REPORT OF VAQUITA EXPEDITION 2008 AND CURRENT CONSERVATION ACTIONS

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INTRODUCTION

Two scientific efforts brought the need for immediate actions to conserve vaquita as a high priority for the Mexican government. Passive acoustic techniques (Jaramillo-Legorreta, 2008) revealed a negative trend of acoustic detection rates over the past decade, which indicated a decreasing trend in vaquita abundance (Jaramillo-Legorreta and Rojas-Bracho, 2008). The second effort inferred that only about 150 vaquitas remain using information on fishing effort, vaquitas by-catch rate and porpoises' population growth rates (Jaramillo-Legorreta *et al*., 2007). Current low vaquita abundance made, finding a new method capable of detecting vaquita trends with greater precision, a necessity.

The mission of Vaquita Expedition 2008 was to evaluate the performance of different passive acoustic detectors to develop methods to monitor trends in abundance of the vaquita in the Upper Gulf of California. The ultimate goal of the expedition was to obtain data on the distribution, movements, and density of the vaquita to allow scientists to design a monitoring scheme and inform management decisions. Monitoring is critical to assess the effectiveness of the Mexican Government's vaquita recovery plan.

VAQUITA SURVEY 2008

Acoustic technology available

Five different technologies were identified that could be used to monitor vaquita. The "Porpoise Detector" (Gillespie and Chappell, 2002) has been used successfully since 1999 to study vaquita. Data obtained with this equipment showed to the Mexican Government the very critical population decline that vaquita experienced over the past decade, which sparked the recent encouraging Government actions to try recover the species. However, this technology uses electronic modules that have become obsolete. The Porpoise Detector has been replaced by the "Rainbow click detector". To maintain continuity in the vaquita acoustic detection rate time series, the new technology needed to be calibrated against the older technology. Neither technologies are autonomous (an operator must be oversee recording).

The other three kinds of equipment work autonomously, which allows implementing a network of autonomous acoustic detectors to monitor vaquita over periods of months without maintenance. These three detectors were: the A-Tag (Akamatsu *et al*., 2005), the T-POD and the C-POD (Tregenza, 2006) (the new C-POD was an improvement developed based on the T-POD).

Conceptually, the A-Tag is a "miniature stereo pulse event recorder" (Akamatsu *et al*., 2005). It captures peak intensities (pressure) in every 0.5 ms time bin and, if the intensity is higher than a threshold, the value is stored in flash memory. This equipment also stores the time difference in the arrival of signals to both hydrophones, in order to calculate bearings to the signal sources. No waveform data is stored.

The T-POD is a click train detector. Once per minute, the equipment runs 6 successive scans, consisting of a comparison of intensities between frequency bands of interest and those of reference. It selects tonal clicks that meet a difference criterion on every scan and records only the time and duration of each click. Both are logged in 10 microsecond units. Digitized sound is not stored. Click train recognition is implemented in computer software once data is downloaded from the equipment. In contrast, the C-POD records time of occurrence, centre frequency, intensity, duration, bandwidth and frequency trend of tonal clicks stored within the frequency range 20 to 150 KHz. It is possible to set the maximum number of clicks stored per second in order to save memory. As with the T-POD, computer software is devoted to manage, manipulate and analyze data.

Methods

Beyond the acoustic expertise of the research team, we invited the inventors of the primary acoustic devices being used by the Vaquita Expedition. Jonathan Gordon (Ecologic and Sea Mammal Research Unit, University of St. Andrews, United Kingdom) is an expert in the equipment used for the past decade to study vaquita (Porpoise Detector) and the newer development called "Rainbow Click". Tomonari Akamatsu (Fisheries Research Agency, Japan) is the inventor of the A-Tag. Nick Tregenza, an independent researcher from the United Kingdom, is the leader of the team that developed T-POD and the C-POD. A telephonic conference was held in SWFSC facilities, La Jolla, USA, between the Mexican and American scientific teams with the inventors and developers (including Doug Gillespie, the engineer behind Porpoise and Rainbow technologies) in order to talk about equipment availability (including the release of the first version of C-POD), objectives and potential sampling designs.

The Expedition used three vessels: *Koipai Yú-Xá*, an 11 meters steel hull power boat property of the Instituto Nacional de Ecología (SEMARNAT - Mexico), designed and built specifically to apply acoustic techniques to study vaquita. *Vaquita Express*, a Corsair type 8 meter trimaran sailboat, towed an acoustic array in shallow water areas, and the. *David Starr Jordan*, a 52 meters NOAA research vessel devoted to visual survey to study distribution and abundance of vaquita, deploying temporary buoys for the autonomous acoustic detectors and gathered depth and oceanographic data.

In June, 2008, field trials were performed aboard Koipai Yú-Xá to test acoustic equipment and become familiarized with its operation. A new testing system, designed by Jay Barlow (SWFSC-NOAA), generated porpoise-like artificial clicks, which could be used to compare the performance of the different passive acoustic devices at different distances. In addition to, a scuba dive to inspect the consistency of the seafloor revealed a bottom of fine clay. The idea to deploy a bottom-mounted trawler-proof acoustic housing was abandoned because it would quickly become buried given this bottom and the high tidal currents.

The 1997 survey demonstrated that vaquita avoided both the large research vessel (out to 900m) and the smaller Mexican vessel used to survey the shallow waters. Porpoises can be detected out to about 700m but reliably out to only about 300m, which made using a quiet vessel necessary for a passive acoustic survey. In 2008 the shallow water area was covered by a sailboat, the Vaquita Express. It surveyed three regions within the extended habitat of vaquita in the Upper Gulf of California: (1) Tandem Survey Area (TSA), (2) Northern Survey Area (NSA), and (3) Western Survey Area (WSA) (Figure 1). The focus of the first three weeks of survey (during September) was to determine the capabilities and limitations of the vessel, and local weather conditions, to obtain positive acoustic encounters with vaquita in the region of known distribution, and to fine-tune the acoustic methods. Based on the conditions encountered during this trial period, tracklines were designed for each of the three study areas. For the remainder of the survey, tracklines were completed as weather conditions allowed and modified according to changing conditions. The Tandem Survey Area (TSA) consisted of a series of tracklines within a box of known relatively high densities of vaquita (Jaramillo-Legorreta, 2008; Jaramillo-Legorreta *et al*., 2005). The box was surveyed by both the Vaquita Express and the David Starr Jordan independently and within a short period, to provide a means of comparing density estimates.

The David Starr Jordan surveyed the remaining vaquita distribution area using distance sampling methods (Figure 2 shows planned tracklines). In addition, this vessel was deployed, relocated, and recovered the buoys used to deploy the acoustic detectors in the locations depicted in Figure 3 (four buoys loaned by SCRIPPS Institution of Oceanography, UCSD, USA). Other data gathered were extensive mapping of depth and oceanographic data, including the use of a transmissometer to study turbidity. Inventors of the acoustic equipment were on board for the first five days to oversee deployment, conduct tests of equipment performance, and gain understanding of the special conditions in this area which included high noise from snapping shrimp and extreme tides and winds that also contribute noise and risk to the equipment.

The performance of the acoustic detectors was tested from the Koipai Yú-Xá using the porpoise-click emulator under conditions of high levels of background noise to obtain data on the detection distances for all devices. The primary research by the Koipai Yú-Xá was to continue using the sampling design similar to that used since 2001 (Jaramillo *et al*., 2008) so that the time series could be calibrated using the new methodologies. The boat was taken to several sampling stations (Figure 4) throughout the vaquita distribution area, where the boat was anchored and the engines turned off (the engines were turned on for some periods to recharge batteries). Sampling time for each station was 24 hours when weather conditions allowed. Rainbow and Porpoise detectors operated continuously. During late October and early November, we also deployed a C-POD and a T-POD. In the second part of November, we also used an additional array of hydrophones to obtain high frequency recordings (330 KHz) to describe background noise. A mini CTD was deployed to obtain salinity, temperature and depth profiles. We applied two kind of sampling designs. The first one consisted of sampling of values at an approximate depth of 8 meters every minute, with a vertical profile taken approximately every three hours matched with tidal phases. The second design consisted in to leave the CTD at a constant depth for an hour. Three depth levels were used at approximately 5, 15 and 25 meters. Additionally, Koipai Yú-Xá was used to recover acoustic equipment from buoys, download data and redeploy acoustic devices.

Results

The Vaquita Express traveled a total of 723 Km under effective effort (Fig. 5). In the NSA zone 186.5 Km were done, 205.9 Km in WSA, 292.4 Km in TSA and a total of 38.4 Km in other areas. A total of 36 certain acoustic detections (click trains) were obtained as well 101 single click detections, which are not considered certain. Enough data to depict a time series of surface temperature and salinity were obtained, showing roughly a decrease in temperature and an increase in salinity.

The David Starr Jordan deployed and relocated acoustic detector buoys at seven locations around vaquita distribution area (Fig. 3). In addition, some deployments were done overnight when the vessel was anchored. In total more than 1,300 hours of acoustic recordings with A-Tag, C-POD and T-POD were obtained. The Jordan traveled a total of 1,439 Km along transects, from which 1,099 were under weather conditions appropriate to gather data to be included in the estimate of density (Beaufort 0-2; Fig. 6). A total of 122 sightings of vaquitas were obtained (31 under off effort operations); 90 of them under good weather conditions. Depths recorded were used to construct a bathymetry chart of the area navigated (Fig. 7).

Aboard the Koipai Yú-Xá we completed a total of 270 hours of effective effort divided in the 16 sampling stations performed (Fig. 4). During a small portion of the sampling time at the start of the survey we sampled with Porpoise Detector only. The remainder time both types of equipment were in operation. Preliminary analysis identified three certain and three probably acoustic detections. About 40 hours of high frequency recordings were obtained and more than 100 hours of oceanographic data.

Further steps and linking to recovery actions

Data are being analyzed independently by the different research teams that participated in the survey. Following analysis, the data will be used in a workshop where the researchers will design several potential monitoring schemes. Topics to be discussed could include modifications to acoustic equipment to improve performance, spatial extent and number of detectors required, and deployment and maintenance needs.

RECENT AND CURRENT RECOVERY ACTIONS

- SEMARNAT (Environment Ministry) applied PACE (recovery program) resources to retire gillnets.
- Vaquita Refuge Area (1,263.85 Km^2) closed to fishing activities and an economic compensation scheme established.
- CONAPESCA (Fisheries National Commission) assess all fishing licenses and permits.
- A law enforcement program is in place. In Figure 6 it is presented the distribution of artisanal fishing boats, which indicates that the enforcement program was effective in to avoid fishing operations inside the vaquita refuge.
- Experiments with alternative fishing gear (suriperas and changos, a kind of trawl net).
- A public awareness and environmental education program is going on together with the State Government of Baja California and Federal Government.
- 500 illegal pangas (fiber glass skiff boats) have been kept out from any fishing activities.
- 246 pangas were bought-out.
- 161 pangas have changed fishing gears.
- A shrimp farm is being rebuilt – 180 fishing boats will be retired.

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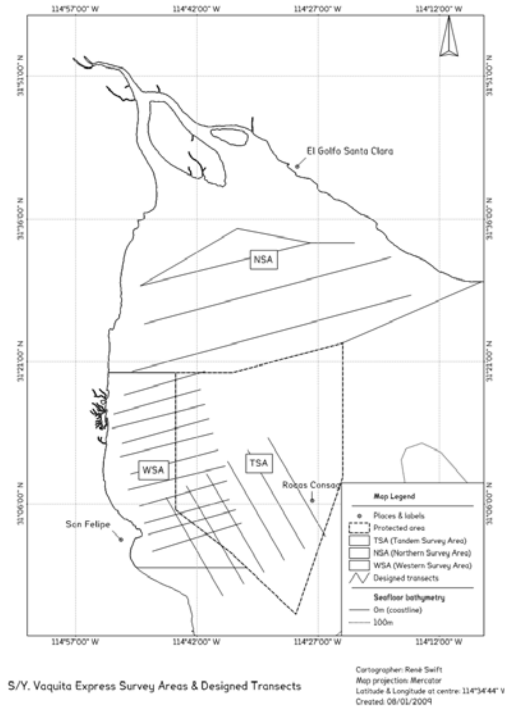

Figure 1. Survey areas covered by the *Vaquita Express*: Tandem Survey Area (TSA), Northern Survey Area (NSA), and Western Survey Area (WSA). The Vaquita Reserve is shown as a polygon enclosing the vaquita 'hot spot' and Rocas Consag.

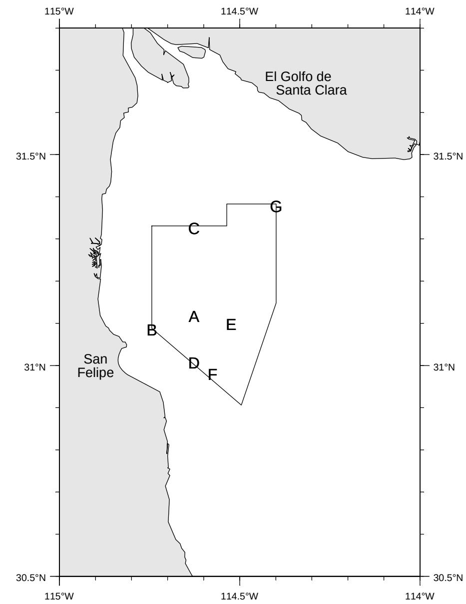

Figure 3. Location of the sites where the buoys used to deploy autonomous acoustic detectors were anchored. It is shown the vaquita refuge polygon.

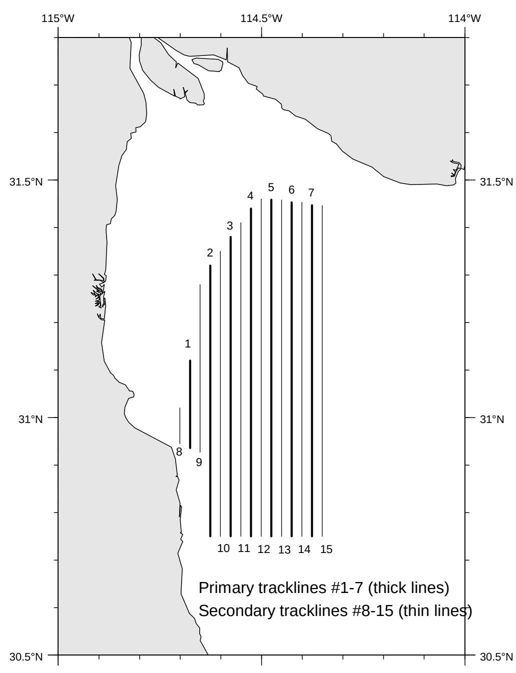

Figure 2. Planned tracklines to be covered aboard *RV David Starr Jordan*.

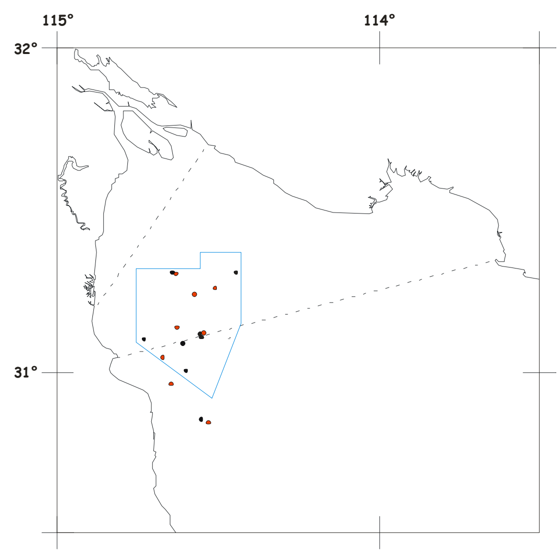

Figure 4. Location of sampling stations done aboard the *RV Koipai Yú-Xá.* It is shown the vaquita refuge polygon.

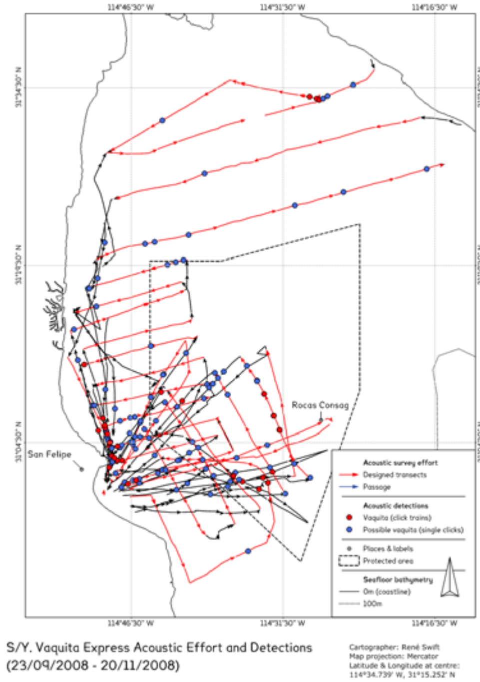

Figure 5. Map of Upper Gulf of California with tracklines and cetacean detections obtained aboard *Vaquita Express*. Detections of acoustic and visual detections of vaquita are shown as dots.

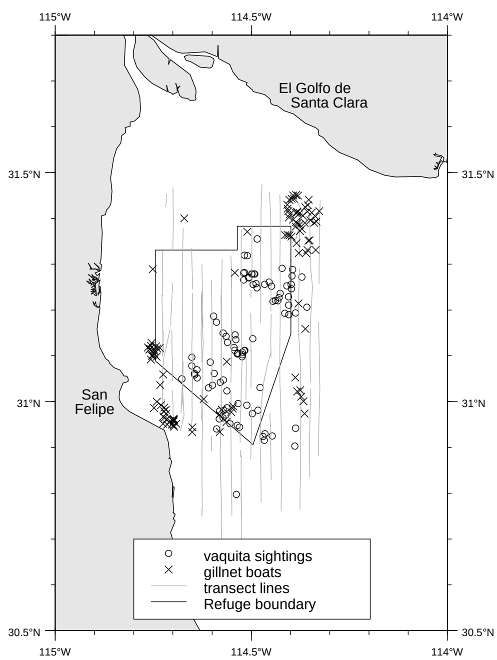

Figure 6. Location of vaquita sightings and artisanal fishing boats detected along transects surveys done aboard *RV Davis Starr Jordan*. It can be observed that most of the fishing boats were aggregated outside the vaquita refuge.

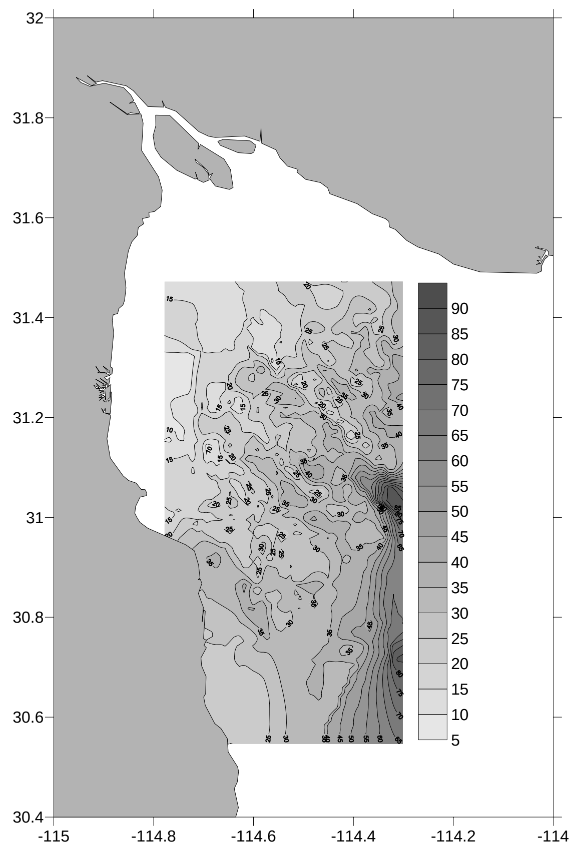

Figure 7. Bathymetry chart constructed with data gathered aboard *RV David Starr Jordan*. It is noted the complexity of the sea bed in vaquita habitat, which must be taken into account for the design of the monitoring scheme.