Report of the Fourth Meeting of the International Committee for the Recovery of the Vaquita (CIRVA)

Hotel Coral y Marina, Ensenada, Baja California, México

February 20–23, 2012

Report of the Fourth Meeting of the International Committee for the Recovery of the Vaquita (CIRVA), Ensenada, Baja California, México, 20–23 February 2012

Executive Summary

The Government of México has convened a committee of international experts to advise it on methods to save the endangered Mexican porpoise, the vaquita, from extinction. The International Committee for the Recovery of the Vaquita (Comité Internacional para la Recuperación de la Vaquita or CIRVA) met previously in 1997, 1999, and 2004. CIRVA met again in February 2012 and reviewed the progress that had been made in protecting vaquitas since the last meeting. CIRVA's recommendations are reported here.

Between 1997 and 2004, not only was no progress made towards protecting vaquitas, but the population decline accelerated. As fishing effort increased greatly, over half of the species population was lost in 11 years, with only about 220 porpoises remaining in 2008. CIRVA recognizes the enormous efforts that have been made by the Government of México in protecting vaquitas since 2008. México established a Vaquita Refuge in the core of the vaquita's distribution and initiated a scheme of monetary compensation ("rent-out", "buy-out," and "switch-out") to eliminate gillnetting and industrial trawling within this Refuge. That scheme reduced, but did not eliminate, un-permitted fishing. The Government of Mexico, with significant support and funding from US government agencies and other groups, conducted a new survey of vaquita abundance, established an acoustics program to monitor population trends, and developed an alternative, "vaquita-safe" method for catching shrimp. Never before has so much serious effort and funding been invested in vaquita conservation. Without these efforts, vaquitas might already have reached a state where recovery would not be possible. The time purchased for this critically endangered species by implementing the first steps of the vaquita recovery plan has set the stage for Mexico to save the vaquita. Such an accomplishment would serve as an example to the world of how a species can be saved while allowing local people to continue making a living from artisanal fisheries.

However, information presented at this meeting showed that the vaquita population is still declining and now likely consists of fewer than 200 individuals. The Vaquita Refuge protects only about half of the population and illegal gillnet fishing is still common inside the Refuge. Also, gillnets are still commonly used to catch shrimp and finfish outside the Refuge. Total fishing effort per boat actually appears to have increased since the late 1990s due to the practices of remaining permit holders who use more nets and longer nets.

Small, light-weight trawls (Red Selectiva-INP) were built and tested in the northern Gulf of California. These nets were found to catch commercial quantities of brown shrimp at night and blue shrimp during the day. Thus a "vaquita-safe" alternative to gillnets is available for catching

shrimp with artisanal fishing vessels (pangas). Additional alternative designs for less expensive small trawls have been built (Scorpion and Box trawls) and are also ready for use in the fishery. Although such light trawls are not commonly used yet, CIRVA sees tremendous potential in replacing gillnets with them. Research aimed at finding vaquita-safe methods for catching finfish continues.

Based on information presented at this meeting, CIRVA has made a number of recommendations for actions to prevent the extinction of the vaquita, the most important being:

- All gillnets and other entangling nets need to be removed from the entire range of the vaquita.
- Artisanal shrimp fishing vessels should be converted from using gillnets to using small trawls immediately.
- Additional research is needed immediately to develop vaquita-safe methods to fish for finfish with artisanal vessels. The conversion of the entire fishing fleet to vaquita-safe methods needs to be accomplished as soon as possible (certainly within the next few years).
- Spatial management measures are needed that provide access incentives for shrimp fishermen who use small trawls rather than gillnets.
- A legal limit on the length of gillnets and the number of nets per vessel needs to be enforced immediately for fisheries with such limits, like the shrimp fishery.
- A legal limit on the length of gillnets and the number of nets per vessel needs to be established and enforced for all other fisheries (besides the shrimp fishery).
- More effective enforcement of no-fishing regulations within the Vaquita Refuge is needed.
- The boundaries of the Vaquita Refuge should be changed to reflect the configuration shown in Figure 3 of this report.
- INE's acoustic monitoring scheme should continue for at least the first planned 5-year period. This scheme offers the only means of tracking vaquita population trends so that recovery strategies can be adapted accordingly.

México has made great progress in its efforts to protect vaquitas, but much more work needs to be done; there are no grounds for hesitancy or complacency. CIRVA believes that if the continuing decline in vaquita abundance is not halted within the next five years (by 2017), the species may be too depleted to ever recover. México will have lost an iconic species, and the enormous investments made to date in saving the species will have been in vain.

Introduction

The fourth meeting of the International Committee for the Recovery of the Vaquita (CIRVA) took place in Hotel Coral & Marina, Ensenada, Baja California, México, on 20-23 February 2012. On this occasion, the committee consisted of Lorenzo Rojas-Bracho (chairman), Oscar Ramírez, Armando Jaramillo-Legorreta, Victor Camacho, Barbara Taylor, Jay Barlow, Arne Bjørge, Peter Thomas, and Randall Reeves. Four international members of the committee – Robert Brownell, Andrew Read, Tim Ragen, and Greg Donovan – were unable to attend. Rojas-Bracho chaired the meeting. Reeves and Thomas served as the rapporteurs, assisted by Taylor and Barlow. The committee's work was supported by a number of invited experts who provided presentations and contributed to plenary discussions. All meeting participants are listed in Annex 1. The agenda is given as Annex 2.

Luis Fueyo, Commissioner of the National Commission for Protected Natural Areas (CONANP), opened the meeting and gave a brief summary of the Vaquita Recovery Plan (PACE-Vaquita) and conservation actions taken to date by the Mexican Government. He concluded that significant progress had been made and that there is reason to hope that an important further step will be taken in 2012. With the progress made on gear development and testing, the opportunity is at hand for eliminating shrimp gillnets from the vaquita's range and replacing them with alternatives that pose little or no risk of vaquita by-catch.

Thomas spoke on behalf of the Marine Mammal Commission and pointed to its long history of support for Mexico's efforts to conserve vaquitas. He highlighted significant developments since the last CIRVA meeting in 2004 and emphasized the importance of developing alternatives to gillnets, which continue to be seen as the main threat to the vaquita's survival and recovery.

Omar Vidal, Director General of WWF-Mexico, acknowledged the leadership shown by the Government of Mexico in efforts to save the vaquita. Over the last three years, WWF has provided support for the development of fishing technology as well as other activities related to vaquita conservation. He encouraged CIRVA to communicate directly with President Felipe Calderón to acknowledge the progress made in addressing threats to vaquitas and to convey the importance of taking stronger and immediate actions to eliminate gillnets from the species' range.

Finally, Francisco Barnés, President of the National Institute of Ecology (INE), welcomed participants to Ensenada. He summarized research on vaquitas carried out collaboratively by INE, the Southwest Fisheries Science Center, and other groups, and noted the importance of this work for establishing a credible scientific foundation for vaquita conservation efforts. Barnés emphasized the relevance of the results of the CIRVA meeting. His expectation is that they will improve the strategies set forth in PACE-Vaquita and thus help to reverse the population decline (due to unsustainable by-catch) in the shortest time possible.

This report of CIRVA-IV includes brief summaries of the presentations within the main text, supplemented by more detailed summaries prepared by the presenters themselves (Appendix 1). The main text also summarizes the points raised in discussions and contains CIRVA recommendations, highlighted in boldface text and summarized in Appendix 2. A table to track progress on previous recommendations was updated from the CIRVA-III report (Table 2).

Review of the Vaquita Conservation Action Plan (PACE-Vaquita)

The Federal Government of Mexico began implementation of the Species Conservation Action Plan for Vaquita: An Integrated Strategy of Management and Sustainable Use of Marine and Coastal Resources in the Upper Gulf of California (PACE-Vaquita) in 2008 through the Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT, Ministry of Environment and Natural Resources). The goal of this program is to ensure the conservation and recovery of the vaquita by promoting the sustainable use and management of marine and coastal resources in the Upper Gulf of California. The conservation strategy is to execute a number of sub-programs, one of the most important being to prevent further by-catch of vaquitas by eliminating the use of trammel nets and gillnets throughout the species' range (http://www.conanp.gob.mx/pdf_especies/PACEvaquita.pdf). Ramírez summarised progress, stressing the value of involvement by many different stakeholders in addition to Federal government agencies, e.g. fishermen and the fishing sector, local and State governments, and NGOs. For details see Appendix 1.

During discussion following Ramírez's presentation, it was explained that the proposed new regulations on fisheries within protected areas are intended as a way of aligning policies of the Fisheries ministry with those of the Environment ministry. That is, the intention is not to prohibit fishing but rather to specify the kinds of fishing that are allowed within such areas. CIRVA stressed the importance of achieving clarity on how 'highly selective gear' is defined. For example, a gillnet for curvina may be 'highly selective' but still pose a risk to vaquitas.

CIRVA **recommends** that INAPESCA explicitly define 'highly selective gear' (*alta selectividad multiespecífica*, Plan de Manejo de la RBAGDRC; literally 'gear with high multi-specific selectivity') in consultation with CONANP. The definition should include the idea that such gear would have very little (preferably zero) risk of catching vaquitas (i.e. it is 'vaquita-safe'). The goal must be to achieve < 1 total by-catch of vaquitas per year in all fisheries combined.

CIRVA also **recommends** that the small or light trawl nets (RS-INP-MEX prototype trawl and similar) recently developed by INAPESCA for use in the shrimp fishery be specified as falling within the definition of 'highly selective gear' (see later in this report for details on the small trawl nets).

Concern was expressed regarding the suggestion by Ramírez that other fishery resources are being investigated as options to help shift effort away from gillnetting. This concern arose for two reasons. First, several decades ago the totoaba fishery was closed because of overfishing and

stock depletion. Ramírez gave assurance that any resumption of a totoaba fishery would be preceded by rigorous stock assessment and fishing would be carefully managed. One possibility is that only sport fishing would be allowed, with permits made available only through an auctioning process similar to that used to issue licenses for sport hunting of bighorn sheep. Catch-and-release would be another possibility. The second reason for concern was that experimental fishing for totoaba in the 1980s had resulted in significant by-catch of vaquitas. Ramírez and others assured participants that totoaba stock assessment would be based only on by-catch in other fisheries and that experimental totoaba fishing has been, and would continue to be, limited to pole and line, i.e. there is no plan for a resumption of large-mesh gillnetting for totoaba even on an experimental basis. Ramírez re-emphasised his view that use of the Upper Gulf's marine resources in general is not nearly as efficient as it could be and that considerable scope remains for improvement in the use and management of a variety of species, including curvina.

Juan Manuel García drew the meeting's attention to rapid changes in export markets for seafood products from the Upper Gulf, noting in particular the growing Chinese market for chano and Spanish mackerel. Consequent increases in the market value of these finfish species are affecting the relative profitability of shrimp, and therefore they could also affect the mix of fishing effort. It was noted that the buy-out is of pangas, not permits, and that a single panga could be used under two and sometimes three different permits – for shrimp, finfish, and elasmobranchs. It is anticipated that a separate permit may be required for curvina by 2013 under a quota system. Approximately 750-800 pangas are still fishing in the Upper Gulf and a trend towards more finfish fishing is worrisome given that the risk of vaquita by-catch may be higher from finfish driftnets than from shrimp gillnets.

Ramírez stressed the importance of having reliable, up-to-date market studies and noted that one such study, sponsored by US-AID, was available and could be used to explore the possibilities of alternative markets for fishery products.

A recently published analysis of PACE-Vaquita concluded that the buy-out program had eliminated from the Upper Gulf fishing fleet individuals who either were close to retirement age or already had the skills for switching to a different livelihood (Avila-Forcada et al. 2012). In other words, the 'low hanging fruit' has been picked, and it will be difficult to get appreciably more fishermen to accept the terms of a buy-out voluntarily. Therefore, without a 'regulatory hammer', i.e. mandatory elimination of gillnets by a certain date, it will likely be impossible to reach the goal of eliminating gillnets and other entangling nets from the vaquita's habitat. There is no indication that fishermen who participated in the buy-out are interested in re-entering the fishery (Avila-Forcada et al. 2012). Rodriguez pointed out that most of the senior fishermen are 30-45 years old and that fishermen generally begin to enter the fishery at around 17-20 years of age. He added that about a third of the fishermen are likely to continue fishing (illegally) even if they are given money not to.

Concerns about enforcement were expressed often during the meeting, and these need to be addressed. Aerial survey data presented to the meeting by García, which supplement data presented in the recent paper by Gerrodette and Rojas-Bracho (2011), demonstrate that fishing continues to occur illegally inside the Vaquita Refuge. Other independent data corroborate this. For example, up to 67 panga-like boats were detected inside the Refuge on a satellite image analyzed by INE, and equipment used in INE's acoustic monitoring effort in the Refuge (see later) has been lost, at least some of it as a result of becoming snagged by (illegal) fishing operations (16 C-pod detectors and 17 anchors have been lost since the monitoring program began).

Unfortunately, CIRVA was not allowed to present the data in García's report, nor have the most recent (and the most relevant) aerial survey data been made available for analyses of the spatial distribution of fishing effort. Such data need to be made publicly available, at least in summary form. Independent spatial/temporal data on fishing effort are vital for assessing the vaquita's conservation status and for improving design of the monitoring program.

CIRVA believes that enforcement is key to vaquita conservation and therefore enforcement efforts and results need to be transparent and available for public accountability. Although the Mexican regulatory framework has specific controls that apply to fishing activities and these would be expected to help mitigate the impacts of fisheries on the vaquita population, there is evidence that violations to fishing and environmental regulations occur often with little risk of penalty. During the meeting, several presentations showed that fishermen are using non-compliant gears and fishing in the Biosphere Reserve's core zone and in the Vaquita Refuge, both of which are no-take zones. Representatives of PROFEPA were invited to the meeting but did not attend. It appears from the evidence presented that considerable improvement of enforcement programs is needed.

Therefore, CIRVA **recommends** that enforcement agencies introduce better inspection protocols, intensify verification effort, and make public the results of their operations. Protocols should focus on both inspecting the use of authorized fishing gear and monitoring fishing operations in the no-take zones. Because enforcement on the water is expensive, it would make good sense to implement enforcement primarily at launching sites, with GPS tracking devices used to monitor where the fishing vessels go. This would require that such devices be mandatory for pangas fishing in the primary distribution area of vaquitas, at least until gears that pose risks to vaquitas are banned entirely from that area.

In a similar vein, information on fishing effort **should be made publicly available**. At a minimum, numbers of boats fishing and the locations and times of fishing should be documented and presented in a transparent manner (see discussion on Environmental Impact Assessment, below).

CIRVA applauded the efforts to date by the Mexican government to reduce gillnet fishing effort in the range of vaquitas via the buy-out, switch-out, and rent-out programs. It concludes that conservation compensation **should continue** (and in fact be strengthened) as one tool to protect vaquitas. Such compensation, however, **should be tied** to demonstrating ongoing compliance with conservation measures in a credible, verifiable manner (e.g. through the use of GIS data loggers; see later).

Alternative Fishing Gear

Jeff Gearhart reported on gear trials conducted to measure and compare the performance of small trawl nets as alternatives to gillnets for catching blue shrimp in the Upper Gulf of California (Appendix 1). These trials were led by INAPESCA in cooperation with the Southeast Fisheries Science Center of the U.S. National Marine Fisheries Service. Previous trials had been hampered by competition for space with gillnets. Three nets (the RS-INP-MX, or "Red Selectiva" developed by INAPESCA, and the Scorpion trawl and Box trawl developed by the Southeast Fisheries Science Center) were evaluated and tuned during initial trials in 2011 in the Gulf of Mexico. In August 2011 they were tested in the Upper Gulf of California. The number of trials was limited by several factors, but the nets, once tuned for the unique conditions of the Gulf, caught blue shrimp in comparable quantities to what was caught in gillnets with similar effort.

Gearhart discussed technical aspects of shrimp trawl design and the trade-offs between different nets and materials. The Red Selectiva is made of a very durable, light, and expensive Spectra material and costs about US$5,000 per net. The scorpion and box trawls are made of less durable, less expensive material that costs only about $1,000.

In addition to net designs and materials, there are other trade-offs that increase the cost-effectiveness of gear conversion. For example, the pangas currently used in the Upper Gulf of California are powered by outboard motors. According to Gearhart these outboards are not as efficient or practical as diesel engines for towing trawl nets. Small diesel engines use less fuel, are more durable (last longer), and provide sufficient power for trawling. NMFS technicians recommended that the feasibility of conversion to diesel be explored as part of the cost-benefit analysis of replacing gillnets with trawls. CIRVA members raised a number of questions about how vessels could be converted, the cost of conversion, speed of the retro-fitted vessels, and their ability to land at ports in the Upper Gulf.

CIRVA **recommends** that a rigorous cost: benefit analysis be carried out to evaluate the merits as well as the feasibility of converting pangas from gas to diesel engines.

Daniel Aguilar of INAPESCA described work over the last five years to develop and test a variety of fishing gears to replace gillnets. Testing alternative gear is hampered, first and foremost, by the intense presence of gillnets in the Upper Gulf during the shrimp fishing season (Fig. 1). While the number of vessels may have been reduced through buy-outs and swap-outs

and there is a legal limit on gillnet length of 200 m, Aguilar reported that fishermen are setting nets up to 2500 m long and, instead of setting the one net allowed, are setting two nets, or sometimes three, at a time. Thus the actual amount of gillnetting in the water in the Upper Gulf may well have increased rather than decreased during the past decade.

Aguilar described the ongoing development of several pot, hook, and fish aggregation devices in collaboration with SEMARNAT, CONANP, NMFS, WWF, and the Swedish government and then presented further details on the testing of the prototype trawl nets, including the Red Selectiva. He described several of the design aspects of this net including Turtle Excluder Devices (that may allow vaquitas to escape in the rare instances that they are entrapped) and by-catch reduction devices designed to allow finfish to escape. This net uses extremely durable Spectra webbing panels. Aquilar explained that this is so the fishermen adopting these nets won't complain about the nets getting ripped or broken.

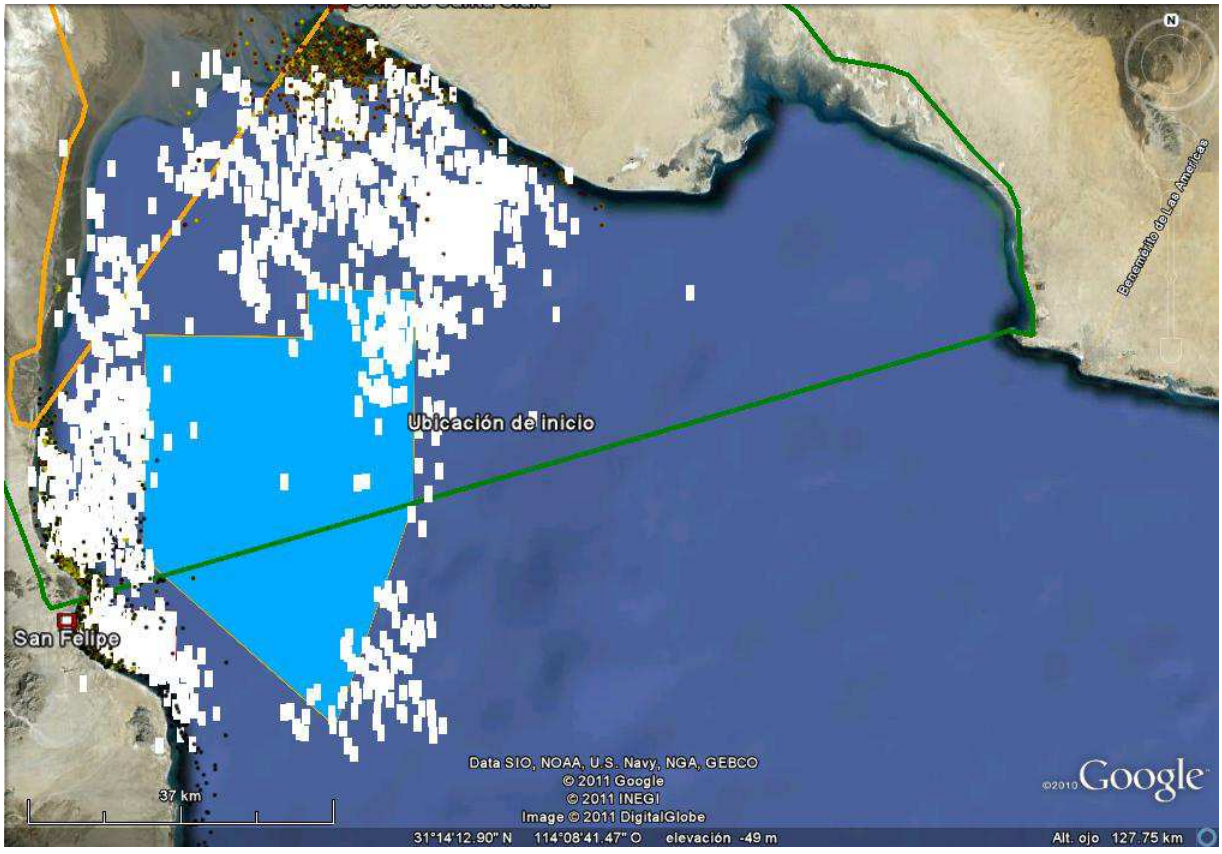

Fig. 1. One-day composite of maximum fishing effort around the edges of the Vaquita Refuge in the 2008-09 shrimp season, based on observer data, courtesy of Daniel Aguilar.

The Red Selectiva has been proven effective in catching shrimp. Because of the direct conflict with gillnet fishermen for space to maneuver during daylight hours, the majority of 907 experimental trips were conducted at night. These nocturnal tows caught brown shrimp. Only in

the last year have daylight tests been conducted for blue shrimp. In those trials the trawls caught on average 15 kg of blue shrimp per hour. The average catch per trip was 37-42 kg with trawl nets and one tow of one hour produced more than 100 kg of blue shrimp. These nets exceeded the per-trip performance of gillnets.

Aguilar and INAPESCA have concluded that these trawls present a viable alternative to replace shrimp gillnets. INAPESCA does not intend to conduct further testing of the trawls, and hopes to move into a phase of encouraging their adoption. They would like to implement a training program for fishermen who want to swap out gillnets for trawl nets in the next shrimp season. This intention may be supported by including provisions that allow the use of small trawl nets in the current update of federal regulations for artisanal shrimp fishing. Also, according to Aguilar, immediate action to enforce the current length limit on gillnets is necessary to give fishermen using the small trawls better opportunities to catch blue shrimp.

CIRVA **recommends** that conversion to the use of prototype trawl nets for catching shrimp proceed as rapidly as possible, but also that work continue on the testing and development of improved gear design and deployment.

CIRVA **recommends** that prototype trawl nets towed by pangas be legally permitted or certified by the relevant authorities immediately and that their use in the vaquita's range becomes mandatory in place of gillnets for shrimp by no later than 1 September 2015.

As a part of that transitional process, training programs designed to educate fishermen in the use of small trawl nets should be created and implemented, and participation in such a program by persons receiving a small-trawl fishing permit should be strongly encouraged.

CIRVA **recommends** that interim spatial management measures be implemented during the small-trawl phase-in period from 2012-2015, a time when gillnets and small trawls may both be present on some of the fishing grounds. Such measures should offer access incentives to encourage shrimp fishermen to use small trawls rather than gillnets.

Aguilar presented further information on the large number of illegal oversized gillnets that completely filled the fishing area of the Upper Gulf of California, leaving no space to fish or test other gear. In an observer-based study of how the length of gillnets is related to catch of shrimp, researchers found that large catches of over 100 kg per set were extremely rare in gillnets. Most catches were in the range of 5-20 kg per set. There was no relationship between gillnet length and the size of the catch per set. Thus, despite the use of longer nets there is no apparent economic reason to use a net more than 200 m long.

Responding to a question of whether the increase in length of gillnets in the last decade may have completely offset the beneficial effects of reducing the number of pangas through buy-outs and other incentive programs, Aguilar and others confirmed that the total length of individual

gillnets in the water has increased greatly and that fishermen are generally setting 2 or 3 nets at once, in some cases even more.

Questions were raised as to whether the current review process of NOM-002 for shrimp gillnet fisheries would change, eliminate, or maintain the current gillnet length limits. Meeting participants felt that the overall goal of PACE-Vaquita was to eliminate gillnets and that setting or condoning any lengths besides that specified in current regulations would imply unwarranted support for gillnetting.

CIRVA has repeatedly recommended the elimination of all gillnet fishing within the vaquita's entire range. CIRVA recognizes the enormous efforts and considerable funds expended by the Government of México to reduce the number of gillnetting permits in and eliminate unpermitted fishing in the northern Gulf of California. Nonetheless, we are still concerned that the gains made by reducing the number of permitted vessels may have been lost because of increases in the size and number of nets being fished by the remaining permit holders. Information presented at this meeting showed that the mean length of fishing nets has increased to approximately 1000 m, which is five times the legal limit of 200 m for shrimp gillnets. Also, it was reported that most pangas currently fish two or three nets rather than the one net that is legally authorized. An additional issue is the lack of net length limits for most finfish fisheries, and the variability in length limits given on permits for the same fishery. CIRVA **recommends** immediate and sustained enforcement of the legal limits on the number and length of nets per vessel, where such limits exist, and that boats with longer nets or more than one net should not be allowed to be launched and should be cited as in violation of the law. Further, CIRVA **recommends** that net length limits be established for all finfish fisheries and that length limits be reflected on permits. CIRVA also **reiterates its recommendation** that all gillnets and other entangling nets be eliminated within the range of vaquitas.

Small artisanal trawl nets are being proposed as a vaquita-safe alternative to gillnets. Gearhart felt that vaquita by-catch would be rare in these trawls because of the small size of the net and the slow speed of towing. The Turtle Excluder Device provides some chance of escape if an animal is entrapped. Barlow added that vaquitas avoid boats with engines underway. Gearhart further explained that cetacean by-catch problems in the northeastern United States trawl fisheries occur mostly in large trawls when marine mammals enter the trawls to feed.

Nevertheless, there is continued general concern about the use of trawl nets in fisheries because of the level of by-catch and because of damage to the benthos that can result from trawling. Aguilar and Gearhart explained that by-catch levels can be reduced by careful net design and skilled operation of a trawl. The ratio of by-catch to shrimp catch reported in some of the recent series of gear trials was high because the nets were being tested in unfamiliar conditions and by inexperienced operators. Among about 20 fishermen currently working with the new trawls, by-catch has been reduced to low levels. In the case of by-catch, there is also potential, in the Upper

Gulf, to sell or consume the by-catch. One participant noted that if there is going to be a shrimp fishery in the Upper Gulf, there will always be some level of by-catch.

With regard to the impact of these small or light artisanal trawls on the benthos, Aguilar and Gearhart explained that they are designed to trawl above the bottom. They have a footrope to trigger avoidance by benthic fish and fish excluders to allow entrapped fish to escape. Moreover, their chains and doors are lighter than those of large commercial trawls, meaning they cause less impact on the bottom. The experts also noted that the soft-bottom communities of the Upper Gulf are more resilient to trawling than hard-bottom communities elsewhere. It was acknowledged that although development of these trawls was intended as a way of promoting and facilitating the elimination of gillnets that entangle vaquitas, there is still a need to monitor and manage the impacts of trawling on the bottom communities of the Upper Gulf over the long term.

At its previous meetings, CIRVA has consistently recommended against trawling in vaquita habitat. At those times, members had in mind industrial trawlers, which are known to be responsible for at least occasional by-catches of vaquitas. Nothing was learned at the present meeting that would allay the committee's previously expressed concerns and recommendations in regard to industrial trawlers. However, given the encouraging recent development and trials of small-scale artisanal trawl nets for shrimp fishing, it is important to clarify that CIRVA fully supports the idea of converting the artisanal shrimp fishery from gillnetting to trawling with small (light) trawl nets as described in this report.

Technology Transfer

Patricia De Beze described the elements of effective technology transfer programs. This led to discussion of methods and messages that can be used to get fishermen to adopt new gear. There was general agreement that fisherman-to-fisherman interactions, such as the ability to observe directly what works and what doesn't within a fisherman's own community, is the most effective means of introducing new technology. Aguilar observed that getting fishermen interested in new gear is not easy and that training and adoption take time and effort. The fishermen in the Upper Gulf are accustomed to using gillnets and many don't know how to fish with more complex equipment. Only a few have mastered the concept of trawling, but those who have are doing well. They catch brown shrimp regularly and blue shrimp when they can. There is resistance by gillnetters to this new fishing method. WWF reported that some gillnetters have actively obstructed the efforts of the 17-20 fishermen who use the prototype trawls.

With regard to financial incentives, Ramírez noted that artisanal trawls may not be as economically viable as gillnets, but economic viability aside, such gear conversion is required to address a severe environmental problem – the risk of causing the extinction of the vaquita. The focus is on developing technology that allows fishermen to catch shrimp without catching vaquitas, part of a process that began with limiting gillnets and encouraging 'vaquita-safe' fishing practices. Concern was expressed about the possibility that the ongoing process of

modifying the shrimp fishery regulations could lead to changes in, or even elimination of, the length requirements for gillnets. While there was continued agreement that gillnet use needs to be eliminated within the range of vaquitas, it was also recognized that this would need to be accomplished through a phased, but mandatory, process involving a transition to use of the prototype artisanal trawl nets. From its inception, PACE-Vaquita has been geared towards such a phase-out of gillnets so participants felt it would not come as a surprise to fishermen. Also, it was anticipated that with 500 million pesos invested thus far, further funding would be available to help make the changeover. Conversion of 700 boats was judged to be reasonable in a five-year period of time, and it was hoped that budgets could be developed to make this happen.

The prototype trawl net developed by INAPESCA has been shown to be efficient for catching both brown and blue shrimp. Optimal operation of this new net is not compatible with drift gillnets of more than 200 m or even with a very high density of 200 m driftnets. Given that the Mexican standard for shrimp fishing is under review, CIRVA **recommends** that the National Fisheries and Aquaculture Commission include the prototype trawl net in the standard and mandate a gradual transition from gillnets to the new trawl net, at a suggested rate of no less than 20% a year over the next five years. In the meantime, **it is essential that the Commission reconfirm and enforce** the existing limit on the length of gillnets of no more than 200 m and that it take action to enable the proper operation of the new trawl gear, such as establishing areas, seasons, or periods of the day for exclusive use of the prototype trawl nets. In addition, CIRVA **recommends** that INAPESCA begin a technology transfer program for making these changes feasible and acceptable in fishing communities. Finally, the idea of phasing out gillnets in favour of alternative vaquita-safe fishing gear **should be extended** to other fisheries within the vaquita's range, such as those for finfish and sharks.

CIRVA **recommends** that research on alternative fishing gear for fin fishing not only continue but accelerate. Once gear that qualifies as vaquita-safe is found to be economically viable, a 2-year phase-in process **is recommended**, as follows:

In Year 1,

- legally certify the gear and create a permitting system for it
- begin training fishermen in how to use the gear
- designate areas for exclusive use by fishermen according to the number using gillnets vs. the number using the new vaquita-safe gear.

In Year 2,

- continue training and permitting
- reconfigure the exclusive-use areas such that those where gillnetting is allowed are greatly reduced and restricted to areas thought to be of lowest use by vaquitas.

Regardless of the state of development of vaquita-safe finfish fishing gear, gillnets **should be banned** from the vaquita's range by 1 September 2016.

Trends in Vaquita Numbers Based on Acoustic Data

Jaramillo-Legorreta presented the results of acoustic monitoring and what they tell us about trends in the vaquita population through time (see Appendix 1). Management authorities need to have some way of determining what recovery of the population would look like and therefore it is important to have an estimate of initial (pre-bycatch) population size, depletion level (approximate ratio of present to initial population size), and a target population size for recovery. From modeling, Jaramillo-Legorreta estimated the maximum rate of increase for vaquitas at about 3%/yr. He then concluded that: (a) the population was probably about 5,000 in 1941, prior to fishing with large-mesh gillnets for totoaba; (b) the current population may be around 2% of its historical level; and (c) recovery to a population size comparable to the maximum sustainable yield level would require that it reaches about 50% of K, i.e. around 2,500 individuals. It will certainly take at least tens of years to achieve such recovery.

Following the presentation, there was discussion of the socio-economic consequences of a complete ban on fishing with gillnets and other entangling nets within the range of the vaquita. Several meeting participants noted that according to socio-economic studies, the communities of San Felipe and Puerto Peñasco would likely be better able than El Golfo to adapt to a major loss of fishing livelihoods. However, it was emphasized, once again, that elimination of fishing has never been part of the vaquita conservation agenda. Rather, the objective has been to enable those individuals wishing to continue fishing to do so in ways that do not put vaquitas at risk.

Current Population Size Estimates

Tim Gerrodette presented the published results of the 2008 vaquita survey (Gerrodette et al. 2011; see abstract in Appendix 1), indicating that there were approximately 245 vaquitas (CV = 73%, 95% CI 68–884) at that time. This estimate is 57% lower than the 1997 estimate, an average rate of decline of 7.6%/yr. Importantly, only about half of the estimated population was in the Vaquita Refuge, meaning that on average half of the population remains exposed to the risk of by-catch in artisanal gillnets.

During discussion it was noted that the greater precision of the estimate for the Refuge area compared with the overall survey area was due to the relatively greater effort and higher vaquita encounter rate there. It is important to recognize that the effective search width of visual transects is about ten times that of acoustic tracklines. This needs to be borne in mind when comparing effort between areas; the amount of effective survey coverage in the shallow northern and western parts of the survey area, which were surveyed acoustically in 2008, is therefore much less than it appears to be when simply compared with the visual survey tracklines in the deeper areas (Gerrodette et al. 2011, their Fig. 2).

Barlow called attention to the lower end of the 95% confidence interval of the 2008 estimate, which might be interpreted as a worst-case scenario – in other words, only about 70 vaquitas could remain. It reinforces the urgency of making greater efforts to reduce the by-catch to zero.

In response to a question of whether vaquitas undertake seasonal migrations, it was noted that the previous surveys in 1993 and 1997 had covered a much larger area than the 2008 survey but no vaquitas had been observed outside the area surveyed in 2008. Also, the acoustic monitoring results have demonstrated that vaquitas are present in the survey area year-round. Although the animals clearly range widely within the known species range, there is no reason to think the 2008 survey failed to account for the entire population.

Gerrodette noted that more may be learned in the future about the distribution of vaquitas from the acoustic monitoring efforts and this could allow for improvements in abundance estimation.

Acoustic Monitoring

Jaramillo-Legorreta presented a summary of INE's efforts to develop an acoustic monitoring program for vaquitas in the Upper Gulf (Appendix 1 for details). This work, which primarily involves the installation of autonomous acoustic recorders in the Vaquita Refuge, has provided a valuable and cost-effective means of assessing population trends. CIRVA expressed appreciation for the efforts of the international team of scientists responsible for designing and implementing this innovative monitoring method and emphasized that the monitoring is critical for maintaining a focus on the vaquita's perilous condition. The meeting was informed that a large percentage of the passive acoustic monitoring devices (C-PODs) had been lost from the perimeter buoys marking the Refuge boundary. This was believed to be the result of either the buoys becoming fouled in fishing gear or the C-PODs being stolen outright, possibly a combination of the two. CIRVA hopes funding can be found to replace lost equipment and that monitoring within the Refuge will improve with greater enforcement effort.

The meeting was advised of an initiative led by Jonathan Gordon to use a large sailboat to obtain acoustic data on vaquitas in the shallow waters of the northern reaches of the Upper Gulf. It was understood that funding for this work would come from external sources. Obtaining such data is a very high priority because little is known about the extent to which vaquitas use these areas.

CIRVA welcomes this initiative by Gordon and **recommends** that relevant permitting agencies facilitate it. At the same time CIRVA **recommends** that the ongoing efforts led by Jaramillo-Legorreta be continued and expanded in two principal ways: (1) by installing more detectors in parts of the Vaquita Refuge where high densities of vaquitas have been observed but relatively little acoustic data has been obtained to date, and (2) by developing ways to obtain more acoustic data from shallow areas in the northern reaches of the Upper Gulf, possibly through arrangements with fishermen who are willing to install acoustic devices on their nets.

In general, there is a need for expanded monitoring of vaquitas in areas outside the Vaquita Refuge and within the known normal range of the species. CIRVA **recommends** that every opportunity be taken for wider monitoring, e.g. using a combination of fixed passive acoustic gear and active towed acoustics recorders, using time/area closures for monitoring in summer months.

A Proposal to Reduce Fishing Effort in the Upper Gulf of California

Gerardo Rodriguez described a proposal to reduce fishing effort in the Upper Gulf of California. Data from a questionnaire survey of fishermen and fishing authorities conducted from 2005 to 2007 were used in a modified production model to characterize vaquita populations under different scenarios. The scenarios that included fishery bans or reductions in numbers of artisanal vessels resulted in increased vaquita populations.

In discussion, it was suggested that besides increased buy-out compensation and more investment in human capital, a third option for reducing by-catch (and therefore allowing the vaquita population to increase) is to get fishermen to switch from using gillnets to using alternative fishing gears such as *suriperas*. However, it was acknowledged that *suriperas* are less efficient than gillnets at catching shrimp and also that many fishermen prefer gillnetting because it requires less experience and skill than fishing with suriperas and other alternative gears. A subsidy on prices of shrimp caught with alternative gear might be one way of encouraging fishermen to switch, but it was emphasized that this kind of market intervention only works well if it is consumer driven, e.g. if consumers are prepared to pay a premium on shrimp caught with the less efficient but more 'environment-friendly' gear. Also, avoiding the problem of fishermen transferring products between pangas could be difficult because of the prevailing low levels of surveillance and enforcement.

Ramírez described how personnel from CONANP and INE had conducted a survey of fishermen to find out what kinds of alternative activities to fishing were of interest to them. He also pointed out that fishermen who received buy-out compensation were required as part of their agreement to invest in alternative employment, and that one of the goals of PACE-Vaquita was that fishermen be allowed to continue fishing but with alternative gears. Rojas-Bracho added that CEDO had previously conducted a fisherman survey similar to that reported by Rodriguez and that although many of the ideas presented at this meeting had been under consideration for a number of years, making them operational was an ongoing challenge. Rodriguez indicated an interest in incorporating into his model the newly available data and the suggestions made at this meeting, noting that his modeling work as presented pre-dated the implementation of PACE-Vaquita.

Likelihood of Success of Three Options for Protection of the Vaquita

Gerrodette presented his work with Rojas-Bracho (Gerrodette and Rojas-Bracho 2011) on modeling three options for protection of vaquitas, from enforcing the current Refuge to completely protecting vaquitas throughout their range (Appendix 1). He used data on abundance, by-catch, and spatial distribution and fishing effort and a simple population model to try to estimate probable success of the different options. He modeled the density of vaquitas and the density of nets, using the assumptions that (a) by-catch is the most important threat factor, (b) there is perfect enforcement, and (3) there is no change in the relative distributions of vaquitas and fishing effort. The first option of maintaining the current Refuge and current levels of protection has a low probability of success. The second option, which expands the Vaquita Refuge but still does not protect the animals throughout their entire range, has a higher probability of success but still less than 50% (i.e. it is more likely to fail than to succeed). Only Option 3, which protects vaquitas from by-catch throughout their range, gives a prediction of 100% probability of population increase. Gerrodette also modeled the consequences of delayed implementation. A five-year delay of implementing complete protection reduces the chance of success by 2018 to 50%. Partial implementation of by-catch reduction measures also reduces the chance of success. Gerrodette reminded the group that we are already three years past the 2008 abundance estimate and that with the by-catch situation unchanged, the projected current abundance is 190 animals at the end of 2011. This may be optimistic given continued gillnetting, the apparent increase in amount (length) of gillnetting in the water, and the ongoing illegal fishing in the Refuge.

Gerrodette was asked whether a number of other factors such as imperfect enforcement, delays in retiring fishing gear, and different levels of fishing effort could be incorporated into the model. He indicated that they could if data were available.

The discussion turned to how to communicate the critical timeline for getting gillnets out of the water and what metric might be used to describe a critical threshold beyond which vaquitas will not be able to recover. In this context the group agreed it was important to provide the 2011 population estimate of 190 to decision makers. Although CIRVA has made very strong statements in the reports of previous meetings about the imminent risk of extinction of the vaquita, information from the 2008 survey strongly reinforces the direness of the vaquita's situation. It is unclear whether a further large analytical investment is necessary or warranted given how compelling the available information already is.

Small populations have inherent risks, such as inbreeding depression and increased variability in population growth rates that can accelerate the decline to extinction. These cumulative, interacting risks can lead to a point of no return where the population has lost its ability to recover. For most species, including the vaquita, there are no data to indicate what that point might be. Because of the importance of avoiding inbreeding depression, Jaramillo et al. (2007) set that number at 50 reproductive individuals for vaquitas. This is the number needed to retain

reproductive fitness (Franklin 1980). Approximately half of the vaquitas would be expected to be adults, so the threshold of total abundance (all ages) would be about 100. Gerrodette used his model to estimate the probability of reaching 100 animals for two scenarios: the case where no conservation measures are taken (the situation in 2007) and the case using the current number of pangas using gillnets in San Felipe and El Golfo de Santa Clara (750 as documented by CEDO for the Environmental Impact Assessment; see later). The model indicates that with current measures and assuming perfect enforcement, the vaquita has a 19% chance to reach that point of no return in the next five years (by 2017) (Figure 2). Since illegal fishing is known to occur within the Refuge (i.e. enforcement is not perfect), this estimate is certainly optimistic. The model also shows that current measures have been effective (but not sufficient) because without them there would have been a 74% chance of reaching 100 individuals by 2017 (Figure 2).

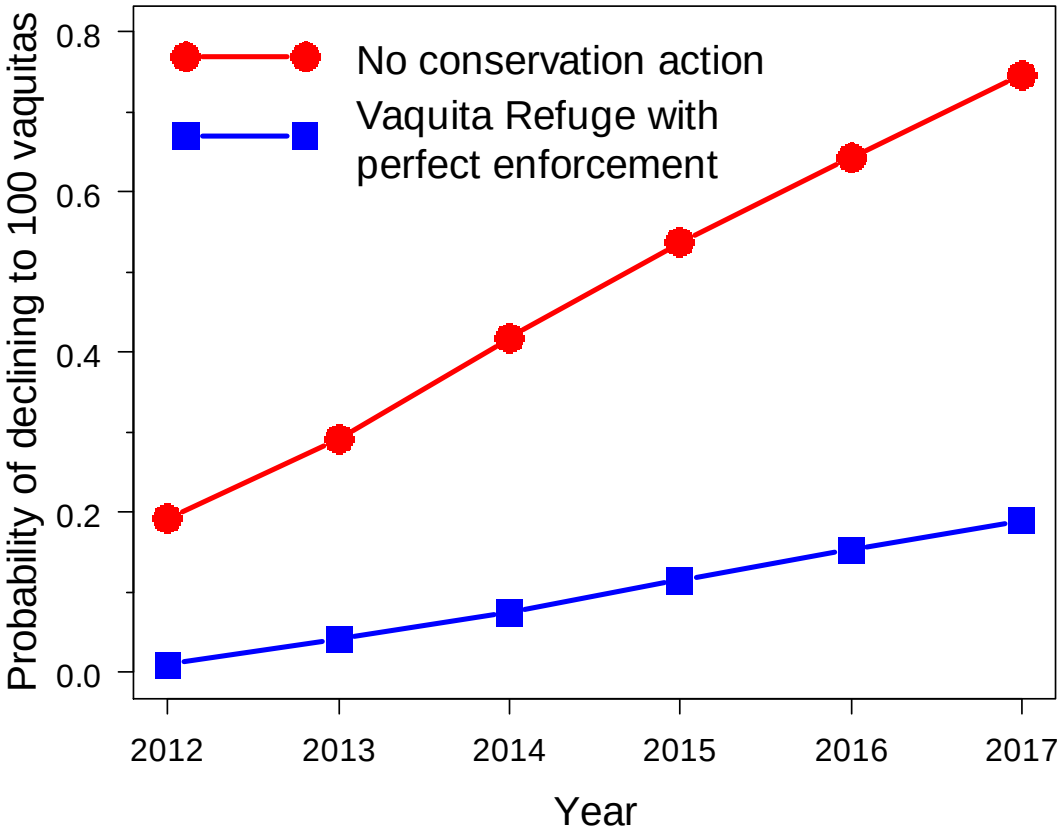

Figure 2. The probability of reaching 100 remaining individuals with no conservation action and with full protection in only the Vaquita Refuge. Note that enforcement within the Refuge is assumed to be perfect and therefore the lower line is optimistic.

The committee concluded that, based on the 2008 survey results, complete protection of vaquitas might not require inclusion of Puerto Peñasco in the Option 3 design. Therefore, CIRVA **recommends** that only vaquita-safe gear (see definition of 'highly selective' above) be allowed for fishing in the primary area of vaquita distribution, which is defined as the area to the north of 30.7°N latitude and west of 114.25°W longitude (Fig. 3). This implies a change to the configuration of the Vaquita Refuge, a change that would be in keeping with the widely accepted principles of adaptive management. Gerrodette and Rojas-Bracho (2011) showed that their Options 1 and 2 were insufficient to stop the population decline. Option 3 would stop the decline but so would this newly proposed area which is the minimum area to contain all vaquita detections and is considered to represent the species' full range. To be clear, CIRVA **recommends** that the boundaries of the Vaquita Refuge be changed to reflect the configuration shown in Figure 3 of this report.

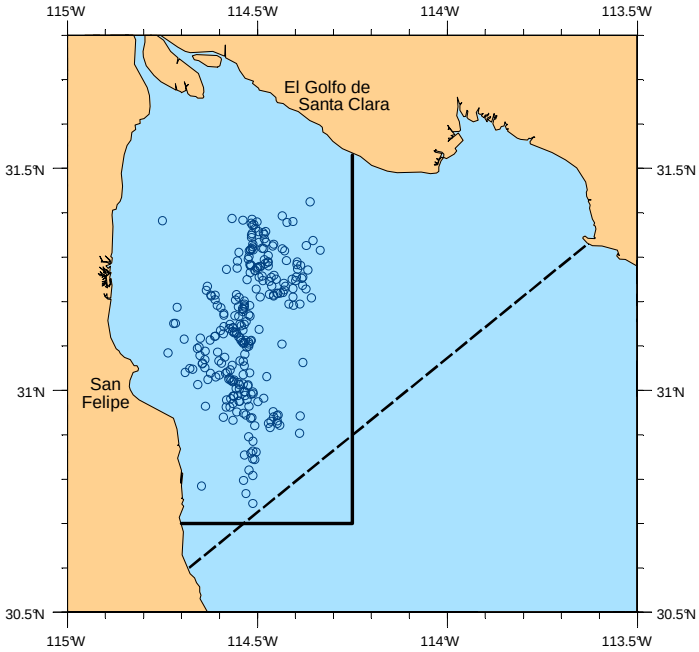

Fig. 3. The dashed line is the boundary proposed as Option 3 in the PACE-Vaquita plan. It is assumed to include the entire current vaquita population. The solid line is an alternative that also probably contains the whole population. The probability of success of this protected area can be considered to be the same as Option 3 of Gerrodette and Rojas-Bracho (2011).

CIRVA **recommends** that analyses be conducted with all available data to improve understanding of micro-habitat use by vaquitas within their range, e.g. differential habitat use by season, tide, etc. Together with data on the location and magnitude of fishing effort, more precise assessments could be made of the vaquita's conservation status.

Ecosystem Health

Salvador Galindo presented information on the impacts of Colorado River flow on the productivity of the Upper Gulf of California (Appendix 1). He emphasized that although by-catch mortality is the main problem for vaquitas, other changes in the environment are also serious problems and may be more difficult to observe and document. He stated that times of high water flow from the Colorado River were correlated with high nutrient concentrations, high primary productivity, and high biomass and that the ecosystem responded to Colorado River flows. He suggested that loss of inflow from the Colorado River had led to changes in the ecological conditions of the Upper Gulf.

Barlow pointed out that environmental quality should be reflected in the condition of the animals, and that by-caught vaquitas generally appear healthy. He also noted that sharks are in worse shape than vaquitas in the Upper Gulf so predation is unlikely to be a significant factor in preventing or slowing recovery of the vaquita population. Morzaria reported that in modeling the Upper Gulf ecosystem, in the absence of fishing pressure but with increased predation, the vaquita population still was projected to increase. Rojas-Bracho noted that everyone agrees the health of the environment must be protected, but that for vaquitas, by-catch is the largest concern and he questioned how low productivity of the Upper Gulf might be related to their survival rates or reproduction. Jaramillo-Legorreta commented that as the vaquita population recovers, the environment could become a limiting factor, but the population is far too small for this to be a problem at present.

Saúl Alvarez-Borrego presented a differing view from that of Galindo on the factors that influence the productivity of the Upper Gulf (Appendix 1). The Gulf of California has a very strong self-fertilization mechanism, through the exchange of water and nutrients with the Pacific Ocean, driven by the kinetic energy of tides, currents, and upwelling. In the warm, clear atmospheric conditions of the Gulf, the water gains heat which is exchanged through circulation of Pacific water. Water that enters the Gulf is nutrient-rich. It is estimated that the Gulf receives 100 times more nutrients from the Pacific Ocean than what used to come from the rivers when they flowed freely. In terms of nutrients and chlorophyll, the Upper Gulf is in good health. There is a net input of millions of tons of nitrogen from the Pacific, so the ecosystem does not really need the nutrients from the rivers. In addition to the nutrient input from the ocean, sediment (nutrient) mobilization still occurs in the mouth of the Colorado River through erosive processes of tidal and wave action.

In response to a question on whether we can conclude that dams have had no effect, Alvarez-Borrego acknowledged that the Colorado River dams have had major ecological impacts, notably on plants and molluscs that depend on estuarine conditions. However, in his view, concerns over impacts on totoaba have been misplaced. He cited a recent publication that found no correlation between juvenile totoaba and salinity. He challenged Galindo's assertions that the loss of freshwater input had caused reductions in fish catches in the Upper Gulf, noting that shrimp fishing results in the deaths of hundreds of thousands of juvenile totoaba every year. Shrimp fishing, according to Alvarez-Borrego, has a much greater impact on the Gulf ecosystem than the loss of freshwater flow. He argued that putting undue emphasis on the issue of dams risks deflecting attention away from the by-catch problem. Also, he stressed that the vaquita is a Mexican species and that if the Upper Gulf of California Biosphere Reserve is going to be a reserve in more than name only, the vaquita must be protected there.

Atlantis Ecosystem Model

Minimizing by-catch threats involves trade-offs between maintaining viable populations and economic benefits. Hem Morzaria described the use of the Atlantis ecosystem model for strategic assessments of the effects of spatial management, gear switching, size limits, and other management actions on ecological and socio-economic outcomes in the northern Gulf of California. The model represents ecosystem structure and function in 2008, simulating biological interactions among ecosystem components in 66 polygons in seven depth layers in the northern half of the Gulf. These biological processes are then affected by human activities. The model contains data for all aspects of fisheries in the region. Diet, reproduction (age structure), by-catch, predation (pelagic sharks), and spatial distribution are simulated for vaquitas and other endangered species represented in the model.

Researchers modeled the effects of spatial management actions in the Upper Gulf Biosphere Reserve on vaquita abundance. As with the work of Gerrodette and Rojas-Bracho (2011), they looked at increasingly strict management options, and, as in that work, they found that only the third option of total protection throughout the range of vaquitas leads to an increase in the population. Such protective measures also resulted in increased biomass of other species of conservation concern, but also in decreased value of the shrimp harvest that was not offset by economic gains.

Morzaria discussed a number of more detailed findings of the model that are described in Appendix 1.

In response to questions, Morzaria said that existing parameters could be modified based on discussions at the meeting and using additional data to more accurately reflect current understanding of by-catch pressures. More work could also be done to validate the model, in particular for population size and by-catch levels back to 1985.

CIRVA **recommends** that a validation exercise be conducted in the Atlantis model, specifically to determine what abundance results in 2008 if the model starts with the vaquita abundance estimate from 1997.

This model was developed as a tool for ecosystem-based management. The results of modeling full compliance with fisheries have been presented to CONAPESCA.

In response to a question about possible environmental limitations, Morzaria reported that they had "driven the population of vaquitas up to a few thousand" in the model and found no food limitation. She commented that vaquita prey species remain abundant regardless of by-catch from fisheries. Similarly, modeling of potential shark predation found that sharks are fished very hard and are not a significant cause of natural mortality of vaquitas.

Environmental Impact Assessment for Small-scale Fishing in the Upper Gulf of California and Colorado River Delta Biosphere Reserve

Sergio Perez Valencia of Centro Intercultural de Estudios de Desiertos y Océanos, A.C. (CEDO) presented a detailed summary of the development and implementation of an Environmental Impact Assessment (EIA) for Responsible Small Scale Fishing in the Upper Gulf of California and Colorado River Delta Biosphere Reserve (see Appendix 1 for details). Such an assessment is required for economic activities inside a Marine Protected Area or when such activities may have impacts on endangered species. The EIA guides decision makers in establishing conditions for the conduct of those activities. The present EIA involves the fishing communities in Puerto Peñasco, El Golfo de Santa Clara, and San Felipe, nine fisheries, and 27 target species.

CEDO was asked by fishermen to support their efforts to comply with measures established for them in their 2009 fishing authorization to continue fishing in the Reserve. One of these conditions was to develop a new EIA that ensures the impacts of fishing will be mitigated in the short, medium, and long term. In May 2010 CEDO agreed to work with fishermen in a three-year process that will include development of new EIAs and implementation of mitigation measures. In carrying out this work, the participants are committed to approaches and measures that are legal, transparent, participatory, technically sound, realistic, and adaptive. Development of the new EIA is underway and it should be completed and approved by May 2012. In the meantime, mitigation measures are being implemented. These include getting fishermen to use logbooks, associated education and training in logbook use and other skills, deploying onboard observers, waste management, and encouraging social participation and community involvement.

The EIA requires development of a list of legal pangas, and CEDO has documented the number of boats and permits for each community. Perez described efforts to implement the logbook program, the observer program (290 trips observed by trained observers to date), and other elements and presented the list of 26 mitigation measures required for the fishery. Among those related to vaquitas are the ban on fishing in the Refuge and the commitment to switch fishing

gear once INAPESCA announces that this is required, regardless of whether the relevant fishery laws or regulations have been changed. The goal of this process is to create a fishery management system that is functional, provides a positive incentive system, and fosters increased stewardship and compliance on the part of the fishing communities themselves. A very important component will be enforcement, which is meant to provide negative incentives for lack of compliance. Fishermen are responsible for implementing the mitigation measures. Monitoring of compliance and catches provides feedback on the fishery that can allow adaptive changes in short timeframes.

Meeting participants sought clarification of whether under the EIA, the prohibition against fishing in the portion of the Vaquita Refuge outside (south of) the Biosphere Reserve was a legal requirement or voluntary. It was stated that the wildlife law links the Reserve and the Refuge and it is illegal to fish in any part of the Refuge. Clarification was also sought on the question of what a fisherman is expected to do in the event that a vaquita is accidentally caught in a net. Perez explained that the fisherman is required to return it to the sea. While the prohibition on being in possession of an endangered species makes sense as a general principle, such specimens are valuable for scientific (and management) purposes. Therefore, CIRVA **recommends** that a way be found to make an exception in the case of by-caught vaquitas so that fishermen are encouraged to turn dead vaquitas found in their nets over to authorities for scientific study, without penalty.

CIRVA also **encourages** efforts by CEDO and others to provide training in alternative livelihoods to people in the three fishing communities. This is a longstanding recommendation of virtually all policy advice documents related to vaquita conservation, but it deserves encouragement and reinforcement.

In response to a question on whether fishermen are complying with the 200 m gillnet requirement, Perez reported that some progress was being made with at least a small portion of the panga fleet.

It was noted that the list of legal vessels from different communities did not match up with previously published numbers from CONANP. Participants then discussed the difficulty of developing comparable lists for different time periods and for vessels that participate in multiple fisheries. They agreed to work together to develop more realistic numbers to plug into the various models.

Ramírez (CONANP) recognized and thanked CEDO for its work and recognized the efforts of the fishermen who have only recently had experience with the kind of permitting and regulations brought by PACE-Vaquita. He noted that the Upper Gulf was the only place in Mexico where such a significant and serious process was happening.

Peggy Turk of CEDO noted that while mitigation measures under the EIA are helping address the spatial extent and time of fishing, they may not be adequate for addressing the immediate

risks to vaquitas. The EIA reconfirms current law and in her view, major strides are being made through this management system and its focus on developing a culture of compliance. However, Turk emphasized that as CEDO works with fishermen to comply, it is essential for law enforcement agencies to do their job.

Finally, Rojas-Bracho drew attention to the government's role in setting up and enabling the EIA process.

Upper Gulf Artisanal Fisheries Studies

Brad Erisman presented work on spatio-temporal interactions of fish, fisheries, ecosystems, and managed areas in the Upper Gulf of California (Erisman et al. 2012). This work, which initially focused on the curvina fishery at and near the spawning areas in the Colorado River Delta, has been expanded to blue shrimp, chano, and sierra as fished by fishermen from El Golfo de Santa Clara. A key element of this work, that may be promising for understanding and monitoring other fisheries in the Gulf, was the use of GPS data loggers to track vessel activity. The work is being expanded to San Felipe. There is potential for collaboration with the passive acoustic monitoring research on vaquitas. For example, it may be possible to add detectors for croakers to learn more about these fish, which are important to the fisheries. Better understanding may be used to improve trap or pot fisheries.

Letter to President of Mexico

CIRVA **recommends** that this report be sent to President Calderón (copies to Ministers of Agriculture and Environment) with a cover letter that commends the President and his administration for their unprecedented commitment to conservation of the vaquita. It should also make clear that more needs to be done and that immediate further investment in conservation measures is essential if the gains made to date are not to have been in vain. It should stress that the recent availability of an alternative method of catching shrimp provides the opportunity for a real breakthrough in the struggle to reduce vaquita by-catch, and without precluding fishermen in the Upper Gulf from pursuing their livelihoods.

Adoption of Report

A complete draft of the report was reviewed and adopted by all meeting participants on 23 February 2012. It was agreed that Reeves would incorporate comments and corrections and carry out final editing, with help from Taylor and Rojas-Bracho, in the days immediately following the meeting.

Acknowledgments

Participants thanked Rojas-Bracho for his vigorous chairmanship and for his lead role in organizing the meeting, and they also gave special thanks to Edwyna Nieto García of CICMM,

INE, CICESE in Ensenada for her efficient and cheerful support to the meeting, Darel Jordan of the US Marine Mammal Commission for her help with participant travel arrangements, and Tim Ragen of the Marine Mammal Commission for his steadfast support of CIRVA and vaquita conservation, in many ways and over many years. Also, special thanks to the major funders of the meeting –World Wildlife Fund-Mexico, the US Marine Mammal Commission, and the Instituto Nacional de Ecología.

REFERENCES CITED

Erisman, B., Aburto-Oropeza, O., Gonzalez-Abraham, C., Mascaren˜as-Osorio, I., Moreno-Ba´ez, M. and Hastings, P.A. 2012. Spatio-temporal dynamics of a fish spawning aggregation and its fishery in the Gulf of California. Scientific Reports 2:284. DOI: 10.1038/srep00284.

Franklin, I.R. 1980. Evolutionary change in small populations. Pages 135-150 in M.E. Soulé and B.A. Wilcox, editors. Conservation biology: an evolutionary-ecological perspective. Sinauer Associates, Sunderland, Massachusetts.

Gerrodette, T. and Rojas-Bracho, L. 2011. Estimating the success of protected areas for the vaquita, *Phocoena sinus*. Marine Mammal Science 27(2): E101–E125.

Gerrodette, T., Taylor, B.L., Swift, R., Rankin, S., Jaramillo-Legorreta, A. and Rojas-Bracho, L. 2011. A combined visual and acoustic estimate of 2008 abundance, and change in abundance since 1997, for the vaquita, *Phocoena sinus*. Marine Mammal Science 27(2): E79–E100.

Jaramillo-Legorreta, A., Rojas-Bracho, L., Brownell, R.L., Jr., Read, A.J., Reeves, R.R. Ralls, K. and Taylor, B.L. 2007. Saving the vaquita: immediate action, not more data. Conservation Biology 21(6):1653-1655.

Table 2. Review of progress towards implementation of measures previously recommended by CIRVA and/or PACE-Vaquita. The subjective judgment categories under "Success" are: H = high, M = Medium, L = Low, N = None (with the Success rating given in the 2004 CIRVA report in parentheses). Colors indicate: black--recommendation from CIRVA II and still relevant, red--recommendation of CIRVA II but current recommendation differs, blue--current recommendation only.

Recommendation	**Current situation**	**Success (H,M,L,N)**
1. The by-catch of vaquitas must be reduced to zero as soon as possible.	By-catch could have been reduced however there is uncertainty. Beginning in the late 1990s, the length of nets and the number of nets per panga have increased. However, the number of pangas was reduced by the buy-out in 2008-2010. There is also evidence for only partial enforcement of the Vaquita Refuge.	L (N)
2. The southern boundary of the Biosphere Reserve should be expanded to include all known habitat of vaquita.	The Vaquita Refuge, initiated in 2005, covers part of the range to the south, but not all. Fishing effort along the southern border of the Refuge where high densities of vaquita are known to occur is very high.	M (N)
3. Gillnets and [industrial] 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; • Restrict fishing activities to residents of San Felipe, El Golfo de Santa Clara, and Puerto Peñasco.	• Large-mesh gillnets banned in the Biosphere Reserve in 2002 and have not been used since 2007. • In 2012 the number of pangas has been reduced and capped (but probably at a level that still is similar to or exceeds the number of pangas in 2000). Get from Gerrodette. • Progress has been made in restricting fishing activities to local permitted pangas and trawlers. This restriction has been enhanced through requirements to conform to Environmental Impact Statements to fish in the reserve.	M (M)
Stage Two (to be	Reduced within Vaquita Refuge though	L[1] (L)

[1] Note that members feel that the past success rating should have been N, and that progress has been made on this recommendation.

Recommendation	Current situation	Success (H,M,L,N)
completed by 1 January 2001) • Eliminate medium-mesh gillnets (i.e. all except chinchorro de linea).	violations are frequent. Reductions have also occurred through the program to switchout from gillnets to vaquita friendly gear (e.g. longlines and pots). However, success rating is Low because effort with medium-mesh gillnets remain high in areas outside the Refuge where approximately half of vaquita can be found.	
Stage Three (to be completed by 1 January 2002) • Eliminate all gillnets and [industrial] trawlers.	Reduced gillnetting within Vaquita Refuge though violations are frequent. Industrial trawling within the Refuge is nearly eliminated. Rating is Low because effort with chinchorra de linea gillnets remains high in areas outside the Refuge where approximately half of vaquita can be found.	L [2](L)
PACE eliminate gillnets throughout the range of vaquitas by 2012	Reduced within Vaquita Refuge though violations are frequent. Rating is Low because effort remains high in areas outside the Refuge where approximately half of vaquita can be found.	L
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.	Progress has been made in terms of permits and reduction of un-permitted fishing. Trawlers are required to carry location devices (VMS). The Vaquita Refuge has been marked with buoys. Fishing (gillnet and trawling) within the Vaquita Refuge has likely been reduced after 2008. However, violations of limits on the length and number of nets/boat are widespread, have occurred for many years, and are a serious concern. Illegal fishing within the Vaquita Refuge is not uncommon.	M[3] (M)
5. Acoustic surveys should start immediately to (a) begin monitoring an index of abundance and (b) gather data on seasonal movements of vaquitas.	Acoustic surveys were done by Jaramillo-Legorreta from 1997-2007 and data indicated a decline in abundance and no evidence for seasonal movements.	H (H)
Acoustic monitoring should be continued to provide the evidence on	Initial data were gathered in 2008 to allow design of a monitoring grid and the first year of the 5-year program is complete and successful though	L

[2] Same comment as footnote 1.

[3] Note that members feel that the past success rating should have been L, and that progress has been made on this recommendation.

Recommendation	Current situation	Success (H,M,L,N)
whether vaquitas are recovering following PACE implementation	too much gear was lost to vandalism and illegal fishing. Further work is needed to monitor areas outside the Refuge. Low rating is given because only one-year has been completed of a 5-year program and it needs to be expanded.	
6. Research should start immediately to develop alternative gear types and techniques to replace gillnets.	Shrimp pots and suriperas were tested and failed. Several small shrimp trawls (RS-INP-MX) were tested and are viable fishing alternatives. Fin-fish traps are in an early testing phase.	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.	The Assessment and Monitoring Board (Organo de Evaluación y Seguimiento, 2008) was formed and includes: fishermen from San Felipe, Golfo de Santa Clara and Puerto Peñasco, academics from Baja California and Sonora states, state and federal governmental institutions from fisheries and environmental sectors and NGOs. The EIA for small-scale fishing in the Upper Gulf provides a structure for continued progress on this.	H(H)
8. Consideration should be given to compensating fishermen for lost income resulting from the gillnet ban.		
Buy-out	247 artisanal boats with 370 fishing permits out of the water (numbers from http://www.conanp.gob.mx/vaquita_marina/; go to Vaquita Marina page)	M
Biodiversity Conservation Actions	An average of 230 boats received compensation not to fish within the Vaquita Refuge Area (1,263 km^2) (http://www.conanp.gob.mx/vaquita_marina/). A Medium success rating was given because fishing within the Refuge is frequent and the overlap between violators and those receiving compensation is unknown.	M
Switch-out	230 pangas (including 247 permits) (http://www.conanp.gob.mx/vaquita_marina/) have participated in the switch-out to alternative 'vaquita-safe' fishing gear (in most cases presumably small trawls). A Low success rating is given because of uncertainty about whether all	L

Recommendation	Current situation	Success (H,M,L,N)
	230 pangas are actually using the alternative gear provided. It is unclear whether they could use small trawls effectively on the fishing grounds given the high density of gillnets, which are obstacles to trawling. There is also uncertainty of whether CONAPESCA has provided the permits to use the alternative gear.	
9. Research should be conducted to better define critical habitat of the vaquita, using data collected during the 1997 abundance survey.	Additional data gathered from both Vaquita Expedition 2008 and acoustic monitoring have been used effectively to delimit the total current distribution of vaquitas	H (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 (Commission for Environmental Cooperation), NGOs (WWF and Cousteau Society) the governments of the US (NOAA Fisheries and the Marine Mammal Commission) and Sweden (Swedish International Development Cooperation Agency) and charitable foundations (Pacific Life and Ocean Foundations) have worked as active partners with the Government of Mexico towards the conservation of the vaquita and the ecosystem of the Upper Gulf.	M (M)

Annex 1: List of Participants

CIRVA Members

Barlow, Jay
Southwest Fisheries
Science Center-NOAA
3333 North Torrey Pines Court
La Jolla, CA 92037-7000
USA

Bjørge, Årne
Institute of Marine Research
Gaustadalléen 21
0349 Oslo, Norway

Camacho, Victor
UABC-IIO
Km 103 Autopista
Ensenada – Tijuana.
Ensenada, Baja California.

Jaramillo Legorreta, Armando
Instituto Nacional de Ecología
Coordinación de Investigación y
Conservación de Mamíferos Marinos
CICESE. Carr. Tijuana-Ensenada No.3918
Ensenada, Baja California 22860
Mexico.

Ramirez, Oscar
CONANP/SEMARNAT
Director de Especies Prioritarias
para la Conservación
Camino al ajusto 200
Col. Jardines de la Montaña,
Tlalpan, DF. México. 14210

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

Rojas Bracho, Lorenzo
Instituto Nacional de Ecología.
Coordinador de Investigacion y
de Conservación de Mamiferos Marinos.
CICESE. Carr. Tijuana-Ensenada No.3918
Ensenada, Baja California 22860
Mexico.

Taylor, Barbara
Southwest Fisheries
Science Center-NOAA
3333 North Torrey Pines Court
La Jolla, CA 92037-7000
USA

Thomas, Peter
US Marine Mammal Commission
International and Policy Program Director
4340 East-West Highway, Suite 700
Bethesda, Maryland 20814

Expert Attendees

Aguilar Ramirez, Daniel
Instituto Nacional de la Pesca
Pitagoras 1320. Sta Cruz Atoyac
Del. Benito Juarez. DF
México 03310

Alvarez Borrego, Saúl
Departamento de Ecología
División de Oceanología
CICESE. Carr. Tijuana-Ensenada No.3918
Ensenada, Baja California 22860
Mexico.

Avila, Dulce María
CONANP-SEMARNAT
Camino al Ajusto 200
Col. Jardines de la Montaña,
Tlalpan, DF. México. 14210

Barnés Regueiro, Francisco
Presidente
Instituto Nacional de Ecología
Av. Anillo Periférico 5000
Col. Insurgentes Cuicuílco
México, DF 04530

Cardenas Hinojosa, Gustavo
Instituto Nacional de Ecología
Coordinación de Investigación y
Conservación
de Mamíferos Marinos
CICESE. Carretera Tij-Ens No. 3918.
Ensenada, Baja California 22860
Mexico.

de la Cueva Salcedo, Horacio
Departamento de Biología de la
Conservación
División de Biología Experimental y
Aplicada
CICESE. Carr. Tijuana-Ensenada No.3918
Ensenada, Baja California 22860
Mexico.

Deveze Murillo, Patricia
Consultora en capacitación y
Transferencia de Tecnología
Av. Costa Verde 708 int. 3
Veracruz, Ver.

Erisman, Brad
Postdoctoral Fellow
Scripps Institution of Oceanography,
University of California San Diego
9500 Gilman Drive, Mail Code 0202
La Jolla CA 92093-0202

Fueyo Mac Donald, Luis
CONANP-SEMARNAT
Comisionado Nacional
Camino al ajusto 200
Col. Jardines de la Montaña,
Tlalpan, DF. México. 14210

García Caudillo, Juan Manuel
Director
Sustainable Fisheries Partnership Mexico
Blvd. Zertuche 937-3, Valle Dorado
Ensenada BC. México 22890

Gearhart, Jeff
Southeast Fisheries
Science Center-NOAA
Mississippi, Lab.
3209 Frederic Street
Pascagula, MS 39567

Gerrodette, Tim
Southwest Fisheries
Science Center-NOAA
3333 North Torrey Pines Court
La Jolla, CA 92037-7000
USA

Gutierrez Carbonel, David
CONANP-SEMARNAT
Director Regional de Operacion Regional
Camino al Ajusto 200
Col. Jardines de la Montaña,
Tlalpan, DF. México. 14210

Mozaria Luna, N. Hem
NWFSC-NOAA
MRAG Americas Inc. Contractor
Atlantis Ecosystem Model Team
NWFSC-NOAA
2725 Montlake Blvd. E.
Seattle WA, 98115
USA

Nieto García, Edwyna
Instituto Nacional de Ecología
Coordinación de Investigación y
Conservación
de Mamíferos Marinos
CICESE. Carr. Tijuana-Ensenada No.3918
Ensenada, Baja California 22860
Mexico.

Recagno Peters Eduardo
Director General IOECE
Instituto Nacional de Ecología
Av. Anillo Periférico 5000
Col. Insurgentes Cuicuílco
México, DF 04530

Perez Valencia, Sergio
CEDO, A.C .
Apartado Postal #53.
Puerto Peñasco, Sonora
México

Rodriguez Quiroz, Gerardo
CIDIR-INP, Unidad Sinaloa
Departamento de Acuacultura
Blvd. Juan De Díos Batiz Paredes
No. 250. Guasave, Sinaloa 81101
México

Sanjurjo, Enrique
World Wildlife Found, INC.
Av. Alvaro Obregon No.1665
Local 305. Edif. Cerralvo, Col. Centro.
La Paz, BCS., Mexico 23000

Sau, Martin
CONANP/SEMARNAT
Director de la Reserva
de la Biosfera del Alto Golfo de
California y Delta del Río Colorado
San Luis Río Colorado, Sonora
México.

Vidal, Omar
Director General
WWF-México
Av. México 51
Col. Hipódromo-Condesa
México DF 06100

Observers

Jennifer Keliher-Venegas
San Diego, CA. U.S.A.

Eric Keen
Scripps Institution of Oceanography
9450 Gilman Drive #40287
La Jolla, CA 92092
USA

Mariana Bobadilla
Instituto de Investigaciones Oceanologicas.
UABC. Carr Tijuana-Ensenada Km 103
Ensenada, 22800, B.C. México.

Catalina López Sagástegui
Scripps Institution of Oceanography,
University of California San Diego
9500 Gilman Drive, Mail Code 0202
La Jolla CA 92093-0202

Myriam Campos Aguilar
Departamento de Ecología Marina
División Oceanología
CICESE. Carr. Tijuana-Ensenada No.3918
Ensenada, Baja California 22860
Mexico.

Martín Daniel Peréz Costiño
Departamento de Biología de la Conservación
División de Biología Experimental y Aplicada
Posgrado de Ciencias de la Vida
CICESE. Carr. Tijuana-Ensenada No.3918
Ensenada, Baja California 22860
Mexico.

Daniela Ramos Enrique
Departamento de Biología de la Conservación
División de Biología Experimental y Aplicada
Posgrado de Ciencias de la Vida
CICESE. Carr. Tijuana-Ensenada No.3918
Ensenada, Baja California 22860
Mexico.

Organizing Committee

Edwyna Nieto Garcia, Lorenzo Rojas Bracho, Armando M. Jaramillo Legorreta and Gustavo Cárdenas Hinojosa

CICMM - Instituto Nacional de Ecología

Annex 2: Meeting Agenda and Documents

Agenda of CIRVA 4
February 20-23, 2012

Monday February 20th

1. Welcome and opening remarks (F. Barnés, L. Fueyo, P. Thomas and O. Vidal) 09:00 – 10:00
2. Appointment of Rapporteurs (Reeves and Thomas)
3. Adoption of the Agenda
4. Review of the Vaquita Conservation Action Plan (PACE-Vaquita; L. Fueyo and O. Ramírez)

a. Background
b. Goals
c. Management
d. Protection and Enforcement Subprogram
e. Awareness and Coordination Subprograms
f. Achievements and assessment of each Subprogram
g. Conclusions 10:00-13:00

5. Alternative Fishing Gear (D. Aguilar) 15:00-18:00

Tuesday February 21st

6. Vaquita monitoring and status

a. History of vaquita population (A. Jaramillo)
b. Current population size estimates (T. Gerrodette)
c. Acoustic monitoring (A. Jaramillo)
d. Protected areas (G. Rodriguez-Quiroz)
e. Success of protected areas (T. Gerrodette) All day

Wednesday February 22nd

7. Other new information

a. Atlantic model (H. Mozaria-Luna)
b. A review of the Colorado River flow and the Upper Gulf productivity (S. Galindo)
c. Productivity of Gulf of California (S. Álvarez-Borrego)
d. CEDO´s EIA for artisanal fishermen (P. Turk)
e. SIO Upper Gulf Fisheries issues (B. Erisman) All day

Thursday February 23rd

8. Review of the draft report Morning

Appendix 1: Summaries of Presentations

Vaquita Conservation Action Plan (Programa de Acción para la conservación de la especie: vaquita *(Phocoena sinus)*

Oscar Ramírez, CONANP/SEMARNAT

To protect the vaquita, considered as the most critically endangered marine mammal, the Mexico´s Protected Areas National Commission (CONANP), formulated this Action Plan. Local fishermen from San Felipe, B.C., Golfo de Santa Clara and Puerto Peñasco, Son., the National Commission on Fisheries and Aquaculture and the National Institute of Fisheries, national NGOs and local governments, participate in this effort; in fact, the subtitle "*Integral Strategy for the Sustainable Use and Management of Marine and Coastal Resources in the Upper Gulf of California,* is one of the recommendations made by fishermen.

Implementation of the Action Plan began in 2007, with the goal of eliminating by-catch, by means of reducing the fishing effort through voluntary buy-out and substitution of gill and trammel nets by more selective fishing methods. Technological development of alternative fishing gear and biologic diversity conservation actions in the Refuge Area were also promoted. Until now, the Secretariat of Environment and Natural Resources through CONANP has spent more than 400 million pesos to buy-out 247 artisanal bouat with 370 fishing permits, also in 230 pangas have replaced their gillnets by alternative fishing gears that prevent by-catch. Also, together with the National Fisheries Institute, during 2009 and 2010, testing of a light and selective trawler for shrimp harvest were financed. Each year, an average of 530 boats do not fish within the Refuge Area, which means the existence of a NO Take Zone in 1,263 km^2 .

However, the protected area's management body has the will but not authority to regulate fisheries, which complicates the chance to succeed and contribute to species conservation. Experiences in the implementation of the Action Plan had taught us various lessons, which now we turn into recommendations for scientist, politicians, decision-makers and civil society organizations concerned about species conservation:

- Threats to vaquita have been reduced significant but not sufficiently
- Fishing effort has been reduced and a fisheries management process is being implemented.
- Fishermen have initiated successfully alternative economic activities which provide them a proper livelihood.
- The mechanisms of permanent dialogue and coordination of efforts between fishermen and government had allow to reach institutional agreements
- Bases for sustainable fishing in the Upper Gulf have been established

- Urgent need of better fishery regulations enforcement and the development of specific ones for the upper Gulf of California

Comparison of the RS-INP-MEX and Scorpion Trawl Designs

Jeff Gearhart, NOAA Fisheries Service, Southeast Fisheries Science Center, Mississippi Laboratories, Harvesting Systems Unit, Pascagoula, Mississippi, USA

In 2001, the US Marine Mammal Commission (MMC) provided funding for a cooperative research project between INAPESCA and NOAA Fisheries Service to compare the configuration and performance of a "Scorpion" and Red Selectiva-Instituto Nacional de Pesca-Mexico (RS-INP-MEX) trawls. The RS-INP-MEX prototype trawl was developed by INAPESCA as an alternative gear to mitigate vaquita (*Phocoena sinus*) by-catch in the gillnet fishery targeting the semi pelagic blue shrimp (*Litopenaeus stylirostris*), while the "Scorpion" trawl is a high performance trawl design used in the Southeast US to target semi pelagic white shrimp (*Litopenaeus setiferus*). This study was completed in three phases, the objectives were:

- Compare gear characteristics between the "Scorpion" and RS-INP-MEX trawls
- Compare catches between the "Scorpion" and RS-INP-MEX trawls in US waters
- Compare catches between the "Scorpion" and RS-INP-MEX trawls in the Upper Gulf of California

The first phase of the study was conducted in May 2011 in the Gulf of Mexico (GOM). A 50 ft "Scorpion" trawl was compared to a 50 ft RS-INP-MEX trawl. Catches were reduced for all catch categories for the RS-INP-MEX trawl when compared to the "Scorpion" trawl with total catch reduced by 40.8%, shrimp reduced by 63.9%, and by-catch reduced by 29.3%. It was evident that the trawl was not effectively tending the bottom during the first leg of testing, which was conducted in deeper water (~30 m) indicating that the doors were undersized for the trawl at these depths.

The next phase of the study was conducted in June 2011 off Panama City, Florida and consisted of diver assisted measurements and evaluations of two trawl designs. The two trawls were the "Scorpion" and a Box trawl with bib attachment. Each of these designs were "Bib" or "Tongue" trawl designs that are typically used to catch the semi pelagic white shrimp. The original 50 ft "Scorpion" was downsized to a 30 ft trawl to facilitate towing by small pangas, while the Box trawl was also constructed in a smaller 32 ft version. Spread and height measurements were collected on each net with different bib cable settings. The "Scorpion" trawl did not perform as expected, while the Box trawl with bib performed well with net spread decreasing and height increasing with longer bib setting. Optimum configurations for each were determined in preparation for phase three of the study.

The final phase of the study was conducted in the Upper Gulf of California in August 2011. Four vessels were contracted to conduct paired comparisons between the 32 ft Box trawl with bib, 30 ft "Scorpion" trawl and 50 ft RS-INP-MEX trawls. Customs delays of the gear shipment prevented valid paired comparisons between gears. However, NOAA staff was able to improve RS-INP-MEX trawl performance by properly rigging doors and increasing speed of towing. These improvements resulted in acceptable catches of Blue Shrimp. Catch levels were comparable to that of gillnets with the trawls catching 38-70 kgs/tow, while gillnets average 40 kgs/set. Fisheries Specialist from NOAA recommend the following:

- Use of wooden plywood doors to improve trawl deployment and performance
- Addition of "flippers" to the trawl footrope to improve performance on muddy bottom
- Converting vessels to diesel power would improve the profit margin
- Adding winches and rigging to the vessels would ease deployment and retrieval processes

Mexican Efforts to Save *Phocoena sinus* from Extinction through Sustainable Fisheries

Daniel Aguilar Ramirez, Instituto Nacional de Pesca (danafishman@yahoo.com)

The vaquita (*Phocoena sinus*) is the smallest living cetacean, with a maximum length of 1.5 m is found only in an area of roughly 5,000 Km2 in the Upper Gulf of California. The vaquita is listed as critically endangered by IUCN; it´s greatest threat is death by entanglement in gillnets used by fisherman in artisanal shrimp and finfish fisheries. However, these fisheries are the principal productive activity in the region. The fishing area is located in the northernmost Gulf of California, included two Mexican States (Sonora and Baja California). There are 3 fishing communities with nearly 70,000 people whose depends mainly of the fishing activity. There is an available fishing space of 274,000 Ha. Inside the fishing area there is a ban area named "vaquita protected polygon" with 126,400 Ha over which is not allowed fish with gill nets, so the use of alternative gears could expand the total fishing area over 400,000 Ha. The most feasible mechanism to further avoid vaquita extinction is to switch these fisheries currently using gillnets into alternative fishing gears which do not cause vaquita by-catch. In the past four years, the Mexican government has made an unprecedented commitment to save the vaquita putting an end to the gillnet mortality and offering fishermen viable alternative livelihoods. To date, the government has invested to bring the gill nets out of the water through buy-outs, rent-outs, and swap-outs. Buy-outs offer compensation to fishermen surrendering their gear and licenses going into alternative livelihoods. Rent-outs are agreements whereby fishermen are compensated for not fish for a specified period of time. Swap-outs offer compensation and technical assistance to those fishermen willing to change to alternative, vaquita-friendly, fishing gear and methods. This latter alternative has been the responsibility of Mexico's National Fisheries Institute (Instituto Nacional de Pesca, INAPESCA). In order to develop fishing gear alternatives to gill nets, in 2009 INAPESCA tested several prototypes which included pots, modified cast nets named "suriperas", trawl nets, fish aggregation devices, and hooks and lines (watch video at

http://www.youtube.com/watch?v=4xW1s5m0ty4). Species targeted were shrimp, finfish, sharks, rays mollusks and other crustaceans with some degree of success. At the present, we have an alternative gear for shrimp fishery which is the most important fishery of the region. The prototype net has been demonstrating its efficiency for fish shrimp over 3,000 sets during 2009-2010 shrimp season. During these fishing activities, not a single vaquita was catch and the trawl prototype show also that is highly selective to avoid finfish by-catch through several excluder devices implemented (watch video at http://www.youtube.com/watch?v=X3m9tN7uPZ4). So, there is now an opportunity to switch from gill nets to a prototype trawl net to catch blue shrimp (*Litopenaeus stilyrostris*) and brown shrimp (*Farfantepenaeus californiensis*). Work is underway seeking best fishing alternatives for the other species. At the present there are 204 permits of 1,412 which are been switching the gill nets into alternative gears: prototype trawl nets for shrimp and long lines for finfish and shark. these switch licenses are been financial supported from the government for fishing gear acquisition and fishing operation expenditures, including improvements of vessels, outboard engines and electronic equipment as video sounders, GPS devices and small winches gasoline operates for gear recovering . There are also involved others stakeholders as World Wildlife Funds in order to look for international markets to reach better market prices for fishing products obtained without vaquita impacts. We expect that during the next two years we can switch the remain licenses to take out of the water the 100% of gill nets in the region, without economic impacts to the fishermen. This research is directly linked to an urgently needed conservation outcome – the reduction of by-catch of one of the most critically endangered cetacean species in the world-. The recommendations that this research project will generate, on the most economically and environmentally appropriate fishing gear technologies for use in the Upper Gulf of California, will provide the essential scientific foundation for a full elimination of gillnet use in the region, and subsequent reduction in vaquita by-catch. for accomplish with this ambitious aim, we have financial support from the government to continue with the fishing trials onboard a research vessel during 2012, however these experimental activities requires time and more budgets that the government can provide, so we are been looking for additional financial support in order to get more time on board testing alternative gears and funds for start with workshops and training for transfer the technology to fishermen. At the end of the project in 2012, INAPESCA would make specific recommendations to national authorities National Fisheries and Aquaculture Commission (CONAPESCA) and National Wild Protected Areas Commission (CONANP) on the most suitable fishing options to be promoted among local fishers for replacing gillnets as well as to include those in the Federal Regulations for fishing activity into a protected biosphere area and into the Normatively for the fishing sustainable species as shrimp, sharks and finfish. A public technical report would be jointly produced by INAPESCA and WWF and would be made available on WWF-Mexico´s and INAPESCA´s websites. At the end of the project, WWF and INAPESCA would also submit for publication in the Journal of Cetacean Research and Management a paper describing and evaluating the variety of alternative fishing gears jointly tested by both institutions at the Upper Gulf of California over the past four years, and outlining their efficiency in reducing vaquita by-catch

A History of Vaquita (*Phocoena sinus*) Population through Data on By-catch, Population Biology and Acoustic Monitoring: Support to the Recovery Plan

Armando Jaramillo-Legorreta, CICMM, Instituto Nacional de Ecología, CISESE, Ensenada

Vaquitas, as well as other odontocetes, emit high-frequency, narrow-band clicks arranged in series of a few to several. This behavior made it possible to design automated equipment to identify these kinds of signals.

These passive acoustic techniques have been used since 1997 to study habitat use of vaquita as well as to monitor the population trend. On that year equipment name "porpoise detector" was tested to locate vaquita signals with success. Later, in 1999, a second generation of the detector was implemented in vaquita field studies. This equipment was used until 2007, bringing a period of ten years of data. The parameter *acoustic encounter rate* (number of acoustic encounters with vaquitas per unit time) was modeled using regression approach. As a result, the model predicted a decline of the encounter rate. Assuming that this rate is proportional to population trend, it was informed to Mexican Government which sparked the current Recovery Plan. However, the plan does not specify any management goals in terms of target population size or time frame to apply recovery measures.

In order to bring some quantitative information in this regards, it was tried to model historical population trend using data available on fishing effort, by-catch rates and biological attributes of vaquita population as well as from harbor porpoise, a close related species. A simple denso-dependent discrete logistic model was used to model the population, including a term to account for by-catch. The parameters to estimate were carrying capacity, maximum intrinsic rate of increase, shape, and terms correlating fishing effort and vaquita abundance with by-catch in totoaba and artisanal fisheries. A Bayesian framework was used to estimate the parameters, using simulation techniques as implemented in AD Model Builder. Prior distributions for K and r were constructed from information available in literature. Uniform distributions with determined intervals were constructed for the other parameters, indicating the lack of information.

The modeling exercise estimate that maximum rate of increase could be than expected for a porpoise, near to 3%. K is estimated to be around 5,000 individuals. Current abundance is around 2% of the historical one, showing extreme levels of depletion. The model also indicates that maximum sustainable yield rates could be around 50% of K, which could be an option to establish the management goal. In any way, every envisioned goal will take in the order of tens of years to be accomplished, as the population has limited potential of growth given the low estimated rate of increase. Given the time frame required to declare the species as recovered, it is recommended to base recovery strategy in the complete elimination of gillnets, instead to use an approach enforcing the use of this kind of gears under a season or areas closure strategy.

2008 Abundance and Change in Abundance since 1997

Tim Gerrodette, Southwest Fisheries Science Center-NOAA, 3333 North Torrey Pines Court, La Jolla, California, USA

A line-transect survey for the critically endangered vaquita, Phocoena sinus, was carried out in October–November 2008, in the northern Gulf of California,Mexico. Areas with deeper water were sampled visually from a large research vessel, while shallow water areas were covered by a sailboat towing an acoustic array. Total vaquita abundance in 2008 was estimated to be 245 animals (CV = 73%, 95% CI 68–884). The 2008 estimate was 57% lower than the 1997 estimate, an average rate of decline of 7.6%/yr. Bayesian analyses found an 89% probability of decline in total population size during the 11 yr period, and a 100% probability of decline in the central part of the range. Acoustic detections were assumed to represent porpoises with an average group size of 1.9, the same as visual sightings. Based on simultaneous visual and acoustic data in a calibration area, the probability of detecting vaquitas acoustically on the trackline was estimated to be 0.41 (CV = 108%). The Refuge Area for the Protection of the Vaquita, where gill net fishing is currently banned, contained approximately 50% of the population. While animals move in and out of the Refuge Area, on average half of the population remains exposed to by-catch in artisanal gill nets.

Monitoring Vaquita Population, a Key Factor for Successful Recovery

Armando Jaramillo-Legorreta, CICMM, Instituto Nacional de Ecología, CISESE, Ensenada

Monitoring based on passive acoustics was applied between 1997 and 2007 to estimate vaquita population trend. Methods used were able to provide a trend of acoustic encounter rate proportional almost 1:1 to direct estimates of population abundance change rate between 1997 and 2008. However, methods applied are not powerful enough to continue monitoring efforts, as the population became so reduced that sampling based in a single boat gathering data in a single spot at a time do not provide enough sample size.

In 2008, a cooperative survey between Mexican and US scientists was done to test alternative acoustic detectors, aimed to design a monitoring scheme with statistical power enough to detect small population increases less than 4% annually or further reductions of 5% in a term of 5 years. The key issue was to increase sample size, so the option was to test autonomous acoustic detectors, able to be working without assistance for extended periods of time. Three of those kinds of detectors were tested: A-Tag, T-POD and C-POD, being the C-POD the one with the better results.

During a workshop held in Ensenada during 2009, a sampling web was designed inside Protection Refuge Area for Vaquita, consisting of 48 sampling sites as well as 16 delimiting buoys, which can be used as a platform of opportunity to moor acoustic detectors. It was

estimated that 5,000 sampling days / year are needed to obtain enough statistical power. A network of 50 detectors working 100 days / year can do the job, hence, the 64 sites planned can even sustain some loses during sampling periods.

Design and pilot tests of mooring designs were done in 2010, obtaining final designs able to hold local oceanographic conditions, however, it was determined that shrimp fishing activities inside refuge take out 60% of moorings. Hence, it was decided to install detectors only during the period between May and September, when fishing activities are in the lowest numbers, to avoid high rates of lost.

First sampling period occurred between June and September 2011, including the deployment of 48 moorings inside refuge and 13 in delimiting buoys. Ten of the moorings inside refuge were not located, although three detectors moored in these sites were returned by fishermen. Eleven of the detectors deployed in buoys get lost. The total sample available is composed of 38 sites inside refuge and two in buoys. Illegal fishing inside the refuge is the most likely cause for the loss of equipment.

The total sample includes 2,840 days and 1,655 acoustic encounters with vaquitas, resulting in an average encounter rate of 0.58 encounters / day and a CV of 0.0485, near to the goal of 3%. A concern was raised by the absence of click series detections in areas with high background noise levels indicated by high number of clicks stored in the detector. To check for the ability of the detection algorithm to identify porpoise like signal under this kind of conditions, vaquita series were inserted into noisy files and algorithm ran again. Low quality (low probability to be identified) and high quality series were inserted at six different time positions. Low quality signal were identified in only one of the sites while the high quality signal was identified at the six sites. Most of vaquita encounters are composed of several series of different qualities, hence it is concluded that identification algorithm could be efficient to identify real encounters. Hence, the absence or low levels of encounter rates must be related to low density of animals or due to a different acoustic behavior under noisy conditions as compared to quieter areas.

Highest acoustic activity of vaquitas is located towards San Felipe and the central and southern portions of the refuge. Sites with the highest encounter rates appear to have low level of background noise.

INE analyzed satellite imagery to count number of pangas in the Upper Gulf of California. Sixty seven panga like boats were inside the refuge, potentially making illegal fishery operations. A bunch of that pangas were aggregated in the middle of the area with the highest encounter rates, which rise a call od concern about the potential of this activity to increase probabilities to catch vaquitas.

A rough view of the complete set of acoustic data since 1997, including the sampling effort described in this work, indicates encounter rate diminished since 2008, when PACE vaquita

started to operate. Hence, population level could be even lower that it was estimated back on 2008.

It was reported that detectors were installed in all 13 available buoys, but using diving to deployed them in order to avoid theft as it happened with the first ones deployed in 2011. Next May moorings will be deployed inside refuge for the second sampling period and will be recovered during September previous to the 2012-2013 season.

A Proposal to Reduce Fishing Effort in the Upper Gulf of California

Gerardo Rodriguez Quiro, CIDIR-INP, Unidad Sinaloa, Dep. Acuacultura, Guasave, Sinaloa

There have been attempts to eliminate vaquita by-catch. Some of them have been implemented, but all of them have been focused on reducing gillnets. Few social studies had been made until the PACE-Vaquita program started in 2008. In this new proposal to reduce vaquita by-catch, there were attempts both to reduce the number of fishing boats and to make a changeover to alternative fishing gear. We interviewed 146 fishermen and asked them questions concerning their willingness to quit fishing. From their responses, we proposed two fishing effort scenarios to recover the vaquita population in a period of 15 years using a deterministic model. We found in the interviews that 30% of the fishermen would continue fishing no matter what, even if the fisheries in the Upper Gulf were closed. Feeding this number of fishermen into the model, we found that by reducing fishing effort by 15% yearly we could reach that number of fishermen who will not stop fishing, and vaquitas will maintain their actual population size. Some management proposals were suggested to decision makers that would allow sustainable fishing without compromising the welfare of fishermen, such as opening a sport fishery for totoaba, training young and elderly fishermen in activities for work in other sectors of the fishing industry, establishing a price subsidy to fishermen who change their nets, and giving incentives to federal and local authorities to support and encourage market strategies in which fishermen upgrade the quality of their products so they can be sold at competitive prices in regional and international markets.

Estimating the Success of Protected Areas for the Vaquita

Tim Gerrodette, Southwest Fisheries Science Center-NOAA, 3333 North Torrey Pines Court, La Jolla, California, USA

By-catch in artisanal gillnets threatens the vaquita, *Phocoena sinus*, with extinction. In 2008, the Mexican government announced a conservation action plan for this porpoise, with three options for a protected area closed to gillnet fishing. The probability of success of each of the three options was estimated with a Bayesian population model, where success was defined as an increase in vaquita abundance after 10 years. The model was fitted to data on abundance, by-catch and fishing effort, although data were sparse and imprecise. Under the first protected area

option, the existing Refuge Area for the Protection of the Vaquita, by-catch was about 7% of population size, and probability of success was 0.08. Under the second option with a larger protected area, the probability of success was 0.35. The third option was large enough to eliminate vaquita by-catch and had a probability of success > 0.99. Probability of success was reduced if elimination of vaquita by-catch was delayed or incomplete. Despite considerable efforts by the Mexican government to support vaquita conservation, vaquita abundance will probably continue to decline unless additional measures to reduce by-catch are taken, such as banning gillnets within the vaquita's range and developing effective alternative fishing gear.

Nutrients in the Upper Gulf of California and Colorado River Delta

Manuel S. Galindo-Bect, Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California, Km 107 Carretera Tijuana-Ensenada, Ensenada, Baja California, MEXICO

The Upper Gulf of California and Colorado River delta is the shallow region located in the northern Gulf of California where one of the most important sources of nutrients was the freshwater input from the Colorado River. The construction of dams in the United States (U.S.) since 1935 has limited fresh surface water entering the estuary only to years with abnormally high rainfall and snowmelt in the upper river basin. This is why most of the time this region has has lost its estuarine conditions. It is widely recognized in CIRVA that the main risk to the vaquita is incidental mortality in gill nets. In 1997 CIRVA concluded, given the high nutrient concentrations and high rates of productivity of the Upper Gulf of California, available data indicating that vaquitas consume a number of different prey species, and the lack of evidence of emaciation on recovered specimens of vaquitas, that the reduced flow from the Colorado River does not pose a short-term risk to the vaquita. At that time it was also concluded that in the long term, changes in vaquita habitat due to reduction of this flow, such as nutrient decline, were matters of concern that should be investigated.

High concentration of nutrients (Cupul-Magaña, 1994), high primary productivity rates (Santamaría-del-Angel et al., 1994) and high zooplancton biomass (Farfán and Alvarez-Borrego 2003) have been used as a base to conclude this. In this presentation I showed that the analysis in this papers was not done properly because these studies of nutrients and primary productivity were made during years of estuarine conditions. Which highlight the importance of the Colorado River for the environmental health of the Upper Gulf. A comparison of nitrate levels with and without the contribution of the river was made, noting that values of nitrate in estuarine conditions should be over 10 µM and now without the contribution of the river values are less than 0.1 µM. Mention also made to the fact that environmental changes by the Colorado River damming are not only nutrients and primary productivity but also loss of protective barrier due changes in salinity, changes in diversity and abundance of species, increase of mortality by predation and osmoregulation and decrease the size of populations. These environmental changes are difficult to relate with decreasing size of the Vaquita population, because there are not

historical data, but the historical data of species estuarine dependent as shrimp and totoaba, show how the Colorado River damming has affected drastically the size of their population. The conclusion is that mortality of the vaquita is mainly due to by-catch, but also is represents a Mexico-USA bilateral problem due environmental changes due the Colorado River damming.

Productivity of Gulf of California

Saúl Alvarez, CICESE

The Gulf of California is the only evaporative basin of the Pacific. Despite the strong evaporative forcing, the gulf differs markedly from the Mediterranean and Red seas, which are the primary evaporative basins of the Atlantic and Indian oceans. Fundamental differences between the Gulf of California and the Mediterranean and Red sea may be attributed to a net heat gain from the atmosphere in the former, compared to a net heat loss to the atmosphere in the other two. In the Gulf of California there is an annual mean net atmosphere-water heat flux into the sea of >100 W m^{-2}. This heat has to be exported to the Pacific somehow; otherwise the gulf's temperature would be increasing. This causes water exchange between the Gulf of California and the Pacific which consists of less dense, warmer, saltier, and nutrient poor surface and near surface (0-200 m) water flowing out from the gulf into the Pacific, and to balance this flow, relatively deep (200-600 m), denser, colder, fresher, and nutrient rich water flows into the gulf. Water exchange between the gulf and the Pacific has a very important ecological implication because it is a natural fertilization mechanism for the gulf; it causes net input of nutrients from the Pacific into the gulf. The dissolved NO_3 input by rivers, agricultural runoff, and N_2 fixation by diazotrophs might add to only ~1.5% of the input from the Pacific.

Once the nutrients are inside the gulf they have to be brought up to the euphotic zone where they can be used for photosynthesis. The mechanisms for this are upwelling, mostly off the eastern coast with "winter" conditions, and tidal mixing, mainly in the area of the midriff islands where it has the effect of a cuasi-continuous upwelling, throughout the whole year.

The northern Gulf is a very productive area that receives nutrients, both from upwelling and advection from the midriff islands region. The northern Gulf has gyres that cover most of the basin, anticyclonic in winter and cyclonic in summer. The speeds of this circulation are such that it takes only some days for a parcel of water, rich in nutrients and phytoplankton, to move from the midriff islands region to the area of the La Vaquita refuge.

These fertilization mechanisms result in very healthy phytoplankton communities in the whole northern gulf, with high chlorophyll concentrations evident both in satellite imagery and in data generated with water samples taken directly at places like off San Felipe, Baja California, and off El Golfo de Santa Clara, Sonora.

Historical data show that back in 1889, when the first Gulf of California Albatross Cruise was carried out, salinities were higher than 36 not far from San Felipe, showing almost no impact of the river in the marine environment of the northern gulf. When the river was flowing freely,

before the dams were built, the impact of freshwater was significant only off Baja California, with almost no impact off Sonora, because of the effect of the rotation of the planet. Data from April of 1993, a wet year with a large amount of freshwater reaching the Upper Gulf, and data from April of 1996, a dry year with no freshwater input to the sea, show no significant differences in nutrient concentrations and phytoplankton biomass.

Atlantis Model

Hem N. Morzaria Luna, Northwest Fisheries Science Center-NOAA, MRAG Americas Inc. Contractor, Atlantis Ecosystem Model Team, 2725 Montlake Blvd. E, Seattle, Washington, USA

Minimizing fishery by-catch threats might involve trade-offs between maintaining viable populations and economic benefits. Understanding these trade-offs can help managers reconcile conflicting goals. An example is a set of by-catch reduction measures for the Critically Endangered vaquita porpoise (*Phocoena sinus*), in the Northern Gulf of California, Mexico. The vaquita is an endemic species threatened with extinction by artisanal gillnet by-catch within its limited range; in this area fisheries are the chief source of economic productivity.

Methodology/Principal Findings

We analyze trade-offs between conservation of the vaquita and fisheries, using an end-to-end Atlantis ecosystem model for the Northern Gulf of California. Atlantis is a spatially explicit model intended as a strategic tool to test alternative management strategies. We simulated increasingly restrictive fisheries regulations contained in the vaquita conservation plan: replacing shrimp driftnets with a fishing gear with no vaquita by-catch; implementing progressively larger spatial management areas that exclude gillnets and trawls; and combining these management actions. We found that only the most extensive spatial management scenarios recovered the vaquita population above the threshold necessary to downlist the species from Critically Endangered. The combined scenario led to an estimated 19% decrease in the net present value of fisheries catch relative to a scenario in which fisheries observed only the currently enforced vaquita refuge, but a 400% increase in the abundance of adult vaquita over the course of 30 years.

Conclusions/Significance

We found no win-win solution for both conservation and fisheries. Current management actions do not assure vaquita recovery and do not yield benefits for fishery species that translate into higher catch value. Extended spatial management resulted in the highest recovery of the vaquita population, but the gillnet and trawl fisheries never recover lost value. Our analysis shows that managers will have to confront difficult trade-offs between management scenarios for vaquita conservation.

Appendix 2: New Recommendations from CIRVA-IV

Most important recommendations

- All gillnets and other entangling nets need to be removed from the entire range of the vaquita.
- Artisanal shrimp fishing vessels should be converted from using gillnets to using small trawls immediately.
- Additional research is needed immediately to develop vaquita-safe methods to fish for finfish with artisanal vessels. The conversion of the entire fishing fleet to vaquita-safe methods needs to be accomplished as soon as possible (certainly within the next few years).
- Spatial management measures are needed that provide access incentives for shrimp fishermen who use small trawls rather than gillnets.
- Legal limit on the length of gillnets and the number of nets per vessel need to be enforced immediately for fisheries with such limits, like the shrimp fishery.
- Legal limit on the length of gillnets and the number of nets per vessel need to be established and enforced for all other fisheries (besides the shrimp fishery).
- More effective enforcement of no-fishing regulations within the Vaquita Refuge is needed.
- CIRVA **recommends** that only vaquita-safe gear (see definition of 'highly selective' above) be allowed for fishing in the primary area of vaquita distribution, which is defined as the area to the north of 30.7°N latitude and west of 114.25°W longitude (Fig. 3). To be clear, CIRVA **recommends** that the boundaries of the Vaquita Refuge be changed to reflect the configuration shown in Figure 3 of this report.
- INE's acoustic monitoring scheme should continue for at least the first planned 5-year period. This scheme offers the only means of tracking vaquita population trends so that recovery strategies can be adapted accordingly.

Other recommendations

Recommendations to government/enforcement

- CIRVA **recommends** that this report be sent to President Calderón (copies to Ministers of Agriculture and Environment), with a cover letter that commends the President and his administration for their unprecedented commitment to conservation of the vaquita.
- CIRVA **recommends** that INAPESCA explicitly define 'highly selective gear' (*art alta selectividad multiespecífica*, Plan de Manejo de la RBAGDRC; literally 'gear with high multispecific selectivity') in consultation with CONANP. The definition should include the idea that such gear would have very little (preferably zero) risk of catching vaquitas (i.e. it is 'vaquita-safe'). The goal must be to achieve < 1 total by-catch of vaquitas per year in all fisheries combined.
- CIRVA **recommends** that the small or light trawl nets (RS-INP-MEX prototype trawl and similar) recently developed by INAPESCA for use in the shrimp fishery be specified

as falling within the definition of 'highly selective gear' (see later in this report for details on the trawl net).

- CIRVA **recommends** that enforcement agencies introduce better inspection protocols, intensify verification effort, and make public the results of their operations. Protocols should focus on both inspecting the use of authorized fishing gear and monitoring fishing operations in the no-take zones. Because enforcement on the water is expensive, it would make good sense to implement enforcement primarily at launching sites, with GPS tracking devices used to monitor where the fishing vessels go. This would require that such devices be mandatory for pangas fishing in the primary distribution area of vaquitas, at least until gears that pose risks to vaquitas are banned entirely from that area.
- CIRVA **recommends** that conversion to the use of prototype trawl nets for catching shrimp proceed as rapidly as possible, but also that work continue on the testing and development of improved gear design and deployment.
- CIRVA **recommends** that prototype trawl nets towed by pangas be legally permitted or certified by the relevant authorities immediately and that their use in the vaquita's range become mandatory in place of gillnets for shrimp by no later than 1 September 2015.
- CIRVA **recommends** that interim spatial management measures be implemented during the small-trawl phase-in period from 2012-2015, a time when gillnets and small trawls may both be present on some of the fishing grounds. Such measures should offer access incentives to encourage shrimp fishermen to use small trawls rather than gillnets.
- CIRVA **recommends** that boats with longer nets or more than one net should not be allowed to be launched and should be cited as in violation of the law.
- CIRVA **recommends** that the National Fisheries and Aquaculture Commission include the prototype trawl net in the standard and mandate a gradual transition from gillnets to the new trawl net, at a suggested rate of no less than 20% a year over the next five years.
- CIRVA **recommends** that INAPESCA begin a technology transfer program for making these changes feasible and acceptable in fishing communities.
- Once finfish fishing gear that qualifies as vaquita-safe is found to be economically viable, a 2-year phase-in process **is recommended**, as follows:

    - In Year 1,
        - legally certify the gear and create a permitting system for it
        - begin training fishermen in how to use the gear
        - designate areas for exclusive use by fishermen according to the number using gillnets vs the number using the new vaquita-safe gear.
    - In Year 2,
        - continue training and permitting
        - reconfigure the exclusive-use areas such that those where gillnetting is allowed are greatly reduced and restricted to areas thought to be of lowest use by vaquitas.
    - Regardless of the state of development of vaquita-safe finfish fishing gear, gillnets **should be banned** from the vaquita's range by 1 September 2016.

- CIRVA **recommends** that a way be found to make an exception in the case of bycaught vaquitas so that fishermen are encouraged to turn dead vaquitas found in their nets over to authorities for scientific study, without penalty.

Recommendations regarding fishing gear research

- CIRVA **recommends** that research on alternative fishing gear for finfishing not only continue but accelerate.
- CIRVA **recommends** that a rigorous cost:benefit analysis be carried out to evaluate the merits as well as the feasibility of converting pangas from gas to diesel engines.

Recommendations regarding vaquita research

- CIRVA **recommends** that the ongoing efforts led by Jaramillo-Legorreta be continued and expanded in two principal ways: (1) by installing more detectors in parts of the Vaquita Refuge where high densities of vaquitas have been observed but relatively little acoustic data has been obtained to date, and (2) by developing ways to obtain more acoustic data from shallow areas in the northern reaches of the Upper Gulf, possibly through arrangements with fishermen who are willing to install acoustic devices on their nets.
- CIRVA **recommends** that every opportunity be taken for wider monitoring, e.g. using a combination of fixed passive acoustic gear and active towed acoustics recorders, using time/area closures for monitoring in summer months.
- CIRVA **recommends** that analyses be conducted with all available data to improve understanding of micro-habitat use by vaquitas within their range, e.g. differential habitat use by season, tide, etc. Together with data on the location and magnitude of fishing effort, more precise assessments could be made of the vaquita's conservation status.
- CIRVA **recommends** that a validation exercise be conducted in the Atlantis model, specifically to determine what abundance results in 2008 if the model starts with the vaquita abundance estimate from 1997.
- CIRVA welcomed the proposal by Jonathan Gordon to survey shallow water areas for vaquitas using a large sailboat and acoustic gear and **recommends** that relevant permitting agencies facilitate it.