CDR Carl Hager's 2012 Research Students

Raychel Minker is investigating *Odontocete* (suspected *Delphinus delphis*) "vocal mimicry" events recorded during a playback experiment at the SOAR Underwater Acoustic Range. Four whistle contours were transmitted at several locations on the range and acoustic data was recorded on both bottom hydrophones and sonobuoys. During post-processing of the recordings, several vocalizations were discovered that matched the synthetic whistles in a slope defined by frequency and time. Raychel will seek to quantify the "likeness" of the response whistles to the synthetic whistles.

Mimicry during a 2005 Playback Experiment at SOAR

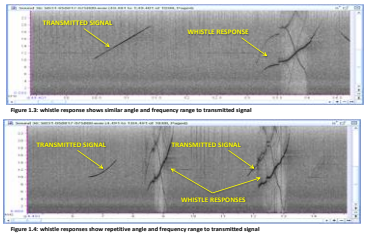


Figure 1.3: whistle response shows similar angle and frequency range to transmitted signal

Figure 1.4: whistle responses show repetitive angle and frequency range to transmitted signal

Mimicry during a 2005 Playback Experiment at SOAR

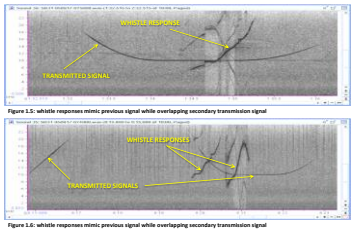
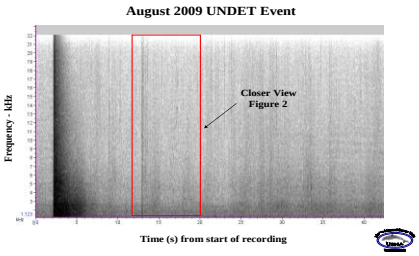


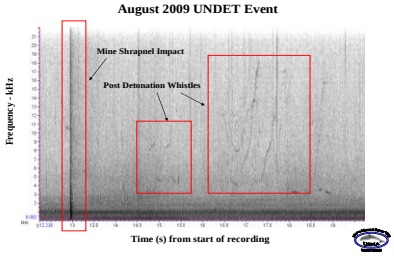
Figure 1.5: whistle responses mimic previous signal while overlapping secondary transmission signal

Figure 1.6: whistle responses mimic previous signal while overlapping secondary transmission signal

The figures above display both transmitted synthetic whistles and whistle responses.

Jeb Thompson is investigating Atlantic bottlenose dolphin (*Tursiops truncatus*) whistle responses to shallow water Explosive Ordnance Disposal exercises or UNDETs. Three visual and acoustic monitoring cruises (2009, 2010, 2011) conducted in W-50 of the Virginia Capes Operating Area have collected several recordings prior to, during and immediately after these events. Jeb will collect additional data throughout the year.





The spectrograms above display (left) the detonation and (right) whistle responses to the detonation.

Kierstin King is constructing a prototype bottom mounted and autonomous recording hydrophone "package" for use in the August 2012 marine mammal monitoring cruise in the Virginia Capes Operating area. The prototype will use previously expended AN/SSQ-53F Sparton sonobuoy Calibrated Omnidirectional (CO) and Constant Shallow Omnidirectional (CSO) hydrophones. Should Kierstin's design prove successful, an array of eight recording packages will be will be deployed in August of 2012.

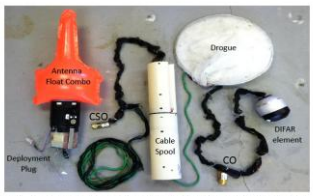
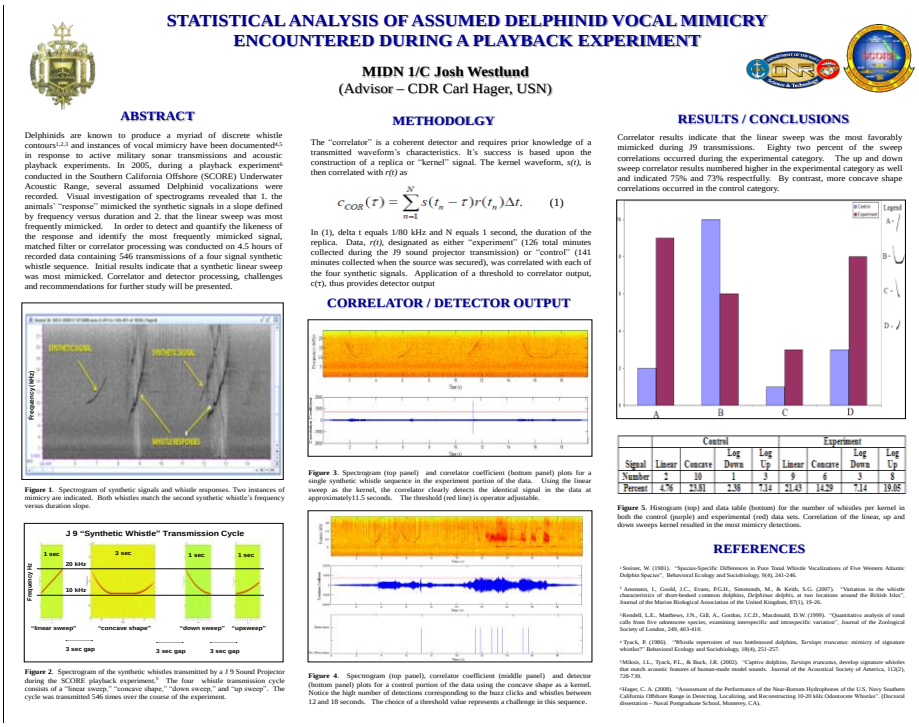


Figure 2. Display of Sonobuoy Hardware Following Deployment. The surface unit consists of the orange antenna / float combo, the battery and the deployment plug. The buoy's three sensors are the Constant Shallow Omni (CSO) hydrophone (set for a fixed depth of 13.7 m), the Calibrated Omni (CO) hydrophone and the DIFAR element (deployed to a selected depth of 27, 61, 122 or 305 m).

The figures above display (left) the hardware associated with an AN/SSQ-53F sonobuoy and (right) the CSO hydrophone.

Recent Student Posters

Joshua Westlund 2011



STATISTICAL ANALYSIS OF ASSUMED DELPHINID VOCAL MIMICRY ENCOUNTERED DURING A PLAYBACK EXPERIMENT

MIDN 1/C Josh Westlund
(Advisor – CDR Carl Hager, USN)

ABSTRACT

Delphinids are known to produce a myriad of discrete whistle contours[1,2,3] and instances of vocal mimicry have been documented[4,5] in response to active military sonar transmissions and acoustic playback experiments. In 2005, during a playback experiment[6] conducted in the Southern California Offshore (SCORE) Underwater Acoustic Range, several assumed Delphinid vocalizations were recorded. Visual investigation of spectrograms revealed that 1. the animals' "response" mimicked the synthetic signals in a slope defined by frequency versus duration and 2. that the linear sweep was most frequently mimicked. In order to detect and quantify the likeness of the response and identify the most frequently mimicked signal, matched filter or correlator processing was conducted on 4.5 hours of recorded data containing 546 transmissions of a four signal synthetic whistle sequence. Initial results indicate that a synthetic linear sweep was most mimicked. Correlator and detector processing, challenges and recommendations for further study will be presented.

Figure 1. Spectrogram of synthetic signals and whistle responses. Two instances of mimicry are indicated. Both whistles match the second synthetic whistle's frequency versus duration slope.

Figure 2. Spectrogram of the synthetic whistles transmitted by a J 9 Sound Projector during the SCORE playback experiment.[6] The four whistle transmission cycle consists of a "linear sweep," "concave shape," "down sweep," and "up sweep". The cycle was transmitted 546 times over the course of the experiment.

METHODOLGY

The "correlator" is a coherent detector and requires prior knowledge of a transmitted waveform's characteristics. It's success is based upon the construction of a replica or "kernel" signal. The kernel waveform, *s(t)*, is then correlated with *r(t)* as

$$c_{COR}(\tau) = \sum_{n=1}^{N} s(t_n - \tau) r(t_n) \Delta t. \qquad (1)$$

In (1), delta t equals 1/80 kHz and N equals 1 second, the duration of the replica. Data, *r(t)*, designated as either "experiment" (126 total minutes collected during the J9 sound projector transmission) or "control" (141 minutes collected when the source was secured), was correlated with each of the four synthetic signals. Application of a threshold to correlator output, c(τ), thus provides detector output

CORRELATOR / DETECTOR OUTPUT

Figure 3. Spectrogram (top panel) and correlator coefficient (bottom panel) plots for a single synthetic whistle sequence in the experiment portion of the data. Using the linear sweep as the kernel, the correlator clearly detects the identical signal in the data at approximately11.5 seconds. The threshold (red line) is operator adjustable.

Figure 4. Spectrogram (top panel), correlator coefficient (middle panel) and detector (bottom panel) plots for a control portion of the data using the concave shape as a kernel. Notice the high number of detections corresponding to the buzz clicks and whistles between 12 and 18 seconds. The choice of a threshold value represents a challenge in this sequence.

RESULTS / CONCLUSIONS

Correlator results indicate that the linear sweep was the most favorably mimicked during J9 transmissions. Eighty two percent of the sweep correlations occurred during the experimental category. The up and down sweep correlator results numbered higher in the experimental category as well and indicated 75% and 73% respectfully. By contrast, more concave shape correlations occurred in the control category.

	Control				Experiment			
Signal	Linear	Concave	Log Down	Log Up	Linear	Concave	Log Down	Log Up
Number	2	10	1	3	9	6	3	8
Percent	4.76	23.81	2.38	7.14	21.43	14.29	7.14	19.05

Figure 5. Histogram (top) and data table (bottom) for the number of whistles per kernel in both the control (purple) and experimental (red) data sets. Correlation of the linear, up and down sweeps kernel resulted in the most mimicry detections.

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Jenny Sturzbecher 2010 – Posters presented at:

- **The 5th International Workshop on Detection, Classification, Localization, and Density Estimation of Marine Mammals using Passive Acoustics**
- **The 19th Biennial Conference on the Biology of Marine Mammals in Tampa, Florida**

Acoustic detection of Atlantic bottlenose dolphin (*Tursiops truncatus*) vocalizations using AN/SSQ53F sonobuoys modified for autonomous data collection

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ABSTRACT

SSQ53F sonobuoys provide a reliable though expendable passive monitoring capability for both aircraft and surface Navy vessels. Acoustic data is transmitted from the buoy to a receiver system on either platform via selectable VHF frequencies. While this sensor and modified forms have proven valuable in most marine mammal detection and localization applications[1-6], monitoring regions with significant VHF interference preclude continuous coverage. The use of autonomous recording packages, constructed from expended SSQ-53F hardware and hydrophones would best suit this purpose. In August of 2010, five "spar buoy" packages were deployed during a three day visual and acoustic survey onboard the U.S. Naval Academy's 109 foot research vessel in the Virginia Capes Operating Area. Portions of the survey track were within 3 miles of the Virginia coastline and as expected, VHF interference was encountered. When deployed, the Constant Shallow Omnidirectional (CSO) hydrophone output voltage was recorded directly from the sonobuoy's Electronic Function System (EFS) circuit board at a 44.1 kHz sampling rate using a MicroTrack II digital recorder. The system proved successful as numerous *Tursiops truncatus* vocalizations were detected. Sonobuoy deconstruct, recording package construction, and results are presented in this poster.

OBJECTIVES

1. Design and build low-cost and autonomous recording packages utilizing expended SSQ-53F sonobuoy hardware.

2. Mount the recording packages on "high flyer" spar buoys for multi-event use.

3. Detect and localize marine mammals using acoustic data collected during acoustic monitoring surveys in support of the VACAPES Environmental Impact Statement.

BACKGROUND / INTRODUCTION

In 2009, the U.S. Naval Academy's 109' research vessel conducted extensive visual surveys in the VACAPES W-50 operating area and documented the presence of sea turtles and bottlenose dolphins (*Tursiops truncatus*). During the same underway period, a single Cetacean Research Technology C55 hydrophone was deployed and recorded several dolphin whistles and echolocation clicks. Unfortunately, the recordings were significantly degraded by ship noise.

In an effort to eliminate ship noise masking and increase the number of monitoring hydrophones for the 2010 survey, five autonomous recording packages were constructed using expended AN/SSQ-53F sonobuoy hardware. The SSQ-53F is an A-size sonobuoy which combines a passive directional and calibrated omni-directional capability into a single multi-functional sonobuoy. The sonobuoy can operate in three selectable acoustic sensor modes. The Constant Shallow Omni (CSO) hydrophone operates at a fixed shallow depth while a Calibrated Omni (CO) hydrophone and DIFAR sensor collect acoustic data at a selectable operational depth. Adjustable settings include operating mode (sensor selection), buoy life, automatic gain control level, depth setting and RF channel.[7]

METHODOLOGY

Prior to pier side deployment, the SSQ-53F was removed from the sonobuoy launch container (SLC) and the parachute disconnected and discarded. Sensor settings were then accomplished via the Electronic Function Select (EFS) entry buttons. Figure 1 displays the buttons and details the settings for this study.

Figure 1. Image of SSQ-53F Sensor Settings and Entry Buttons. The life, depth, sensor type and AGC selections are accomplished using the two buttons on the surface unit. Once settings of 8 hours, depth "4ft" (13.7 m), "CO" and "AGC off" were selected and verified, the buoy was deployed pier side. Following inflation of the float antenna combination and separation of the cable spool from the surface unit, the buoy was retrieved.

Figure 2 displays the hardware collected from the water after deployment. Note that the white cylinder housing the cable spool disconnected from the floating surface unit and left a deployment plug open to the water.

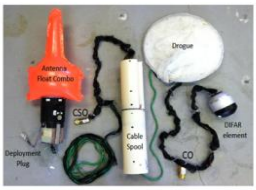

Figure 2. Display of Sonobuoy Hardware Following Deployment. The surface unit consists of the orange antenna / float combo, the battery and the deployment plug. The buoy's three sensors are the Constant Shallow Omni (CSO) hydrophone (set for a fixed depth of 13.7 m), the Calibrated Omni (CO) hydrophone and the DIFAR element (deployed to a selected depth of 27, 61, 122 or 305 m).

To access the EFS circuit board, the orange antenna/float combination was deflated and the pressurized cap and sensor selection buttons were removed. After disconnecting the seven wire lead from the EFS board, both the EFS and Transceiver boards were removed. Figure 3 displays the removed EFS and transceiver circuit boards in a stacked configuration. Figure 4 displays a top view of the plug (left) and origins (right) of the seven wire lead. The salt water activated battery is visible on the underside of the unit.

Figure 3. Removal of the EFS Circuit Board from the Surface Unit Housing. Following deflation of the antenna float combo and removal of the pressure seal and function select buttons, the stacked EFS (top) and Transceiver circuit boards can be removed.

METHODOLOGY (CONT)

Figure 4. Additional Views of the Surface Unit Housing and Battery. The left image displays a top view of the seven wire lead that plugs into the EFS board. The right image displays the origin of the seven wires leading to the plug. The green and white wires are merged to form the spool cabling beneath the housing, two leads (red and black) attach to the battery, and the remaining black, blue and red wires attach to the deployment retracted plug.

The seven wire lead was removed through the bottom of the surface unit housing and the cabling is cut after the CSO sensor. The cable spool, the CO hydrophone and the DIFAR element are discarded. A 1/8" mono plug was connected to the printed circuit board connector positions 2 and 3 of port "P1" on the EFS board.[8] The recording package (figure 5) was then mounted on a "high flyer" spar buoy. Power was provided by a salt water activated battery mounted on the spar buoy below the water line. The EFS board and a MicroTrack II Digital Recorder were housed in a waterproof Pelican box mounted on a horizontal platform above the water line.

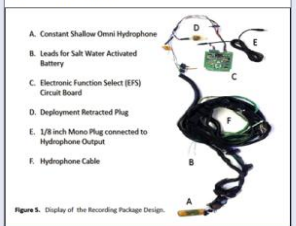

Figure 5. Display of the Recording Package Design.

RESULTS

During the transit to the operating area, the ship encountered a pod of approximately 20 bottlenose dolphins foraging near the surface. A single spar buoy (hydrophone depth set to 6 m / 44kHz sampling rate) was deployed to record vocalizations. Figure 6 displays two spectrograms from the approximately 30 minutes of recordings associated with that event.

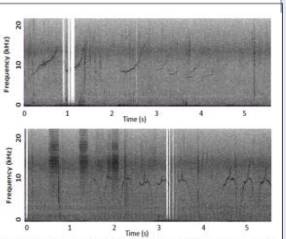

Figure 6. Example spectrograms of digital recordings conducted during the experiment reveal whistle contours and buzz clicks. The dolphins were approximately 200 m away. The "blanked" areas correspond to Spar buoy self noise.

RESULTS (CONT)

The spectrograms in figure 6 display several frequency modulated whistles and buzz clicks associated with bottlenose dolphins. Although the recordings peaked in response to spar buoy self noise, the recording package proved successful in an appropriate field test.

CONCLUSIONS

1. For the three days of the survey, recording packages suffered a failure rate of 20% (1 of 5) on the first day, 25% (1 of 4) on the second day and 33% (1 of 3) on the final day. Of the five originally constructed, two recording packages still maintain their functionality. Unfortunately, this design appears to very sensitive to multiple use scenarios.

2. Previously deployed SSQ-53F's CSO hydrophones appear to be functional and valuable sensor for future marine mammal monitoring. Additional research should be directed to use of the hydrophone independent of the EFS circuit board.

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