Saving the Vaquita: Immediate Action, Not More Data

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Diversity

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Introduction

The recent likely extinction of the baiji (Chinese river dolphin [*Lipotes vexillifer*]) (Turvey et al. 2007) makes the vaquita (Gulf of California porpoise [*Phocoena sinus*]) the most endangered cetacean. The vaquita has the smallest range of any porpoise, dolphin, or whale and, like the baiji, has long been threatened primarily by accidental deaths in fishing gear (bycatch) (Rojas-Bracho et al. 2006). Despite repeated recommendations from scientific bodies and conservation organizations, no effective actions have been taken to remove nets from the vaquita's environment. Here, we address three questions that are important to vaquita conservation: (1) How many vaquitas remain? (2) How much time is left to find a solution to the bycatch problem? and (3) Are further abundance surveys or bycatch estimates needed to justify the *immediate* removal of all entangling nets from the range of the vaquita? Our answers are, in short: (1) there are about 150 vaquitas left, (2) there are at most 2 years within which to find a solution, and (3) further abundance surveys or bycatch estimates are not needed. The answers to the first two questions make clear that action is needed now, whereas the answer to the last question removes the excuse of uncertainty as a delay tactic. Herein we explain our reasoning.

Remaining Vaquitas

We extrapolated from data in D'Agrosa et al. (2000) and Jaramillo et al. (1999) that roughly 150 vaquitas remain. D'Agrosa et al. (2000) monitored fishing activities and vaquita bycatch in 1993–1994 in El Golfo de Santa Clara, one of three fishing villages in the northern Gulf, and estimated that at least 39 vaquitas were killed per year. D'Agrosa et al. (2000) assumed that fishing effort in San Felipe was comparable to that in El Golfo de Santa Clara. Almost no data were available for the third village, Puerto Peñasco, but J. Campoy (personal communication) told us that few pangas from Puerto Peñasco fish in vaquita habitat. Therefore, we used 78 as a reasonable minimum number of vaquitas removed that year by the two main villages. From a dedicated line-transect survey Jaramillo et al. (1999) estimated that 567 (CV = 0.51) vaquitas were present in the northern Gulf in 1997. We used a simple discrete model that estimated the number of vaquitas in each year by taking the number in the previous year plus the number of births and minus the number of deaths. We assumed that the vaquita population would be at its maximal rate of increase and so used for births a net rate of 4%/year, a value commonly used for porpoises (Rojas-Bracho et al. 2006). For deaths we assumed that the probability of death per individual per net remained constant, that is, an individual porpoise encountering a net had the same probability of entanglement irrespective of year. Because the actual number of nets was unknown, we made the simplifying assumption that the number of pangas adequately represented fishing effort. The number of pangas is poorly documented, but has roughly doubled from 500 in 1993 (D'Agrosa et al. 2000) to 1000 in 2007 (J. Campoy, personal communication). To calculate the number of deaths in a particular year, we multiplied the number of pangas times the probability of death per individual per panga. The latter is a constant and is the number killed in 1993 per number of vaquitas alive in 1993 per number of pangas in 1993 (79/767/500). We solved for the number

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of vaquitas in 1993 iteratively, assuming there were 567 in 1997. This discrete model indicated that 150 vaquitas remained in 2007.

Time Remaining to Find a Solution

We estimated that only about 2 years remain before we reach the point where the options for conserving the vaquita are severely reduced. At a small population size, our simple model of a constant rate of decline overestimates the time remaining because the rate of decline increases as new risks arise (e.g., demographic stochasticity and inbreeding depression) (Gilpin & Soulé 1986). Captive breeding will not be a solution. Although some species have been saved by captive breeding when very few individuals remained, captive breeding is not feasible for vaquitas. Safely capturing these small, cryptic, solitary, and elusive animals in relatively deep water would be extremely difficult, and even if it were possible, maintaining other marine porpoises (Phocoenidae) in captivity in good health over long periods has proven difficult. Captive vaquitas would likely have a high rate of initial mortality, as seen with other small cetaceans such as baiji, *Delphinus*, and *Platanista*, and, as with other wild species taken into captivity, some of the survivors would not reproduce. Furthermore, experience with other species has shown that captive-bred individuals often lack behaviors needed for survival in the wild and consequently have a poor survival rate when reintroduced. Thus, an in situ approach has the best chance of saving the species because the food base is still excellent, and there are no serious threats other than bycatch (Rojas-Bracho et al. 2006).

We therefore chose 50, the number needed to retain reproductive fitness (Franklin 1980), as a rough threshold effective population size, below which risk accelerates. Approximately half of the vaquitas would be expected to be adults, so that threshold would represent a total abundance of about 100. We estimated the time remaining to this threshold to be about 2 years. To say that time is running out is, if anything, an understatement.

Need for Further Abundance Estimates

Additional estimates of abundance are not needed because imprecision will make it impossible to detect expected rates of decline. We investigated the utility of spending limited conservation dollars on further surveys by examining the statistical power to detect a 10%/year decline in vaquita numbers (Table 1). Power calculations were completed with the TRENDS program available from http:// swfsc.noaa.gov/textblock.aspx?Division=PRD&ParentMenuId=147&id=1446 (Gerrodette 1987). Constant features were set as follows: 10% rate of decline per year; one-tailed test; coefficient of variation proportional to $1/\sqrt{\text{abundance}}$; and equal intervals between sampling occasions. Precision of abundance estimates is poor because sighting rates are low because of the vaquita's small body size, inconspicuous surfacing, small group size (average of one to two individuals), and habit of avoiding boats within about 700 m.

Table 1. For given survey intervals, the number of years needed to detect a 10%/year decline (assuming $\alpha = 0.05$) together with the number of vaquitas remaining and the survey cost.

Survey interval (years)	*Years*	*Vaquita remaining*	*Cost (millions US$)**
1	20	80	13
10	71	1	5

**Cost estimates are a minimum estimate because they are simply generated by multiplying the cost of the 1997 survey by the number of surveys needed.*

We also estimated the time (number of years) needed to elapse before an increase in the population would be detected if all mortality in fishing nets were to cease. For annual surveys, detecting the 4%/year expected increase would take 25 years and cost US$17 million. For decadal surveys, detecting this increase would take 51 years and cost US$4 million. Both the cost and the time suggest that managers should be warned against expecting proof of success in the short term. Standard line-transect surveys are not effective on a time scale useful for vaquita conservation. Taylor and Gerrodette (1993) estimated that by the time a decline could be detected the vaquita could be extinct, and no new methodology has been developed to change this conclusion. In addition, the costs for such surveys are high and would significantly reduce funds needed to implement direct conservation actions.

Need for Further Estimates of Bycatch Mortality

Further estimates of bycatch mortality are not needed because there is no reason to believe mortality rate has decreased, and it would not be logistically feasible to detect a change in any case. The methods used by D'Agrosa et al. (2000) cannot be repeated because interviews with fishers, who are now aware of the potential consequences, would no longer provide reliable information on the scale of bycatch (strategic response bias). The only method otherwise available to estimate vaquita mortality involves direct estimates from data collected by mandated observers on the artisanal fishing boats (pangas). This would not be feasible because of the infrequent (but significant) bycatches made by a very large number of small fishing boats.

For a current population of around 200 vaquitas, a population growth rate of 4% would result in only 8 new vaquitas each year. So, to avoid further decline, mortality would need to be lower than eight individuals in all fisheries and all three villages combined. Although net fishing for shrimp accounts for roughly half of vaquita deaths (D'Agrosa et al. 2000), this type of fishing provides the greatest income to fishers, making this fishery the most important to retain. We calculated whether an observer program would be able to generate meaningful data to measure a bycatch rate of four or fewer vaquita deaths/year in this fishery.

For the shrimp season of 1993, D'Agrosa et al. (2000) estimated 1358 fishing trips. During the 2006-2007 shrimp season, about 15,000 fishing trips were conducted to obtain 700,000 kg, assuming 50 kg/trip (J. Campoy, personal communication).

As an analytical exercise, we considered that a single bycatch removal per year in the shrimp net fishery would be the highest catch rate the vaquita population could sustain and still recover. With the 15,000 fishing trips currently estimated for the shrimp fisheries only, a rate of 0.00006 vaquitas/trip would be required to capture only 1 vaquita (1/15,000). To observe one vaquita captured within a 95% confidence interval (using bootstrap procedures), at least 12,200 trips would need to be observed. Fewer trips could lead to the false conclusion that no vaquitas were caught. Observing 12,200 trips would require more than 200 observers (assuming 45 effective days of effort/season). The practical implications and expense of such a sampling regime in the northern Gulf of California make this effort all but prohibitive.

Conclusion

The current number of vaquitas is likely about 150. As it will take time to plan and raise money to buy out entangling net fisheries, the first step in 2008 must be to find funds to establish a total fishing moratorium on all entangling nets so that vaquita mortality can be immediately reduced to zero. Most important, there is very little time remaining until the population will be so small that it will be vulnerable to stochastic events or processes (ecological, genetic, and demographic).

We further conclude that more surveys or estimates of bycatch mortality will not provide useful information needed for the conservation of this critically endangered species. Instead, resources would be better invested in a comprehensive program to eliminate entangling nets from the range of the vaquita through a buyout program or other system of compensation to affected fishing communities. The problem of unsustainable kills of dolphins and porpoises in artisanal fishing gear is chronic throughout coastal waters worldwide. Many species (other than the vaquita and certain river dolphins) have large enough populations and wide enough distributions that they are not yet on the verge of global extinction, but some regional populations are at high risk. Designing innovative economic or technical solutions to solve the vaquita problem could lead the way to prevent a wave of extirpations and extinctions caused by bycatch in artisanal fisheries.

The baiji was the first cetacean species to be documented as being driven to extinction by humans. The vaquita could soon join it, which would represent another failure of our community of scientists to explain in simple terms the plight of a critically endangered species and thus convince decision makers to act decisively and urgently. Scientists must play a critical role in working to inform and assess conservation planning, but the highest priority now is to finalize a comprehensive plan to buy out all entangling nets. Such a plan must be developed by socioeconomists with input from local communities and the local and federal Mexican governments. To this end, the ministries of agriculture and environment are collaborating to develop such a plan. A cooperative multinational effort including governments, nongovernmental organizations, and private donors will then be needed to fund the buyout, and currently the Mexican government has indicated that it has the political will to rapidly implement the plan and provide enforcement.

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