Unsubstantiated Claims Can Lead to Tragic Conservation Outcomes

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The vaquita porpoise (*Phocoena sinus*) is Mexico's only endemic—and the world's most endangered—marine mammal. With a population of fewer than 30 individuals (Thomas et al. 2017, IUCN 2018), any delay in taking needed conservation actions will result in its extinction. A recent article in the journal *Sustainability* (Manjarrez-Bringas et al. 2018) reasserts, without providing any scientific evidence, the baseless claims that the vaquita is fundamentally an estuarine species and that decline in vaquita is due to reduction of freshwater flow into the Upper Gulf of California (UGC) due to damming and diversion of the Colorado River. These unsupported claims detract from the real cause of vaquita decline—deaths in gillnets, in both legal and illegal fisheries. Here, we focus on setting the record straight, again, that there is no evidence that damming of the Colorado River has affected the fate of vaquita, in the hope that management efforts can be correctly and effectively directed to protect this marine mammal. As we describe below, the Upper Gulf did not have a large, long-term, continuous river flow nor brackish-water conditions even before the damming of the Colorado River.

The Gulf of California is an arm of the Pacific Ocean, approximately 267,000 square kilometers, characterized by good tidal flushing, strong upwelling, and exchange with the open Pacific that lead to high, year-round productivity (Hidalgo-González et al. 1997, Lluch-Cota et al. 2007). The Upper Gulf experiences extreme tidal flushing and mixing and has some of the highest biological productivity of any marine region in the world (Brusca et al. 2017). At the northernmost boundary of the Upper Gulf is Montague Island, and above that is the wide expanse of the Colorado River Delta. The estuary of the river has, historically, included Montague Island and the seawaters north of it. Although predam Colorado River flows into the Gulf were not recorded, they were very low relative to other North American rivers. For example, using an average flow estimate for the Colorado River of 15×10^9 cubic meters (m^3) per year past the city of Yuma, Arizona (see the supplemental material), this discharge is small relative to the Columbia and Fraser Rivers, which discharge 236×10^9 m^3 per year and 110×10^9 m^3 per year to the Pacific, respectively. Both of these rivers have concentrations of harbor porpoise (*Phocoena phocoena*) at their mouths, but harbor porpoises are also found continuously along the coasts from California to Japan and clearly do not depend on estuarine conditions, nor do any of the other six species of porpoise (including vaquita; Read 1999). The physiology and biology of vaquita also clearly indicate it is a marine species, not an estuarine animal (see the supplemental material).

No long-term, predam salinity data exist for the Upper Gulf. However, salinities for hydrographic stations between San Felipe and El Golfo de Santa Clara recorded before damming, in March 1889, were between 35.8 and 36 parts per thousand (ppt; Roden 1958), which indicates the presence of typical marine water masses in the Upper Gulf in predam years and not brackish waters. The best assessment of predam river influence on salinity is the measured effect of a 1993 flood release (Lavín and Sánchez 1999). An estimated maximum 550 m^3 per second of river water crossed the border into Mexico during a March–April pulse release, for a total 2-month discharge of about 2.9×10^9 m^3, or an average daily flow of 47.5×10^6 m^3 during that 2-month period. That last value—47.5×10^6 m^3—is about 0.1% of the volume of the Upper Gulf. During that period, a slight drop in surface salinity extended only along the northernmost western shore of the Upper Gulf for about 70 kilometers, with salinities off San Felipe being approximately 35.4 ppt, similar to today's oceanic salinities, whereas the lowest salinity value of approximately 32.0 ppt was recorded southwest of Montague Island. The eastern side of their northernmost transect also had salinities of approximately 35.4 ppt, "typical of the surface mixed layer just outside the UGC" (Lavín and Sánchez 1999). This demonstrates that the Upper Gulf has never been estuarine or brackish (i.e., below 30 ppt) in nature, except for the area between Montague Island and the mouth of the Colorado River—where vaquita have never been reported.

These studies indicate that the only significant penetration of delta waters into the Gulf, historically, was from the mouth of the river (Montague Island) to San Felipe, only along the extreme northwest shore of the Upper Gulf and probably only during very high flow periods (normally, May–July). The assertions by Manjarrez-Bringas and colleagues (2018) that "the estuary condition of the UGC changed radically due to the severe modification of freshwater discharge" and that "in the estuary environment of the vaquita, the salinity ranges from 38–42 ppt, which are not characteristic of healthy estuary environments" and that "between 20 to 25 ppt are suitable for life adapted to estuary environments," implying that 20–25 ppt is the healthy range for the vaquita, are completely unsubstantiated. There is no evidence that short-term salinity variability in the northwesternmost region of the Upper Gulf has affected biological productivity (Brusca et al. 2017). Over 50 vaquita necropsies have shown no emaciated animals, which might be expected if habitat degradation was an issue (Hohn et al. 1996, Vidal et al. 1999). Many studies have shown that the Upper Gulf remains one of the world's most highly productive marine areas, with no evidence of postdam decreased productivity (reviewed in Brusca et al. 2017).

Earlier claims (Aragón-Noriega and Calderón-Aguilera 2000, Lau and Jacobs 2017) that there was a significant increase in the Upper Gulf's salinity following the construction of Hoover Dam in 1935 have been rebutted (Brusca et al. 2017, Brusca 2018a, 2018b). Although the reduction of river flow to the Colorado River Delta's riparian corridor has clearly been detrimental to that terrestrial habitat, the amount of water reaching the Upper Gulf has historically been too little to have any significant impact on the salinity of the region. Given the average 3.87-meter tidal range in the Upper Gulf, and the semidiurnal nature of its tides, around 25.5×10^9 m^3 of tidal water flushes into and out of the region daily (see the supplemental material), which is far more than the highest estimates of Colorado River water reaching the Upper Gulf in an entire year. Therefore, in general, the influence of the river's discharge on salinity in the Upper Gulf had been nil. The idea of the Upper Gulf having continuous freshwater flow or being low salinity year-round in predam years or being a brackish water estuary before the building of the dams on the river is simply not supported by any scientific data.

It has been well documented, for decades, that the primary cause of death among vaquita is incidental capture in gillnets (Norris and Prescott 1961, Brownell 1983, Vidal 1995, D'Agrosa et al. 2000, Rojas-Bracho et al. 2006, Jaramillo-Legorreta et al. 2007, Rojas-Bracho and Reeves 2013, CIRVA 2016a, 2016b, 2016c). Illegal gillnets for totoaba (*Totoaba macdonaldi*), an endangered sciaenid fish endemic to the Gulf, are the deadliest fishing gear for vaquita. Of the 128 vaquitas killed in gillnets between 1985 and early 1992, 65% were in the totoaba fishery (Vidal 1995). A large, illegal totoaba fishery resumed in about 2011, fueled by high prices for their swim bladders in China (anonymous 2016, 2018). This illegal fishery resulted in the well-documented decline in vaquita numbers (Thomas et al. 2017) that today leaves fewer than 30 remaining. Nine dead vaquita were recovered since 2015 during totoaba spawning season, and the eight for which cause of death could be determined were killed by gillnets. None of those specimens showed signs of starvation attributable to a lack of food due to habitat alteration, nor did the many vaquitas killed in gillnets and necropsied from 1985 to 1995. The most recent analyses by the International Committee for Recovery of the Vaquita (CIRVA 2016a, 2016b, 2016c) also concluded that the main threat to vaquita remains mortality in gillnets. Manjarrez-Bringas and colleagues (2018) noted the gillnet problem but chose to follow the unsupported claims of Fleischer and colleagues (1996), Galindo-Bect and colleagues (2013), and Santamaría-del-Ángel and colleagues (2017), rather than this widely accepted body of evidence.

Thaler and Shiffman (2015) defined *fake science* as unsound conclusions drawn from invalid premises. Such claims can easily spread through government agencies and the lay public, especially when they enter the world of social media. A well-known example is the now-retracted Lancet paper that sparked the modern antivaccination movement (Eggertson 2010, Rao and Andrade 2011). False information can remain in the unchecked pool of common knowledge for a long time (Thaler and Shiffman 2015). Suggesting that the Colorado River's flow caused the decline of vaquitas has been asserted and challenged for years (Rojas-Bracho and Taylor 1999, CIRVA meetings, Brusca et al. 2017), yet no scientific evidence to support the connection between vaquita and the Colorado River's flow has been forthcoming. There are failures at many levels that have positioned the vaquita for extinction (e.g., poor fisheries management, demand for illegal products such as totoaba bladders, a culture of corruption), but a reduction of Colorado River flow is not one of them. In our opinion, Manjarrez-Bringas and colleagues (2018) created a diversion that can only result in further divisions between the collaborative efforts critically needed among fishermen, the seafood supply chain, environmental and fisheries agencies, and the conservation community seeking real solutions.

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Supplemental material
Supplemental data are available at *BIOSCI* online.

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