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Commentary: State of knowledge of the population of the vaquita (*Phocoena sinus*) from the Upper Gulf of California: a bibliometric analysis

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A Commentary on

State of knowledge of the population of the vaquita (*Phocoena sinus*) from the Upper Gulf of California: a bibliometric analysis

By Arreguín-Sánchez F, Zetina-Rejón MJ, Vergara-Solana FJ, Del Monte-Luna P, Rodríguez-Fuentes M, Arreguín-Rodríguez GJ, Medina-Contreras D and Sánchez-Velasco L (2025) *Front. Conserv. Sci.* 5:1480035. doi: 10.3389/fcosc.2024.1480035

A paper by Arreguín-Sánchez et al., 2025 in *Frontiers in Conservation Science* on the "state of knowledge of the population of the vaquita" is flawed and gravely misleading.

The authors seem to be driven by a strong bias toward the idea that depletion of Colorado River discharge has driven significant environmental changes in the Upper Gulf of California that could be detrimental to vaquita and the ecosystem in general. That has been a recurrent theme in several of Arreguín-Sánchez's papers and has been repeatedly criticized (e.g., Johnson et al., 2017). There are simply no data to support the idea that depletion of Colorado River discharge has destroyed a once large estuarine region in the Upper Gulf nor driven significant environmental changes in that area that could be detrimental to vaquita, but there are many incontrovertible published data that falsify that hypothesis (provided in Ramírez-León et al., 2015; Brusca et al., 2017; Rojas-Bracho et al., 2019; Vidal et al., 2024, and others). The idea that the Colorado River once created a large brackish-water estuary in the Gulf of California is a myth.

These unsupported claims detract from the real cause of vaquita decline—gillnets, mostly illegal. It has been well documented that the primary cause of death among vaquita is incidental capture in gillnets (Norris and Prescott, 1961; Brownell, 1982; Vidal, 1995; D'Agrosa et al., 2000; Rojas-Bracho et al., 2006; Jaramillo-Legorreta et al., 2007, Rojas-Bracho and Reeves, 2013, Brusca et al., 2017; Vidal et al., 2024) and the distraction of clinging to the idea of vaquita loss being in any way related to changes in river flow makes conservation efforts more difficult for a species which, with less than 13 individuals, is today the world's most endangered mammal.

The recent CONANP (Mexico's National Commission on Natural Protected Areas) emplacement of metal hooks on the seafloor of the vaquita range (which Arreguín-Sánchez et al. do not mention) offers further evidence that gillnets are the primary cause of vaquita deaths. These net-entangling devices are highly successful in deterring fishers from the area and protecting the vaquita, prompting the 2023 vaquita survey team to write, "This is the most encouraging news ever of human intervention to save vaquitas" (Jaramillo-Legorreta et al., 2023). If the vaquita is to be saved, it will likely be through these kinds of direct and highly effective devices to eliminate gillnets from their range. Plus, of course, decisive government enforcement to stop the totoaba and other illegal fisheries and offer sustainable economic alternatives to fishers.

Arreguín-Sánchez et al. claim that the loss of Colorado River water has "caused the transition from estuarine to anti-estuarine conditions" in the Upper Gulf (i.e., the Upper Gulf of California and Colorado River Biosphere Reserve). However, they do not state where, precisely, this alleged transition has occurred in the Upper Gulf, nor do they specifically state that this area includes the range of the vaquita. The Upper Gulf Biosphere Reserve includes everything north of a line running from San Felipe in the west to Puerto Peñasco in the east, which encompasses all of this porpoise's original habitat. This region has *never* been an estuarine environment and the Colorado River estuary has always been restricted to a small area north of Isla Montague and on the river's delta, where vaquita have never been reported. That the Upper Gulf never had a large, long-term, continuous river flow, nor brackish-water conditions, even before the damming of the Colorado River is well documented (Lavín and Sánchez, 1999; Johnson et al., 2017; Brusca et al., 2017; Brusca, 2018; Rojas-Bracho et al., 2019).

In addition, there is no evidence whatsoever that the vaquita is an estuarine species, and the physiology and biology of this species clearly indicates it is a wholly marine species, not an estuarine one (Rojas-Bracho et al., 2019; Vidal et al., 2024). The Arreguín-Sánchez et al. argument that the biology of vaquita is poorly understood is incorrect; it is quite well known and summarized in the extensive review of this species by Vidal et al. (2024) (which Arreguín-Sánchez et al. also do not cite).

Arreguín-Sánchez et al. claim there is no information on whether or not Upper Gulf habitat and ecosystem conditions are suitable for the vaquita population, that such information is "non-existent knowledge." Nothing could be further from the truth. Oceanographic conditions in the Upper Gulf have been studied for over a hundred years and the environmental needs of vaquita are well known (summarized in Vidal et al., 2024). That Arreguín-Sánchez et al. choose to ignore and misrepresent this large body of work cast serious doubts on their intentions with this article. A comprehensive bibliography of the Gulf of California can be easily downloaded at https://rickbrusca.com/http:_www.rickbrusca.com_index.html/Research_files/Gulf%20Bibliography.pdf.

That the former estuarine/brackish zone of the Colorado River occurred only in the small area at the mouth of the river, north of Isla Montague and well outside the present and historic range of the vaquita, has been documented by many researchers but most powerfully validated by oceanographic data in four key papers by Roden (1958); Lavín and Sánchez (1999); Brusca et al. (2017), and Rojas-Bracho et al. (2019), as follows.

Roden (1958), not cited by Arreguín-Sánchez et al., analyzed oceanographic data from the Upper Gulf recorded *before damming*, in March 1889. Salinities for hydrographic stations between San Felipe and El Golfo de Santa Clara were between 35.8 and 36 parts per thousand, indicating the presence of fully marine waters.

Lavín and Sánchez (1999) took advantage of a natural experiment to assess predam Colorado River influence on salinity in the Upper Gulf by measuring the effects of a large 1993 flood release on the river. 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 latter value—47.5×10^6 m^3—is about 0.1% of the volume of the Upper Gulf. During this period, salinities off San Felipe remained oceanic, averaging 35.4 ppt. This natural experiment also demonstrated that the Upper Gulf has never been estuarine or brackish.

Brusca et al. (2017) reviewed the history of oceanographic research in the Northern Gulf of California (including nearly 350 papers), concluding that: (1) the Upper Gulf has never been brackish; (2) the amount of river water reaching the Upper Gulf has rarely been large, often absent altogether (the river instead emptying into the Salton Basin or Laguna Salada and other basins on the delta), and never enough to create brackish conditions below Isla Montague; and (3) a brackish Colorado River estuary, in years it might have been present, never extended beyond Montague Island.

Rojas-Bracho et al. (2019), not cited by Arreguín-Sánchez et al., calculated the amount of oceanic water exchanged in the Upper Gulf due to the area's extreme tides. They found that the amount of Colorado River water reaching the Upper Gulf has historically been far too small to have any significant impact on the salinity of the region, and the size of the daily tidal exchange makes it *physically impossible* for the Upper Gulf to become brackish. Given the average 3.87-meter tidal range in the Upper Gulf, and the semidiurnal nature of its tides, more than 25.5×10^9 m^3 of oceanic tidal water flushes into and out of the region daily (Rojas-Bracho et al., 2019), which is far more than the highest estimates of Colorado River water reaching the Upper Gulf *in an entire year*. Thus, the influence of the river's discharge on salinity in the Upper Gulf has always been trivial, predam and postdam, and the idea of this region having continuous freshwater flow or being low salinity year-round or ever being a brackish water estuary is not supported by any scientific data. Nor is there any evidence of decreased productivity in the Upper Gulf since the building of dams on the river, and the region remains one of the world's most highly productive marine areas (see Ramírez-León et al., 2015; Brusca et al., 2017, and numerous others).

Arreguín-Sánchez et al. also misrepresent the work of other researchers. For example, their claim that Brusca et al. (2017) said, "hydrographic changes caused the transition from estuarine to anti-estuarine conditions" is false; those authors, in fact, argued just the opposite. Finally, it should not be a surprise that funding for "research, authorship, and/or publication" of the Arreguín-Sánchez et al. article was provided by Mexico´s government

entities. For many years government officials (e.g., Fleischer, 1996; Fleischer et al., 1996) and a handful of Mexican researchers (Galindo-Bect et al., 2013; Manjarrez-Bringas et al., 2018), against a bulk of available information (see Vidal et al., 2024), have claimed incidental mortality in gillnet fisheries for totoaba is not the major cause driving the vaquita to extinction and have failed to take clear actions to deter those illegal activities.

Author contributions

RB: Conceptualization, Formal Analysis, Investigation, Project administration, Validation, Writing – original draft, Writing – review & editing, Resources. OV: Conceptualization, Formal Analysis, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing.

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