5-YEAR REVIEW

Riverside fairy shrimp
(*Streptocephalus woottoni*)

GENERAL INFORMATION

Species: Riverside fairy shrimp (*Streptocephalus woottoni*), an invertebrate species
Date listed under the Endangered Species Act: August 3, 1993
Federal Register citation: USFWS 1993 (58 FR 41384)
Classification: Endangered
Recovery Plan: Final, September 3, 1998. Recovery Plan Clarification, October 1, 2019.
Recovery Priority Number: 8C
Final Revised Critical Habitat Designation: December 4, 2012 (77 FR 72070).

BACKGROUND

Under the Endangered Species Act of 1973, as amended (Act; 16 U.S.C. 1531 et seq.), the U.S. Fish and Wildlife Service (USFWS), referred to as "we" in this document, maintain lists of endangered and threatened wildlife and plant species (referred to as the List) in the Code of Federal Regulations (CFR) at 50 CFR 17.11 (for wildlife) and 17.12 (for plants). Section 4(c)(2)(A) of the Act requires us to review each listed species' status at least once every 5 years.

Most recent status review: USFWS 2008. Riverside fairy shrimp (*Streptocephalus woottoni*) 5-year review: Summary and evaluation. Prepared by the Carlsbad Fish and Wildlife Office, Carlsbad, California. September 2008. 57 pp. + appendices

We initiated a status review for Riverside fairy shrimp on March 22, 2006. The review was finalized on September 30, 2008, and recommended no change in status.

Federal Register notice announcing this status review: On January 27, 2020, we published a *Federal Register* notice announcing initiation of the 5-year review of this species, and the opening of a 60-day comment period to receive information (USFWS 2020, pp. 4692–4694). Two comments relative to Riverside fairy shrimp were received. The Center for Natural Lands Management provided updates regarding the status of Riverside fairy shrimp on properties they manage in Riverside County at Skunk Hollow and Johnson Ranch, and feedback on trends, surveys, and threats (Rogers and Klementowski 2020, *in litt*). The U.S. Marine Corps provided comments and data regarding the status of the species and conservation measures at Marine Corps Base Camp Pendleton (Asmus 2020, *in litt*).

Species Overview and Habitat: The Riverside fairy shrimp (*Streptocephalus woottoni;* RFS) is a small [0.56–0.92 inch (14–23 millimeter)] aquatic crustacean in the order Anostraca. The species is generally restricted to vernal pools and other non-vegetated ephemeral (i.e., lasting a short time) pools in Ventura, Riverside, Orange, and San Diego counties of southern California. The historical distribution also extended into Los Angeles County and northwestern Baja California, Mexico. Our understanding of the species status comes from survey data for adult individuals and cysts. Cysts can be identified to genus and are therefore assumed to be RFS;

however, in the absence of adult survey data it is not clear if the habitat provides sufficient hydrology to support adults and a viable population.

Vernal pools and vernal swales are often clustered into pool "complexes" (Bauder 1986, Appendix 1, 4; Keeler-Wolf *et al.* 1998, pp. 60–61, 63–64), and may form dense, interconnected mosaics of small pools, or a sparse scattering of larger pools. Vernal pool complexes that support from one up to many distinct vernal pools are often interconnected by a shared watershed. Both the pool basin and the surrounding watershed are essential for a functioning vernal pool system (Hanes and Stromberg 1998, p. 48). Loss of upland vegetation, increased overland water flow due to urban runoff, and alteration of the microtopography can modify the function of vernal pool systems, and alter the physiochemical parameters that the RFS requires for survival. Because the RFS requires ephemerally ponded areas for its conservation (Belk 1998, pp. 147–148), vernal pools are best described from a watershed perspective.

ASSESSMENT

Information acquired since the last status review

This 5-year review was conducted by the USFWS Carlsbad Fish and Wildlife Office. Data for this review were solicited from the public and interested parties through a *Federal Register* notice announcing this review on January 27, 2020. We also contacted State agencies, species experts, non-governmental organizations, partners, and stakeholders to request any data or information we should consider in our review. Additionally, we conducted a literature search and a review of information in our files.

SUMMARY OF NEW INFORMATION SINCE 2008

Genetics

In 2010, a team of researchers studied the genetics of RFS using dry and wet season samples, including both new collections and stored soil samples from previous projects (Lahti *et al.* 2010, pp. 1–47). In total, the project sequenced 179 individuals from 32 pools comprising 20 complexes through most of the species' range (Lahti et al 2010, p. 17). Using mtDNA, they found five main haplotypes (described as Haplotype A, B, C, D, and E), with Haplotype A being the most common and found in all regions sampled (Lahti et al 2010, p. 17). Haplotype B was limited to pools on Otay Mesa in southern San Diego County. Haplotypes C, D, and E were limited to single locations in San Diego County. Overall, genetic variability was limited to San Diego County (Haplotypes B through E), and all sampled pools in Riverside and Orange counties only exhibited Haplotype A. The study recommended that pools in San Diego County be of particular conservation concern to preserve known genetic diversity of RFS. In summary, they found that *Streptocephalus woottoni* represents a unique species, but genetic variation in the surveyed gene was low, suggesting that additional genetic markers should be developed to better understand population genetic structure (Lahti et al 2010, p. 22).

Regional Updates

In Table 1, we discuss RFS occurrences using general complex or area names because we are unaware of a universal vernal pool complex naming standard utilized throughout the range of the species. Some location names have been updated in this review from the occurrence table we presented in 2008 (USFWS 2008, Appendix 1). The locations discussed in Table 1 can support vastly different numbers of pools and individual RFS. Where we have additional information regarding the size, number of occupied pools, or number of RFS detected within a vernal pool complex or general area, we have provided that information in Table 1. The species' status is considered unknown if the record relies solely on the observation of cysts and/or the persistence of appropriate vernal pool hydrology could not be confirmed.

Ventura County

The status of RFS in Ventura County has changed since the last review conducted in 2008. One vernal pool complex was described in the 2008 review as potentially supporting RFS, called the Tierra Rejada complex (also known as Carlsberg, California Natural Diversity Database (CNDDB) Element Occurrence (EO) 9) (CDFW 2021, p. 13). We considered the complex to be occupied by RFS in the 1998 Recovery Plan (USFWS 1998, p. 36), but the status was unknown in 2008 (USFWS 2008, p. 7). The species was not detected during surveys conducted from 2002 through 2006 (CDFW 2021, p. 13). In 2019, the species was again detected in the Tierra Rejada complex and this single occurrence in Ventura County is considered extant (Livergood 2019, p. 7). This complex is conserved by the Mountains Recreation and Conservation Authority and is unlikely to be developed. However, the complex is surrounded by development and is threatened by habitat modification and edge effects from surrounding properties, including potential changes in hydrology, invasion of exotic species, and habitat disturbance from unauthorized access. In addition, there may be gaps in funding to adequately manage the complex to support conservation of RFS.

Los Angeles County

The status of RFS in Los Angeles County has not changed substantially since the review conducted in 2008. Two vernal pool complexes were described in the 2008 review as potentially supporting RFS, known as the Los Angeles (LA) Airport Complex (EOs 56 and 57) and the Madrona Marsh Complex (EO 67) (CDFW 2021, pp. 63–64, 75; USFWS 2008, p. 7). Habitat supporting RFS was removed at the LA Airport Complex in the early 2000s, and we determined RFS was not extant at that site in our 2008 review (USFWS 2008, p. 7). The status at the LA Airport complex status is unchanged.

The status of the Madrona Marsh Complex (EO 67) was unknown in 2008 and was previously documented by a small number of *Streptocephalus* cysts documented in 2003 (CDFW 2021, p. 75). Adults have not been recorded from Madrona Marsh and it is unknown if the vernal pools contain the environmental characteristics necessary to support RFS. Madrona Marsh was identified as a potential location to receive RFS from the LA Airport Complex through a

translocation effort as compensatory mitigation for habitat impacts at the airport. Ultimately, that translocation effort was not attempted. The status of RFS remains unknown at Madrona Marsh.

RFS was considered extirpated in Los Angeles County in the 2008 review. We have no new information to suggest it occurs in any historically occupied or newly discovered locations; therefore, one record is considered extirpated and the status of the other remains unknown (Table 1).

Orange County

The status of RFS remains largely unchanged in Orange County with the exception of a newly occupied location at Fairview Park, located in the city of Costa Mesa (EO 84) (CDFW 2021, p. 92). Fairview Park was not identified as an occupied site in the Recovery Plan (USFWS 1998, Appendix E), nor the recent 5-year review (USFWS 2008, p. 7). According to the CNDDB, low densities of mature RFS were discovered during the 2016–2017 rain season (CDFW 2021, p. 92). Suitable habitat for RFS at Fairview Park consists of a network of natural and created/restored vernal pools within the City-owned park. While the site is unlikely to be lost to development, recreation pressure and insufficient protection and management funding have led to direct habitat disturbance and indirect habitat degradation from nonnative species and altered hydrology. There are a total of 10 records in Orange County of which 5 are extant, one is considered extirpated (EO 4), and the status of 4 remaining occurrences are unknown, although 3 of the 4 were considered extant at the last 5-year review (Table 1).

Riverside County

On October 5, 2020, cysts of *Streptocephalus* were collected at a newly recorded site in Riverside County along Wickerd Road, in the City of Menifee. Soil samples were collected during dry season surveys and processed prior to a sewer pipeline replacement project (Mattson 2020, p. 2). The *Streptocephalus* cysts were considered RFS because it is the most likely species within the genus to be found in the local area. The site is within the Western Riverside Multiple Species Habitat Conservation Plan (MSHCP) boundary, but it is not protected by any existing or planned conservation program.

Five additional new locations of RFS have been detected within or adjacent to lands conserved by the MSHCP since the 2008 status review. Two locations were documented on the Lake Skinner Investors Property (EOs 60 and 62) (CDFW 2021, pp. 68, 70) to the northwest of Lake Skinner. Element Occurrence 63 is south of Lake Skinner, adjacent to conserved land called the Multi-Species Reserve. Based on review of maps created by the CNDDB and the MSHCP, it is difficult to determine if the vernal pool habitat supporting EO 63 is adequately conserved by the Multi-Species Reserve. In addition, two pools within the Santa Rosa Plateau Ecological Reserve are now known to support RFS, known as pool 4 and pool 5 (EO 69) (CDFW 2021, p. 77). Lastly, one new location occupied by RFS was documented to the east of the French Valley Airport, on a narrow strip of conserved land known as the French Valley Donation site (Biological Monitoring Program 2019).

In the 2008 review, we noted that cysts had been detected at the March Air Reserve Base (EOs 27 and 28) (USFWS 2008, p.7; CDFW 2021, EO 27 and 28). Based on review of satellite imagery and notes contained in the CNDDB, changes to infrastructure and roads have occurred onsite and it is unclear if habitat conditions remain to support RFS presently and into the future (CDFW 2021, p. 34).

A total of 23 records are known from Riverside County of which 14 are extant, including the 6 new areas described above. Six records are considered extirpated and were extirpated at the last 5-year review. The status is unknown at the remaining 3 records, although the species was observed as adults or cysts at the 2008 5-year review (Table 1).

San Diego County

U.S. Marine Corps Base Camp Pendleton

The status of RFS on Marine Corps Base Camp Pendleton (MCBCP) remains largely unchanged since the 2008 status review. We previously understood that MCBCP contained approximately 8 large complexes with over 111 pools occupied by RFS totaling at least 2.4 acres (ac) [0.97 hectares (ha)] of basin surface area (USFWS 2008, p. 18). Based on a more recent compilation of MCBCP GIS information, the U.S. Marine Corps (Marine Corps) currently estimates that MCBCP has at least 196 pools occupied by RFS totaling at least 4.8 ac (1.9 ha) of basin surface area (Marine Corps 2019, p. 35). This current estimate includes an update of the status of individual pools within known complexes that had not previously been surveyed and does not significantly expand the geographic range where this species has been found on MCBCP. Due to the difficultly in mapping and summarization of occupied habitat across locations and years, the 195 pools on MCBCP occupied by RFS have been combined to represent 1 general location (instead of tracking separate complexes) and is considered extant in the occurrence table (Table 1) and status summary below.

Conservation of RFS on MCBCP is primarily driven through Section 7 consultation, where compensatory mitigation for impacts to the species has resulted in an increase in the acres occupied through restoration, enhancement, and management of existing vernal pools and areas with appropriate soils and hydrology to support pool creation. The Marine Corps has focused conservation efforts for RFS on coastal terraces within the species historical range on MCBCP, including Wire Mountain, Cocklebur Mesa, Vernal Pool Group 68, and White Beach. A vernal pool management plan for MCBCP is in development that is intended to conserve RFS and other co-occurring vernal pool species; this program will balance increased military training flexibility with increased restoration and management to improve vernal pool habitat quantity and quality. Overall, RFS on MCBCP is managed to promote recovery of the species while balancing the need for regulatory flexibility to support training activities on Base.

Marine Corps Air Station Miramar

Marine Corps Air Station (MCAS) Miramar supports one of the largest and most contiguous areas of vernal pool habitat in southern California, with one of the most important assemblages of endangered and sensitive vernal pool species (Bauder and Wier 1991, p. 1). While MCAS Miramar contains numerous large vernal pool complexes with thousands of pools or basins, only

two pools are occupied by RFS and are considered a single extant occurrence (Table 1; Black 2021, *in litt.*).

The primary threat to RFS on MCAS Miramar is destruction and degradation of habitat through construction of new facilities, expansion of infrastructure, and unintentional damage by vehicles. However, MCAS Miramar has restored, created, and managed pools to offset impacts to vernal pool habitat. Overall, the Marine Corps' management of vernal pools at MCAS Miramar has provided a net benefit to the vernal pool resources through implementation of management objectives defined in Chapter 4 of their Integrated Natural Resource Management Plan (U.S. Marine Corps 2018, p. 4-1) and by offsetting project-related impacts through habitat restoration and enhancement efforts.

City of Carlsbad

Poinsettia Station (also known as complex JJ2) in the City of Carlsbad continues to be occupied, as reported in the 2008 review (USFWS 2008, p. 8). Lack of management over the last several decades resulted in significant degradation of the complex; however, the management and conservation status at this location has recently improved. In 2018, a project to expand the existing railroad station platform adjacent to the vernal pool complex resulted in minor temporary impacts to the pools. Funding was provided to enhance the pools as offsetting mitigation for the platform project. The City of Carlsbad took over management of the complex in 2019 to fulfill commitments under their Habitat Management Plan, a Subarea Plan within the North County Multiple Habitat Conservation Plan. The City of Carlsbad is working with the regulatory agencies and local jurisdictions to record an expanded conservation easement to protect the entire complex. The Poinsettia Station vernal pool complex continues to face challenges with the surrounding hydrology due to nearby residential runoff and the train station platform, but it will receive more management moving forward and is likely to continue to support RFS.

City of San Diego

We issued a Section 10(a)(1)(B) permit to the City of San Diego in association with the City's Vernal Pool Habitat Conservation Plan (VPHCP) on August 3, 2018. The VPHCP addressed species and habitats not adequately addressed by the City's existing Multiple Species Conservation Plan, issued in 1997 (City of San Diego 2019, p. 1-1). Covered projects and activities associated with the VPHCP are not anticipated to result in the loss of any of the 131 known vernal pools occupied by RFS within the plan area (City of San Diego 2019, p. 6-9). The objective of the plan for RFS is to conserve all 131 pools within seven vernal pools complexes owned by the City or under the City's land use authority and manage sites consistent with the Vernal Pool Management and Monitoring Plan (City of San Diego 2020, p. 2). The plan aims to establish viable RFS populations within additional sites (known as J11, J12, J13, J14, J16-18, J20-21, J21, J27 and J28E) (City of San Diego 2020, p. 2).

Southwest Village in the City of San Diego is a recently discovered occurrence on Otay Mesa based on surveys conducted in 2019 (Busby *et al.* 2019). RFS was detected in one pool within the project area (Busby *et al.* 2019, p. 7). The site is slated for development, but the cysts will be

salvaged and relocated to adjacent habitat that will be restored, monitored, and managed consistent with the VPHCP.

The Upham vernal pool complex (also known as J26, EO 61) on Otay Mesa was not known to be occupied by RFS in the last 5-year review (USFWS 2008, p. 8). In 2009, cysts of RFS were detected (CDFW 2021, p. 69). Additional information about the status of RFS at this site is unknown. The Upham complex is a former vernal pool mitigation site and was protected by a conservation easement; therefore, the site is unlikely to be developed. However, the easement was abandoned and lacks funding for easement enforcement and management.

The Sunroad Centrum/Otay 250 vernal pool complex (also known as J22) was not known to support RFS when the Recovery Plan (USFWS 1998, p. E2) was published, but the we subsequently assumed presence of this species onsite (USFWS 2008, p. 8). RFS was recently confirmed at this location with the discovery of RFS cysts onsite in 2020 (USFWS 2021, p. 10). The proposed construction of a residential housing development will avoid direct impacts to basins occupied by RFS; however, these occupied basins will be surrounded by development which will reduce the size of the surrounding watershed. Hence, construction is anticipated to degrade the ability of the pools to support RFS in the long-term and will not provide long-term conservation value to the species (USFWS 2021, p. 11). Offsetting measures associated with the project will result in vernal pool restoration and enhancement of additional pools (i.e., in addition to the existing RFS occupied pools that will be surrounded by development) on the property aimed at benefitting the species over the long-term, including preservation and management in perpetuity (USFWS 2021, pp. 11–14).

The Brownfield airport vernal pool complex (also known as J35++, EO 64) was considered extant at the time of the last status review (USFWS 2008, p. 8; CDFW 2021, p. 72). The J35++ complex is adjacent to the airport runway and consists of former concrete basins for drying sea kelp. It is unknown if the species continues to be extant, and if the habitat conditions are suitable to support RFS.

The Dennery West vernal pool complex (also known as J31) was not identified in the Recovery Plan (USFWS 1998, p. 20) nor the recent 5-year review (USFWS 2008, Appendix 1) as a site occupied by RFS. The site consists of a complex of pools enhanced and/or restored by the California Department of Transportation (Caltrans) to offset project impacts associated with State Route 905. The site was slated to receive soil inoculum with the goal of translocating RFS onsite, but after Caltrans completed restoring vernal pool habitat onsite, the species was detected naturally in 10 pools and the inoculum was not needed (Scatolini 2021, *in litt*; AECOM 2010, pp. 4–7). The site is unlikely to be developed and will support the conservation of RFS into the future.

Within San Diego County, there are currently 25 RFS records including 20 that are extant, of which 3 were recently recorded (Table 1). Three records are extirpated including 2 that were recognizes as extirpated at the 2008 5-year year. The third possibly extirpated record is due to recently permitted projects (East Otay Mesa). The status of 2 records remains unknown due to a lack of recent surveys.

Status Summary

In the 2008 5-year review, we estimated that approximately 45 vernal pool complexes were occupied by RFS (USFWS 2008, Appendix 1, pp. 1–9). We now estimate that RFS occurs in 40 vernal pool locations or complexes, as described in Table 1. The new estimate should not be interpreted as a decrease in the total number of vernal pools or complexes occupied by RFS from 2008 to 2021 because of differences in the way pool complexes and occupied habitat have been mapped and tabulated for this summary. In fact, we estimate that there are up to nine newly occupied locations for RFS in 2021 (known as: Tierra Rejada, Fairview Park, Wickerd Road, Lake Skinner Investor, Lake Skinner Multi-Species Reserve, Santa Rosa Plateau, French Valley Donation, Southwest Village Development, and Dennery West). Information was not available for a status determination to be made for 12 pools, and as such, some of these pools may no longer support RFS (known as: Madrona Marsh, Whiting Ranch/SCE Viejo, El Toro, Live Oak Plaza, O'Neill Park, March Air Force Base, Scott Pool, Rainbow Canyon Pool, Upham, Brownfield Airport, and two locations in Mexico).

Threats

At the time of listing in 1993, we considered RFS to be threatened by urban, road, and agricultural development; off-road vehicle use; trash dumping; cattle trampling; human trampling; military activities; water management activities; and habitat isolation (USFWS 2008, p. 11). In the 2008 5-year review, we identified the following threats: habitat loss and indirect effects of development/habitat fragmentation, nonnative plants, inadequacy of existing regulatory mechanisms, climate change, and fire (USFWS 2008, pp. 12–37).

We believe each of the threats discussed in the 2008 status review are still relevant and acting upon the species throughout its range, although the magnitude of each threat may be slightly higher or lower than in 2008.

Habitat loss and indirect effects from development and fragmentation are ongoing threats to RFS but impacts to the species have been reduced in part by the conservation implemented at many locations through regional Habitat Conservation Plans (HCP) (e.g., City of San Diego VPHCP and Western Riverside MSCHP). Nonnative plants continue to threaten RFS by degrading habitat such that the environmental conditions at some locations may no longer support RFS (e.g., expansion of nonnative plants may cause pools to dry more quickly and no longer support the inundation duration needed for RFS). Implementation of some HCPs, Integrated Natural Resource Management Plans on military bases, and consultations through Section 7(a)(2) of the Act lend support to habitat management and control of invasive species, but the threat of invasive species remains.

While RFS is protected by the Act, alteration of hydrology remains a threat to the species that was formerly ameliorated to some degree through the implementation of Section 404 of the Clean Water Act. Since the last 5-year review there has been a change in the regulatory definition of what is considered a jurisdictional water or wetland that is subject to the regulatory protections of the Clean Water Act. These regulatory changes have eliminated U.S. Army Corps of Engineers oversight of vernal pools and other ephemeral water bodies unless they meet a

narrow definition of an adjacent wetland (i.e., water bodies that have a surface connection to a navigable water or territorial sea through flooding in a typical year) (DOD and EPA 2020, p. 22251). While we no longer consider the lack of regulatory mechanisms as a threat, these changes to the regulations have removed the protections that were formerly in place that helped reduce impacts. Therefore, RFS are more at risk due to alterations in the hydrology of vernal pools and ephemeral water bodies.

CONCLUSION

New data were received from the Center for Natural Lands Management, the U.S. Marine Corps, and from coordination with partners in each region where RFS occurs. While RFS is no longer considered extant at a small number of locations where the species historically occurred, the species has been observed at approximately 10 new locations within the species historical distribution. Impacts from habitat loss and indirect effects of development and habitat fragmentation, nonnative plants, climate change, and fire are ongoing. Conservation through the implementation of HCPs, Integrated Natural Resource Management Plans on military lands, and consultation through Section 7(a)(2) of the Act have led to conservation of many occupied sites.

After reviewing the best available scientific information, we conclude that RFS remains an endangered species. The evaluation of threats affecting the species under the factors in 4(a)(1) of the Act and analysis of the status of the species in our 2008 status review remains an accurate reflection of the species current status.

RECOMMENDATIONS FOR FUTURE ACTIONS

The recommended actions listed below are to be completed over the next 5 years. Successful implementation of these actions will reduce threats to RFS and provide information to better understand the biological and physical factors limiting the population growth and distribution. We recognize that conservation of this taxon will require cooperation and coordination with partners (Tribes, Federal, State, and local agencies) to minimize impacts from current threats, aid future restoration, and maximize effectiveness of limited funding.

Many of these recommended actions were identified in the 2008 status review and we continue to believe the actions are relevant to the conservation of the species (USFWS 2008, pp. 44–45).

1. Provide funding to conservation partners for ongoing management, monitoring, and stewardship of occupied habitat.

2. Support continued conservation, enhancement, management, and monitoring of vernal pool habitat consistent with the 1998 Recovery Plan (USFWS 1998, Appendix F and G).

3. Determine the extent of all remaining occupied habitat, including status (e.g., conserved, restored, managed, monitored, impacted, illegally impacted) and management needs (e.g., conservation, restoration, management, monitoring) for all Riverside fairy shrimp occupied vernal pool complexes. Utilize this information to update Appendix 1 of the

2008-review (USFWS 2008, Appendix 1 and 2) and Table 1 of this review. Cross-reference these tables with the Recovery Plan (USFWS 1998, Appendix F and G).

4. Develop a population viability analysis (PVA) for the Riverside fairy shrimp, including the following subtasks:

    a. Develop and implement protocols to determine quantitative estimates of cyst abundance;

    b. Define ranges within which cyst banks would be considered adequately populated;

    c. Develop a quantitative estimate for adult abundance to reflect a healthy population (given sufficient pooling); and implement abundance estimates at occupied pools;

    d. Update the survey protocol to include acquisition of abundance data;

    e. Apply this knowledge to develop restoration and conservation success targets; and

    f. Apply this knowledge to assist in determining areas for preservation and translocation.

REFERENCES CITED

AECOM. 2010. 90-day report of protocol wet season fairy shrimp surveys for listed branchiopod species for Dennery Canyon West restoration site. 9+ pp. Unpublished report prepared by AECOM and submitted to U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.

Bauder, E.T. 1986. San Diego vernal pools, recent and projected losses, their condition, and threats to their existence 1979–1990, Volume 1. Report and Appendices 1, 4, 5, 6, 8, and 9. Prepared for Endangered Plant Project, California Department of Fish and Game, 33 pp.

Bauder, E.T. and H.A. Wier. 1991. Vernal pool management plan Naval Air Station Miramar. Southwest Division, Naval Facilities Engineering Command, U.S. Navy. 106 pp.

Belk, D. 1998. Global status and trends in ephemeral pool invertebrate conservation: implications for Californian fairy shrimp. Pages 147–150 *in* Ecology, conservation, and management of vernal pool ecosystems – Proceedings from a 1996 conference, Anonymous Witham, C.W, E.T. Bauder, D. Belk, W.R. Ferren Jr., and R. Ornduff (Editors); Sacramento, California, U.S.

Biological Monitoring Program. 2019. Species occurrence GIS data 2005–2019. Western Riverside County Multiple Species Habitat Conservation Plan Biological Monitoring Program.

Busby, D., M. Busby, E. LaCoste, and C. Dickson. 2019. Survey summary report for the 2018/2019 protocol-level, wet season large Branchiopod survey for the proposed southwest Village Development Project, San Diego California. 8+ pp. Unpublished report prepared by Busby Biological Services and submitted to U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.

[CDFW]. California Department of Fish and Wildlife. 2021. Occurrence report for Riverside fairy shrimp, *Streptochphalus woottoni*. California Natural Diversity Database, State of California. 92 pp.

City of San Diego. 2019. Revised final City of San Diego Vernal Pool Habitat Conservation Plan. 292 pp.

City of San Diego. 2020. Revised Final City of San Diego Vernal Pool Habitat Conservation Plan, Vernal Pool Management and Monitoring Plan. 326 pp.

[DOD and EPA]. Department of Defense, Corps of Engineers and Environmental Protection agency. 2020. The navigable waters protection rule: definition of "Waters of the United States". Federal Register 85:22250–22342.

Hanes, T. and L. Stromberg. 1998. Hydrology of vernal pools on non-volcanic soils in the Sacramento Valley. Pages 38–49 *in* Ecology, conservation, and management of vernal pool ecosystems – Proceedings from a 1996 conference, Anonymous Witham, C.W., E.T. Bauder, D. Belk, W.R. Ferren Jr., and R. Ornduff (Editors).California Native Plant Society; Sacramento, California, U.S.

Keeler-Wolf, T., D.R. Elam, K. Lewis, and S.A. Flint. 1998. California vernal pool assessment preliminary report. California Department of Fish and Game, State of California. 159 pp.

Lahti, M.E., A.G. Vandergast, Y. Matta, A.J. Bohonak, K. Davis, and M. Simovich. 2010. Data summary for the 2010 field and genetic surveys of the Riverside fairy shrimp (*Streptocephalus woottoni*) in southern California. U.S. Geological Survey Data Summary prepared for the U.S. Fish and Wildlife Service, Carlsbad CA, Department of the Interior. 47 pp.

Mattson, A. 2020. Wickerd Road Sewer Pipeline Replacement Project, 2020 dry season survey report. Prepared by Helix Environmental Planning, Prepared for Eastern Municipal Water District. 16 pp.

Snapp-Cook, J. 2020. Wet-season vernal pool branchiopod sampling on Pechanga Reservation at pool 6, Temecula, Riverside County, California. Prepared for Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation, California, 12+ pp. Unpublished report prepared by Jonathan Snapp-Cook, Biologist, Carlsbad Fish and Wildlife Office, Carlsbad, California.

[USFWS]. U.S. Fish and Wildlife Service. 1993. Endangered and threatened wildlife and plants; determination of endangered status for three vernal pool plants and the Riverside fairy shrimp. Federal Register 58:41384–41392.[USFWS]. U.S. Fish and Wildlife Service. 1998. Recovery plan for vernal pools of southern California. Region 1, Department of the Interior. 153 pp.

[USFWS]. U.S. Fish and Wildlife Service. 2008. Riverside fairy shrimp (*Streptochphalus woottoni*). Carlsbad Fish and Wildlife Office, Department of the Interior. 86 pp.

[USFWS]. U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; revised critical habitat for the Riverside fairy shrimp. Federal Register 77: 72070-72140.

[USFWS]. U.S. Fish and Wildlife Service. 2019. Recovery Plan Clarification for the Vernal Pools of Southern California. Department of the Interior. 2 pp.

[USFWS]. U.S. Fish and Wildlife Service. 2020. Endangered and threatened wildlife and plants; initiation of 5-year status reviews of 66 plant species in California and Nevada. Federal Register 85:4692–4694.

[USFWS]. U.S. Fish and Wildlife Service. 2021. Re-initiation of consultation for the Biological Opinion for the Otay 250 Specific Plan Amendment Project (formerly Sunroad Centrum Project) on East Otay Mesa, San Diego County, California. Carlsbad Fish and Wildlife Office, Department of the Interior. 24 pp.

Western Riverside County Regional Conservation Authority. 2021. Interactive RCA/MSHCP Map. Website viewed August 8, 2021. https://wrcrca.maps.arcgis.com/apps/webappviewer/index.html?id=a73e69d2a64d41c29ebd3acd67467abd.

Personal communications

Asmus, J. 2020. Ecologist, Environmental Security, Land Management Section, U.S. Marine Corps Base Camp Pendleton. Email correspondence to Bradd Bridges, Listing and Recovery Division Supervisor, USFWS, Carlsbad Fish and Wildlife Office. Dated March 31, 2020. Subject: SDFS and RFS data for Camp Pendleton.

Black, C. 2021. Wildlife Biologist, Marine Corps Air Station Miramar. Email correspondence to Colleen Draguesku, Fish and Wildlife Biologist, USFWS, Carlsbad Fish and Wildlife Office. Dated May 12, 2021. Subject: San Diego and Riverside fairy shrimp on Marine Corps Air Station Miramar.

Naegele, J. 2021. Natural Resources Manager, Orange County Parks, Orange County, California. Email correspondence to William Miller, Fish and Wildlife Office, USFWS, Carlsbad Fish and Wildlife Office. Dated June 22, 2021. Subject: Tijeras Creek Pool.

Rogers, D.L. and K. Klementowski. 2020. Director of Conservation Science and Stewardship and Regional Preserve Manager, Orange and Riverside County. Email correspondence to Bradd Bridges, Listing and Recovery Division Supervisor, USFWS, Carlsbad Fish and Wildlife Office. Dated March 17, 2020. Subject: Comments on the status of the Riverside fairy shrimp (*Streptocephalus woottoni*) pertaining to USFWS 5-year status reviews of 66 species in california and Nevada 0150FWS-R8-ES-2019-N134.

Scatolini, S. 2021. Caltrans District 1 Biologist. Email correspondence to Sally Brown, Fish and Wildlife Biologist, USFWS, Carlsbad Fish and Wildlife Office. Dated June 15, 2021. Subject: Dennery restoration site and shrimp inoculation.

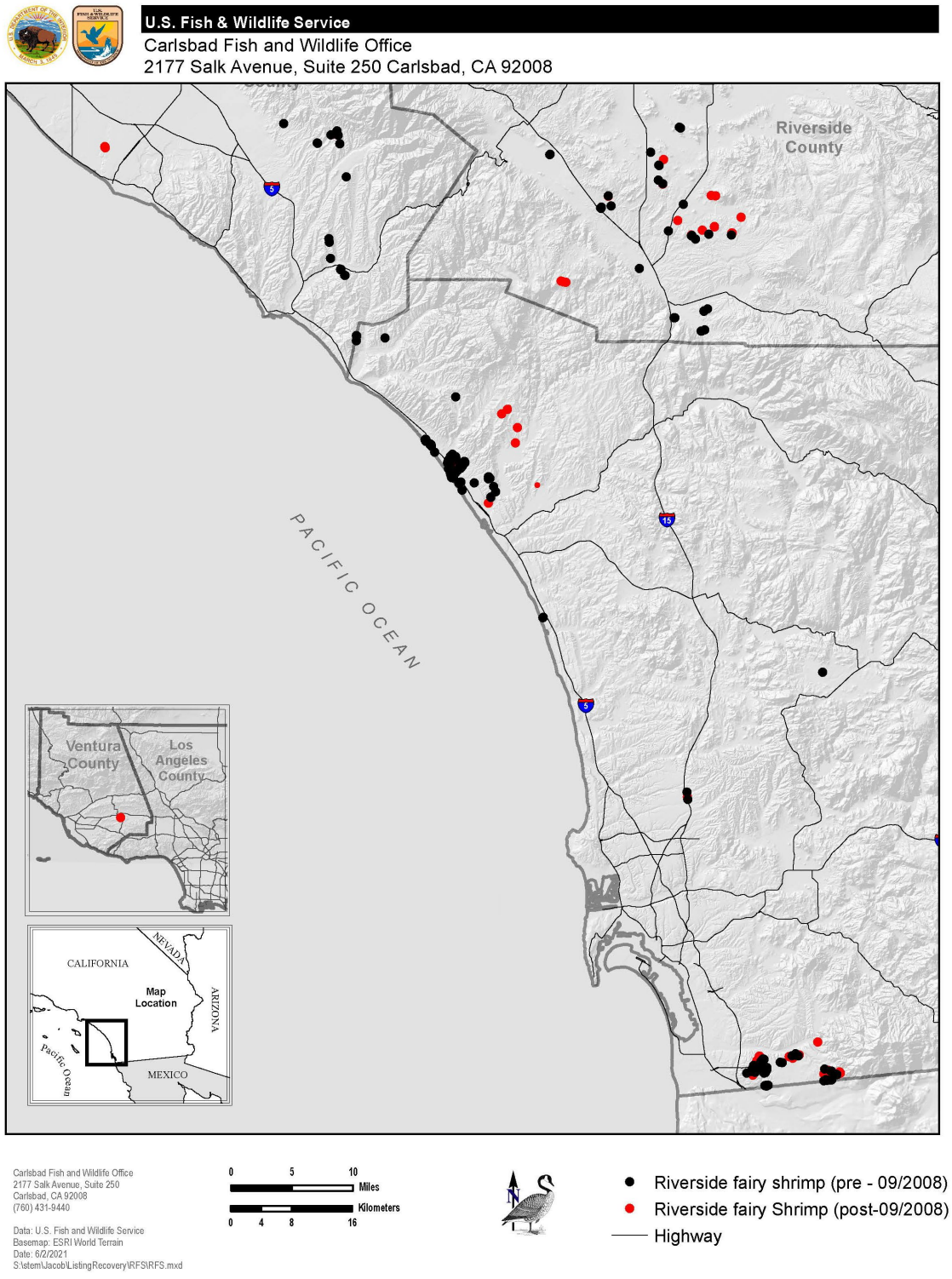

Figure 1. Distribution of point locations of Riverside fairy shrimp known in 2008 and 2021.

Table 1. Occurrence table for Riverside fairy shrimp.

County	Complex or General Area Name	Complex ID*	CNDDB EO	Extant in 2008?	Extant in 2021?	Comments- new information on surveys, status or threats
Ventura	Tierra Rejada (Carlsberg)	N/A	9	Unknown	Yes	See discussion above
Los Angeles	Los Angeles Airport	N/A	56, 57	No	No	See discussion above
Los Angeles	Madrona Marsh	N/A	67	Unknown	Unknown	See discussion above
Orange	Fairview Park	N/A	84	Not recorded	Yes	See discussion above
Orange	Whiting Ranch (SCE Viejo)	N/A	10	Unknown	Unknown	Last observed in 1998 (CDFW 2021, p. 14)
Orange	Saddleback Meadows	N/A	43	Yes	Yes	Cysts collected in 2009 (CDFW 2021, p. 49)
Orange	Tijeras Creek	N/A	42	Yes	Yes	Area conserved by the County of Orange (Naegele 2021, *in litt.*). Last observed in 2000 (CDFW 2021, p. 48)
Orange	Chiquita Ridge	N/A	5	Yes	Yes	10,000+ observed in 2010 (CDFW 2021, p. 8)
Orange	Radio Tower Road	N/A	15, 16	Yes	Yes	Last observed in 2001 (CDFW 2021, pp. 19–20)
Orange	El Toro	N/A	41	Yes	Unknown	1,000+ observed 2005 (CDFW 2021, p. 47)
Orange	Live Oak Plaza	N/A	N/A	Yes	Unknown	Unknown status
Orange	O'Neill Park/Clay Flats Pond Property	N/A	17	Yes	Unknown	Last observed in 2001 (CDFW 2021, p. 21)
Orange	Antonio Parkway	N/A	4	No	No	Considered extirpated
Riverside	Wickerd Road	N/A	N/A	Not recorded	Yes	Newly documented location based on *Streptocephalus* cysts (Mattson 2020)
Riverside	Lake Skinner Investors Property	N/A	60, 62	Not recorded	Yes	Two newly documented locations to the northwest of Lake Skinner (CDFW 2021, pp. 68, 70).
Riverside	Lake Skinner Multi-Species Reserve	N/A	63	Not recorded	Yes	Newly documented location to the south of Lake Skinner (CDFW 2021, p. 71)

County	Complex or General Area Name	Complex ID*	CNDDB EO	Extant in 2008?	Extant in 2021?	Comments- new information on surveys, status or threats
Riverside	Santa Rosa Plateau	N/A	69	Not recorded	Yes	Newly documented location
Riverside	French Valley Donation	N/A	N/A	Not recorded	Yes	Newly documented location (Biological Monitoring Program 2019; Western Riverside County Regional Conservation Authority 2021)
Riverside	Johnson Ranch	N/A	30, 31, 32	Yes	Yes	Received translocated individuals from Redhawk property. Expansion of number of pools occupied onsite (CDFW 2021, pp. 36–38)
Riverside	Schleuniger Pool	N/A	8	Unknown	Yes	Received translocated individuals from Clayton Ranch (CDFW 2021, p. 11).
Riverside	March Air Force Base	N/A	27, 28	Cysts	Unknown	Loss of EO 27 (CDFW 2021, p. 33). 1 cyst collected from EO 28 in 2009 (CDFW 2021, p. 34). Unknown if suitable habitat remains.
Riverside	Pechanga (Pala) Pool	N/A	34	Yes	Yes	2 immature individuals collected 2019 (Snapp-Cook 2020, p. 1).
Riverside	Skunk Hollow Pool	N/A	3	Yes	Yes	Some survey information reported in CNDDB is combined with Field Pool (CDFW 2021).
Riverside	Field Pool	N/A	3	Yes	Yes	Some survey information reported in CNDDB is combined with Skink Hollow Pool (CDFW 2021).
Riverside	Schau Pools	N/A	39	Yes	Yes	1000s estimated in 2 pools in 2008, samples collected for genetics study in 2009 (CDFW 2021)
Riverside	Australia Pool	N/A	11	Yes	Yes	10s present in 2010 (CDFW 2021)
Riverside	Scott Pool	N/A	24	Cysts	Unknown	Low density of cysts discovered in 2003. No new information
Riverside	Rancho California Road	N/A	33	Yes	Yes	1000s detected in 2 visits in 2010 (CDFW 2021)
Riverside	Rainbow Canyon Pool	N/A	20	Yes	Unknown	1 mature male collected in 2003, no new information (CDFW 2021).
Riverside	Grizzle Ranch	N/A	26	No	No	Considered extirpated
Riverside	Garbani Property	N/A	35	No	No	Considered extirpated
Riverside	Redhawk property	N/A	13, 14	No	No	Relocated to Johnson Ranch (CDFW 2021)

County	Complex or General Area Name	Complex ID*	CNDDB EO	Extant in 2008?	Extant in 2021?	Comments- new information on surveys, status or threats
Riverside	French Valley Town Center	N/A	38	No	No	Considered extirpated
Riverside	Warm Springs Property	N/A	36, 37	Yes	Yes	Last observed in low 10s in 2006 at EO 36; 10,000+ immature observed in 2006 at EO 37 (CDFW 2021)
Riverside	Clayton Ranch	N/A	19	No	No	Relocated to Schleuniger Pool (CDFW 2021)
Riverside	Temecula Education Complex	N/A	40	No	No	Considered extirpated
San Diego	Southwest Village Development	N/A	N/A	Not recorded	Yes	Newly documented location since 2008
San Diego	Upham	J26	61	Not recorded	Unknown	Possibly newly occupied location since 2008 based on cysts collected in 2009 (CNDDB 2021, EO 61). Additional info needed.
San Diego	Otay Mesa: Dennery West	J31	18	Not recorded	Yes	Newly documented location since 2008. Approximately 10 pools occupied by RFS (City of San Diego 2019, p. B-1)
San Diego	Otay Mesa: Brownfield	J35++	64	Yes	Unknown	Possibly extirpated. See discussion above.
San Diego	Otay Mesa: J11 W	J11 W	N/A	Yes*	Yes	*Location was documented before 2008, but this location was not identified as occupied in 2008 review. Discrepancy updated
San Diego	Otay Mesa: Goat Mesa/ Wruck Canyon	J16-18	N/A	Yes*	Yes	*Location was documented before 2008, but this location was not identified as occupied in 2008 review. Discrepancy updated
San Diego	Marine Corps Air Station Miramar	AA1	1	Yes	Yes	2 pools onsite support RFS. Noted as AA1 east and AA1 south in 2008
San Diego	Marine Corps Base Camp Pendleton	N/A	Multiple	Yes	Yes	Approximately 111 pools were occupied by RFS in 2007. Approximately 195 pools are currently occupied by RFS. See discussion above
San Diego	Ramona T	N/A	44	Yes	Yes	Cysts last detected in 2006 (CDFW 2021). Site partially conserved by Ramona Grasslands Preserve.
San Diego	Poinsettia Station	JJ2	7	Yes	Yes	See discussion above
San Diego	Otay Mesa: Sunroad Centrum	J22		Yes	Yes	See discussion above
San Diego	Otay Mesa: Sweetwater High School	J33++	65	Yes	Yes	3 occupied pools (City of San Diego 2019, p. B-1).
San Diego	Otay Mesa: Lonestar W	J29	2	Yes	Yes	1 occupied pool (City of San Diego 2019, p. B-1).
San Diego	Otay Mesa: Lonestar E	J30	2	Yes	Yes	35 occupied pools (City of San Diego 2019, p. B-1).

County	Complex or General Area Name	Complex ID*	CNDDB EO	Extant in 2008?	Extant in 2021?	Comments- new information on surveys, status or threats
San Diego	Otay Mesa: Calterraces N, Otay Mesa Rd Parcels	J2	18	Yes	Yes	93 occupied pools (City of San Diego 2019, p. B-1).
San Diego	Otay Mesa: Robinhood Ridge	J4-5	55, 18	Yes	Yes	Previous documents noted this complex as J4-7. Complex now reflects to J4-5 per updated mapping. 6 occupied pools (City of San Diego 2019, p. B-1).
San Diego	Otay Mesa: Anderprises	J14	53	Yes	Yes	Habitat enhancement at "Anderprises Phase 2" by Caltrans has resulted in an increased number of occupied pools onsite. 3 occupied pools (City of San Diego 2019, p. B-1).
San Diego	Otay Mesa: Calterraces S	J14++	53	Yes	Yes	26 pools occupied (City of San Diego 2019, p. B-1)
San Diego	Otay Mesa: Arnie's Point	J15	50	Yes	Yes	30 occupied pools onsite (City of San Diego 2019, p. B-1)
San Diego	Otay Mesa: West Otay A and B	J32++	66	Yes	Yes	1 occupied pool occupied on West Otay A (City of San Diego 2019, p. B-1)
San Diego	Otay Mesa: Candlelight	J34	54	Yes	Yes	1 occupied pool onsite (City of San Diego 2019, p. B-1)
San Diego	Otay Mesa: St. Jerome's Church	J2W++	18	Yes	Yes	3 occupied pools onsite (City of San Diego 2019, p. B-1)
San Diego	Otay Mesa: East Otay Mesa++ (Arnaiz Parcel, Area 2 Secondary Border Fence Project, SR-11/Otay Crossings Commerce Park)	N/A	59, 25, 58, 21	Yes	Possibly Extirpated	Pools have already been, or are likely to be, removed through completed permits and consultations for various projects.
San Diego	Otay Mesa: Calterraces	J1	N/A	No	No	Considered extirpated
San Diego	Otay Mesa J3	J3	51	No	No	Considered extirpated
Mexico	Location 1 (possibly Valle de las Palmas)	N/A	N/A	Unknown	Unknown	No information found regarding the status in Mexico.
Mexico	Location 2 (possibly El Rosario)	N/A	N/A	Unknown	Unknown	No information found regarding the status in Mexico.

* "Complex ID" is in reference to alphanumeric vernal pool naming system in San Diego County (Bauder 1986, Appendix 1, 4)

FIELD OFFICE APPROVAL

Lead Field Supervisor, Fish and Wildlife Service

☒ Approve

SCOTT SOBIECH

Digitally signed by SCOTT SOBIECH
Date: 2021.08.31 10:06:54 -07'00'

Scott A. Sobiech
Field Supervisor