Passive Acoustic Monitoring of Artificial Reef Sites Reveals General Boat Traffic Patterns (but not Fishing Effort) in the Northwest Florida Gulf of Mexico

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Summary

We used passive acoustic monitoring (PAM) to investigate boater behavior on 13 sites where artificial reefs have been or will be constructed in Northwest Florida from Feb 2017 – May 2019 (Fig 1-2), with the goal of improving our ability to monitor and manage recreational use of artificial reefs. We developed automated algorithms to differentiate vessel noise from ambient oceanic noise and biological sounds in data collected by underwater acoustic dataloggers ("hydrophones"). Unfortunately, the algorithm was unable to differentiate between idling and transient boat sounds, failing to identify boats that had stopped to make use of artificial reefs. However, analyses remotely detected transient vessels traveling within thousands of feet of underwater dataloggers to accurately identify general patterns of boating behavior off Northwest Florida. We are continuing to explore opportunities to develop this technology in order to eventually quantify recreational angler activity on artificial reefs.

Figure 1. Deploying 8 and 15 ft. tall modules. Hydrophones are attached to these types of modules post-deployment.

Goals and Objectives

1. Assess our ability to detect boat traffic using acoustic hydrophones (**success**)
2. Analyze broad patterns of boat traffic in NW FL using acoustic data (**success**)
3. Quantify recreational fishing effort on artificial reef sites (**unsuccessful**)
4. Identify remaining challenges and opportunities for using hydrophones to improve our understanding of recreational artificial reef use (**ongoing**)

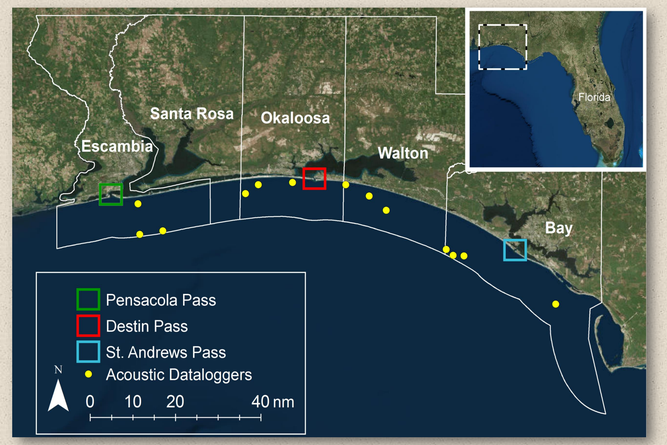

Figure 2. Map of three inlet access points (passes) into the Gulf of Mexico and 13 hydrophone locations offshore northwest Florida.

Methods

1. Deployed 13 hydrophones in new artificial reef areas to record underwater sound for one minute every 10 minutes (Fig 3).
2. Developed an algorithm to distinguish boat noise from ambient and biological noise based on a difference in the 3-4 kHz sound frequency range (Fig 4)
3. Compared boat detections for weekdays vs. weekends/holidays, summer vs. winter, and calm days vs. windy days to assess algorithm performance

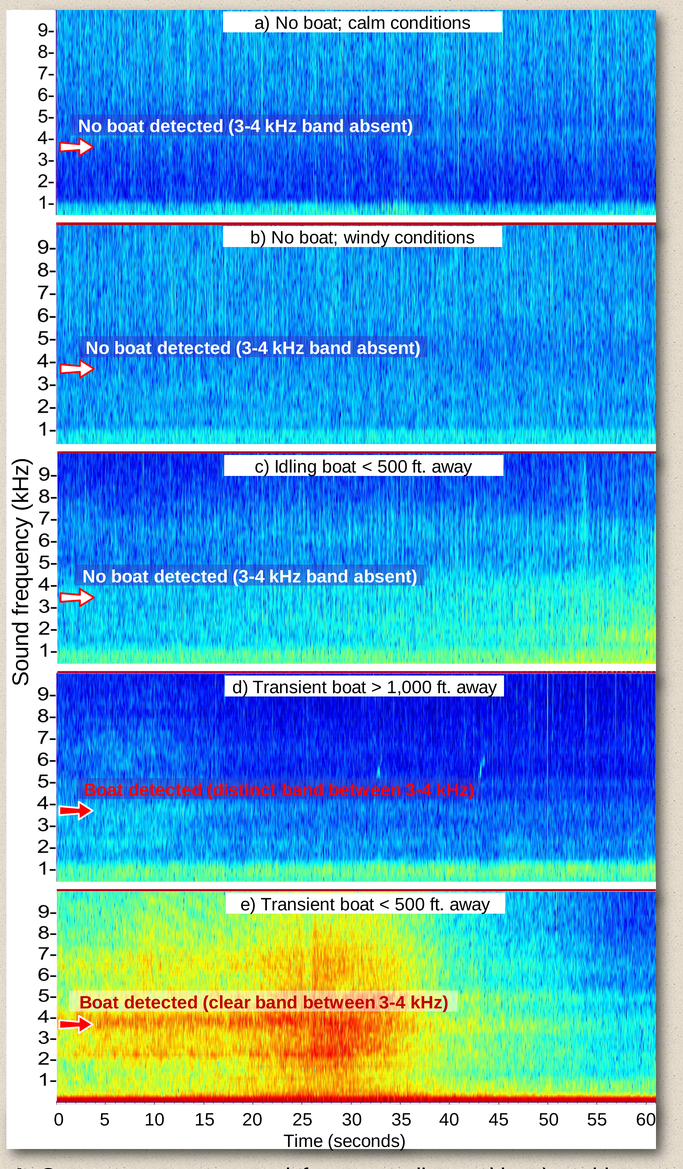

Figure 4. Spectrograms generated from recordings with: a) ambient oceanic noise, calm conditions; b) ambient oceanic noise, windy conditions; c) an idling boat approaching a datalogger; d) a high-speed boat >1,000 ft. away from a datalogger; and e) a high-speed boat <500 ft. away from a datalogger. The key difference between sounds from ambient conditions or slow-moving (idling) boats (a-c) versus fast-moving (transient) boats (d-e) is the sound presence between 3-4 kHz when transient boats are present (red arrows), but not when idling boats or no boats are present (white arrows). Idling boats (c) may also be difficult to detect because they generate sounds similar to windy conditions (b).

Results to date

- Our algorithm detected significantly more boats on weekends/holidays (Fig 6), in summer months (Fig 7), and on calm days (not shown).
- The algorithm can therefore reliably detect the presence/absence of transient boats within hundreds or thousands of feet from a datalogger
- The algorithm cannot identify idling boats that may have stopped to make use of an artificial reef site. Only the 3-4 kHz range was used to differentiate boats from biological and other ambient noise, and only transient boats had sufficiently distinct sound profiles in this range.
- At this time, results can only be used to demonstrate general patterns of regional boating behavior, rather than to estimate site-specific recreational fishing effort on artificial reefs

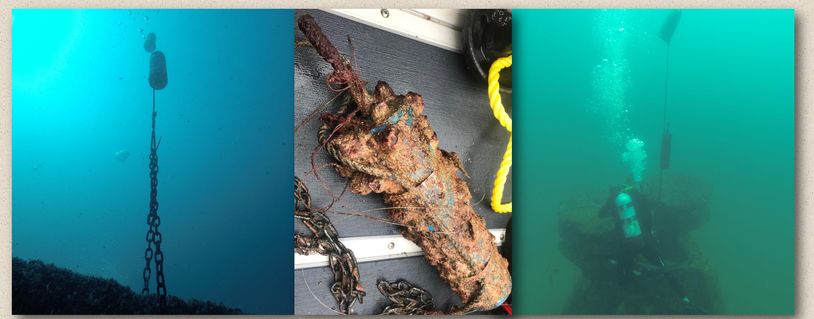

Figure 3. Acoustic datalogger (hydrophone) attached to a module in the field (left); a newly retrieved hydrophone, found entangled with fishing braid (center); FWC diver attaching a hydrophone to a reef module (right).

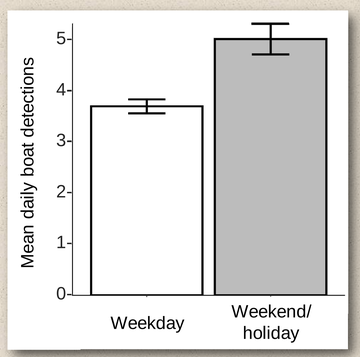

Figure 5. Mean daily boat detections on weekdays (white) vs. weekends and holidays (gray) from acoustic dataloggers at artificial reef sites across all counties. Error bars = standard error. *$p<0.01$*

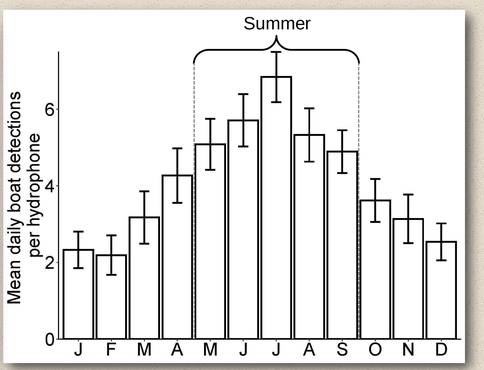

Figure 6. Mean daily boat detections per month across all counties, 2018 (the only year for which we have 12 months' data analyzed). ANOVA and *post hoc* testing showed that significantly more boats were detected during the summer months (May–Sep; $p < 0.01$). Error bars = standard error.

Future Directions

- Determine whether the boating behavior patterns we detected agree with recreational angler behavior recorded in the State Reef Fish Survey.
- Collaborate with Loggerhead Instruments to 1) determine whether idling and transient boat sounds can be separated, and 2) evaluate high-frequency SONAR pings from depth sounders on recreational vessels as an alternative method of identifying recreational anglers using artificial reefs

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Topic: Acoustic Monitoring of Artificial Reefs

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