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Short Communication

Addition of passive acoustic telemetry mitigates lost data from satellite-tracked manatees

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Abstract. Satellite-tracked manatees routinely lose satellite tags or tag functionality, resulting in the loss of valuable data on migration and habitat use patterns. Fortunately, some movement data from these animals remain salvageable because manatees typically retain a peduncle belt containing an acoustic transmitter that can be detected with a submersible hydrophone. We deployed an array of moored datalogging hydrophones at key locations in our study area to detect manatee belt-embedded acoustic transmitters, a technique not typically used to track manatees. Our array was successful in detecting five tagged manatees, and concurrently detected compatible acoustic tags of other estuarine fauna (e.g. Bull Sharks) tagged by local researchers. Moored datalogging hydrophones, therefore, provided a method to mitigate the loss of satellite tags from estuarine megafauna, and enhanced collaborative opportunities with researchers who tagged other species using compatible equipment.

Additional keywords: animal movement, hydrophone, sirenia.

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Introduction

Satellite-linked telemetry is a powerful method to track movements of mobile fauna (Tomkiewicz *et al.* 2010). For manatees and dugongs, satellite tracking systems have evolved during the past 30 years (Marsh and Rathbun 1990; Reid *et al.* 1995; Deutsch *et al.* 1998) and currently consist of three main components: (1) the buoyant 'tag' unit, housing the electronics, batteries and antenna; (2) a belt fitted around the animal's peduncle commonly containing an embedded acoustic transmitter; and (3) a flexible nylon tether connecting the floating unit to the peduncle belt that enables the unit to be towed behind the animal along the water's surface. This tracking system is somewhat unique among aquatic animals in that the tag floats and is linked to the animal with a tether rather than directly attached to the animal with a collar or an implant. Although a floating tag provides better data reception and transmission, tether breakage is commonplace in satellite telemetry studies of manatees and other aquatic species, substantially shortening the duration of tag deployments relative to potential (Reid *et al.* 1995; Deutsch *et al.* 1998; Ajemian and Powers 2014). Although disadvantageous from a data-collection perspective, tag release must occur to ensure animal safety should the tag become snagged on or tangled in an obstruction. Loss of telemetry functionality can also occur due to other causes such as equipment malfunction, obscured GPS reception, animal submersion, or water intrusion after a boat strike or alligator interaction (Deutsch *et al.* 1998; Weigle *et al.* 2001). These unpredictable but fairly common events can limit tracking duration and result in data loss from telemetered animals at great expense to researchers.

Despite loss of satellite telemetry functionality, manatees with detached or non-functional satellite tags can be identified by acoustic transmitters embedded in peduncle belts. These acoustic transmitters typically are used for active tracking and relocating animals with detached or non-functional satellite tags. Researchers locate and follow a focal animal, typically by boat, using a portable directional hydrophone with the ultimate goal of replacing the non-functional satellite tag. These efforts are not always successful, especially if the animal has moved from its last known location. Hence, additional measures are often needed to locate animals or recover data.

In this study, we tested the use of moored omnidirectional datalogging hydrophones to detect belted manatees and potentially mitigate data loss from detached or non-functional satellite tags. The hydrophone array was designed to test: (1) the efficacy of this method to detect residence or passage of belted manatees within targeted travel corridors and known habitat areas; and (2) the potential for concurrently detecting other acoustically tagged estuarine fauna, thus supporting and enhancing collaborative research efforts with other area investigators.

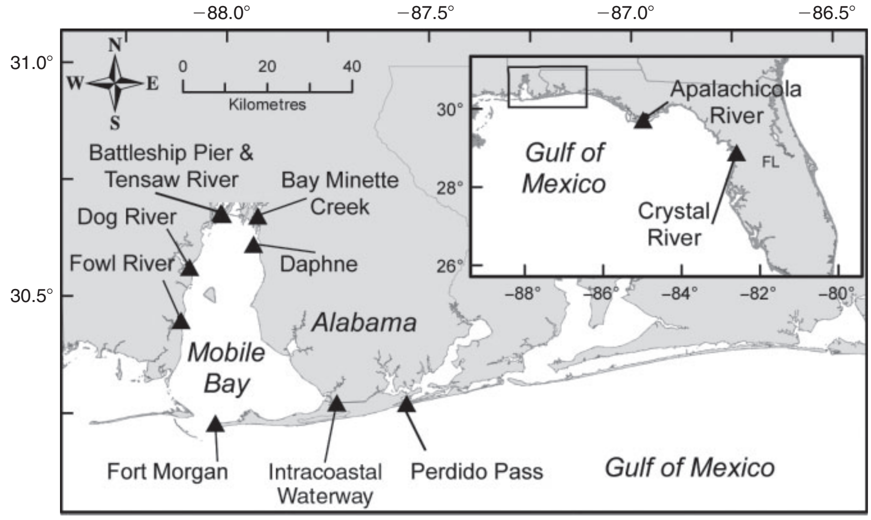

Fig. 1. Hydrophone deployment sites in Alabama and Florida, USA.

Materials and methods

We captured a total of eight manatees on the northern Gulf of Mexico coast in Mobile Bay, Alabama, USA, in 2009, 2010 and 2012 using standard manatee open-water boat capture methods and handling techniques (e.g. Weigle *et al.* 2001). Each manatee was fitted with a Telonics GPS satellite tag (Telonics Inc., Mesa, AZ, USA), tether and peduncle belt containing an embedded Sonotronics CHP-87-L acoustic transmitter (Sonotronics Inc., Tucson, AZ, USA) having a manufacturer-stated ideal range of 3000 m and expected battery life of 18 months. Satellite tags were set up to record GPS locations every 30 min to a horizontal accuracy of less than 10 m. Animal locations were monitored through ARGOS service and occasional visual observation while the satellite tag remained attached and functional.

Lotek WHS2000 datalogging submersible acoustic receivers (Lotek Wireless Inc., Newmarket, ON, Canada, hereafter referred to as 'hydrophones') were deployed to monitor belted manatees and other estuarine fauna with compatible acoustic transmitters at 11 sites in coastal Alabama and Florida, USA (Fig. 1). We chose sites based on: (1) known manatee use of the area; and (2) location at aquatic bottlenecks such as river mouths or passes (where possible), ensuring reasonably close passage of transient fauna to the hydrophone. Receivers were programmed to sequentially monitor frequencies 70–83 kHz for the constantly transmitting Sonotronics CHP transmitters used in manatee belts, and 69 kHz for Lotek Rcode transmitters used by collaborating researchers, which transmitted every 60 s. We tested the detection ranges at select sites by submerging a Sonotronics CHP-87-L transmitter 1 m below the surface for 3 min at a series of distances from 100 to 500 m away from the hydrophone. For each test, the time of transmitter submersion was noted and was later cross-referenced against hydrophone detection timestamps to determine if the test transmitter was detected.

Detection data downloaded from the hydrophones were post-processed in two different stages. Raw data were initially processed with manufacturer-provided Sonotronics SURsoftDPC software and then analysed using a custom script to exclude tag detection records isolated in time by more than 60 min (modified from Grothues *et al.* 2005). The 60-min exclusion approach removed detections of ambient environmental noises, boats, depth finders or other noises that may mimic an acoustic transmitter signal. Spurious detections, although common, are not likely to mimic any particular transmitter code more than once within a small time window (Grothues *et al.* 2005). Thus, we are confident that the filtered hydrophone detection data represented the presence of focal animals.

To assess hydrophone performance during periods when manatees were satellite-tracked, we found all GPS-derived animal locations within each hydrophone's expected detection radius (300 m) using GIS tools. We cross-referenced the time-stamps of those locations to hydrophone detection data to determine if animals near each hydrophone were detected by the hydrophone.

Table 1. Results of acoustic transmitter range tests at each hydrophone deployment site
+, the transmitter was detected by the hydrophone; −, no detection

Location	Distance from hydrophone (m):				
	100	200	300	400	500
Fowl River, AL	+	+	+	+	+
Dog River, AL	+	+	+	−	−
Battleship Park Pier, AL	+	+	+	−	+
Bay Minette Creek, AL	+	+	+	+	+
Intracoastal Waterway, AL	+	+	+	+	+
Apalachicola River, FL	−	−	+	−	−

Results and discussion

The detection range tests indicated that hydrophones reliably detected acoustic transmitters out to 300 m and in some cases as far as 500 m at all tested sites except Apalachicola River, FL (Table 1). These detection ranges are consistent with tests by other researchers using similar equipment in the region (Drymon *et al.* 2014). The Apalachicola River hydrophone was

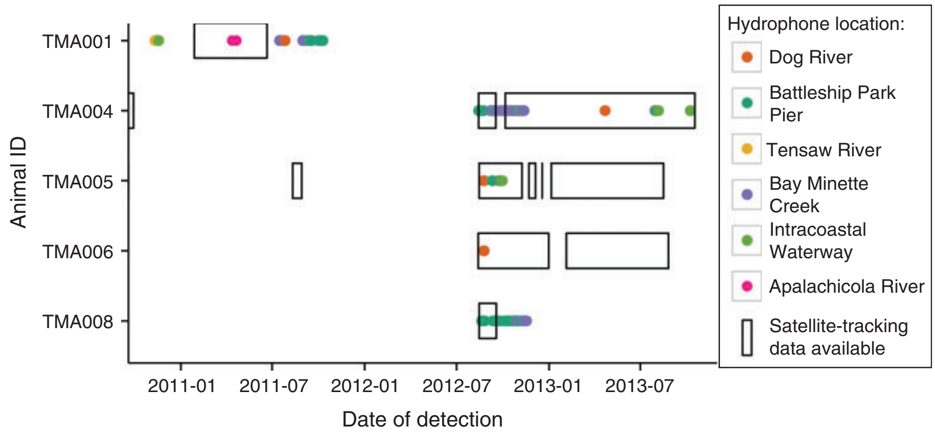

Fig. 2. Hydrophone detections of belted manatees by day of detection. Multiple detections in 1 day at the same site are symbolised only once. Periods when each animal was satellite tagged are indicated.

situated in an area with high boat traffic, significant water movement, variable bathymetry and submerged and floating aquatic vegetation. These factors along with other site-specific attributes such as salinity, tides, currents and sediment composition are known to mediate acoustic transmissions (Clements *et al.* 2005; Grothues *et al.* 2005; Heupel *et al.* 2006; Mathies *et al.* 2014) and likely accounted for the poorer detection range at Appalachicola River compared with other sites. The most effective hydrophone placement for detection of belted manatees, therefore, may be in deeper or dredged areas used for travel or rest rather than in shallow vegetated manatee foraging habitats, which may include more attributes that attenuate acoustic transmitter signals (Miksis-Olds and Miller 2006).

All eight tagged animals monitored in this study experienced tether breakage resulting in premature loss of satellite tags. Our hydrophone array detected the presence of five of those eight animals at six hydrophone sites, both while the animals retained satellite tags and after satellite tracking data became unavailable due to tag loss (TMA001, TMA004, TMA008: Fig. 2). These hydrophone detections ($n = 1903$) provided valuable information on movements of those focal animals that otherwise would have been unavailable due to satellite tag detachment. For example, hydrophone detections of TMA001 in 2011 enabled us to conclude that the animal had undertaken a significant, regional-scale movement from Apalachicola FL (where that animal's satellite tag stopped functioning) to Mobile Bay AL, where that animal resided for several months. These results suggest that strategically placed 'sentinel' acoustic receivers could be effective tools to detect presence of focal manatees at known aggregation sites or when traveling along predictable routes, potentially allowing researchers to infer timing of migrations. In addition to manatees, we also detected 35 acoustically tagged individuals of other estuarine species, including Bull Sharks (*Carcharhinus leucas*) and Gulf Sturgeon (*Acipenser oxyrinchus desotoi*), at eight hydrophone sites. These data were shared with the appropriate collaborating researchers.

In all, we found 96 instances when satellite-tracked manatees' GPS-derived locations fell within the expected detection radius (300 m) of a deployed hydrophone. Of those 96 locations, 50 were accompanied by one or more hydrophone detections of that animal's acoustic transmitter within 30 min before or after the time of the GPS reading. Of the remaining 46 GPS-derived manatee locations, 43 were completely undetected by the hydrophone and three were detected but subsequently rejected by the time filtering step in the data post-processing. These rejections likely indicate that the animal passed through the hydrophone's detection area too briefly to be detected more than once. Within 30 min of the GPS-derived location, successful manatee detections occurred regardless of manatee location within the 300-m radius (logistic regression, $P = 0.58$). Although this approach successfully detected manatee presence more than 50% of the time, these data indicate that non-detection is not necessarily evidence of absence of the animal from the study area.

This study demonstrates the potential application of moored datalogging hydrophones in a passive tracking role, an application that researchers have not traditionally used to monitor the West Indian manatee. Passive acoustic monitoring, implemented with carefully planned hydrophone arrays, can provide records of animal presence to supplement and corroborate high-resolution satellite tag data and may be particularly valuable when satellite tracking function is lost from these animals. This approach also has the potential to contribute to other researchers' compatible acoustic monitoring arrays with little additional effort, by concurrently detecting other acoustically tagged fauna. This type of multi-platform, coordinated and collaborative monitoring among fisheries and marine mammal researchers in acoustic monitoring networks has potential to be highly beneficial in minimising equipment and maintenance costs while maximising data collection and expanding the overall scale of tracking studies.

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