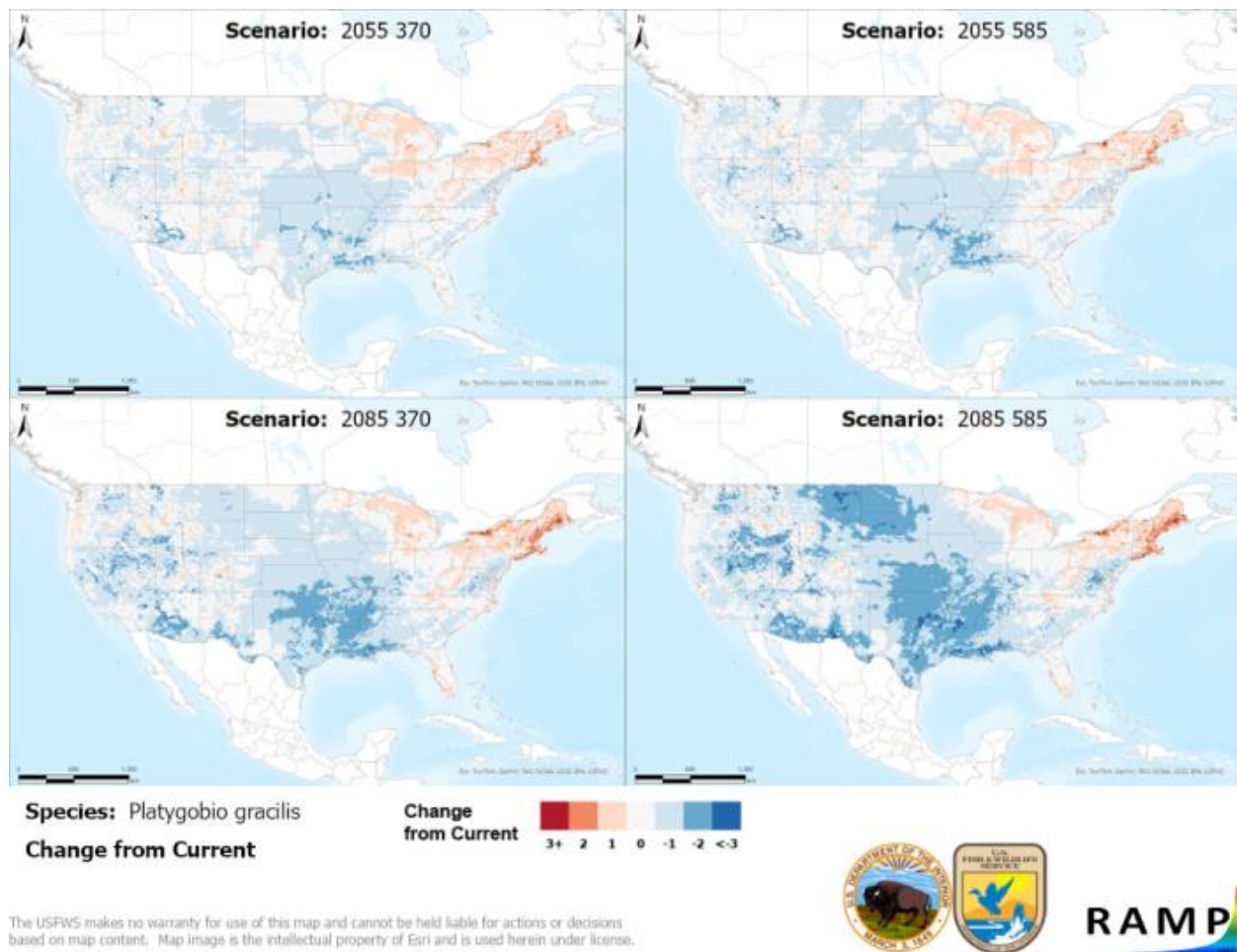


Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 4) and the median target point score for future climate scenarios (figure A1) for *Platygobio gracilis* based on source locations reported by GBIF Secretariat (2023). 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.

Literature Cited

GBIF Secretariat. 2023. GBIF backbone taxonomy: *Platygobio gracilis* (Richardson, 1836). Copenhagen: Global Biodiversity Information Facility. Available: <https://www.gbif.org/species/2362460> (August 2023).

[IPCC] Intergovernmental Panel on Climate Change. 2021. Climate change 2021: the physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Karger DN, Conrad O, Böhner J, Kawohl T, Kreft H, Soria-Auza RW, Zimmermann NE, Linder P, Kessler M. 2017. Climatologies at high resolution for the Earth land surface areas. *Scientific Data* 4:170122.

Karger DN, Conrad O, Böhner J, Kawohl T, Kreft H, Soria-Auza RW, Zimmermann NE, Linder HP, Kessler M. 2018. Data from: Climatologies at high resolution for the earth's land surface areas. *EnviDat*. Available: <https://doi.org/10.16904/envidat.228.v2.1>.

Sanders S, Castiglione C, Hoff M. 2023. Risk Assessment Mapping Program: RAMP. Version 5.0. U.S. Fish and Wildlife Service.