Sacramento Pikeminnow (*Ptychocheilus grandis*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, January 2024
Revised, January 2025
Web Version 8/11/2025

Organism Type: Fish
Overall Risk Assessment Category: High

Photo: Zayd Wheeler. Licensed under Creative Commons (CC BY-NC 4.0). Available: https://www.inaturalist.org/photos/92857115 (January 2024).

1 Native Range and Status in the United States

Native Range

From Nico (2024):

"Clear Lake, Russian, Sacramento-San Joaquin, Pajaro-Salinas, and upper Pit River drainages, California (Page and Burr 1991)."

Status in the United States

From Nico (2024):

“Native Range: Clear Lake, Russian, Sacramento-San Joaquin, Pajaro-Salinas, and upper Pit River drainages, California (Page and Burr 1991).”

From Georgakakos et al. (2023):

“Sacramento pikeminnow (*Ptychocheilus grandis*, […]) was introduced to the Eel River, California, USA, in 1979 and, in less than a decade, became widespread in the basin (Brown and Moyle 1991).”

From Fofonoff et al. (2018):

“Sacramento Pikeminnows were discovered in the Eel River, in northern California, in 1979 and by 1987-1989 they were widespread through the Eel River system. They were most widespread in the mainstem of the river, but also found in the larger tributaries (Brown and Moyle 1997). Genetic studies indicate that the effective founding population was as small as three to four individuals (Kinziger et al. 2014). […] In 2008, seven pikeminnows were caught in the Elk River, a small tributary of Humboldt Bay. Genetic analysis indicated that these fish were derived from the Eel River population (Kinziger et al. 2014).”

According to Nico (2024), *Ptychocheilus grandis* has also been introduced and become established within Chorro Creek and Los Osos Creek in San Luis Obispo County, California. *P. grandis* is reported as “collected” from Pyramid Lake (Los Angeles County) and Lake Arrowhead (San Bernardino County).

No records of *Ptychocheilus grandis* 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 Georgakakos et al. (2023):

“The initial introduction has been traced back to just 3–4 individuals from Clear Lake, Lake Co., California being transferred into Pillsbury Reservoir, the only large impoundment on the mainstem Eel River (Kinziger et al. 2013).”

From Nico (2024):

“Fish found in Pyramid Lake probably arrived through the aqueduct with central California water (Swift et al. 1993).”

Remarks

A former common name for *Ptychocheilus grandis*, sq***fish, includes a derogatory term (Secretarial Order 3404, U.S. Department of the Interior 2021). Where this former common name was used within material quoted by this report, it has been replaced by the common name "Sacramento Pikeminnow" in brackets. Publication titles for sources cited in this report (sections 10 and 11) were not altered.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2024):

Kingdom Animalia
  Subkingdom Bilateria
    Infrakingdom Deuterostomia
      Phylum Chordata
        Subphylum Vertebrata
          Infraphylum Gnathostomata
            Superclass Actinopterygii
              Class Teleostei
                Superorder Ostariophysi
                  Order Cypriniformes
                    Superfamily Cyprinoidea
                      Family Leuciscidae
                        Subfamily Laviniinae
                          Genus *Ptychocheilus*
                            Species *Ptychocheilus grandis* (Ayres, 1854)

According to Fricke et al. (2024), *Ptychocheilus grandis* (Ayres 1854) is the current valid name for this species.

Size, Weight, and Age Range

From Froese and Pauly (2024):

"Max length : 140 cm TL [total length] male/unsexed; [Page and Burr 1991]; common length : 40.0 cm TL male/unsexed; [Hugg 1996]; max. reported age: 9 years [Taft and Murphy 1950]"

From Brown (1990):

"The oldest [Sacramento Pikeminnow] from Bear Creek was age VI+ (304 mm SL [standard length]), but [Sacramento Pikeminnow] are known to survive to much older ages. Taft and Murphy (1950) found fish age IX+ in the Sacramento River, while B. Vondracek and P. B. Moyle (pers. comm.) obtained ages of up to age XII+ for Sacramento River fish. The oldest fish from the North Fork of the Feather River was age VIII+ (Moyle et al., 1983). The oldest fish from Coyote Creek, the stream most similar in size and physical conditions to Bear Creek, was age V (298 mm SL). Scoppettone (1988) aged a 662 mm SL [Sacramento Pikeminnow] from the Russian River as age XVI + using opercular bones and indicated that large [Sacramento Pikeminnow] may be older than previously thought due to difficulty in aging old fish using scales."

Environment

From Georgakakos et al. (2023):

"Historically, Sacramento pikeminnow occupied middle to low elevation sections of stream in their native range […] (Taft and Murphy 1950; Moyle 2002)."

From Fofonoff et al. (2018):

"They tolerate salinities up to 8 PSU."

From Froese and Pauly (2024):

"Inhabits rocky and sandy pools and runs of small to large rivers. Usually found in clear, warm streams [Page and Burr 2005]."

Climate

From Froese and Pauly (2024):

"Temperate; 39°N - 35°N"

Distribution Outside the United States

Native

The native range of *Ptychocheilus grandis* is entirely within the contiguous United States. See section 1.

Introduced

No records were found for introduction of *Ptychocheilus grandis* in the wild outside the United States.

Means of Introduction Outside the United States

No records were found of introduction of *Ptychocheilus grandis* in the wild outside the United States.

Short Description

From Carney and Paige (1990):

"Species of *Ptychocheilus* have a long conical head, somewhat flattened between the eyes; a very large, horizontal, terminal mouth extending to or past the front of the eye; lips that extend in front of the snout; a slender, barely compressed body; a large, deeply forked caudal fin; the dorsal-fin origin slightly behind the pelvic-fin origin; a moderately decurved, complete lateral line; a short intestine; and long, caniniform or slightly hooked pharyngeal teeth in two rows (usually 2,5-4,2). Smith (1975) noted that *Ptychocheilus* is distinct among North American cyprinids because it has "long gnathal bones adapted for carnivorous feeding, with a sharp, vertical gnathal ridge on the rather straight dentary." Adults show little variation in color and are usually gray-green above, silver on the side, and white below. Juveniles have a dusky stripe on the posterior half of the side and a black spot at the base of the caudal fin. All fins are clear to gray with yellow to orange margins on large individuals. Large males may have bright orange anal, pelvic, and pectoral fins."

"Species of [pikeminnows] differ morphologically from one another primarily in the relative sizes of their scales, and scale counts have been used to diagnose the species."

From Froese and Pauly (2024):

"Anal soft rays: 8. Dorsal fin usually with 8 rays; anal fin with 8 rays; 38-44 scales on back from head to dorsal fin; 65-78, usually 67-75, scales on lateral line; and 12-15 scales above lateral line [Page and Burr 2011]."

Biology

From Froese and Pauly (2024):

"Voracious minnow with pike-like habits. Small pikeminnows (less than or equal to 7 cm SL) are found in shallow water with cover and lower velocities. The microhabitat use of these juveniles is controlled by the presence of large pikeminnows which connotes intraspecific predation. The microhabitat shift is observed to be significantly influenced by the presence rather than the number of large pikeminnows in the area [Gard 2005]."

From Brown (1990):

"Aquatic insects and other small invertebrates are the major prey of small [Sacramento Pikeminnows], while fish and crayfish predominate in the diet of adults [in Bear Creek, California]. The information available on other Sacramento [pikeminnow] populations indicates that this transition from insects to fish occurs at a size between 200 and 300 mm SL, with fish becoming the predominant prey (> 50% by weight) at 400 to 500 mm SL (P. B. Moyle, pers. comm.). Bear Creek [Sacramento Pikeminnows] began consuming fish at a smaller size (51 to 100 mm SL), and at 101 to 150 mm SL fish became the major prey (> 50% by weight)."

"Moyle (1976) noted that, despite their apparent longevity and ability to reach large sizes, [pikeminnows] grow slowly compared to other large cyprinids, such as carp or hardhead. […] Though data from Moyle (1976) indicate that [pikeminnows] do not exhibit high fecundities compared to other California cyprinids, a larger energetic investment per egg, energetically more expensive spawning behaviors, such as long spawning migrations, or a combination of such factors are possible. Diversion of energy into fat stores, poor assimilation of digested materials, or both are also possible and could result in poor growth, as measured by increase in length."

Human Uses

From Froese and Pauly (2024):

"Fisheries: minor commercial; bait: usually"

Diseases

No information was found associating *Ptychocheilus grandis* with any diseases listed by the World Organisation for Animal Health (2024).

No information was found on diseases associated with *Ptychocheilus grandis*.

Threat to Humans

From Froese and Pauly (2024):

"Harmless"

3 Impacts of Introductions

From White and Harvey (2001):

"We used field surveys to compare the density and mesohabitat-scale distribution of the native coastrange sculpin (*Cottus aleuticus*) and the prickly sculpin (*C. asper*) in coastal rivers in north-western California, U.S.A., with and without an introduced piscivorous fish, the Sacramento pikeminnow, *Ptychocheilus grandis*."

"Average sculpin density (*C. aleuticus* and *C. asper* combined) in two rivers without pikeminnow was 21 times higher than the average density in two rivers in a drainage with introduced pikeminnow. In riffles, differences in the density of sculpins among rivers could be linked to differences in cover. However, riffles in rivers without pikeminnow had an average sculpin density 77 times higher than rivers with pikeminnow, yet only nine times more cover. In pools, cover availability did not differ among rivers, but the density of sculpins in rivers without pikeminnow was 11 times higher than rivers with pikeminnow."

"This study indicates that introduced [Sacramento] pikeminnow have had a severe negative impact on the abundance of sculpins in the Eel River. The pikeminnow has rendered pools in the MS [mainstem] and SF [South Fork] Eel rivers virtually uninhabitable, although pools contain the highest densities of prickly sculpin in nearby rivers without pikeminnow. Additionally, while our study was limited to late summer, pikeminnow predation may have a greater impact on sculpin populations during other times of the year. Both coastrange and prickly sculpin make downstream spawning migrations in the late winter and spring (Moyle, 1976) that involve moving through pools."

"[…] by severely reducing sculpin abundances in the Eel River, introduced pikeminnow undoubtedly have increased the probability of extinction for coastrange and prickly sculpin populations in this system, while also altering the food web and ecosystem processes."

From Brown and Moyle (1991):

“The introduction of [Sacramento Pikeminnows] into the Eel River was associated with some dramatic changes in partitioning of habitat and microhabitat within the resident fish assemblage. Prior to the establishment of [Sacramento Pikeminnows], the resident fishes were distributed throughout the width of the stream, except for the very shallow edges (< 110 cm). After [Sacramento Pikeminnows] became established, the fishes used the deeper parts of the stream much less often, either exhibiting microhabitat shifts within habitats or changes in the use of habitats. These changes in habitat and microhabitat use resulted in decreases in spatial overlaps between many species, particularly between species which specialized in using different habitat types in the presence of [Sacramento Pikeminnows].”

“There were some differences in the response of fishes to [Sacramento Pikeminnows] between the two study areas that may have reflected differences in habitat structure and recentness of invasion. At the South Fork Eel River site, juvenile rainbow trout and suckers were completely absent from pools where [Sacramento Pikeminnows] were present, but in the Van Duzen River, they were found in reduced numbers in shallow areas.”

“The most extreme differences in habitat or microhabitat use occurred in sticklebacks, juvenile suckers, and juvenile rainbow trout. […] These species may be especially vulnerable to predation in the Eel River because they have not experienced [Sacramento Pikeminnows], or any other freshwater piscivorous fish, in their recent evolutionary history. Other studies support this hypothesis.”

“The effects of [pikeminnows] on rainbow trout are potentially important from a management perspective because of the significance of the sport fishery for steelhead (anadromous rainbow trout) in the Eel River. We feel that the changes we have documented are relatively unimportant from this perspective because trout and [pikeminnows] tend to be spatially segregated on the basis of differences in the physical environment, particularly temperature (Moyle and Nichols 1973; Dettman 1976; Moyle and Daniels 1982; Smith 1982; Baltz et al. 1987). Rainbow trout are most abundant in cool headwater and tributary streams. [Pikeminnows] are most abundant in the warmer downstream portions of streams and in warm tributaries. This pattern is also found in the Eel River system (L. R. Brown md P. B. Moyle, unpubl. data). [Pikeminnows] are most abundant in downstream areas or tributaries that are too warm to provide good trout habitat, although there are a few exceptions such as the Van Duzen River (L. R. Brown and P. B. Moyle, unpubl. data). Thus, the presence of [pikeminnows] does not affect the majority of the oversummering salmonid population. Production in the limited areas of overlap may be reduced due to direct predation, increased mortality due to heat stress because thermal refugia (thermal stratification and spring inflow) occurring in pools are no longer available, and decreased growth due to crowding in the limited riffle areas available. Predation during outmigration of smolts may be important but evidence from other systems suggests that outmigration losses are relatively small in natural streams (Brown and Moyle 1981).”

The following source discusses negative impacts of *Ptychocheilus grandis* on native species in a laboratory experiment:

From Reese and Harvey (2002):

"We examined the temperature dependence of interactions between juvenile steelhead *Oncorhynchus mykiss* and juvenile Sacramento pikeminnow *Ptychocheilus grandis* in laboratory streams. Growth of dominant steelhead in water 20–23°C was reduced by more than 50% in trials with Sacramento pikeminnow compared with trials with steelhead alone. Comparison of the two species treatment with one with an equal density of fish comprised of steelhead alone indicated that the per capita effect of Sacramento pikeminnow was similar to the intraspecific effect of steelhead in water 20–23°C. In contrast, the growth of dominant steelhead in water 15–18°C was unaffected by Sacramento pikeminnow. The temperature-dependence of the effect of Sacramento pikeminnow on dominant steelhead was also reflected in the size of the area defended by steelhead and in the behavior of Sacramento pikeminnow under the two thermal regimes. Compared with all other treatment combinations, dominant steelhead defended the smallest areas when accompanied by Sacramento pikeminnow in warm water. Behavioral interactions with steelhead initiated by Sacramento pikeminnow were about 50 times more frequent in warm water. For the growth of subdominant steelhead, the effect of intraspecific competition exceeded the interspecific effect of Sacramento pikeminnow regardless of water temperature. While thermal regime affects the distributions of these two species, this experiment suggests that it also affects the outcome of competition between them."

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

4 History of Invasiveness

The History of Invasiveness for *Ptychocheilus grandis* is classified as High. Although this species has not been widely introduced, there are several populations established in California outside of its native range. Establishment of *P. grandis* in the Eel River, California, has led to a decline in the abundance of two native sculpin species. The presence of *P. grandis* shifts habitat use of other native fishes from pools to shallower riffle areas. Other possible impacts of *P. grandis,* such as temperature-dependent competition with native steelhead trout, have been hypothesized and researched in the laboratory setting but not yet documented in wild populations. Despite this, there is ample convincing and reliable information to classify *P. grandis* as having a High History of Invasiveness.

5 Global Distribution

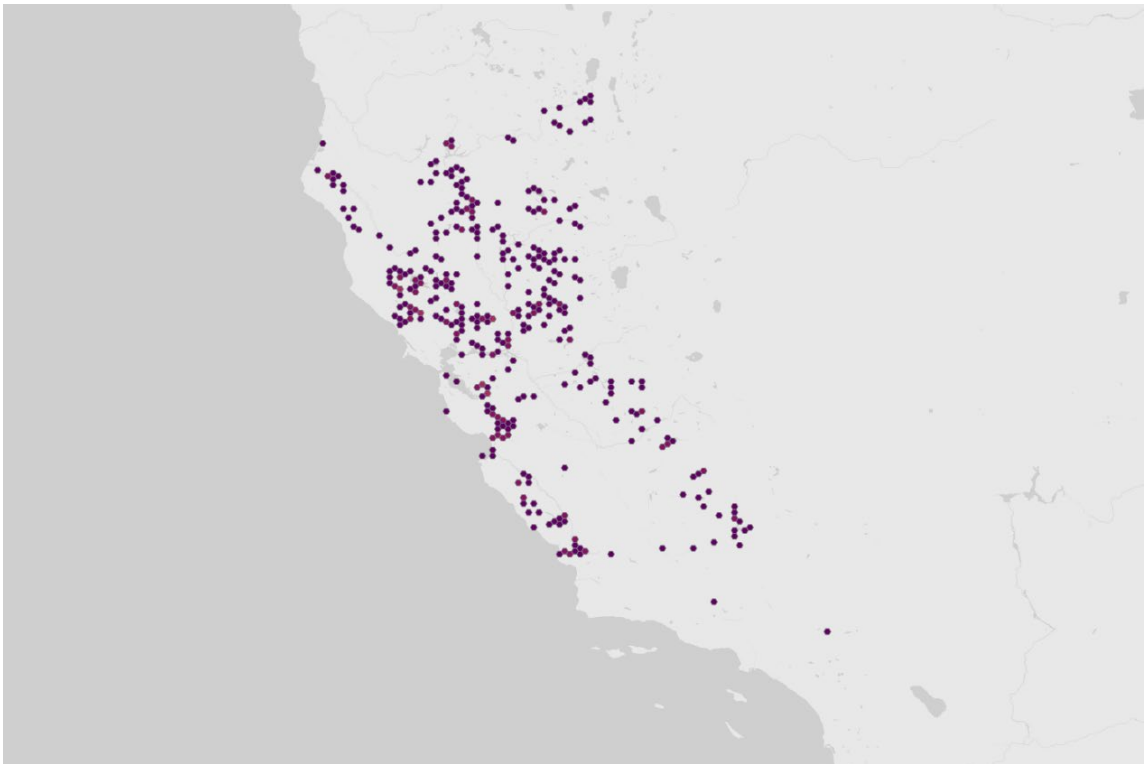

Figure 1. Reported distribution of *Ptychocheilus grandis*. Map from GBIF Secretariat (2023). Observations are reported from California. This map includes points representing both native and introduced occurrences of *P. grandis*. The southernmost points shown on the map (in San Bernardino and Los Angeles counties, California) do not represent established populations of *P. grandis* and were excluded from the climate matching analysis. Similarly, points in Washington and Oregon were excluded from the extent of this map and from the climate matching analysis because they do not represent established populations of this species.

6 Distribution Within the United States

Figure 2. Reported distribution of *Ptychocheilus grandis* in the United States. Map from USGS (2025). Observations are reported from California. Orange polygon represents the native range of *P. grandis*. Yellow points represent established nonnative populations and orange points represent other nonnative occurrences. Only established populations were used to select source points for the climate matching analysis.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Ptychocheilus grandis* to the contiguous United States was high from the Pacific Coast eastward through the Great Basin, including the areas within California where *P. grandis* is currently established. The rest of western half of the United States had a medium climate match. The climate match was low in the eastern United States. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.182, 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 *Ptychocheilus grandis* (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.

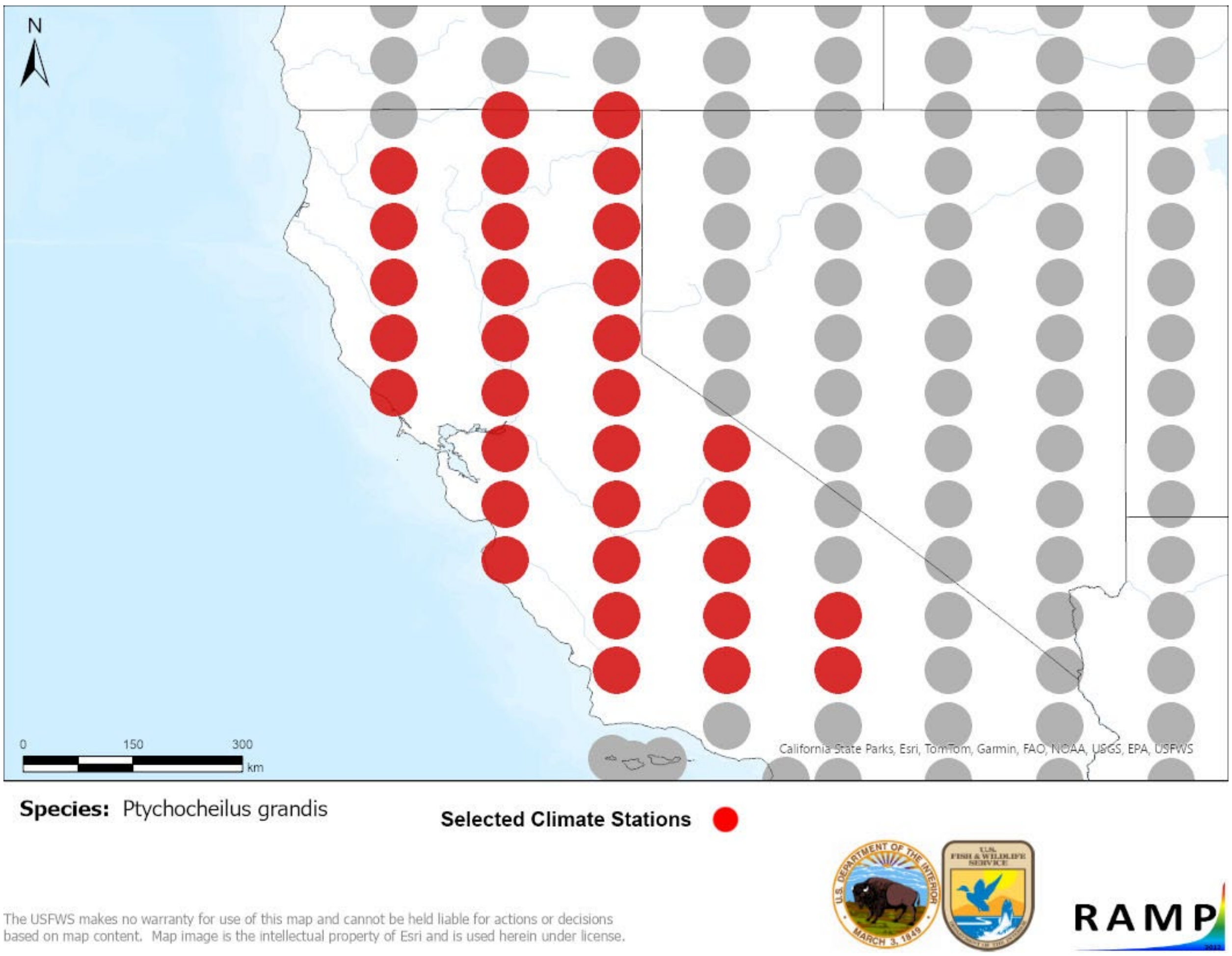

Figure 3. RAMP (Sanders et al. 2023) source map showing weather stations in the western United States selected as source locations (red) and non-source locations (gray) for *Ptychocheilus grandis* climate matching. Source locations from GBIF Secretariat (2023). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

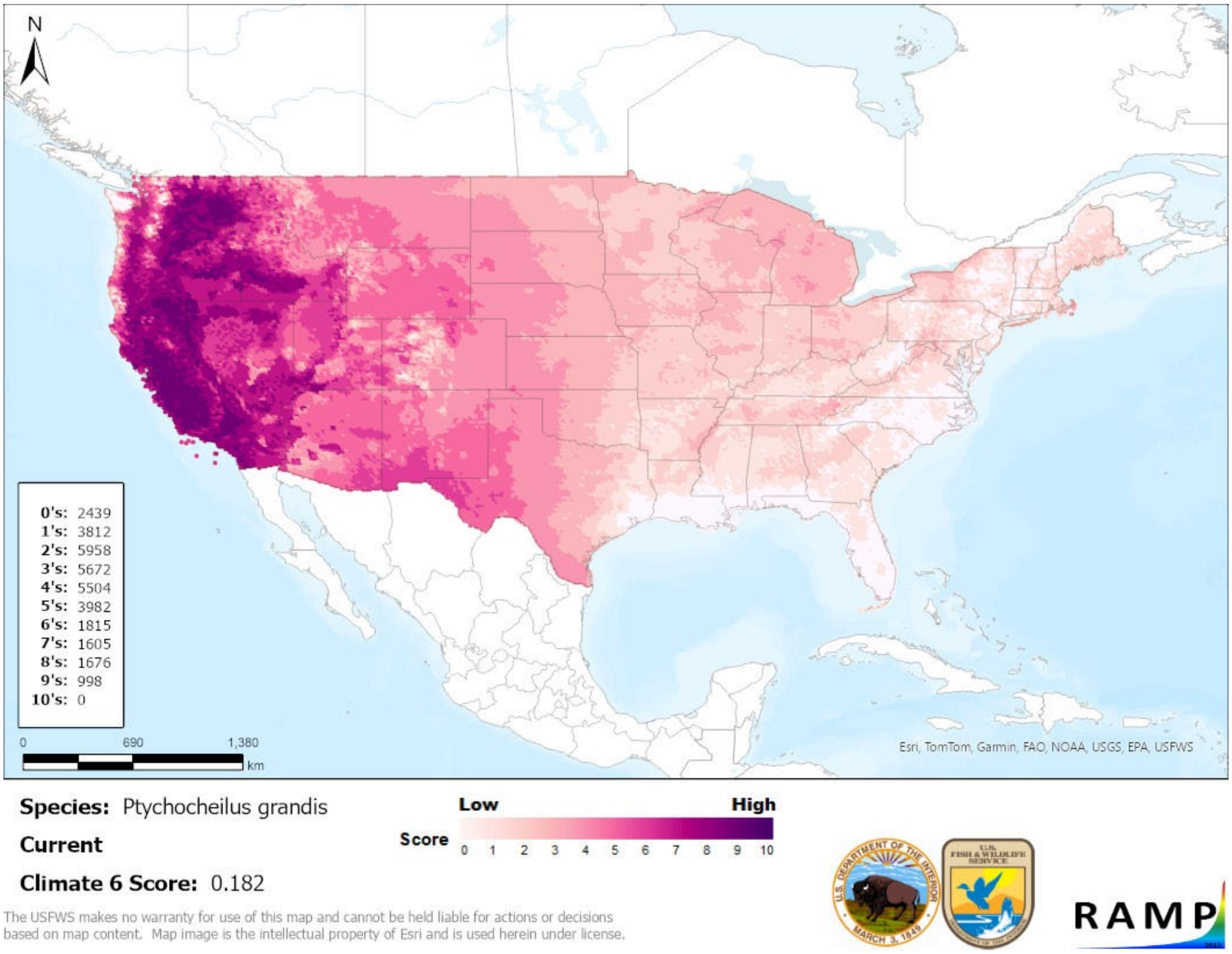

Figure 4. Map of RAMP (Sanders et al. 2023) climate matches for *Ptychocheilus grandis* in the contiguous United States based on source locations reported by GBIF Secretariat (2023). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *Ptychocheilus grandis* is classified as High. The biology of this species is well-documented. Its pathway of introduction and nonnative range are known. There is adequate, clear, and reliable documentation from which to draw conclusions about the risk *P. grandis* poses outside its native range in the contiguous United States.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Ptychocheilus grandis, Sacramento Pikeminnow, is a freshwater fish that is native to central and northern California. It has been introduced outside of its native range in California, such as in the Eel River basin and along the central California coast, where it has become established. This species is a large, slow-growing carnivorous cyprinid. It reduces native fish abundance and alters habitat use by native fish in areas where it has been introduced. The History of Invasiveness for

P. grandis is classified as High due to multiple well-documented, scientifically-credible 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 climate match was medium to high across the western half of the United States. The Certainty of Assessment for this ERSS is classified as High due to abundant high-quality information documenting impacts of introduction of this species. The Overall Risk Assessment Category for *Ptychocheilus grandis* 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): High**
- **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.

Brown LR. 1990. Age, growth, feeding, and behavior of Sacramento squawfish (*Ptychocheilus grandis*) in Bear Creek, Colusa Co., California. The Southwestern Naturalist 35:249–260.

Brown LR, Moyle PB. 1991. Changes in habitat and microhabitat partitioning within an assemblage of stream fishes in response to predation by Sacramento squawfish (*Ptychocheilus grandis*). Canadian Journal of Fisheries and Aquatic Sciences 48:849–856.

Carney DA, Page LM. 1990. Meristic characteristics and zoogeography of the genus *Ptychocheilus* (Teleostei: Cyprinidae). Copeia 1990(10):171–181.

Fofonoff PW, Ruiz GM, Steves B, Simkanin C, Carlton JT. 2018. *Ptychocheilus grandis*. National Exotic Marine and Estuarine Species Information System. Edgewater, Maryland: Smithsonian Environmental Research Center. Available: https://invasions.si.edu/nemesis/species_summary/163524 (January 2024).

Fricke R, Eschmeyer WN, van der Laan R, editors. 2024. Eschmeyer's catalog of fishes: genera, species, references. California Academy of Science. Available: http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp (January 2024).

Froese R, Pauly D, editors. 2024. *Ptychocheilus grandis* (Ayres, 1854). FishBase. Available: https://fishbase.mnhn.fr/summary/ptychocheilus-grandis.html (January 2024).

GBIF Secretariat. 2023. GBIF backbone taxonomy: *Ptychocheilus grandis*. Copenhagen: Global Biodiversity Information Facility. Available: https://www.gbif.org/species/5205694 (January 2024).

Georgakakos PB, Dralle DN, Power ME. 2023. Spring temperature predicts upstream migration timing of invasive Sacramento pikeminnow within its introduced range. Environmental Biology of Fishes 23:1–4.

[ITIS] Integrated Taxonomic Information System. 2024. *Ptychocheilus grandis* (Ayres, 1854). Reston, Virginia: Integrated Taxonomic Information System. Available: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=163524#null (January 2024).

Nico L. 2024. *Ptychocheilus grandis*. Nonindigenous Aquatic Species Database. Gainesville, Florida: U.S. Geological Survey. Available: https://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=627 (January 2024).

Reese CD, Harvey BC. 2002. Temperature-dependent interactions between juvenile steelhead and Sacramento pikeminnow in laboratory streams. Transactions of the American Fisheries Society 131:599–606.

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

U.S. Department of the Interior. 2021. Secretarial Order 3404. Declaring "squaw" a derogatory term and implementing procedures to remove the term from Federal usage. Available: https://www.doi.gov/sites/doi.gov/files/elips/documents/so-3404-508.pdf (January 2025).

[USFWS] U.S. Fish and Wildlife Service. 2024. Standard operating procedure: how to prepare an "Ecological Risk Screening Summary." Version 3. Available: https://www.fws.gov/media/standard-operating-procedures-how-prepare-ecological-risk-screening-summary-2024 (December 2024).

[USGS] U.S. Geological Survey. 2025. *Ptychocheilus grandis*. Nonindigenous Aquatic Species Database. Gainesville, Florida: U.S. Geological Survey. Available: https://nas.er.usgs.gov/viewer/omap.aspx?SpeciesID=627 (August 2025).

White JL, Harvey BC. 2001. Effects of an introduced piscivorous fish on native benthic fishes in a coastal river. Freshwater Biology 46:987–995.

World Organisation for Animal Health. 2024. Animal diseases. Paris: World Organisation for Animal Health. Available: https://www.woah.org/en/what-we-do/animal-health-and-welfare/animal-diseases/ (January 2024).

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.

Armstrong JB, Schindler DE, Omori KL, Ruff CP, Quinn TP. 2010. Thermal heterogeneity mediates the effects of pulsed subsidies across a landscape. Ecology 91:1445–1454.

Armstrong JB, Fullerton AH, Jordan CE, Ebersole JL, Bellmore JR, Arismendi I, Penaluna BE, Reeves GH. 2021. The importance of warm habitat to the growth regime of cold-water fishes. Nature Climate Change 11:354–361.

Baltz DM, Vondracek B, Brown LR, Moyle PB. 1987. Influence of temperature on microhabitat choice by fishes in a California stream. Transactions of the American Fisheries Society 116:12–20.

Brown LR, Brasher AM. 1995. Effect of predation by Sacramento squawfish (*Ptychocheilus grandis*) on habitat choice of California roach (*Lavinia symmetricus*) and rainbow trout (*Oncorhynchus mykiss*) in artificial streams. Canadian Journal of Fisheries and Aquatic Sciences 52:1639–1646.

Brown LR, Moyle PB. 1981. The impact of squawfish on salmonid populations: a review. North American Journal of Fisheries Management 1:104–111.

Brown LR, Moyle PB. 1997. Invading species in the Eel River, California: successes, failures, and relationships with resident species, Environmental Biology of Fishes 47:271–291.

Dettman DH. 1978. Distribution, abundance and microhabitat segregation of rainbow trout and Sacramento Squawfish in Deer Creek, California. Masters thesis. Davis: University of California, Davis.

Gard MF. 2005. Ontogenetic microhabitat shifts in Sacramento pikeminnow, *Ptychocheilus grandis*: reducing intraspecific predation. Aquatic Ecology 39:229–235.

Harvey BC, Nakamoto RJ. 1999. Diel and seasonal movements by adult Sacramento pikeminnow (*Ptychocheilus grandis*) in the Eel River, northwestern California. Ecology of Freshwater Fish 8:209–215.

Hugg DO. 1996. MAPFISH georeferenced mapping database. Freshwater and estuarine fishes of North America. Edgewater, Maryland: Life Science Software.

Kinziger AP, Nakamoto RJ, Harvey BC. 2013. Local-scale invasion pathways and small founder numbers in introduced Sacramento pikeminnow (*Ptychocheilus grandis*). Conservation Genetics 15:1–9.

Moyle PB. 1976. Inland fishes of California. Berkeley: University of California Press.

Moyle PB. 2002. Inland fishes of California; revised and expanded. Berkeley: University of California Press.

Moyle PB, Daniels RA. 1982. Fishes of the Pit River system, McCloud River system and the Suprise Valley region. Pages 1–82 in Moyle PB, Smith JJ, Daniels RA, Taylor TL, Price DG, Baltz DM, editors. Distribution and ecology of stream fishes of the Sacramento-San Joaquin drainage system, California. Berkeley: University of California Publications in Zoology.

Moyle PB, Nichols RD. 1973. Ecology of some native and introduced fishes of the Sierra Nevada foothills in central California. Copeia 1973(28):478–490.

Moyle PB, Vondracek B, Grossman GD. 1983. Responses of fish populations in the North Fork of the Feather River, California, to treatments with fish toxicants. North American Journal of Fisheries Management 3:48–60.

Nielsen JL, Lisle TE, Ozaki V. 1994. Thermally stratified pools and their use by steelhead in northern California streams. Transactions of the American Fisheries Society 123:613–626.

Page LM, Burr, BM. 1991. A field guide to freshwater fishes of North America north of Mexico. Boston: Houghton Mifflin Company.

Rossi GJ, Power ME, Pneh S, Neuswanger JR, Caldwell TJ. 2021. Foraging modes and movements of Oncorhynchus mykiss as flow and invertebrate drift recede in a California stream. Canadian Journal of Fisheries and Aquatic Sciences 78:1045–1056.

Scoppettone GG. 1988. Growth and longevity of the cui-ui and longevity of other catostomids and cyprinids in western North America. Transactions of the American Fisheries Society 117:301–307.

Smith GR. 1975. Fishes of the Pliocene Glenns Ferry Formation, southwest Idaho. University of Michigan Papers on Paleontology 14:1–87.

Smith JJ. 1982. Fishes of the Pajaro River system. Pages 85–169 in Moyles PB, Smith JJ, Daniels RA, Baltz DM, editors. Distribution and ecology of stream fishes of the Sacramento-San Joaquin drainage system, California. Berkeley: University of California Publications in Zoology.

Swift CC, Haglund TR, Ruiz M, Fisher RN. 1993. The status and distribution of the freshwater fishes of southern California. Bulletin of the Southern California Academy of Sciences 92(3):101–167.

Taft AC, Murphy GI. 1950. Life history of the Sacramento squawfish (*Atychocheilus grandis*). California Fish and Game 36:147–164.

Vondracek B. 1987. Digestion rates and gastric evacuation times in relation to temperature of the Sacramento squawfish, *Ptychocheilus grandis*. Fishery Bulletin 85:159–163.

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 *Ptychocheilus grandis* was projected to occur in California. Areas of low climate match was projected to occur in the eastern contiguous United States. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.084 (model: UKESM1-0-LL, SSP5, 2085) to a high of 0.186 (model: MPI-ESM1-2-HR, SSP5, 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 (0.182, figure 4) falls within 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. At time step 2055, areas within the Southwest region saw a large increase in the climate match relative to current conditions, but this tempered to a moderate increase relative to current conditions by time step 2085. Under one or more time step and climate scenarios, areas within California and the Great Basin saw a large decrease in the climate match relative to current conditions. Additionally, areas within the Appalachian Range, Colorado Plateau, Great Lakes, Gulf Coast, Mid-Atlantic, Northeast, Northern Pacific Coast, Southeast, Southwest, and Western Mountains saw a moderate decrease in the climate match relative to current conditions. Additional, very small areas of large or moderate change may be visible on the maps (figure A3).

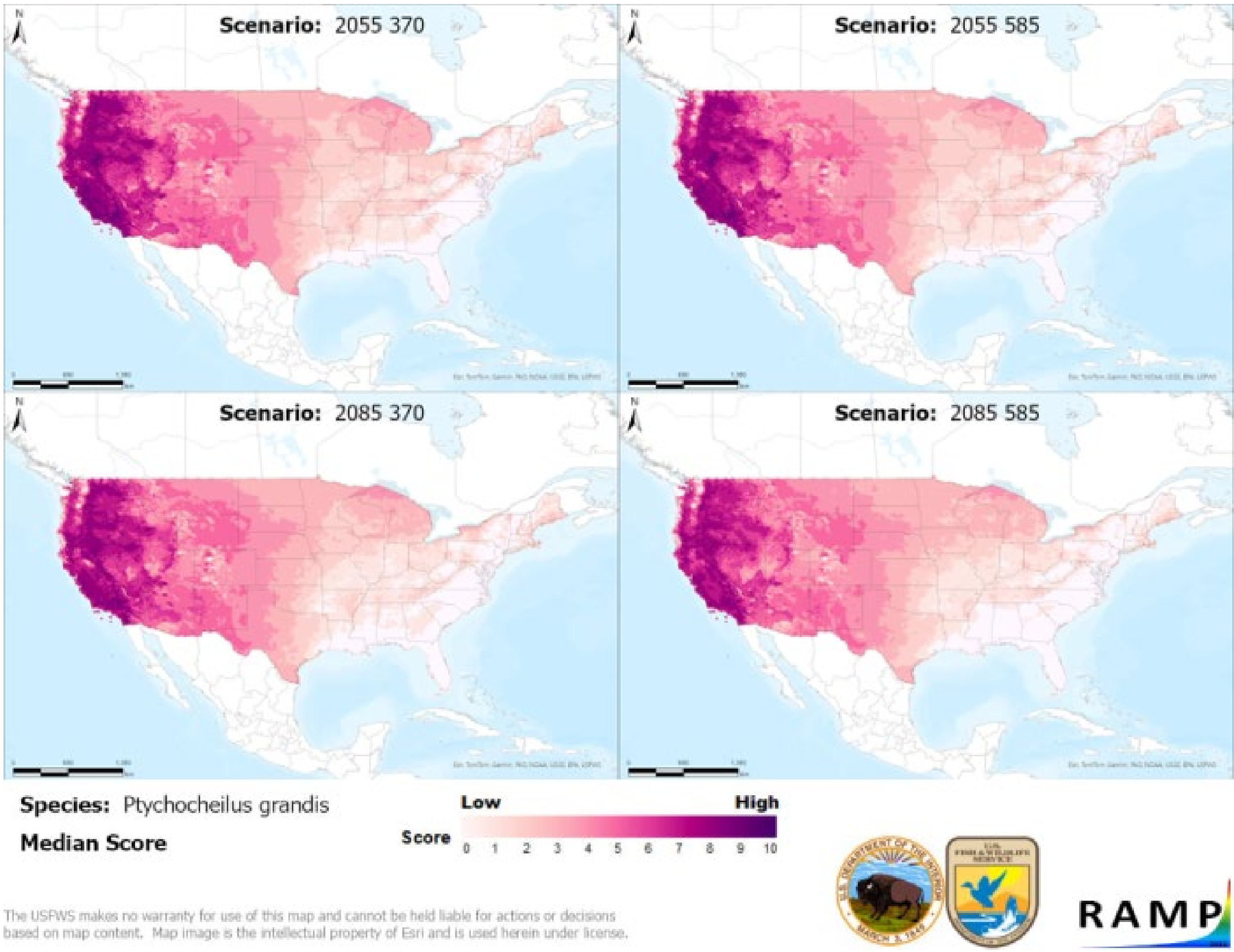

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Ptychocheilus grandis* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2024). Shared 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.

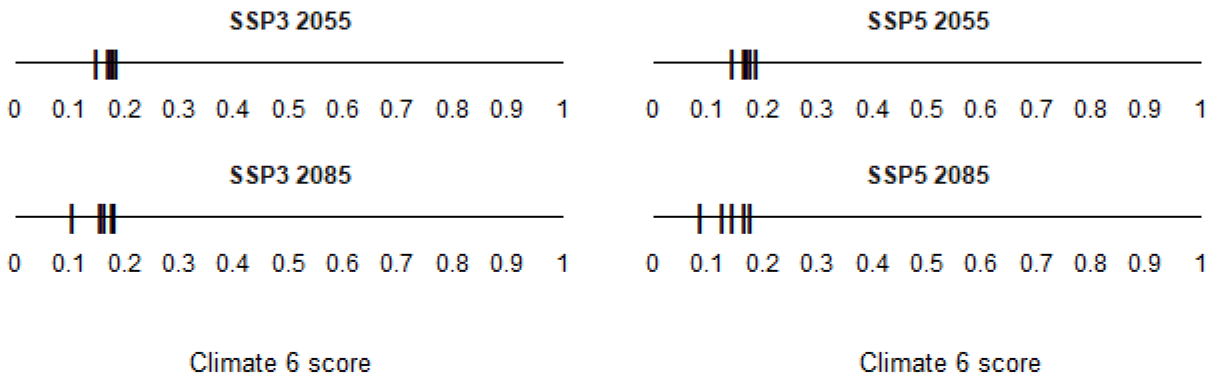

Figure A2. Comparison of projected future Climate 6 scores for *Ptychocheilus grandis* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018;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

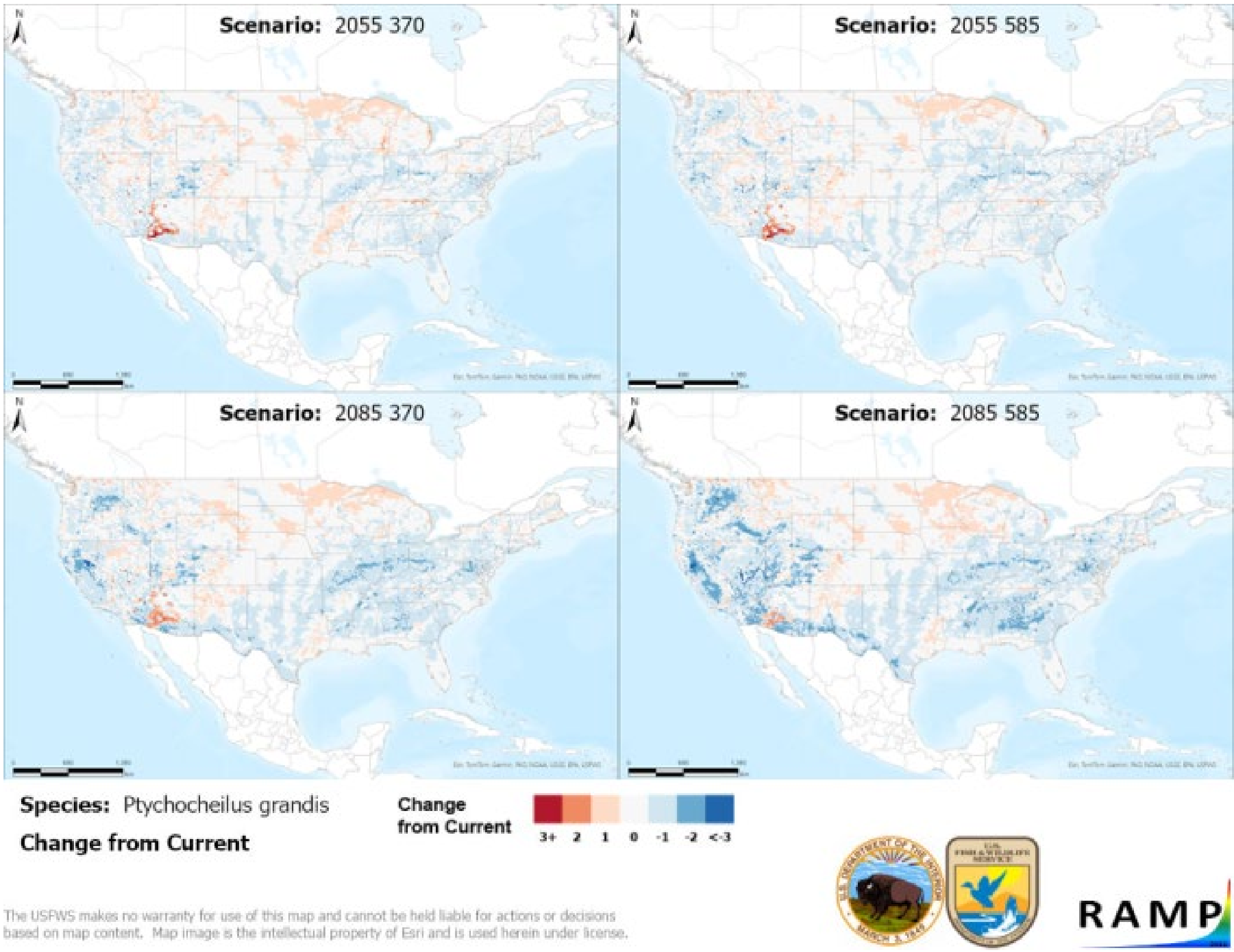

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 4) and the median target point score for future climate scenarios (figure A1) for *Ptychocheilus grandis* based on source locations reported by GBIF Secretariat (2024). 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: *Ptychocheilus grandis*. Copenhagen: Global Biodiversity Information Facility. Available: https://www.gbif.org/species/5205694 (January 2024).

[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 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.

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.

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