LAGUNA SAN IGNACIO ECOSYSTEM SCIENCE PROGRAM

ACOUSTIC RESEARCH

2013 WINTER SEASON REPORT

By: Kerri Seger, Melania Guerra, and Aaron Thode

September 3, 2013

TEAM

The core LSIESP Acoustic Research Team that performed the 2013 season fieldwork at Laguna San Ignacio included P.I. Aaron Thode, graduate student Kerri Seger (Scripps Institution of Oceanography, SIO), Ludovic Tenorio (Grenoble Institute of Technology), and post-doctoral researcher Melania Guerra (Cornell University).

TRAVEL DATES AND TRIP SUMMARY

1) Deployment of the acoustic gear was performed in early February by Aaron Thode and Kerri Seger, with assistance from Sergio Martinez. Aaron and Kerri traveled by bus from San Diego to Laguna San Ignacio on Jan. 29, 2013. On Feb. 1 the two researchers deployed three sets of instruments at three different sites. Two sites had been used previously, while a new site was tested at the mouth of the lagoon. Two new sets of acoustic instruments were tested this year. First, multiple-hydrophone recorders that consisted of eight hydrophones each, with a 24 m aperture, were deployed at two locations within the lagoon near Punta Piedra and the so-called "Punta Piedra West" location. Next, a new recorder that could detect sounds up to 50 kHz (dolphin whistle range) was deployed at the mouth of the lagoon. In addition to these two systems, a "tried-and-true" recorder was also deployed along with the multiple-hydrophone system at the Eastern Punta Piedra site.

After the deployment on Feb. 4 Aaron and Kerri flew with the World Wildlife Fund team on Feb. from La Laguna to La Paz, B.C.S. From La Paz. They continued with the UABCS visual team (Jorge Urban, Juan Carlos Salinas, Pamela Loustalot Martinez, and Diana Lopez) to San Jose del Cabo and Cabo San Lucas to deploy additional acoustic gear for another project.

2) Recovery of the acoustic gear was performed by Kerri, Melania, and Ludovic between March 22 and March 27. They also travelled by bus from San Diego to La Laguna. The two sites within the lagoon were successfully recovered, but the deployment at the lagoon mouth was never grappled successfully. A reward poster for $500 (US dollars) was left with the kitchen staff at Kuyima in case any of the local fisherman either accidentally retrieved the gear at the mouth of the lagoon or intentionally dived for the gear during a

slack tide and were successful in the recovery. The local fishermen at Baja Discovery informed the team that the deployment site was subject to high currents and high sedimentation rates.

Once the data was collected and archived back at SIO, several undergraduate volunteers and interns (Patrica Fernan, Gina Horath, and Alexa Hasselman) contributed additional help to perform a preliminary stage of post-processing and analysis. Kerri Seger performed some basic ambient noise analysis that will be presented later in this report.

Picture 1: The acoustic recovery team (left) and deployment team (right) with the visual team from UABCS and visitors. Photo credit to Sergio Martinez.

DATA COLLECTION

A) Acoustic Data

The acoustic research executed in Laguna San Ignacio during the 2013 season involved deploying three underwater recording stations, each with a slightly different configuration. They were a combination of custom-designed, autonomous instruments (called Configurable Acoustic Recording Devices [CARDs], or "Gen ones," depending on whom you ask) and 8-element horizontal arrays. The exact station locations and specific configurations are as follows:

1) PUNTA PIEDRA EAST
    a. ELEMENTS included array A1 and the single generation 1 CARD
    b. LOCATION was closer to the shore of Punta Piedra. GPS locations were taken at the first anchor (N26°47.685, W113°14.656) and the array case (N26°47.637, W113°14.677).

2) PUNTA PIEDRA WEST
    a. ELEMENTS included array A2 alone
    b. LOCATION was farther from the shore of Punta Piedra. It was placed 2 km away from Punta Piedra East. GPS locations were taken at the first anchor (N26°42.812, W113°15.371), the array case (N26°46.795, W113°15.385).

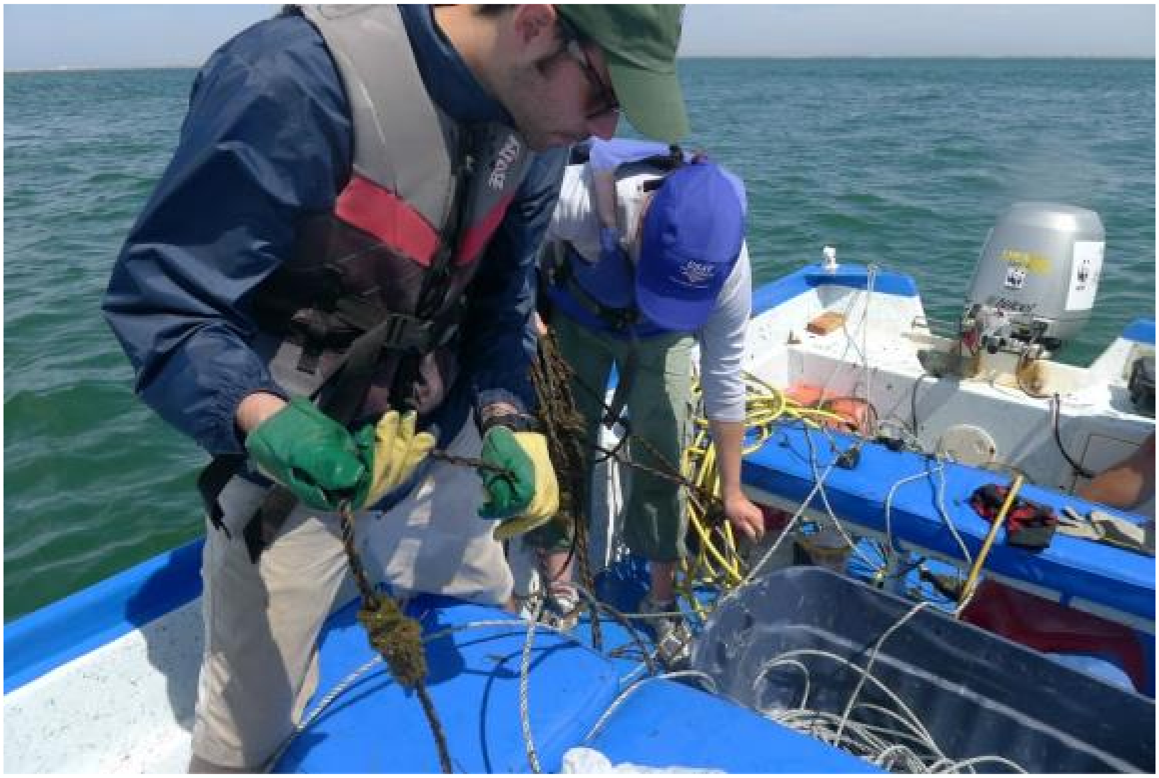
These two stations were chosen to provide continuity to previous acoustic records collected off Punta Piedra (2008-2012) by the same research effort. By placing the arrays of Punta Piedra East and West parallel to each other, it was hoped that tracking capabilities would be possible. It is of note that the Eastern station had a single CARD attached to it, meant to provide redundancy to the system. During this deployment, this independent CARD proved to be critical because the plugs connecting the arrays to the hard drives were dislodged during deployment. Therefore, a reassessment for deployment strategy based on these considerations will ensue for the 2014 field season.

3) LAGOON MOUTH
   a. ELEMENTS included a single generation 1 CARD (S1)
   b. LOCATION was on the eastern side of the mouth of the lagoon (farther South than the array locations) at GPS coordinates of the anchor (N26°42.130, W113°16.715) and the CARD itself (N26°42.164, W113°16.717).

The remaining CARD was placed as a single unit at the mouth of the lagoon. This was intended as an exploratory deployment designed to monitor vocally-active whales entering and exiting the lagoon, as well as the ambient noise conditions created by the local surf zone and tidal changes. However, recovery of this instrument was unsuccessful, likely caused by the elevated accumulation rates of sediment over the instrument from high current flow in the area. This theory is supported by conversations with local fishermen at the Baja Discovery site, who related that lobsterpots (twice as tall as a CARD) deployed at the mouth are commonly buried within a day. While the team had consulted with local knowledge at the Kuyima location, the experience of this year clearly indicates that a broader spectrum of local experience should be consulted before attempting to deploy in a new region.

B) Auxiliary Data

Circular paths were driven by the pangas after deployment and before recovery to calibrate the recordings later during analysis. The recordings of these boats will also be used as sources of opportunity, for analyses such as outboard motor signal source strength and transmission loss across the unique bathymetry and water depth of each location.



Picture 2: Ludovic Tenorio and Kerri Seger untangling the anchor lines form the array cable for Punta Piedra East. Photo credit to Melania Guerra.

PRELIMINARY ANALYSIS

SIO graduate student Kerri Seger has conducted a preliminary analysis of the data from the Punta Piedra East CARD to investigate the overall noise budget across four different frequency bands. Analysis was performed using custom built code in Matlab 2012b. The bands were purposefully selected to approximately match various known sound sources. They include 5-25 Hz (related to tidal noise and fish sounds), 10-140 Hz (mainly dominated by gray whale calls), 200-1000 Hz (due to boat engines and some gray whale calls), and 1000-3125 Hz (caused by near-by boat engines, wind, and snapping shrimp). A comparative analysis was performed between this year's noise budget and past years (2008-2012) at both the Punta Piedra location and the North Station, close to the campsite of Kuyima Ecoturismo. Some example plots are presented in Figures 1 and 2, while Figure 3 shows representative noise plots ("Wenz curves") for the world's oceans.

PRELIMINARY RESULTS

An initial inspection of the recordings made at the 2013 Punta Piedra East station demonstrated that, as expected, the CARD documented gray whale calls and naturally occurring biological and non-biological noise (e.g., tides, snapping shrimp, & fish).

Preliminary results of sound pressure level (SPL) are plotted as cumulative distribution plots (Figures 1 and 2), which describe the probability or percentage of time (y-axis) when the acoustic sound pressure level (SPL) off Punta Piedra occurred at or below a specific decibel (dB) level (x-axis). Figure 1 illustrates the SPL (relative to 1 microPascal) cumulative percent distribution computed across four frequency bandwidths on acoustic data collected at LSI in 2013. It can be noticed that the highest SPLs are attained by the curve representing the highest frequency range (1000-3125 Hz range, black line). Relatively, the least amount of sound energy is generated in the 5-25 Hz range. This suggests that sound levels caused from tidal activity are, at all times, lower than those from snapping shrimp, wind, and other high frequency sources from boat engines.

Figure 2 shows the Sound Pressure Level (SPL) cumulative percent distribution for all seasons when the LSIESP Acoustics Team has collected data (2008-20013), computed in the frequency range between 10 and 145 Hz (associated with gray whale calls). Overall, 2012 presents the “loudest” levels, while 2010 is the “quietest” year. For example, 50% of the time, levels in 2010 (green) were 20 dB lower than 50% of the time in 2012 (blue).

Another way of interpreting Figure 2 is presented here. The green line (2010) from Figure 2 indicates that the overall amount of sound in the environment between 10 to 145 Hz stayed at or below 90 dB for 60% of the time. Additionally, all of the sound energy (100%) stayed below 110 dB. This means that the environment was never "louder" than 110 dB over the entire 2010 deployment time. In comparison the overall amount of sound in the environment between 10 to 145 Hz for 2012 (blue line), stayed at or below 108 decibels for 60% of the time. The "loudest" that the marine environment became at Punta Piedra in 2012 was 128 dB rms. It was never “quieter” than 88 dB rms.

How does one put these numbers into perspective? The median SPL during a "typical year" in the lagoon is between 10 and 145 Hz is 95 dB re 1 microPascal. This yields a "power spectral density" (average power per unit frequency) of 95-10log(145-10)=95-21=74 dB re 1 uPa^2/Hz. Figure 3 is a classic "Wenz curve plot" that shows typical distributions of ocean noise throughout both coastal and deep waters. One sees that 75 dB between 10 and 145 Hz is about midrange, lying in the "Usual traffic noise+shallow" interval. What has not been determined is whether panga traffic during daylight hours is a substantial contributor to the noise field over this frequency range.

The frequency range between 1 and 3 kHz, generally dominated by wind and snapping shrimp, is more interesting. From Figure 2, one sees that in 2013 the median power spectral density in this band was 105-10log(3000-1000)= 72 dB re 1uPa^2/Hz. Figure 3 indicates that this is quite noisy, in terms of the open ocean: it corresponds to sea state levels of 6 in the open ocean. Thus over this frequency range the lagoon is quite a noisy place. We suspect snapping shrimp is the major contributor to this noise

Fig 1: Sound Pressure Level (SPL) cumulative percent distribution computed across four frequency bands on the acoustic data collected at Punta Piedra for 2013 only.

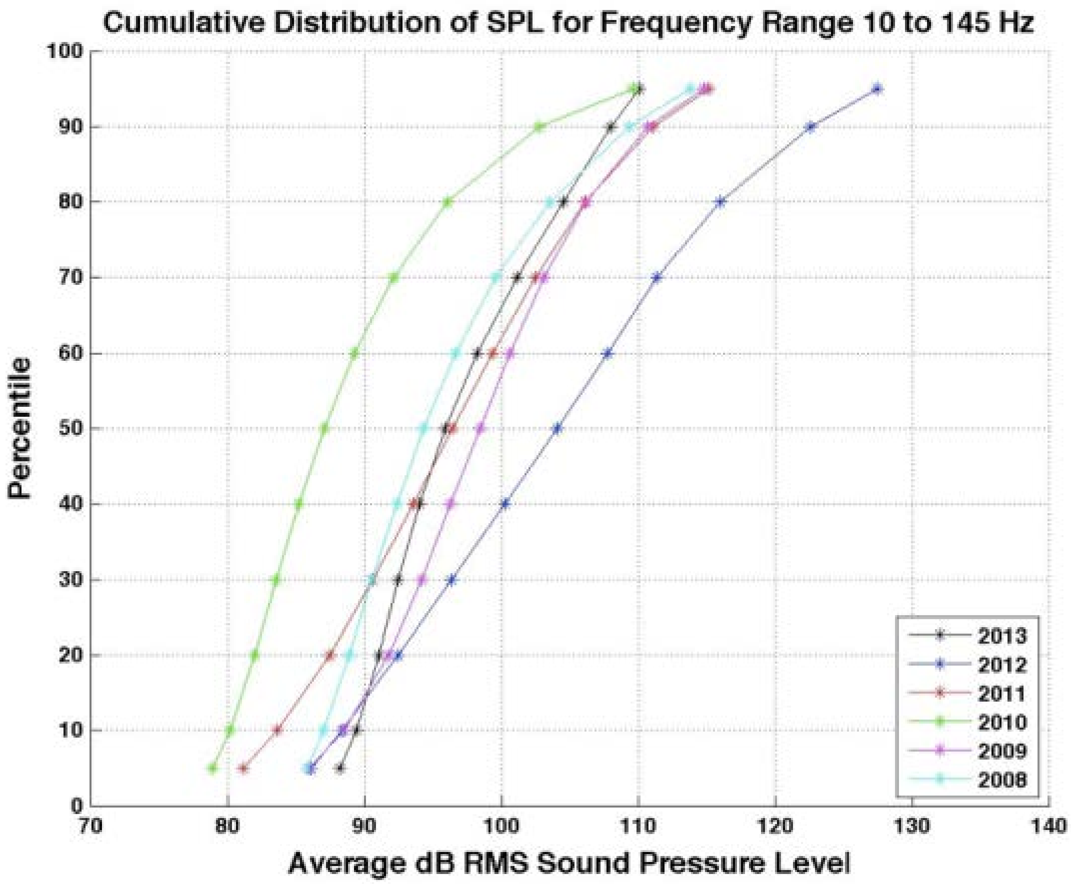


Fig 2: Sound Pressure Level (SPL) cumulative percent distribution for all seasons when the LSIESP Acoustics Team has collected data (2008-2013), computed for the frequency range between 10 and 145 Hz (a range associated with gray whale calls).

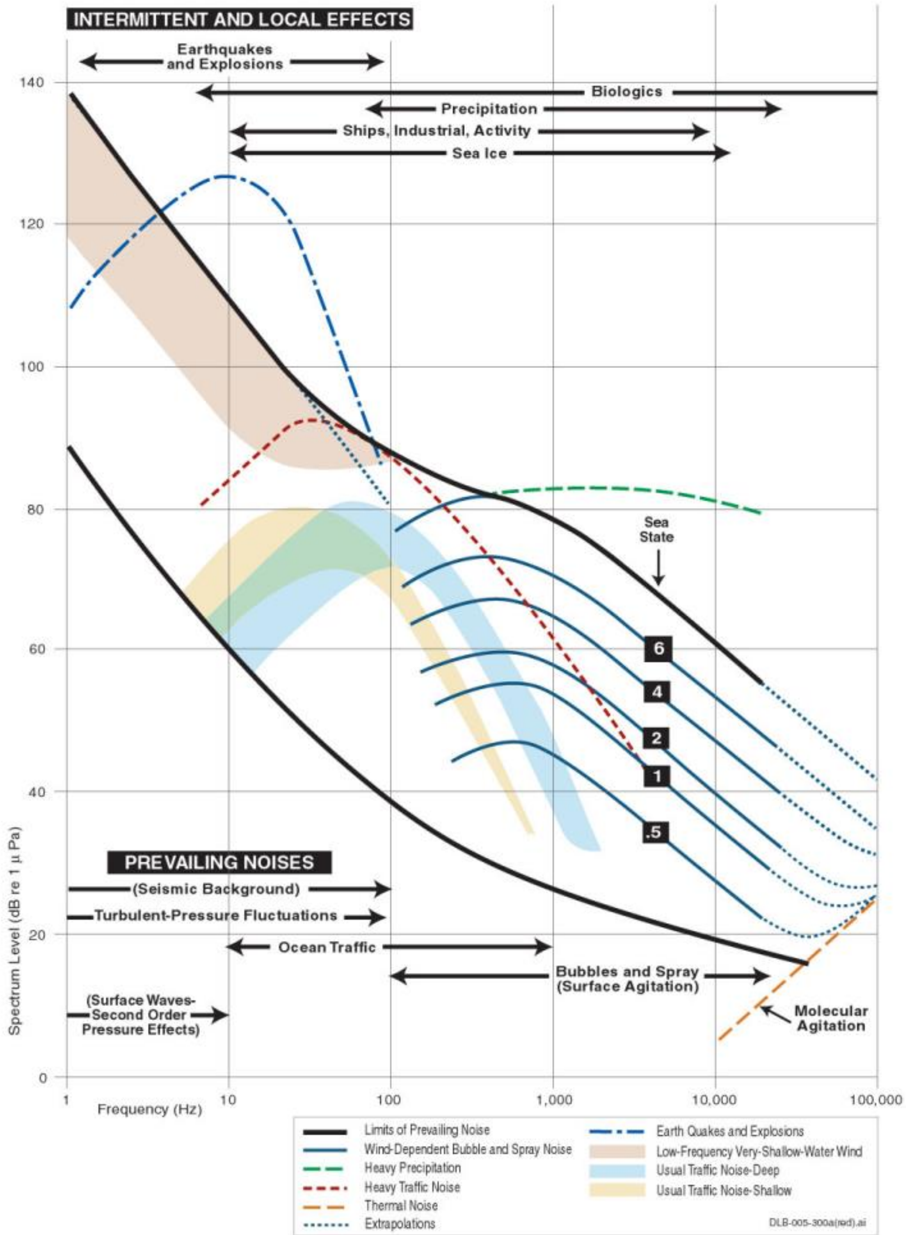


Fig. 3: "Classic" background noise levels in the ocean as a function of frequency. To make the units compatible with Figures 1 and 2, one has to add 20 dB to this figure. For example, median noise levels in Fig. 2 would lie at 75 dB between 10 and 100 Hz on this figure.

FUTURE WORK

Additional analyses that will likely be performed include the following:

1) Comparing the acoustic time series plots with sunrise/sunset and tide charts to explore the variability of these noise-generating mechanisms and their potential impact on the

acoustic environment. The noise patterns during daytime and nighttime will also be computed and compared. Since panga activity only occurs during the day, the contrast will be enlightening.

2) Statistical analysis to quantify the noise source contributions by frequency ranges (similar to Figure 1) and to determine which ones add significant acoustic energy to the Lagoon environment.

3) The aforementioned undergraduate researchers are currently working on manually extraction of gray whale calls from the 2013 data, to continue to explore how the number of animals present in the lagoon is related to call detection rates.

AKNOWLEDGEMENTS
For transportation assistance, we would like to thank Art and Celia Condit and the use of their boat, The Searcher. We give additional thanks to the World Wildlife Federation and the family of Constanza Torres for inviting members of the research team on last minute travel to La Paz. We are especially grateful to the Ocean Foundation and the NSF's IGERT program for providing the funding that made this research possible.