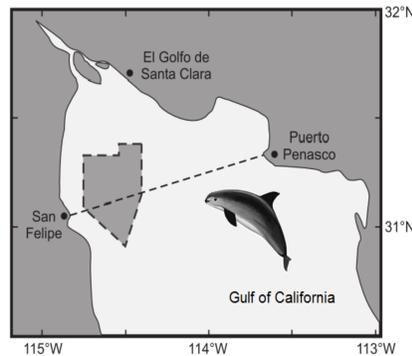


## INTRODUCTION

The vaquita (*Phocoena sinus*), a small porpoise endemic to the northern Gulf of California, is the most critically endangered cetacean species in the world. As fishing effort increased, over half of the species population was lost in 11 years. Incidental mortality in the shrimp gillnet fishery has been recognized as the principal threat for vaquita (Rojas-Bracho et al. 2006).

## OBJECTIVE

To estimate the fishing effort of the artisanal fleet of San Felipe and El Golfo de Santa Clara during shrimp fishing season (September to March) to analyze its effect on the mortality rate of the vaquita (*Phocoena sinus*) using available demographic information.



## METHODOLOGY

Fishing activities conducted by artisanal fishermen in the Port of San Felipe were monitored from September 15<sup>th</sup> to December 14<sup>th</sup>, 2013 and from October 17<sup>th</sup> to the 21<sup>st</sup>, 2013 in El Golfo de Santa Clara. Since every panga (small skiff) makes one round trip from port to sea and back per day, we consider the number of trips as our measure of fishing effort.



To estimate the number of trips ( $\lambda$ ) for the days that were not monitored, we identified the factors that may affect the number of pangas fishing on a given day within the framework of a Generalized Linear Model (GLM), assuming a negative binomial distribution.

$$\lambda = e^{\text{global constant} + \text{tidal effect} + \text{wind effect} + \text{town effect}}$$

We used the Maximum Likelihood Estimation within the Bayesian framework to estimate the coefficients for the parameterization of the model. To compute the posterior distribution of both the coefficients of the parameters and the number of trips for the days that were not monitored, the Monte Carlo Markov Chain analysis was used. The observed trips plus the estimated trips represented the estimation for **total fishing effort**.

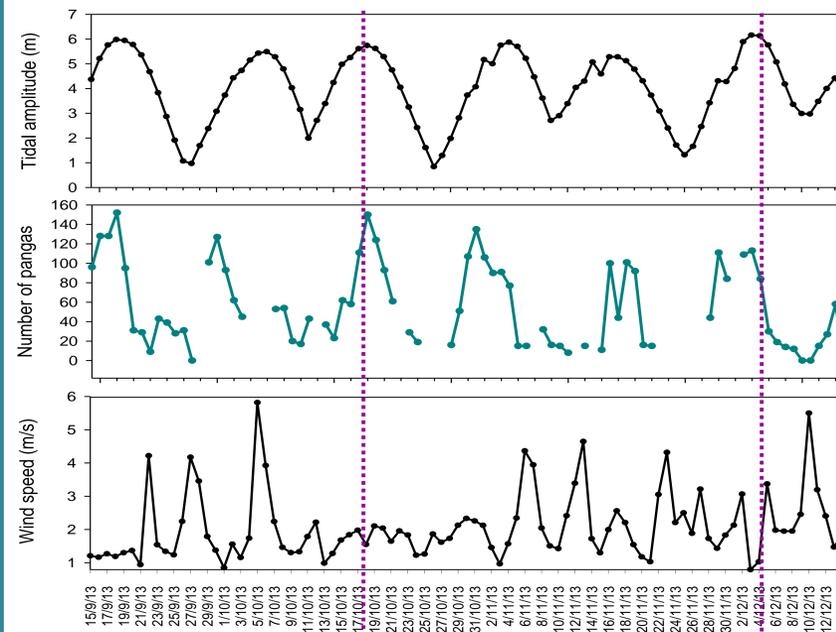
Equations used to calculate mortality rates:

$$M_i = \frac{V_c}{ET * (3/2)} \quad M_c = \frac{V_c}{V * (ET * 3/2)}$$

Where  $M_i$  denotes the mortality rate (vaq/trip) for the period of study (2013-2014),  $M_c$  is the mortality rate per capita (trips<sup>-1</sup>),  $V_c$  denote the number of vaquitas that should have been captured during the period 2013-2014,  $V$  is the abundance of the vaquita population by 2013 and  $ET$  is the total fishing effort estimated.

## RESULTS

Tidal amplitude was the greatest factor influencing fishing effort on a given day, followed by wind speed. As tidal amplitude increased, more pangas went out to fish. As wind speed decreased, less pangas went fishing.



### OBSERVED TRIPS (September 15th – December 15th 2013)

San Felipe	4,079 trips
Golfo de Santa Clara	1,426 trips

### ESTIMATED TRIPS (September 15th 2013 – March 15th 2014)

San Felipe	5,366 trips
El Golfo de Santa Clara	39,821 trips

**TOTAL FISHING EFFORT 50,692 trips**

$$\lambda = e^{1.1415 + 0.3040X_1 + 0.4261X_2 + 1.4527X_3}$$

### MORTALITY RATES

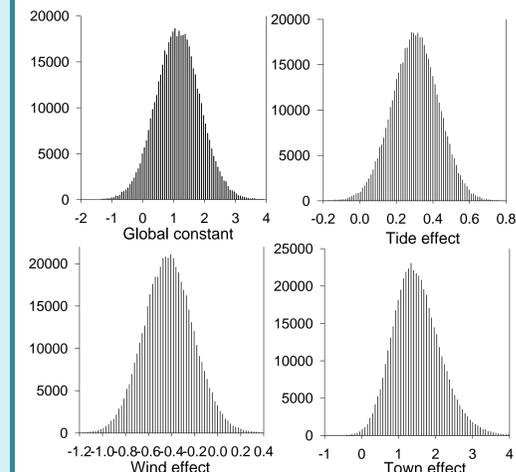
2013-2014	0.00038 vaq/trip	95% C.I. 0.00036-0.00039
Per capita	0.00000315 trips <sup>-1</sup>	95% C.I. 0.0000031- 0.0000033

2013- 2014 → 28 captured vaquitas

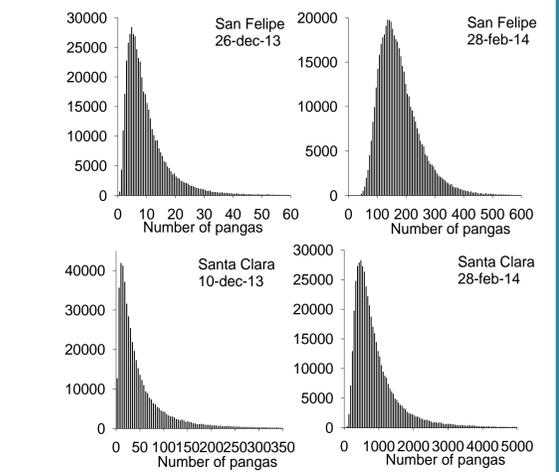
### LITERATURE CITED

Rojas-Bracho, L., R.R. Reeves y A.M. Jaramillo-Legorreta. 2006. Conservation of the vaquita *Phocoena sinus*. Mammal Review 36:179-216.  
CIRVA (2014) Report of the fourth meeting of the International Committee for the Recovery of the Vaquita (CIRVA). Final report 8-10 July 2014. Ensenada, Baja California, Mexico: International Committee for the Recovery of the Vaquita. 43 p.  
**ACKNOWLEDGEMENTS**  
Laboratorio de Ecología Pesquera - CICESE, Coordinación de Investigación y de Conservación de Mamíferos Marinos Instituto Nacional de Ecología y Cambio Climático.

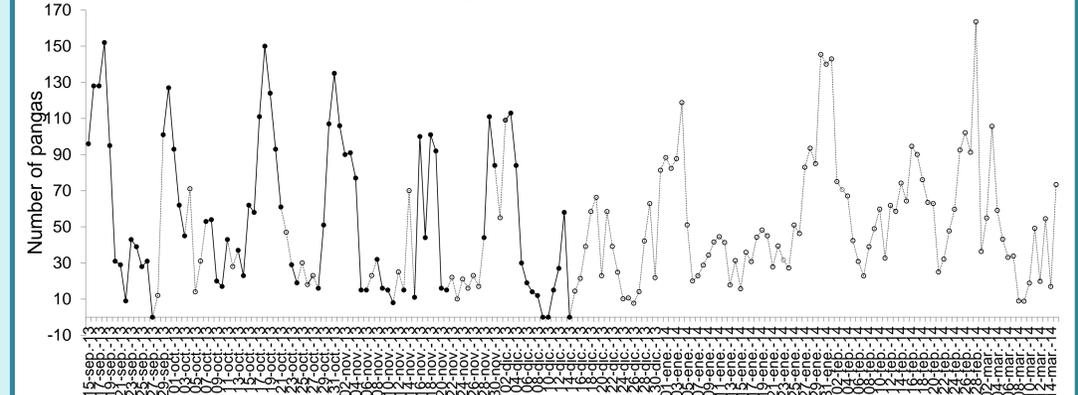
Posterior distributions for the estimated coefficients of the parameters (A) and the estimated. The median of each distribution represented the punctual value for each coefficient.



Posterior distributions of the fishing effort for the days with less (left) and most (right) number of trips estimated for San Felipe and El Golfo de Santa Clara. The median of each distribution represented the punctual value for each day.



Observed (solid line) and estimated (dotted line) fishing effort for the 2013-2014 shrimp season of San Felipe.



## DISCUSSION

This study represents the first update in 20 years documenting the dynamics and behavior of the Upper Gulf of California artisanal fishing activities to measure and describe the fishing effort in which the vaquita population is under.

In 2014, the Comité Internacional para la Recuperación de la Vaquita (CIRVA, 2014) estimated that the vaquita population was less than 100 individuals. To estimate the number of vaquitas captured during 2013-2014, we multiply the number of trips conducted during the year by the population estimation by the estimated mortality rate. This tells us that the number of vaquitas that should have been captured in 2013-2014 is 28 individuals. In 1995 and later in 2002, the International Whaling Commission recommended that incidental mortality of small cetaceans should not exceed one quarter of the potential rate of increase. The vaquita mortality rate of 24% per year is six times its potential rate of increase.

A mortality rate of this magnitude suggests that the vaquita population could soon reach its minimum viable population size, decreasing any possibility of recovery. An immediate solution is to have the Mexican Government increase enforcement resources to ban gillnets and eliminate illegal fishing in the vaquita refuge. It is necessary to implement an alternative fishing gear that could benefit the local fishermen. Training and environmental education programs are required to teach local communities conservation strategies involving recovery. Vaquita population increase can only be achieved if all the involved organizations enforce strict conservation measures in collaboration with the government. The vaquita will soon be lost if bycatch is not eliminated immediately.

## CONCLUSION

Less than 100 vaquitas remain. Approximately 51,000 trips by the artisanal fleet were conducted, resulting on a mortality rate of more than 25 vaquitas per year. With a population growth rate of only 4%, the vaquita population is not capable of bearing with the current amount of fishing effort, particularly if the skiffs continue using gillnets as fishing gear. The vaquita can only recover if all gillnet fishing is eliminated.