Effects of anthropogenic noise and natural soundscape on larval fish behavior in four estuarine species

Efectos del ruido antropogénico y paisaje sonoro natural en el comportamiento de las larvas de cuatro peces estuarinas

Effets du bruit anthropique et du paysage sonore naturel sur le comportement des larves de quatre espèces de poissons d'estuaire

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EXTENDED ABSTRACT

Larval and post-larval forms of many marine organisms, such as multiple species of oyster, crab, lobster, coral, and fish, rely on acoustic cues to orient, settle, or metamorphose (Montgomery et al., 2006). Ambient acoustic cues are useful because they can inform organisms about the health of the environment. Acoustic cues also generally have a larger detection range than other cues (e.g. chemical, physical, and visual), are not significantly impacted by turbidity and light conditions, and propagate in every direction. Anthropogenic noise often disrupts or delays larval orientation, settlement, or metamorphosis (Popper and Hawkins, 2019). Therefore, understanding the impact of acoustic cues on animal behavior is important, especially as the marine environments becomes noisier due to increased human activity. In this study, we examined the effect of anthropogenic and ambient sounds on the orientation behavior of four larval estuarine fishes.

Lab-reared, pre-settlement size larvae of red drum *Sciaenops ocellatus*, southern flounder *Paralichthys lethostigma*, spotted seatrout *Cynoscion nebulosus*, and Florida blenny *Chasmodes saburrae* were individually placed inside an acoustic chamber and exposed to one of four sound treatments—seismic airgun, ship propeller, estuarine soundscape, and control. These four species are found in the Gulf of Mexico and the first three of them are popular gamefish, greatly contributing to the regional economy and culture. Airgun and ship noise treatments were chosen because of their prevalence in the Gulf of Mexico, their acoustic differences (intermittent and high intensity vs continuous and low intensity, respectively), and because the species are likely to be exposed to one or both sounds, or sounds similar to them (e.g. pile driving, underwater construction, low flying airplanes). Times spent "near" and "away" from the actively playing speaker were compared using a paired Wilcoxon signed-rank test; occupancy of the two sections was calculated for the first minute, three minutes, and full six-minute exposure period to observe if habitation to each sound occurred over the trial duration (Rossi et al. 2018).

The peak-to-peak sound pressure levels (SPL_{pp}) of the three playback files (airgun, ship, and estuarine) in the closest recording location to the actively playing speaker were approximately 10 dB re: 1µPa above the SPL_{pp} in the experimental tank (control). SPL_{pp} decreased with increasing distance from the actively playing speaker in the acoustic chamber. As expected, most acoustic energy was in the lower frequency range (<700 Hz).

Both anthropogenic noises caused significant avoidance behavior in at least one of the four species of larval fish. Red drum, southern flounder, and spotted seatrout initially (first minute) avoided the actively playing speaker when airgun noise played; however, only southern flounder continued to significantly avoid the airgun noise three minutes into the playback. None of the species significantly avoided the airgun noise for the full six-minute exposure period, but all spent less average time near the speaker. All species spent less time, on average, near the active speaker when ship noise played for the first minute, three minutes, and full six-minute exposure period. Only spotted seatrout spent significantly less time near the active speaker for the first three minutes of ship noise exposure. None of the species were significantly attracted to the ambient estuarine sound. Only red drum larvae spent more time, on average, near the actively playing speaker than away from it; the other three species spent less average time near the speaker when the estuarine soundscape was broadcast.

These results indicate that different species react differently to anthropogenic sounds and that larval fish can potentially habituate to anthropogenic noise in less than 10 minutes. This study is the first to examine the impact of airgun noise on larval fish behavior and our results suggest that larval fish may habituate to high intensity, intermittent sounds in a relatively short time period. Even though significant avoidance behavior was not observed consistently for any species (except for spotted seatrout during the first 3 minutes) during ship noise playback, all species spent less time on average near the speaker, which is similar to other larval fish playback studies, which reported negative changes in behavior in the presence of small-boat noise (Holles et al., 2013). Lastly, the observed aversion to the ambient soundscape was surprising because other studies recorded attraction to ambient sound (Simpson et al., 2004).

KEYWORDS: estuarine soundscape, anthropogenic noise, larval fish, orientation behavior, acoustic cue

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