Global wind patterns help move millions of migrating birds and bats through the Great Lakes region where shorelines provide important stopover habitat. Shorelines are thought to concentrate migrants because they offer the last refuge near a geographic barrier and are likely used for navigation. Shorelines also offer areas attractive for wind energy development. With this potential for conflicting interests, more information is needed on the aeroecology of the Great Lakes shorelines. We used two avian radar systems to identify the activity patterns, timing, and duration of migration that occurred along the shorelines of the Great Lakes.

We split the season into two parts and surveyed two sites with avian radar systems in the Upper Peninsula of Michigan near the shorelines of Green Bay, Lake Michigan in August. We then surveyed two sites in the Lower Peninsula of Michigan near the shorelines of Saginaw Bay, Lake Huron for the remainder of the fall migration season (September through early November). While operating at each of the four sites, each of the avian radar systems tracked and recorded target (bird and bat) movements continuously. We calculated direction of movement, target passage rates, and altitude profiles for the air space above our study areas. We also developed a model of our vertical sample volume that allowed us to report an estimate of target density by altitude band.

Migration occurred at all of our study sites; however, by moving locations on the first of September, we likely missed the majority of fall migration at our Upper Peninsula study sites and only captured a few days of what appeared to be heavy migration. We also were not able to document the duration of migration at the Upper Peninsula study sites; however, based on data collected at the study sites in the Lower Peninsula during the second part of our survey season, as well as from past seasons of data (Bowden et al. 2015, Horton et al. 2016c, Rathbun et al. 2016, Rathbun et al. 2017), we suspect that migration at these sites continued through at least October. The mean nocturnal passage rates were greater than the mean passage rates for dawn, day, and dusk combined at all of our locations. Nocturnal movement was generally orientated to the south for all sites. We also recorded other behaviors associated with migrants such as reverse migration, which was especially common at the sites in the Upper Peninsula, dawn ascent, and migrants over water returning to land at dawn. Peak density occurred between 100 - 350 m above ground-level; however, density may have been underestimated at higher and lower altitudes.

The results of our research highlight the potential role of radar in implementing the Land-Based Wind Energy Guidelines and help identify areas where impacts to wildlife would be minimized. We documented migration activity in the air space above our study areas and suspect the density of targets at low altitudes may present conservation concerns. The data we collected showed the ebb and flow of migration across the sampling periods and that the nocturnal peaks continued through late October. Given the amount of time during which migration occurred, it seems that curtailing wind energy operations during nocturnal pulses could result in limited operational time along shorelines during the migration season. Combining the results of radar studies and fatality searches would greatly improve risk assessments and assist with the interpretation of standardized radar studies.

Avian radar is increasingly relied upon to perform surveys for pre-construction risk analysis. While it is recognized as an important tool, few regulatory agencies have experience implementing avian radar or otherwise recognize the strengths and limitations of the technology. This report highlights a number of considerations in the use of avian radar, and reviews certain potentially confusing metrics. In addition to providing information relevant to conservation in the Great Lakes region, the concepts we present in this report are widely relevant to reviews of avian radar studies, and we provide methods that identify components of migration such as:

- Nocturnal pulses
- Season length
- Estimated density per altitude band
- Migrant behavior near a geographical obstacle

Given the rapid growth of the wind energy sector, our most effective conservation effort might be our ability to identify and avoid development in locations where migrants concentrate.