California Fish and Game 98(4):202-213; 2012

Conservation status of the Tomales Bay Isopod *Caecidotea tomalensis* (Malacostraca: Isopoda)

G. O. Graening*, Darren Fong, Larry Serpa, Navneet S. Sharma, and Guy J. Graening

Department of Biological Sciences, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819, USA (GOG, NSS)

Golden Gate National Recreation Area, Building 1061, Fort Cronkhite, Sausalito, CA 94965, USA (DF)

California Program, The Nature Conservancy, 201 Mission Street, 4th Floor, San Francisco, CA 94105, USA (LS)

Brown and Caldwell, Inc., 10540 White Rock Road, Suite 180, Rancho Cordova, CA 95670, USA (GJG)

**Correspondent: graening@csus.edu*

Almost 50 years have lapsed since the last publication on the distribution and ecology of the Tomales Bay Isopod, *Caecidotea tomalensis*, a rare crustacean endemic to California's north coastal mountain region. The loss of the type specimen, taxonomic errors, and the presence of morphologically similar congeners have made it difficult to accurately assess its distribution and abundance. We revisited most of the historic locations of *C. tomalensis*, and present the results of these and other aquatic bioinventories and the examination of museum accession records. We detected at least 40 new populations and we expanded the species' range into Del Norte, Monterey, and Sonoma Counties. We also document the disappearance of several known populations, which is attributed to habitat degradation. We also made recommendations on the conservation ranking of the taxon and future research directions.

Key words: *Caecidotea*, endangered species, habitat degradation, isopod, Tomales Bay, zoogeography

---

The Tomales Bay Isopod, *Caecidotea tomalensis* (Figure 1), is an enigmatic crustacean whose physiological traits and ecological niche are poorly understood. It appears to be unique among its congeners in its preference for lentic habitats and its toleration of wide fluctuations in water quality variables where it occupies ephemeral pools. The

Figure 1.—The Tomales Bay isopod (*Caecidotea tomalensis*) photographed live from Glenbrook Creek, Point Reyes, Marin County, California. Photo by Ron Davis, April 2010. The specimen in the photograph measures 14 mm in length.

convoluted taxonomic history of this species has exacerbated past attempts to accurately assess its distribution and abundance. The taxon *Asellus tomalensis* was established with the description of a single female specimen one and one-half centuries ago, although the male sexual pleopods are typically required for differentiating Isopoda. Harford (1877:55) described this collection event and the need for additional study as follows:

> "This interesting little Isopod was recently obtained by Mr. W. N. Lockington while collecting at Tomales Bay and vicinity, and is, so far as I am aware, the first example of the genus on this Coast...A single specimen only was found, although several casts of the net were made. It would seem, therefore, very uncommon in that locality. We hope, however, that by diligently searching the fresh water ponds and streams along our Coast it may be found in greater numbers, with, possibly, other species of the genus. I hope that collectors will carefully examine our fresh waters for this Crustacean, thereby enhancing the value of our cabinet, and aiding students in acquiring a knowledge of these very interesting little creatures."

However, according to Van Name (1936:460), "Harford (1877) described this species very briefly and insufficiently from a single mutilated specimen..." To complicate matters, Richardson (1904: 668) extended the range of *C. tomalensis* with this conjecture:

> "Eight specimens of a species of *Asellus* were collected by the Harriman Alaska expedition at Lake Washington, Seattle. I have referred them to the above species, being unwilling to describe a new species of *Asellus* from a locality so close to that from which *A. tomalensis* was found (Tomales Bay, California), when so little is known about *A. tomalensis*."

Holmes (1904: 323) did not accept the redescription of *C. tomalensis* by Richardson (1904), stating, "The form recently described as *Asellus tomalensis* by Miss Richardson is quite different from this species, as I have determined by a re-examination of Mr. Harford's type." Holmes redescribed *C. tomalensis* and figured the type, but not sufficiently to determine its diagnostic characters and relationships. Williams (1970: 72) criticized Holmes (1904)'s redescription, stating, "Harford's type was redescribed in 1904 by Holmes, but the

redescription, though more complete, provided no further clarification of the species identity; moreover, it indicated that the specimen was a female...". The type specimen was then lost when the San Francisco earthquake and fire of 1906 destroyed the California Academy of Sciences and its alcoholic collections (Williams 1970).

Even though the type specimen was lost and the description inadequate, biologists such as Johansen (1922), Fee (1926), Carl (1937), Hatch (1947), and Ellis (1971) confidently, but apparently incorrectly, identified their specimens located north of California as *C. tomalensis*. The exception was Williams (1972), who correctly recognized a new species—*C. occidentalis* in these northern areas. Almost 70 years after the destruction of the Academy, Bowman (1974) redescribed *C. tomalensis* using topotypic material from a shallow pond near Bolinas Lagoon, which is just 21 km south of Tomales Bay. Furthermore, Bowman (1974) restricted the range of *C. tomalensis* to California and reassigned specimens from Oregon, Washington, and British Columbia to other taxa (primarily *C. occidentalis*). By the 1990s, biologists began to detect *C. tomalensis* in counties surrounding Tomales Bay as well as the continued invasion of congeners from eastern North America, particularly *C. communis* and *C. racovitzai* (Serpa 1991, Toft et al. 2002).

C. tomalensis is known from various freshwater habitats—a well, peat bogs, mill ponds, springs, and coastal lakes with slightly brackish water (Hatch 1947). Bowman (1974:437) reported the "...requirement for slowly moving water containing considerable vegetation...". In 1966, D. Chivers first reported *C. tomalensis* in a sag pond (NMNH database); Rogers (2005) posited that it was common in such ponds that form in topographic depressions along strike-slip fault lines under tension.

C. tomalensis is generally associated with perennial, shallow lentic habitats, but it can be found in ephemeral pools and moist mud where it burrows into the substrate during drought (Pennak 1989, Serpa 1991, Post 2010, this study). In his dytiscid study, Post (2010:258,260) described a new *C. tomalensis* habitat as follows: "These [beetle] species were found to be strongly associated with the pygmy forest of Mendocino, California. The soils of the pygmy forest are strongly podsolized and nearly impenetrable to water. As a result, rain water pools and quickly becomes acidified. ... Very few other aquatic insects were observed in these acidic pools, but isopods and copepods were common." Although the diet of *C. tomalensis* has not been studied, caecidotids are generally omnivorous, and specifically, detritivores and scavengers (Lewis 2009).

This current study effort revisited most of the historic locations of *C. tomalensis*, and reports on both the loss of some known populations and the discovery of new ones, discusses the impacts of habitat loss and invasive species, and updates the conservation status of the taxon.

Methods and Study Areas

We performed an exhaustive literature review of *C. tomalensis*, and all known occurrence records from the literature are summarized. We also incorporated occurrence records from unpublished agency reports, and where possible, checked taxonomic determinations with the assistance of isopod specialist J. J. Lewis (Lewis and Associates, LLC). Serpa (1991) performed a *C. tomalensis* survey in 35 ponds and streams in Mendocino, Marin, San Mateo, and Sonoma counties between 1989 and 1991. Fong (1996) surveyed a total of 31 sites (including 11 streams) in Golden Gate National Recreation Area for *C. tomalensis* in 1995. Lobianco and Fong (2003) searched for isopods during aquatic

surveys at Point Reyes National Seashore and Golden Gate National Recreation Area in 2002. During a survey of aquatic beetles (Dytiscidae) in Mendocino County, Post (2010) collected caecidotids from many ephemeral pools.

The following databases were also queried for *C. tomalensis* records and specimens: California Academy of Sciences (CAS) Department of Invertebrate Zoology and Geology's Invertebrate Collection Catalog Database; California Department of Fish and Game's Natural Diversity Database (CDFG 2011); CDFG's Aquatic Bioassessment Laboratory database, which includes data from the State Water Board's Surface Water Ambient Monitoring Program, US Environmental Protection Agency's Environmental Monitoring and Assessment Program, and regional agency and citizen monitoring programs; California Department of Water Resources' (CDWR) Bay Delta and Tributaries Project, Interagency Information Systems Services Office and Bay-Delta Monitoring and Analysis Section (CDWR 2011); and the invertebrate zoology collections database of the Smithsonian Institution's National Museum of Natural History (NMNH).

An attempt was made to revisit every historic locality for *C. tomalensis*, but many collection records were too vague to determine the exact location. Landowner permission was secured before entry, and collections were made under the following permits: National Park Service Scientific Research and Collecting Permits: PORE-2010-SCI-0014, GOGA-2010-SCI-0009, and WR-GOGA-95-005; and CDFG Scientific Collecting Permit No. SC-006802. Collection methods in lentic habitats consisted of scraping hydrophytic vegetation and other substrates with a dipnet, and in lotic habitats, sifting stream cobbles with a D-ring kicknet. Collected materials were placed in a white enamel pan to assist the sorting of invertebrates out of substrate. Specimens were preserved in 95% EtOH and deposited in the California Academy of Sciences.

Results

In the twentieth century, field biologists assigned the taxon *C. tomalensis* to a variety of asellid isopods collected in Oregon, Washington, and British Columbia. However, Bowman (1974) assigned all material collected north of California to *C. occidentalis* with the following assumptions:

> " ...*A. tomalensis* does not occur north of California, that none of the above records are of the eastern species reported from Washington (*A. communis*, *A. racovitzai racovitzai*, see Williams, 1970), and that no undescribed species occur within the range of *A. occidentalis*. Additional collecting is needed to test these assumptions."

L. Fleming also reassigned specimens labeled *C. tomalensis* at the NMNH from British Columbia, Washington and Oregon to *C. communis* (NMNH database, unpub. data). Winger et al. (1972) reported *Asellus tomalensis* from the Provo River, Utah; Bowman (1975) reassigned it to *C. racovitzai*. *Caecidotea occidentalis* may have been introduced into this river (Gray 2004).

We follow Bowman (1974) in restricting *C. tomalensis* to California, but we understand that northern California, and the Pacific Northwest in general, also hosts *C. occidentalis* (Figure 2) as well as the introduced taxa *C. communis* and *C. racovitzai sensu lato* (Figure 3), and that the region is still understudied.

The following is an annotated list of all known *C. tomalensis* locales (Figure 2 and 4).

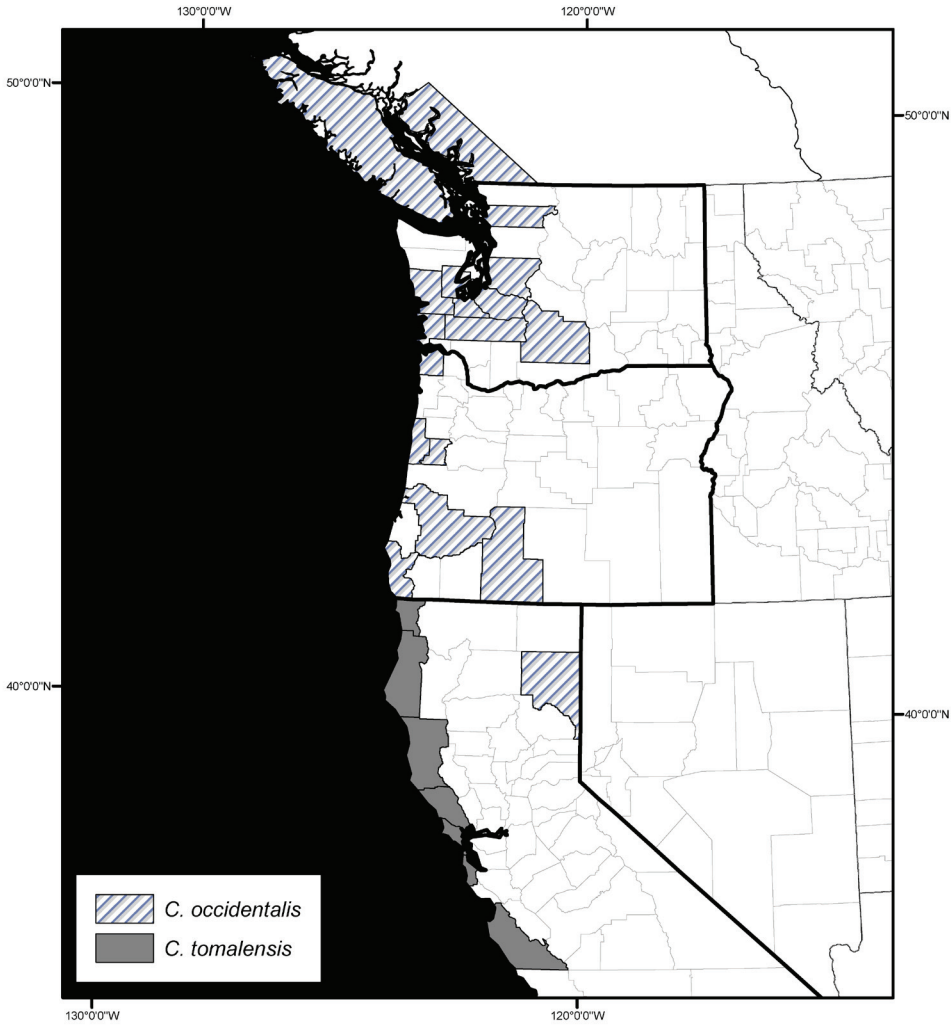

Figure 2.—Distribution of *Caecidotea occidentalis* and *C. tomalensis* by occupied counties. County records for *C. tomalensis* are previously cited in this study. Records for *C. occidentalis* are from Richardson 1904, 1905, Johansen 1922, Fee 1926, Saunders 1933, Van Name 1936, Carl 1937, Hatch 1947, Williams 1970, Ellis 1971, Bowman 1974, Wones and Larson 1991, and the National Museum of Natural History Invertebrate Zoology Collections database.

Del Norte County—Lagoon Creek, 10 collected by R. Fujimura, identified by T. Bowman in 1981 (NMNH database); we were not able to determine the exact location of this collection. Unnamed tributary of upper Lopez Creek, 4.3 km northwest of the town of Smith River, 3 specimens collected on 2 June 2012 by G. O. Graening, M. and K. Downing (deposited in CAS).

Humboldt County— "*A well*" (Holmes 1904); we were not able to determine the exact location of this collection.

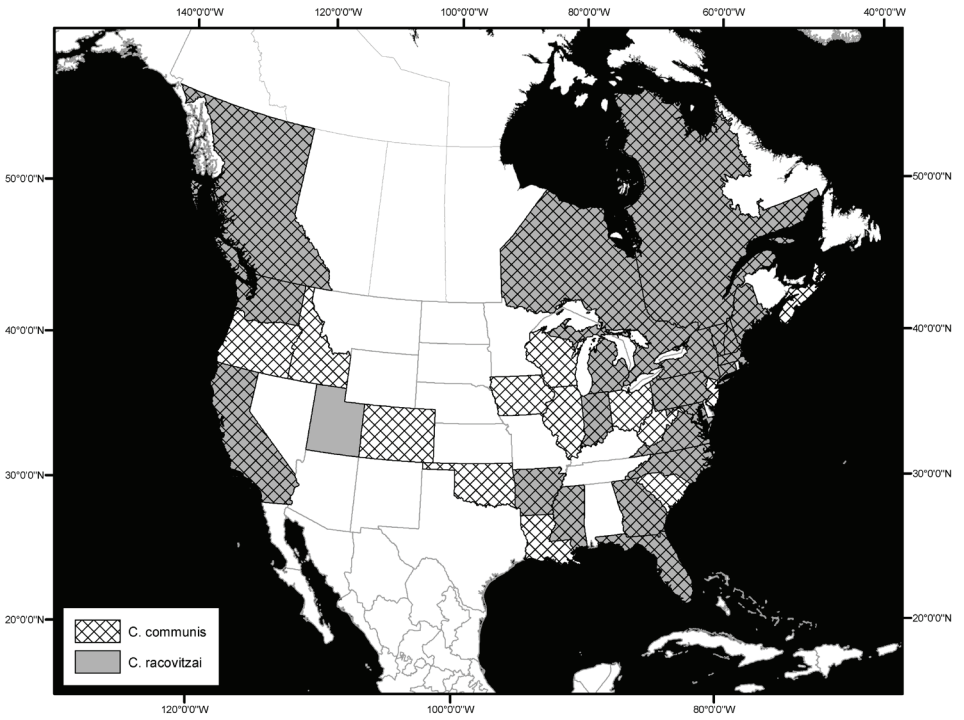

Figure 3. —Distribution of *Caecidotea communis* and *C. racovitzai* by occupied American states and Canadian provinces (from Richardson 1905, Mackin and Hubricht 1938, Hatch 1947, Williams 1970, 1972, Robison and Schram 1987, Graening et al. 2007). Occurrences west of the Continental Divide are considered introductions of these taxa, which are native to the east.

Marin County—Tomales Bay / Bolinas Lagoon area: a freshwater habitat described only as "Tomales Bay and vicinity" (type locality), collection by W.N. Lockington, as *Asellus tomalensis* (Harford 1877), but we could not determine the exact location of this collection; "Tomales Bay, Dillon Beach, Rolland Pond, in mud... about 500 km N of Tumaco", 10 July 1935, 7 coll. by O. Hartmann (NMNH database); "In small creek on S side Dillon Beach Road, approx. 1 mile E of beach", 25 specimens collected on 29 Aug. 1959 by G. Morijohn (NMNH database); "Offshoot of Lagunitas Creek near Point Reyes Station", 8 specimens collected by J. Brill in Sep. 1987, (NMNH database); lower Olema Creek, as *Caecidotea* sp., collection by M. Cooprider on 29 Mar. 2004 (this study); "shallow pond adjacent to nearby Bolinas Lagoon" (Bowman 1974); "shallow freshwater pond on Audubon Canyon Ranch, Volunteer Canyon" (Bowman 1974), 7 collected by M. Schneider on 1 Dec. 1971 (CAS) and 14 by E. Iverson and J. Carleton on 21 Feb. 1972 (USNM 141809), "many" counted and 30 collected by L. Serpa on 23 Jan. 1984 (Serpa 1984; NMNH database), several seen at this locale by G. O. Graening and C. Akin, 12 Feb. 2010 (this study); "Polio Pond" at Stinson Beach, several collected by G. O. Graening, N. Macias, and R. Gordon on 23 Sep. 2011 (this study; deposited in CAS). Point Reyes Peninsula: "pool in creek in Tomales Bay State Park", 10 specimens collected by J. Riegel on 17 Jan. 1958 (NMNH database); lower

Home Ranch Creek, as *Caecidotea* sp., collection by M. Cooprider on 18 May 2000 (this study); pond in Glenbrook Creek at Estero Trail bridge, collection by Lobianco and Fong (2003), and confirmed to be present and very abundant (est. 1,000 individuals) by G. O. Graening, T. Audisio, and R. Davis on 25 Apr. 2010 (this study); Marin peninsula (Golden Gate National Recreation Area): Backdoor Pond, collection by L. Serpa in 1991 and by D. Fong in 1995 (this study); lower Elk/Tennessee Creek, Tennessee Cove Pond, Rodeo Creek, and Rodeo Lake, collections by D. Fong in 1995 (this study).

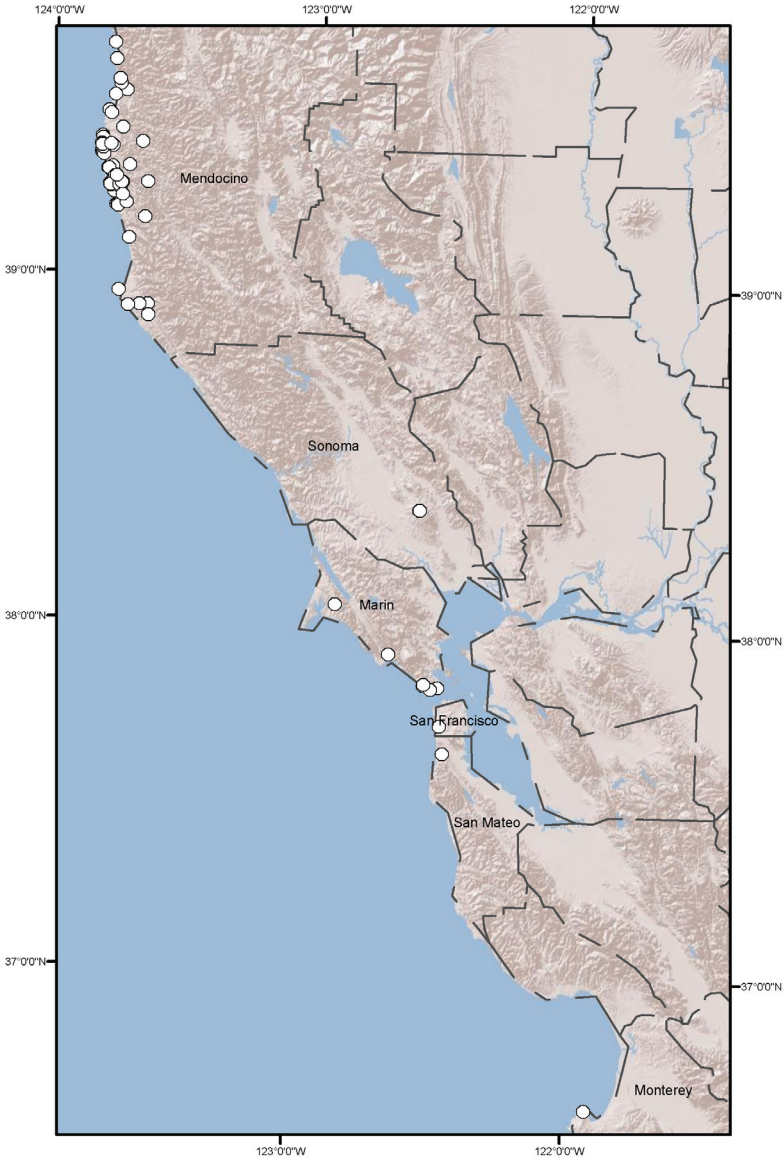

Figure 4.—Site records of the Tomales Bay isopod (*Caecidotea tomalensis*), with western California county boundaries and shaded topographical relief in the background (records for Del Norte and Humboldt Counties not shown here; see Results section for data sources).

Mendocino County—Point Arena (Holmes 1904); "Pygmy Forest Preserve, in stream falls among decaying leaves", 30 specimens collected by L. Serpa on 28 Oct. 1989 (NMNH database). Post (2010) reported isopods to be common in ponds and seasonal rainpools, especially in pygmy forest preserves, from Gualala in the south to the town of Rockport in the north; the following are *C. tomalensis* collection records from the Post (2010) study, the majority of which were examined by J. Lewis. Hans Jenny Pygmy Forest (University of California Natural Reserve System): rain pools near middle of Reserve, 4 specimens collected on 27 Jan. 2007; rain pools at back edge of Reserve, 1 specimen collected on 30 Mar. 2007; and a drainage ditch near the middle of the Reserve, 1 specimen collected on 27 Jan. 2007. Van Damme State Park, collection in Jan. – Mar. 2007. Mendocino Pygmy Forest (Jug Handle State Nature Reserve), collection in Dec. 2007. "Pygmy Forest off Gibney Lane", in rain pools, 3 specimens collected on 8 Dec. 2007. "Nature Conservancy Pygmy Forest near Ltl R. Airport", in rain pools and ponded ephemeral stream, 12 specimens collected on 28 Jan. 2007.

Monterey County—Pacific Grove, June 1905, collection by J. Benedict, and Apr. 1927 by J. Maloney (NMNH Invertebrate Zoology Collections database); we were not able to determine the exact location of this collection.

San Francisco County—"Lake Merced, NE side of north lake", 1 specimen collected by Bogatin in 1971 (Bowman 1974), 3 specimens collected by L. Serpa on 26 Jan. 1984 (Serpa 1984), but none were found subsequently by Environment and Ecology, Inc. (1993), White (2005), or by G. O. Graening on 19 Jan. 2010 (this study).

San Mateo County—"under boards in sag pond on east side of Skyline Blvd., 100 yards S. of Kings Drive., Sierra Monte development", 13 specimens collected by D. Chivers on 1 Apr. 1966 (Bowman 1974; CAS database), and later found in "fairly good numbers" and 29 specimens collected by L. Serpa on 17 Jan. 1984 (Serpa 1984), but none detected by G. O. Graening in July 2010 (this study); Pillar Point Marsh upstream of West Point Avenue, collection by D. Fong and D. Cook on 3 June 2000 (this study); Huddart Park, McGarvey Gulch, collection by M. Cooprider on 8 Apr. 2004 (this study).

Sonoma County—"Cheney Gulch, 3 miles SE Bodega Bay, Highway 1", 76 specimens collected by J. Brill in Sep. 1967 (NMNH database); "Marshall Gulch, in stream", 5 specimens collected by J. Bodle on 21 Sep. 1968 (NMNH database); "Stempe Creek, about 2.5 km upstream of Walker Road", 6 specimens collected by L. Serpa in leafpacks on 17 Apr. 1991 (NMNH database); "Portuguese Beach - spring near N Parking Lot - E side Highway #1", 1 specimen collected by J. Bodle on 21 Sep. 1968 (NMNH database); "Schoolhouse Beach, spring at end of culvert", 3 specimens collected by J. Bodle on 24 Sep. 1968 (NMNH database); Fairfield Osborn Preserve, in Courtship Creek and "a tule pond" [Frog Heaven Pond], reported as "abundant" and 76 specimens collected by L. Serpa on 7 Dec. 1982 (Serpa 1984), and on 24 Jan. 2010, G. O. Graening found it common in Frog Heaven Pond but none were detected in Courtship Creek (this study). Serpa (1984) also reported *C. tomalensis* in a "seep pond, Roth property" on June 3 1983, which is now part of the Fairfield Osborn Preserve (California Department of Fish and Game 2011).

Discussion

Examination of unpublished museum records and recent taxonomic determinations of specimens from stream bioinventories have resulted in a substantial increase in the species' range and number of populations. Specimens housed in the NMNH and CAS expanded the range of *C. tomalensis* into the counties of Del Norte, Monterey, and Sonoma. Aquatic inventories by the authors resulted in the detection of at least 40 new populations. Of particular interest is the study by Post (2010), who discovered numerous populations in a new habitat type—acidic, ephemeral pools in podsolized soils of pygmy forests. This study also documents the disappearance of several known populations, and we attribute these losses to habitat degradation. For example, most of the sag ponds that were present along Highway 35 in San Mateo County are now filled and underneath housing developments, or their groundwater recharge zones are severely reduced, resulting in the elimination of certain habitats, especially the *C. tomalensis* population at Skyline Boulevard reported by Bowman (1974). The population in Lake Merced (San Francisco County) may have been extirpated by habitat alteration and degradation from activities such as diking to isolate tidal influence and the introduction of pollutants from golf course lawn maintenance chemicals, urban runoff, and lead from a shotgun shooting range (Miller 1958, Environment and Ecology, Inc. 1993, White 2005, this study). Although we have not found any documentation of impacts upon *C. tomalensis* from invasive species, numerous crustacean species have been introduced into California's inland waters (see review by Graening et al. 2012), including the asellid isopods *Asellus hilgendorfii*, *C. communis*, and *C. racovitzai* (Lewis 2001, Toft et al. 2002).

However, some populations of *C. tomalensis* are already protected from habitat degradation by virtue of their enclosure within land preserves; examples include the artesian ponds in the Fairfield Osborn Preserve (Sonoma State University), the pygmy forest preserves on State and federal lands in Mendocino County, ponds and low gradient streams on the Marin headlands (Golden Gate National Recreation Area) and Point Reyes peninsula (Golden Gate National Sea Shore), and Lopez Creek (Smith River Rancheria tribal preserve land).

We feel that the current Natural Heritage Program conservation status global and subnational ranks of "2" (imperiled) are accurate because the species has a very restricted range, has less than 100 populations, some of which have experienced steep declines, and is vulnerable to habitat loss and invasive species (see ranking system rationale in Master 1991 and NatureServe 2012). For the same reasons, we suggest that the rank of "VU-B2,D1" (vulnerable to extinction) be assigned to this species on the International Union for Conservation of Nature and Natural Resources' Red List (IUCN 2012).

Further investigation of this species is recommended, especially in northern California and southern Oregon, where the range limit is not clearly defined. We are confident that additional bioinventory of aquatic habitats will detect new populations of *C. tomalensis*, but possibly not in sufficient quantity to upgrade their conservation status. It would also be interesting to explore the possibility of a groundwater dispersal mechanism, because many of the habitats are associated with regional faults that convey freshwater and that have surface expressions such as sag ponds and artesian springs (limnocrenes).

Acknowledgments

We are indebted to the scientists who graciously shared their unpublished data, including T. Bowman, D. Cook, M. Cooprider J. Lee, R. Lobianco, and J. Toft. We also acknowledge the fieldwork performed by colleagues, including T. Audisio, L. Babcock, L. Cao, R. Davis, B. Dong, R. Gordon, N. Macias, and Y. Shcherbanyuk. We also thank J. Smith and A. Gleason (CSUS Interlibrary Services Dept.) for literature acquisition, and the many land managers and landowners, for granting access and for protecting their aquatic resources, including S. DeCoursey (Sonoma State University, Fairfield Osborn Preserve), and G. Heistand (Audubon Canyon Ranch/Bolinas Preserve).

Literature Cited

Bowman, T. E. 1974. The California freshwater isopod, *Asellus tomalensis*, rediscovered and compared with *Asellus occidentalis*. Hydrobiologia 44:431-441.

Bowman, T. E. 1975. Three new troglobitic asellids from western North America (Crustacea: Isopoda: Asellidae). International Journal of Speleology 7:339-56.

California Department of Fish and Game. 2011. California Natural Diversity Database. Rarefind 3.1.5 computer application, Biogeographic Data Branch, California Department of Fish and Game, Sacramento, California, USA.

California Department of Water Resources. 2011. Environmental Monitoring Program [Internet]. Bay Delta Monitoring and Analysis Section, California Department of Water Resources; [cited 2011 November 12]. Available from: http://bdat.ca.gov/Php/Data_Retrieval/data_retrieval_by_category.php

Carl, G. C. 1937. Flora and fauna of brackish water. Ecology 18:446-453.

Environment and Ecology, Inc. 1993. Environmental lead characterization, Pacific Rod and Gun Club, Lake Merced, San Francisco, California, Final Report. Prepared for San Francisco Utilities Commission and Recreation and Park Department, City and County of San Francisco. Environment and Ecology, Inc., Lancaster, New York, USA.

Ellis, R. J. 1971. Notes on the biology of the isopod *Asellus tomalensis* in an intermittent pond. Transactions of the American Microscopical Society 90:51-61.

Fee, A. R. 1926. The Isopoda of Departure Bay and vicinity with descriptions of new species, variations, and colour notes. Contributions to Canadian Biology and Fisheries 3:13-46.

Fong, D. 1996. Tomales Asellid distribution and habitat survey. Aquatic Ecology Program 1995 Annual Report. Golden Gate National Recreation Area, National Park Service, Sausalito, California, USA.

Graening, G. O., M. E. Slay, D. B. Fenolio, and H. Robison. 2007. Annotated checklist of the Isopoda (Subphylum Crustacea: Class Malacostraca) of Arkansas and Oklahoma, with emphasis upon subterranean habitats. Proceedings of the Oklahoma Academy of Science 87:1-14.

Graening, G. O., D. C. Rogers, J. R. Holsinger, C. Barr, and R. Bottorf. 2012. Checklist of inland aquatic Amphipoda (Crustacea: Malacostraca) of California. Zootaxa 3544:1-27.

Gray, L. 2004. Changes in water quality and macroinvertebrate communities resulting from urban stormflows in the Provo River, Utah, U.S.A. Hydrobiologia 518:33-46.

Harford, W. G. 1877. Description of a new genus and three new species of sessile-eyed crustacea. Proceedings of the California Academy of Sciences Volume VII, Part I, 1876, p. 53-55.

Hatch, M. H. 1947. The Chelifera and Isopoda of Washington and adjacent regions. University of Washington Publications in Biology 10(5):155-274.

Holmes, S. J. 1904. On some new or imperfectly known species of west American Crustacea. Proceedings of the California Academy of Sciences 3:307-324.

International Union for Conservation of Nature and Natural Resources. 2012. The IUCN Red List of Threatened Species [Internet database]. IUCN Red List Unit, Cambridge, United Kingdom; [cited 2012 August 1]. Available from: http://www.iucnredlist.org/

Johansen, F. 1922. A freshwater-isopod new to Canada. Canadian Field Naturalist 36:156.

Lewis, J. J. 2001. Three new species of subterranean asellids from western North America, with a synopsis of the species of the region (Crustacea: Isopoda: Asellidae). Speleological Monographs (Texas Memorial Museum) 5:1-15.

Lewis, J. J. 2009. Isopoda (aquatic sowbugs). Pages 346-355 *in* G. E. Likens, editor. Encyclopedia of inland waters, volume 2. Elsevier, Oxford, United Kingdom.

Lobianco, R. M., and D. Fong. 2003. 2002 California freshwater shrimp (*Syncaris pacifica*) surveys within Point Reyes National Seashore and Golden Gate National Recreation Area. Prepared for U.S. National Park Service and U.S. Fish and Wildlife Service. Division of Natural Resource Management and Science, Golden Gate National Recreation Area, Sausalito, California, USA.

Mackin, J. G., and L. Hubricht. 1938. Records of distributions of species of isopods in central and southern United States, with descriptions of four new species of *Mancasellus* and *Asellus* (Asellota, Asellidae). American Midland Naturalist 19:628-637.

Master, L. L. 1991. Assessing threats and setting priorities for conservation. Conservation Biology 5:559–563.

Miller, R. C. 1958. The relict fauna of Lake Merced, San Francisco. Journal of Marine Research 17:375-381.

NatureServe, Inc. 2012. NatureServe explorer: an online encyclopedia of life, Version 7.1 [Internet database]. NatureServe, Arlington, Virginia; [cited 2012 August 1]. Available from: http://www.natureserve.org/explorer

Pennak, R.W. 1989. Fresh-water invertebrates of the United States: protozoa to mollusca. Second edition. John Wiley and Sons, New York, USA.

Post, D. L. 2010. Habitat identification for three California species of *Sanfilippodytes* Franciscolo (Coleoptera: Dytiscidae). The Coleopterists Bulletin 64:258-264.

Richardson, H. E. 1904. Contributions to the natural history of the Isopoda, V. Isopod crustaceans of the northwest coast of North America [Harriman Alaska Expedition]. Proceedings of the United States National Museum 27:657-681.

Richardson, H. E. 1905. A monograph on the isopods of North America. Bulletin of the United States National Museum 54.

Robison, H. W., and M. D. Schram. 1987. Checklist of the aquatic isopoda of Arkansas. Arkansas Biota Survey Checklist 48. Arkansas Academy of Science, Little Rock, Arkansas, USA.

Rogers, D. C. 2005. Identification manual to the freshwater Crustacea of the western United States and adjacent areas encountered during bioassessment. Technical Publication 1, EcoAnalysts, Inc., Moscow, Idaho, USA.

Saunders, L.G. 1933. Fresh-water amphipods of Vancouver Island. Contributions to Canadian Biology of Fishes 8(19): Series A Number 38.

Serpa, L. 1984. The status of *Caecidotea tomalensis* (Asellidae). Unpublished report to California Department of Fish and Game. Fairfield Osborn Preserve, The Nature Conservancy, Penngrove, California, USA.

Serpa, L. 1991. Tomales asellid contract survey progress report. Prepared for the U.S. Fish and Wildlife Service, Sacramento Field Office, Sacramento, California, USA.

Toft, J. D., J. R. Cordell, and W. C. Fields. 2002. New records of crustaceans (Amphipoda, Isopoda) in the Sacramento/San Joaquin Delta, California, and application of criteria for introduced species. Journal of Crustacean Biology 22:190-200.

Van Name, W. G. 1936. The American land and fresh-water isopod Crustacea. Bulletin of the American Musuem of Natural History 71:1-535.

White, N. 2005. The biogeography of Lake Merced: invertebrate fauna of Lake Merced [Internet]. Friends of Lake Merced, San Francisco State University; [cited 2011 December 1]. Available from: http://www.lmtf.org/FoLM/Data/SFSUReports/invertebrates.htm

Williams, W. D. 1970. A revision of North American epigean species of Asellus (Crustacea: Isopoda). Smithsonian Contributions to Zoology 49.

Williams, W. D. 1972. Freshwater isopods (Asellidae) of North America. Biota of Freshwater Ecosystems, Identification Manual 7. Environmental Protection Agency, Washington, D.C., USA.

Winger, P. V., E. J. Peters, M. J. Donahoo, J. R. Barnes, and D. A. White. 1972. A checklist of the macroinvertebrates of the Provo River, Utah. Great Basin Naturalist 32:211-219.

Wones, A. G., and G. L. Larson. 1991. The benthic macroinvertebrate community in a coastal sand dune lake relative to habitat and changing lake levels. Hydrobiologia 213:167-181.

Received 22 August 2012
Accepted 5 October 2012
Associate Editor was J. Harrington