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Opportunistic Vessel-Based Detections of Migratory Bats in the Gulf of Maine

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Abstract - Offshore wind energy is being pursued in the Gulf of Maine (Gulf) to reduce dependence on fossil fuels; yet wind turbines pose a collision risk for bats. Previous efforts to monitor bat activity in the Gulf have involved acoustic surveys from stationary platforms, such as buoys and islands. However, acoustic monitoring from vessels opportunistically transiting through the Gulf offers a promising method to capture bat activity further offshore and across both spatial and temporal gradients. To explore the utility of this approach and expand on the growing research on bat presence in the Gulf, acoustic bat detectors were deployed on marine vessels in the Gulf and collected data during periods from April through May and August through October 2024. A total of 69 offshore bat passes were recorded, including calls from *Lasiurus cinereus* (Hoary Bat), *Lasionycteris noctivagans* (Silver-haired Bat), and *Lasiurus borealis* (Eastern Red Bat). Eastern Red Bat and Silver-haired Bat detections were the furthest from shore (136 km and 169 km, respectively), indicating the presence of bats near offshore wind-lease areas during both spring and fall.

Introduction

Offshore wind energy is contributing to a broad effort to reduce carbon dioxide emissions. In October 2024, the Bureau of Ocean Energy Management (BOEM) leased 4 offshore wind-energy areas to developers in the Gulf of Maine (Gulf; BOEM 2024). Collision with wind turbines is considered a threat to bats in the US and Canada (Adams et al. 2024), and while offshore wind energy is an important renewable energy resource, it has the potential to negatively impact bats (Solick and Newman 2021). Efforts to collect data on bats in the offshore environment to understand these potential interactions have employed various approaches, such as stationary acoustic monitoring from wind-turbine generators (e.g., Lagerveld et al. 2014, Normandeau Associates 2022), as well as visual observations from aerial surveys and vessels (e.g., Hatch et al. 2013). Opportunistic sightings of bats from vessels have also occurred incidentally to other research efforts (e.g., Kennerley et al. 2024). Mobile acoustic monitoring with detectors deployed on vessels has also offered new insights into offshore bat activity at further distances from the coast, revealing links between bat activity and wind speed (Sjollema et al. 2014). This approach also has the potential to detect bats more frequently given the homogeneity of the landscape (Fisher-Phelps et al. 2017) and provide information on population trends (Evans et al. 2021).

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Eight species of bats are known to be present in Maine, 5 of which are year-round residents (MEDIFW 2024). These species are separated into 2 groups based on their wintering strategy: cave-hibernating bats and migratory tree-roosting bats. Research conducted in other regions of the Atlantic Outer Continental Shelf indicates that cave-hibernating bats, which migrate from their summer habitats to hibernacula in the New England region (Perry 2013), may occur offshore but are generally not observed as frequently as migratory tree-roosting bats (Doucette et al. 2024, Dowling and O'Dell 2018, Thompson et al. 2015). Migratory tree-roosting bats, however, fly to coasts or areas with a mild climate to winter (Cryan 2003), have historically been observed offshore (Solick and Newman 2021), and have been detected up to 44 km offshore in the mid-Atlantic region during fall migration (Hatch et al. 2013).

To date, information on the occurrence of these groups in the Gulf has been based primarily on stationary acoustic-monitoring survey efforts by Peterson et al. (2014) and Peterson (2016), where acoustic data were collected from bats at Maine islands and nearshore buoys. These studies provide considerable temporal coverage of baseline bat activity in the region, but findings are limited spatially to nearshore locations. In particular, there remain data gaps on bat activity in the Gulf beyond the islands and in the offshore leases proposed by BOEM for wind-energy development, 4 of which are located 51 km northeast of Provincetown, Cape Cod, MA, and 2 of which are located 114 km southeast of Portland, ME. We installed acoustic bat detectors on marine vessels opportunistically transiting through the Gulf to provide new insights on bats offshore in the Gulf, with monitoring efforts conducted in the spring and fall of 2024.

Methods

The Canadian Wildlife Service, Environment and Climate Change Canada (ECCC-CWS), in support of the Regional Assessment of Offshore Wind Development in Nova Scotia (Government of Canada 2025), deployed an SM4Bat detector with a weatherproofed ultrasonic U2 microphone (Wildlife Acoustics, Maynard, MA), designed for recording echolocation calls of bats, on the Fisheries and Oceans Canada (DFO) vessel Canadian Coast Guard Ship (CCGS) *Teleost* from 11 April to 1 May 2024 (Table 1). The CCGS *Teleost* is a fisheries-research vessel used by DFO in the Maritime provinces, Quebec, and Newfoundland and Labrador regions. During the mission, DFO deployed oceanographic sampling equipment at fixed monitoring stations from southwestern Newfoundland to the Gulf. The CCGS *Teleost* mission operated 24 hours a day and only stopped during short periods (<4 hours) when the gear was in the water or when the vessel was in port. For this study, data were only analyzed from nights when the vessel was offshore between sunset and sunrise and the detector was operating; we refer to these nights as "monitoring nights". The CCGS Teleost made one 24-hour port stop on 25 April, which we excluded from the analysis. We georeferenced any confirmed bat acoustic detections using the ship's NMEA navigation GPS data.

For the fall monitoring effort, the Biodiversity Research Institute (BRI), with support from the Maine Department of Inland Fisheries and Wildlife, deployed a second SM4Bat detector with a U2 microphone cabled to an aluminum pole on the upper deck of the US fishing vessel (US F/V) *Maria Jo-Ann* from 19 August to 1 October 2024 (Table 1). While the detector was recording, the vessel made transits both in the daytime and at night to and from Georges Bank during 19–26 August, 8–16 September, 24 September–1 October. The vessel would make stops to tend fishing gear, but the vessel was never anchored during these periods. We derived locations of offshore acoustic bat detections made within the survey periods from an external GPS puck (Garmin 18x LVC, 5 m: Olathe, Kansas) connected to the SM4Bat detector. The device settings were in accordance with survey protocols established by the US Fish and Wildlife Service (USFWS) in the Range-wide Indiana Bat Summer Survey (IBat) Guidelines (USFWS 2023).

For both vessels, to assess survey effort, we overlaid the tracklines with 10 km by 10 km grid cells, in alignment with the grid-based sampling approach of the North American Bat Monitoring Program (Loeb et al. 2015). We calculated trackline length within each cell relative to the area of each grid cell and binned the data into 3 categories of effort for each vessel survey.

Initial processing of the Canadian acoustic data from the CCGS *Teleost* was conducted by ECCC-CWS and included filtering by a SonoBat 30 Batch File Scrubber (Arcata, CA) using an autofilter-low process. Filtering of the US acoustic data followed a similar process and was conducted by BRI in accordance with the USFWS survey protocols in the IBat Guidelines (USFWS 2023). We filtered the data in the USFWS-approved software (USFWS 2025) Kaleidoscope Pro Version 5.6.8 (KPro; Wildlife Acoustics, Maynard, MA) to remove files that contained only noise or

Table 1. Acoustic survey information for the CCGS *Teleost* and US F/V *Maria Jo-Ann* monitoring efforts. Survey extent based on NAD 1983 Contiguous US Albers projection.

	Vessel survey	
	CCGS *Teleost*	US F/V *Maria Jo-Ann*
Survey extent	43.0855776–43.4943748°N, 65.3243828-70.2969255°W	42.1840045–42.9435778°N, 67.3218177–71.1002533°W
Monitoring period	11–24 April, 26 April–1 May	19–26 Aug, 8–16 Sept, 24 Sept–1 Oct
Height of microphone above sea level	30 m	10 m
Sampling rate	256 kHz	256 kHz
Trigger window	2 sec	3 sec
Trigger level	12 dB	12 dB
16 kHz filter	Off	On
Recording schedule	1 hr before sunset to 1 hr after sunrise (UTC-03)	Continuous
Max file length	15 sec	15 sec
Bat pass identification process	SonoBat30 and manual vetting	Kaleidoscope Pro v. 5.6.8, SonoBat 30, and manual vetting

poor-quality recordings unsuitable for species identification. KPro then identified acoustic files that may contain bat signals, denoted as possible bat passes, assigning 1of 8 bat species to each possible bat-pass file using the classifier Bats of North America 5.4.0 region, Maine. For audio files in which KPro recognized that a bat echolocation pulse may be present in the audio file but was unable to confidently determine the species, a designation of NoID was given. Following the automated classification, we reanalyzed all possible bat passes, including NoID files, using SonoBat 30, a USFWS candidate program for bat species identification, which measures additional call characteristics in the full frequency spectrum.

Two experienced acoustic technicians manually vetted the filtered data from both efforts, including those files designated with NoID, to confirm the absence of identifiable bat tonal features. During the manual vetting process, we examined each file for call quality and species-specific features (i.e., maximum and minimum frequency, duration, multiple pulses within a call, and call shape; Szewczak 2022). If all parameters were present, we made a species-level identification to confirm or change the auto-identification in each possible bat pass. If the information was insufficient to identify species, we then classified calls by the file's phonic and recording-quality characteristics (Table 2). Low-frequency species, as noted in Table 2, produce calls from 20 kHz to 35 kHz, and high-frequency species produce calls from 35 kHz to 50 kHz. We denoted possible bat passes confirmed through the

Table 2. Manual bat vetting call criteria and call identifiers. Low-frequency (Low) species produce calls from 20 kHz to 35 kHz, and high-frequency (High) species produce calls from 35 kHz to 50 kHz. Confirmed = confirmed bat pass

Manual call definition	Call identifier	Phonic group	Classification
No bat calls present in the file	Noise	NA	No bat pass
Species can be identified	Silver-haired Bat	Low	Confirmed bat pass; species-level ID
	Big Brown Bat	Low	
	Hoary Bat	Low	
	Eastern Red Bat	High	
	Little Brown Bat	High	
	Tricolored Bat	High	
	Northern Long-eared Bat	High	
	Eastern Small-footed Bat	High	
Call has ≥5 good-quality pulses below 35 kHz	LoF	Low	Confirmed bat pass; phonic-group–level ID
Call has <5 good-quality pulses below 35 kHz	LoFrag	Low	
Calls above 40 kHz with steep drops in frequency at the end of the body of the call are indisputably from the *Myotis* genus	40KHzMyo	High[A]	
Call has ≥5 good-quality pulses above 35 kHz	HiF	High	
Call has <5 good-quality pulses above 35 kHz	HiFrag	High	

[A]Excluding Tricolored Bats and Eastern Red Bats.

manual vetting process to contain bat signals, either to the species level or classified by the file characteristics, as confirmed bat passes. We then processed confirmed bat passes with the 'batch buzz detector' in the Sonobat 30 NA Data Wizard to identify any feeding buzzes within the file that may indicate foraging activity.

Results

Within the Gulf study area, the CCGS *Teleost* traveled 956 km across 117 grid cells, and the US F/V *Maria Jo-Ann* traveled 1449 km across 111 grid cells (Fig. 1). Effort by the CCGS *Teleost* was more evenly distributed across the Gulf, while ef-

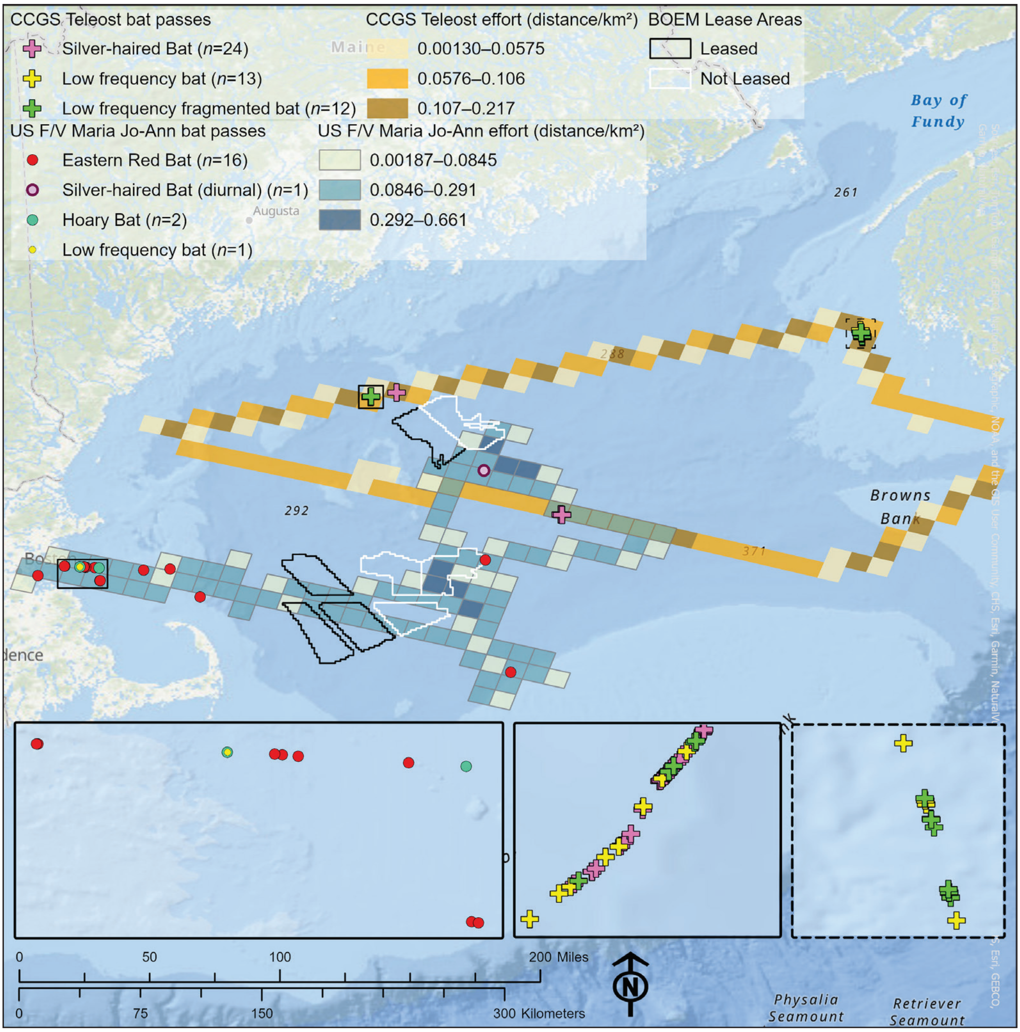

Figure 1. Survey effort of the US F/V *Maria Jo-Ann* and CCGS *Teleost* vessels within 100-km² grid cells. Bat passes recorded offshore in the Gulf in spring 2024 during the CCGS *Teleost* monitoring effort (n = 49) and fall 2024 during the US F/V *Maria Jo-Ann* (n = 20). Insets provide close up view of areas with concentrated call detections delineated by the solid-outlined rectangle and the solid- and dashed-outlined squares on the base map.

fort of the US F/V *Maria Jo-Ann* was more concentrated in areas that overlapped with the BOEM offshore wind-lease areas. The farthest distances the US F/V *Maria Jo-Ann* and the CCGS *Teleost* traveled from the contiguous mainland of New England and Nova Scotia were 190 km and 178 km, respectively.

A total of 49 confirmed bat passes were detected over 19 monitoring nights on the CCGS *Teleost* while transiting through the Gulf, including areas off the coast of southwest Nova Scotia (Fig. 1). All passes were recorded from 15 to 16 April. *Lasionycteris noctivagans* (LeConte) (Silver-haired Bat) was the only species-level identification possible (n = 24). The remaining passes were denoted as either LoF, defined as a call with ≥5 good-quality pulses below 35 kHz (n = 13), or LoFrag, defined as a call with <5 good-quality pulses below 35 kHz (n = 12). Either of these phonic-group classifications indicate the presence of low-frequency signaling species and could include either *Lasiurus cinereus* (Palisot de Beauvois) (Hoary Bat), Silver-haired Bat, or *Eptesicus fuscus* (Palisot de Beauvois) (Big Brown Bat). Of the 49 bat passes, feeding buzzes were identified in only 1 Silver-haired Bat file (n = 2). The 24 Silver-haired Bat passes were recorded from 65 to 169 km from land (Fig. 1, Table 3).

The SM4Bat deployed on the *Maria Jo-Ann* collected data offshore from 19 August to 1 October for a total of 23 monitoring nights (Fig. 1). In total, 20 bat passes were collected and then assigned as *Lasiurus borealis* (Müller) (Eastern Red Bat; n = 16), Hoary Bat (n = 2), and Silver-haired Bat (n = 1), as well as 1 LoF pass that could not be identified to the species level (Table 3). No feeding buzzes were identified within the 20 bat passes. One pass of an Eastern Red Bat was detected within 0.4 km of the Gulf offshore wind-lease areas (Fig. 1). When passes were assessed relative to land, defined as the contiguous mainland, Eastern Red Bats were detected closest (0.6 km) and farthest (136 km) from land (Table 3). Hoary Bat passes were recorded 12 and 19 km from land, and the Silver-haired Bat was detected 127 km from land (Table 3).

Of particular interest, there are 2 discrete examples of multiple, subsequent bat passes occurring along the track of the CCGS *Teleost*, with a maximum separation of 5 minutes between passes. In the first example, 12 passes were recorded southwest of Yarmouth, NS, Canada, on 15 April (Fig. 1). Passes occurred along a 2.6-km track over 5.5 minutes. In the second example, 34 passes were recorded southeast of Boothbay Harbor, ME, on 16 April (Fig. 1), occurring along a 0.63-km track over 26 minutes. All passes from both examples were classified as either a Silver-haired Bat, or a LoF or LoFrag pass, which could also indicate the presence of Silver-haired Bats. Intervals between passes varied between 0.08 and 4.45 minutes, and no records of multiple bats in the same recording occurred.

Discussion

Our results demonstrate that tree bats are present in the Gulf during both spring and fall migration at varying distances from shore. The species, timing of fall occurrence, and distances from land are similar to and within the range of detections previously collected in the Gulf, as Peterson et al. (2014) and Peterson (2016)

Table 3. Summary of bat passes detected during each vessel survey, as well as percentage of monitoring nights with bat passes by monitoring period. Distance = min–max distance from coast (km), # = # of passes, % = percent nights with bats.

	Monitoring period			All bats		Eastern Red Bat		Silver-haired Bat		Hoary Bat	
Vessel survey	Dates	# of nights	%	#	Distance	#	Distance	#	Distance	#	Distance
CCGS *Teleost*	11–24 April	14	14.29	49	19–169	-	-	24	65–169	-	-
	26 April–1 May	5	0.00								
US F/V *Maria Jo-Ann*	19–26 August	8	50.00	20	0.6–136	16	0.6–136	1	127	2	12–19
	8–16 September	8	12.50								
	24 Sept–1 Oct	7	14.29								

acoustically detected the same 3 tree-roosting species, as well as cave-hibernating Big Brown Bats and an unidentified *Myotis* species, on Maine islands up to 42 km from the coast, with activity peaking between mid-August and mid-September. Our results also align with historical records in the Gulf, where Eastern Red Bats were collected from vessels 111.9–201.6 km from shore (Solick and Newman 2021). In addition, recent surveys on Sable Island National Park Reserve, Canada (175 km from the mainland), detected Eastern Red Bats, Hoary Bats, Silver-haired Bats, and *Myotis* spp. between late September and early December (2015–2016; Doucette et al. 2024), potentially extending the known duration of bat migration across the Gulf. However, these studies collected minimal detections of bats during the spring, with monitoring effort primarily focused on the fall, and thus our findings indicate that tree bats may occur more frequently offshore during the spring than previously thought. Our results reflect a need for a longer effort of offshore baseline monitoring from early spring through late fall to assess possible bat exposure to offshore wind projects.

The detection of an Eastern Red Bat within the boundary of a Gulf offshore wind-lease area demonstrates that tree-roosting bats, which as a group have high fatality rates at onshore wind facilities (Allison and Butryn 2020), may be exposed to future offshore wind projects in the Gulf. Fatality rates of tree-roosting bats from onshore turbines are also highest during the fall migration period (Allison and Butryn 2020), when bat passes were most frequently recorded offshore during this study. Importantly, further study is needed to understand if the bats detected were isolated individuals or represent a portion of the population that frequently uses the offshore environment, and if bats present offshore are vulnerable to collision.

The detections of multiple passes over a short time and distance suggest bats, in some instances, may follow vessels. Further, the timing between recordings and likely presence of a single species, Silver-haired Bat, suggest that 1 bat may have followed the vessel rather than successive bats flying past, although multiple occurrences of bats circling survey vessels have been documented (Solick and Newman 2021). Bats may either be drawn to vessels as a potential landing spot or for foraging opportunities (Brabant et al. 2020, Hüppop and Hill 2016) or attracted by emitted light, as some migratory European bats may be attracted by certain light wavelengths (Voigt et al. 2017, 2018). Though only 1 bat pass contained evidence of foraging activity, the absence of feeding buzzes does not equate to the absence of foraging activity. The data contained excessive background noise across the entire frequency range of bat pulses, which may have obscured the quieter feeding buzz pulses, and it is possible that foraging activity occurred outside of the microphone's detection range. Additional studies are needed to accurately assess bat behavior around vessels.

This study demonstrates the utility of marine vessels as an opportunistic platform to host acoustic bat detectors and collect meaningful information on bats offshore in the Gulf of Maine and beyond. Although the vessels participating in this study were conducting missions incidental to bat monitoring, they provided information on bats over 42 monitoring nights across 2400 km of trackline up to

190 km from shore. As such, these opportunistic vessel platforms offer a low-cost, minimal-effort approach to study bat occurrence at distances far from shore and over extended periods, when dedicated surveys would otherwise be cost-prohibitive. The uneven sampling effort of these opportunistic vessels can be mitigated by selecting vessels that have consistent and regular routes, as well as by pairing vessel deployments with stationary offshore sites, such as offshore islands and buoys. Collectively, consistent monitoring efforts using offshore vessels in the Gulf can help identify which species are most likely to be exposed to offshore wind-lease areas, the seasons when exposure is highest, and the environmental conditions that increase exposure. Ideally, bat surveys need to be conducted concurrently at onshore, coastal, nearshore, and offshore locations, to fully understand how bat activity in the Gulf is related to spatial and temporal variables, such as distance from shore and season, as well as environmental variables, such as temperature and wind speed. The utility of vessel-based mobile surveys could be increased by developing methods to account for multiple detections of individual bats and vessel-following behaviors vs individual encounters. Such developments could potentially allow for estimates of bat occupancy or relative abundance derived from mobile survey data.

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