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Armando Jaramillo-Legorreta (1964–2024)

Lorenzo Rojas-Bracho[1,*], Edwyna Nieto-García[2], Gustavo Cárdenas-Hinojosa[2], Barb Taylor[3], Jay Barlow[4], Len Thomas[5], Nick Tregenza[6], Annette Henry[7], Sarah Mesnick[7], Juan Carlos Salinas[8], Ernesto Vázquez Morquecho[8], Horacio de la Cueva[9], Kristin Nowell[10], Valeria Towns-Alonso[11], and Jorge Urbán-Ramirez[12], and Robert Brownell[7]

[1]National Marine Mammal Foundation, San Diego CA., USA
[2]Comisión Nacional de Áreas Naturales Protegidas, Ensenada, BC, Mexico
[3]IUCN, Cetacean Specialist Group, San Diego, CA., USA
[4]Oregon State University, OR., USA
[5]University of St. Andrews, UK
[6]Chelonia Limited. UK.
[7]Southwest Fisheries Science Centre/NOAA, La Jolla, CA., USA
[8]Independent Resarcher, Mexico
[9]Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California, Ensenada, BC, Mexico
[10]Cetacean Action Treasury, Cape Neddick, ME, USA
[11]Pronatura, Ensenada, BC. Mexico
[12]Universidad Autónoma de Baja California Sur, La Paz, BCS. Mexico

*Corresponding author: lrojasbracho@gmail.com

We pay tribute to Armando Jaramillo-Legorreta, a conservation hero who worked over decades to pioneer acoustic methods for monitoring the critically endangered vaquita porpoise (*Phocoena sinus*) and to bring his scientific findings to decision-makers.

Vaquita is endemic to the Gulf of California, Mexico; the species is endangered by unsustainable bycatch in a gillnet fishery and only a handful of animals remain. Monitoring population trends of this very rare cetacean is particularly difficult because they are hard to observe using standard visual methods: they are cryptic when they surface and hard to spot underwater due to the turbid water. Recognizing the need for alternative methods, Armando was in the vanguard of scientists pioneering the use of passive acoustic monitoring (PAM) to study trends in the abundance of vaquita and other endangered marine mammal species. From 1997 to 2007, he deployed hydrophones from anchored vessels at random locations within the vaquita's range to monitor trends. In his PhD dissertation (Jaramillo-Legorreta, 2008), he used Bayesian methods to estimate a 58% decline during that period. To further increase the statistical power of monitoring efforts, Armando developed methods to deploy C-PODs (autonomous acoustic detectors) in the vaquita range.

Starting in 2011, he led the effort to deploy a grid of 46 C-PODs to monitor vaquita abundance in the central part of its range. Between 2011 and 2015, his team documented an additional 80% decline in vaquita abundance (Jaramillo-Legorreta et al., 2016). His monitoring continued through 2018, documenting an even greater rate of decline between 2015 and 2018, with a 47-49% annual decline (Thomas et al., 2017; Jaramillo-Legorreta et al., 2019).

Despite these declines vaquita persists in its natural habitat, and a key priority over recent years has been to undertake surveys to sight animals and provide definitive proof of their continued existence. Acoustic data has proven key to focus visual survey effort, and Armando devised the method for collecting acoustic data at night, organizing his dedicated team of fishermen to retrieve the acoustic early the next evening. He would then analyze, with collaborators Gustavo Cárdenas-Hinojosa and Edwyna Nieto-Garcia, the data overnight and

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send the visual survey team lead Barbara Taylor the results in the early hours of the following day, around 4 am, so she would know where to visually search. He also mapped the detections, calculated swimming speeds and, perhaps most importantly, kept Mexican government officials informed of the findings.

Armando developed specialized software, and his team gained unique expertise in identifying vaquita sounds in a challenging environment where the rare animal coexisted with significant sources of acoustic interference. He conducted pioneering work in estimating the impact of noise on detections by the C-PODs, and more recently, he was working on a new method to estimate the size of a very small population by analyzing detection times on a grid in comparison to minimum travel times between grid positions.

He was also responsible for suggesting that the Mexican Navy add entanglement hooks to concrete blocks, in the vaquita Zero Tolerance Area (a no-take zone in the Upper Gulf of California). This practical conservation measure has created a nearly net-free sanctuary and is likely one of the key reasons why the species continues to persist.

Armando's first experience with marine mammals came during his undergraduate studies in marine biology in 1986 when he participated in a survey to study sea lions. He then worked in Dr. Jorge Urban's marine mammal lab at the University of Baja California Sur, where he obtained his B.Sc. with a thesis on humpback whales. Since then, his activities focused on the research of marine mammals, primarily cetaceans.

In 1996, Armando was hired by the National Fisheries Institute to participate in vaquita population research, as part of the National Marine Mammal Research and Conservation Program (known in Spanish as PNICMM) under the supervision of Dr. Lorenzo Rojas-Bracho. The following year, he participated in the first survey to estimate vaquita abundance and was later responsible for the analytical work, which helped him earn a master's degree in science. He was the first author of the resulting paper (Jaramillo-Legorreta et al., 1999). That same year, he participated in the first study testing passive acoustic techniques to monitor the vaquita population, a line of research he led after that, working for the National Institute of Ecology (INE) when the PNICMM was transferred to INE.

The first combined visual-acoustic vaquita population survey in 1997 was marked by an accident that could have changed the course of his life. Armando fell and broke his back, and though we feared he might never walk again, his indomitable spirit never wavered. With his characteristic optimism, he joked about designing a wheelchair that would allow him to continue fieldwork. Thankfully, he fully recovered and not only returned to work but displayed tireless dedication that seemed limitless.

Armando's technical expertise was already evident from a young age. He worked in his uncle's electronics shop, an experience he made the most of. Because of this, he could repair almost anything—from cell phones to intervening in the machinery of our boats to assist the mechanic or provide service. This unique skill set made him invaluable in the field, where he was always ready to solve any technical problem that arose.

In 2007, he prepared a report to inform the Mexican government about the vaquita population's decline, sparking the development of the Action Program to Recover the Vaquita. He was also the first author of a paper calling for urgent recovery actions (Jaramillo-Legorreta et al., 2007). That same year, he participated in the second vaquita abundance survey as part of the expert group responsible for developing an acoustic monitoring scheme.

His brilliance as a scientist also led him to serve as the president of the Mexican Society of Marine Mammalogy (SOMEMMA, A.C.) in the 2014-2016 period.

Armando was not just an exceptional scientist; he was also a person of extraordinary kindness, generosity, and humanity. He listened to people with the same attention and respect with which he listened to cetaceans. His warmth and compassion inspired all who had the privilege of working alongside him. For many of us, he was not only a colleague but a true friend.

All the authors of this eulogy worked for decades with Armando. Until the end, he kept himself informed about the vaquita research. We will miss you dearly, Armando, and we are committed to continuing your work and supporting your family whenever we can. The loss of Armando is immeasurable, but his legacy of hope, determination, and love for the natural world will endure forever.

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