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Occurrence of the Bluefin Killifish, *Lucania goodei,* in the San Dieguito River, Southern California

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The genus *Lucania* is comprised of three species restricted to North America: *L. goodei, L. interioris,* and *L. parva.* These are small-bodied fishes (less than about 60 mm total length) of the family Fundulidae. The Cuatro Ciénegas killifish, *L. interioris,* is endemic to the freshwater Cuatro Ciénegas Basin in Coahuila, Mexico (Hubbs and Miller 1965), and is an international critically endangered species (IUCN 2000). The rainwater killifish, *L. parva,* is a native of salt marshes, bays, and lagoons from Cape Cod, Massachusetts to Tampico, Mexico (Lee et al. 1980). It is especially abundant in the southeastern portion of its range, particularly in the St. Johns River system in Florida, and the Rio Grande and Pecos Rivers in Texas and New Mexico (Hubbs and Miller 1965; Page and Burr 1991). Non-indigenous populations of *L. parva* have been established in marine and freshwater environments in New Jersey, Texas, New Mexico, Utah, Nevada, California, and Oregon (Fuller et al. 1999). In California, the rainwater killifish is found in Irving Lake and Arroyo Seco Creek near Vail Lake in southern California (McCoid and St. Amant 1980), sloughs and streams flowing into the San Francisco Bay, and Lake Merritt in Oakland (Moyle 1976). The bluefin killifish, *L. goodei,* is found in freshwater habitats in the southeastern United States. Its endemic range encompasses most of Florida, except in the panhandle where it is found only east of the Choctawhatchee River, and the Chipola River drainage in southeastern Alabama (Page and Burr 1991). It is also found sporadically along the Atlantic coast up to central North Carolina where it is possibly introduced (Loyacano 1975; Lee et al. 1980; Menhinick 1991). Fuller et al. (1999) state that nonindigenous populations of *L. goodei* are established in North Carolina and South Carolina.

All three species of *Lucania* have similar body shapes and share many traits. They are fairly slender with compressed bodies and small, upturned mouths. The origin of their dorsal fin is anterior to the origin of their anal fin. They are dusky brown to olive above, and silvery white below. Their scales have dark edges, and their anal and dorsal fins both have thin black edges. *Lucania goodei* can be distinguished from its congeners by a distinctive stripe along the midline of the body, starting from the tip of the snout and ending at a black spot at the base of the caudal fin (Page and Burr 1991). In addition, the caudal and anal fins of adult male *Lucania goodei* are bright, iridescent blue in color and have a black stripe at their bases.

On 27 July 2000, seven individuals of *L. goodei* (Fig. 1) were captured in

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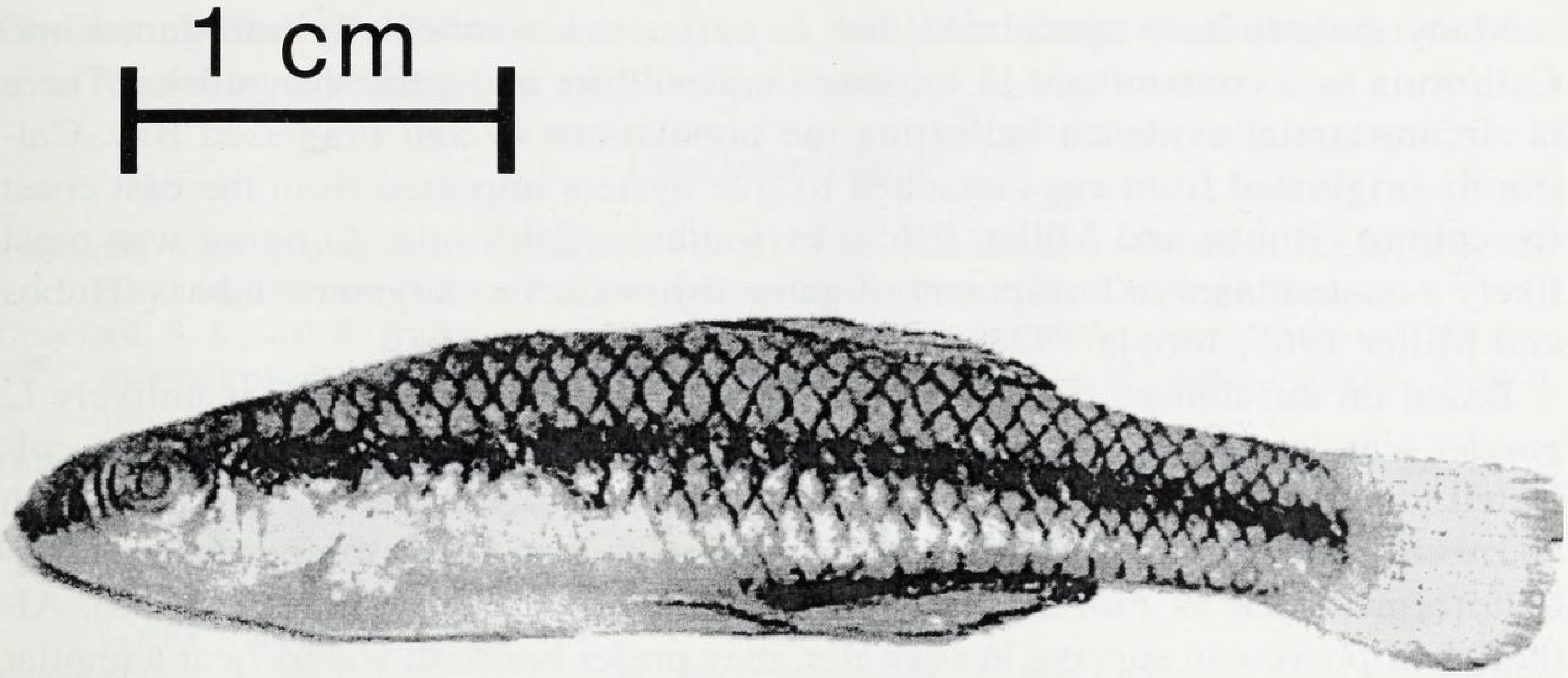

Fig. 1. Bluefin killifish, *Lucania goodei,* taken from upper San Dieguito River (SIO 01-192). Photograph by David Huang.

beach seines during annual monitoring conducted by the Marine Science Institute at the University of California, Santa Barbara of the upper San Dieguito River, San Diego County. These specimens are deposited at the Scripps Institution of Oceanography, SIO 01-192. On 23 September 2000, five more individuals were collected from the same location using dip nets. Salinity of the water at the times and locations of capture were between 15.9 and 16.2 ppt, a condition more saline than those in which they are typically found. All of the specimens had a distinct mid-lateral stripe from the tip of the snout to the base of the caudal fin, which was used to identify them as *L. goodei.* Two of the larger specimens also had the bright, iridescent blue caudal and anal fins characteristic of adult male *L. goodei.* Morphometric and meristic characters are summarized in Table 1.

Table 1. Counts and morphometric measurements of *Lucania goodei* specimens taken from upper San Dieguito River on 27 July 2000 (SIO 01-192). Morphometric measurements are in millimeters (mm).

	1	2	3	4	5	6	7
Counts:							
Dorsal fin	10	10	12	10	10	10	11
Anal fin	10	11	11	11	10	8	10
Pectoral fin	11	10	9	9	9	9	11
Lateral line scales	28	27	26	27	28	27	26
Morphometrics:							
Standard length	28.5	32.8	33.4	33.4	34.5	37.3	39.2
Total length	34.5	38.9	38.6	38.8	40.8	45.9	45.1
Head length	8.7	8.9	8.2	8.6	8.5	10.0	10.0
Snout length	1.8	2.3	2.1	2.2	2.1	3.1	3.0
Interorbital width	3.0	3.5	3.0	2.6	3.1	3.9	3.7
Orbit width	2.3	2.3	2.3	2.1	2.7	2.7	2.7
Pectoral length	4.5	4.8	4.2	4.4	5.0	4.9	4.9
Pelvic length	4.5	4.2	3.9	4.3	4.5	4.6	4.5
Caudal peduncle depth	3.6	3.8	3.2	3.4	3.9	4.5	4.0
Weight (g)	—	0.6	0.4	0.6	0.6	0.9	0.8

Many authors have speculated that *L. parva* was accidentally introduced into California as a contaminant in imported aquaculture and game fish stocks. There is circumstantial evidence indicating the populations in San Francisco Bay, California originated from eggs attached to live oysters imported from the east coast for culture (Hubbs and Miller 1965). In southern California, *L. parva* was most likely a contaminant in a shipment of game fishes such as largemouth bass (Hubbs and Miller 1965; Moyle 1976; McCoid and St. Amant 1980).

Based on differences in their natural distributions and habitats, it is unlikely *L. goodei* was introduced into California with *L. parva.* These fish are rarely collected together in their native range (Crawford and Balon 1994). The salt marsh and estuarine habitat of *L. parva* is similar to that of other temperate Cyprinodontiformes such as *Floridichthys, Fundulus,* and *Menidia* (Duggins 1980). Although *L. parva* can survive in seawater, they prefer brackish waters near a regular supply of fresh water (Jordan and Evermann 1896; Hubbs and Miller 1965). They are rarely found in completely fresh water. In contrast, *L. goodei* is almost always found in freshwater, although collections from mildly brackish water, such as in the current study, are also known.

Although the introduction of *L. goodei* with *L. parva* is unlikely, the only record of *L. goodei* in California was also the result of contaminated stocks. In late 1980, stocks of Asian milfoil (*Myriophyllum*) imported into Los Angeles from Florida were contaminated with *L. goodei* eggs, which hatched and survived several months in an outdoor pond (Swift et al. 1993). However, since that time there have been no records of this fish in any public waters in the state (Dill and Cordone 1997).

Hubbs and Miller (1965) discounted aquarium release as a source of introduction for *L. parva.* However, this now seems a likely source of *L. goodei* in the San Dieguito River. Considered to be one of the more attractive native killifish, *L. goodei* is a popular species in the aquarium trade (Schleser 1998). The introduction of new species into San Diego County by aquarium dumping is certainly not without precedent. Recently, aquarium dumping has been blamed for the threatening presence of the green alga, *Caulerpa taxifolia,* in the Agua Hedionda Lagoon as well as Huntington Harbor in Orange County, California (CWQCB 2001). The hypothesis of aquarium dumping is consistent with data taken during previous monitoring of the San Dieguito River, which shows no earlier records for *L. goodei.* This suggests that this population may have been introduced fairly recently.

Data from the 2001 San Dieguito River annual monitoring indicates the salinity at this study site has increased to 34–35 ppt, a condition considered abnormal for *L. goodei* habitat. Nonetheless, this population has persisted and become increasingly numerous (pers. obs., DH). Still, it is too early to determine the impacts of this introduction. Future monitoring will show whether *Lucania goodei* becomes permanently established in the San Dieguito River.

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