PARAMETRIC ALARMS PROTECTING MANATEES

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ABSTRACT

Manatees have difficulty detecting the dominant low frequency noise of approaching vessels in their shallow water habitats. Speed restrictions do not address the underlying sensory causes of collisions, and can actually increase the risk of collisions. An acoustic alarm for boats is being tested in Cape Canaveral, FL. It is proving to be effective and will be deployed on Navy vessels to further test it under real world conditions at installations in FL and GA. The device **effectively alerts manatees by providing directional acoustic cues manatees need to avoid approaching vessels. It** will allow DoD vessels to operate unimpeded at optimum speeds. Aside from direct military benefits, the device could be mandated in Florida to provide more effective and affordable protection for manatees throughout their range.

Figure 1. Most manatees bear the scars from multiple boat encounters. These encounters are so prevalent that manatees are routinely identified and catalogued by their characteristic scar patterns from boats and propellers. One individual had propeller scars acquired from 50 different boat collisions.

BACKGROUND

Manatees are not adapted for hearing the dominant low frequency spectra from watercraft. Near surface propagation characteristics and shallow-water transmission loss, in concert with the manatees' unique auditory constraints, are underlying sensory causes for the collisions with boats and slow moving barges. Slow speed zones implemented to protect manatees do not address these underlying acoustical causes for collisions. Ironically, this strategy can be counter-productive in turbid waters and exacerbate the problem. It makes vessels more difficult or impossible for manatees to detect while increasing their transect times, and thus the opportunities for collisions. After more than a decade of slow speed zones, and millions of dollars spent on enforcement of this policy, manatee watercraft mortalities and related injuries have reached record highs. Though manatees are not well equipped to detect low frequency vessel noise, they are well adapted for hearing higher frequencies which propagate effectively in their environment. This hearing sensitivity provides a sensory window through which to alert manatees of approaching vessels. Understanding their hearing abilities and the propagation characteristics of their shallow water habitats, Dr. Joseph E. Blue, an expert in sonar technologies and transducer design, conceived of a parametric method to exploit the manatees' best hearing abilities and alert them to the presence of motor boats and commercial vessels. Unfortunately, Dr. Blue did not survive to see a permit issued to test this technology, this study is dedicated to his memory.

APPROACH

The purpose of the study is to evaluate the efficacy of an underwater acoustic alarm for alerting manatees of approaching watercraft. The research has been documenting the behavior of wild manatees prior to, during, and after controlled slow boat approaches. Two experimental conditions are being tested; (1) boat approaches without an acoustic alarm, and (2) approaches using the same boat with an alarm. Control observations are recorded prior to any boat approaches, or at least 30 minutes after any boat approaches. Field trials are continuing this year in the Banana River within the USFWS Merritt Island National Wildlife Refuge (MINWR), adjacent to the NASA Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAS), in Brevard County, Florida. The MINWR site is in a restricted security zone of the KSC where public boating is not permitted. This provides relatively controlled conditions with few anthrogenic and related acoustical variables to influence manatee behavior. Instrumented acoustic buoys, synchronized with aerial video recorders document manatee behavior and the associated received acoustical conditions during control and experimental conditions.

MATERIALS AND METHODS

ACOUSTIC BUOYS

To both visually and acoustically grid each test site, bright yellow floatation buoys are numbered. These buoys are instrumented with correspondingly numbered GPS units and Digital Acoustic Recording Packs (DARPs). DARPs are configured with an M-Audio Microtrack 24/96 two channel digital recorder, a 24 hour battery sled, and walkie talkie. A sealed external cable runs from each DARP to a calibrated U.S. Navy USRD F37 hydrophone suspended 1.5 m from the surface (Figure 2a). USRD F37 hydrophones are robust with a flat frequency range of 10 Hz to 37 kHz at 0 to 35°C. They are omnidirectional in the horizontal plane and narrow in the vertical plane which works well for detecting boat and biological noise and minimizing noise contamination from surface interactions with the buoys. Eight instrumented buoys were deployed at varying intra-buoy distances ranging from 5 to 20 m to grid areas ranging from 40 to 160 square meters. Buoy tethers of varying lengths were covered with garden hose to negate any possible entanglement risks for manatees (Figure 2b). They were quietly deployed using a kayak to minimize disturbance to manatees in the area (Figure 2c). Deployments were completed at least thirty minutes before any control periods or boat approaches. Once deployed the network of buoys formed a relatively static acoustical receiving field in which manatees foraged, socialized, traversed and rested. (Figures 2d, e).

Figure 2d. Helicopter view of a buoy set and boat at White Point (Photo courtesy of Eric Reyier, Dynamac).

Figure 2e. Manatees routinely entered and stayed inside the buoy fields

Figure 2a. DARP components: two channel digital flash card recorder, power sled, walkie talkie and hydrophone.

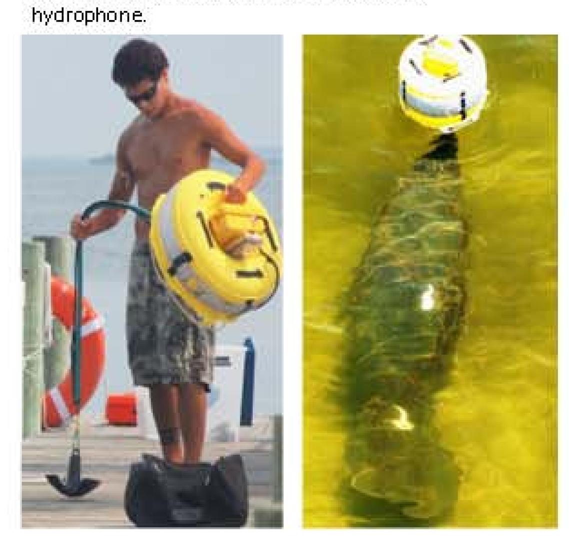


Figure 2b. The buoy anchoring system negated risks of possible entanglements with any curious manatees.

Figure 2c. Buoys were soft deployed using a kayak to minimize any possible disturbance to manatees in the area

PARAMETRIC ALARM

A low intensity, highly directional, dual frequency parametric array was developed to reduce collision risks by alerting animals in the direct path of approaching vessels. The parametric transducers project stable narrow beams of sound just under the surface of the water for distances of up to 100 m. The manatee-alerting signal is being projected at very low intensities 120 dB re 1 uPa. Since the device has been designed to exploit the manatees best hearing abilities very little power is required. The parametric array (Figure 3a) was created to achieve a highly directional alarm with an aperture small enough so that it would result in minimal drag on the smaller boats that hit manatees. The system projector is comprised of multiple elements, band centered to transmit a high carrier frequency along with a lower side band signal. The primaries are higher than any marine mammal are presently known to hear. A single-side band modulation and phase-shift method are employed, and the nonlinearity of water demodulates the mixed high frequency carrier into a lower frequency waveform audible to manatees. The resulting parametric wave that is alerting manatees falls within their best hearing range of 10 to 20 kHz. As shown in Figure 3b, the manatee parametric projector generates very narrow 6° acoustical beam of sound directly ahead of the boat. The reason for such a directional device is to insure that only individuals in the direct path of an approaching vessel are alerted. This helps to insure that manatees are alerted only when they are at risk of an eminent collision. The narrow beam and high frequencies also minimize any possible cumulative noise effects of multiple devices.

Figure 3a. Parametric alarm systems

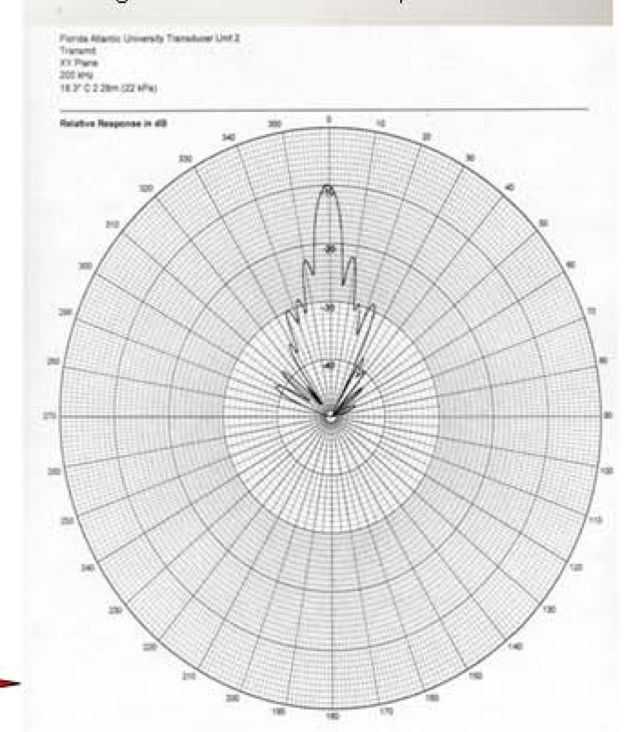


Figure 3b. Directivity curve for projector

Figure 5. Pontoon boat with three observation decks and a 46 ft video camera pole

APPROACH BOATS

Two approach boats have been used for this study. The first is a 21 ft pontoon boat modified with an electric outboard engine, a tower with elevated observation platforms, and a 46 ft high telescoping video camera pole (Figure 5). The boat serves as an approach and observation platform. It provides a stable forward aerial perspective of direct boat approaches. The figure in the top right hand corner is a captured video scene of an alarm trial. The wider view is from the video pole and the close up view is from a camera on the third platform. The tower also provided a spectacular view of the Space Shuttle launch (Figure 6). When conducting trials near the NASA parkway causeway bridge we also utilize the bridge as a fixed elevated vantage (45 ft above the water) to record both controls and boat approach trials (Figures 7, 8a, 8b). The second boat is a 20 ft. mono hull work boat configured with a 90 hp outboard gasoline engine with a 26 ft telescoping video camera pole above the cabin (Figure 9).

Figure 6b. Viewing a Space Shuttle launch from the boat tower

Figure 7. View from 26 ft high platform on the pontoon boat

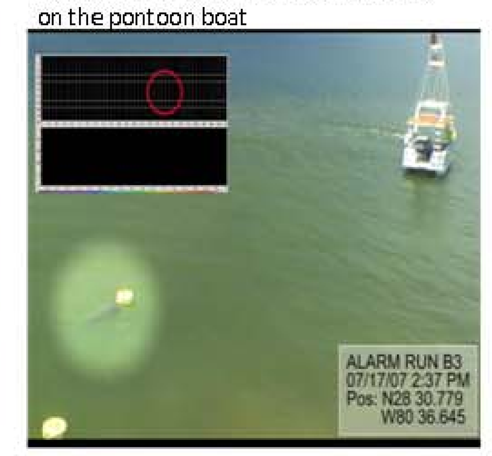


Figure 8a . Alarm approach sequence

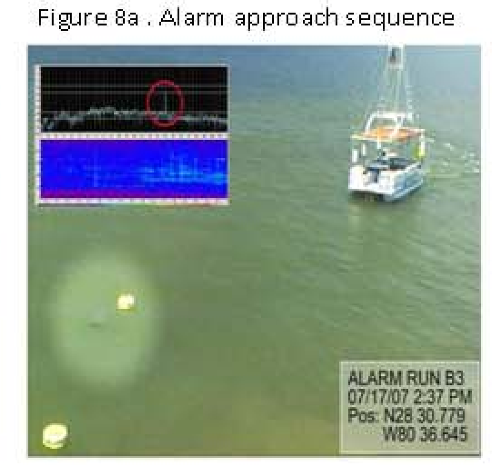


Figure 8b . Alarm approach sequence. Manatee dives during alarm trial, 15 meters ahead of the approach boat. The spectral plot below shows that the manatee reacted when the alarm was 117 dB re 1 uPa.

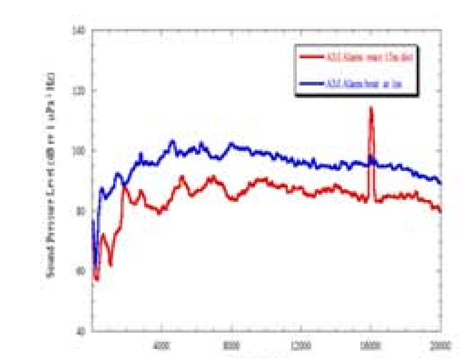
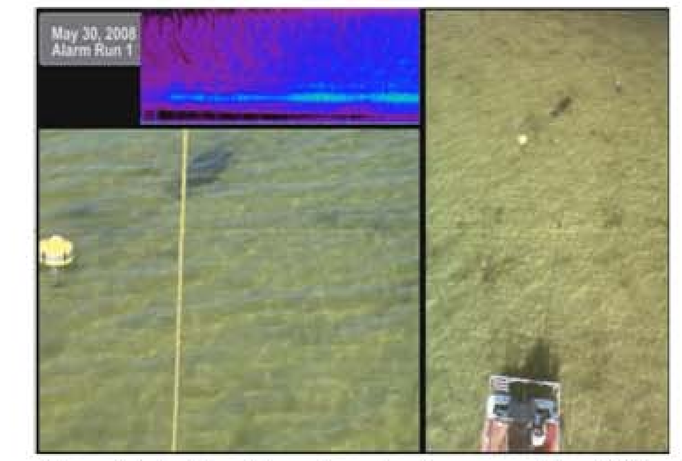


Figure 9. Dynamac's work boat, on loan for outboard approach trials



Alarm trial: video taken from the tower and the 46 ft pole extension. The manatee responds at 35 m.

PRELIMINARY RESULTS AND DISCUSSION

Controlled approach trials with wild manatees were only run when water visibility was clear enough to view focal animals and track their positions throughout approach sequences. A total of 101 trials have been run to date. Only five (7%) of the no-alarm approach trials have resulted in a measurable avoidance reaction or change in behavior. For 93% of these no-alarm trials manatees did not react to the approaching boat. During these no-alarm trials some avoidance reactions were observed but only after the the boat passed the animal and was forced to veer in order to avoid hitting the manatee. In contrast, (97%) of the alarm trials elicited overt avoidance responses (a change from resting or feeding to swimming away or diving). These changes were exhibited at distances ranging from 12 m to 30 m ahead of the bow. The mean response change in behavior was significantly greater during alarm trials ($F=198$, $df=1$, $p < 0.01$). The mean distance at which focal manatees responded was also significantly greater during alarm trials ($F= 46.46$, $df=1$, $p < 0.01$). These differences are illustrated in Figures 10a, b. The predominant effect during no-alarm trials was no-response. However, behavioral changes significantly increased only at the moment the bow passed or when the boat was forced to veer away (t- statistic = 5.348, $p<0.05$). This result indicates that these manatees would have responded during the boat approaches had they been able to detect the boat sooner.

SUMMARY OF TRIALS TO DATE

- ❑ 101 total controlled slow boat trials
- ❑ 71 no-alarm trials and 30 alarm trials
- ❑ **In 66 of 71, (93%) of the no-alarm trials, manatees did not react until the bow of the boat passed or the boat had to veer away sharply to avoid hitting them.**
- ❑ **In 5 of 71, (7%) of the no-alarm trials, manatees reacted at distances ranging from 5m to 7.5m from the bow. These avoidance reactions could have be visually and or acoustically mediated.**
- ❑ **In 29 of 30 (97%) of the alarm trials, manatees exhibited avoidance responses. Distances ranged 12m to 30 m from the bow. These responses were acoustically mediated. One individual (Romeo) did not react. This animal was sexually preoccupied with the buoy and did not react during silent or alarm trials.**
- ❑ **Peak received acoustic levels of the alarm at the time of reactions ranged from 110 dB to 118 dB re 1 uPa.**

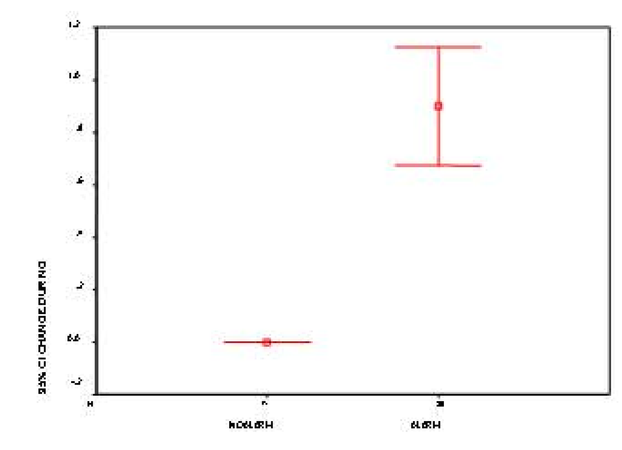


Figure 10a . Reaction / change in behavior during controlled approaches

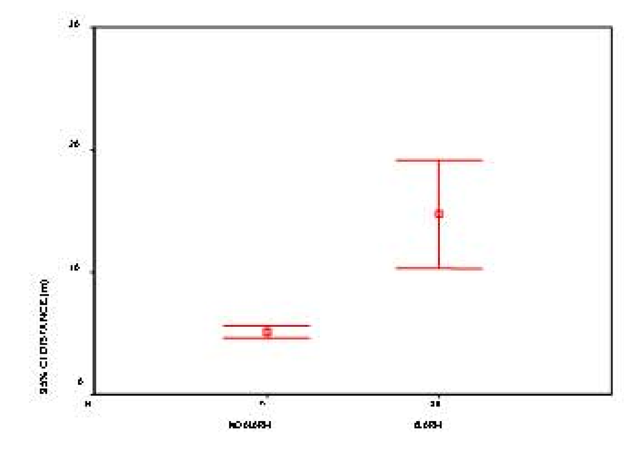


Figure 10b. Mean distances at which manatee reacts to approach

CONCLUSION

Manatees do not react to, and are unable to detect the sounds of approaching boats traveling at slow speeds. The manatees' low frequency hearing constraints, along with measured shallow water and near surface propagation factors, render these sounds inaudible against the ambient noise. The tests demonstrate the parametric alarm's efficacy for reliably alerting manatees of approaching boats (at received levels ≥ 118 dB).

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