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Historical Perspectives

Barbara L. Taylor
(born 25 December 1954)

Barbara Taylor has been researching marine mammals for over 30 years. She led the marine mammal genetics program at the Southwest Fisheries Science Center in La Jolla, California, for 15 years and now is a senior scientist. The group identifies Units to Conserve using genetic data and has promoted developing guidelines and standards to facilitate naming new taxa of cetaceans using primarily genetic data. She also specializes in estimating risk of extinction and has worked with some of the most endangered species. She chaired the Conservation Committee of the Society for Marine Mammalogy and serves as the Listing Authority for the Cetacean Specialist Group of the International Union for Conservation of Nature. In 2016, she was awarded the Society for Conservation Biology's LaRoe Award for her outstanding career achievements in translating conservation science into real-world conservation efforts. She was chief scientist together with Dr. Lorenzo Rojas-Bracho on all of the vaquita surveys. She is a member of the vaquita recovery team and of the steering committee for the acoustic monitoring project, and she led the search effort for the attempt to take vaquitas into captivity. She co-chaired a workshop on *Ex-Situ* Options for Cetacean Conservation in 2018 and chaired a 2019 workshop to develop a One Plan Approach for conserving Yangtze finless porpoise.

Save Nature and Save Ourselves Through Embracing that Shared Sacrifice Can Lead to Shared Success

Barbara L. Taylor

Southwest Fisheries Science Center,
National Marine Fisheries Service, National Oceanic and Atmospheric Administration, La Jolla, CA 92037, USA
E-mail: barbara.taylor@noaa.gov

Nature is not safe from our meddling until we, or at least key leaders, truly believe we are simply a cell in the super-organism called Earth. What about my life led me to this conclusion? How can we induce humanity to save nature and thereby save itself? Perhaps my story will reveal some small clues to help solve these questions or at least inspire some creative thinking.

As I write this essay, I am in the waning months of a three-decade career as a marine conservation biologist working for the U.S. National Marine Fisheries Service specializing in marine mammals. For many years, I led the marine mammal genetics program at the Southwest Fisheries Science Center, chaired the Society for Marine Mammalogy's Conservation Committee, served on the U.S. delegation to the International Whaling Commission, and continue to serve as the International Union for Conservation of Nature's (IUCN) Cetacean Specialist Group lead for Red List assessments. I have spent a year of my life living on the sea ice and many years at sea, which is ironic given that I grew up in landlocked Montana not far from the Canadian border.

Most Montanans enjoy nature on a daily basis, and I was no exception. Our house on the edge of town made it easy for me to cross the street, run down the trails of a steep bank, and pick a leech out of the stream to take home as a pet. My parents tolerated the leech, and I think even enjoyed its sinuous ribbon dancing through the goldfish bowl waters as breakfast entertainment. Next to the leech's bowl was a 10-gallon aquarium made into a terrarium for my toad, named Hotrum Toady. Watching these creatures gave me a glimpse into their world. The leech consumed the stream snails by putting one sucker on the shell and the other into the opening. Five minutes later *et voila*! The snail had vanished. Hotrum continually startled me as it glommed onto my finger to ingest the fly-sized lump of hamburger. I learned that I had to move my finger around as if it were a live fly (which were hard to come by in Montana winters) so that the toad could perceive my pinky as prey and jump when the prey (my finger) least expected it.

One of my earliest memories is standing at my mother's side in front of bulldozers threatening to push down the lovely fir trees that the authorities of Kalispell, Montana, claimed were destabilizing the steep clay bank across the street. I was probably about 4. She saved those trees, and such success inspired me to start an environmentalist club and organize the state of Montana for the first Earth Day over 50 years ago. After high school, I had the good luck to be a foreign exchange student with a family that lived in the Finnish archipelago in the Baltic Sea. The father was a biology professor whose passion was lichens. I was hooked on the marine world and hooked on science.

Standardized education at the University of Washington bored me, so I transferred to The Evergreen State College. Students were encouraged to design their own interdisciplinary programs to propose to the professors. In my last year, I worked alongside my fellow student John Calambokidis and nine other hippie undergraduates to study the effects of polychlorinated biphenyls on harbor seals. John has been a huge influence on the marine mammal field since the time we founded the Cascadia Research Collective in the mid-1970s. We all lived off a $3,000 National Science Foundation Student Originated Study grant for nearly a year. Victor Scheffer, a poetic naturalist and author who led marine mammal research in the Pacific Northwest, hosted us and showed us his inspiring collection of field notebooks. He

Glacier Bay harbor porpoise study, 1980

demonstrated the importance of mentors who were passionate about nature but also possessed a keen intellect with broad interests in "life, the universe, and everything" (wisdom from *The Hitchhiker's Guide to the Galaxy* [Adams, 1980]). We learned that when he started working in Puget Sound, harbor porpoises (*Phocoena phocoena*) were commonly seen. We had seen none. The seal populations seemed to be increasing despite high loads of pollutants in their blubber and recent bounty hunting. But why had the porpoises disappeared?

I had the chance to ponder that question during my decade of being a field biologist in Alaska. My Alaskan boyfriend, Pierre Dawson, and I worked a series of amazing jobs. We volunteered to help a graduate student with her polar bear (*Ursus maritimus*) project. I learned not only about the life of bears but the life of field biologists. Our camp on Devon Island in the high Canadian Arctic was perched not far from a high cliff from which we could safely spy on the life of our subjects. Contact with the outside world consisted of a daily weather report where we radioed our crappy weather and got to hear whether our weather was even crappier than other researchers' weather. One day, when Pierre went out to measure the wind speed (which exceeded 70 miles per hour!), I heard him yell. I was in our "cook tent" and emerged to see our sleeping tent rolling away end-over-end like a giant tumbleweed of the arctic. All of our clothing and our rifle was in that tent, and Pierre gave desperate chase. I also tore out after the tumbling tent and saw Pierre take a very hard fall. No time to spare, I raced after the tent and caught it just before it took its final leap. All I could do was hold on. At last, Pierre caught up and said over and over "You don't know the half of it." And I didn't. It turns out that in the foul weather, he had been content to stay inside the tent, read his books, and pee into a liter plastic bottle. The bottle was full. The rifle had now shattered that bottle, and everything was pee-soaked. Until the helicopter retrieved us, we were so aromatic, I think we were safe even from bears.

We spent two years studying harbor porpoises in Glacier Bay where we kayaked to our study sites and lived in a pup tent (Taylor & Dawson, 1984). We participated in some of the early humpback whale (*Megaptera novaengliae*) studies that were led by Scott Baker, who later became a well-known genetics professor in New Zealand and at Oregon State University. The research was initiated to see whether cruise ships were causing the whales to abandon that feeding area and was some of the earliest work on the effects of ship noise on cetacean behavior.

My volunteer arctic polar bear and pee experience gave me the street-cred needed to land a job counting bowhead whales (*Balaena mysticetus*). Throughout my 20s, this study sustained my gypsy biologist lifestyle because it paid a decent salary. The hunt of this endangered species was a hot point of debate in the International Whaling Commission (IWC) where the U.S. government opposed commercial whaling but allowed its own subsistence hunt by Alaska native whaling communities. The seemingly precarious status of bowhead whales had its origin in overhunting nearly a century earlier. The Bering-Chukchi-Beaufort population of bowhead whales had probably numbered over 15,000 and was reduced in a few years to at most a few thousand whales in the late 1800s through commercial whaling by Yankee whalers. Bowhead whales in the Atlantic had already been decimated, so this North Pacific population was the main hope for the species.

With Pierre Dawson, Bowhead Survey, 1980

And what an amazing species bowhead whales are! Each spring, this population of bowhead whales migrate through cracks in the ice to get from their winter home in the Bering Sea to their summer feeding grounds in the Canadian Arctic. As they parade past Point Barrow (now referred to by the traditional Iñupiaq name, Utqiaġvik), their closer proximity to land allows the Inuit to hunt them and the biologists to count them. During the years I worked there, between 1978 and 1986, an

With whaling captain in front of a traditional umiak (whaling boat), 1981

ivory-metal-tipped harpoon head that hadn't been used for a century was pulled from a whale killed in the hunt, and stone-tipped heads were found in whales killed later. These whales were over 100 years old and showed no sign of disease. Imagine these same whales swimming past the gauntlet of Yankee whaling ships and past many native hunters. These elders had been key individuals in perpetuating their species.

Forty years have passed since I first watched these whales navigating through the heavy ice that was then the norm in spring. If I were standing there today, most of the whales swimming past, likely about 16,800 (Givens et al., 2016), would have been born since I stood there as a young biologist when there were about 5,000 (Zeh & Punt, 2005). On the other hand, if I were standing there today, I might be up to my ankles in slush from the warming conditions that have changed both the lives of the Inuit and many of the animals they also hunt. So far, bowhead whale recovery remains a fantastic success story about a species that was both hunted and saved by the Inuit. It is a story about what makes people change their ways. In economist-speak, a story about what incentivizes us. More about that later.

My Arctic adventures ended with a splash when our Twin Otter plane crashed into the Arctic Ocean's Beaufort Sea. The objective of this aerial survey was to document the summer distribution of bowhead whales and also take vertical photographs to individually identify them and measure their length. We'd just started the season and had four biologists, including one young woman who had never flown a survey. We had just taken off from Tuktoyuktuk on a long survey that required refueling mid-day. I was looking out the side bubble window when I felt the plane do an odd wiggle and looked over to see the propeller standing still. That can't be good! The co-pilot radioed, "Ground Tuk, our engines are out and we're going down." And down we went like a very fast elevator. I had time to pull my survival suit from under my seat and brace for impact. I couldn't resist looking when we hit the water. Spectacular. The large window cut in the belly of the plane to allow photography smashed instantly. It seemed like I watched in slow motion as the water and glass coursed through the plane and hit the bulkhead that separated me from the pilots. When we came to a sudden stop, the water was already up to my knees. We couldn't get the emergency windows out, but the back door was opened by Dave Rugh, and he shouted to come quickly. I swam for all I was worth, somehow thinking I could get sucked down with the plane. When Dave yelled "Look!," only the blinking light on the tip of the plane's tail could be seen. Then it was gone. Between the six of us, we had four survival suits and an emergency raft we'd put on board that morning. The raft looked like a child's backyard swimming pool, but it saved our lives. We were rescued by an Exxon exploration ship, helicoptered to a hospital, and later returned to our rooms, which had been taped off. It turns out that all along the way, our survival was a complete surprise. Indeed, no one had ever survived the ditching of a Twin Otter. Usually when the landing gear caught the water, the plane flips and no one gets out. I guess we were lucky?! It turns out that the pilots refueled the wing tanks from old improperly stored barrels that had sucked melt water into the barrels over the past summer. When they switched to use the wing tanks so we could land and refuel later, they doused both engines with water. With a survey altitude of 500 feet, there is no room for such an error. When we flew with the same company out of Barrow the next spring, we were both educated and cautious customers!

With photo team in survival suits, Barrow, 1986. New survival suits resulted from heightened safety awareness following the crash the previous summer.

The fateful premature ending of that summer bowhead survey opened an opportunity to participate in the first abundance estimation survey for harbor porpoises along the U.S. west coast being led by Jay Barlow from the Southwest Fisheries Science Center in San Diego, California. This was my first experience doing survey work from a large ship. I was impressed by Jay (who I later married) and the Southwest Fisheries Science Center (where I've worked for the rest of my career). I was also impressed by the numbers of harbor porpoise along the coast of northern California. I was thinking about where you did and did not see harbor porpoises and noticing for the first time that there was a strong correlation with the presence or absence of gillnet fishing. While Alaska brings to mind a pristine wilderness area, in the marine realm, it has been heavily fished, except in Glacier Bay due to its National Park status.

I had reached the point in my career where I wanted not only to do the field work but also to design, analyze, and publish the research. I went to graduate school at the University of California San Diego to hone my analytical skills and had the good fortune to be a student in conservation biology with Mike Gilpin as my mentor and a great committee that included Dan Goodman and Doug DeMaster. Mike made all his students read Garrett Hardin's (1968) essay on the tragedy of the commons. The *Reader's Digest* version of the essay is that the common area for grazing will be ruined if everyone acts in their own self-interest. To graze the common resource sustainably takes "mutual coercion, mutually agreed upon." I recently learned that management of a river in Montana by a coalition of ranchers, anglers, and hikers improved upon Hardin's somewhat off-putting phrase. They coined the phrase "shared sacrifice, shared success." Much more inspiring!

That seems so simple. It is so obvious that natural resources will not be used sustainably if the primary motive is individual gain. Yankee whalers made huge short-term profits by nearly exterminating bowhead whales. Inuit hunters wanted bowhead whales for themselves but also for their progeny. They could feel the immediate effects of Yankee whaling on the whales and their own livelihoods and culture. They had an incentive that led to the formation of the Alaska Eskimo Whaling Commission where they shared sacrifice, in the form of annual quotas for each village, so they could share the success of recovering bowhead whales. How can those lessons be used to motivate people who live far from nature and don't experience the consequences of their decisions?

Barrow photogrammetry, 1986

On a vaquita cruise

Graduate school inspired me to think about the inherent biases in science and how those biases can affect conservation. With humans touching the fate of everything in nature, conservation by necessity is about making choices about how we, as humans, behave. Science was wed to the paradigm that hypotheses must be tested and only be considered "true" when a certain degree of certainty, called "significance," had been achieved. Russ Lande, a well-known conservation theoretician, had written a paper that suggested that action to preserve spotted owl habitat need not be taken until the decline was statistically significant (Lande, 1988). Estimating trends in abundance is no easy task for animals that are hard to see. I had the experience of spending 6 years to get only a few usable counts of bowhead whales. To be able to observe the full migration required a narrow migration corridor that was maintained throughout the migration. Often enough, winds would push the ice in so that we couldn't see the whales, but the amazing bowhead could still sneak past. Those years had incomplete counts. The expensive large-ship surveys used to estimate harbor porpoise abundance were imprecise for different reasons. Line-transect surveys sample the distribution of a species and estimate density from that sample to arrive at abundance. The smaller the

Vaquita CPR team thrilled by guiding the capture of the adult female we hoped would be the beginning of saving vaquitas from their habitat filled with lethal gillnets. The death of that female during the night was soul crushing for all involved.

proportion sampled, the less precise the estimate. Harbor porpoises are small and hence can't be seen for long distances. In contrast, a blue whale's (*Balaena musculus*) blow can be seen for many miles, and a large school of dolphins leaping about with birds swarming overhead can be seen from even farther away. As a result, the same survey will have a more precise estimate for the blue whales and dolphins than it will for the porpoises because a larger proportion of their distribution was sampled.

Requiring a high degree of proof of decline before taking action for an endangered species seemed a very risk-prone practice. I argued that for conservation, science needed different standards to trigger actions and used the example of Mexico's vaquita porpoise (*Phocoena sinus*), which, by its secretive nature, was likely to have even less precise estimates than harbor porpoises, to make the point that if a 95% chance that a population was declining was required as proof before actions were taken, vaquitas could go extinct before the proof standard was met (Taylor & Gerrodette, 1993).

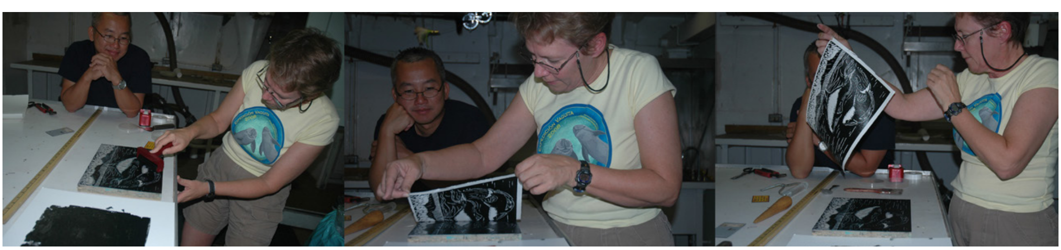
Doug DeMaster gave me a wonderful opportunity as my post-doctoral National Science Foundation advisor. Congress asked the National Marine Fisheries Service to propose changes to the Marine Mammal Protection Act (MMPA). A flaw in that law that threatened all fisheries had been exposed in litigation surrounding the high seas drift gillnet fishery in Alaska where many Dall's porpoises (*Phocoenoides dalli*) and a few northern fur seals (*Callorhinus ursinus*) were killed. In essence, the 1972 version of the MMPA had an on/off switch for management: if the species was above Optimum Sustainable Population Level (OSPL), there was no management action triggered; if below, there were no kills allowed, which resulted in fishery closure. Two problems were immediately apparent. First, OSPL was extremely difficult to estimate for marine mammals and, hence, as a trigger was pretty useless. Dall's porpoises, for example, had and still have no abundance estimate for the area in which the fishery occurred. The area in question is remote, so surveys would be expensive. Also, Dall's porpoises have their own peculiar issue of being attracted to ships because they love to play in the pressure wave pushed by the bow. The density-estimation method assumed that animals were seen before being affected by the ship. In essence, OSPL could only be estimated for the few marine mammals for which monitoring was easy and relatively cheap (i.e., seals and sea lions, and maybe sea otters [*Enhydra lutris*] in some places). Fur seals were closely monitored and were listed as being below OSPL, which is called "depleted." Fur seal deaths, therefore, flipped the switch to "no kills allowed." The second problem was that all species listed under the Endangered Species Act (ESA) were defined in the MMPA as being depleted and, therefore, below OSPL. Thus, any fishery that killed even one individual of an endangered species (and most of the large whales are ESA listed) could not be permitted. Such a stringent criterion was not acceptable to Congress.

Jay Barlow came up with the great idea of basing management on data that we knew we could obtain and on some default values for population growth rates for cetaceans and pinnipeds. He came up with a formula that used these values and incorporated some policy values that embodied what was acceptable with respect to the level of human impact allowed. The level of allowable impact differed for healthy populations compared to unhealthy endangered populations. My contribution was to use a "performance testing" approach to examine how Jay's formula might work in practice (Taylor, 1993). This testing approach had been developed by the IWC's Scientific Committee to compare the performance of different proposed management models. Paul Wade, a fellow government biologist, improved the modeling effort by adding some "tuning parameters" that allowed choosing the policy values in Jay's formula to fit the desired societal outcome.

There were several important conservation innovations in this approach. The abundance used to determine the allowable human-caused mortality depended on the precision of the estimate: the less precise the estimate, the lower the allowable mortality. Take the hypothetical survey described above where blue whales, dolphins, and porpoises are all seen from the same survey. The precision is quantified by the density estimation method so the blue whales and dolphins would have greater precision than the porpoises because a larger proportion of their habitat has been effectively sampled due to their being seen from farther away. The goal of the new management process was to keep healthy populations above an agreed level. Assuring that species that inherently have imprecise abundance estimates are managed as well as those with precise estimates means that this imprecision has to be accounted for. An analogy is imagining that a person is trying to shoot at a target and hit above a certain line 90% of the time (society's tolerance for what constitutes a "healthy" population). A shooter using a blunderbuss (imprecise gun) will have to aim higher than if that person were using a rifle (precise gun). Thus, using the lower 20th percentile of the distribution of the abundance estimate provides equal conservation for species with a precise or imprecise estimate and an incentive to get more precise estimates. The other innovation was to include a "recovery factor" that reduces the allowable kill for already endangered or depleted populations. For these "at risk" populations, the allowable kill could be 1/10th that for healthy populations. This factor could also be used to reduce allowable kill by up to one half if its status relative to historical numbers was unknown.

But what, for the MMPA, is a "population"? I finally landed a permanent job (just days shy of my 40th birthday), analyzing genetic data. Specifically, I was tasked to address statistical power in detecting population structure: if two groups of animals were essentially independent from one another in their birth and death rates, what were the chances that the genetic study would be able to detect that? Doing this research led to my understanding that my earlier simulations performance-testing the MMPA management formula had assumed that population structure was known. Clearly, this was not the case for most marine mammals. I remembered the harbor porpoise surveys that ran from central California to the U.S./Canada border. Some areas, like the Big Sur coast, had no harbor porpoises. Were the porpoises in Morro Bay to the south of Big Sur mixing freely with those in northern California? We knew that porpoises were being killed in large numbers in Morro Bay. Certainly, there were likely to be multiple populations within the west coast survey area, but where should the population boundaries be drawn to achieve the management goals set forth in the newly adopted 1994 version of the MMPA? My first research in genetics was devoted to the complexity of defining population structure to meet the MMPA objective to maintain marine mammals as functioning elements of their ecosystem (Taylor, 1997). Placing the boundaries incorrectly could lead to biases in the abundance estimate far beyond what I had earlier used in performance testing. However, the battle to draw lines on a map to meet those objectives has been uphill because the originally defined "population stocks" were large, and the evidence bar has proven too high to change from those mostly arbitrary units. Delineating MMPA "population stocks" is still very much a work in progress (Martien et al., 2019).

Not only is delineating Units to Conserve problematic under various conservation rules (including Distinct Population Segments for the U.S. Endangered Species Act and similar domestic legislation around the world aimed at preventing extinction), but for marine mammals, it is apparent that taxonomy is far from perfect. As a member of the team assembled to assess the status of a group of killer whales (*Orcinus orca*; specifically the southern resident killer whales) when this group was petitioned for listing under the ESA (Krahn et al., 2002, 2004), we struggled with taxonomic uncertainty. Whether a group of individuals qualified as a Distinct Population Segment depended on meeting criteria that assumed taxonomy was correct. For example, one criterion is that the loss of this group would result in a significant gap in the range of the taxon. Even among the assembled team of scientists, there was no agreement on killer whale taxonomy except that the currently published taxonomy, positing a single global killer whale species with no subspecies, was wrong. I had the great fortune to have my office next door to Bill Perrin, a great taxonomist. Many lines of evidence suggested that there were many types of killer whales that differed in morphology, genetics, diet, behavior, acoustics, and distribution. But whether they are subspecies or species or Distinct Population Segments remains unresolved.



My art shop, Vaquita Survey, 2008


Searching for vaquitas, 2008

I found (and find) this very frustrating as a conservationist in the midst of the 6th mass extinction. Taxonomists are a methodical bunch who often take decades to assemble the evidence needed to argue for a taxonomic change. When we struggled with killer whale taxonomy, I learned there were no rules or committees to make progress in a timely fashion. Most taxonomy is based on measurements of collections of skulls. Cetaceans are notably scarce in such collections, and obtaining skulls for the types of killer whales found far out to sea is not likely to happen, perhaps in centuries. Fortunately, we can obtain genetic samples through biopsy, but how do we interpret those genetic data in a way consistent with accepted taxonomy based on morphology? A group of us read every paper published that used genetics as the primary basis to describe new taxa. We published a special issue in *Marine Mammal Science* that culminated in a set of guidelines to help geneticists improve the quality and pace of describing new taxa (Taylor et al., 2017). We formed a taxonomy committee within the Society for Marine Mammalogy to maintain an official list of accepted species and subspecies and to record the shortcomings of papers proposing new taxa when the proposal was deemed inadequate so that researchers could more quickly rectify the shortcomings. We also used the empirical data to help us choose genetic metrics that performed best at classifying agreed groupings (populations, subspecies, and species). The derived quantitative criteria were not meant to be mindlessly applied. For some clear cases, taxonomic arguments would be easy (and quick) to make. For cases that did not meet the quantitative thresholds, but for which the researcher felt their case warranted being a new taxon, the thresholds could inspire researchers to make strong arguments to justify their conclusions.

As a conservationist, I have come to embrace the benefit of using decision rules or guidelines to move actions forward at a pace that is meaningful to the species we hope will benefit. I worked for several years to try to develop guidelines for the Endangered Species Act that would make both listing and downlisting easier (Regen et al., 2013; Boyd et al., 2016). Too often, science contributes too little, too late. Such was the case in 2006 when I participated in a survey to find the last baiji (also called the Yangtze River dolphin [*Lipotes vexillifer*]) so that they could be removed from the Yangtze River and taken into protected semi-natural reserves. An international team of scientists joined Chinese colleagues to cover the range of baiji four times using both visual and acoustic methods. Not a single baiji was heard or seen (Turvey et al., 2007). This lineage that survived for 30 million years disappeared while no one was looking. Truly a shocking experience. We did see and estimate the abundance for Yangtze finless porpoises (*Neophocaena phocaenoides*), which, at the time, were also vanishing from parts of their distribution. China was in the midst of heavy industrialization that polluted the river and made the air so thick that by 3:00 in the afternoon we had to stop the survey because it was too dark! In addition, fishing methods known to kill baiji and finless porpoises were everywhere to be seen. Overall, this was a devastating but influential experience.

This catastrophe led Lorenzo Rojas-Bracho and me and a dedicated vaquita research team to increase our efforts to save vaquitas. We had been working closely together since the first survey in 1997. The second survey in 2008 revealed that only about 200 remained, which was a loss of well over half the species in the past decade. Mexico's endemic porpoise was now the most endangered marine mammal in the world. Research during the survey compared different acoustic listening (or detection) devices that we hoped would allow annual monitoring of the species at low cost. The Government of Mexico now started protecting the Vaquita Refuge. We formed an international expert panel to oversee the design and analysis of the monitoring so that results could be quickly published and time would not be wasted challenging the quality of the science. An acoustic monitoring grid was established to detect the hoped for 4%/year increase resulting from the new protections. Instead, our first results revealed a collapse of the species. Vaquitas were being accidentally killed in gillnets set in the illegal fishery for totoaba (*Totoaba macdonaldi*), a vaquita-sized fish, to supply the lucrative Chinese black market with swim bladders that are believed to have medicinal properties. The Government announced enforcement actions, but we demonstrated through the continuing decline revealed by acoustic monitoring that the actions were insufficient. An additional line of evidence showing the inadequacy of enforcement was the removal of hundreds of illegal gillnets each year by the Sea Shepherd Conservation Society and the Museo de Ballena. By 2017, vaquitas were declining at 50%/year, and there were only about 30 vaquitas left.

That same year, an international team of over 90 scientists attempted to take vaquitas into captivity until their habitat could be made safe. The attempt failed when both vaquitas captured were highly stressed, and the adult female died (Rojas-Bracho et al., 2019). Tears still fill my eyes every time I remember that day. Everything seemed to be going so well. The capture went quickly; the female was not a recent mother and seemed calm. Just before going to bed, I got a text from Lorenzo that she was not doing well. I hated to look at my phone in the morning. There was Lorenzo's text. She was dead, and so was that hope for saving the species. So little was understood about how to deal with stress in vaquitas that veterinarians could not in good conscience continue since the prognosis for the next captured vaquita was no better than for the last. We should have started trying to capture vaquitas when there were hundreds instead of tens of individuals. It was too little, too late again.

Why was this situation so different from the success story for bowhead whales? I think it was all about incentives. The local fishermen had no incentives to make them fish sustainably, even before totoaba became the cocaine of the sea. The fishermen who did sacrifice did not share this sacrifice with other fishermen, and there were no successes to share either. There may be some blue market methods where using sustainable fishing gears could be incentivized, but with both poor governance and corruption, such methods have not been possible. The negative consequences of ongoing pillaging of the marine environment are not immediate enough to change people's behavior.

Ironically, the tragedy of the vaquitas led me back to China. We will never know whether vaquitas could have been saved through what is termed *ex situ* methods. *Ex situ* conservation means maintaining individuals outside their natural habitat. While most people immediately think of zoos and aquaria when they hear about "taking animals into captivity," *ex situ* methods also include cases like the Yangtze finless porpoise that swim, eat, and raise their young independently in large semi-natural reserves. Many terrestrial species have been saved from extinction using *ex situ* methods, including California condors (*Gymnogyps californianus*), Pere David's deer (*Elaphurus davidianus*), black-footed ferrets (*Mustela nigripes*), and the New Zealand robin (*Petroica australis*) that got down to only two remaining individuals! Many of those same species had similar issues with stress during capture, and veterinarians had to learn how to manage the stress to reduce or eliminate mortalities. Learning takes time and money, and it involves risk to individuals, and, therefore, it may be difficult to get buy-in from governments, researchers, and NGOs.

Lorenzo Rojas-Bracho and me with a life-sized vaquita model, 2015

Those of us who experienced the sadness of failing the vaquita wanted to learn from that lesson. We convened a workshop so that we could be better prepared for other porpoises and dolphins that are at risk of extinction (Taylor et al., 2020). We examined the many data gaps for these species living in rivers and coastal waters—particularly for health data pertaining to stress and what more we needed to know to assess suitability of these species for *ex situ* options in light of the IUCN (2013) guidelines. The IUCN developed a One Plan Approach to incorporate both *in situ* and *ex situ* options in conservation planning to maximize success in saving species (Byers et al., 2013). On our list of prioritized projects, one of the most important was to evaluate the only case where both those options were being employed for a cetacean: the Yangtze finless porpoise.

By this time, it was a struggle for me to maintain optimism. No one had solved the gillnet issue. In fact, it was getting worse. Human populations were growing, and the need for cheap protein was keeping pace. The countries adjacent to the endangered species' only habitat often suffered the same issues as Mexico had: poor governance coupled with corruption and poverty. In 2006, China had been the scene for the most depressing research of my life. Like Mexico, China had created baiji reserves in the river and made the worst types of fishing gear illegal. Like Mexico, they were paper reserves with essentially no enforcement to back up fishing regulations. And where were the incentives? Most people in China were focused on making the most of the economic boom for themselves and their families and were pretty disconnected from nature.

With Omar Vidal (left) and Lorenzo Rojas-Bracho (right), 2015

To my surprise, our visit to China in 2019 left me smiling. China had really turned things around. The President decreed that their mother river, the Yangtze, was sick and needed to be cured. Despite the city of Wuhan growing from 8 million in 2006 to 14 million in 2019, the air was cleaner and the city a much nicer place to live. Polluting mopeds were replaced with electric ones. Industrialized areas along the river had been replaced with lovely parks where people strolled and posed for pictures. More amazing was a complete ban on commercial fishing in the river in 2020. When we toured the reserves that in 2006 were filled with gillnets, we not only saw no fishing, but we also saw lots of very fat porpoises in the river and swans circling over the peaceful lakes. Chinese scientists had figured out how to keep the porpoises calm after capture so that they could insert a subcutaneous individually identifying tag and genetically sample each individual and track its success in the reserves. And despite large declines inside the river in the first decade following 2006, the latest survey suggested the decline had slowed or potentially stopped. We now look forward to developing a One Plan Approach document for this subspecies that can serve as a good example for other species. One other important surprise was having the workshop attended by some of the 40 citizen porpoise conservation groups. In Nanjing, people can watch porpoises as they enjoy parks along the river. These urban dwellers had learned to love their little porpoises.

What were the incentives? China embraces top-down authority rather than bottom-up incentives. The President decreed the clean-up, and it is happening. The success of the fishing ban remains to be seen, but it doesn't hurt that there are many jobs that pay far more than fishing. When young people had alternative livelihoods that paid better and were almost certainly less hard work than fishing, decreasing fishing was an easier task.

These experiences have made me a practical optimist. I still believe that *if* the remaining ten vaquitas are protected from gillnets, the species could recover. But that is a big IF. Conservation remains dependent on changing human behavior. Changing human behavior can take longer than many of our beloved marine mammal species have, even without unexpected catastrophes like the illegal totoaba trade. So, the practical part of me responds that we need to change our conservation practices if we can hope to save species.

With President Nieto, Leonardo DiCaprio, and Carlos Slim Helú

Vaquita talk, 2015

Looking back over the sad history of vaquita conservation, it is clear that documenting the decline and knowing the reason for the decline and reporting regularly to the Government of Mexico and governments of the world about the decline was ineffective. Even if we had been successful in enlisting economists and sociologists to work on developing solutions within the fishing communities, with poor governance and deeply engrained corruption, could the declines have been halted and reversed in time? At least for some of these cases (and hopefully not all of them!), developing semi-natural reserves for insurance populations may be the most prudent strategy. We must continue to work for the best by doing all we can for populations in the wild, but we must also be better prepared for the worst. Fortunately, filling knowledge gaps almost always is important for both conservation in the wild and preparing for the time an insurance population needs to be created (as was done for Yangtze finless porpoises).

Perhaps the impending disaster of global climate change will motivate humanity to save nature and thereby save itself. If these ecological problems have been exacerbated by a failure to understand that shared success is predicated on shared sacrifice, perhaps the rising generation that inherits these problems will become leaders to steer a corrective course. The consequences of humanity's unsustainable practices are being felt, but a new ethos that recognizes humans as part of the fabric of life needs to be shared so that necessary sacrifices will be taken.

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