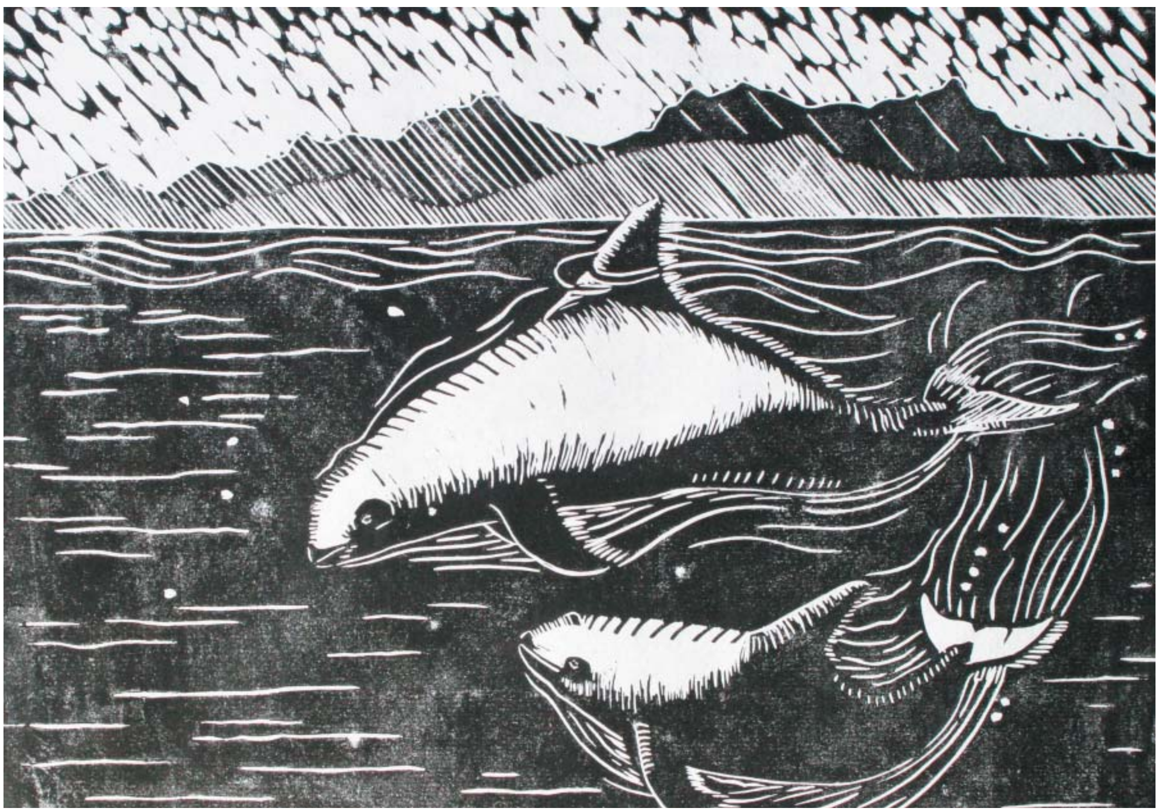
Comite Internacional Para la Recuperacion de la Vaquita

CIRVA

International Committee for the Recovery of the Vaquita



Artwork courtesy of Barbara L. Taylor

Scientific Reports of:
First Meeting, 25–26 January 1997
Second Meeting, 7–11 February 1999
Third Meeting, 18–24 January 2004

Report of the First Meeting of the International Committee for the Recovery of the Vaquita (CIRVA) Ensenada, Baja California, México 25–26 January 1997

Background

During the 48th meeting of the International Whaling Commission in Aberdeen, UK, México presented a recovery strategy for the vaquita (IWC/48/25). The main component was the creation of a Committee of International and National scientists. The Committee was conformed by invitation of the Mexican Government, through the President of the Instituto Nacional de la Pesca (México's National Fisheries Institute) and the first meeting was held in late January of this year in Ensenada, Baja California, México. The mandate of this group is to create a Recovery Plan for this species. The Plan should present the best chance of recovery based on the present state of knowledge and information.

Summary of Presentations and Discussions

Saturday, 25 January 1997

1. Greetings and Introduction

Arenas-Fuentes, as chairman of the Committee, and Rojas-Bracho as Coordinator, welcomed all the participants and laid the groundwork for the meeting objectives. Participants introduced themselves and provided a brief summary of their research interests. Barlow and Taylor were appointed as rapporteurs for the first session. Read was appointed rapporteur for the second session. Arenas-Fuentes asked the participants to help to create a collection of all papers and documents referring directly or indirectly to vaquita.

2. Oceanography of the Upper Gulf of California

Camacho summarized information about the oceanography of the Gulf, with special emphasis on the Colorado River Delta and river inputs to this system. Oceanographically, the northern Gulf is separated from the rest of the Gulf by a relatively shallow sill located approximately at the mid-rift islands. The freshwater river input into the northern Gulf through the Colorado River has decreased approximately 90 percent since the building of a series of dams in the U.S. starting in the early 1900s. Currently, water flow is much more seasonal and sporadic than it had been and sediment transport and nutrient inputs have been cut dramatically. Water flow models suggest that low salinity surface waters extended far into the Upper Gulf when the Colorado flow was unimpeded. Now, throughout most of the year, the delta is a negative (hypersaline) estuary.

The tidal range in the northern Gulf is huge, up to 10 m in some of the delta channels, with measured tidal currents of 3 m/sec in the channels and 0.8 m/sec in the Upper

Gulf itself. Circulation is generally counter-clockwise. Despite the decrease in Colorado River inputs, nutrient levels in the entire northern Gulf remain above those levels that are thought to limit phytoplankton growth. High chlorophyll a pigment concentrations and primary productivity have been measured in the Upper Gulf year-round, and this area appears buffered from the El Niño (ENSO) changes in productivity that are experienced in the rest of the eastern Pacific. In the estuarine basin, heterotrophic (bacterial) biomass and productivity are actually higher that those values for the autotrophs (algae). Analyses on a limited number of samples suggests that zooplankton densities are also very high in the Upper Gulf of California.

Currently, the loss of sediments in the Colorado River Delta due to tidal currents and wave action is much greater than the accretion of sediments by river transport. The net effect is that the delta is entering a net erosional phase. In the short term, however, there have been no obvious catastrophic effects from the loss of river input on the oceanography of the northern Gulf. Nutrient concentrations and productivity are high. The problems related to depletion of fish stocks and endangered species (such as vaquita) in this area seem to be more related, in the short term, to inadequate fisheries management, than to the lack of freshwater or nutrient inputs. However, because nutrients captured in sediments may be contributing to the northern Gulf's high productivity and because there is a net loss of sediments, the long term future is not known. Additional information is needed about the source of nutrients driving productivity in the northern Gulf.

3. Species Description, Life History, and Diet

3.1 Description

Brownell summarized some of the historical information about the discovery of the species, his finding of the first whole specimens in 1966/67, and external morphological features of the species. Vaquita are a small porpoise, with a maximum length of 150 cm. Of particular note are the black markings around the eyes and mouth and the large size of the dorsal fin and pectoral flippers.

3.2 Life History

Read described the natural history of the species from a paper he co-authored (Hohn *et al.* 1996). This species shares many life history traits with related, better known porpoise species, such as the harbor porpoise. The specimens caught in gillnets and stranded on beaches displayed an unusual age distribution, with most of the individuals between zero and two years and between 11 and 16 years, with few specimens between three and ten years. The sample of animals may be biased due to spatial segregation of different age classes or the susceptibility of various ages to capture in nets. Alternatively, if this is the true age distribution of the population, this would represent a complete recruitment failure in recent years.

Like other porpoise, vaquita is a seasonal reproducer, with most births occurring around March. There are no data, but gestation is probably 10–11 months, as with other porpoises. The maximum observed lifespan is 21 years, which is consistent with maximum lifespans of harbor porpoise. Age of sexual maturity is difficult to estimate because of the lack of juvenile animals in the sample, but all females less than three years were immature and all females older than six years were mature. Most female harbor porpoise mature at age three and give birth first at age four, which is consistent with these observations for vaquita. Reproductive rates could not be accurately estimated, but unlike harbor porpoise in the Gulf of Maine, vaquita are certainly not annual reproducers. Many of the older females exhibited an ovarian pathology that resulted in the calcification of corpora albicantia.

In questions, it was pointed out that an analysis of age structure, stratified by year of collection, could help resolve whether the unexpected paucity of individuals age 3–10 years is an artifact of sampling or whether it reflects the true age structure of the population. If there were no recruitment into the population beyond age three, then the proportion of adults older than 10 would decrease rapidly over time. In other words, the observed age distribution could not be stable over time. For example, with no recruitment the youngest adult age 10 could only be expected to live another 10 years at which point, vaquita could be extinct. Thus, data on the year animals used in the distribution were killed could resolve whether or not this distribution could represent the true distribution. Read promised to present these data for closer examination. Because the distribution is characteristic of a population very close (within a few years) of extinction, Committee members felt it unlikely to represent the true distribution because vaquita are still extant. The Committee felt it seems more likely that the incidental catch is age selective, either due to age-specific distribution of the vaquita in relation to fishing effort, or behavioral differences in different age vaquita.

It was pointed out that lactating females may be more at risk of entanglement if they attempt to rescue or investigate entangled calves. It was pointed out from Hohn et al (1966) paper that the sex ratio in the sample was near parity, indicating that males and females could be equally vulnerable to gillnet entanglement. It was questioned whether vaquita might be attracted to small prey species that might be aggregating around gillnets, but no one knew if this was the case. It was pointed out that not all porpoises have a 1-year calving interval and that a 2-year calving interval is typical for harbor porpoise in central California.

3.3 Diets

Pérez-Cortés presented the results of his studies of vaquita diet based on a small number of stomachs (10) collected over a 10-year period. He found that prey consisted primarily of a wide variety of fish (11 species), squid (two species), and crustaceans (one species, plus two that were fish parasites). Several of the fish prey species (such as croakers) are known to be sound producers, so it is possible that vaquita are frequently using passive sound rather than echolocation to find their prey. This might make them more vulnerable to blundering into gillnets. Pérez-Cortés found very little diet overlap between vaquita and totoaba. He noted that diet probably varies seasonally, but he did not have sufficient data to examine this.

Responding to questions, Pérez-Cortés and others noted that two of the vaquita prey species are fished commercially (chano and corvina) and that most of the others are caught incidentally in shrimp trawls. Barrera noted that stomachs of vaquita and totoaba that he had looked at showed very similar prey compositions, however he presented no data.

Conclusions

The Committee agreed that:

1. It is highly unlikely that the age structure, with a significant absence of age interval 3–6 years, reflects the true age structure of the population. It seems likely that the incidental catch is age selective, either due to age-specific distribution of the vaquita in relation to fishing effort, or behavior differences in different age vaquita.
2. A temporal evaluation of the age structure could help resolve this problem: whether the paucity of age interval 3–6 years individuals is an artifact of sampling or whether it reflects the true age structure of the population.
3. Available data indicate that vaquita consume a different number of prey species, particularly fishes, two of which are fished commercially.

4. Vaquita Distribution

Brownell reviewed his paper (Brownell 1986) on the distribution of vaquita. By that time, several reports had placed the species as occurring from the northern Gulf of California as far south as Islas Tres Marías. In his paper, Brownell reviewed all the physical and sighting records of the species prior to the early 1980s. He found that all of the physical evidence (bones, photographs, etc) come from specimens found in the northern Gulf of California. All sighting records south of the Gulf were poorly documented, were of questionable authenticity, and/or did not match the habitat preferences of vaquita. He concluded that vaquita distribution is actually limited to the northern Gulf.

Gallo-Reynoso presented a summary of his recent work on compiling sighting locations for vaquita. The locations of 102 well-documented sightings appeared to be correlated with bottom sediment type, with vaquita sightings being most common over silt and clay sediments (and less common over sand). It was noted that sediment type is related to the strength of currents and to benthic fish fauna, either of which could be the proximate reason for this correlation. Vaquita were typically found in depths between 20 and 50 m. Sightings occurred in the same general region (near Rocas Consag) in spring, summer, and fall, but based on a few sightings appeared to be concentrated further north in winter. Approximately 40 percent of sightings occurred south of the established Sanctuary in the northern Gulf, approximately 60 percent were inside the sanctuary, but only one unconfirmed sighting was within the “nucleus” of the Sanctuary.

In discussions, it was pointed out that the majority of vaquita entanglements have occurred north of the center of sighting distributions. This may be because many of the known entanglements are reported in the fishing ports and/or because entanglement locations were from boats fishing out of the center of sighting distributions. It was pointed out that sightings are difficult to interpret without information on where search effort was concentrated.

The relations of vaquita with other small cetaceans was discussed relative to what might constrain vaquita distribution. A review of Silber's paper (Silber 1990) showed that bottlenose dolphins were found in shallow coastal waters primarily on the eastern side of the Gulf. Common dolphins were found in waters deeper than 20 m throughout the northern Gulf. Neither remain in this area in the warm summer months. Pérez-Cortés noted that he had observed vaquita in a mixed school only once and that generally bottlenose dolphins and vaquita distributions are mutually exclusive.

Conclusions

The Committee agreed that:

1. There is no reliable evidence that the vaquita´s current or historical distribution extends south of the Upper Gulf.
2. Data so far indicate that the distribution of vaquita is related to depths between 20–50 m and to bottom sediment type (silt and clay). The proximate reason for this correlation could be the strength of current and/or benthic fish fauna.
3. The main area of distribution (majority of sightings) has been reported for the western coast, mainly around the Rocas Consag.

5. Vaquita Abundance

Barlow presented a description of survey techniques, a review of what data are available, and an explanation of the abundance estimates given in Barlow, Gerrodette, and Silber (1997). All estimates were made using line-transect techniques. This technique requires defining a study area and setting tracklines to uniformly cover the area in either a systematic grid or randomly. The most difficult part of the estimation analysis is calculating the proportion of the study area surveyed. If the assumption could be made that all animals were seen within a certain distance, that distance could define a "strip" and the proportion of the study area covered by the strips could be easily calculated. Unfortunately, the probability of sighting animals usually decreases with distance and even animals directly on the transect line are not seen with certainty. For this reason angle and distance are recorded to each sighting. To estimate the strip width effectively covered by the survey, a function is fit to the frequency of sightings. This function is used to calculate the effective strip width (ESW).

A separate set of data generated by several different techniques is used to estimate the probability of detecting animals on the trackline (g(0)). The choice of technique depends on the special properties of each species. Although several techniques have been used for harbor porpoise, no estimates have been made for vaquita. It was assumed that because both porpoise species have similar surfacing behavior and groups size that g(0) would also be similar.

The first surveys by Silber were from an 8 m vessel from 1986–1988. They were designed to maximize vaquita encounters for behavioral research and were therefore neither random nor systematic. To analyze these data several assumptions were made to compensate for data inadequacies. The data were post-stratified into four effort strata. No distance measurements were made so the ESW was taken from a study from a similarly sized small boat doing harbor porpoise surveys. The probability of sighting an animal in the direct path of the survey platform (g(0)) was also taken from the same harbor porpoise survey.

Silber also completed aerial surveys from 1986–1989 which were non-random, non-systematic and did not gather distance data. A similar approach was taken post-stratifying the area into four effort areas, using harbor porpoise aerial surveys for estimates of ESW and g(0).

In 1991, Barlow *et al.* (1993) did the first systematic aerial survey. Most effort was in the far north of the Gulf because of weather precluded much effort elsewhere. They had a single confirmed sighting near Puertecitos. Barlow noted that this experience convinced him that aerial surveys were inappropriate for vaquita because rapid changes in turbidity made estimation of the proportion visible on the trackline (g(0)) impossible.

The best and most recent survey was completed in 1993 by NMFS. On a multi-species survey, ideal conditions were encountered and relatively high numbers of vaquita were seen on planned tracklines. Plans were modified to obtain several further days of effort. The greater number of sightings was attributed to both the Beaufort 0 conditions and the use of high power (25X) binoculars, which increases the distance vaquita can be seen (and therefore the ESW). The only parameter that had to be taken from harbor porpoise for this estimate was the estimate of g(0).

Estimates for all four surveys with levels of precision and confidence intervals are given in Table 1.1. Barlow noted that the most significant finding was that the abundance could be clearly stated to be in the hundreds and probably the low hundreds. An estimate of trends was admittedly poor because of the high level of imprecision in the first three surveys. Barlow noted that although he obtained a mean decline of 18 percent, the confidence levels were very large. He expressed more confidence in comparing the current estimates of incidental mortality to the 1993 estimate of abundance to understand population status.

Table 1.1. Abundance estimates with precision for the four available vaquita data sets.

Survey	**N**	**CV**	**Lower 95% CI**	**Upper 95% CI**
Boat 1986–1988	503	0.63	163	1,551
Aerial 1988–1989	855	0.50	340	2,149
Aerial 1991	572	1.43	73	4,512
Ship 1993	224	0.39	106	470

Barlow was questioned about how the 1993 abundance estimate might be biased because the shallow water (<20 m) areas were not covered. Barlow replied that although his comparison of Silber's sightings outside the 1993 study area to Silber's sightings within the area indicated a shallow water density that is 10 percent of that in the "core" area covered in the 1993 survey, future surveys should try to include the shallow waters.

Buckland noted that the CV for the 1993 survey were probably underestimated because of potential biases in estimating ESW caused both by pooling sightings made by naked eye and 25X binoculars and by not accounting for imprecision caused by the choice of the model uncertainty to estimate ESW. Barlow added that CVs of all the estimates were also probably low because no uncertainty was included to account for the use of parameters from the harbor porpoise studies. The underestimation of CVs is especially crucial in estimating trends in abundance.

Barlow also compared the density of vaquita (0.05 porpoise/km^2) to that of harbor porpoise in an area in Central California considered to be low density (0.75 porpoise/km^2). He noted that if vaquita were found in such density in their current distribution they would number approximately 3,000. In the following discussion of the utility of estimates of previous numbers Buckland emphasized that in his view, the lesson learned by the International Whaling Commission was that management based on the use of carrying capacity was impractical.

Hilborn noted that a range of possible historical abundances could be used together with data on the totoaba fishery to limit the range on other parameters, such as the growth rate of vaquita. For example, an estimate of thousands of animals killed in the early fishery (1940s) would not fit with the very few available historical accounts. Brownell noted that besides a 1941 photo of a dead vaquita probably killed in the totoaba fishery, there were no reliable accounts.

The committee discussed but did not achieve consensus on the relative effort that should be given to increasing precision in the core area versus assuring that no major areas of distribution were missed by surveying areas of likely low vaquita abundance. Some members felt that the credibility of a low abundance estimate made only from surveying the core area could be challenged by arguing that there may have been a distributional shift. Others felt that any effort expended in likely low density areas would come at a cost of better precision in the high density area. It was agreed that more ship time (4–5 weeks versus three weeks) could allow both sides to be satisfied.

A tiered priority design was discussed whereby the core area would be surveyed until a desirable level of precision had been achieved, which would be followed by a sparse coverage of adjacent areas bordering the core area to the South and East. However, consensus was not achieved on the level of desired precision with some members desiring that surveys be continued until there was no probability that abundance was below a certain threshold (a suggested value of 100), while others felt the level of precision appropriate would depend on what decisions or conservation actions would depend on the abundance estimate. For example, if abundance were to be used to set an annual kill quota, a very precise estimate would be desirable. On the other hand a demonstration that a given level of mortality was unsustainable would probably require a less precise but hopefully unbiased estimate of abundance.

It was agreed that a working group would continue discussion of optimal survey design via e-mail. This group will be headed by Gerrodette, the likely head of a planned joint survey, with other participants including Arenas-Fuentes, Barlow, Buckland, Cisneros, Jaramillo-Legorretta and Rojas-Bracho.

Conclusions
The committee agreed that:

1. Abundance is likely in the hundreds and probably the low hundreds.
2. A better abundance estimate is required as soon as possible.
3. No abundance technique except line-transect estimation appears feasible for vaquita.
4. Boat surveys are preferred.
5. All parameters needed to estimate abundance should be obtained internal to the survey.
6. Shallow water areas North and West of the core area should be surveyed.
7. A two-ship design is preferred (a large ship for the deeper-water core area around Rocas Consag and a 12–15 m boat with a 15–20 ft high platform for shallow (<20 m) areas).
8. A working group will continue discussion of optimal survey design. This group will be headed by Gerrodette with other participants including Arenas-Fuentes, Barlow, Buckland, Cisneros, Jaramillo-Legorretta, and Rojas-Bracho.

Sunday, 26 January 1997

....

Brownell noted with sadness the passing of Steve Leatherwood yesterday in San Diego. Arenas Fuentes noted the great contribution that Steve had made to the conservation of marine mammals and the Committee observed a minute of silence in his honor.

....

6. Biosphere Reserve

Barrera described the Biosphere Reserve of the Upper Gulf of California and the Colorado River Delta. The Reserve was established in June 1993 and encompasses terrestrial and marine areas extending over 930,000 hectares, with a core nuclear area of approximately 168,000 hectares and a larger adjoining buffer area. The Reserve contains over 726 species, 17 percent of which are endemic to the Upper Gulf or Delta. The 1990 population survey indicated a total human population living within the Reserve of over 37,000 with more than 2,500 people living within the buffer area in eight settlements. Approximately 21 percent (7,749) of the population is employed. The primary sector, which directly utilizes natural resources, is constituted by 77 percent (5,967), and 75 percent of this sector (4,475) earn their income from fishing. Barrera indicated that there are about 700 small outboard motor boats or "pangas" and 100 shrimp vessels in San Felipe, B.C., Puerto Peñasco and El Golfo de Sata Clara, Sonora. Industry is related to the fishing activity (i.e. fish processing, package, boat repair). Aquaculture of shrimp and suspended cultures of molluscs like scallop and sport fishing are developing. The service based sector's most important activity is small scale tourism.

Threats to the integrity of the Reserve include the introduction of exotic species, overexploitation of fisheries resources, the diminution of freshwater input from the Colorado River, illegal harvesting and the bycatch of various protected species in fishing gear. The primary objective of the Reserve is to conserve the diversity and integrity of resources for current and future use as guided by the principles of sustainable development. To achieve this objective, an integrated management plan which includes complete protection for resources in the core zone and other selected areas, and resource use with either protection or control in the buffer zone. The management plan includes education, outreach and research as essential components. Arenas-Fuentes noted that management of fisheries within the Reserve was still the responsibility of the Instituto Nacional de Pesca and that coordination with managers of the Reserve was still being developed.

Conclusions

The Committee noted that:

1. That there is considerable flexibility to modify the regulations and boundaries pertaining to activities within the Reserve, offering various options for implementing conservation strategies for the vaquita.

7. Identification of Risk Factors

7.1 Inbreeding

Taylor described an analysis that she had conducted Rojas-Bracho to determine whether a lack of genetic diversity could compromise the recovery of this species (Taylor and Rojas-Bracho ms). A sample of 43 vaquita contained no variability in the hypervariable region of mitochondrial DNA (mtDNA). This, coupled with observations of polydactyly and unusual ovarian pathology, has led some observers to question whether the potential recovery vaquita could be compromised by inbreeding. A simulation model was developed to address the issue of whether the lack of genetic diversity is (1) a recent phenomenon that could inhibit recovery, or (2) whether it is a historical phenomenon in which selection has already acted against potentially deleterious recessive alleles.

The results of the model indicate that the current lack of diversity could have resulted from either (i) a population that has existed at a small size for a long period, or (ii) a strong founder effect in which the population originated from only a few individuals. Thus, a recent decline in abundance is unlikely to lead to a severe reduction in genetic diversity that could affect the potential for recovery.

Taylor also described the results of their second analysis designed to examine whether inbreeding depression could cause demographic effects that contribute to extinction. This analysis combined data from life history of the species (Hohn *et al.* 1996) and other marine mammals with information from studies of the effects of inbreeding on the survival rate of captive mammals (Ralls and Ballou 1983). The results of the model were inconclusive, due to the large range in uncertainty regarding the vital rates (age at first reproduction, fecundity and adult and juvenile survival rates). However, if only those vital rate values that fit most probably the life history of vaquita are considered, even strong increments of juvenile mortality due to inbreeding would not prevent a positive population growth.

In the discussion that followed the presentation, it was noted that several species (notably northern elephant seals, among others) have recovered from dramatic reductions in population size, despite very low levels of genetic diversity. All lines of evidence suggest that the vaquita has existed at relatively small population sizes for a very long period, so the low levels of genetic diversity we see in current samples do not indicate that inbreeding is likely to be a significant factor inhibiting the short-term recovery of the species.

7.2 Fisheries

7.2.1 Fisheries activities in the Upper Gulf

Pedrin-Osuna described the fisheries of the Upper Gulf. Total landings remained stable at approximately 12,000 mt per year between 1985 and 1992, but significant changes occurred in the composition of the catch. Landings of shrimp, the most valuable species, decreased from about 7,000 mt to 2,000 mt from 1989–1992, while the landings of finfish increased.

Many fishermen have switched from working on the larger trawlers to smaller pangas. There are approximately 300 pangas in San Felipe, 200 in El Golfo de Santa Clara and an additional 200 shrimp trawlers. Pangas from other areas of the Gulf fish in the Upper Gulf during the shrimp season. Fishermen use gill nets to take a variety of species, including chano, sierra, shark, corvina and shrimp. Mesh size, area fished and season vary with target species. The fishing effort for shrimp using demersal drift gill nets has recently increased dramatically because of economic and regulatory factors.

7.2.2 Entanglement in Fishing Gear and Incidental Mortality

Arenas-Fuentes reviewed several studies of the incidental mortality of vaquita in fisheries. He noted that virtually no information is available on the natural mortality of the species, although vaquita are known to be preyed on by large sharks and perhaps killer whales and other large odontocetes. Vidal (1995) noted 128 records of bycatch, the majority of which (65 percent) occurred in gill nets set for totoaba. A further 28 percent of these bycatches were recorded in nets for sharks and rays and 7 percent in nets for sierra and shrimp. The vast majority of these bycatches occurred in large (>10 cm) mesh gill nets, which have now been prohibited. Four vaquita were taken in an experimental fishery for totoaba, in which 682 sets were made between 1983 and 1993 (0.0058651 vaquita/set). It is possible to use this bycatch rate to examine trends in vaquita bycatch over time using totoaba landing data. Such extrapolations, however, require assumptions regarding totoaba catch per unit effort, fishing practices and constant vaquita abundance that are likely unreasonable.

Results from D'Agrosa work (D'Agrosa 1995) were commented. She estimated vaquita mortality in pangas fishing from El Golfo de Santa Clara between January 1993 and April 1994. She used trips per day, onboard observers and interviews data, analyzed within the Generalized linear Model framework, to estimate both byctach rate and fishing effort. Separate estimates of bycatch rate were generated by (1) onboard observers data only and (2) information collected from both interviews and onboard observers (i.e. all data). The total mortality estimate for El Golfo de Santa Clara was 39 (from pooled observer plus

Table 1.2. Vaquita mortality estimates with precision from the Gulf of Santa Clara (D'Agrosa 1995).

Data	Mortality Rate	Lower 95% CI	Upper 95% CI
Observers only	84/year	14	455
Interviews and observers	39/year	14	93

interview data) or 84 (using observer bycatch rate data). Vaquita were taken in a variety of gill net fisheries including shrimp, chano, shark and sierra (7–15 cm).

There was considerable discussion following the presentation of these data. Buckland and Taylor noted that it was difficult to reconcile these estimates of mortality and abundance with the current existence of the vaquita population. It was generally agreed that considerable uncertainty existed with both estimates of abundance and bycatch, in addition to gaps in our knowledge regarding the potential rate of increase in this species. Barlow noted that it would be useful to explore a variety of feasible scenarios using existing information.

The Committee discussed the absence of individuals in the age interval 3–10 years from the incidental mortality records and its relation to the fishing areas. This could be explained either by a low gillnet fishing effort in the core area (sightings) around the Rocas Consag, where this age classes could be distributed or by a lack of monitoring effort in this area. Pedrín-Osuna mentioned that gillnets are not so frequent around the Rocas Consag. The Committee recommended that a fishing effort map should be produced. Pedrín-Osuna and Barrera mentioned that there is probably enough information to build one, and that they could do it.

Cisneros presented a model life table analysis of the effects of incidental mortality on the demography of the vaquita population. The model assumed a stable age distribution and a value of lambda of 1.0 Population growth was more sensitive to changes in survival, particularly of juveniles and subadults, than to changes in fecundity. Model results suggested that a population of 550 individuals is unlikely to risk extinction from chance demographic effects alone. Stochastic environmental effects (expressed as introduced variation in survival rates) produced dramatic increases in the probability of extinction. Additional anthropogenic mortality further increased the likelihood of extinction.

Taylor pointed out that, because the initial parameterization of the model specified a value of lambda of 1.0, additional mortality or variance in survival in the model population will always lead to extinction, thus limiting the utility of the analysis. She further suggested that the results of the sensitivity analysis may have been affected by the parameter values used, especially the relatively low survival rates in the model. Further exploration of the effects of various vital rate parameters on population growth is warranted.

Hilborn then presented the outline of a synthetic age-structured model of vaquita demography. The model includes age-specific survival rates, vulnerability and fecundity rates and is tuned by likelihood to information from surveys, bycatch estimates, the age distribution of bycatch and reasonable speculation about initial population size. The model can be used for several purposes including an estimation of lambda and a Bayesian approach to risk analysis. The Committee encouraged further development of this model.

The Committee then turned its attention to the potential benefits of an observer program dedicated to estimating total bycatch mortality for all fisheries in the Upper Gulf of California. Buckland suggested that a program to estimate bycatch mortality could include interviews with fishermen (from all ports) and an observer program, perhaps using independent vessels. Several Committee members questioned the utility of estimates of vaquita mortality based on self-reporting by fishermen, due to (1) the potential implications this might have on fishing and (2) killing vaquitas is a Federal offense. However, it was indicated that such interviews might provide useful data on fishing effort. Barlow noted that many observers would be required to generate sufficient observations of bycatch.

The Committee discussed the logistical problems of such an observer program, including the number of observed mortalities required to generate a reliable estimate of mortality. Fisheries landings could perhaps serve as a surrogate for actual effort data. There was considerable discussion of the merits of various types of observer programs. Barlow suggested that perhaps an observer program based in the most important area of vaquita habitat might provide useful information on bycatch rates and fishing practices. The Committee agreed that currently available data are sufficient to indicate that immediate action is necessary and is a higher priority than additional gathering of mortality data. Read suggested that it is not be necessary to estimate total mortality, because it is apparent from existing data that effective and immediate conservation action is required to ensure the future survival of the vaquita. Although agreeing that conservation action has a higher priority than gathering further mortality data, Buckland thought that convincing management agencies of the necessity of appropriate conservation action might require a more reliable estimate of total mortality. Here a significant discussion was held regarding the practical difficulties to estimate the latter. Most felt that obtaining better estimates of mortality would be very difficult and costly.

The Committee agreed that an observer program dedicated to examining fishing practices, vaquita mortality and perhaps distribution in the core area of vaquita habitat could provide useful information. This observer program could utilize both shore-based and small vessel platforms and should perhaps concentrate on vessels from San Felipe. The Committee recommended that further information be compiled on the distribution of fishing effort by fishermen from San Felipe. Although better estimates of mortality are desirable, the Committee agreed that existing mortality estimates strongly indicate actions to reduce bycatch be implemented at the soonest possible time. Better estimates of mortality will be hard to obtain.

A prolonged discussion followed regarding the potential utility of various management options, so that the Committee could determine the relative costs and benefits of various types of observer schemes. The discussion focused on the concept of a sanctuary in the vicinity of Rocas Consag where the majority of vaquita sightings have been observed. The Committee agreed that a full discussion of mitigation measures was necessary and should be conducted at the next meeting.

7.4 Habitat Degradation

7.4.1 The Colorado River Flow Reduction

Rojas-Bracho mentioned that lack of agreement over most significant risk factors can hinder management decisions. He listed from his paper with Taylor (Rojas-Bracho and Taylor ms) various factors that could affect the survival of the vaquita through degradation of its habitat. Perhaps the most significant potential threat is the past reduction of fresh water input into the northern Gulf of California from diversions and dams on the Colorado River. This has been one of the main arguments to explain vaquitas population decline. Nevertheless, nutrient levels are high or higher than those reported for estuaries and antiestuatries. Primary productivity remain high in the northern Gulf, two to three times greater then in the open Pacific or Atlantic at similar latitudes. Zooplankton biomass values fall within ranges reported for other estuarine and oceanic waters and zooplankton volumes exceeded by a factor of two those reported for upwelling regions (Costa Rica and Peru) (two hypotheses can explain this high productivity: nutrients from the Delta and/or upwelling, tidal mixing and characteristic circulation). There is no independent evidence to suggest that reduced food availability is a risk to the current survival of the vaquita.

Camacho asked if it was likely that the phytoplankton community compostion of the Upper Gulf had changed with the reduced fresh water input, and what influence could this have on vaquita. Rojas-Bracho indicated that it was not possible to assess what influence this change might have had on the vaquita, but so far none of the vaquitas recovered shows signs of emaciation. The 21 prey species reported to date indicate a species that does not specialize and hence is less likely to be affected by shifts in relative prey abundance. Brownell added that the stomach contents of all the vaquitas have prey species typical for other species of porpoises which are also generalist feeders.

7.4.2. Chemical pollution

Chemicals, such as chlorinated pesticides, also pose a potential risk to the vaquita. However, levels of these chemicals in both the environment and tissues of the vaquita are very low, suggesting that they do not pose a risk to the survival or recovery of the species at this time. Barlow asked whether hydrocarbon exploration and production could occur within the Biosphere Reserve. Arenas-Fuentes replied that it was possible, but that no activity was currently occurring.

Conclusions

The Committee agreed that:

1. Inbreeding (inbreeding depression) is not a risk factor for the survival of the vaquita.
2. Chlorinated pesticides concentrations in the Upper Gulf are not at present a risk factor for vaquita.
3. The high nutrient concentrations and high rates of productivity of the Upper Gulf of California, that available data so far indicate that vaquitas consume a number of different prey species, and that so far none of the specimens recovered show signs of emacitation, seems to indicate that the reduced flow of the Colorado River, does not pose a short term risk for the vaquita.
4. In the long-term changes in vaquita habitat due to reduction of this flow, such as nutrient decline, are matters of concern and should be investigated.
5. So far, in the short term, gillnets are the greatest risk to the survival of vaquita due to incidental take in fisheries.
6. That an observer program dedicated to examining fishing practices, vaquita mortality and perhaps distribution in the core area of vaquita habitat would provide useful information. This observer program could utilize both shore-based and small vessel platforms and should perhaps concentrate on vessels from San Felipe.

The Committee recommended that:

1. Further information be compiled on the distribution of fishing effort by fishermen from San Felipe. Although better estimates of mortality are desirable, the Committee felt that existing mortality estimates strongly indicate actions to reduce bycatch be implemented at the soonest possible time. Better estimates of mortality will be hard to obtain.

8. Recent Developments

Arenas-Fuentes noted that perhaps the most important recent action regarding conservation of the vaquita was the recognition, for the first time, of the importance of this issue by the Government of México and the formation of this Committee. These actions were announced at the 48th Annual Meeting of the IWC and the Mexican Government received congratulations from the Commission (Resolution IWC/48/43) The recovery strategy will be coordinated by the Instituto Nacional de Pesca.

Permits have been issued recently for shrimp gill nets (chinchorro de linea), in addition to the implementation of an observer program and a reduction in the number of pangas registered to fish in the Upper Gulf. Reductions in the length and mesh size of these gill nets were also instituted, as well as prohibitions of fishing in certain areas (river mouths and water shallower than five fathoms).

Perez-Cortés reviewed other current regulations with relevance to the vaquita. These include a ban on gill net fishing for totoaba (1975), protection of cetaceans from direct harm (1991), prohibition of gill nets with mesh sizes greater than 10 inches (1992) and, of course, the establishment of the Biosphere Reserve (1993). He noted that many of these regulations are not enforced, leading to incidental mortality of the vaquita in some fishing activities and areas that are currently prohibited. Enforcement of these regulations could lead to a reduction in incidental mortality, even in the absence of other mitigation measures. The Committee agreed with this sentiment and recommended that all existing regulations be enforced. He also stressed the need to develop any further regulations in consultation with the human inhabitants of the vaquita's range.

Buckland asked what proportion of the known incidental catches occurred within the nuclear zone of the Reserve. This information was not available, but the Committee recommended that all known bycatch records should be plotted on a map of the Upper Gulf of California that includes the boundaries of the Biosphere Reserve, Core Nuclear Zone, and Buffer Zone. Separate plots should be produced for juveniles, calves, mature males, and mature females to determine whether there is any evidence of spatial segregation by age or sex.

Arenas-Fuentes asked whether these or other factors might pose a future risk to the vaquita. Rojas-Bracho replied that it was not possible to determine this at the present time.

Conclusions

The Committee recomended that:

1. All existing regulations be enforced and the need to develop any further regulations in consultation with the human inhabitants of the vaquita's range.
2. All incidental catches should be plotted with respect to sex, age, reproductive status and the location of existing regulatory boundaries.

3. That a fishing effort map should be produced.

9. Next Meeting

It was asked to send to Rojas-Bracho the probable dates for next meeting. Most probably after the late Summer cruise.

APPENDIX 1.1

Summary of Conclusions

The International Committee for the Recovery of the Vaquita agreed:

Life History

1. A temporal evaluation of the unusual age structure could help resolve wether the unexpected paucity of juvenile and young mature individuals is an artifact of sampling or wether it reflects the true age of the population.
2. Available data indicate that vaquita consume a different number of prey species, particularly fishes, two of which are fished commercially.

Distribution

1. There are no current nor past evidences that could suggest that vaquita's distribution range could have extended south of the Upper Gulf.
2. Data so far indicate that this porpoises' distribution is related to depth (20–50 m) and to bottom sediment type (silt and clay). The proximate reason for this correlation could be the strength of current and/or benthic fish fauna.
3. The majority of sightings have been reported for the western coast, mainly around the Consag Rocks.

Abundance

1. Abundance is likely in the hundreds and probably the low hundreds.
2. A better abundance estimate is required as soon as possible.
3. No abundance technique except line-transect estimation appears feasible for vaquita.
4. Boat surveys are preferred.
5. All parameters needed to estimate abundance should be obtained internal to the survey.
6. Shallow water areas North and West of the core area should be surveyed.
7. A two-ship design is preferred (a large ship for the deeper-water core area around Rocas Consag and a 12–15 m boat with a 15–20 ft high platform for shallow (<20 m) areas).
8. A working group will continue discussion of optimal survey design.

Risk Factors

1. Inbreeding (inbreeding depression) is not a risk factor for the survival of the vaquita.
2. Chlorinated pesticides concentrations in the Upper Gulf are not at present a risk factor for vaquita.
3. The high nutrient concentrations and high rates of productivity of the Upper Gulf of California, the fact that available data indicate that vaquitas consume a number of different prey species, and that so far none of the specimens recovered show signs of emaciation , seem to indicate that the reduced flow of the Colorado River, does not pose a short term risk for the vaquita.
4. In the long-term changes in vaquita habitat due to reduction of this flow, such as nutrient decline, are matters of concern and must be investigated.
5. So far, in the short term, gillnets are the greatest risk to the survival of vaquita due to incidental take in fisheries.

Recommendations on Fisheries and Bycatch

1. Further information should be compiled on the distribution of fishing effort by fishermen from San Felipe. Although better estimates of mortality are desirable, the Committee felt that existing mortality estimates strongly indicate actions to reduce bycatch be implemented at the soonest possible time. Better estimates of mortality will be hard to obtain.
2. All existing regulations be enforced and that any further regulations be developed in consultation with the human inhabitants of the vaquita's range.
3. All incidental catches should be plotted with respect to sex, age, reproductive status and the location of existing regulatory boundaries.
4. A fishing effort map should be produced.

APPENDIX 1.2

Participants

Centro de Investigación en Alimentación y Desarrollo
Juan Pablo Gallo-Reynoso

Colegio de la Frontera Norte
Carlos Israel Vásquez

Conservación Internacional
Alejandro Robles

Duke University
Andy Read

Instituto Nacional de la Pesca, Secretaría del Medio Ambiente, Recursos Naturales y Pesca
Antonio Díaz de León
Pablo Arenas Fuentes
Pedro Ulloa Ramírez
Laura López González
Oscar Pedrín Osuna
Lorenzo Rojas Bracho
Armando Jaramillo Legorreta
Héctor Pérez-Cortés
Miguel Angel Cisneros Mata

Instituto Nacional de Ecología, Secretaría del Medio Ambiente, Recursos Naturales y Pesca
José María Reyes
Juan Carlos Barrera

Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California
Victor Camacho Ibar

International Union for the Conservation of Nature
Randall Reeves

Southwest Fisheries Science Center, U.S. National Marine Fisheries Service
Jay Barlow
Robert L Brownell, Jr.
Barbara Taylor

The Zoological Society of San Diego/
Center for Reproduction of Endangered Species
Olyver A. Ryder

United Nations Environmental Programme
Omar Vidal

University of Saint Andrews
Steve Buckland

University of Washington, Seattle
Raymond Hilborn

APPENDIX 1.3

List of Documents

Barlow, J., *et al.* 1997. First estimates of vaquita abundance. Marine Mammal Science 13(1):44–58

Brownell, R.L. 1986. Distribution of the vaquita, *Phocoena sinus*, in Mexican waters. Marine Mammal Science 2(4):299–305.

Brownell, R.L., *et al.* 1987. External morphology and pigmentation of the vaquita, Phocoena sinus (Cetacea: Mammalia). Marine Mammal Science 3(1):22–30.

Camacho-Ibar, C. draft. Oceanographic and environmental settings of the Colorado River Delta, the vaquita's habitat.

Cisneros-Mata, M.A., *et al.* draft. Evaluating threats and viability of the vaquita (*Phocoena sinus*).

D'Agrosa, C., *et al.* 1995. Mortality of the vaquita (*Phocoena sinus*) in gillnets fisheries during 1993–1994 Report of the International Whaling Commission (Special Issue 16):283–291.

Gerrodette, T,. *et al.* 1995. Distribution of the vaquita, *Phocoena sinus*, based on sightings from systematic surveys. Report of the International Whaling Commission (Special Issue 16):273–281.

Hohn, A.A., *et al.* 1996. Life history of the vaquita, *Phocoena sinus* (Cetacea: Phocoenidae). Journal of Zoology, London 239:235–251.

Rojas-Bracho, L. and B. Taylor. draft. Risk factors affecting the vaquita.

Taylor, B. and L. Rojas-Bracho. draft. Are vaquita inbred and should we care?

Vidal, O. 1995. Population biology and incidental mortality of the vaquita, *Phocoena sinus*. Report of the International Whaling Commission (Special Issue 16):247–272.

Report of the Second Meeting of the International Committee for the Recovery of the Vaquita (CIRVA) Ensenada, Baja California, México 7–11 February 1999

Summary prepared by Rojas-Bracho, L., A. Diaz de León, O. Ramírez, A. Jaramillo-Legorretta, and H. Peres-Cortés

Background

Díaz de León, President of the Instituto Nacional de la Pesca (México's National Fisheries Institute), in the presence of officers representative of SEMARNAP (Ministry of the Environment), the State Government and University, inaugurated the second meeting of CIRVA. Díaz de León made a brief review of the status of marine mammals in México. He gave examples of México's participation in protecting and recovering the gray whale and the elephant seal. He also indicated that similar efforts will be concentrated to protect the vaquita.

Rojas-Bracho as Coordinator, welcomed all the participants and laid the groundwork for meeting objectives. He reviewed the mandate that was given to the Team. Reading and translating the opening statements made by Díaz de León, Rojas-Bracho said that the goal of the Team will be the creation of a recovery plan based on the best available scientific information and which contemplates and considers the socio-economic impacts of any required regulations on the resource users in the affected areas. The first meeting of this Team was primarily of scientists familiar with vaquita, abundance estimates, and fisheries and associated bycatch issues in the Upper Gulf.

This second meeting was expanded to include government officials, non-governmental organizations (NGOs), sociologists, and economists familiar with fishing communities in the Upper Gulf in order for the biologists to interact with members of these disciplines. The aim of this was to ensure that all have an understanding of the vaquita problem. The next (third) meeting is anticipated to concentrate more on developing socio-economically-viable approaches to implementing the measures that are required to save vaquita. Participants introduced themselves and provided a brief summary of their academic background and research interests.

Summary of Presentations and Discussions

First Session

1997 Estimate of Vaquita Abundance

In 1997 the Mexican and U.S. Governments jointly carried out a survey in the

Northern Gulf of California to estimate the abundance of vaquita. This effort met the recommendation of the first CIRVA meeting to obtain, as soon as possible, a more accurate and precise estimate, based on distance sampling methodology.

Jaramillo-Legorretta presented the results of this survey (Jaramillo *et al.* 1999). Three ships were used to cover the whole potential area of vaquita distribution. The area was pre-stratified into four areas: Core, Southeastern, Shallow and Colorado River Delta. No vaquitas were found in the second and fourth areas. Sea state was found to substantially influence the probability of sighting a vaquita, so analysis was restricted to Beaufort states 0–2.

It was possible to estimate all parameters required in the Core Area. The best estimate of abundance in this area is 432 vaquitas (CV = 38.74 percent, 95 percent log-normal CI = 204–918). A bootstrap procedure was applied in order to include in the total variation the uncertainty due to choosing a model to fit f(0) and uncertainty due to average group size calculation base on simple average or size-biased regression average. This procedure yielded a CV of 28.04 percent and a 95 percent Confidence Interval between 242 and 714.

Sightings only occurred in the northwestern portion of the Shallow Area. The probability term [f(0)/g(0)] was estimated from the density estimated in the Core Area. (Barlow commented here that the estimation of this term might be problematic, due that is based in only one sighting). It was estimated that 74 vaquitas inhabit this area with a CV of 27.28 percent, estimated from a bootstrap procedure. The 95 percent confidence interval is between 44 and 125.

The pooled estimate for Core Area and Shallow Area (weighted by area) is 506 vaquitas (95 percent log-normal CI 190, 1350). The authors noted that a substantial proportion of this total occurred outside the existing boundary of the Biosphere Reserve. Read commented that sightings were made right up to the boundary of the core area (of vaquita distribution) and asked whether in retrospect the boundary of this area should have been extended. Gerrodette replied that vaquitas had not been seen in the area immediately outside the boundary of this area, so the existing lines were probably appropriate.

In response to questions about what could be inferred by comparing the 1997 results with those obtained during the 1993 survey (Barlow *et al.* 1997), there was agreement that such a comparison was not valid because the two surveys were so different in terms of effort and area covered. The abundance estimate derived from the 1997 survey should be regarded as superseding all previous estimates. However, although the difference between these estimates was large in relative terms, the absolute difference between them is small. Both indicate a population size in the hundreds, so the result of this latest survey is consistent with the working assumption of the first CIRVA meeting in this regard.

Committee members commented on the clumped distribution of sightings and asked whether there was any evidence to indicate that this distribution may be seasonally variable. There are insufficient data to allow full understanding of the seasonal distribution of vaquita.

Summary of Abundance Revision and Discussion (Held 10 February 1999)

The committee provided comments on the paper of Jaramillo *et al.* reporting the results of the 1997 cruise to estimate vaquita abundance. Barlow pointed out that the estimated ratio f(0)/g(0) for the BIP, which is needed to estimate abundance in shallow water, implied unreasonable values for the effective strip width or the probability of detecting animals on the trackline. Buckland noted in written comments that:

1. Use of the negative exponential function as a sighting model was not reasonable and should be removed from the choice of models during bootstrapping.
2. Post-stratification of the core area into east and west parts was not valid.
3. The bootstrap estimate of variance of the abundance estimate in shallow water did not include all sources of uncertainty.

Barlow's comments affect the estimate of abundance in the shallow water area; Buckland's comments affect the estimates of variance, but not the point estimates of abundance, in both the core and shallow water areas.

In response to the above comments and further consideration by the authors themselves, Jaramillo revised the analysis and presented the results to the committee. All the recommendations of Buckland were adopted. Barlow's comments prompted several analyses:

1. An estimate of shallow water abundance based on sightings and effort in Beaufort sea states 0–3 instead of Beaufort 0–2.
2. An estimate of shallow water abundance based on sightings and effort only on days when BIP and DSJ were both in the core area together.
3. A comparison of BIP radial sighting distances in the core and shallow water areas to look for possible differences in the BIP's detection process in the two areas.
4. Comparisons of the ratio of shallow water density to core area density during the 1997 survey to the same ratios derived from Silber's surveys in the 1980s and from recent acoustic measurements.
5. A comparison of sighting rates on the BIP and DSJ bridge to evaluate the possible use of f(0) and g(0) values from the DSJ bridge instead of the BIP.

After considering the results of the above re-analysis, and the comments by two more reviewers, the committee agreed that the estimate of shallow water abundance based on sightings and effort in Beaufort 0–3 was the most internally consistent. The revised estimate of shallow water abundance was 158 vaquitas with a CV of 0.94 and a confidence interval from 20–655. The high variance was mainly due to the highly variable encounter rate of the BIP in the core area. The revised total estimate of abundance was 567 vaquitas with a CV of 0.51 and a 95 percent log-normal confidence interval from 177–1,073.

Acoustic Techniques

Jaramillo-Legorretta presented the results of an assessment to use an automated acoustic device to detect vaquitas. A brief description of the technology was presented as a background to understand how the process can specifically detect porpoises. This equipment developed by Chapell *et al.* (1996) was designed to work with harbor porpoise.

As Silber (1991) found, vaquita emits the same kind of cliks as harbor porpoise. During April 1977, a survey was conducted with the combined efforts of IFAW and Oxford University (UK), and INP (México) to test the detector with vaquitas. A survey was carried out for several days in the waters around San Felipe, Rocas Consag, Santa Clara and the channels of the Colorado River Delta.

No vaquitas were detected in the delta and Santa Clara portions. On the Baja California side several groups of vaquita were acoustically detected, both during surveys aboard a sailboat out to Rocas Consag and aboard a small fiberglass boat (with engine off) at a fixed point approximately 5 nm from San Felipe.

The results of this testings showed success of the equipment to detect vaquitas. In addition, the results indicated that, at least during some period in spring, the density of vaquitas in the proximity of San Felipe is higher than previously thought.

The Committee agreed that the use of acoustic techniques looks very promising and practical. Standardize techniques should be developed as soon as technological feasible, both to understand the distribution and seasonal movements of vaquita and to monitor the effectiveness of any management action.

Analysis of Earlier Sightings, Strandings and Bycatch Data

Jaramillo-Legorretta and Rojas-Bracho presented a brief analysis of the locality of capture of vaquitas documented in Hohn *et al.* (1996). Three major concentrations were identified: offshore of the Sonoran coast between Santa Clara and La Salina, at El Quelele, and around Rocas Consag and El Canalon. The latter sites are on the Baja California side of the Gulf.

On the Sonoran side a similar number of adults and calves were captured, and the sex ratio is close to 1:1. The situation is different on the Baja California side, where the ratio of adult females to calves is 1:8. It was suggested that the low occurrence of adults in the Baja California catch may be explained by fishermen discarding the larger animals because of difficulties in handling them. However, there is no evidence for this or any other explanation. The adult female/calf ratio in this area, and the occurrence of vaquita age/sex classes in the bycatch more generally, may accurately reflect what animals are in the area or may simply be an artifact. Possible reasons for bias include differential spatial distributions of age/sex classes, their vulnerability to being caught and the likelihood of them being landed by fishermen.

Gallo-Reynoso presented an analysis of vaquita critical habitat using sightings and bycatches from 1980 to 1994. This porpoise lives in a very dynamic area of the Upper Gulf of California. The area is characterized by having mainly silt-clay-sand bottom sediment types. Few sightings were made in areas composed mainly of sandy bottoms. Vaquitas prefer waters from 20–50 m depth; no sightings have been made in waters <10 m or >50 m. Vaquita sightings also seem to be related to more turbid waters (transparency 1–2.5 m). Gallo-Reynoso suggested that further analysis of this type be done using the data from the 1997 cruise.

The seasonal distribution of sightings indicates that vaquitas may occur closer to the Sonoran coast in winter and closer to Rocas Consag and the Baja Californian coast between spring and autumn, but data are insufficient to allow any certainty in this pattern.

The distribution of incidental catches of vaquita shows a close relationship between the fishing towns and the areas of bycatch. More vaquitas have been caught on the Sonoran coast than on the Baja Californian coast, and most of them on traditional fishing grounds. The distribution of vaquita captures by season suggests that in winter, spring and summer vaquitas are caught all over the Upper Gulf, but in the spring captures were more concentrated near the Sonoran coast. Again, though, the lack of data at some times of year may result in a sampling artifact. Strandings of vaquitas are concentrated in the Golfo de Santa Clara and San Felipe areas, probably because vaquitas are discarded before the fish catch is landed.

Temporal Assessment of the Unusual Age Distribution

Taylor and colleagues presented an updated analysis of the age distribution of by-caught vaquitas (Taylor *et al.* 1999). The study was prompted by an earlier paper (Hohn *et al.* 1996) which demonstrated an apparent lack of 3–6 year old animals in a 1985 sample. Taylor *et al.* sought to discover if this 'gap' was real or a sampling artifact, and whether a similar pattern occurred in animals collected between 1990 and 1993.

Analysis of the more recent sample showed evidence of a similar gap and, by back-calculation, that some of the animals dying in 1990–1993 had been aged 3–6 in 1985. Consequently, the unexpected age distribution of the sample examined by Hohn *et al.* was not random with respect to the actual age distribution of the population.

Fisheries, Fishery Management and Socio-Economic Aspects of the Upper Gulf

Cudney presented an overview of the development of small-scale fisheries in the Northern Gulf, as well as of the current fishing patterns, and the proposals of fishermen to improve fishery management in the region (based on Cudney and Turk-Boyer 1998). Currently, there are approximately 700 active pangas in the communities of El Golfo de Santa Clara, Peñasco and San Felipe. More than 70 species of fish, mollusks, crustaceans, and echinoderms are harvested on a regular basis by the small-scale sector, and approximately

40 percent of these species are exported to the oriental market in California, Japan, and Korea.

The northern fishing communities are diverse in the species targeted, methods used for fishing, views on fisheries management and attitudes towards the Biosphere Reserve and its management. Fishing patterns in the region are dependent on seasonal and diurnal tidal fluctuations. The tides define what type of gear to use how to use it (bottom/drifting, surface/drifting, anchored, etc), what species to target, and when to go out and fish. This diversity has to be considered in any fishery management decision process. An important characteristic of the Upper Gulf fishery in general is that it routinely targets different species, often using different gear, on a year-to-year basis. This may reflect market trends or the sequential loss of species due to over-harvesting.

In general, depending on the gear used, most small-scale fishery activity can be divided into four main categories:

1. Long line fishing: used mainly to target baqueta (Gulf coney) in deep waters surrounding the Wagner's basin.
2. Trap fishing: used to catch blue crab close to shore.
3. Hooka diving: 16 species of mollusks, echinoderms, and fish.
4. Gill net fishing: the most prominent type of fishing in the region. The mesh size of gill nets ranges between 2.5–8.5 inches.

The proposals of fishermen to bring about an enhancement of their fisheries are concentrated in five main areas:

1. Manage trawler boats more efficiently (either completely banning them from the Reserve or limiting their fishing territories.
2. Increase enforcement evenly for everyone fishing within the Reserve.
3. Increase Colorado River water flow.
4. Establish season and gear restrictions according to the reality of the region.
5. Decrease fishing effort.

A very clear proposal of fishermen is that the increase of pangas in the region has to stop and there should be a serious commitment to identify and give privileges to the fishermen of the northern communities, outlawing the entry of any other fisher. Cudney emphasized on the importance of involving fishermen in decision-making processes for the conservation of vaquita or other fishery management issues.

Recent Bycatch and Distribution of Shrimp Gillnet Fishing Effort

Pedrin reviewed his recent (Oct–Dec 1996) study of the bycatch and geographic distribution of effort for the shrimp gillnet fishery in the Upper Gulf. The total level of fishing effort could not be estimated, but his study did show the geographic distribution.

Observers from México's tuna/dolphin program were placed on a sample of shrimp gillnet (chinchorro de linea) boats from San Felipe and El Golfo de Santa Clara. Typically two fine-mesh nets are set from each panga on the bottom in areas of fast currents and are typically 200–800 m long and 2 m wide. Approximately 300 trips were observed and information was collected on GPS position, numbers of other boats seen (pangas and trawlers), fish bycatch, etc. Locations of fishing overlapped with known areas of vaquita abundance, but the highest densities of fishing effort were generally outside the areas where vaquita have most frequently been sighted. Some illegal effort was observed in the Biosphere nuclear zone and in waters deeper than the maximum allowed depth (10 m).

No vaquita bycatch was observed during this study. Rojas-Bracho pointed out that, based on the kill rate estimated by D'Agrosa, only about one vaquita mortality would be expected in 300 sets, so that observation of zero mortalities would not be at all surprising. The fishing effort includes approximately 600 pangas from El Golfo and San Felipe and an unspecified number from Puerto Peñasco and from outside the Upper Gulf. Several members noted that effort at the start of the fishing season in September is high and tapers off in winter. Funds were not sufficient to continue this study on panga fisheries for other fish species.

The Upper Gulf of California Fishing Communities: Socioeconomic Aspects

Vázquez presented a study of the socio-economic aspects of fishing communities in the Upper Gulf of California. One of the objectives of this work was to examine the possible linkage between environmental degradation in the region, exemplified by overfishing, and the wealth of the people living there. Vázquez found that the proportion of fishermen in the Upper Gulf living in poverty as defined by INEGI (1993) was only about half that of fishermen in México as a whole. He therefore concluded that environmental degradation due to overharvesting in the Upper Gulf was not due to the level of poverty, and was more likely due to technological and management problems. Vázquez also looked at the type of employment in the three communities, and found that the importance of fishing is inversely related to the size of the community. The three communities are economically very different. For example, Santa Clara derives as much as 99 percent of its income from fishing, whereas the other two are less dependent on this single industry.

When discussing the data presented the Committee noted that the contribution to the local economy from the illegal narcotic/drug traffic based on demand from the north is unknown. This might possibly be a significant factor in the changing structure of communities in the Upper Gulf.

The presentation also looked at eight possible alternative sources of employment or means of increasing the value of the fish harvest to the communities, among them:

- Aquaculture farms
  - Shrimp
  - Fish

  - Mollusk
- Marine products freezer plant
- Ecotourism
- Sport fishing and hunting
- "Maquiladora"

The Biosphere Reserve: An Update

Campoy gave an overview of the current status and management of the Biosphere Reserve in the Upper Gulf. He described the educational and enforcement campaigns, which have recently been established, and gave an assessment of progress towards implementation of the Reserve objectives. Although the Reserve is relatively new, its establishment has now resulted in the permanent presence of personnel in the area, and coordination with other authorities, fishing organizations and the communities.

Staff collects information from fishermen and local residents about vaquita bycatch and strandings, and use small boats to police the waters of the Reserve. However, the staff does not have punitive powers and, although they discourage illegal fishing activities, they are unable to prevent illegal fishing in even the nuclear zone of the Reserve. In discussion, it was agreed that effective enforcement of the Reserve laws or management measures recommended by this Committee would require a fundamental change in the level and manner of enforcement currently in place. Although the Biosphere Reserve is an important conservation effort and its declaration paves the way for future vaquita recovery measures, protection of vaquita from bycatch has probably not been significantly affected by the current boundary of the Reserve nor by the zones within it.

Sediment Distribution and Transport

A recent paper on sediment distribution and transport in the Upper Gulf of California was brought to the attention of the Committee. Camacho summarized the findings of this paper (J.D. Carriquiry and A. Sánchez. In press. Sedimentation in the Colorado River delta and Upper Gulf of California after nearly a century of discharge loss. Marine Geology.). Studies of vaquita distribution by Gallo-Reynoso showed that sediment type is an important determinant of vaquita habitat. The currents in the Upper Gulf are generally counter-clockwise, therefore sediments from the delta are primarily carried down the western side. The recent study confirmed that finer sediments are found on the western side of the Upper Gulf. Fine bottom sendiments on the eastern side may be re-suspended and transported to the western side by predominant currents. Currently salinity is higher on the western side of the Gulf due to currents and evaporation; however, the opposite may have been true during periods of high input from the Colorado River. The authors expressed concern that changes in sediment (due to loss of input from the Colorado) could cause a loss of habitat for vaquita. The members of the committee reiterated the conclusion of the first meeting that loss of Colorado River input is not an immediate risk factor for the species. de los Angeles emphasized that we should be considering the long-term survival of the species and that loss of Colorado River input could seriously impact ecosystem health.

Second Session: Evaluation of Potential Mitigation Measures

Acoustic Deterrents (Pingers)

Read briefly summarized experience in Europe and North America with acoustic alarms, or pingers, to reduce cetacean bycatch in gillnet fisheries. The cost of pingers is about $40–45 apiece, and an instrumented gillnet requires one pinger for every 100 m of netting. Pingers are thought to function in one of two ways. The sound may alert the cetacean to the gillnet's presence, or it may constitute an aversive stimulus. Either way, the cetacean would not approach the net closely, and entanglement would be avoided. Successful experiments have been conducted in the Gulf of Maine sink gillnet fishery for groundfish, in the California driftnet fishery for sharks and swordfish, and elsewhere. In the former, the harbor porpoise was the species of concern. In the latter, a variety of delphinids, beaked whales, and the sperm whale. In both fisheries, the demonstrated effectiveness of pinger use in reducing bycatch has resulted in mandatory pinger use for continued fishery operations.

Read cited several reasons why pingers are not a good option for solving the bycatch problem in the northern Gulf, as follows:

1. Their use does not reduce the bycatch to zero, which must be the goal in the case of a species as endangered as the vaquita.
2. The need for experimental verification of effectiveness would result in the deaths of some vaquitas.
3. The cost of an experiment would be prohibitive. For example, the two experiments in the U.S. each cost approximately $1 million, and considering the comparatively low frequency of vaquita bycatch, a comparable experiment in the Upper Gulf could cost even more.
4. Given the nature of the gillnet fisheries in the northern Gulf, it would be extremely difficult to convince and educate fishermen to use pingers and to ensure that they kept the devices in working order (battery replacement, etc).
5. Fishermen are often deeply skeptical of the idea of placing a noise-maker on a net, and it would be very difficult to convince them that doing so would not reduce their catches of target species.
6. Two workshops (one in 1996 sponsored by the U.S. National Marine Fisheries Service and the other in 1998 at the World Marine Mammal Conference in Monaco) concluded that acoustic alarms are not appropriate for reducing the bycatch of highly endangered species.

Experiments with other acoustic approaches, such as reflective devices, to reducing bycatch have not yielded conclusive evidence that they reduce bycatch rates.

Season/Area Closures

Seasonal closures of specific areas to promote conservation and fisheries management goals will be referred to here as season/area closures. They differ from protected areas (discussed later) in that areas are open for fishing for part of each year.

Read gave a summary of the use of season/area closures in the Gulf of Maine to reduce harbor porpoise bycatch in gillnet fisheries. These fisheries are similar to the panga fisheries in the Gulf of California in that fishermen use small boats, seasonally change gear and methods to catch a variety of fish species and, fish a variety of areas, and have undergone recent changes in the abundance of exploited fish populations that have led to changes in fishing practices.

Read said that in order to effectively use season/area closures, detailed information is needed on geographic and temporal patterns of fishing effort, patterns of habitat use of the protected species, and patterns in bycatch. In the Gulf of Maine, attempts to implement season/area closures were aided by a long-term observer program that provided detailed information on the patterns of bycatch. This approach was not popular among the fishermen because it was not felt to be “fair;” the regulations inevitably had greater impact on some fishermen than on others. The method frequently resulted in the displacement of fishing effort from areas of high known bycatch to surrounding areas, which resulted in higher bycatches in those areas.

Read felt that season/area closures would have the greatest chance of success in areas with stable fisheries and where large areas could be closed for a sufficiently long period. Overall, he said that season/area closures failed at protecting harbor porpoise in the Gulf of Maine, primarily because the fisheries were too dynamic. They found that by the time regulations could be proposed, reviewed, and finally approved, the fishery had changed completely. Despite a decade of contentious and expensive negotiations, harbor porpoise bycatch did not decrease under a system of season/area closures. It was also noted that harbor porpoise populations numbered in the tens of thousands which made bycatch common, allowed data to be collective relatively easily, and allowed time to try various management techniques without putting the population at severe risk.

In order to work, season/area closures would have to be accompanied by a sufficiently large observer program to monitor bycatch and fishing effort. Currently there is no on-board observer program to monitor vaquita bycatch in the Upper Gulf. Fishing effort has not been estimated, but some members felt that aerial surveys could be used to monitor fishing effort (but not bycatch). Campoy explained that a national program of vessel registration is being implemented which will help improve estimates of the numbers of fishing vessels. This system would also allow identification of “local fishermen” which could aid in establishing systems of limited entry into fisheries.

The entire committee debated whether season/area closures could be expected to assure the survival of the vaquita. It was pointed out that the main area inhabited by vaquita is known to be occupied year-round and that a permanent management system would likely be needed in that core vaquita area. There was general agreement that for vaquita there was insufficient knowledge of temporal and spacial patterns of bycatches, that such a complicated system would be unenforceable in the Upper Gulf, and that such a system would probably not be politically acceptable because it would disproportionately affect certain fishermen. These factors, combined with the year-round residency patterns of vaquita in most of their areas, resulted in the committee rejecting season/area closures as a workable tool to ensure vaquita survival.

Gear Restrictions

Data on vaquita (from D'Agrosa 1995) confirm that they (like other cetaceans) are more likely to become entangled in a large-mesh gillnet than in a small-mesh gillnet if both nets were set in the same area. However, if small-mesh nets are more common, they may have a greater total bycatch and therefore a greater total effect on the vaquita population. D'Agrosa's data illustrated that point; vaquita bycatch rate was higher in large-mesh shark nets, but the total vaquita bycatch was higher in small-mesh shrimp gillnets. The biologists agreed that in order to assure the survival of vaquita, the goal should be to reduce vaquita bycatch to zero. Although it was recognized that this will be difficult or impossible to achieve (given the socio-economic impacts and the likelihood of illegal fishing), there is very little chance of success unless this goal is set. Although there was some reluctance to ban small-mesh gillnets (given the economic importance of shrimp), the group concluded that vaquita survival was not compatible with estimated mortality levels in small-mesh (based on available scientific information, circa 1994). Furthermore, fishing effort in the shrimp gillnet fishery has increased since 1994, which increases our concern over the effect of this fishery.

The committee found that a complete ban on all gillnets is the only gear restriction that would provide a reasonable assurance of vaquita survival. Discussion of the required area of such a ban was delayed until later in the meeting. There was discussion of the possibility of allowing certain types of gillnets that are set in such a manner that they are extremely unlikely to catch vaquita (such as a "rodeo" set in which a gillnet is set actively around a school of fish). Although this method may have very little risk for vaquita, the type of net is exactly the same as nets that are used as gillnets. The group decided that the only hope for enforcing a ban on gillnets would be to eliminate all types of gillnet. Enforcement would be very difficult if it were based on methods of fishing a particular gear type. The group therefore concluded that rodeo nets would have to be included in a general ban on all gillnets.

There is no known vaquita mortality in any hook-and-line fishery, so there was no suggestion that long-lines, hand-lines or sport fishing need to be restricted. Known vaquita mortality in shrimp trawl fisheries was generally considered to be sufficiently small and would not warrent a ban on this gear type. However, it was noted that the ecological damage of trawl fisheries may not be compatible with the long-term health of the ecosystem in the Upper Gulf of California. Thus, limitations on shrimp trawling would promote vaquita recovery, but would not be essential for that purpose. The committee recognized the tremendous social, political, and economic impacts of banning the use of gillnets in the Upper Gulf.

Marine Protected Areas

Barlow gave a brief summary of the use of Marine Protected Areas in fisheries management and conservation. We use the term "Marine Protected Area" to refer to a region that has allowable fishing or other extractive resource use of any kind. (The regulations for the nuclear zone of the Biosphere reserve make it a Marine Protected Area, but the bulk of the Biosphere reserve is a multi-use area and thus would not be considered a Marine Protected Area under this definition.) The purpose of a Marine Protected Area is to set aside a sufficient area to allow all native species to thrive. This area would then serve as a seed area to repopulate adjacent fishing areas. This concept is getting considerable attention world wide as an alternative to traditional fisheries management methods. It is particularly attractive where other management measures have failed; enforcement of a total ban within a small area is often easier than the enforcement of a wide variety of gear/season/area regulations over a wide area. The method does, however, have limitations and will not work for all species. The primary requirement is that the area be sufficiently large to be self-supporting and to be a net exporter of recruits (typically through larval dispersal) to surrounding areas. The method would therefore fail to adequately protect highly migratory species. Shrimp in the Upper Gulf are one species for which Marine Protected Areas are very likely to work. A successful Marine Protected Area is one that increases the net fishery production in a wider area. Successes were described from protected areas in Australia, the Phillippines, and Amazon River Basin.

The use of a Marine Protected Area to protect vaquita is desirable because it could be presented as a win-win situation for the fisheries in the Upper Gulf. Taylor added that Marine Protected Areas are also recognized as the only fishery management tool that prevents fishing from causing selective changes in fish size (fishing over long times results in early maturation and stunting). Taylor also pointed out that in an area of high endemism (such as in the Upper Gulf), Marine Protected Areas can protect a wide range of species. Pedrin reminded the group that enforcement problems in the Upper Gulf cannot be underestimated. Enforcement of a Marine Protected Area would require widespread community-based support.

Changes to Boundaries of the Biosphere Reserve

Recognizing that at least 40 percent of the recorded sightings of vaquitas have been south of the Biosphere Reserve, the Committee concluded that the Reserve boundaries should be redrawn to enclose the entire "core area" as defined by survey data and historical sighting records (Barlow *et al.* 1997, Jaramillo *et al.* 1999, Gallo-Reynoso 1999). Thus, it is recommended that the boundary be extended to include the area north of the 30° 45 N line from the Baja California coast east to 114° 20 W and thence northward to the existing boundary. After a lengthy discussion, it was agreed that the boundary line from that point eastward to the vicinity of Puerto Peñasco should remain unchanged (Fig. 2.1).

Figure 2.1.

The committee also noted that the existing nuclear zone of the Reserve, designed primarily to protect totoaba spawning habitat, provides no meaningful protection to the vaquita. Therefore, if the Reserve is to benefit the vaquita by reducing bycatch, it will be necessary either to substantially redesign the existing nuclear zone or to create one or more additional nuclear zones centered on areas of high vaquita density. Recent changes in the legal framework for reserves in México should make it relatively easy to do this. However, "no take" regulations in the nuclear zone(s) must be strictly enforced if any change in size or location is to make a positive difference. It is important to emphasize that changing the nuclear zone and enforcing the no-take policy will not eliminate the vaquita bycatch problem. As long as there is fishing with gillnets in areas where vaquitas occur, the threat of bycatch will remain.

Limited Entry to Fisheries of the Upper Gulf

There was strong agreement that entry to fisheries in the Upper Gulf should be closed to people who are not currently residents of the area. A strict limitation on entry is one way of mitigating the socio-economic impacts of reductions in gillnet fishing effort on local people.

"No Take" Marine Protected Area

Although not directly related to the goal of preventing the vaquita's extinction in the near term, a "no take" protected area in the northern Gulf, if properly designed and managed, could be expected to benefit both the people and endemic marine species, including the vaquita. It would provide protection to brood stocks of commercially valuable species, thereby enhancing fisheries. It would promote the recovery of vaquitas by improving the overall ecological conditions in the northern Gulf. The committee did not have the necessary information or expertise to develop a detailed recommendation for a protected area at this time. Among the main considerations about siting would be to identify a source area for shrimp, Gulf endemics (preferably including the vaquita), and as many commercially important species as possible.

Fishery Buy-outs

The subject of fishery buy-outs was discussed, but few participants could offer examples in which this approach had been taken elsewhere. Brownell noted that the government of Taiwan had bought out Taiwanese driftnet vessels after the UN moratorium on high seas driftnet fishing was declared. Also, Fisher had cited an example in which the government of Norway bought and disposed of codfishing vessels and gear in order to reduce the impact of a fishery closure to allow recovery of cod stocks. Barlow cited an example in which the government of the state of Florida bought back gillnets from fishermen after instituting a state-wide ban on gillnet use in coastal waters. He pointed out the importance of appropriate disposal of such equipment to ensure that it is not simply sold for use elsewhere.

A long discussion ensued concerning the desirability and feasibility of buying out gillnet fishermen in the Upper Gulf. Although the buying of nets seemed like a fairly straightforward (albeit expensive) proposition, it was generally agreed that the buying out of fishing permits would be problematic. Permits are issued for fishing categories, e.g., for finfish generally, for shrimp, and for sharks. These permits are non-transferable.

It was recognized that the purchase of gillnets from fishermen in the Upper Gulf would affect their income on an immediate basis if no alternatives to gillnetting were implemented. Nevertheless, it was also stated that in the long run, the gillnet buy-out would serve a dual function, as it would ameliorate the economic hardship experienced by the fishing communities as a result of bycatch reduction measures while at the same time reducing fishing effort and thus the level of vaquita bycatch.

Lourdes Flores suggested that a buy-out scheme might best be staged so that a high price would be offered in the first year, a lower price the second year, and a still lower price the third and last year before complete closure of gillnetting (see below).

Fishing Regulations: What Seems to Work and What Not, Two Examples

Fischer provoked a wide-ranging discussion by using examples from Newfoundland and Norway of unsuccessful and successful bans respectively. He examined the key ingredients of one ban which contributed to a recovery of fishing. These include politicians responding quickly to scientific warnings of low stock levels, buying out fishing vessels and assisting fishermen to leave the fishery. Bans are simpler to enforce than regulations aimed at changing fishing effort.

Ban on Gillnet Fishing in the Expanded Biosphere Reserve

The committee was well aware of the difficulty of reconciling the vaquita's need for immediate protection with the economic needs of people living on the shores of the Upper Gulf. There is no painless solution to the problem caused by these conflicting needs. There was a consensus in the committee that the vaquita's survival cannot be assured unless the bycatch is reduced immediately to a level approaching zero. Given the economic and political realities in México, however, it was considered necessary to propose the introduction of management measures on a step-wise basis.

A staged reduction in fishing effort, along the following lines, was proposed:

Stage One

1. Stop the use of large-mesh gillnets (6-inch stretched mesh or larger) in the expanded Biosphere Reserve.

2. Stop the increase in the number of pangas fishing in the Upper Gulf.
3. Stop anyone who does not live in one of the communities of the Upper Gulf from fishing in the expanded Reserve.

Stage Two

1. Stop the use of medium-mesh gillnets (i.e., all except those used for shrimp fishing) in the expanded Reserve.

Stage Three

1. Stop all gillnetting and trawling in the expanded Reserve.

Any such scheme for eliminating gillnet use in the Upper Gulf will depend on an active community participation program to design and promote alternative fishing gear and techniques as well as other non-fishing economic activities. It would also depend on a vigorous and consistent enforcement regime. It is crucial that any change in fishing regulations be supported by credible enforcement effort. To be effective, enforcement will require the availability of at least one large, fast boat with sufficient personnel and appropriate equipment on board to be permanently present in the expanded Reserve. The PROFEPA (Federal Attorney General of the Environment) and the Navy must assume this role. Enforcement of fishing regulations must be coupled with firm measures to prevent immigration by new fishermen into the Upper Gulf or any increase in gillnetting capacity in the region. Equally important are the development of methods of fish and shrimp harvesting that do not involve bycatch of vaquitas, and alternative ways for people in the northern Gulf to make their livelihoods.

It was recognized that for successful implementation of the measures outlined above, the national fishery resource management agency will need to consult and coordinate closely with the relevant regional, state, and local authorities.

Trawl Fishing

There was some discussion of whether trawl fishing is compatible with the survival of the vaquita. Vaquitas are known to be taken at least occasionally by trawlers (Norris and Prescott 1961, Vidal *et al.* 1999). Committee members generally agreed that the level of take by trawlers is much less than that by gillnets, but also that trawling damages the bottom, reducing biological diversity and abundance. Elimination of trawling in the expanded Biosphere Reserve would improve ecological conditions and at least marginally contribute to the reduction of vaquita bycatch. For these reasons, it was agreed that trawling should be banned in the Reserve.

IUCN Red List Status of the Vaquita

Taylor reported on the status of the vaquita's listing on the IUCN red list. The red list criteria recently were changed to a series of quantitative criteria to standardize how species are listed relative to their global risk of extinction. The vaquita are currently listed as Critically Endangered under the Small Population Size and Decline Criterion. This criterion requires that the number of mature individuals be less than 250 and one of two of the following: (1) a decline of 25 percent in one generation (about 10 years for vaquita) or (2) all individuals in a single population.

According to the IUCN criteria, species should be listed under all criteria for which they qualify. They need only qualify for one to be listed under a risk category (such as Critically Endangered). To be downlisted to Endangered, the vaquita must be shown not to qualify for any of the criteria under Critically Endangered. Taylor reported to the committee that the vaquita qualifies under more criteria than they are currently listed for it. For example, the Declining Population criterion requires a population decline of 80 percent in three generations (30 years) either in the past or projected into the future. The Cetacean Specialist Group is currently working to complete and document listings for all cetaceans and will add the additional criteria for the vaquita.

Recommendations from the Second CIRVA Meeting

Only about 600 vaquitas remain and the species is in critical danger of extinction. To prevent extinction, bycatches of vaquita must be reduced to zero as soon as possible. Complete protection for the vaquita will need to continue for at least 20–30 years. The Committee recognized that protective measures will cause a significant socio-economic impact on residents of the Upper Gulf and that it will not be possible to implement complete protection immediately. The Committee also noted, however, that these protective measures will improve the health of the ecosystem in the Upper Gulf and increaes economic opportunities for residents in the longer term. Therefore, the Committee recommended that the recommended conservation measures be implemented in three phases. The future survival of the vaquita depends on taking these drastic actions. Therefore, the international community and non-governmental organizations should be invited to join the Government of México and provide technical and financial assistance to implement the conservation measures described in this Recovery Plan and to support the continued conservation activities of the Biosphere Reserve.

Noting that vaquita are critically endangered and that immediate action is required to prevent extinction, the committee strongly recommends that:

1. Vaquita bycatch be reduced to zero as soon as possible.
2. The southern boundary of the Biosphere Reserve be expanded to include all known habitat of the vaquita (see Fig. 2.1 on p. 13)
3. Gillnets and trawlers be banned in the enlarged Biosphere Reserve (see Fig. 2.1 on p. 13), in the following sequence:

   Stage One

   1. Eliminate large-mesh gillnets (6-inch stretch mesh or greater).
   2. Restrict the numbers of pangas to present levels.

3. Restrict fishing activities to residents of San Felipe, El Golfo de Santa Clara and Puerto Peñasco, and other permanent residents of the Biosphere Reserve.

Stage Two

1. Eliminate medium-mesh gillnets (i.e. all those except chinchorro de linea, 3-inch stretch mesh or grater).

Stage Three

1. Eliminate all gillnets and trawlers.

4. Effective enforcement of fishing regulations begin immediately. The development of effective enforcement techniques should be given high priority because all the committee's recommendations depend on enforcement.
5. Acoustic surveys be started immediately to begin monitoring an index of abundance and gather data on seasonal movements of vaquita.
6. Research be started immediately to develop and test alternate gear types and techniques to replace gillnets.
7. Education and consultation begin immediately among fishers, social scientist and biologist to seek the best alternative to gillneting.
8. A program be developed to promote community involvement, widespread education and public awareness of the importance of the Biosphere Reserve, the vaquita and the relevance of its protection as a Mexican and world heritage. Development of public support is critical to the success of this conservation program.
9. Measures be developed to offset the economic hardship imposed by these regulations on residents of the Upper Gulf.
10. Research be conducted to better define critical habitat of vaquita using data collected during the 1997 abundance survey.

APPENDIX 2.1

Participants

Scientific Recovery Team

Centro Intercultural de Estudios de Desiertos y Océanos, México
Richard Cudney

Centro de Investigación en Alimentación y Desarrollo, México.
Juan Pablo Gallo-Reynoso

Colegio de la Frontera Norte, BC, México.
Carlos Israel Vásquez

Conservación Internacional, DF, México.
Alejandro Robles

Duke University, USA
Andy Read

Instituto Nacional de la Pesca, Secretaría del Medio Ambiente, Recursos Naturales y Pesca, México.
Antonio Díaz de León
Oscar Ramírz Flores
Pablo Arenas Fuentes
Oscar Pedrín Osuna
Lorenzo Rojas Bracho
Armando Jaramillo Legorreta
Héctor Pérez-Cortés
Miguel Angel Cisneros Mata

International Union for the Conservation of Nature, Canada
Randall Reeves

Sea Mammal Research Unit, UK
Anthony R. Martin

Southwest Fisheries Science Center, National Marine Fisheries Service, USA
Jay Barlow
Robert L Brownell, Jr.
Barbara Taylor
Tim Gerrodette

Universidad Autónoma de Baja California, México
Victor Camacho Ibar
David W Fischer

The Zoological Society of San Diego/
Center for Reproduction of Endangered Species, USA
Olyver A. Ryder

University of Saint Andrews, UK
Steve Buckland

University of Washington, Seattle, USA
Raymond Hilborn

Government Observers
Instituto Nacional de Ecología, Secretaría del Medio Ambiente,
Recursos Naturales y Pesca
David Gutierres Carbonel
José Campoy
Mauro Silva
Julio Palleiro

Procuraduría Federal de Protección al Ambiente
Tobías Contreras Salgado

Intergovernmental Organisation Observers
United Nations Environmental Programme
Omar Vidal

Non-Governmental Organisation Observers
World Wide Fund for Nature
Karen Baragona

Whale and Dolphin Conservation Society
Kate O'Connel

Conservación Internacional
María de los Angeles Carvajal

Fundación Sierra Madre/Unidos por la Conservación
Patricio Robles-Gil

Report of the Third Meeting of the International Committee for the Recovery of the Vaquita (CIRVA)
Ensenada, Baja California, México
18–24 January 2004

Summary prepared by Rojas-Bracho, L., A. Jaramillo-Legorreta,* and J. Urbán***

** Programa de Mamíferos Marinos, Instituto Nacional de Ecología, Ensenada, B.C., México*

*** Laboratorio de Mamíferos Marinos, Universidad Autónoma de Baja California Sur, La Paz, BCS, México*

AGENDA

PART I: SCIENTIFIC INFORMATION

Monday, 19 January
9:30 am
Welcome Address by Ezcurra, President of the Instituto Nacional de Ecología

- Introduction of participants
- Election of rapporteurs
- Agenda approval and comments

10:00 am
First Session

- A review of the mortality estimate for vaquita: D'Agrosa, C., C.E. Lennert-Cody, and O. Vidal. 2000. Vaquita bycatch in México's artisanal gillnet fisheries: driving a small population to extinction (Read)
- A review of vaquita distribution and comments and concerns to the bycatch estimate (Jaramillo-Legorretta and Rojas-Bracho)
- An update of the Biosphere Reserve (Campoy)
- Status of the knowledge of vaquita and potential effects of the shrimp trawlers in the Upper Gulf of California (Document by the Industrial Fisheries Chamber of Commerce)

Tuesday, 20 January
9:00 am
Second Session

- Alternative fishing gear (Blackwood and Walsh)
- Break for rapporteur to write session reports
- Discussion of session reports
- Presentation by the Aramadores Unidos de Puerto Peñasco and The Directorate of EIA (SEMARNAT) on new evidence on vaquita distribution and seasonal movements: a criticism to the core area of

vaquita distribution as proposed by CIRVA

- A report on the recovery plan progress (Rojas-Bracho, Jaramillo-Leggoretta and Barrera)
- Break for rapporteurs to write session reports
- Discussion of session reports

PART II: SOCIO-ECONOMIC CONSIDERATIONS

Thursday, 22 January
9:00 am

1. Welcome Address by Rojas-Bracho, Chairman of CIRVA
    - Introduction of participants
    - Election of rapporteurs
    - Agenda approval and comments
2. Project Exposition and presentation of participants
   Meeting objectives and goals (Rojas-Bracho)
    - Regulation costs and economic valuation of alternatives: topics and questions to be addressed (Muñoz, INE)
    - Diagnosis Information
    - Social Accounting Matrix (Bracamontes, COLSON)
    - Fishermen attitude towards the vaquita, Biosphere Reserve of the Upper Gulf of California and fishing restrictions (Turk, CEDO)
3. Discussion Session (Objectives: Identify information gaps, analysis tools to develop, key people/institutions to contact)
    - Prioritize questions according to their potential utility and to plan how the evaluation results will be utilized once they are available
    - Decide on instruments and data collection
    - Data analysis methods and reporting
4. Experiences on Socioeconomic Alternatives
    - PRODERS (Rural Sustainable Development Programs) (Guevara, UIA)
    - "Getting-to-Yes in Marine Conservation: Social and Economic Considerations" (Chuenpagdee, St. Francis Xavier University)
5. Discussion Session (Objectives: Identify information gaps, analysis tools to develop, key people/institutions to contact)
    - Prioritize questions according to their potential utility and to plan how the evaluation results will be utilized once they are available
    - Decide on instruments and data collection

- Data analysis methods and reporting

Friday, 23 January

6. Conclusions from the previous day
7. Working sessions:
    - Social Accounting Matrix
    - Regulation costs valuation
    - Economic alternatives evaluation.
    - Questions rephrased clearly, regrouped for each working sessions if necessary.
8. Strategic planning (future meeting), to study the evaluations reports and decide on follow-up steps. (Objective: Identify information gaps, analysis tools to develop, key people/institutions to contact)
9. Break for rapporteur to write session reports
    - Discussion of session reports

Summary and Conclusions

PART I: SCIENTIFIC INFORMATION

After reviewing the available evidence, participants in the scientific portion of the 3rd CIRVA meeting concluded that the vaquita population has almost certainly continued to decline since the last meeting in 1999. Whilst acknowledging the effort undertaken thus far, CIRVA therefore reiterates and strengthens its expression of grave concern that the species is in serious danger of extinction in the near future, unless strong conservation measures are implemented immediately by the Government of México. Specifically, CIRVA noted that:

1. The best available abundance estimate remains that obtained from the 1997 survey, i.e. around 570 animals (95 percent confidence interval 177–1,073).
2. The estimated level of bycatch mortality (D'Agrosa *et al.* 2000) for the 1993–1994 period was clearly unsustainable.
3. Indeed, since that time, fishing effort (numbers of pangas) has at least doubled, and therefore the rate of decline in vaquita abundance has probably increased.
4. Therefore, current (2004) abundance will certainly be below the 1997 level.

CIRVA considers it a matter of absolute urgency that every effort is made to eliminate anthropogenic mortality. The most important source of such mortality is bycatch in gillnet fisheries. Using both national and international guidelines to estimate sustainable rates of removal, bycatches of less than one per year are required to allow the vaquita population to increase to healthy levels. Reducing bycatches appears to be the only direct way to improve the chances of survival for this species. In addition, the vaquita's low absolute abundance and restricted distribution make it particularly vulnerable to habitat-related threats.

Given this compelling evidence, CIRVA emphasises that carrying out further research to refine estimates of abundance or mortality rate is no reason for delaying immediate management action. CIRVA discussed the proposed management plan for the Biosphere Reserve, which includes establishment of a special vaquita conservation area. CIRVA reiterated its previous view that the cessation of all gillnetting and trawling throughout the Reserve is essential for vaquita recovery. However, it noted that the best scientific evidence indicates the highest density of vaquitas in a core area between 30° 45.00 N – 31° 26.65 N and 114° 20.00 W – 114° 38.45 W. This includes waters both within and outside the Biosphere Reserve (see Fig. 3.1). CIRVA agreed that as an absolute minimum, immediate action should be taken to prevent any net fishing (Even though the risk of capture from gillnets is higher, the risk of capture in trawl nets is not zero.) within this core area, which represents about 30 percent of the total marine area of the Reserve. An appropriate mechanism must be found quickly to extend the same protection to the key area of vaquita occurrence outside the Biosphere Reserve. CIRVA did not reach this conclusion lightly. It recognised that such action will cause economic hardship for fishermen but stressed that this action alone will not guarantee the recovery of the vaquita. It is the minimum action required to reduce the possibility of further decline and allow time for additional developmental work on alternative fishing gear and methods, as well as socio-economic initiatives. Recovery of the vaquita population will require extension of the net-free zone in the future. Even under optimistic scenarios, recovery will take many tens of years. Even though the risk of capture from gillnets is higher, the risk of captures in trawl nets is not zero.

In terms of research funding, CIRVA recommends that priority must be given to research that will enable improved management actions to be taken and the performance of such actions to be evaluated. This will include research to improve our understanding of the seasonal distribution of the vaquita and of fishing effort, as well as research into developing alternative fishing gear. Despite the difficulties, CIRVA urges all parties involved, fishermen, communities, NGOs, scientists and managers, as well as regional and national governments, to work together to try to ensure the survival of one of the world's most endangered cetacean species (as recognised by IUCN, IWC and other international organisations).

Report of Part I: Scientific Information

1. Introductory Items

The meeting was chaired by Rojas-Bracho of the Marine Mammal Programme of Instituto Nacional de Ecología (INE). Ezcurra, President of INE, welcomed the participants to the meeting and explained its importance in providing advice on vaquita conservation in México, particularly in the context of the development of a revised management programme for the Biosphere Reserve. Rojas-Bracho laid the groundwork for meeting objectives. He reminded that the mandate of the Team is: to create a recovery plan based on the best available scientific information and which contemplates and considers the socio-economic impacts of any required regulations on the resource users in the affected areas. Reeves was appointed rapporteur, assisted by Donovan and Read. The Committee agreed to an outline agenda proposed by the Chair. The list of participants is given as Appendix 3.1 and the list of circulated documents as Appendix 3.2. Appendix 3.3 summarises discussions related to submissions by CANAINPESCA on behalf of the fishing industry.

2. Present Status

2.1 Abundance and trends in abundance

No new studies of vaquita abundance have been conducted since the second CIRVA meeting. CIRVA reaffirmed that the 1997 estimate of 567 (CV = 0.51; Jaramillo-Legorreta *et al.* 1999) is still the best available, noting (see below) that the population has continued to decline, possibly at an accelerated rate since that time. Considerable time was spent discussing the need for a new abundance estimate (and see Item 3). The document submitted by CANAINPESCA (México's Chamber of Industrial Fisheries) had stated that such an estimate was needed to compare with the 1997 estimate 'in order to determine if there really has been a decrease in abundance.' Given (1) the inevitable lack of precision in obtaining abundance estimates of cetaceans, particularly rare ones and (2) that bycatches continue at unsustainable levels, power analysis studies show that the species will become extinct before it is possible to detect a statistically significant decline through abundance surveys (Taylor and Gerrodette 1993). There is no evidence to suggest that a new survey would alter the view that the vaquita is critically endangered. Similarly, even under the most optimistic scenarios of population growth and no bycatches, it would require five surveys at five-year intervals to detect a significant increase in population size. Given the above, CIRVA recommends that any funds that might have been used to support another abundance survey in the near future, should be devoted instead to research that will enable improved management actions to be taken and the performance of such actions to be evaluated. The need for a future abundance survey should be reconsidered at a later time when there is a possibility that it will provide valuable information.

2.2 Distribution

The vaquita bycatch locations shown in the most recent thorough review (D'Agrosa *et al.* 2000) suggest a fairly broad distribution in the Upper Gulf. However, most of the locations were from interviews and the positions therefore may not be precise. A similar conclusion applies to the manuscript by Gallo-Reynoso (1999) discussed at the second CIRVA meeting, where the inferences concerning seasonal distribution (derived from sightings, strandings, and bycatches in the literature) were considered as possibly a "sampling artifact" (see 1999 CIRVA report). While such information may be important, the data and methods applied by Gallo-Reynoso do not lead to reliable conclusions.

Scientific research effort since 1999 has centred on the development and use of acoustic detection systems to survey vaquitas. The objectives of this work are to refine understanding of the vaquita's seasonal distribution and movements (important in developing the most appropriate mitigation measures) and, eventually, to provide a means of monitoring trends. The work undertaken to date was presented by Jaramillo-Legorreta and Rojas-Bracho. The results indicate that vaquitas are present in the core area of their distribution throughout the year. Moreover, in spite of considerable survey effort, no reliable evidence of individuals occurring outside the core area has been obtained, although further work and improved survey design outside the core area are required to confirm that this is indeed the case.

CIRVA agreed that the distribution indicated from sighting locations in the 1997 abundance survey, in combination with detections made during acoustic studies carried out since 1999, provides the best estimate of current vaquita distribution. These are shown in Figure 3.1, along with the proposed 'core area' of present vaquita distribution (and see Item 3.2). CIRVA welcomed the results of the acoustic studies and strongly recommends that they continue. A number of suggestions for future work were made directly to Jaramillo-Legorreta.

Figure 3.1. Map showing the visual (black circles) and acoustic (blue circles) detections of vaquitas since 1997. The grey area shows the current polygon within the reserve. The red polygon represents the original area proposed in the management plan. The blue-bounded extension to the west was proposed by the Marine Mammal Programme. Biosphere Reserve southern boundary.

Figure 3.2. Map showing the visual (black circles) and the 'core area' proposed by CIRVA as the minimum area in which a ban on net fishing should be implemented immediately.

2.3 Bycatch

The estimates of vaquita mortality presented in D'Agrosa *et al.* (2000) and D'Agrosa *et al.* (1995) were reviewed. These estimates were derived from data collected in El Golfo de Santa Clara, Sonora, where D'Agrosa and colleagues worked from January 1993 to April 1994. Fishermen were interviewed as they returned from fishing trips and a small sample of trips (54) was observed directly. Between January 1993 and January 1994, 14 vaquitas were either observed or reported killed in a variety of gillnet fisheries and an additional animal was reported killed in a shrimp trawl. The unit of fishing effort was the number of daily trips; this was either from direct observations or estimated via a model during unmonitored periods.

Mortality rate was calculated as the number of vaquitas killed per trip. Using a combination of observed and reported bycatches, D'Agrosa *et al.* (2000) estimated that 39 vaquitas were killed in gillnets used by fishermen from El Golfo between January 1993 and January 1994. This estimate was negatively biased because only 11 bycatches were used in the calculations (the fishery responsible for three of them was not fully documented). Further, no data were available for the fishing towns of Puerto Peñasco and San Felipe, which undoubtedly resulted in additional mortality. Assuming that fishing effort and vaquita mortality rates were comparable in San Felipe and El Golfo, then the total mortality in these two ports would have been 78 (note that this does not include additional mortality from gillnet fisheries based in Puerto Peñasco).

CIRVA agreed with the analysis and estimates presented by D'Agrosa *et al.* (2000) for vaquita mortality in the gillnet fisheries of El Golfo in 1993–94, noting that these were almost certainly underestimates for the region. There is no reliable evidence to suggest that the study period was atypical. No new studies of incidental mortality (bycatch) have been completed since the last CIRVA meeting. However, there is no evidence to suggest that bycatch levels have decreased since then. Indeed, the number of pangas fishing in the Upper Gulf has increased substantially (more than doubled) since the D'Agrosa *et al.* study. CIRVA agreed that bycatch rate has probably increased since 1994.

Considerable time was spent discussing whether further estimates of bycatch are necessary in the near future. CIRVA concluded that this was unnecessary at the present time for a number of reasons, including:

1. The available estimates were conservative and these led to the unequivocal conclusion the bycatch rates were unsustainable.
2. There is no evidence to suggest that sufficient action has been taken since the study to reduce bycatches to near zero (it is more likely that rates have increased)—any other result would not alter the conclusion that immediate action is required to eliminate vaquita bycatches.
3. Given the current sensitivity of the issue, it is doubtful that a repeat of the 'interview' approach would provide reliable estimates of bycatch.
4. The agreed method for obtaining reliable estimates of bycatches is through a well-designed observer scheme—given the level of fishing effort and the likely levels of bycatch, this would require nearly 100 percent coverage which, in addition to being extremely costly, is infeasible given the nature of the fisheries in the area.

Given the above, CIRVA recommends that any funds that would otherwise have been used to try to obtain a new estimate of bycatch in the near future should be devoted instead to research that will enable improved management actions to be taken and the performance of such actions to be evaluated.

2.4 Status Assessment

Assuming a population growth rate of 4 percent (typically considered reasonable for small cetaceans, e.g. REF) and using the estimated rates of fishery mortality (6.9 percent or 13.8 percent per year for mortalities of 39 and 78, respectively) agreed above, the net rate of population decline would be 2.9 percent or 9.8 percent per year. Given these rates, the population would be expected to have declined from 567 in 1997 to 464 or 268 (respectively) in 2004. If the population growth rate of the vaquita is instead 6 percent (the most optimistic growth rate conceivable for this species), the rates of population decline would be 0.9 percent or 7.8 percent (respectively) and the resulting population size in 2004 would be 533 or 329 (respectively). This reaffirms CIRVA's previous conclusion that the vaquita bycatch is not sustainable and refutes the argument proffered by some, that the vaquita would now be extinct if the mortality and abundance estimates were accurate.

Given the information presented on recent trends in the fisheries known to catch vaquitas, and the negatively biased character of the 1993–94 bycatch mortality estimates, CIRVA concluded that bycatch rates have almost certainly increased over the past decade; no evidence was presented to the present meeting that would indicate an improvement in the status of the vaquita. Therefore, it was agreed that the vaquita population has continued to decline and the species' status is almost certainly now worse than was believed at the last CIRVA meeting. CIRVA therefore reiterates and strengthens its expression of grave concern that the species will remain in serious danger of extinction in the near future, unless strong conservation measures are implemented immediately by the Government of México. CIRVA repeats that it is a matter of absolute urgency that every effort is made to eliminate anthropogenic mortality. The most important source of such mortality is bycatch in gillnet fisheries. This is considered further under Item 3.

3. Implementation of Conservation Measures

3.1 Review of progress in implementation of measures previously recommended by CIRVA

The general conclusion on the status of the vaquita made at this meeting remains the same as that reached at earlier meetings. CIRVA therefore reviewed progress made on its earlier recommendations. This is shown in Table 3.1.

Table 3.1. Summary of progress on previous recommendations made by CIRVA. The subjective judgement categoires under "Success" are: H = High, M = Medium, L = Low, and N = None.

Recommendation	Current Situation	Success (H, M, L, N)
1. The bycatch of vaquitas must be reduced to zero as soon as possible.	As discussed under Item 2, there is no evidence that any reduction in bycatch has been acheived. Bycatches of vaquitas continue to occur (participants were shown a vaquita carcass, with gillnet marks on it, recovered by a fisherman in December 2003) and fishing effort (measured by the number of pangas) has increased significantly (in fact, more than doubled) since 1993.	N

Table 3.1. Summary of progress on previous recommendations made by CIRVA. The subjective judgement categoires under "Success" are: H = High, M = Medium, L = Low, and N = None.

Recommendation	Current Situation	Success (H, M, L, N)
2. The southern boundary of the Bioshpere Reserve should be expanded to include all known habitat of vaquita.	This change has not been made. However, a new proposal is being considered that would create a seperate protected area outside the Researve to cover the currently unprotected portion of the core area of vaquita habitat. CIRVA expressed strong support for this initiative (see Item 3.2).	N
3. Gillnets and trawlers should be banned from the Biosphere Reserve, in the following sequence:		
Stage One (to be completed by 1 January 2000) • Eliminate large-mesh gillnets (6-inch stretched mesh, or greater); • Cap the number of pangas at present levels; and • Restrict fishing activities to residents of San Felipe, El Golfo de Santa Clara, and Puerto Peñasco.	Large-mesh gillnets were banned in the Biosphere Reserve in 2002, under Act 139 implemented by SERMANAT. However, the numbers of pangas has more than doubled since 1993. Trawling effort has been reduced but some vessels from outside the three communities continue to be allowed to enter the Reserve.	M
Stage Two (to be completed by 1 January 2001) • Eliminate medium-mesh gillnets (i.e. all except chinchorra de linea).	No progress has been made under this recommendation, although there is a proposal to exclude gillnets from the core area of vaquita habitat within the Biosphere Reserve.	L
Stage Three (to be completed by 1 January 2002) • Eliminate all gillnets and trawlers.	No progress has been made under this recommendation, although there is a proposal to exclude gillnets and trawlers from the core area of vaquita habitat within the Biosphere Reserve. This is discussed further below.	L

Table 3.1. Summary of progress on previous recommendations made by CIRVA. The subjective judgement categoires under "Success" are: H = High, M = Medium, L = Low, and N = None.

Recommendation	Current Situation	Success (H, M, L, N)
4. Effective enforcement of fishing regulations should begin immediately. The development of effective enforcement techniques should be given high priority because all of the committee's recommendations depend upon effective enforcement.	Some enforcement actions have been taken, such as the issuing of fines for illegal fishing activities within the nuclear zone of the Biosphere Reserve and for illegal trawling in the vaquita-protection polygon of the Reserve.	M
5. Acoustic surveys should start immediately to (a) begin monitoring an index of abundance and (b) gather data on seasonal movements of vaquitas.	As noted under Item 2.2, considerable progress has been made in the development of acoustic survey techniques and useful insights on vaquita distribution have been obtained from this monitoring programme.	H
6. Research should start immediately to develop alternative gear types and techniques to replace gillnets.	CIRVA welcomed the information provided by Blackwood and Walsh on a new research programme to assess the use of alternative fishing gear (pots) in the shrimp fishery. It strongly encourages such work and recommends that similar work be conducted for finfish gillnet fisheries.	M
7. A program should be developed to promote community involvement and public awareness of the importance of the Biosphere Reserve and the vaquita, stressing their relevance as part of México's and the world's heritage. Public support is crucial.	CIRVA was pleased to note that considerable progress has been made on this recommendation. This included the holding of stakeholder meetings, outreach at the local and national levels, public input into revision of the Biosphere Reserve's management plan (see below) and the present CIRVA meeting. In this regard, CIRVA was pleased to receive both a paper and a presentation on behalf of CANAINPESCA (the Industrial Fisheries Chamber of Commerce). For convenience, a summary of the discussions under this item are given in Appendix 3.3.	H

Table 3.1. Summary of progress on previous recommendations made by CIRVA. The subjective judgement categoires under "Success" are: H = High, M = Medium, L = Low, and N = None.

Recommendation	Current Situation	Success (H, M, L, N)
8. Consideration should be given to compensating fishermen for lost income resulting from the gillnet ban.	This recommendation was not considered in the scientific portion of the meeting.	
9. Research should be conducted to better define critical habitat of the vaquita, using data collected during the 1997 abundance survey.	A full analysis of the critical habitat of the vaquita has not yet been performed. The recent acoustic surveys, described under Item 2.2, have provided additional information on vaquita distribution in the Upper Gulf.	M
10. The international community and NGOs should be invited to join the Government of México and provide technical and financial assistance to implement the conservation measures described in this recovery plan and to support further conservation activities.	International organizations (e.g. IUCN and IWC), NGOs (e.g. WWF, IFAW and Conservation International) and the U.S. government (National Marine Fisheries Service and the Marine Mammal Commission) continue to work as active partners with the Government of México towards the conservation of the vaquita and the ecosystem of the Upper Gulf.	M

3.2 Review of the proposed Biosphere Management Plan

Campoy updated participants on developments within the Biosphere Reserve (see Appendix 3.3). Discussion under this item centred on issues surrounding the question of an exclusion zone for net fisheries (trawlers and gillnets) within a 'polygon' inside the reserve. CIRVA noted that its earlier recommendations had called for a staged process leading to the complete exclusion of net fisheries from the Biosphere Reserve by 1 January 2002 (Table 3.1, Recommendation 3).

The evolution of the boundaries for the present 'polygon' (see Fig. 3.1) was complex. A proposal derived from the core area of vaquita distribution for two irregularly shaped zones (a core zone and an outer zone) was presented to ?? in October 2002 by the Marine Mammal Program of NE/CICESE. Upon receiving a request for simpler boundaries, this was modified to the 'core area' shown in Figure 3.2 (which was based on the sightings from the visual survey in 1997 and subsequent acoustic detections; see Item 2.2

for details). This core area (between 30° 45.00 N – 31° 26.65 N and 114° 20.00 W – 114° 38.45 W) of around 800 nm^2 encompassed waters both within and outside the Reserve. For legal reasons, it is easier to act on recommendations pertaining areas within the Reserve, and therefore discussions have concentrated on those. After a number of public and other consultations, the 'polygon' was fixed as shown in Figure 3.1 and a ban on trawling within its boundaries adopted and enforced in 2003; this ban is to be extended to gillnets in 2004. The boundaries to the 'polygon' have subsequently been challenged by the industry and a smaller area proposed.

Discussions within CIRVA initially focussed on the needs of the vaquita, irrespective of the legislative framework. CIRVA reiterated its previous recommendation that the cessation of all gillnetting and trawling throughout the Reserve is essential for vaquita recovery. However, it noted that the best scientific evidence indicates the highest density of vaquita in a key area between 30° 45.00 N – 31° 26.65 N and 114° 20.00 W – 114° 38.45 W. This includes areas both within and outside the Biosphere Reserve (see Fig. 3.1).

CIRVA recommends that as an absolute minimum, immediate action should be taken to prevent any net fishing within this key area; that found within the Biosphere Reserve represents only 30 percent of the marine area of the Reserve. An appropriate mechanism must be found to extend the same protection to the key area outside the Biosphere Reserve (e.g. the establishment of a Wildlife Refuge). Consequently, the proposal by the industry for a smaller area, which excludes a large part of key vaquita habitat, is unacceptable. CIRVA did not reach this conclusion lightly. It recognises that such action will cause economic hardship for fishermen and this is taken into account in its minimum recommendation for immediate action. It stresses that this action alone will not guarantee the recovery of the vaquita. It is rather the minimum action required to reduce the possibility of further decline and allow time for additional developmental work on alternative fishing gear and methods, as well as socio-economic initiatives. Recovery of the vaquita population will require extension of the net-free zone in the future. Even under optimistic scenarios, recovery will take many tens of years.

3.3 Conclusions

Although CIRVA welcomed the progress that had been made with some of its previous recommendations (see Item 3.1), it noted that little progress had been made with certain key recommendations with respect to eliminating bycatches. It reiterates the urgent need for these measures and strongly recommends that the Government of México should implement them as quickly as possible. Despite the recognised socio-economic, legislative and other difficulties, CIRVA strongly urges all parties involved, fishermen, communities, NGOs, scientists and managers, as well as regional and national governments, to work together to try to ensure the survival of one of the world's most endangered cetacean species (as recognised by IUCN, IWC and other international organisations).

4. Adoption of Report

The outline report was adopted by participants on the evening of 20 January 2004.

It was agreed that Reeves and Donovan would incorporate participants' specific and general comments and carry out the final editing of the report in consultation with Rojas-Bracho. The participants thanked Rojas-Bracho for chairing the meeting with good humour and wisdom. They also thanked the students of CISESE for the efficient manner in which the meeting was run. Finally, thanks are due to INE, WWF-US and the U.S. Marine Mammal Commission for their generous financial support.

APPENDIX 3.1

Participants

Alfredo Cota
CRIP-Ensenada
Km 97.5 Tijuana-Ensenada
México

Andrew Read
Assistant Professor and Rachel Carson Chair of Marine Conservation Biology
Duke University Marine Laboratory
135 Duke Marine Lab Road
Beaufort, NC 28516
USA

Arne Bjorge
University of Oslo
Institute of Biology
P.O. Box 1064 Blindern
0316 Oslo
Norway

Armando Jaramillo-Legorretta
Instituto Nacional de Ecología (INE)
c/o CICESE
Km. 107 Carretera Ensenada - Tijuana
Apto. Postal 2732
Ensenada, Baja California 22860
México

Barbara Taylor
Southwest Fisheries Science Center
U.S. National Marine Fisheries Service
8604 La Jolla Shores Dr.
La Jolla, CA 92037
USA

Eugene Lee
Species Conservation Program
World Wildlife Fund US
1250 24th St., NW
Washington, DC 20037-1193
USA

Greg Donovan
International Whaling Commission
The Red House, 135 Station Road
Impington, Cambridge CB4 9NP
UK

Glenn Blackwood
Centre for Sustainable Aquatic Resources.
Fisheries and Marine Institute of Memorial University of Newfoundland
Newfoundland
Canada

Jay Barlow
Southwest Fisheries Science Center
U.S. National Marine Fisheries Service
8604 La Jolla Shores Dr.
La Jolla, CA 92037
USA

Jorge Urbán R
Programa de Investigación de Mamíferos Marinos
Universidad Autónoma de Baja California Sur
Km.5.5 Carretera al Sur. Mesquitito.
23081 La Paz, B.C.S.
México

José R. Campoy F
Reserva de la Biosfera del Alto Golfo de California y Delta del Río Colorado
CONANP/SEMARNAT.
San Luis Río Colorado, Sonora.
México

Juan Manuel García
Conservación Internacional
Guaymas, Son
México

Karen Baragona
Species Conservation Program
World Wildlife Fund US
1250 24th St., NW
Washington, DC 20037-1193
USA

Lorenzo Rojas-Bracho
Instituto Nacional de Ecología (INE)
c/o CICESE
Km. 107 Carretera Ensenada - Tijuana
Apto. Postal 2732
Ensenada, Baja California 22860
México

Julian Guardado
CRIP-Ensenada
Km 97.5 Tijuana-Ensenada
México

Martha Rosas
International Fund for Animal Welfare
Regional Office for Latin America
Prolongación Angelina 10
Colonia Guadalupe Inn
D.F. 01020
México

Miguel Angel Cisneros
WWF-Programa Golfo de California
Blvd. Beltrones Rivera 264, Local 3
Edificio Hacienda Plaza
San Carlos, Sonora 85506
México

Philip Walsh
Centre for Sustainable Aquatic Resources
Fisheries and Marine Institute of Memorial University of Newfoundland
Newfoundland
Canada

Randall Reeves
IUCN Cetacean Specialist Group
27 Chandler Lane
Hudson, Quebec JOP 1H0
Canada

Robert Brownell
Southwest Fisheries Science Center
U.S. National Marine Fisheries Service
1352 Lighthouse Ave.
Pacific Grove, CA 93950
USA

Tim Ragen
U.S. Marine Mammal Commission
4340 East-West Highway
Bethesda, MD 20814-4447
USA

APPENDIX 3.2

List of Circulated Documents

1. Anon. 1997. México. Progress report on cetacean research, June 1995–April 1996. Forty-seventh Report of the International Whaling Commission. Part 1. Pgs. 349–351.

2. Brownell, R.L., Jr. Shark predation on small cetaceans, especially porpoises: theoretical versus real threats.

3. Centro de Investigaciones Biológicas del Noroeste, S.c. Programa Ecología Pesquera. Status of knowledge about the vaquita *Phocoena sinus* and the potential effects of shrimp trawling in the Upper Gulf of California. Evidential document presented to the Cámara Nacional de la Industria Pesquera y Acuícola Canainpesca (Industrial Fisheries Chamber of Comerce).

4. D'Agrosa, C., C.E. Lennert-Cody and O. Vidal. 2000. Vaquita bycatch in México's artisanal gillent fisheries: driving a small population to extinction. Conservation Biology 14:1110–1119.

5. Jaramillo-Legorreta, A. and L. Rojas-Bracho. Intensity of the artisanal fisheries in the Upper Gulf California: an updated estimation of incidental mortality of the vaquita based on previous estimates.

6. Norse, A.E., P.K. Dayton, E. Sala, S. Thrust, L. Watling, P. Auster, and J. Lindholm. Letter about trawlers impact and the Gulf of California.

7. Perezcortés Moreno, H. 1996. Contirbución al conocimiento de da biología de la vaquita, *Phocoena sinus*. Tesis de Maestría. Icmyl. Unam. Pgs. 25, 32, and 45.

APPENDIX 3.3

Discussions related to a paper and presentation submitted to CIRVA by Centro de Investigaciones Biologicas del Noroeste on behalf of CANAINPESCA CIRVA was pleased to receive a paper submitted for its consideration by El Centro de Investigaciones Biologicas del Noroeste on behalf of CANAINPESCA, entitled "Status of Knowledge about the Vaquita *Phocoena sinus* and the Potential Effects of Shrimp Trawling in the Upper Gulf of California" and a presentation by Hernandez. Considerable time was allocated to discussing the paper and presentation.

The summary below addresses the major topics related to the status of vaquitas and management actions, and presents CIRVA's conclusions. Several of the issues raised concerned possible threats to the survival of the vaquita in addition to the major threat of bycatch. Taking action on these, even where feasible, does not alter the fact that the highest priority for immediate action is the adoption of measures that will result in the elimination of bycatch. Incidentally, the current projections of the effect of bycatches on the species assume successful reproduction and low natural mortality. Should these assumptions not be true, then the need to eliminate bycatch, the only threat that can be addressed immediately, would become even more urgent.

1. Predation

All species are subject to natural mortality, and for many of them, predation contributes to that mortality. The vaquita is no exception. There is no evidence to suggest a recent increase in predation, e.g. by sharks. In fact, it was noted that shark populations, presumably including those species most likely to prey upon vaquitas (list here, from Brownell?) have themselves been declining in the Gulf of California (Red Book reference to come).

2. Reduced flow from Colorado River

CIRVA recognises that the changes to the Colorado River as a result of the building of dams in the USA has had a major impact on aspects of the ecosystem of the Biosphere Reserve. In the present context, the issue is whether this has had an immediate impact on the survival of the vaquita. The anadromous prey species (*Bairdiella icistia*) stressed in the CANAINPESC report is only one of a wide variety of species known to be taken by vaquitas. There is no evidence to suggest that food shortages are affecting the reproductive success of the vaquita or increasing its mortality rate. As discussed by Rojas-Bracho and Taylor (1999), the bycaught and stranded vaquitas examined to date have all appeared to be healthy and in good condition. Similarly, mothers with apparently healthy calves have been observed during surveys, suggesting that reproduction is occurring normally in the population.

In conclusion, while there is clear evidence that vaquita bycatch levels are unsustainable, there is no evidence that vaquitas are suffering from nutritional stress as a result of lowered productivity in their environment.

3. Contaminants

Rojas-Bracho and Taylor (1999, citing Calambokidis, 1988) report that vaquitas have relatively low levels of chlorinated hydrocarbon pesticide residues and PCBs in their tissues compared to other cetaceans. Although exposure to anthropogenic chemicals could conceivably affect the health and reproductive potential of vaquitas, the available evidence suggests that it is unlikely to be a significant risk factor, particularly when compared with the known threat from bycatch.

In conclusion, there is no evidence to suggest that chemical pollutants pose a significant risk to the vaquita. CIRVA nevertheless concurred with the authors of the report that every effort should be made to limit the release of potentially harmful chemicals into the marine environment.

4. Captive breeding programmes

Hernandez, citing the case of the totoaba, suggested that a captive breeding programme might be a useful tool in the recovery of the vaquita. However, as noted under the points above, there is no evidence to suggest that the vaquita is not reproducing successfully. Even if there was such evidence, there are many reasons why such an approach cannot be recommended and indeed why it might exacerbate the situation of the vaquita, which has never been kept in captivity. These include:

1. The difficulty of finding and capturing live animals.
2. The risk to the survival of the animals during the capture process.
3. The low survival rate and breeding success in captivity of 'new' cetacean species.
4. The low success rate for similar cetacean species.

Finally, it is clear that the biological differences between a fish such as the totoaba and a cetacean such as the vaquita are such that the approaches to achieving their recovery will be very different.

4. Natural rarity and low genetic variability

This issue was clearly addressed by Rojas-Bracho and Taylor (1999) and there is no reason to believe that the vaquita is "naturally" as rare as we observe it to be today, or that genetic factors are implicated in its endangered status. Genetic data indicate that vaquitas are naturally rare and that their historical abundance was more likely in the thousands than tens of thousands (Taylor and Rojas-Bracho, unpublished manuscript). Given the history of large bycatches, however, there is no doubt that the current population is well below the environmental carrying capacity.

5. Additional surveys and estimates of bycatch

This issue has been thoroughly dealt with elsewhere in the report (see Item 2).

In conclusion, there is no value in the near-term in trying to obtain new estimates of abundance or bycatch.

6. Specific issues related to trawling bycatches

CIRVA has previously stated that bycatch mortality in gillnets is the greatest single threat to the vaquita. As reported under Item 2, only a single incident of vaquita bycatch in a trawl was reported by D'Agrosa *et al.* (2000). However, in other regions, demersal trawls are known to take other porpoise species that have similar behaviour to that of the vaquita (Northridge reference here).

In conclusion, although the bycatch rate in trawls is low compared to that in gillnets, even a single kill per year is excessive for this critically endangered species, and therefore mortality in trawl nets represents a serious concern.

Seabed disturbance

Research on demersal trawling in various regions has shown varying levels of damage to the seabed and abilities of the seabeds to recover. However, there is no doubt that in many cases, serious physical impacts on the sea floor occur, with associated effects on benthic communities. There have been no substantial published papers on this issue for the Biosphere Reserve.

In conclusion, despite the lack of scientific evidence on the level of seabed damage caused by demersal trawls within the Biosphere Reserve, it seems clear that there are unlikely to be any beneficial effects and there is a high likelihood of negative effects.

Other disturbance

As noted by Hernandez and reported in other documents, vaquitas respond strongly to the approach of trawlers. Although there is no direct evidence of a serious negative impact (which would be scientifically difficult to establish if present), the intensity of trawling and the extremely restricted distribution of vaquitas suggest that such disturbance is unlikely to have a beneficial effect and could have important negative effects on the animals' foraging, reproductive, and other activities.

In conclusion, despite the lack of direct scientific evidence, it is clear that disturbance of vaquitas by trawlers is unlikely to have a beneficial effect and could have important negative effects on population status.