バキータの保護：研究と管理の現状

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VAQUITA CONSERVATION : CURRENT SCIENCE AND MANAGEMENT

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The vaquita, *Phocoena sinus*, is the only cetacean endemic to Mexico (Vidal, Findley and Leatherwood, 1993). It is restricted to the upper Gulf of California (Brownell, 1986; Vidal, 1993, 1995; Gerrodette *et al.*, 1995; Vidal, Brownell and Findley, in press) north of an imaginary line connecting Puertecitos, Baja California, and Puerto Peñasco, Sonora (Fig. 1). This small, relatively unknown member of the family Phocoenidae, was recently described by Norris and McFarland (1958) from three skulls found on the beach near San Felipe, Baja California. It was not until 1985, however, that the first fresh specimen was collected when seven animals were retrieved from fishing nets (Brownell *et al.*, 1985), long thought to be a significant cause of mortality for this species.

Vaquitas live in productive waters surrounded by desert. Therefore, fishing is an important means for the local people to make a living. Gillnets are the most widely used type of fishing gear within the habitat of the vaquita and are thought to be the most important factor in vaquita incidental mortality (Vidal, 1995). Fleischer *et al.* (1994) estimated that between 1983 and 1993 the mortality rate due to "experimental" nets set for totoaba (*Totoaba macdonaldi*, an endangered sciaenid corvina endemic to the Gulf of California) to be 0.0058 vaquitas/set. If this mortality rate is extrapolated to the number of commercial nets set for totoaba between 1935 and 1965 (10,000 sets/year; Fleischer *et al.*, 1994) the resulting estimated mortality for the totoaba fishery since 1935 was 58 vaquitas per year

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(D'Agrosa, Lennert and Vidal, in prep)[3]. Vidal (1995) estimated that at least 35 vaquitas/year were taken in gillnets between 1985 and 1992 using data primarily from research conducted in El Golfo de Santa Clara, Sonora (Fig. 1). Between March 1985 and February 1992, 128 vaquitas were documented to have been incidentally caught in gillnets. Most of these, 68%, were taken in gillnets (mesh size 20-30.5cm) set illegally for totoaba, a fishery that was banned in 1975 due to the status of the totoaba (Diario Oficial de la Federación, 1975). An additional 28% were taken in nets set for sharks and rays (mesh sizes between 10-15cm), and 7% were taken in nets set to catch mackerels (*Scomberomorus* spp.) (mesh size 8.5cm) (Vidal, 1995). At about the same time, on the basis of 110 sightings between 1986 and 1989, Silber (1988, 1990) roughly estimated the population size to be only between 200-500 animals.

Armed with these distressing data on the potential levels of fishery mortality relative to population size, and lacking information about other population parameters, the vaquita was classified as 'vulnerable' by the IUCN in 1978 (IUCN 1978), listed as 'endangered' under the U.S. Endangered Species Act in 1985, and then reclassified by the IUCN as 'endangered' in 1991 (Klinowska, 1991). To help remedy a potentially disastrous situation, Conservation International-Mexico launched a comprehensive research program in 1993 entitled "The Fragile Ecosystem of the Upper Gulf of California" to increase our understanding of the biology of vaquita, the impacts of fishing activity, and the socio-economic factors that would ultimately affect options for mitigating the mortality of vaquita, thereby preventing its extinction. Within this multidimensional endeavor were included studies on life history, genetics, osteology, and feeding habits, and monitoring of incidental mortality of the vaquita in gillnet fisheries. Independently, but simultaneously, other projects were also undertaken to determine abundance (U.S. National Marine Fisheries Service, NMFS), distribution (joint effort by the NMFS and the National Program of Marine Mammal Research within the Mexican Secretariat of Fisheries), and feeding habits (National Institute of Fisheries in Mexico).

Cumulatively, these endeavors have resulted in a better understanding of the species and the creation of a biosphere reserve for its protection. Yet, additional questions remain and further actions are needed.

ABUNDANCE AND DISTRIBUTION

Under the direction of Dr. Tim Gerrodette, NMFS conducted research vessel

3 D'Agrosa *et al.* (in prep.) is the manuscript resulting from the thesis of D'Agrosa (1995).

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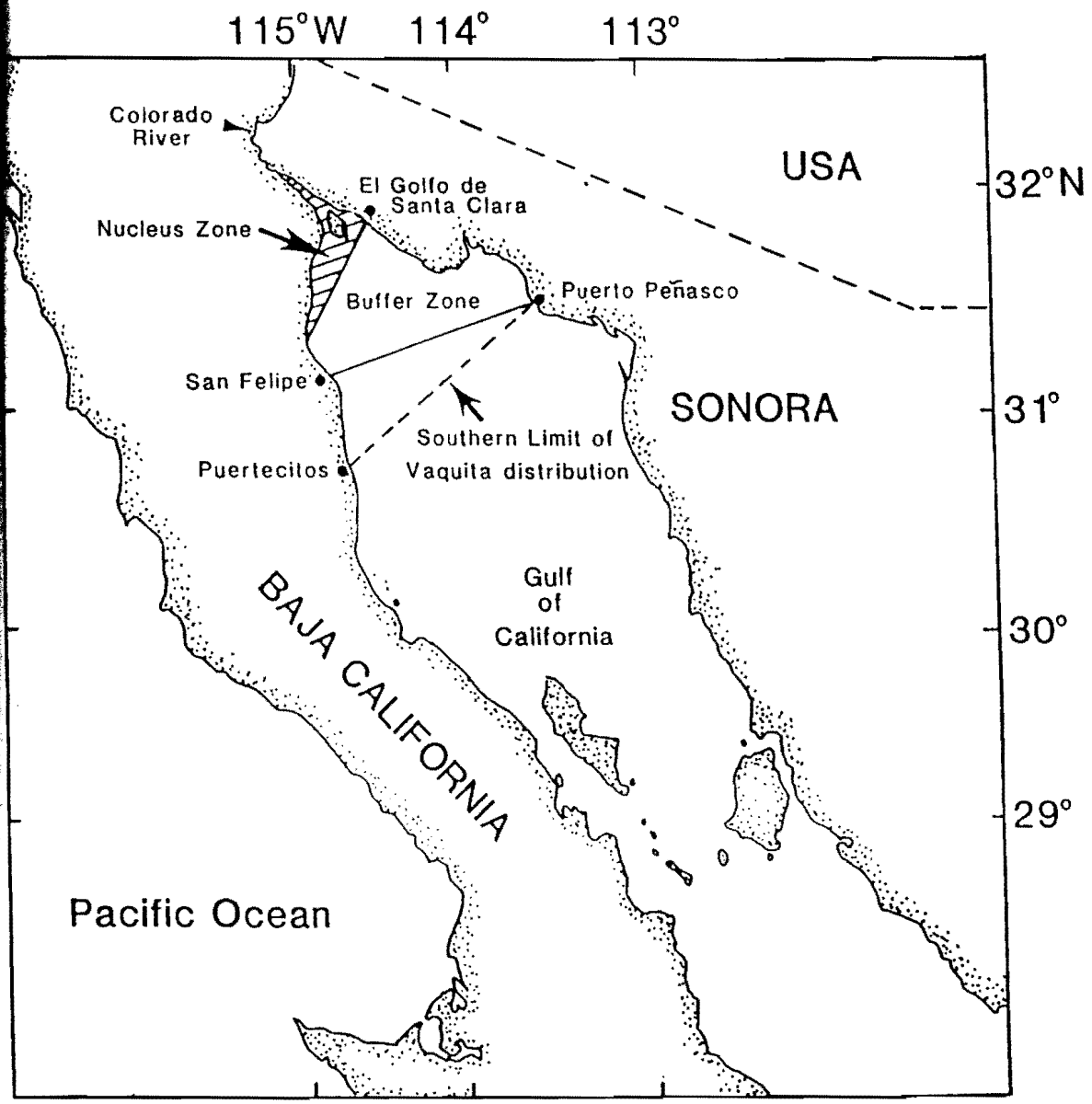

Fig. 1. Distribution of the vaquita in the upper Gulf of California ranges from the Colorado River estuary to an imaginary line connecting Puerto Peñasco and Puertecitos. The Upper Gulf of California and Colorado River Delta Biosphere Reserve comprises two areas: the Nucleus Zone (protected area) and the Buffer Zone (managed-use area). Vaquitas inhabit areas outside the boundaries of the Reserve.

surveys of the upper Gulf of California in August 1993 (Gerrodette, 1994); surveys covered both inside and outside the known range of the species. With excellent sighting conditions and using line-transect methods, he produced the first rigorous abundance estimate for this species, indicating a total vaquita population size of about 224 animals [95% CI: 106, 470] (Barlow, Gerrodette and Silber,

1997). Barlow, Gerrodette and Silber (1997) went a step further, using estimates of vaquita abundance from four different surveys conducted between 1986 and 1993 (including the 1993 survey) to estimate an 18% per year decline in the population from 1986 to 1993.

As explained by Gerrodette *et al.* (1995), during 1992-1993 the collective efforts of NMFS, Mexico's National Program of Marine Mammal Research, and the Institute of the National Autonomous University of Mexico (IBUNAM), using different survey methods and working independently, confirmed the range of the vaquita to be within a relatively limited geographic region. All sightings but one occurred in a small area in the northwestern part of the Gulf; that one occurred just outside this range, south of Puerto Peñasco (Gerrodette *et al.*, 1995).

BIOLOGY

Although still limited by small sizes, knowledge of the biology of the vaquita is emerging largely due to the retrieval of carcasses from entangled animals. It is reassuring that in many ways the life history of the vaquita is similar to its better-known congener, the harbor porpoise (*P. phocoena*) (Hohn *et al.*, 1996). For example, both have a longevity of about 20 years, mature early (3 yrs for harbor porpoise, likely close to 3 but potentially up to 6 yrs for the vaquita), have similar patterns of postnatal growth, and exhibit synchronized reproduction resulting in a seasonal pattern of births. In the vaquita, these births occur primarily in March and April. Testis size and spermatogenic activity are maximal during the same season. Their common characteristics of large testes relative to body mass, sexual dimorphism with females larger than males, and small group sizes suggest common social and breeding systems. One critical difference between the vaquita and harbor porpoise was found in reproductive rates; most sexually mature female harbor porpoise calve annually while the sample of mature female vaquitas available for life history studies indicate that calving is not annual. As a result, the estimated maximum population growth is lower than the 4% estimated for harbor porpoise in a well-studied population in the Bay of Fundy, Canada (Woodley and Read, 1991).

Stomach contents from entangled animals have been examined for prey species identification. Pérez-Cortés, Silber, and Villa-Ramírez (1995) found primarily epipelagic and demersal fishes in stomachs from 10 vaquitas. They also reported squid but considered it to be secondary. Stomachs from another 24 vaquitas contained primarily two species of endemic fishes, a small corvina (*Isopisthus altipinnis*) and a midshipman toadfish (*Porichthys mimeticus*), and one of two species of small squids (Findley, Nava and Torre, 1995). The 19 species of prey

identified primarily represented demersal and benthic fishes and squids. An earlier study by Fitch and Brownell (1968) showed a bronzestriped grunt (*Orthopristis reddingi*) and the bairdiella croaker (*Bairdiella icistia*) in the stomachs of a few decomposed vaquita found beach-cast. Findley *et al.* (1995) note that biological and ecological information on most of these species is unknown.

Torre (1995) prepared a detailed description of the vaquita skeleton, including sexual dimorphism and allometric growth in the skull on the basis of 62 specimens. He also reported that 24.3% of the examined specimens presented vertebral bone malformations, such as the occurrence of hyperosteosis and small protuberances along the neural spines of lumbar vertebrae, and the fusion of vertebrae 26-27 via neural spines. This last malformation was found in 55% of the specimens with malformations, and in both juveniles and adults (Torre, 1995). Torre (1995), Villa-Ramírez, Peralta-Perez, and Delgado-Estrella (1996), and Ortega-Ortíz (1993) gives detailed descriptions of the bones in the pectoral fin, which is notable because it contains a sixth digit between the third and fourth metacarpal bones. This polydactyly occurs in most specimens (93%), and ranges in size from being just a small protuberance to a fully developed digit (Torre 1995). Such polydactyly is unusual in mammals but has been identified in inbred populations (Torre, 1995); Torre (1995) speculates that the presence of polydactyly in vaquita also may be due to inbreeding.

Indeed, earlier studies of mt DNA by Dr. Patricia Rosel (Rosel, 1992) found no variability in a segment of 400 base-pairs in a sample of 10 vaquitas collected in different areas and different seasons. One explanation was that the lack of variability was due to a possible population bottleneck in the founding population (Rosel, 1992). Rosel and Rojas-Bracho (1993) are investigating this possibility further by increasing the sample size and examining nuclear DNA (Rosel, pers. comm.).

FISHERY INTERACTIONS

D'Agrosa *et al.* (in prep.) and D'Agrosa, Vidal and Graham (1995) were the first to relate incidental mortality to fishing effort. Gillnet fisheries in El Golfo de Santa Clara, Sonora, were monitored continuously from January to August 1993 and semi-continuously from September 1993 to March 1994. Data regarding fishing effort and vaquita mortality were collected by non-systematically interviewing as many fishermen as possible on the beach when they returned from fishing and by placing observers on as many boats as possible to corroborate the information obtained in the interviews. The deaths of 15 vaquitas were documented during 1993-1994, 14 of which died in gillnets with mesh sizes

ranging from 7cm to 15cm (D'Agrosa *et al.*, 1995). Total estimated fishing effort in El Golfo de Santa Clara between January 1993 and January 1994 was 3,946 trips (SE=139) (D'Agrosa *et al.*, in prep.). Evaluation of the contribution of various factors associated with fishing (mesh size, fishery, area, soak time, etc.) showed that none contributed significantly to the incidental mortality of the vaquita, which implies that the principal cause of this mortality is fishing with gillnets, *per se* (D'Agrosa *et al.*, in prep.). D'Agrosa *et al.* (in prep.) further found that two estimates of total incidental mortality were obtained using the two different approaches to data collection. When data collected from both interviews and observers were used, the total estimated incidental mortality due to the fleet of El Golfo de Santa Clara is 39 vaquitas per year [95% CI: 14, 93]. However, when only the data collected by observers were used, total estimated mortality for this fishing port is 84 vaquitas per year [95% CI: 14, 455]. To obtain a more precise estimate of fishing effort and incidental mortality in all of the upper Gulf, visits were made simultaneously to El Golfo de Santa Clara and Puerto Peñasco, Sonora, and to San Felipe, Baja California, from October 1994 to April 1995 (D'Agrosa *et al.*, in prep.). Preliminary results indicate that incidental mortality rates for San Felipe are comparable to those estimated for El Golfo de Santa Clara (D'Agrosa *et al.*, in prep.).

CONSERVATION MEASURES IN THE UPPER GULF

On June 10, 1993, the Mexican government officially established the Upper Gulf of California and Colorado River Delta Biosphere Reserve (Diario Oficial de la Federación, 1993), primarily to protect the vaquita and its habitat (Diario Oficial de la Federación, 1994). The Management Plan for the Reserve (Instituto Nacional de Ecología[4], 1995; released on 7 June, 1996) was designed to reduce immediate threats to the vaquita as well as to ensure sustainable development for the local residents. The Reserve is divided into two principal areas: a Nucleus Zone and a Buffer Zone (Fig. 1). These two areas are further divided, based on three primary management strategies, into (1) protection, or no-use, regions (Nucleus Zone); (2) protection within active-use regions (Buffer Zone); and (3) controlled-use regions (Buffer Zone). There are short-, mid- and long-term guidelines for each of these regions with regard to which activities (*i.e.*, tourism, science, fishing, aquaculture, hunting and sustainable development) can occur in each region. The Management Plan is designed to be dynamic, changing as new information warrants; thus, mid- and long-term guidelines are general so they can be responsive to that new

4 The Instituto Nacional de Ecología (National Institute of Ecology, INE) is part of the Secretaría de Medio Ambiente, Recursos Naturales y Pesca (Secretariat of the Environment, Natural Resources and Fisheries, SEMARNAP).

information.

Much of the information summarized in the present paper was not available when the Management Plan was drafted. The emerging picture indicates the direction these dynamic guidelines should take in order to fulfill the objective of protecting the vaquita and its habitat. That new direction should take into account the following information and considerations.

1. Reservations about the Reserve's boundaries

Approximately 40% of the vaquita sightings made by Gerrodette *et al.* (1995) occurred south of the Buffer Zone (*i.e.*, outside of the Reserve). Many previous sightings (Silber, 1990) were also outside of the Reserve's boundaries. This implies that the establishment of the Reserve, given its actual boundaries, will not ensure the conservation of this endangered species. The Reserve represents only an important first step. D'Agrosa *et al.* (in prep.) suggested the boundary of the Reserve be extended south to include Puertecitos, Baja California, in order to incorporate the known habitat range of the vaquita. A resolution for the protection of the vaquita has been proposed by members of the Sociedad Mexicana para el Estudio de los Mamíferos Marinos (Mexican Society for the Study of Marine Mammals, SOMEMMA). This resolution includes a proposal to consider the creation of protected areas inclusive of vaquita's critical habitat (Marine Mammal Society Newsletter, 1996). This recommendation should receive serious consideration by the Instituto Nacional de Ecología.

2. Net income, net survival

The *minimum* estimated annual mortality (*i.e.*, 39 vaquitas/year) corresponds to approximately 13% of the most accurately estimated total vaquita population (less than 300 individuals, Barlow *et al.*, 1997). As noted above, not only is the maximum population growth rate of the vaquita lower than the 4% estimated for *P. phocoena* (Hohn *et al.*, 1996), but the population is estimated to be declining at a rate of 18% per year (Barlow *et al.*, 1997). It is obvious that with minimum incidental mortality rates triple that of even optimistic population growth rates, the vaquita population cannot withstand this mortality for very long. Many recent reviews of the plight of the vaquita have noted that the cessation of fishing mortality must occur immediately (Silber, 1990; D'Agrosa *et al.*, 1995, in prep; IWC, 1995; Vidal, 1995; Hohn *et al.*, 1996).

The Management Plan (INE, 1995) acknowledges that the most significant threat to the vaquita population is the use of gillnets by the Reserve's inhabitants. Therefore, specific guidelines regarding the use of nets that might entangle vaquitas must be established and enforced (D'Agrosa *et al.*, in prep.). One of the guidelines included in the Management Plan is that there shall be no fishing of

any kind in the Nucleus Zone; however, as of June 1996 enforcement has been inconsistent. With the official release of the Management Plan as well as the appointment of the Reserve's Director, enforcement of this guideline should become more rigorous. The Management Plan makes allowances for new information by stating that studies should be conducted to mitigate the impacts of gillnets in the Buffer Zone; however, this does not address the *immediate* requirement to reduce these impacts. The need for more studies should not be an excuse to postpone action. Furthermore, the Management Plan, in an attempt to reduce the demands made on the Reserve's fish populations, states that only local fishermen can fish within the Reserve. This provision was included because, in the past, vessels from other parts of México as well as from other countries have fished in the Upper Gulf. Differentiating the home port of small fishing vessels, *pangas*, will be difficult but is important.

The commercial shrimp (trawl) fishery is deemed fundamental in maintaining the local economy, but due to the impact of trawling on both non-target species and on the ocean floor, the Management Plan restricts shrimp trawling to depths of greater than 10 meters and requires use of bycatch-excluding devices. D'Agrosa *et al.* (1995, in prep.) and Vidal (1995) note that vaquitas have been taken in shrimp trawls. The depths at which these vaquitas were caught is unknown; however, the majority of the incidental takes in gillnets reported by D'Agrosa *et al.* (1995, in prep.) and Vidal (1995) occurred in less than 30 meters of water. This means there is an overlap of 20 meters between trawling grounds and areas of known vaquita mortality. In addition, the artisanal shrimp fishery, which uses small-mesh (7cm) gillnets and is pervasive in the upper Gulf, also is known to take vaquitas (D'Agrosa *et al.*, 1995, in prep.). The Management Plan does not address the potential interaction of shrimp fisheries with vaquita despite the fact that the large number of nets could result in significant vaquita mortality.

In fact, the Management Plan does not include any specific measures regarding the use of gillnets. The ideal solution for the vaquita would be to prohibit gillnets within vaquita habitat while simultaneously providing an alternate source of income for local residents (D'Agorsa *et al.*, in prep.). In addition, to optimize efforts to protect the vaquita and minimize hardships to local residents of the Reserve, research is needed to determine the fine-scale spatial and temporal patterns of the vaquita and to identify critical habitat. This information might be useful to design and implement limited fishing bans, such as time-area closures.

3. Where are all the vaquitas?

The extant population of vaquita must be larger than what has been estimated given the estimates of sustained mortality (D'Agrosa *et al.*, in prep.). So, where

are they ? D'Agrosa *et al.* (1995, in prep.) mention that the spatio-temporal distribution is not clear because: (1) there is insufficient information on incidental mortality for the San Felipe and Puertecitos areas; (2) with the exception of a few surveys done by Silber (1988, 1990) and Gerrodette *et al.* (1995), there has been no survey effort along the northernmost coasts (*i.e.*, <20 meters water depth); however, most of the vaquitas reported by D'Agrosa *et al.* (1995, in prep.) and Vidal (1995) occurred in less than 30 meters of water, and (3) much of the older survey and monitoring effort took place during one season, the spring. Hohn *et al.* (1996) concluded that the bimodal structure of the population could be due to spatio-temporal segregation of age and reproductive classes. If so, this implies that both abundance and life history estimates could be biased. However, they also mention the possibility that these juveniles simply "do no exist", in which case, the status of the vaquita is worse than the abundance estimates alone would imply. As noted by D'Agrosa *et al.* (in prep.), even if there were three times as many vaquita (*i.e.*, 800 individuals) the conservative estimated mortality (39 individuals/year) would constitute 5% of the population; a rate which is still too high for this population to withstand over a long period of time.

Surveys in vessels with smaller drafts which are systematically conducted year-round and which include the shallow waters in the northernmost reaches of the upper Gulf (*i.e.*, where most incidental takes are recorded), in concert with surveys in deeper waters, would provide more comprehensive abundance estimates (D'Agrosa *et al.*, in prep.). Understanding movement patterns of the vaquita, perhaps by telemetry, would contribute to information about the way they use their habitat.

Like some of the river dolphins in Asia (Perrin *et al.*, 1989; Liu and Wang, 1996), this species is one that may well go extinct as we watch. Unlike the river dolphins, the underlying causes of mortality for the vaquita are more discrete and easily managed. But for both the vaquita and the river dolphins time is running out. We dare not lose this opportunity.

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